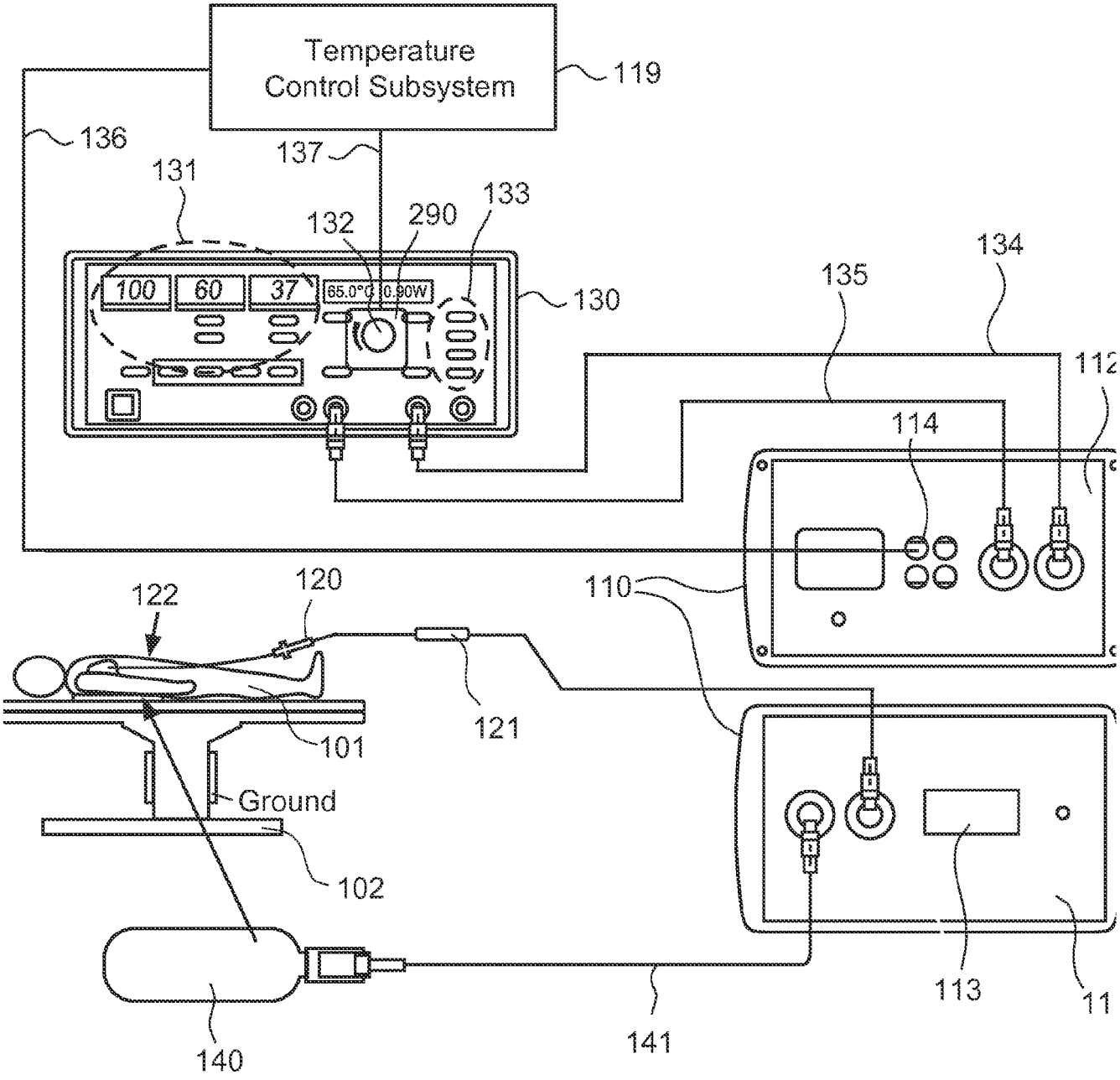

Temperature
Control Subsystem
119
136
137
131
132
290
133
134
135
130
100
60
37
65.0°C
0.90W
112
114
110
122
120
121
101
Ground
102
140
141
113
11

FIG. 1A

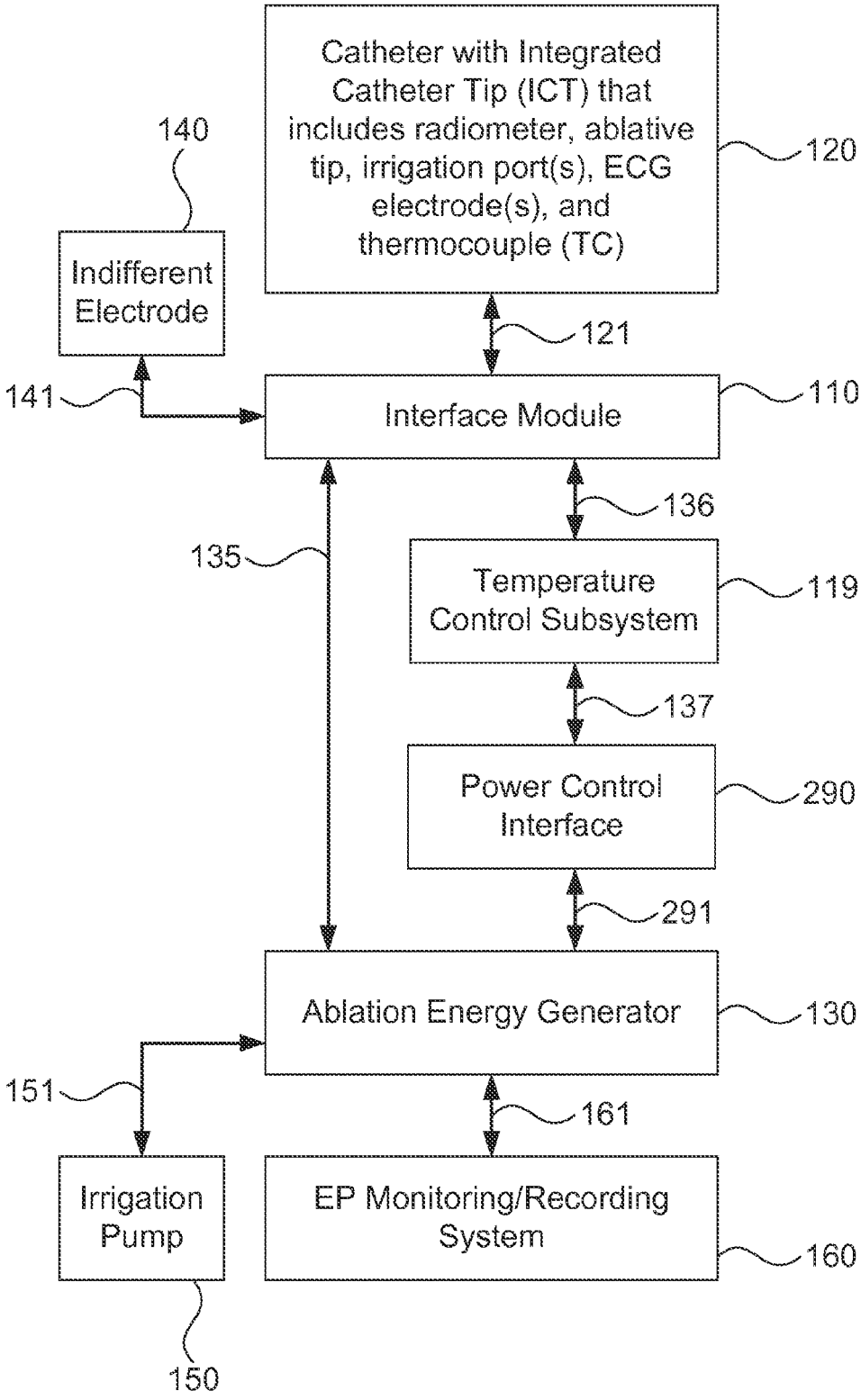

Catheter with Integrated Catheter Tip (ICT) that includes radiometer, ablative tip, irrigation port(s), ECG electrode(s), and thermocouple (TC)
120
140
Indifferent Electrode
121
141
Interface Module
110
136
135
Temperature Control Subsystem
119
137
Power Control Interface
290
291
Ablation Energy Generator
130
151
161
Irrigation Pump
EP Monitoring/Recording System
160
150

FIG. 1B

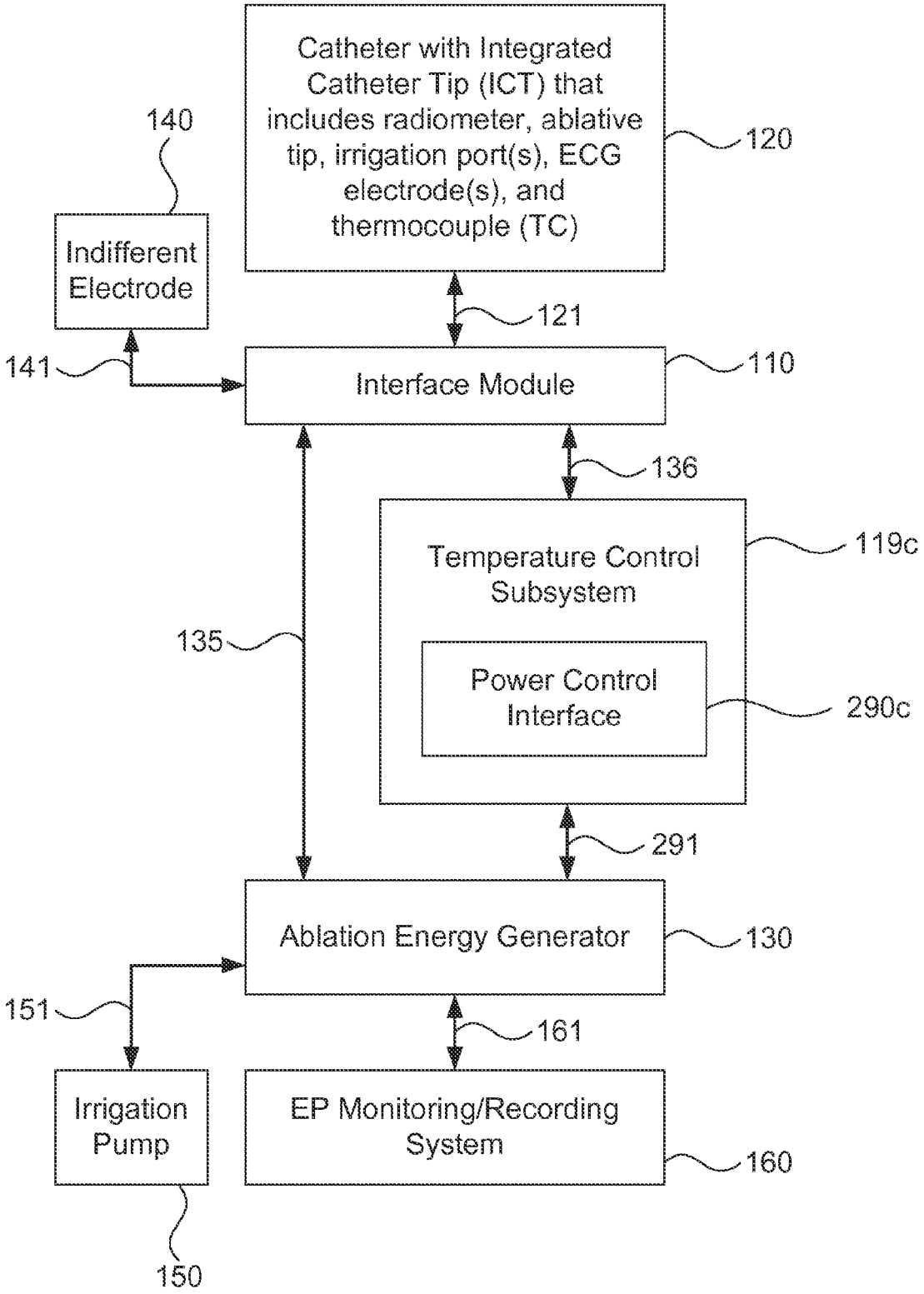

Catheter with Integrated Catheter Tip (ICT) that includes radiometer, ablative tip, irrigation port(s), ECG electrode(s), and thermocouple (TC)
120
140
Indifferent Electrode
121
141
Interface Module
110
136
Temperature Control Subsystem
119c
135
Power Control Interface
290c
291
Ablation Energy Generator
130
151
161
Irrigation Pump
EP Monitoring/Recording System
160
150

FIG. 1C

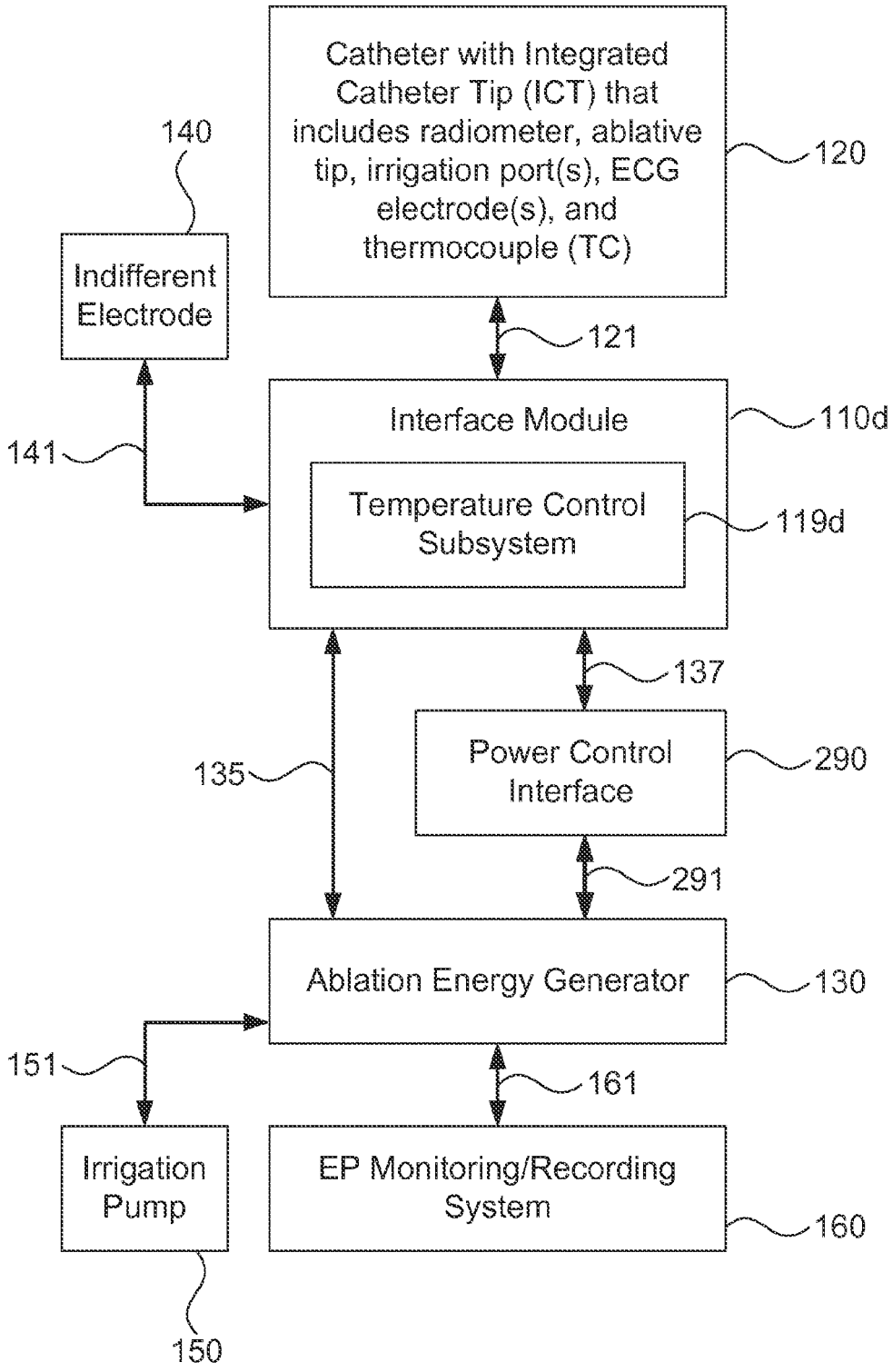

Catheter with Integrated Catheter Tip (ICT) that includes radiometer, ablative tip, irrigation port(s), ECG electrode(s), and thermocouple (TC)
120
140
Indifferent Electrode
121
Interface Module
110d
141
Temperature Control Subsystem
119d
137
135
Power Control Interface
290
291
Ablation Energy Generator
130
151
161
Irrigation Pump
EP Monitoring/Recording System
160
150

FIG. 1D

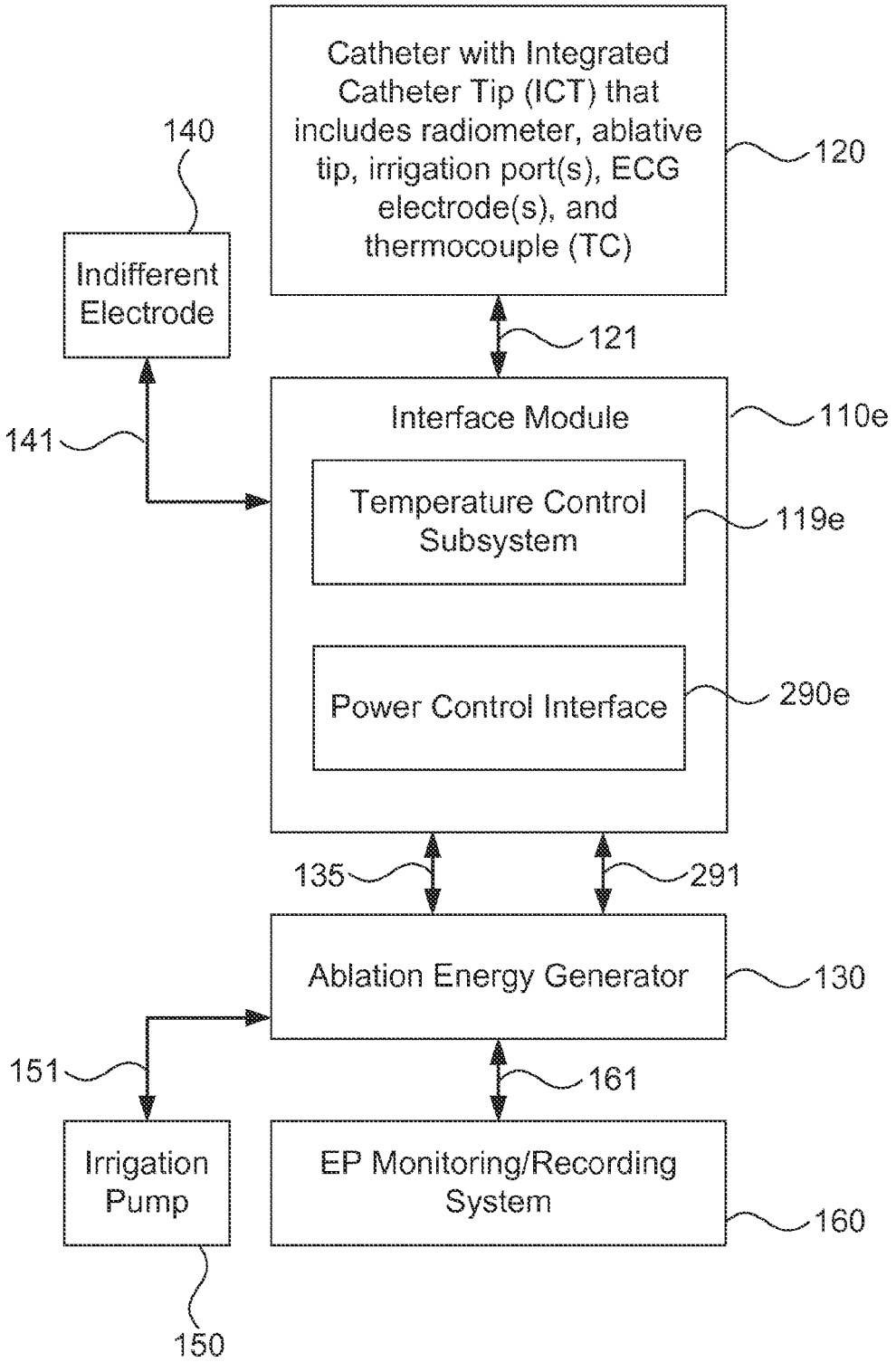

Catheter with Integrated Catheter Tip (ICT) that includes radiometer, ablative tip, irrigation port(s), ECG electrode(s), and thermocouple (TC)
120
140
Indifferent Electrode
121
Interface Module
110e
141
Temperature Control Subsystem
119e
Power Control Interface
290e
135
291
Ablation Energy Generator
130
151
161
Irrigation Pump
EP Monitoring/Recording System
160
150

FIG. 1E

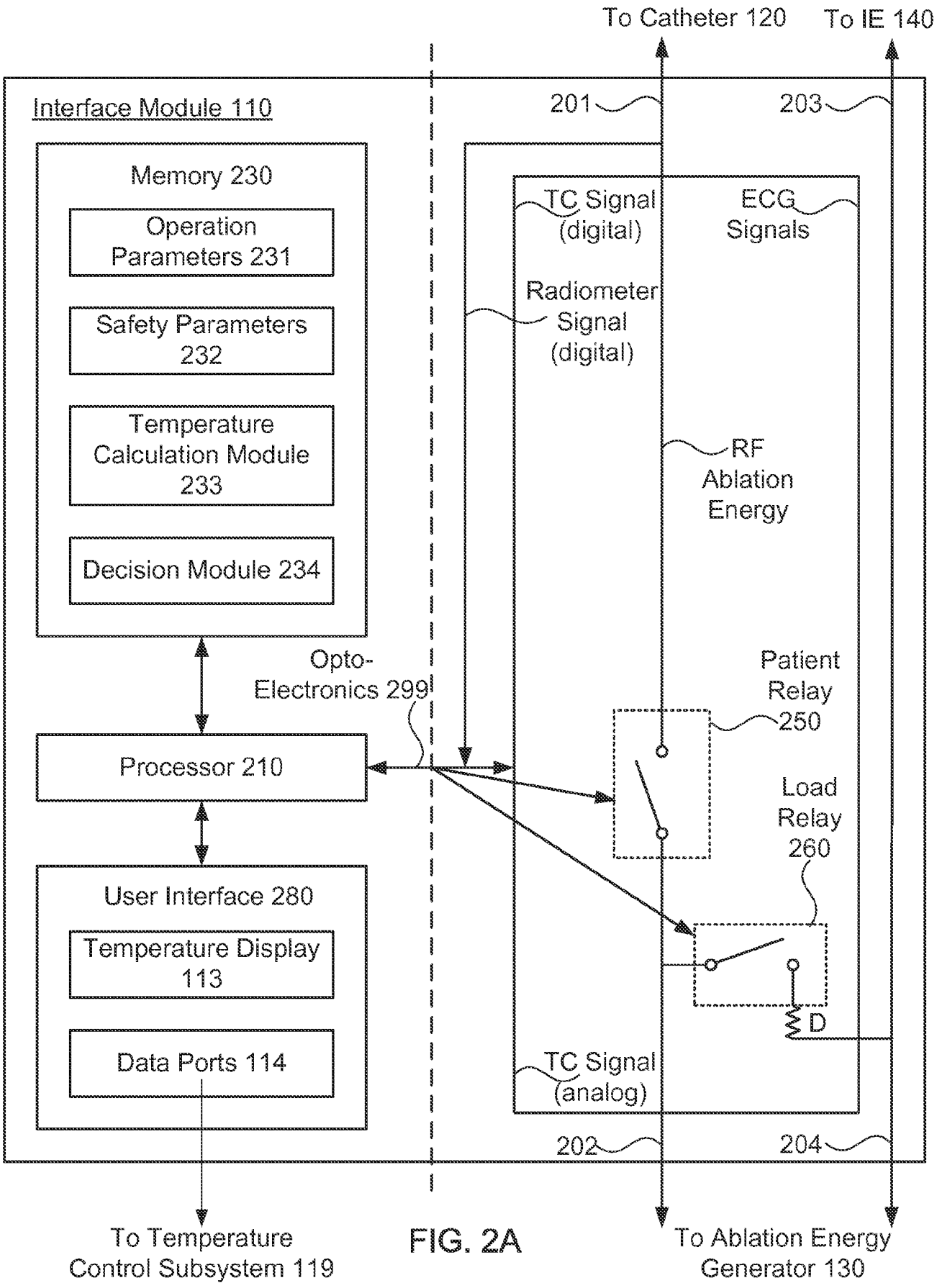

To Catheter 120
To IE 140
Interface Module 110
201
203
Memory 230
Operation Parameters 231
Safety Parameters 232
Temperature Calculation Module 233
Decision Module 234
TC Signal (digital)
ECG Signals
Radiometer Signal (digital)
RF Ablation Energy
Opto-Electronics 299
Patient Relay 250
Processor 210
Load Relay 260
User Interface 280
Temperature Display 113
Data Ports 114
D
TC Signal (analog)
202
204
To Temperature Control Subsystem 119
To Ablation Energy Generator 130

FIG. 2A

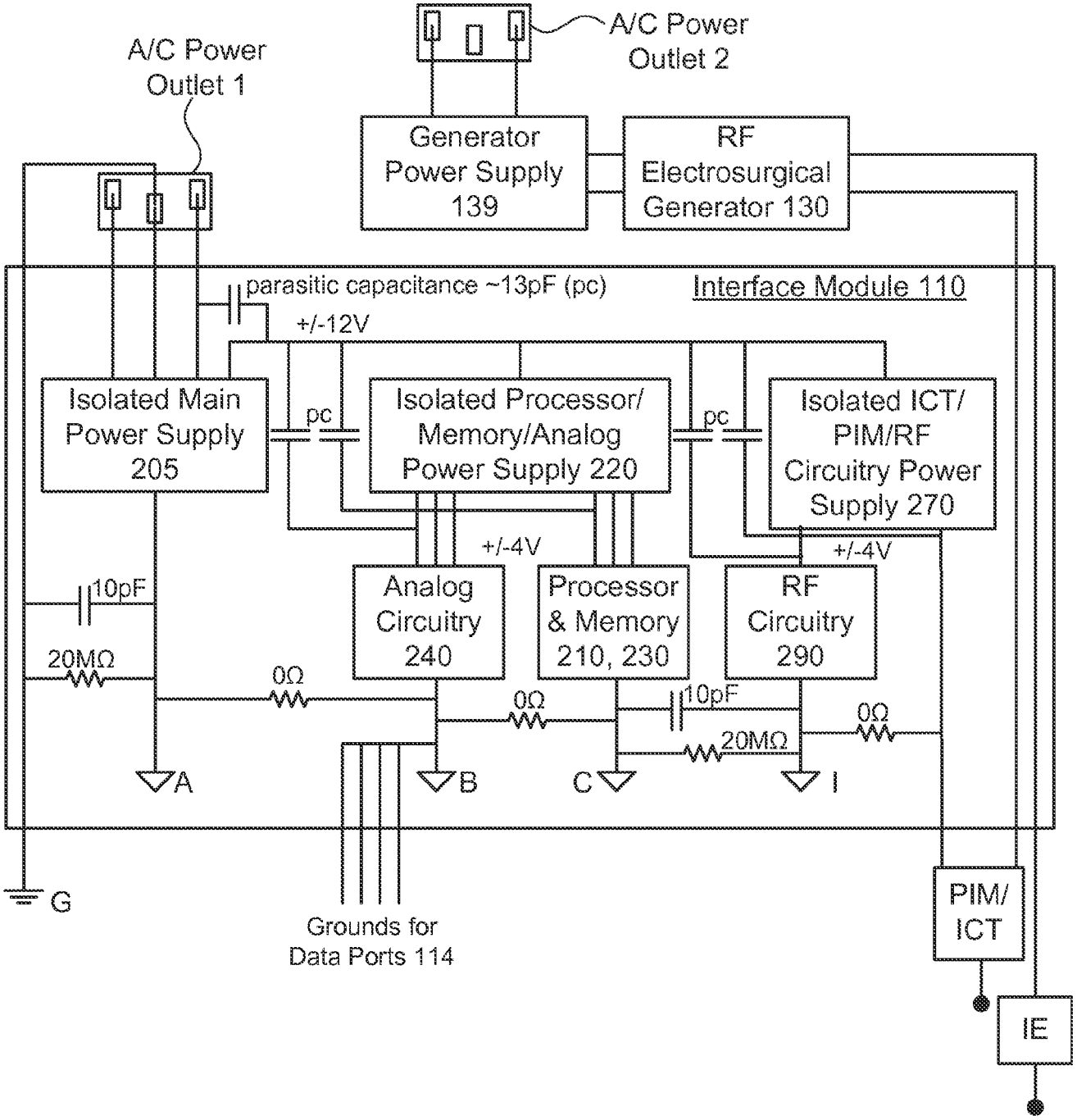

A/C Power Outlet 1
A/C Power Outlet 2
Generator Power Supply 139
RF Electrosurgical Generator 130
parasitic capacitance ~13pF (pc)
Interface Module 110
+/-12V
Isolated Main Power Supply 205
pc
Isolated Processor/ Memory/Analog Power Supply 220
pc
Isolated ICT/ PIM/RF Circuitry Power Supply 270
+/-4V
+/-4V
10pF
20MΩ
Analog Circuitry 240
Processor & Memory 210, 230
RF Circuitry 290
0Ω
0Ω
10pF
20MΩ
0Ω
A
B
C
I
G
Grounds for Data Ports 114
PIM/ ICT
IE

FIG. 2B

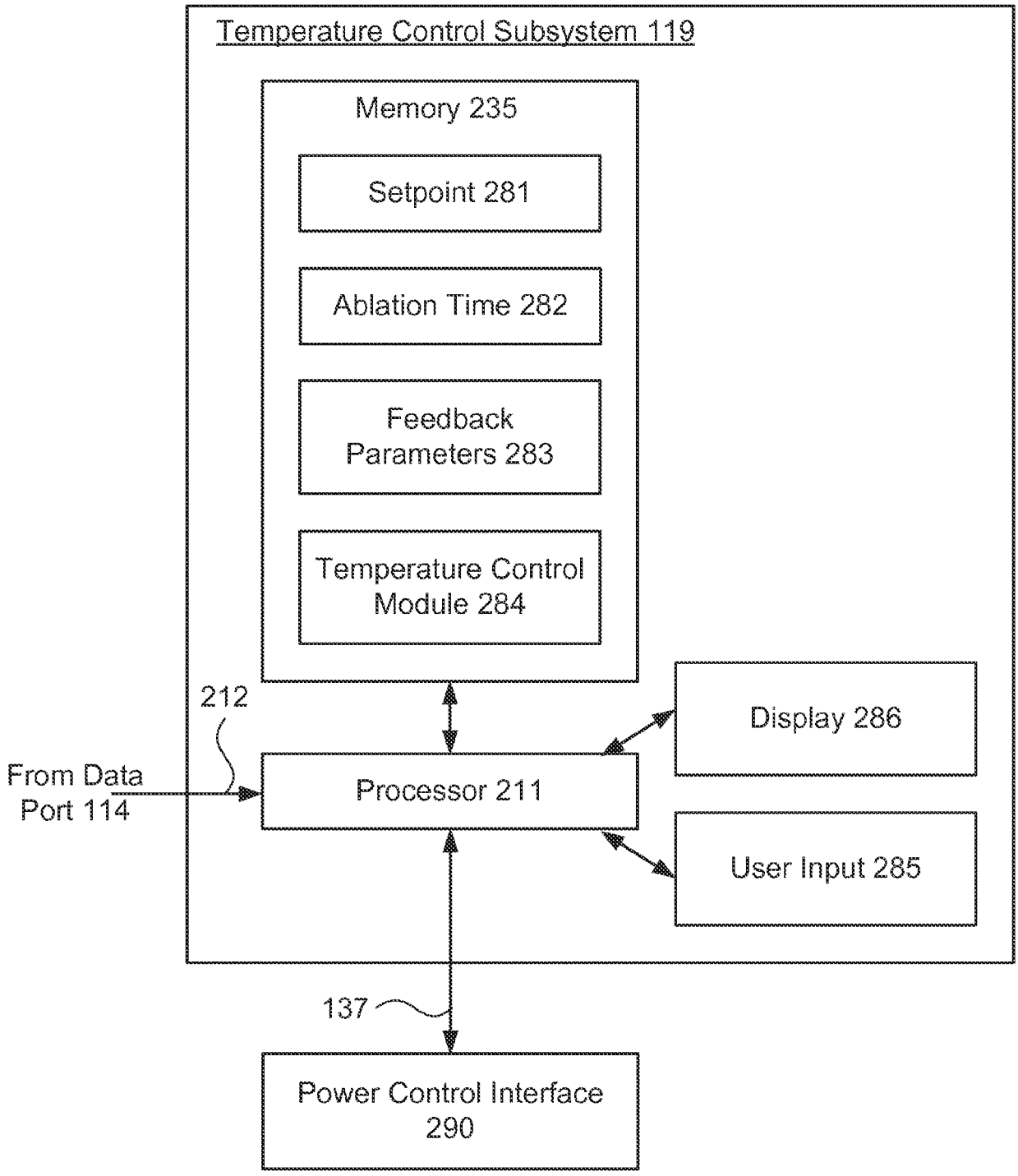

Temperature Control Subsystem 119
Memory 235
Setpoint 281
Ablation Time 282
Feedback Parameters 283
Temperature Control Module 284
212
From Data Port 114
Processor 211
Display 286
User Input 285
137
Power Control Interface 290

FIG. 2C

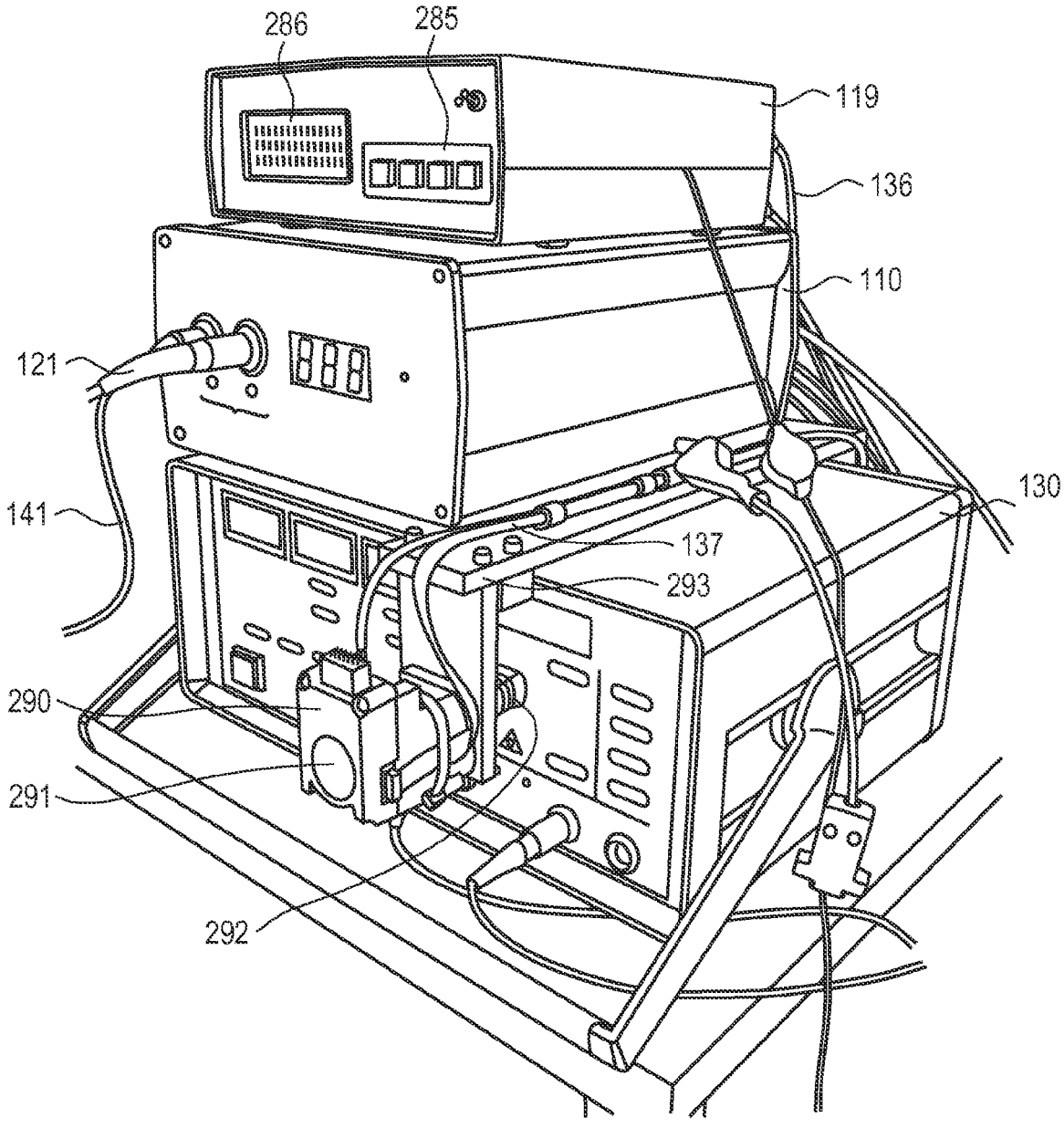


FIG. 2D

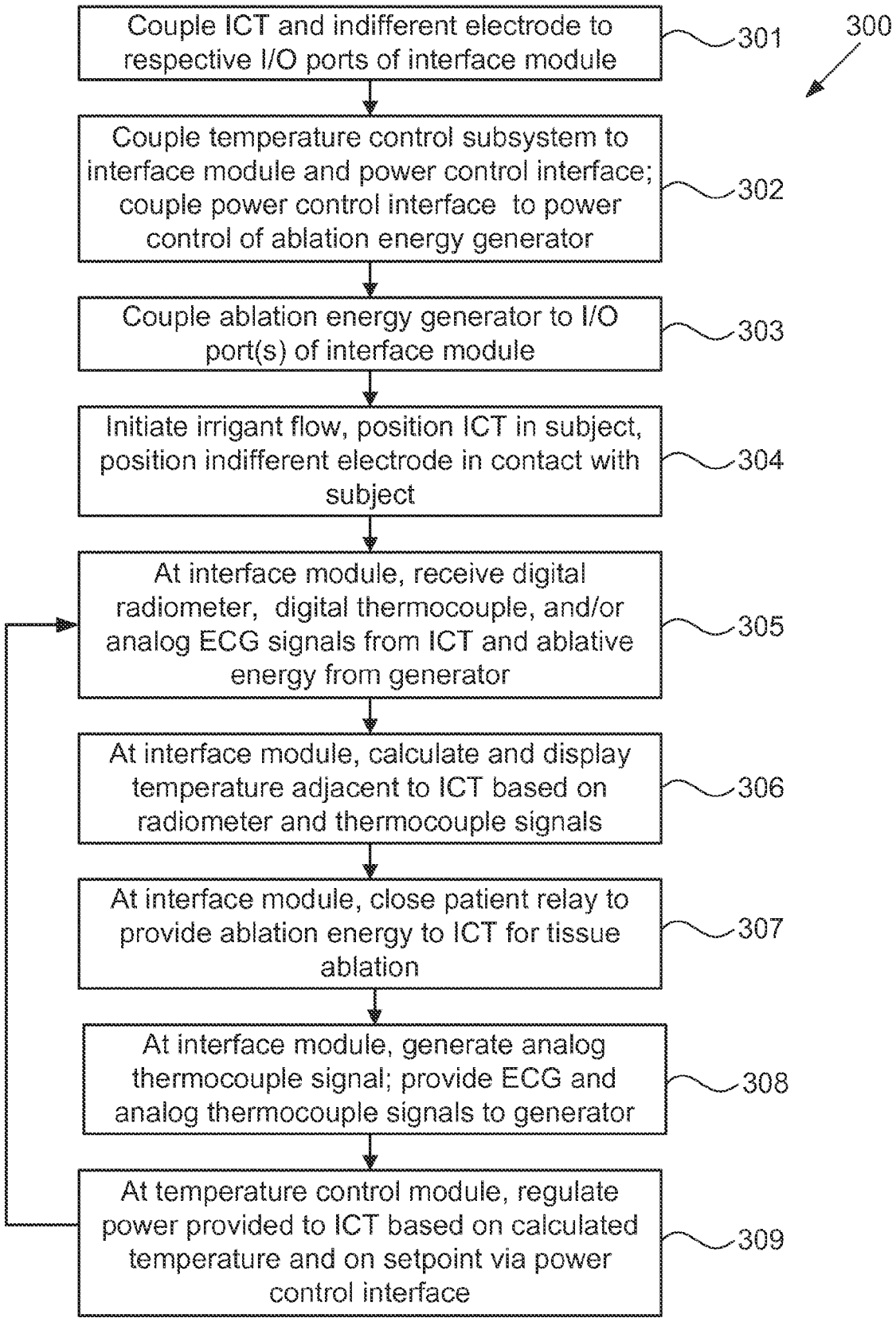

Couple ICT and indifferent electrode to respective I/O ports of interface module
301
300
Couple temperature control subsystem to interface module and power control interface; couple power control interface to power control of ablation energy generator
302
Couple ablation energy generator to I/O port(s) of interface module
303
Initiate irrigant flow, position ICT in subject, position indifferent electrode in contact with subject
304
At interface module, receive digital radiometer, digital thermocouple, and/or analog ECG signals from ICT and ablative energy from generator
305
At interface module, calculate and display temperature adjacent to ICT based on radiometer and thermocouple signals
306
At interface module, close patient relay to provide ablation energy to ICT for tissue ablation
307
At interface module, generate analog thermocouple signal; provide ECG and analog thermocouple signals to generator
308
At temperature control module, regulate power provided to ICT based on calculated temperature and on setpoint via power control interface
309

FIG. 3A

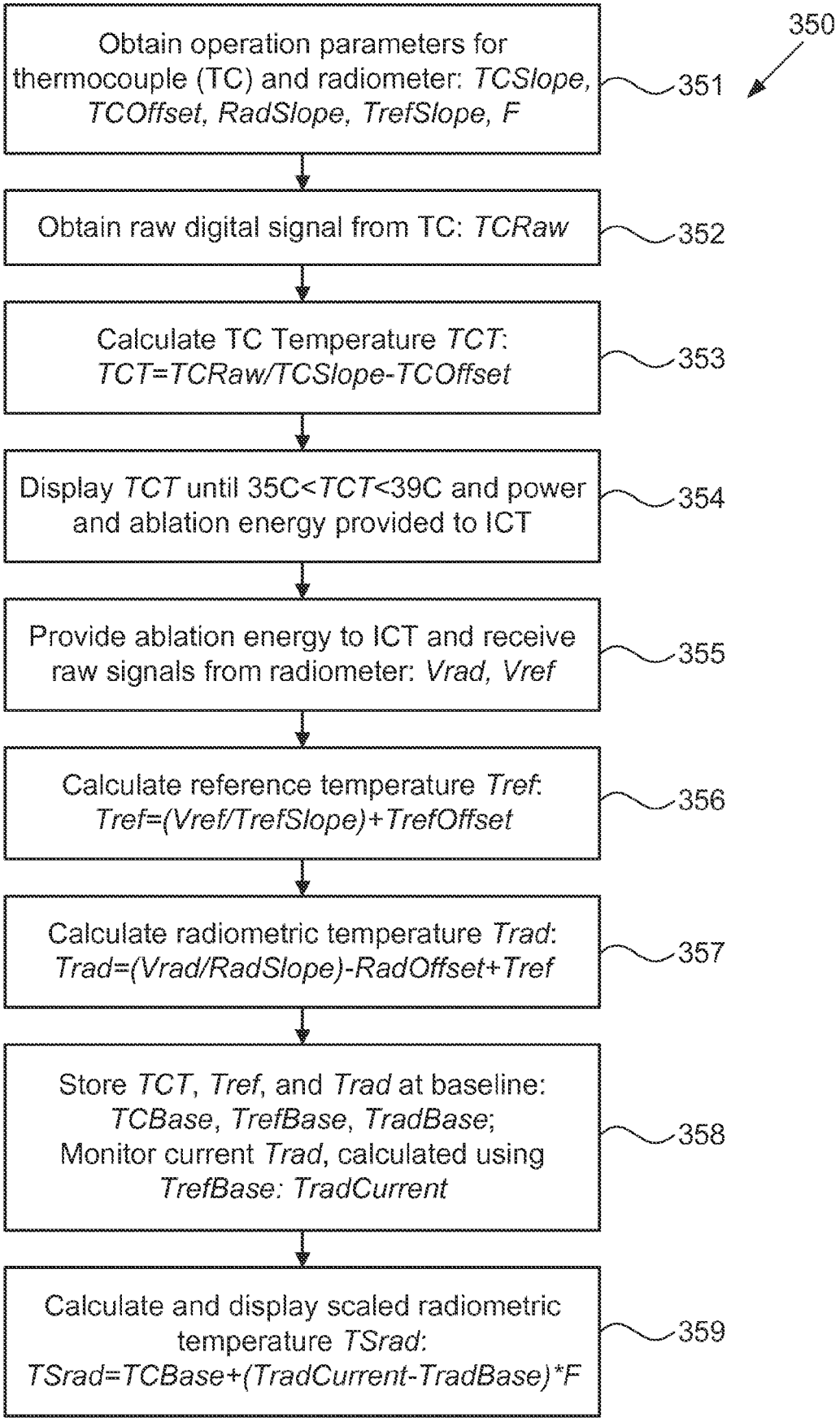

350
Obtain operation parameters for thermocouple (TC) and radiometer: *TCSlope*, *TCOffset*, *RadSlope*, *TrefSlope*, *F*
351
Obtain raw digital signal from TC: *TCRaw*
352
Calculate TC Temperature *TCT*: *TCT=TCRaw/TCSlope-TCOffset*
353
Display *TCT* until 35C<*TCT*<39C and power and ablation energy provided to ICT
354
Provide ablation energy to ICT and receive raw signals from radiometer: *Vrad*, *Vref*
355
Calculate reference temperature *Tref*: *Tref=(Vref/TrefSlope)+TrefOffset*
356
Calculate radiometric temperature *Trad*: *Trad=(Vrad/RadSlope)-RadOffset+Tref*
357
Store *TCT*, *Tref*, and *Trad* at baseline: *TCBase*, *TrefBase*, *TradBase*; Monitor current *Trad*, calculated using *TrefBase*: *TradCurrent*
358
Calculate and display scaled radiometric temperature *TSrad*: *TSrad=TCBase+(TradCurrent-TradBase)*F*
359

FIG. 3B

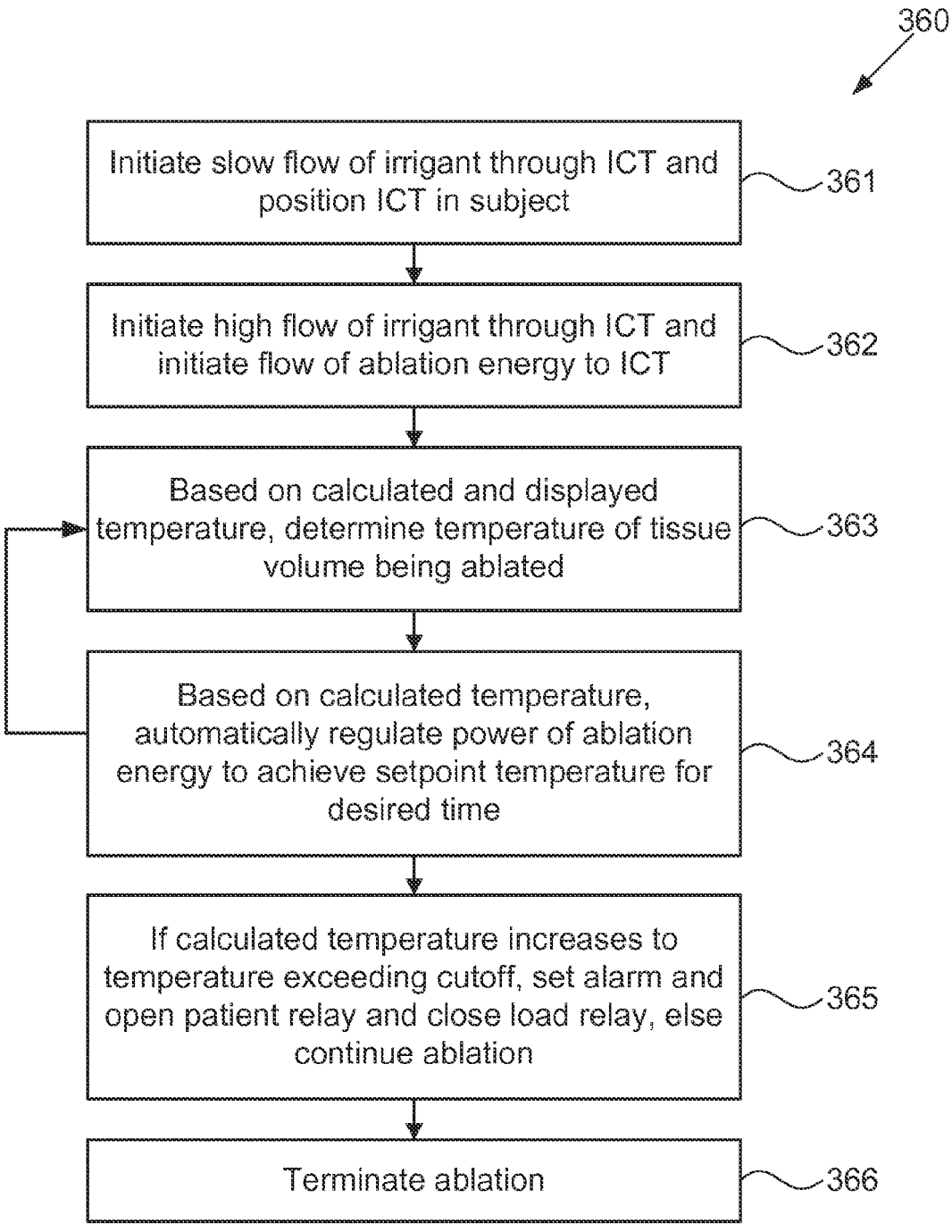

360
Initiate slow flow of irrigant through ICT and position ICT in subject
361
Initiate high flow of irrigant through ICT and initiate flow of ablation energy to ICT
362
Based on calculated and displayed temperature, determine temperature of tissue volume being ablated
363
Based on calculated temperature, automatically regulate power of ablation energy to achieve setpoint temperature for desired time
364
If calculated temperature increases to temperature exceeding cutoff, set alarm and open patient relay and close load relay, else continue ablation
365
Terminate ablation
366

FIG. 3C

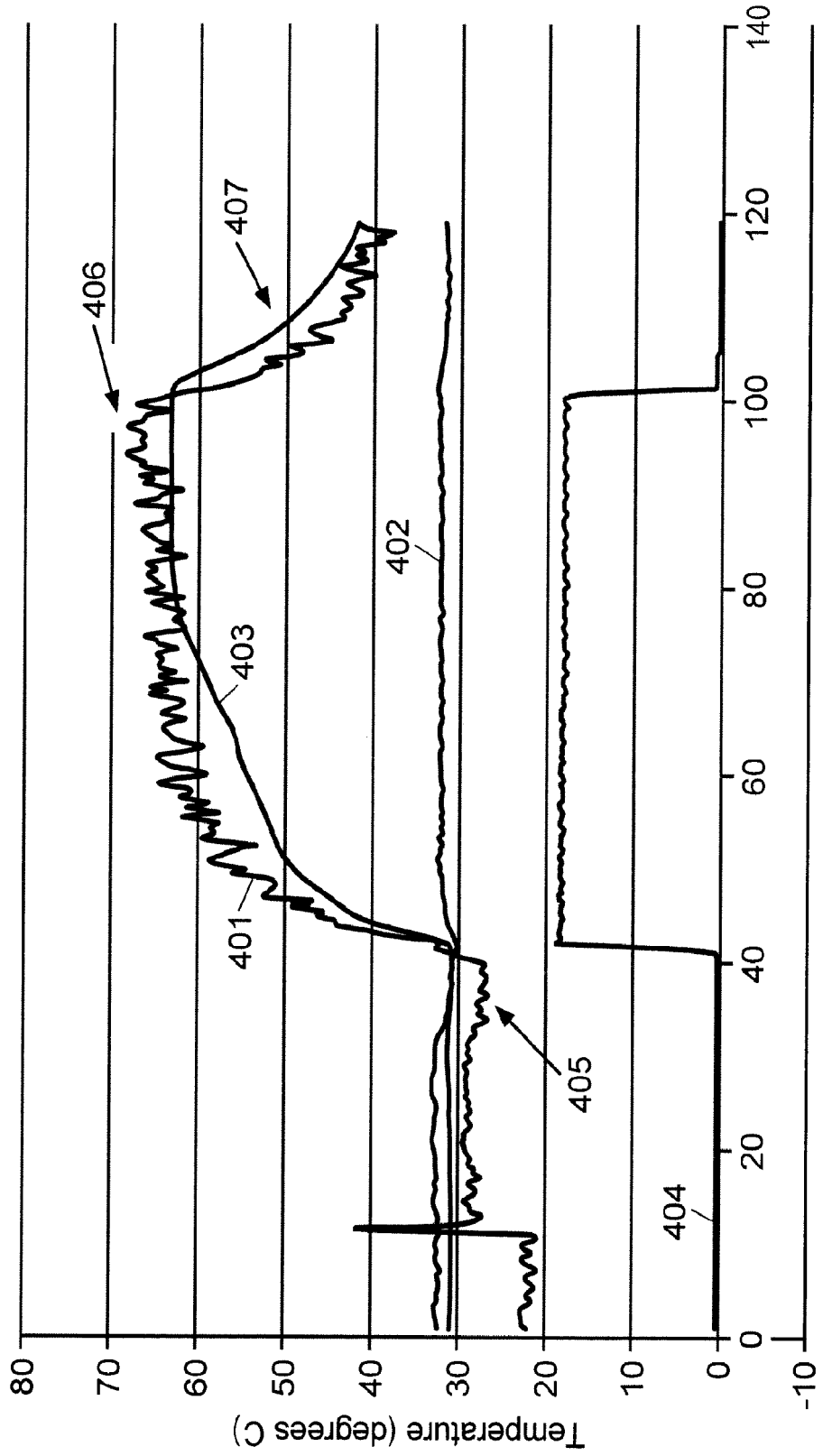

Temperature (degrees C)
80
70
60
50
40
30
20
10
0
-10
Time (seconds)
0
20
40
60
80
100
120
140
406
407
402
403
401
405
404

FIG. 4A

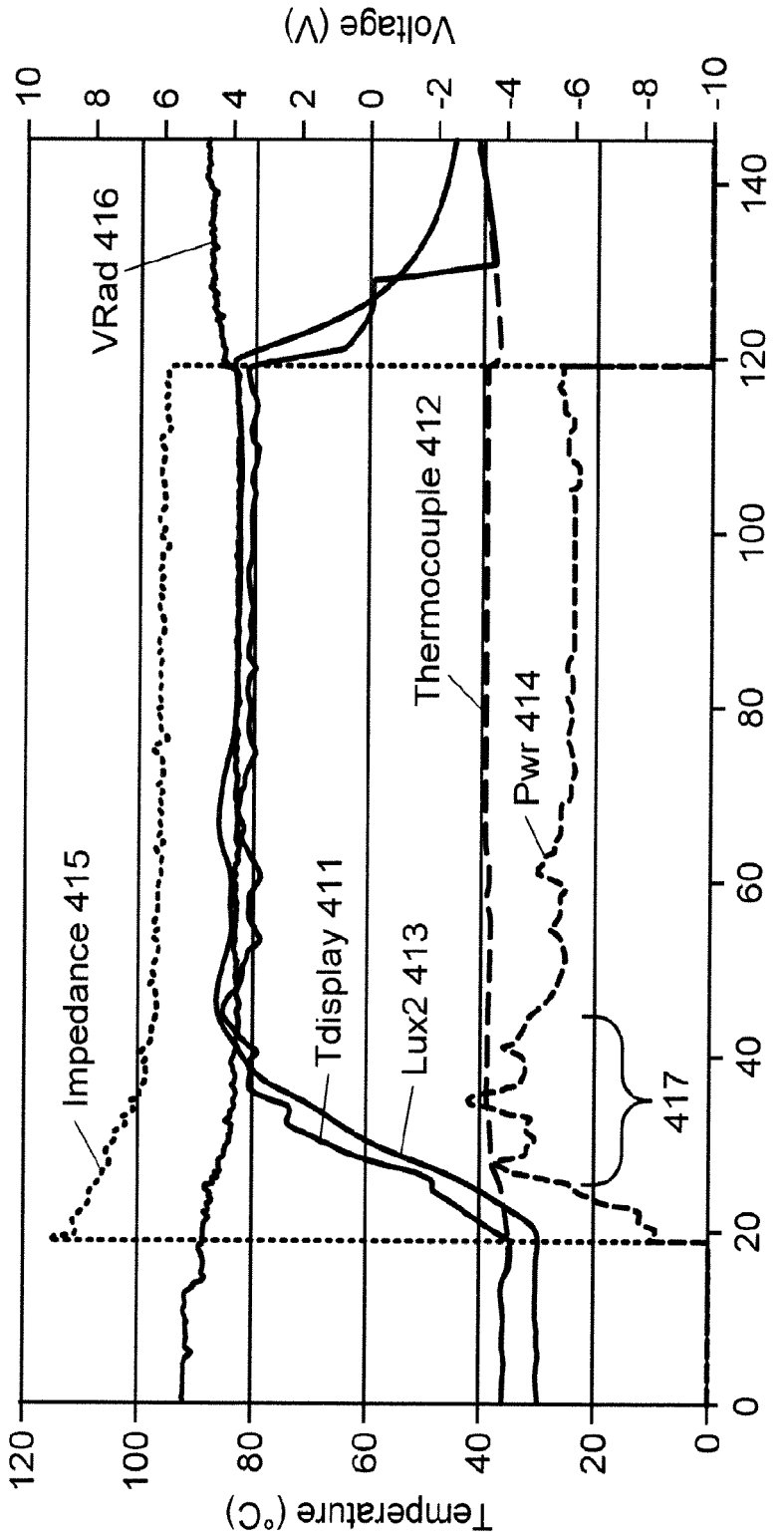

Voltage (V)
10
8
6
4
2
0
-2
-4
-6
-8
-10
VRad 416
Thermocouple 412
Pwr 414
Impedance 415
Tdisplay 411
Lux2 413
417
Temperature (°C)
120
100
80
60
40
20
0
0
20
40
60
80
100
120
140
Time (s)

FIG. 4B

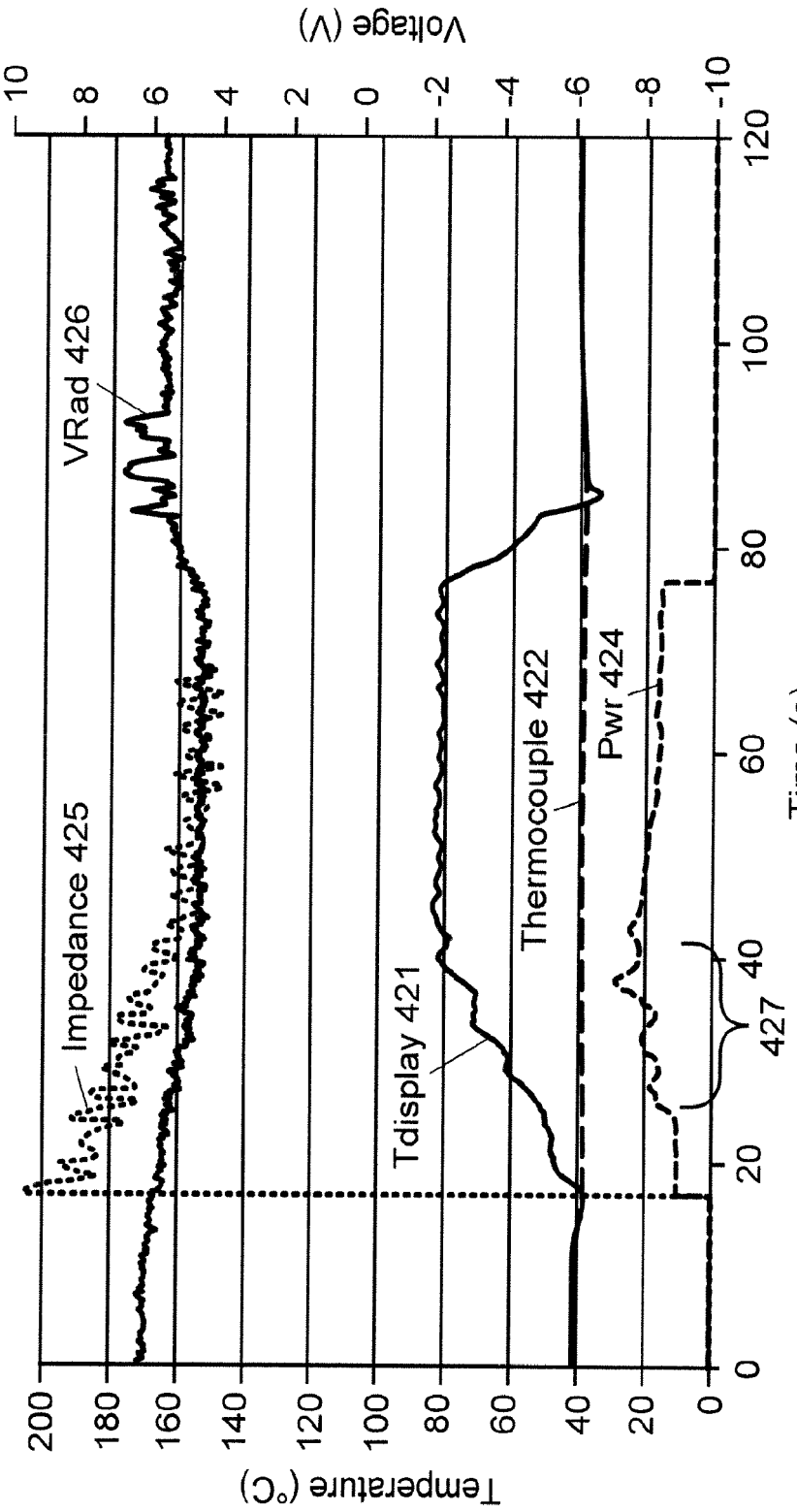

Voltage (V)
10
8
6
4
2
0
-2
-4
-6
-8
-10
120
100
80
60
40
20
0
Time (s)
VRad 426
Impedance 425
Tdisplay 421
Thermocouple 422
Pwr 424
427
Temperature (°C)
200
180
160
140
120
100
80
60
40
20
0

FIG. 4C

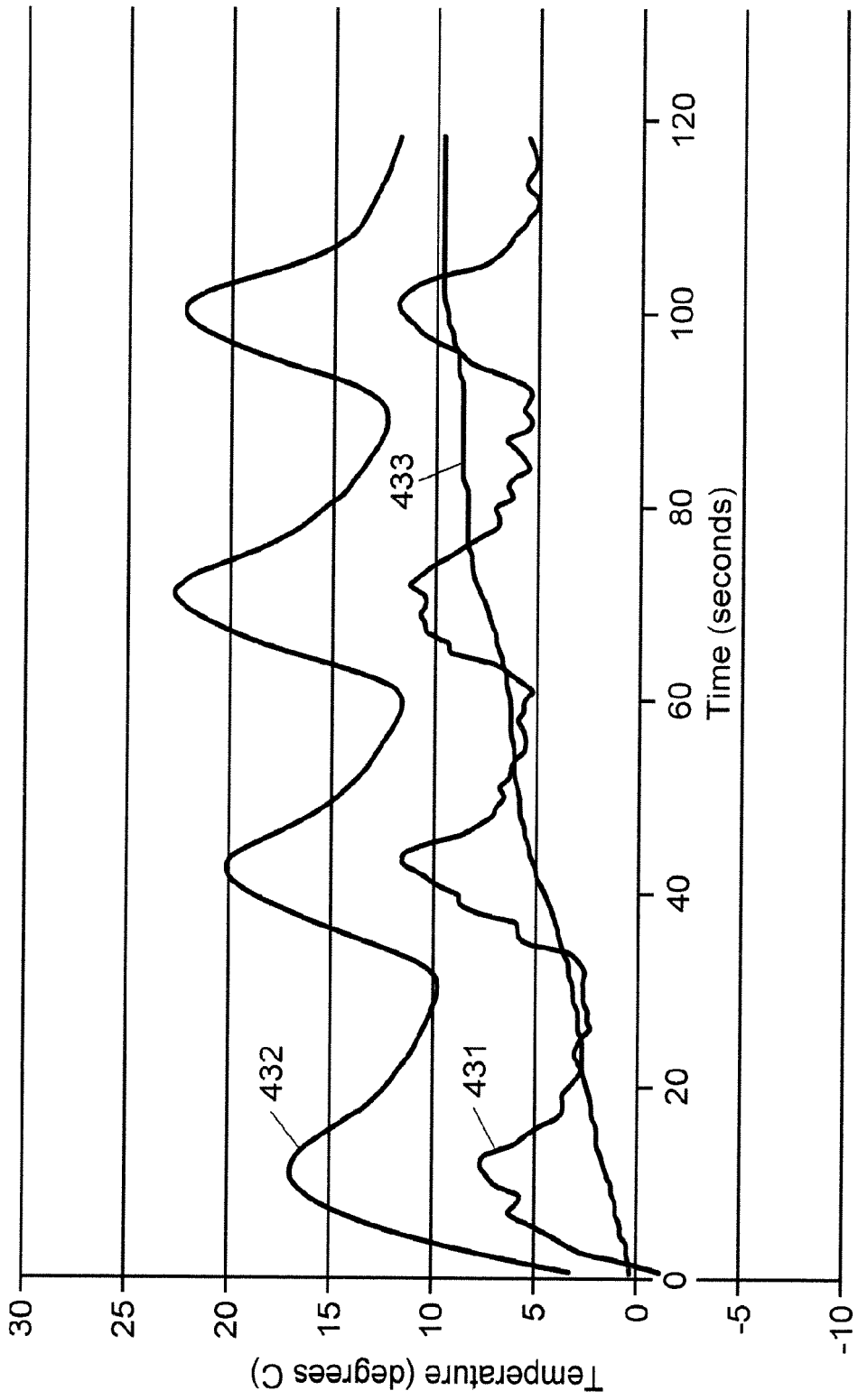

Temperature (degrees C)
30
25
20
15
10
5
0
-5
-10
0
20
40
60
80
100
120
Time (seconds)
431
432
433

FIG. 4D

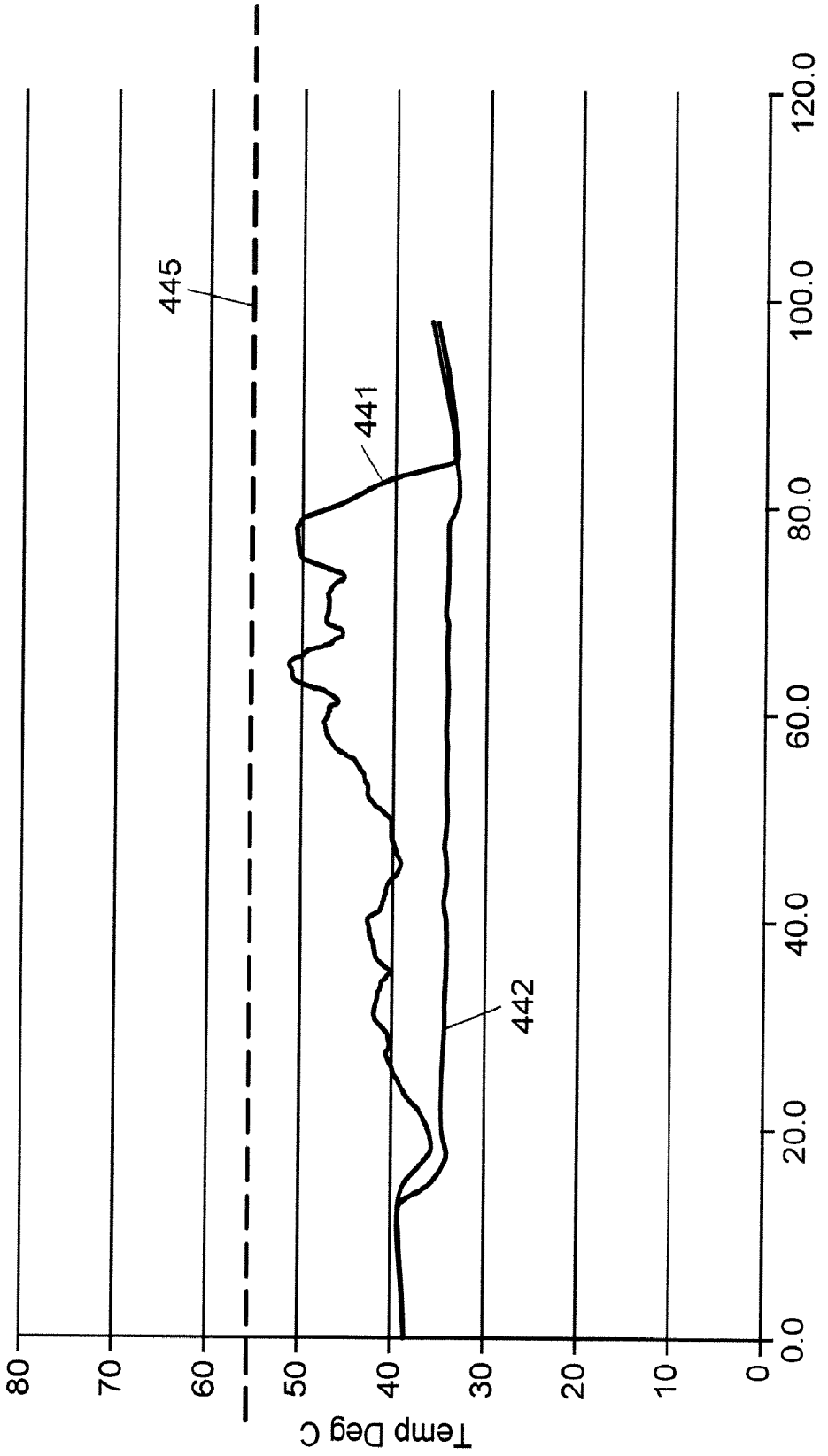

445
441
442
Temp Deg C
80
70
60
50
40
30
20
10
0
0.0
20.0
40.0
60.0
80.0
100.0
120.0
Time (sec)

FIG. 4E

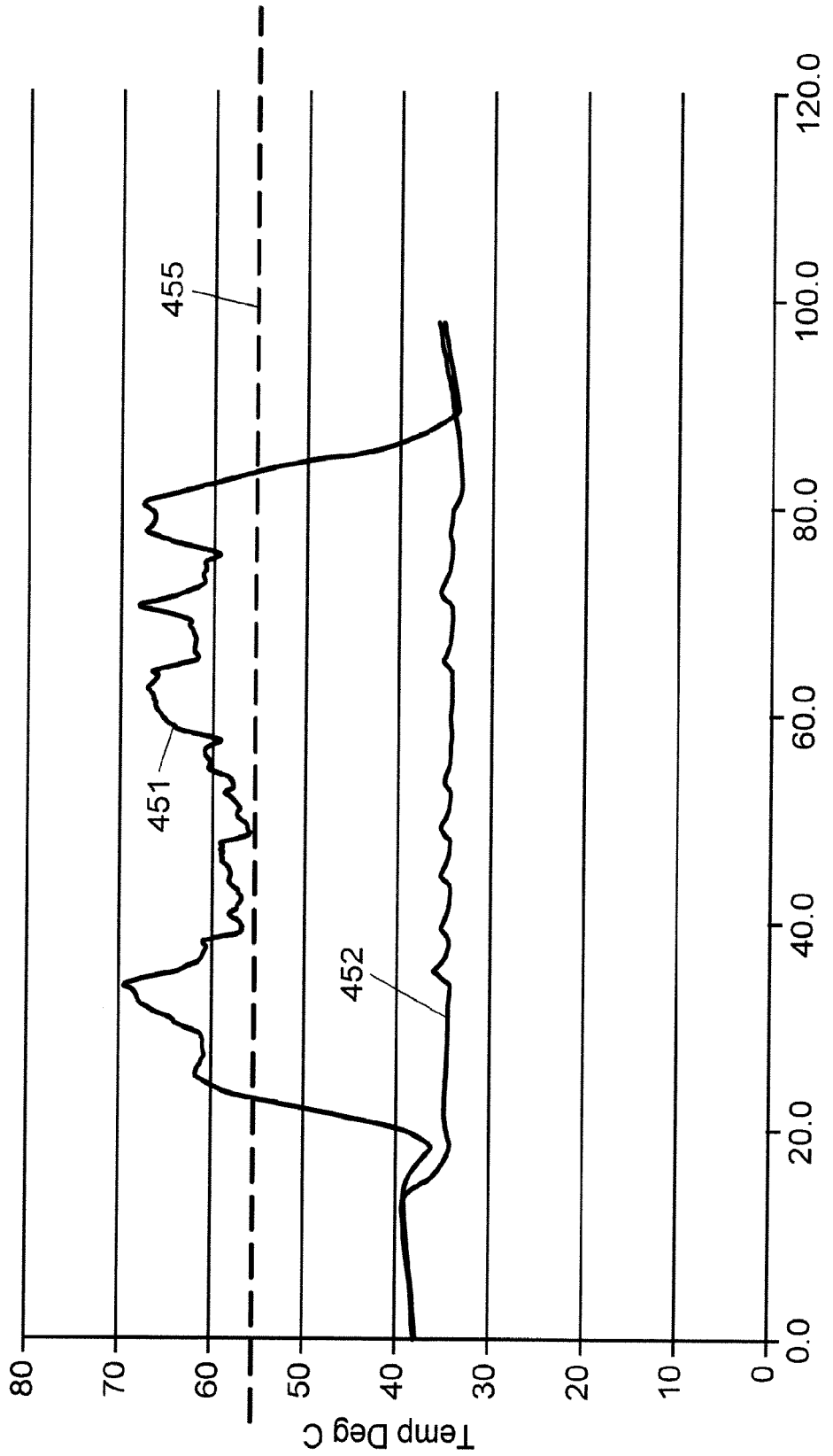

Temp Deg C
80
70
60
50
40
30
20
10
0
0.0
20.0
40.0
60.0
80.0
100.0
120.0
Time (sec)
455
451
452

FIG. 4F

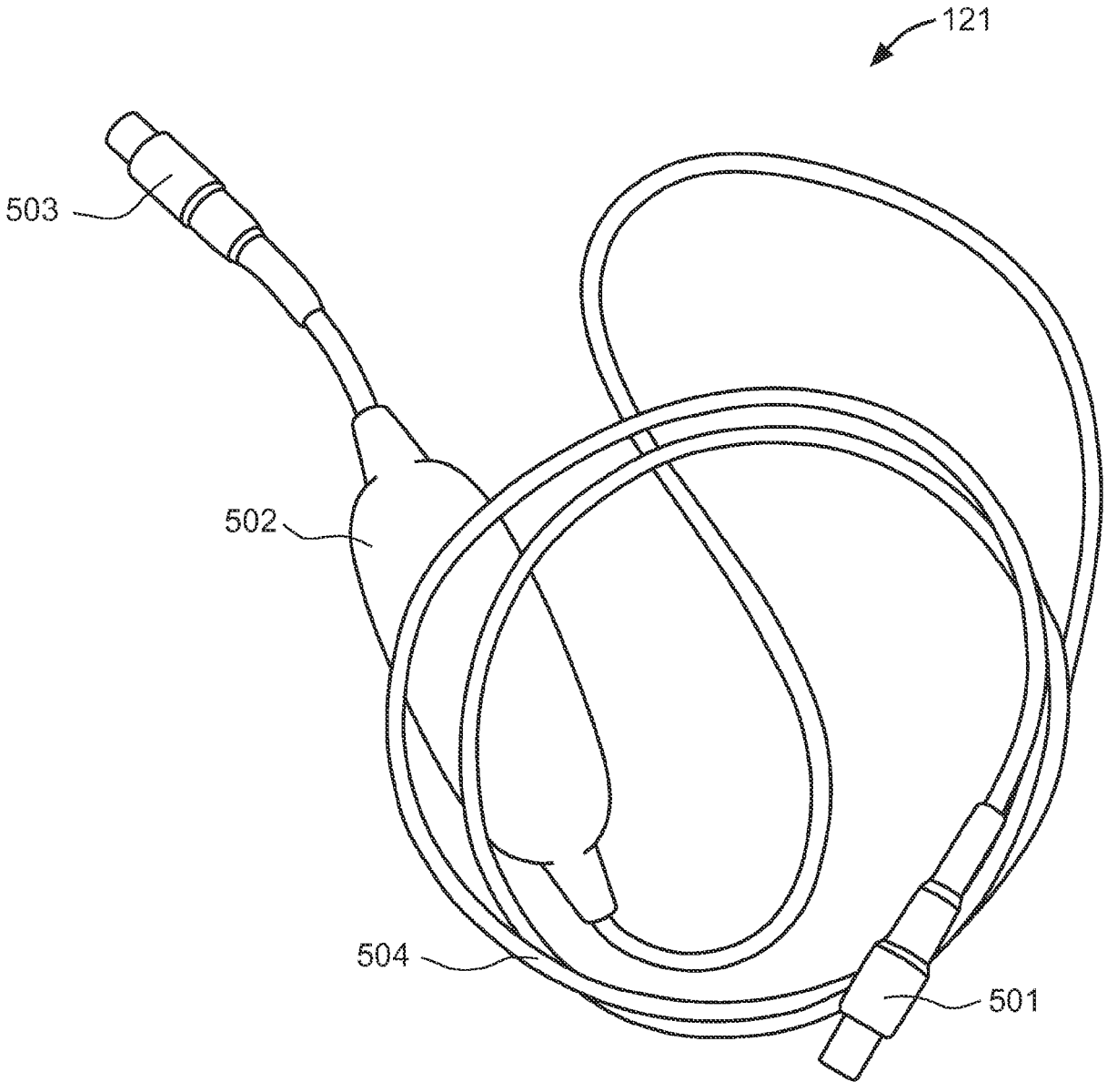


FIG. 5A

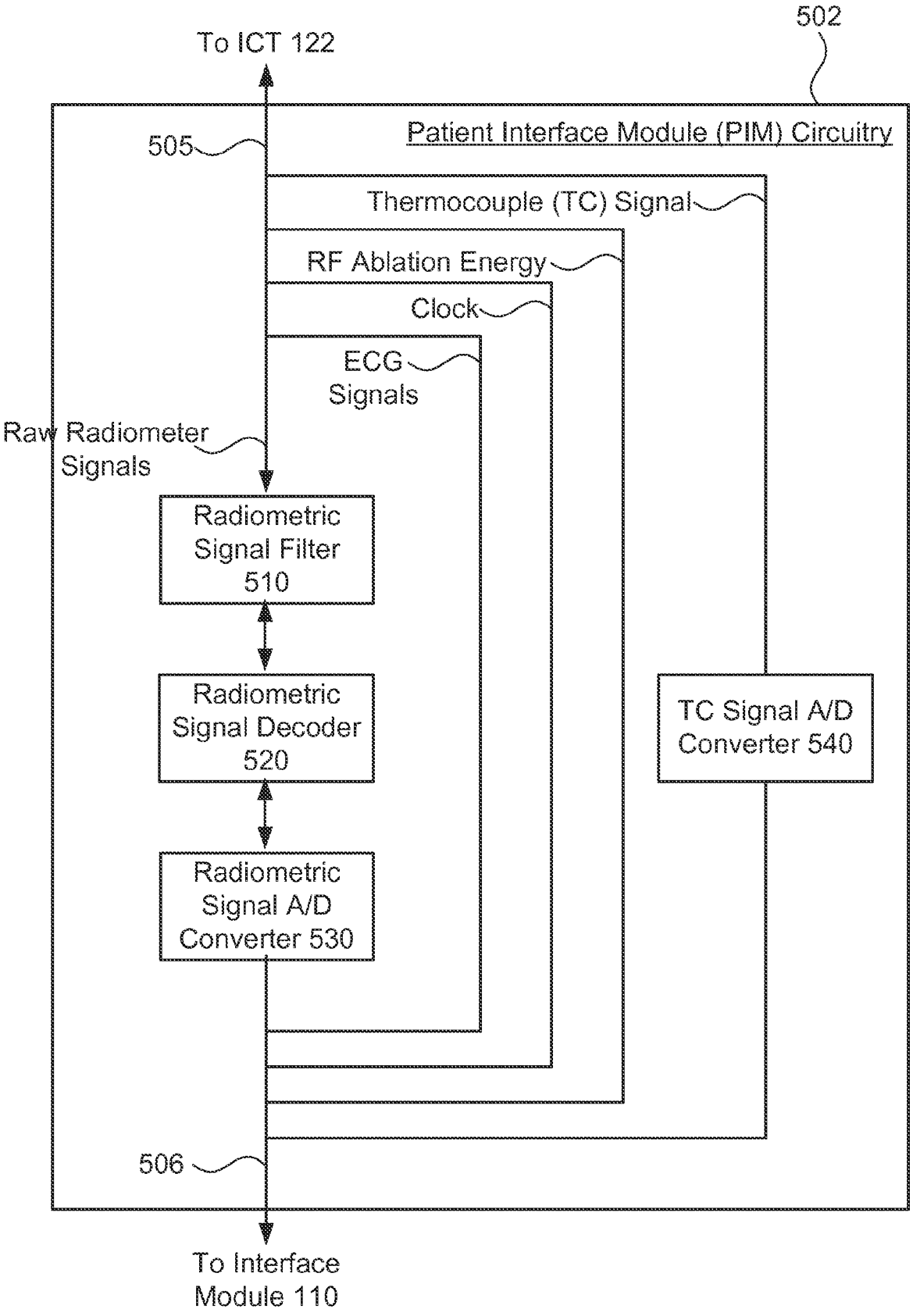

502
To ICT 122
Patient Interface Module (PIM) Circuitry
505
Thermocouple (TC) Signal
RF Ablation Energy
Clock
ECG Signals
Raw Radiometer Signals
Radiometric Signal Filter 510
Radiometric Signal Decoder 520
Radiometric Signal A/D Converter 530
TC Signal A/D Converter 540
506
To Interface Module 110

FIG. 5B

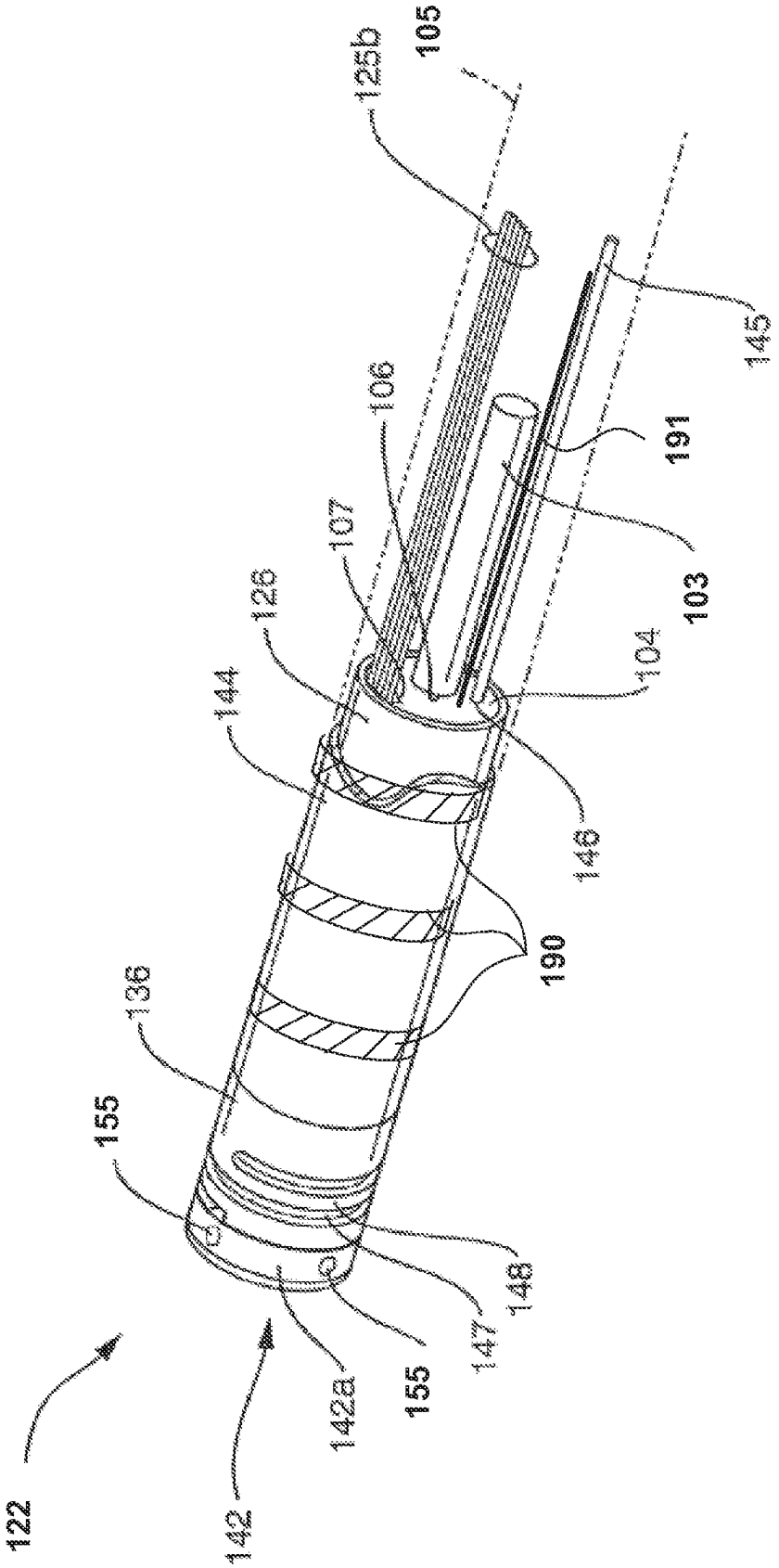

122
142
142a
155
147
148
155
136
190
148
144
126
107
106
125b
105
145
191
103
104

FIG. 6A

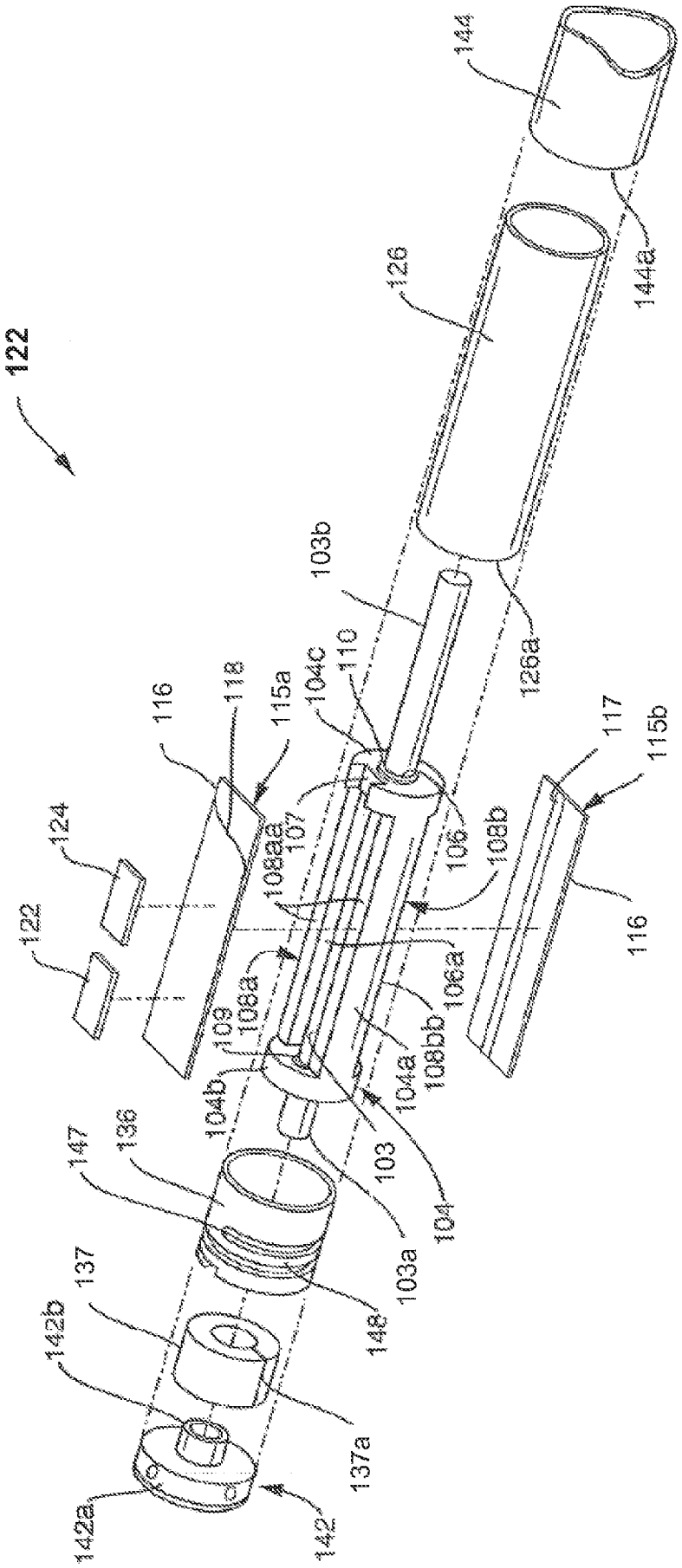

122
144
144a
126
103b
126a
110
104c
115a
118
116
117
115b
124
122
107
108aa
106
108b
108a
109
108aa
108bb
104a
104b
103
104
147
136
103a
137
148
142b
137a
142a
142

FIG. 6B