US 20160066859A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2016/0066859 A1**

Crawford et al.

(43) **Pub. Date: Mar. 10, 2016**

(54) **DEVICE-BASED ACTIVITY CLASSIFICATION USING PREDICTIVE FEATURE ANALYSIS**

(71) Applicants: **Stuart Crawford**, Piedmont, CA (US); **Piyush Savalia**, San Francisco, CA (US); **Prasad Panchalan**, San Francisco, CA (US); **Sylvia Hou-Yan Cheng**, San Francisco, CA (US); **Chris Singleton**, Palm Harbor, FL (US); **Sheila Nabanja**, San Jose, CA (US); **Ilyas Mohammad**, San Francisco, CA (US); **Sumit Sharma**, San Jose, CA (US)

(72) Inventors: **Stuart Crawford**, Piedmont, CA (US); **Piyush Savalia**, San Francisco, CA (US); **Prasad Panchalan**, San Francisco, CA (US); **Sylvia Hou-Yan Cheng**, San Francisco, CA (US); **Chris Singleton**, Palm Harbor, FL (US); **Sheila Nabanja**, San Jose, CA (US); **Ilyas Mohammad**, San Francisco, CA (US); **Sumit Sharma**, San Jose, CA (US)

(73) Assignee: **AliphCom**, San Francisco, CA (US)

(21) Appl. No.: **14/121,941**

(22) Filed: **Nov. 5, 2014**

Related U.S. Application Data

(63) Continuation-in-part of application No. 14/480,628, filed on Sep. 8, 2014.

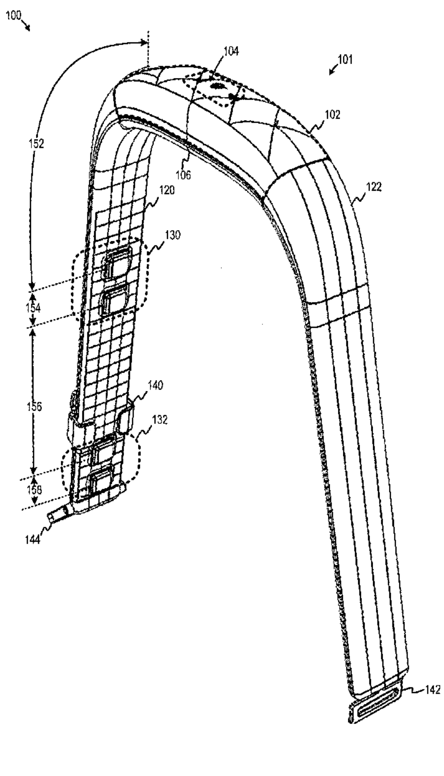
Publication Classification

(51) **Int. Cl.**
A61B 5/00 (2006.01)
A61B 5/0205 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 5/7264*** (2013.01); ***A61B 5/7275*** (2013.01); ***A61B 5/7278*** (2013.01); ***A61B 5/0205*** (2013.01); ***A61B 5/742*** (2013.01); ***A61B 5/7475*** (2013.01); ***A61B 5/681*** (2013.01); *A61B 2562/0219* (2013.01); *A61B 5/024* (2013.01)

(57) **ABSTRACT**

Device-based activity classification using predictive feature analysis is described, including receiving a signal from a sensor coupled to a device, the sensor being configured to detect the signal over a time period and to detect motion, evaluating the signal to generate data, the data being used to indicate motion, the data being further evaluated to select a classifier based on whether the motion is detected, activating another sensor coupled to the device, the another sensor being configured to detect another signal that is substantially different than the signal, the another signal being used to generate other data associated with whether the motion is detected, invoking the classifier, the classifier being configured to evaluate a predictive feature to identify a type associated with whether the motion is detected, the predictive feature invoking an application configured to determine the type and a state using a feature interpreter, and processing the data using the application and the feature interpreter to generate information associated with a biological state associated with whether the motion is detected, the information being configured to display on an interface associated with the device.



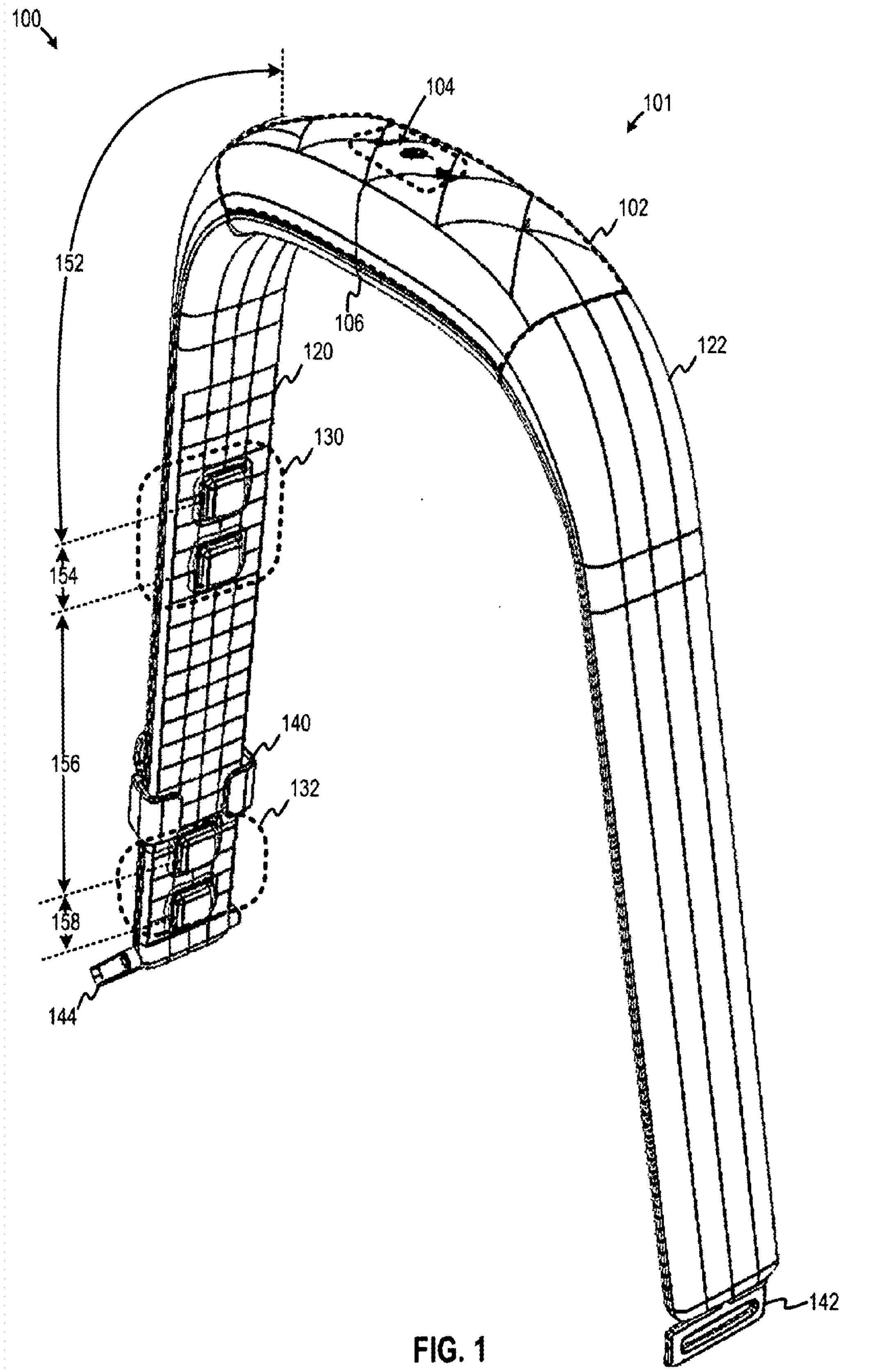


FIG. 1

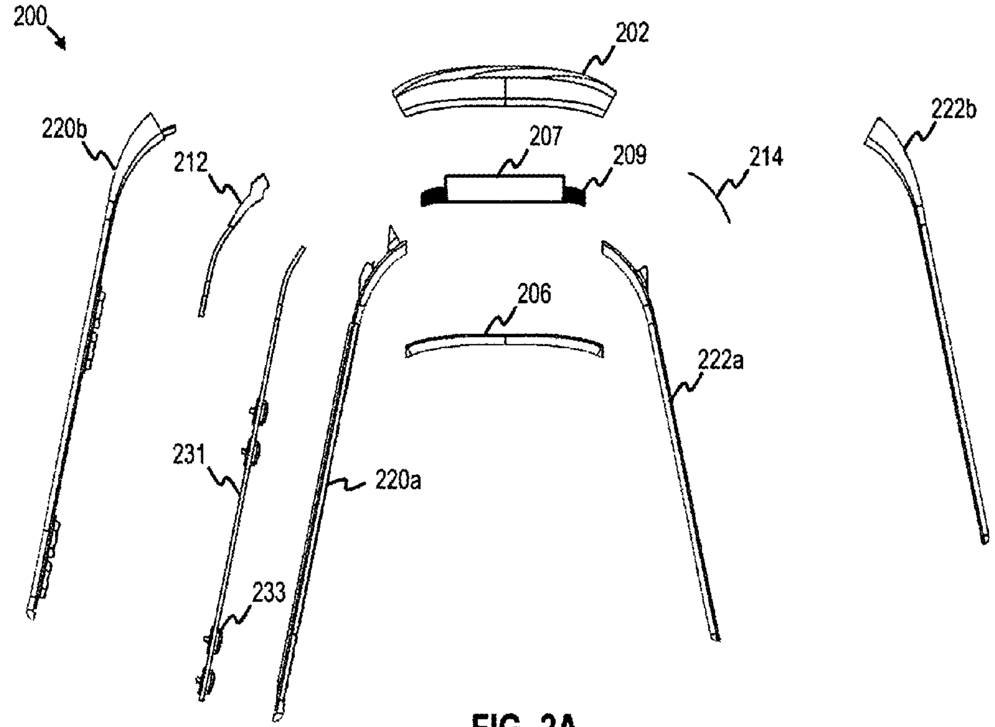

200
202
220b
222b
212
207
209
214
206
222a
231
220a
233

FIG. 2A

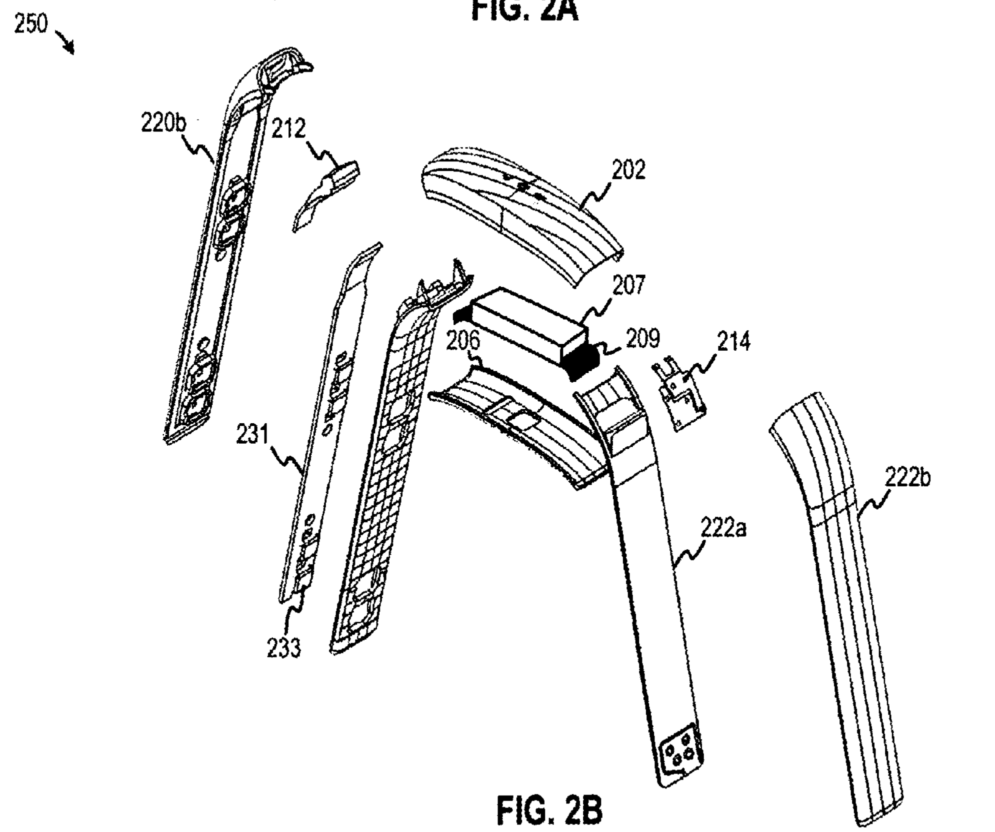

250
220b
212
202
207
206
209
214
231
222a
222b
233

FIG. 2B

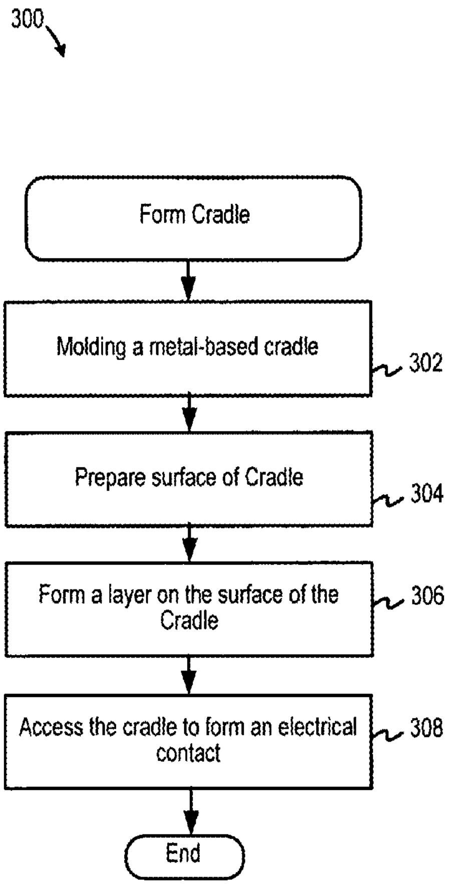

300
Form Cradle
Molding a metal-based cradle
302
Prepare surface of Cradle
304
Form a layer on the surface of the Cradle
306
Access the cradle to form an electrical contact
308
End

FIG. 3

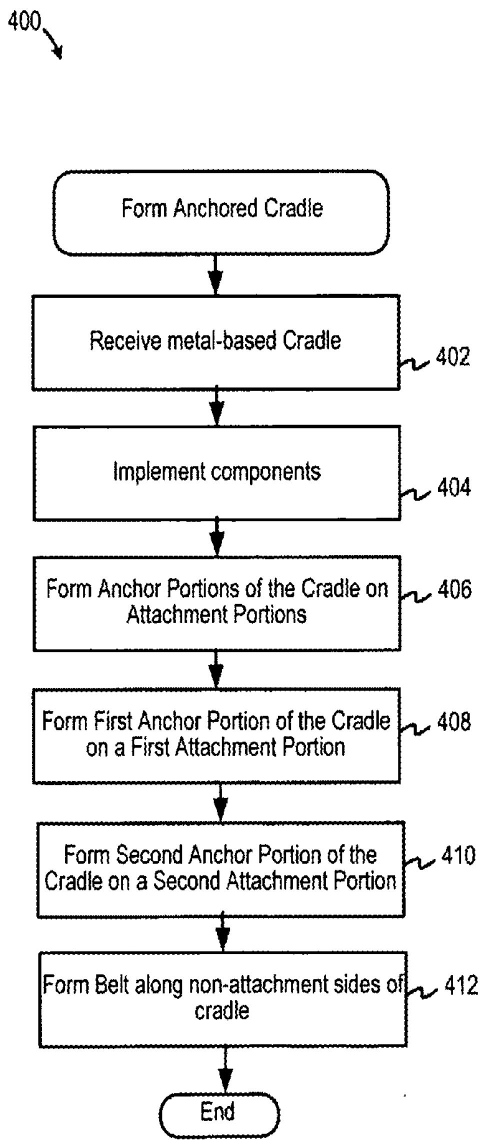

400
Form Anchored Cradle
Receive metal-based Cradle
402
Implement components
404
Form Anchor Portions of the Cradle on Attachment Portions
406
Form First Anchor Portion of the Cradle on a First Attachment Portion
408
Form Second Anchor Portion of the Cradle on a Second Attachment Portion
410
Form Belt along non-attachment sides of cradle
412
End

FIG. 4

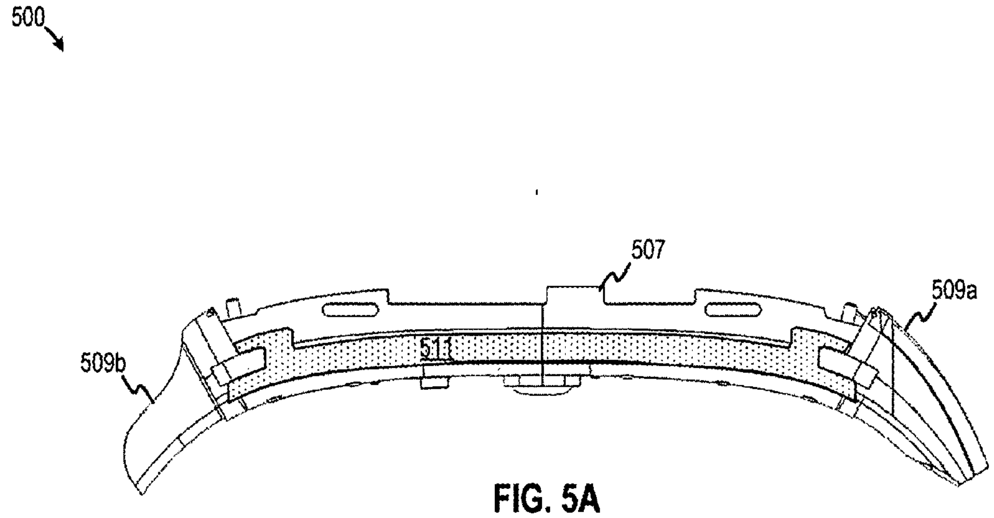


FIG. 5A

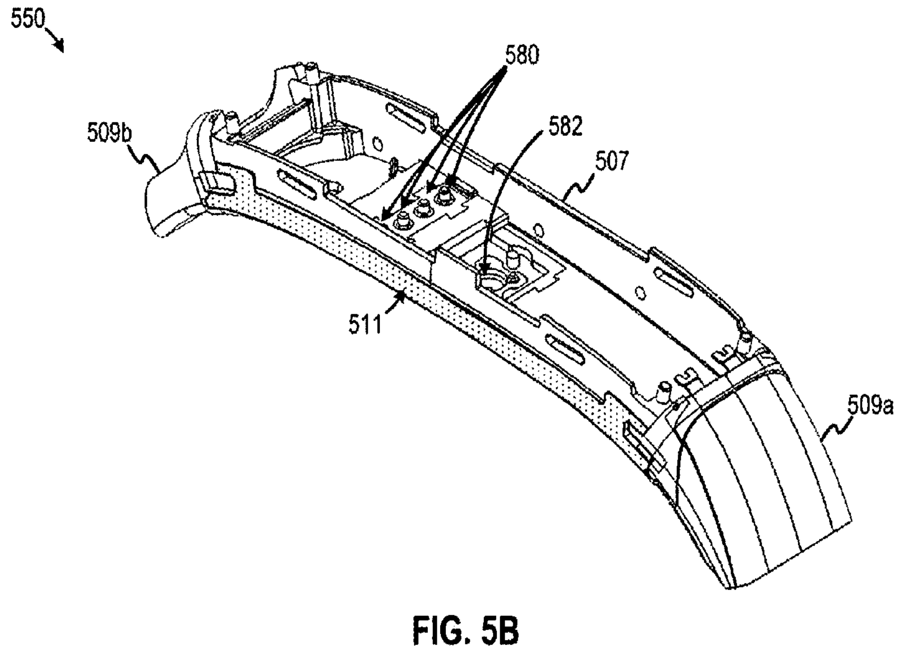


FIG. 5B

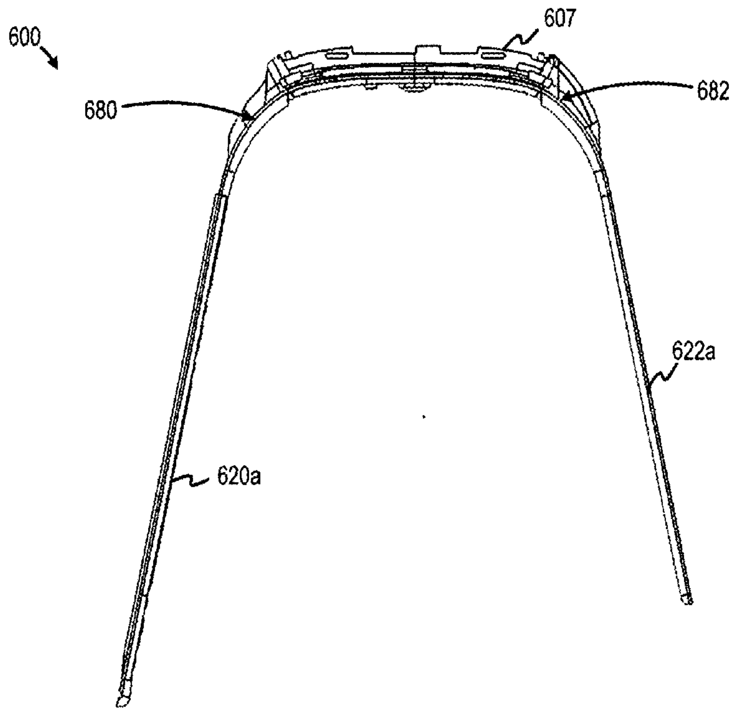


FIG. 6A

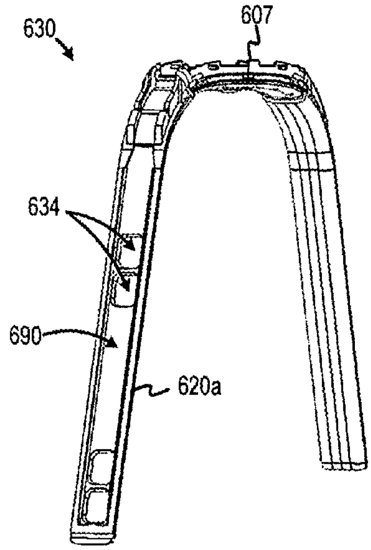


FIG. 6B

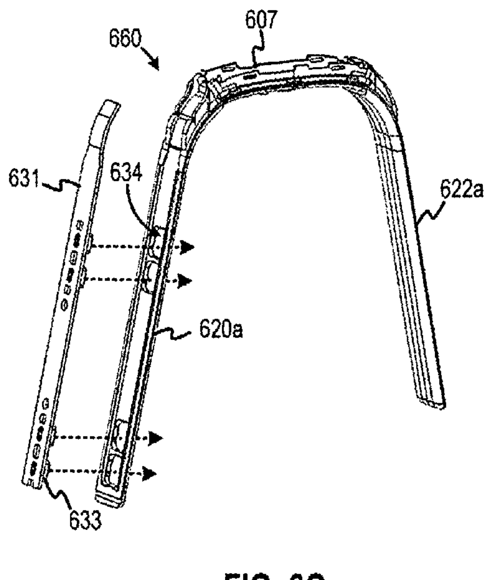


FIG. 6C

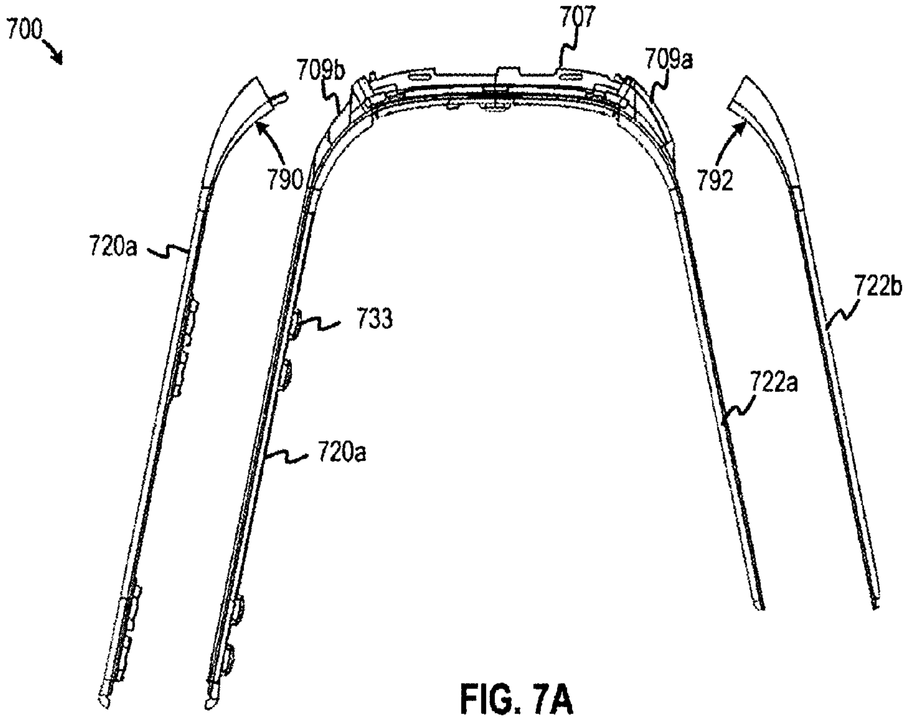

700
707
709b
709a
790
792
720a
733
722b
722a
720a

FIG. 7A

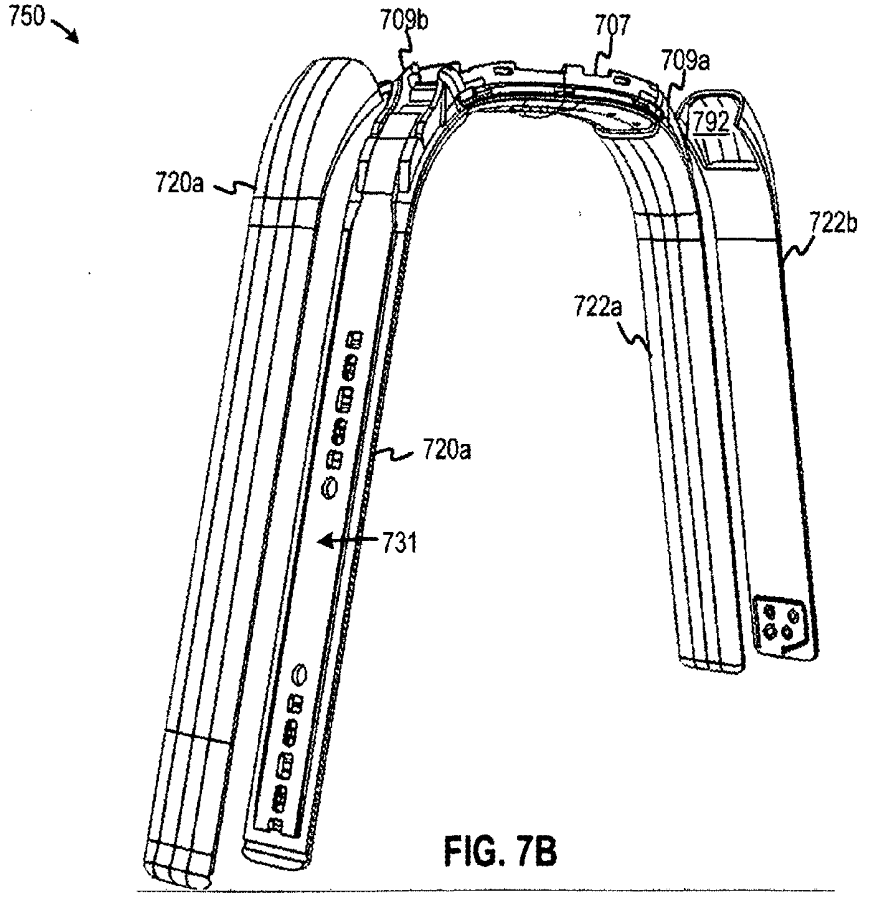

750
709b
707
709a
792
720a
722b
722a
720a
731

FIG. 7B

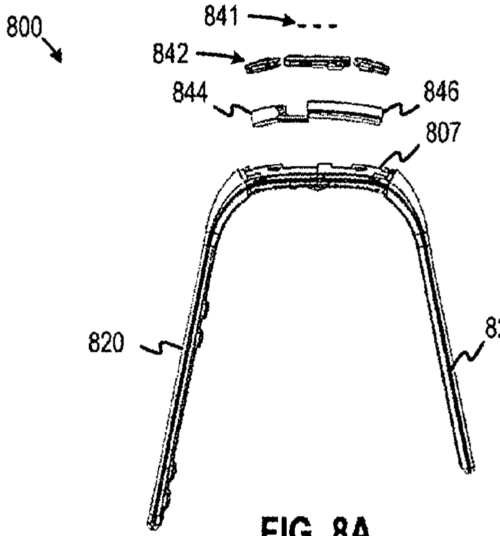


FIG. 8A

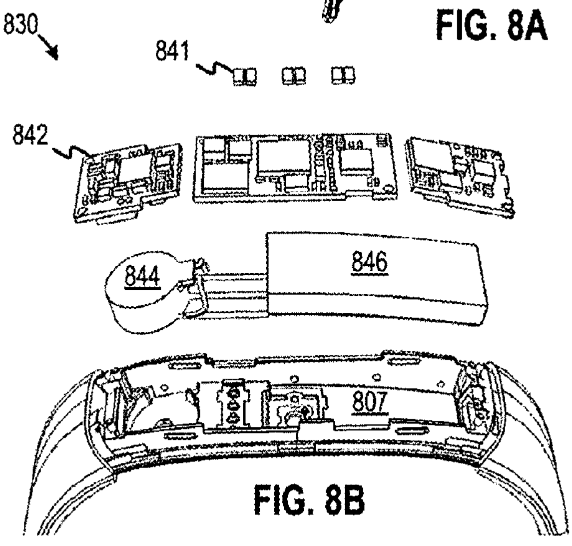


FIG. 8B

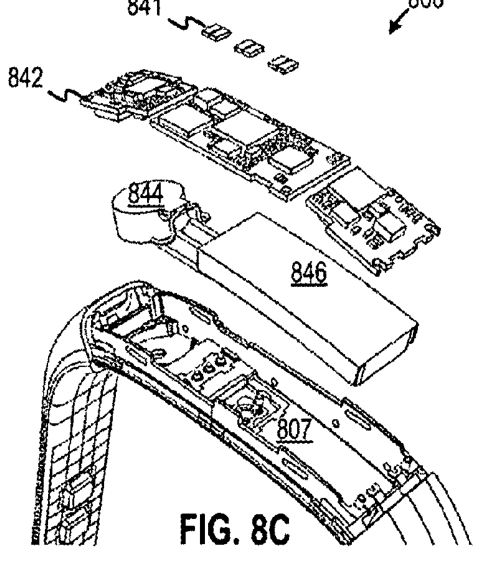


FIG. 8C

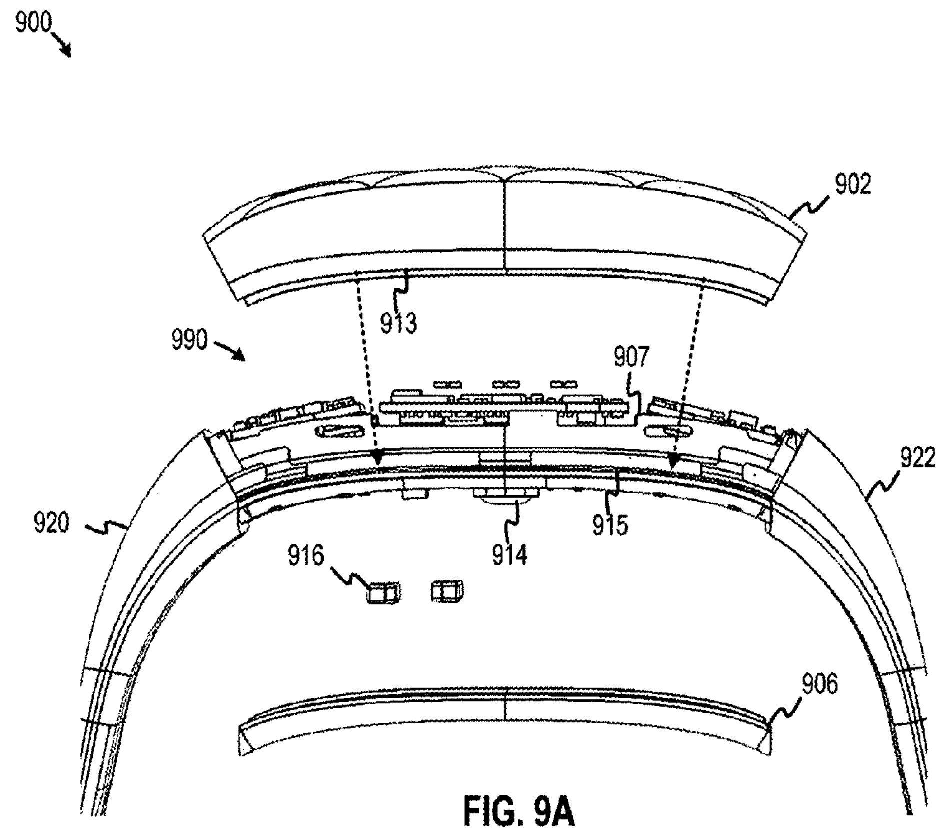

900
902
913
990
907
922
920
915
914
916
906

FIG. 9A

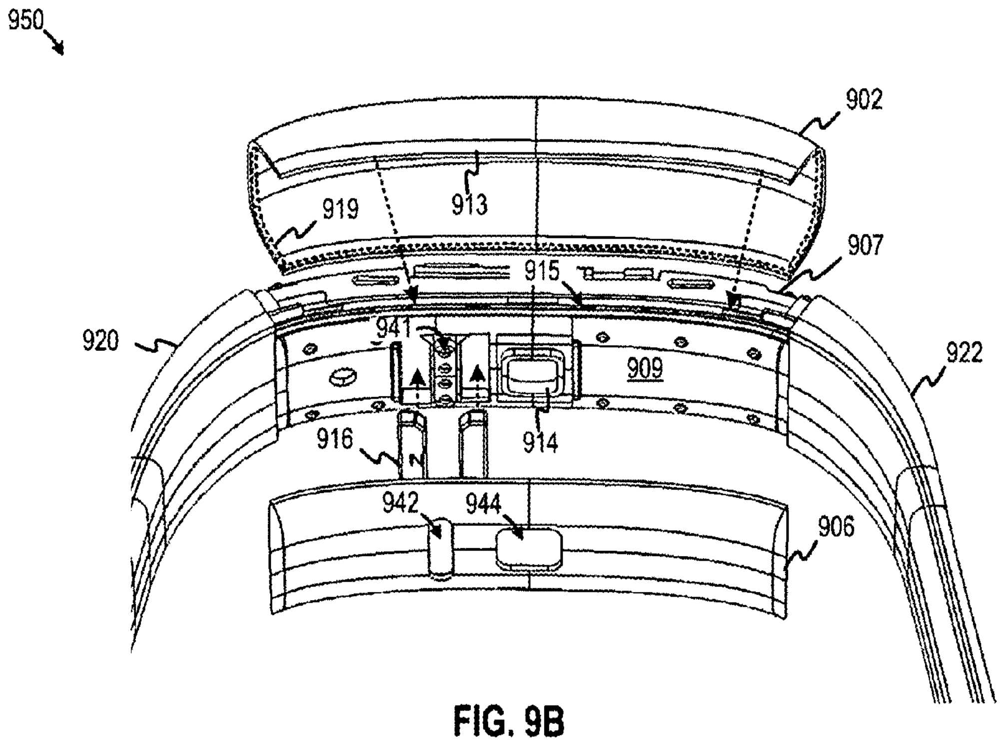

950
902
919
913
907
915
920
941
909
922
916
914
942
944
906

FIG. 9B

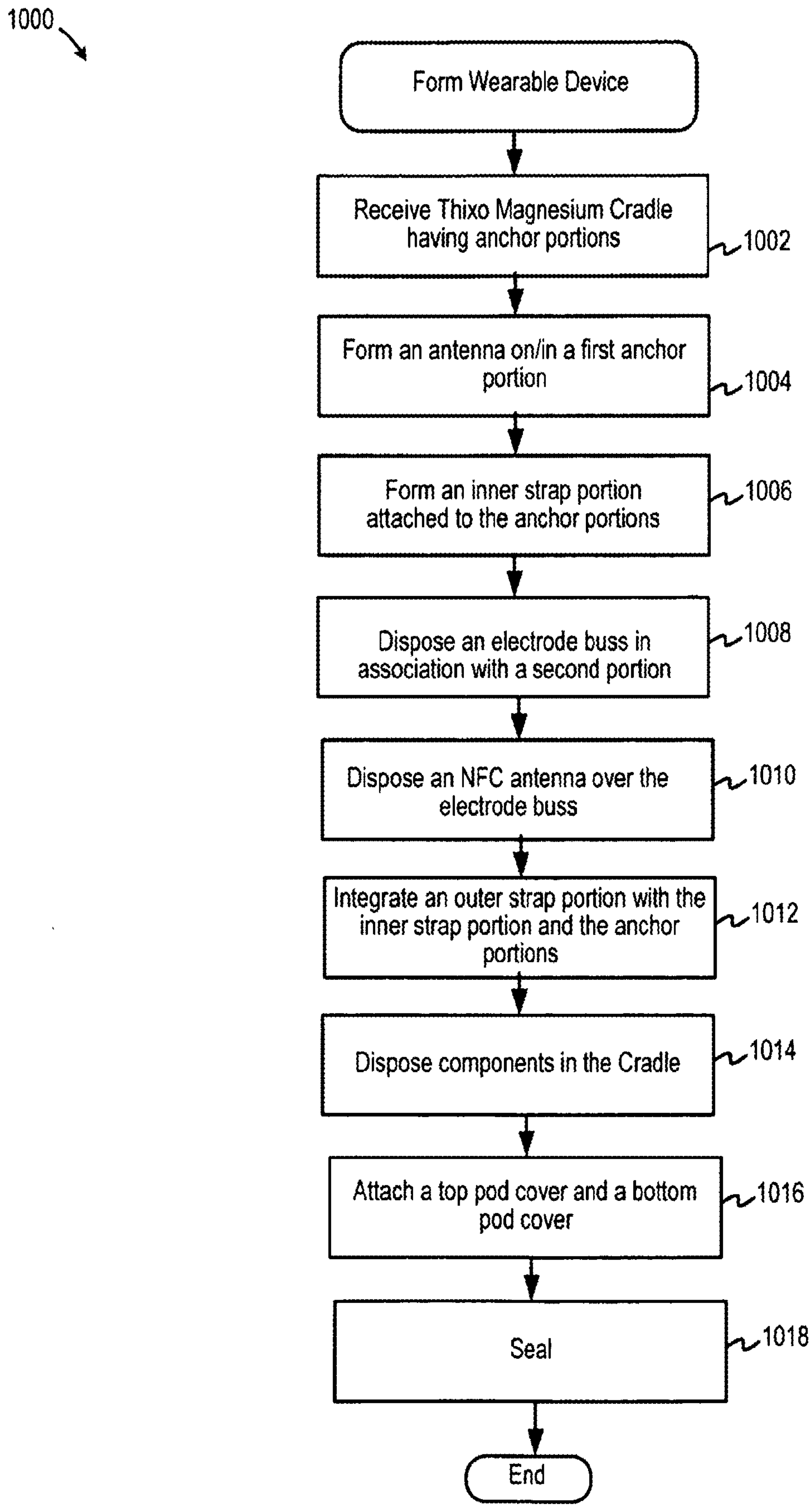

1000
Form Wearable Device
Receive Thixo Magnesium Cradle having anchor portions
1002
Form an antenna on/in a first anchor portion
1004
Form an inner strap portion attached to the anchor portions
1006
Dispose an electrode buss in association with a second portion
1008
Dispose an NFC antenna over the electrode buss
1010
Integrate an outer strap portion with the inner strap portion and the anchor portions
1012
Dispose components in the Cradle
1014
Attach a top pod cover and a bottom pod cover
1016
Seal
1018
End

FIG. 10

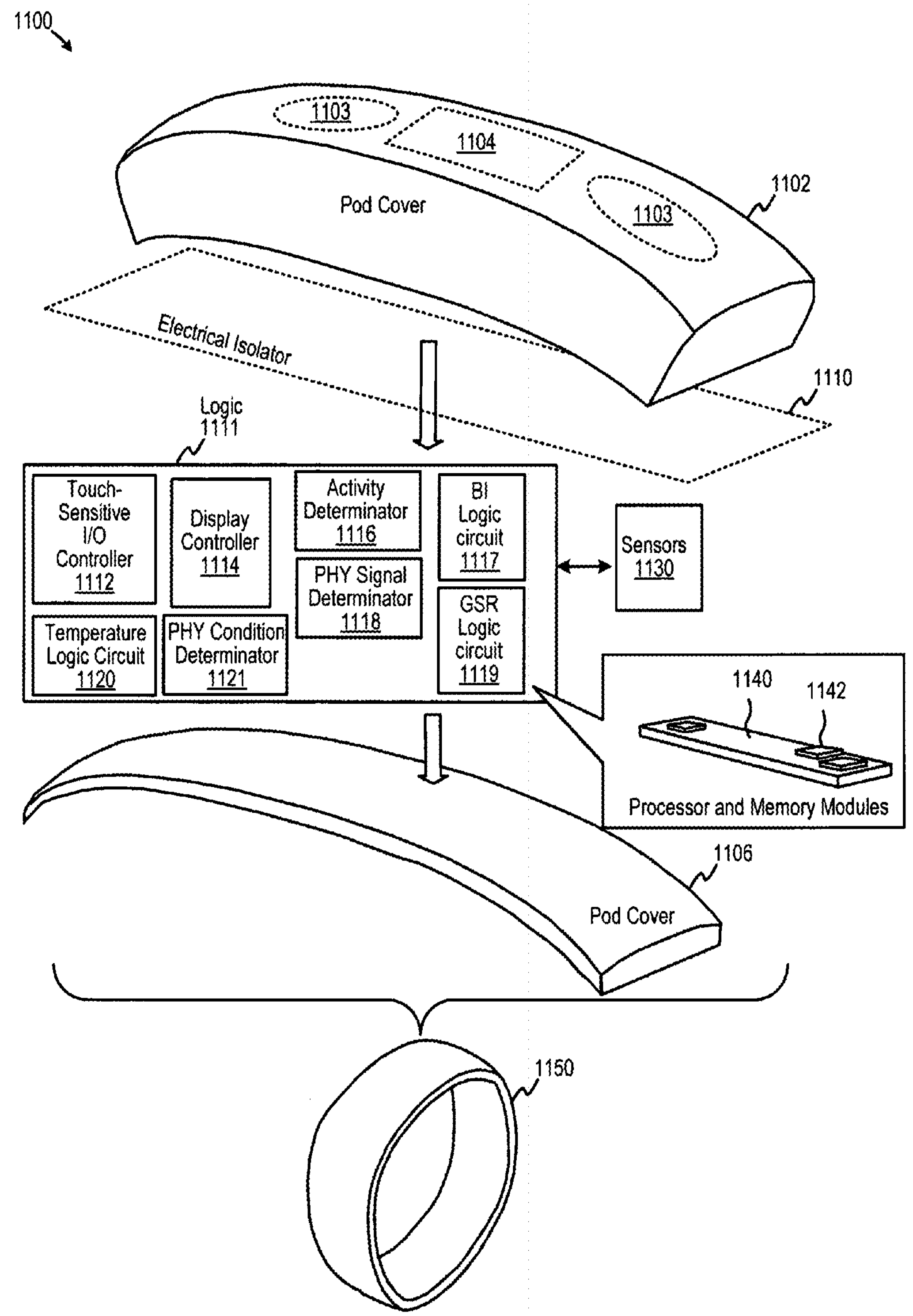

1100
1103
1104
1103
Pod Cover
1102
Electrical Isolator
1110
Logic
1111
Touch-Sensitive I/O Controller 1112
Display Controller 1114
Activity Determinator 1116
BI Logic circuit 1117
PHY Signal Determinator 1118
GSR Logic circuit 1119
Temperature Logic Circuit 1120
PHY Condition Determinator 1121
Sensors 1130
1140
1142
Processor and Memory Modules
1106
Pod Cover
1150

FIG. 11

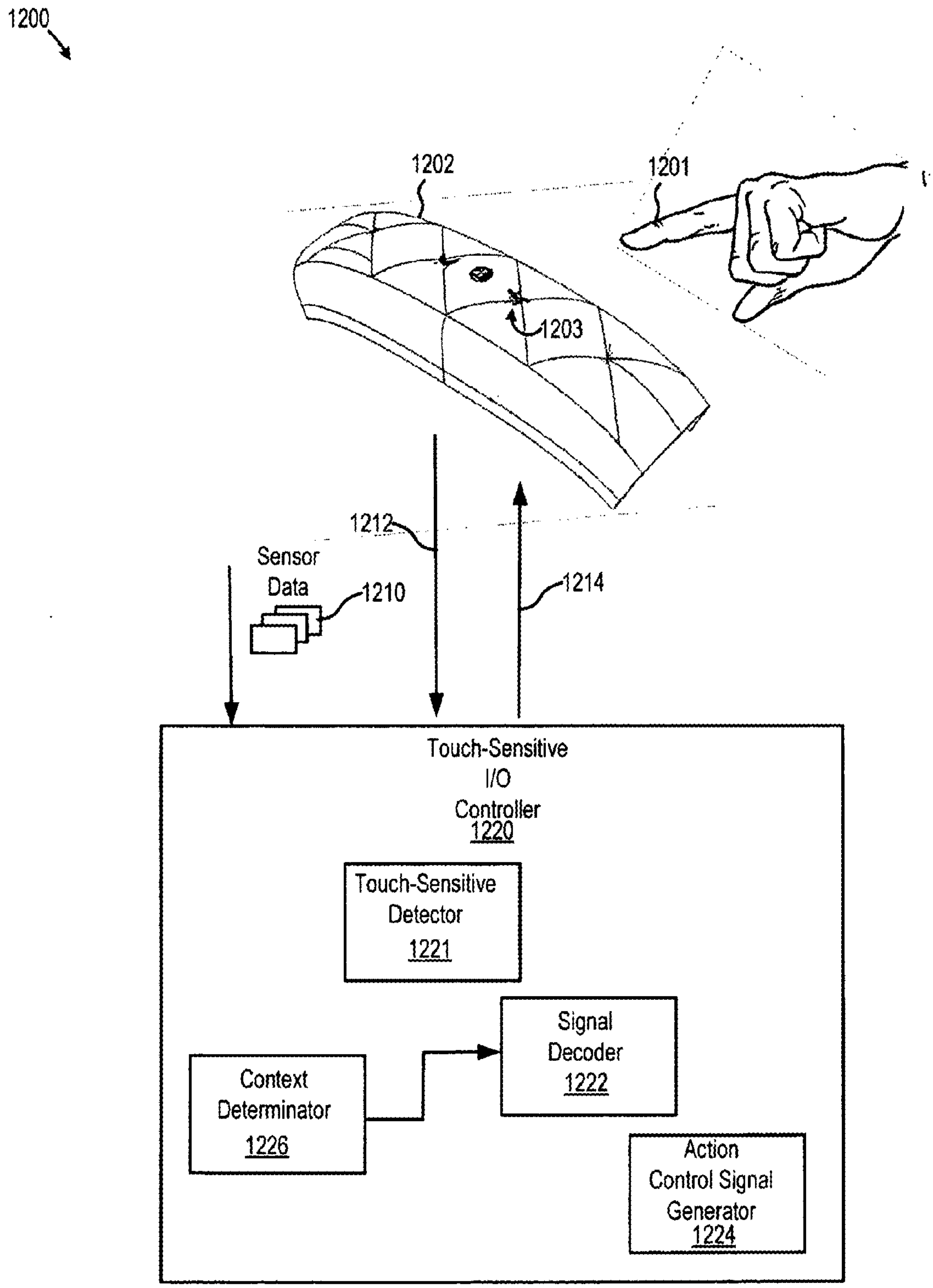

1200
1202
1201
1203
1212
Sensor
Data
1210
1214
Touch-Sensitive
I/O
Controller
1220
Touch-Sensitive
Detector
1221
Signal
Decoder
1222
Context
Determinator
1226
Action
Control Signal
Generator
1224

FIG. 12

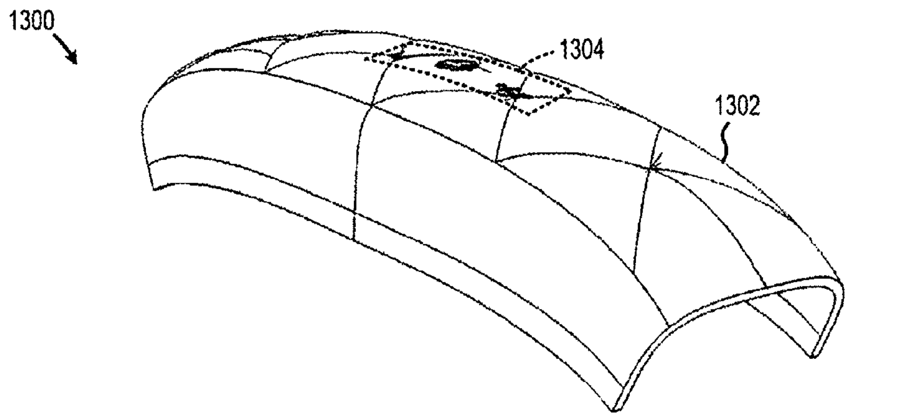


FIG. 13A

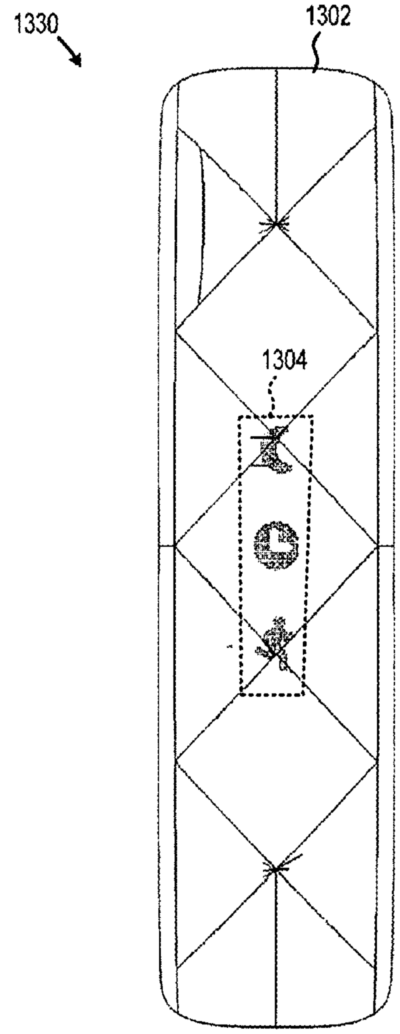


FIG. 13B

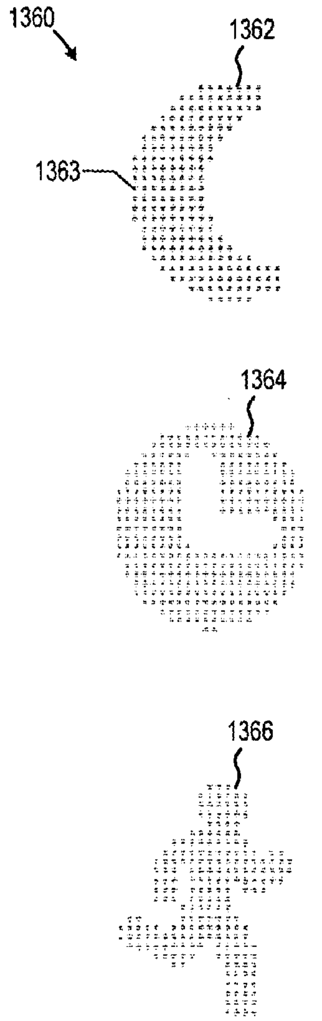


FIG. 13C

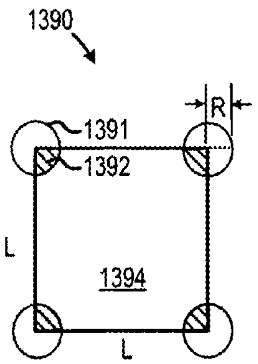


FIG. 13D

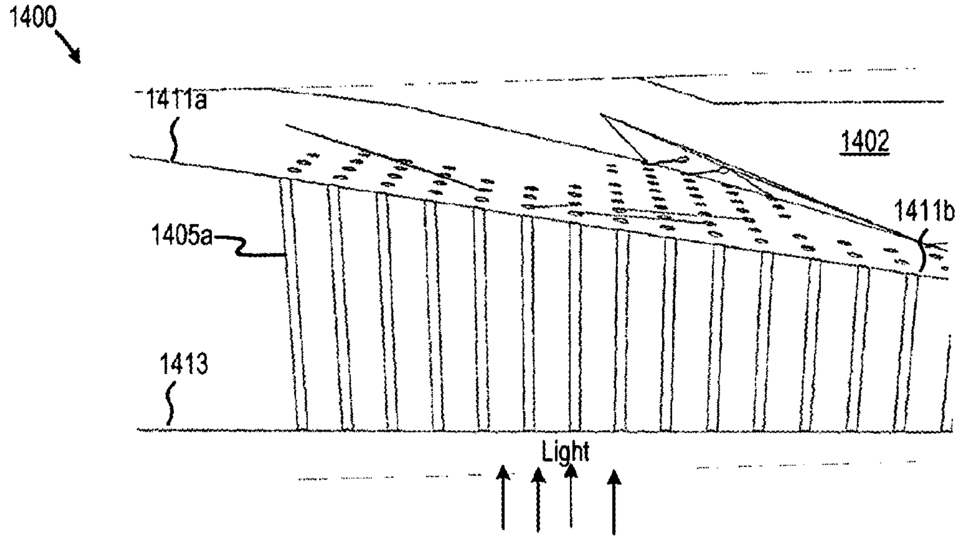


FIG. 14A

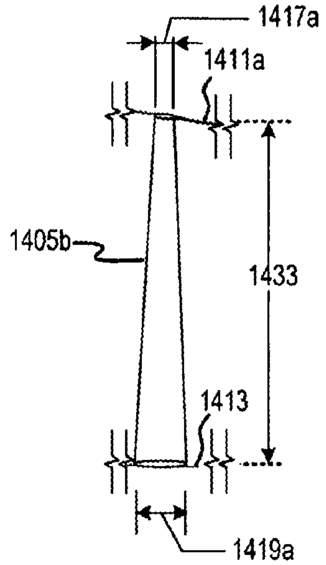


FIG. 14B

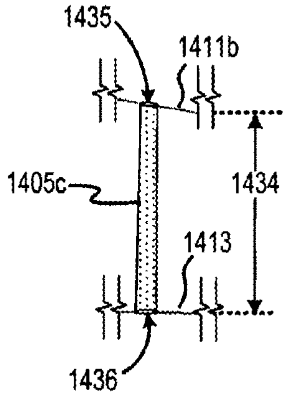


FIG. 14C

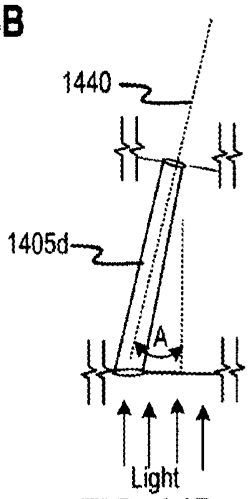


FIG. 14D

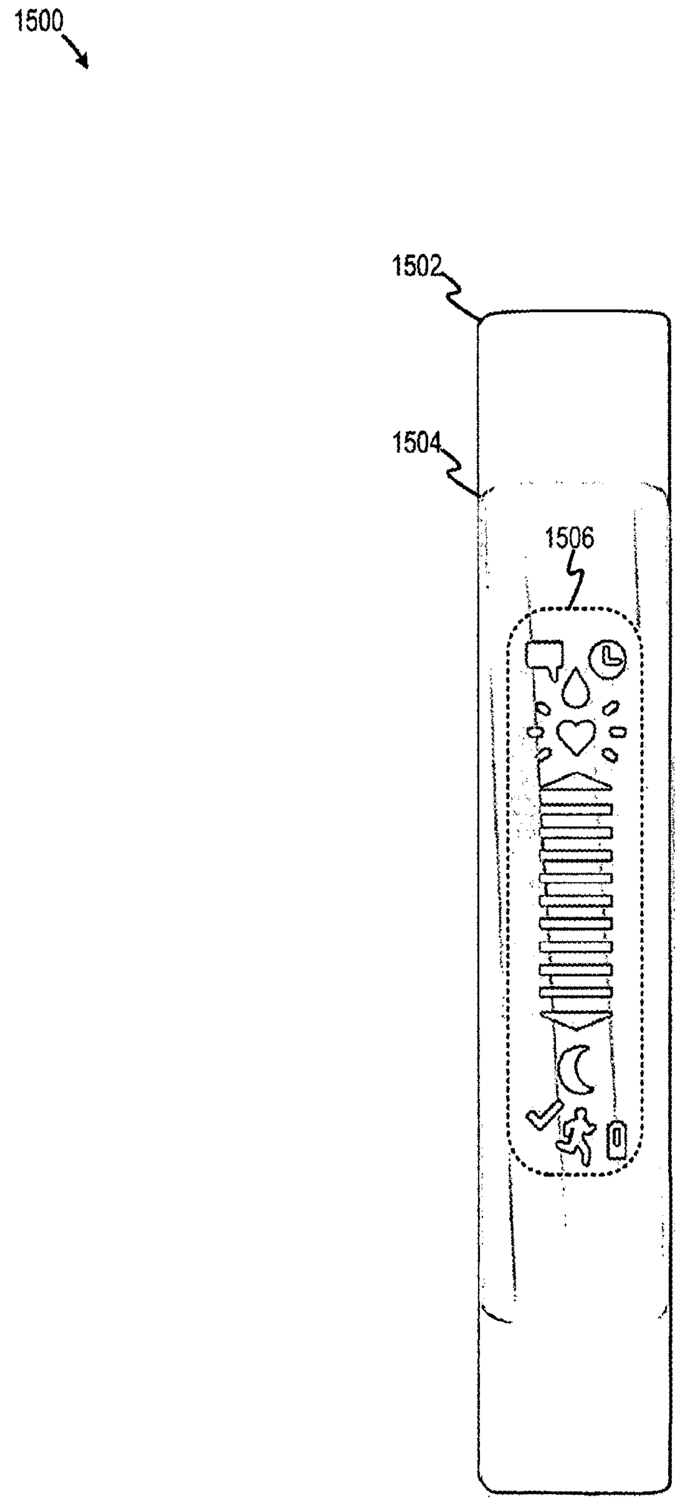


FIG. 15A

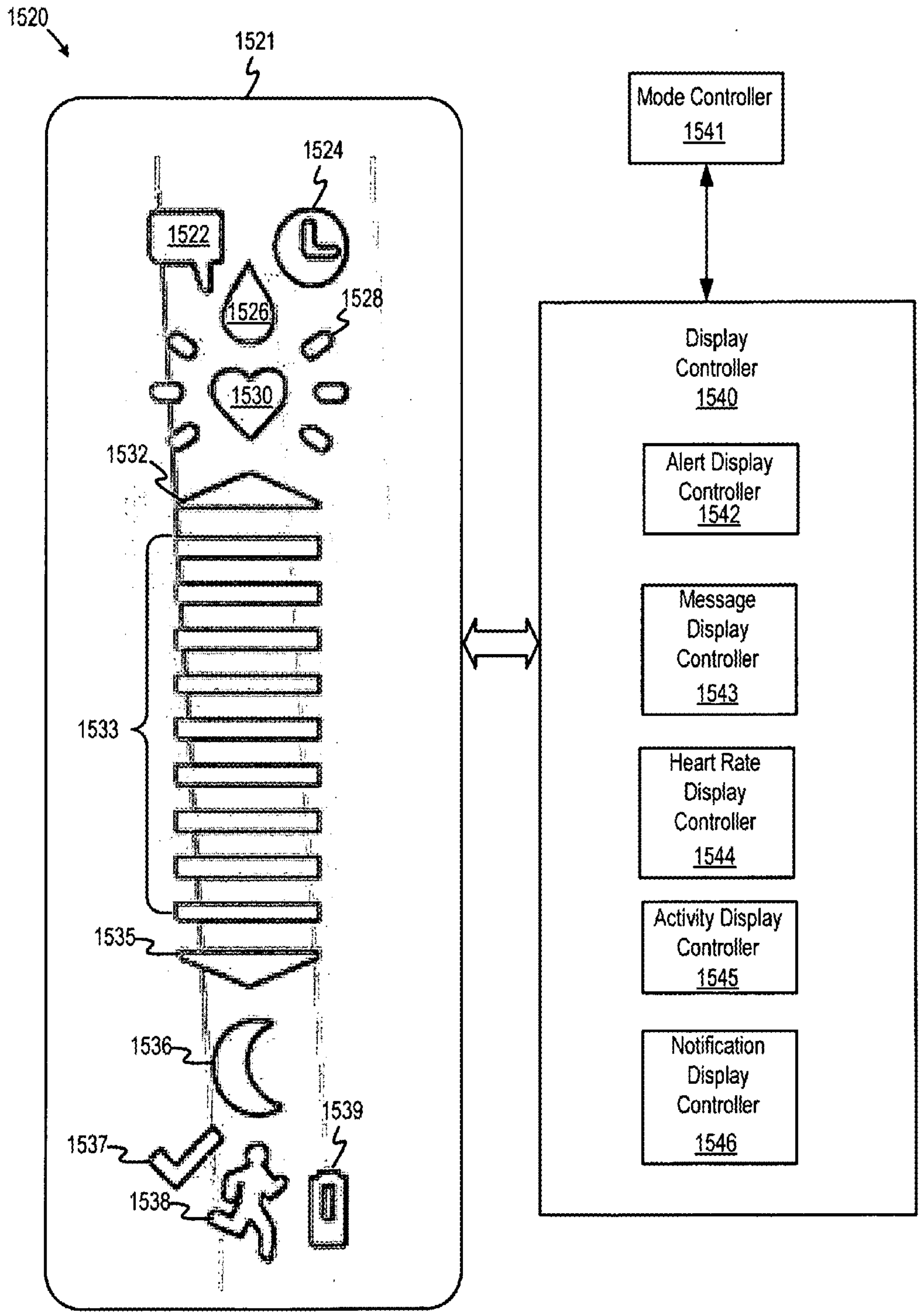

1520
1521
1522
1524
1526
1528
1530
1532
1533
1535
1536
1537
1538
1539
Mode Controller
1541
Display
Controller
1540
Alert Display
Controller
1542
Message
Display
Controller
1543
Heart Rate
Display
Controller
1544
Activity Display
Controller
1545
Notification
Display
Controller
1546

FIG. 15B

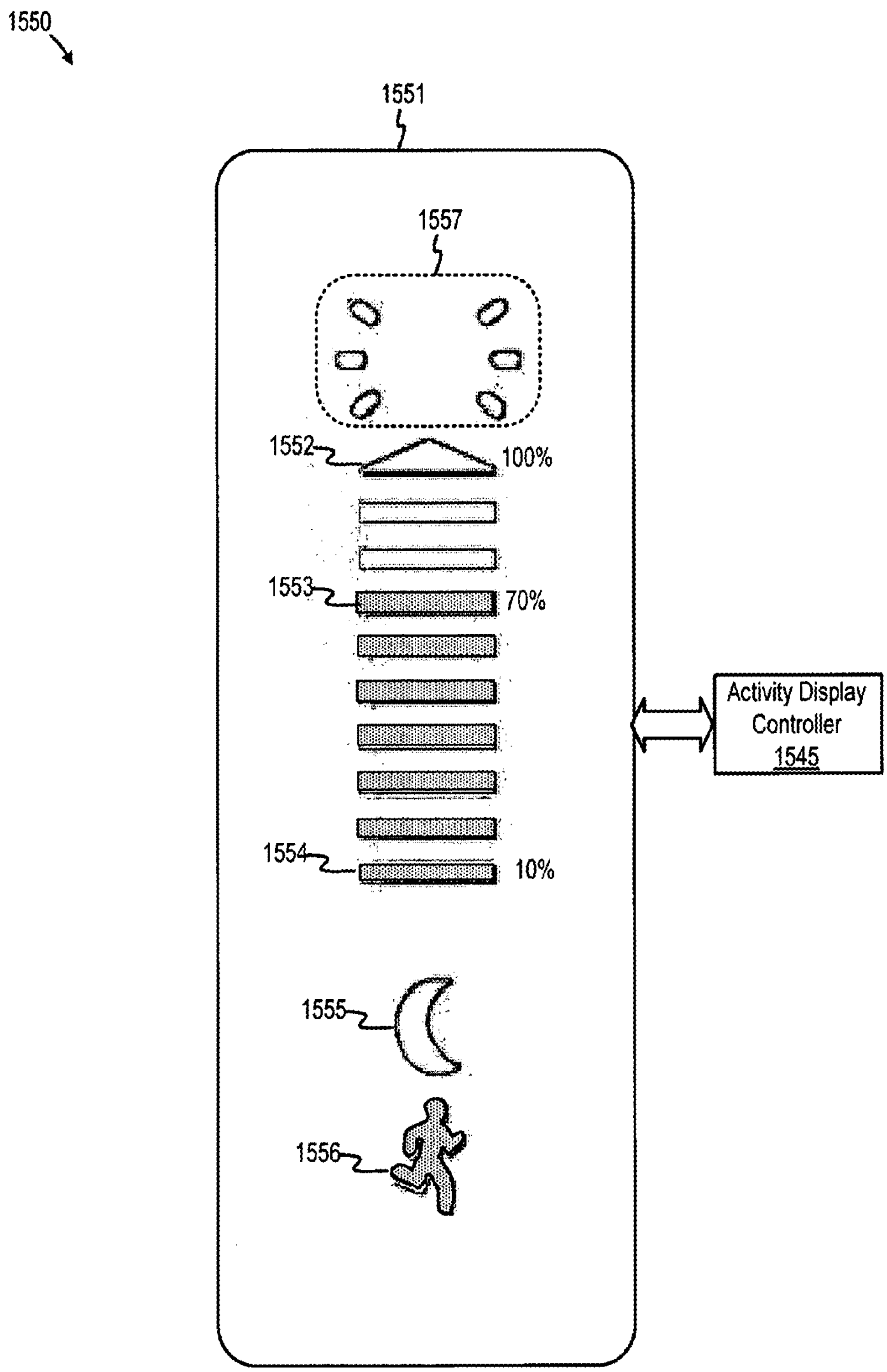
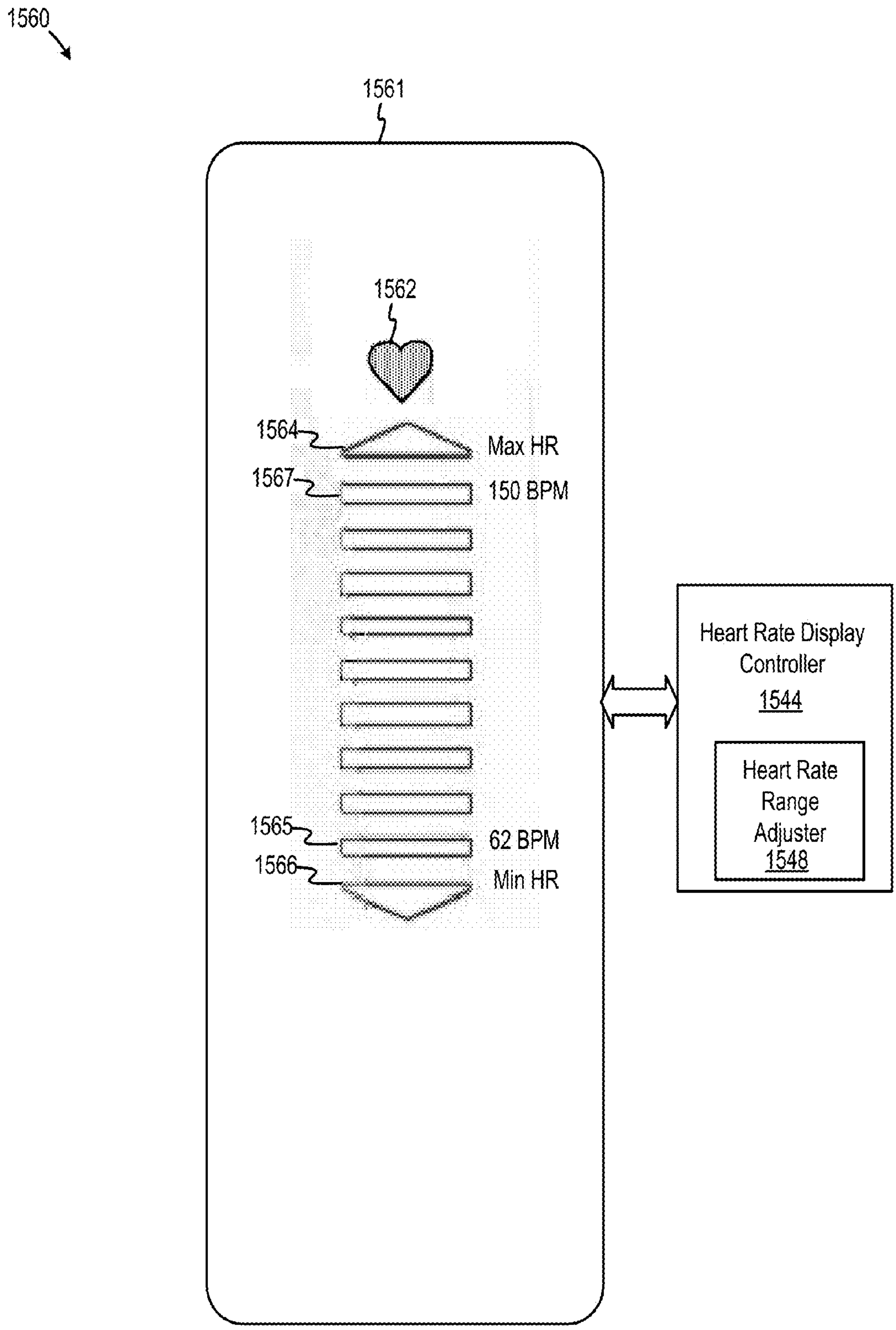

1550
1551
1557
1552
100%
1553
70%
1554
10%
1555
1556
Activity Display Controller 1545

FIG. 15C



1560
1561
1562
1564
Max HR
1567
150 BPM
1565
62 BPM
1566
Min HR
Heart Rate Display Controller
1544
Heart Rate Range Adjuster
1548

FIG. 15D

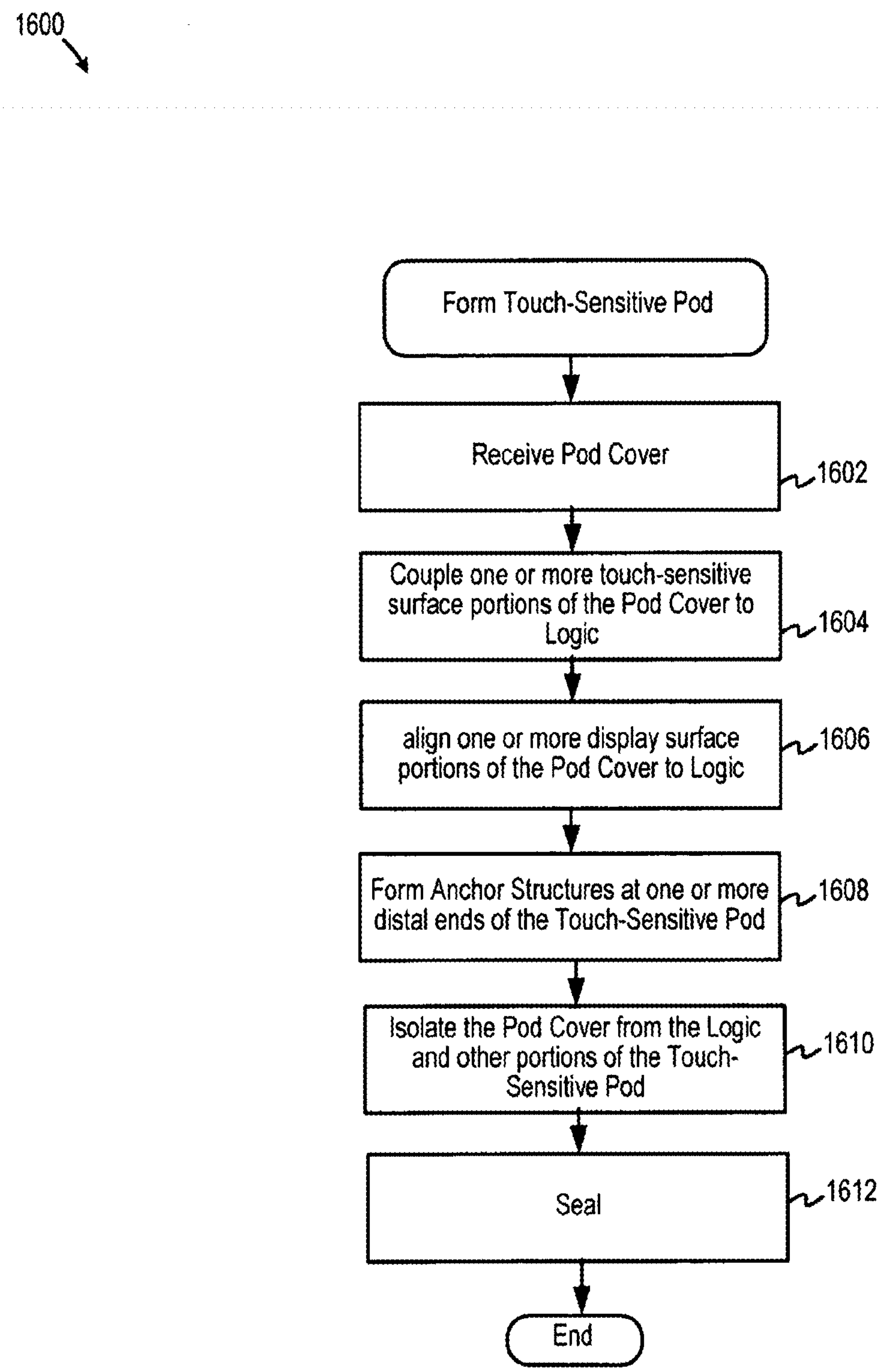

1600
Form Touch-Sensitive Pod
Receive Pod Cover
1602
Couple one or more touch-sensitive surface portions of the Pod Cover to Logic
1604
align one or more display surface portions of the Pod Cover to Logic
1606
Form Anchor Structures at one or more distal ends of the Touch-Sensitive Pod
1608
Isolate the Pod Cover from the Logic and other portions of the Touch-Sensitive Pod
1610
Seal
1612
End

FIG. 16

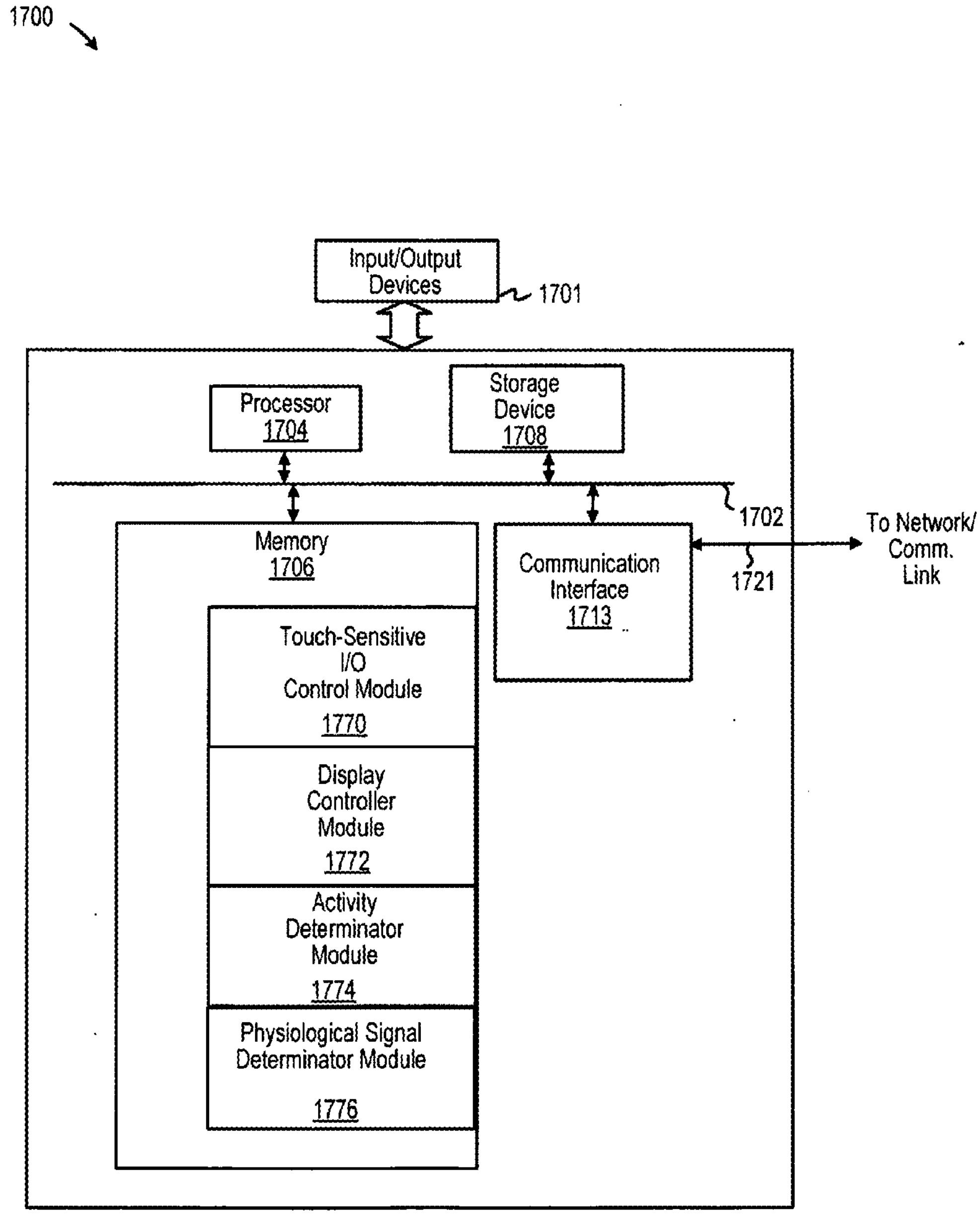

1700
Input/Output Devices
1701
Processor
1704
Storage Device
1708
1702
Memory
1706
Communication Interface
1713
1721
To Network/ Comm. Link
Touch-Sensitive I/O Control Module
1770
Display Controller Module
1772
Activity Determinator Module
1774
Physiological Signal Determinator Module
1776

FIG. 17

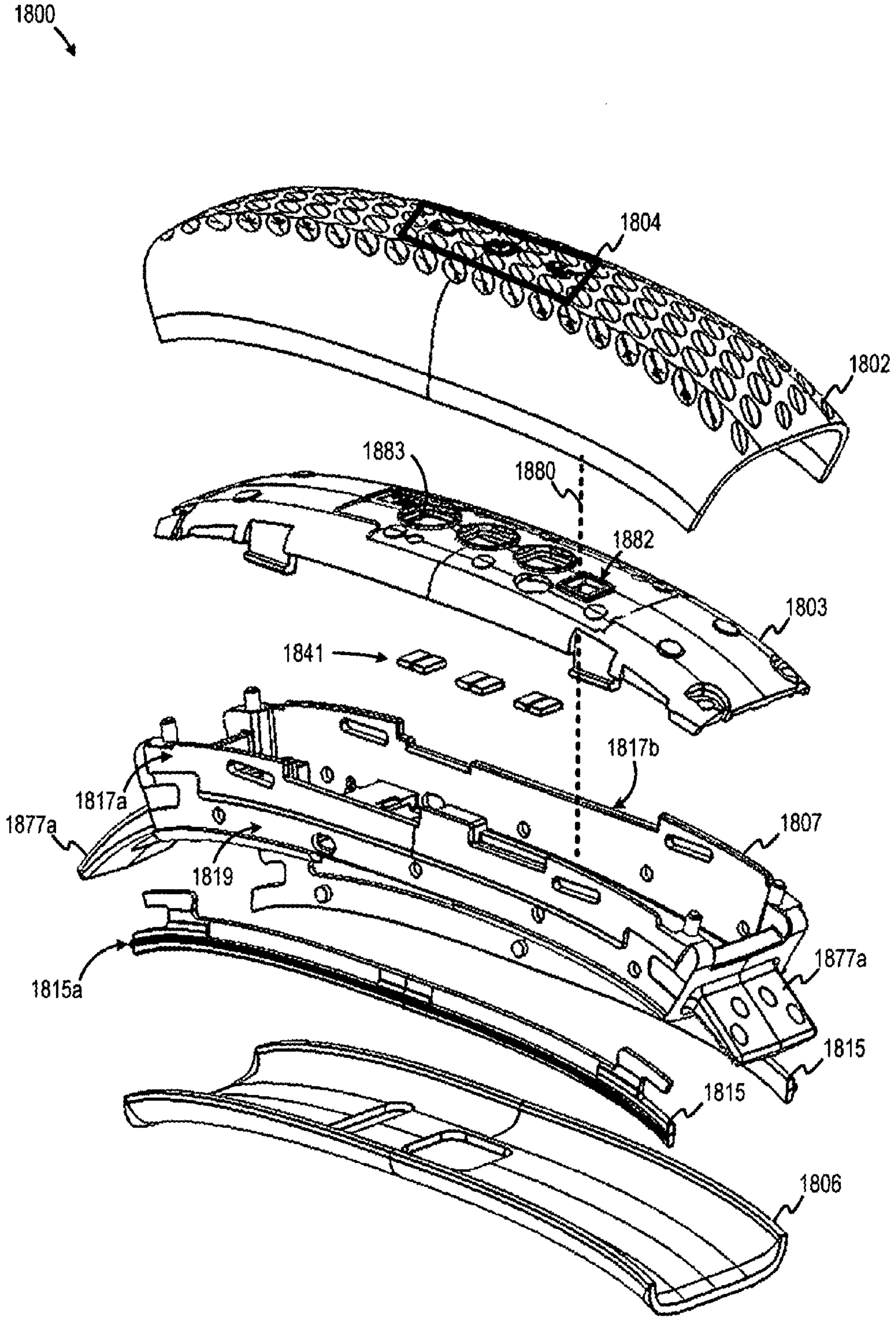

1800
1804
1802
1883
1880
1882
1803
1841
1817b
1817a
1877a
1807
1819
1877a
1815a
1815
1815
1806

FIG. 18

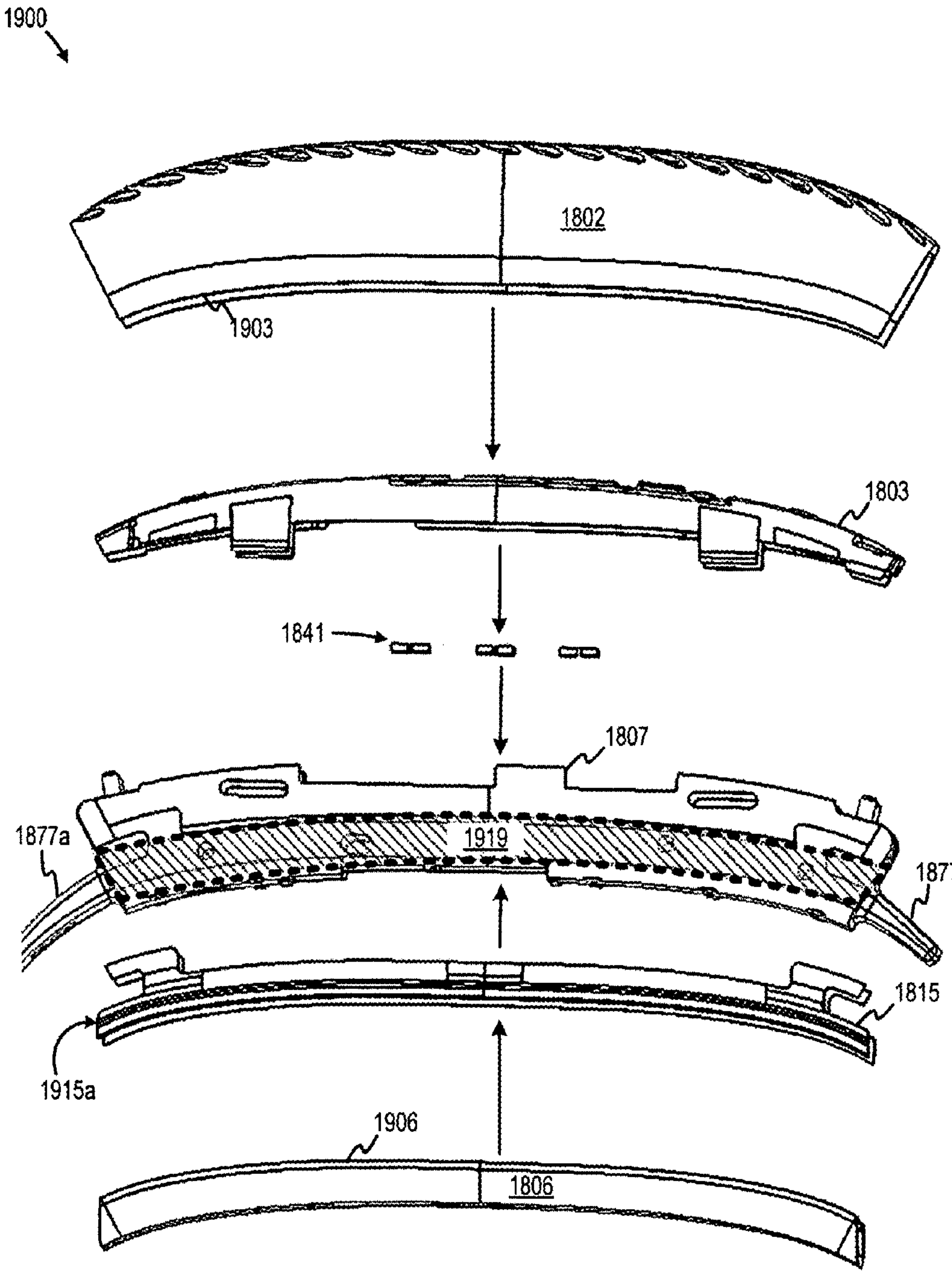

1900
1802
1903
1803
1841
1807
1877a
1919
1877a
1815
1915a
1906
1806

FIG. 19

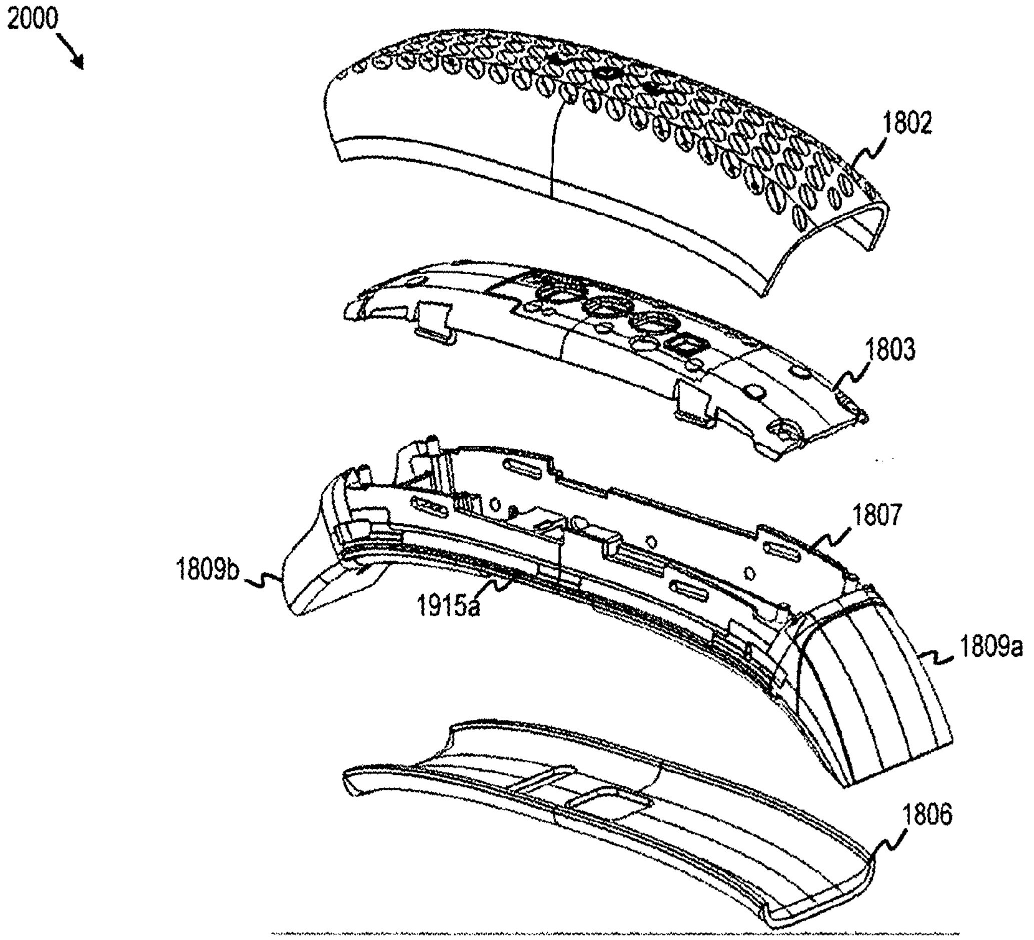


FIG. 20A

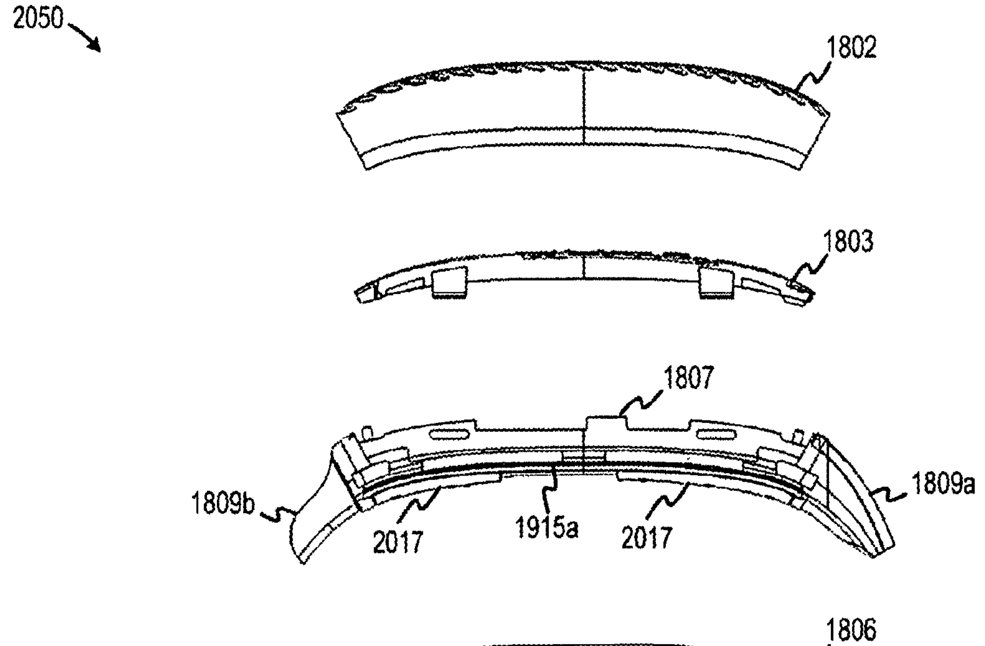


FIG. 20B

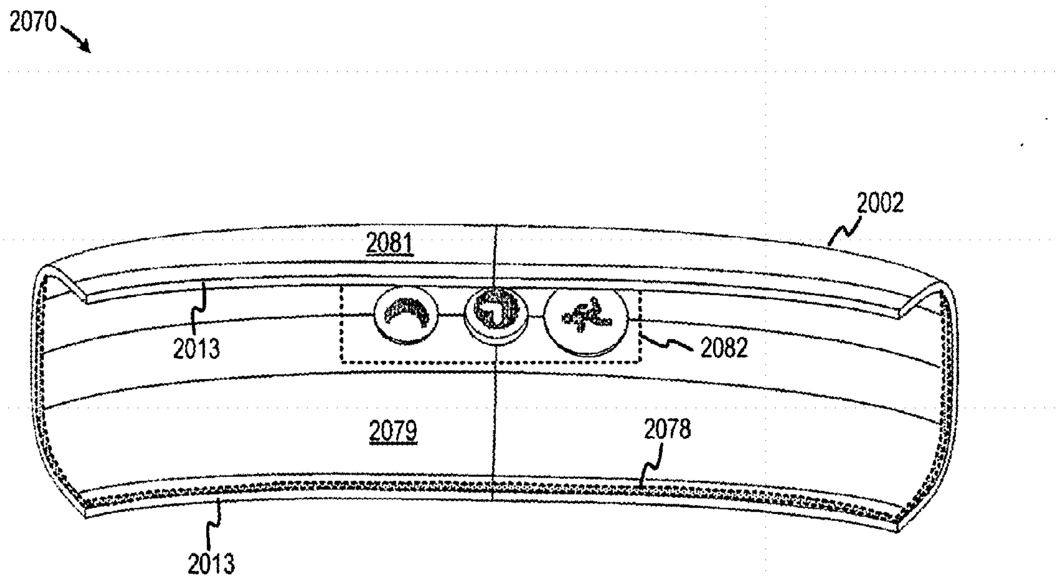


FIG. 20C

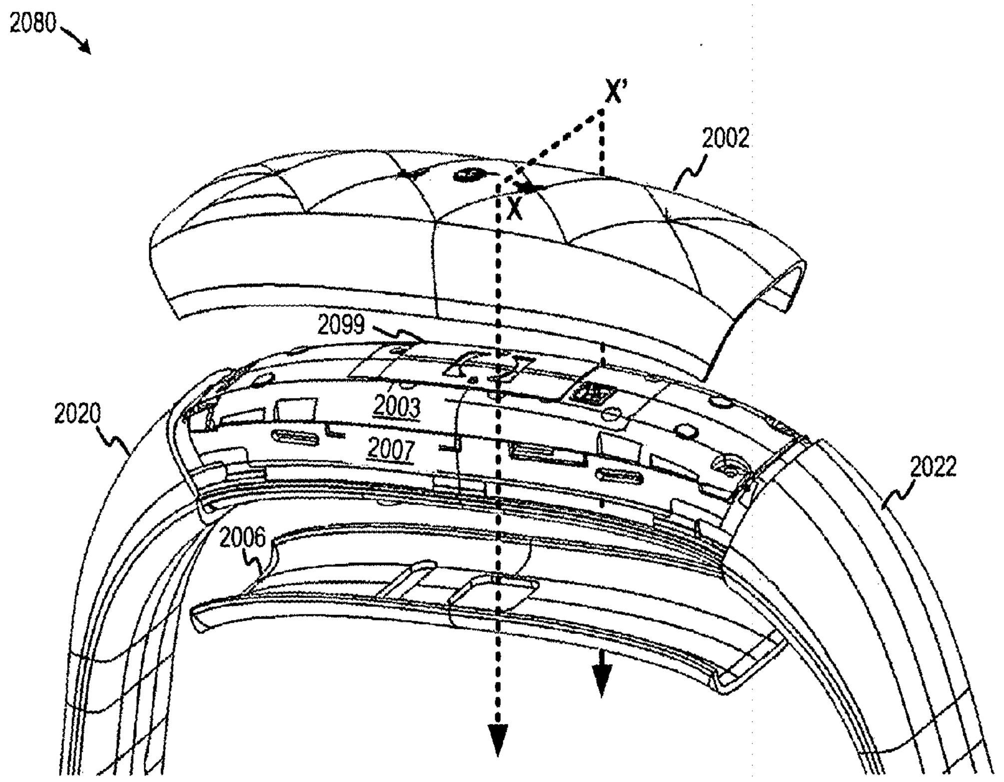


FIG. 20D

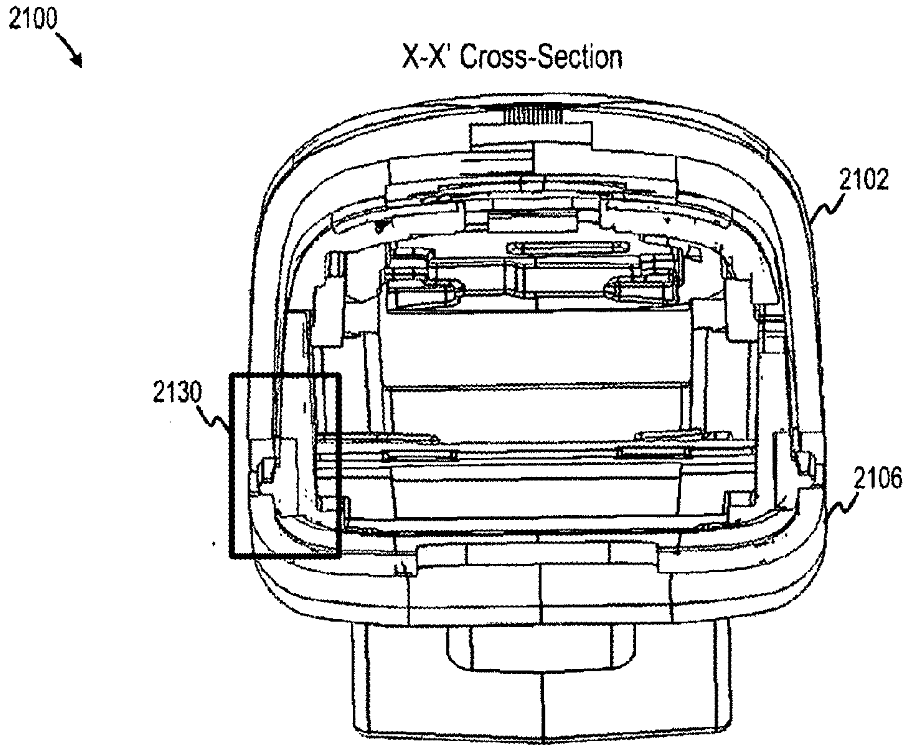


FIG. 21A

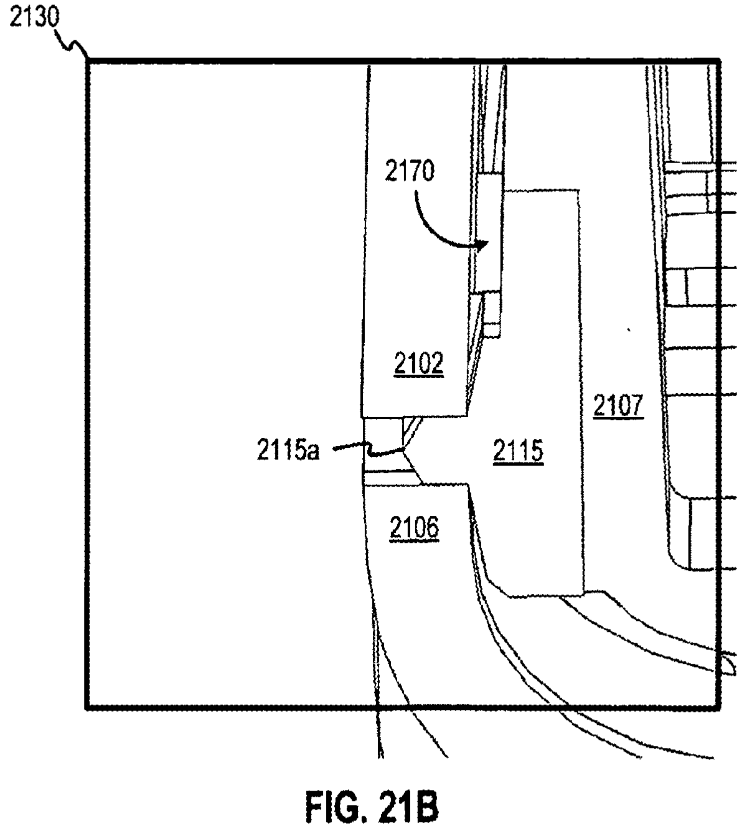


FIG. 21B

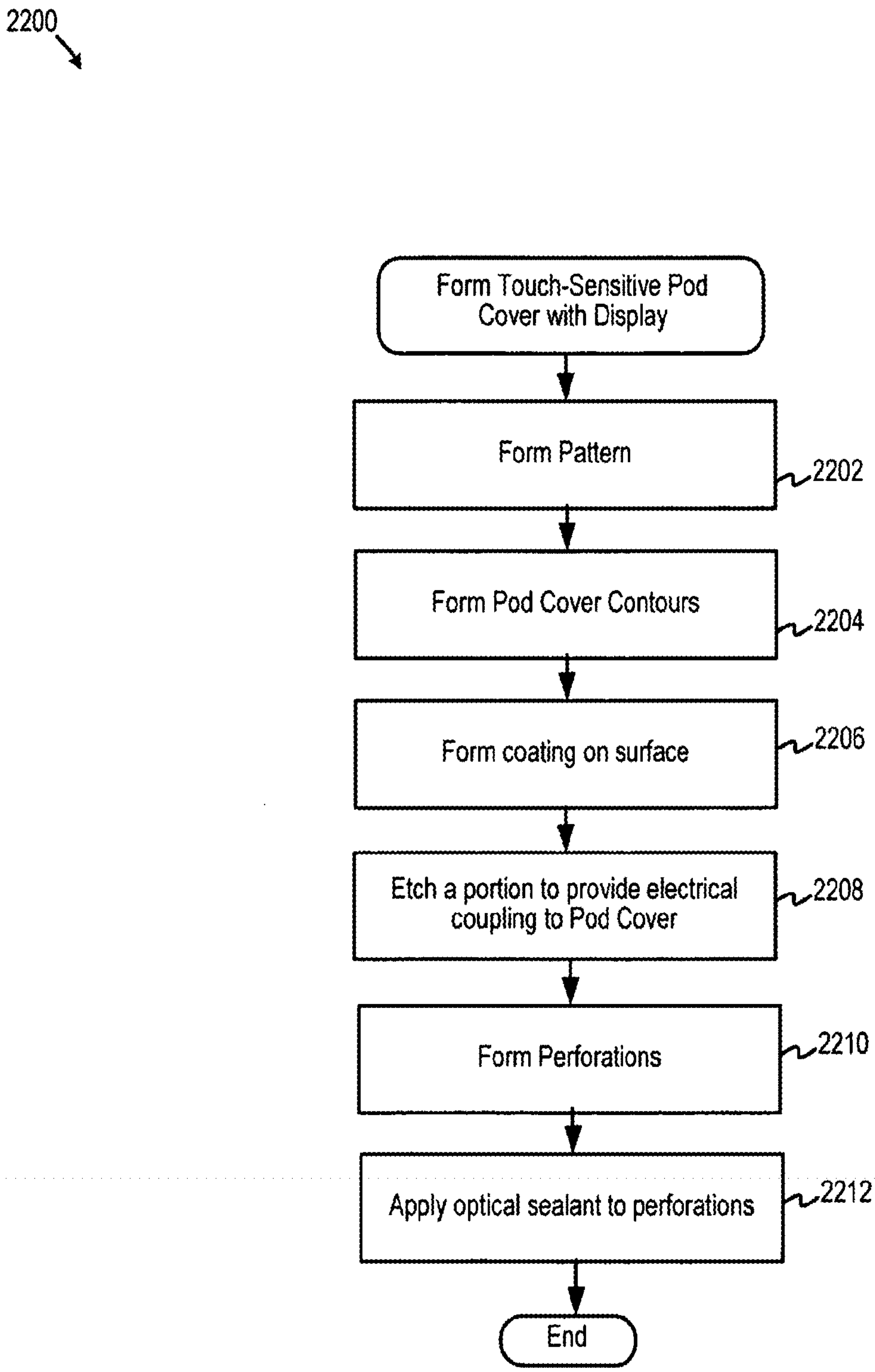

2200
Form Touch-Sensitive Pod Cover with Display
Form Pattern
2202
Form Pod Cover Contours
2204
Form coating on surface
2206
Etch a portion to provide electrical coupling to Pod Cover
2208
Form Perforations
2210
Apply optical sealant to perforations
2212
End

FIG. 22

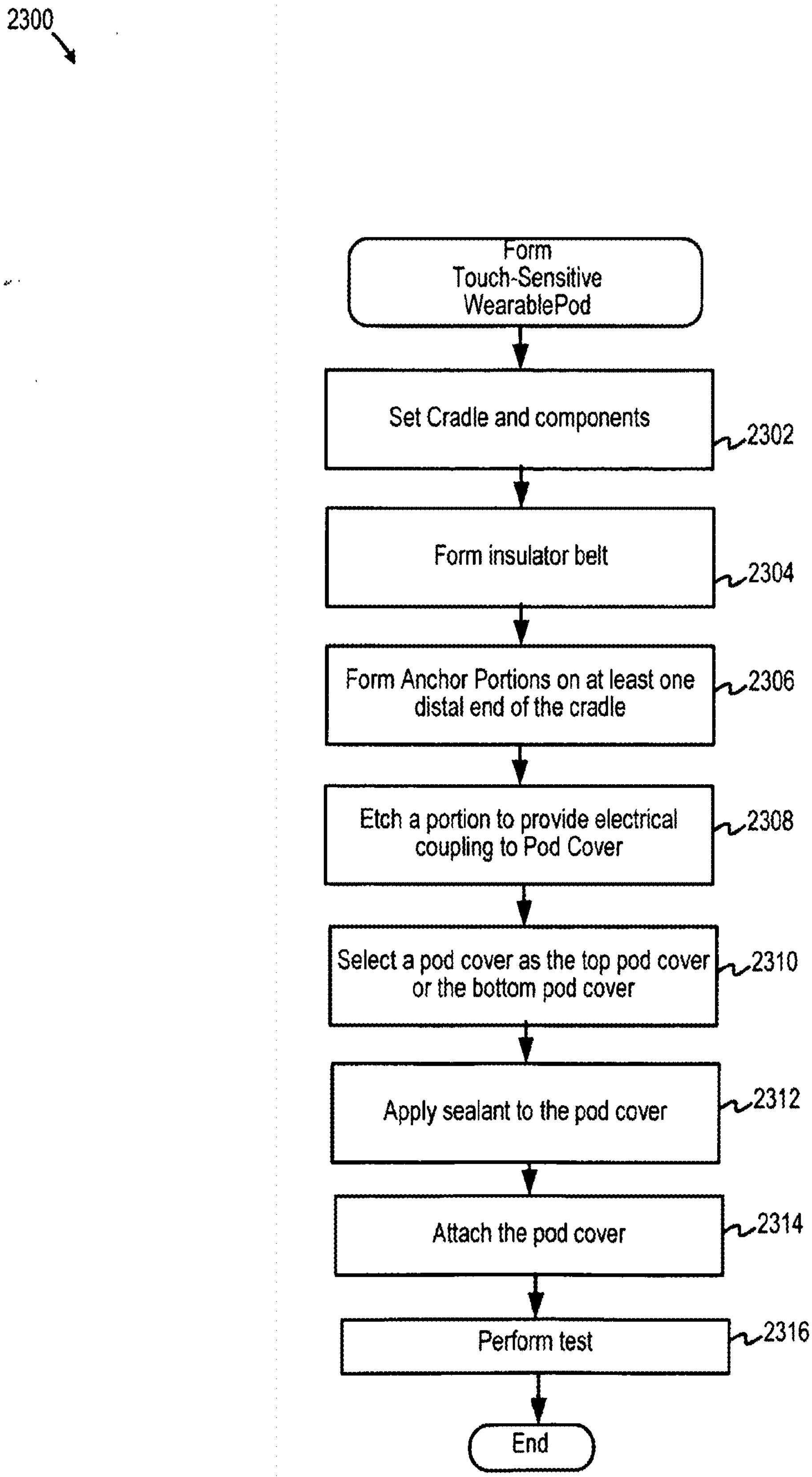

2300
Form
Touch-Sensitive
WearablePod
Set Cradle and components
2302
Form insulator belt
2304
Form Anchor Portions on at least one distal end of the cradle
2306
Etch a portion to provide electrical coupling to Pod Cover
2308
Select a pod cover as the top pod cover or the bottom pod cover
2310
Apply sealant to the pod cover
2312
Attach the pod cover
2314
Perform test
2316
End

FIG. 23

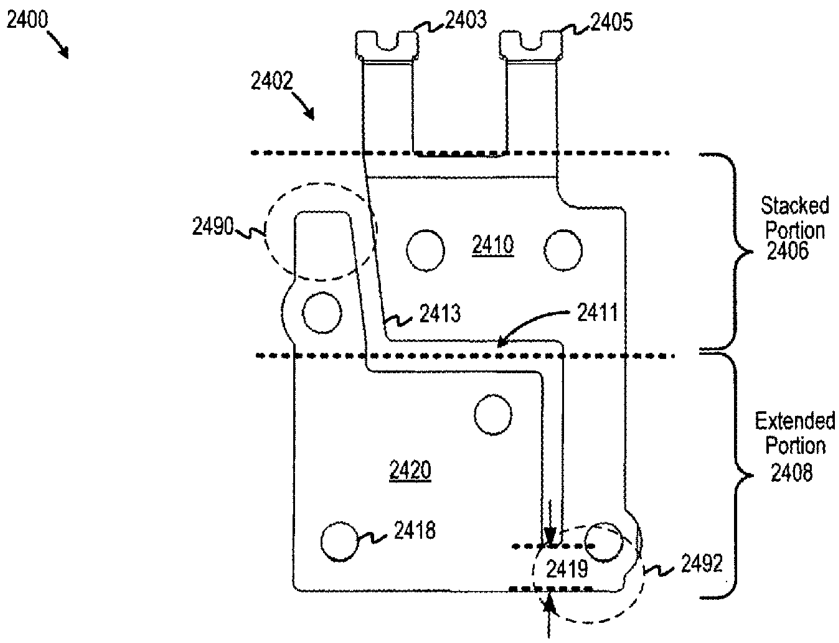


FIG. 24

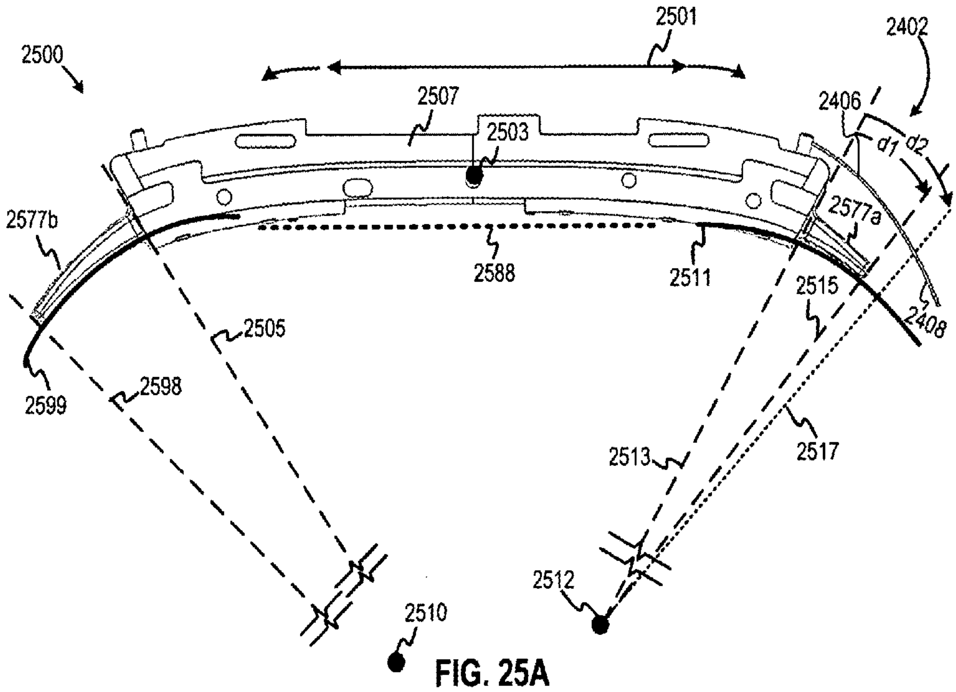


FIG. 25A

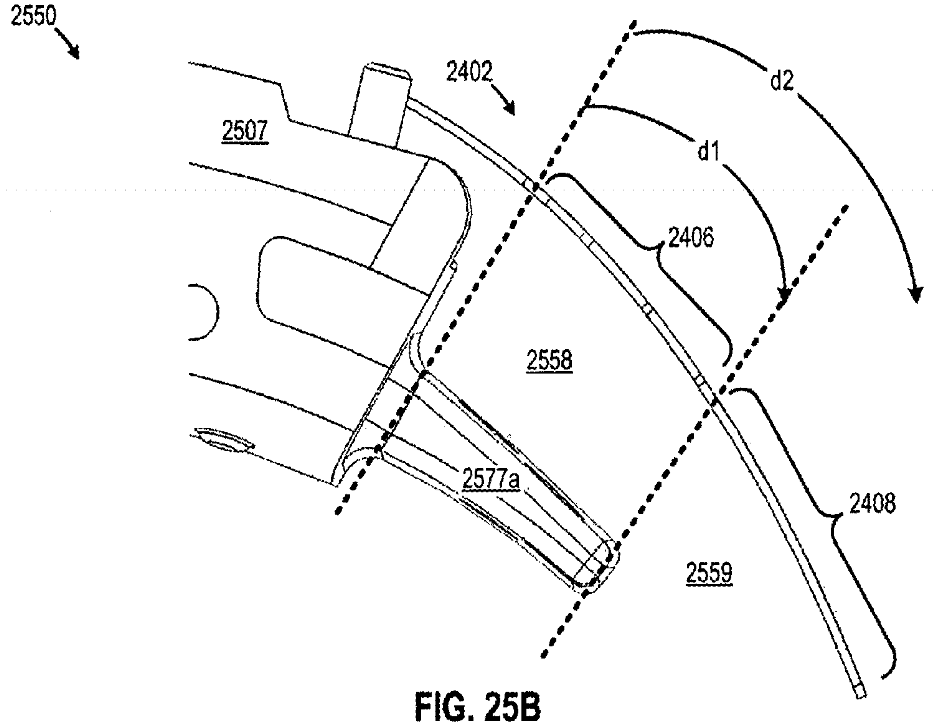


FIG. 25B

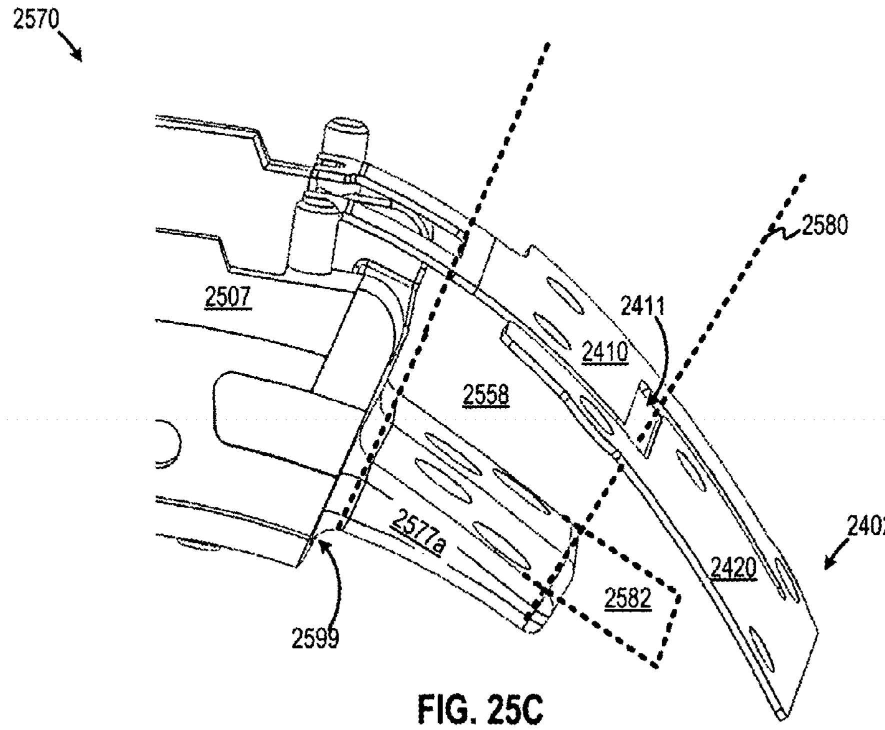


FIG. 25C

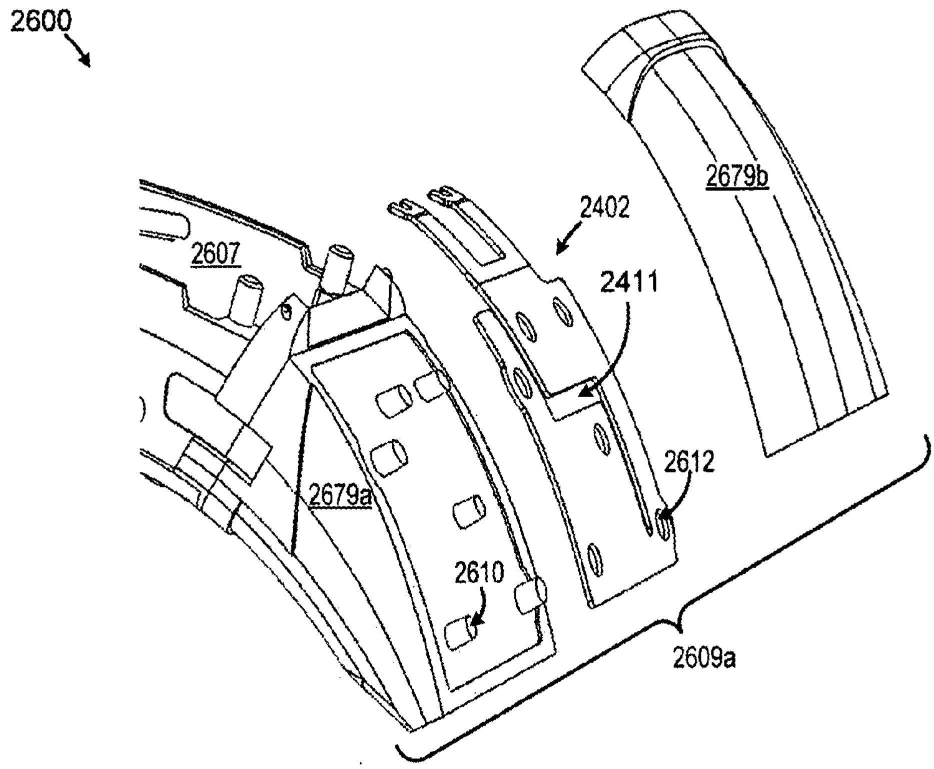

2600
2679b
2402
2607
2411
2612
2679a
2610
2609a

FIG. 26

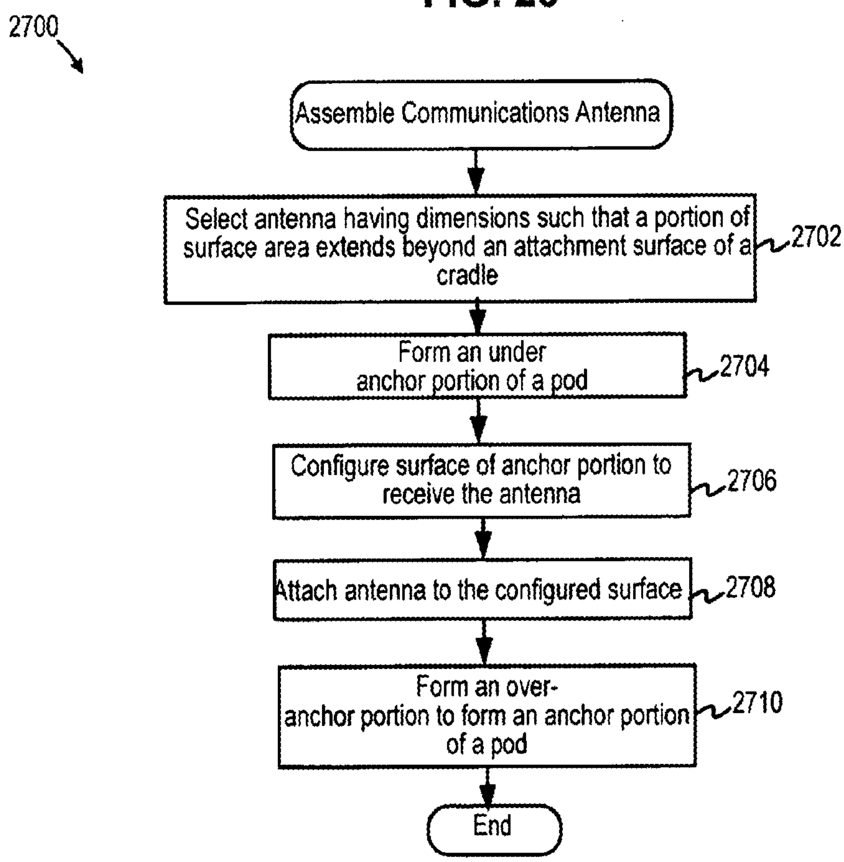

2700
Assemble Communications Antenna
Select antenna having dimensions such that a portion of surface area extends beyond an attachment surface of a cradle
2702
Form an under anchor portion of a pod
2704
Configure surface of anchor portion to receive the antenna
2706
Attach antenna to the configured surface
2708
Form an over-anchor portion to form an anchor portion of a pod
2710
End

FIG. 27

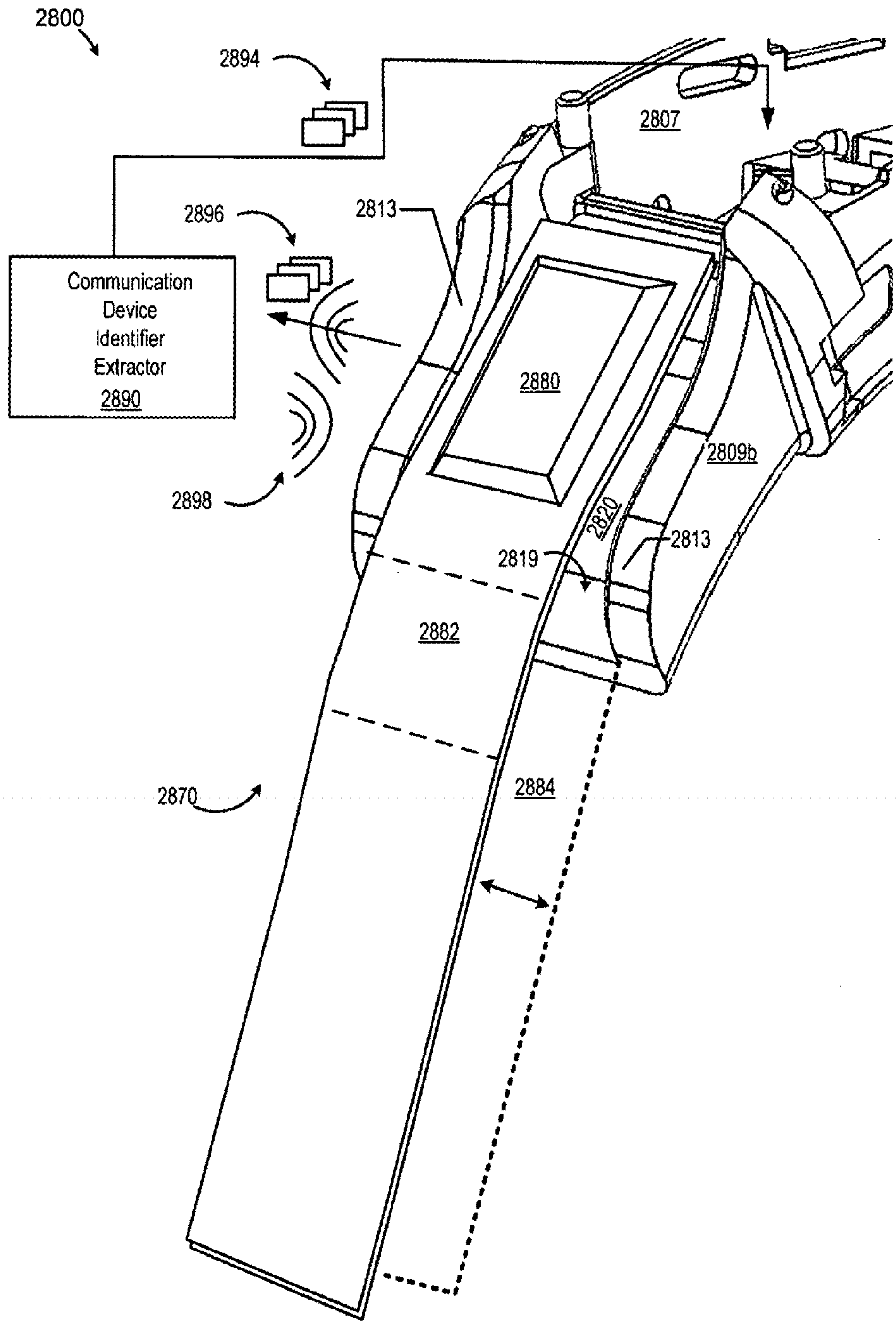

2800
2894
2807
2813
2896
Communication
Device
Identifier
Extractor
2890
2880
2809b
2898
2820
2813
2819
2882
2870
2884

FIG. 28

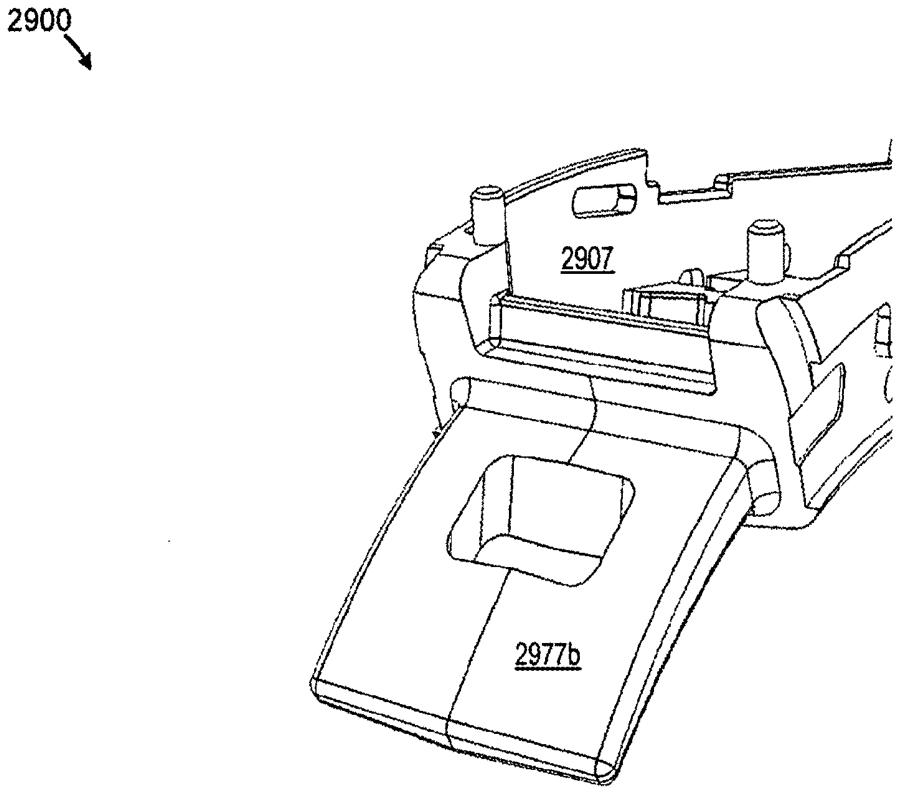


FIG. 29A

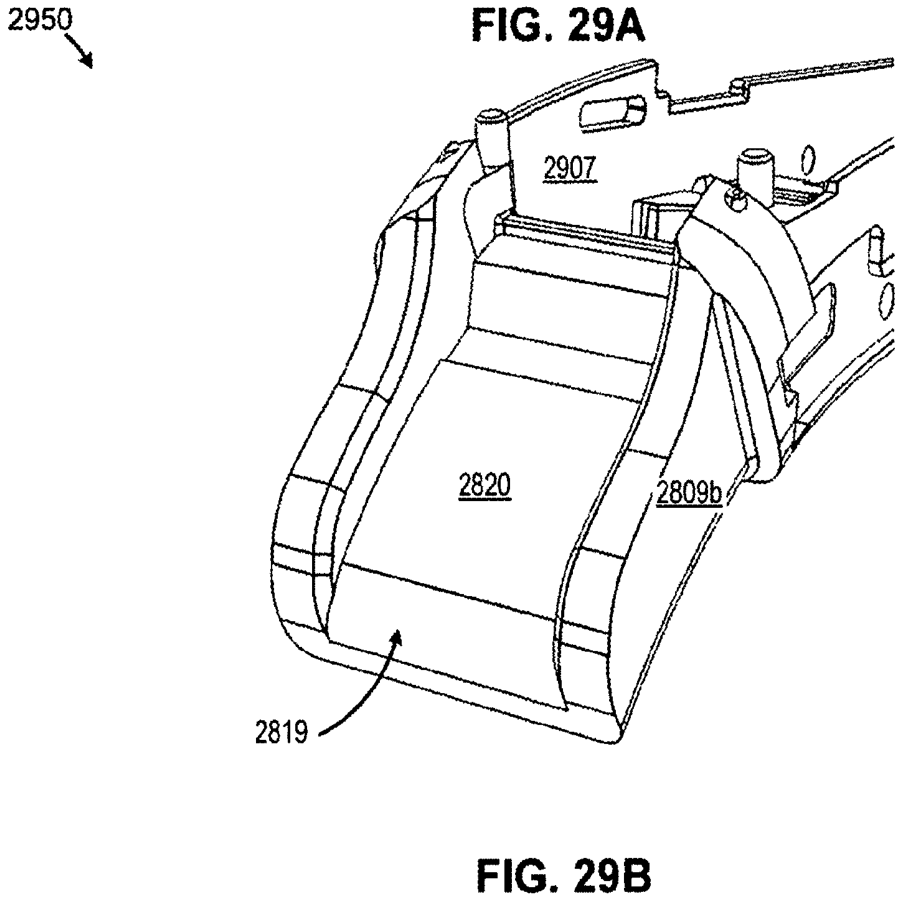


FIG. 29B

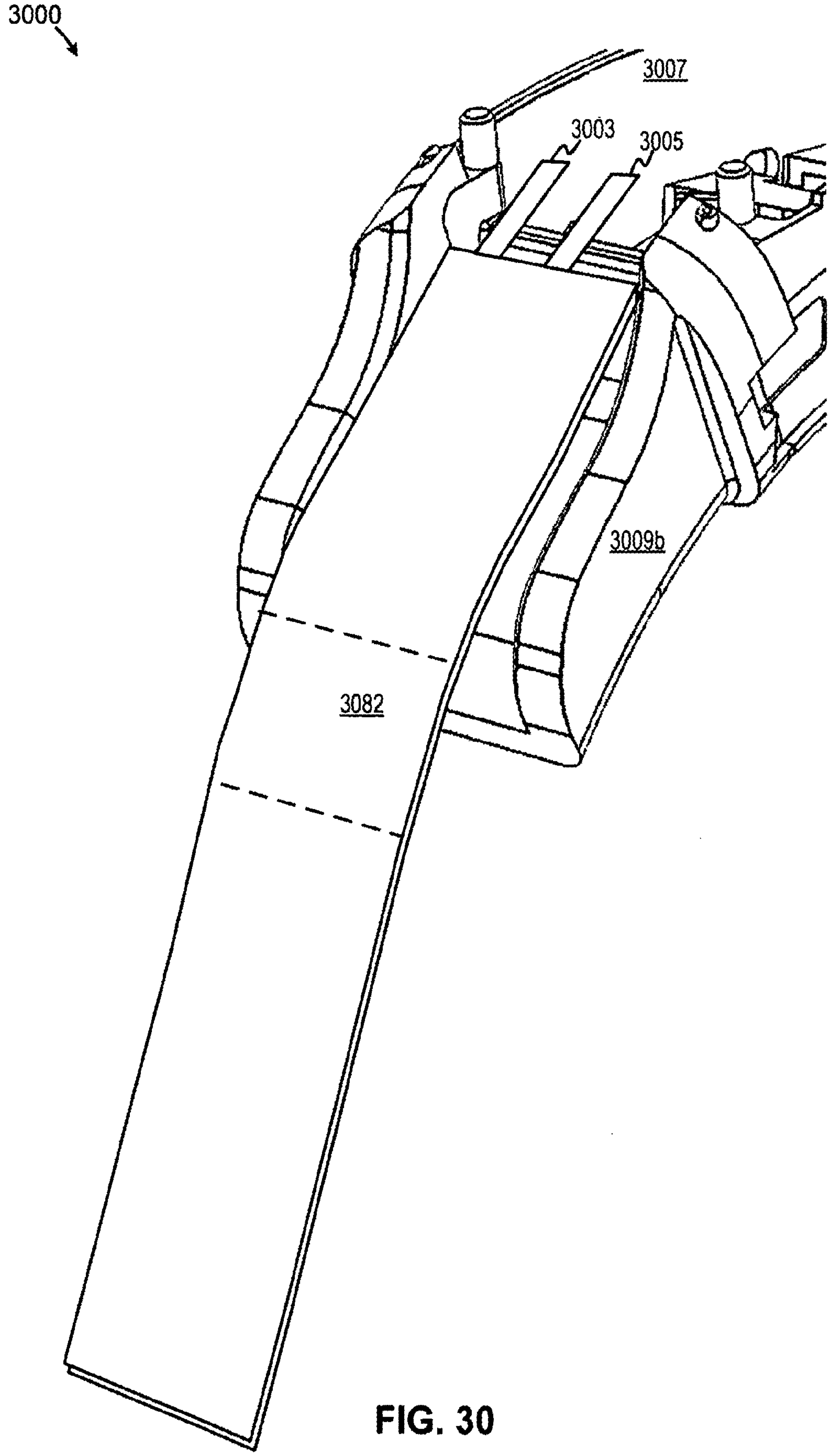


FIG. 30

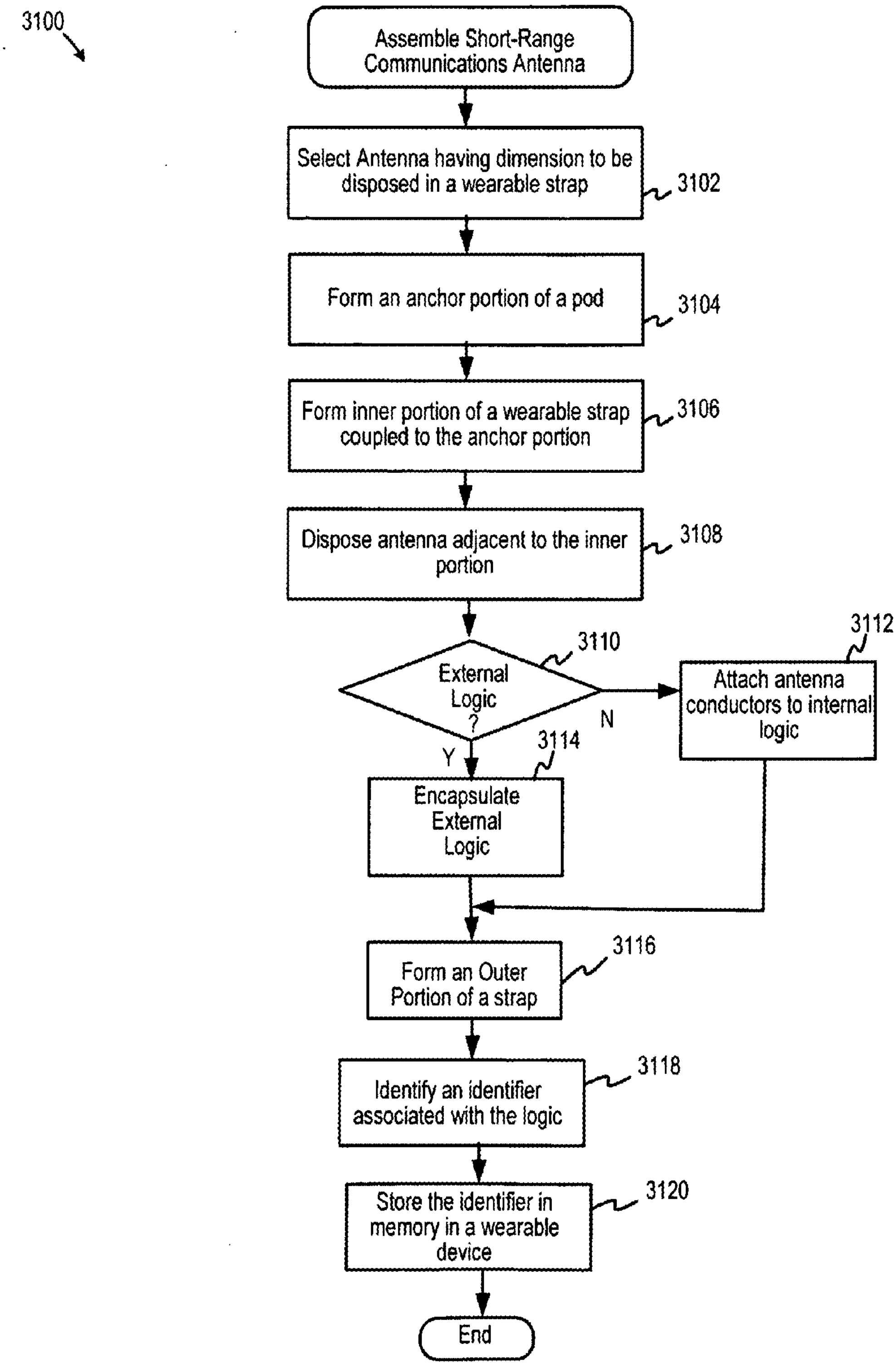

3100
Assemble Short-Range Communications Antenna
Select Antenna having dimension to be disposed in a wearable strap
3102
Form an anchor portion of a pod
3104
Form inner portion of a wearable strap coupled to the anchor portion
3106
Dispose antenna adjacent to the inner portion
3108
External Logic ?
3110
N
Attach antenna conductors to internal logic
3112
Y
Encapsulate External Logic
3114
Form an Outer Portion of a strap
3116
Identify an identifier associated with the logic
3118
Store the identifier in memory in a wearable device
3120
End

FIG. 31

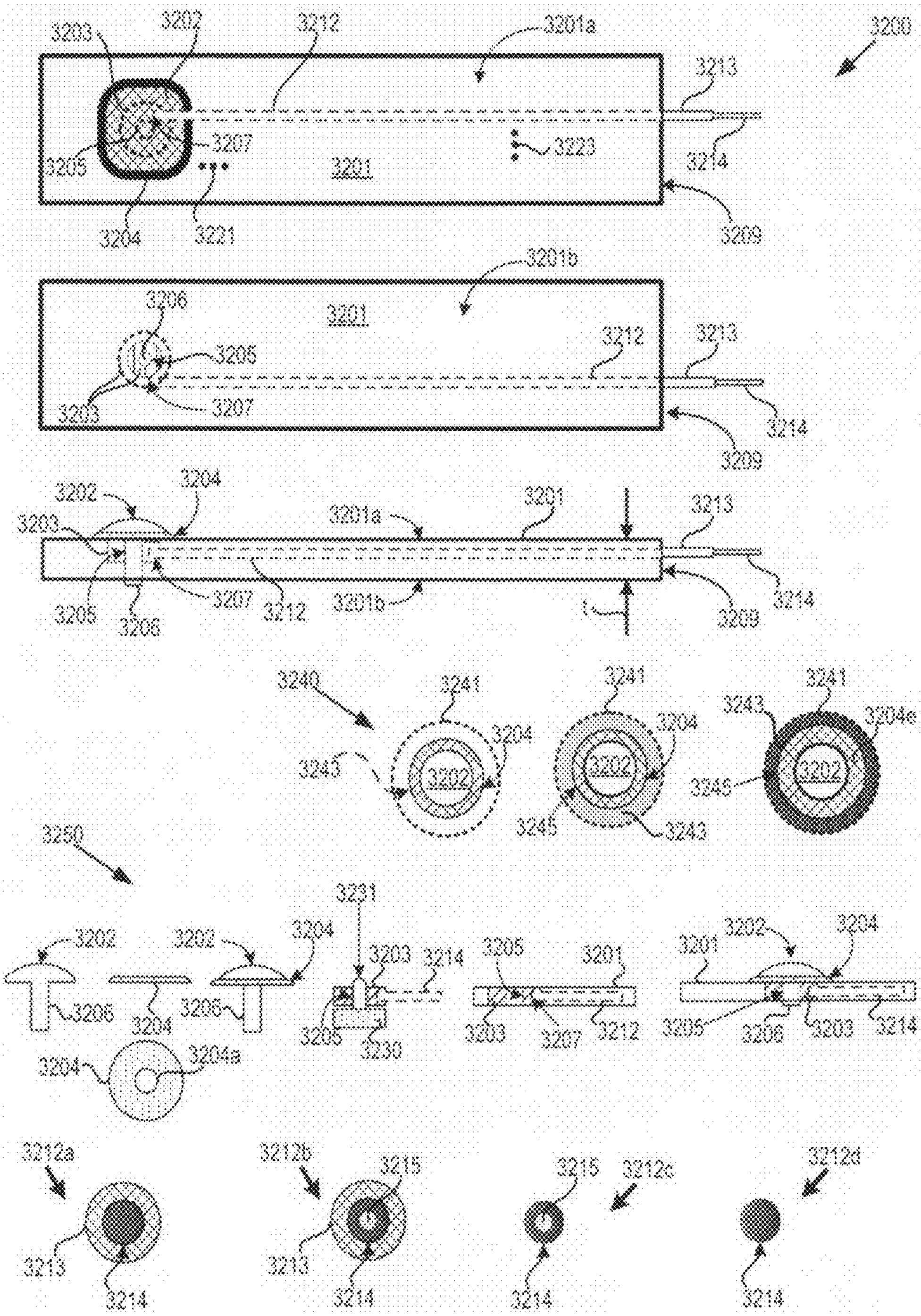

3200
3201a
3201b
3201
3202
3203
3204
3204a
3204e
3205
3206
3207
3209
3212
3212a
3212b
3212c
3212d
3213
3214
3215
3221
3223
3230
3231
3240
3241
3243
3245
3250
t

FIG. 32

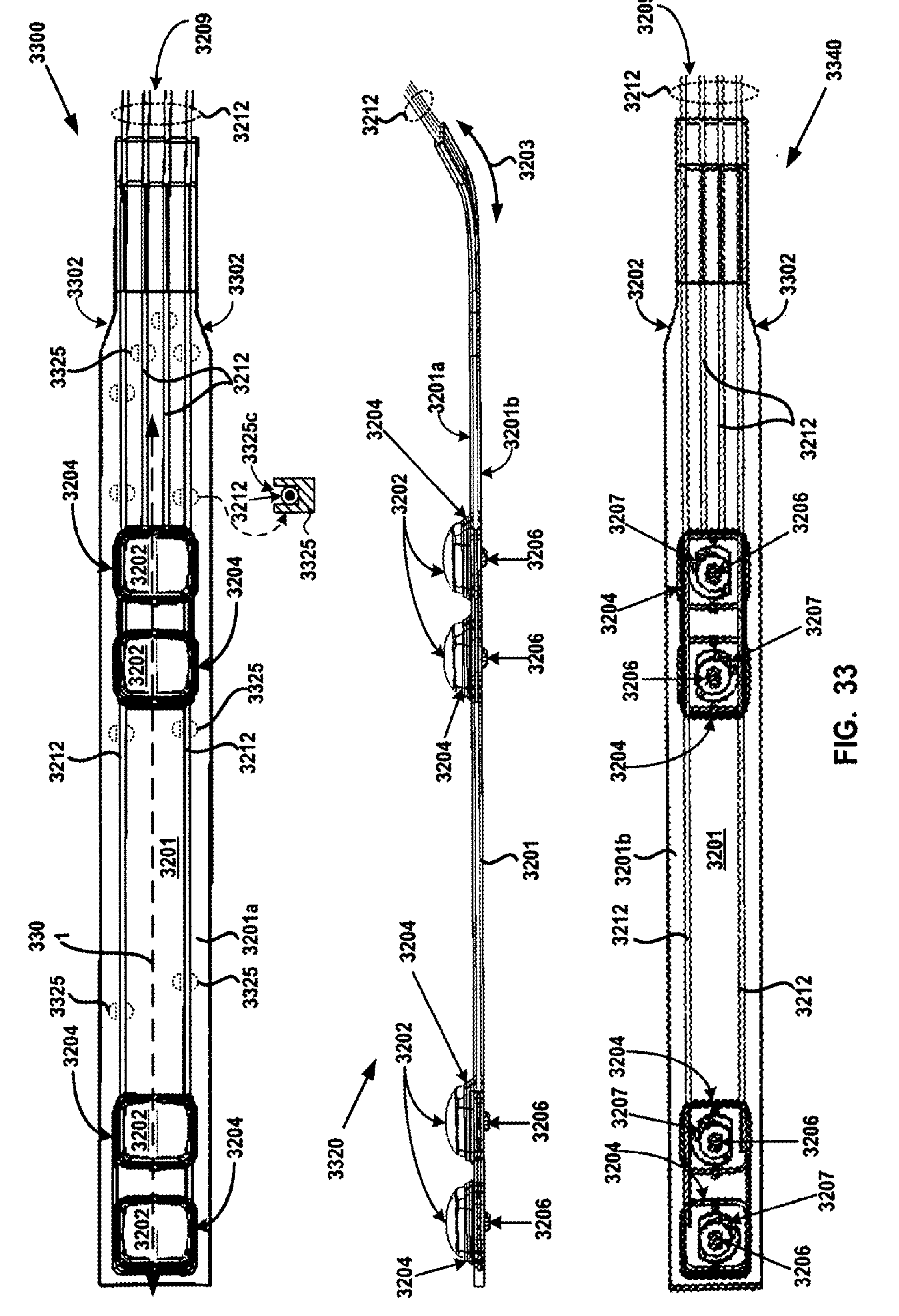

3300
3209
3212
3302
3302
3325
3212
3325c
3212
3325
3204
3202
3204
3202
3325
3212
3212
3201
330
3201a
3325
3325
3204
3202
3204
3202
3212
3203
3201a
3201b
3204
3202
3206
3206
3204
3201
3204
3202
3206
3320
3206
3204
3209
3212
3340
3202
3302
3212
3207
3206
3204
3207
3206
3204
3201b
3201
3212
3212
3204
3207
3206
3204
3207
3206

FIG. 33

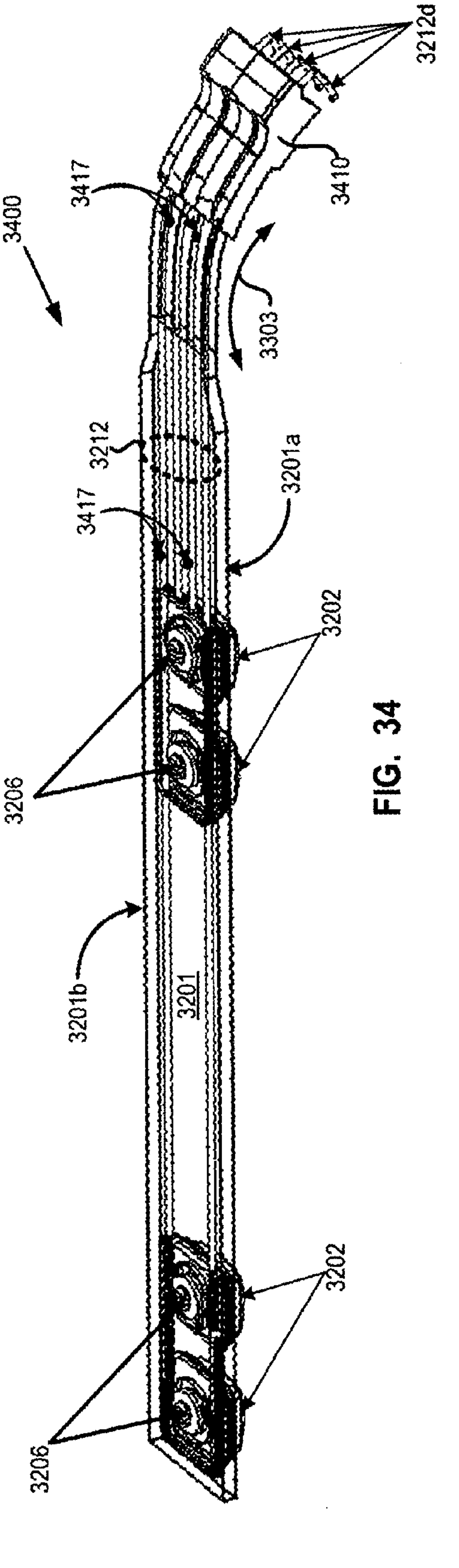

3400
3212d
3417
3410
3303
3212
3417
3201a
3202
3206
3201b
3201
3202
3206

FIG. 34

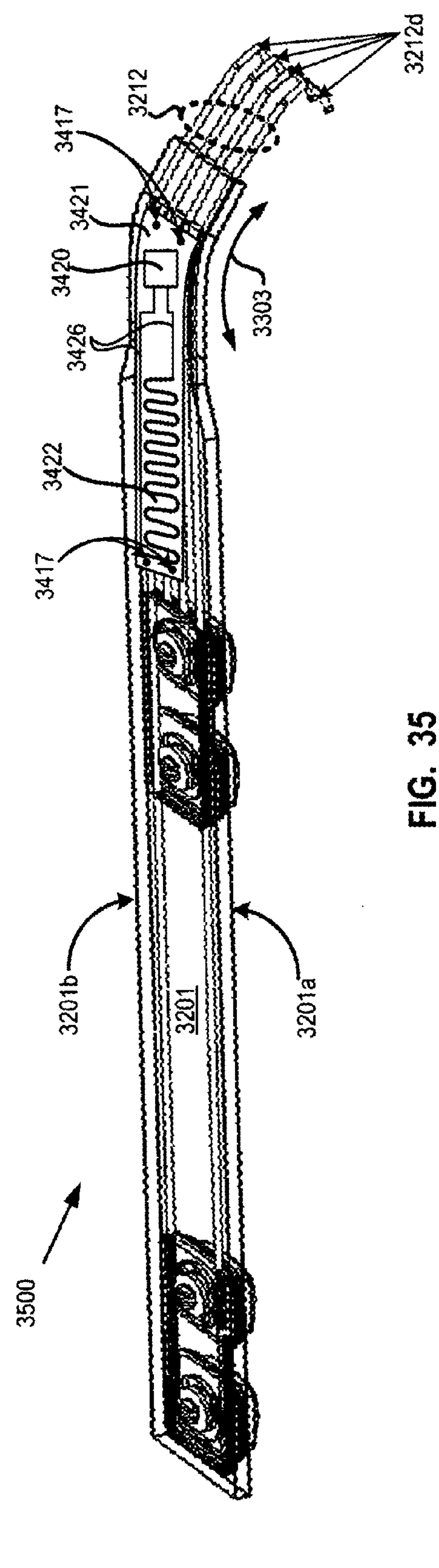

3212d
3212
3417
3421
3420
3303
3426
3422
3417
3201b
3201
3201a
3500

FIG. 35

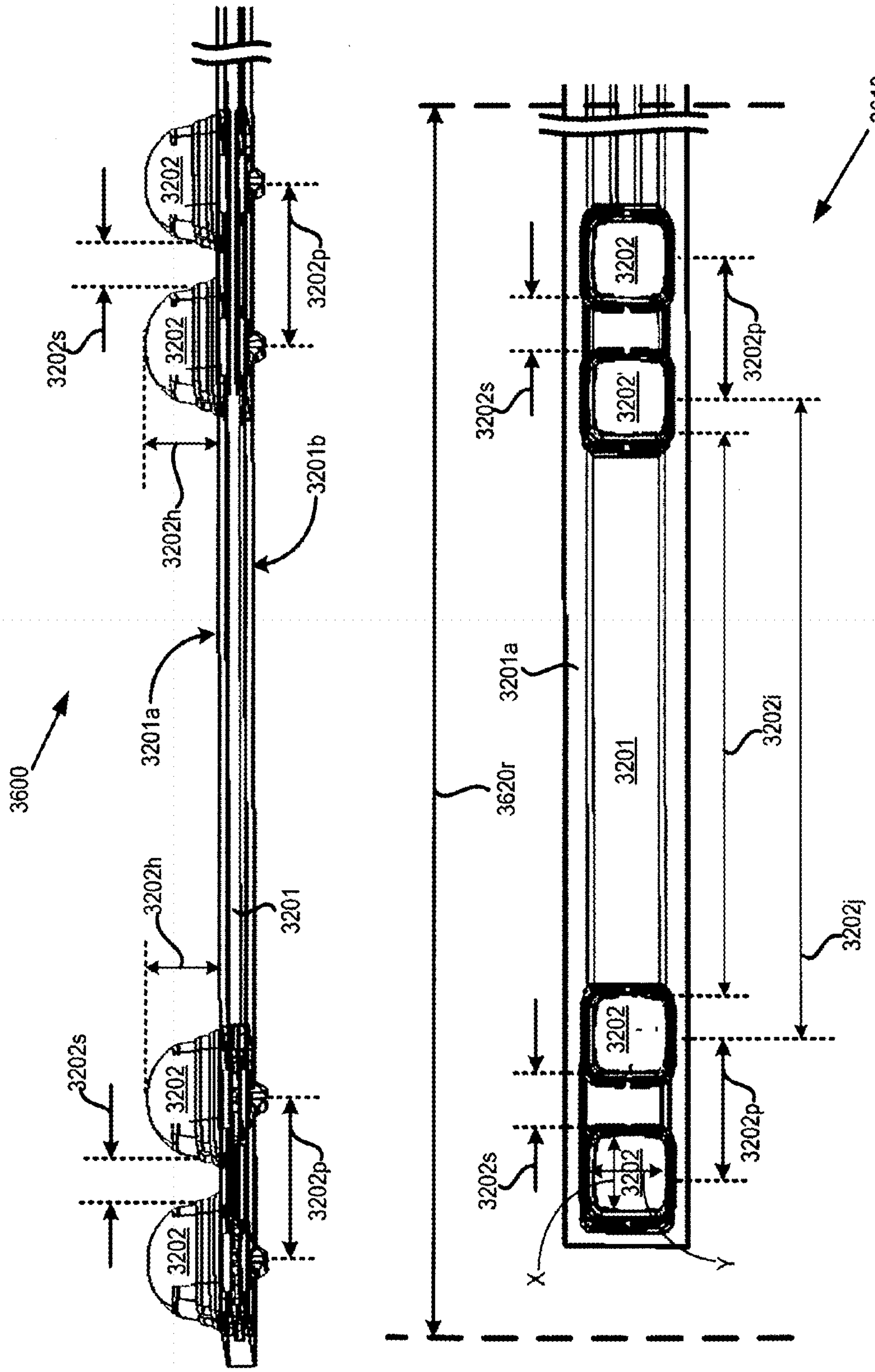

3600
3201a
3201b
3201
3202
3202s
3202p
3202h
3610
3620r
3202i
3202j
X
Y

FIG. 36

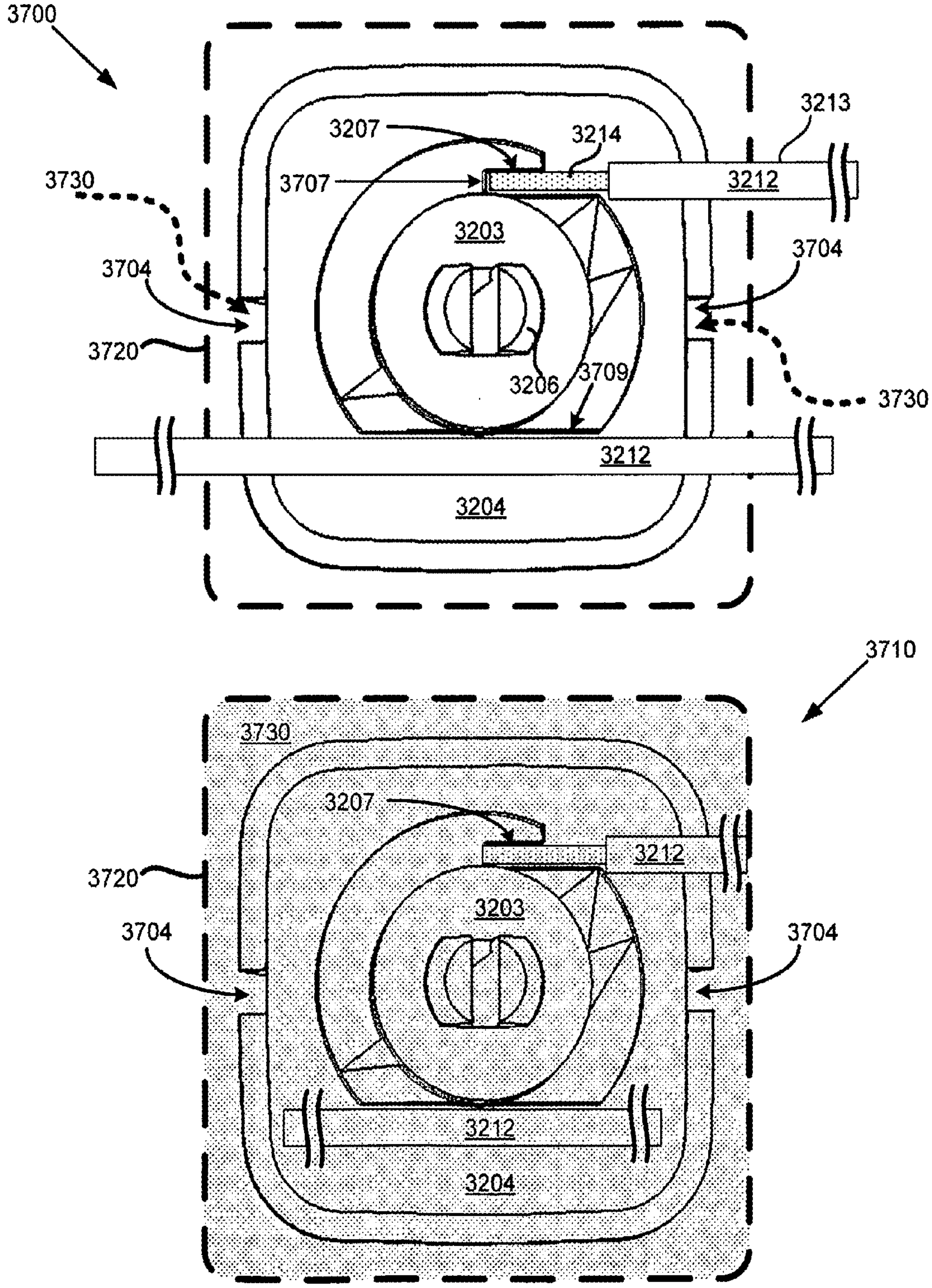

3700
3207
3214
3213
3730
3707
3212
3203
3704
3704
3720
3206
3709
3730
3212
3204
3710
3730
3207
3212
3720
3203
3704
3704
3212
3204

FIG. 37

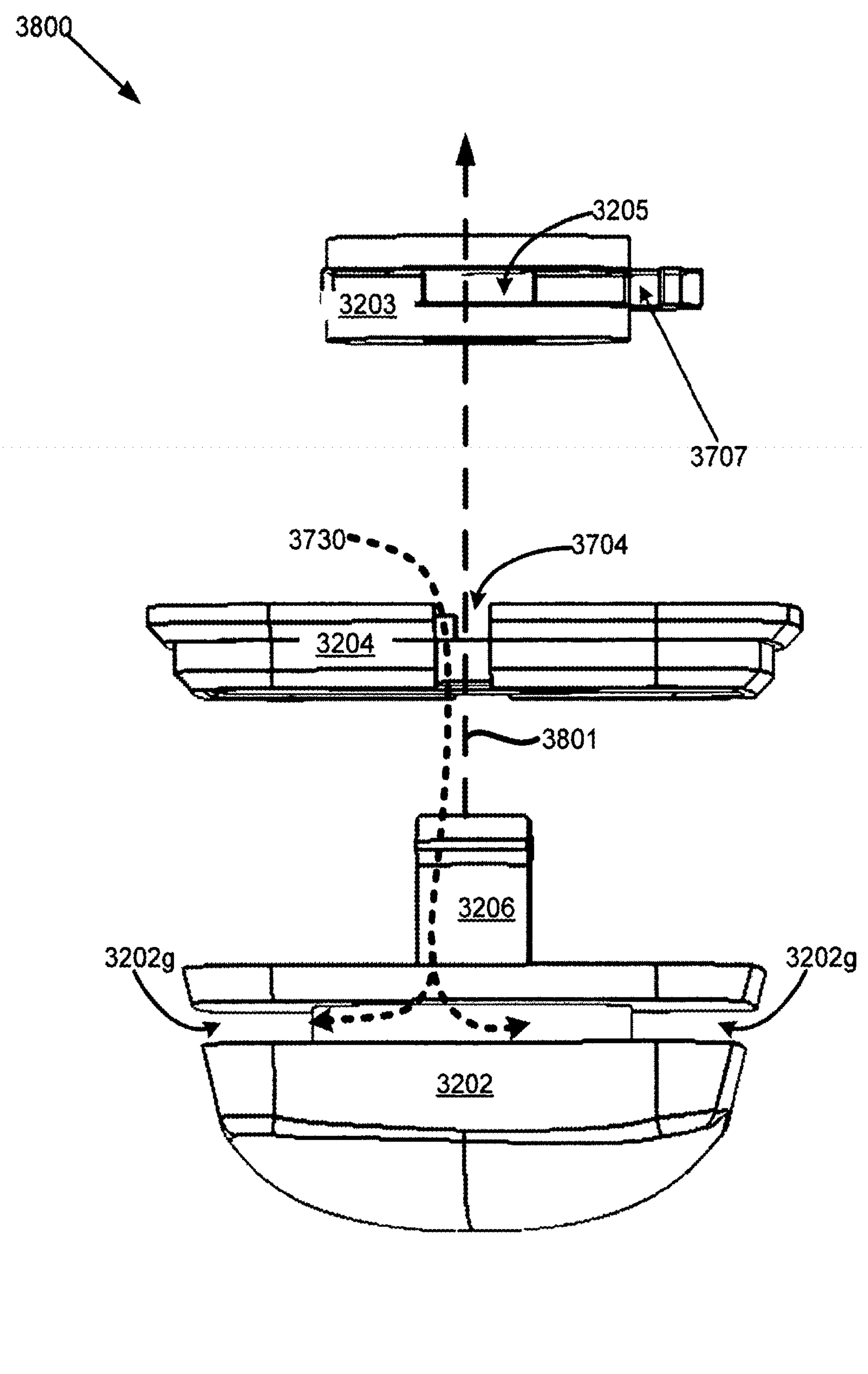

3800
3205
3203
3707
3730
3704
3204
3801
3206
3202g
3202g
3202

FIG. 38

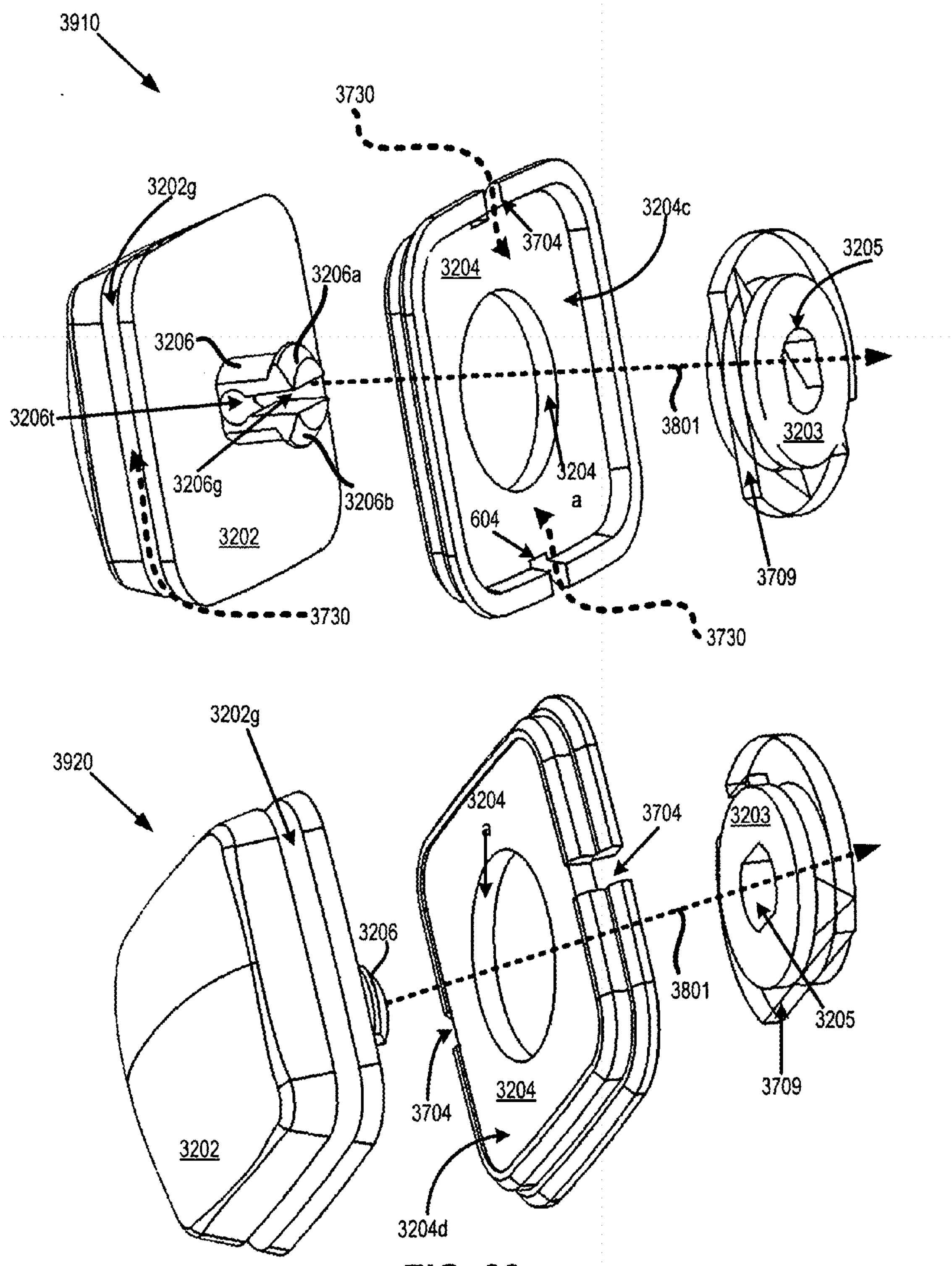

3910
3730
3202g
3204c
3704
3205
3206a
3204
3206
3206t
3801
3203
3204
a
3206g
3206b
604
3202
3709
3730
3730
3202g
3920
3204
a
3704
3203
3206
3801
3205
3709
3704
3204
3202
3204d

FIG. 39

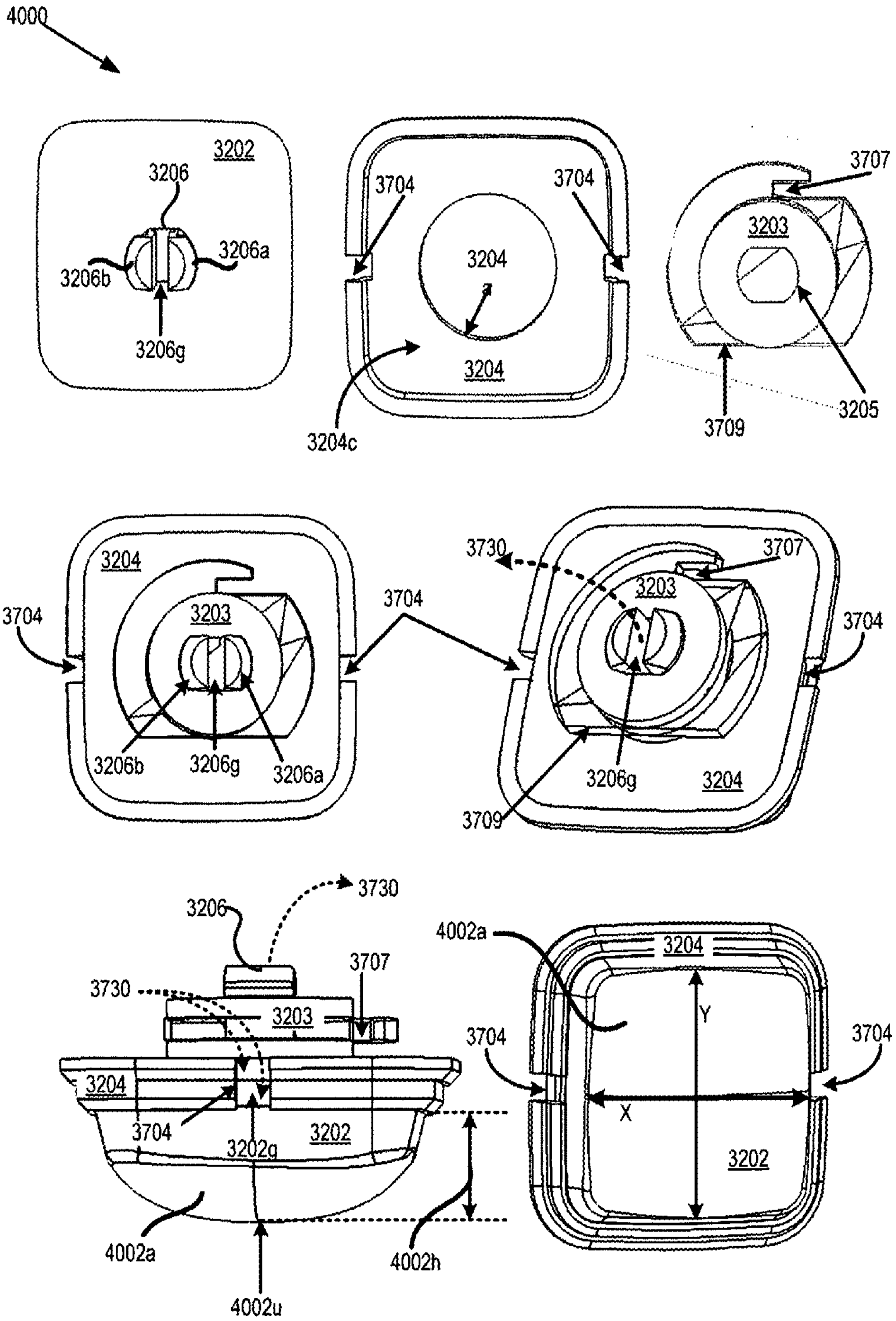

4000
3202
3206
3206a
3206b
3206g
3704
3704
3204
a
3204
3204c
3707
3203
3709
3205
3204
3730
3707
3704
3203
3704
3704
3206b
3206g
3206a
3709
3206g
3204
3206
3730
3707
3730
3203
3204
3704
3202
3202g
4002a
4002u
4002h
4002a
3204
Y
3704
3704
X
3202

FIG. 40

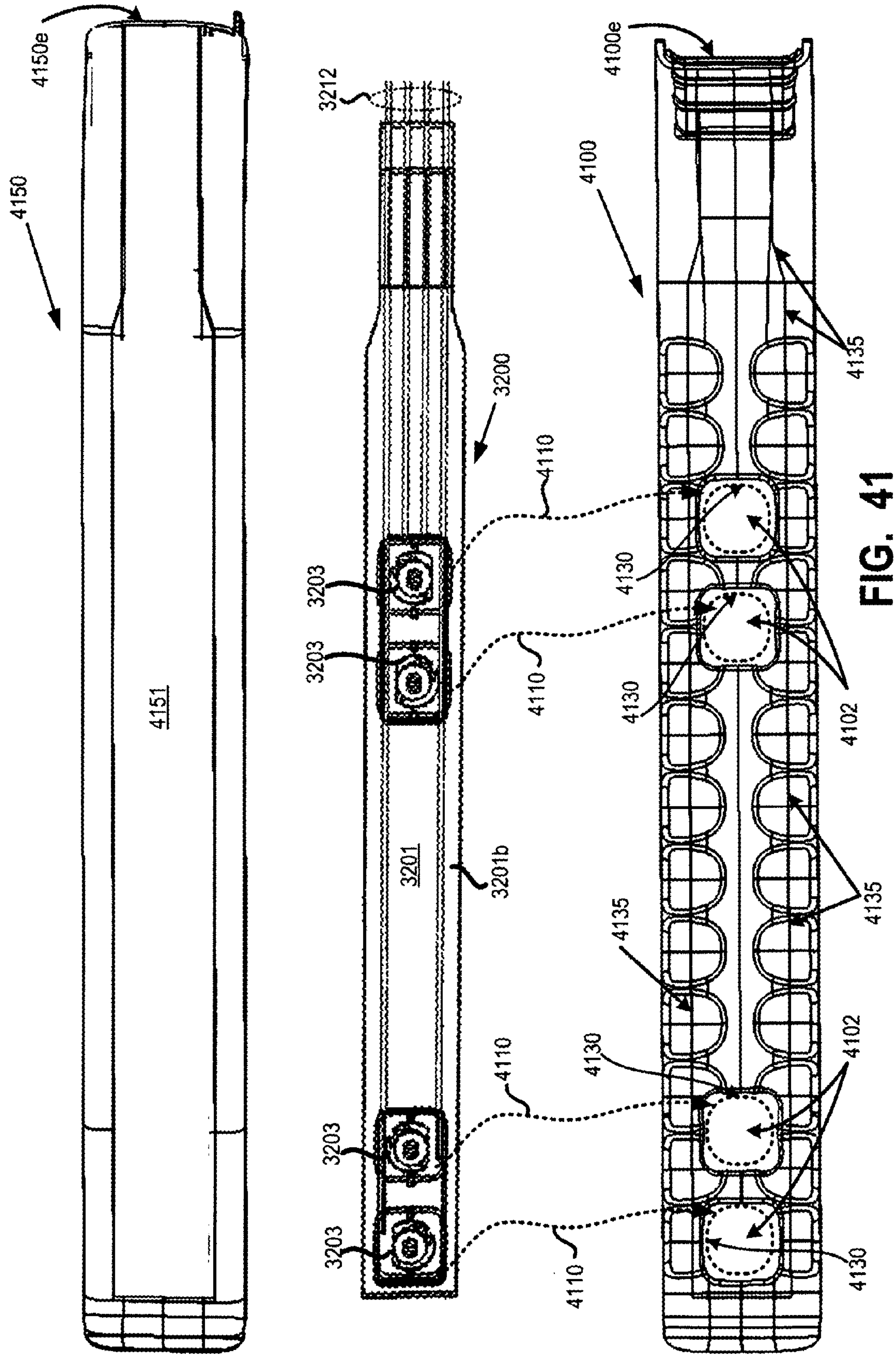

4150e
4150
4151
3212
3200
3201
3201b
3203
3203
3203
3203
4110
4110
4110
4110
4100e
4100
4135
4135
4135
4130
4130
4130
4130
4102
4102

FIG. 41

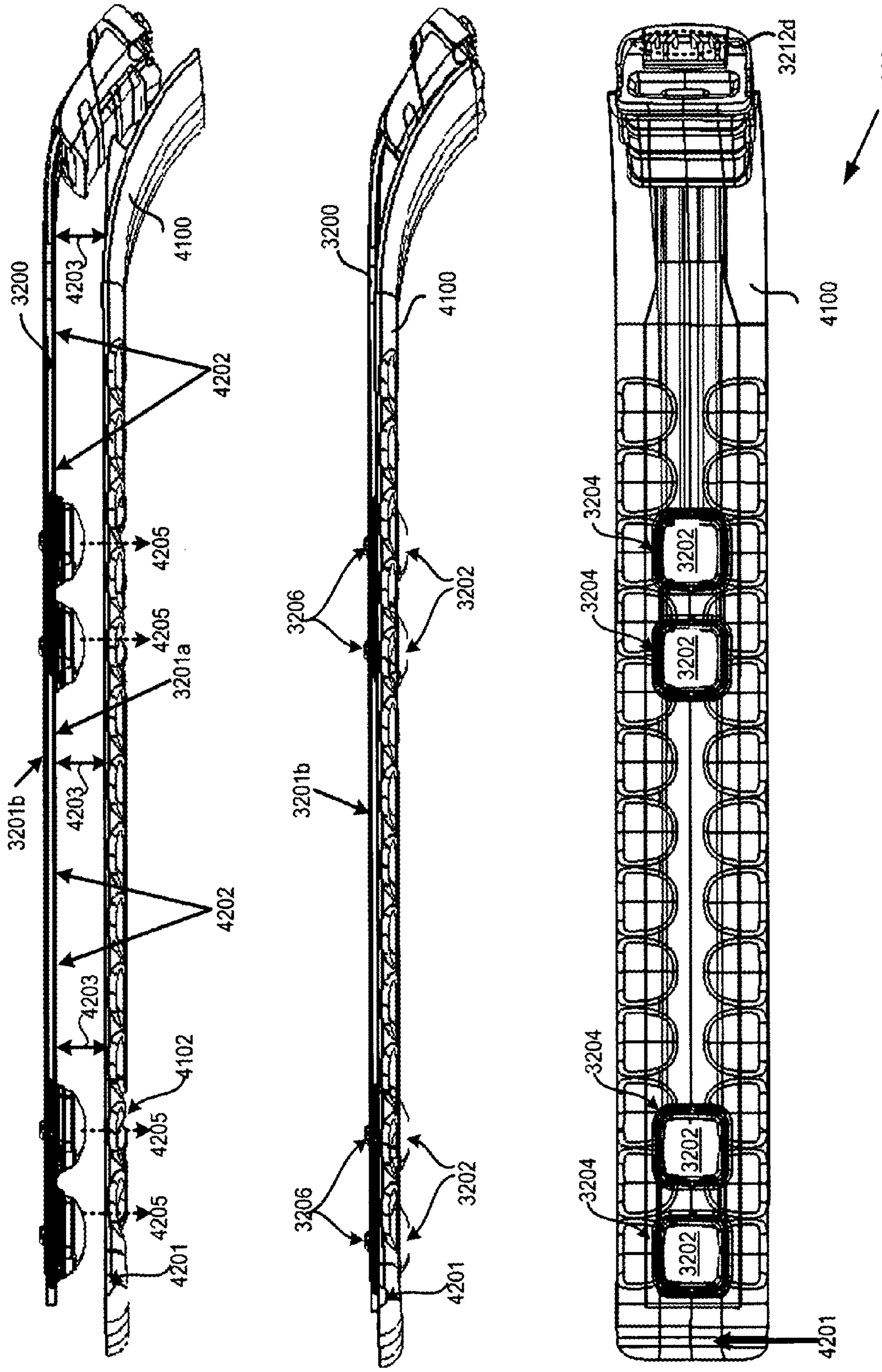

3200
4203
4100
4202
4205
4205
3201a
3201b
4203
4202
4203
4102
4205
4205
4201
3200
4100
3206
3202
3201b
3206
3202
4201
3212d
4200
4100
3204
3202
3204
3202
3204
3202
3204
3202
4201

FIG. 42

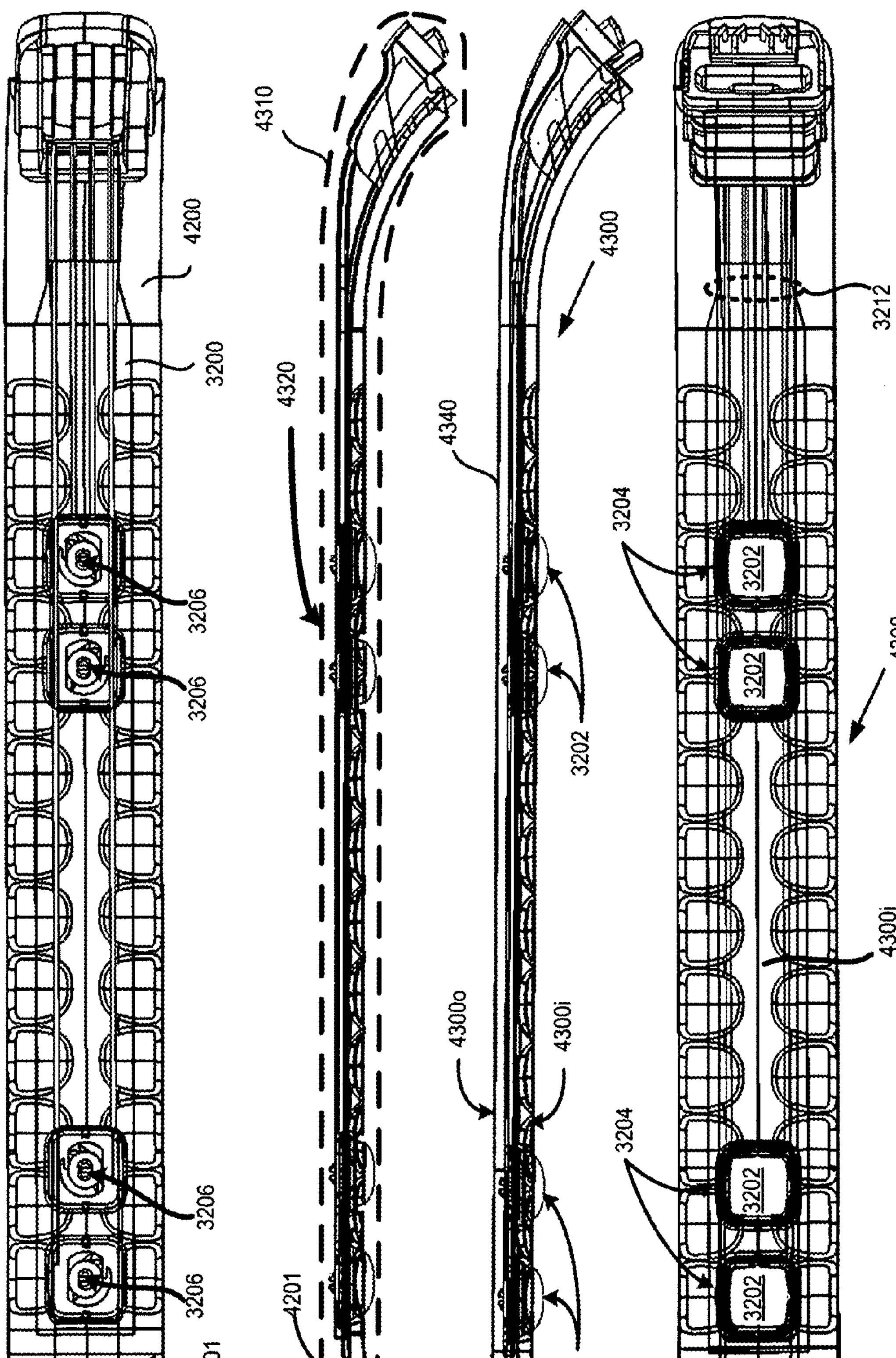

4200
3200
3206
3206
3206
3206
4201
4310
4320
4201
4300
4340
3202
4300o
4300i
3202
3212
3204
3202
3202
4300
4300i
3204
3202
3202

FIG. 43

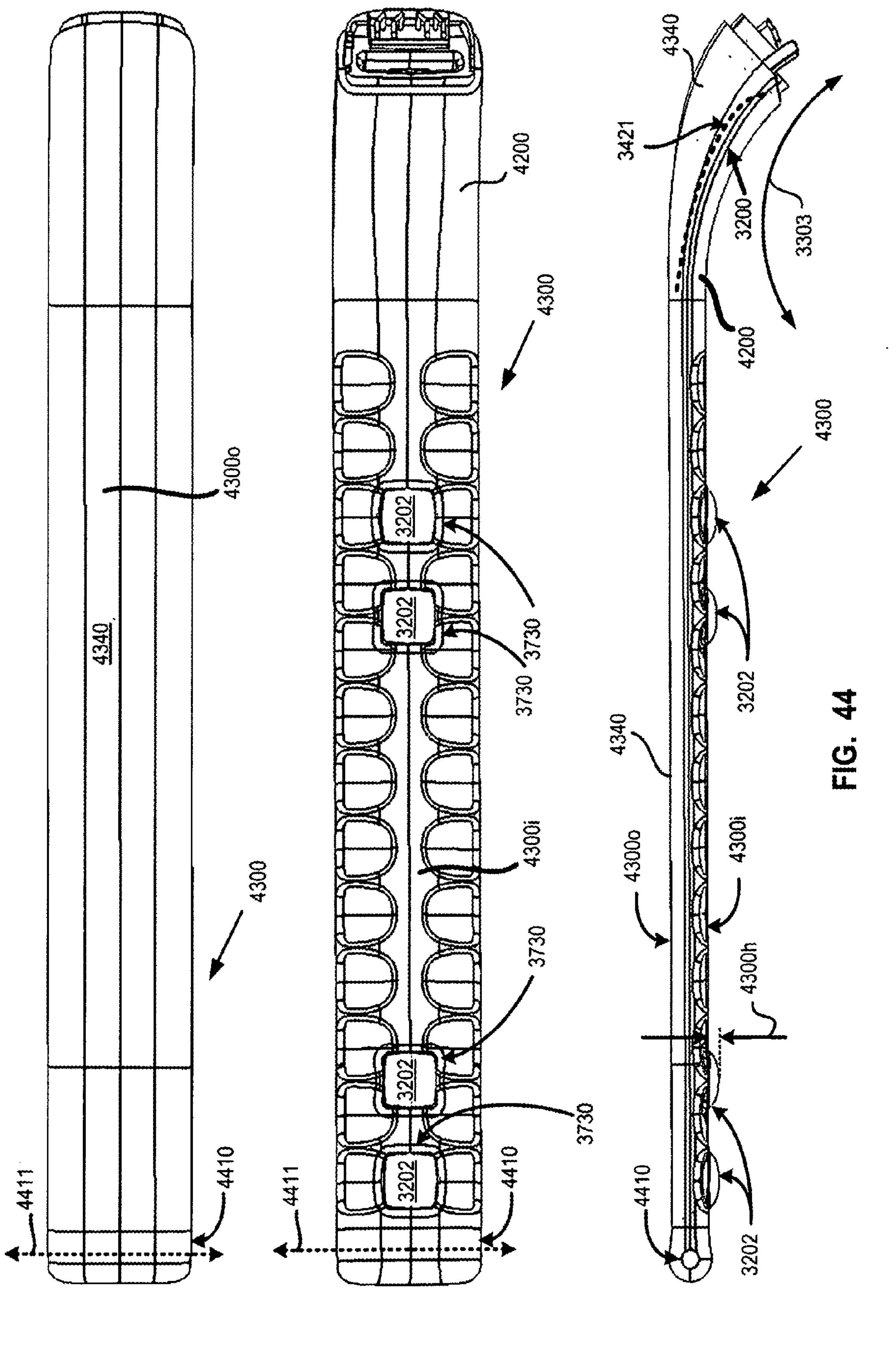

4340
4300o
4300
4411
4410
4200
4300
3202
3730
3730
4300i
3730
3730
3202
3202
3202
4340
3421
3200
3303
4200
4300
3202
4340
4300o
4300i
4300h
3202
4410

FIG. 44

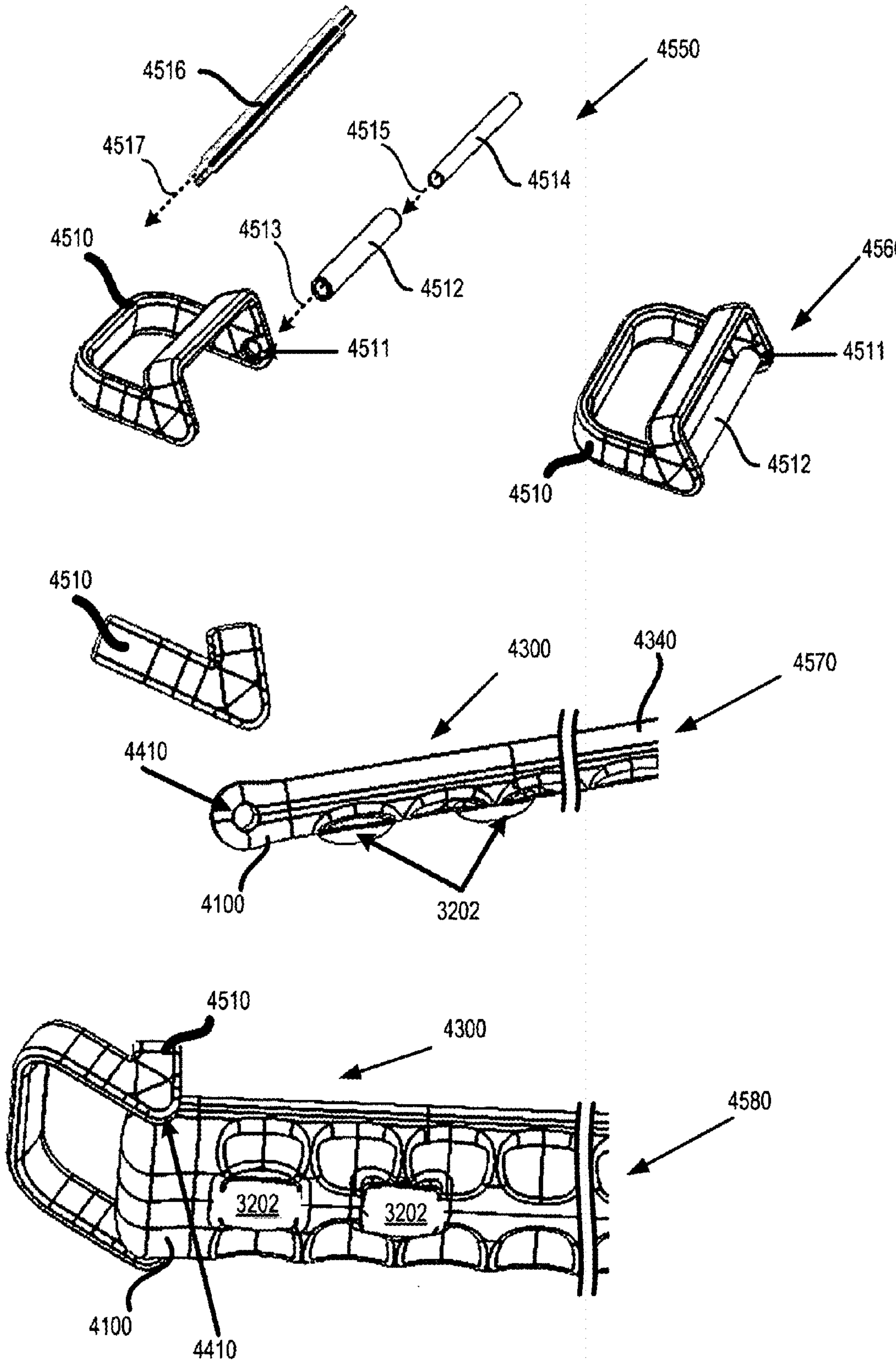

4516
4550
4517
4515
4514
4510
4513
4512
4511
4560
4511
4512
4510
4510
4300
4340
4570
4410
4100
3202
4510
4300
4580
3202
3202
4100
4410

FIG. 45

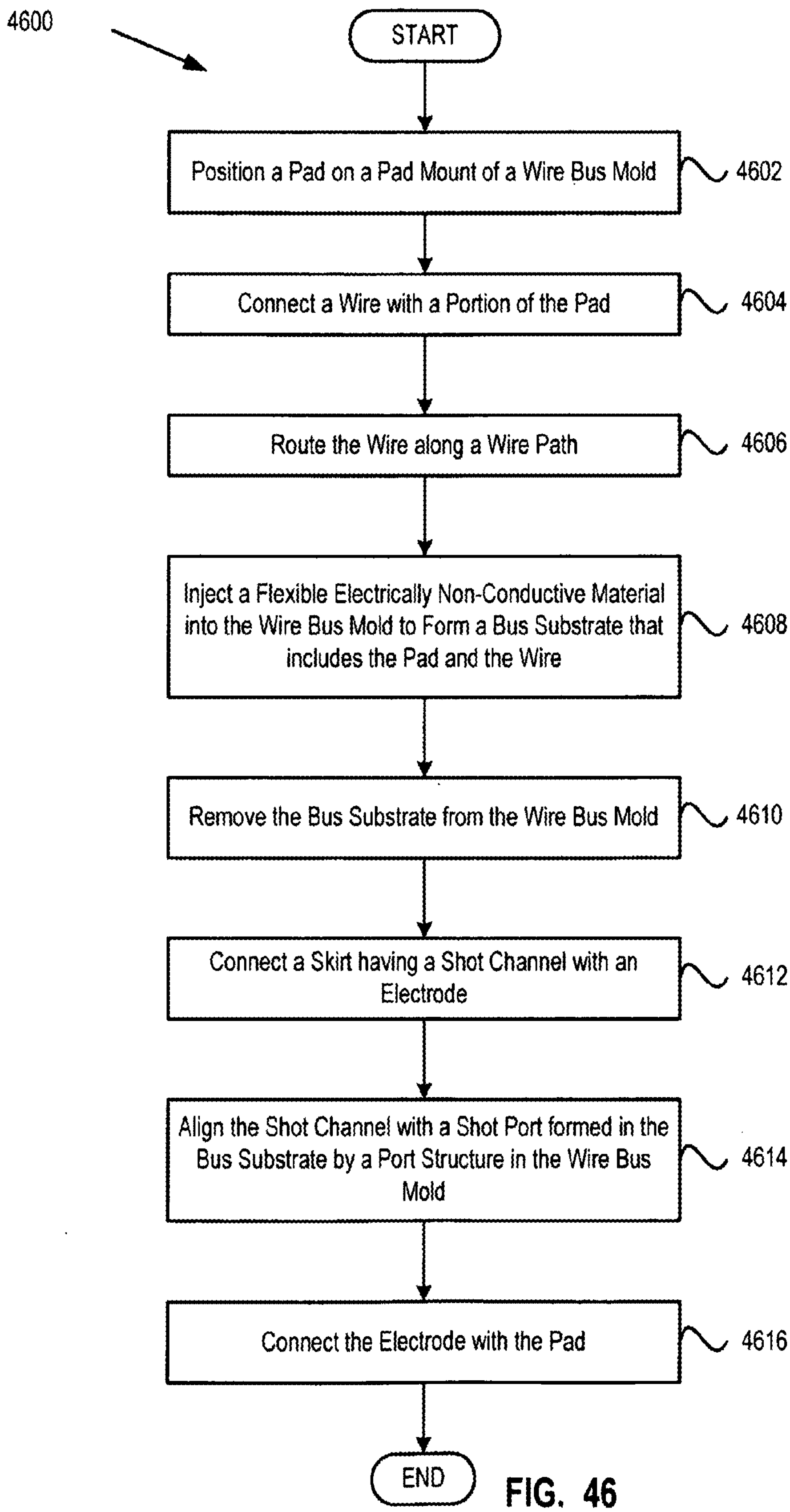

4600
START
Position a Pad on a Pad Mount of a Wire Bus Mold
4602
Connect a Wire with a Portion of the Pad
4604
Route the Wire along a Wire Path
4606
Inject a Flexible Electrically Non-Conductive Material into the Wire Bus Mold to Form a Bus Substrate that includes the Pad and the Wire
4608
Remove the Bus Substrate from the Wire Bus Mold
4610
Connect a Skirt having a Shot Channel with an Electrode
4612
Align the Shot Channel with a Shot Port formed in the Bus Substrate by a Port Structure in the Wire Bus Mold
4614
Connect the Electrode with the Pad
4616
END

FIG. 46

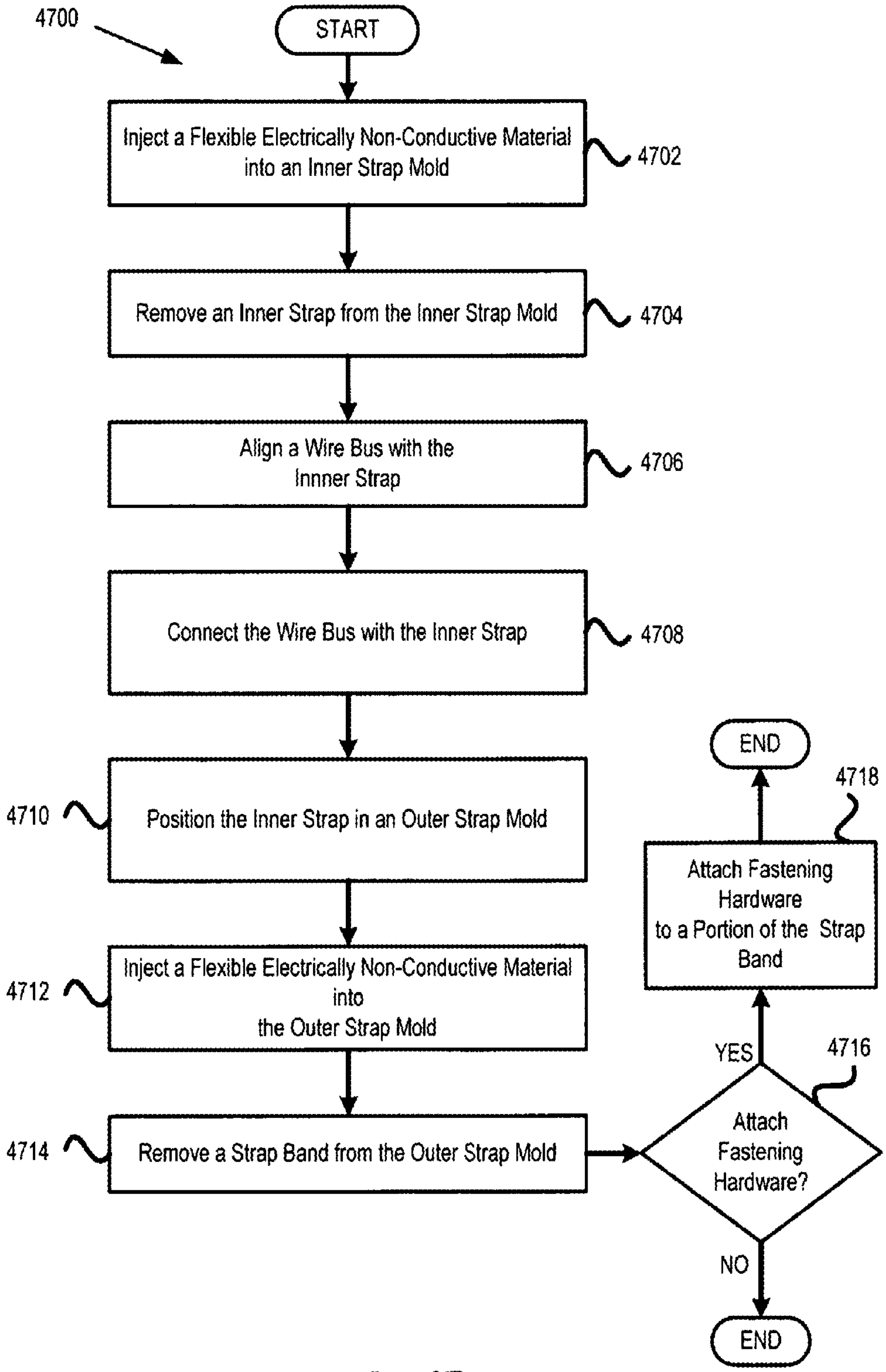

4700
START
Inject a Flexible Electrically Non-Conductive Material into an Inner Strap Mold
4702
Remove an Inner Strap from the Inner Strap Mold
4704
Align a Wire Bus with the Innner Strap
4706
Connect the Wire Bus with the Inner Strap
4708
4710
Position the Inner Strap in an Outer Strap Mold
4712
Inject a Flexible Electrically Non-Conductive Material into the Outer Strap Mold
4714
Remove a Strap Band from the Outer Strap Mold
4716
Attach Fastening Hardware?
YES
NO
4718
Attach Fastening Hardware to a Portion of the Strap Band
END
END

FIG. 47

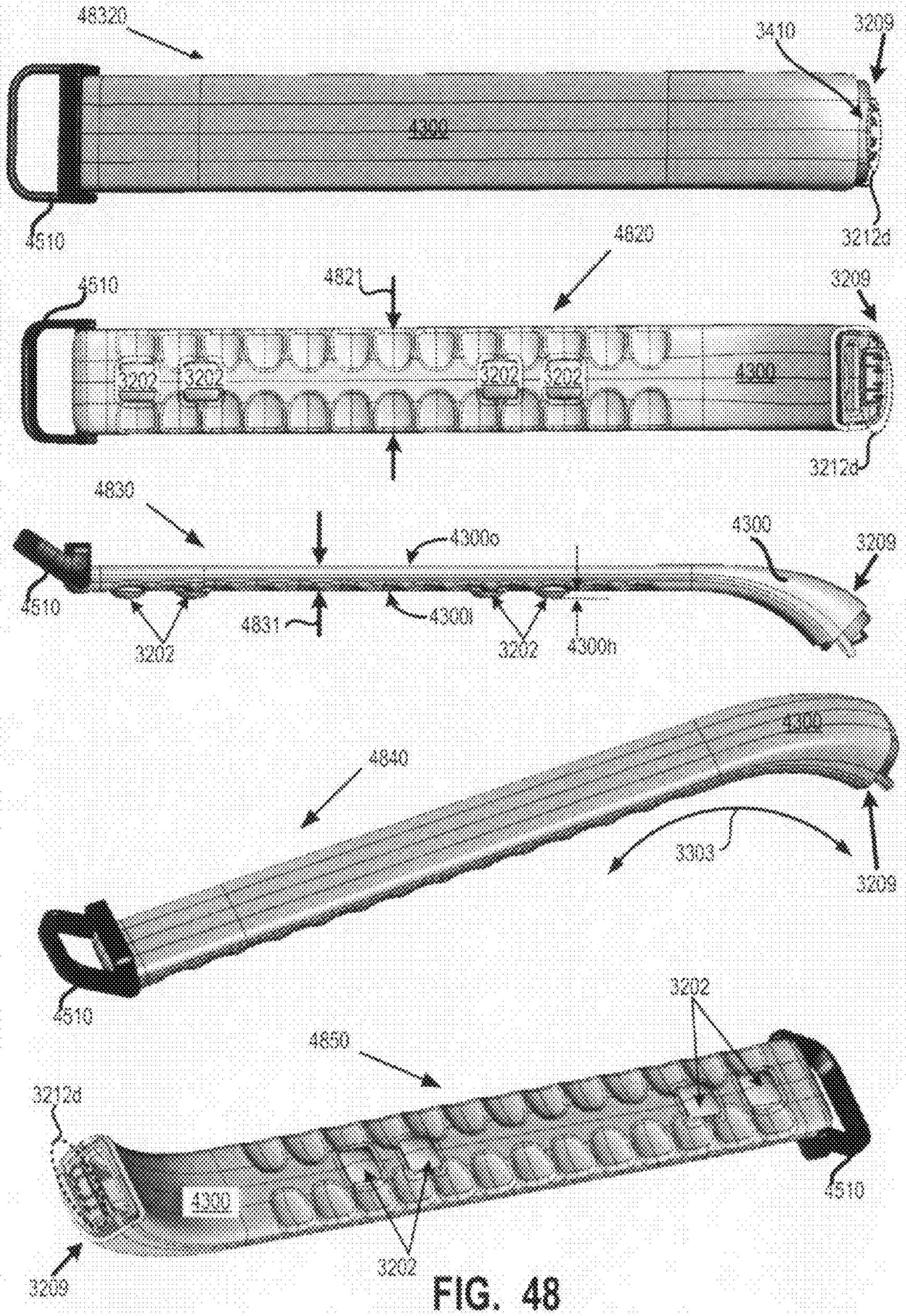

48320
3410
3209
4300
4510
3212d
4820
4510
4821
3209
3202
3202
3202
3202
4300
3212d
4830
4300o
4300
3209
4510
4831
4300i
3202
3202
4300h
4300
4840
3303
3209
4510
3202
4850
3212d
4300
4510
3202
3209

FIG. 48

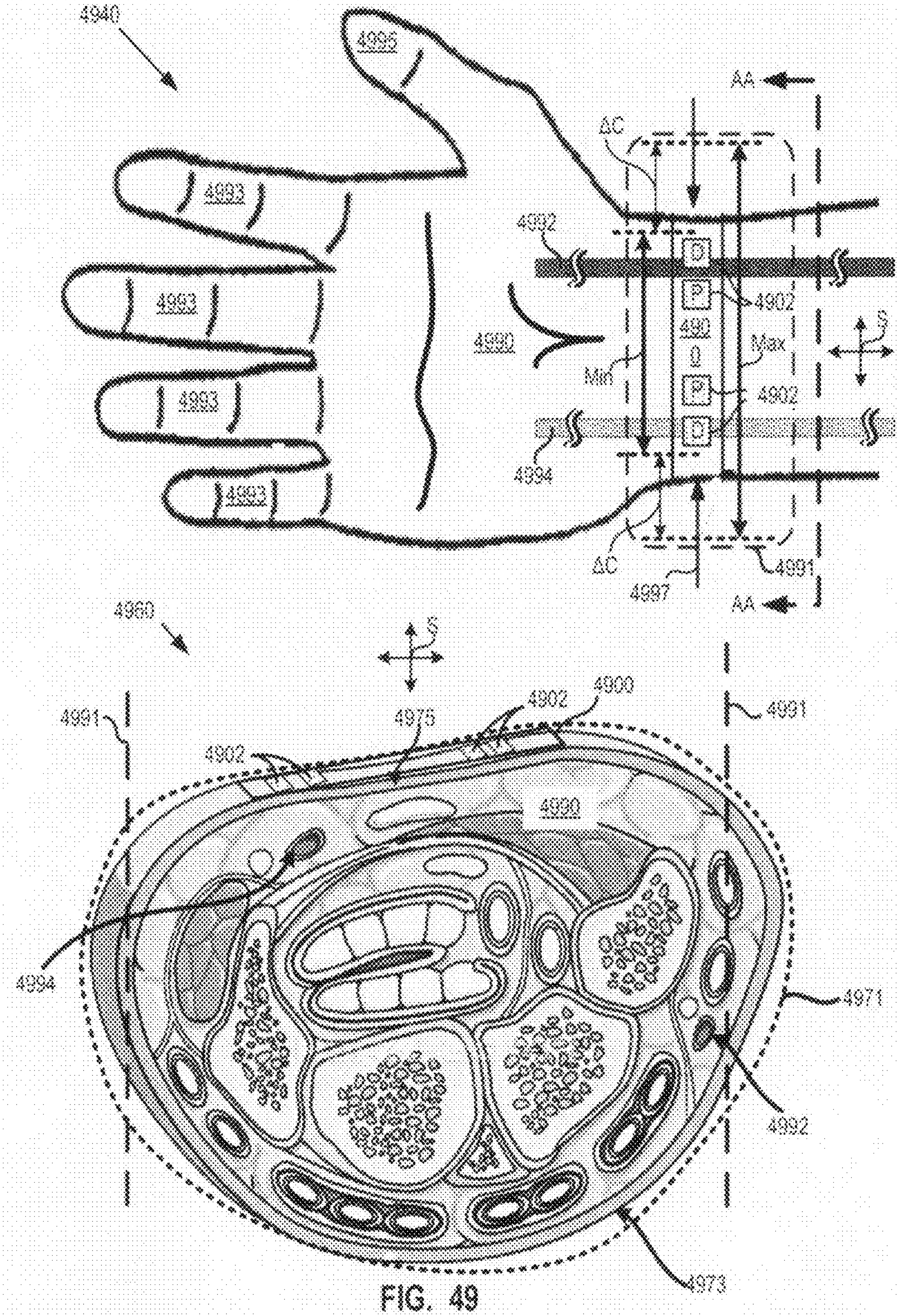

4940
4995
4993
4993
4993
4993
AA
ΔC
4992
D
P
4902
490
0
Max
S
4990
Min
P
4902
D
4994
ΔC
4997
4991
AA
4960
S
4902
4900
4991
4975
4991
4902
4990
4994
4971
4992
4973

FIG. 49

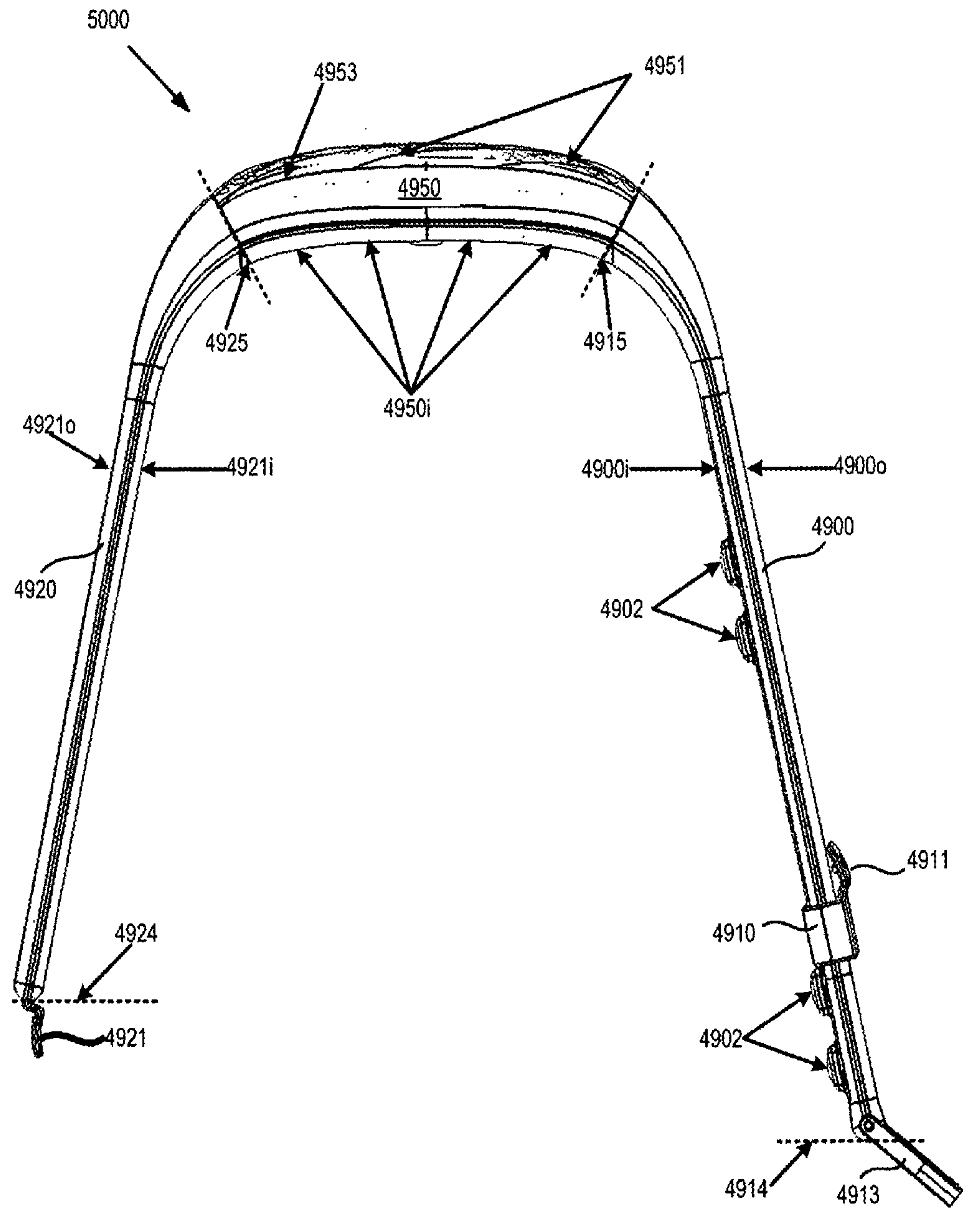
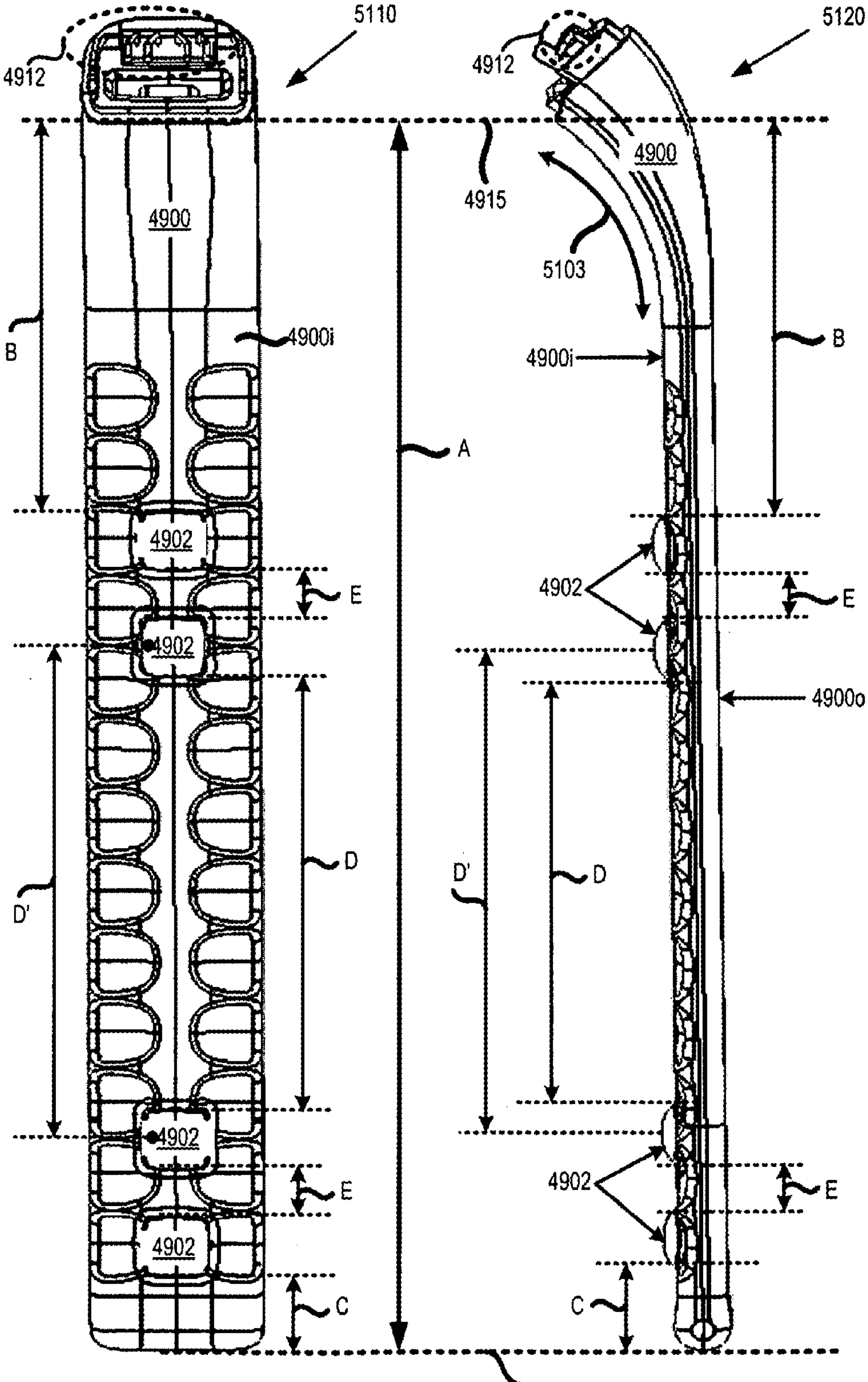

5000
4953
4951
4950
4925
4915
4950i
4921o
4921i
4900i
4900o
4900
4920
4902
4911
4910
4924
4921
4902
4914
4913

FIG. 50



5110
4912
4900
4900i
B
A
4902
4902
E
D'
D
4902
E
4902
C
5120
4912
4900
4915
5103
4900i
B
4902
E
4900o
D'
D
4902
E
C
4914

FIG. 51

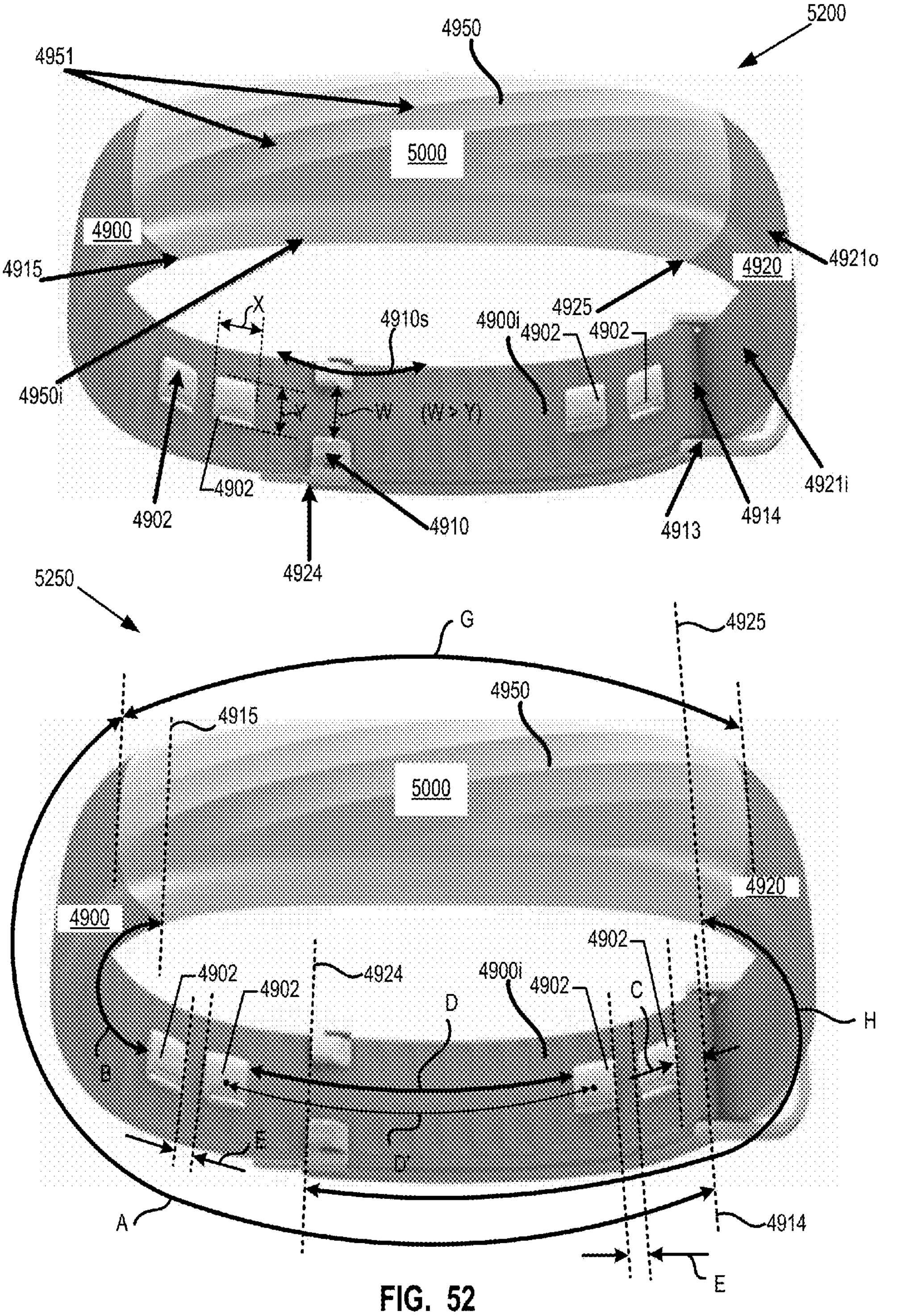

5200
4950
4951
5000
4900
4915
4920
4921o
4925
4950i
X
4910s
4900i
4902
Y
W
(W > Y)
4910
4924
4913
4914
4921i
5250
G
4925
4950
4915
5000
4920
4900
4902
4924
4900i
D
C
H
B
E
D'
A
4914
E

FIG. 52

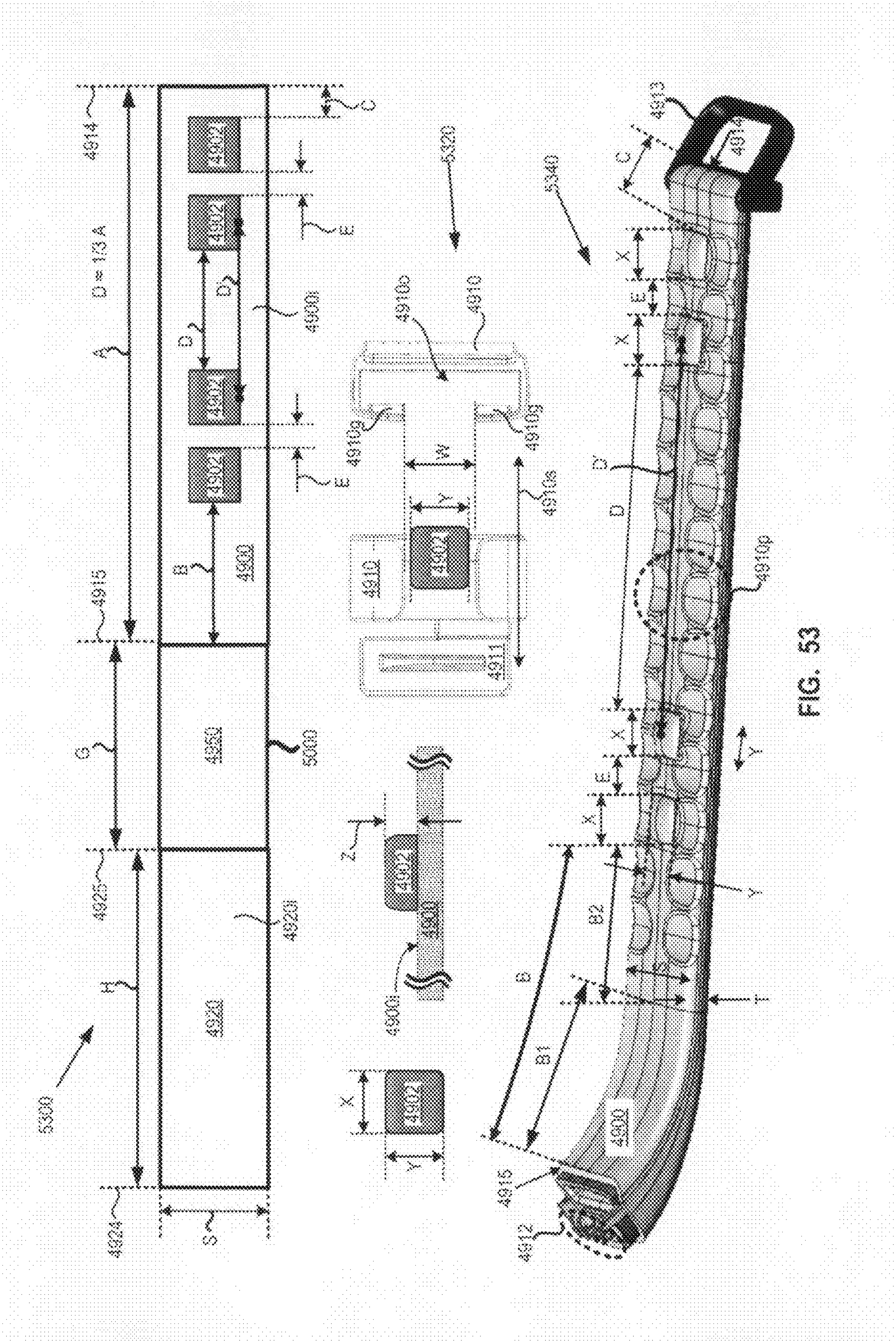

5300
4914
D = 1/3 A
A
4915
G
4925
H
4924
S
C
E
D
D2
B
4902
4900
4950
5000
4920
5320
4910
4910c
4910g
W
Y
4910s
4911
Z
X
5340
4913
4912
D'
4910p
B1
B2
T

FIG. 53

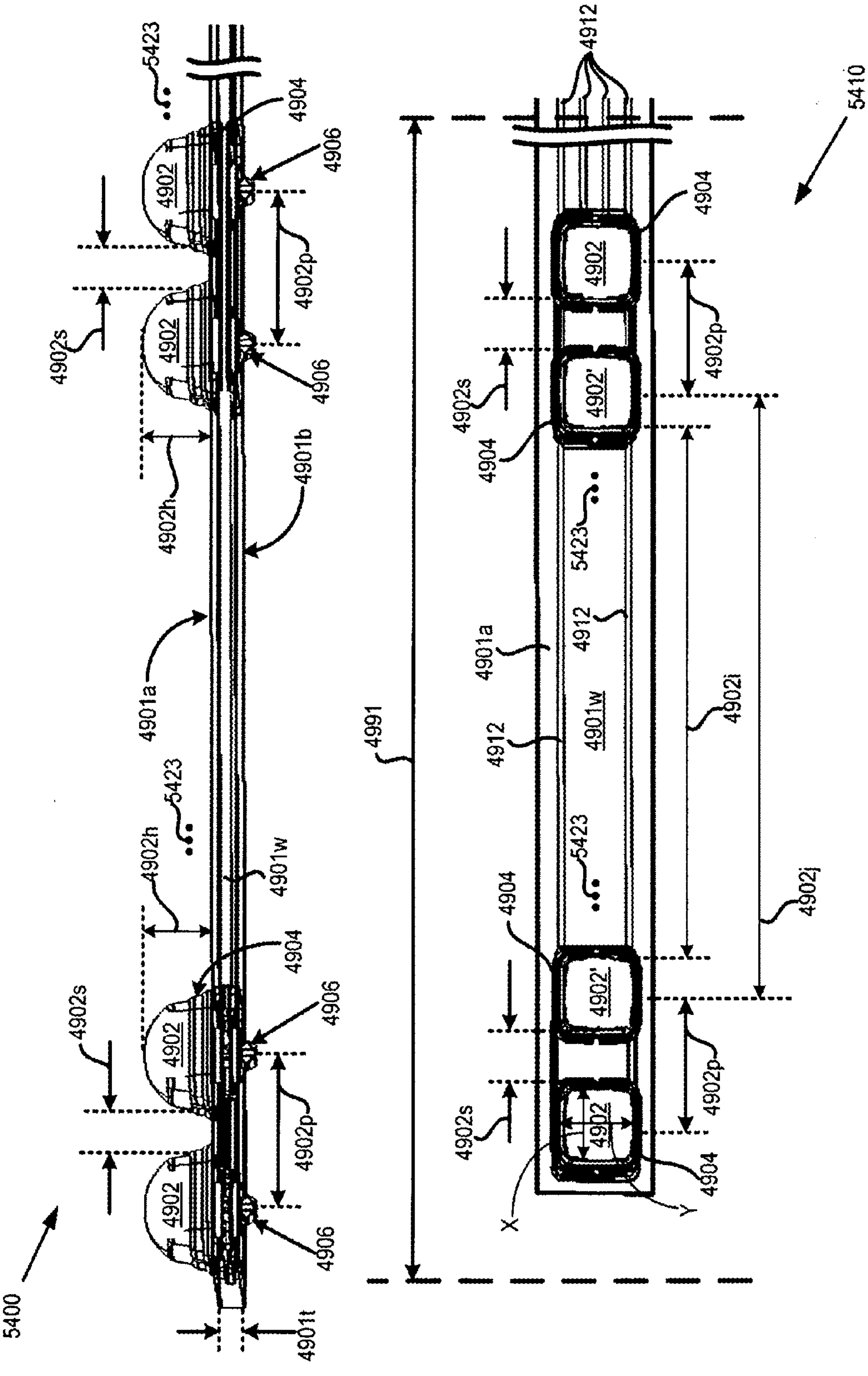
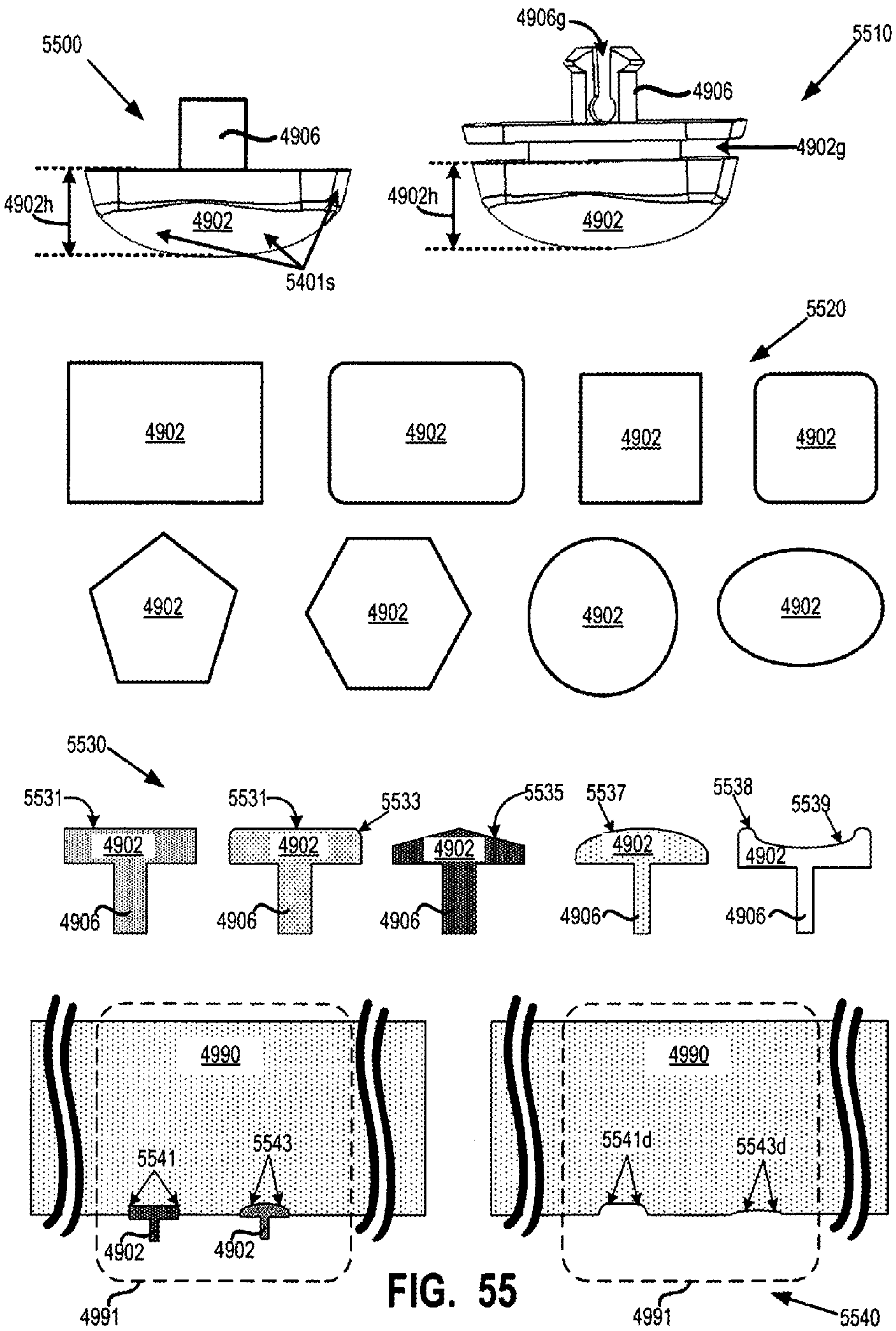

5423
4904
4906
4902
4902p
4902s
4902h
4901b
4901a
4901w
4901t
5400
4912
5410
4902'
4991
4902i
4902j
X
Y

FIG. 54



5500
4906
4902h
4902
5401s
4906g
5510
4906
4902g
4902h
4902
5520
4902
4902
4902
4902
4902
4902
4902
4902
5530
5531
4902
4906
5531
5533
4902
4906
5535
4902
4906
5537
4902
4906
5538
5539
4902
4906
4990
5541
5543
4902
4902
4991
4990
5541d
5543d
4991
5540

FIG. 55

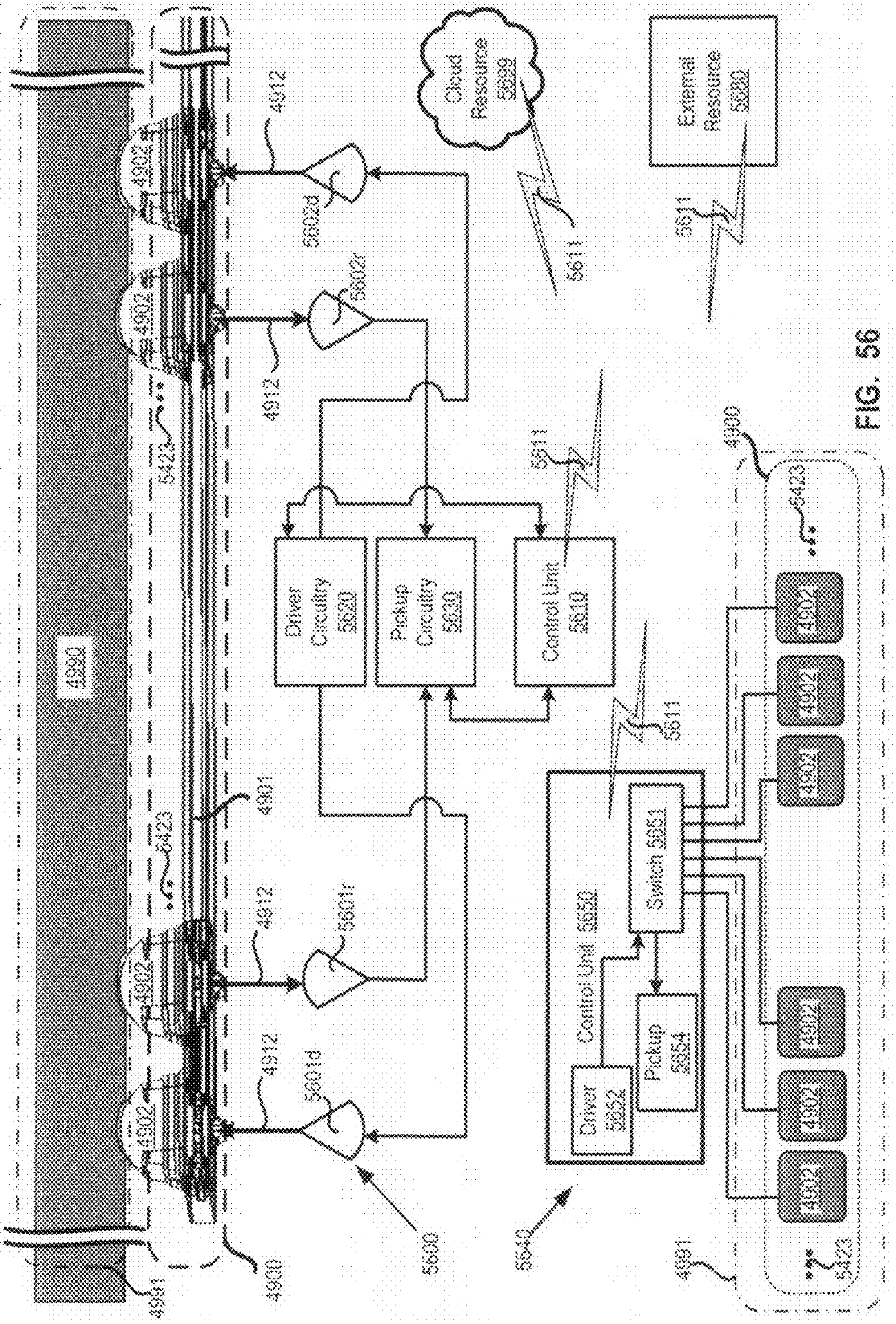
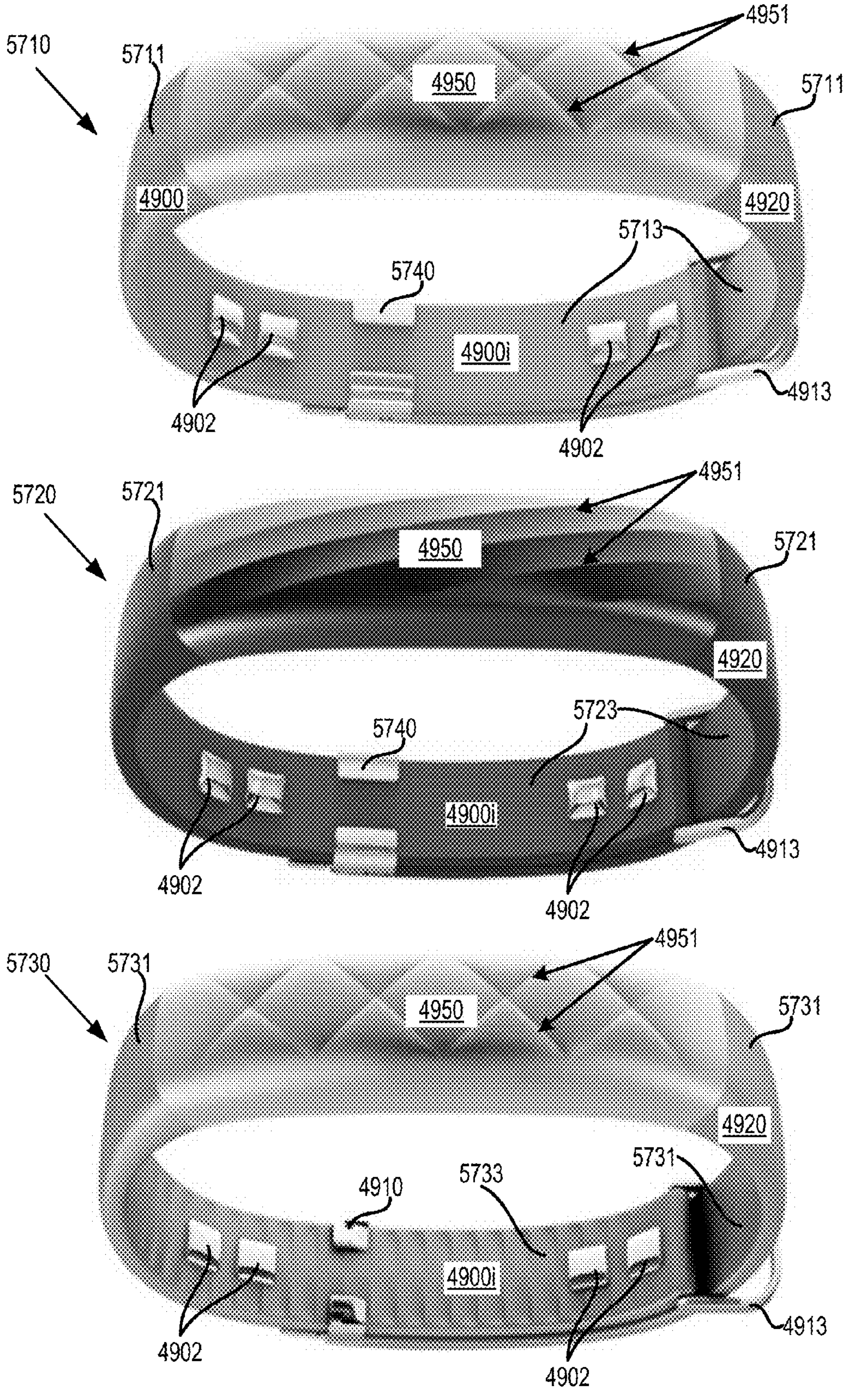

4990
4902
5423
4901
4912
5602d
5602r
5601r
5601d
5600
4900
4991
Cloud Resource
External Resource
5611
Driver Circuitry 5620
Pickup Circuitry 5630
Control Unit 5610
Control Unit 5650
Switch 5651
Driver 5652
Pickup 5654
5640

FIG. 56



5710
5711
4951
4950
5711
4900
4920
5713
5740
4900i
4913
4902
4902
5720
5721
4951
4950
5721
4920
5723
5740
4900i
4913
4902
4902
5730
5731
4951
4950
5731
4920
5731
4910
5733
4900i
4913
4902
4902

FIG. 57

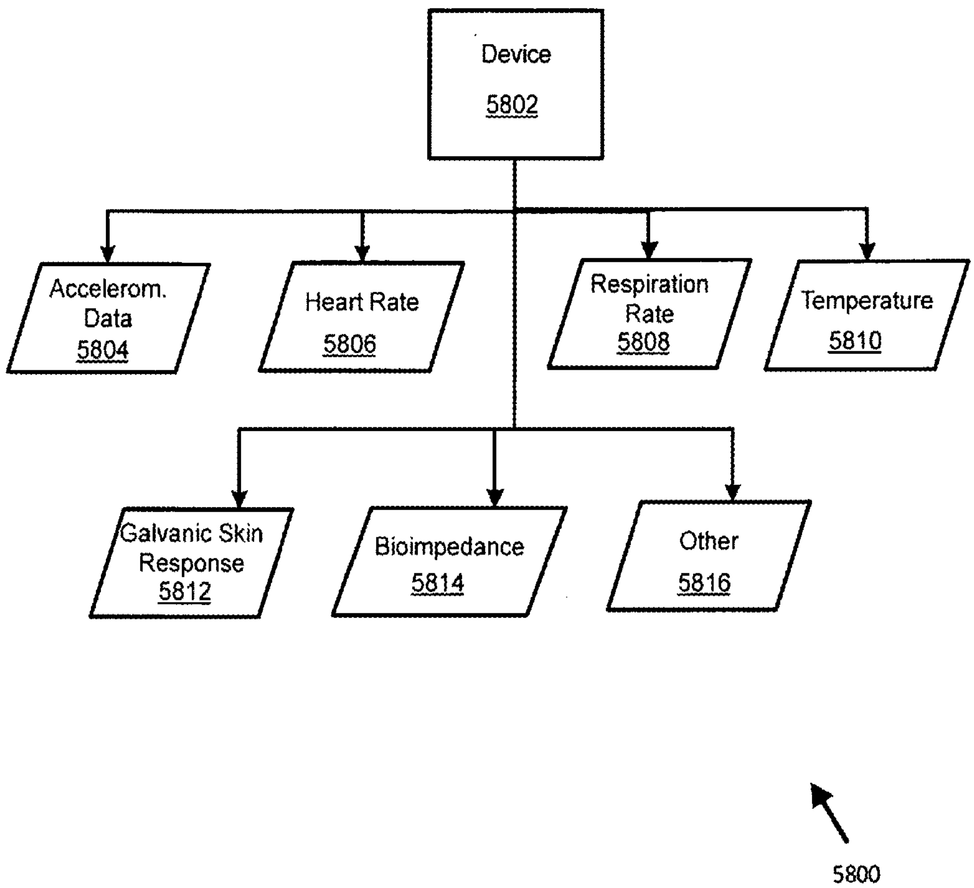

Device
5802
Accelerom. Data
5804
Heart Rate
5806
Respiration Rate
5808
Temperature
5810
Galvanic Skin Response
5812
Bioimpedance
5814
Other
5816
5800

FIG. 58

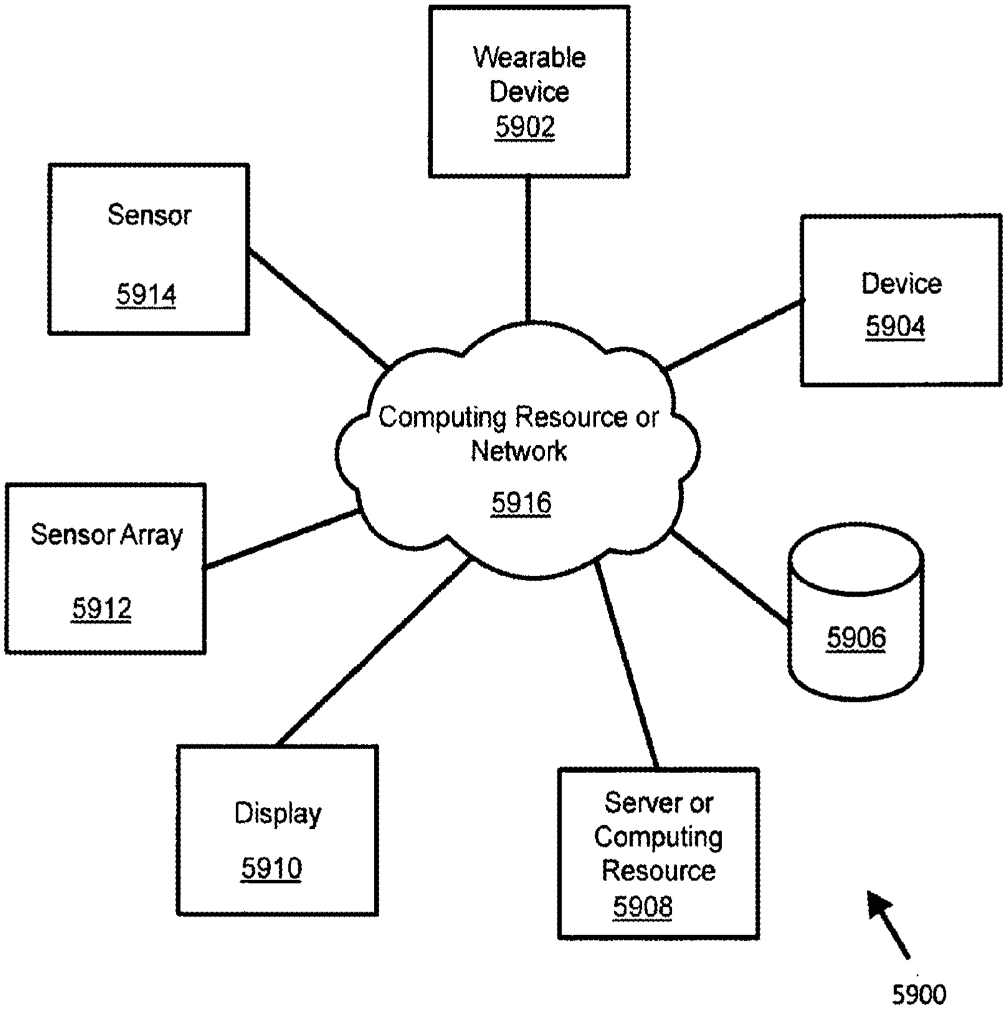

Wearable Device
5902
Sensor
5914
Device
5904
Computing Resource or Network
5916
Sensor Array
5912
5906
Display
5910
Server or Computing Resource
5908
5900

FIG. 59

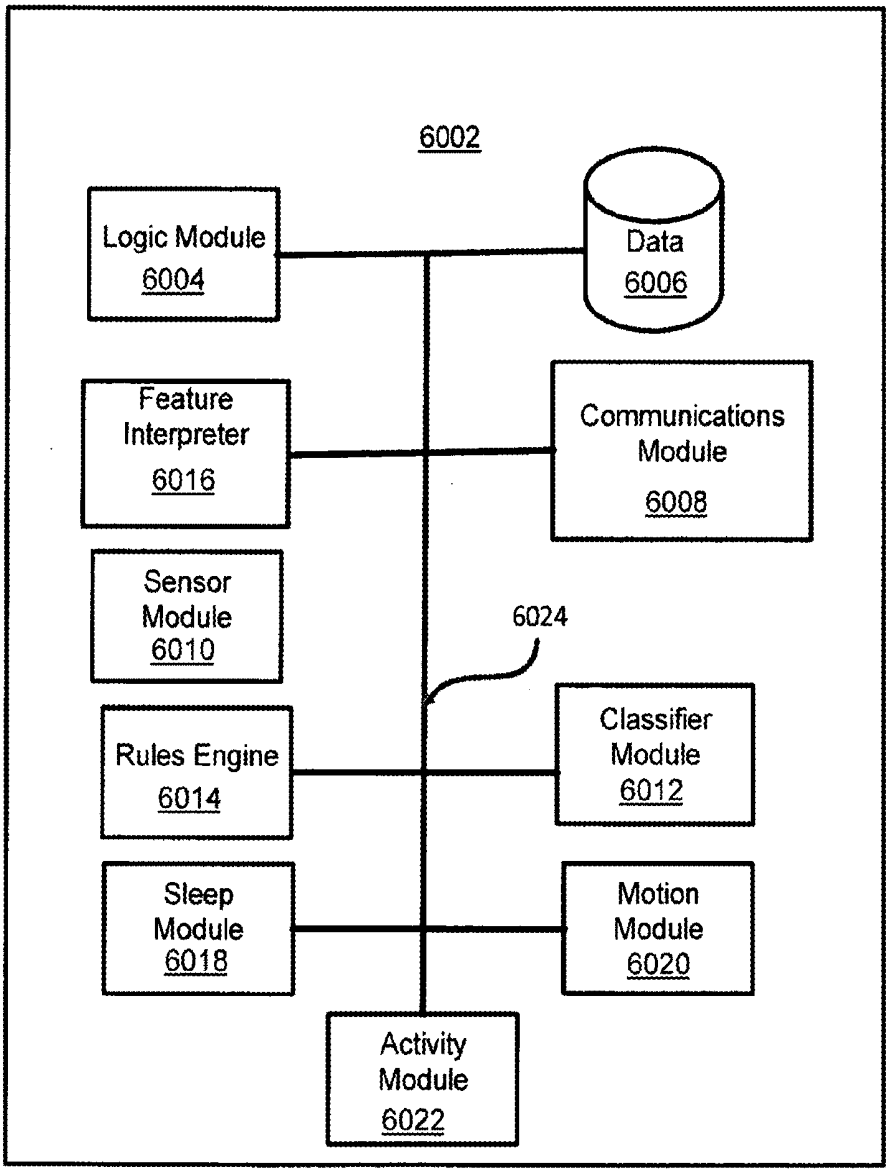

6002
Logic Module
6004
Data
6006
Feature
Interpreter
6016
Communications
Module
6008
Sensor
Module
6010
6024
Rules Engine
6014
Classifier
Module
6012
Sleep
Module
6018
Motion
Module
6020
Activity
Module
6022

FIG. 60

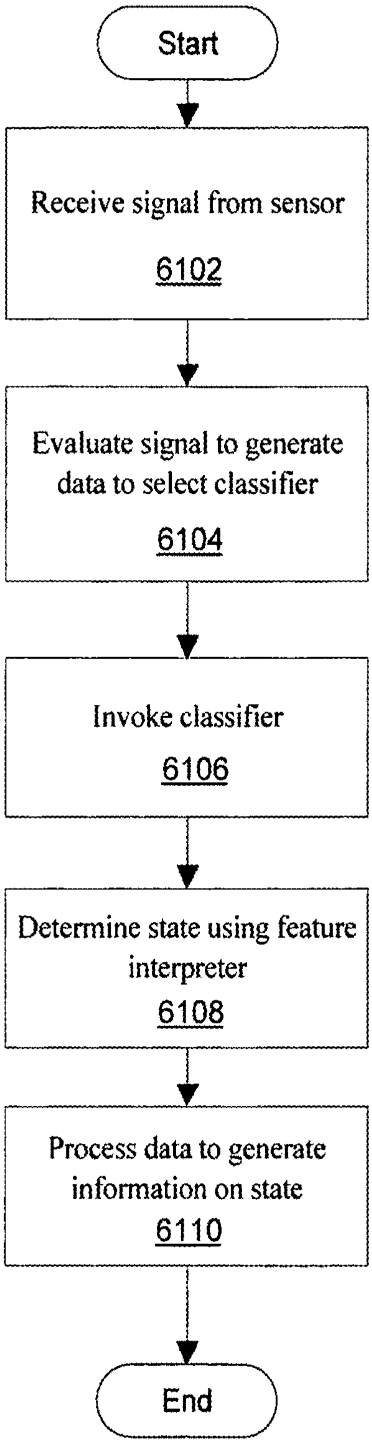

Start
Receive signal from sensor
6102
Evaluate signal to generate data to select classifier
6104
Invoke classifier
6106
Determine state using feature interpreter
6108
Process data to generate information on state
6110
End

FIG. 61

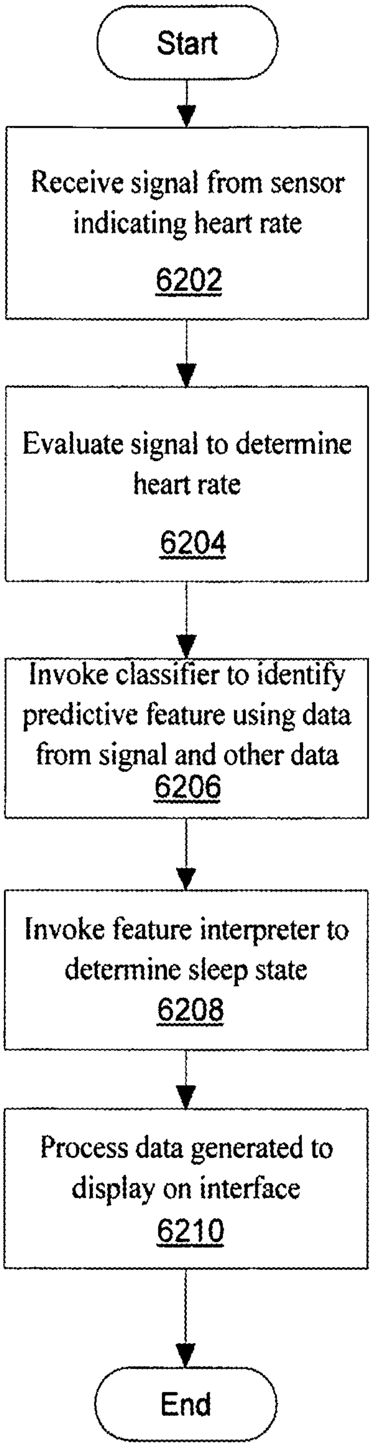

Start
Receive signal from sensor indicating heart rate
6202
Evaluate signal to determine heart rate
6204
Invoke classifier to identify predictive feature using data from signal and other data
6206
Invoke feature interpreter to determine sleep state
6208
Process data generated to display on interface
6210
End

FIG. 62

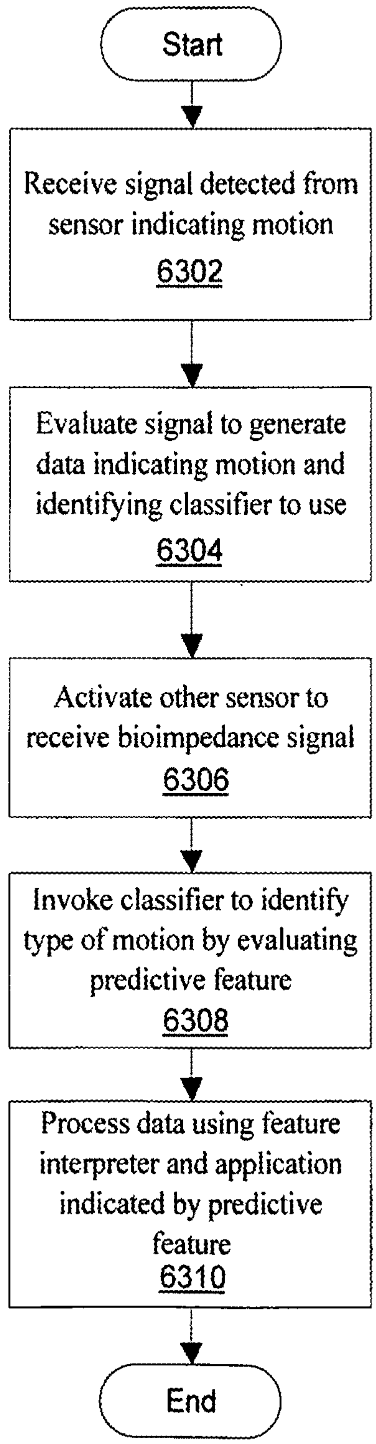

Start
Receive signal detected from sensor indicating motion
6302
Evaluate signal to generate data indicating motion and identifying classifier to use
6304
Activate other sensor to receive bioimpedance signal
6306
Invoke classifier to identify type of motion by evaluating predictive feature
6308
Process data using feature interpreter and application indicated by predictive feature
6310
End

FIG. 63

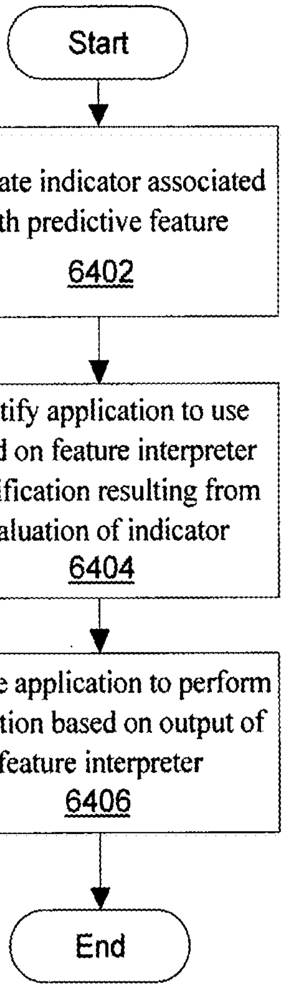

Start
Evaluate indicator associated with predictive feature
6402
Identify application to use based on feature interpreter identification resulting from evaluation of indicator
6404
Invoke application to perform operation based on output of feature interpreter
6406
End

FIG. 64

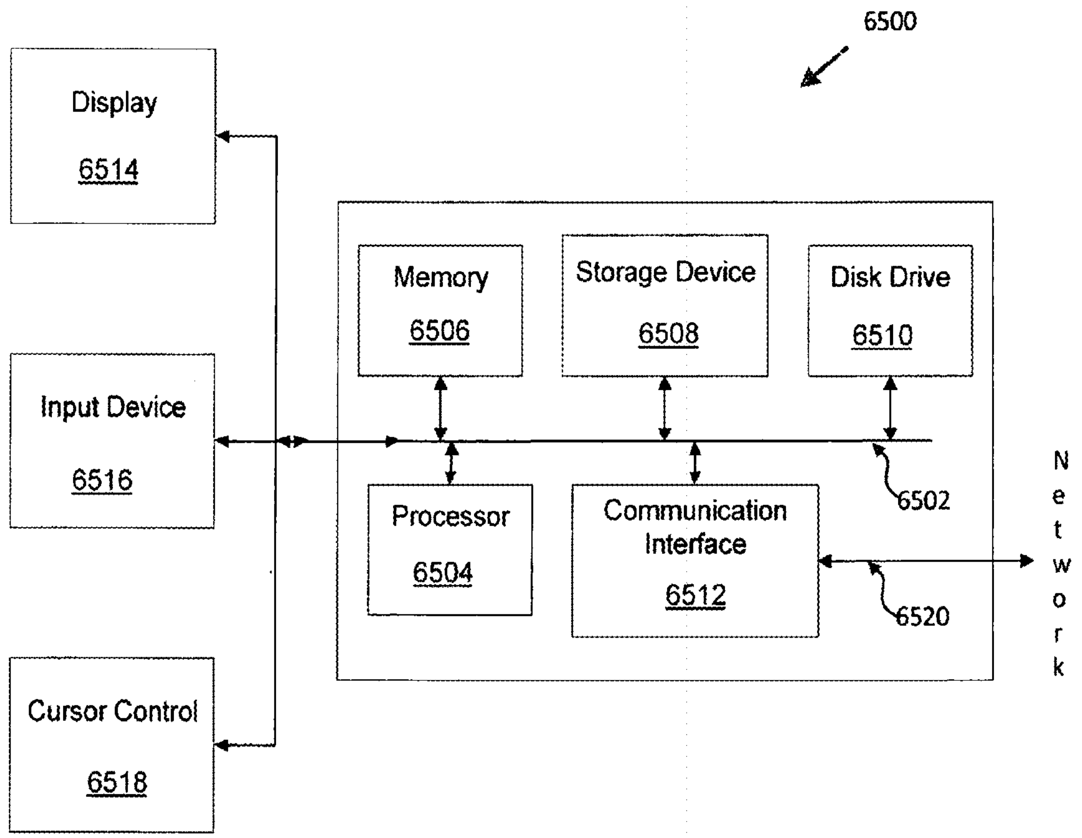

6500
Display
6514
Input Device
6516
Cursor Control
6518
Memory
6506
Storage Device
6508
Disk Drive
6510
Processor
6504
Communication Interface
6512
6502
6520
Network

FIG. 65

DEVICE-BASED ACTIVITY CLASSIFICATION USING PREDICTIVE FEATURE ANALYSIS

FIELD

[0001] Embodiments relate generally to electrical and electronic hardware, computer software, wired and wireless network communications, and computing devices, and, in particular, to using predictive feature information and classifier functions in wearable devices.

BACKGROUND

[0002] Wearable devices have leveraged increased sensor and computing capabilities that can be provided in reduced personal and/or portable form factors, and an increasing number of applications (i.e., computer and Internet software or programs) for different uses, consumers (i.e., users) have given rise to large amounts of personal data that can be analyzed on an individual basis or an aggregated basis (e.g., anonymized groupings of samples describing user activity, state, and condition).

[0003] Presently, development and design of many wearable devices, such as so-called "smart watches," are including glass-based touchscreens to enable users to interact with glass (or transparent plastic) to provide user input or receive visual information. An example of a glass-based touch screen includes CORNING® GORILLA® GLASS, or those formed using OLED or other like technology. Developers of wearable devices using such touchscreens continue to face challenges, not only technically but also in user experience design. For example, relatively large glass-based touchscreens may be perceived to be to "bulky" or "unwieldy" for some consumers, whereas miniaturized glass-based screens may fail to provide sufficient information to a user. Moreover, some conventional touchscreens are susceptible to the environments in which users typically expect reliable operation.

[0004] Further, some conventional smart watches implement short range communication systems (e.g., transceivers and antennas) adjacent glass portions and/or plastic portions of a housing to interference from metal structures. While conventional wearable devices typically are functional, such devices have sub-optimal properties that consumers view less favorably.

[0005] Thus, what is needed is a solution for improving the efficacy and effectiveness of signal processing and data operations in wearable devices without the limitations of conventional devices or techniques.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Various embodiments or examples ("examples") of the invention are disclosed in the following detailed description and the accompanying drawings:

[0007] FIG. **1** is a perspective view of a wearable device, according to some embodiments;

[0008] FIGS. **2**A and **2**B are diagrams depicting an exploded front view and an exploded perspective view, respectively, of a wearable device, according to some embodiments;

[0009] FIGS. **3** and **4** are flow diagrams depicting examples of flows for forming a cradle and forming an anchored cradle, respectively, according to some embodiments;

[0010] FIGS. **5**A and **5**B are diagrams depicting a front view and a perspective view, respectively, of an anchored cradle, according to some embodiments;

[0011] FIGS. **6**A to **6**C are diagrams depicting formation of an intermediate assembly structure formed in molding process, according to some examples;

[0012] FIGS. **7**A to **7**B are diagrams depicting formation of another intermediate assembly structure formed in molding process, according to some examples;

[0013] FIGS. **8**A to **8**C are diagrams depicting exploded views of logic, circuitry, and components disposed within the interior of a cradle anchored to two straps, according to some embodiments;

[0014] FIGS. **9**A and **9**B are diagrams depicting an assembly step in which one or more pod covers of a wearable pod are integrated into a wearable device, according to some embodiments;

[0015] FIG. **10** is an example of a flow to form wearable device, according to some embodiments;

[0016] FIG. **11** is an exploded view of an example of a wearable pod having, for example, an opaque surface, according to some embodiments;

[0017] FIG. **12** is a diagram depicting a touch-sensitive I/O controller, according to some embodiments;

[0018] FIGS. **13**A to **13**D are diagrams depicting various aspects of an interface of a wearable pod, according to some examples;

[0019] FIGS. **14**A to **14**D depict examples of micro-perforations, according to some examples;

[0020] FIGS. **15**A to **15**D are diagrams depicting another example of a display portion for a wearable pod, according to some embodiments;

[0021] FIG. **16** is an example of a flow to form a wearable pod, according to some embodiments;

[0022] FIG. **17** illustrates an exemplary computing platform disposed in a wearable pod configured to facilitate a touch-sensitive interface in an opaque or predominately opaque surface in accordance with various embodiments;

[0023] FIG. **18** is an exploded perspective view of an example of a wearable pod having, for example, a metal surface, according to some embodiments;

[0024] FIG. **19** is an exploded front view of an example of a wearable pod having, for example, a metal surface, according to some embodiments;

[0025] FIGS. **20**A to **20**B are respective exploded perspective and exploded front views of a wearable pod including anchor portions, according to some embodiments;

[0026] FIG. **20**C is a bottom perspective view of a pod cover implementing a sealant during assembly, according to some embodiments;

[0027] FIG. **20**D is a diagram depicting a perspective front view of a wearable pod being assembled as part of a wearable device, according to some embodiments;

[0028] FIGS. **21**A and **21**B are diagrams depicting a cross-section of a portion of an isolation belt, according to some examples;

[0029] FIG. **22** illustrates an example of a flow to form a touch-sensitive pod cover for a wearable pod, according to some examples; and

[0030] FIG. **23** illustrates an example of a flow for a touch-sensitive wearable pod, according to some embodiments

[0031] FIG. **24** is a diagram depicting an antenna configured for implementation in a wearable pod having a metallized interface, according to some embodiments;

[0032] FIGS. **25**A to **25**C depict examples of an antenna oriented relative to an attachment portion of a cradle, according to some embodiments;

[0033] FIG. **26** is an exploded perspective view of an anchor portion, according to some embodiments;

[0034] FIG. **27** is an example of a flow to manufacture a communications antenna in a wearable pod and/or device, according to some embodiments;

[0035] FIG. **28** is a diagram depicting an antenna configured for implementation in a wearable pod having a metallized interface, according to some embodiments;

[0036] FIGS. **29**A and **29**B are perspective views of an attachment portion and an anchor portion, respectively, according to some embodiments;

[0037] FIG. **30** is a diagram depicting another example of a near field communication antenna implemented in a wearable device;

[0038] FIG. **31** is an example of a flow to manufacture a short-range communications antenna in a wearable pod and/or device, according to some embodiments.

[0039] FIG. **32** illustrates various examples of a wire bus and components coupled with the wire bus, according to some embodiments;+

[0040] FIG. **33** illustrates top, side, and bottom plan views of a wire bus, according to some embodiments;

[0041] FIG. **34** illustrates one example of a wire bus including a wire bridge, according to some embodiments;

[0042] FIG. **35** illustrates one example of a wire bus including a substrate having an antenna coupled with a near field communication chip, according to some embodiments;

[0043] FIG. **36** illustrates examples of relative spacing and dimensions of electrodes included in a wire bus, according to some embodiments;

[0044] FIG. **37** illustrates examples of wire routing and connection with pads included in a wire bus, according to some embodiments;

[0045] FIG. **38** illustrates a side view of one example of an electrode, a skirt, and a pad that may be included in a wire bus, according to some embodiments;

[0046] FIG. **39** illustrates profile views of other examples of an electrode, a skirt, and a pad that may be included in a wire bus, according to some embodiments;

[0047] FIG. **40** illustrates various views of yet other examples of an electrode, a skirt, and a pad that may be included in a wire bus, according to some embodiments;

[0048] FIG. **41** illustrates one example of an assembly order of a strap band that includes a wire bus, an inner strap and an outer strap, according to some embodiments;

[0049] FIG. **42** illustrates one example of a wire bus being coupled with an inner strap, according to some embodiments;

[0050] FIG. **43** illustrates one example of an outer strap being formed on wire bus coupled with an inner strap, according to some embodiments;

[0051] FIG. **44** illustrates top, side and bottom views of one example of a strap band that includes an encapsulated wire bus and sealed electrodes, according to some embodiments;

[0052] FIG. **45** illustrates examples of fastening hardware that may be coupled with a strap band, according to some embodiments;

[0053] FIG. **46** illustrates one example of a flow diagram for a method of fabricating a wire bus, according to some embodiments;

[0054] FIG. **47** illustrates one example of a flow diagram for a method of fabricating a strap band that includes a wire bus, according to some embodiments;

[0055] FIG. **48** illustrates various views of a strap band, according to some embodiments;

[0056] FIG. **49** illustrates examples of a strap band positioned on a body portion, according to some embodiments;

[0057] FIG. **50** illustrates a side view of a strap band coupled with a device, according to some embodiments;

[0058] FIG. **51** illustrates a top plan view and a side view of a strap band, according to some embodiments;

[0059] FIG. **52** illustrates profile views of a system including a strap band, according to some embodiments;

[0060] FIG. **53** illustrates views of a strap band and relative dimensions and positions of components of the strap band, according to some embodiments;

[0061] FIG. **54** illustrates a side view and top plan view of a wire bus, according to some embodiments;

[0062] FIG. **55** illustrates various examples of electrodes, according to some embodiments;

[0063] FIG. **56** illustrates examples of circuitry coupled with electrodes of a strap band, according to some embodiments;

[0064] FIG. **57** illustrates profile views of systems that include a strap band, according to some embodiments;

[0065] FIG. **58** illustrates exemplary data types for device-based activity classification using predictive feature analysis;

[0066] FIG. **59** illustrates an exemplary computing network topology for device-based activity classification using predictive feature analysis;

[0067] FIG. **60** illustrates an exemplary application architecture for device-based activity classification using predictive feature analysis;

[0068] FIG. **61** illustrates an exemplary process for device-based activity classification using predictive feature analysis;

[0069] FIG. **62** illustrates another exemplary process for device-based activity classification using predictive feature analysis;

[0070] FIG. **63** illustrates a further exemplary process for device-based activity classification using predictive feature analysis;

[0071] FIG. **64** illustrates yet another exemplary process for device-based activity classification using predictive feature analysis; and

[0072] FIG. **65** illustrates an exemplary computer system suitable for device-based activity classification using predictive feature analysis.

DETAILED DESCRIPTION

[0073] Various embodiments or examples may be implemented in numerous ways, including as a system, a process, an apparatus, a user interface, or a series of program instructions on a computer readable medium such as a computer readable storage medium or a computer network where the program instructions are sent over optical, electronic, or wireless communication links. In general, operations of disclosed processes may be performed in an arbitrary order, unless otherwise provided in the claims.

[0074] A detailed description of one or more examples is provided below along with accompanying figures. The detailed description is provided in connection with such examples, but is not limited to any particular example. The scope is limited only by the claims and numerous alternatives, modifications, and equivalents are encompassed. Numerous specific details are set forth in the following description in order to provide a thorough understanding. These details are provided for the purpose of example and the described techniques may be practiced according to the claims without some or all of these specific details. For clarity, technical material that is known in the technical fields related to the examples has not been described in detail to avoid unnecessarily obscuring the description.

[0075] FIG. **1** is a perspective view of a wearable device, according to some embodiments. Diagram **100** illustrates a wearable device including a wearable pod **101** including logic, whether in hardware, software or combination thereof, a strap band **120** and band **122**. Among other things, strap band **120** and band **122** are composed of material designed to provide comfort while being worn by a user. In the example shown, the logic is disposed between a top pod cover **102** and a bottom pod cover **106**. Top pod cover **102** may be formed in a substrate of an opaque material, such as metal. According to some embodiments, one or more portions of pod cover **102** are configured to accept user input by way of detected capacitance values (or changes in capacitance values), thereby effectuating capacitive touch sensing (e.g., "cap touch") as a means receiving commands or inputs from a user.

[0076] A display portion **104** is disposed at the predominately opaque portion of talk pod cover **102**, and is configured to emit light of various shapes (e.g., any type of symbol) and colors to convey information to a user. In one example, display portion **104**, or portions thereof, is selectably opaque in that some portions selectable do not emit light while and other arrangements of light to transmit through the surface. As such, display portion **104** may be configured to provide or output information to a user, the information describing aspects of the activity in which users engaged, progress toward a goal of completing the activity, physiological information, such as heart rate, among other things. Further, wearable pod **101** includes any number of sensors and related circuitry, such as bioimpedance circuitry and sensors, galvanic skin response circuitry and sensors, temperature-related circuitry and sensors, and the like.

[0077] Strap band **120** includes any number of groups of electrodes. As shown, a group **130** of electrodes is disposed at an approximate distance **152** from wearable pod **101**, whereby a first electrode is separated by an approximate distance **154** from the second electrode in group **130**. Group **132** of electrodes is shown to be disposed at an approximate distance **156** from group **130**, with a first electrode in group **132** being separated at an approximate distance **158** from a second electrode. The approximate distances are configured to dispose one of either group **130** of electrodes or group **132** of electrodes adjacent to a first blood vessel (e.g., an ulnar artery) and to dispose the other group of either group **130** of electrodes or group **132** of electrodes adjacent to a second blood vessel (e.g., a radial artery). Logic in a wearable pod **101** can be coupled to electrodes in groups **130** and **132** to employ bioimpedance sensing for extracting heart-related information, as well as other physiological information, including but not limited to respiration rates. According to some examples, distances **154** and **158** may be about 4.0 mm+/−50%, and distance **156** may range from about 31.5 mm to about 36.0 mm+/−30%, depending on technologies used to pick-up and monitor bioimpedance signals. Distance **152** may be about 32.0 mm+/−30%.

[0078] According to some embodiments, one or more electrodes of groups **130** and **132** of electrodes may be configured for multi-mode use. For example, an electrode may be implemented to effect bioimpedance sensing in one mode, and electrode may be used to implement galvanic skin conductance sensing in another mode. In some instances, electrode from group **130** may operate cooperatively with an electrode in group **132**. Note that while strap **120** may be described as a "strap band" and strap **122** may be described as a "band," the terms strap and band may be used, at least in some examples, interchangeably.

[0079] In the example shown, the wearable device includes a latch **142**, a loop **144**, and a latched buckle **140** are configured to engage so as to secure the wearable device around an appendage, such as a wrist. For example, a user may place wearable pod **101** on a top of a wrist, and insert latch **142** through loop **144** adjacent the bottom of the user's wrist, whereby latch **142** engages latched buckle **140**. Note while the wearable device is described as being configured to encircle a wrist, and various other embodiments facilitate attachment to any other appendage of the user, including an ankle, neck, ear, etc.

[0080] FIGS. **2**A and **2**B are diagrams depicting an exploded front view and an exploded perspective view, respectively, of a wearable device, according to some embodiments. Diagram **200** of FIG. **2**A illustrates a wearable device in an exploded front view, the wearable device including a top pod cover **202** and a bottom pod cover **206** that are configured to enclose an interior region within a cradle **207** having anchor portions **209** that securely couples strap band **220** and band **222** to cradle **207**. Strap band **220** is shown to include an inner portion **220*a*** upon which an electrode bus **231** is disposed thereupon. Electrode bus **231** includes electrodes **233** and conductors coupled between electrodes **233** and circuitry within cradle **207**. In some embodiments, a near field communications ("NFC") system **212** can be disposed in contact on electrode bus **231**, which may support system **212**. Near field communication system **212** may include an antenna to receive/transmit via NFC protocols, and an active near field communication semiconductor device to receive/transmit data. An outer portion **220*b*** is then formed to encapsulate electrode bus **231** and NFC system **212** in portions **220*b*** and **220*a*** to form strap band **220**, which is anchored at anchor portion **209** to cradle **207**. Band **222** is shown to include an inner portion **222*a*** and an outer portion **222*b*** that encapsulates a short-range antenna **214**, such as a Bluetooth® LE antenna, and attaches to cradle **207** at anchor point **209**. FIG. 2B is a diagram **250** that illustrates an exploded perspective view of wearable device described in FIG. **2**A.

[0081] FIGS. **3** and **4** are flow diagrams depicting examples of flows for forming a cradle and forming an anchored cradle, respectively, according to some embodiments. FIG. **3** is a flow **300** to form a cradle where, at **302**, a metal-based cradle is molded. According to various examples, a metal injection molding ("MIM") process may be used to form a cradle that is configured to rigidly house circuitry and to secure a strap band and a band to each other. According to some examples, the cradle can be formed using semi-solid metal ("SSM") casting techniques. A cradle may also be formed thixomolding processes to form, for example, a magnesium-based cradle ("thixo magnesium cradle") having sufficient strength and being relatively light-weight, according to some embodiments. At **304**, a surface of the cradle is prepared by removing unnecessary material and cleaning the cradle, as an example. At **306**, a layer is deposited on the surface of the cradle, such as during electro-deposition. In some cases, the layer is protective (e.g., corrosion resistant) and nonconductive. At **308** the metallic interior is accessed to form electrical contact so that, for example, the cradle can be electrically coupled to ground, which is a common ground for some circuitry and, in some cases, the bottom pod cover.

[0082] FIG. **4** is a flow **400** to form an anchored cradle, according to some examples. At **402** a metal-based cradle is received, an example of which is formed by flow **300** of FIG. **3**. Further to flow **400** of FIG. **4**, some components implemented in a cradle may be set for further processing (e.g., molding). For example, pins, such as pogo pins, can be set prior to molding to prepare formation of a communication port and/or a charging port, which may be implemented as a USB port. As another example, a temperature sensor can be set prior to molding, the temperature sensor configured to extend through the bottom pod cover. At **406**, anchor portions of the cradle are formed on the attachment portions. In some embodiments, a first anchor portion of the cradle is formed on a first attachment portion at **408**, and a second anchor portion is formed on a second attachment portion of the cradle at **410**. Further, an isolation belt may be formed at **412** along sides of the cradle (e.g., the longitudinal sides), the isolation belt being configured to isolate metallic portions of a wearable device from electrically contacting each other. For example, a top pod cover may be electrically isolated from a bottom pod cover or other portions of the wearable device to facilitate capacitive touch sensing. According to some embodiments, the above-described blocks **408**, **410**, and **412** can be performed in parallel. In one instance, and anchored cradle can be formed in a polycarbonate molding process to form anchor portions and an isolation belt, as well as a layer below the cradle to secure the pins and temperature sensor in place. In some embodiments, one of blocks **408** and **410** can include encapsulating an antenna in an anchor portion, as described herein.

[0083] FIGS. **5**A and **5**B are diagrams depicting a front view and a perspective view, respectively, of an anchored cradle, according to some embodiments. FIG. **5**A is a diagram **500** depicting a front view of an anchored cradle **507** having anchor portions **509***a* and **509***b* formed at the distal ends of cradle **507**. Also shown, and isolation belt **511** formed along a longitudinal side of cradle **507**. Anchor portion **509***a* may include, for example, a Bluetooth® low energy ("LE") antenna formed therein, and anchor portion **509** be configured to receive an electrode bus and an NFC antenna (and NFC chip). FIG. **5**B is a diagram **550** depicting a perspective view of an anchored cradle **507** of FIG. **5**A. Further, diagram **550** illustrates pins **580** and a temperature sensor **582** molded and integrated into anchored cradle **507**.

[0084] FIGS. **6**A to **6**C are diagrams depicting formation of an intermediate assembly structure formed in molding process, according to some examples. Consider that an anchored cradle is placed in a mold for forming straps (e.g., strap bands and bands) for a wearable device. Diagram **600** of FIG. **6**A illustrates a front view of an anchored cradle **607** integrated with an inner strap portion **620***a* and an inner strap portion **622***a*. Inner strap portion **620***a* is secured to an anchor portion at an interface **680**, whereby the interface materials of the anchor portion form relatively secure physical and chemical bonds. Similarly, inner strap portion **622***a* is secured to the other anchor portion and at an interface **682**.

[0085] According to some embodiments, the interface materials that form the anchor portions can include, but are not limited to, polycarbonate materials, or other like materials. Polycarbonate may provide an interface to couple metal cradle **607** to an elastomer material used to form inner portions **620***a* and **622***a*. Thus, an interface materials, such as polycarbonate, bridges the difficulties of bonding metal and elastomers together in some cases. Anchor portions can be formed using polycarbonate molding techniques. According to some embodiments, an elastomer material may be a thermoplastic elastomer ("TPE"). In one embodiment, elastomer includes a thermoplastic polyurethane ("TPU") material. In some examples, the elastomer has a hardness in a range of 58 to 72 Shore A. In one case, the lesser has a hardness in a range of 60 to 70 Shore A. An example of an elastomer is a GLS Thermoplasic Elastomer Versaflex™ CE Series CE **3620** by PolyOne of OH, USA.

[0086] FIG. **6**B is a diagram depicting a perspective view of a strap band, going to some examples. Diagram **630** illustrates a cavity **690** and apertures **634** in inner portion **620***a* formed by a mold. Apertures **634** can be for receiving electrodes. FIG. **6**C is a diagram **660** depicting a perspective view of an assembly of an electrode bus with an inner portion **620***a*. As shown, electrode bus **631** includes electrodes **633**, which are inserted through corresponding apertures **634** prior to a molding step (e.g., a second shot). According to some embodiments, an elastomer material, such as TPE or TPU, may be used to form a flexible substrate in which Kevlar™-based conductors are encapsulated. In one example, the flexible substrate is formed of TPE and has a hardness of approximately 85 to 95 Shore A (e.g., about 90 Shore A).

[0087] FIGS. **7**A to **7**B are diagrams depicting formation of another intermediate assembly structure formed in molding process, according to some examples. Diagram **700** of FIG. **7**A illustrates formation of outer portion **720***a* and outer portion **722***b* in a molding step. In particular, an anchored cradle **707** includes anchored portions **709***a* and **709***b* integrated and/or physically coupled to inner portion **722***a* and inner portion **720***a*, respectively, subsequent to the molding process described in FIGS. **6**A to **6**B. Further to FIG. **7**A, anchored cradle and inner portions **720***a* and **722***a* can be inserted into a mold and material can be injected into the mold to form outer portion **720***b* over anchor portion **709***b* and inner portion **720***a*, and to form outer portion **722***b* over anchor portion **709***a* and inner portion **722***a*. In some embodiments, inner portions **720***a* and **722***a* are formed with the same materials as outer portion **720***b* and **722***b*. Further, inner surface areas **790** and **792** may be integrated and/or coupled to respective surfaces of anchor portion **709***b* and **709***a* to form a secure mechanical coupling between metal cradle **707** and straps **720** and **722**. Diagram **750** of FIG. **7**B is a perspective view showing formation of outer portions **720***a* and **722***b*, whereby surface area **792** of outer portion **722***b* forms a secure physical and/or chemical bond to an exposed surface of anchor portion **709***a*.

[0088] A manufacturing process, according to some embodiments, includes placing an anchored cradle of FIG. **6**A on a fixture for alignment in a mold for receiving a "first shot" of an elastomer to form the inner portions, and the anchored cradle is then transition to receive a "second shot" of elastomer to form the outer portions integrally with the inner portions. Therefore, according to some embodiments, an anchored cradle can be formed in one or two polycarbonate molding steps, with a subsequent formation of a band (including one or more straps) in one or two elastomer molding steps.

[0089] FIGS. **8**A to **8**C are diagrams depicting exploded views of logic, circuitry, and components disposed within the interior of a cradle anchored to two straps, according to some embodiments. Diagram **800** is an exploded front view depicting a cradle **807** integrated with a strap **820** (or strap band) and a strap **822** (or band). A motor **844**, as a source of vibratory energy, and a battery **846** are assembled in the interior of cradle **807**. Next, one or more logic modules and/or circuits **842** are disposed over motor **844** and battery **846**. Light are positioned above logic modules and/or circuits **842** to emit light through a top pod cover (not shown).

[0090] FIG. **8**B is a diagram **830** depicting an exploded front perspective view, according some examples. As shown, a vibratory motor **844** and battery **846** are configured to be mounted within the interior of cradle **807**. Logic modules and/or circuits **842** are mounted over motor **844** and battery **846** (the mounting hardware is omitted for purposes of clarity). Light sources **841** are oriented above the logic modules and/or circuits **842**.

[0091] FIG. **8**C is an exploded perspective view of the components of FIG. **8**B. Logic modules and/or circuits **842** can include a touch-sensitive input/output ("I/O") controller to detect contact with portions of a pod cover (not shown), a display controller to facilitate emission of light via an opaque or predominately opaque substrate to communicate information to a user, an activity determinator configured to determine an activity based on, for example, sensor data from one or more sensors (e.g., disposed in an interior region between pod covers, or disposed externally thereto). Further, logic modules and/or circuits **842** may include a bioimpedance ("BI") circuit to use bioimpedance signals to determine a physiological signal (e.g., heart rate), and a galvanic skin response ("GSR") circuit to use signals to determine skin conductance. Logic modules and/or circuits **842** may include a physiological ("PHY") signal determinator configured to determine physiological characteristics, such as heart rate, respiration rate, among others, and a temperature circuit configured to receive temperature sensor data to facilitate determination of heat flux or temperature. A physiological ("PHY") condition determinator implemented in logic modules and/or circuits **842** may be configured to implement heat flux or temperature, or other sensor data, to derive values representative of a condition (e.g., a biological condition, such as caloric energy expended or other calorimetry-related determinations). Other structures, circuits, and/or functions within the scope of the present disclosure.

[0092] FIGS. **9**A and **9**B are diagrams depicting an assembly step in which one or more pod covers of a wearable pod are integrated into a wearable device, according to some embodiments. Diagram **900** illustrates a top pod cover **902** oriented for assembly to enclose an interior region **990** of cradle **907** that includes logic, components, circuitry, etc. described, for example, in FIGS. **8**A to **8**C. At this stage of assembly, straps **920** and **922** are anchored to cradle **907**, which includes a temperature sensor **914** configured to protrude external to bottom pod cover **906**. Edges **913** of pod cover **902** may include adhesive/epoxy configured to form a fluid-resistant seal as a barrier to prevent fluids (e.g., gas, liquid, moisture, etc.) from entering interior region **990**. An isolation belt **915**, as shown, is configured to isolate top cover **902** and bottom cover **906**. Similarly, edges of pod cover **906** (and other portions) may also include epoxy to couple to form a wearable pod.

[0093] FIG. **9**B is diagram **950** depicting a bottom perspective view of elements shown in FIG. **9**A. Diagram **950** illustrates top cover **902** having epoxy **919** or sealant in the interior of top cover **902** and disposed at or near edges **913**. A wired communications port includes a number of pins **941** (e.g., a USB port) disposed adjacent to magnets **916** mounted in cavities within the bottom **909** of cradle **907**. Magnets **916** are configured to form a magnetic attachment to a corresponding connector that can provide power, ground, and data signals via aperture **942** of bottom pod cover **906**. Also shown in FIG. **9**B is a temperature sensor **914** that extends through temperature **944** to contact skin of a user.

[0094] FIG. **10** is an example of a flow to form wearable device, according to some embodiments. Flow **1000** includes receiving a fix so magnesium cradle having anchor points at **1002**, and forming an antenna in a first anchor portion at **1004**. An example of an antenna being formed in a portion is described in, for instance, FIG. **26**. At **1006**, and neuter strap portion is formed attached to the anchor portions. At **1008**, an electrode bus can be disposed within the inner portion of the strap band, and an NFC antenna can be disposed over the electrode bus at **1010**. At **1012**, an outer strap portion is integrated with the inner strap portion and is further integrated with, or attached to, the anchor portions. At **1014** components including logic, sensors, circuitry, etc. are disposed in a cradle, and pod covers are attached at **1016**. The pod covers are sealed at **1018** to form a fluid-resistant barrier for a wearable pod or device.

[0095] FIG. **11** is an exploded view of an example of a wearable pod having, for example, an opaque surface, according to some embodiments. Diagram **1100** illustrates a pod cover **1102** and a pod cover **1106** configured to house circuitry **1142** including one or more substrates **1140** (e.g., printed circuit board, such as a flex circuit board) and any number of associated processor modules, semiconductor devices (e.g., sensors, radio frequency or "RF" transceivers, etc.), electronic components (e.g., capacitors, resistors, sensors, etc.), and memory modules. Diagram **1100** illustrates the structure and/or functionality of circuitry **1142** as logic **1111**. According to some embodiments, pod cover **1102** is shown to include touch-sensitive portions **1103** and a display portion **1104** disposed in a top surface **1102*a*** that predominantly includes an opaque material, such as a metal, a non-transparent plastic, etc. Note that touch-sensitive portions of pod cover **1102** need not be limited to portions **1103**. For example in some examples, display portion **1104** may also be configured to function as touch-sensitive portion **1103**. As another example, one or more sides and/or surfaces of pod cover **1102** can be implemented as a touch-sensitive portion. An electrical isolator **1110** is shown in diagram **1100**, whereby electrical isolator **1110** is configured to electrically isolate touch-sensitive portions **1103** from logic **1111**, pod cover **1106**, and other components or elements of a wearable pod. In some examples, isolator **1110** can electrically isolate pod cover **1102** and its constituent materials from logic **1111**, pod cover **1106**, and other components or elements of a wearable pod.

[0096] According to some embodiments, pod cover **1102**, logic **1111**, and pod cover **1106** can be assembled to form a wearable pod that can be integrated into a band **1150** of one or more attachment members (e.g., one or more straps, etc.) to form a wearable device. A wearable pod and/or wearable device may be implemented as data-mining and/or analytic device that may be worn as a strap or band around or attached to an arm, leg, ear, ankle, or other bodily appendage or feature. In other examples, a wearable pod and/or wearable device may be carried, or attached directly or indirectly to other items, organic or inorganic, animate, or static. Note, too, that wearable pod enough be integrated into band **1150** and can be shaped other than as shown in FIG. **11** for example, a wearable pod circular or disk-like in shape with display portion **1104** disposed on one of the circular surfaces.

[0097] According some embodiments, logic **1111** includes a number of components formed in either hardware or software, or a combination thereof, to provide structure and/or functionality for elemental blocks shown. In particular, logic **1111** includes a touch-sensitive input/output ("I/O") controller **1112** to detect contact with portions of pod cover **1102**, a display controller **1114** to facilitate emission of light, an activity determinator **1116** configured to determine an activity based on, for example, sensor data from one or more sensors **1130** (e.g., disposed in an interior region between pod covers **1102** and **1106**, or disposed externally). A bioimpedance ("BI") circuit **1117** may facilitate the use of bioimpedance signals to determine a physiological signal (e.g., heart rate), and a galvanic skin response ("GSR") circuit **1119** may facilitate the use of signals representing skin conductance. A physiological ("PHY") signal determinator **1118** may be configured to determine physiological characteristic, such as heart rate, among others, and a temperature circuit **1120** may be configured to receive temperature sensor data to facilitate determination of heat flux or temperature. A physiological ("PHY") condition determinator **1121** may be configured to implement heat flux or temperature, or other sensor data, to derive values representative of a condition (e.g., a biological condition, such as caloric energy expended or other calorimetry-related determinations). Logic **1111** can include a variety of other sensors, some which are described herein, and others that can be adapted for use in the structures described herein.

[0098] Touch-sensitive portions **1103** are configured to detect contact by an item or entity as an input to logic **1111**. According to some embodiments, touch-sensitive portions **1103** are coupled to touch-sensitive input/output ("I/O") controller **1112**, which is configured to detect a capacitance value at one or more touch-sensitive portions **1103**. Further, touch-sensitive I/O controller **1112** can be configured to detect a change from one value of capacitance relative to a touch-sensitive portion **1103** to another value of capacitance. If the value of capacitance is within a range of capacitive values that define a contact as a valid "touch," touch-sensitive I/O controller **1112** can generate a signal including data describing touch-related characteristics of the contact. Examples of a range of capacitance values include approximate values of 0.75 pF to 2.4 pF, or other equivalent values. Further, examples of items or entities for which a "touch" is detected can include tissue (e.g., a finger), a capacitive stylus (or the like), etc. Touch-related characteristics, for example, can include a number of touches per unit time, a time interval during which a touch is detected, a pattern of different durations per unit time (e.g., such as Morse code or other simplified schemes).

[0099] While touch-related characteristics may be a function of time, various implementations need not so limited. For example, consider an implementation of pod cover **1102** with multiple touch-sensitive portions **1103**. Touch-related characteristics in this case may also include an order of touching touch-sensitive portions **1103** to simulate, for instance, a swiping gesture from left-to-right or right-to-left. Other types-related characteristics are possible.

[0100] Display controller **1114** is configured to receive signals indicative of, for example, a mode of operation of a wearable pod, a value associated with a physiological signal (e.g., a heart rate), a value associated with an activity (e.g., a number of steps, a percentage of completion for a goal, etc.), and other similar information. Further, display controller **1114** is configured to cause selective emission of light via display portion **1104**, the emission of light having certain characteristics, such as symbol shapes and colors, to convey specific information.

[0101] Bioimpedance circuit **1117** includes logic in hardware and/or software to apply and receive electrical signals include bioimpedance-related information, which physiological signal determinator **1118** can receive and determine one or more physiological characteristics. For example, physiological signal determinator **1118** can extract a heart rate and/or a respiration rate from one or more bioimpedance signals. One or more examples implementing bioimpedance signals to derive physiological signal values are described in U.S. patent application Ser. No. 13/831,260 filed on Mar. 14, 2013, U.S. patent application Ser. No. 13/802,305 filed on Mar. 13, 2013, and U.S. patent application Ser. No. 13/802,319 filed on Mar. 13, 2013, all of which are incorporated by reference herein. A galvanic skin response circuit **1119** includes logic in hardware and/or software to apply and receive electrical signals that includes skin conductance-related information. According to some embodiments, logic **1111** is configured to use electrodes in a first mode to determine bioimpedance signals, and to use at least one for the electrodes in a second mode to determine galvanic skin conductance. Therefore, one or more electrodes may have multiple functions or purposes. Temperature circuit **1120** includes logic in hardware and/or software to apply and receive electrical signals that includes thermal energy-related information, which, for example, physiological condition determinator **1121** can use to derive values representative of a condition of a user, such as a caloric burn rate, among other things.

[0102] Examples of other sensors **1130** include accelerometer(s), an altimeter/barometer, a light/infrared ("IR") sensor, an audio sensor (e.g., microphone, transducer, or others), a pedometer, a velocimeter, a GPS receiver, a location-based service sensor (e.g., sensor for determining location within a cellular or micro-cellular network, which may or may not use GPS or other satellite constellations for fixing a position), a motion detection sensor, an environmental sensor, a chemical sensor, an electrical sensor, a mechanical sensor, a light sensor, and others.

[0103] FIG. **12** is a diagram depicting a touch-sensitive I/O controller, according to some embodiments. Diagram **1200** illustrates a touch-sensitive I/O controller **1220** including a touch-sensitive detector **1221**, a signal decoder **1222**, an action control signal generator **1224** and a context determinator **1226**. According to some embodiments, touch-sensitive detector **1221** is coupled to a surface of a pod cover **1202** and is configured to receive one or more signals via a conductive path **1212**, the one or more signals indicating a value of detected capacitance. A detected capacitance value can be determined responsive to contact by tissue (e.g., finger **1201**) with a portion of pod cover **1202**. Touch-sensitive detector **1221** can also be coupled to pod cover **1202** to detect a capacitive value based on contact in a display portion **1203**. In some examples, a surface of a pod cover **1202** can include to a surface portion of a substrate, such as a metal substrate, regardless of whether pod cover **1202** is covered in a coating (e.g., anodized or the like).

[0104] Signal decoder **1222** is configured to receive one or more signals to decode or otherwise determine a command based on one or more detected capacitance values, according to some examples. As an example, signal decoder **1222** may decode an enable command to enable decoding of one or more detected capacitance signals, thereby enabling a wearable pod to acquire user input via touch. Or, signal decoder **1222** may decode a disable command to disable decoding of one or more signals detected capacitive signals, thereby preventing inadvertent contact (e.g., during sleep, etc.) from being interpreted as being a valid touch. Further, signal decoder **1222** is further configured to decode a number of detected capacitive values to identify patterns of the detected capacitance values, whereby signal decoder **1222** can decode a pattern of detected capacitance values as a specific command. Signal decoder **1222** can determine a pattern of detected capacitance values based on, for example, a quantity of detected capacitance values per unit time, a time interval during which a detected capacitance value is detected, a pattern of varied durations per unit time and/or different detected capacitance values, etc. Thus, signal decoder **1222** can decode detected capacitance values to determine a command as a function of time.

[0105] Further to the above-described examples, signal decoder **1222** can identify a first pattern of detected capacitance values associated with a first command to, for example, disable implementation of a subset of subsequent detected capacitance values, thereby disabling implementation by a wearable pod of subsequent detected capacitance values (e.g., turning "off" a 'cap touch' input feature to exclude inadvertent touches). Signal decoder **1222** can identify a second pattern of detected capacitance values associated with a second command (e.g., a mode command) to, for example, transition the wearable pod to a mode of operation as a function of a capacitance pattern. Also, signal decoder **1222** can transmit a signal indicating a mode command to action control signal generator **1224**, which can directly or indirectly effectuate a change in mode of operation. Or, in some other examples, a mode controller of FIG. **15**B can be implemented to cause a change in mode. In some embodiments, action control signal generator **1224** can cause, directly or indirectly, a particular pattern of the light **1214** to be emitted via display **1203** based on the decoded command.

[0106] Context detector **1226**, which is optional, may be configured to receive sensor data **1210** and/or data indicating a state of activity (e.g., whether an activity is running, sleeping, or the like). Based on sensor data **1210** and/or activity state data, context detector **1226** can detect context of the wearable pod (e.g., a type of activity in which as user is engaged). Context detector **1226** can transmit context data to signal decoder **1222**, which, in turn, can be configured to implement a first set of commands based on one pattern of capacitance values based on a first context (e.g., a person is sleeping), and is further configured to implement a second set of commands based on the identical pattern of detected capacitance value based on a second context (e.g., a person is moving). Thus, context detector **1226** can enable a wearable pod to generate different commands using the same pattern of detected capacitance values based on different contexts.

[0107] FIGS. **13**A to **13**D are diagrams depicting various aspects of an interface of a wearable pod, according to some examples. FIG. **13**A is a diagram **1300** depicting a perspective view of a pod cover **1302** including a display portion **1304** of an interface. As an interface of a wearable pod, an interface can include a portion of pod cover **1302** that is configured to either accept user inputs or provide an output to a user, or both. Therefore, display portion **1304** can be configured to both output information to a user and accept user input. According to some embodiments, pod cover **1302** includes a conductive material, such as metal, to facilitate touch-sensitive interfacing with a wearable pod. As shown, pod cover **1302** has an elongated shape and includes at least a top surface into side surfaces, all of which are configured to form an interior region into which interior components, such as circuitry, can be disposed. Note that various other embodiments, pod cover **1302** can be formed of any shape including, for example, a circular-shaped cover. In some cases, pod cover **1302** can include a surface treatment (e.g., stamped pattern) including cosmetically-pleasing features.

[0108] FIG. **13**B is a diagram **1330** depicting a top view of pod cover **1302** including display portion **1304**. According to some examples, display portion **1304** includes pixelated symbols formed in an opaque material, such as a metal, a non-transparent plastic, etc. Further, the pixelated symbols may be formed in material to form a predominately opaque material. Other portions of pod cover **1302** can also be formed in an opaque material.

[0109] FIG. **13**C is a diagram **1360** depicting an enhanced view of display portion **1304**. As shown, a display portion can include pixelated symbol **1362** representing a crescent moon (e.g., related to sleep activities and characteristics), pixelated symbol **1364** representing a clock (e.g., related to reminders or information regarding various things, such as sleep activities and workout activities), and pixelated symbol **1366** representing a running person (e.g., related to movement-related activities and characteristics). Further to FIG. **13**C, pixelated symbols **1362**, **1364**, and **1366** are shown to include arrangements of symbol elements **1363**. According to some embodiments, a symbol element **1363** may include a micro-perforation. Thus, pixelated symbols **1362**, **1364**, and **1366** may include arrangements of micro-perforations and/or emissions of light therefrom. The micro-perforations facilitate a display implementing an opaque material or predominately opaque material, whereby a micro-perforation is difficult to see, or is otherwise not visible to most individuals without magnifying equipment.

[0110] FIG. **13**D is a diagram **1390** that illustrates an example of a density of micro-perforations per unit area in a predominately opaque material. As shown, a unit surface area **1394** of an opaque material, such as anodized aluminum, is shown to include four (4) quarters **1392** of micro-perforation. Area **1394** can be defined by the product of the side lengths, L, whereas the area **1392** is one-fourth (¼) an area defined by a circular (in this example) having a radius, R. In one example, micro-perforations **1391** have diameters of 30 microns (e.g., 0.03 mm) and L is 100 microns (e.g., 0.10 mm). Thus, micro-perforations **1391** in this example may account for about 7% of unit area **1394**, and the opaque material is approximately 93% of unit area **1394**. With these dimensions, the density of micro-perforations is approximately 100 micro-perforations per square millimeter. Other micro-perforation sizes and densities may be implemented.

[0111] According to one example, a predominately opaque material as a portion of a surface can be composed of about 93% opaque material and 7% transparent material per unit area. In another example, a predominately opaque material as a portion of a surface can be composed of about 85% to 98% opaque material per unit area (e.g., approximately 16 to 44 microns), whereas in other examples a predominately opaque material can be composed of about 67% to 99% unit area. In at least one example, a predominately opaque material can be composed of 51% opaque material per unit area. Accordingly, the diameters of micro-perforations **1391** can vary so long as the area consumed by micro-perforations **1391** do not, for example, consume more than 49% of an opaque material. Note while micro-perforations **1391** are depicted as being circular, the size and shape of micro-perforations **1391** are not so limited.

[0112] FIGS. **14**A to **14**D depict examples of micro-perforations, according to some examples. FIG. **14**A is a diagram **1400** depicting a cross-section of a pod cover **1402** and micro-perforations **1405***a* extending from an outer surface **1411***a*, **1411***b* to an inner surface **1413**, which is adjacent to light sources (not shown) that transmit light for emission via micro-perforations **1405***a*. FIG. **14**B illustrates an example of a tapered micro-perforation, according to some examples. Tapered micro-perforation **1405***b* is configured to include an opening having a diameter or size **1419***a* in inner surface **1413**, whereas another opening may have a diameter or size **1417***a* in outer surface **1411***a*. As shown, diameter **1417***a* is less than diameter **1419***a*. According to some embodiments, the ratio of diameter **1419***a* to diameter **1417***a* can vary based on the depth **1433** of micro-perforation **1405***b*. In one example, the ratio can be larger as the depth **1433** increases. In another example, the differences in diameters **1417***a* and **1419***b* can vary by +/−10 microns. A larger-size diameter **1419***a* can increase collection of light or scattered light rays from a light source such as one or more LEDs.

[0113] FIG. **14**C illustrates an example of another tapered micro-perforation **1405***c*. In this example, micro-perforation **1405***c* has an opening in inner surface **1413** having a diameter **1436** and another opening an outer surface **1411***b* having a diameter **1435**. In one example, size of diameter **1436** may be slightly larger than diameter **1435** as a function of depth **1434**, which is less than depth **1433** of FIG. **14**B. An example of one of depths **1433** and **1434** is approximately 300 microns, and can vary by 50% (or greater in some cases). Or, in some examples diameters **1435** and **1436** are equivalent. The shading of micro-perforation **1405***c* may depict optically-transparent material disposed therein. In some examples, the optically-transparent material may be an optical adhesive, epoxy resin, or sealant having relatively high refractive indices ranging from 1.50 to 1.56, or higher. For example, the refractive index may range from 1.57 to 1.60, or greater. Rather, the optically-transparent material or filler disposed in micro-perforation **1405***c* may be configured to transmit 95% visible light (e.g., for sidewall areas determined by a diameter of a micro-perforation). The epoxy or filler material may prevent humidity and other environmental factors from affecting internal LEDs (or the like) and/or circuitry. FIG. **14**D illustrates an example of an angled micro-perforation, according to some embodiments. As shown, micro-perforation **1405** is formed to focus emission of light along at line **1440** at an angle "A," to focus light in a direction a user's eyes most likely are positioned. In this configuration, angle A places line **1440** non-orthogonal to the initial direction of emission from below an inner surface of pod cover **1402**. Angle A thereby assists in directing luminosity toward a user and reduces the visibility of such information to other persons' eyes at other positions.

[0114] FIGS. **15**A to **15**D are diagrams depicting another example of a display portion for a wearable pod, according to some embodiments. Diagram **1500** illustrates a wearable pod including a pod cover **1504** integrated or otherwise coupled (e.g., detachably coupled) to a band **1502** or strap **1502** to form a wearable device. In this example, display portion **1506** includes a variety of symbols having multiple functions to convey multiple types of information based on a mode of operation, a type of activity, a contacts, etc. Display portion **1506** can include symbol elements composed of micro-perforations. Further, the symbol elements may emit different colors of light based on the types of information being conveyed.

[0115] FIG. **15**B is a diagram depicting another display portion interacting with a display controller, according to some examples. Diagram **1520** illustrates a display portion **1521** that includes a display formed in predominately opaque material, whereby the symbol elements formed therein may include various arrangements of micro-perforations. Display controller **1540** includes either hardware or software, or a combination thereof, to implement an alert display controller **1542**, a message display controller **1543**, a heart rate display controller **1544**, an activity display controller **1545**, and a notification display controller **1546**. Further, display controller **1540** can be coupled to a mode controller **1541**, which is configured to provide mode data to display controller **1540**. The mode data can describe a mode of operation, a context, an activity, or a condition in which a wearable pod is operating. Responsive to the mode data, display controller **1540** can implement one or more of the above-described controllers **1542** to **1546** to provide mode-specific via display portion **1521**. As an example, display controller **1540** can identify a subset of light sources and/or micro-perforations to emit light through an arrangement of micro-perforations constituting one or more symbols indicative of a value of a physiological signal, such as a heart rate.

[0116] Alert display controller **1542** is configured to implement symbols **1522**, **1524**, and **1526** to provide alerts to a user. Upon detecting a notification to check an application residing, for example, on a mobile computing device, alert display controller **1542** may be configured to cause symbol **1522** to emit light. Note that according to some embodiments, an illuminated symbol **1522** can alert a user to the availability of an insight. The term "insight" can refer to, for example, data correlated among a state of user (e.g., number of steps taken, number of our slapped, etc.) and other sets of data representing trends, patterns, and correlations to goals of a user (e.g., a target value of a number of steps per day) and/or supersets of generalized (e.g., average values) of anonymized data for a population at-large. With insight data, the user can understand how an activity (e.g., running, etc.) can affect other aspects of health (e.g., amount of sleep as a parameter). In some embodiments, insight data can include feedback information. For example, insights can include data derived by the structures and/or functions set forth in U.S. Pat. No. 8,446,275, which is herein incorporated by reference to illustrate at least some examples.

[0117] Should a reminder or notification arise that requires a user to hydrate or consume water, alert display controller **1542** is configured to cause symbol **1526** to illuminate. Alert display controller **1542** is configured to maintain calendared events and times, and is further configured to receive reminders from another computing device, such as a mobile phone. When emitting light, symbol **1524** may alert a user as a reminder to undertake one of variety of actions based on time or a calendar event. Further, symbol **524** may illuminate with different colors and/or with other symbols in display portion **1521** to indicate one or more of a sleep reminder, a workout reminder, a meal reminder, a custom reminder, and the like.

[0118] Message display controller **1543** is configured to convey a message via display portion **1521**. While symbols **1528** and **1530** can have multiple functionalities, the following descriptions are in the context of conveying messages. For example, message display controller **1543** can cause symbol **1528** to emit light responsive to detecting that the wearable pod and/or a mobile computing device has received, or is receiving, a message of encouragement (electronic "dopamine") from a friend or family regarding a user's state or activity. Message display controller **1543** is configured to detect that a friend or family member has communicated a "love tap" (e.g., a gesture, like a squeeze or tap of a wearable pod in the other's possession). To convey the love tap, message display controller **1543** is configured to cause symbol **1530** and symbols **1528** to emit light.

[0119] Heart rate display controller **1544** is configured to receive physiological signal information based on one or more sensors. For example, the physiological signal information can specify a heart rate related to, for example, a particular mode of operation (e.g., at rest, asleep, moving, running, walking, etc.). Upon receiving data representing a heart rate, heart rate display controller **1544** can select symbols **1530**, **1532**, **1535** in one or more of symbols **1533** to convey heart rate information. In some cases, symbol **1534** indicates a minimum heart rate and symbol **1532** indicates a maximum heart rate. In this context, symbol **1530** may indicate a heart rate measurement is being performed or has been performed.

[0120] Activity display controller **1545** is configured to receive motion or movement-related signal information based on one or more sensors. For example, the motion data can specify a number of motion units (e.g., steps) relative to a goal of total motion units, or the motion data can specify percentage of completion of a user's activity goal (e.g., a number of steps per day). As such, activity display controller **1545** is configured to select a number of symbols **1533** to specify an amount of progress is being made to a goal. Also, activity display controller **1544** can select either symbol **1536** to specify progress toward a sleep goal or symbol **1538** to specify progress to a movement goal.

[0121] Notification display controller **1546** is configured to receive data representing a power level of a battery supplying power to a wearable pod. Based on an amount of charge stored in the battery, the notification display controller **1546** can cause symbol **1539** to emit light to indicate a charge level. Notification display controller **1546** is also configured to receive data representing an indication that a user's action either regarding a wearable pod or a mobile computing device (e.g., an application) has been implemented. To confirm implementation, the notification display controller **1546** is configured to emit light via symbol **1537**.

[0122] FIG. **15**C is a diagram depicting an example of an activity display controller interacting with a display portion, according to some examples. Diagram **1550** illustrates a display portion **1551** coupled to an activity display controller **1545**. Activity display controller **1545** can receive data originating as accelerometer signals indicative of an activity, and can determine a value indicative of an activity (e.g., an amount of steps toward a goal). Activity display controller **1545** can also determine whether sleep-related information is to be displayed or whether movement-related information as to be displayed, and can identify a quantity of lights from which to emit light, the quantity of lights being proportional to a value indicative of an activity. As shown, activity display controller **1545** is configured to convey information related to a movement-related activity, and thus causes symbol **1556** to illuminate (i.e., shown as shaded). Activity display controller **1545** is configured to determine a user's progress relative to a goal and selects a subset of symbols from which to emit light. As shown, a user is at 70% toward a goal of 100%. Therefore, activity display controller **1545** causes symbol **1554** (e.g., 10%), symbol **1553** (e.g., 70%), and intervening symbols to illuminate (i.e., shown as shaded). Note that activity display controller **1545** may illuminate symbol **1552** upon reaching a goal, and may further illuminate symbols **1557** to indicate a user's goal is surpassed (e.g., a user is at 110% of a goal).

[0123] FIG. **15**D is a diagram depicting an example of a heart rate display controller interacting with a display portion, according to some examples. Diagram **1560** illustrates a display portion **1561** coupled to a heart rate display controller **1544**. Heart rate display controller **1544** can determine that a heart rate is to be displayed, and can identify a quantity of lights and/or micro-perforations from which to emit light, the quantity of lights being proportional to a heart rate. As shown, heart rate display controller **1544** is configured to convey information related to heart rate, and thus causes symbol **1562** to illuminate (i.e., shown as shaded). Heart rate display controller **1544** is configured to determine a user's heart rate relative to a minimum heart rate ("Min HR") associated with symbol **1566** and to a maximum heart rate ("Max HR") associated with symbol **1564**. Further, heart rate display controller **1544** is configured to determine an approximate value of the heart rate relative to gradations from, for example, from 62 beats per minute ("BPM"), which is associated with symbol **1565**, to 150 BPM, which is associated with symbol **1567**. Note that in some examples, each symbol illuminated from symbol **1565** indicates an additional 11 beats per minute (e.g., +/−2 to 4 bpm). In some embodiments, heart rate display controller **1544** can include a heart rate range adjuster **1548** that is configured to track a user's maximum and minimum heart rates during one or more activities and can adjust the maximum heart rate values and minimum heart rate values associated with symbols **1567** and **1566**, respectively. Therefore, based on the wellness and health of a user's cardiovascular system and other factors, heart rate range adjuster **1548** can customize the gradations of symbols from symbol **1565** to symbol **1567** for a particular user. Note that the examples of the above-described display controllers are non-limiting examples can include controllers for displaying other information, such as a rate at which calories are burned, among other things.

[0124] FIG. **16** is an example of a flow to form a wearable pod, according to some embodiments. At **602**, a pod cover is received. For example, flow **600** can being by receiving a top pod cover including interface portions including one or more touch-sensitive portions and one or more display portions. In some examples, a top pod cover is configured to have a surface oriented away (e.g., away from a surface of a user) from a point of attachment to or positioning adjacent a user. At **604**, one or more touch-sensitive surface portions may be coupled to logic for detecting contact upon the touch sensitive surface. At **606**, a display portion is aligned adjacent to one or more sources of light such that perforations of the display portion are aligned to respective light sources. The one or more sources of light may be configured to emit light via a predominately opaque surface, at least in some examples. At **608**, anchor portions or structures are formed at one or more distal ends of a touch-sensitive wearable pod. In some examples, a wearable pod and its top pod cover can be elongated in dimensions such that the wearable pod has two or more sides longer than the other two or more sides. In one case, the longer sides extend across a surface of an appendage (e.g., across a wrist) of a user. Shorter sides can be at the distal ends relative to the center or centroid of a wearable pod and/or its cradle. At **610**, the top pod cover is isolated from logic and other portions of a touch-sensitive wearable pod. At **612**, the wearable pod is sealed. For example, a top pod cover can be sealed and a bottom pod cover can be sealed to form a fluid-resistant (e.g., gas-resistant, liquid-resistant, etc.) barrier.

[0125] FIG. **17** illustrates an exemplary computing platform disposed in a wearable pod configured to facilitate a touch-sensitive interface in an opaque or predominately opaque surface in accordance with various embodiments. In some examples, computing platform **1700** may be used to implement computer programs, applications, methods, processes, algorithms, or other software to perform the above-described techniques.

[0126] In some cases, computing platform can be disposed in wearable device or implement, a mobile computing device, or any other device.

[0127] Computing platform **1700** includes a bus **1702** or other communication mechanism for communicating information, which interconnects subsystems and devices, such as processor **1704**, system memory **1706** (e.g., RAM, etc.), storage device **17012** (e.g., ROM, etc.), a communication interface **1713** (e.g., an Ethernet or wireless controller, a Bluetooth controller and radio/transceiver, or other logic to communicate via a variety of protocols, such as IEEE 802.11a/b/g/n (WiFi), WiMax, ANT!™, ZigBee®, Bluetooth®, Near Field Communications ("NFC"), etc.) to facilitate communications via a port on communication link **1721** to communicate, for example, with a computing device, including mobile computing and/or communication devices with processors.

[0128] One or more antennas may be implemented as a portion of communication interface **1713** to facilitate wireless communication. Also, one or more antennas may be formed external to a wearable pod (e.g., external to a cradle and/or one or more pod covers).

[0129] Processor **1704** can be implemented with one or more central processing units ("CPUs"), such as those manufactured by Intel® Corporation, or one or more virtual processors, as well as any combination of CPUs and virtual processors. Computing platform **1700** exchanges data representing inputs and outputs via input-and-output devices **1701**, including, but not limited to, keyboards, mice, audio inputs (e.g., speech-to-text devices), user interfaces, displays, monitors, cursors, touch-sensitive displays, LCD or LED displays, and other I/O-related devices.

[0130] According to some examples, computing platform **1700** performs specific operations by processor **1704** executing one or more sequences of one or more instructions stored in system memory **1706**, and computing platform **1700** can be implemented in a client-server arrangement, peer-to-peer arrangement, or as any mobile computing device, including smart phones and the like. Such instructions or data may be read into system memory **1706** from another computer readable medium, such as storage device **1708**. In some examples, hard-wired circuitry may be used in place of or in combination with software instructions for implementation. Instructions may be embedded in software or firmware. The term "computer readable medium" refers to any tangible medium that participates in providing instructions to processor **1704** for execution. Such a medium may take many forms, including but not limited to, non-volatile media and volatile media. Non-volatile media includes, for example, optical or magnetic disks and the like. Volatile media includes dynamic memory, such as system memory **1706**.

[0131] Common forms of computer readable media includes, for example, floppy disk, flexible disk, hard disk, magnetic tape, any other magnetic medium, CD-ROM, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, RAM, PROM, EPROM, FLASH-EPROM, any other memory chip or cartridge, or any other medium from which a computer can read. Instructions may further be transmitted or received using a transmission medium. The term "transmission medium" may include any tangible or intangible medium that is capable of storing, encoding or carrying instructions for execution by the machine, and includes digital or analog communications signals or other intangible medium to facilitate communication of such instructions. Transmission media includes coaxial cables, copper wire, and fiber optics, including wires that constitute bus **1702** for transmitting a computer data signal.

[0132] In some examples, execution of the sequences of instructions may be performed by computing platform **1700**. According to some examples, computing platform **1700** can be coupled by communication link **1721** (e.g., a wired network, such as LAN, PSTN, or any wireless communication link or network, such a Bluetooth LE or NFC) to any other processor to perform the sequence of instructions in coordination with (or asynchronous to) one another. Computing platform **1700** may transmit and receive messages, data, and instructions, including program code (e.g., application code) through communication link **1721** and communication interface **1713**. Received program code may be executed by processor **1704** as it is received, and/or stored in memory **1706** or other non-volatile storage for later execution.

[0133] In the example shown, system memory **1706** can include various modules that include executable instructions to implement functionalities described herein. In the example shown, system memory **1706** includes a touch sensitive I/O control module **1770**, a display controller module **1772**, an activity determinator module **1774**, and a physiological signal determinator module **1776**, one or more of which can be configured to provide or consume outputs to implement one or more functions described herein.

[0134] In at least some examples, the structures and/or functions of any of the above-described features can be implemented in software, hardware, firmware, circuitry, or a combination thereof. Note that the structures and constituent elements above, as well as their functionality, may be aggregated with one or more other structures or elements. Alternatively, the elements and their functionality may be subdivided into constituent sub-elements, if any. As software, the above-described techniques may be implemented using various types of programming or formatting languages, frameworks, syntax, applications, protocols, objects, or techniques. As hardware and/or firmware, the above-described techniques may be implemented using various types of programming or integrated circuit design languages, including hardware description languages, such as any register transfer language ("RTL") configured to design field-programmable gate arrays ("FPGAs"), application-specific integrated circuits ("ASICs"), or any other type of integrated circuit. According to some embodiments, the term "module" can refer, for example, to an algorithm or a portion thereof, and/or logic implemented in either hardware circuitry or software, or a combination thereof. These can be varied and are not limited to the examples or descriptions provided.

[0135] In some embodiments, a wearable pod or one or more of its components (e.g., a touch-sensitive I/O controller or a display controller), or any process or device described herein, can be in communication (e.g., wired or wirelessly) with a mobile device, such as a mobile phone or computing device, or can be disposed therein.

[0136] In some cases, a mobile device, or any networked computing device (not shown) in communication with a wearable pod (or a touch-sensitive I/O controller or a display controller) or one or more of its components (or any process or device described herein), can provide at least some of the structures and/or functions of any of the features described herein. As depicted in FIG. **11** and/or subsequent figures, the structures and/or functions of any of the above-described features can be implemented in software, hardware, firmware, circuitry, or any combination thereof. Note that the structures and constituent elements above, as well as their functionality, may be aggregated or combined with one or more other structures or elements. Alternatively, the elements and their functionality may be subdivided into constituent sub-elements, if any. As software, at least some of the above-described techniques may be implemented using various types of programming or formatting languages, frameworks, syntax, applications, protocols, objects, or techniques. For example, at least one of the elements depicted in any of the figure can represent one or more algorithms. Or, at least one of the elements can represent a portion of logic including a portion of hardware configured to provide constituent structures and/or functionalities.

[0137] For example, a wearable pod or one or more of its components (e.g., a touch-sensitive I/O controller or a display controller), any of its one or more components, or any process or device described herein, can be implemented in one or more computing devices (i.e., any mobile computing device, such as a wearable device, an audio device (such as headphones or a headset) or mobile phone, whether worn or carried) that include one or more processors configured to execute one or more algorithms in memory. Thus, at least some of the elements in FIG. **11** (or any other figure) can represent one or more algorithms. Or, at least one of the elements can represent a portion of logic including a portion of hardware configured to provide constituent structures and/or functionalities. These can be varied and are not limited to the examples or descriptions provided.

[0138] As hardware and/or firmware, the above-described structures and techniques can be implemented using various types of programming or integrated circuit design languages, including hardware description languages, such as any register transfer language ("RTL") configured to design field-programmable gate arrays ("FPGAs"), application-specific integrated circuits ("ASICs"), multi-chip modules, or any other type of integrated circuit.

[0139] For example, a wearable pod or one or more of its components (e.g., a touch-sensitive I/O controller or a display controller), including one or more components, or any process or device described herein, can be implemented in one or more computing devices that include one or more circuits. Thus, at least one of the elements in FIG. **11** (or any other figure) can represent one or more components of hardware. Or, at least one of the elements can represent a portion of logic including a portion of circuit configured to provide constituent structures and/or functionalities.

[0140] According to some embodiments, the term "circuit" can refer, for example, to any system including a number of components through which current flows to perform one or more functions, the components including discrete and complex components. Examples of discrete components include transistors, resistors, capacitors, inductors, diodes, and the like, and examples of complex components include memory, processors, analog circuits, digital circuits, and the like, including field-programmable gate arrays ("FPGAs"), application-specific integrated circuits ("ASICs"). Therefore, a circuit can include a system of electronic components and logic components (e.g., logic configured to execute instructions, such that a group of executable instructions of an algorithm, for example, and, thus, is a component of a circuit). According to some embodiments, the term "module" can refer, for example, to an algorithm or a portion thereof, and/or logic implemented in either hardware circuitry or software, or a combination thereof (i.e., a module can be implemented as a circuit). In some embodiments, algorithms and/or the memory in which the algorithms are stored are "components" of a circuit. Thus, the term "circuit" can also refer, for example, to a system of components, including algorithms. These can be varied and are not limited to the examples or descriptions provided.

[0141] FIG. **18** is an exploded perspective view of an example of a wearable pod having, for example, a metal surface, according to some embodiments. Diagram **1800** includes a pod cover **1802** composed of conductive material, such as anodized aluminum in which the interior metal is conductive, a pod cover **1806** composed of similar material, and a cradle **1807** configured to be disposed within an interior region defined by pod covers **1802** and **1806**. Cradle **1807** is further configured to house circuitry, including but not limited to a bioimpedance circuit, a galvanic skin response circuit, an RF transceiver (e.g., a Bluetooth Low Energy transceiver), and other electronic components and devices. As shown, cradle **1807** includes attachment portions **1877*a*** and **1877*b*** extending from distal ends of cradle **1807**, attachment portions **1877*a*** and **1877*b*** being configured to adhere to an interface material that can constitute one or more anchor portions. Diagram **1800** also illustrates an isolation belt **1815** being formed at a region **1819** along or adjacent one or more longitudinal sides (e.g., sides **1817*a*** and **1817*b***) of cradle **1807**. Region **1819** along sides **1817*a*** and **1817*b*** can include one or more edges of pod cover **1802** disposed adjacent to one or more edges of pod cover **1806**. A portion **1815*a*** of isolation belt **1815** may be disposed between one or more edges of pod cover **1802** and one or more edges of pod cover **1806** to electrically isolate at least a portion of pod cover **1802** from pod cover **1806** and/or cradle **1807** or other circuitry that need not be related to detecting touch.

[0142] Further to FIG. **18**, light sources **1841**, such as light-emitting diodes ("LEDs") or other sources of light, can be positioned to emit light to respective symbols in display portion **1804**. Also shown is a mounting frame **1803** in which to house light sources **1841** in corresponding apertures **1883**.

Mounting frame **1803** also includes another aperture **1882** to enable a conductive path **1880** to extend from pod cover **1804** to a touch-sensitive I/O controller circuit (not shown). Other examples of light sources **1841** include, but are not limited to, interferometric modulator display (IMOD), electrophoretic ink (E Ink), organic light-emitting diode (OLED), or other display technologies.

[0143] FIG. **19** is an exploded front view of an example of a wearable pod having, for example, a metal surface, according to some embodiments. Diagram **1900** illustrates elements having structures and/or functions as similarly-named or similarly-numbered elements of FIG. **18**. Note that edges **1903** of pod cover **1802** and edges **1906** of pod cover **1806** are configured to be adjacent each other, when assembled, at or near region **1919**. According to some embodiments, a portion **1915***a* (e.g., a ridge or rib) is configured to isolate edges **1903** and edges **1906** from contacting each other, thereby facilitating touch-sense of capabilities of pod cover **1802** (e.g., by preventing electrical shorts or other conditions or phenomena).

[0144] FIGS. **20**A to **20**B are respective exploded perspective and exploded front views of a wearable pod including anchor portions, according to some embodiments. Diagram **2000** illustrates elements having structures and/or functions as similarly-named or similarly-numbered elements of FIGS. **18** and **19**. Further, diagram **2000** illustrates formation of anchor portions **1809***a* and **1809***b* on attachment portions at the distal ends of cradle **1807**. Also shown is portion **1915***a* of an isolator belt that can be formed during the formation of anchor portions **1809***a* and **1809***b*. As such, the isolator belt and ridge **1915***a* can be composed of a material used to form portions **1809***a* and **1809***b*. Diagram **2050** illustrates elements having structures and/or functions as similarly-named or similarly-numbered elements of FIGS. **18** to **20**A. Further, diagram **2050** illustrates formation of anchor portions **1809***a* and **1809***b* formed, for example, contemporaneous with the formation of portion **1915***a* of an isolation belt and the formation of an under-layer material **2017**, all of which can be composed of a common material (e.g., an interface material). In some embodiments, anchor portions **1809***a* and **1809***b*, portion **1915***a* of an isolation belt, and under-layer material **2017** can be composed of a thermoplastic. For example, the thermoplastic can include polycarbonate or other similar materials.

[0145] FIG. **20**C is a bottom perspective view of a pod cover implementing a sealant during assembly, according to some embodiments. Diagram **2070** illustrates a pod cover **2002** having edges **2013** at least two of which may be disposed adjacent to edges of a bottom pod cover once assembled. Diagram **2070** also shows a sealant **2078** applied on an inner surface portion of pod cover **2002** at or adjacent to one or more edges **2013** of pod cover **2002** to form a fluid-resistant bond to a cradle, an isolation belt, or another structure. In one example, a fluid-resistant bond or barrier is formed to withstand intrusions of water at 1 ATM. Arrangements of micro-perforations **2082** are shown to extend from an inner surface **2079** of a portion of pod cover **2002** to an outer surface **2081** of pod cover **2002**.

[0146] FIG. **20**D is a diagram depicting a perspective front view of a wearable pod being assembled as part of a wearable device, according to some embodiments. Diagram **2080** illustrates a pod cover **2002** and a pod cover **2006** being brought together to form respective seals to encapsulate the interior structures and circuitry. For example, when assembled, pod covers **2002** and **2006** enclose a light diffuser **2099** (e.g., for diffusing LED-generated light), which may be optional, mounting frame **2003**, and cradle **2007**. Further, straps **2020** and **2022** are respectively molded on anchor portions **1809***b* and **1809***a*, respectively, whereby anchor portions **1809***a* and **1809***b* are composed of interface materials configured to securely couple cradle **2007** to straps **2020** and **2022**. In some embodiments, cradle **2007** comprises a metal material and straps **2020** and **2022** may be composed of a pliable material, such as an elastomer. Note that logic may be disposed within cradle **2007** under mounting frame **2003**. Examples of such logic include a bioimpedance circuit disposed in cradle **2007** and configured to couple to a first subset of conductors to receive electrical signals embodying physiological data originating from points in space adjacent to blood vessels in tissue. Also, such logic can include a galvanic skin response circuit disposed in cradle **2007** and configured to couple to a second subset of conductors to receive electrical signals indicative of a conductance value across a portion of tissue. Further, a cross-section view X-X' of a portion of an isolation belt and the edges of pod covers **2002** and **2006** are depicted in FIGS. **21**A and **21**B.

[0147] FIGS. **21**A and **21**B are diagrams depicting a cross-section of a portion of an isolation belt, according to some examples. Diagram **2100** is a cross-section view of an assembled wearable pod including a pod cover **2102** attached to interior structures and a pod cover **2106** that is also attached to interior structures. Diagram **2100** also illustrates an inset **2130** diagram that includes a cross-section view of an isolation belt. As shown in inset **2130** diagram of FIG. **21**B, an isolation belt **2115** formed on or adjacent a cradle **2107**. Isolation belt **2115** includes a portion **2115***a* (or ridge **2115***a*) that isolates pod cover **2102** from pod cover **2106**. According to some embodiments, a sealant **2170** is configured to form a fluid-resistant bond between pod cover **2102** and isolation belt **2115** and/or **2107**.

[0148] FIG. **22** illustrates an example of a flow to form a touch-sensitive pod cover for a wearable pod, according to some examples. Flow **2200** includes forming a pattern at **2202** on a substrate, such as a metal substrate. At **2202**, a cosmetic pattern may be formed on a top surface using stamping or CNC-based machine patterning. Prior to **2202**, a pod cover can be singulated or separated from other metal. In some examples, the pod cover is an aluminum metal substrate. At **2204**, the contours (e.g., the dimensions and spatial characteristics) of the pod cover are formed. Forming the contours include forming shapes of the sides and top surfaces. At **2206**, a coating can be formed on the surface of the pod cover. For example, an aluminum pod cover can be anodized to form covered surface on the pod cover. At **2208**, a portion of the pod cover is etched to provide access to the aluminum metal substrate (e.g., under the coating) for purposes of electrically coupling the pod cover to, for example, a touch-sensitive I/O control circuit to detect a touch event. For example, a portion of an inner surface of a top pod cover may be etched to facilitate formation of an electrical path to couple one or more touch-sensitive portions of the pod cover to touch-detection logic. At **2210**, perforations may be formed in a touch-sensitive portion of the pod cover. In some examples, the perforations and/or micro-perforations can be formed by drilling a number of perforations with a laser to form one or more symbols. At **2212**, an optically-transparent sealant can be applied to the perforations and/or micro-perforations for form a display portion.

[0149] FIG. **23** illustrates an example of a flow for a touch-sensitive wearable pod, according to some embodiments. Flow **2300** includes setting a cradle and components in a first mold. For example, the components can include a temperature sensor and pins (e.g., pogo pins) to form a USB connector (or other types of connectors). At **2304**, an insulator belt is formed and, at **2306**, one or more anchor portions may be formed at one or more attachment portions at one or more distal ends of a cradle. In some examples, the formation of anchor portions includes molding over metal surfaces of the one or more attachment portions with an interface material having properties to facilitate bonding to an elastomer. In at least one example, a thermoplastic material is molded over a magnesium metal surface of one or more cradle attachment portions. In various embodiments, the various thermal plastic materials are suitable for the above-described implementation. In at least one embodiment, the thermal plastic material includes polycarbonate or equivalent. At **2308**, a portion of a pod cover can be etched to provide for electrical contact to a touch-detection circuit. At **2310**, one or more pod covers are selected and a sealant **2312** may be applied thereto. For example, an epoxy may be applied adjacent to one or more edges of a top pod cover, whereby the epoxy may contact a one or more surface of a cradle disposed within an interior region formed between the top pod cover and a bottom pod cover. Note that flow **2300** is not intended to be exhaustive in may be modified within the scope of the present disclosure.

[0150] FIG. **24** is a diagram depicting an antenna configured for implementation in a wearable pod having a metallized interface, according to some embodiments. Diagram **2400** includes an antenna **2402** having terminals **2403** and **2405** formed in a first end, the terminals being configured to couple a transceiver disposed in a region enclosed by or defined by a top pod cover and a bottom pod cover, neither of which are shown. As such, antenna **2402** is configured to be implemented external to a metal-based enclosure formed by the pod covers of a wearable pod. Diagram **2400** further shows that antenna **2402** includes a stacked portion **2406** and an extended portion **2408**. Stacked portion **2406** is a portion of metal (e.g., planar metal) that is configured to be oriented in a "stacked" position over an attachment portion, whereas extended portion **2408** is a portion of metal that is configured to "extend" beyond the attachment portion. In some embodiments, extended portion **2408** includes a greater amount of surface area than stacked portion **2406**. Further, diagram **2400** illustrates a gap **2413** in antenna **2402** that separates a metal portion **2410** from a metal portion **2420**, the gap **2413** extending from adjacent one corner **2490** to an opposite corner **2492**. Opposite corner **2042** is disposed diagonally from the other corner **2490** as shown. Note that metal portion **2410** is coupled to metal portion **2420** at a transition portion **2419**, which, at least in some examples, has the smallest width dimension across the surface area of antenna **2402**. In some examples, metal portion **2410** and metal portion **2420** may have equivalent surface areas. In at least one example, metal portion **2410** is disposed predominantly in stacked portion **2406**, whereas metal portion **2420** is disposed predominantly in extended portion **2408**. In some embodiments, stacked portion **2406** is defined, at least in one example, by a portion **2411** of a non-conductive gap **2413**. Diagram **2400** also illustrates a number of holes **2418** in antenna **2402** that are configured to align with alignment posts (not shown) on an under-anchor portion during antenna placement. According to some embodiments, antenna **2402** can be configured as a Bluetooth® antenna, such as Bluetooth low energy (Bluetooth LE) antenna, the specifications of which are maintained by Bluetooth Special Interest Group ("SIG") of Kirkland, Wash., USA. According to other embodiments, antenna **2402** can be designed to receive radio frequency ("RF") signals associated with other wireless communication protocols, including, but not limited to various WiFi protocols, cellular data signals, etc. According to various other embodiments, other antenna shapes for antenna **2402** are also the scope of the present disclosure. As such, antenna **2402** can serve as antenna for multiple types of RF signals, such as Bluetooth and WiFi.

[0151] FIGS. **25**A to **25**C depict examples of an antenna oriented relative to an attachment portion of a cradle, according to some embodiments. FIG. **25**A is a diagram **2500** depicting a front view of a cradle **2507** having an attachment portion **2577***a* extending from a distal end of cradle **2507**, and an attachment portion **2577***b* extending from another distal end of cradle **2507**. In this example, cradle **2507** has elongated dimensions, whereby attachment portion **2577***a* extends longitudinally (longitudinal direction **2501**) and/or circumferentially away from a center point **2503** of cradle **2507**. In one example, cradle **2507** is composed of metal, such as magnesium, and is configured to be disposed between a top pod cover the bottom pod cover (not shown). Cradle **2507** was further configured to have an interior region for housing circuitry and to accept conductors, such as terminals **2403** and **2405** of FIG. **24**, that extend externally from cradle **2507**.

[0152] Further to diagram **2500**, a stacked portion **2406** of planar metal disposed at a first distance to a portion of attachment portion **2577***a* of metal cradle **2507**, whereas a portion of extended portion **2408** may be disposed at a second distance (from the portion of attachment portion **2577***a*), which is greater than the first distance. In some non-limiting examples, a portion of stacked portion **2406** may parallel or substantially parallel (e.g., non-intersecting in a region) to a portion of attachment portion **2577***a*. In some cases, a portion of stacked portion **2406** may be shaped to have one or more radii of curvature as a portion of attachment portion **2577***a*.

[0153] In some examples, antenna **2402** can include a stacked portion **2406** that traverses a first region from a radial plane **2513** to a radial plane **2515**, the first region including attachment portion **2577***a*. Extended portion **2408** is shown to traverse a second region at an angular distance, d**2**, which is greater than an angular distance between radial plane **2513** and radial plane **2515**. Note that the second region excludes attachment portion **2577***a*, wherein radial plane **2513** and radial plane **2515** extend radially from a line **2512** parallel to a bottom plane **2588** coextensive with a portion of a bottom of cradle **2507**. Radial plane **2517** extends from line **2512** without passing through attachment portion **2577***a*.

[0154] According to other examples, attachment portion **2577***a* and a short-range communication antenna **2402** may include bottom surface portions that are coextensive with a curved surface **2511** having one or more radii centered at a point (e.g., on line **2512**) in a region below the bottom pod cover. In various implementations, curved surface **2511** may be configured to facilitate attachment to a strap configured to encircle a portion of a wrist (or other circularly-shaped appendages).

[0155] Attachment portion **2577***b* is configured to extend at a greater distance from a side of a cradle **2507** than attachment portion **2577***a* to, for example, accommodate different structures and/or functions. As shown, attachment portion **2577***b* has a surface coextensive with a curved surface **2599** extending from a radial plane **2505** to a radial plane **2598**. Radial planes **2505** and **2598** can extend radially from line **2510**. According to some embodiments, attachment portion **2577***b* can be configured to support circuitry, such as conductors, electrodes, a collection of electrodes, electrode bus, and circuitry, such as near-field communications devices (e.g., NFC semiconductor chip).

[0156] FIG. **25**B is a diagram **2550** depicting a magnified front view of a cradle **2507** having an attachment portion **2577***a* extending from a distal end of cradle **2507**. As shown, extended portion **2408** is shown to traverse a region **2559** at an angular distance, d**2**, which is greater than angular distance, d**1**. Note that stacked portion **2406** that traverses a region **2558** that includes attachment portion **2577***a*. Note that region **2558** can include in interface material, such as polycarbonate, when forming an anchor portion. Similarly, region **2559** may include some interface material as well.

[0157] FIG. **25**C is a diagram **2570** depicting a magnified perspective view of a cradle **2507** having an attachment portion **2577***a* extending from a distal end **2599** of cradle **2507**. In the example shown, stacked portion **2406** and extended portion **2408**, at least in one example, are separated by a portion **2411** of a non-conductive gap **2413**. Portion **2411** of non-conductive gap **2413** can include a portion of the plane **2580** that may be orthogonal or substantially orthogonal to plane **2582**, which can be coextensive with a surface of attachment portion **2577***a*. Further, a portion of the interface material may be disposed in gap **2411** when an anchor portion is formed. According to other embodiments, a shortest distance between plane **2582** and stacked portion **2410** may be greater than the shortest distance(s) between extended portion **2408** and plane **2582** as the shortest distances between plane **2582** and stacked portion **2410** are configured to minimize interference for metallic surface of attachment portion **2577***a* during operation of antenna **2402**.

[0158] FIG. **26** is an exploded perspective view of an anchor portion, according to some embodiments. Diagram **2600** includes a cradle **2607** having an under-anchor portion **2679***a* formed (e.g., molded) thereupon. An antenna **2402** is aligned such that posts **2610** pass through holes **2612** during assembly. According to some embodiments, antenna **2402** is secured to the surface of under-anchor portion **2679***a* by heat staking posts **2610** (e.g., deforming the tops of posts **2610** to expand at diameters larger than holes **2612**). In one case, the material of posts **2610** are heated and pressure is applied thereto to deform the posts. An over-anchor portion **2679***b* can be formed (e.g., molded) over antenna **2402** and under-anchor portion **2679***a* to form a portion **2609***a*.

[0159] FIG. **27** is an example of a flow to manufacture a communications antenna in a wearable pod and/or device, according to some embodiments. In flow **2700**, an antenna is selected, whereby the antenna has a first surface area that extends beyond a second surface area associated with an attachment portion a cradle for a wearable pod, the first surface area being greater than the second surface area. At **2074**, an under-anchor portion on the attachment portion maybe formed. Forming the under-anchor portion can include configuring the surface of the under-anchor portion to receive the antenna at **2706**. For example, the surface of the under-anchor portion can be configured to include posts extending from the surface of the under-anchor portion. In some cases, a portion of the interface material can be disposed in a first portion of a gap in the antenna, the gap being coextensive with a first plane that is orthogonal or is substantially orthogonal (i.e., more orthogonal than not, or +/−30% from a vector normal to the surface) to a second plane coextensive with a surface of the attachment portion. The under-anchor portion can be formed by shaping surface of the under-anchor portion to be coextensive with a curved surface having one or more radii centered at a point in a region below a bottom of the cradle.

[0160] Further, an antenna can be disposed at **2708** upon the surface of the under-anchor portion. For example, the holes in the antenna may be aligned with the posts, and the antenna can be placed on the surface of the under-anchor portion. For example, the antenna may be disposed on a surface of the under-anchor portion at a distance from a surface area associated with the attachment portion. In at least one example, the posts can be deformed to lock the antenna in position. At **2710**, an over-anchor portion may be formed over the antenna and the under-anchor portion to form an anchor portion configured to attach to, for example, a strap composed of the elastomer. Further, the under-anchor and/or over-anchor portions may be composed of an interface material configured to bind to the cradle and to an elastomer. An example of an interface material is polycarbonate, and an example of an elastomer is a thermoplastic elastomer ("TPE"). In one embodiment, an elastomer includes a thermoplastic polyurethane ("TPU") material.

[0161] In one embodiment, selecting the antenna can include selecting a short-range antenna including terminals coupled to a Bluetooth circuit in a cradle of a wearable pod. The antenna includes a stacked portion of planar metal configured to be disposed at a first distance from the attachment portion of metal cradle, and an extended portion of the planar metal configured to be disposed at a second distance, which is greater than the first distance. Also, selecting the antenna can include selecting a Bluetooth antenna to transmit and receive radio signals implementing a Bluetooth protocol. In addition, selecting the antenna can include selecting an antenna having a first metal portion electrically isolated from a second metal portion by a gap extending diagonally or substantially diagonal (i.e., more diagonal than not, or +1-30% from a line passing through two corners) from adjacent one corner of the antenna to an opposite corner of the antenna.

[0162] FIG. **28** is a diagram depicting an antenna configured for implementation in a wearable pod having a metallized interface, according to some embodiments. Diagram **2800** includes a cradle **2807** including an anchor portion **2809***b* at which a near field communication ("NFC") system is disposed. Anchor portion **2809***b* is formed with a channel **2819** having a channel support floor **2820** and channel walls **2813**. Channel **2819** is configured to support one or more layers of material above plane **2884**, which is coextensive at least a portion of channel floor **2820**. As shown, near field communication system **2870** includes a communication device **2880** and an antenna **2882**, whereby near-field communication antenna **2882** has a first end disposed in channel **2819** of anchor portion **2809***b*. In this example, near field communication system **2870** is disposed external to cradle **2807**. Further, near field communication system **2870** may be disposed external to a periphery of a first pod cover and a second pod cover (neither are shown) over cradle **2807**. Communications device **2880** may have a potting compound formed thereupon.

[0163] In diagram **2800**, antenna **2882** may include a subset of terminals (not shown) disposed at a first end of the antenna in channel **2819**, the subset of terminals being coupled to near-field communication device **2880** mounted on the first end of antenna **2882**. According to some embodiments, near-field communication device **2880** may include an active near-field communication device that may be configured to receive power from adjacent the near-field communication antenna upon which radio frequency radiation is received. This amount of power may be sufficient to cause near field communication device **2880** to transmit data including, for example, a communication device ID. Antenna **2882** includes a metal-based pattern configured to receive near-field communications signals and may include polyamide. According to some embodiments, a region between antenna **2882** and plane **2884** may include one or more other layers, one of which may include an electrode bus as described herein. As such, an electrode bus can provide support for antenna **2882** as well as near field communication device **2880**.

[0164] Further to diagram **2800**, a communications device identifier extractor **2890** is configured to program an identifier into a memory (not shown) in cradle **2807**. The identifier uniquely identifies near field communications device **2880**. As shown, communication device identifier extractor **2890** may be configured to transmit radiation **2898** to cause near field communications device **2880** to transmit an identifier as data **2896**. Then, a communication device identifier extractor can program identifier as data **2894** into memory. In some cases, communication device identifier extractor **2890** may be used during assembly, final test and/or packaging stages of manufacture. A memory in cradle **2807** can store data representing the identifier of near-field communication device **2880**, memory being disposed in a wearable pod. The identifier is accessible to facilitate activation of the near-field communication device. For example, consumer can couple the memory in Internet network to activate, for example, a credit card account.

[0165] According to some embodiments, near-field communication antenna is configured to facilitate radio reception and/or transmission of signals in accordance with near field communication interface and protocols, such as those set forth and/or maintain by International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) of Geneva, Swtizerland.

[0166] FIGS. **29**A and **29**B are perspective views of an attachment portion and an anchor portion, respectively, according to some embodiments. Diagram **2900** of FIG. **29**A illustrates attachment portion **2977***b* prior to formation of an anchor portion **2809***b*, as shown in diagram **2950** in FIG. **29**B.

[0167] FIG. **30** is a diagram depicting another example of a near field communication antenna implemented in a wearable device, according to some examples. Diagram **3000** illustrates a near field communication antenna **3082** having terminals **3003** and **3005** being configured to couple via anchor portion **3009***b* to circuitry in a cradle **3007** (e.g., a metal cradle), the antenna including planar metal disposed in a layer of material, such as polyamide. A near-field communication device (not shown) in cradle **3007** can be coupled to the near-field communication antenna **3082** via terminal **3003** and **3005**. In some examples, near-field communication antenna may include another set of terminals (not shown) to perform either transmit or receive operations, or both, of the near-field communication device (and/or to provide power to the antenna for communication or processing).

[0168] FIG. **31** is an example of a flow to manufacture a short-range communications antenna in a wearable pod and/or device, according to some embodiments. In flow **3100**, an antenna is selected at **3102**, whereby the antenna has a width dimension configured to be disposed in a wearable strap. For example the width dimension of the antenna is less than the width of the strap and/or wearable pod (e.g., a width less than a top or bottom pod cover). In another example, the width of the antenna is less than the distance between channel walls formed in an anchor portion. In particular, an antenna having a width dimension sized less than a width dimension of a channel may be selected. At **3104**, a cradle having an attachment portion for a wearable pod can be selected, and an anchor portion may be formed on the attachment portion. The anchor portion can be composed of an interface material configured to bind to the cradle and to an elastomer, and the anchor portion can also include a channel to provide support. In one case, the anchor portion as a surface shaped to be coextensive with, for example, a curved surface having one or more radii centered at a point in a region below a bottom of the cradle.

[0169] At **3106**, an inner portion of a wearable strap is formed coupled to an anchor portion including the channel. At **3108**, a portion of the antenna may be disposed in the channel and/or a part of an inner portion of a wearable strap located adjacent a wearable pod. According to some embodiments, a portion of the antenna disposed in the channel may also include and/or be coupled to a near field communications device (e.g., a near-field communication semiconductor device). In particular, terminals of antenna can be coupled to circuitry of a near-field communication semiconductor device disposed on the antenna or substrate that includes an antenna.

[0170] At **3110**, a determination is made whether near field communication logic is external. In particular, a determination is made whether the near field communication device is located external or internal to a cradle. If the near field communication device disposed within a cradle, flow **3100** moves to **3112** at which antenna conductors or terminals are attached coupled to internal logic, including a near-field communication device. Otherwise, flow **3100** moves to **3114** at which a near field communication device mounted on the antenna is encapsulated as an outer portion of the strap is formed at **3116**. At **3118**, identifier associated with logic in the near field communication device is identified. For example, an electromagnetic field can be applied adjacent to the antenna, and the identifier can be read. The identifier may be stored in memory at **3120**. For example, identifier can be programmed in a memory residing in the cradle for subsequent activation by a user.

[0171] FIG. **32** is a diagram depicting examples of an electrode-based wire bus for facilitating physiological characteristic sensing, according to some embodiments. Electrode or wire bus wire bus **3200**, and components coupled with the electrode bus **3200** are depicted. Electrode wire bus **3200** may include a bus substrate **3201** that may be made from a flexible and electrically non-conductive material including but not limited to a thermoplastic elastomer and rubber, for example. In one example, the elastomer material can include, for example, TPE or TPU, to form a flexible substrate in which Kevlar™-based conductors are encapsulated. In one example, the flexible bus substrate **3201** is formed of TPE and has a hardness of approximately 85 to 95 Shore A (e.g., approximately 90 Shore A ins some cases). A side view of bus substrate **3201** illustrates a wire **3212** encapsulated between an upper surface **3201***a* and a lower surface **3201***b* of the bus substrate **3201**. Wire **3212** may be coupled **3207** with a pad

3203 (shown in dashed line) and pad **3203** may be coupled with an electrode **3202**. Electrode **3202** may be coupled with a skirt **3204** and may include a pin **3206** that is positioned in an aperture **3205** of the pad **3203**. A dimension of the pin **3206** may be selected to be slightly greater than a diameter of the aperture **3205** so that when the pin **3206** is inserted into the aperture **3205** a press fit is established between the pin **3206** and aperture **3205**. Press fitting the pin **3206** into the pad **3203** may provide for a pressure fit that retains the electrode **3202** in contact with the pad **3203** and may also provide for a low electrical resistance connection between the electrode **3202** and pad **3203**. The press fit may also be operative to securely couple the skirt **3204**, pad **3203** and electrode with one another. Crimping, soldering, or other techniques may be used to couple the pad **3203** and the electrode **3202** with each other, and the press fit is one non-limiting example of how the pad **3203** and electrode may be coupled with each other. A portion of pin **3206** may extend outward of the lower surface **3201*b*** of the bus substrate **3201**. After the wire bus **3200** has been fabricated (e.g., by injection molding) the exposed portion of the pin **3206** may be used for electrical continuity testing of one or more of the pad **3203**, the electrode **3204**, and wire **3212**.

[0172] Wire **3212** may be connected with a portion of pad **3203** using soldering, crimping, wrapping, or welding for example. As one example, wire **3212** may be laser welded to a portion of pad **3203**. Pad **3203**, the electrode **3202** or both may be made from an electrically conductive material including but not limited to a metal, a metal alloy, copper, gold, silver, platinum, aluminum, stainless steel, and alloys of those metals. As one example, pad **3203** may be a copper (Cu) washer. Wire **3212** may include insulation **3213** that may be stripped to expose a conductor **3214** that may be connected with the pad **3203**. Wire **3212** may be routed along a path in the wire bus **3200** and may exit the wire bus **3200** at a distal end **3209**. A portion of the wire **3212** positioned at the distal end **3209** may be stripped to expose conductor **3214** and the conductor **3214** may be tinned (e.g., with solder) in preparation for connecting the conductor **3214** with another structure, such as an electrical node, printed circuit board (PCB) trace, or circuitry, for example. A portion of the wire **3212** positioned at the distal end **3209** may be dressed for subsequent connection with other structures. There may be more electrodes **3202**, pads **3203**, skirts **3204** and wires **3212** than depicted as denoted by **3221** and **3223**.

[0173] Bus substrate **3201** may include alignment structures (e.g., see **3407** in FIGS. **34** and **35**) that may be used to mount other components to the wire bus **3200**, such as an antenna and a near field communication chip, for example. Bus substrate **3201** may include a thickness t that may be 1 mm or less in thickness. The material used for bus substrate **3201** may be selected to sustain a continuous pull load of about 2 kg and to sustain a maximum pull load of about 8 kg. Actual force loads may be application dependent and the foregoing are non-limiting examples.

[0174] In example **3240**, electrode **3202** and skirt **3204** may be positioned relative to an aperture **3241** of an inner strap of a strap band (not shown). A material **3243**, such as a material used to form an outer strap of the strap band (e.g., via injection molding). Wire bus **3200**, skirt **3204**, or structures in a mold may include channels, ports, or other structures configured to provide a path for material **3243** to enter into aperture **3241**. From left to right in example **3240**, material **3243** (e.g., a thermoplastic elastomer) enters into aperture **3241**, fills the aperture **3241** and connects with skirt **3204** along an interface **3245**. Skirt **3204** may be made from a material that interfaces with material **3243** to establish a seal between the skirt **3204** and the aperture **3241**. A temperature of material **3243** may be operative to heat skirt **3204** and the heat may be operative to form a seal between the electrode **3202** and skirt **3204**, skirt **3204** and aperture **3241** or both. Material **3243** may not interface with the electrode **3202** (e.g., a metal material for electrode **3202**) and skirt **3204** may be operative as a material that interfaces with electrode **3202** and with material **3243**. In some embodiments, skirt **3204** may be made from in interface material configured to integrate electrodes **3203** with a material used to form a strap band, a band, or the like. According to some examples, skirt **3204** may be composed of a polycarbonate material or like material. In some examples, skirt **3204** may expand in dimension when contacted by material **3243** or heat in material **3243** as denoted by **3204*e***.

[0175] In example **3250**, electrode **3202** may include a pin **3206** and skirt **3204** may include an aperture **3204*a*** through which the pin **3206** may be inserted. A mold in which the wire bus **3200** is molded or a jig may include a support structure **3230** having a post **3231** upon which the pad **3203** is mounted. Wire **3212** (e.g., stripped to expose conductor **3214**) may be connected with the pad **3203** by soldering, crimping, wire wrapping, welding, or by application of an electrically conductive adhesive or epoxy, for example. A material for the bus substrate **3201** may be formed over the pad **3203** and wire **3212**. Post **3231** may prevent the material from entering into the aperture **3205** of the pad **3203** so that in a subsequent processing step, pin **3206** of electrode **3202** and skirt **3204** may be connected with the pad **3203**. As described above, a pressure or friction fit may be used to connect the pad **3203** with the pin **3206** of the electrode **3202**.

[0176] Examples **3212*a*-3212*d*** depict various configurations for wire **3212**. In example **3212*a***, wire **3212** may include a conductor **3214** surrounded by an insulator **3213**. In example **3212*b***, wire **3212** may include a conductor **3214** surrounded by an insulator **3213** and the conductor **3214** surrounding a core **3215** (e.g., a concentrically positioned core). Core **3215** may be made from a high strength material such as a composite, Kevlar, fibers, carbon fiber, or the like, for example. Core **3215** may be electrically conducting or electrically non-conducting. Core **3215** may be used to structurally strengthen wire **3212** against forces that may be caused by stretching wire bus **3200** or a strap band that includes the wire bus **3200**. In example **3212*c***, wire **3212**, sans insulation **3213**, may include the conductor **3214** surrounding the core **3215**. In example **3212*d***, wire **3212** may include a conductor **3214** (e.g., sans insulation **3213** and core **3215**).

[0177] FIG illustrates examples of a top, side, and bottom plan views of an electrode or wire bus, according to some examples. In a top view **3300**, electrodes **3202** may be positioned on bus substrate in alignment with an axis **3301**. There may be more or fewer electrodes **3202** disposed on bus substrate **3201** than depicted and those electrodes **3202** may be positioned in alignment with each other or some or all of the electrodes **3202** may not be aligned with one another. Bus substrate **3201** may have a different shape than depicted. For example, bus substrate **3201** may have a taper **3302** in its width. Wires **3212** may be routed along a path in the bus substrate **3201**. The path may be determined by one or more wire guides **3325** (depicted in dashed line) positioned in a mold or jig (not shown) that may be used to form the wire bus

3200. Wire guide **3325** may include a slot or channel **3325***c* in which a portion of the wire **3212** may be positioned. Side portions of electrodes **3202** may be coupled with the skirt **3204**.

[0178] In a side view **3320**, a portion of the pins **3206** of electrodes **3202** may extend outward of lower surface **3201***b* of bus substrate **3201**. In other examples the pins may not extend outward of lower surface **3201***b* or may be cut, trimmed, grounded down or otherwise machined to be flush with or inset from lower surface **3201***b*. Wire bus **3200** may be formed from a material and may include components (e.g., core-reinforced wires) configured to allow flexing, pulling, stretching, twisting of the wire bus **3200** as denoted by **3303**. The material for bus substrate **3201** and its associated components may be selected to withstand a range of torsional loads that may be applied to the wire bus **3200** and/or strap bands the wire bus **3200** is positioned in.

[0179] In a bottom view **3340**, wires **3212** may be coupled **3207** with their respective pads **3203** and the pads **3203** may include a connection portion configured to receive the wire **3212**. Pads **3203** may also include a flat (as will be described below) that allows one of the wires **3212** to be routed past the pad **3203** to another pad **3203**.

[0180] FIG. **34** is a diagram depicting an example of a can electrode-wire bus implementing a wire bridge, according to some examples. As shown, wire bridge **3410** may be operative to position wires **3212** for attachment to another structure (e.g., internal to a wearable pod) and may also be used to dress the wires **3212** into a configuration for connection to another structure. A surface of the wire bus **3200** may include one or more structures **3417** configured to receive a component to be connected with the wire bus **3200**. Structures **3417** may include a post, a pillar, a notch, a groove, etc., for example.

[0181] FIG. **35** is a diagram depicting an example of a surface of a wire bus including a substrate in which an antenna is formed, according to some examples. As shown, surface **3201***b* of the wire bus **3200** includes a substrate **3421** having an antenna **3422** coupled **3426** to, for example, a near field communication ("NFC") semiconductor device or chip **3420**. Substrate **3421** may be a flexible substrate that may be mounted to wire bus **100** using the structures **3417**. For example, structure **3417** may be posts and substrate **3421** may include apertures that match positions with and mate with structures **3417**. Other components may be coupled with wire bus **3200** and the above mentioned substrate **3421** is a non-limiting example. Components coupled with wire bus **3200** may include wires or other types of interconnect structures that may be connected with other components.

[0182] FIG. **36** is a diagram depicting examples of relative spacing and dimensions of electrodes disposed in a wire bus, according to some embodiments. In example **3600**, in a side view of wire bus **3200**, electrodes **3202** may be positioned relative to one another by a spacing **3202***s*. In other examples, electrodes **3202** may be spaced apart from one another by a pitch **3202***p* (e.g., as measured between centers of pins **3206**). Electrodes **3202** may have a height **3202***h* (e.g., as measured from upper surface **3201***a* to an uppermost surface of the electrode **3202**). In example **3610**, pairs of adjacent electrodes **3202** may be spaced apart by spacing **3202***s* or pitch **3202***p*, and an inner most electrodes **3202'** in each pair may be spaced apart by a distance **3202***i* or a pitch **3202***j* (e.g. as measured between pin **3206** centers of electrodes **3202'**). Spacing **3202***s*, **3202***i* and/or pitches **3202***p*, **3202***j* may be selected to position the electrodes **3202** within a target range **3620***r*, when the wire bus **3200** is included in a system or device that positions the electrodes into contact with a surface of a body portion, such as skin on a wrist, arm, leg, neck, torso, etc. As one example, target range **3620***r* may be determined by a range of sizes for human wrists ranging from skinny wrists having a small circumference and large wrists having a larger circumference. Although there may be some outlier wrist sizes above and below the target range **3620***r*, the target range **3620***r* may be selected to capture wrist sizes for a majority of a population of users. Target range **3620***r* may encompass a portion of a circumference of those wrists that is positioned on a bottom side of the wrists, for example. Electrodes **3202** positioned within the target range **3620***r* may be positioned to sense or otherwise detect structures or properties on the skin or beneath the skin (e.g., subcutaneous). For example, subcutaneous structures may include blood vessels or other tissues associated with the sympathetic nervous system (SNS); whereas, skin conductance may be a property measured by contact of electrodes with a surface of the skin. In some examples, electrodes **3202** may be components of a biometric sensor system, such as one that senses bioimpedance (BI). Wire bus **3200** may be positioned in a strap band that is mounted to a wrist or other body portion, and as that strap band shifts its position relative to the body portion, the electrodes **3202** may be positioned within the target range **3620***r* such that reliable signals may be received from electrodes **3202**.

[0183] Electrode height **3202***h* may be selected to provide sufficient contact pressure between the electrode **3202** and a skin surface the electrode **3202** is brought into contact with when the strap band or other device that carriers the wire bus **3200** is mounted to a body portion, such as an arm or wrist for example. As will be described below, an upper surface of electrode **3202** may include a surface area (e.g., X*Y) operative to minimize contact resistance between the electrode **3202** and a skin surface it is placed into contact with and/or to improve a signal-to-noise ratio (S/N) of signals generated by the electrode **3202**. The upper surface of the electrode **3202** may have an arcuate shape configured to provide comfort when the electrode **3202** is engaged with the body portion and/or to increase surface area of the electrode **3202**.

[0184] FIG. **37** illustrates examples of wire routing configurations and connection to conductive pads formed in a wire bus, according to some embodiments. In example **3700** a back view of skirt **3204** and pad **3203** includes, for example, a flat **3709** formed in the pad **3203** and operative to allow wire **3212** to be routed pass the pad **3203** for connection with another pad **3203**, for example. Pad **3203** may include a notch **3707** where a stripped end of wire **3212** may be positioned for connection of the wire **3212** with the pad **3203**. Skirt **3204** may include one or more shot channels **3704**. Wire bus **3200** may be positioned in another structure, such as an inner strap band that includes an aperture denoted by dashed line **3720** through which the electrode **3202** and its skirt **3204** may be disposed. A material may be introduced (e.g., injected as part of an injection molding process) into the shot channels **3704** and flow into voids or spaces in the pad **3203**, skirt **3204**, pad **3203**, and into aperture **3720**. In example **3710**, the material **3730** may fill in and seal a space between the aperture **3720** and the skirt **3204**. The material **3730** may also encapsulate structures in the wire bus **3200**, such as wires **3212**, portions of pad **3203**, and portions of skirt **3204**, for example. Material **3730** may be introduced into shot channels **3703** via one or more shot ports formed in the wire bus **3200** and aligned with shot channels **3704** during an injection molding process, for example.

[0185] FIG. **38** is a side view **3800** illustrates one example of an electrode and related structures, according to some embodiments. As shown, electrode-wire bus **3200** may include an electrode **3202**, a skirt **3204**, and a pad **3203**, among other things. Pin **3206** of electrode **3202** may be inserted **3801** into an aperture **3204***a* of skirt **3204** and then into aperture **3205** of pad **3203**. Electrode **3202** may include a grooved portion **3202***g* that is positioned in contact with the skirt **3204** and may open into one of the shot channels **3704**. The material **3730** (e.g., a thermoplastic elastomer) may flow through shot channels **3704** and a portion of the material **3730** may flow into grooved portion **3202***g* as well as into other portions (e.g., aperture **3720**) as was described above.

[0186] FIG. **39** illustrates profile views **3910** and **3920** of other examples of electrode structures, according to some embodiments. As shown, an electrode structure may include an electrode **3202**, a skirt **3204**, and a pad **3203** formed in wire bus **3200**. Pin **3206** of electrode **3202** may include a slot **3206***g* that may divide a portion of the pin **3206** into sides **3206***a* and **3206***b*. Pin **3206** may be inserted **3801** through aperture **3204***a* and into aperture **3205** of pad **3203**. Insertion through aperture **3205** may cause sides **3206***a* and **3206***b* to deflect inward toward each other and then expand outward away from each other upon exiting the aperture **3205**. The outward expansion of sides **3206***a* and **3206***b* may exert force against walls of aperture **3205** and provide a press fit or friction fit between the pad **3203** and the pin **3206**, such that the electrode **3202** is securely coupled with pad **3203**. The press fit or friction fit may also be operative to securely couple the skirt **3204** between the pad **3203** and the electrode **3202**. Front and rear sides of skirt **3204** may include recessed portions **3204***c* and **3204***d*. Material **3730** may flow into recessed portions **3204***c* and **3204***d*, groove **3202***g*, and into pad **3203** via opening **3206***t* in pin **3206**.

[0187] FIG. **40** illustrates views of yet other examples of an electrode structure, according to some embodiments. For example, electrode structure can include electrode **3202**, a skirt **3204**, and a pad **3203** that may be included in a wire bus **3200** are depicted. An uppermost portion **4002***u* of electrode **3202** may have a height **4002***h* (e.g., as measured from a top of the skirt or from surface **3201***a* of bus substrate **3201**) that may be in a range from about 1.0 mm to about 2.5 mm. Height **4002***h* may be determined in part by a thickness of an aperture (e.g., **3720**) that surrounds the electrode **3202** when wire bus **3200** is positioned in another structure, such as an inner strap, for example. If a material that forms the aperture is thick (e.g., 2.0 mm thick), then height **4002***h* may be higher than would be the case if the material that forms the aperture is thin (e.g., 1.0 mm thick). In some examples, height **4002***h* may vary among the electrodes **3202**. For example, one electrode **3202** may have a height **4002***h* of approximately 1.5 mm and another electrode **3202** may have a height **4002***h* of approximately 1.7 mm.

[0188] A surface area **4002***a* of electrode **3202** may be in a range from about 8.0 mm2 to about 20 mm2. For example, surface **4002***a* may have a dimension of about 4.0 mm in a X-dimension and about 4.00 mm in a Y-dimension for an area of about 16 mm2. Area for surface **4002***a* may be selected to provide a desired signal-to-noise ratio (S/N) in circuitry coupled with electrode **3202** (e.g., via wire **3212**).

[0189] FIG. **41** is a diagram depicting an example of an assembly of a strap band that including a wire bus, an inner strap, and an outer strap, according to some embodiments. In a rear view, wire bus **3200** may be positioned in a previously fabricated lower strap **4100**. Inner strap **4100** may include a portion **4100***e* configured to connect inner strap **4100** with another structure or component. Inner strap **4100** may be connected with another structure or component as part of the previous fabrication. Inner strap **4100** may include apertures **4102** formed in the inner strap **4100** during the previous fabrication. Wire bus **3200** may be moved **4110** into position in inner strap **4100** with its electrodes **3202** and skirts **3204** aligned with apertures **4102** as denoted by dashed lines **4130** which represent an outline of a desired alignment with the apertures **4102** when the wire bus **3200** is positioned in the inner strap **4100**. Inner strap **4100** may include a cavity **4135** formed during the previous fabrication and configured to receive the wire bus **3200**. Cavity **4135** may mirror an outline of an outer perimeter of the wire bus **3200**. The outer strap **4150** will be formed over the connected wire bus and lower strap in a subsequent processing step as will be described below. Outer strap **4150** may also include a portion **4150***e* configured to connect outer strap **4150** with another structure or component. Portions of surface **3201***a* of bus substrate **3201** may include a glue, adhesive or the like applied to surface **3201***a* and operative to facilitate connecting wire bus **3200** with inner strap **4100** (e.g., connecting bus substrate with cavity **4135**.

[0190] FIG. **42** illustrates an example of a wire bus coupled to an inner strap or inner strap portion, according to some embodiments. Portions **4202** of surface **3201***a* of bus substrate **3201** may have an adhesive or glue applied to surface **3201***a*, for example, a pressure sensitive adhesive tape may be applied to one or more portions **4202** of surface **3201***a*. Wire bus **3200** and inner strap **4100** may be brought into contact **4103** with each other with electrodes **3202** and skirts **3204** aligned **4205** with apertures **4102** as described in reference to FIG. **41**. After wire bus **3200** is connected with inner strap **4100**, electrodes **3202** extend outward of their respective apertures **4102**, and the wire bus **3200** and the inner strap **4100** form sub-assembly **4200**.

[0191] In FIG. **43** one example of an outer strap **4340** being formed on sub-assembly **4200** (e.g., wire bus **3200** coupled with an inner strap **4100**) is depicted. Sub-assembly **4200** may be positioned in a mold **4310** including features for an outer strap **4340**. A material **4320** (e.g., **3730**) such as a thermoplastic elastomer may be injected into mold **4310** to form the outer strap **4340** around the sub-assembly **4200**. The outer strap **4340** and inner strap **4200** may form a strap band **4300** that includes portions of the wire bus **3200** encapsulated in the strap band **4300** (e.g., the electrodes **3202** extend outward of inner strap **4200**). The material **4320** may flow into shot channels **3704** of skirts **3204** and may seal apertures **4102** as was described above. Inner strap **4200** and outer strap **4340** may be integral with one another after the molding process, such that there may be no visible demarcation of where the inner strap **4200** interfaces with the outer strap **4340**. Materials for the inner and outer straps may be the same materials or different materials. Materials for the inner and outer straps may have different colors and may have different surface features or ornamentation. As shown in FIG. **43**, a strap band **4300** may be formed with a thermoplastic elastomer material **4320** encapsulating the circuitry therein (e.g., an electrode-wire bus, an NFC chip, an antenna, etc.) to protect it from environmental conditions. Further, interface materials of the skirt and the anchor portions (e.g., as described herein) ensure that elastomer material **4320** bonds/integrates with metal (e.g., stainless steel electrodes and magnesium cradle in the wearable pod).

[0192] A system may include one or more strap bands, with one of the strap bands being configured as strap band **4300** and another of the strap bands not including the wire bus **3200**. The system may include two strap bands **4300** with each strap band **4300** having its own encapsulated wire bus **3200** and associated wires **3212**, pads **3203**, electrodes **3202**, and skirts **3204**, for example. The number and placement of electrodes **3202** in the two strap bands **4300** may be the same or different (e.g., one strap band **4300** may have four electrodes **3202** and the other strap band **4300** may have two electrodes **3202**). Each strap band in the system may include fastening hardware (e.g., a buckle, a clasp, a latch, etc.) configured to couple the two strap bands with each other and/or to mount the two strap bands to a structure, such as a portion of a human body, such as the arm, the wrist, the leg, the torso, the neck, etc., for example. A system may include two strap bands with each strap band coupled with a device. For example, distal ends of each strap band in the system may couple with a main module that may include structures (e.g., circuitry, PCB traces, etc.) that couple with wires **3212** positioned at the distal end or one or both of the strap bands.

[0193] FIG. **44** illustrates top, side and bottom views of one example of a strap band **4300** that includes an encapsulated wire bus **3200** and sealed electrodes **3202**. An aperture **4410** configured to accept **4411** fastening hardware for strap band **4300** may be formed by a portion **4201** (e.g., see **4201** in FIGS. **42** and **43**) and the molding process of FIG. **43**. Strap band **4300** may be flexible **3303** as described above. Moreover, prior to the molding of the outer strap **4340**, the substrate **3421** including the antenna **3422** and near field communication chip **3420** may be positioned on the wire bus **3200**. Upper surface **4002*u*** of electrodes **3202** (see FIG. **40**) may extend above a surface **4300*i*** (e.g., an inner surface) of the inner strap **4200** by a height **4300*h*** in a range from about 1.0 mm to about 2.0 mm, for example. In some examples, height **4300*h*** may vary among the electrodes **3202**. For example, one electrode **3202** may have a height **4300*h*** of approximately 0.9 mm and another electrode **3202** may have a height **4300*h*** of approximately 1.2 mm. Subsequent to forming the strap band **4300**, a demarcation between the inner strap **4200** and outer strap **4340** may not be discernible (e.g., visually) and the inner and outer straps may appear as a single integrated unit.

[0194] FIG. **45** illustrates examples **4550-4580** of fastening hardware that may be coupled with a strap band **4300**. In example **4550** a buckle **4510** may include an aperture **4511** through which a sleeve **4512** may be inserted **4513**. A pin **4514** may be inserted **4515** into the sleeve **4512** to secure the buckle **4510** to aperture **4410** in the strap band **4300** as depicted in examples **4560-4580**. Pin **4514** may be a spring pin or spring bar **4516** (e.g., like those used with watch bands) that may replace pin **4514**, sleeve **4512** or both. Spring pin **4516** may include dimensions configured to allow the spring pin **4516** to be inserted **4517** into aperture **4511** of buckle **4510**, or if sleeve **4512** is used, then insertion **4517** into sleeve **4512**.

[0195] Referring now to FIG. **48**, various views **4810-4850** of the strap band **4300** are depicted. Strap band **4300** depicted in views **4810** to **4850** is just one non-limiting example and strap band **4300** may include more of fewer elements than depicted in FIG. **48** and may have an appearance that differs from the examples depicted in FIG. **48**. Strap band **4300** may include one or more colors. Strap band **4300** may include one or more surface finishes (e.g., glossy, flat, matte, etc.). Strap band **4300** may be translucent or transparent (e.g., to reveal structure beneath surfaces **4300*o*** and/or **4300*i***). After strap band **4300** has been fabricated as described above (e.g., in reference to FIGS. **41-45**), inner strap **4200** and outer strap **4340** may not be discernible (e.g., visually discernable) and strap band **4300** may appear as a unitary whole (e.g., no visible seems or structures that would indicate strap band **4300** is composed of inner and outer straps). Strap band **4300** may include surface features and/or ornamentation (e.g., for esthetic purposes) on outer surface **4300*o*** and/or inner surface **4300*i***, for example. Although views **4810-4850** depict dressed wires **3212*d***, actual configurations for the wires **3212** may be application dependent and are not limited to the exampled depicted herein.

[0196] In views **4810-4850**, the buckle **4510** is depicted attached to strap band **4300**; however, the strap band **4300** need not include the buckle **4510** and the types of fastening hardware that may be coupled with strap band **4300** are not limited to examples depicted herein. Although actual dimensions for strap band **4300** may be application dependent, strap band **4300** may have a width **4821** (see view **4820**) in a range from about 8 mm to about 15 mm, for example. In some examples, a width of the strap band **4300** may vary along a length of the strap band **4300**. For example, strap band **4300** may be wider at the buckle **4510**. Width **4821** may be the smallest width of strap band **4300**, for example. A thickness of strap band **4300** may vary along a length of the strap band **4300** (e.g., strap band **4300** may be thicker at distal end **3209**); however, notwithstanding the height **4300*h*** of the electrodes **3202** above surface **4300*i***, strap band **4300** may include a thickness **4831** (see view **4830**) in a range from about 0.9 mm to about 3.2 mm, for example. Strap band **4300** may include thickness **4831** along portions of the strap band **4300** that are positioned into contact with a body portion of a user when a device that includes strap band **4300** is worn by the user, such as a portion of an arm adjacent to a wrist of the user. Thickness **4831** may be selected to be the thinnest portion of strap band **4300**.

[0197] FIG. **46** illustrates one example of a flow diagram **4600** for a method of fabricating a wire bus **3200**. At a stage **4602** a pad (e.g., **3203**) may be positioned on a pad mount (e.g., **3230**) of a wire bus mold. At a stage **4604** a wire (e.g., **3214** of **3212**) may be connected with a portion of the pad. At a stage **4606** the wire may be routed along a wire path. At a stage **4608** a flexible electrically non-conductive material (e.g., a thermoplastic elastomer) is injected into the wire bus mold to form a bus substrate (e.g., **3201**) that includes one or more pads with each pad having a wire connected to it. At a stage **4610** the bus substrate may be removed from the wire bus mold. At a stage **4612**, a skirt (e.g., **3204**) having a shot channel (e.g., **3704**) may be connected with an electrode (e.g., **3202**). At a stage **4614** the shot channels in the skirts may be aligned with a shot port formed in the bus substrate by a port structure in the wire bus mold. At a stage **4616** the electrode may be connected with the pad (e.g., the electrode **3202** with its connected skirt **3204**).

[0198] FIG. **47** illustrates one example of a flow diagram **4700** for a method of fabricating a strap band (e.g., **4300**) that includes a wire bus **3200**. At a stage **4702** a flexible electrically non-conductive material (e.g., a thermoplastic elastomer) may be injected into an inner strap mold. At a stage **4704** an inner strap (e.g., **4100**) may be removed from the inner strap mold. At a stage **4706** a wire bus (e.g. **3200**) may be aligned with the inner strap. At a stage **4708** the wire bus may be positioned into contact with the inner strap while maintaining alignment between the wire bus and the inner strap. At a stage **4710** the inner strap and its connected wire bus (e.g., sub-assembly **4200**) may be positioned in an outer strap band mold. At a stage **4712** a flexible electrically non-conductive material (e.g., a thermoplastic elastomer) may be injected into the outer strap mold. At a stage **4714** a strap band may be removed from the outer strap mold. At a stage **4716** a decision may be made as to whether or not to attach fastening hardware (e.g., **4510**, **4512**, **4514**) to the strap band. If a NO branch is taken, then the flow **4700** may terminate. On the other hand, if a YES branch is taken, then flow **4700** may transition to another stage, such as a stage **4718**, for example. At the stage **4718**, the fastening hardware is attached to a portion of the strap band.

[0199] Reference is now made to FIG. **49** where examples **4940** and **4960** of a strap band **4900** positioned on a body portion **4990** are depicted. Here, for purposes of explanation, a non-limiting example of a body portion is a wrist; however, the present application is not limited to a wrist and strap band **4900** may be used with other body portions, including but not limited to the torso, the neck, the head, the arm, the leg, and the ankle, for example.

[0200] In example **4940**, electrodes **4902** of strap band **4900** may be configured to sense signals, such as biometric signals, from structures of body portion **4990** positioned in a target region **4991**. As one non-limiting example, the structure of interest may include the radial artery **4992** and the ulnar artery **4994**. The radial artery **4992** is the largest artery that traverses the front of the wrist and is positioned closest to thumb **4995**. Ulnar artery **4994** runs along the ulnar nerve (not shown) and is positioned closest to the pinky finger **4993**. The radial **4992** and ulnar arteries arch together in the palm of the hand and supply the fingers **4993**, thumb **4995** and front of the hand with blood. A heart pulse rate may be detected by blood flow through the radial **4992** and ulnar arteries, and particularly from the radial artery **4992**. Accordingly, strap band **4900** and electrodes **4902** may be positioned within the target region **4991** to detect biometric signals associated with the body, such as heart rate, respiration rate, activity in the sympathetic nervous system (SNS) or other biometric data, for example.

[0201] Target region **4991** is depicted as being wider than the wrist **4990** and spanning a depth along the wrist **4990** to illustrate that variations in body anatomy among a population of users will result in differences in wrist sizes and some user's may position the strap band **4900** closer to the hand; whereas, other user's may position the strap band **4900** further back from the hand. Now the view in example **4940** is a ventral view of the hand **4990**; however, the wrist **4990** has a circumference C that may vary ΔC among users. Arrows **4994** indicate a width of the wrist **4990** for the example **4940**; however, in a population of users, circumference (see **4971** of example **4960**) of a wrist may vary from a minimum Min (e.g., a very small wrist) to a maximum Max (e.g., a very large wrist). To accommodate variations in wrist circumference ΔC from Min to Max, dimensions of strap band **4900**, dimensions of electrodes **4902** and positions of the electrodes **4902** relative to each other and relative to other structures the strap band **4900** may be coupled with, may be selected to position the electrodes **4902** within the target region **4990** for wrist sizes spanning a minimum wrist size of about 135 mm in circumference to a maximum wrist size of about 180 mm in circumference, for example. In other examples, the dimensions and positions may be selected to position the electrodes **4902** within the target region **4990** for wrist sizes spanning a minimum wrist size of about 130 mm in circumference to a maximum wrist size of about 200 mm in circumference. For example, within the target region **4990**, electrodes of strap band **4900** may be positioned to sense signals from the radial **4992** and ulnar **4994** arteries for wrist circumferences within the aforementioned 130 mm to 200 mm range, even when the strap band **4900** overlays a flat or curved surface of the wrist **4990** or is displaced to the left, the right, up, or down as denoted by arrow for S on wrist **4990** due to variations in where user's like to place their strap bands on their wrist **4990**. Therefore, the strap band **4900** may not require an exact centered location on writs **4990** in order for electrodes **4902** to sense signals from structure in the target region **4991** (e.g., **4992** and **4994**).

[0202] Some of the electrodes **4902** may have signals applied to them (e.g., are driven) and are denoted as D; whereas, other electrodes **4902** may pick up signals (e.g., receive signals) and are denoted as P. Positioning and sizing of the electrodes **4902** that are adjacent to each other (e.g., a driven D electrode next to a pick-up P electrode) may be selected to prevent those electrodes from contacting each other when the strap band **4900** is bent or otherwise curved when donned by the user. For example, if electrodes **4902** lie on an approximately flat portion of wrist **4990**, then adjacent electrodes **4902** (e.g., a D and P) may not be significantly urged inward toward each other because they are lying on an approximately planar surface. On the other hand, if electrodes **4902** lie on a curved portion of wrist **4990**, then adjacent electrodes **4902** (e.g., a D and P) may be urged inward toward each other, and if the adjacent electrodes are spaced to close to each other, then their inward deflection might bring them into contact with each other (e.g., they become electrically coupled) and the signal being received by the pick-up P electrode will be the signal being driven on the drive D electrode and not the signal from structure in target region **4991**.

[0203] Example **4960** illustrates a cross-sectional view of wrist **4990** along a dashed line AA-AA. A circumference of the wrist **4990** is denoted as **4971** and will vary based on wrist size. As depicted, strap band **4900** is positioned on a ventral portion of wrist **4990** in a region **4975** that is relatively flat; however, in the target region **4991**, moving left or right away from **4975** towards the boundary of the target region **4991**, the surface of wrist **4990** becomes curved. Moreover, wrist **4990** has curvature in a region **4973** of a dorsal portion of the wrist **4990**. Although many users will likely wear a device that includes the strap band **4900** in a prescribed manner in which the electrodes **4902** of the strap band **4900** are placed against the bottom of the wrist **4990** (e.g., the ventral portion), some users may prefer to place the strap band **4900** and its electrodes **4902** on the dorsal portion **4973** where the surface of wrist **4990** includes curvature. In either case, strap band dimensions and electrode dimensions and placement may be selected to establish sufficient contact of the electrodes **4902** with skin of the wrist **4990** within the target region **4991** so that signals driven onto drive D electrodes are coupled with wrist **4990** and signals from wrist **4990** are received by pick-up electrodes P.

[0204] Moving now to FIG. **50** where a side view of a strap band **4900** coupled with a device **4950**, such as a wearable pod, is depicted. Here, wearable pod **4950**, a band **4920**, and strap band **4900** may form a system **5000**. Device **4950** may include circuitry, one or more processors (e.g., DSP, µP, µC), memory (e.g., non-volatile memory), data storage (e.g., for algorithms configured to execute on the one or more processors), one or more sensors (e.g., temperature, motion, biometric, ambient light), one or more radios (e.g., Bluetooth—BT, WiFi, near field communications—NFC), circuit boards, a power source, a display (e.g., LED, OLED, LCD), transducers (e.g., a loudspeaker, a microphone, a vibration engine), one or more antennas, a communications interface (e.g., USB), a capacitive touch interface, etc. for example. Device **4950** may include an arcuate inner surface **4950***i* having a curvature selected to prevent or minimize rotation of system **5000** around wrist **4990** (or other body portion) when system **5000** is donned by a user. Preventing or minimizing rotation of system **5000** may be operative to maintain position of electrodes **4902** within the target region **4991** and/or maintain contact between the electrodes **4902** and skin within the target region **4991**. Device **4950** may include ornamentation **4951** (e.g., for esthetic purposes) on an upper surface **4953**.

[0205] Band **4920** may be a mechanical band, that is, a band configured to couple with strap band **4900** for donning system **5000** on a body portion of a user, such as the wrist **4990** of FIG. **49**. Band **4900** may be purely passive (e.g., no electronics disposed in it) or may be active (e.g., includes circuitry and/or passive and/or active electronic components). Band **4920** may include a latch **4921** configured to mechanically couple with a buckle **4910** disposed on strap band **4900**. Latch **4921** and a portion of band **4920** may be inserted through a loop **4913** disposed on strap band **4900**. Band **4920** may include an inner surface **4920***i* and an outer surface **4920***o*. When band **4920** is inserted into loop **4913** and buckle **4910** a portion of inner surface **4920***i* may contact a portion of an outer surface **4900***o* of strap band **4900**.

[0206] Strap band **4900** may include a plurality of electrode **4902** positioned on and extending outward of an inner surface **4900***i*. Electrodes **4902** and a portion of inner surface **4900***i* may be positioned in contact with skin in target region **4991** (e.g., skin on wrist **4990**) when the system **5000** is donned by a user. In addition to electrodes **4902**, strap band **4900** may house other components, such as wires for coupling electrodes **4902** with circuitry, antenna, a power source, circuitry, integrated circuits (IC's), passive electronic components, active electronic components, etc., for example.

[0207] Strap band **4900** and band **4920** may couple with device **4950** at attachment points denoted as **4915** and **4925** respectively. For purposes of explanation, attachment points **4915** and **4925** may be used as non-limiting examples of reference points for dimensions described herein. Further, dashed line **4914** on strap band **4900** and dashed line **4924** on band **4920** may be used as non-limiting examples of reference points for dimensions described herein.

[0208] Turning now to FIG. **51** where a top plan view **5110** and a side view **5120** of a strap band **4900** are depicted. In view **5110** (e.g., looking down on inner surface **4900***i*), dashed line **4915** may serve as a reference point for dimensions A-E. Strap band **4900** may include wires **4912** that exit strap band **4900** proximate its connection point with another structure, such as device **4950** of FIG. **50**, for example. Wires **4912** may be coupled with electrodes **4902** and may be coupled with circuitry (e.g., circuitry in device **4950**). An overall length of strap band **4900** as measured from line **4915** to line **4914** may be dimension A. Dimension B may be a distance from line **4915** to an edge of electrode **4902**. Dimension C may be a distance from line **4914** to an edge of electrode **4902**. Dimension D may be a distance between inner facing edges of the two innermost electrodes **4902**. Dimension D' may be a distance between centers of the two innermost electrodes **4902**, with distance D' being greater than the distance D (i.e., D'>D). Dimension E may be a distance between edges of adjacent electrodes **4902**.

[0209] Dimensions A-E are presented in side view in view **5120**. In side view **5120**, strap band **4900** may include an arcuate portion as denoted by arrows for **5103**. Strap band **4900** may be flexible along its length (e.g., from **4915** to **4914**). Although some dimensions other than D' are measured from edge-to-edge (e.g., dimension E between edges of adjacent electrodes **4902**), center-to-center dimensions may also be used and the present application is not limited to edge-to-edge or center-to-center dimensions for measurements described herein. Side view **5120** illustrates electrodes **4902** extending outward of inner surface **4900***i* of strap band **4900**.

[0210] FIG. **52** illustrates profile views **5200** and **5250** of a system **5000** including strap band **4900**. Views **5200** and **5250** depict the system **5000** in a configuration the system would have if donned on a user (e.g., system **5000** attached to wrist **4990** of FIG. **49**). In view **5200**, device **4950** is coupled with band **4920** and strap band **4900** with band **4920** inserted through loop **4913** and latch **4921** coupled with buckle **4910**. Electrodes **4902** are depicted positioned along inner surface **4900***i* and having dimensions X and Y. Buckle **4910** includes a gap having a width dimension W that is greater than the Y dimension of electrodes **4902** (e.g., W>Y), so that sliding **4910***s* buckle **4910** along the strap band **4900** in the direction of arrows for **4910***s* will allow the buckle **4910** to slide past the electrodes **4902** without making contact with and without establishing electrical continuity with the electrodes **4902**.

[0211] Moving to view **5250** where the aforementioned dimensions A-E are depicted along with dimensions for other components of system **5000**, namely, dimension G for wearable pod device **4950** and dimension H for band **4920**. Dimensions A-E, X, Y, W and G-H may be selected to form a system **5000** that when donned by a user having a body portion circumference (e.g., a circumference of a wrist) in a range from about 130 mm to about 200 mm, will position the electrodes **4902** within the target region **4991** with sufficient contact force with skin in the target region to obtain a high signal-to-noise-ratio for circuitry that receives signals from pick-up electrodes P (e.g., the two innermost electrodes **4902**) in response from signals driven onto drive electrodes **4902** (e.g., the two outermost electrodes **4902**). Although a range from about 135 mm to about 180 mm may be a typical range of wrist sizes found in a population of users, the larger range of from about 130 mm to about 200 mm may represent outlier ranges that are not typical but nevertheless may occasionally be encountered in a population of users. For example, a very skinny wrist of about 130 mm or a very large wrist of about 200 mm may be corner case exceptions to the more typical range beginning at about 135 mm and ending at about 180 mm of circumference.

[0212] Reference is now made to FIG. **53** where views of strap band **4900** and relative dimensions and positions of components of strap band **4900** are depicted. In view **5300**, a system **5000** may include the following example dimensions in millimeters (mm) with an example dimensional tolerance of +1-0.2 mm or less (e.g., +1-0.1 mm): dimension H for band **4920** may be 80.0 mm (e.g., from **4924** to **4925** in FIG. **50**); dimension G for device **4950** may be 45.0 mm (e.g., from **4925** to **4915** in FIG. **50**); dimension A for strap band **4900** may be 95.0 mm (e.g., from **4915** to **4914** in FIG. **50**); dimension B from **4915** to an edge of outermost electrode **4902** may be 32.0 mm; dimension E from an edge of outermost electrode **4902** to an edge of adjacent innermost electrode **4902** may be 4.0 mm; dimension D from an edge of innermost electrode **4902** to an edge of the other innermost electrode **4902** may be 31.5 mm edge-to-edge or dimension D' for innermost electrodes **4902** may be 36.0 mm center-to-center; distance E from an edge of innermost electrode **4902** to the other outermost electrode **4902** may be 4.0 mm; distance C from an edge of the outermost electrode **4902** to **4914** may be 5.5 mm; and a distance S of band **4920**, strap band **4900** or both may be 1 mm-11 mm (e.g., a width of the band **4920** and/or strap band **4900**). As one example, distance D may be approximately one-third (⅓) the dimension A for strap band **4900**, such that if A=95.0 mm, then D may be approximately 31.6 mm, with a tolerance of +/−0.2 mm or less (e.g., +/−0.1 mm).

[0213] Next, consider that a strap band may be configured to dispose a first subsets of electrodes **4902** at about 61 mm along the strap from center of wearable pod **4950** (e.g., (45 mm/2)+32 mm+4.5 mm (width of 1st electrode)+2.0 mm (half-way between first two electrodes)=61 mm). Also consider, that the second subset of electrodes are located a total of 105.5 mm from the center of wearable pod **4950**. In this example, the first subset is disposed about 58% along a curvilinear line (e.g., following the strap) between the center of the wearable pod to the second subset of electrodes. In some embodiments, the first subset of electrodes may be disposed at ratio of 0.45 to 0.70 relative to the distance at which the second subset of electrodes are disposed (e.g., 45% to 70% of the distance).

[0214] In view **5320**, example dimensions for electrodes **4902** may include a X dimension of 4.5 mm and a Y dimension of 4.5 mm. Electrodes **4902** may have a height Z above inner surface **4900*i*** of strap band **4900** of 1.5 mm. Dimensional tolerances for dimensions X, Y, and Z may be +/−0.2 mm or less (e.g., +/−0.1 mm). In view **5320** dimension W of buckle **4910** may be selected to be greater than dimension Y of electrode **4902** to provide clearance between opposing edges of electrode **4902** and buckle **4910** so that as buckle **4910** slides **4910*s*** along strap band **4900**, the buckle **4910** does not make contact with electrodes **4902** (e.g., the opposing edges). Dimension W may be selected to be about 0.3 mm to about 0.6 mm greater than dimension Y of electrodes **4902**. For example, if dimension Y is 4.5 mm, then dimension W may be 5.0 mm. Buckle **4910** may include guides **4910*g*** configured to engage with features **4910*p*** on inner surface **4900*i*** of strap band **4900** (see view **5340**). For example, prior to attaching loop **4913** to strap band **4900**, strap band **4900** may be inserted through an opening **4910*o*** of buckle **4910** and guides **4910*g*** may engage features **4910*p*** to allow indexing (e.g., a mechanical stop) of the buckle **4910** as it slides **4910*s*** along the strap band **4900**. The indexing may allow a user of the system **5000** to adjust the fit of the system **5000** to their individual wrist size (e.g., by sliding **4910*s*** the buckle **4910** along strap band **4900**), while also providing tactile feedback caused by guides **4910*g*** engaging features **4910*p*** as the buckle slides **4910*s*** along the strap band **4900**. Guides **4910*g*** may also be operative to fix the position of the buckle **4910** on the strap band **4900** after the user adjustment has been made so that the buckle **4910** does not move (e.g., buckle **4900** remains stationary unless moved by the user).

[0215] Dimensions X, Y, and Z of electrodes **4902** may be selected to determine a surface area of the electrodes **4902** (e.g., for surfaces of electrodes **4902** that are urged into contact with skin in target region **4991**). For example, surface area for electrodes **4902** may be in a range from about 10 mm2 to about 20 mm2. In some examples, structure connected with the electrodes **4902** may cover some portion of the surface of the electrodes **4902** and/or sidewall surfaces of the electrodes **4902** and reduce their actual surface area (e.g., skirts **4904** that surround the electrodes **4902**, material of strap band **4900**). For example, with dimensions X and Y being 4.5 mm such that electrodes **4902** have an actual surface area of 20.25 mm2, an effective surface area of the electrodes **4902** that may be exposed above inner surface **4900*i*** for contact with skin may be 18 mm2.

[0216] In view **5340**, structure on inner surface **4900*i*** of strap band **4900** is depicted in greater detail than in view **5300**. For example, proximate **4915** a portion of dimension B may be arcuate and dimension B may include dimensions B**1** and B**2**, where dimension B**1** may be the curved portion of B. The Y dimension for only one of the electrodes **4902** is depicted; however, for purposes of explanation it may be assumed that the Y dimensions of the other electrodes **4902** are identical. In view **5340**, strap band **4900** may have a width S of 10.0 mm and a thickness T of 2.0 mm measured between inner **4900*i*** and outer **4900*o*** surfaces. Thickness T may be the thinnest section of strap band **4900** and strap band **4900** may be thicker along portions of dimension B**1**. Thickness T may be in a range from about 0.9 mm to about 3.2 mm, for example. The following are another example of dimensions in millimeters (mm) for strap band **4900** with example dimensional tolerances of +1-0.2 mm or less (e.g., +1-0.1 mm): dimension B**1** may be 16.91 mm; dimension B**2** may be 15.02 mm; dimension X for electrodes **4902** may be 4.46 mm; dimension Y for electrodes **4902** may be 4.46 mm; dimension E between adjacent electrodes **4902** may be 3.54 mm; may be 3.54 mm; dimension D (edge-to-edge) may be 32.54 mm or D' (center-to-center) may be 37.0 mm; and distance C may be 5.96 mm.

[0217] Attention is now directed to FIG. **54** where side view **5400** and top plan view **5410** of a wire bus **4901*w*** is depicted. Wire bus **4901*w*** may be a sub-assembly that is encapsulated (e.g., by injection molding) or otherwise incorporated into strap band **4900**. Electrodes **4902** may be mounted on wire bus **4901*w*** and wires **4912** may be connected with electrodes **4902** by a process such as soldering, welding, crimping, for example. Some of the dimensions as described above in regards to FIGS. **51** to **53** may be determined in part by dimensions and placement of electrodes **4902** on wire bus **4901*w***. As one example a length of wire bus **4901*w*** may be selected to span dimension A of strap band **4900** so that electrodes **4902** on wire bus **4901*w*** are positioned within the target range **4991**. Similarly, dimensions B, E, X, Y, D, D', C, S, and T on strap band **4900** may be determined in part by dimensions, positions and sizes of electrodes **4902** on wire bus **4901*w***. Wire bus **4901*w*** may be made from a material such as a thermoplastic elastomer (e.g., TPE or TPU). The material for wire bus **4901*w*** may be a flexible material. Wire bus **4901*w*** may have a thickness **4901*t*** in a range from about 0.3 mm to about 1.1 mm, for example. Skirt **4904** may be made from a polycarbonate material, for example.

[0218] Electrodes **4902** may include pins **4906** used in mounting the electrodes **4902** to wire bus **4901***w*. A distance (e.g., a pitch) between centers of pins **4906** may determine the spacing between electrodes **4902** on strap band **4900**. For example, spacing **4906** may determine an edge-to-edge distance **4902***s* between adjacent electrodes **4902** and the distance **4902***s* may determine distance E on strap band **4900**. As another example, an edge-to-edge distance **4902***i* or a center-to-center distance **4902***j* between the innermost electrodes **4902**' may determine distances D and D' respectively on strap band **4900**. A height **4902***h* from a surface **4901***a* of wire bus **4901***w* to a top of electrodes **4902** may determine height Z (see view **5320** of FIG. **53**) on strap band **4900**, for example. Due to the material used to form the strap band **4900** over the wire bus **4901***w* the dimension for Z will typically be less than the dimension for **4902***h*. For example, if Z is 1.5 mm, then **4902***h* may be 1.7 mm. There may be more or fewer electrodes **4902** on wire bus **4901***w* as denoted by **5423**. Skirts **4904** may be coupled with electrodes **4902** and may be operative as an interface between materials for the strap band **4900** and electrodes **4902** and may form a seal around the electrodes **4902**. Skirts **4904** and material used to form the strap band **4900** around the wire bus **4901***w* may reduce actual surface area of the electrodes to an effective surface area as described above.

[0219] FIG. **55** illustrates various examples of electrodes **4902**. In example **5500**, electrode **4902** may include an arcuate surface and a pin **4906**. Height **4902***h* may be measured from a top surface to a bottom surface of electrode **4902**. In example **5510**, electrode **4902** may include a groove **4902***g* and a pin **4906** that includes a slot **4906***g*. Height **4902***h* may be measured from a top surface to a surface of groove **4902***g*. Groove **4902***g* may be surrounded by skirt **4904** described above in reference to FIG. **54**.

[0220] In example **5520**, different shaped for electrode **4902** are depicted. Electrode **4902** may have a shape including but not limited to a rectangular shape, a rectangle with rounded corners, a square shape, a square with rounded corners, a pentagon shape, a hexagon shape, a circular shape, and an oval shape, for example.

[0221] In example **5530**, surfaces of electrode **4902** may have surface profiles including but not limited to a planar surface **5531**, a planar surface **5531** with rounded edges **5533**, a sloped surface **5535**, an arcuate surface **5537** (e.g., convex), and an arcuate surface **5539** (e.g., concave). Arcuate surface **5539** may include rounded edges **5538**. Surface profiles of electrodes **4902** may be configured to maximize surface area of the electrodes **4902** that contact skin, to provide a comfortable interface between the electrode and the user's skin (e.g., for prolong periods of use, such as 24/7 use), to maximize electrical conductivity for improved signal to noise ratio (S/N), for example.

[0222] In example **5540**, electrode **4902** with a planar surface profile **5541** and electrode **4902** having an arcuate surface profile **5543** are depicted engaged with skin of body portion **4990** (e.g., a wrist). After the electrodes **4902** are disengaged with the skin, each electrode **4902** may leave an impression in the skin denoted as **5541***d* and **5543***d*. After a period of time has elapsed after the disengaging, the impression **5543***d* from the electrode **4902** having the arcuate surface profile **5543** may be less pronounced and may fade away faster than the more pronounce impression **5541***d* left by the electrode **4902** with the planar surface profile **5541**. Accordingly, some surface profiles for electrodes **4902** may be more desirable for esthetic purposes (e.g., minimal impression after removal) and for comfort purposes (e.g., sharp edges may be uncomfortable).

[0223] Suitable materials for electrodes **4902** include but are not limited to metal, metal alloys, stainless steel, titanium, silver, gold, platinum, and electrically conductive composite materials, for example. Electrodes **4902** may be coated **5401***s* with a material operative to improve signal capture, such as silver or silver chloride, for example. Electrodes **4902** may be coated **5401***s* with a material operative to prevent corrosion or other chemical reactions that may reduce electrical conductivity of the electrodes **4902** are damage the material of the electrodes **4902**. Examples of substances that may cause corrosion or other chemical reactions include but are not limited to body fluids such as sweat or tears, salt water, chlorine (e.g., from swimming pools), water, household cleaning fluids, etc.

[0224] Reference is now made to FIG. **56** where examples of circuitry coupled with electrodes **4902** of a strap band **4900** are depicted. In example **5600**, electrodes **4902** are depicted engaged into contact with skin of body portion **4990** within target region **4991**. Outermost electrodes **4902** may be coupled (e.g., via wires **4912**) with drivers **5601***d* and **5602***d* operative to apply a signal to the outermost electrodes **4902** (e.g., driven D electrodes **4902**). Innermost electrodes **4902** may be coupled (e.g., via wires **4912**) with receivers **5601***r* and **5602***r* operative to receive signals picked up by innermost electrodes **4902** from electrical activity on the surface of and/or within body portion **4990**. Drivers **5601***d* and **5602***d* may be coupled with driver circuitry **5620** and receivers **5601***r* and **5602***r* may be coupled with pickup circuitry **5630**. A control unit **5610** may be coupled with driver circuitry **5620** and with pickup circuitry **5630**. Control unit **5610** may include one or more processors, data storage, memory, and algorithms operative to control driver circuitry **5620** and pickup circuitry **5630** to process data received by pickup circuitry **5630**, and to generate data used by driver circuitry **5620** to output driver signals coupled with drivers **5601***d* and **5602***d*, for example. As one example, electrodes **4902** may sense and/or generate signals associated with biometric functions of the body, such as bioimpedance (BI). Control unit **5610** may perform signal processing of signals associated with driver circuitry **5620** and/or pickup circuitry **5630**, or an external resource **5680** and/or cloud resource **5699** in communication **5611** (e.g., via a wired or wireless communication link) may perform some or all of the processing. For example, control unit **5610** may transmit **5611** data to **5680** and/or **5699** for processing. External resource **5680** and/or cloud resource **5699** may include or have access to compute engines, data storage, and algorithms that are used to perform the processing.

[0225] In example **5640**, strap band **4900** may include a plurality of electrodes **4902** coupled with a switch **5651** that is controlled by a control unit **5650**. Control unit **5650** may command switch **5651** to couple one or more of the electrodes **4902** with driver circuitry **5652** such that electrodes **4902** so coupled become driven electrodes D. Control unit **5650** may command switch **5651** to couple one or more of other electrodes **4902** with pickup circuitry **5654** such that electrodes **4902** so coupled become pick-up electrodes P. There may be more or fewer of the electrodes **4902** as denoted by **5423**. Processing of signals and/or data may be handled by control unit **5650** and/or by external resource **5680** and/or cloud resource **5699** using communications link **5611** as described above. Algorithms and/or data used in the processing may be embodied in a non-transitory computer readable medium (e.g., non-volatile memory, disk drive, solid state drive, DRAM, ROM, SRAM, Flash memory, etc.) configured to execute on one or more processors, compute engines or other compute resources in control unit **5610**, **5650**, external resource **5680** and cloud resource **5699**. Electrodes **4902** in example **5640** may be used to cover additional surface area on body portion **4990** as may be needed to accommodate differences in size of body portion **4990** among a user population. External resource **5680** may be a wireless client device, such as a smartphone, tablet, pad, PC or laptop and may execute an algorithm or application (APP) operative to determine which electrodes **4902** to activate via switch **5651** as driver D or pick-up P electrodes. A user may enter information about their wrist size or other body portion size as data used, by the APP to make electrode **4902** selections. Control unit **5610** and/or **5650** may be included in device **4950** of FIG. **50**, for example.

[0226] FIG. **57** illustrates profile views of systems **5710**-**5730** that include strap band **4900**. System **5710** may include device **4950**, band **4920**, and strap band **4900**. Band **4920** and strap band **4900** may be made from a thermoplastic elastomer such as TPE, TPU, TPSV, or others, for example. The thermoplastic elastomer may be covered with an exterior fabric material **5711**, such as cloth or nylon, for example. The electrode **4902** and fastening hardware **4913**, **4921**, **5740** may be anodized or coated with a surface finish such as a colored chrome finish, for example. In system **5710**, buckle **4910** may be replaced with a buckle **5740** configured to slide **4910***s* along the exterior fabric material **5711** without damaging the fabric material **5711**.

[0227] System **5720** may include a faux leather exterior surface material **5721** which may have a variety of finishes such as matte, flat, glossy, etc. The finishing layer can be added prior to molding. An example of synthetic leather is known as "leatherette," among others. The fastening hardware of system **5720** may be coated with a surface finish as described above.

[0228] System **5730** includes band **4920** and strap band **4900** that may be from a material **5731**, such as a thermoplastic elastomer such as TPE, TPU, TPSV, or others, for example. Inner surface **4900***i* of strap band **4900** includes features operative to index buckle **4910** as was described above in reference to FIG. **53**. Material **5721** which may have a variety of finishes such as matte, flat, glossy, etc. The fastening hardware of system **5730** may be coated with a surface finish as described above. Device **4950** may include top and bottom portions made from a material such as anodize aluminum that may be anodized in a variety of colors, for example. An upper surface may include ornamental elements **4951**.

[0229] FIG. **58** illustrates exemplary data types for device-based activity classification using predictive feature analysis. In some examples, data group **5800** depicts various types of data that may be received, processed, modified, operated upon, manipulated, stored, operated, transmitted, transceived, or otherwise used by device **5802**. While some data types are shown, there are other data types that may be used beyond those shown and described. Here, device **5802** may be implemented with one or more sensors of various types, including, but not limited to accelerometer, temperature, galvanic skin response, bioimpedance, digital, analog, or any other type, configuration, or quantity of sensor beyond those described. While not shown, sensors implemented with device **5802** may be configured to detect signals from a user or wearer (or from tissue or a body on which device **5802** may be, in some examples, worn) or a surrounding environment to which sensors (not shown) onboard device **5802** may be exposed. As used herein, a sensor may be implemented as a single or multiple sensors that can be implemented using any type of sensor, sensory device, circuit, or other implementation that is configured to detect an input and, once detected, transmit or transceiver a corresponding signal to device **5802**, a processor (e.g., local or remote; not shown), or any other destination configured to receive signals that be interpreted and/or used to derive data, such as those shown in FIG. **58**.

[0230] Here, some data types may be derived or determined from signals that indicate motion (e.g., accelerometer data **5804**), heart rate (**5806**), respiration rate (**5808**), temperature (**5810**), galvanic skin response (**5812**), bioimpedance (**5814**), or other types of data (**5816**), including, but not limited to salinity, barometric pressure, vapor detection, carbon monoxide, carbon dioxide, outgassing, or others, without limitation. Various types of data may be derived from signals received from sensors (e.g., sensors coupled or implemented with device **5802**) after performing one or more digital or analog operations on signals obtained from a sensor or sensor array (i.e., multiple sensors implemented locally, remotely, or distributed using device **5802** and other devices (not shown)).

[0231] In some examples, the described techniques, here and below, may be implemented as a computer program or application ("application") or as a plug-in, module, or sub-component of another application. The described techniques may be implemented as software, hardware, firmware, circuitry, or a combination thereof. If implemented as software, the described techniques may be implemented using any type of structured or unstructured programming, development, compiling, scripting, or formatting languages or programs, frameworks, syntax, applications, protocols, objects, or techniques, including, but not limited to, FORTH, ASP, ASP.net, .Net framework, Ruby, Ruby on Rails, C, Objective C, C++, C#, Adobe® Integrated Runtime™ (Adobe® AIR™), ActionScript™, Flex™, Lingo™, Java™, Javascript™, Ajax, Perl, COBOL, Fortran, ADA, XML, MXML, HTML, DHTML, XHTML, HTTP, XMPP, PHP, and others. Design, publishing, and other types of applications such as Dreamweaver®, Shockwave®, Flash®, Drupal and Fireworks® may also be used to implement the described techniques. Database management systems (i.e., "DBMS"), search facilities and platforms, web crawlers (i.e., computer programs that automatically or semi-automatically visit, index, archive or copy content from, various websites (hereafter referred to as "crawlers")), and other features may be implemented using various types of proprietary or open source technologies, including MySQL, Oracle (from Oracle of Redwood Shores, Calif.), Solr and Nutch from The Apache Software Foundation of Forest Hill, Md., among others and without limitation. The described techniques may be varied and are not limited to the examples or descriptions provided.

[0232] FIG. **59** illustrates an exemplary computing network topology for device-based activity classification using predictive feature analysis. In some examples, topology **5900** may include wearable device **5902**, device **5904**, repository (e.g., data repository, storage, memory, facility, or the like) **5906**, server/computing resource **5908**, display **5910**, sensor array **5912**, sensor **5914**, and computing resource/network **5916**. In other examples, the number, type, configuration, and implementation of elements **5902-5916** may be varied and are not limited to the examples shown.

[0233] Here, wearable device **5902** may be implemented as a data-capable band, such as those shown and described herein (e.g., FIG. **57**). Other types of devices (e.g., device **5904**) may also be used with the techniques described herein and are not limited. As shown and described wearable device **5902** and device **5904** may be implemented having one or more sensors (not shown) or sensor arrays that may, for example, include electrode(s) that are configured, formed, adapter, or otherwise implemented to detect a signal using, among other techniques, bioimpedance (i.e., detecting resistance (in both magnitude and phase) to an electrical current introduced into a biologic body or tissue (e.g., a body, arm, leg, appendage, or the like) that can be used, alone or in connection with the techniques described herein, to provide, generate, or otherwise produce data associated with various types of biological parameters such as heart rate, respiration rate, galvanic skin response, temperature, and many others, without limitation. Here, wearable device **5902** and device **5904** may be in data communication with each other or other devices over computing resource/network (e.g., data network, computing cloud, local area network (LAN), wide area network (WAN), or the like, without limitation) **5916**. As described, any type of sensor, including sensor **5914**, or sensor array **5912** (e.g., multiple sensors implemented together to provide a single sensory receptacle or receiver or as a "battery" of sensors, each of which may be adapted to detect the same or dissimilar types of signals) may be implemented and are not limited to those shown and described. In some examples, signals may be received as input by sensors implemented with wearable device **5902** or device **5904**, or by sensor array **5912** and sensor array **5914** and, upon sensing or detection, may be converted (e.g., analog-to-digital, digital-to-analog, digital-to-digital, and the like), translated, rectified or otherwise modified to generate data that may be stored in repository **5906** or used by server/computing resource **5908** and sending or receiving resulting data over computing source/network **5916**. In other examples, server/computing resource **5908** may be a node, server, computer, application, or other local, networked, or distributed computing facility or resource that may be used to evaluate a signal sensed by, for example, wearable device **5902**, device **5904**, sensor **5914**, or sensor array **5914**. Evaluating the sensed signal may result in data that is generated and used to indicate various types of conditions or parameters associated with a user or wearer (e.g., heart rate, respiration rate, temperature, galvanic skin response, salinity, outgassing, and others). In other examples, different topologies having more, fewer, or different types of elements apart from those shown and described may be implemented, without limitation.

[0234] FIG. **60** illustrates an exemplary application architecture for device-based activity classification using predictive feature analysis. Here, application **6002** may be implemented as a standalone or distributed computer program, software, circuit, or other type of computing resource. As shown, application **6002** includes logic module **6004**, data repository **6006**, communications module **6008**, sensor module **6010**, classifier module **6012**, rules engine **6014**, feature interpreter **6016**, sleep module **6018**, motion module **6020**, or activity module **6022**. In some examples logic module **6004** may be implemented as a single or multiple processors, including as software, firmware, hardware, or circuitry, without limitation and configured to process data received by application **6002** using, for example, communications module **6008**. Communications module **6008**, in some examples, may be configured to provide data communication capabilities using any type of digital or analog communication technique, protocol, or facility such as Bluetooth®, BTLE (Bluetooth® Low Energy), near field communication (NFC), RFID (radio frequency identification), WiFi (using various types of data communication protocols such as any variant of the IEEE 802.11 standard (e.g., a, b, c, g, n, and others, without limitation)), or others. As shown, sensor module **6010** may be configured to provide signal and signal data directly to logic module **6004** and application **6002** or, indirectly, using communications module **6008** using bus **6024**. Although shown, bus **6024** is not required to transfer data between any of the elements shown and is provided for purposes of illustrating an exemplary technique for transferring data between elements. In other examples, application architecture **6000** is used to illustrate representative processing functions within application **6002** using detected signals (e.g., signals detected by sensors or sensor arrays (not shown) in electrical or data communication with sensor module **6010**) or data received from sensors or sensor arrays (not shown). Here, sensor module **6010** may be configured to manage one or more sensors that are used by application **6002** to provide input to logic module **6004**, for example, to classify various types of detected activities based on signals received for individual components of activities such as counted steps, three-dimensional motion, temperature, galvanic skin response, temperature (body or environmental), heart rate, respiration rate, bioimpedance-based signals that can be interpreted using feature interpreter **6010** to perform various operations such as algorithmic comparisons or decisions to determine whether quantitative thresholds have been met or exceeded in order to identify and associate specific activities with detected signals. Examples of types of activities that may be detected, evaluated, and classified by "classifiers" such as sleep module **6018**, motion module **6020**, and activity module **6022**. As used herein, classifier may be used to refer to any type of application, computer program, module, engine, circuit, or logic that may be designed or implemented to classify an activity by evaluating a signal detected by a sensor or sensor array such as those described herein and in connection with bands such as those described above. Further, activity classification may be refined using a single or multiple signals, such as the detection of signals from an accelerometer, a bioimpedance circuit, temperature sensor, salinity sensor, galvanic skin response (GSR) sensor, and many others, without limitation. For example, an accelerometer may be configured to detect a signal that could identify motion is occurring using, for example, wearable device **5902** (FIG. **59**). Once detected, classifier module **6012** may activate other sensors (e.g., a bioimpedance sensor) to detect heart rate or respiration rate, among other bodily parameters, to further refine an evaluation of signals received by sensors on wearable device **5902**, to more precisely or specifically identify the type of motion (e.g., running, walking, skipping, galloping, sprinting, and the like) that is occurring. Where single sensor devices such as accelerometer-only fitness "trackers" can detect motion, the described techniques may be configured to provide a highly resolved degree of accuracy as to the type, category, degree, or other aspects of a given activity. In other words, by using feature interpreter **6016** to determine what rules to apply using, for example, rules stored in rules engine **6014** or data repository **6006**, rapid processing of detected signals may be used from multiple sensors to provide accurate detection, identification, and classification of activities ranging from running and walking to sleep, among many others.

[0235] As described herein, feature interpreter **6016** may be implemented as an application, software, or firmware that is configured to interpret various types of "predictive features" that can be used to identify and classify particular types of activities. For example, if sensor module **6010** receives a signal that indicates heart rate, feature interpreter **6016** may execute or apply a rule from rules engine **6014** that suggests that if the detected heart rate exceeds a given threshold, then a classifier for running, walking, or locomotion (e.g., motion module **6020**) should be "activated" (i.e., invoked, executed, instanced, called, run, instantitated, triggered, "turned on," or the like) in order to classify the detected motion. In other examples, if a detected signal indicates that a user's heart rate has fallen below a given threshold, feature interpreter **6016** may be configured to activate sleep module **6018** in order to determine whether a "state" (e.g., physical, physiological, psychological, anatomical, emotional, chemical, biochemical, mechanical, biomechanical, or others) of a wearer of, for example, wearable device **5902**, is light sleep, deep sleep, or sleep associated with rapid eye movement (REM). In other examples, state determination may also be performed using other types of classifiers (e.g., motion module **6020** or activity module **6022**, the latter of which may be used to implement classification logic for any type of activity using any type of sensor input beyond those shown and described herein.

[0236] In some examples, feature interpreter **6016** may be implemented as an application that is configured to determine a state associated with a given user by applying one or more rules managed by rules engine **6014**. Examples or rules may include, but are not limited to, logic that is embedded or implemented with other software or firmware stored on and executed by, for example, wearable device **5902** or device **5904**. Some rules may include determining when a sleep state is determined for a given number of time periods (i.e., a set quantity or amount of time may be used to establish a threshold below which, if no motion is detected or if a lowered heart rate or respiration rate are detected, sleep is occurring, thus triggering feature interpreter **6016** to further determine and classify the type of sleep (e.g., light, deep, REM, waking, rousing, or others)). Other rules may include predicting when sleep module **6018** (i.e., a classifier) predict a user's state has changed from sleeping to waking, then motion module **6020** (i.e., which may also be referred to as a "step classifier") may be activated in order to begin tracking steps or motion using, for example, an accelerometer-based sensor, in addition to a bioimpedance-based sensor that was used to initially detect an increasing heart rate or respiration rate to indicate waking. Other rules may be implemented, without limitation, including those that may not only be used to classify activities, but to also manage other aspects or conditions associated with wearable device **5902** or device **5904**, such as power consumption or conservation by activating or deactivating (i.e., turning on or off) a given sensor, set of sensors, sensor array, electrodes, or the like. Further, rules managed by rules engine **6014** may also be used to manage, for example, the operation of various types of sensors based on predictive features. For example, if sleep is detected by a sensor adapted to detected bioimpedance-related signals, wearable device **5902** may be configured or modified by logic module **6002** to lessen, lower, or altogether stop the generation and transmission of electrical currents (which may be of any current or voltage used to implement bioimpedance related electrode measurement such as driving small (e.g., fractions of a micro amp of electrical current) amounts of electrical current into tissue, bone, or other biological structures to sense impedance for purposes of determining heart rate or respiration rate. In addition to rules that may be used to manage sensor operation/disabling/suspension and activity classification, other rules managed by rules engine **6014** may be implemented without limitation and are not confined to those described.

[0237] FIG. **61** illustrates an exemplary process for device-based activity classification using predictive feature analysis. Here, a signal is received (e.g., detected) by a sensor, which may be implemented using any of the sensor types or techniques described herein (**6102**). The detected signal may be evaluated, in some examples, to generate data that can be further evaluated in order to determine whether a classifier (i.e., firmware, software, computer program, application used to evaluate data to classify a given activity based on the detected signal(s)) should be activated for a given detection (**6104**). This may also include identifying the type of activity in order to select a classifier that can, using input (e.g., other detected signals) from other sensors, to classify the activity (**6106**). Upon evaluation, a classifier may be invoked and, using data generated from the initially detected signal, receive other signals or detected associated with other detected signals to determine a state associated with wearable device **5902** or device **5904** and a given user (**6108**). For example, an accelerometer may determine that a user has not moved for an extended period of time (in some examples, a period of time may be referred to as a "press") and, using feature interpreter **6016** (FIG. **60**), a bioimpedance sensor or circuit may be activated in order to detect other signals that can invoke a sleep classifier (e.g., sleep module **6018** (FIG. **60**)) to further determine whether the detected state (i.e., sleep) is light, deep, or REM-based sleep. In other examples, different classifiers may be invoked in order to identify or define with greater accuracy a given activity. Once determine, data associated with a given state (i.e., state data) may be further processed to create or generate an output representation (e.g., graphical, haptic, luminescent, vibratory, or others, without limitation) to an interface, which may be implemented using any of the techniques described herein. In still other examples, the above-described process may be varied in order, steps, function, or other aspects, without limitation to the examples shown and described.

[0238] FIG. **62** illustrates another exemplary process for device-based activity classification using predictive feature analysis. Here, an exemplary process for sleep classification is shown, including receiving a signal from a sensor indicating or measuring heart rate (e.g., bioimpedance, optical, acoustic, or others) (**6202**). The received signal is evaluated to determine a measurement for the detected heart rate (**6204**). Once determined, the heart rate may be further evaluated by feature interpreter **6016** (FIG. **60**) to identify and invoke a classifier for further classifying the detected activity (e.g., light sleep, deep sleep, REM sleep, and the like) (**6206-6208**). Finally, the data may be processed to generate information to be provided via an interface such as those described above. This information may be reviewed by a user (e.g., of wearable device **5902** (FIG. **59**)) to evaluate the nature, quality, duration, type, or other characteristics of his/her sleep. In still other examples, the above-described process may be varied in order, steps, function, or other aspects, without limitation to the examples shown and described.

[0239] FIG. **63** illustrates a further exemplary process for device-based activity classification using predictive feature analysis. Here, a signal may be received from a sensor indicating motion has occurred (**6302**). The received signal may be evaluated to generate data indicating one or more characteristics or parameters associated with the motion that may be used by feature interpreter **6016** (FIG. **60**) to activate another sensor to receive, for example, bioimpedance signals (**6304-6306**). Although the type of sensor indicated here is bioimpedance-related, other types of sensors may be used and are not limited to those described herein, which are provided solely for purposes of illustrating the described techniques. Once activated, other signals are detected and evaluated to generate additional data that is used to identify and select a classifier (e.g., sleep module **6018**, motion module **6020**, activity module **6022**, and others) that, once invoked, may be used to classify (i.e., further identify) the type of motion (**6308**). Finally, the data generated from the initially detected signal and the bioimpedance-related signal may be processed to generate information to present on an interface that may be implemented locally on, for example, wearable device **5902** or device **5904**, or on a remote device (e.g., display **5910** (FIG. **59**)) that is in data communication with a given device. Various types of interface technologies may be used and are not limited to those shown and described. In yet other examples, the above-described process may be varied in order, steps, function, or other aspects, without limitation to the examples shown and described.

[0240] FIG. **64** illustrates yet another exemplary process for device-based activity classification using predictive feature analysis. Here, an exemplary process for feature interpretation as implemented by feature interpreter **6016** (FIG. **60**) is shown. In some examples, an indicator associated with a predictive feature (e.g., a signal detected by a sensor) is evaluated (**6402**). Once evaluated, an application such as a classifier (e.g., sleep module **6018**, motion module **6020**, activity module **6022**, and others) is identified (**6404**). Once identified the classifier (i.e., application) is invoked by feature interpreter **6016** to perform a further evaluation or data operation (e.g., compare or other data operation configured to algorithmically evaluate data to determine whether a rule or set of rules such as those managed by rules engine **6014** (FIG. **60**) should be applied in order to generate an activity classification) (**6406**). The above-described process may be varied in order, steps, function, or other aspects, without limitation to the examples shown and described.

[0241] FIG. **65** illustrates an exemplary computer system suitable for device-based activity classification using predictive feature analysis. In some examples, computer system **6500** may be used to implement computer programs, applications, methods, processes, or other software to perform the above-described techniques. Computer system **6500** includes a bus **6502** or other communication mechanism for communicating information, which interconnects subsystems and devices, such as processor **6504**, system memory **6506** (e.g., RAM), storage device **6508** (e.g., ROM), disk drive **6510** (e.g., magnetic or optical), communication interface **6512** (e.g., modem or Ethernet card), display **6514** (e.g., CRT, LED, LCD, plasma, OLED, etc.), input device **6516** (e.g., keyboard), and cursor control **6518** (e.g., mouse or trackball).

[0242] According to some examples, computer system **6500** performs specific operations by processor **6504** executing one or more sequences of one or more instructions stored in system memory **6506**. Such instructions may be read into system memory **6506** from another computer readable medium, such as static storage device **6508** or disk drive **6510**. In some examples, hard-wired circuitry may be used in place of or in combination with software instructions for implementation.

[0243] The term "computer readable medium" refers to any tangible medium that participates in providing instructions to processor **6504** for execution. Such a medium may take many forms, including but not limited to, non-volatile media and volatile media. Non-volatile media includes, for example, optical or magnetic disks, such as disk drive **6510**. Volatile media includes dynamic memory, such as system memory **6506**.

[0244] Common forms of computer readable media includes, for example, floppy disk, flexible disk, hard disk, magnetic tape, any other magnetic medium, CD-ROM, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, RAM, PROM, EPROM, FLASH-EPROM, any other memory chip or cartridge, or any other medium from which a computer can read.

[0245] Instructions may further be transmitted or received using a transmission medium. The term "transmission medium" may include any tangible or intangible medium that is capable of storing, encoding or carrying instructions for execution by the machine, and includes digital or analog communications signals or other intangible medium to facilitate communication of such instructions. Transmission media includes coaxial cables, copper wire, and fiber optics, including wires that comprise bus **6502** for transmitting a computer data signal.

[0246] In some examples, execution of the sequences of instructions may be performed by a single computer system **6500**. According to some examples, two or more computer systems **6500** coupled by communication link **6520** (e.g., LAN, PSTN, or wireless network) may perform the sequence of instructions in coordination with one another. Computer system **6500** may transmit and receive messages, data, and instructions, including program, i.e., application code, through communication link **6520** and communication interface **6512**. Received program code may be executed by processor **6504** as it is received, and/or stored in disk drive **6510**, or other non-volatile storage for later execution

[0247] Although the foregoing examples have been described in some detail for purposes of clarity of understanding, the above-described inventive techniques are not limited to the details provided. There are many alternative ways of implementing the above-described invention techniques. The disclosed examples are illustrative and not restrictive.

What is claimed:

1. A method, comprising:

receiving a signal from a sensor coupled to a device, the sensor being configured to detect the signal over a time period and to detect motion;

evaluating the signal to generate data, the data being used to indicate motion, the data being further evaluated to select a classifier based on whether the motion is detected;

activating another sensor coupled to the device, the another sensor being configured to detect another signal that is substantially different than the signal, the another signal being used to generate other data associated with whether the motion is detected;

invoking the classifier, the classifier being configured to evaluate a predictive feature to identify a type associated with whether the motion is detected, the predictive feature invoking an application configured to determine the type and a state using a feature interpreter; and

processing the data using the application and the feature interpreter to generate information associated with a biological state associated with whether the motion is detected, the information being configured to display on an interface associated with the device.

2. The method of claim **1**, further comprising determining whether the signal indicates the motion.

3. The method of claim **1**, wherein the sensor is configured to detect bioimpedance.

4. The method of claim **1**, wherein the sensor is an accelerometer.

5. The method of claim **1**, wherein the sensor is an accelerometer and the another sensor is configured to detect bioimpedance.

6. The method of claim **1**, further comprising determining whether the data indicates the motion.

7. The method of claim **1**, further comprising applying a rule to the data to select an operation to perform, the operation being configured to use the signal or the another signal, wherein at least one of the signal or the another signal is configured to detect bioimpedance.

8. The method of claim **1**, further comprising applying a first rule to the data to invoke an operation to perform, wherein a result of the applying the first rule to the data determines a second rule that invokes another operation to perform using the data.

9. The method of claim **1**, further comprising applying a rule to the data to invoke an operation to perform, wherein a result of the applying the rule determines a second rule that invokes another operation to perform using the data.

10. The method of claim **1**, further comprising applying a rule to the data and another rule to the other data.

11. The method of claim **1**, wherein the sensor is an accelerometer configured to detect the motion and the another sensor is configured to detect bioimpedance, wherein the other data is generated to indicate a heart rate.

12. The method of claim **1**, wherein the sensor is configured to detect a heart rate using bioimpedance and the another sensor is configured to detect a respiration rate using bioimpedance.

13. The method of claim **1**, further comprising using an electrode associated with the sensor to detect the signal and using another electrode associated with the another sensor to detect the another signal using bioimpedance, wherein the data and the other data are used to identify the state comprises motion and the type comprises walking.

14. The method of claim **1**, further comprising using an electrode associated with the sensor to detect the signal and using another electrode associated with the another sensor to detect the another signal using bioimpedance, wherein the data and the other data are used to identify the state and the type, wherein the state comprises motion and the type comprises running.

15. The method of claim **1**, further comprising using an electrode associated with the sensor to detect the signal and using another electrode associated with the another sensor to detect the another signal using bioimpedance, wherein the data and the other data are used to identify the state and the type, wherein the state comprises a step and the type comprises walking.

16. The method of claim **1**, wherein the signal indicates motion and the data is used to activate the another sensor, wherein the another sensor is configured to detect a heart rate.

17. The method of claim **1**, wherein the signal indicates a step and the data is used to activate the another sensor, wherein the another signal detected by the another sensor is configured to detect a respiration rate using bioimpedance.

18. The method of claim **1**, wherein the signal indicates a step and the data is used to activate the another sensor, wherein the another signal detected by the another sensor is configured to detect the another signal associated with bioimpedance, the another signal being evaluated by the classifier to identify a heart rate.

19. A system, comprising:

a memory configured to store data generated by evaluating a signal detected by a sensor and other data generated by evaluating another signal detected by another sensor, the sensor and the another sensor being coupled to a device; and

a processor configured to receive the signal from the sensor coupled to the device, the sensor being configured to detect the signal over a time period and to detect motion, to evaluate the signal to generate the data, the data being used to indicate motion, the data being further evaluated to select a classifier based on whether the motion is detected, to activate the another sensor coupled to the device, the another sensor being configured to detect the another signal that is substantially different than the signal, the another signal being used to generate the other data associated with whether the motion is detected, to invoke the classifier, the classifier being configured to evaluate a predictive feature to identify a type associated with whether the motion is detected, the predictive feature invoking an application configured to determine the type and a state using a feature interpreter, and to process the data using the application and the feature interpreter to generate information associated with a biological state associated with whether the motion is detected, the information being configured to display on an interface associated with the device.

20. A computer readable medium including instructions for performing a method, the method comprising:

receiving a signal from a sensor coupled to a device, the sensor being configured to detect the signal over a time period and to detect motion;

evaluating the signal to generate data, the data being used to indicate motion, the data being further evaluated to select a classifier based on whether the motion is detected;

activating another sensor coupled to the device, the another sensor being configured to detect another signal that is substantially different than the signal, the another signal being used to generate other data associated with whether the motion is detected;

invoking the classifier, the classifier being configured to evaluate a predictive feature to identify a type associated with whether the motion is detected, the predictive feature invoking an application configured to determine the type and a state using a feature interpreter; and processing the data using the application and the feature interpreter to generate information associated with a biological state associated with whether the motion is detected, the information being configured to display on an interface associated with the device.

* * * * *

专利名称(译)	使用预测特征分析的基于设备的活动分类		
公开(公告)号	[US20160066859A1](US20160066859A1)	公开(公告)日	2016-03-10
申请号	US14/121941	申请日	2014-11-05
[标]申请(专利权)人(译)	CRAWFORD STUART SAVALIA PIYUSH PANCHALAN普拉萨德 成希尔维亚后燕 辛格尔顿CHRIS NABANJA希拉 MOHAMMAD ILYAS SHARMA SUMIT		
申请(专利权)人(译)	克劳福德STUART SAVALIA，PIYUSH PANCHALAN，普拉萨德 程，希尔维亚hou-yan 辛格尔顿，CHRIS NABANJA希拉 MOHAMMAD，ILYAS SHARMA，SUMIT		
当前申请(专利权)人(译)	Alifak		
[标]发明人	CRAWFORD STUART SAVALIA PIYUSH PANCHALAN PRASAD CHENG SYLVIA HOU YAN SINGLETON CHRIS NABANJA SHEILA MOHAMMAD ILYAS SHARMA SUMIT		
发明人	CRAWFORD, STUART SAVALIA, PIYUSH PANCHALAN, PRASAD CHENG, SYLVIA HOU-YAN SINGLETON, CHRIS NABANJA, SHEILA MOHAMMAD, ILYAS SHARMA, SUMIT		
IPC分类号	A61B5/00 A61B5/0205		
CPC分类号	A61B5/7264 A61B5/7275 A61B5/7278 A61B5/0205 A61B5/742 A61B5/7475 A61B2560/0475 A61B2562/0219 A61B5/024 A61B5/053 A61B5/1123 A61B5/0816 A61B2562/0214 A61B5/681 A61B5/02055 A61B5/021 A61B5/02438 A61B5/0404 A61B5/0531 A61B5/0533 G16H50/20		
外部链接	Espacenet USPTO		

摘要(译)

描述了使用预测特征分析的基于设备的活动分类，包括从耦合到设备的传感器接收信号，传感器被配置为在一段时间内检测信号并检测运动，评估信号以生成数据，数据用于指示运动，进一步评估数据以基于是否检测到运动来选择分类器，激活耦合到设备的另一传感器，另一传感器被配置为检测与信号基本上不同的另一信号，另一传感器信号用于生成与是否检测到运动相关联的其他数

据，调用分类器，分类器被配置为评估预测特征以识别与是否检测到运动相关联的类型，预测特征调用被配置为确定运动的应用。使用特征解释器输入类型和状态，并使用应用程序处理数据并且特征解释器生成与与是否检测到运动相关联的生物状态相关联的信息，该信息被配置为显示在与设备相关联的接口上。