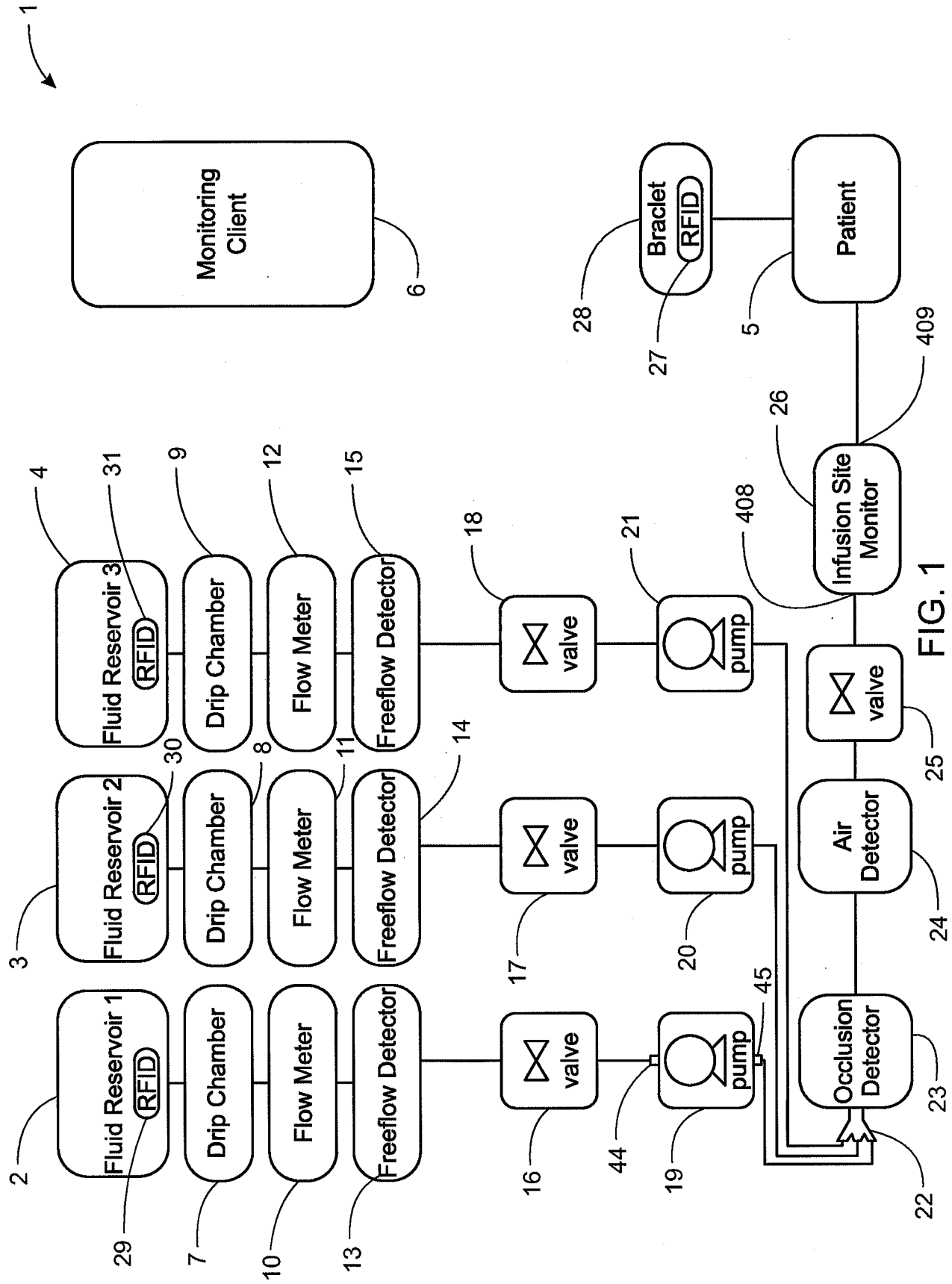

1
Monitoring Client
6
Bracelet RFID
28
27
Patient
5
409
26
Infusion Site Monitor
408
Fluid Reservoir 3 RFID
4
31
Drip Chamber
9
Flow Meter
12
Freeflow Detector
15
18
valve
21
pump
Fluid Reservoir 2 RFID
3
30
Drip Chamber
8
Flow Meter
11
Freeflow Detector
14
valve
17
pump
20
Air Detector
24
valve
25
Fluid Reservoir 1 RFID
2
29
Drip Chamber
7
Flow Meter
10
Freeflow Detector
13
valve
16
pump
44
19
45
Occlusion Detector
23
22

FIG. 1

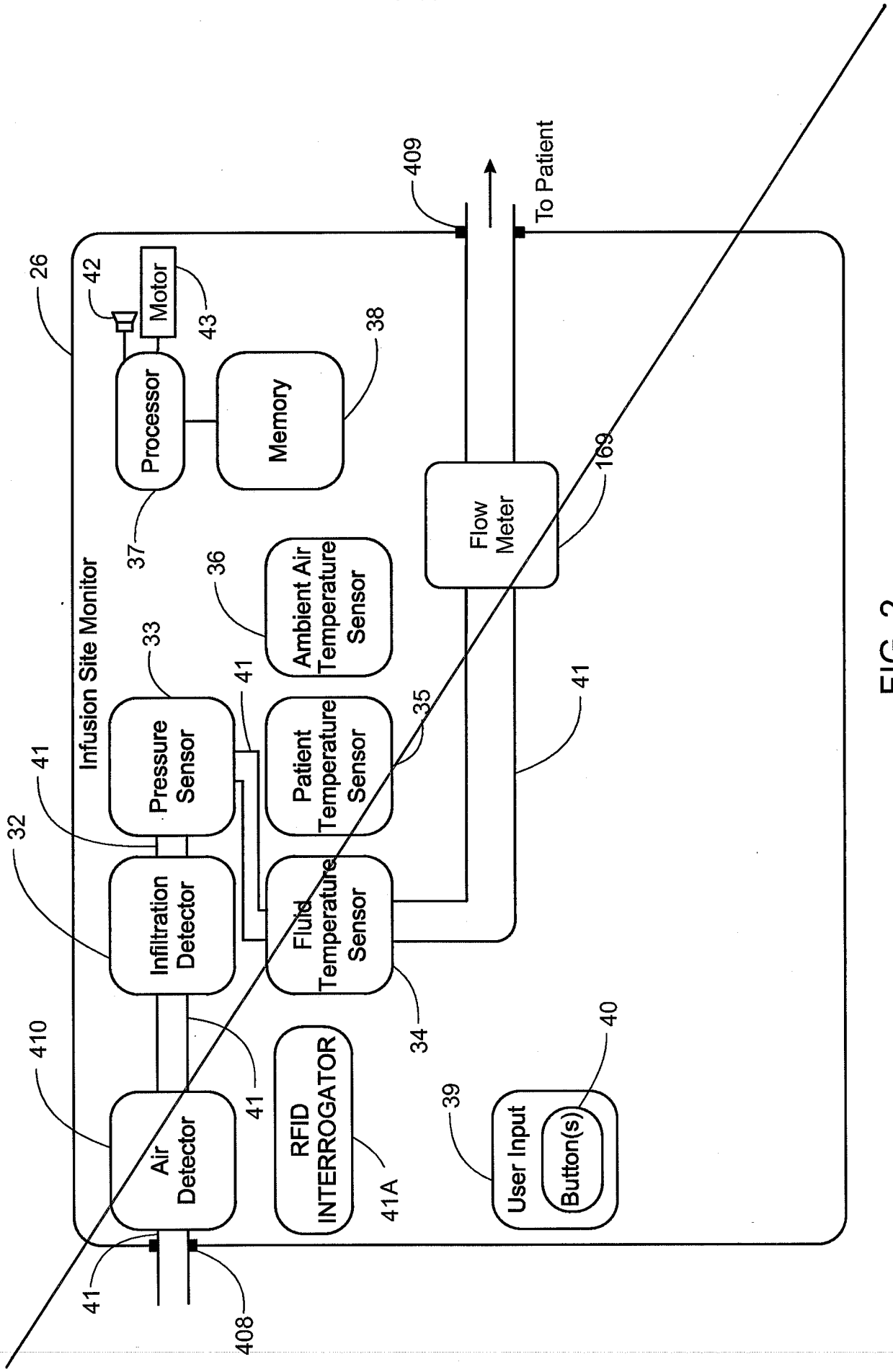

Infusion Site Monitor
26
Processor
37
Motor
42
43
Memory
38
409
To Patient
Flow Meter
169
Ambient Air Temperature Sensor
36
Pressure Sensor
33
Patient Temperature Sensor
35
Infiltration Detector
32
Fluid Temperature Sensor
34
41
Air Detector
410
RFID INTERROGATOR
41A
User Input
39
Button(s)
40
408

FIG. 2

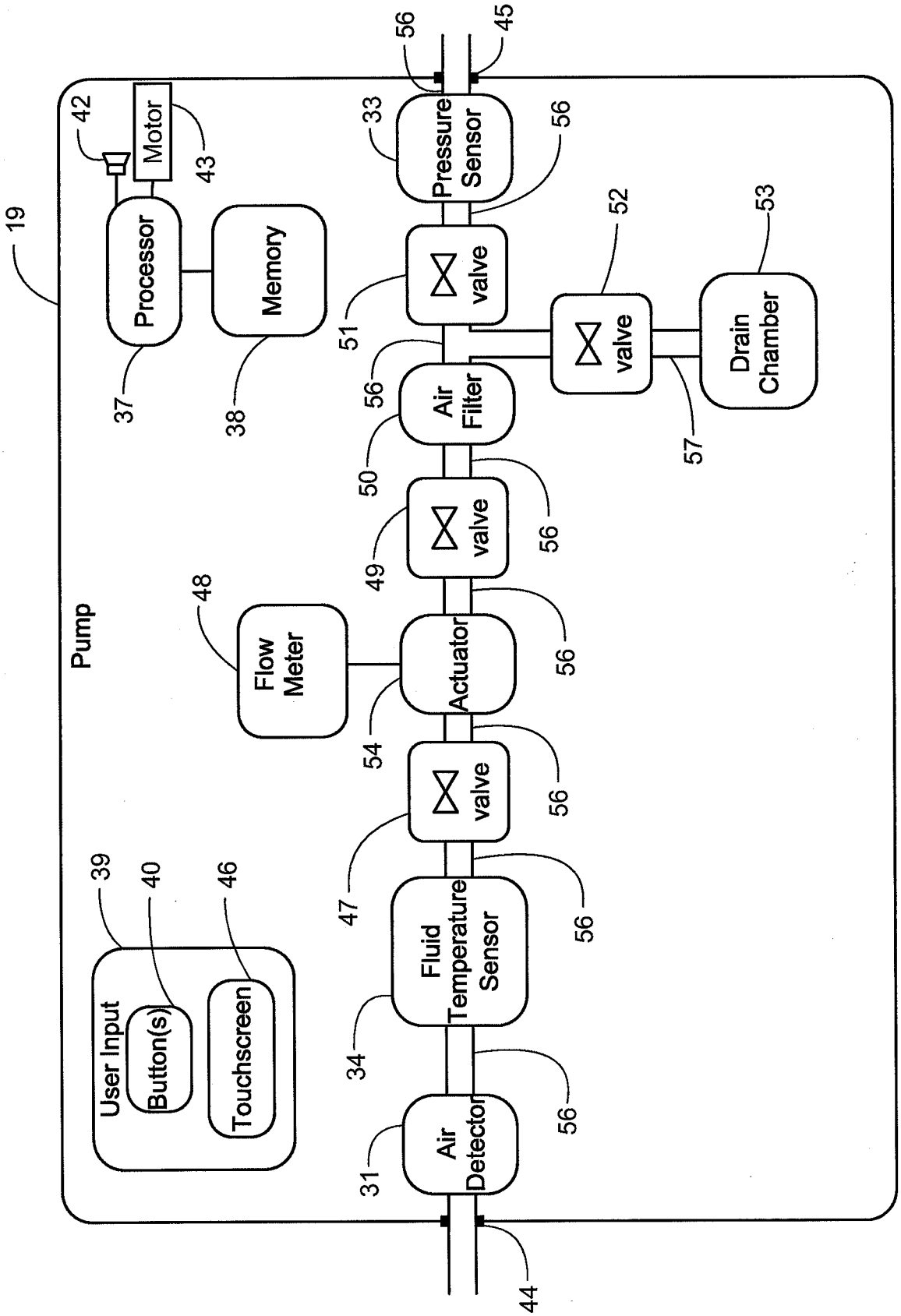

Pump
19
Processor
37
Memory
38
Motor
43
42
Pressure Sensor
33
45
56
valve
51
valve
52
Drain Chamber
53
57
Air Filter
50
56
valve
49
56
Flow Meter
48
Actuator
54
56
valve
47
56
Fluid Temperature Sensor
34
56
Air Detector
31
44
User Input
39
Button(s)
40
Touchscreen
46

FIG. ~~3~~

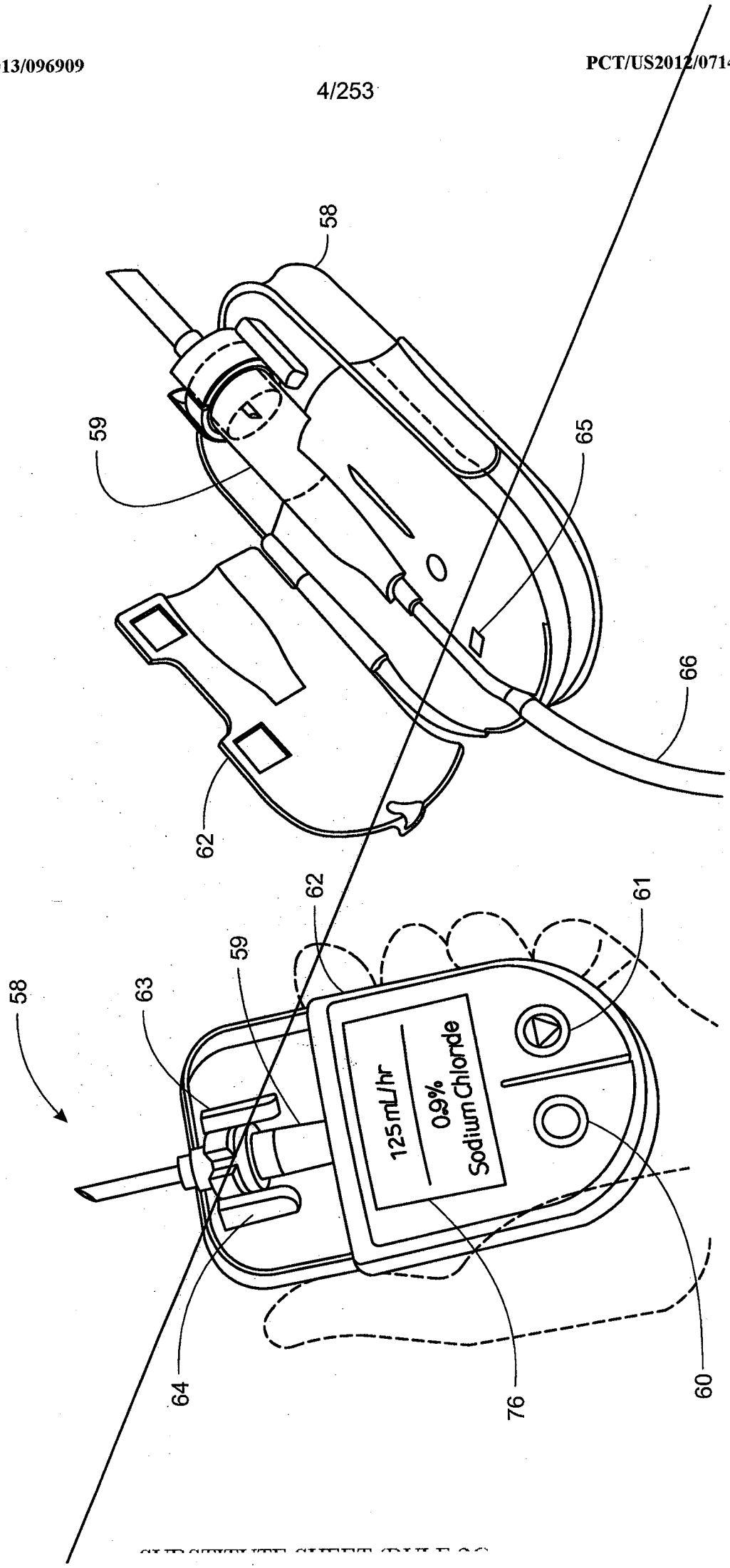


FIG. 5

FIG. 4

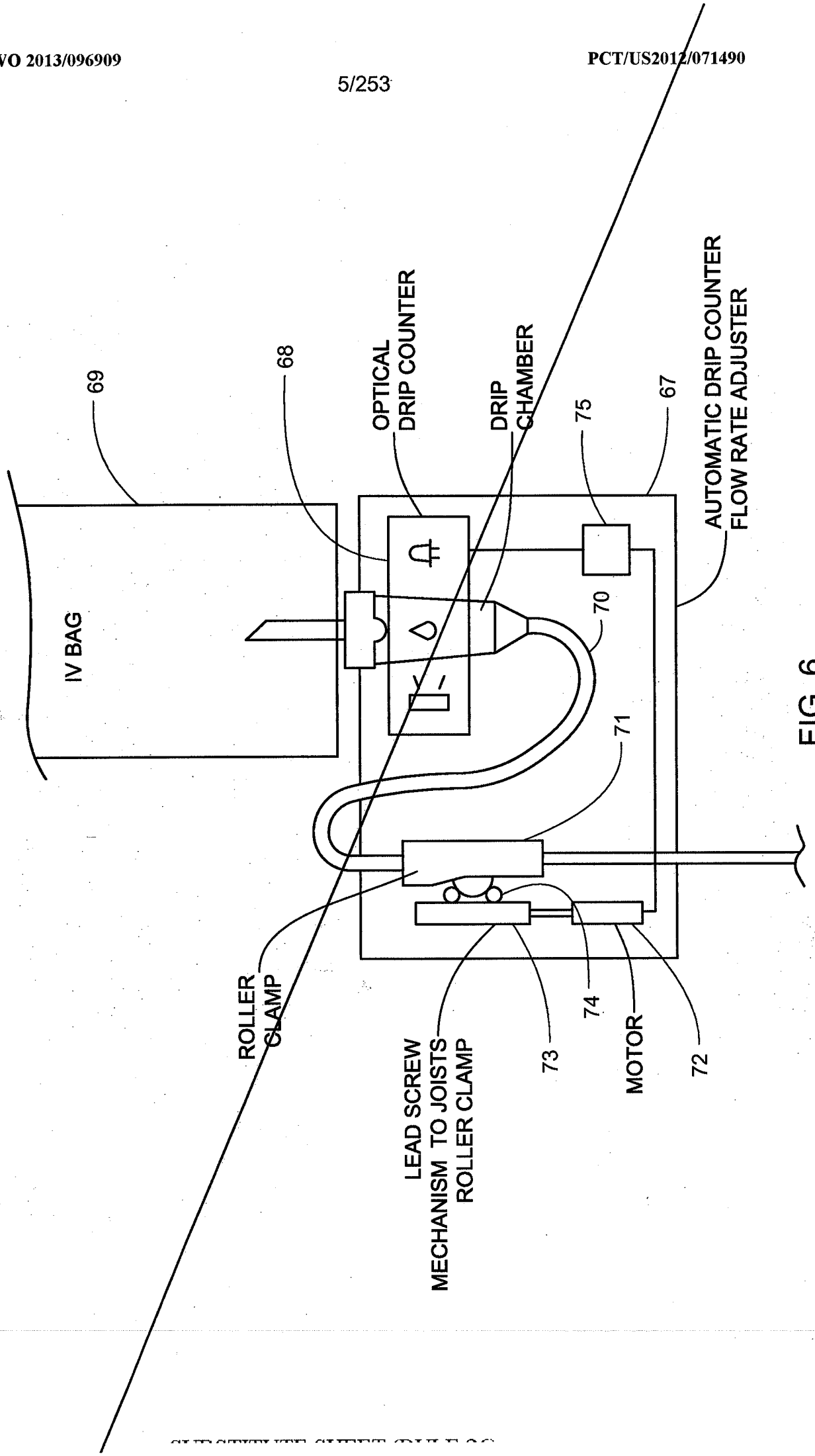

IV BAG
69
68
OPTICAL DRIP COUNTER
DRIP CHAMBER
75
67
AUTOMATIC DRIP COUNTER FLOW RATE ADJUSTER
70
71
ROLLER CLAMP
LEAD SCREW MECHANISM TO JOISTS ROLLER CLAMP
73
74
MOTOR
72

FIG. 6

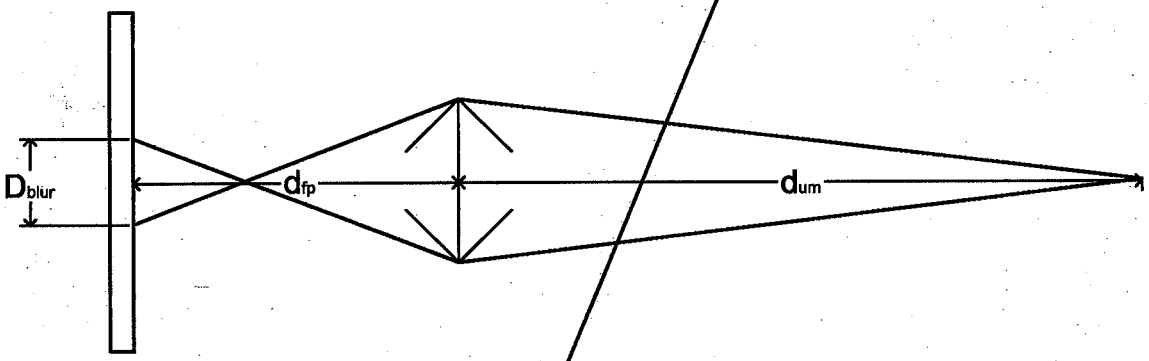


FIG. 7

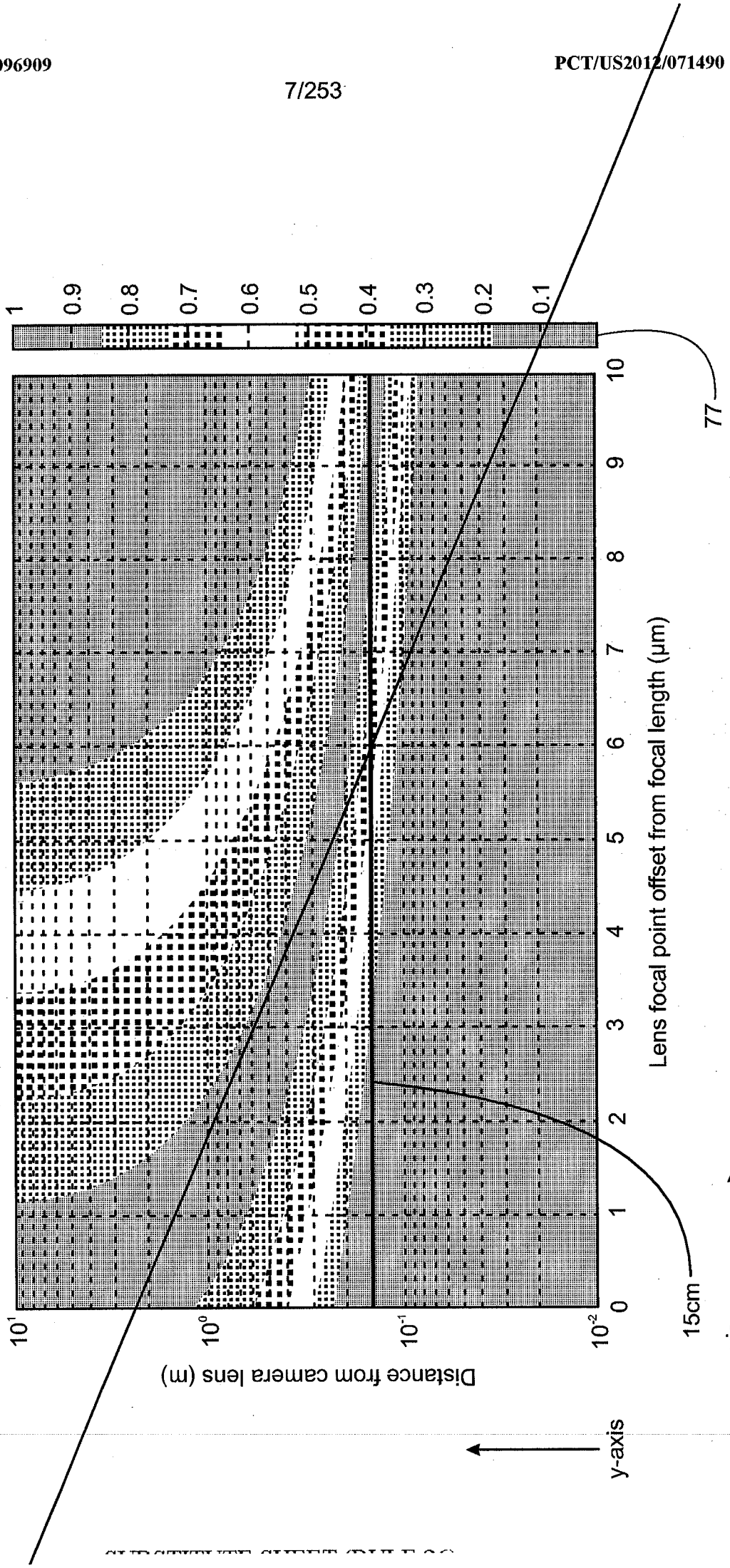

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
77
0
1
2
3
4
5
6
7
8
9
10
Lens focal point offset from focal length (µm)
10^{1}
10^{0}
10^{-1}
10^{-2}
Distance from camera lens (m)
15cm
x-axis
y-axis

FIG. 8

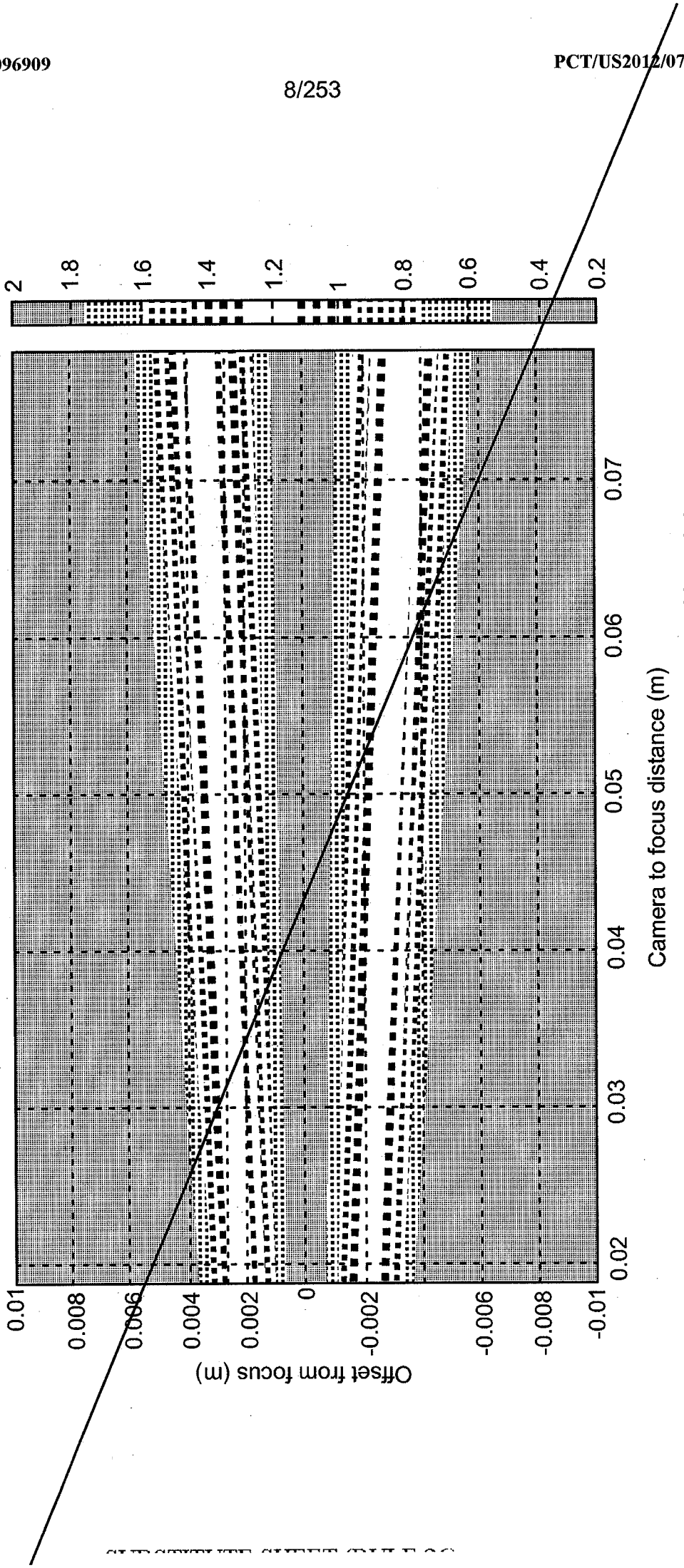

Offset from focus (m)
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.006
-0.008
-0.01
0.02
0.03
0.04
0.05
0.06
0.07
Camera to focus distance (m)
Blur circle divided by pixel size for a 20mm focal length lens
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2

FIG. 9

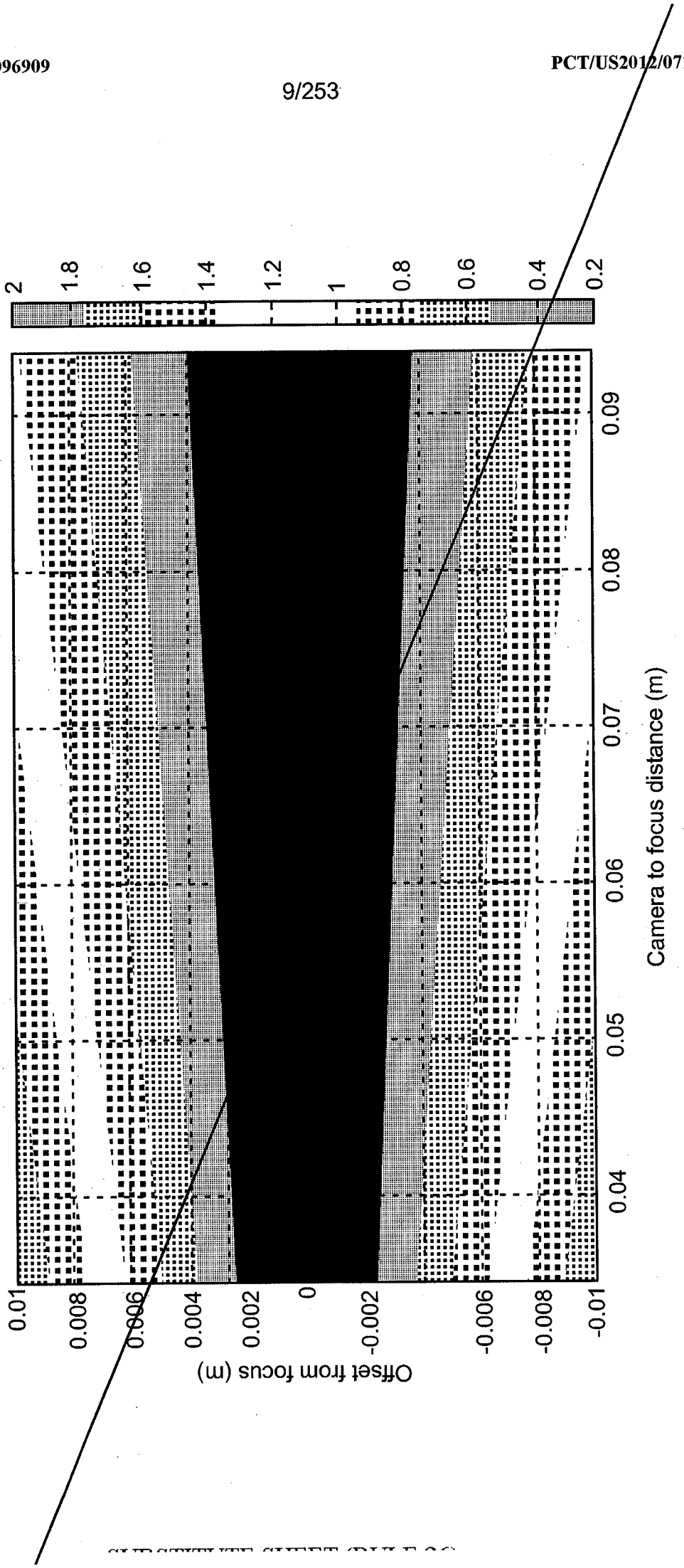

Blur circle divided by pixel size for a 40mm focal length lens
Camera to focus distance (m)
Offset from focus (m)
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.006
-0.008
-0.01
0.04
0.05
0.06
0.07
0.08
0.09
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2

FIG. 10

Lens focal length	Lens separation from the camera	Focus separation from the camera	Field of view	Depth of Field (D_{blur} /D_{pixel})=1	Depth of Field (D_{blur} /D_{pixel})=2
20mm	0mm	18.6mm	±9.7mm	±2mm	±4mm
20mm	60mm	78.2mm	±12.3mm	±3mm	±6mm
40mm	0mm	34.8mm	±18.2mm	±5mm	≥10mm
40mm	60mm	93.5mm	±22.6mm	±10mm	≥10mm
60mm	0mm	48.9mm	±25.6mm	≥10mm	≥10mm
60mm	60mm	106.4mm	±31.4mm	≥10mm	≥10mm

FIG. 11

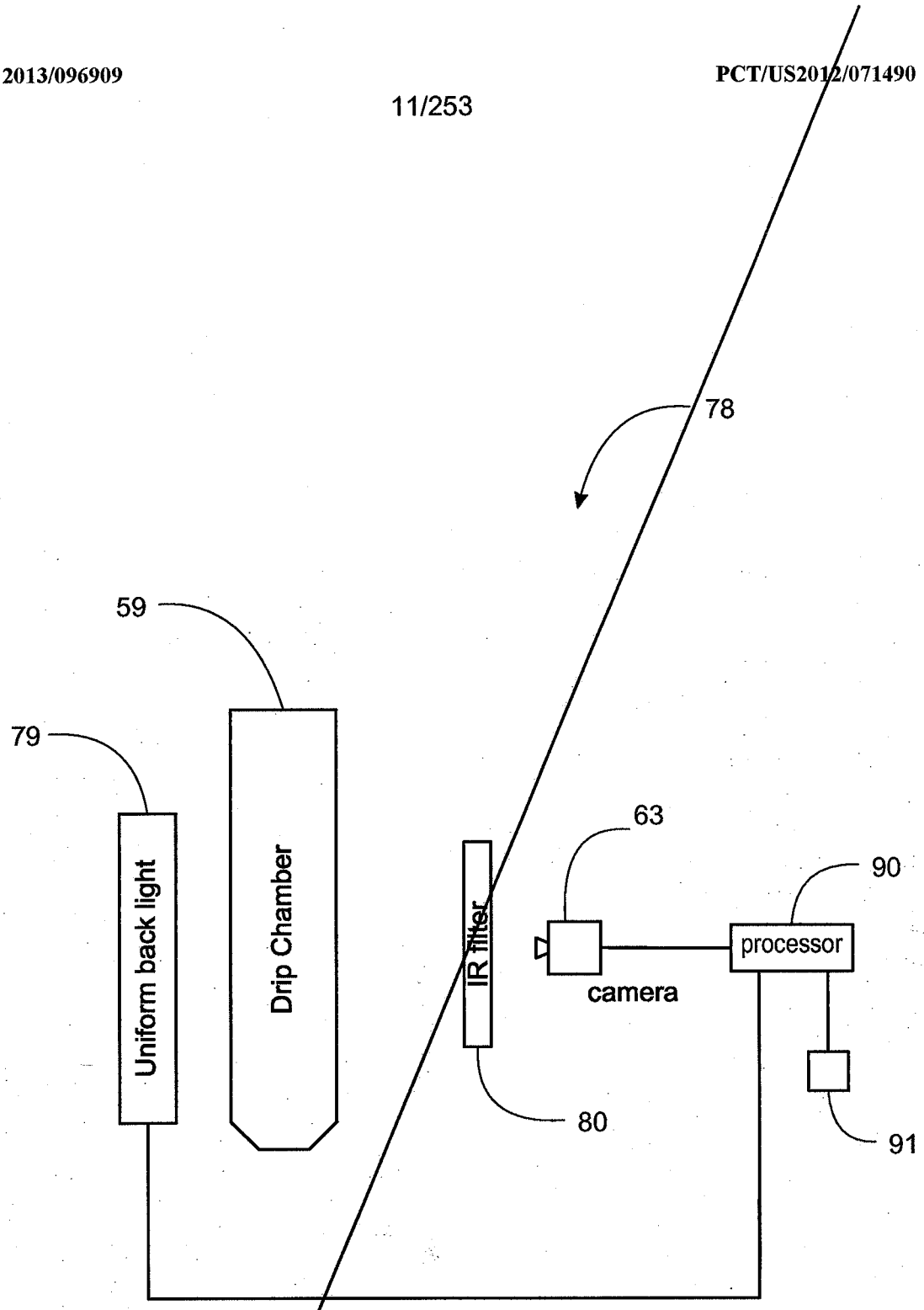

78
59
79
Drip Chamber
Uniform back light
IR filter
63
camera
90
processor
80
91

FIG. 12

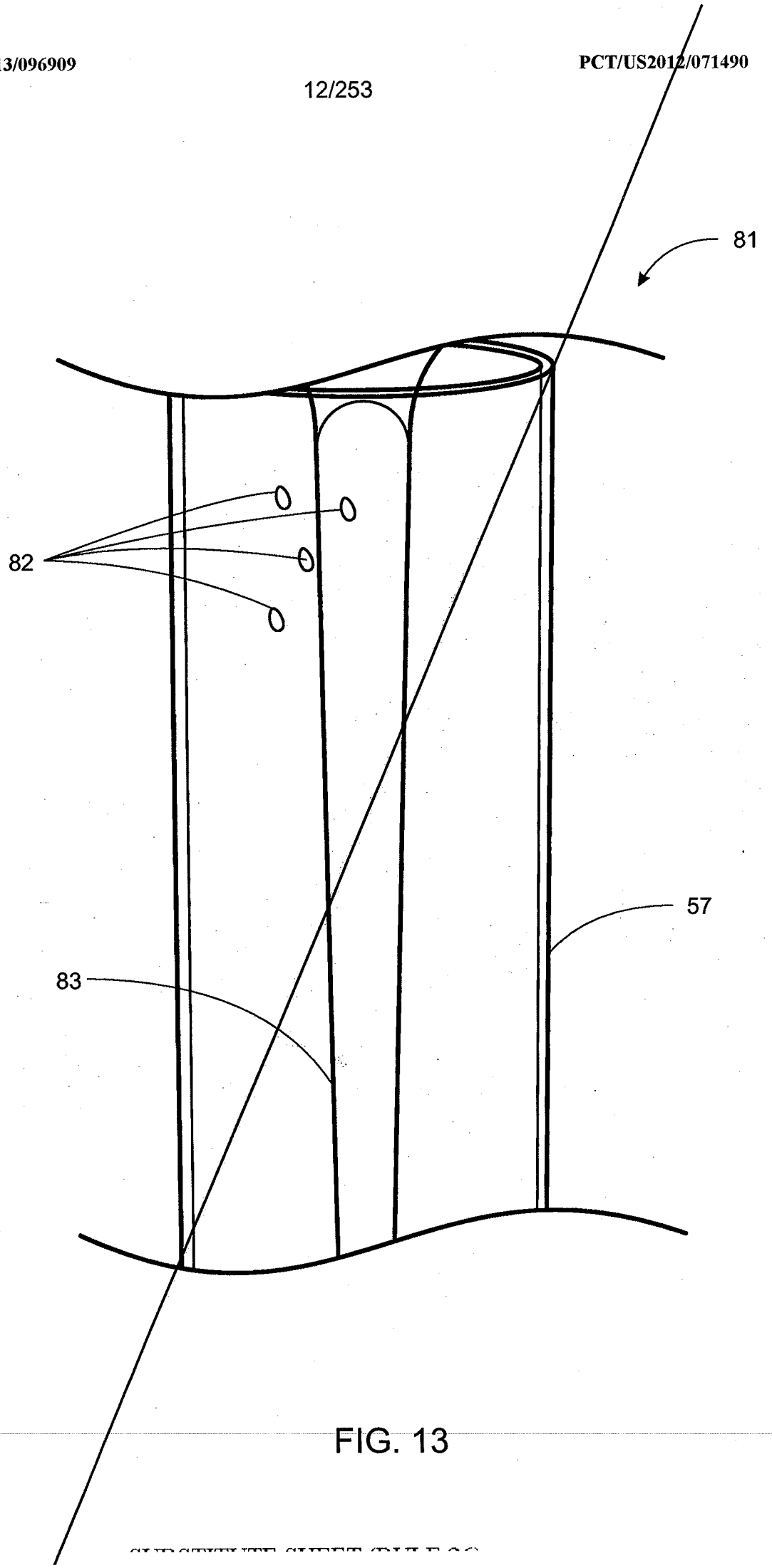


FIG. 13

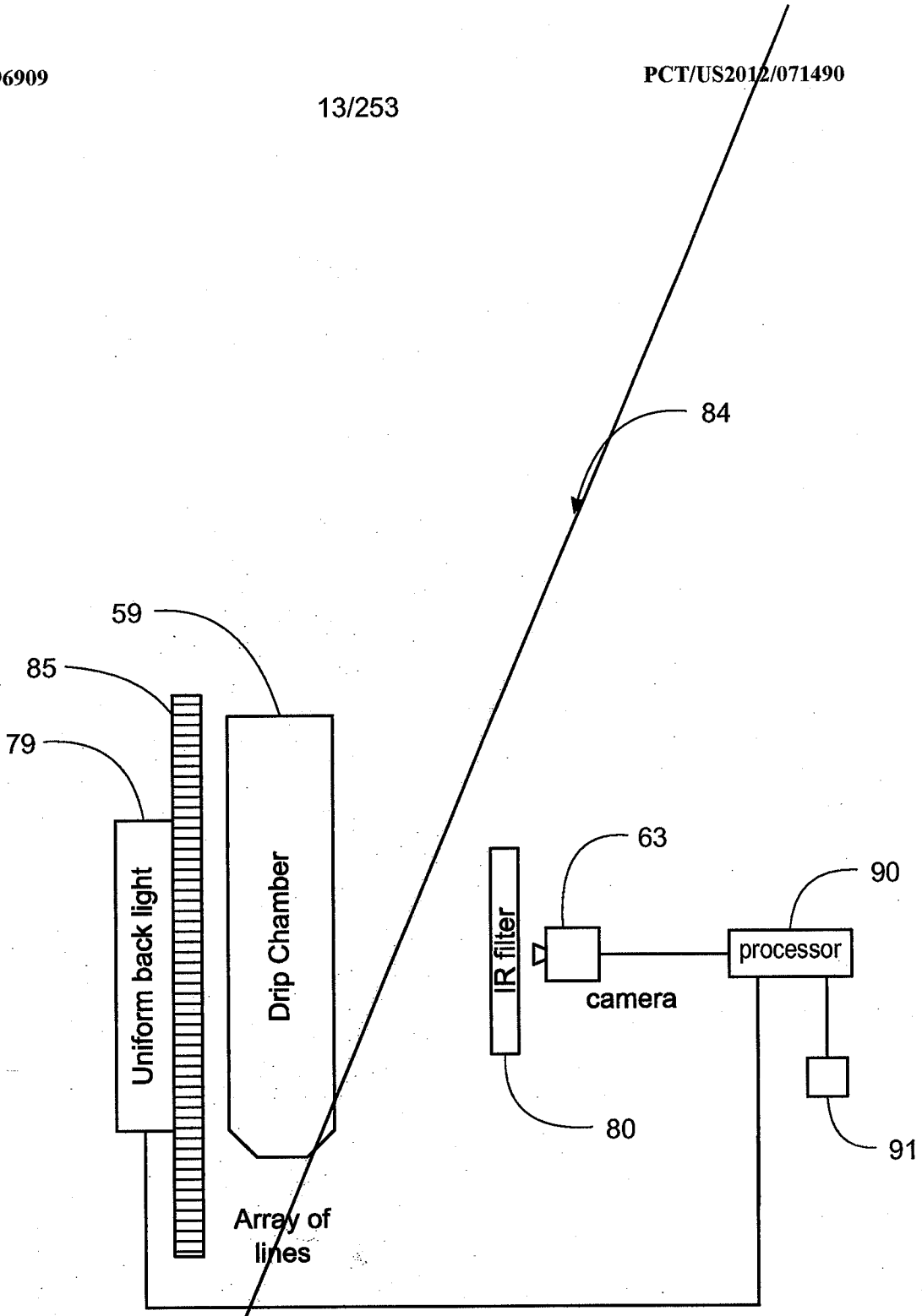

84
59
85
79
Uniform back light
Drip Chamber
Array of lines
63
90
IR filter
camera
processor
80
91

FIG. 14

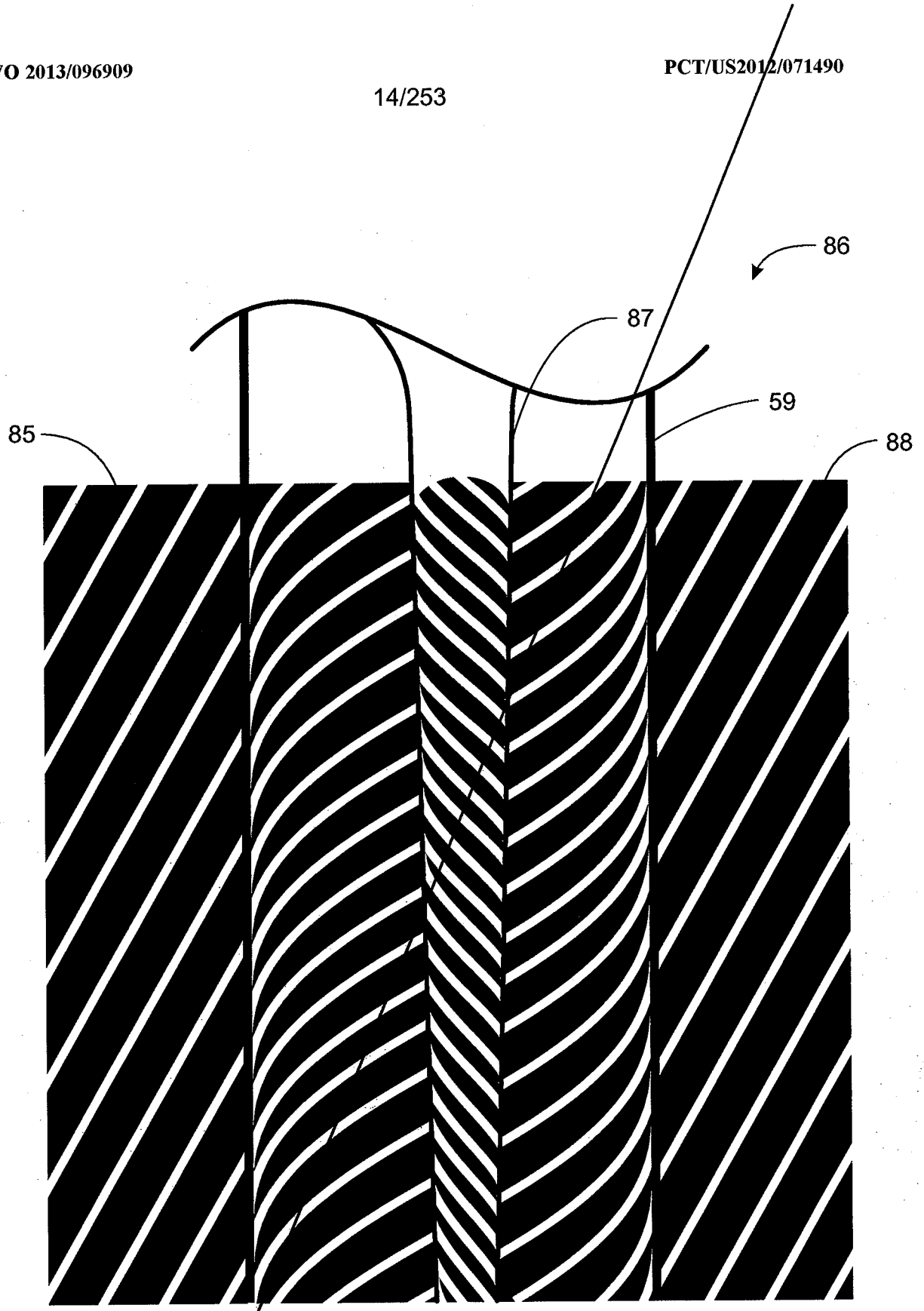
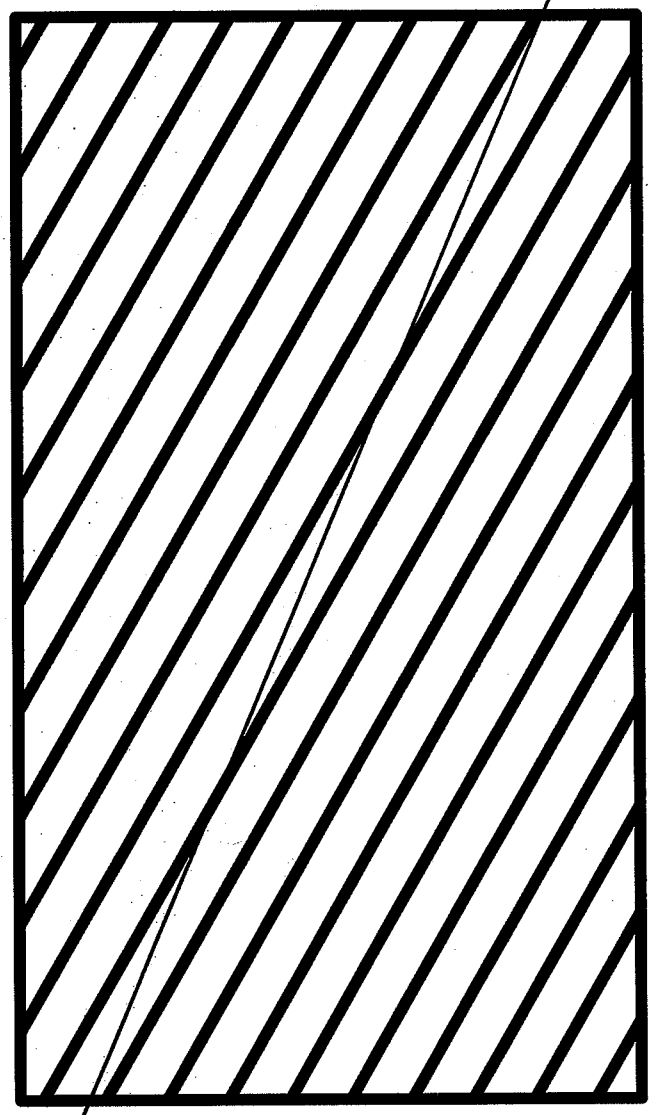


FIG. 15



Typical background image

FIG. 16

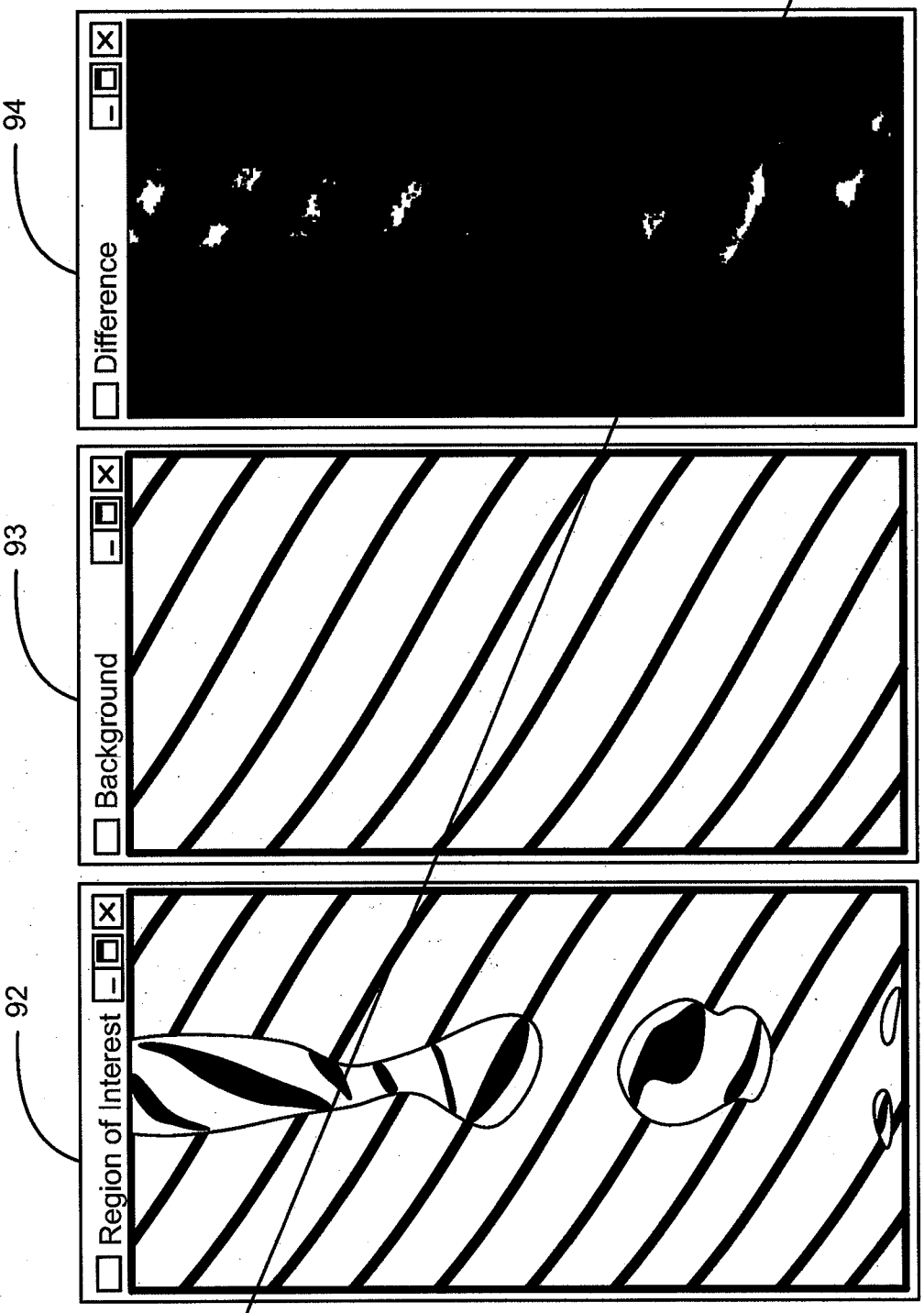


FIG. 17

FIG. 18

FIG. 19

Droplet image, background image, and difference between the background image and the droplet

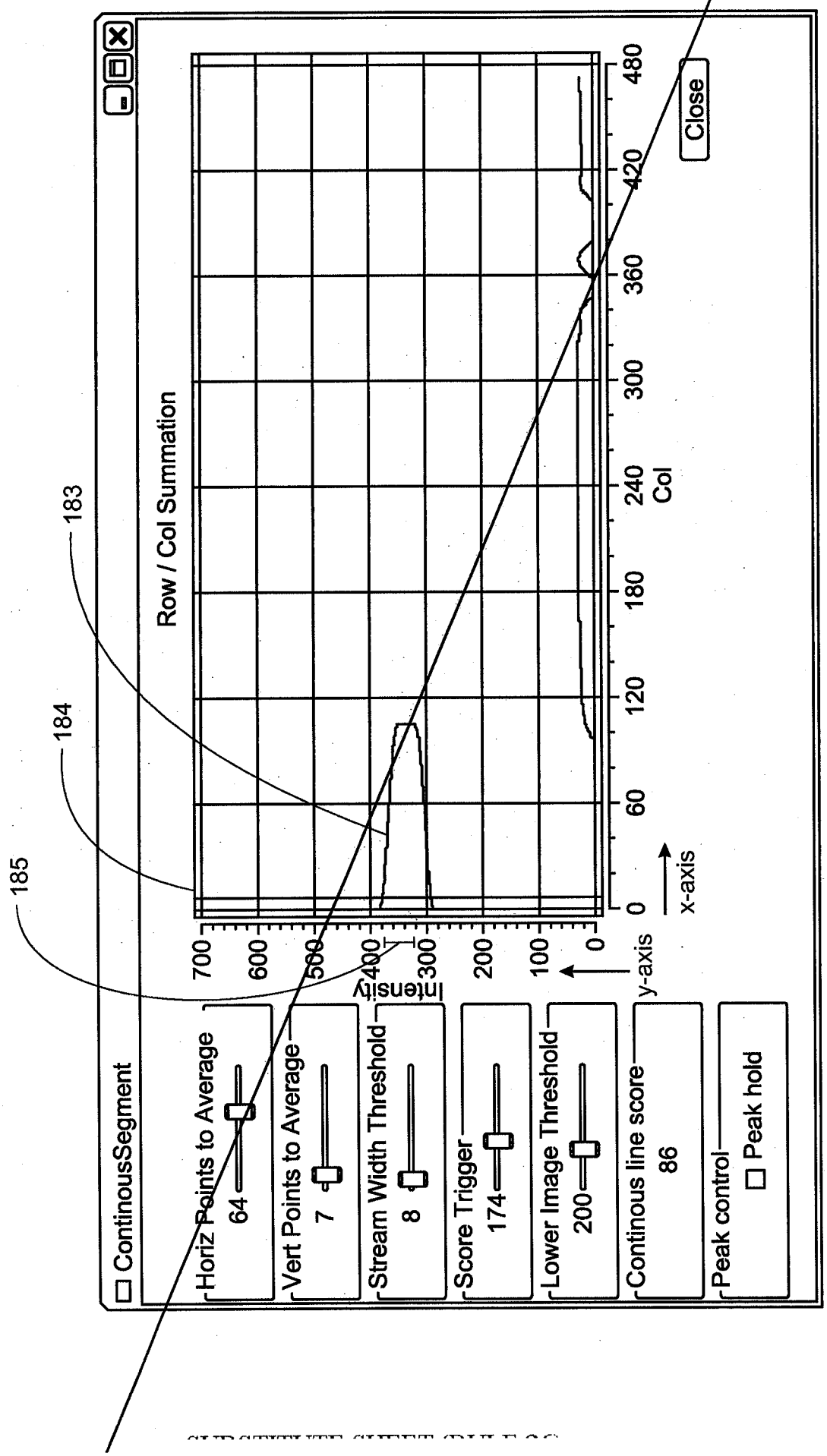

ContinousSegment
Row / Col Summation
Close
Intensity
700
600
500
400
300
200
100
0
y-axis
0
60
120
180
240
300
360
420
480
Col
x-axis
Horiz Points to Average
64
Vert Points to Average
7
Stream Width Threshold
8
Score Trigger
174
Lower Image Threshold
200
Continous line score
86
Peak control
Peak hold
183
184
185

FIG. 20

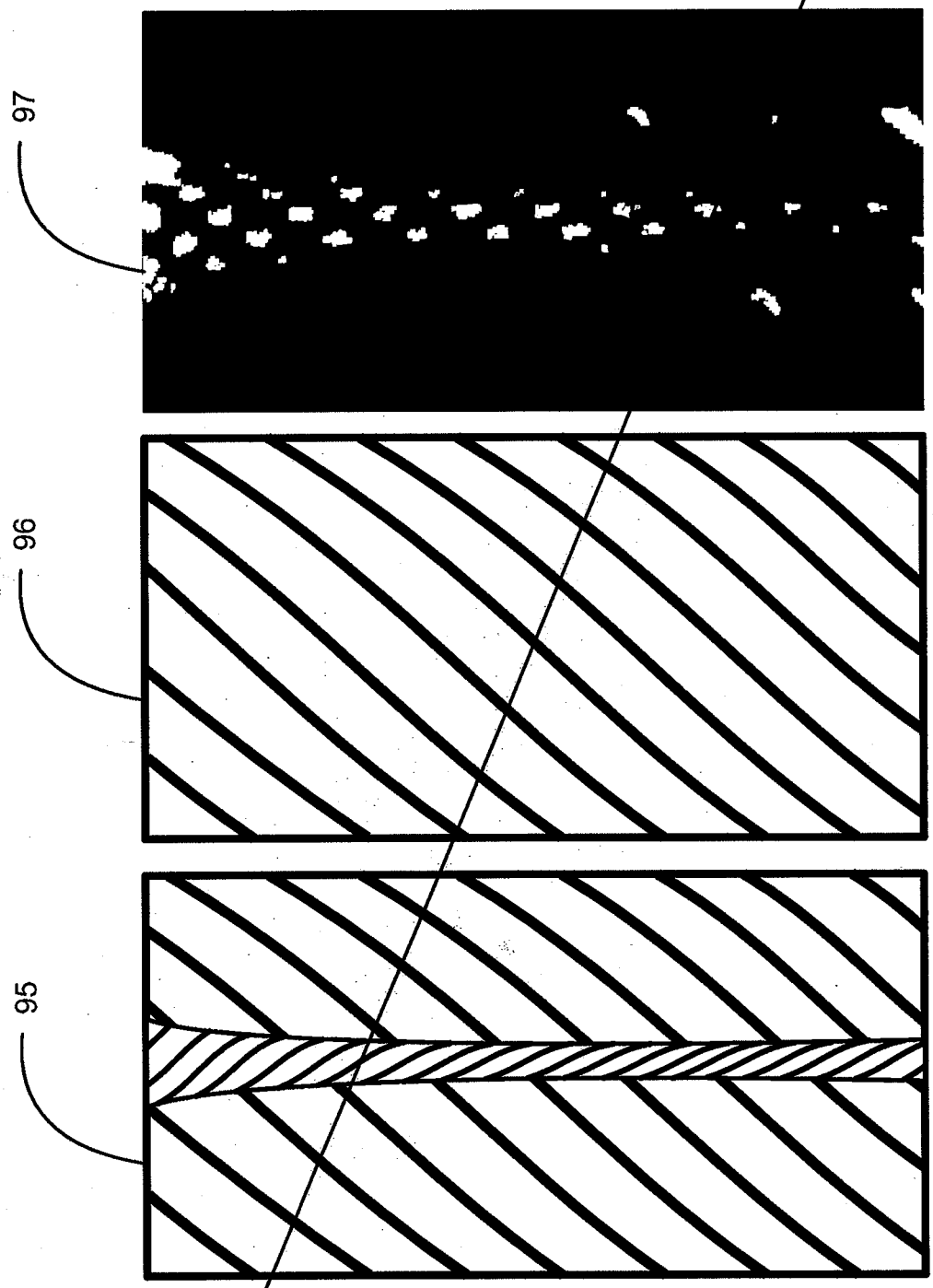


FIG. 23

FIG. 22

FIG. 21

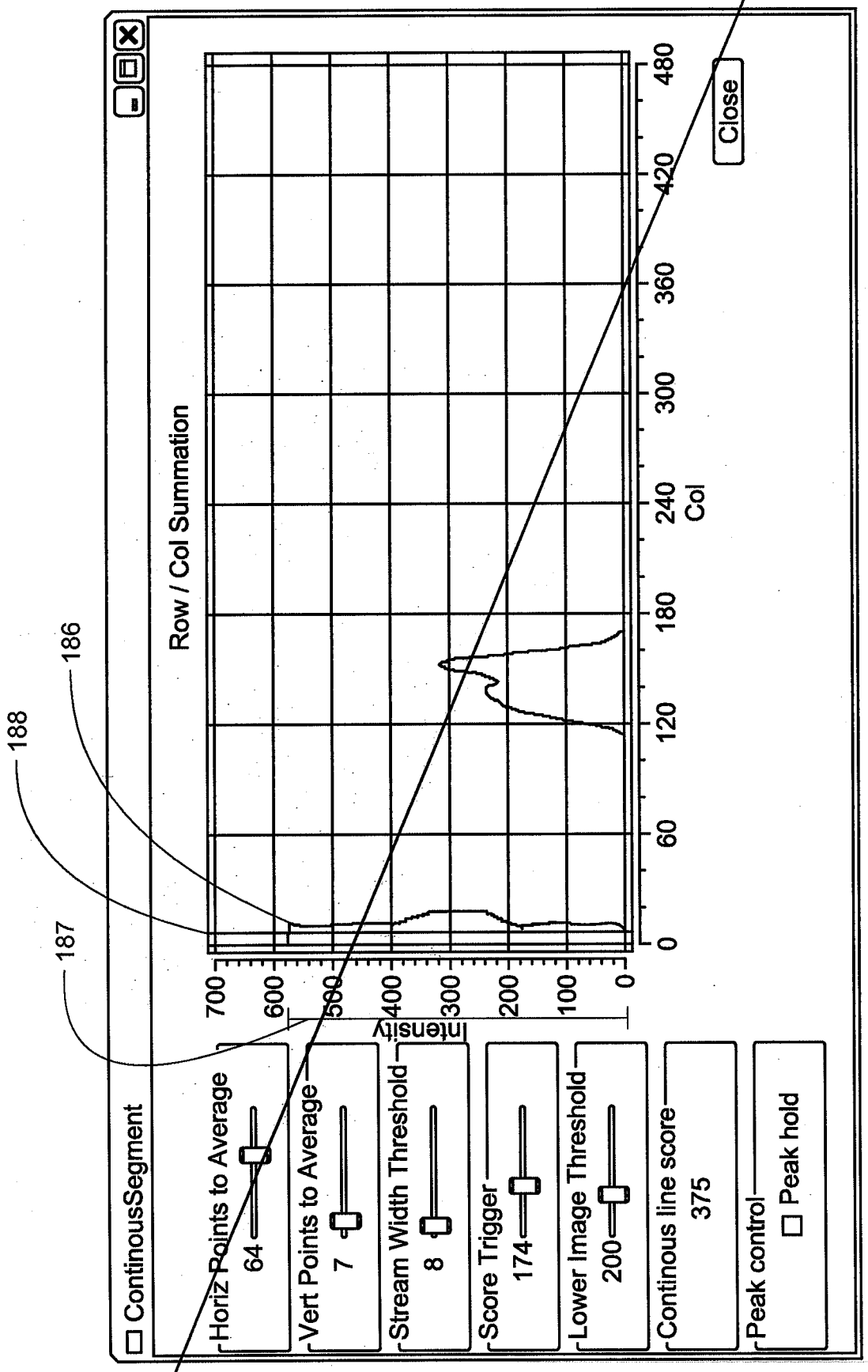

ContinousSegment
Row / Col Summation
Intensity
Col
Close
Horiz Points to Average
64
Vert Points to Average
7
Stream Width Threshold
8
Score Trigger
174
Lower Image Threshold
200
Continous line score
375
Peak control
Peak hold
186
188
187

FIG. 24

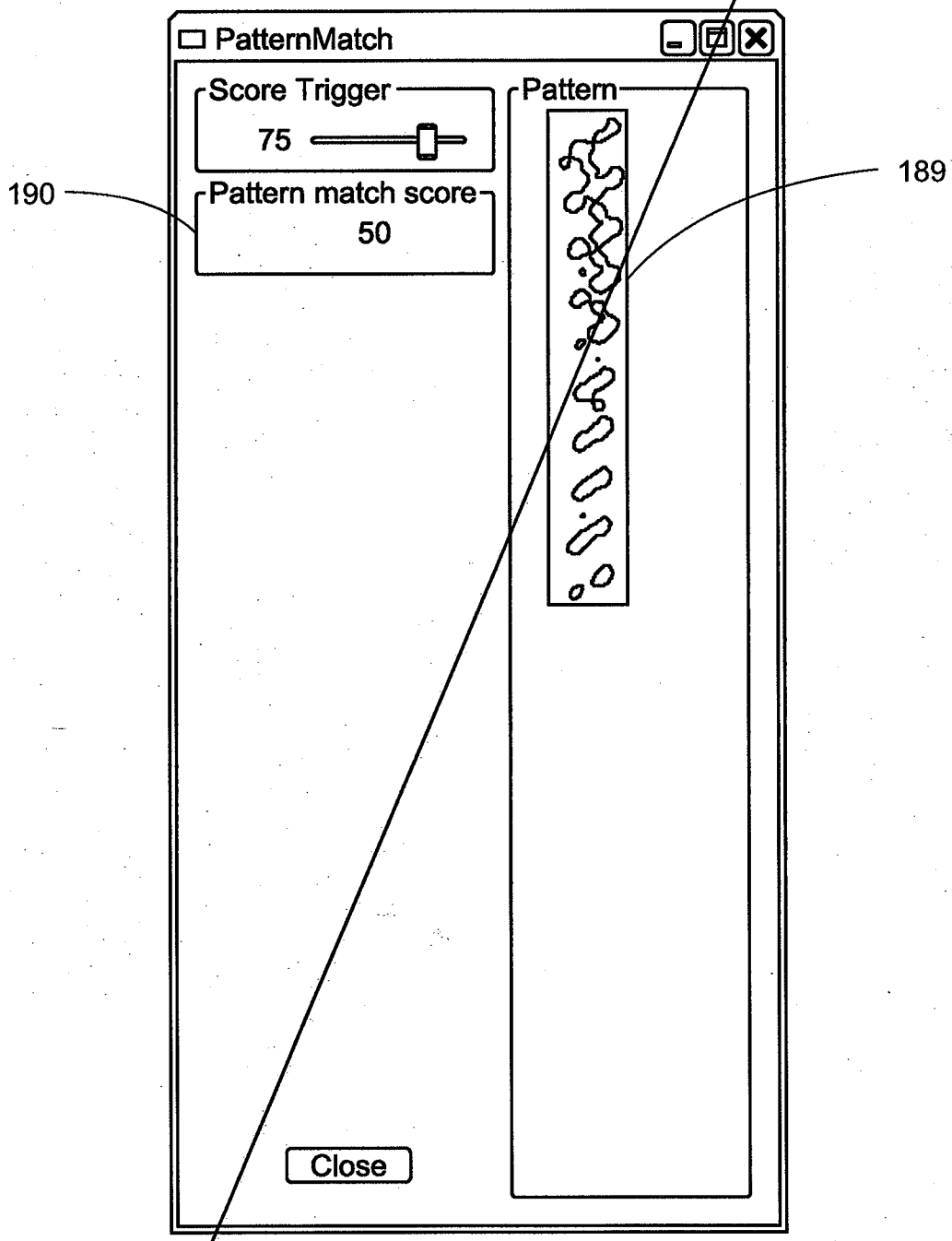

PatternMatch
Score Trigger
75
Pattern match score
50
Pattern
Close
190
189

FIG. 25

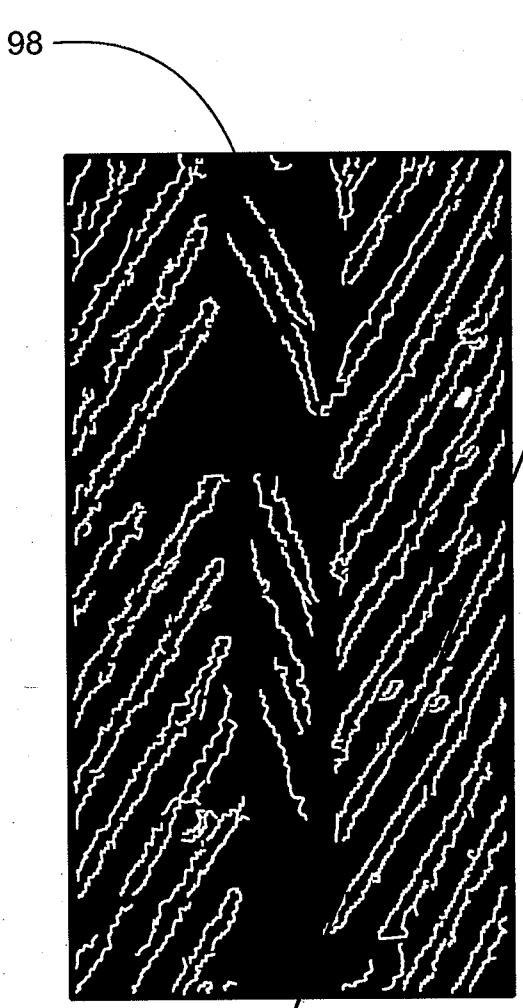


FIG. 26

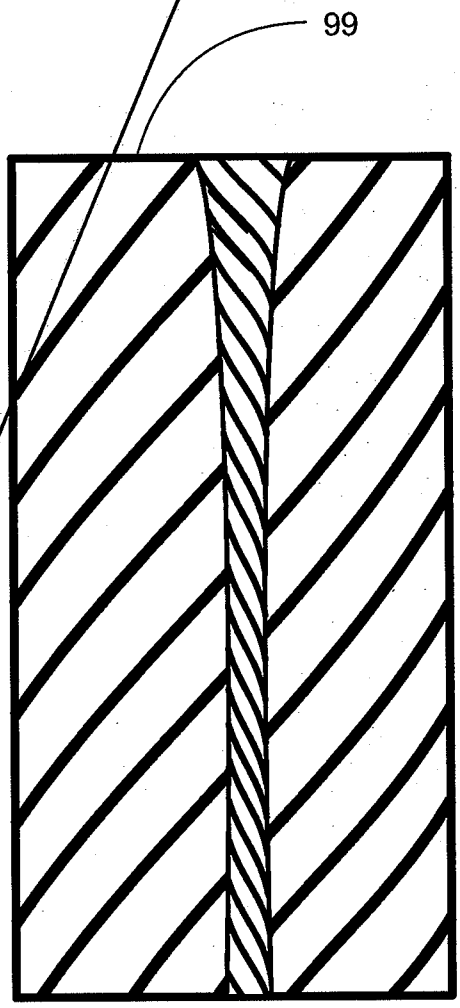


FIG. 27

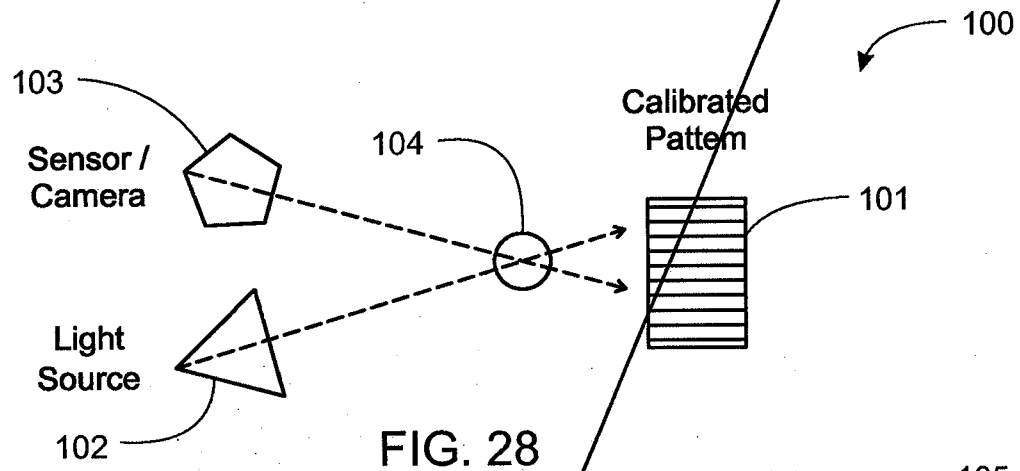


FIG. 28

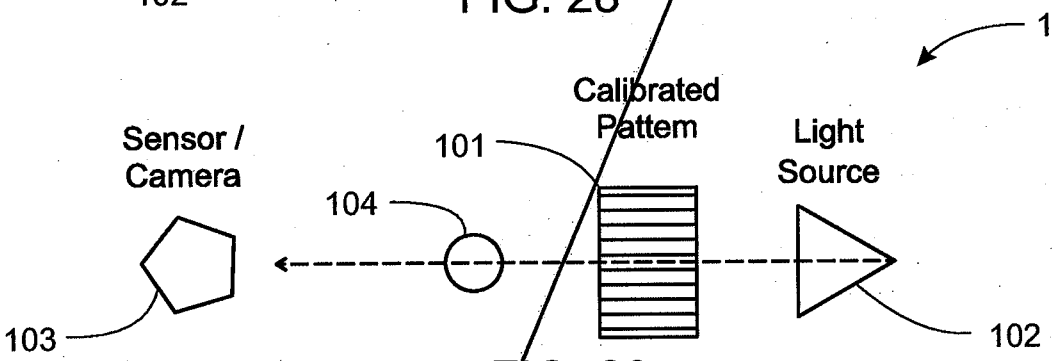


FIG. 29

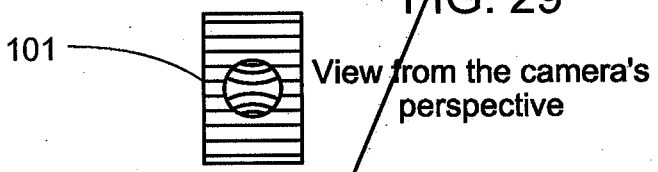


FIG. 30

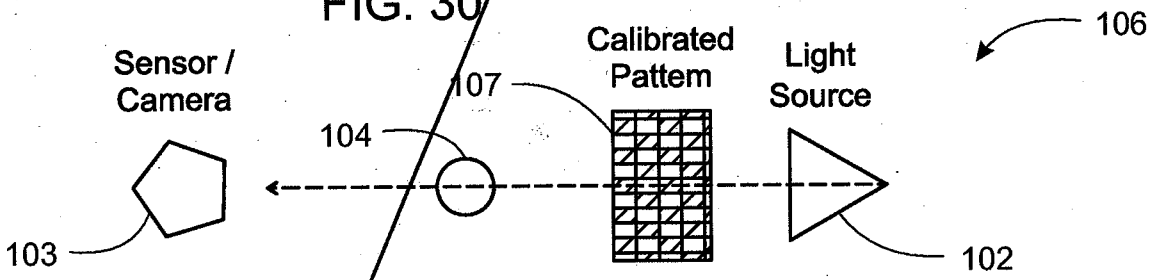


FIG. 31

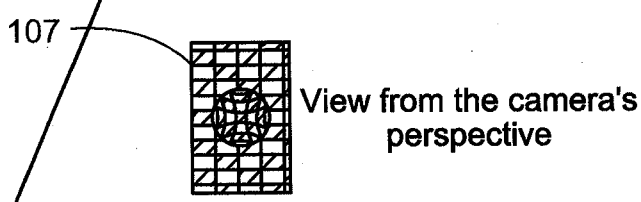


FIG. 32

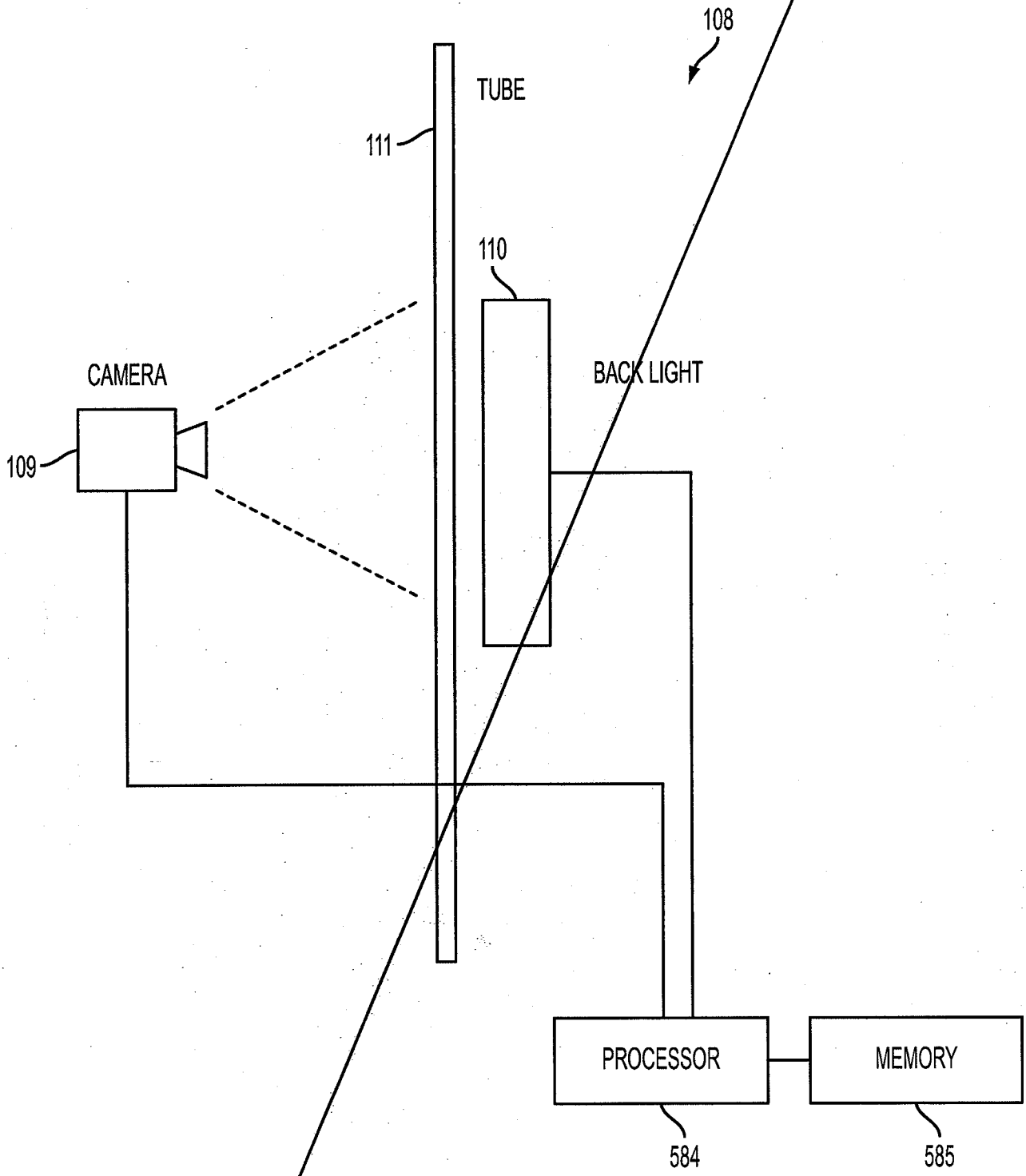

108
TUBE
111
110
CAMERA
BACK LIGHT
109
PROCESSOR
MEMORY
584
585

FIG. 33

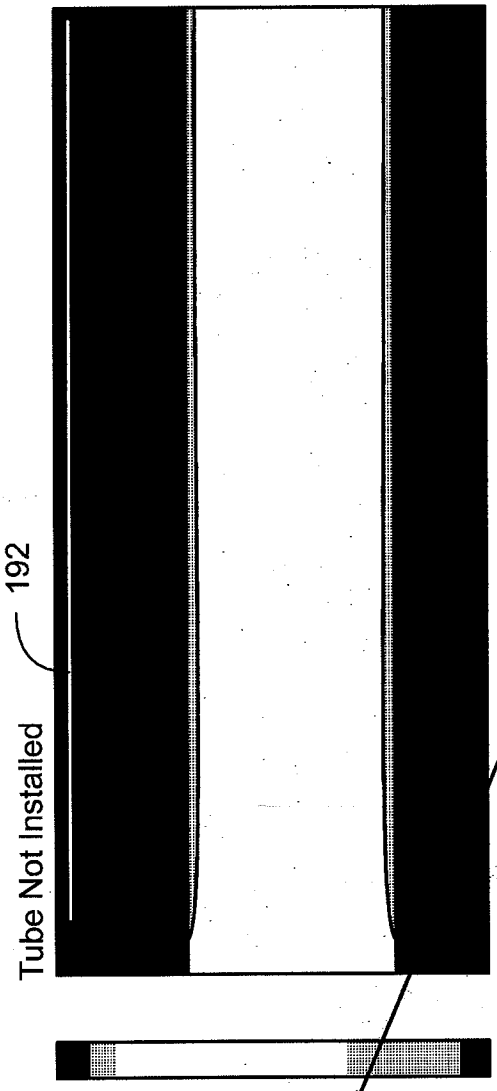


FIG. 34

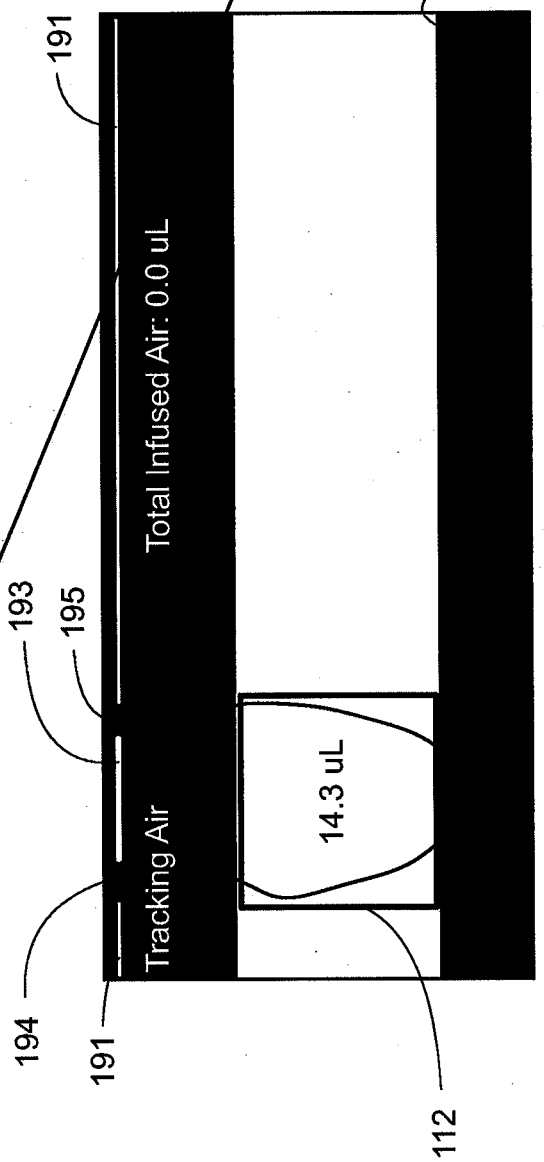


FIG. 35

FIG. 36

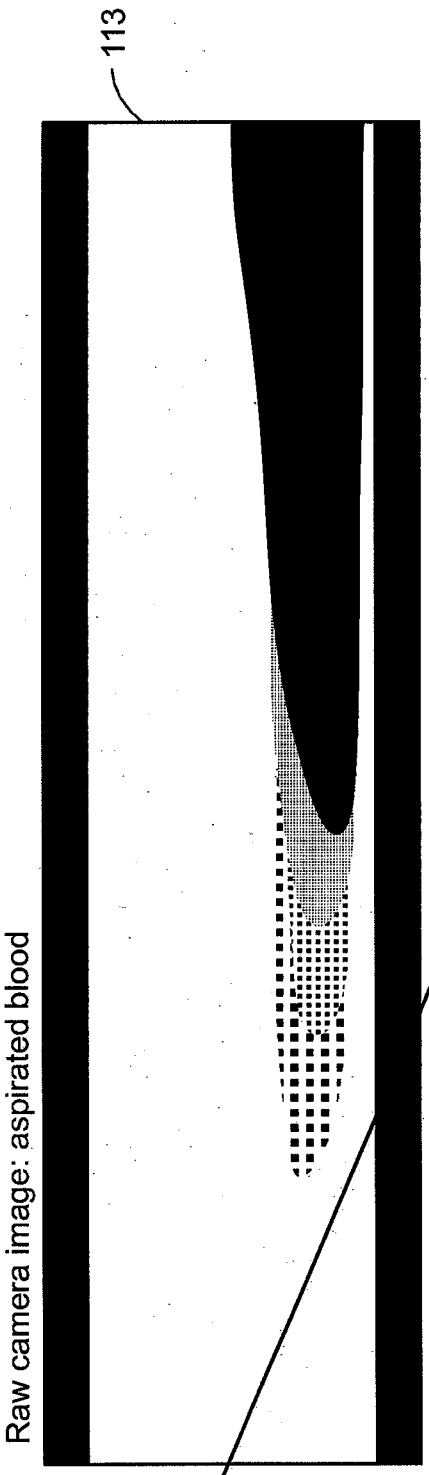

113
Raw camera image: aspirated blood

FIG. 37

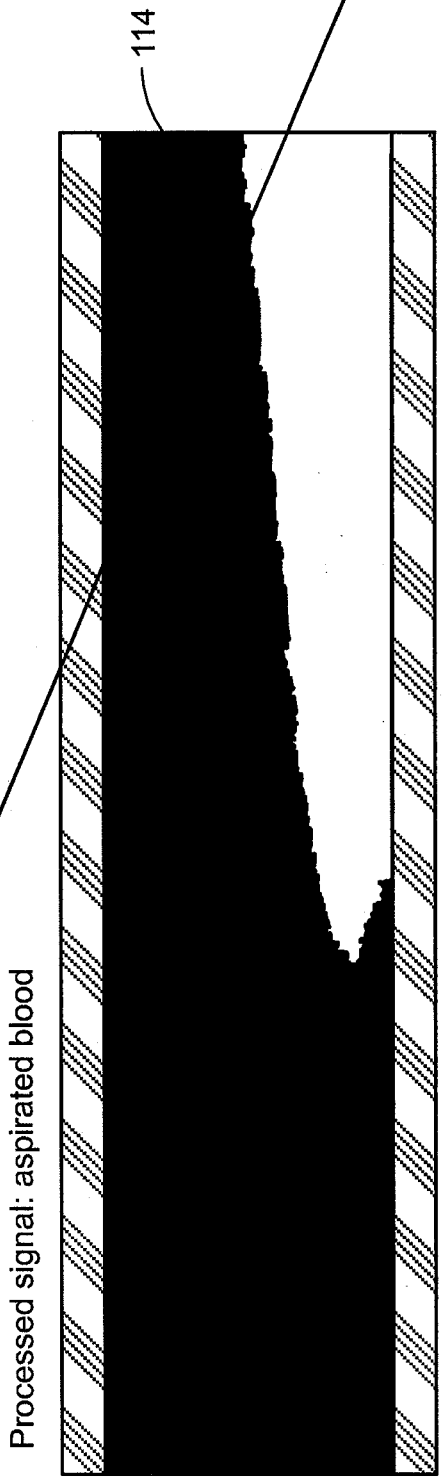

114
Processed signal: aspirated blood

FIG. 38

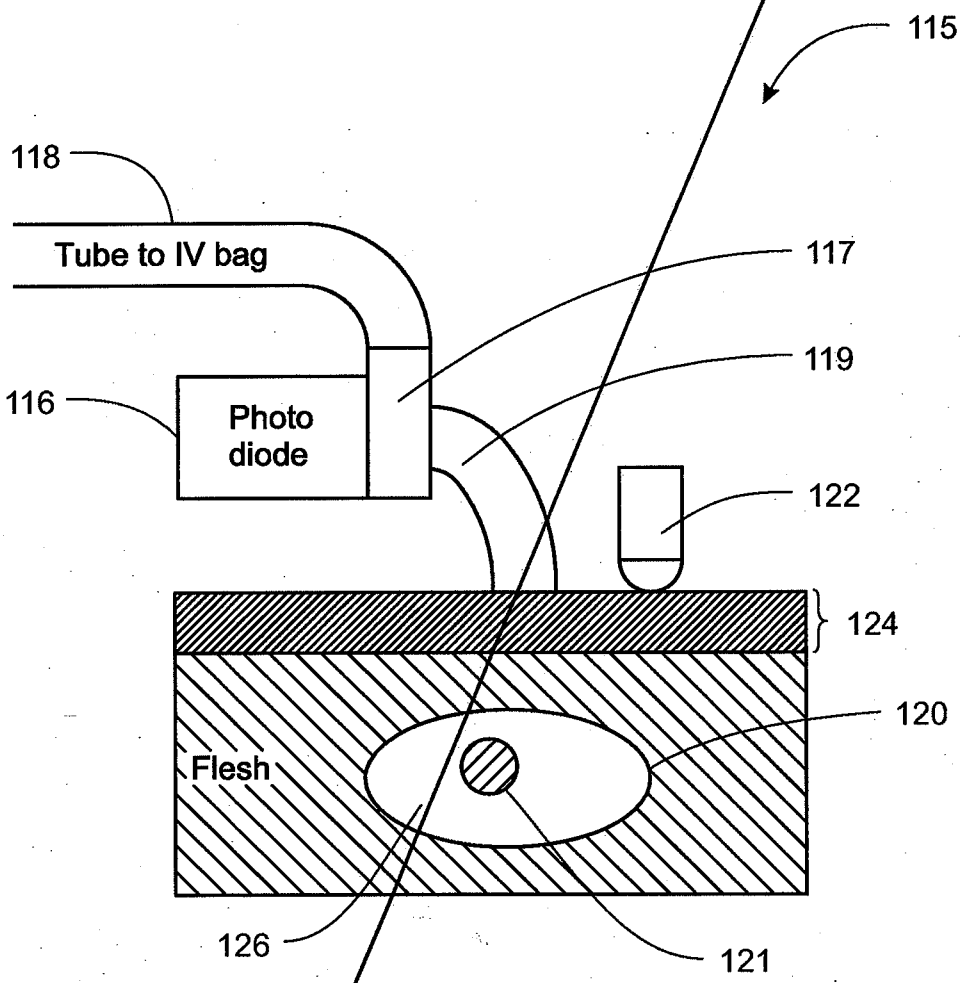

115
118
Tube to IV bag
117
119
116
Photo diode
122
124
120
Flesh
126
121

FIG. 39

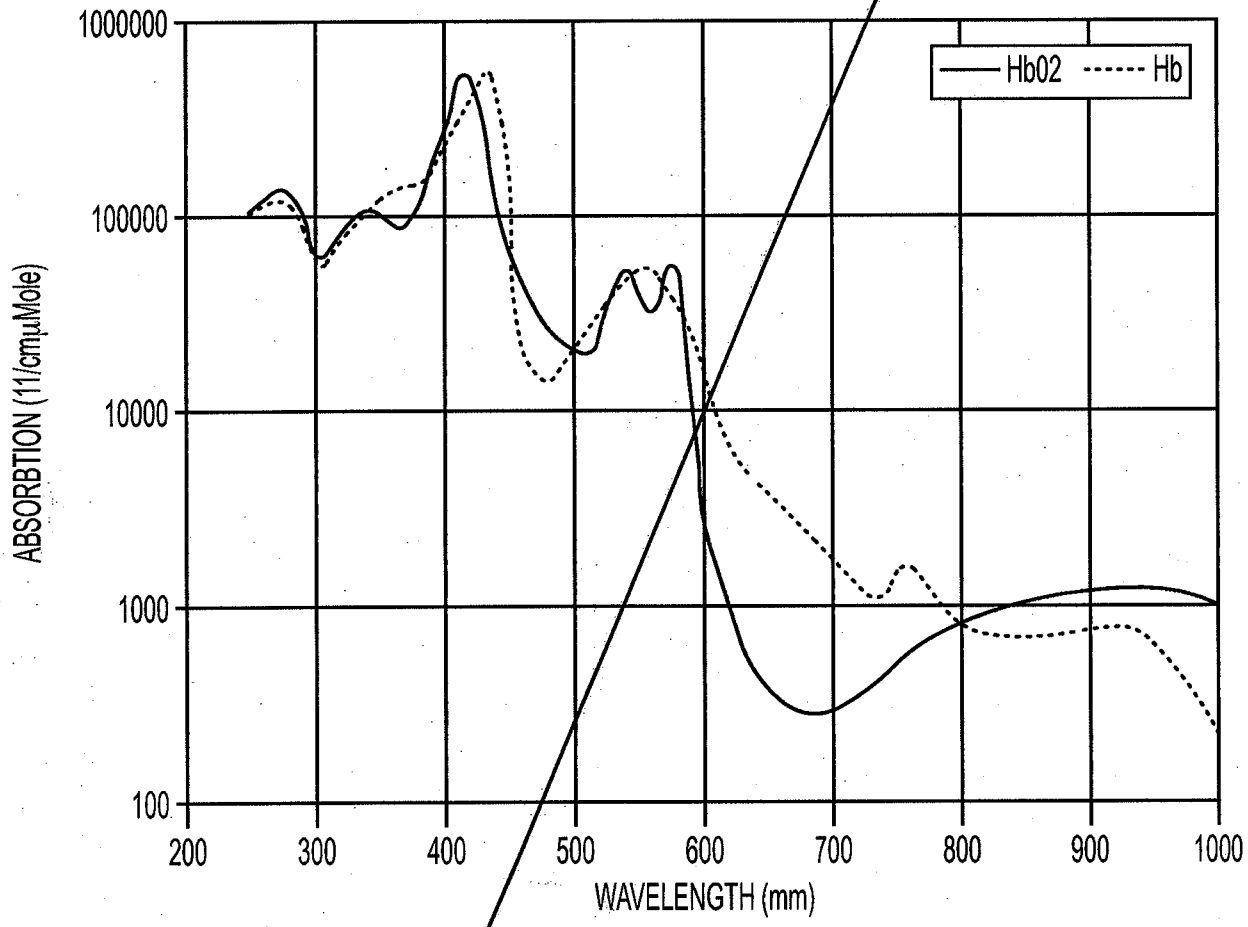

127
1000000
100000
10000
1000
100
ABSORBTION (11/cmμMole)
200
300
400
500
600
700
800
900
1000
WAVELENGTH (mm)
Hb02
Hb

FIG. 40

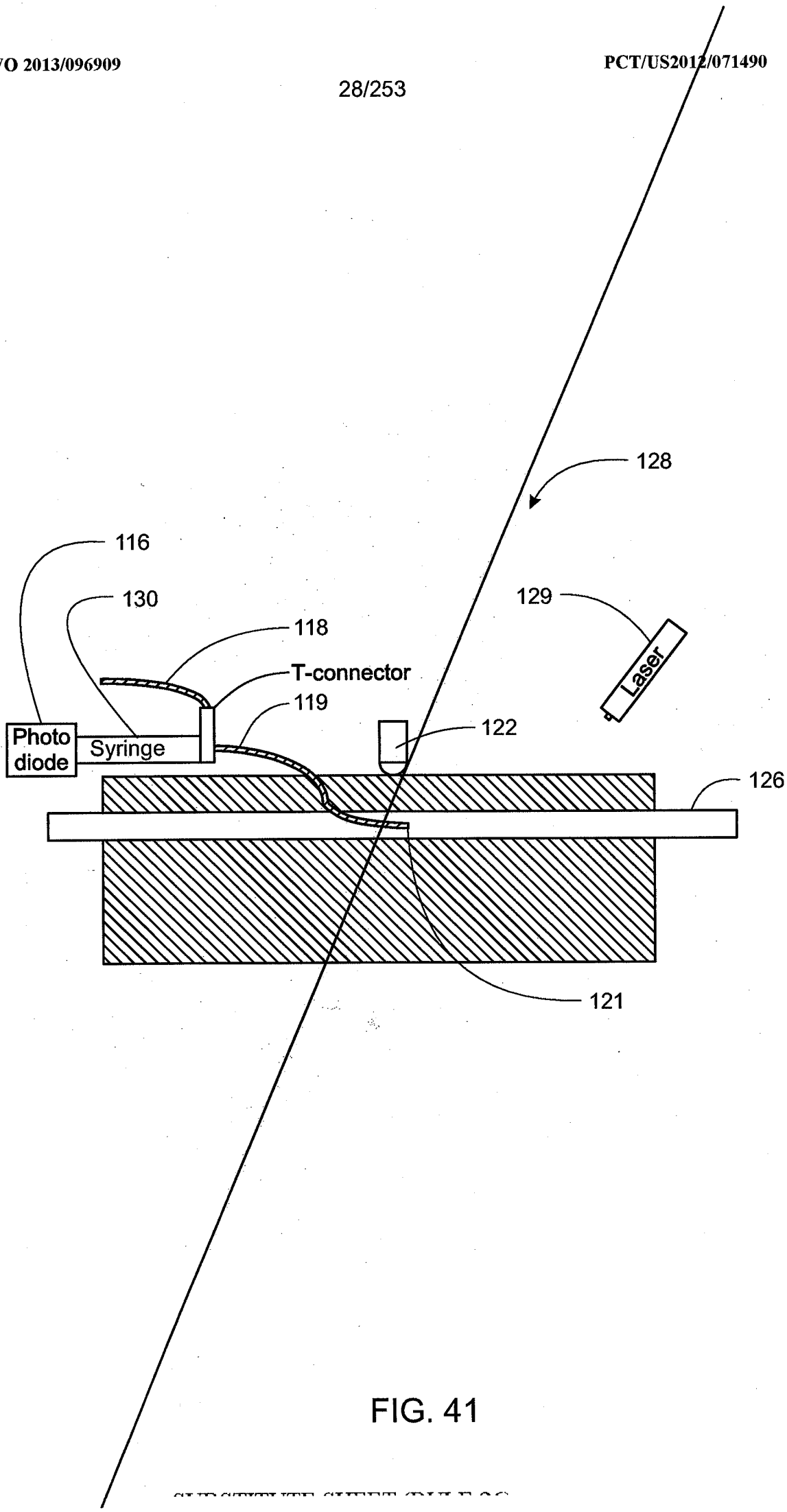

128
116
130
129
118
T-connector
Laser
119
Photo diode
Syringe
122
126
121

FIG. 41

FIG. 42

FIG. 43

FIG. 44

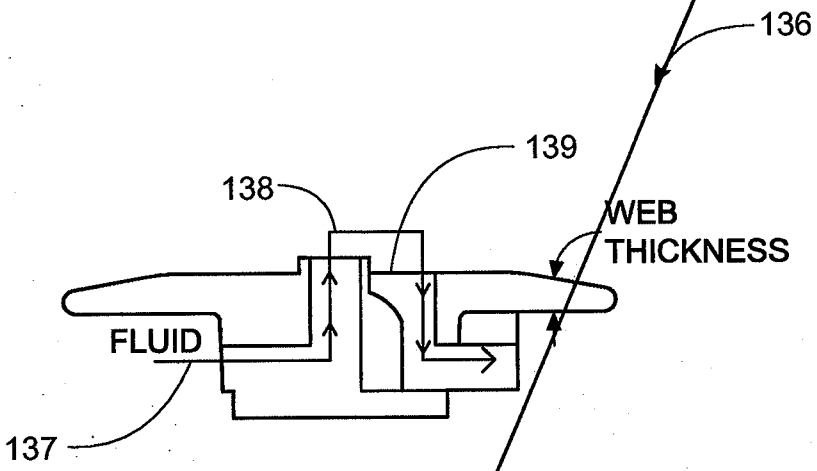


FIG. 45

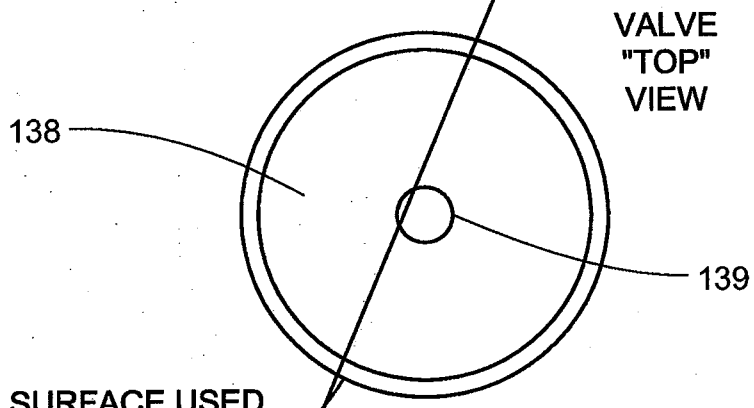


FIG. 46

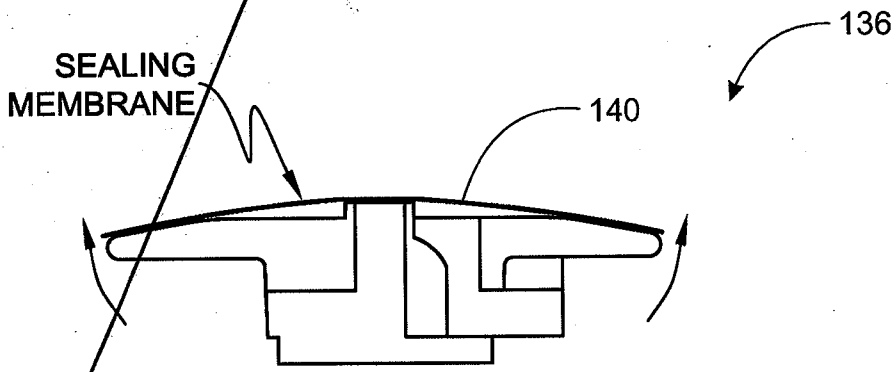


FIG.47

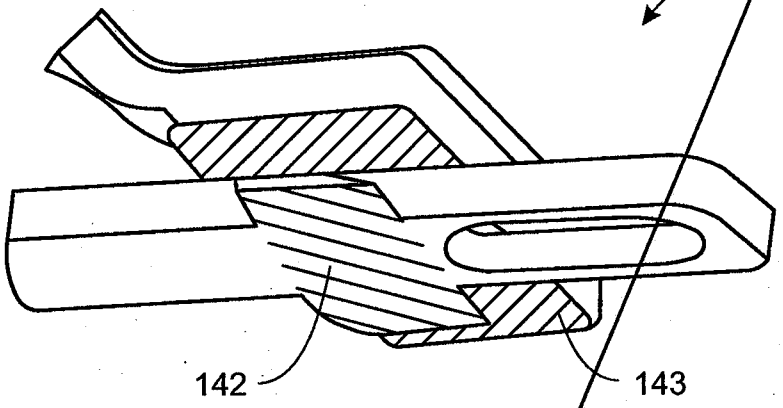


FIG. 48

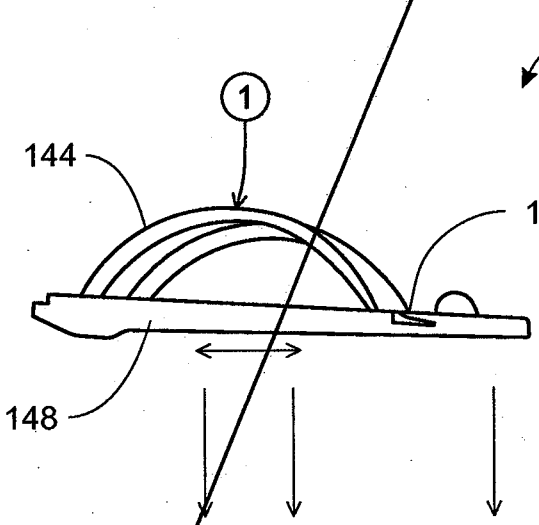


FIG. 49

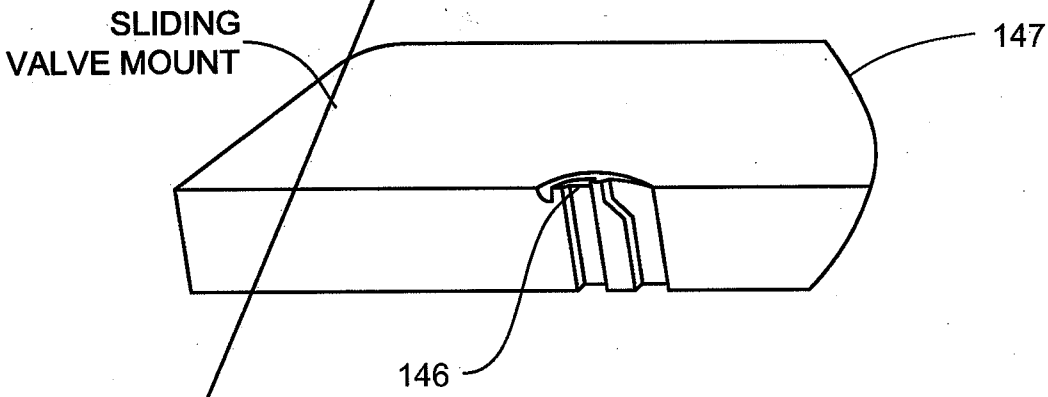


FIG. 50

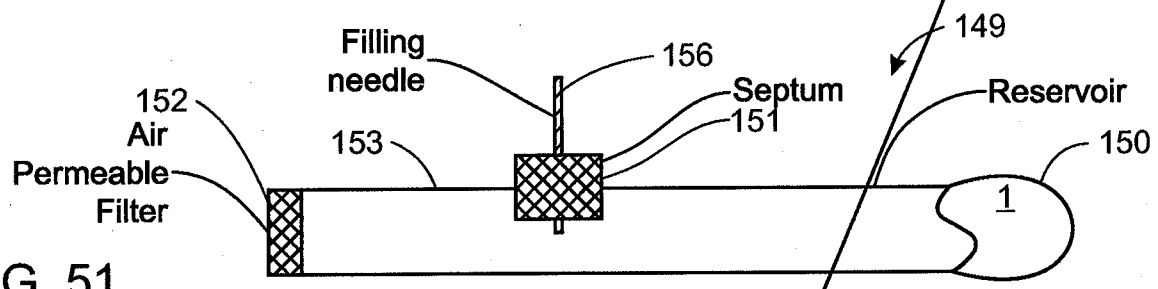


FIG. 51

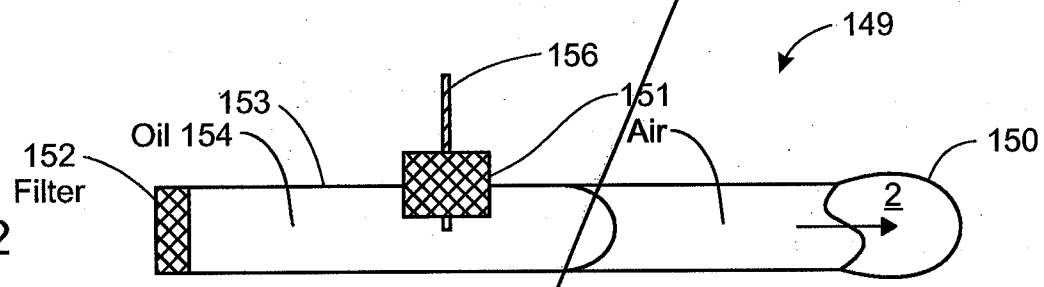


FIG. 52

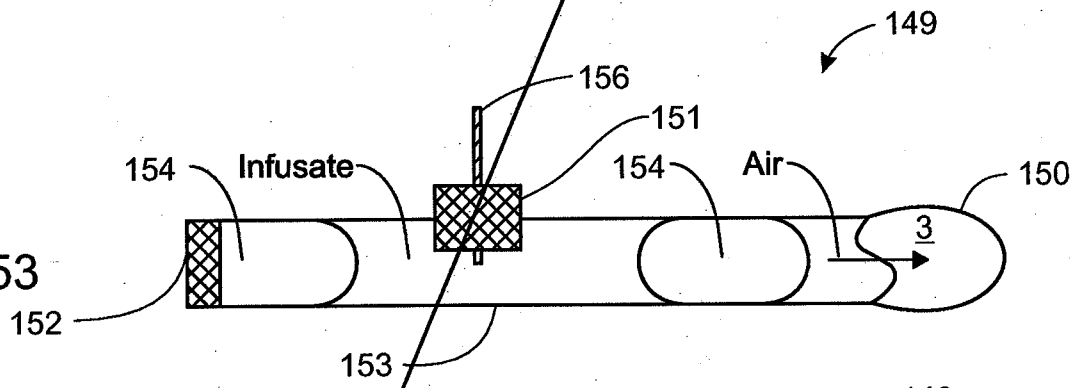


FIG. 53

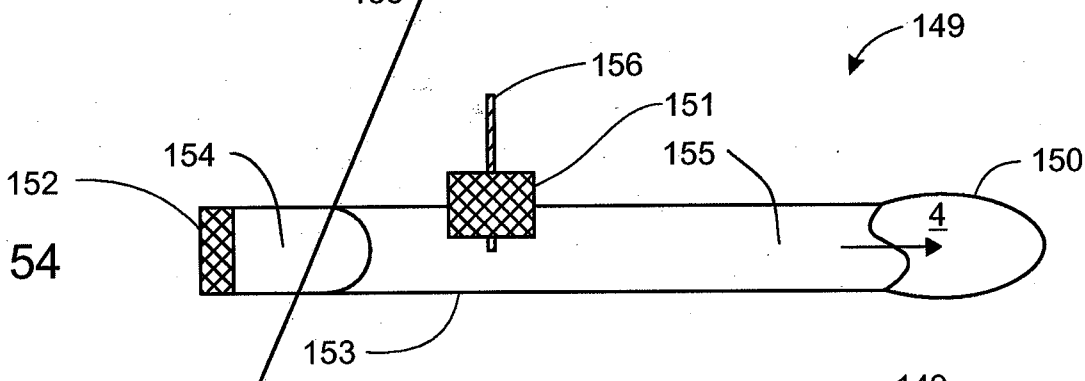


FIG. 54

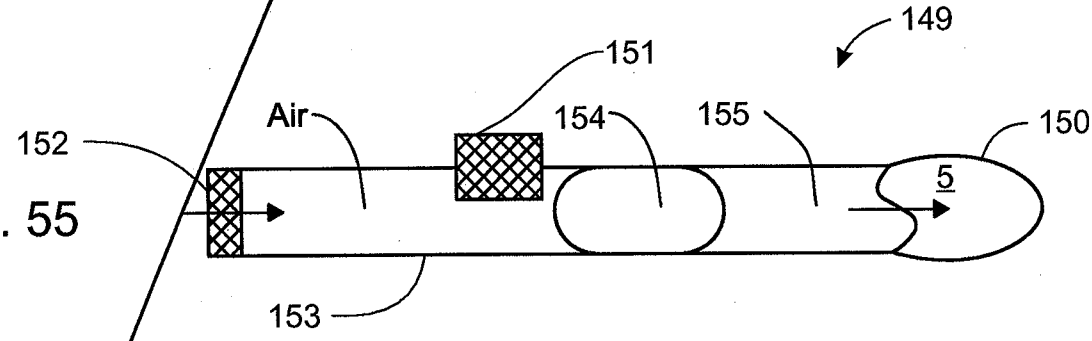


FIG. 55

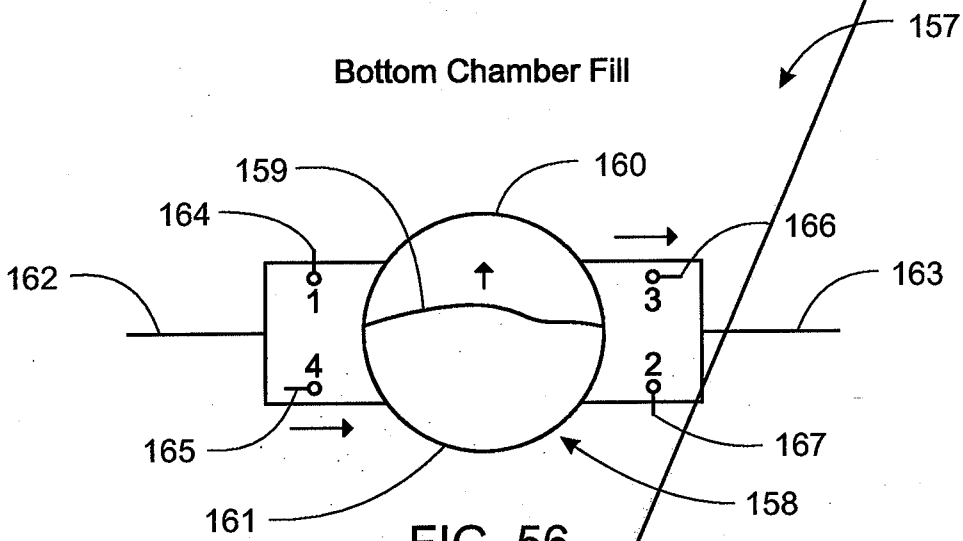


FIG. 56

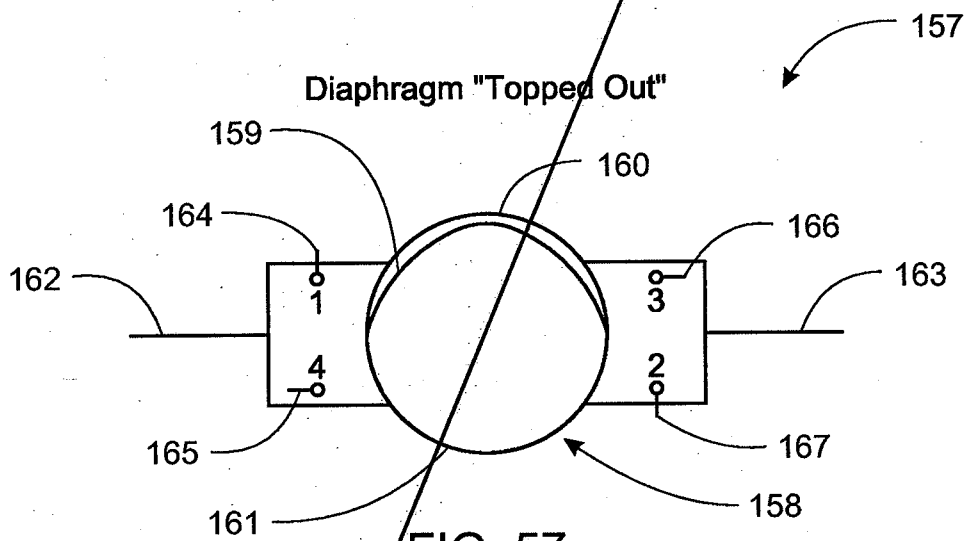


FIG. 57

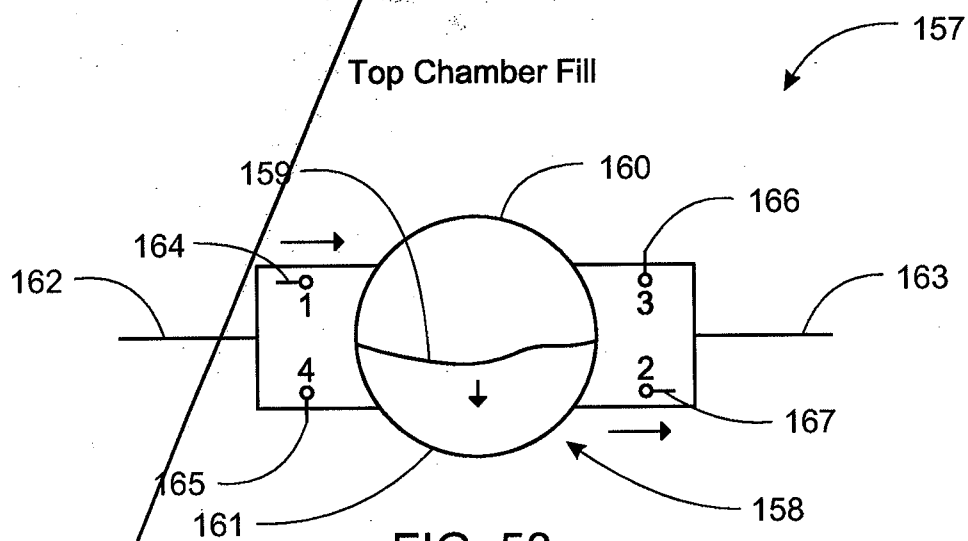


FIG. 58

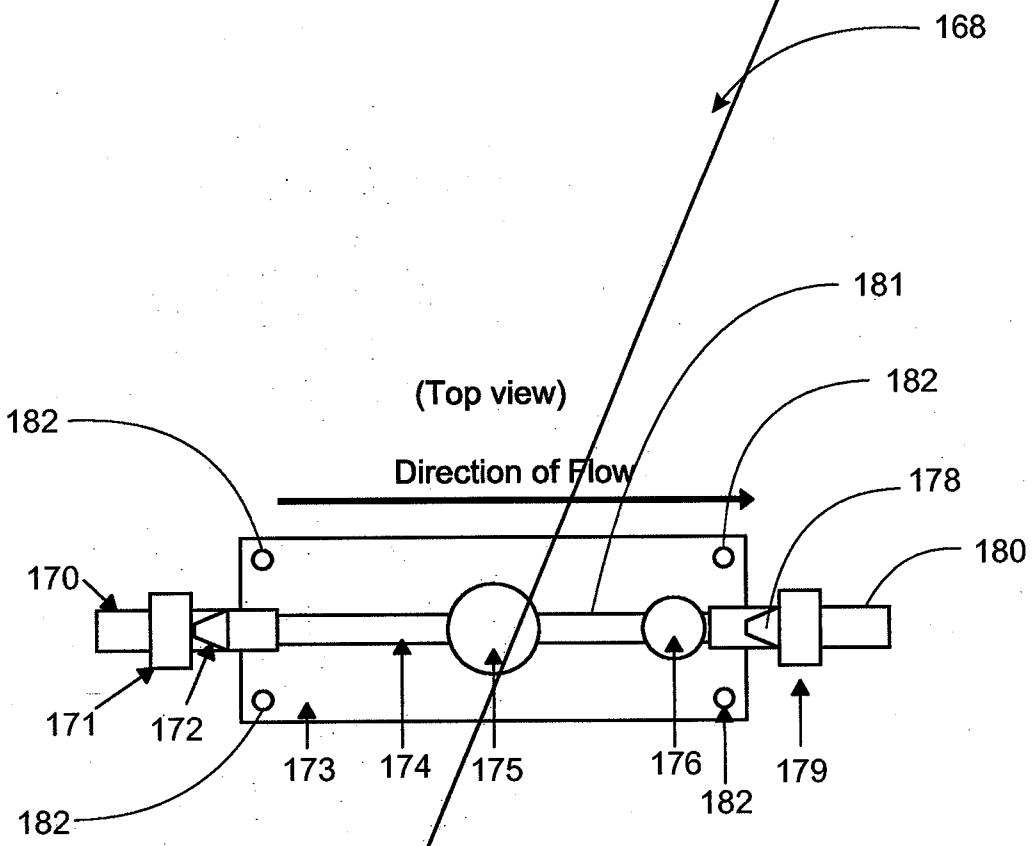

168
181
182
(Top view)
182
Direction of Flow
178
180
170
171
172
173
174
175
176
182
179
182

FIG. 59

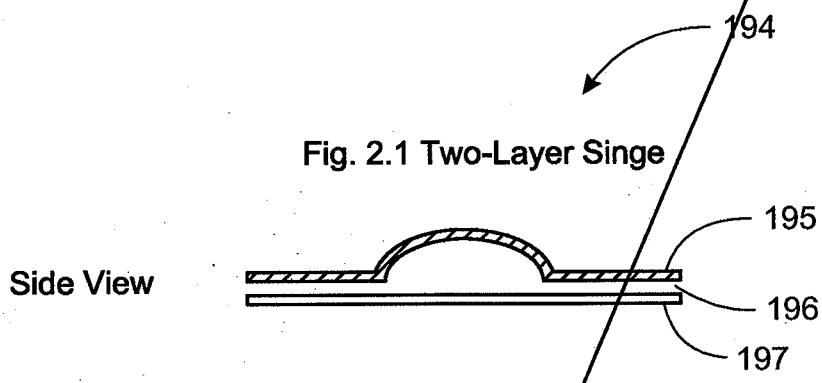


Fig. 2.1 Two-Layer Singe

FIG. 60

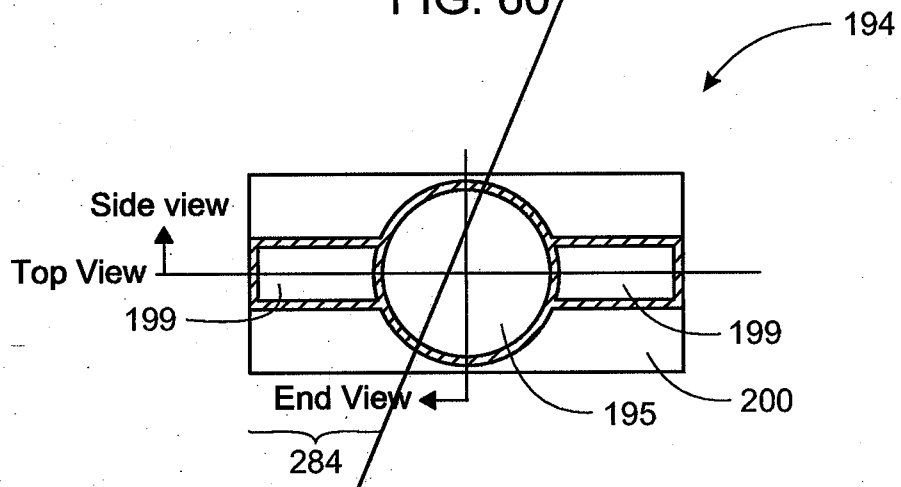


FIG. 61

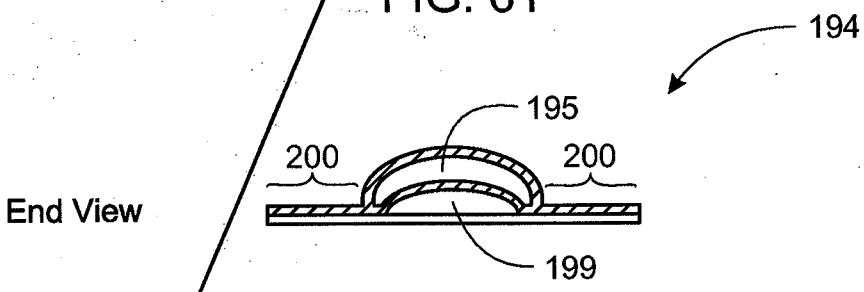


FIG. 62

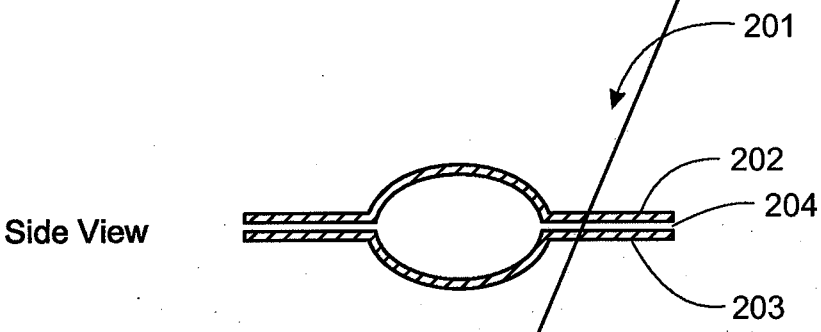


FIG. 63

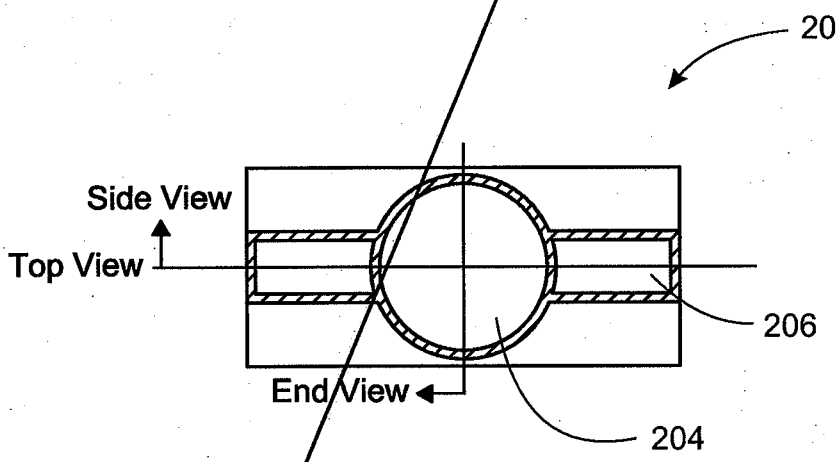


FIG. 64

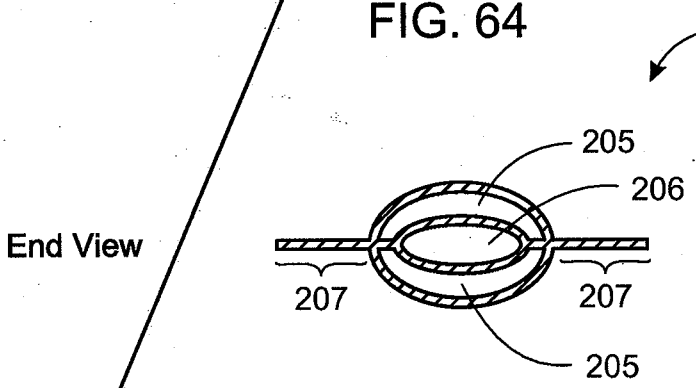


FIG. 65

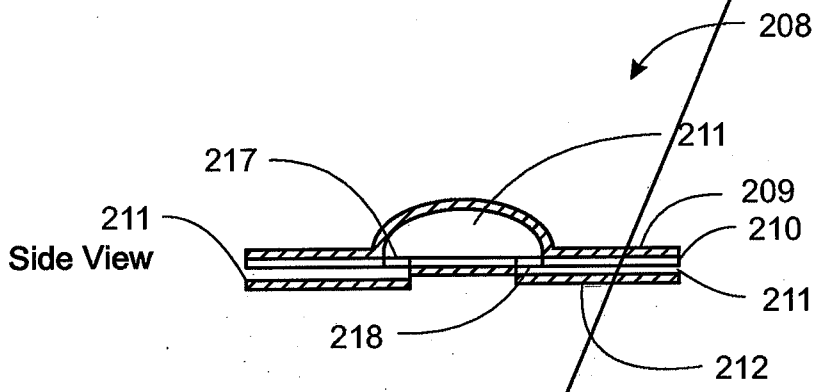


FIG. 66

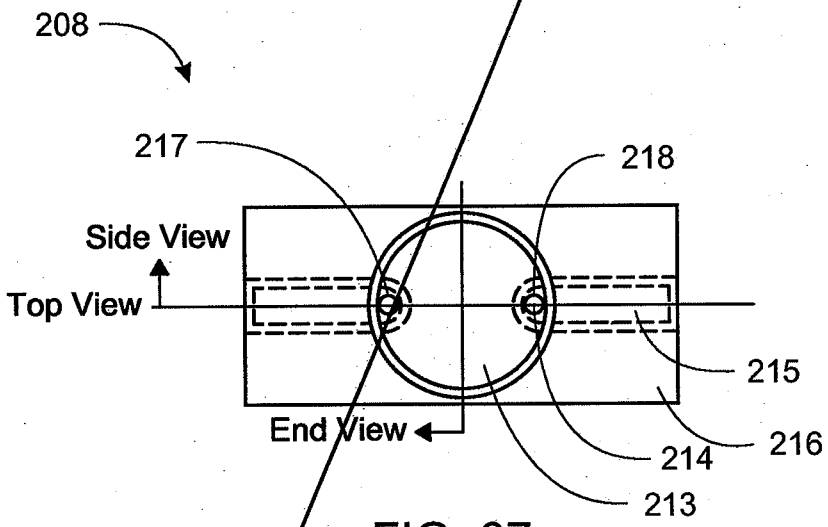


FIG. 67

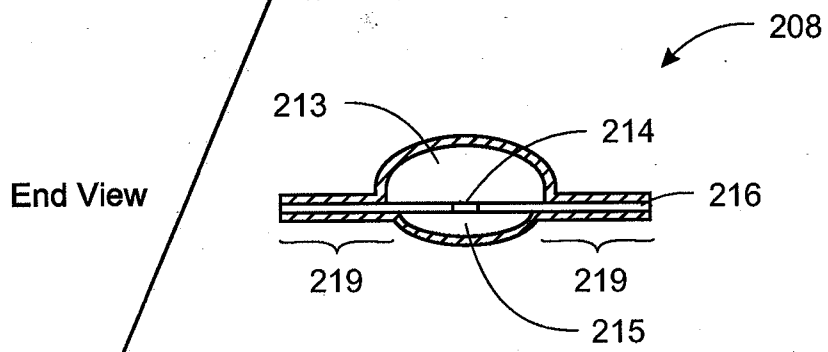


FIG. 68

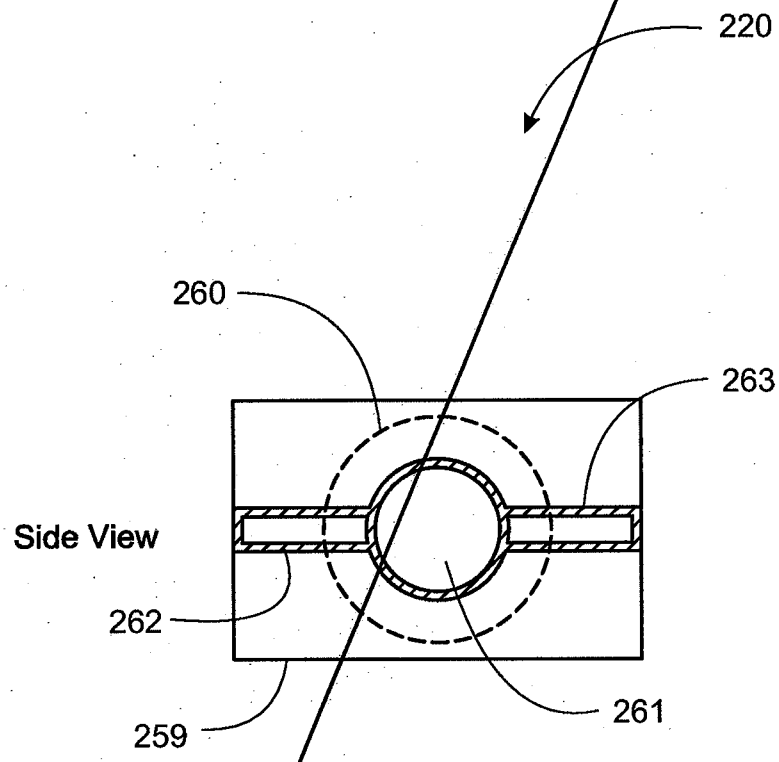


FIG. 69

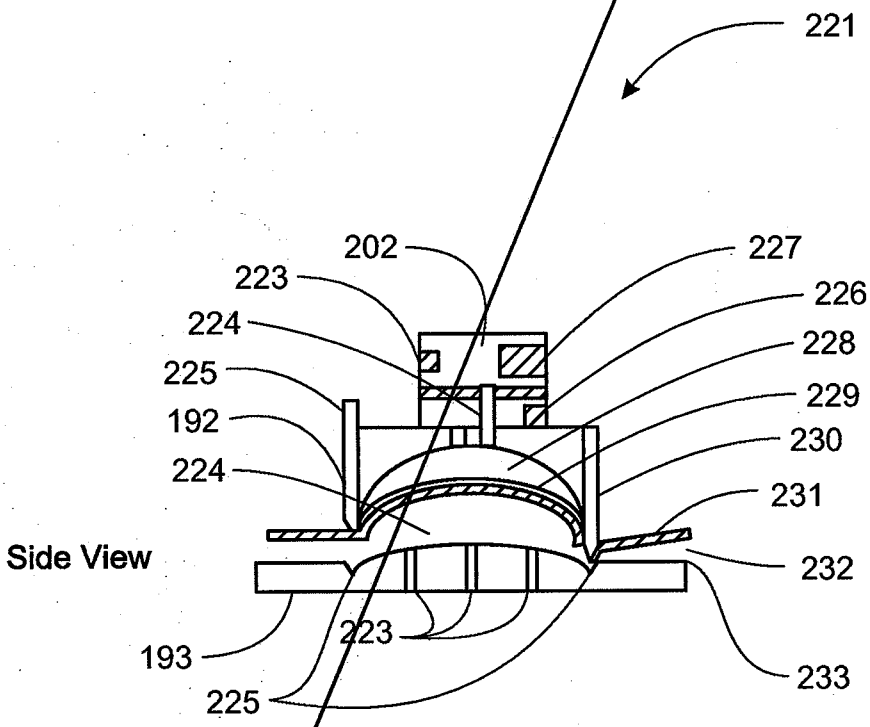

221
202
223
224
225
192
224
227
226
228
229
230
231
232
233
223
193
225
Side View

FIG. 70

Fig. 3.2 Double Sided AVS with Integral Perimeter Seal Valves

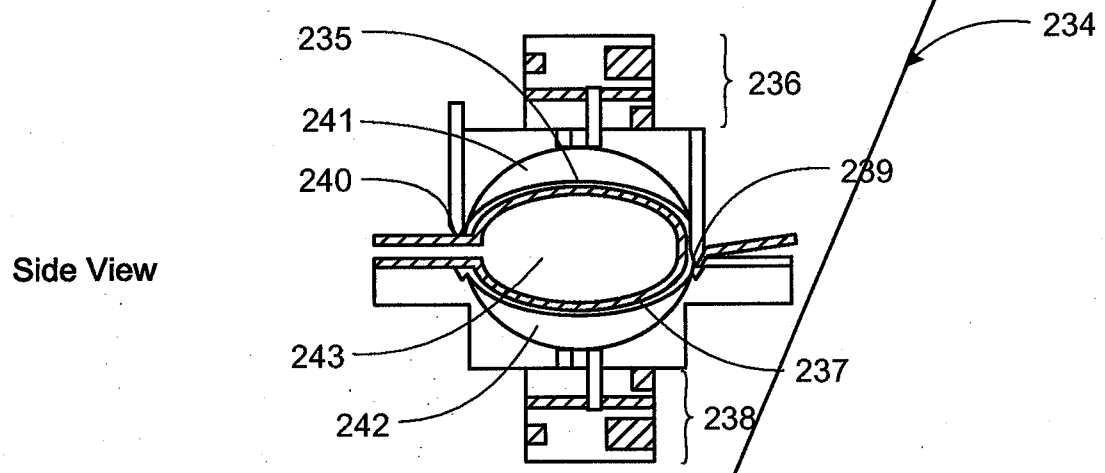


FIG. 71

Fig. 3.3 3-D AVS with Integral Perimeter Seal Valves

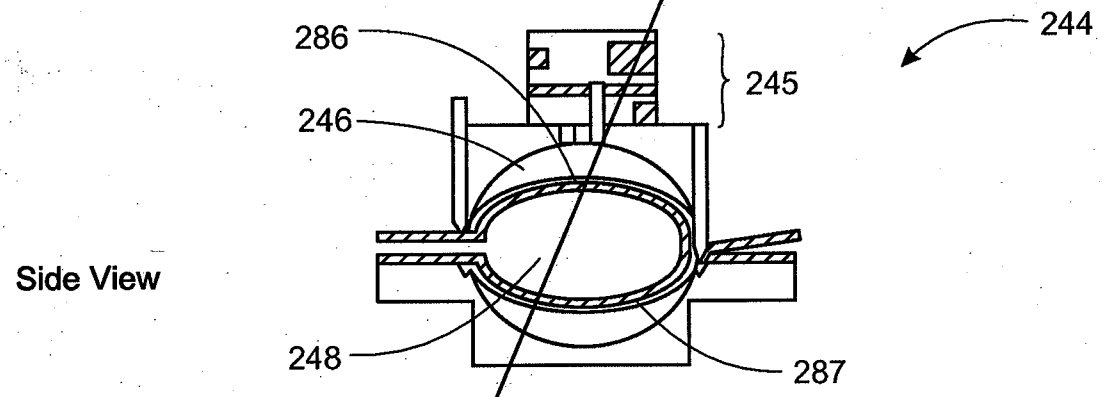


FIG. 72

Fig. 3.4 Three-Layer Single Sided AVS with Piston Valves

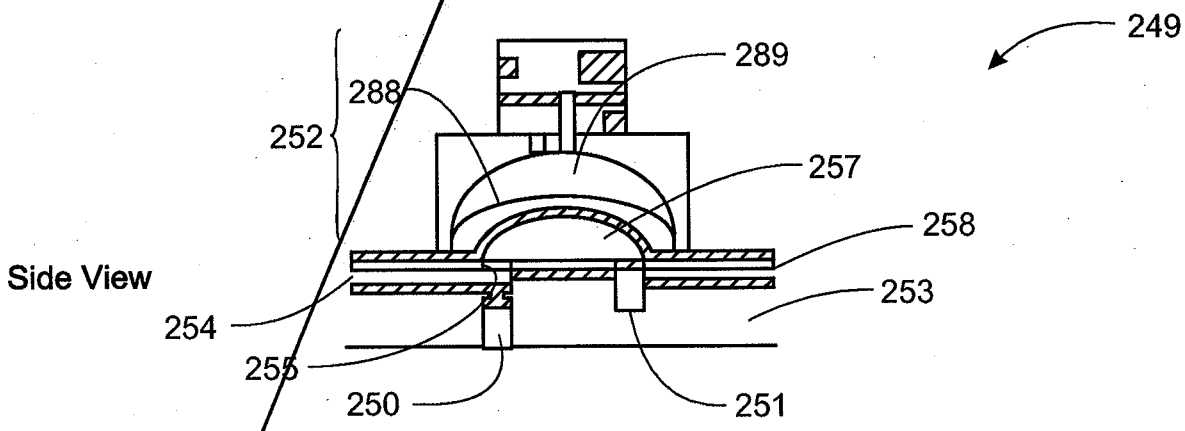


FIG. 73

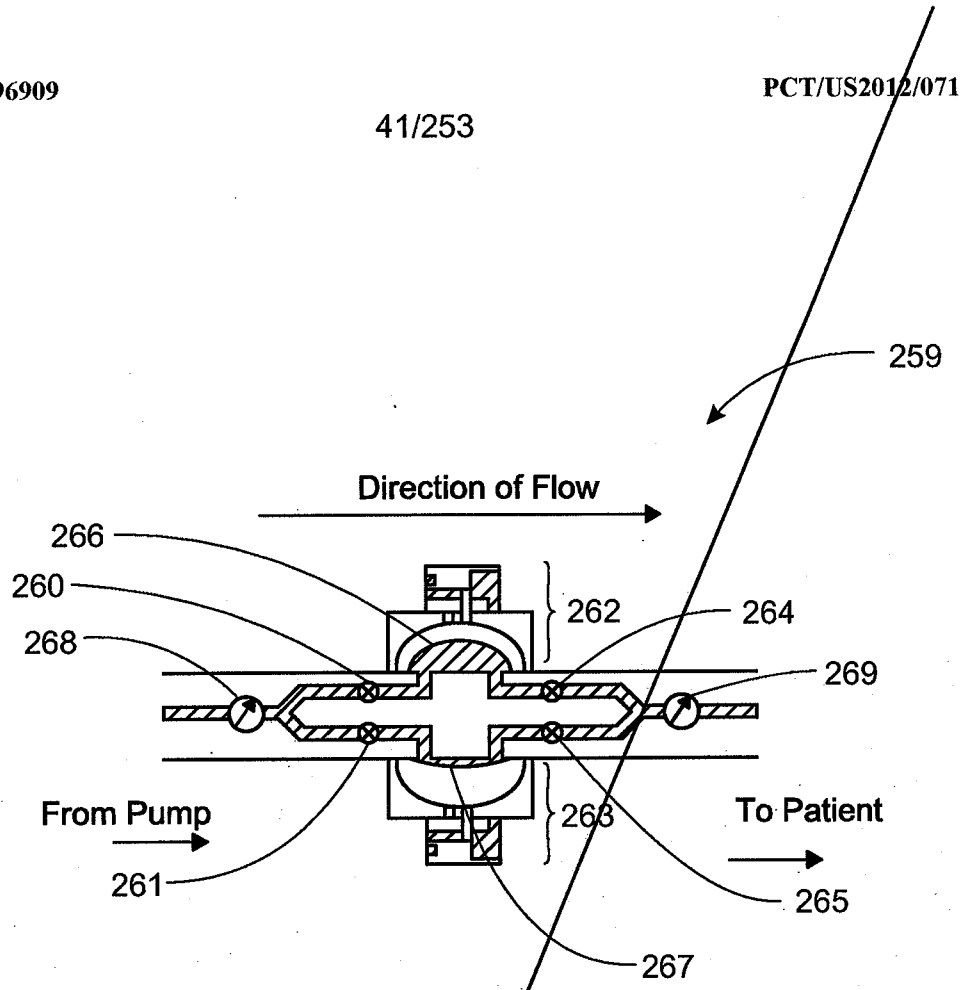

259
Direction of Flow
266
260
268
262
264
269
From Pump
261
263
To Patient
265
267

FIG. 74

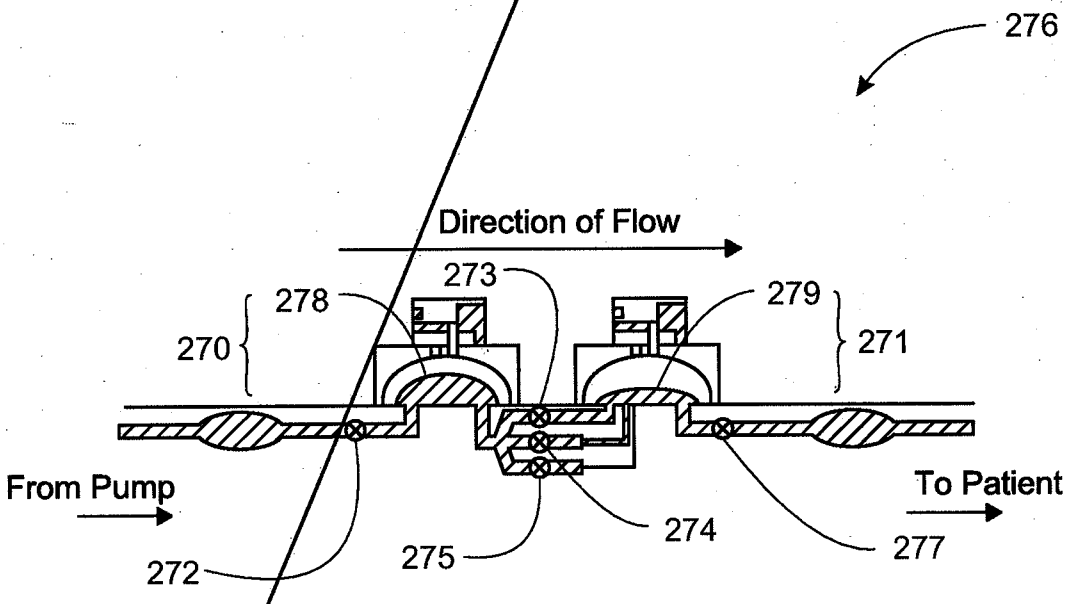

276
Direction of Flow
273
278
279
270
271
From Pump
To Patient
272
275
274
277

FIG. 75

Figure 1: Example Active Fill/Passive Empty Pumping AVS

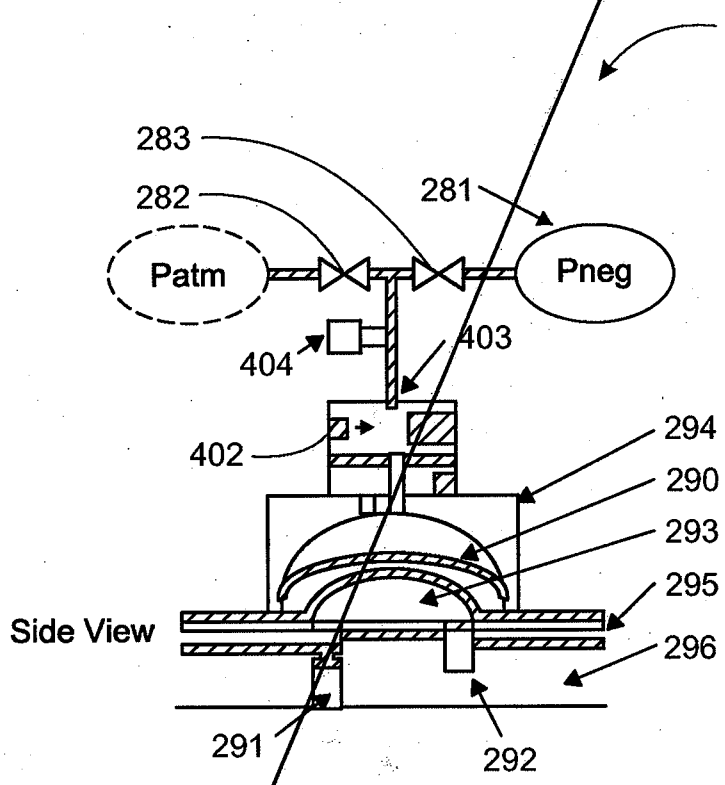


FIG. 76

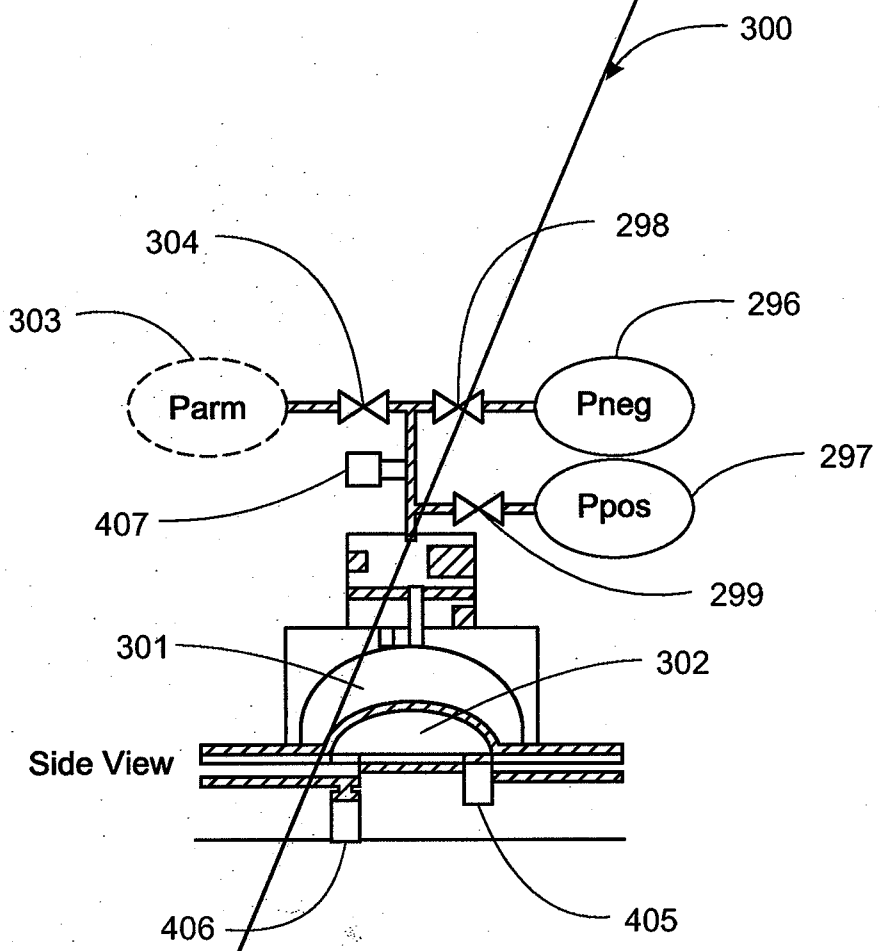

300
304
298
303
296
Parm
Pneg
297
407
Ppos
299
301
302
Side View
406
405

FIG. 77

Figure 1: Example Optical Line Pressure

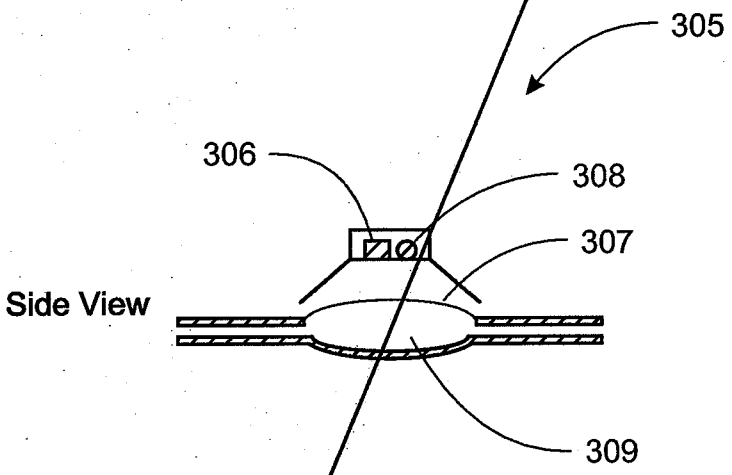


FIG. 78

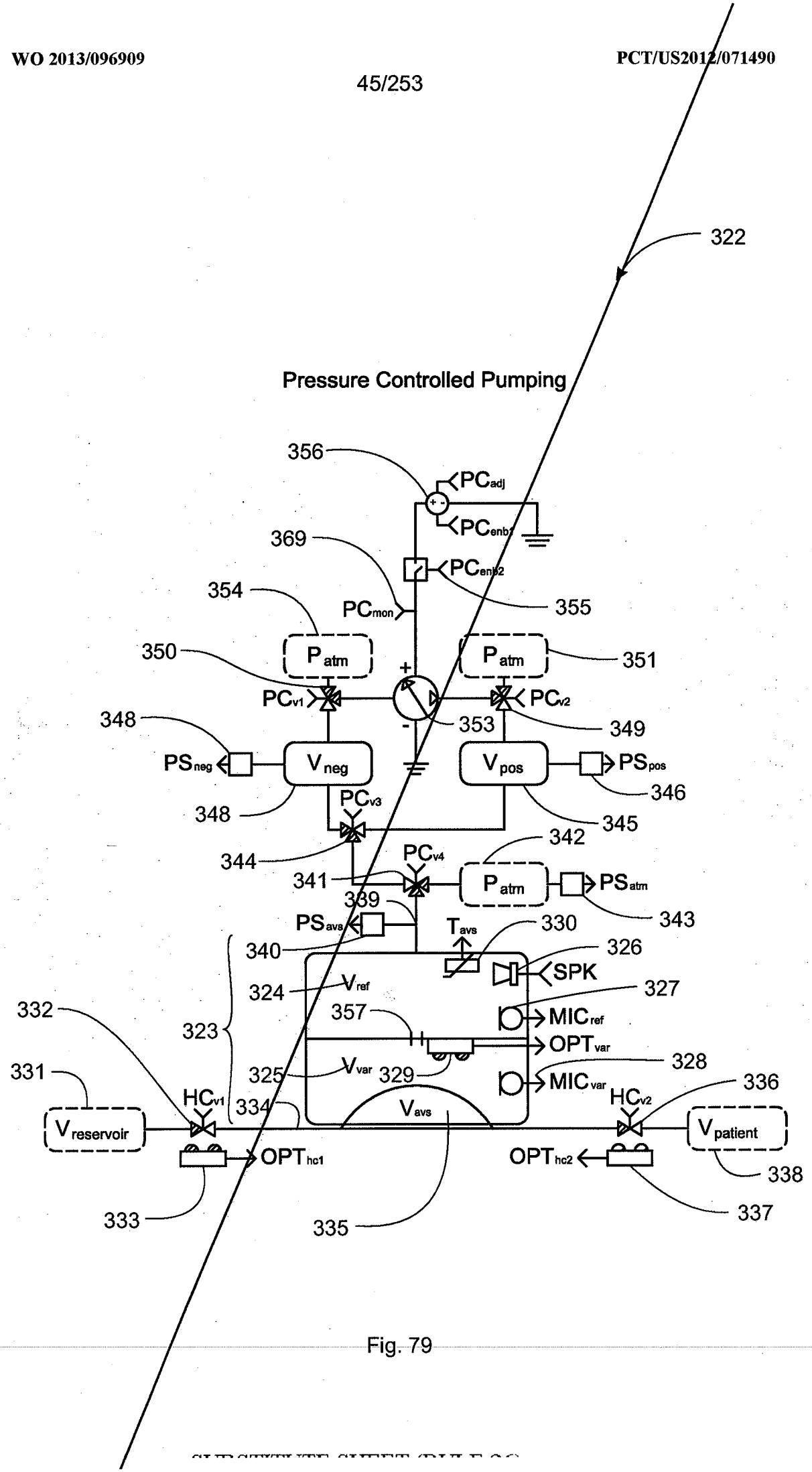

322
Pressure Controlled Pumping
356
PCadj
PCenb1
369
PCenb2
355
354
PCmon
350
Patm
Patm
351
PCv1
PCv2
353
349
348
PSneg
Vneg
Vpos
PSpos
346
348
PCv3
345
342
344
PCv4
341
Patm
PSatm
343
339
PSavs
Tavs
330
340
326
SPK
324
Vref
327
332
357
MICref
323
OPTvar
328
331
325
Vvar
329
MICvar
336
HCv1
334
Vavs
HCv2
Vreservoir
Vpatient
OPThc1
OPThc2
338
333
335
337

Fig. 79

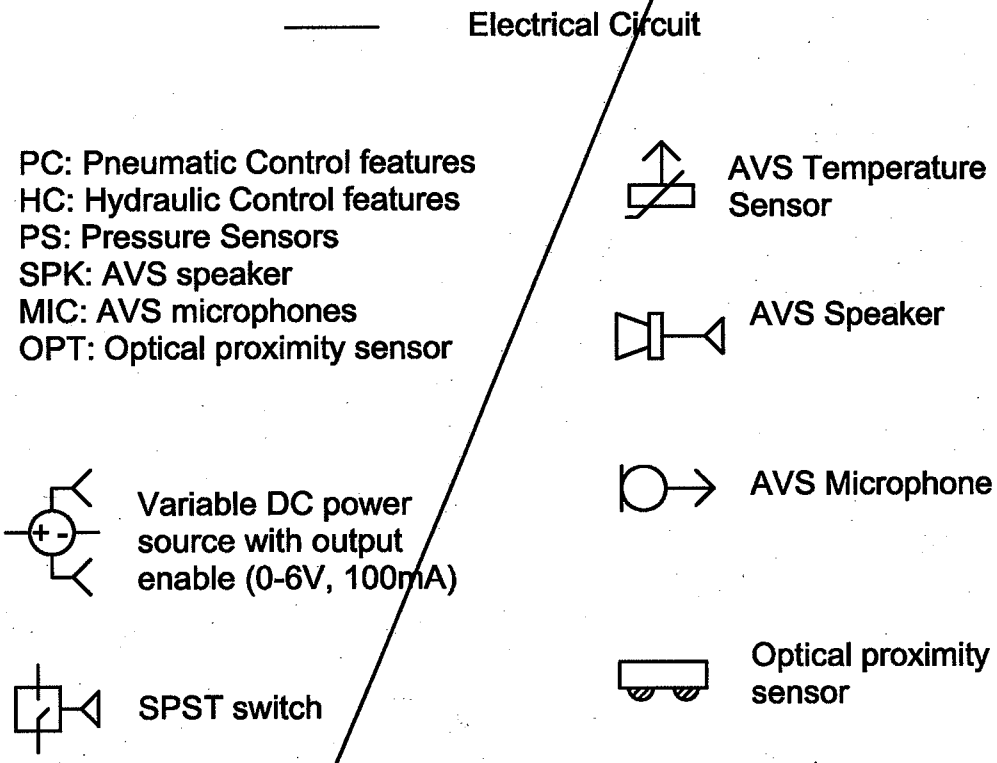

Electrical Circuit
PC: Pneumatic Control features
HC: Hydraulic Control features
PS: Pressure Sensors
SPK: AVS speaker
MIC: AVS microphones
OPT: Optical proximity sensor
AVS Temperature Sensor
AVS Speaker
AVS Microphone
Optical proximity sensor
Variable DC power source with output enable (0-6V, 100mA)
SPST switch

FIG. 80

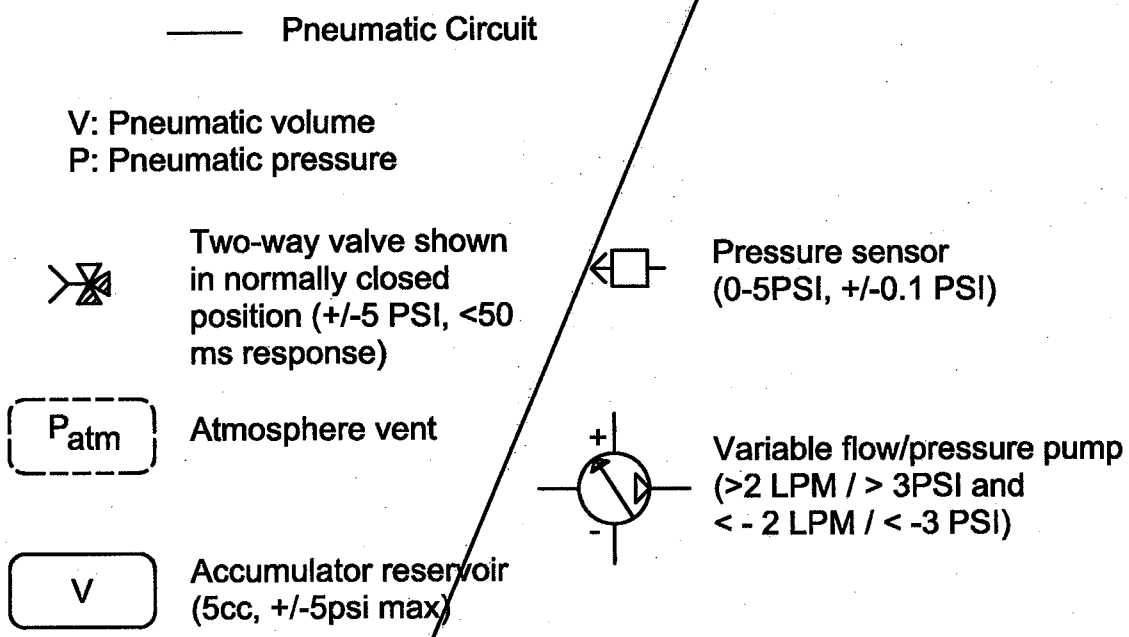

Pneumatic Circuit
V: Pneumatic volume
P: Pneumatic pressure
Two-way valve shown in normally closed position (+/-5 PSI, <50 ms response)
Pressure sensor (0-5PSI, +/-0.1 PSI)
Patm
Atmosphere vent
+
-
Variable flow/pressure pump (>2 LPM / > 3PSI and < - 2 LPM / < -3 PSI)
V
Accumulator reservoir (5cc, +/-5psi max)

FIG. 81

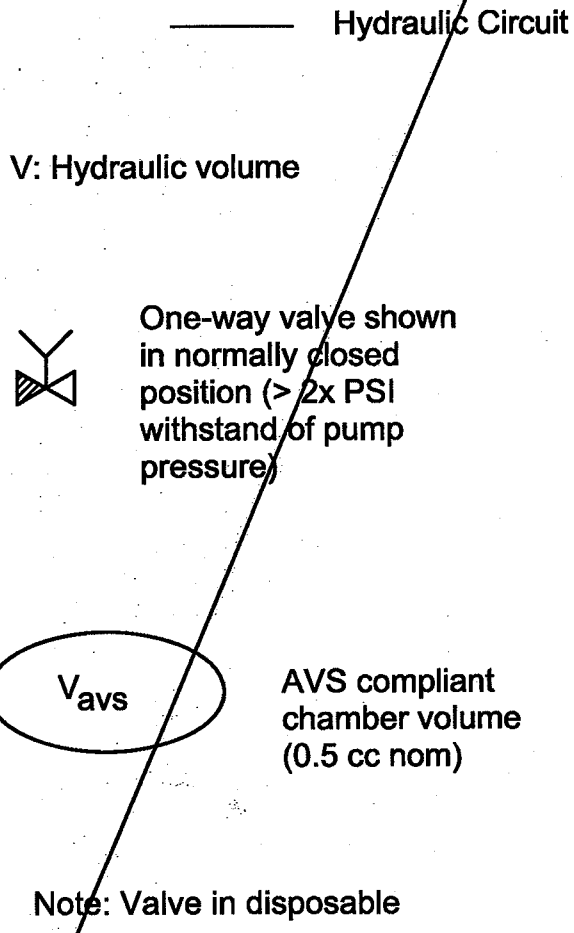

Hydraulic Circuit
V: Hydraulic volume
One-way valve shown in normally closed position (> 2x PSI withstand of pump pressure)
V_{avs}
AVS compliant chamber volume (0.5 cc nom)
Note: Valve in disposable

FIG. 82

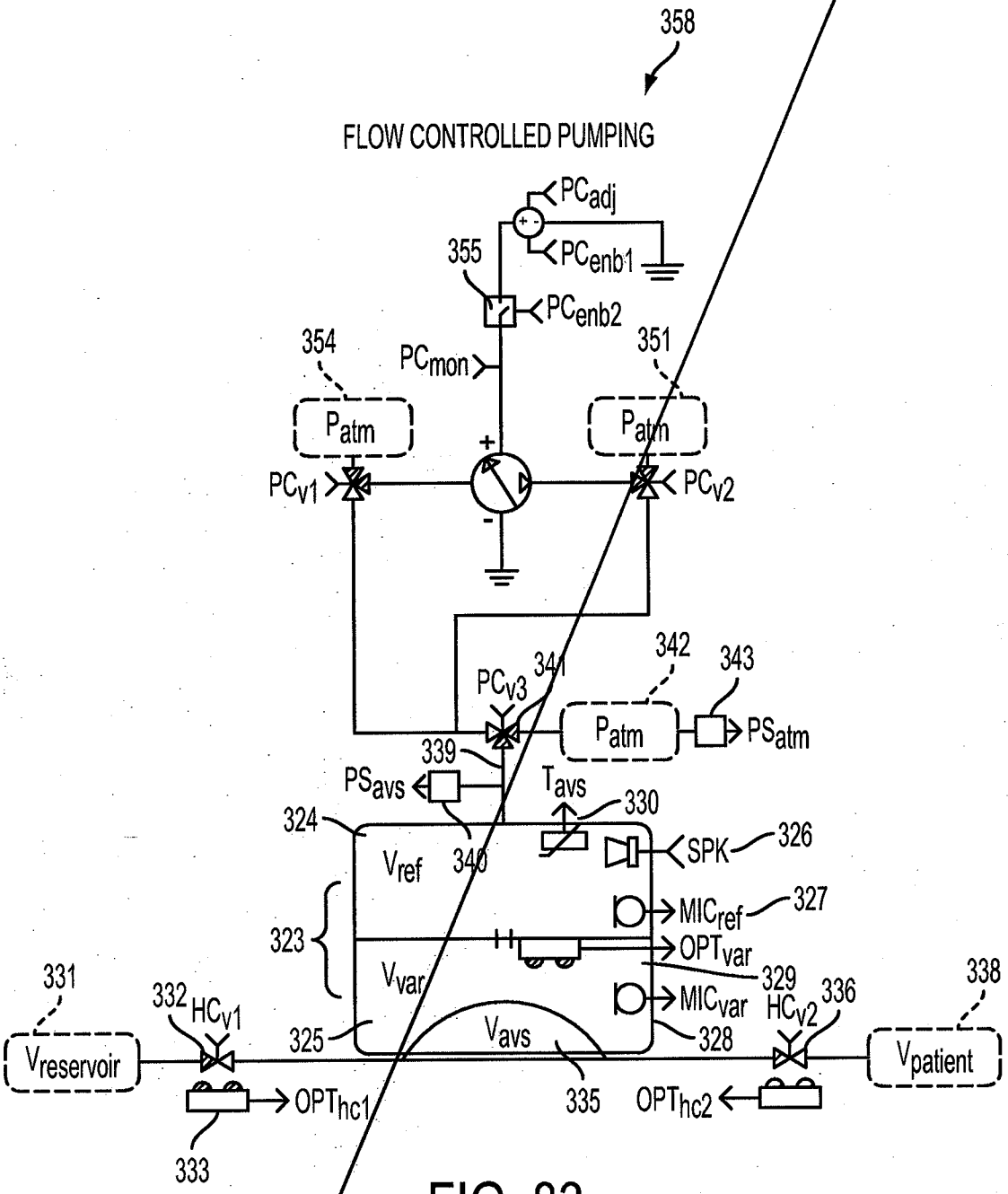

358
FLOW CONTROLLED PUMPING
PCadj
PCenb1
PCenb2
355
354
PCmon
351
Patm
Patm
PCv1
PCv2
PCv3
341
342
343
Patm
PSatm
339
PSavs
Tavs
330
324
Vref
340
SPK
326
MICref
327
323
OPTvar
Vvar
329
MICvar
HCv2
336
338
331
332
HCv1
325
Vavs
328
Vreservoir
Vpatient
OPThc1
335
OPThc2
333

FIG. 83

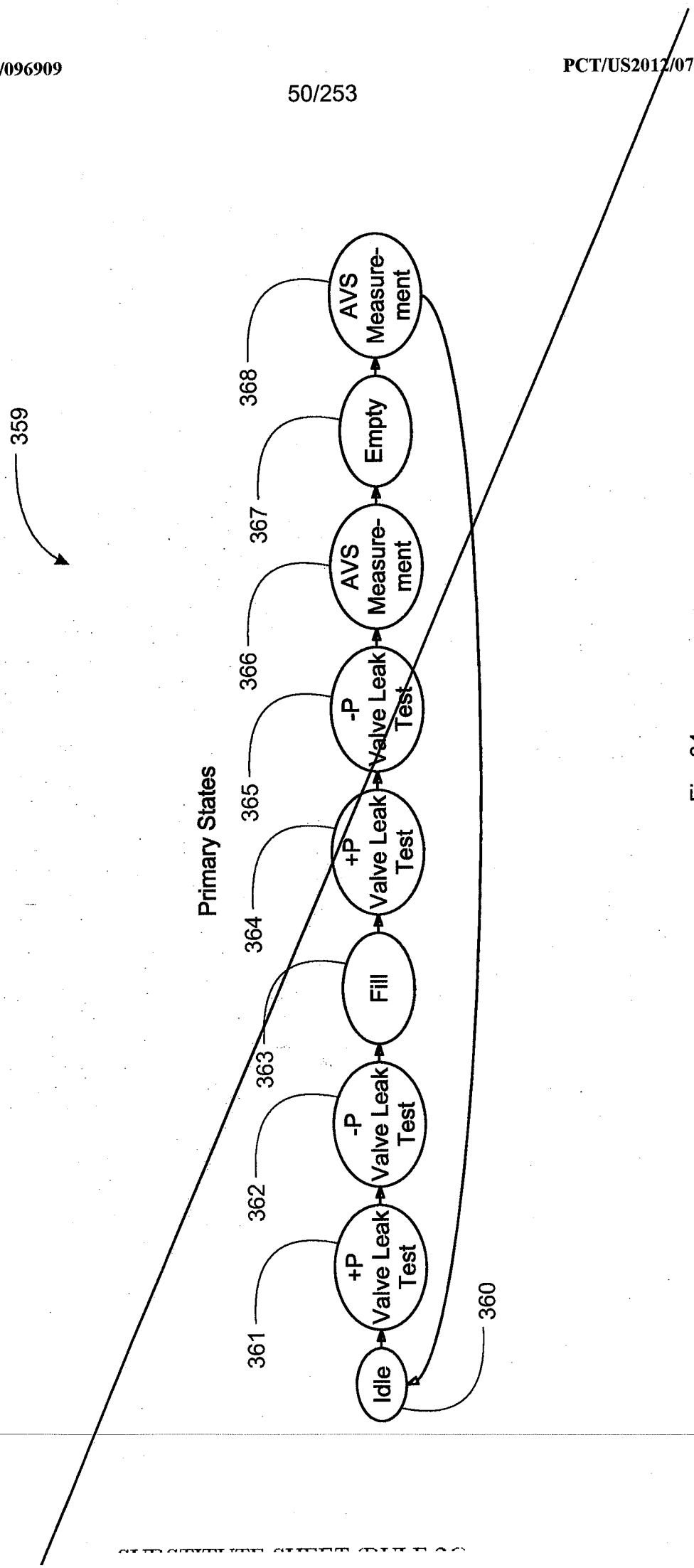

359
Primary States
Idle
+P Valve Leak Test
-P Valve Leak Test
Fill
+P Valve Leak Test
-P Valve Leak Test
AVS Measure-ment
Empty
AVS Measure-ment
361
362
363
364
365
366
367
368
360

Fig. 84

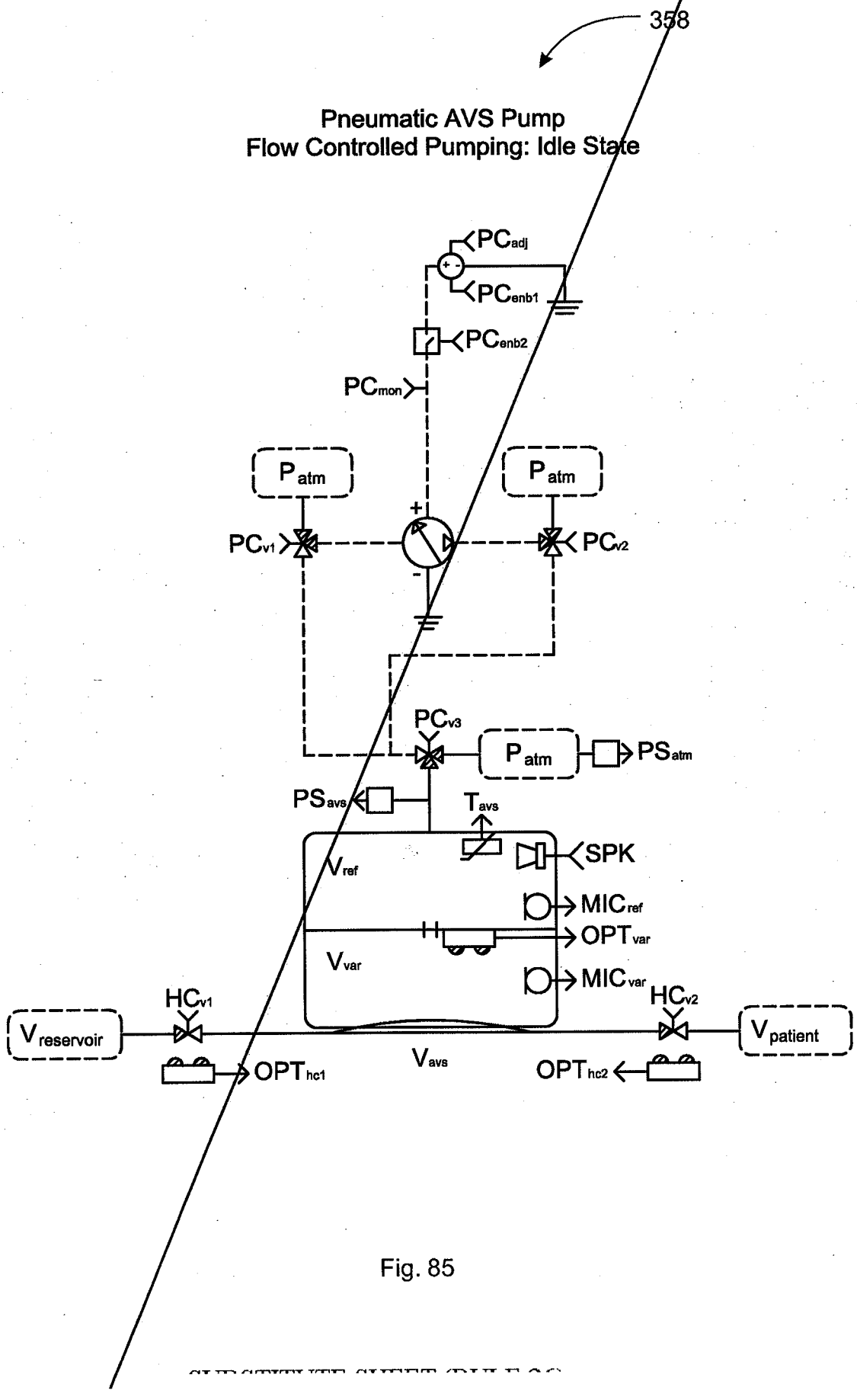

358
Pneumatic AVS Pump
Flow Controlled Pumping: Idle State
PCadj
PCenb1
PCenb2
PCmon
Patm
Patm
PCv1
PCv2
PCv3
Patm
PSatm
PSavs
Tavs
SPK
Vref
MICref
OPTvar
Vvar
MICvar
HCv1
HCv2
Vreservoir
Vpatient
OPThc1
Vavs
OPThc2

Fig. 85

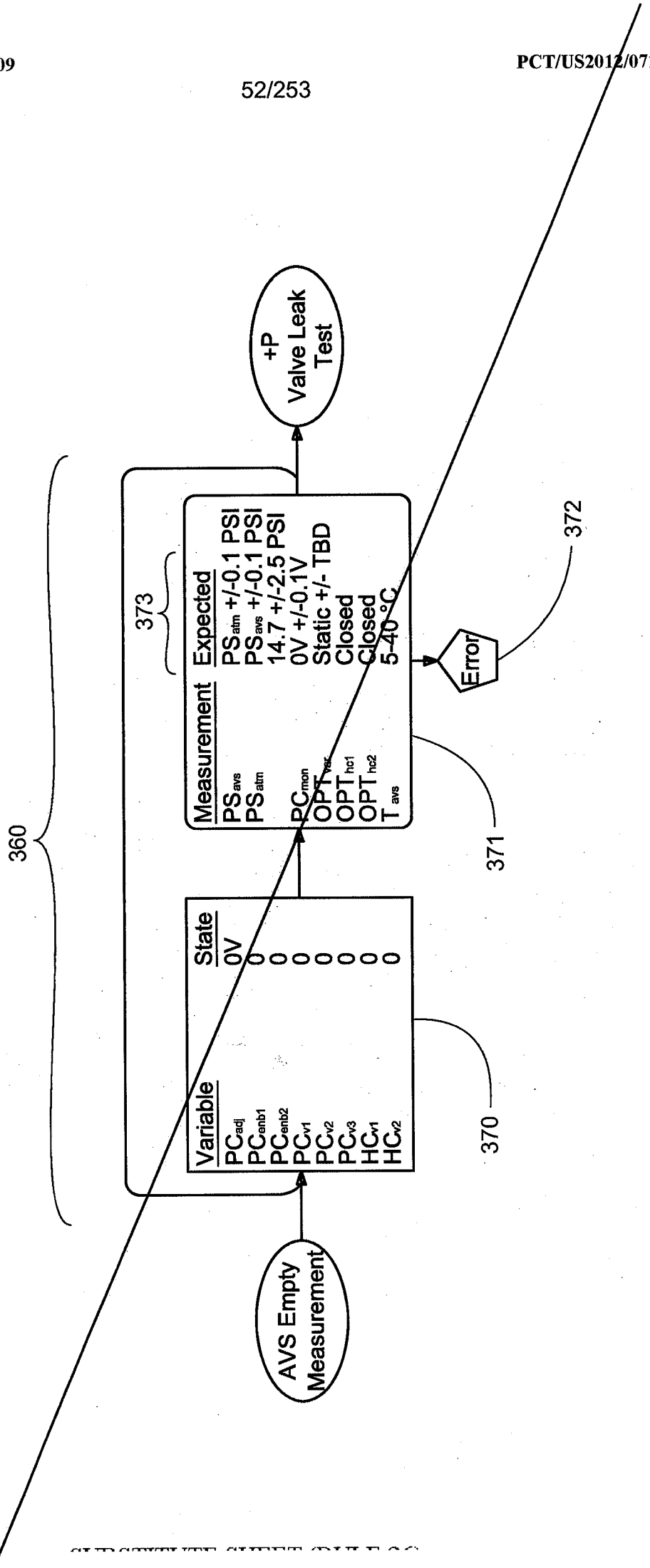

+P Valve Leak Test
AVS Empty Measurement
360
373
Measurement
Expected
PS avs
PS atm
PC mon
OPT ves
OPT hc1
OPT hc2
T avs
PS atm +/-0.1 PSI
PS avs +/-0.1 PSI
14.7 +/-2.5 PSI
0V +/-0.1V
Static +/- TBD
Closed
Closed
5-40 °C
Error
372
371
Variable
State
0V
PC adj
PC enb1
PC enb2
PC v1
PC v2
PC v3
HC v1
HC v2
370

Fig. 86

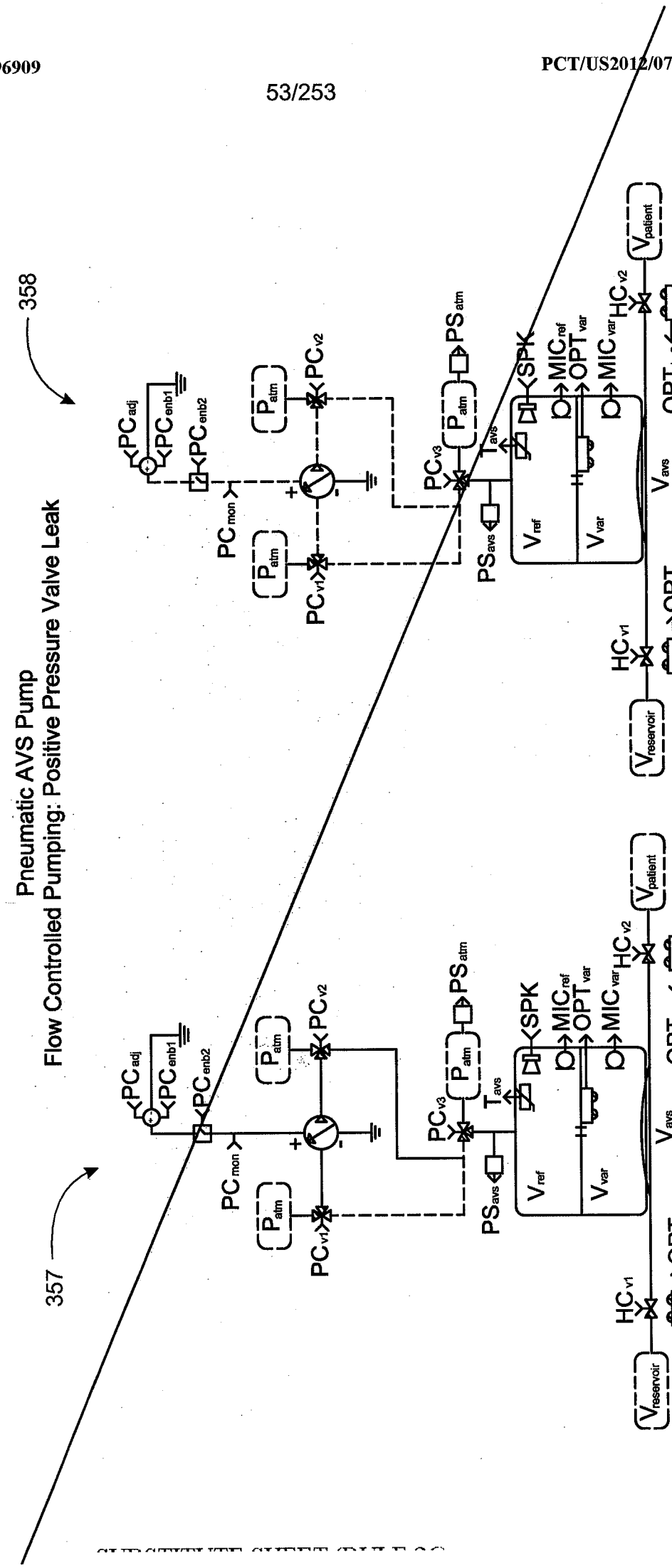

Pneumatic AVS Pump
Flow Controlled Pumping: Positive Pressure Valve Leak
357
358
PC adj
PC enb1
PC enb2
PC mon
P atm
PC v1
PC v2
PC v3
PS atm
PS avs
T avs
SPK
MIC ref
OPT var
MIC var
OPT hc2
HC v2
V patient
V avs
V ref
V var
OPT hc1
HC v1
V reservoir

Fig. 87

Fig. 88

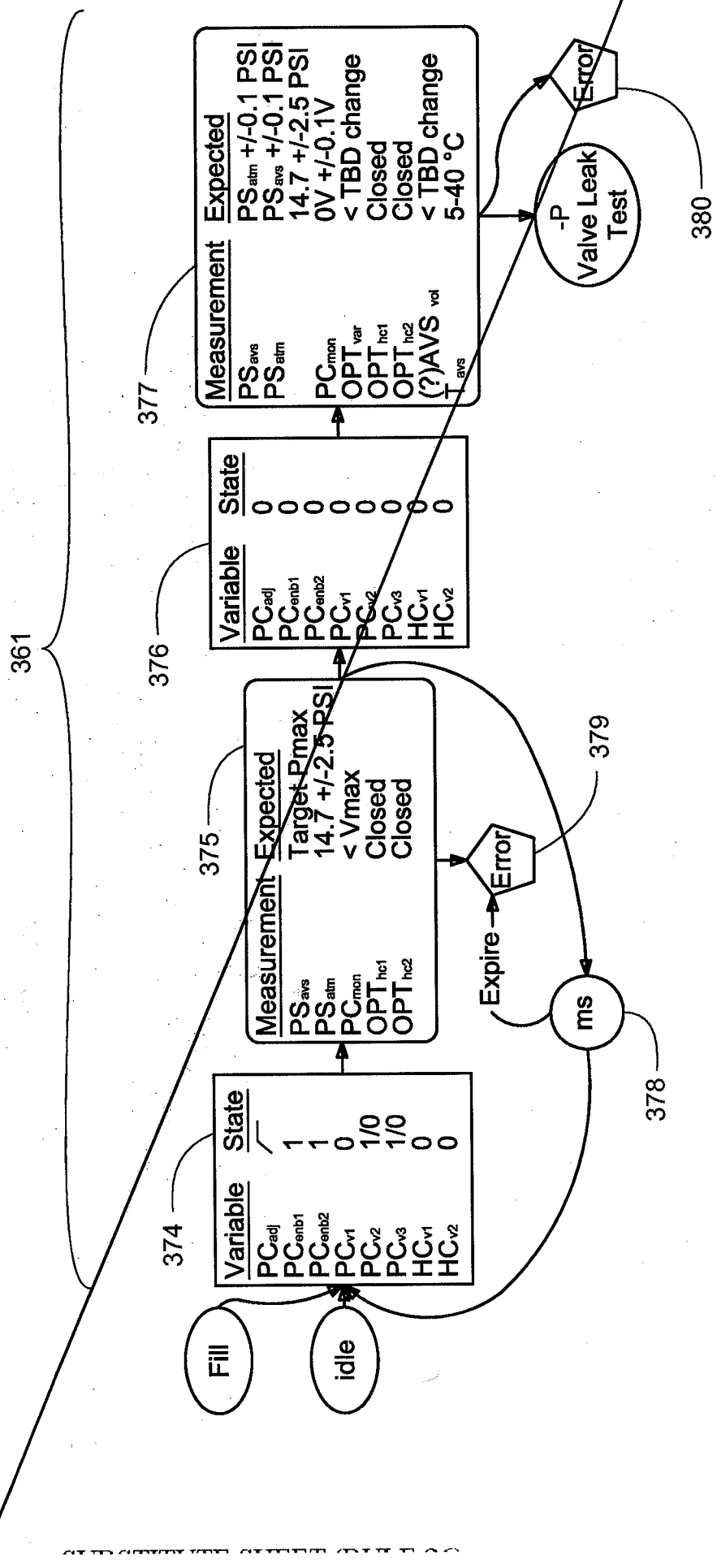

361
374
Variable
State
PCadj
PCenb1
PCenb2
PCv1
PCv2
PCv3
HCv1
HCv2
1
1
0
1/0
1/0
0
0
375
Measurement
Expected
PSavs
PSatm
PCmon
OPThc1
OPThc2
Target Pmax
14.7 +/-2.5 PSI
< Vmax
Closed
Closed
376
Variable
State
PCadj
PCenb1
PCenb2
PCv1
PCv2
PCv3
HCv1
HCv2
0
0
0
0
0
0
0
0
377
Measurement
Expected
PSavs
PSatm
PCmon
OPTvar
OPThc1
OPThc2
(?)AVS vol
Tavs
PSatm +/-0.1 PSI
PSavs +/-0.1 PSI
14.7 +/-2.5 PSI
0V +/-0.1V
< TBD change
Closed
Closed
< TBD change
5-40 °C
Fill
idle
Expire
ms
Error
Error
-P
Valve Leak
Test
378
379
380

Fig. 89

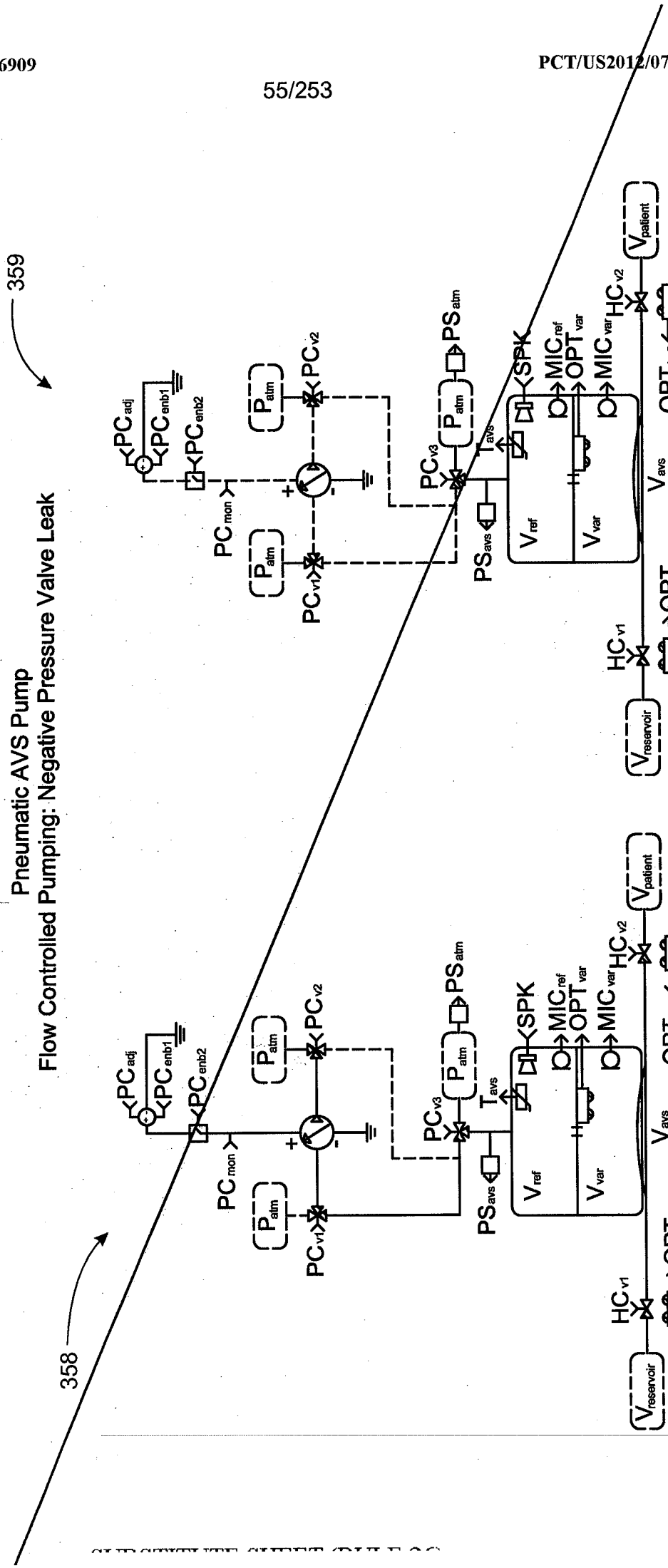

359
Pneumatic AVS Pump
Flow Controlled Pumping: Negative Pressure Valve Leak
358
PC adj
PC enb1
PC enb2
PC mon
P atm
PC v2
PC v1
PC v3
PS atm
PS avs
T avs
SPK
MIC ref
OPT var
MIC var
HC v2
V patient
OPT hc2
V ref
V var
V avs
HC v1
OPT hc1
V reservoir

Fig. 91

Fig. 90

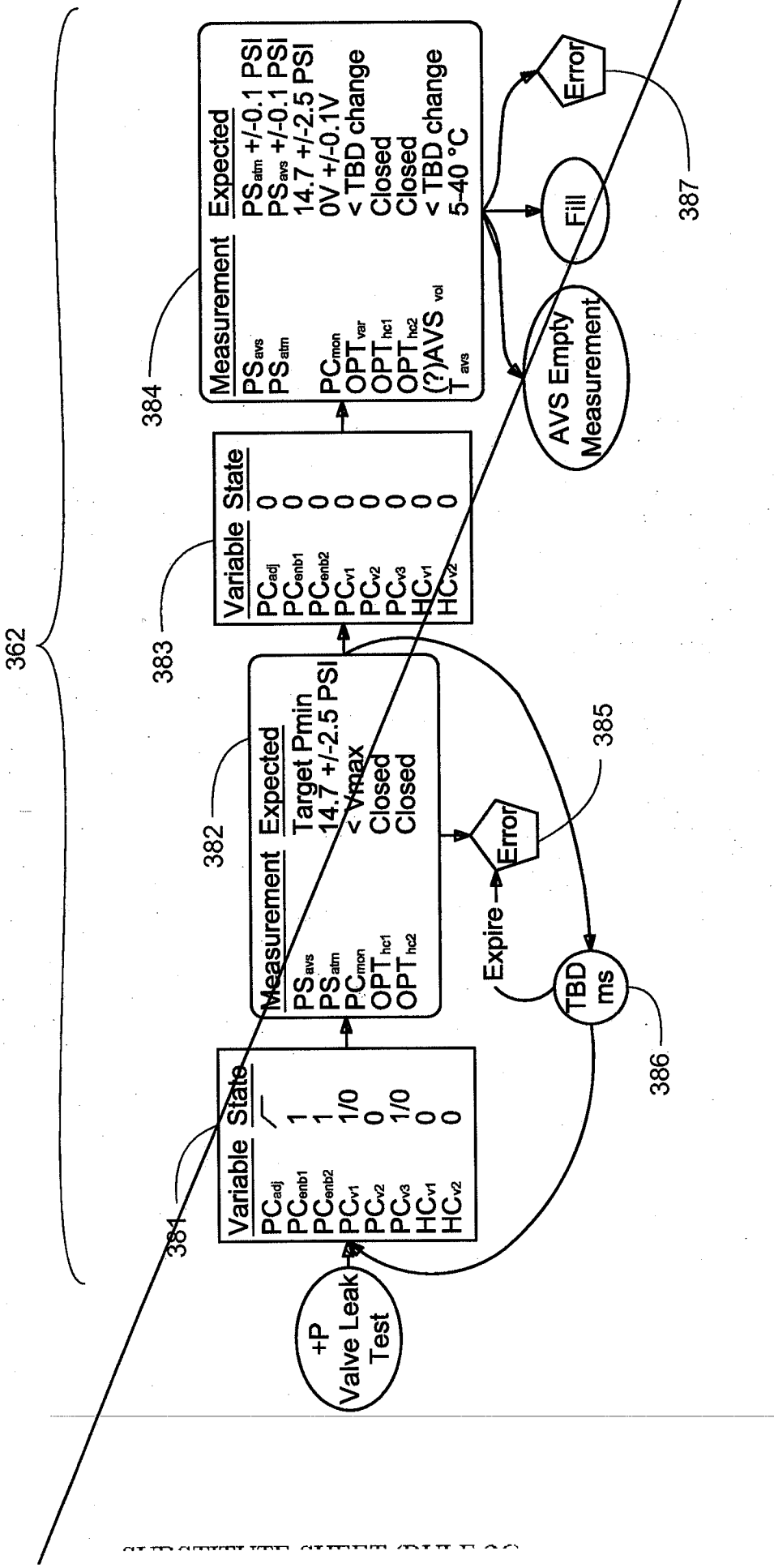

362
384
Measurement
PS avs
PS atm
PC mon
OPT var
OPT hc1
OPT hc2
(?)AVS vol
T avs
Expected
PS atm +/-0.1 PSI
PS avs +/-0.1 PSI
14.7 +/-2.5 PSI
0V +/-0.1V
< TBD change
Closed
Closed
< TBD change
5-40 °C
383
Variable State
PC adj 0
PC enb1 0
PC enb2 0
PC v1 0
PC v2 0
PC v3 0
HC v1 0
HC v2 0
382
Measurement Expected
PS avs Target Pmin
PS atm 14.7 +/-2.5 PSI
PC mon < Vmax
OPT hc1 Closed
OPT hc2 Closed
381
Variable State
PC adj 1
PC enb1 1
PC enb2 1/0
PC v1 0
PC v2 1/0
PC v3 0
HC v1 0
HC v2 0
+P Valve Leak Test
Expire
TBD ms
386
Error
385
Fill
Error
387
AVS Empty Measurement

Fig. 92

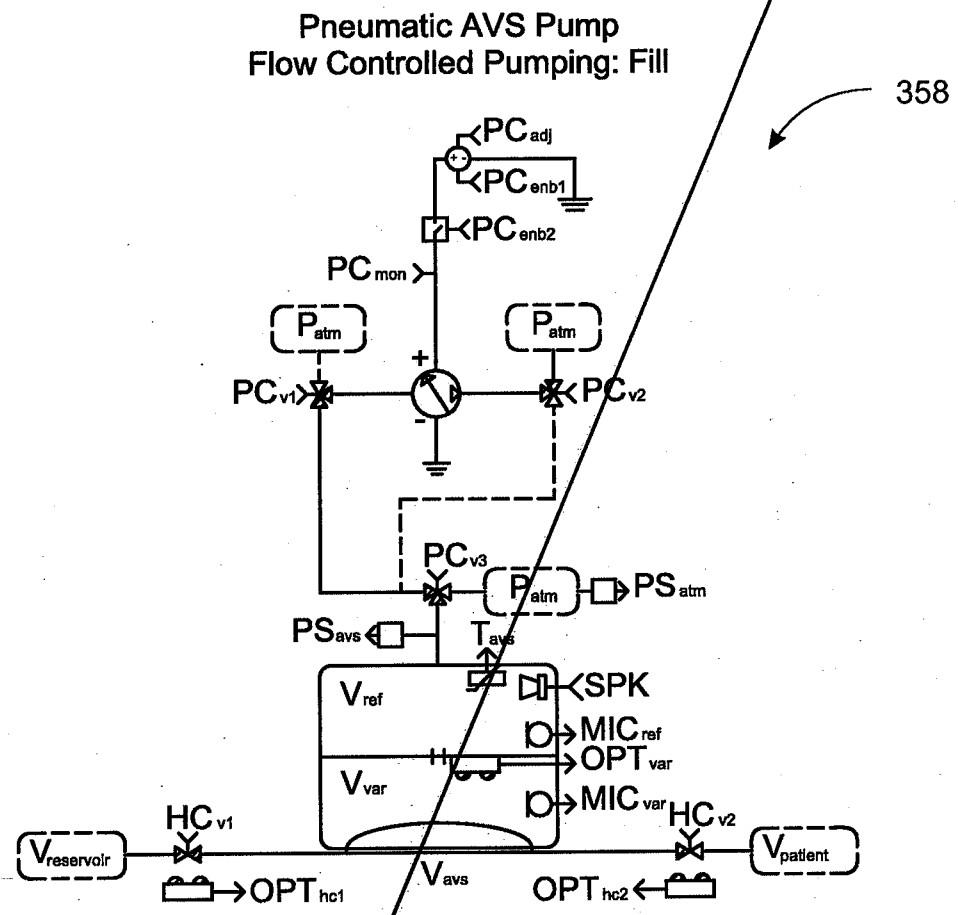

Pneumatic AVS Pump
Flow Controlled Pumping: Fill
358
PC adj
PC enb1
PC enb2
PC mon
P atm
P atm
PC v1
PC v2
PC v3
P atm
PS atm
PS avs
T avs
V ref
SPK
MIC ref
OPT var
V var
MIC var
HC v1
HC v2
V reservoir
V patient
OPT hc1
V avs
OPT hc2

Fig. 93

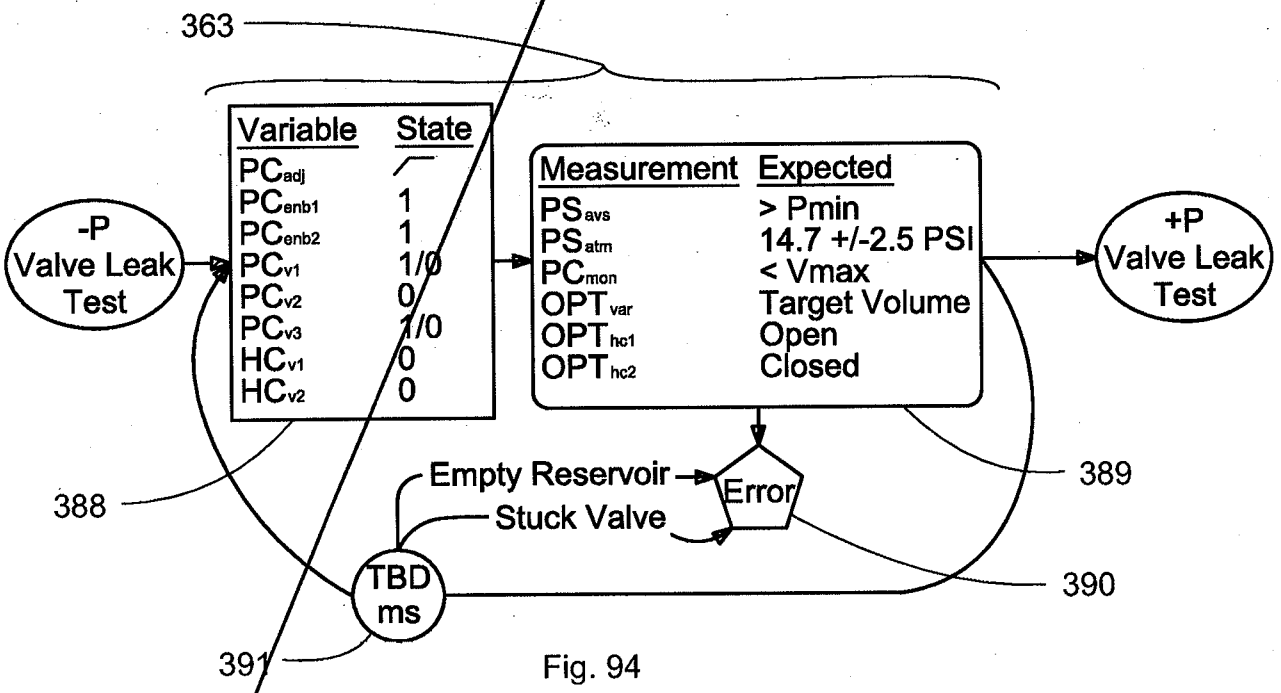

363
Variable State
PC adj
PC enb1 1
PC enb2 1
PC v1 1/0
PC v2 0
PC v3 1/0
HC v1 0
HC v2 0
Measurement Expected
PS avs > Pmin
PS atm 14.7 +/-2.5 PSI
PC mon < Vmax
OPT var Target Volume
OPT hc1 Open
OPT hc2 Closed
-P Valve Leak Test
+P Valve Leak Test
Empty Reservoir
Stuck Valve
Error
TBD ms
388
389
390
391

Fig. 94

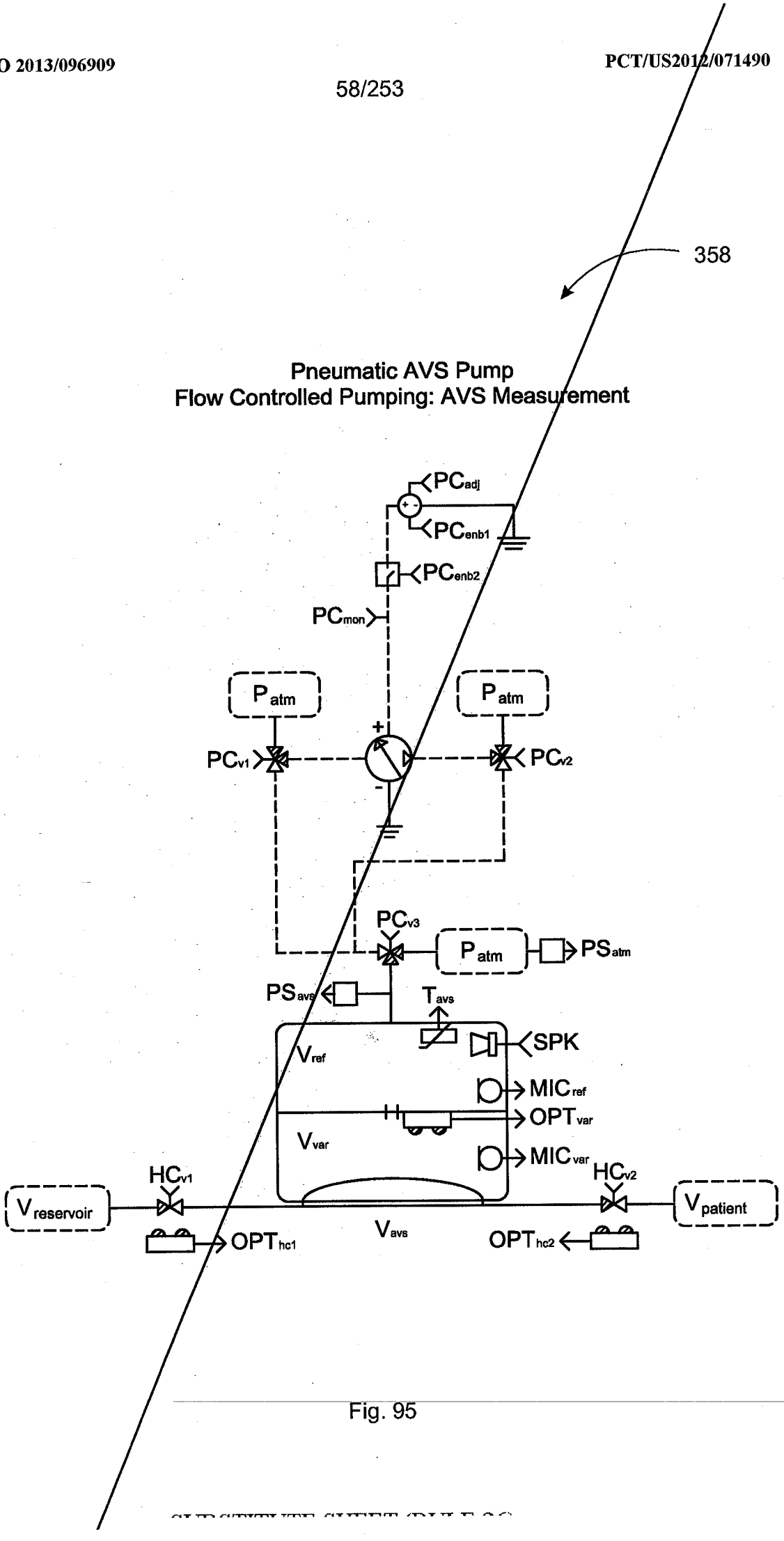

358
Pneumatic AVS Pump
Flow Controlled Pumping: AVS Measurement
PCadj
PCenb1
PCenb2
PCmon
Patm
Patm
PCv1
PCv2
PCv3
Patm
PSatm
PSavs
Tavs
SPK
Vref
MICref
OPTvar
Vvar
MICvar
HCv1
HCv2
Vreservoir
Vpatient
OPThc1
Vavs
OPThc2

Fig. 95

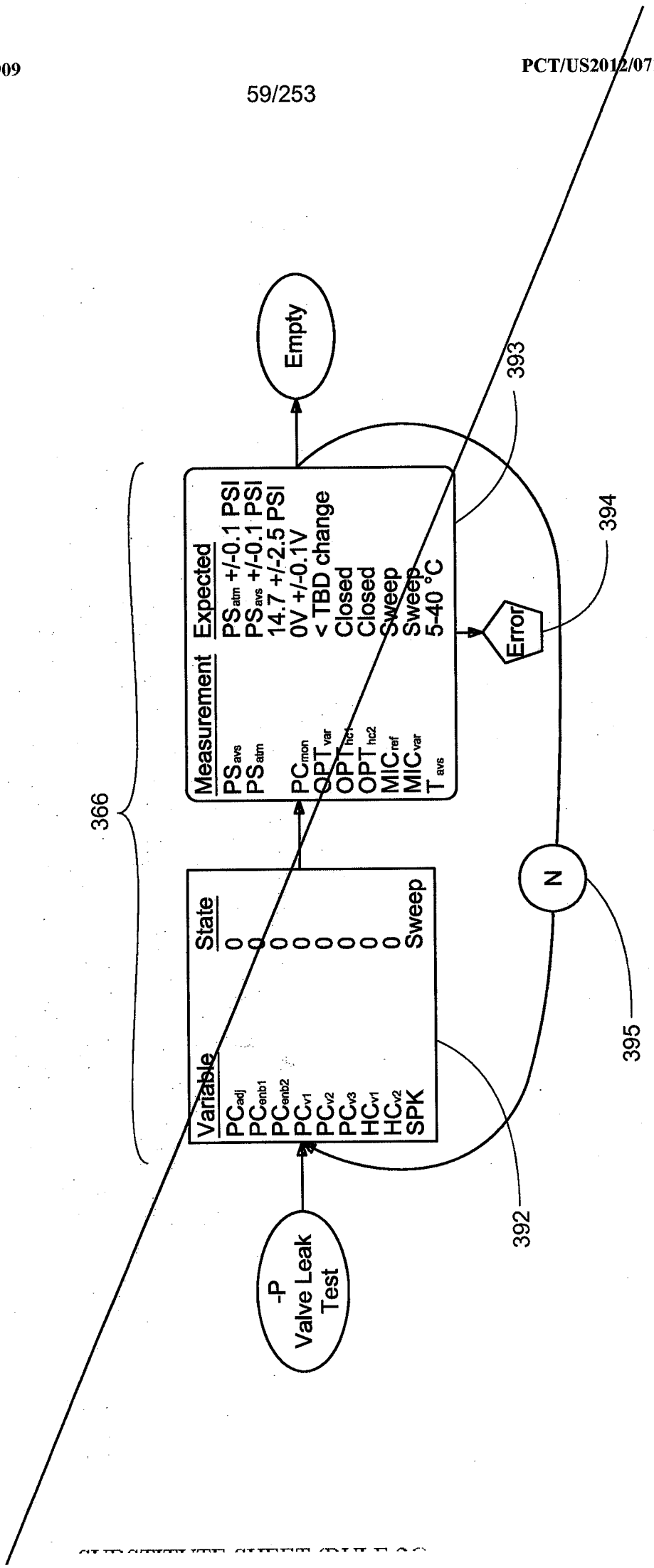

-P
Valve Leak
Test
Variable
State
PCadj 0
PCenb1 0
PCenb2 0
PCv1 0
PCv2 0
PCv3 0
HCv1 0
HCv2 0
SPK Sweep
366
Measurement
Expected
PSavs
PSatm
PCmon
OPTvar
OPThc1
OPThc2
MICref
MICvar
Tavs
PSatm +/-0.1 PSI
PSavs +/-0.1 PSI
14.7 +/-2.5 PSI
0V +/-0.1V
< TBD change
Closed
Closed
Sweep
Sweep
5-40 °C
Empty
Error
N
392
393
394
395

Fig. 96

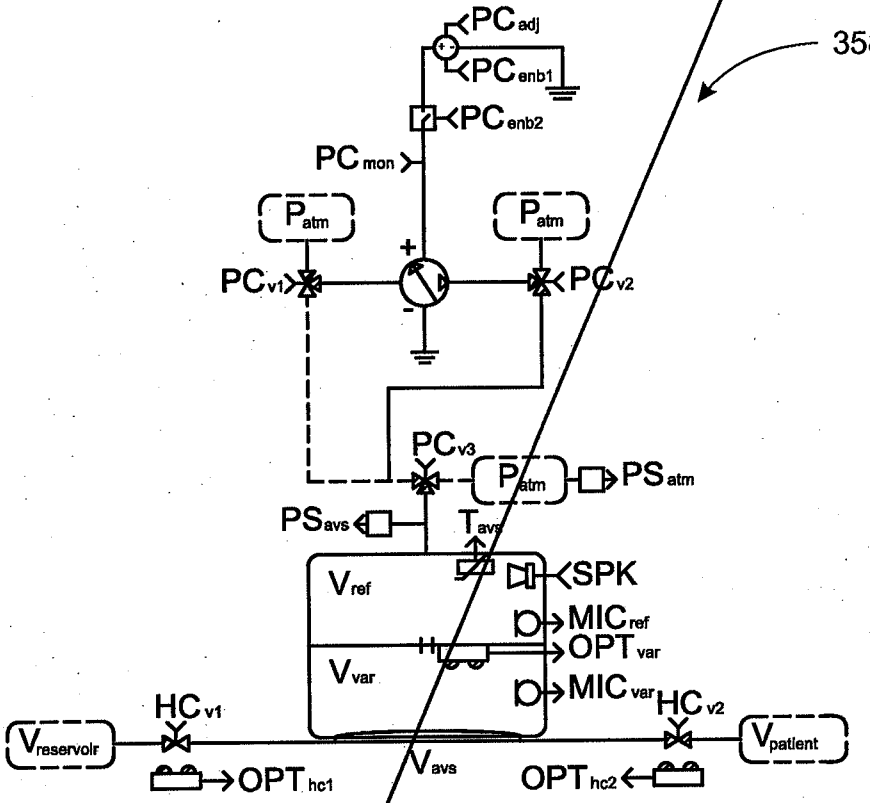

Pneumatic AVS Pump
Flow Controlled Pumping: Empty
358
PC adj
PC enb1
PC enb2
PC mon
P atm
P atm
PC v1
PC v2
PC v3
P atm
PS atm
PS avs
T avs
V ref
SPK
MIC ref
OPT var
V var
MIC var
HC v1
HC v2
V reservoir
V patient
OPT hc1
V avs
OPT hc2

Fig. 97

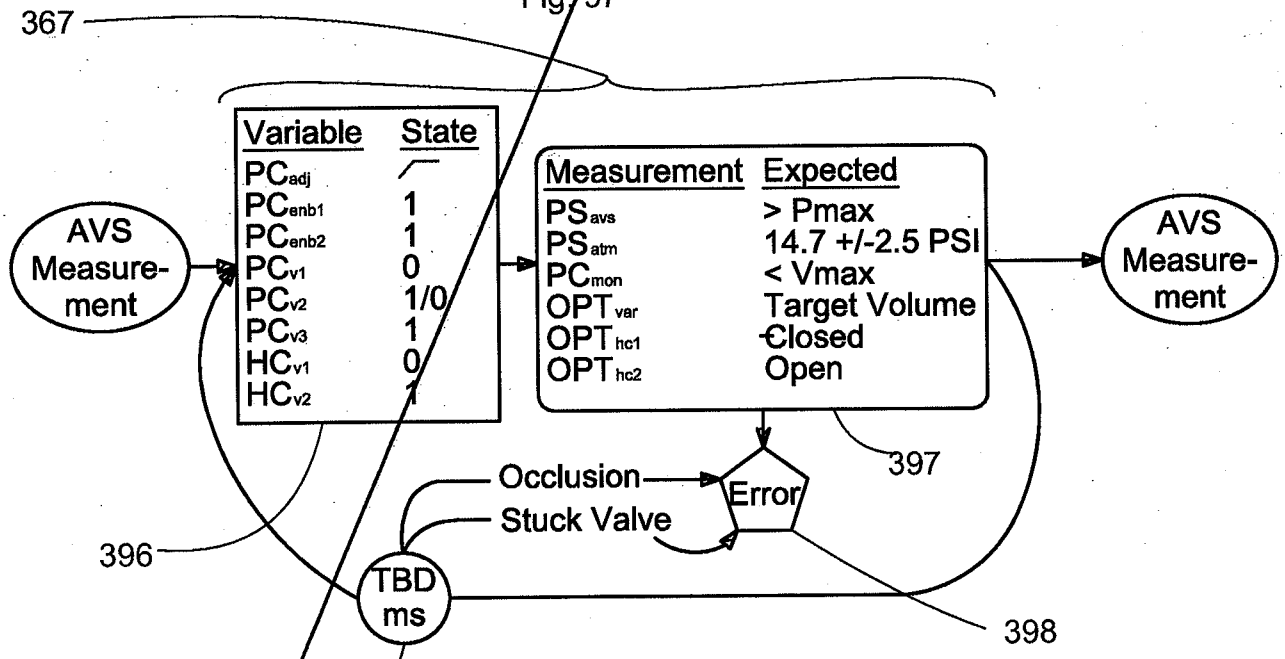

367
Variable
State
PC adj
PC enb1 1
PC enb2 1
PC v1 0
PC v2 1/0
PC v3 1
HC v1 0
HC v2 1
Measurement
Expected
PS avs > Pmax
PS atm 14.7 +/-2.5 PSI
PC mon < Vmax
OPT var Target Volume
OPT hc1 Closed
OPT hc2 Open
AVS Measure-ment
AVS Measure-ment
Occlusion
Stuck Valve
Error
TBD ms
396
397
398
399

Fig. 98

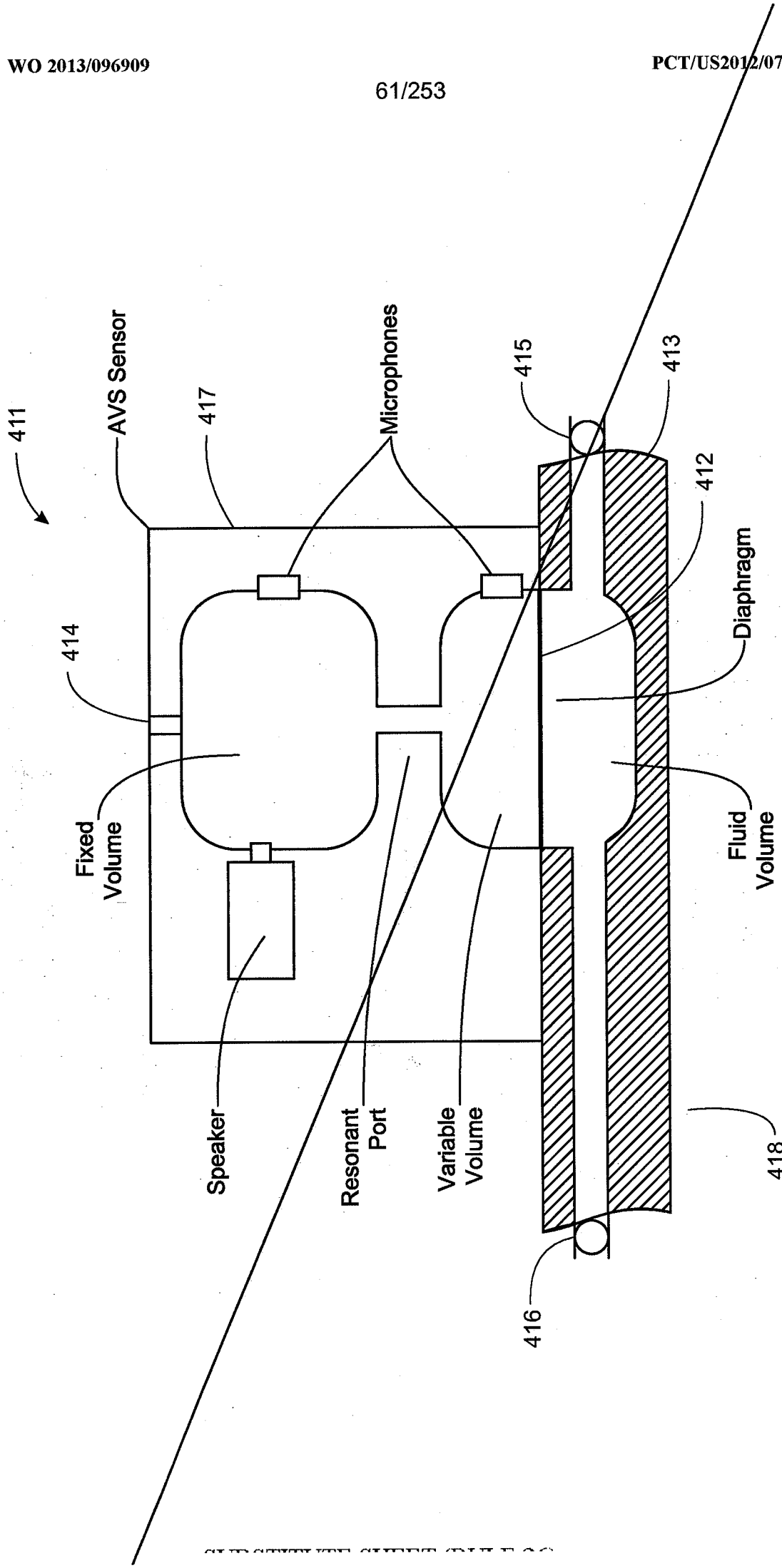

411
AVS Sensor
417
Microphones
415
413
412
414
Diaphragm
Fixed Volume
Fluid Volume
Speaker
Resonant Port
Variable Volume
418
416

Fig. 99

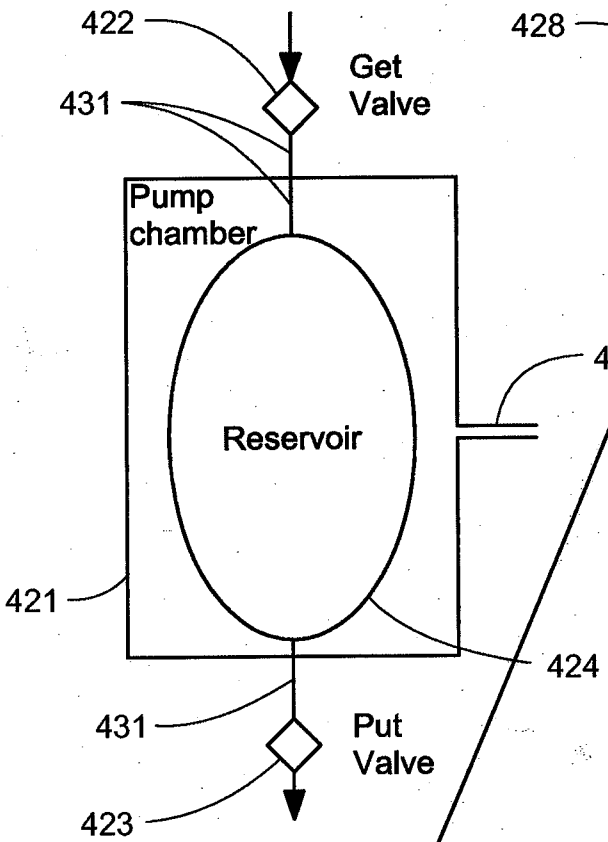


Fig. 100

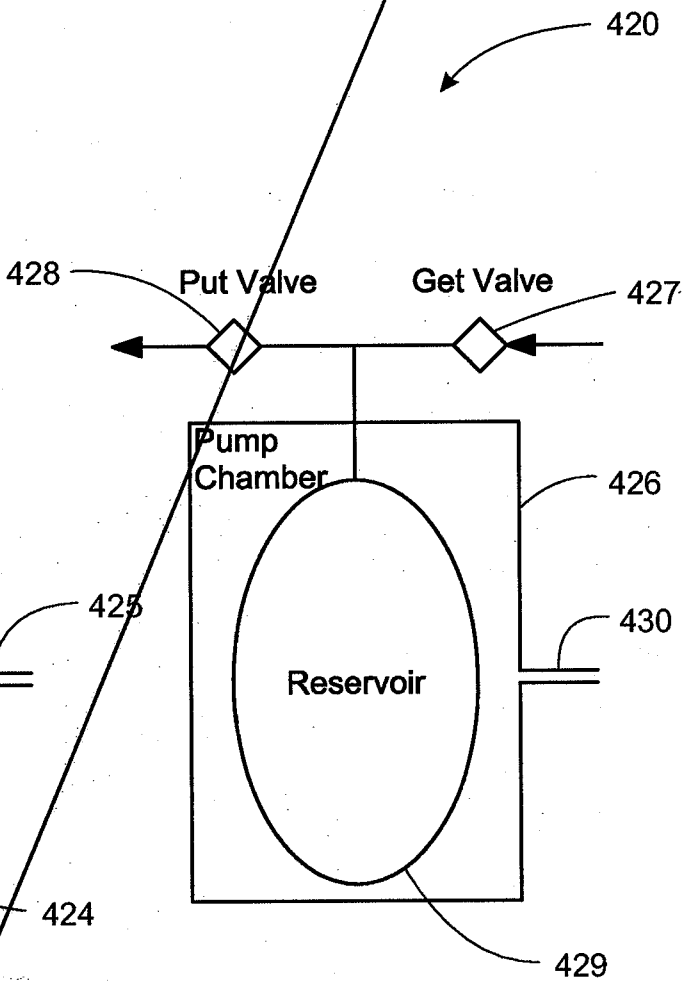


Fig. 101

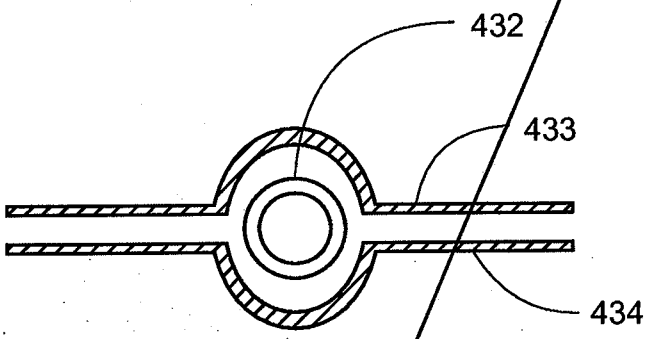


Fig. 102

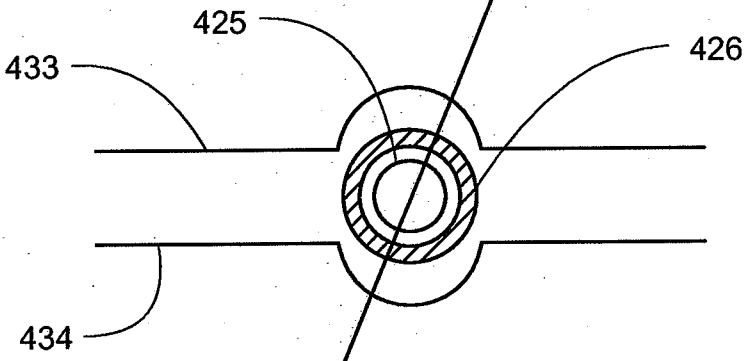


Fig. 103

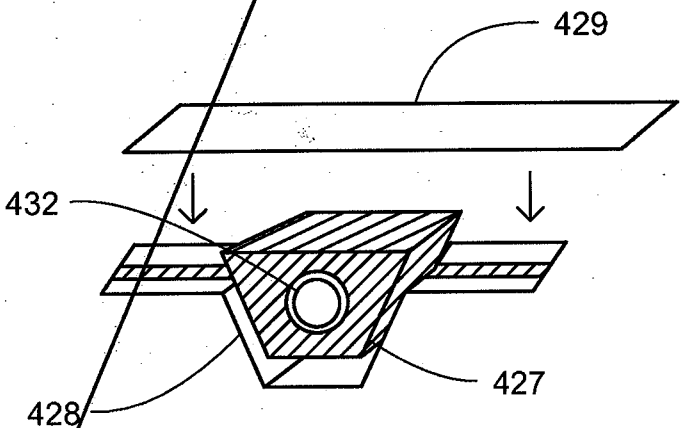


Fig. 104

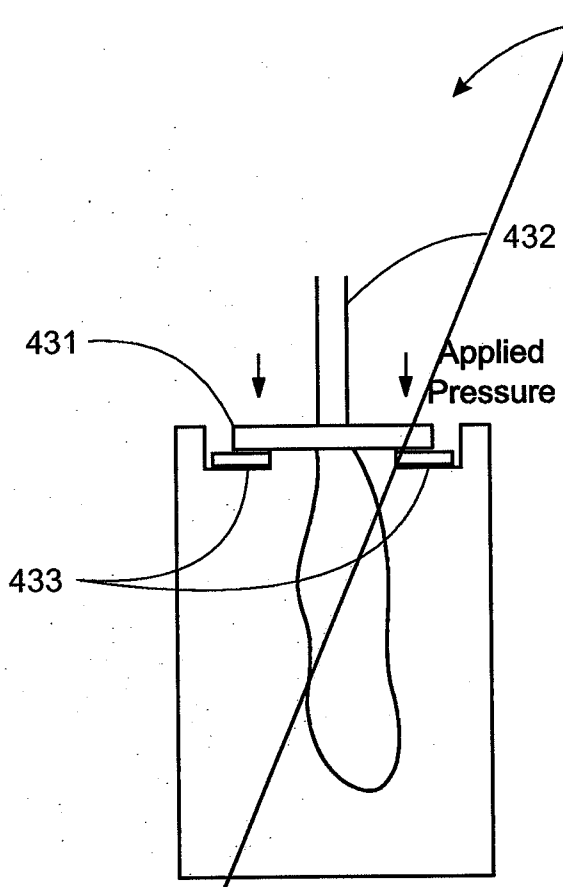


Fig. 105

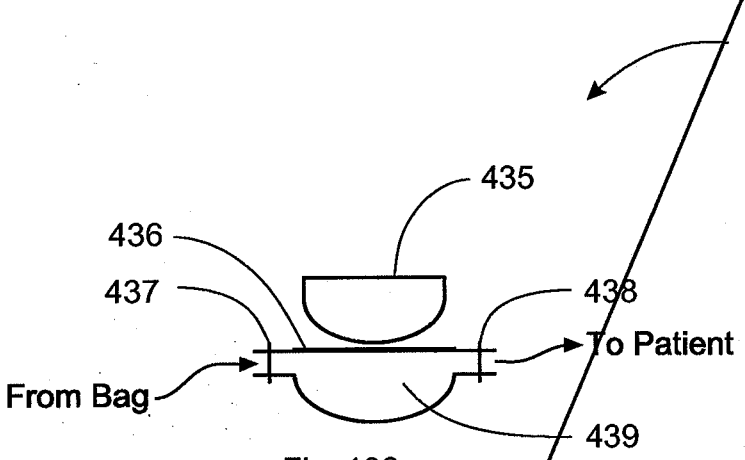


Fig. 106

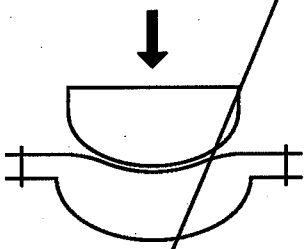


Fig. 107

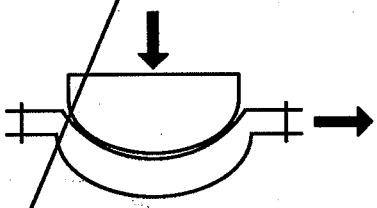


Fig. 108



Fig. 109

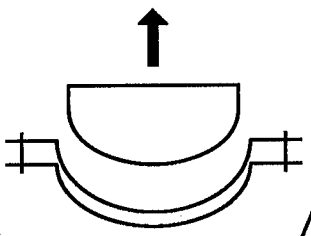


Fig. 110

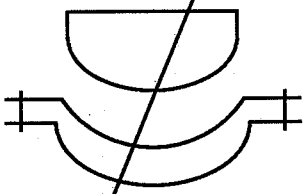


Fig. 111

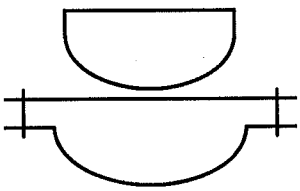


Fig. 112

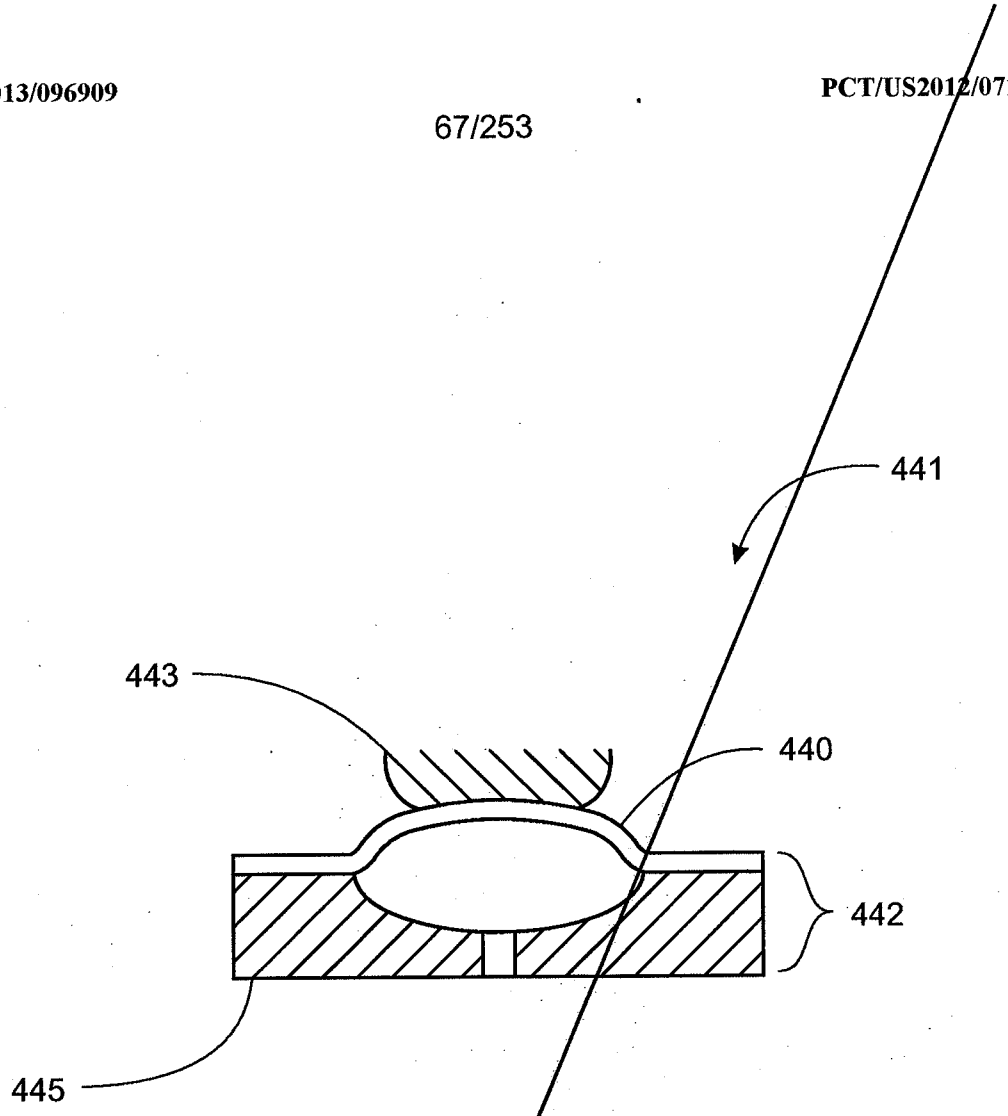


Fig. 113

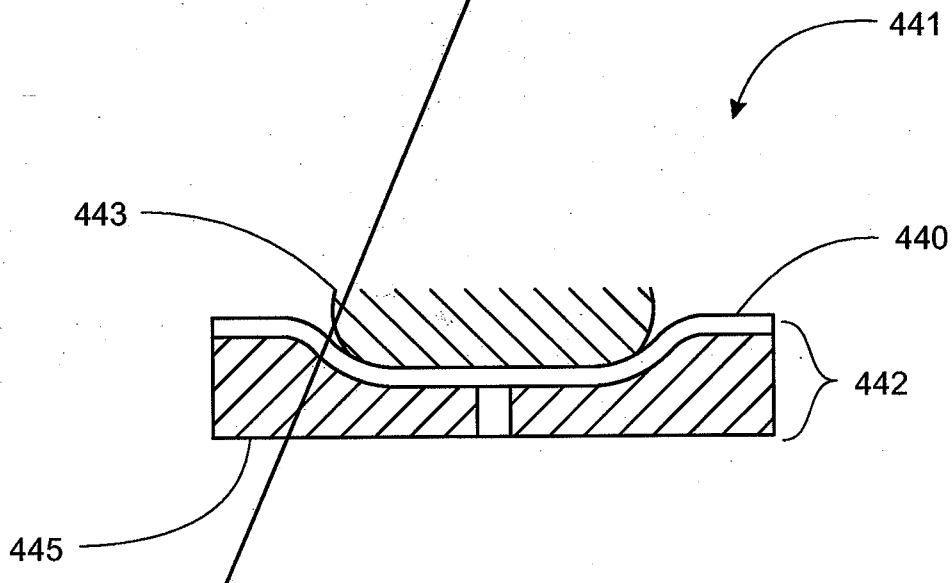


Fig. 114

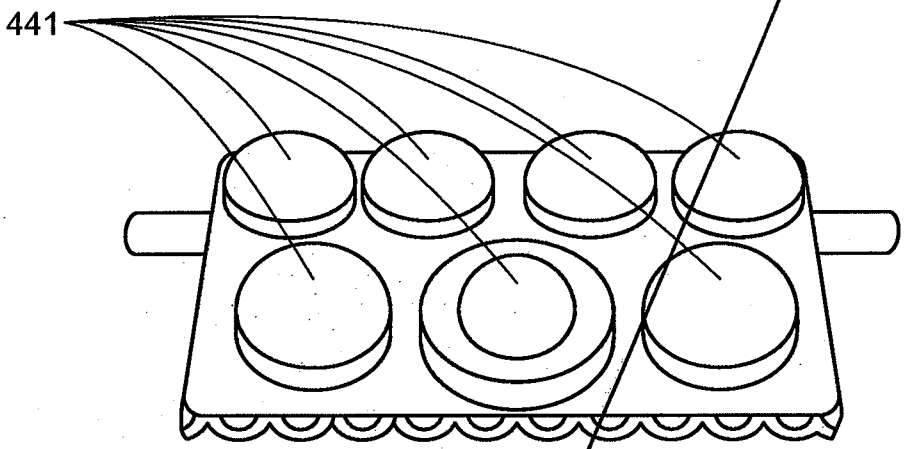


Fig. 115

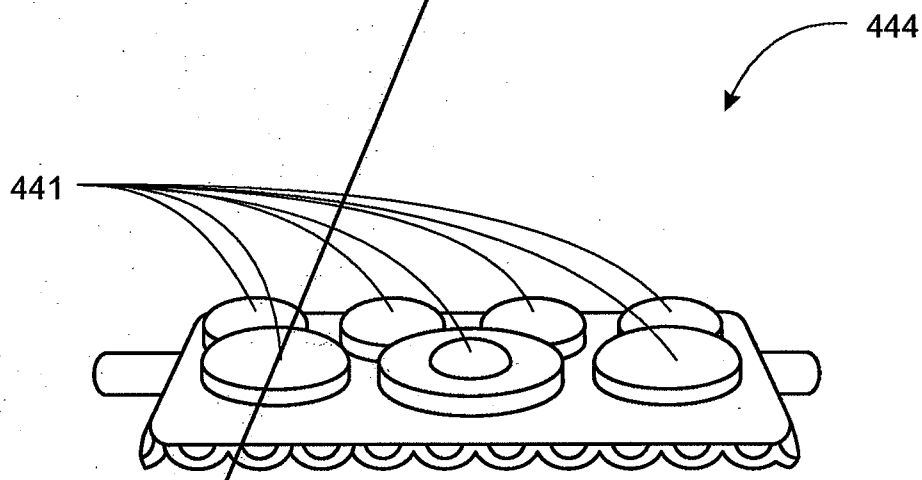


Fig. 116

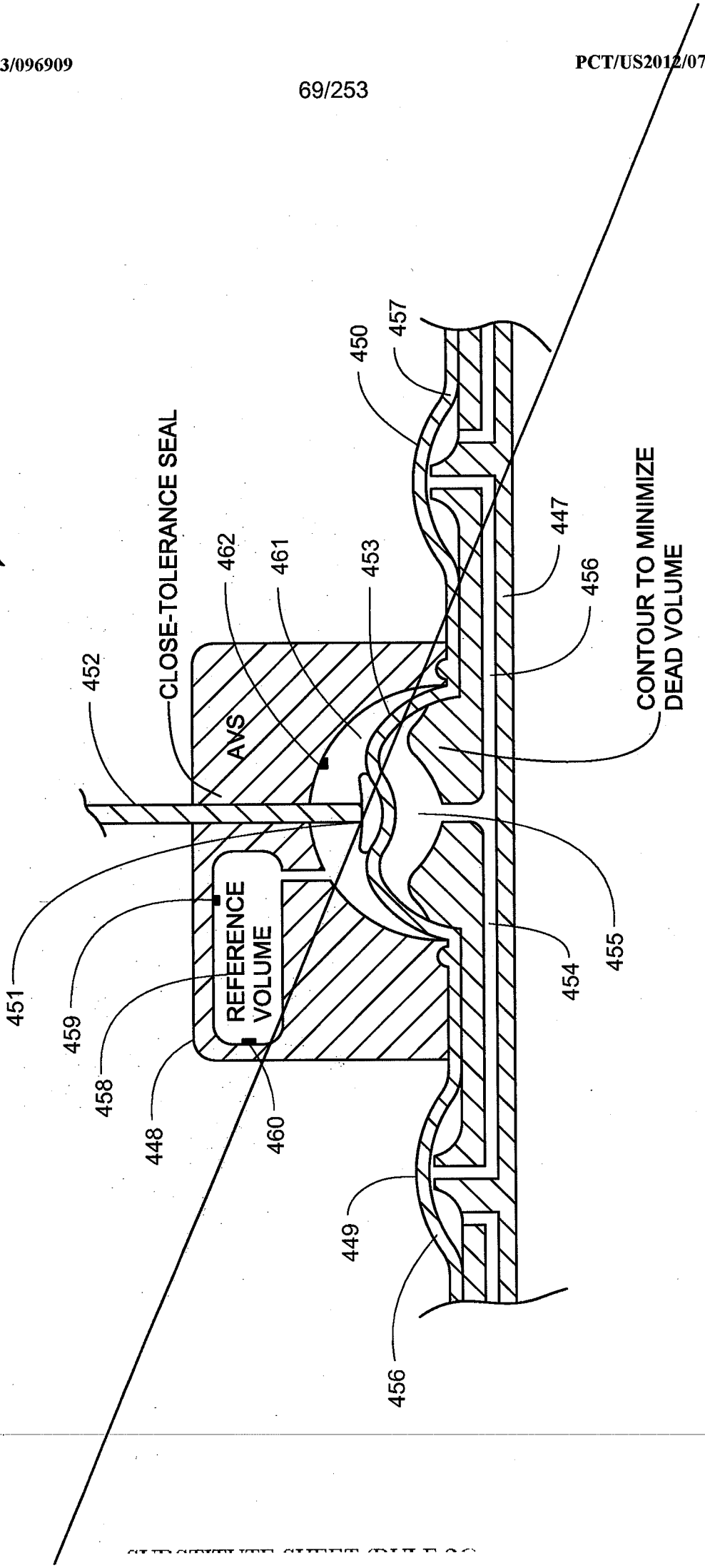

446
CLOSE-TOLERANCE SEAL
452
AVS
462
461
453
450
457
447
456
CONTOUR TO MINIMIZE DEAD VOLUME
451
459
458
448
REFERENCE VOLUME
460
454
455
449
456

Fig. 117

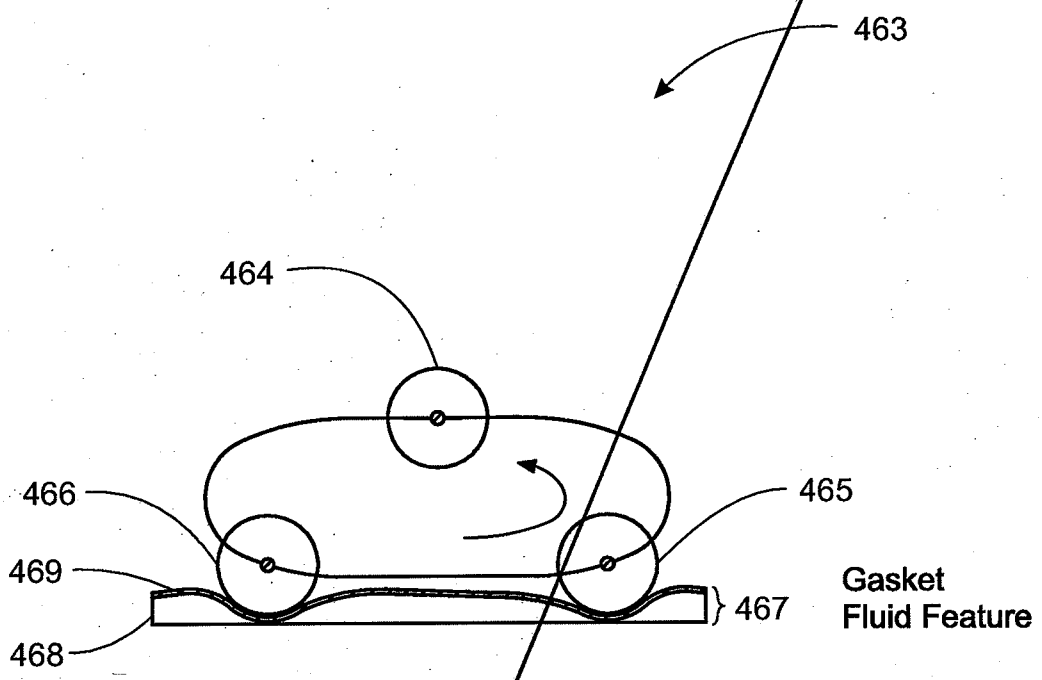


Fig. 118

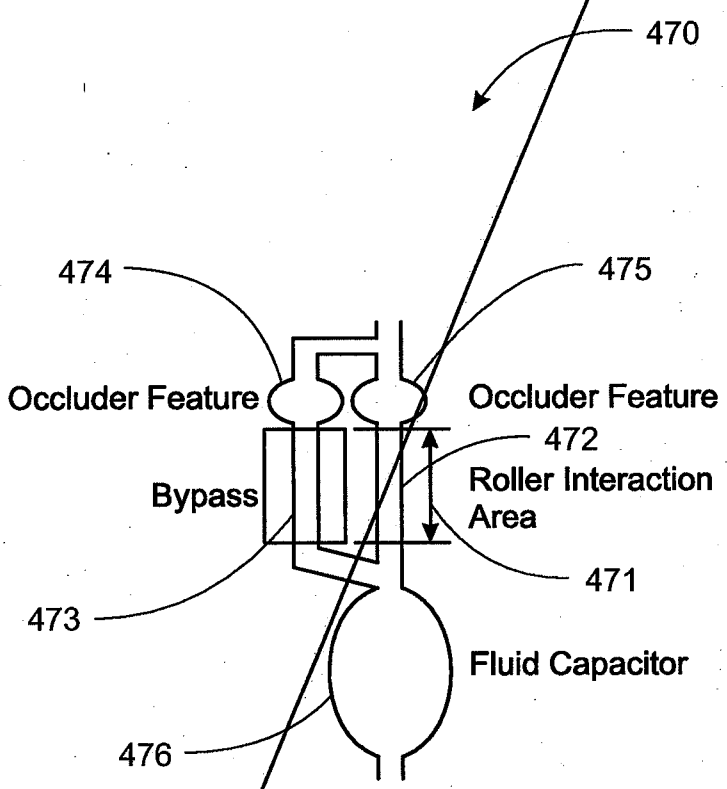

470
474
475
Occluder Feature
Occluder Feature
472
Bypass
Roller Interaction Area
471
473
Fluid Capacitor
476

Fig. 119

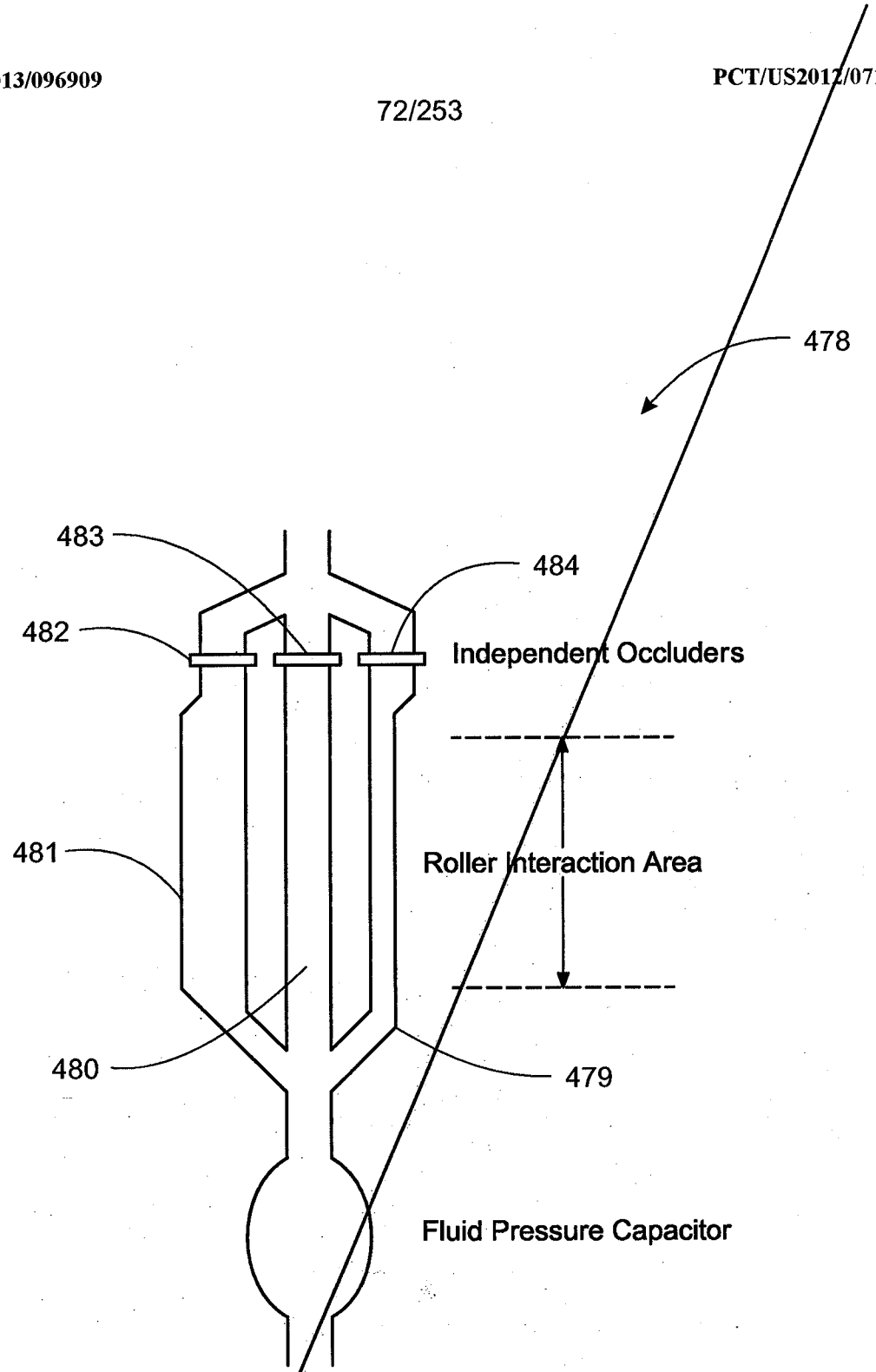

478
483
484
482
Independent Occluders
481
Roller Interaction Area
480
479
Fluid Pressure Capacitor

Fig. 120

Figure 1: Rolling Occluder Drawback Method

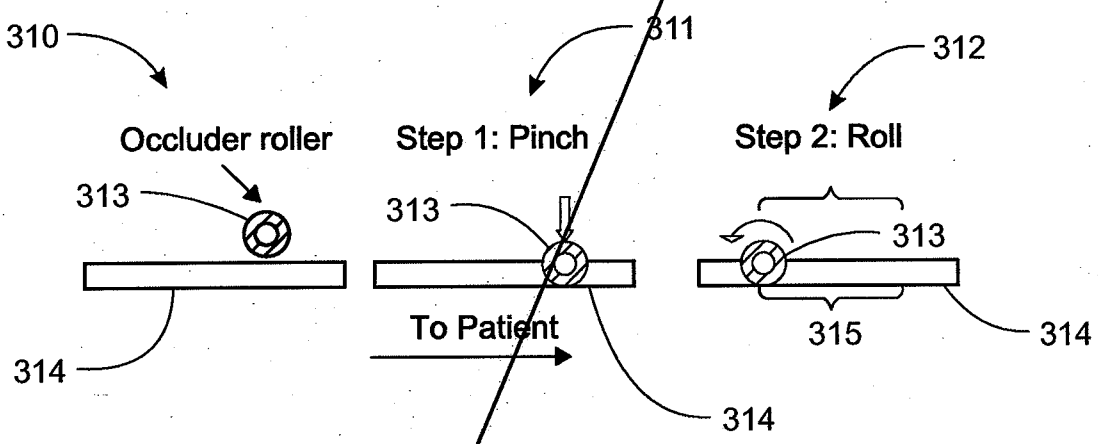


Fig. 121

Figure 2: Piston/Chamber Drawback Method

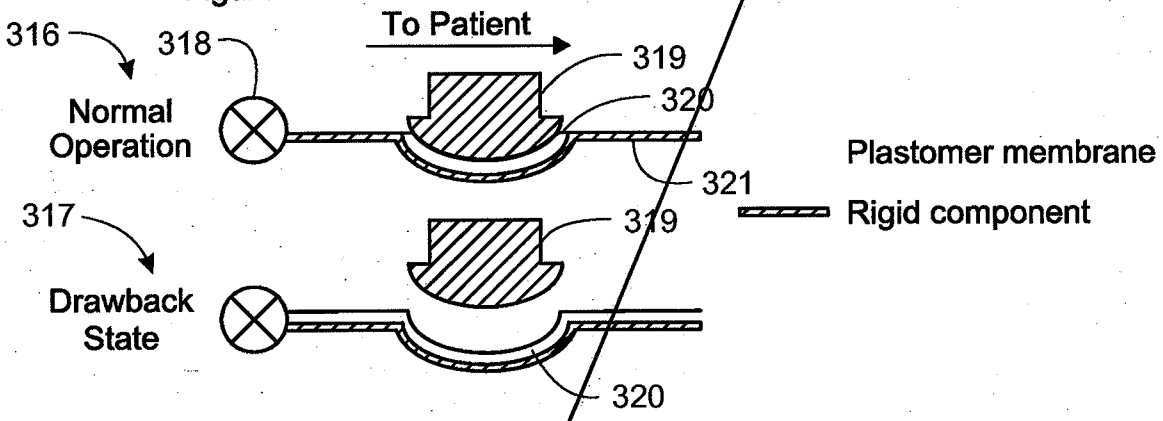


Fig. 122

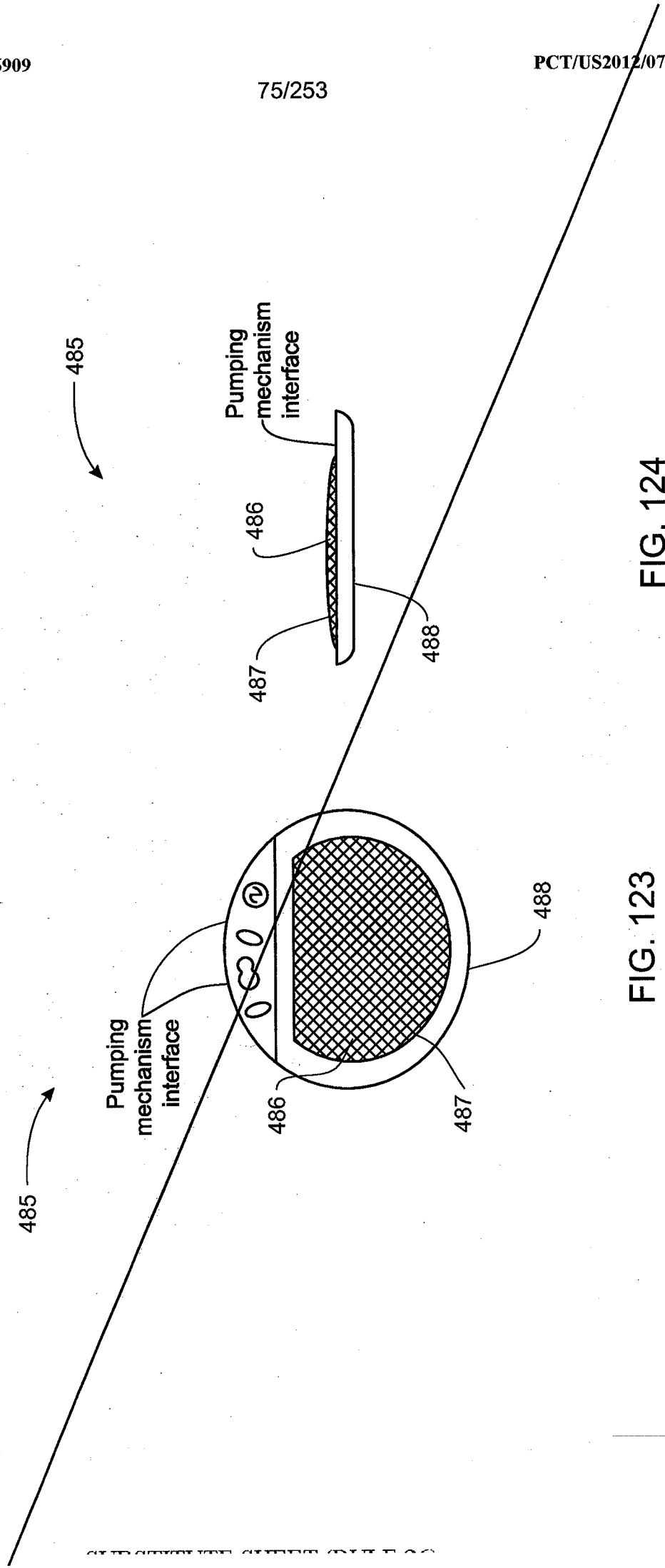


FIG. 124

FIG. 123

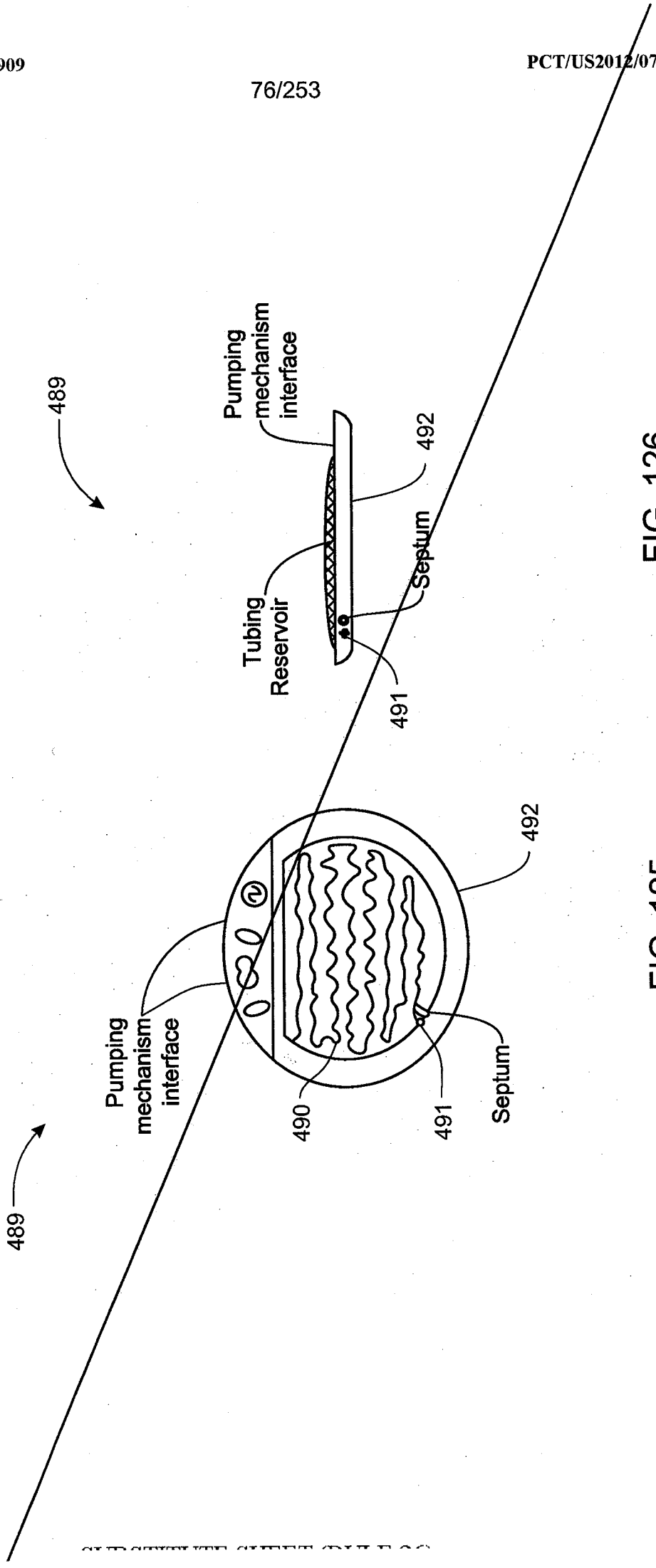


FIG. 126

FIG. 125

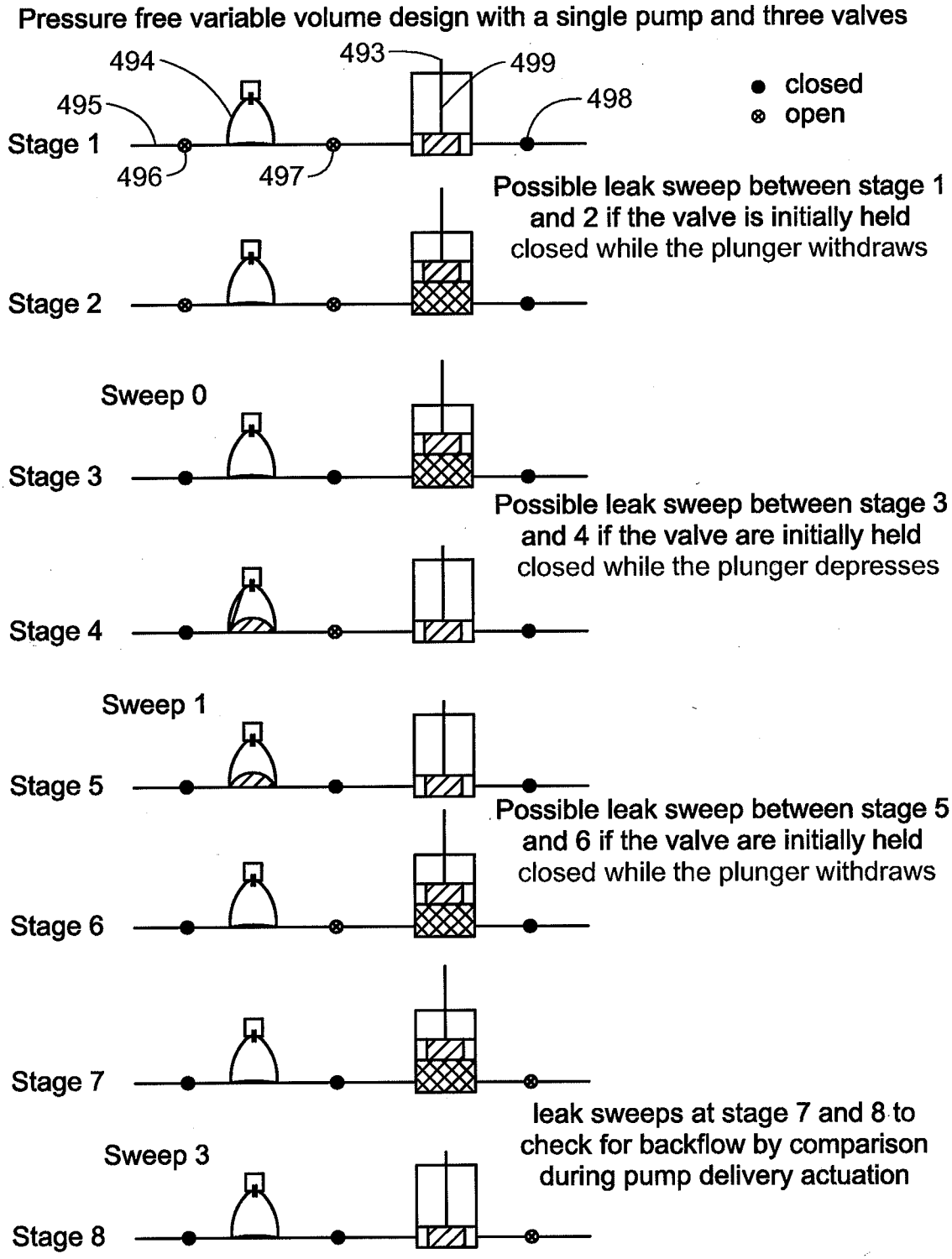

Pressure free variable volume design with a single pump and three valves
494
493
499
498
495
Stage 1
496
497
closed
open
Possible leak sweep between stage 1 and 2 if the valve is initially held closed while the plunger withdraws
Stage 2
Sweep 0
Stage 3
Possible leak sweep between stage 3 and 4 if the valve are initially held closed while the plunger depresses
Stage 4
Sweep 1
Stage 5
Possible leak sweep between stage 5 and 6 if the valve are initially held closed while the plunger withdraws
Stage 6
Stage 7
leak sweeps at stage 7 and 8 to check for backflow by comparison during pump delivery actuation
Sweep 3
Stage 8

FIG. ~~127~~

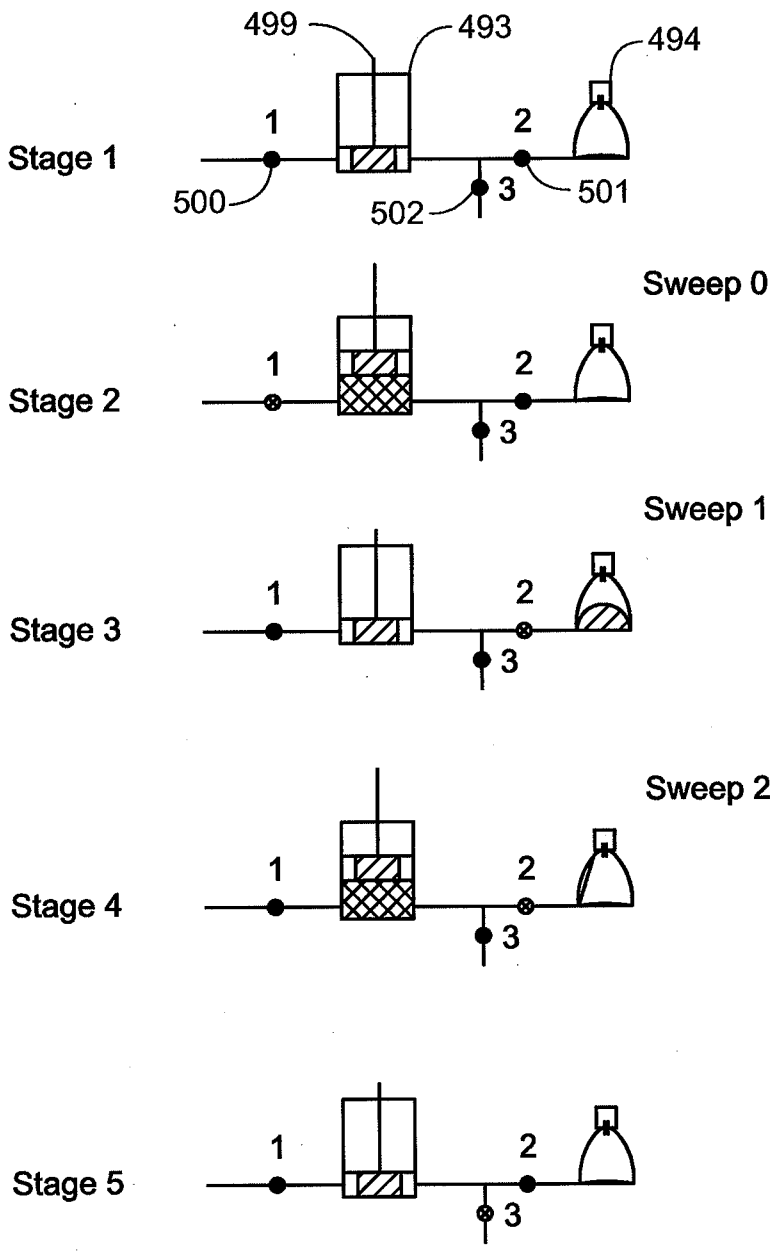

499
493
494
Stage 1
1
2
3
500
502
501
Sweep 0
Stage 2
1
2
3
Sweep 1
Stage 3
1
2
3
Sweep 2
Stage 4
1
2
3
Stage 5
1
2
3

FIG. ~~128~~

Actuator in pressure-free variable volume design with a single pump and two valves

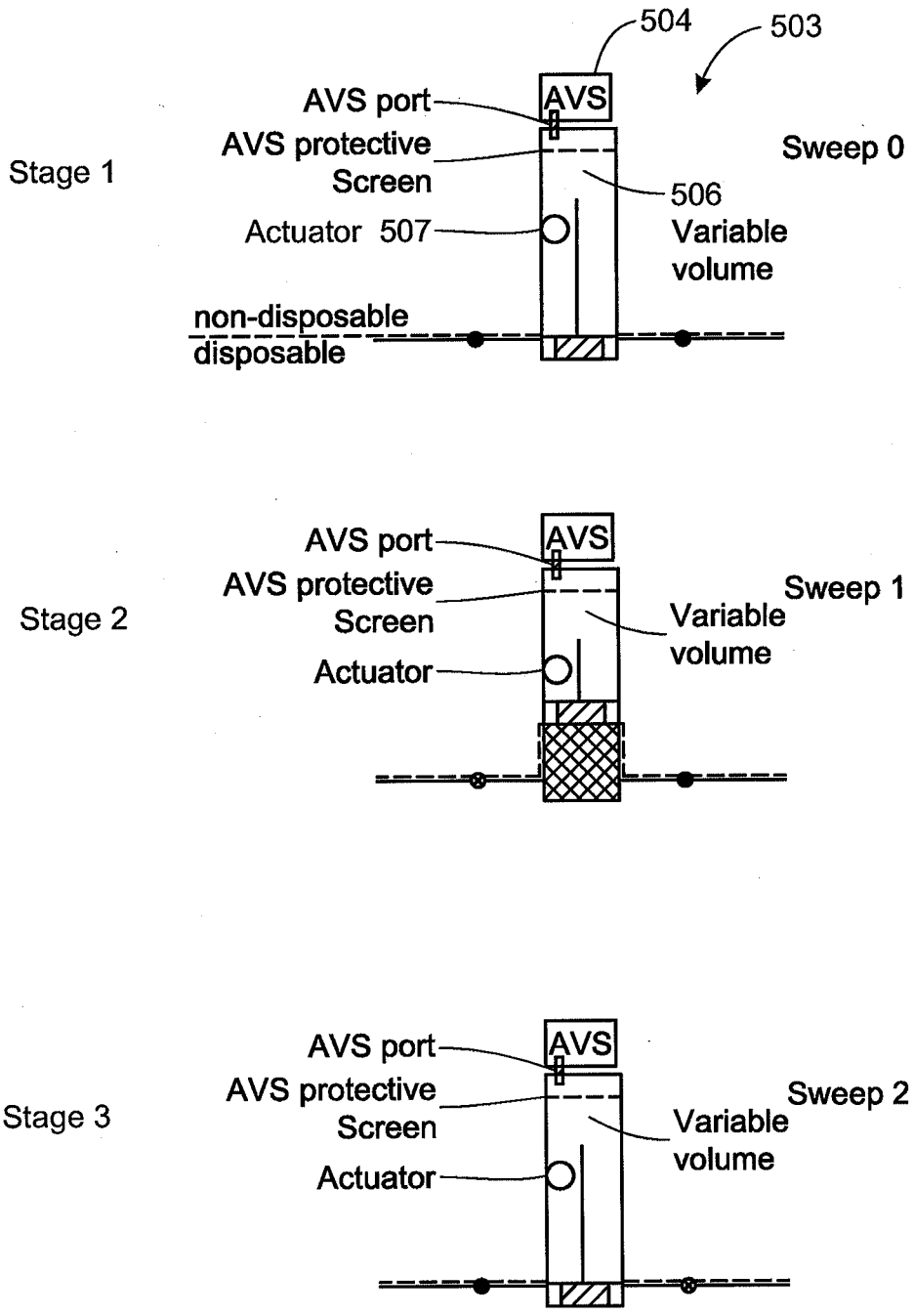


FIG. ~~129~~

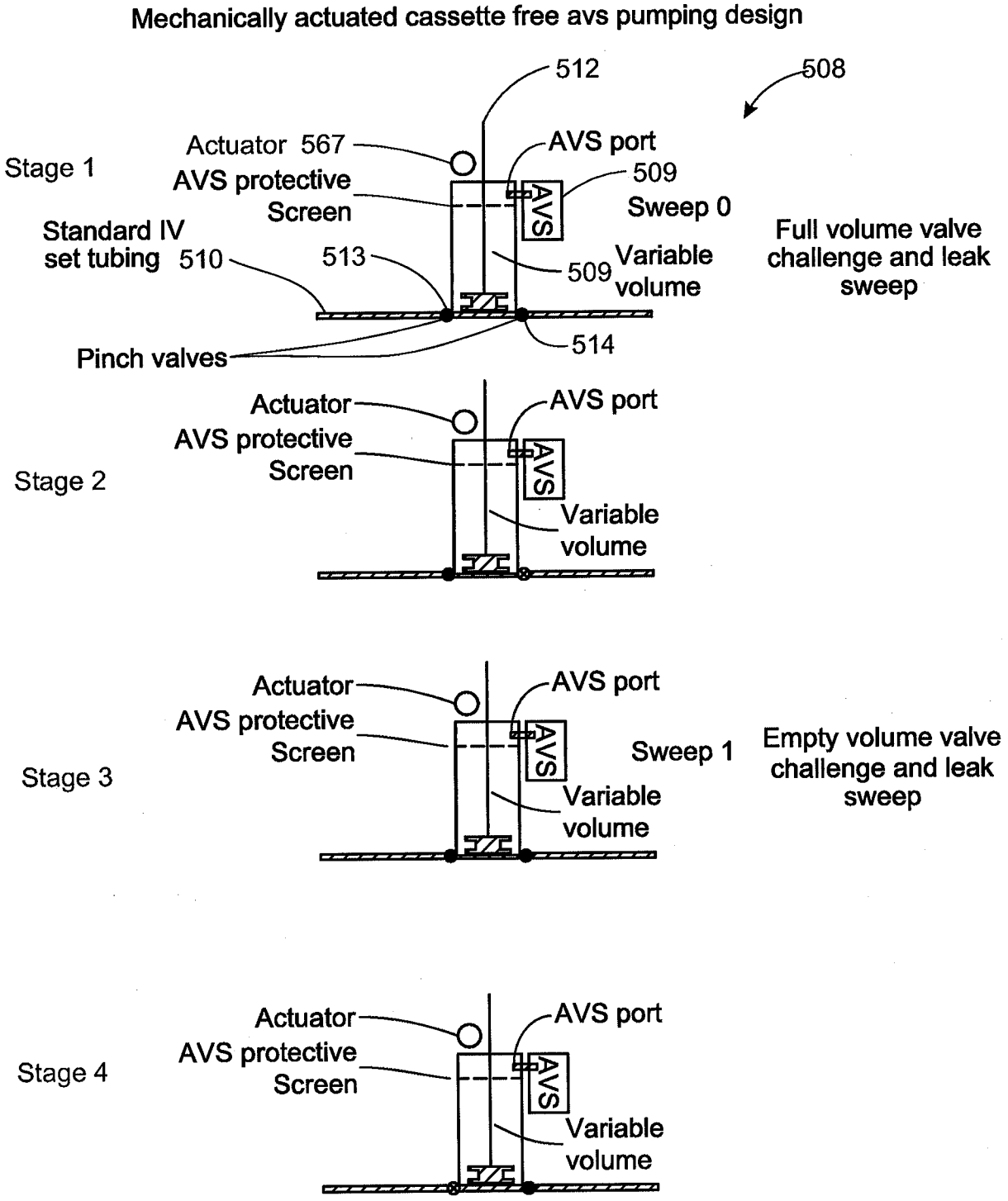

Mechanically actuated cassette free avs pumping design
512
508
Stage 1
Actuator 567
AVS protective Screen
AVS port
509
Sweep 0
Standard IV set tubing
510
513
509
Variable volume
Full volume valve challenge and leak sweep
Pinch valves
514
Stage 2
Actuator
AVS protective Screen
AVS port
Variable volume
Stage 3
Actuator
AVS protective Screen
AVS port
Sweep 1
Variable volume
Empty volume valve challenge and leak sweep
Stage 4
Actuator
AVS protective Screen
AVS port
Variable volume

FIG. 130

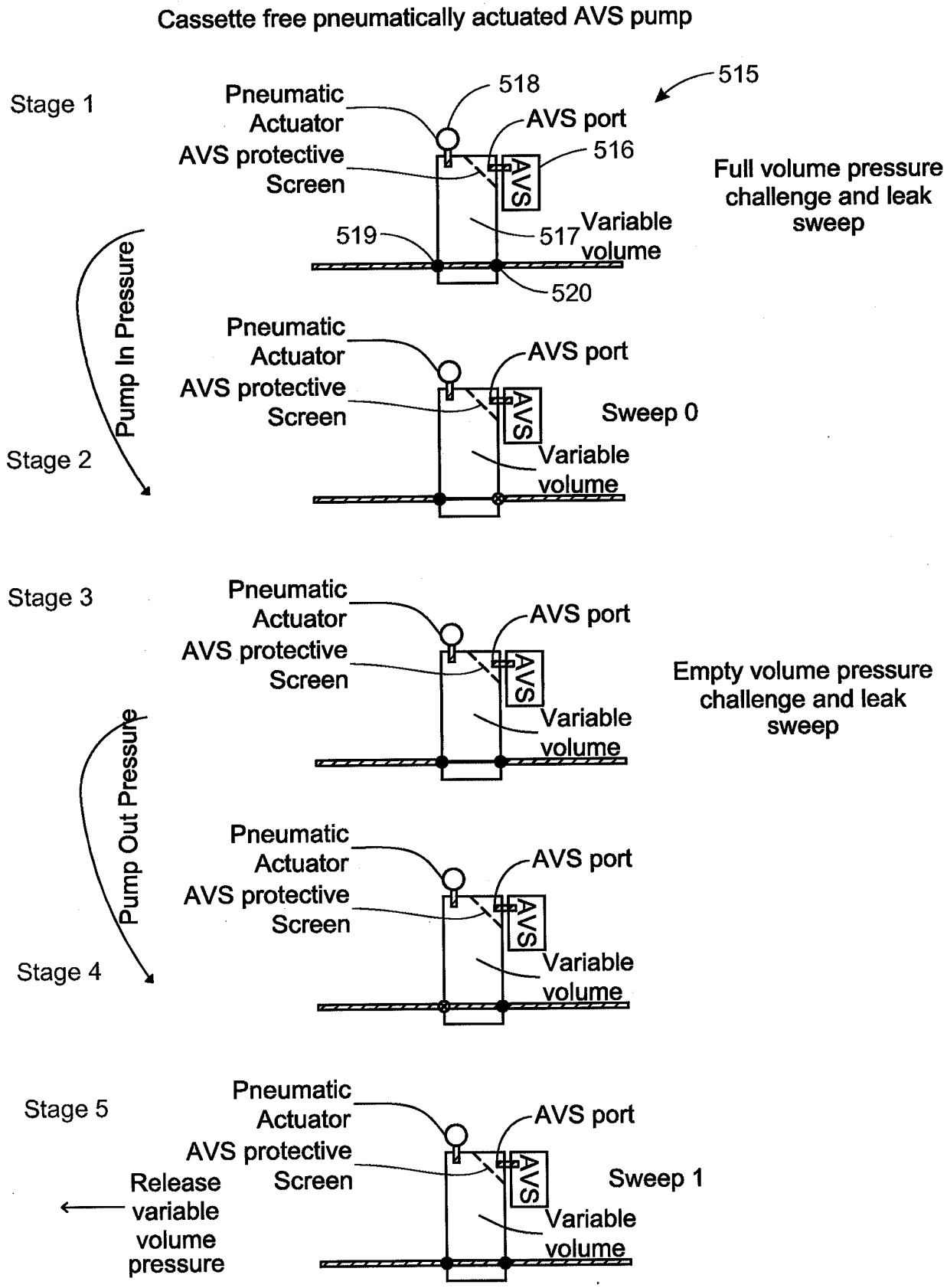

Cassette free pneumatically actuated AVS pump
Stage 1
Pneumatic Actuator
AVS protective Screen
518
AVS port
515
516
AVS
Full volume pressure challenge and leak sweep
519
517
Variable volume
520
Pump In Pressure
Stage 2
Pneumatic Actuator
AVS protective Screen
AVS port
AVS
Sweep 0
Variable volume
Stage 3
Pneumatic Actuator
AVS protective Screen
AVS port
AVS
Empty volume pressure challenge and leak sweep
Variable volume
Pump Out Pressure
Stage 4
Pneumatic Actuator
AVS protective Screen
AVS port
AVS
Variable volume
Stage 5
Pneumatic Actuator
AVS protective Screen
AVS port
AVS
Sweep 1
Release variable volume pressure
Variable volume

FIG. ~~131~~

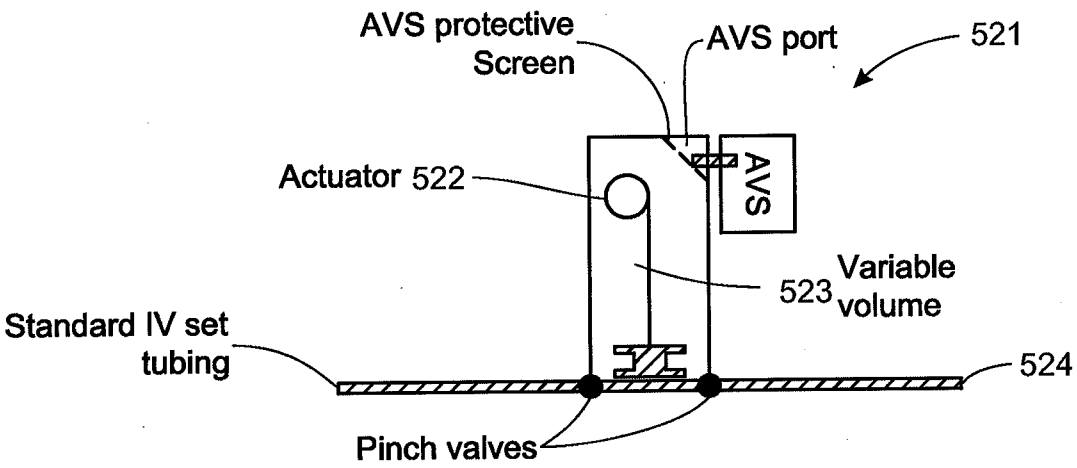


FIG. 132

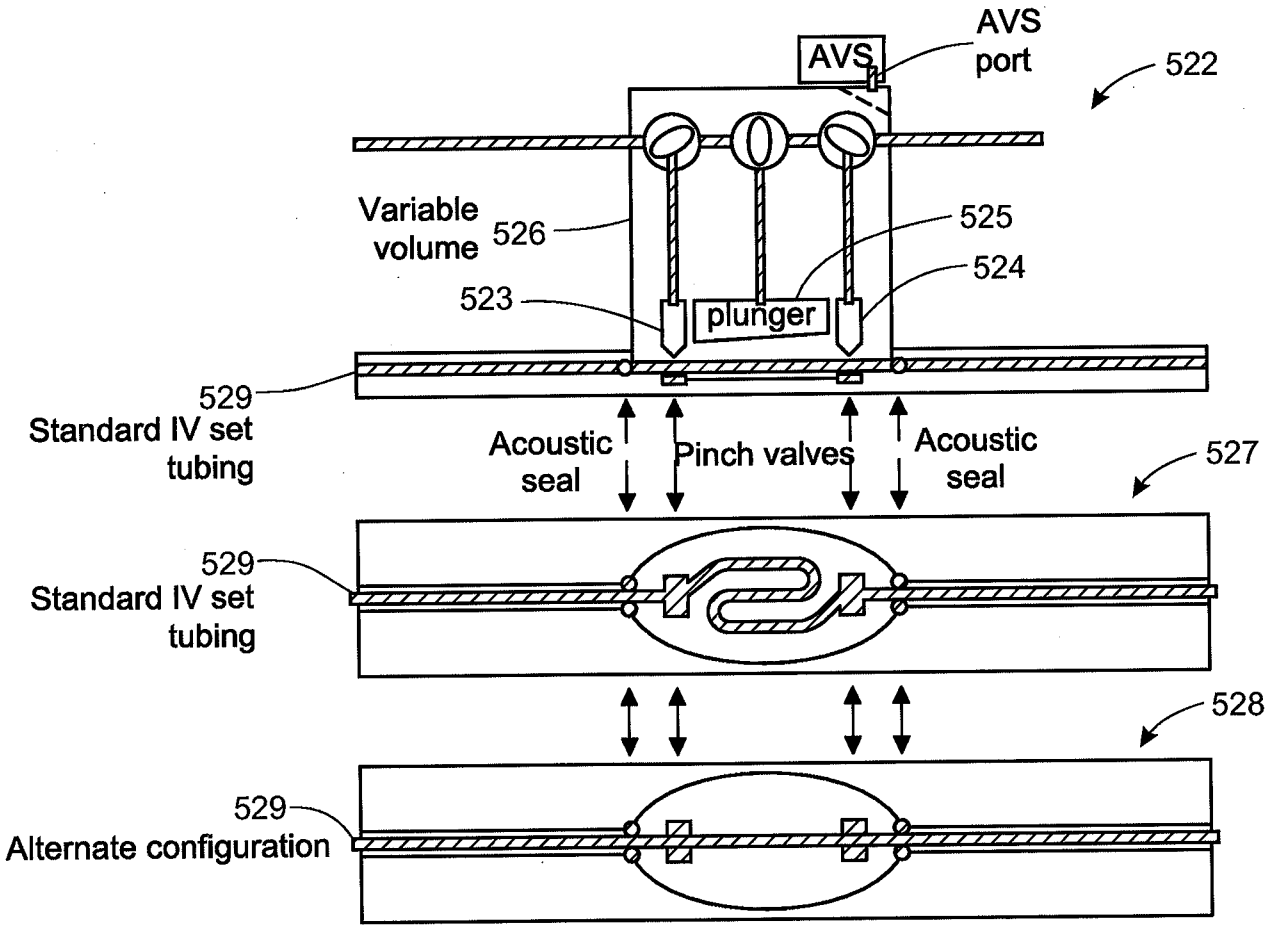


FIG. ~~133~~

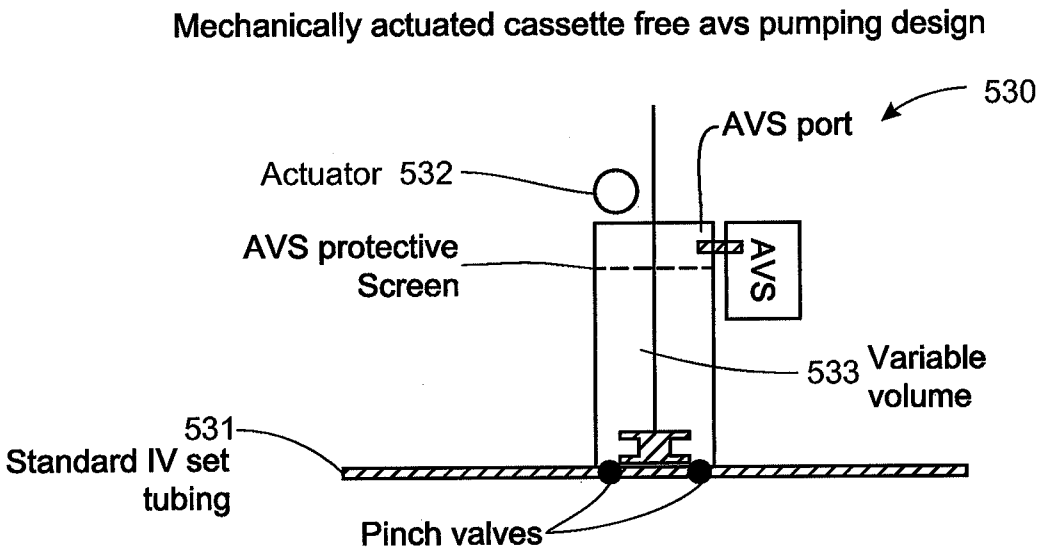


FIG. 134

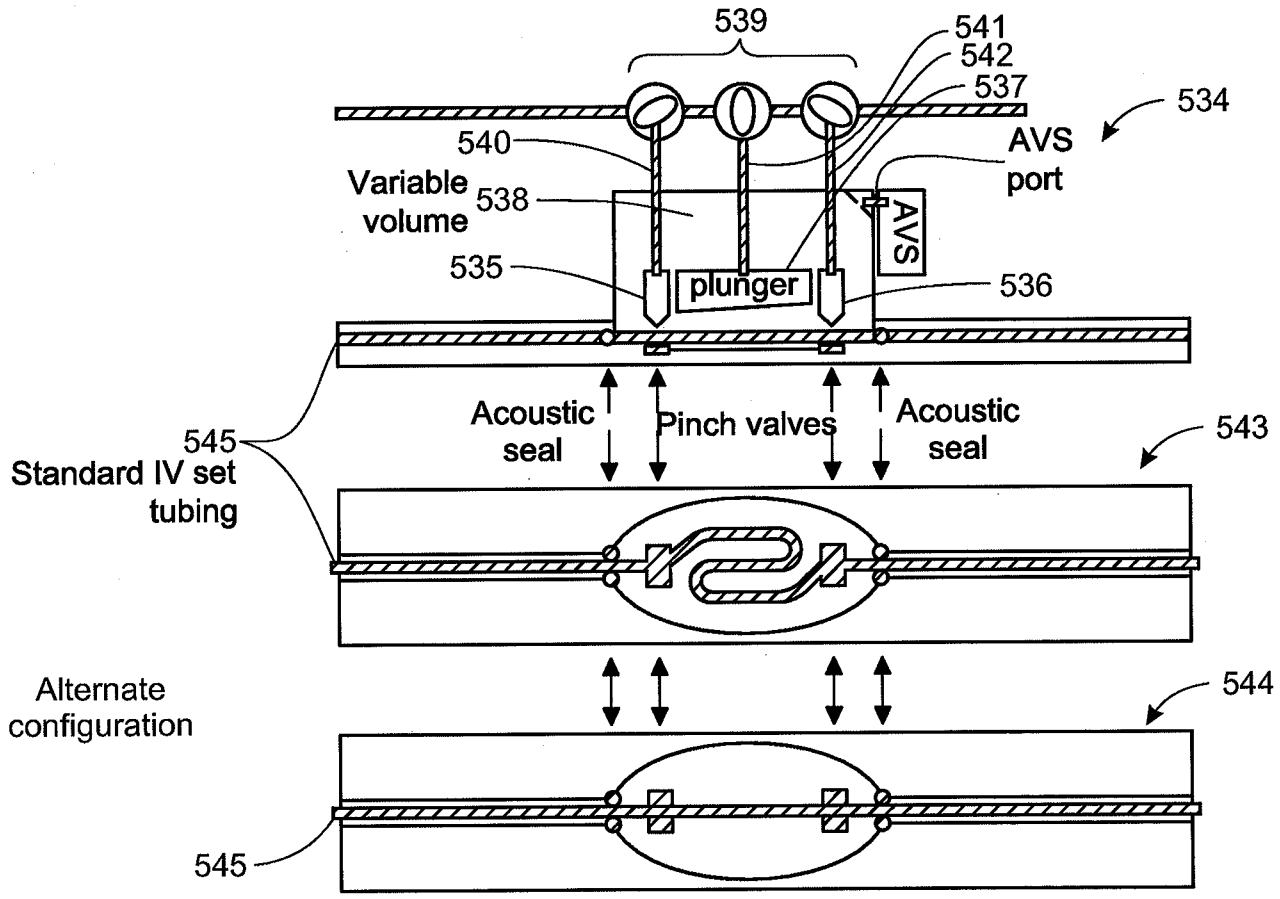


FIG. ~~135~~

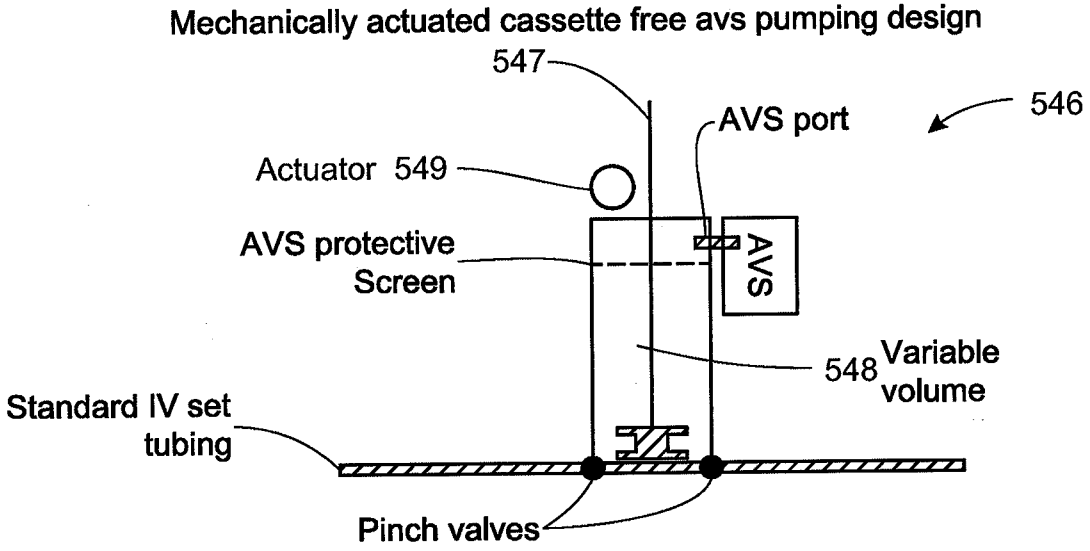


FIG. 136

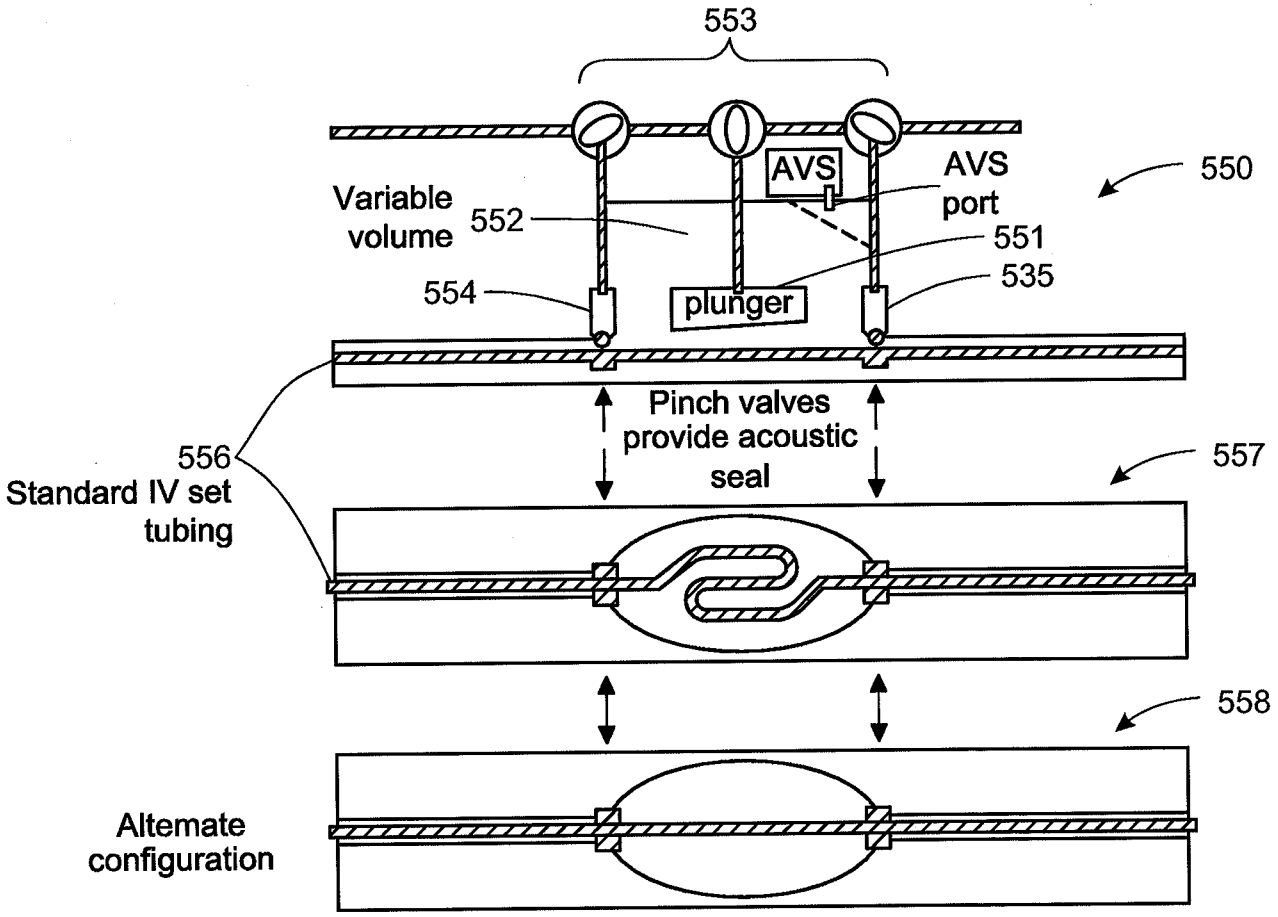


FIG. 137

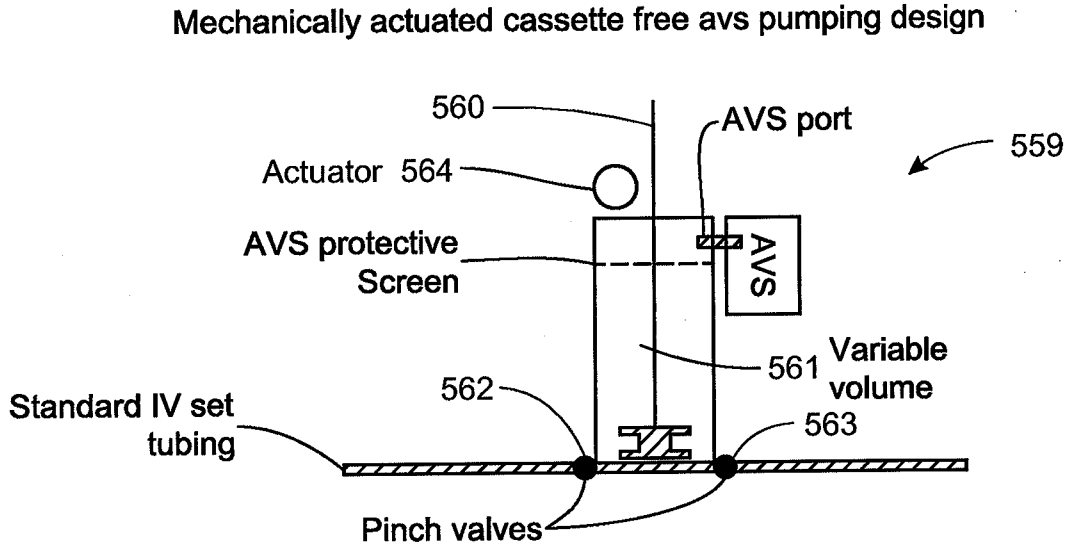


FIG. 138

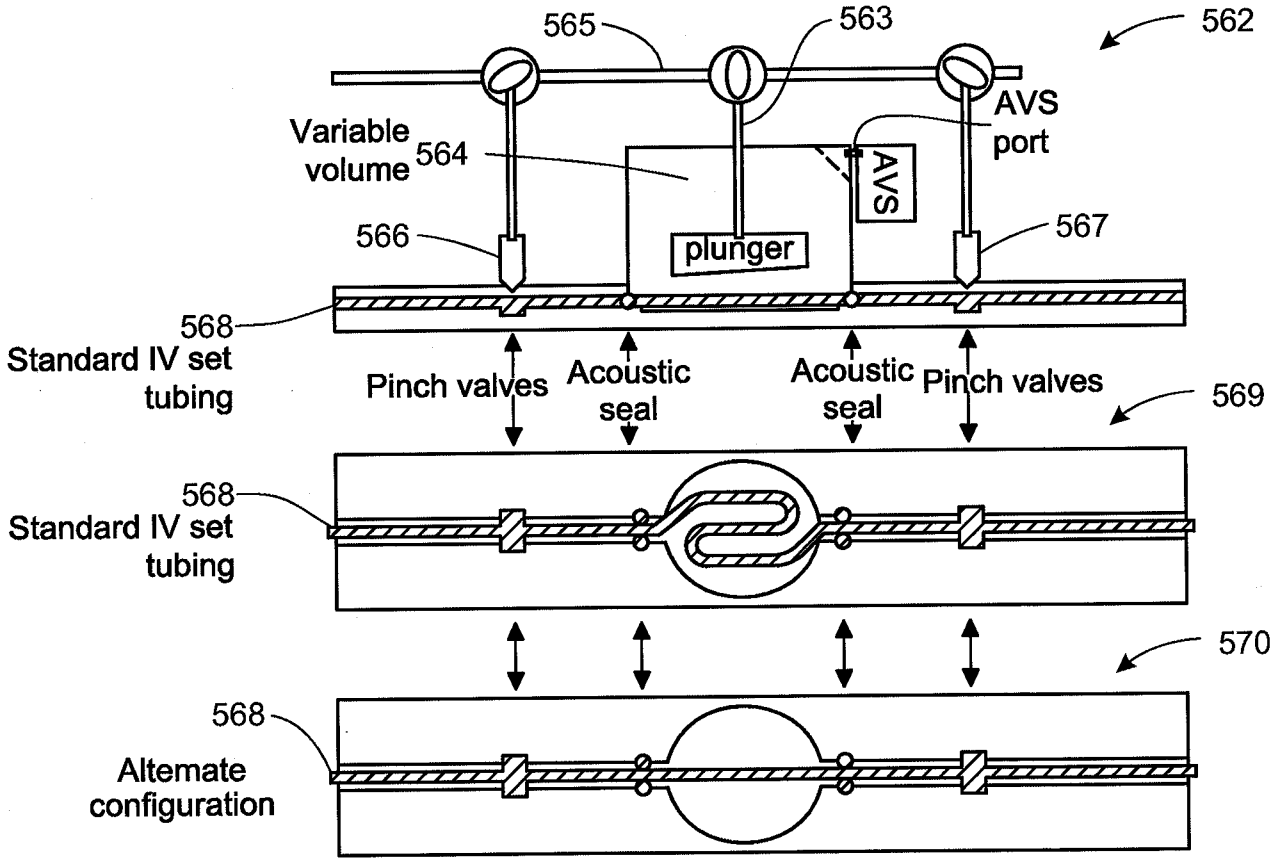


FIG. 139

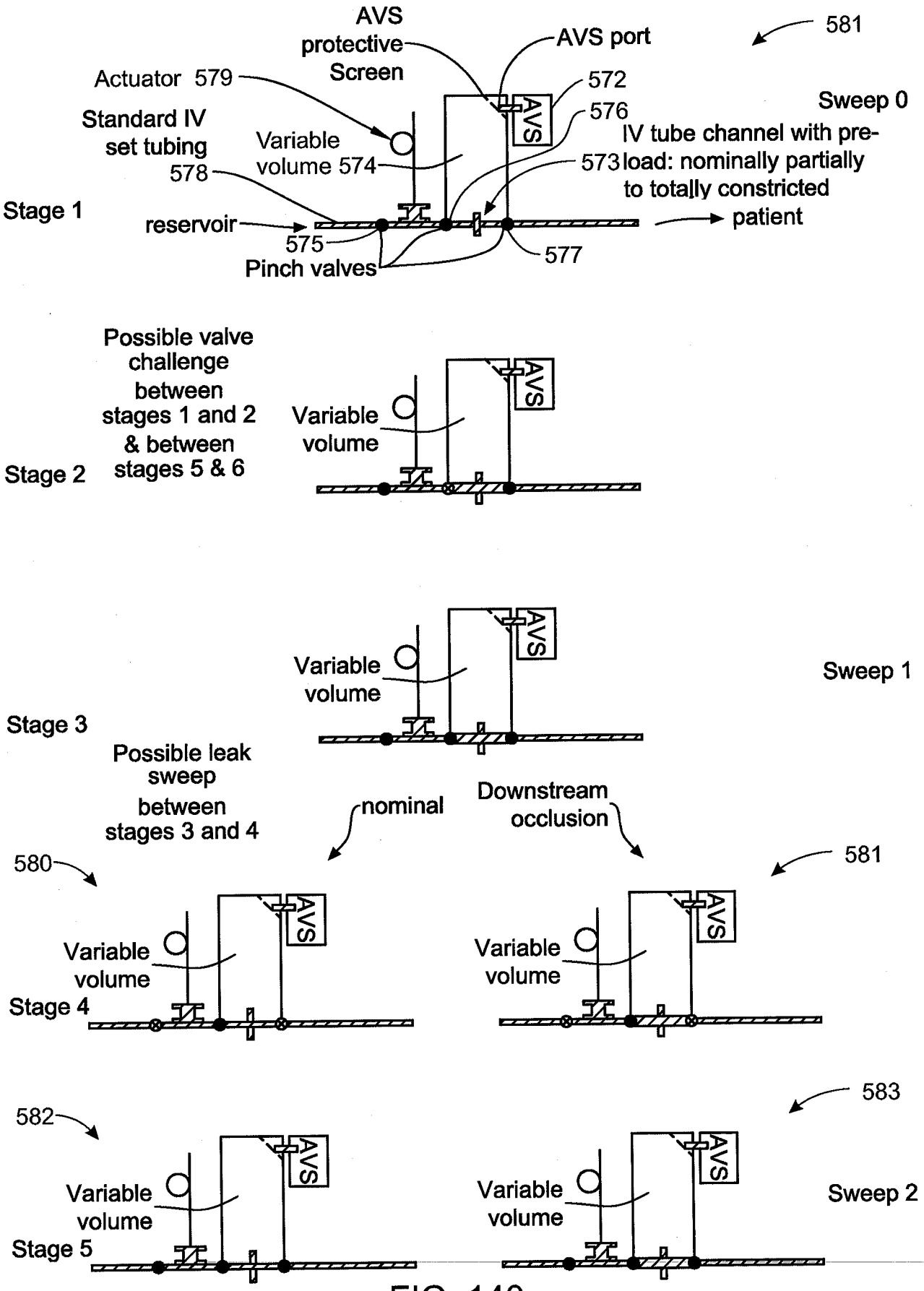

AVS protective Screen
AVS port
581
Actuator 579
572
Sweep 0
576
Standard IV set tubing
Variable volume 574
IV tube channel with pre-load: nominally partially to totally constricted
573
578
Stage 1
reservoir
patient
575
577
Pinch valves
Possible valve challenge between stages 1 and 2 & between stages 5 & 6
Variable volume
Stage 2
AVS
Variable volume
Sweep 1
Stage 3
Possible leak sweep between stages 3 and 4
nominal
Downstream occlusion
580
581
Variable volume
Stage 4
582
583
Variable volume
Stage 5
Sweep 2

FIG. 140

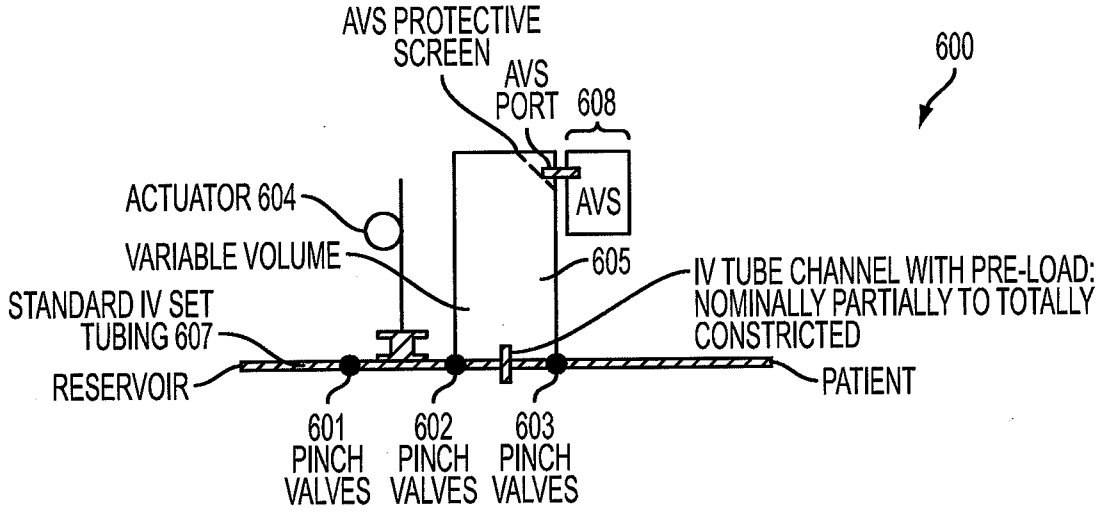


FIG. 141

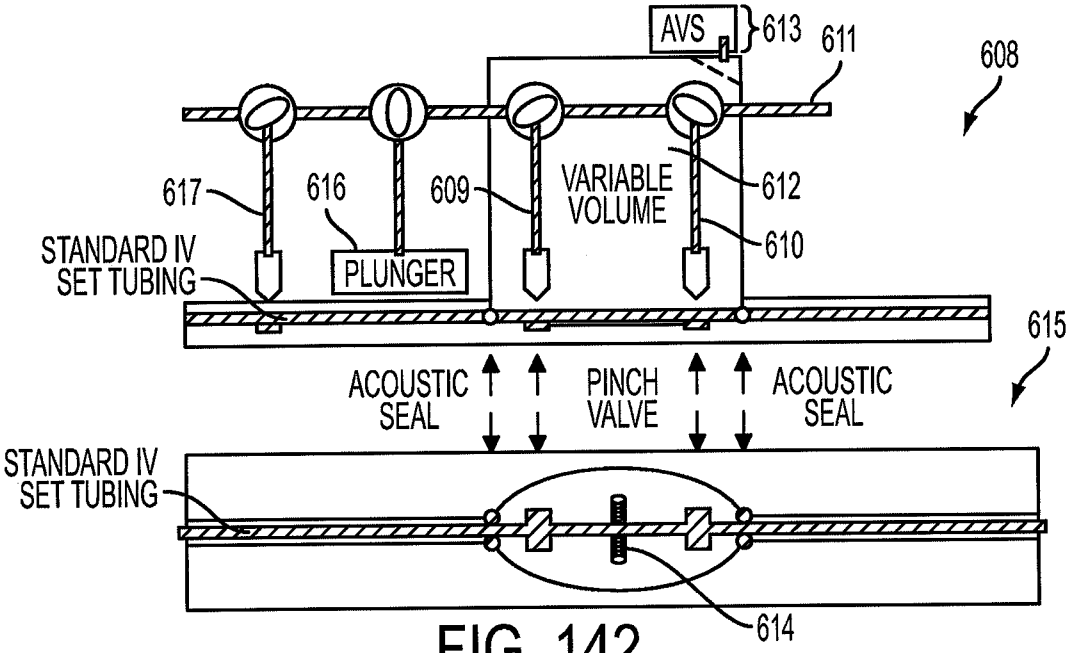


FIG. 142

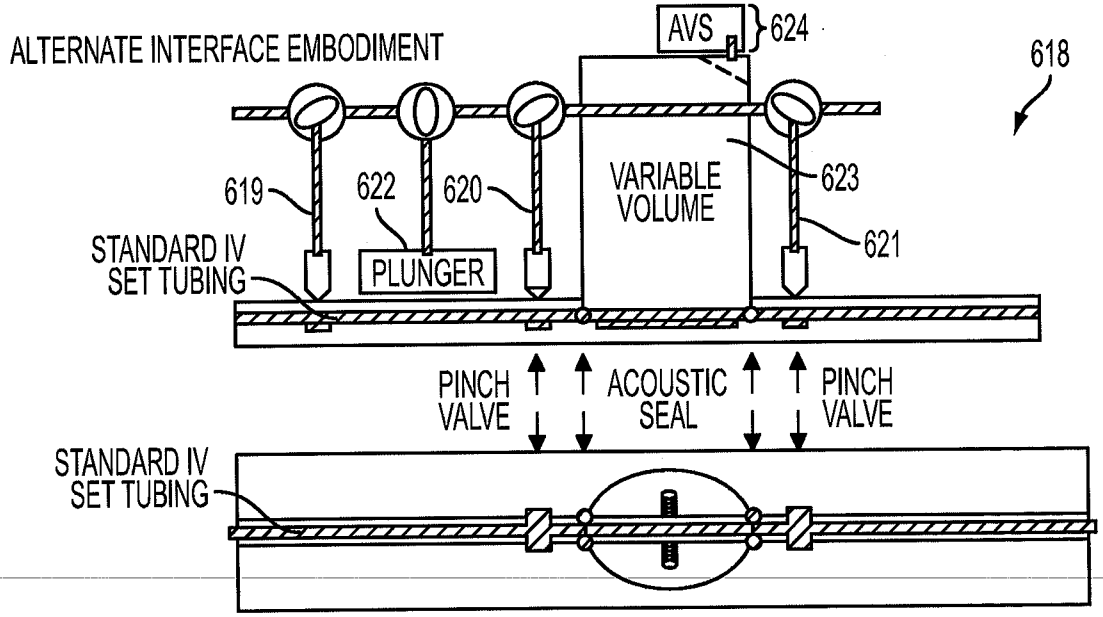


FIG. ~~143~~

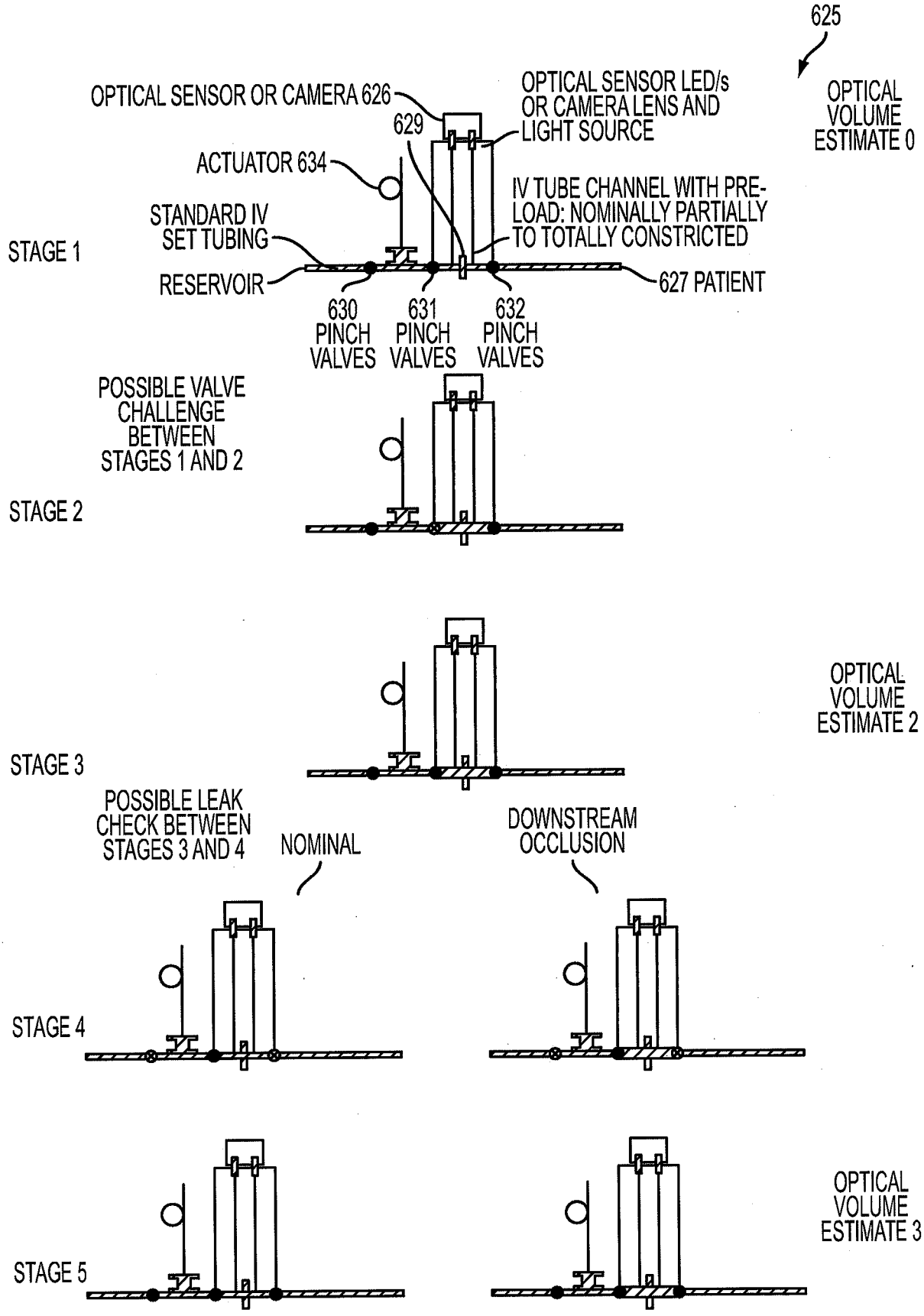

625
OPTICAL SENSOR OR CAMERA 626
629
OPTICAL SENSOR LED/s OR CAMERA LENS AND LIGHT SOURCE
OPTICAL VOLUME ESTIMATE 0
ACTUATOR 634
IV TUBE CHANNEL WITH PRE-LOAD: NOMINALLY PARTIALLY TO TOTALLY CONSTRICTED
STANDARD IV SET TUBING
STAGE 1
RESERVOIR
627 PATIENT
630 PINCH VALVES
631 PINCH VALVES
632 PINCH VALVES
POSSIBLE VALVE CHALLENGE BETWEEN STAGES 1 AND 2
STAGE 2
OPTICAL VOLUME ESTIMATE 2
STAGE 3
POSSIBLE LEAK CHECK BETWEEN STAGES 3 AND 4
NOMINAL
DOWNSTREAM OCCLUSION
STAGE 4
STAGE 5
OPTICAL VOLUME ESTIMATE 3

FIG. 144

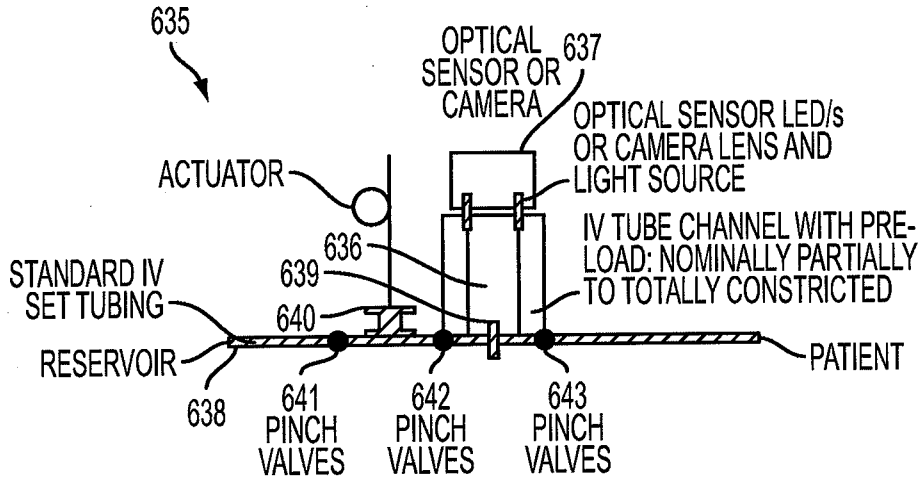


FIG. 145

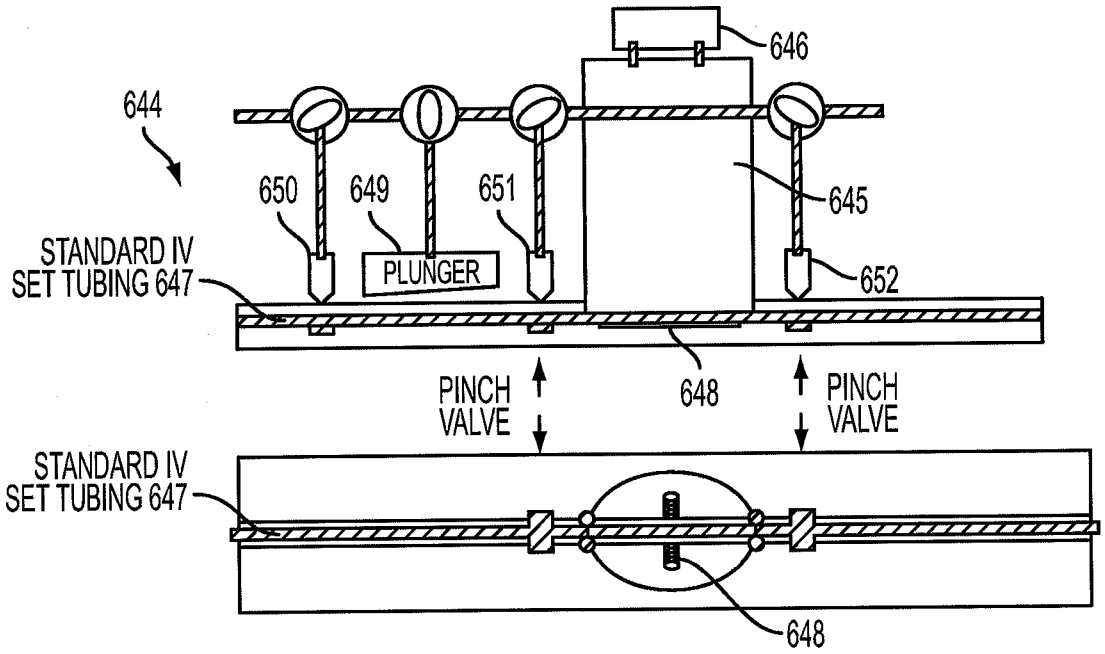


FIG. 146

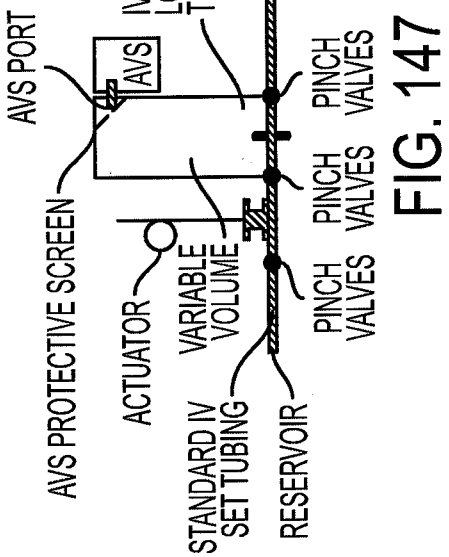
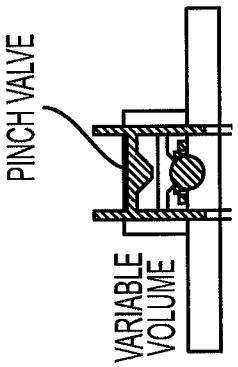


FIG. 147



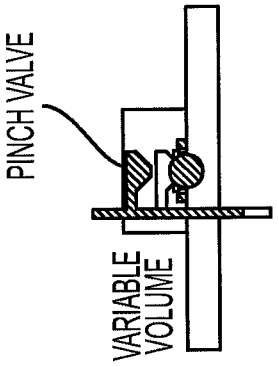


FIG. 149

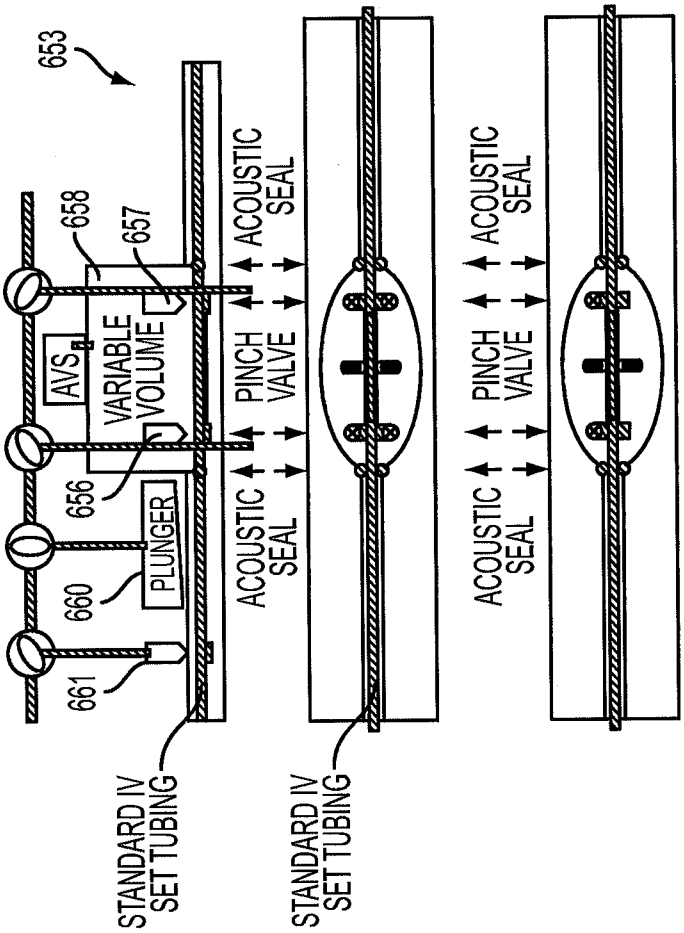


FIG. 148

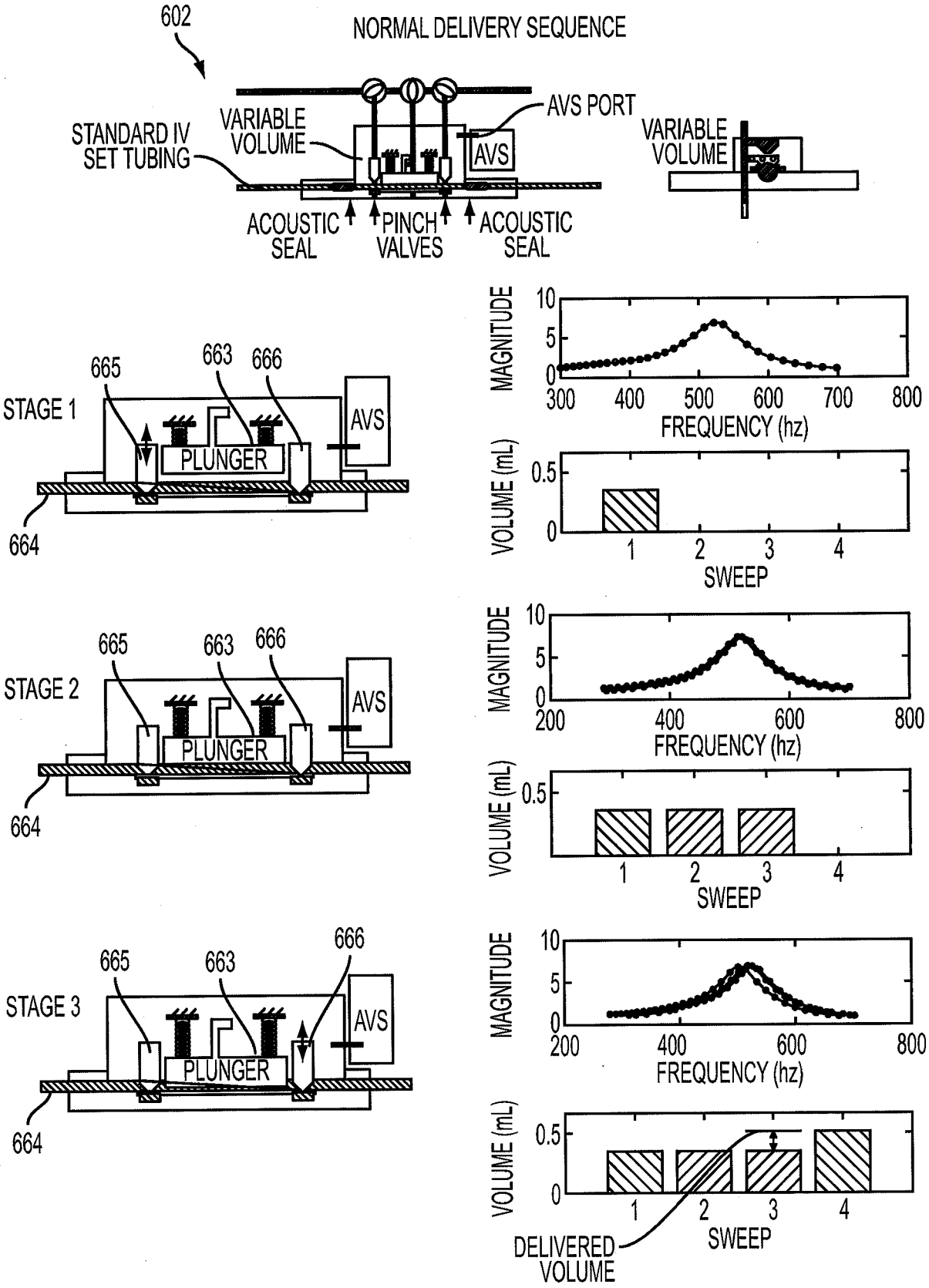

602
NORMAL DELIVERY SEQUENCE
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS PORT
AVS
VARIABLE VOLUME
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
STAGE 1
665
663
666
AVS
PLUNGER
664
MAGNITUDE
10
5
0
300
400
500
600
700
800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1
2
3
4
SWEEP
STAGE 2
665
663
666
AVS
PLUNGER
664
MAGNITUDE
10
5
0
200
400
600
800
FREQUENCY (hz)
VOLUME (mL)
0.5
1
2
3
4
SWEEP
STAGE 3
665
663
666
AVS
PLUNGER
664
MAGNITUDE
10
5
0
200
400
600
800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1
2
3
4
SWEEP
DELIVERED VOLUME

FIG. ~~150~~

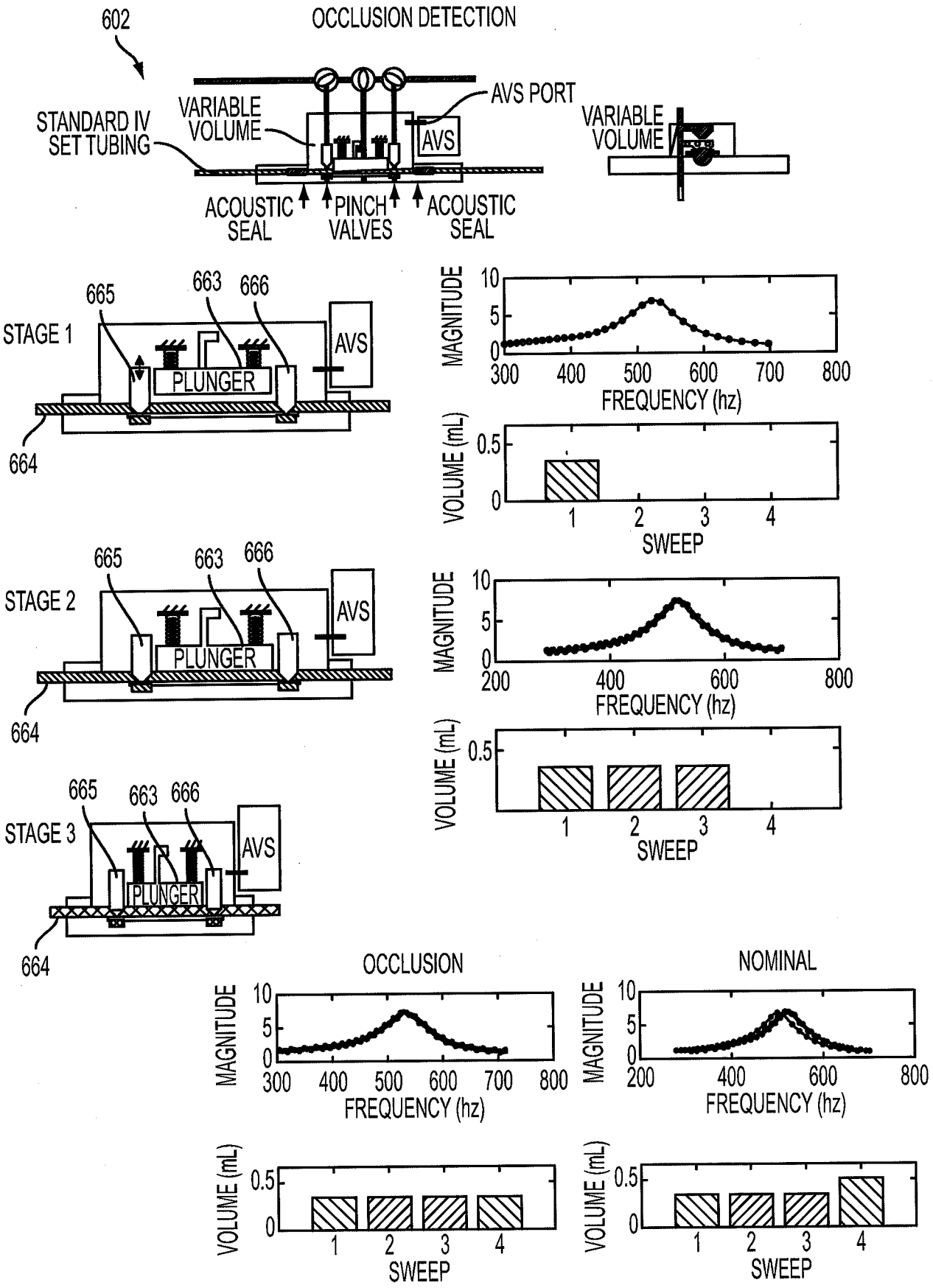

602
OCCLUSION DETECTION
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS PORT
AVS
VARIABLE VOLUME
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
STAGE 1
665
663
666
PLUNGER
AVS
664
MAGNITUDE
FREQUENCY (hz)
VOLUME (mL)
SWEEP
STAGE 2
STAGE 3
OCCLUSION
NOMINAL

FIG. 151

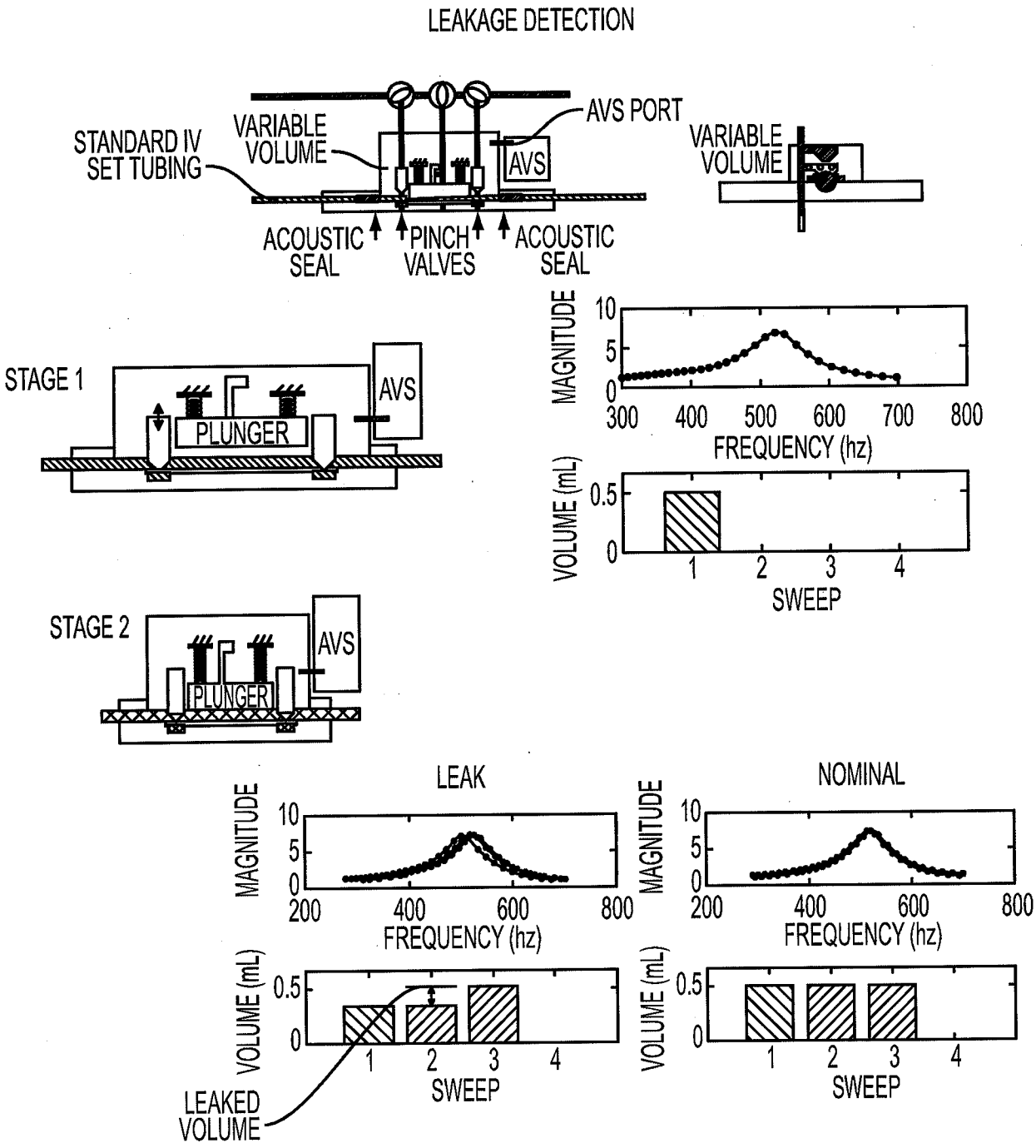

LEAKAGE DETECTION
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS PORT
AVS
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
VARIABLE VOLUME
STAGE 1
PLUNGER
AVS
MAGNITUDE
10
5
0
300 400 500 600 700 800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP
STAGE 2
PLUNGER
AVS
LEAK
NOMINAL
MAGNITUDE
10
5
0
200 400 600 800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP
LEAKED VOLUME

FIG. ~~152~~

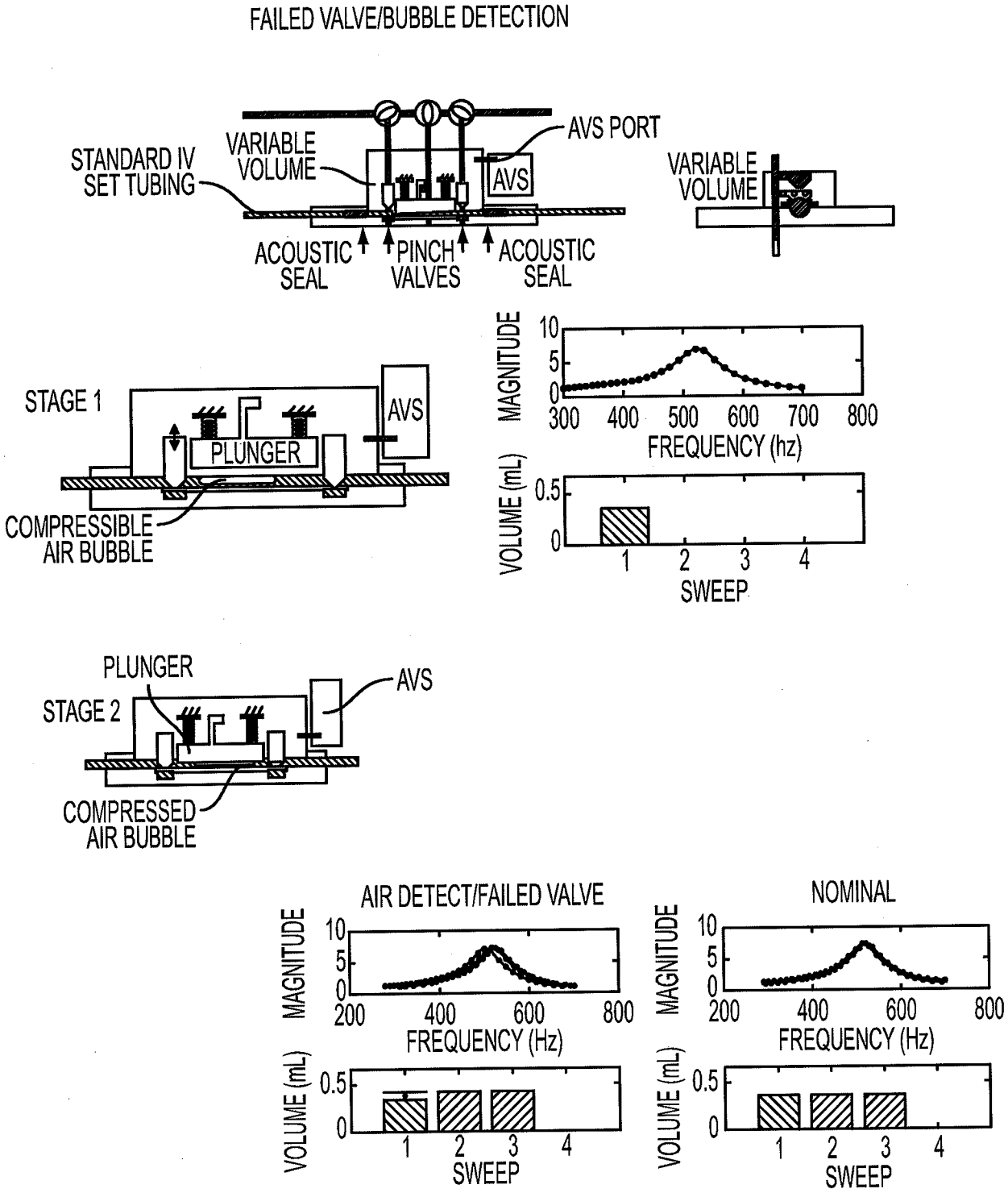

FAILED VALVE/BUBBLE DETECTION
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS PORT
AVS
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
VARIABLE VOLUME
STAGE 1
PLUNGER
AVS
COMPRESSIBLE AIR BUBBLE
MAGNITUDE
10
5
0
300 400 500 600 700 800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP
PLUNGER
STAGE 2
AVS
COMPRESSED AIR BUBBLE
AIR DETECT/FAILED VALVE
MAGNITUDE
10
5
0
200 400 600 800
FREQUENCY (Hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP
NOMINAL
MAGNITUDE
10
5
0
200 400 600 800
FREQUENCY (Hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP

FIG. ~~153~~

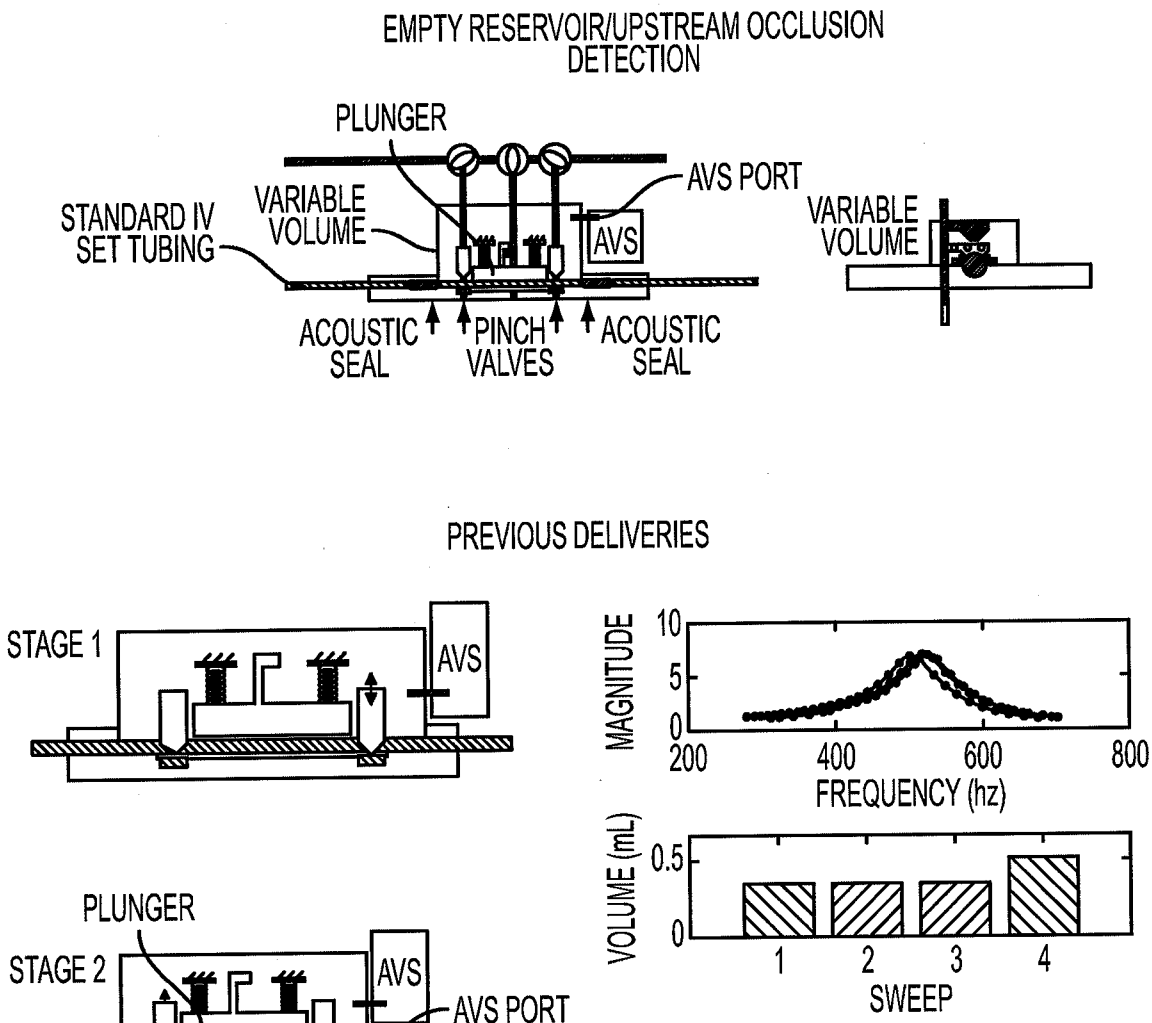

EMPTY RESERVOIR/UPSTREAM OCCLUSION DETECTION
PLUNGER
AVS PORT
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS
VARIABLE VOLUME
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
PREVIOUS DELIVERIES
STAGE 1
AVS
MAGNITUDE
10
5
0
200
400
600
800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1
2
3
4
SWEEP
PLUNGER
STAGE 2
AVS
AVS PORT
CURRENT DELIVERIES
EMPTY RESERVOIR OR UPSTREAM OCCLUSION
MAGNITUDE
10
5
0
300
400
500
600
700
800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1
2
3
4
SWEEP
NOMINAL
MAGNITUDE
10
5
0
300
400
500
600
700
800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1
2
3
4
SWEEP

FIG. ~~154~~

Free-Flow Detection

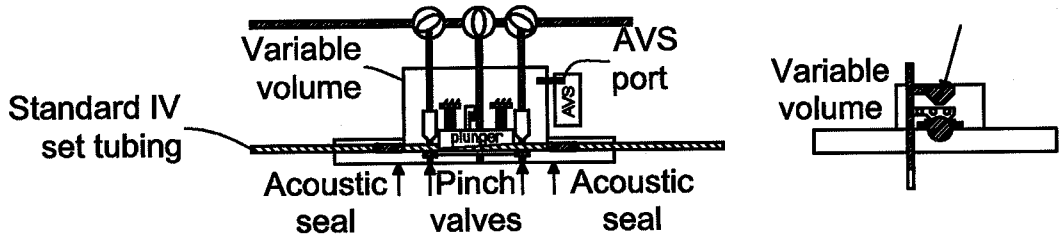


FIG. ~~155~~

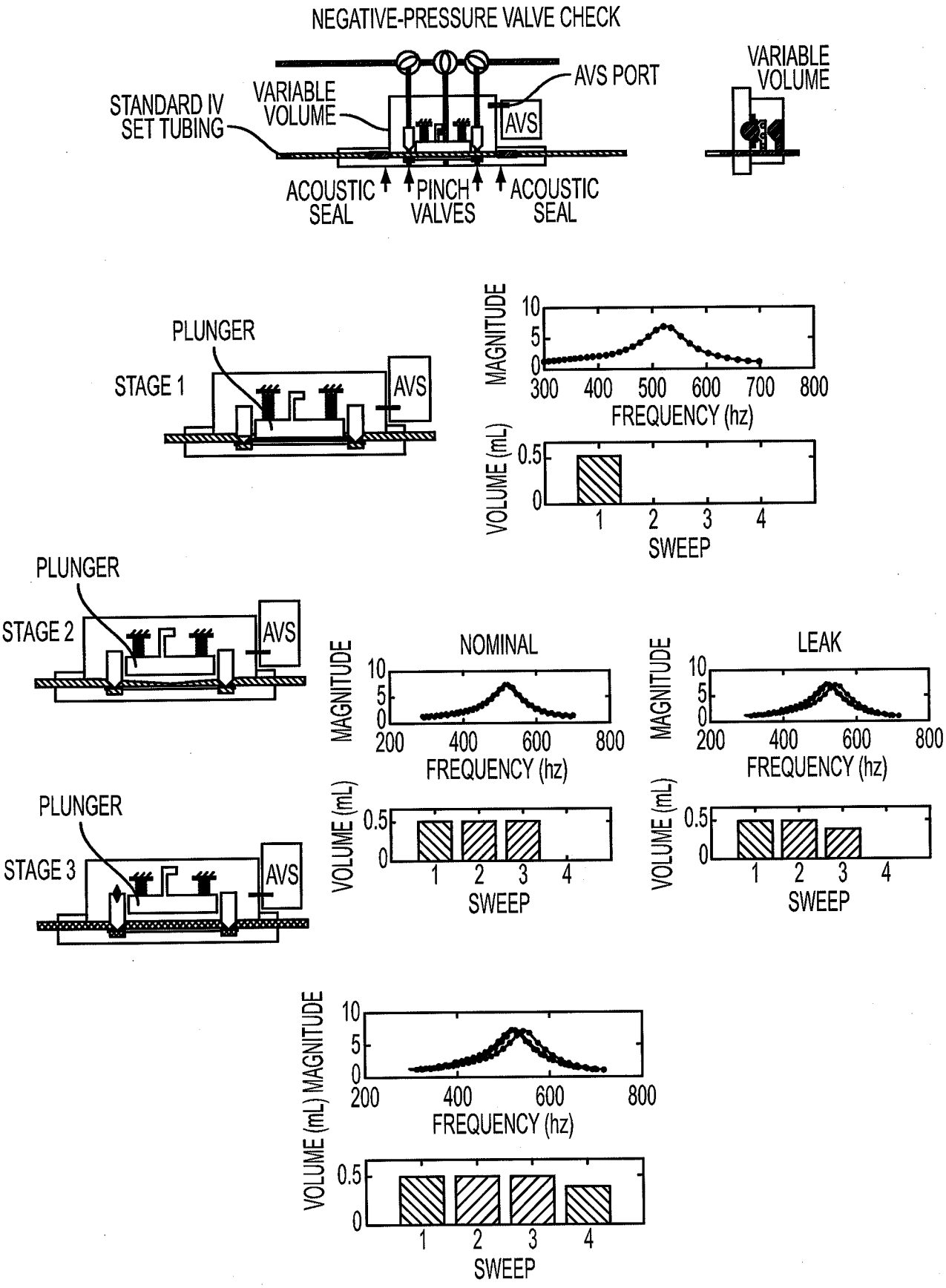

NEGATIVE-PRESSURE VALVE CHECK
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS PORT
AVS
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
VARIABLE VOLUME
PLUNGER
STAGE 1
AVS
MAGNITUDE
10
5
0
300 400 500 600 700 800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP
PLUNGER
STAGE 2
AVS
NOMINAL
MAGNITUDE
10
5
0
200 400 600 800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP
LEAK
MAGNITUDE
10
5
0
200 400 600 800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP
PLUNGER
STAGE 3
AVS
VOLUME (mL) MAGNITUDE
10
5
0
200 400 600 800
FREQUENCY (hz)
0.5
0
1 2 3 4
SWEEP

FIG. ~~156~~

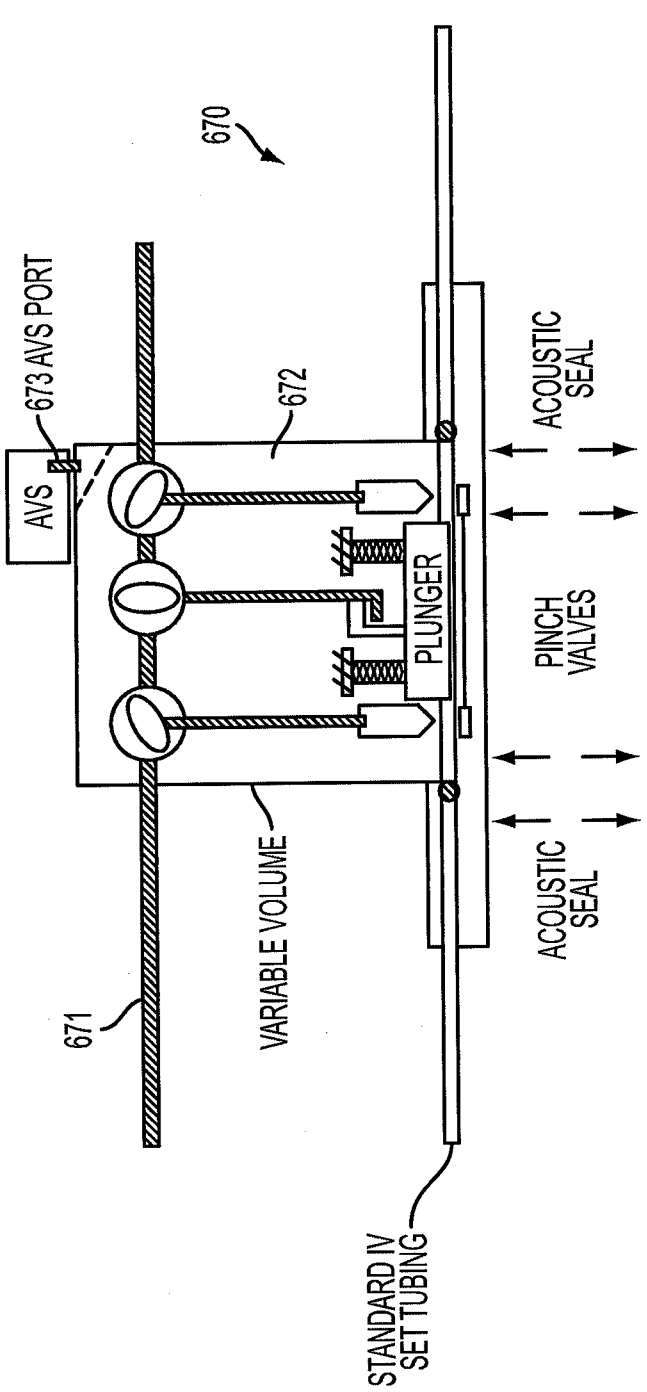


FIG. 157

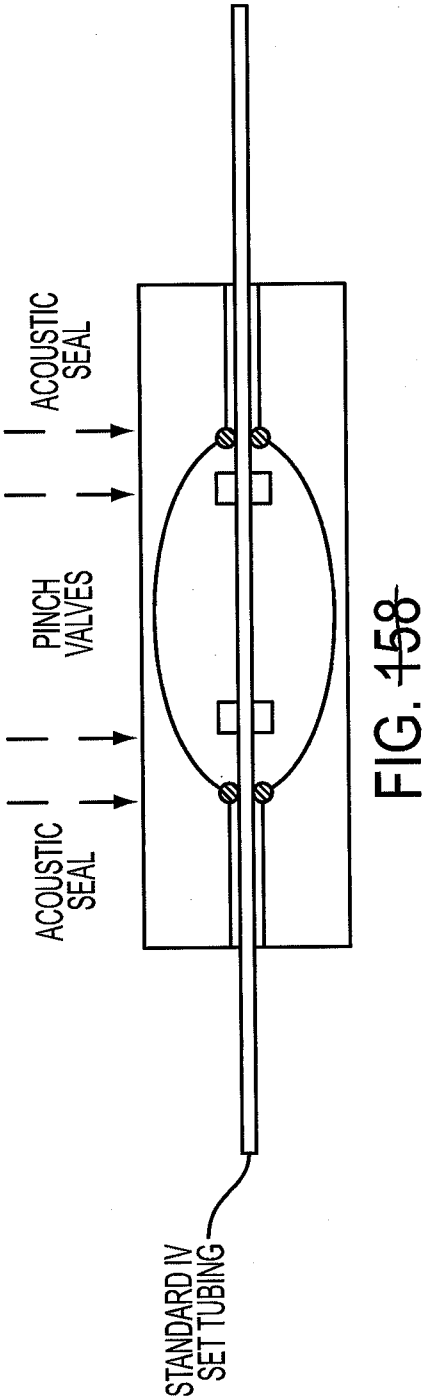


FIG. 158

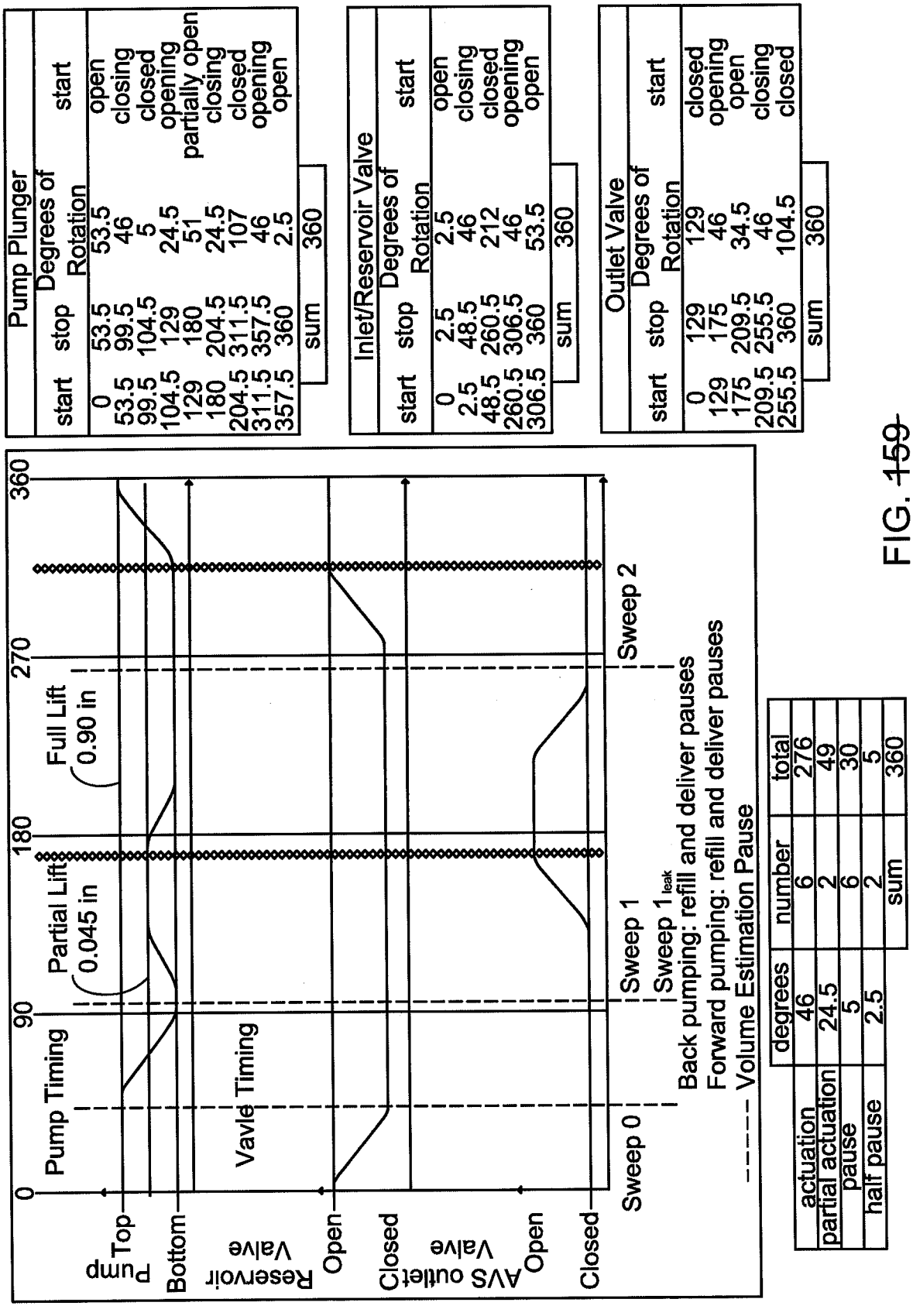

Pump Plunger
Degrees of Rotation
start stop start
0 53.5 53.5 open
53.5 99.5 46 closing
99.5 104.5 5 closed
104.5 129 24.5 opening
129 180 51 partially open
180 204.5 24.5 closing
204.5 311.5 107 closed
311.5 357.5 46 opening
357.5 360 2.5 open
sum 360
Inlet/Reservoir Valve
Degrees of Rotation
start stop start
0 2.5 2.5 open
2.5 48.5 46 closing
48.5 260.5 212 closed
260.5 306.5 46 opening
306.5 360 53.5 open
sum 360
Outlet Valve
Degrees of Rotation
start stop start
0 129 129 closed
129 175 46 opening
175 209.5 34.5 open
209.5 255.5 46 closing
255.5 360 104.5 closed
sum 360
0
90
180
270
360
Pump Timing
Partial Lift 0.045 in
Full Lift 0.90 in
Vavle Timing
Pump Top
Bottom
Reservoir Valve
Open
Closed
AVS outlet Valve
Open
Closed
Sweep 0
Sweep 1
Sweep 1 leak
Sweep 2
Back pumping: refill and deliver pauses
Forward pumping: refill and deliver pauses
Volume Estimation Pause
degrees number total
actuation 46 6 276
partial actuation 24.5 2 49
pause 5 6 30
half pause 2.5 2 5
sum 360

FIG. 159

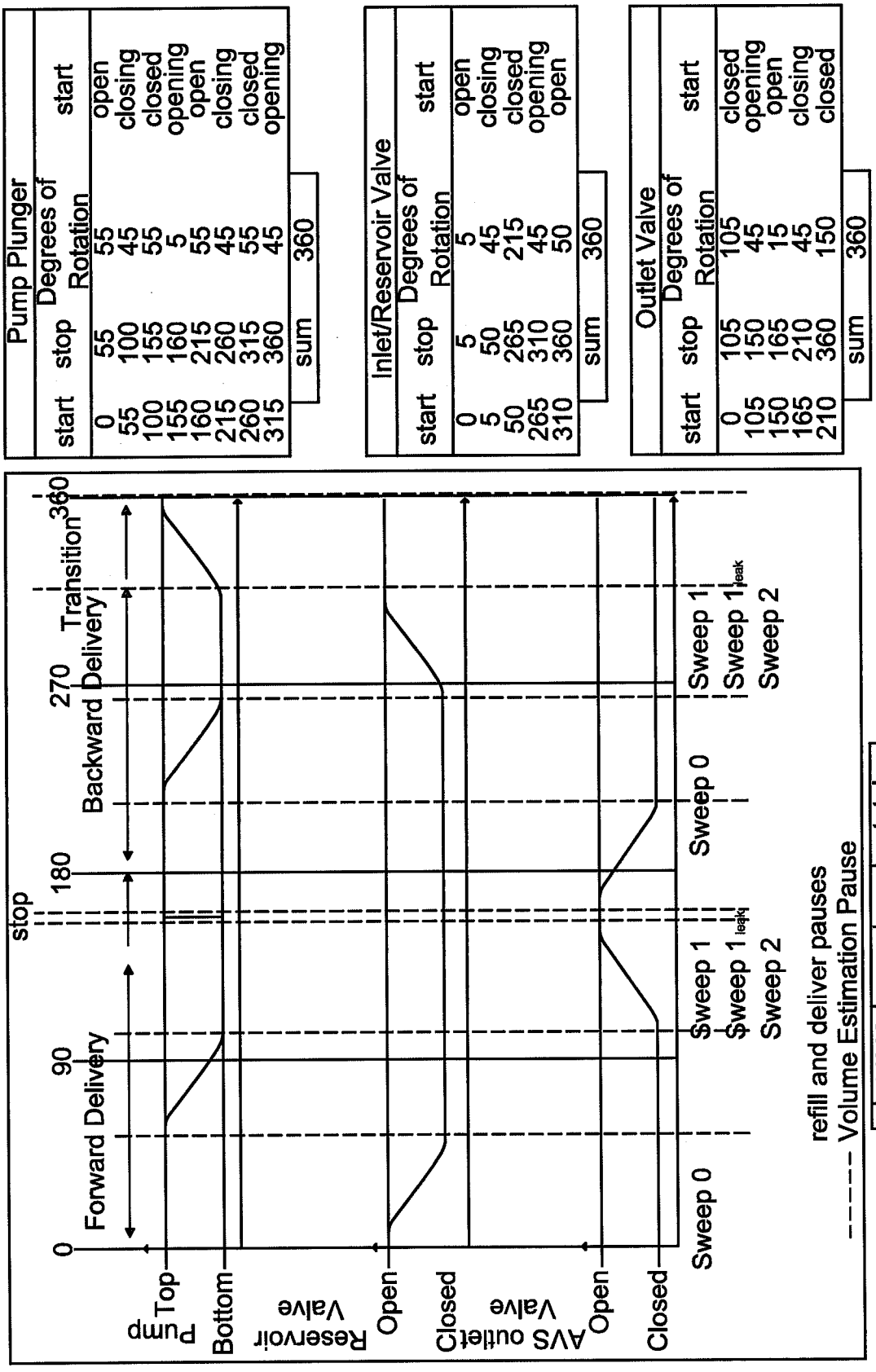

Pump Plunger
Degrees of Rotation
start stop start
0 55 55 open
55 100 45 closing
100 155 55 closed
155 160 5 opening
160 215 55 open
215 260 45 closing
260 315 55 closed
315 360 45 opening
sum 360
Inlet/Reservoir Valve
Degrees of Rotation
start stop start
0 5 5 open
5 50 45 closing
50 265 215 closed
265 310 45 opening
310 360 50 open
sum 360
Outlet Valve
Degrees of Rotation
start stop start
0 105 105 closed
105 150 45 opening
150 165 15 open
165 210 45 closing
210 360 150 closed
sum 360
stop
0
90
180
270
360
Forward Delivery
Backward Delivery
Transition
Pump
Top
Bottom
Reservoir Valve
Open
Closed
AVS outlet Valve
Open
Closed
Sweep 0
Sweep 1
Sweep 1leak
Sweep 2
Sweep 0
Sweep 1
Sweep 1peak
Sweep 2
refill and deliver pauses
Volume Estimation Pause
degrees number total
actuation 45 7 315
stop 5 1 5
pause 5 8 40
sum 360

FIG. ~~160~~

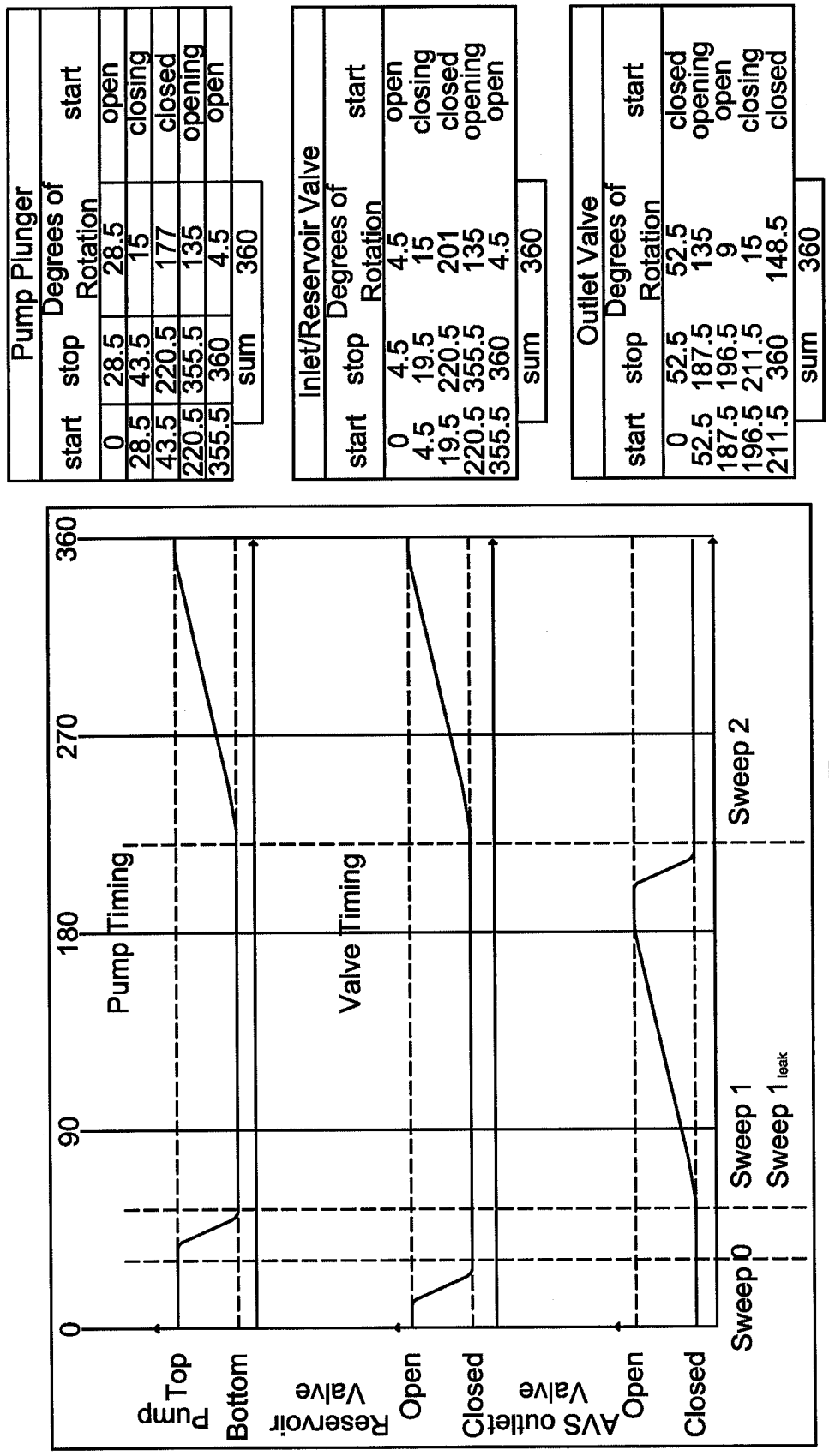
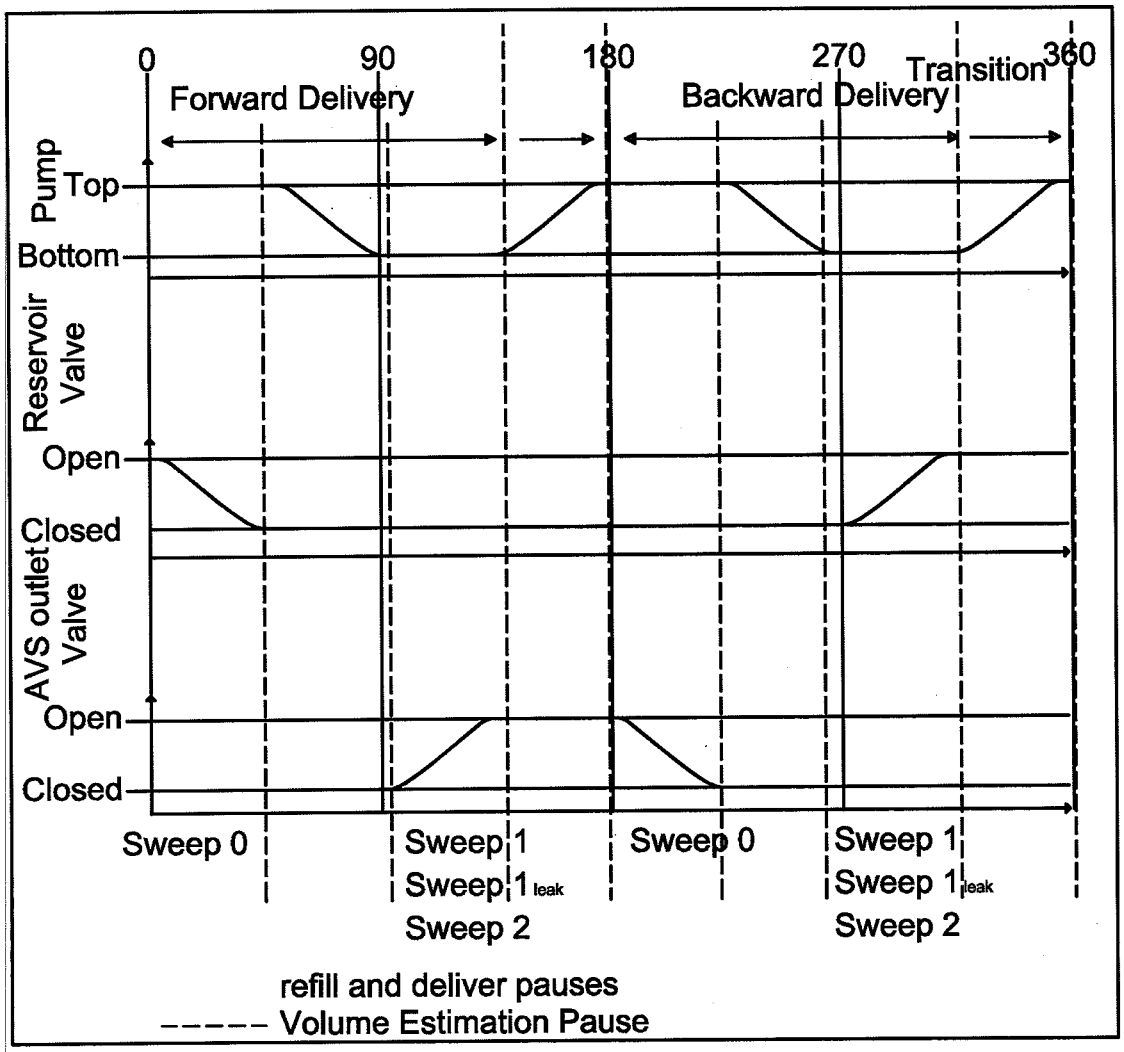

Pump Plunger
Degrees of Rotation
start stop start
0 28.5 28.5 open
28.5 43.5 15 closing
43.5 220.5 177 closed
220.5 355.5 135 opening
355.5 360 4.5 open
sum 360
Inlet/Reservoir Valve
Degrees of Rotation
start stop start
0 4.5 4.5 open
4.5 19.5 15 closing
19.5 220.5 201 closed
220.5 355.5 135 opening
355.5 360 4.5 open
sum 360
Outlet Valve
Degrees of Rotation
start stop start
0 52.5 52.5 closed
52.5 187.5 135 opening
187.5 196.5 9 open
196.5 211.5 15 closing
211.5 360 148.5 closed
sum 360
0
90
180
270
360
Pump Timing
Valve Timing
Sweep 0
Sweep 1
Sweep 1 leak
Sweep 2
Pump Top Bottom
Reservoir Valve Open Closed
AVS outlet Valve Open Closed
degrees number total
lift actuation 135 2 270
drop actuation 15 3 45
pause 9 4 36
half pause 4.5 2 9
sum 360

FIG. ~~161~~



Pump Plunger			
start	stop	Degrees of Rotation	start
0	50	50	open
50	90	40	closing
90	140	50	closed
140	180	40	opening
180	230	50	open
230	270	40	closing
270	320	50	closed
320	360	40	opening
	sum	360	

Inlet/Reservoir Valve			
start	stop	Degrees of Rotation	start
0	5	5	open
5	45	40	closing
45	275	230	closed
275	315	40	opening
315	360	45	open
	sum	360	

Outlet/Measurement Valve			
start	stop	Degrees of Rotation	start
0	95	95	closed
95	135	40	opening
135	185	50	open
185	225	40	closing
225	360	135	closed
	sum	360	

	degrees	number	total
actuation	40	8	320
pause	5	8	40
		sum	360

0 $\longleftrightarrow$ 140 forward delivery
0 $\longleftrightarrow$ 180 downstream swish
180 $\longleftrightarrow$ 320 backward delivery
180 $\longleftrightarrow$ 360 upstream swish
0 $\longleftrightarrow$ 360 upstream & downstream
360 $\longleftrightarrow$ 0 swish

FIG. ~~162~~

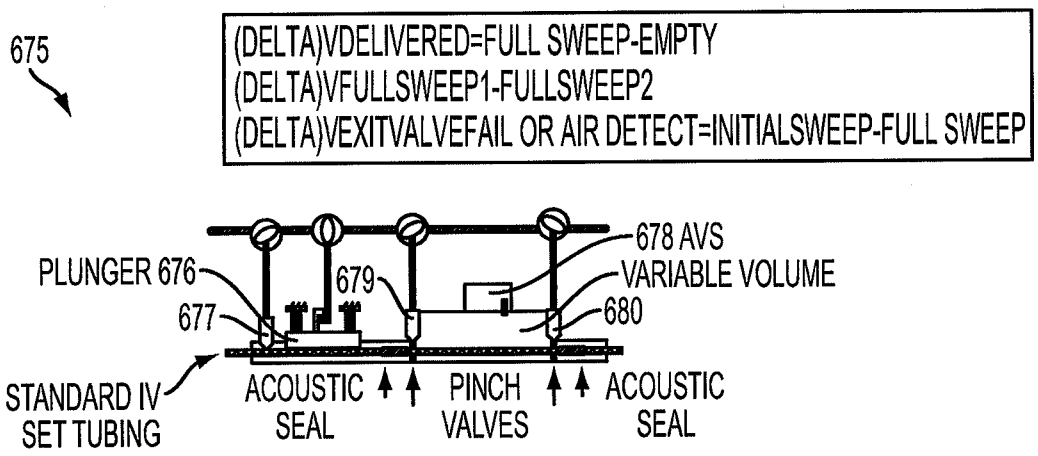


FIG. ~~163~~

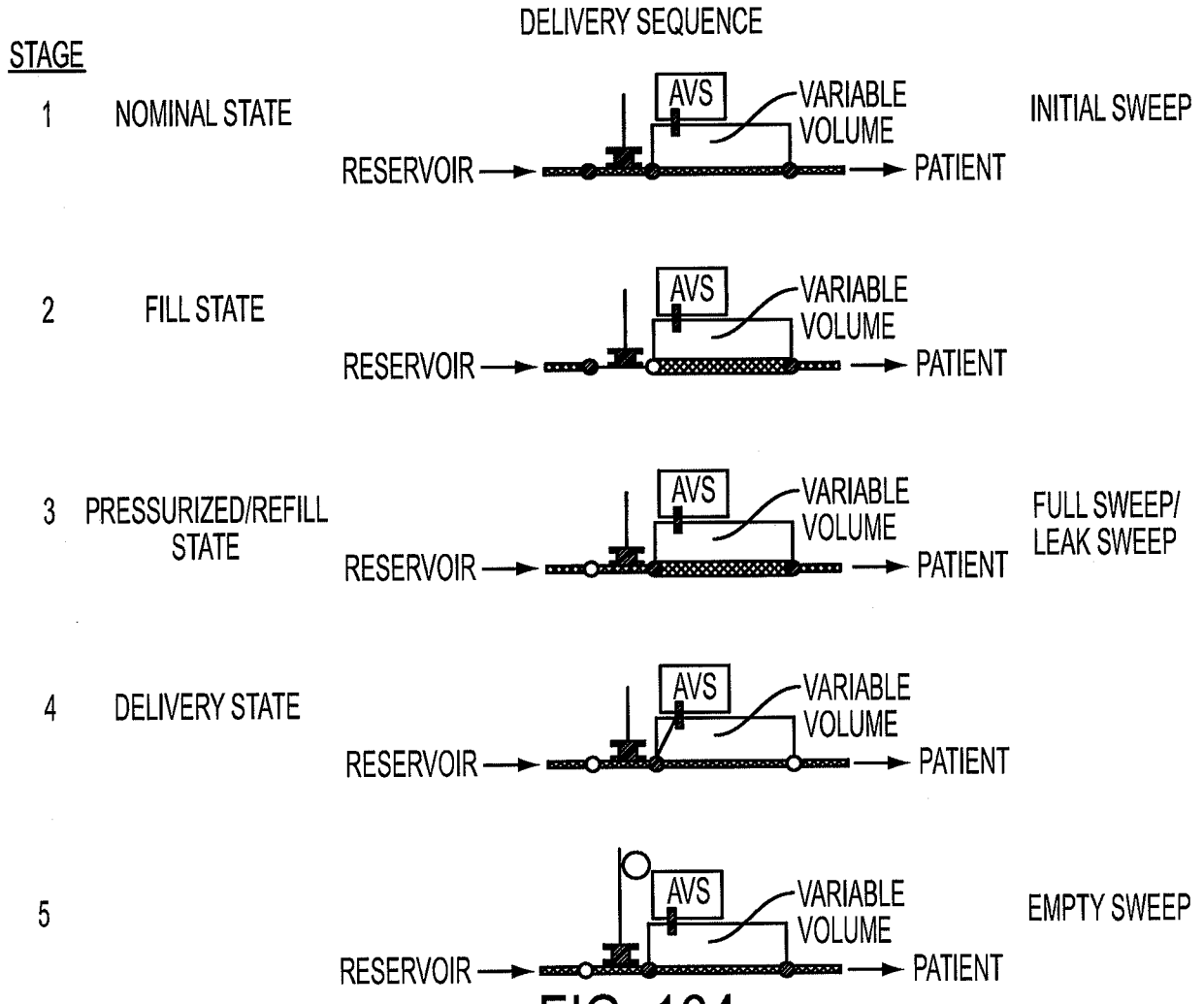


FIG. ~~164~~

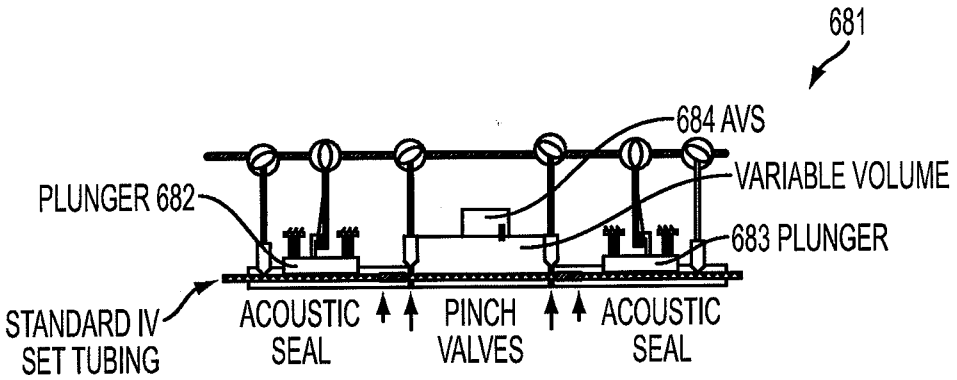


FIG. ~~165~~

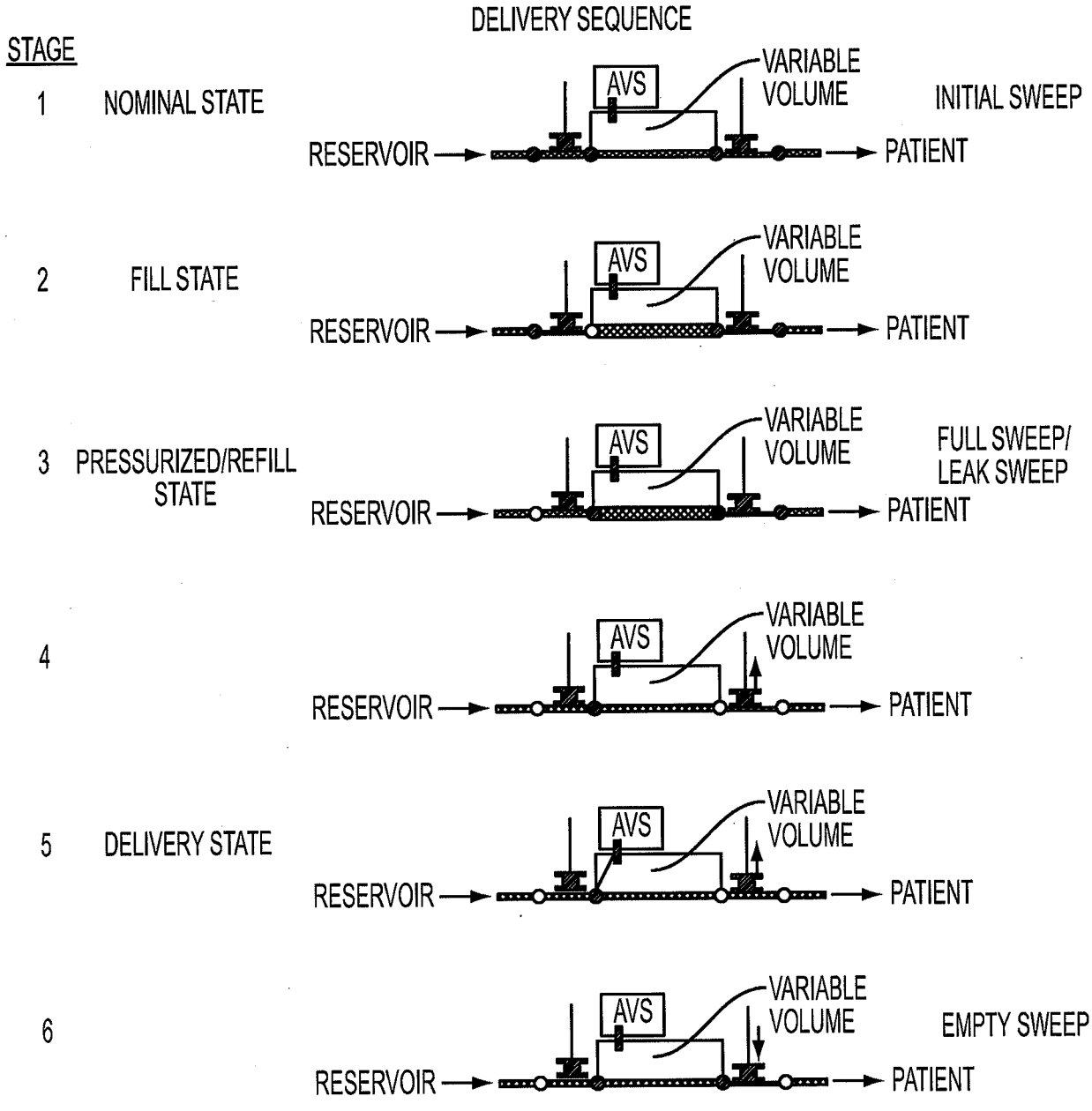


FIG. ~~166~~

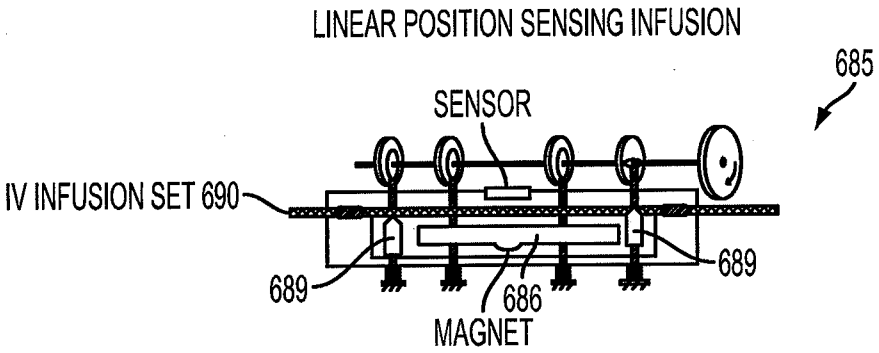


FIG. ~~167~~

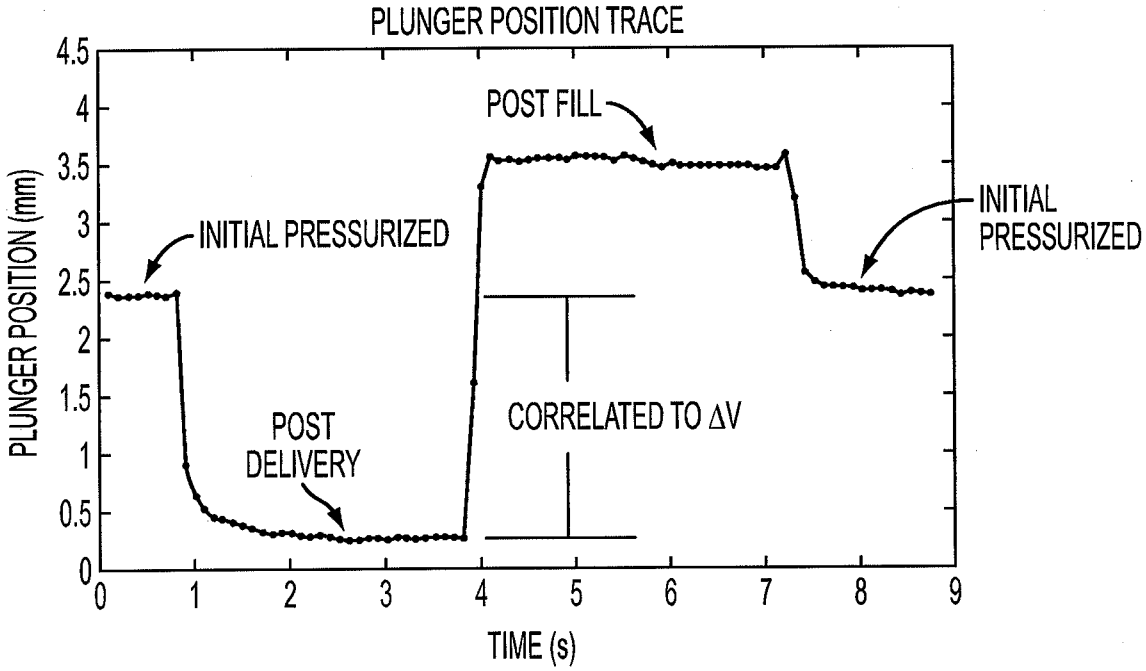


FIG. ~~168~~

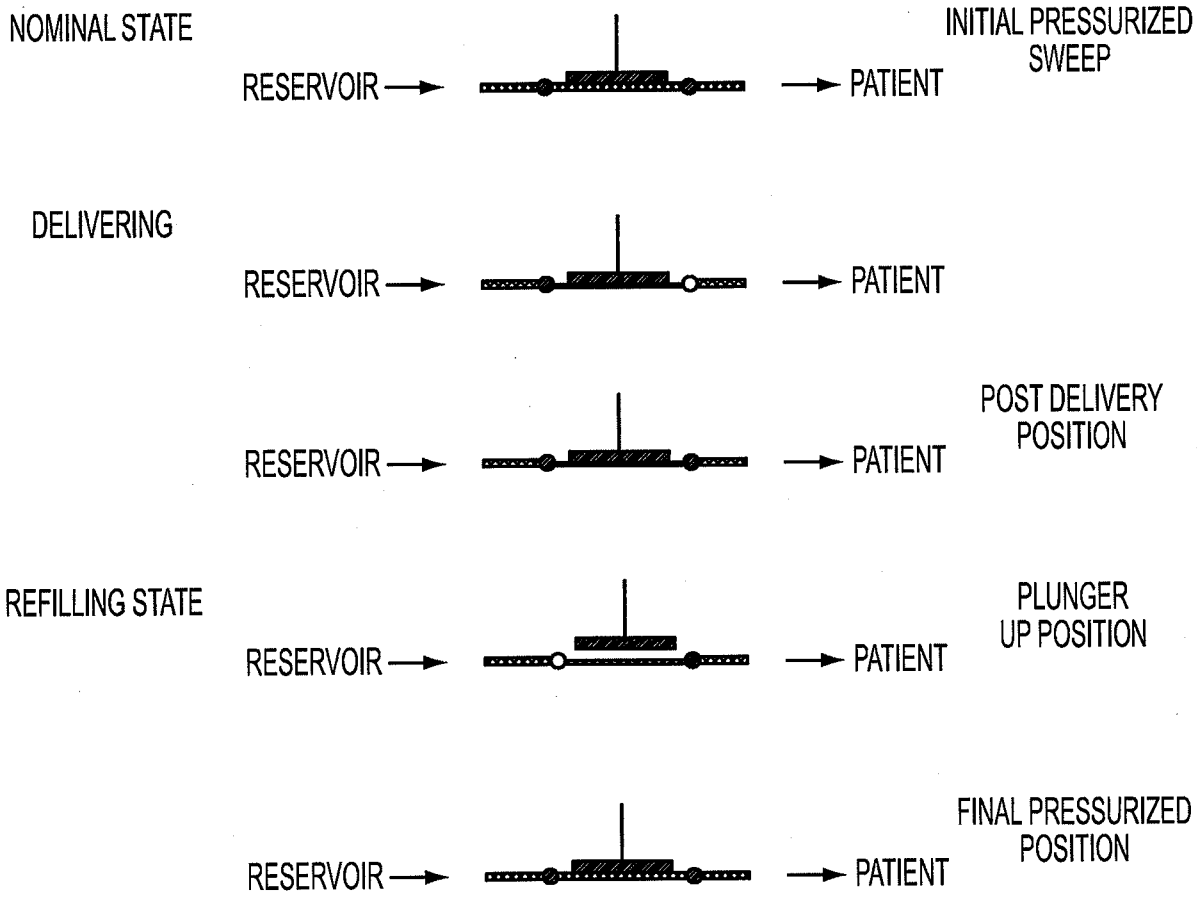

NOMINAL STATE
RESERVOIR
PATIENT
INITIAL PRESSURIZED SWEEP
DELIVERING
RESERVOIR
PATIENT
RESERVOIR
PATIENT
POST DELIVERY POSITION
REFILLING STATE
RESERVOIR
PATIENT
PLUNGER UP POSITION
RESERVOIR
PATIENT
FINAL PRESSURIZED POSITION

FIG. ~~169~~

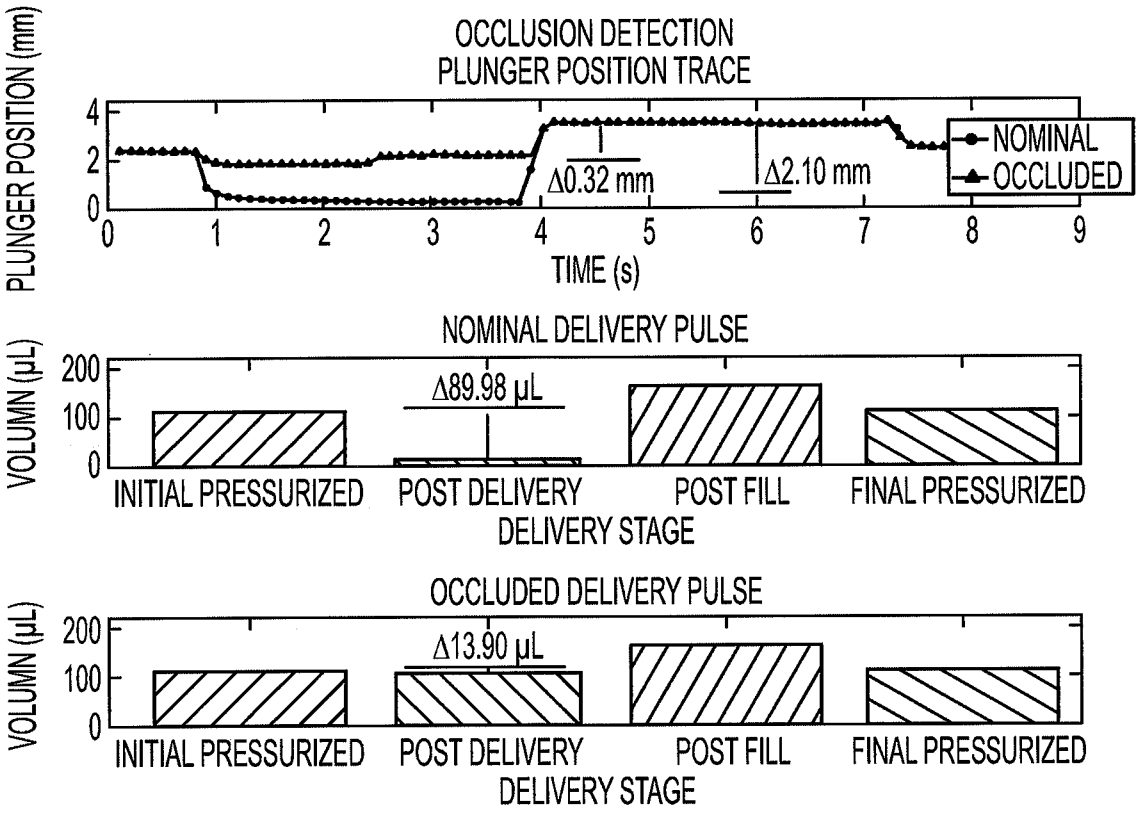

OCCLUSION DETECTION
PLUNGER POSITION TRACE
PLUNGER POSITION (mm)
4
2
0
0
1
2
3
4
5
6
7
8
9
TIME (s)
Δ0.32 mm
Δ2.10 mm
NOMINAL
OCCLUDED
NOMINAL DELIVERY PULSE
VOLUMN (µL)
200
100
0
Δ89.98 µL
INITIAL PRESSURIZED
POST DELIVERY
POST FILL
FINAL PRESSURIZED
DELIVERY STAGE
OCCLUDED DELIVERY PULSE
VOLUMN (µL)
200
100
0
Δ13.90 µL
INITIAL PRESSURIZED
POST DELIVERY
POST FILL
FINAL PRESSURIZED
DELIVERY STAGE

FIG. ~~170~~

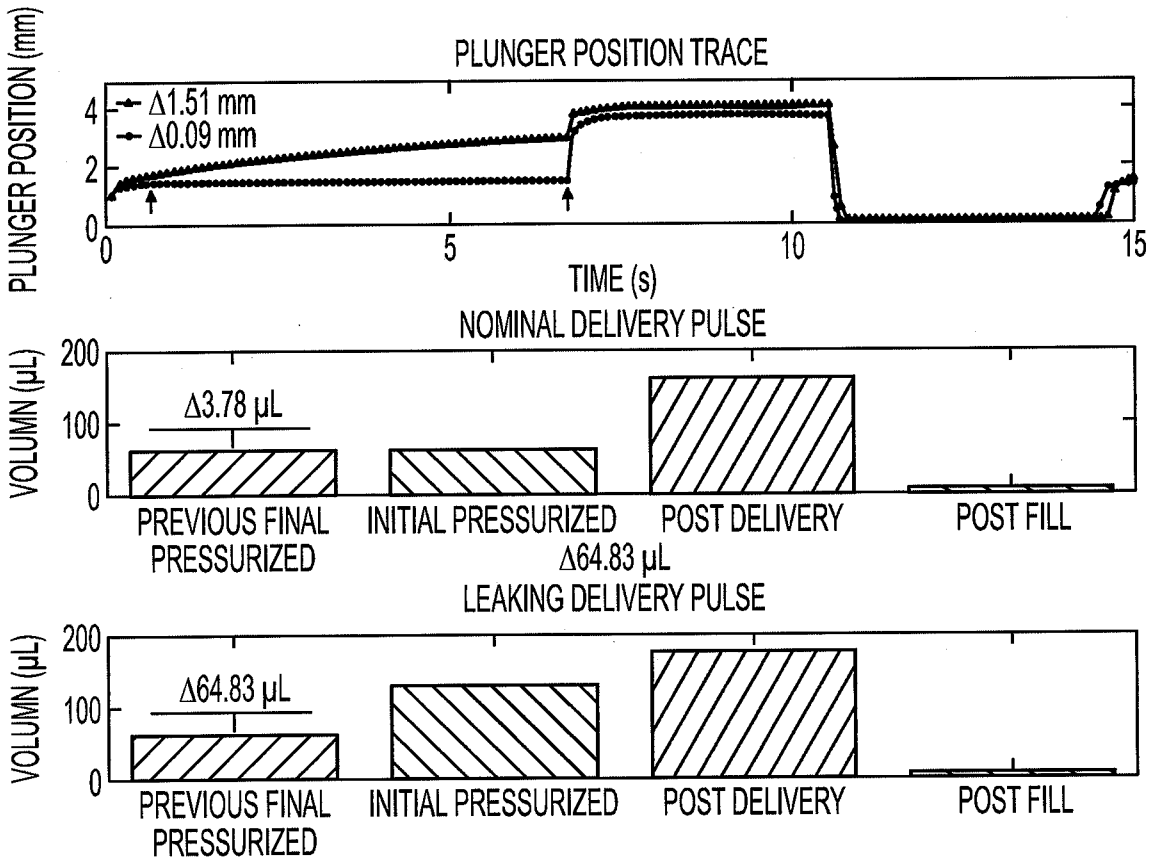

PLUNGER POSITION TRACE
PLUNGER POSITION (mm)
Δ1.51 mm
Δ0.09 mm
4
2
0
0
5
10
15
TIME (s)
NOMINAL DELIVERY PULSE
VOLUMN (μL)
200
100
0
Δ3.78 μL
PREVIOUS FINAL PRESSURIZED
INITIAL PRESSURIZED
POST DELIVERY
POST FILL
Δ64.83 μL
LEAKING DELIVERY PULSE
VOLUMN (μL)
200
100
0
Δ64.83 μL
PREVIOUS FINAL PRESSURIZED
INITIAL PRESSURIZED
POST DELIVERY
POST FILL

FIG. ~~171~~

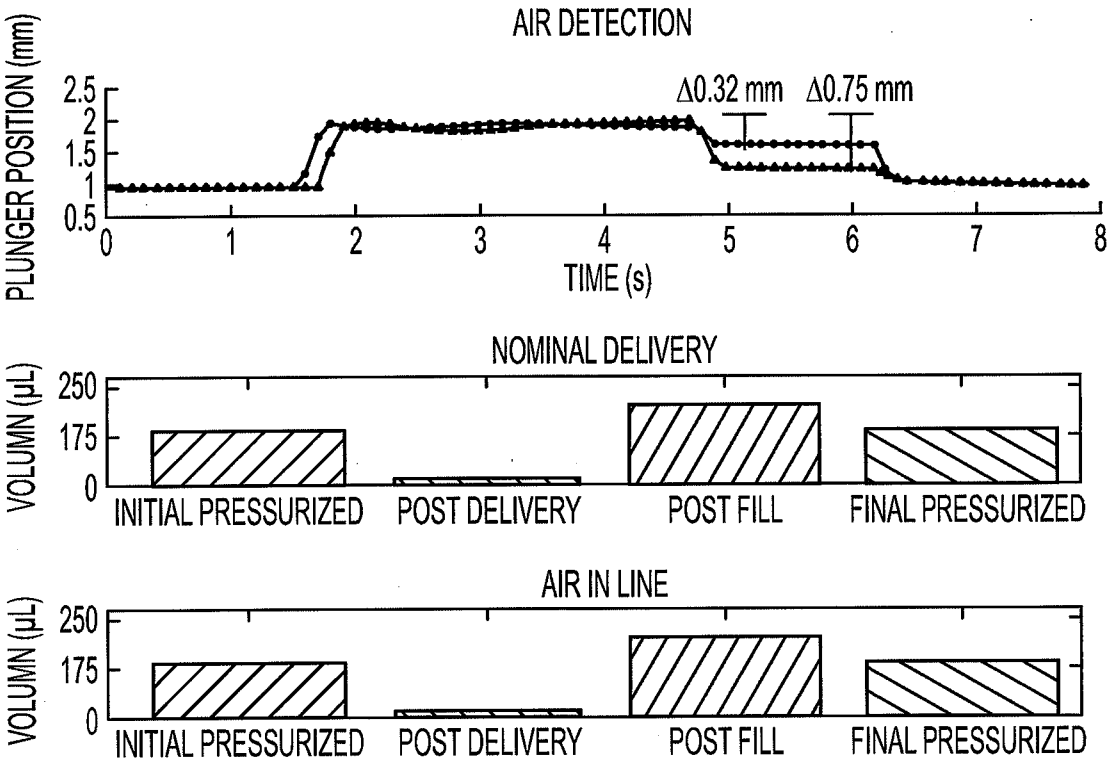

AIR DETECTION
PLUNGER POSITION (mm)
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
8
TIME (s)
Δ0.32 mm
Δ0.75 mm
NOMINAL DELIVERY
VOLUMN (µL)
250
175
0
INITIAL PRESSURIZED
POST DELIVERY
POST FILL
FINAL PRESSURIZED
AIR IN LINE
VOLUMN (µL)
250
175
0
INITIAL PRESSURIZED
POST DELIVERY
POST FILL
FINAL PRESSURIZED

FIG. ~~172~~

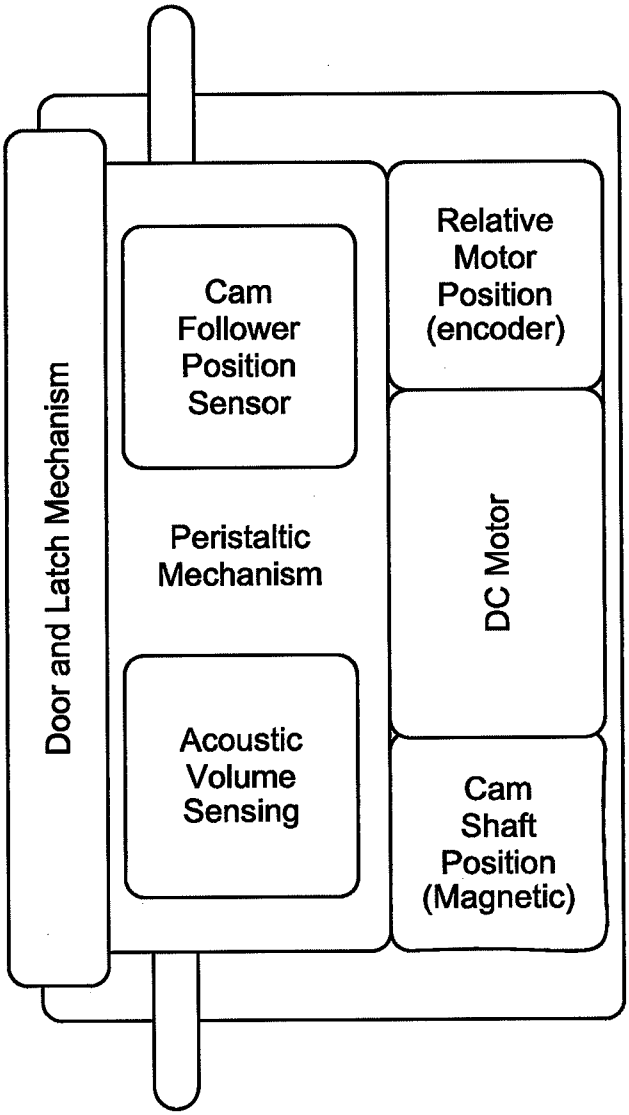

Door and Latch Mechanism
Cam Follower Position Sensor
Peristaltic Mechanism
Acoustic Volume Sensing
Relative Motor Position (encoder)
DC Motor
Cam Shaft Position (Magnetic)

Fig. ~~173~~

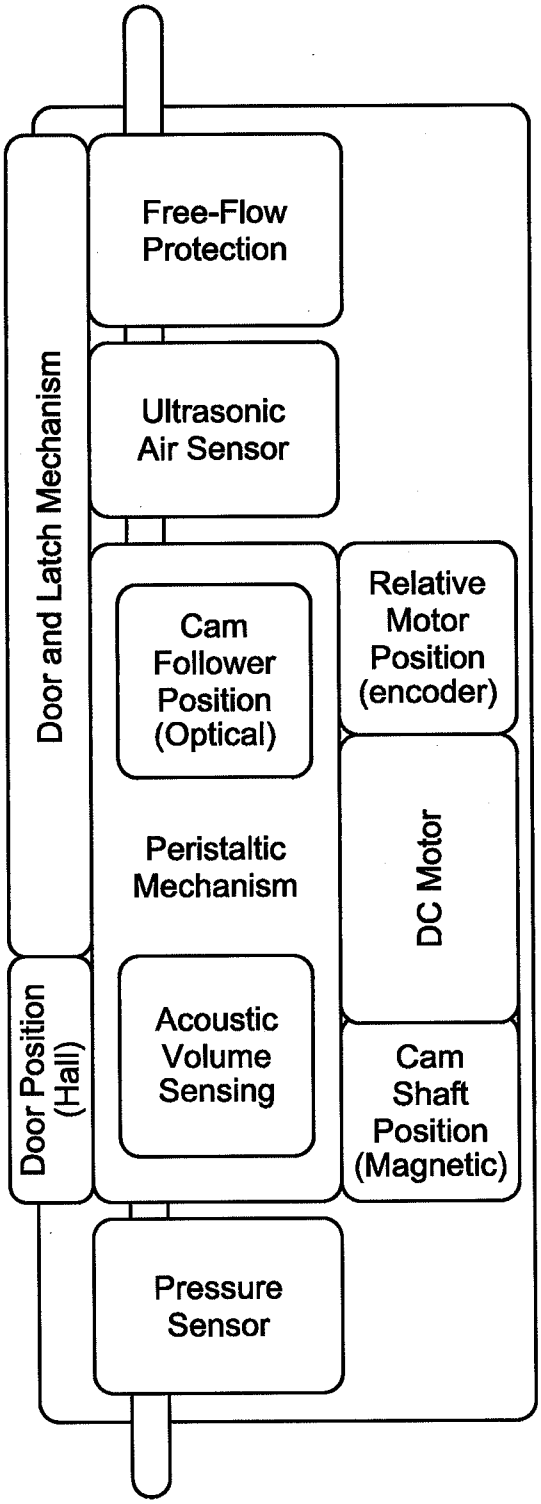

Free-Flow Protection
Ultrasonic Air Sensor
Door and Latch Mechanism
Cam Follower Position (Optical)
Relative Motor Position (encoder)
Peristaltic Mechanism
DC Motor
Door Position (Hall)
Acoustic Volume Sensing
Cam Shaft Position (Magnetic)
Pressure Sensor

Fig. ~~174~~

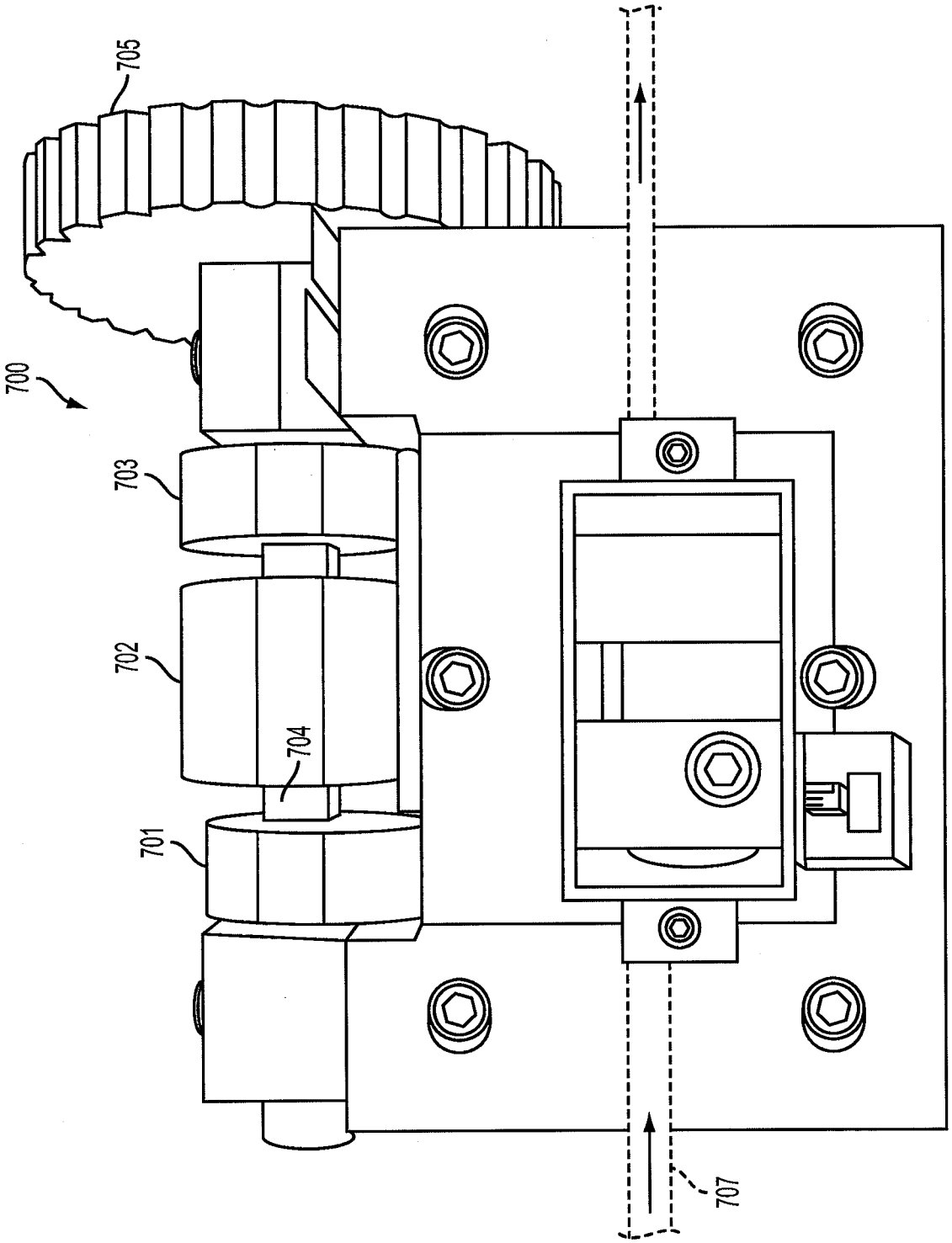


FIG. ~~175~~

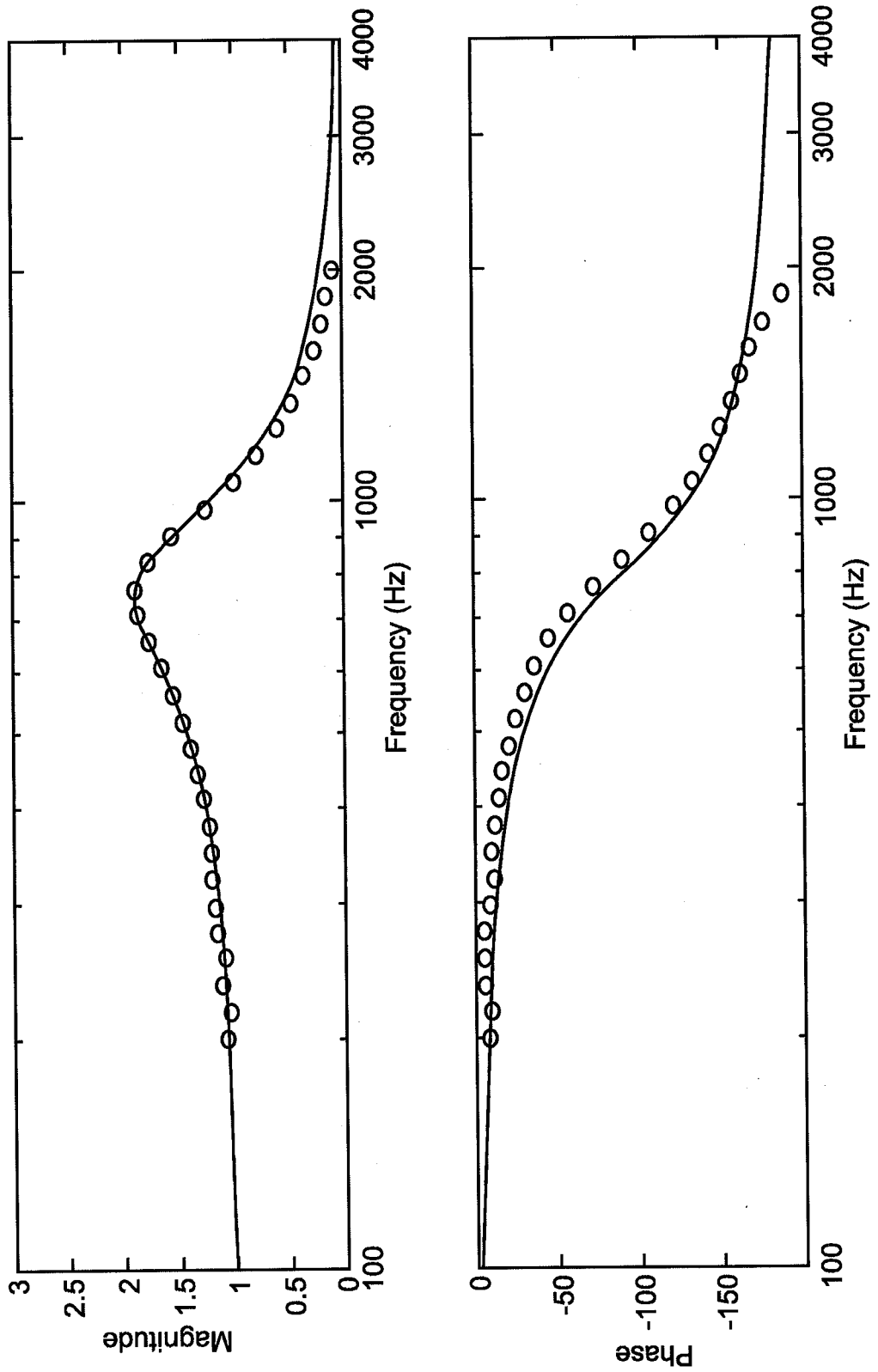

Magnitude
3
2.5
2
1.5
1
0.5
0
100
1000
2000
3000
4000
Frequency (Hz)
Phase
0
-50
-100
-150
100
1000
2000
3000
4000
Frequency (Hz)

Fig. ~~17C~~

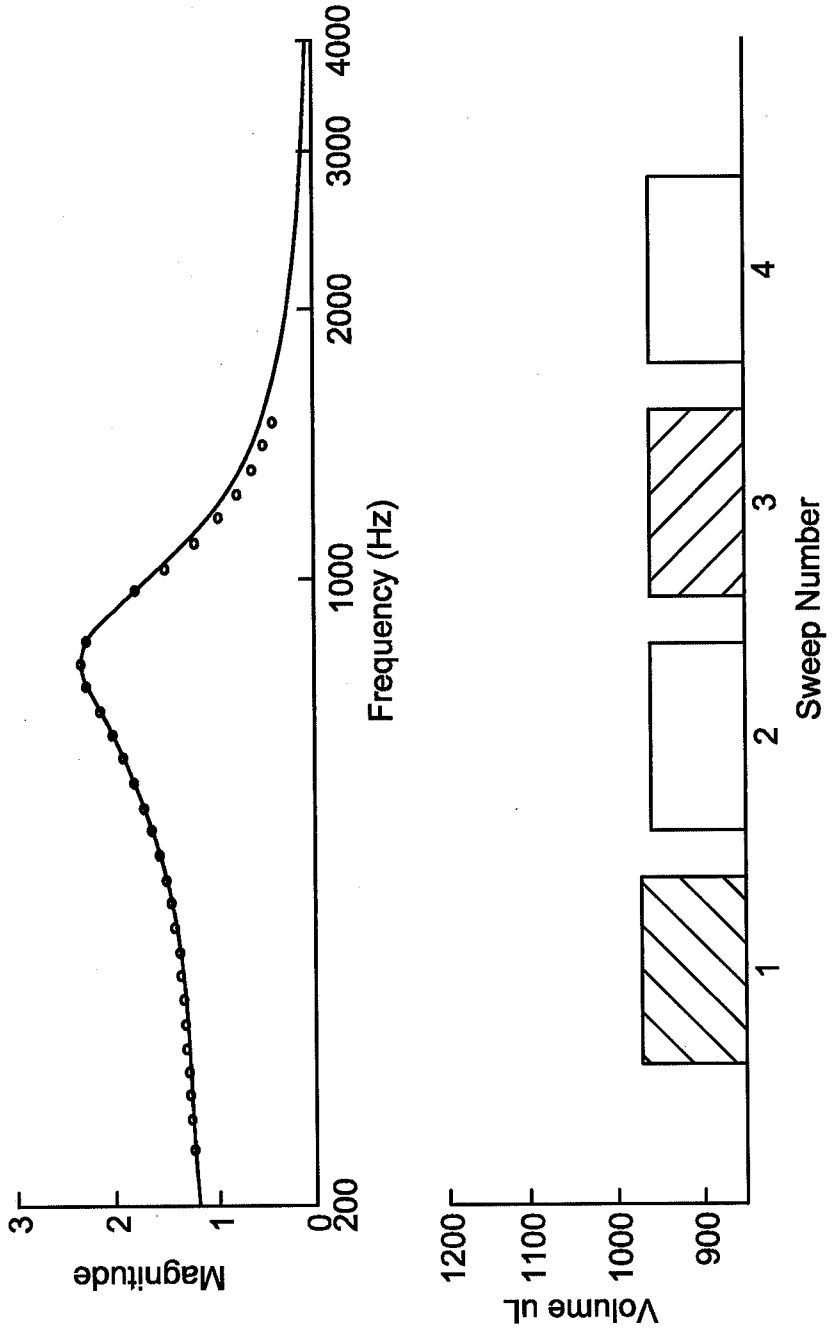

Magnitude
3
2
1
0
200
1000
2000
3000
4000
Frequency (Hz)
Volume uL
1200
1100
1000
900
1
2
3
4
Sweep Number

Fig. ~~17~~

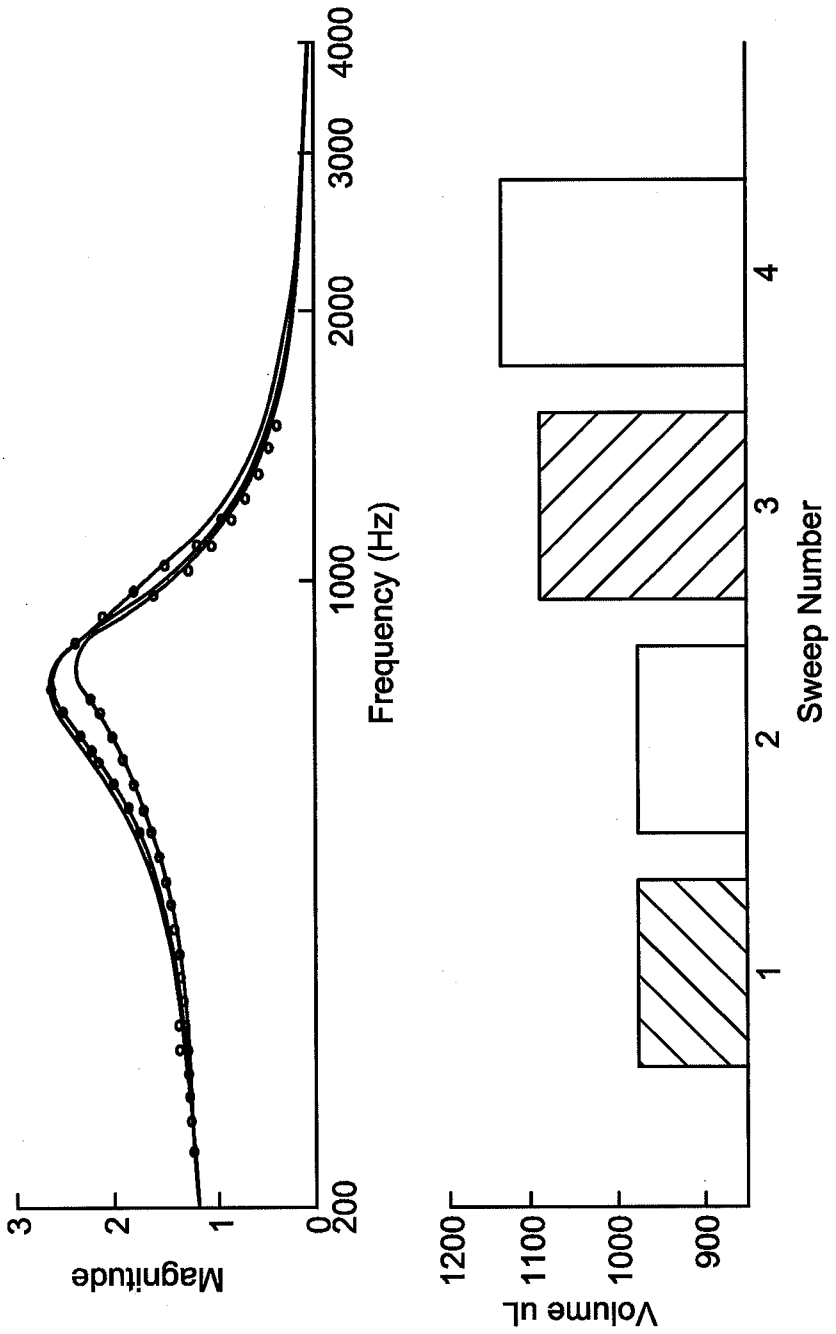

Magnitude
3
2
1
0
200
1000
2000
3000
4000
Frequency (Hz)
Volume uL
1200
1100
1000
900
1
2
3
4
Sweep Number

Fig. 178

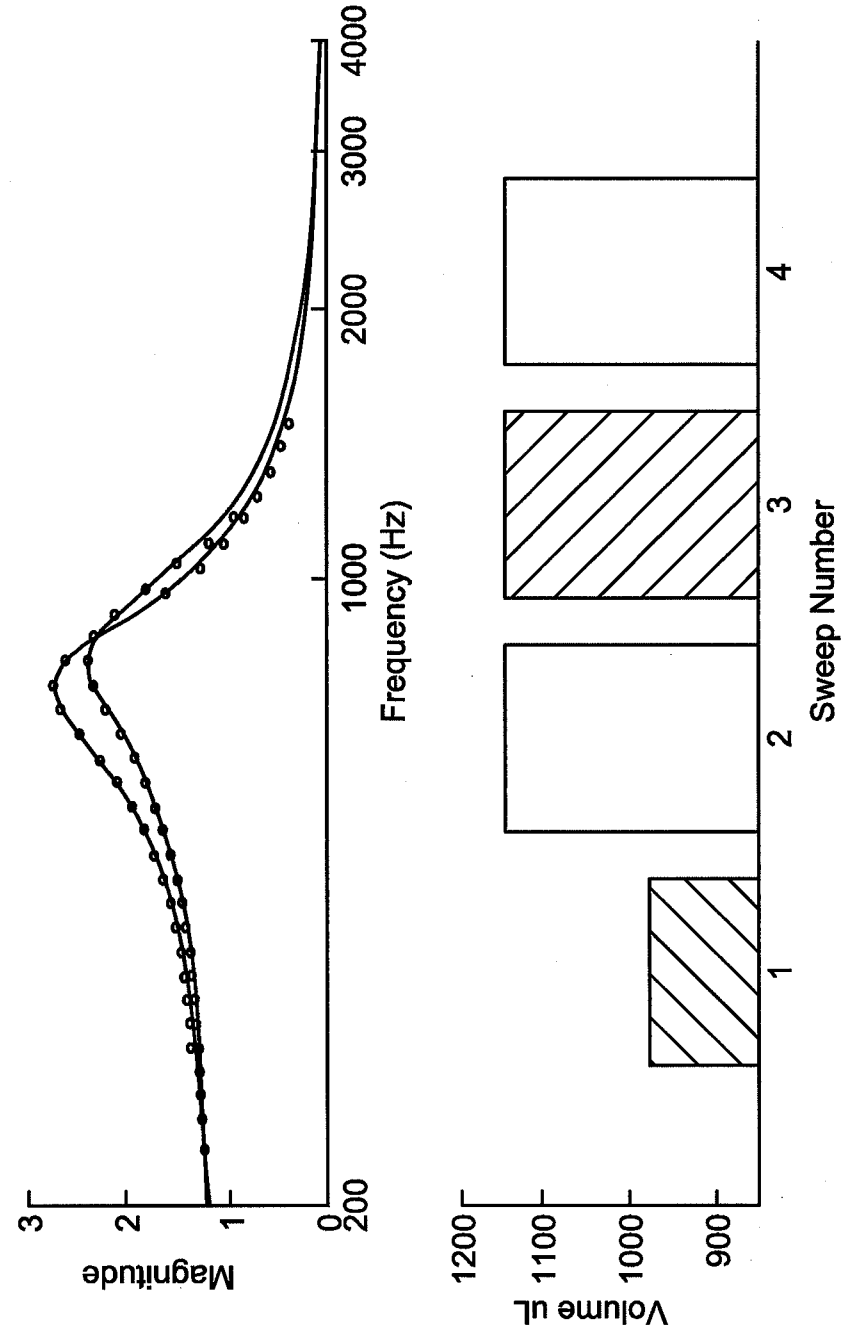

Magnitude
0
1
2
3
200
1000
2000
3000
4000
Frequency (Hz)
Volume uL
900
1000
1100
1200
1
2
3
4
Sweep Number

Fig. ~~17~~9

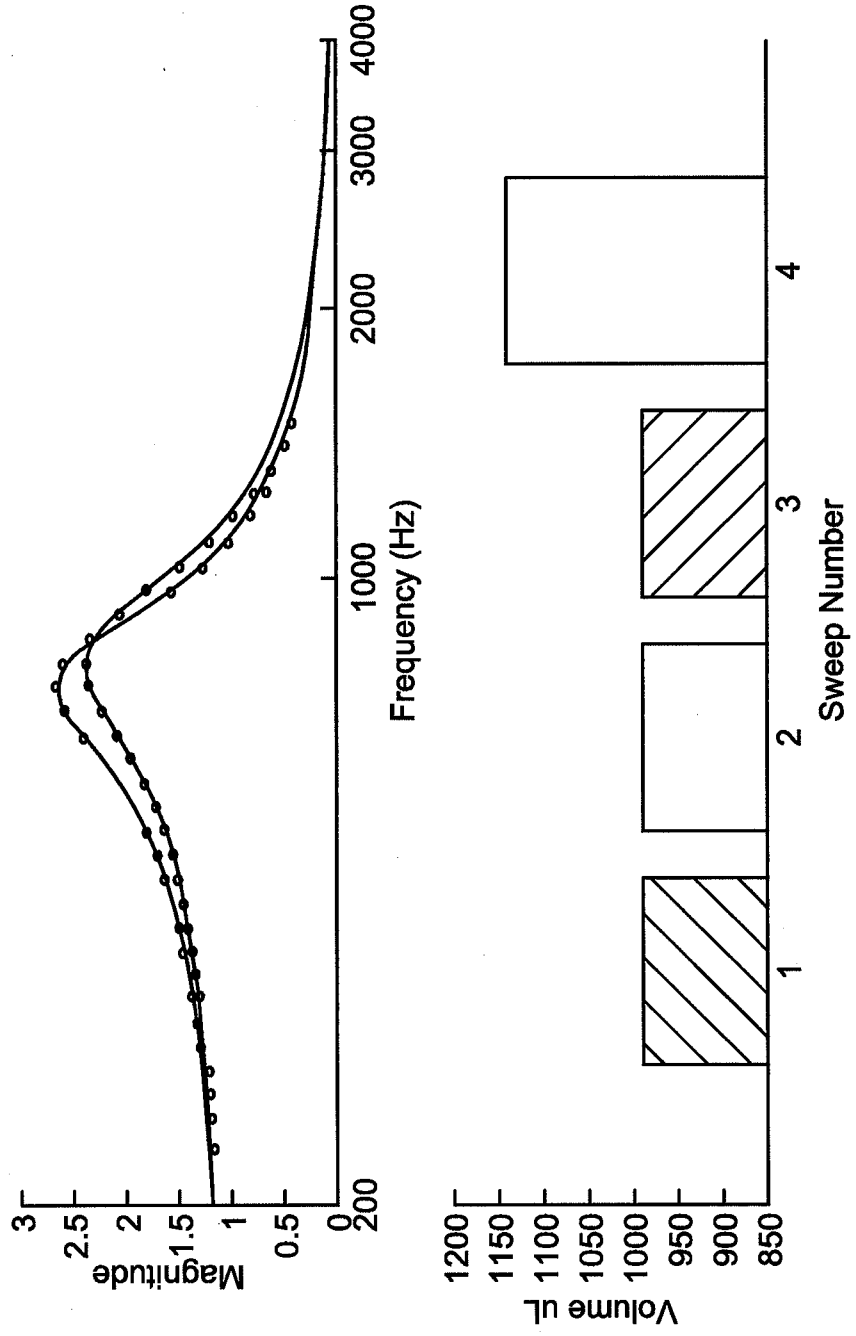

Magnitude
3
2.5
2
1.5
1
0.5
0
200
1000
2000
3000
4000
Frequency (Hz)
Volume uL
1200
1150
1100
1050
1000
950
900
850
1
2
3
4
Sweep Number

Fig. ~~48C~~

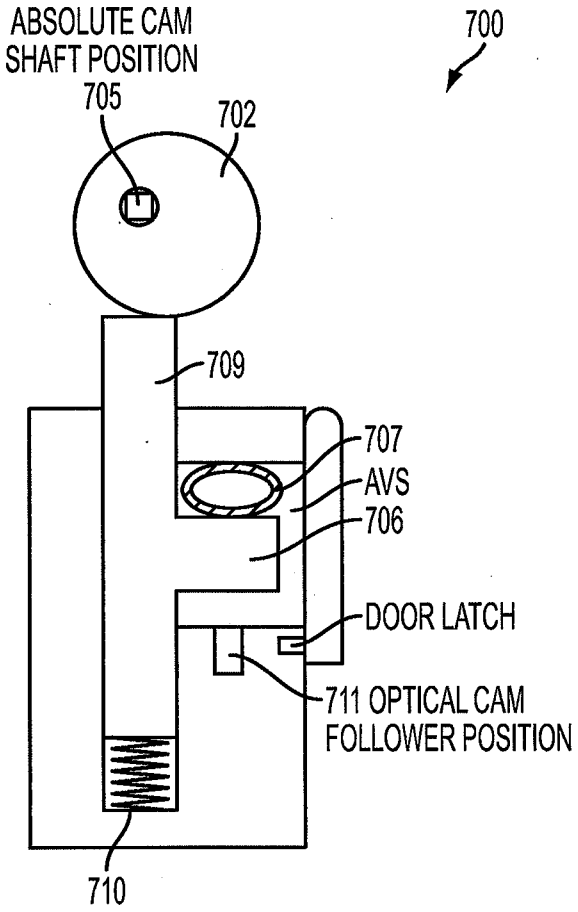

ABSOLUTE CAM
SHAFT POSITION
705
702
700
709
707
AVS
706
DOOR LATCH
711 OPTICAL CAM
FOLLOWER POSITION
710

FIG. ~~181~~

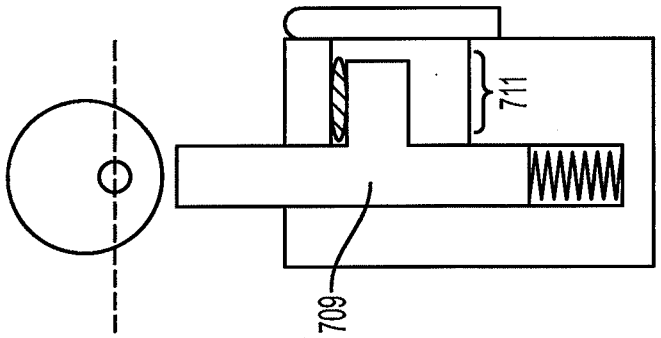


FIG. ~~182C~~

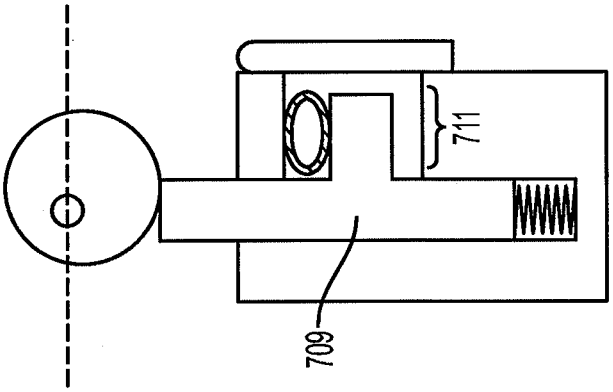


FIG. ~~182B~~

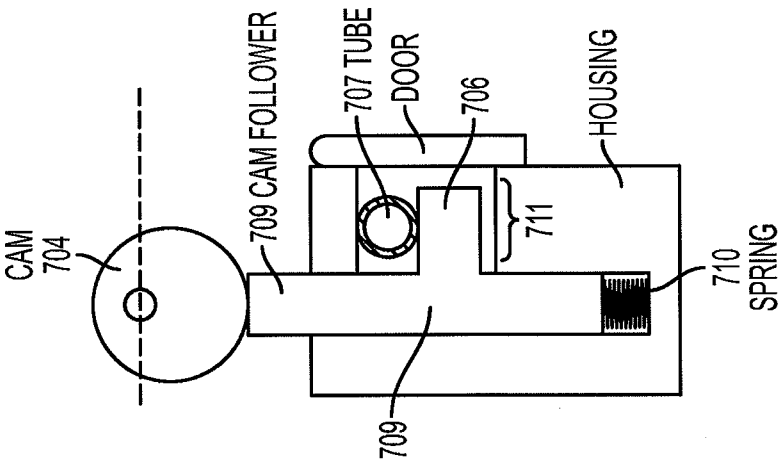


FIG. ~~182A~~

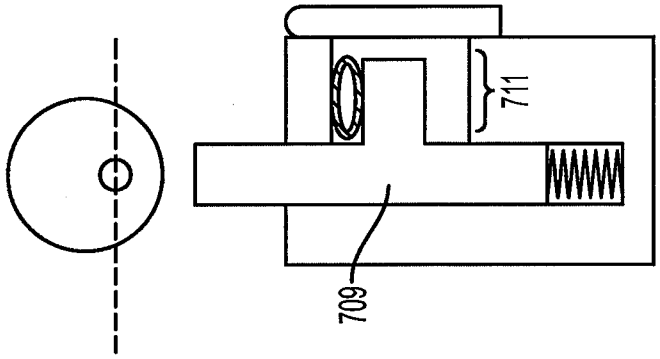


FIG. 183C

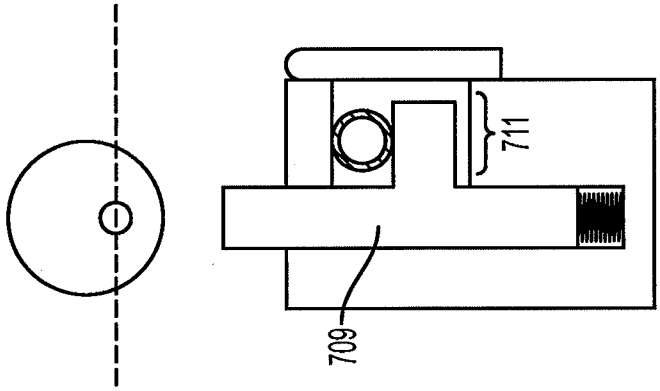


FIG. 183B

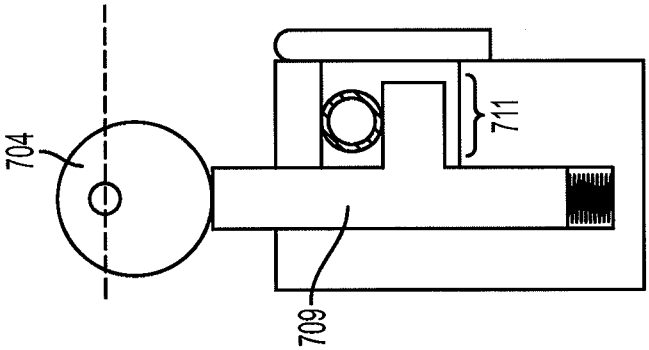


FIG. 183A

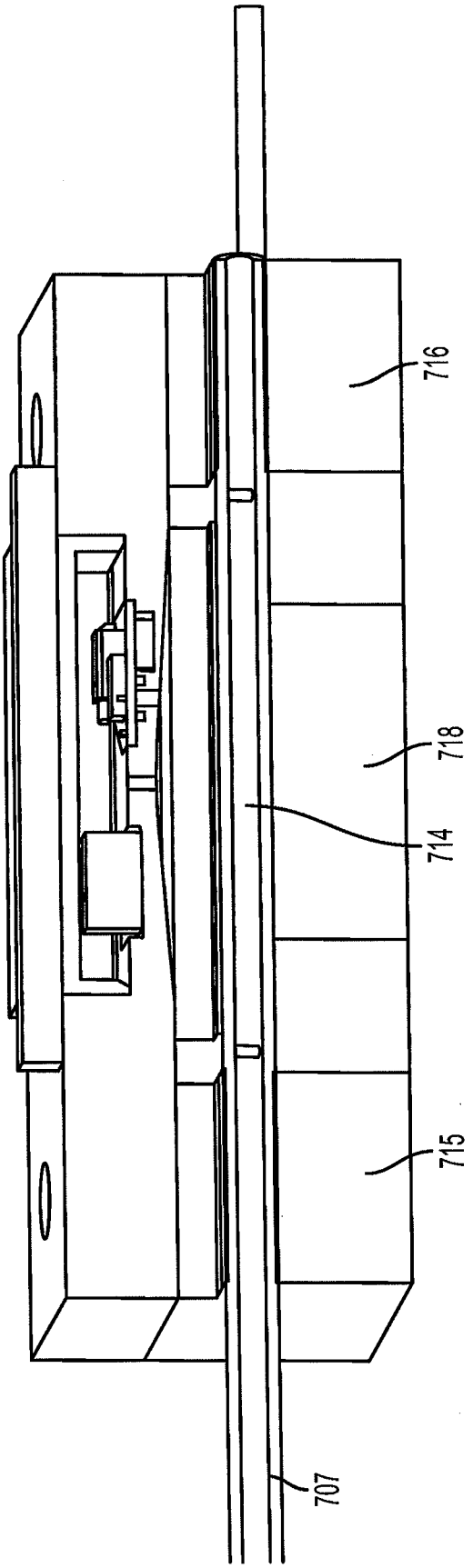


FIG. ~~184~~

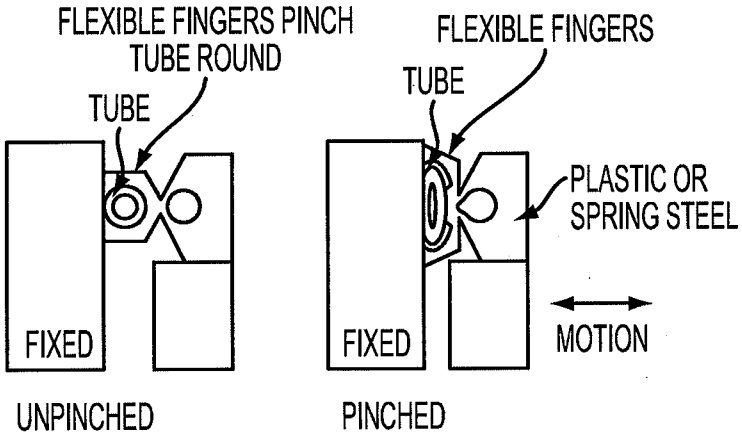

FLEXIBLE FINGERS PINCH TUBE ROUND
TUBE
FIXED
UNPINCHED
FLEXIBLE FINGERS
TUBE
PLASTIC OR SPRING STEEL
FIXED
MOTION
PINCHED

FIG. ~~185~~

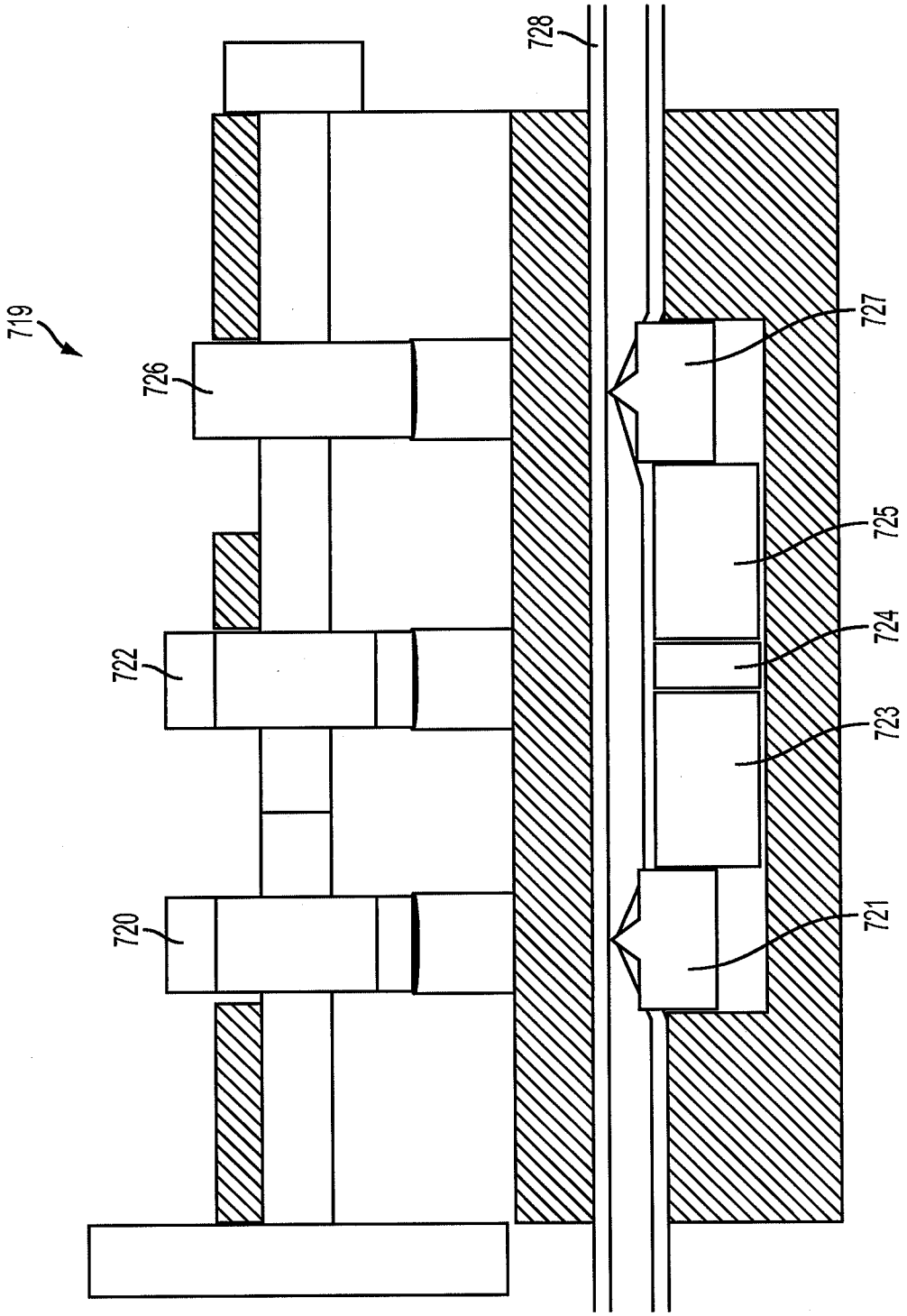


FIG. ~~186~~

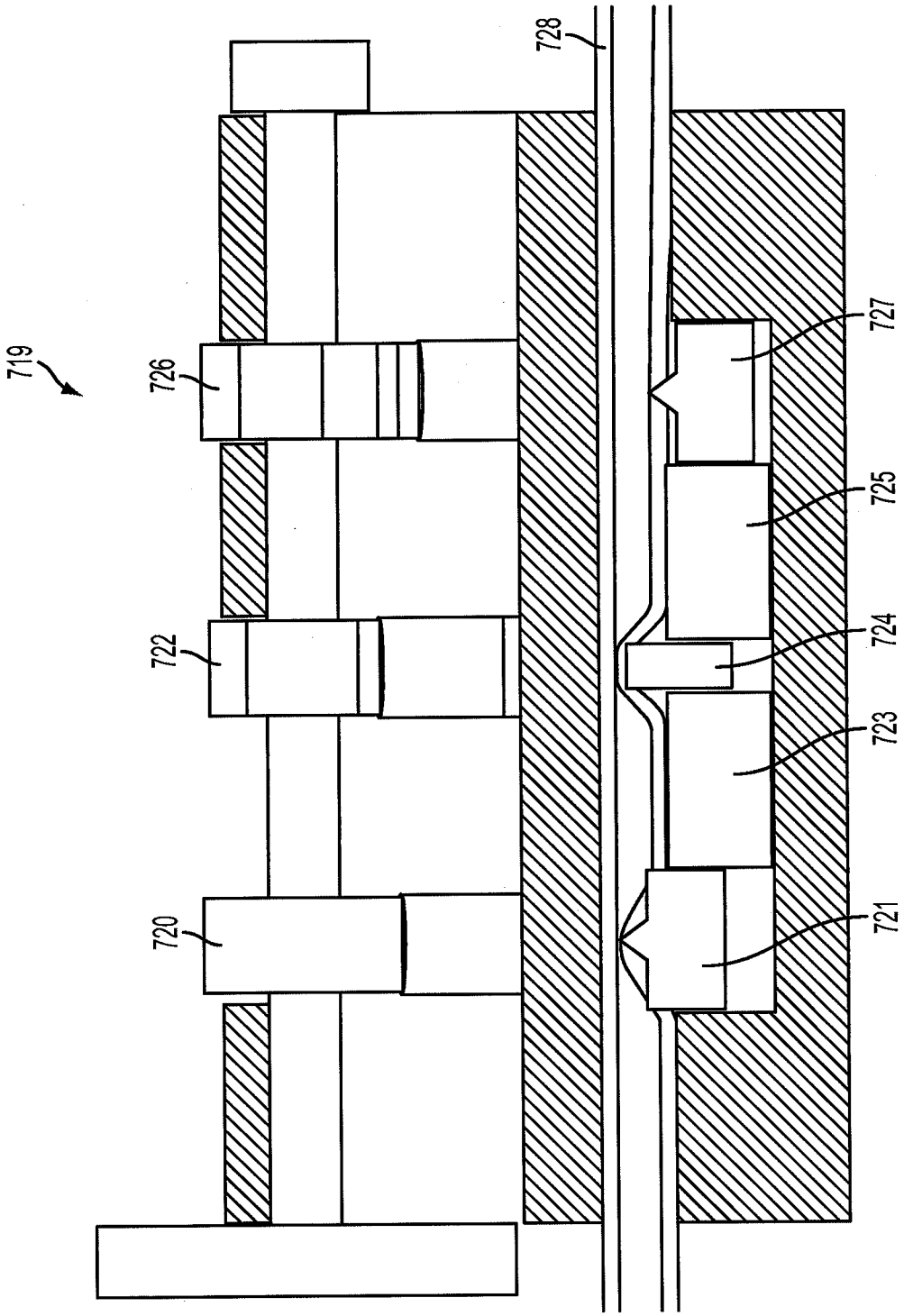


FIG. ~~187~~

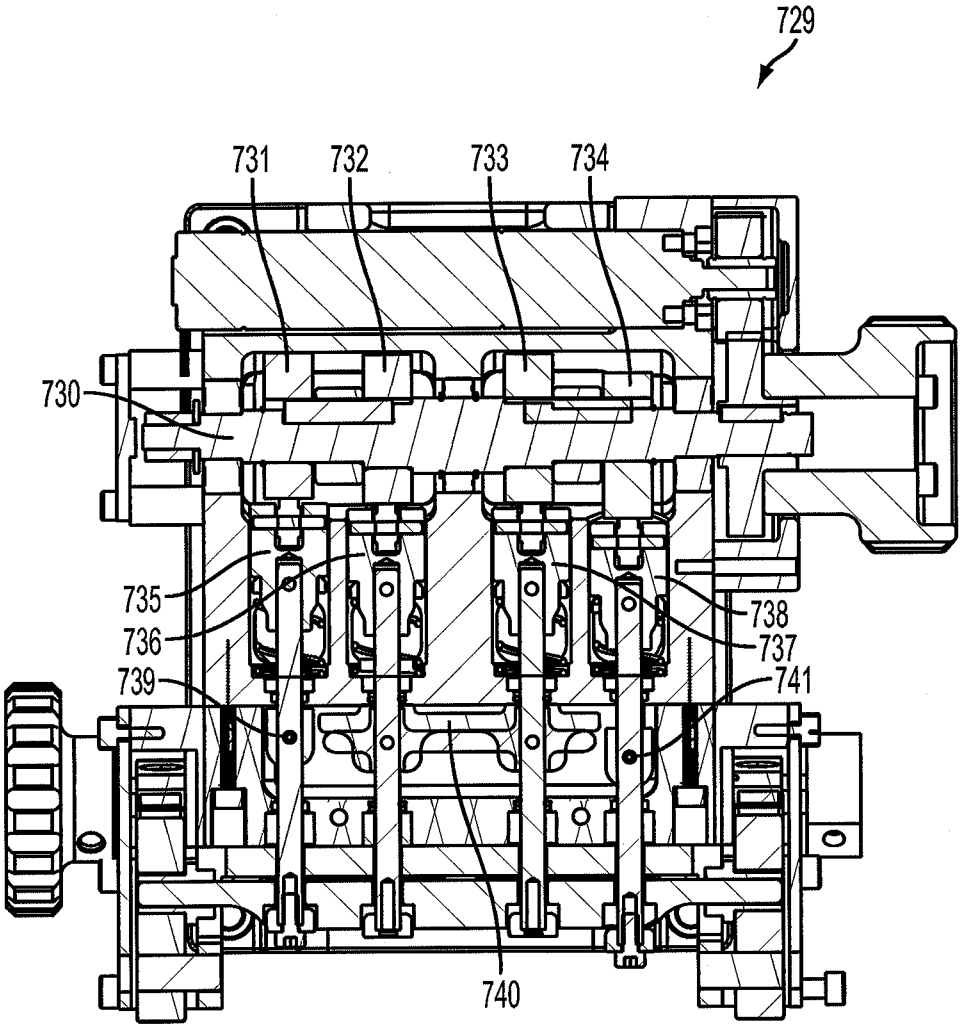


FIG. ~~188~~

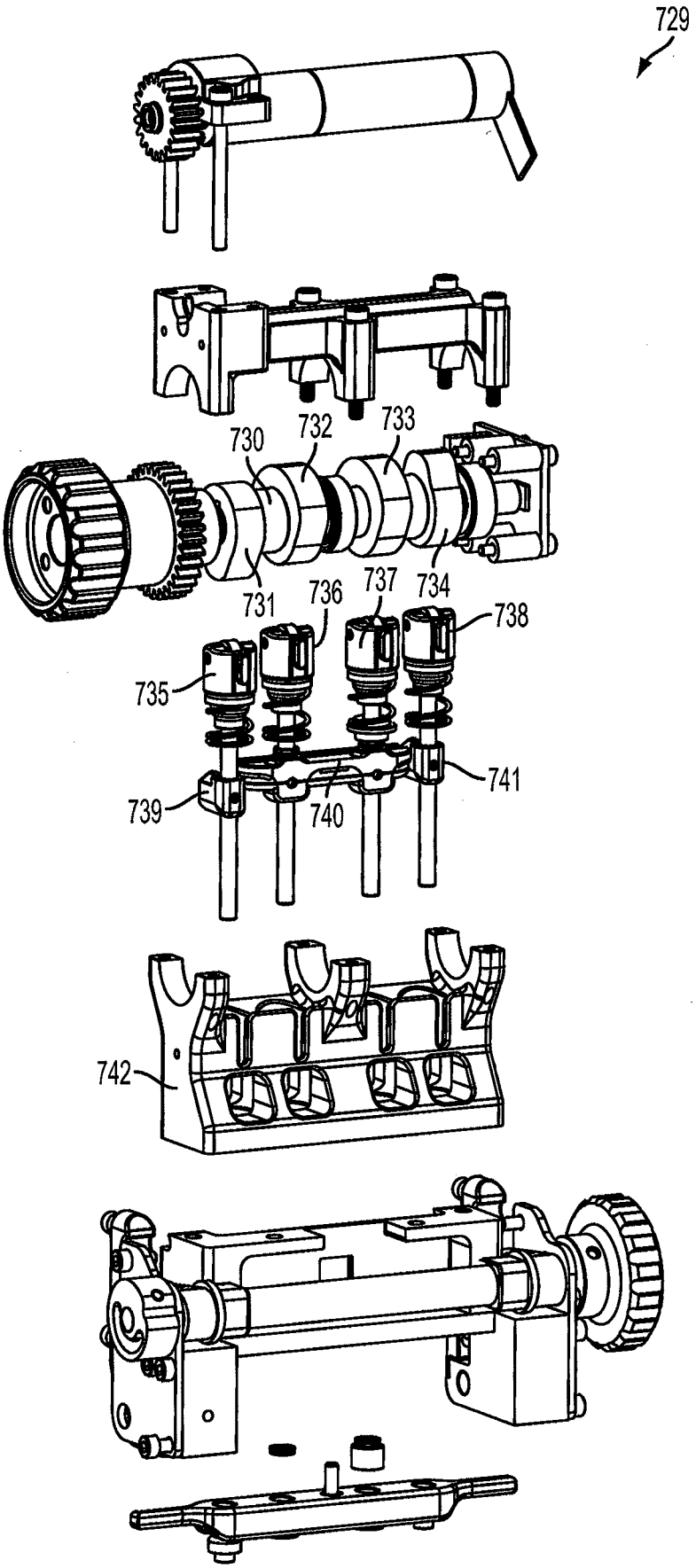


FIG. ~~189~~

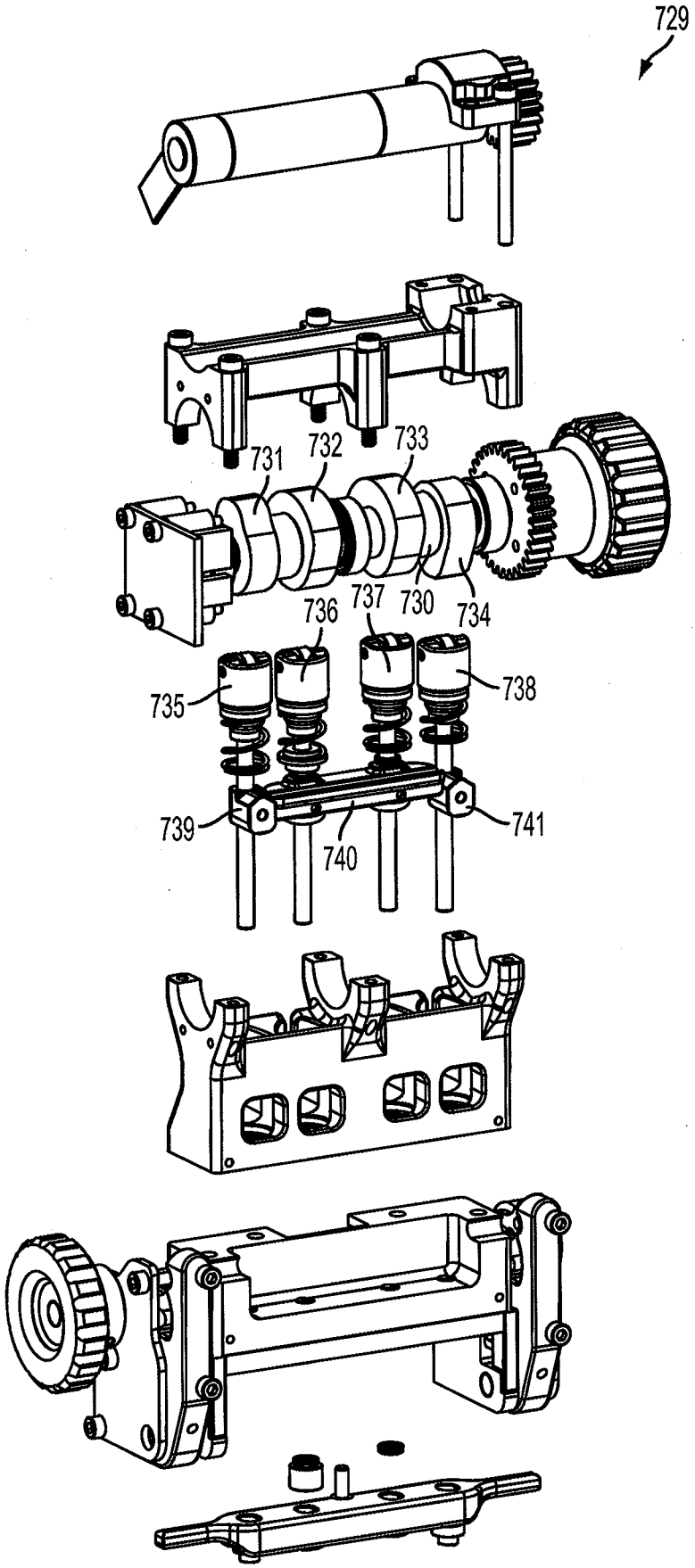


FIG. ~~190A~~

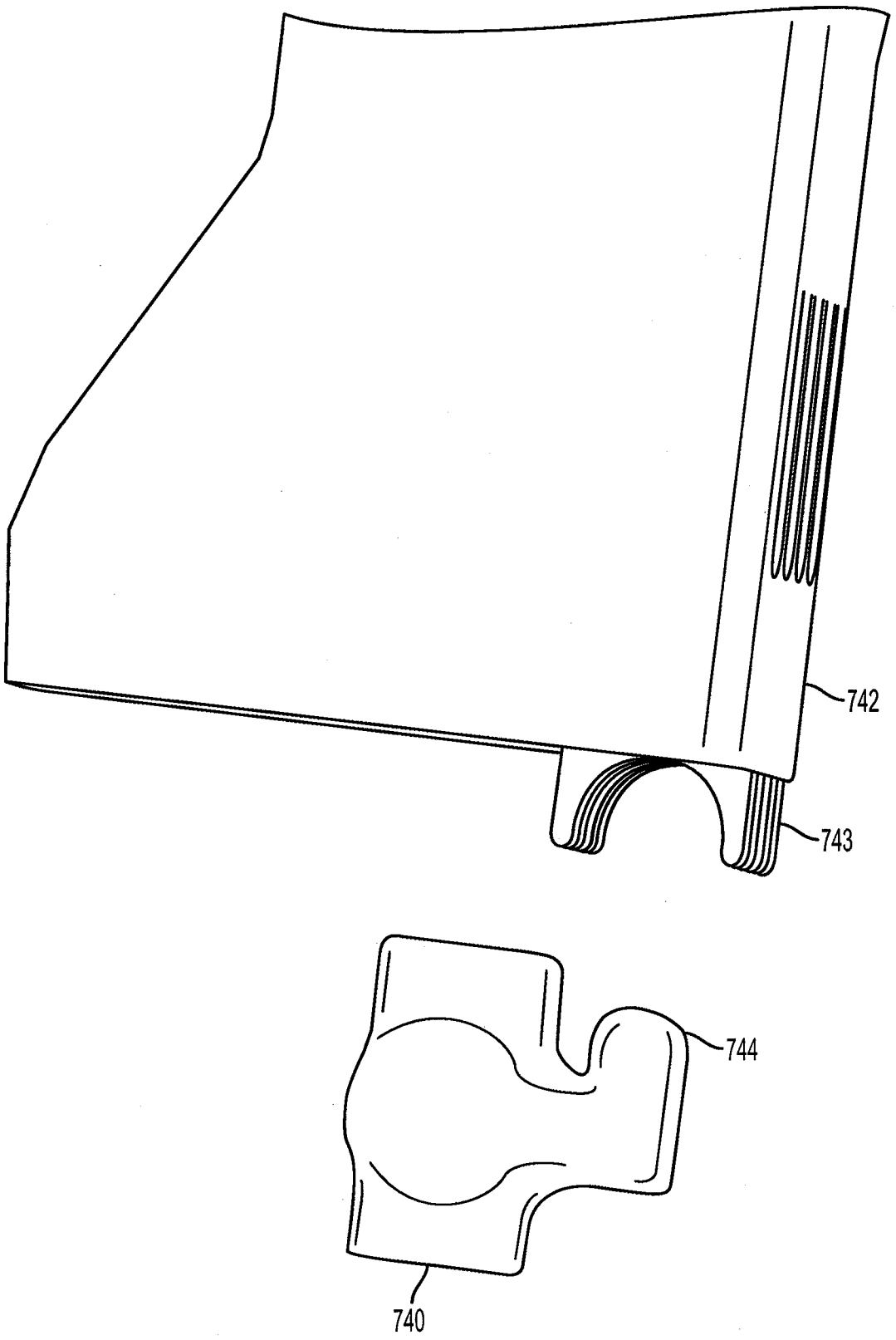


FIG. ~~190B~~

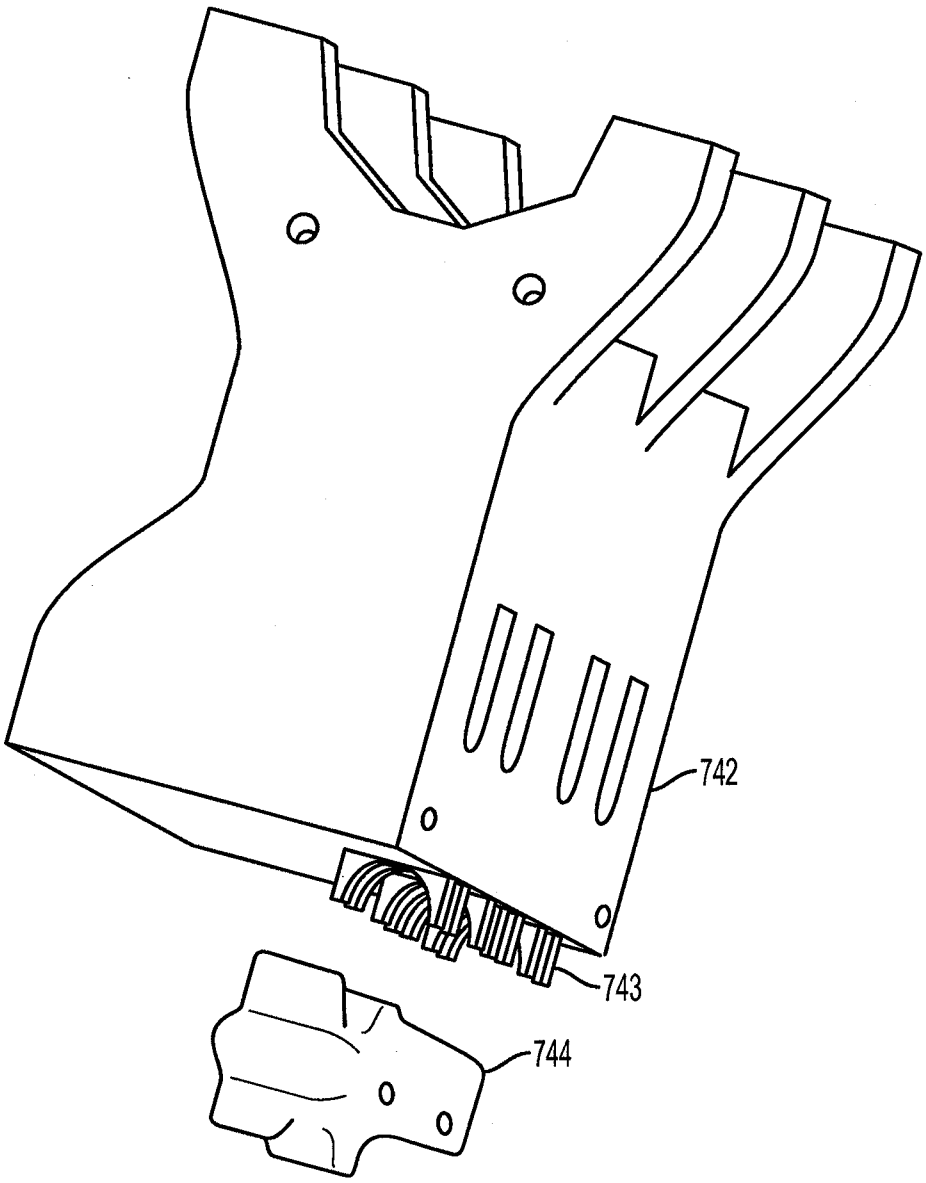


FIG. ~~190C~~

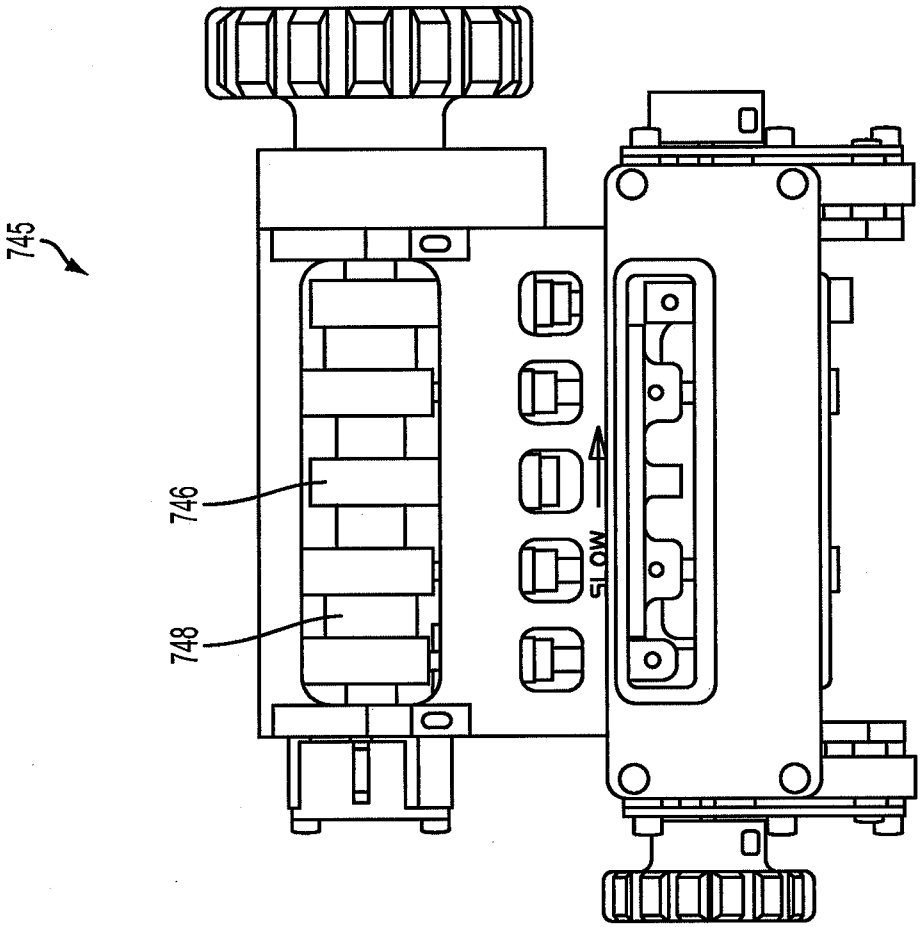


FIG. ~~192~~

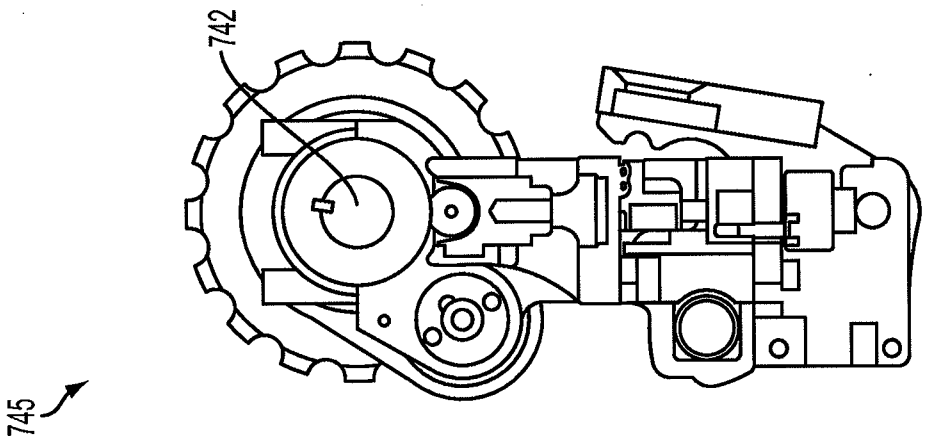


FIG. ~~191~~

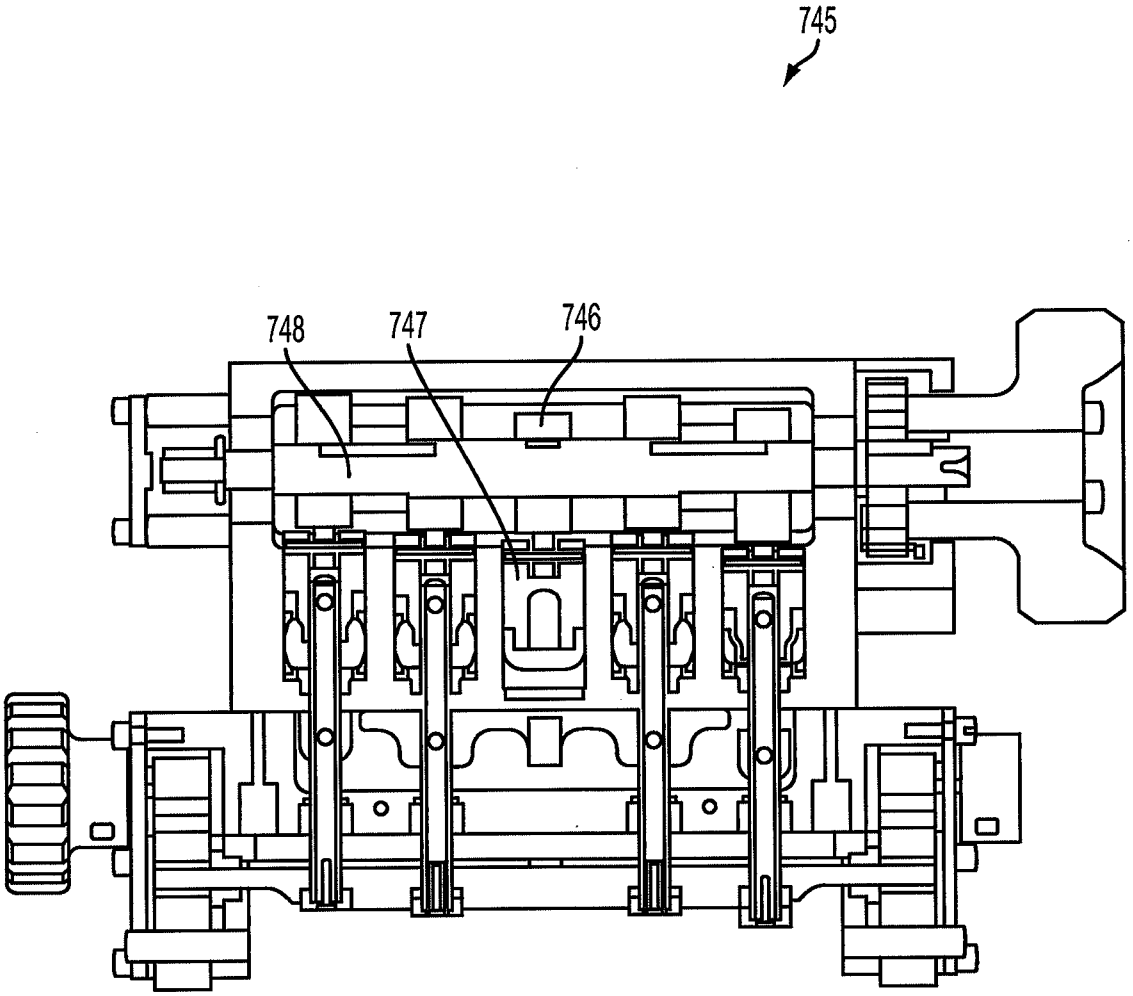


FIG. ~~193~~

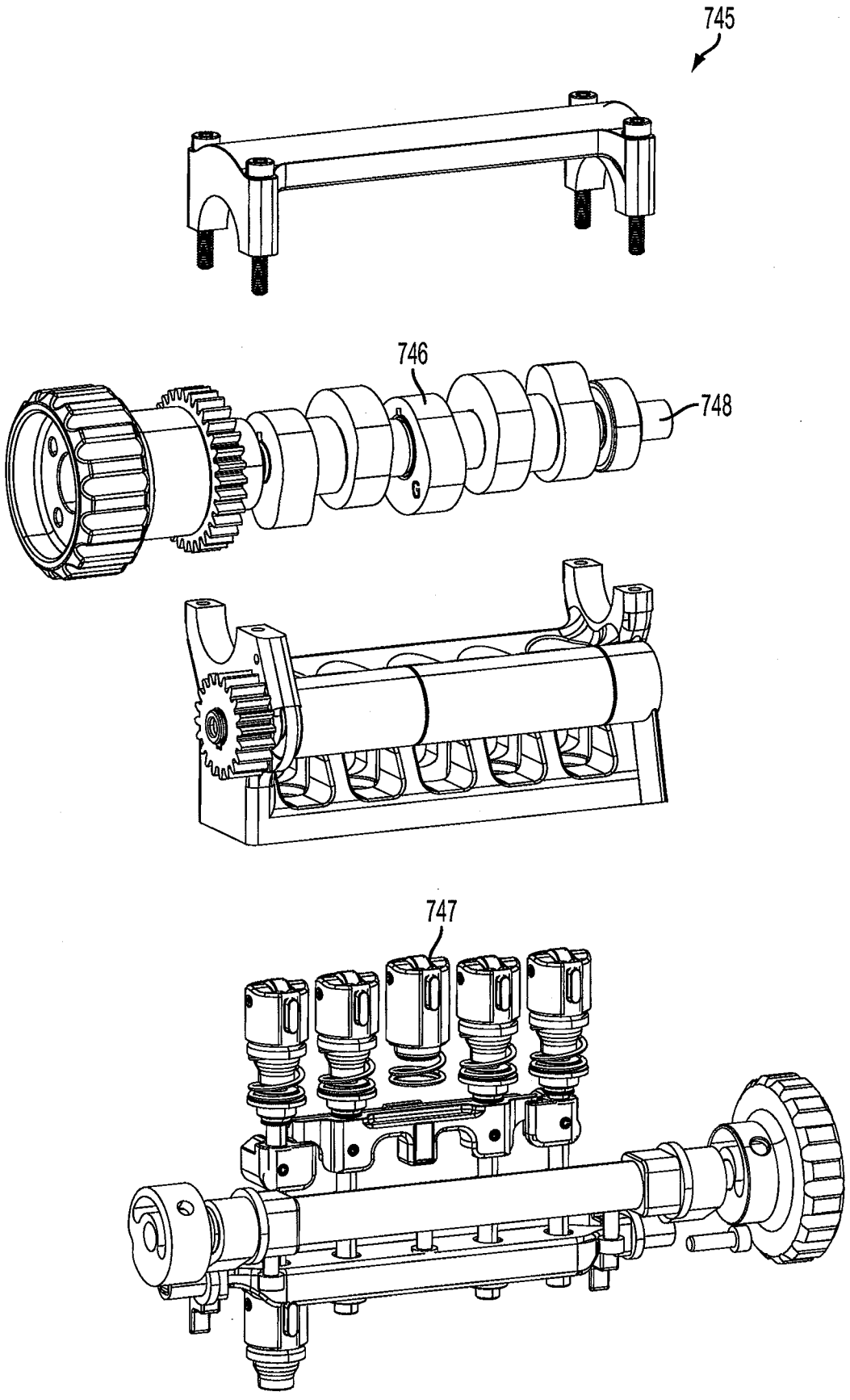


FIG. ~~194~~

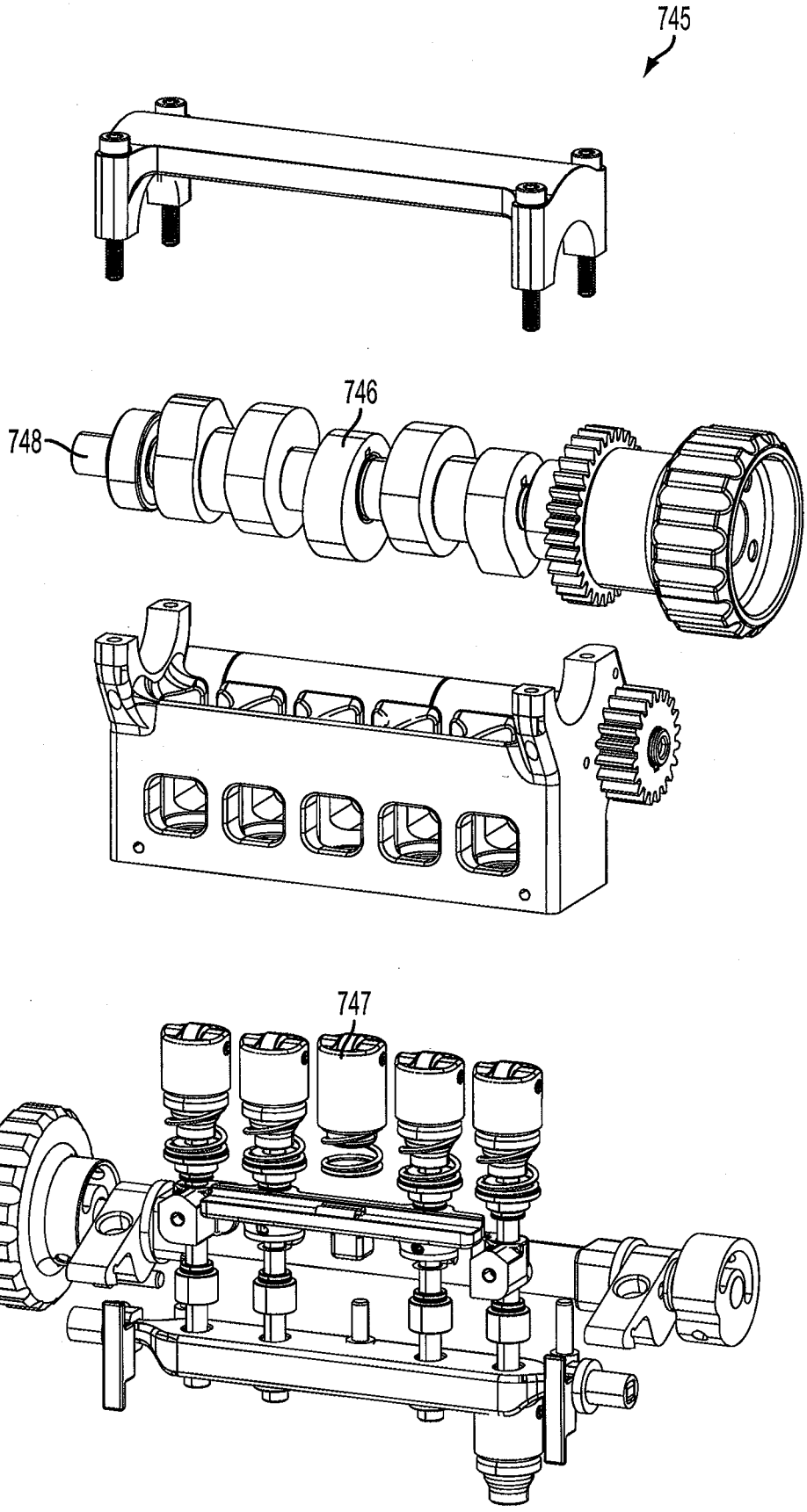


FIG. ~~195~~

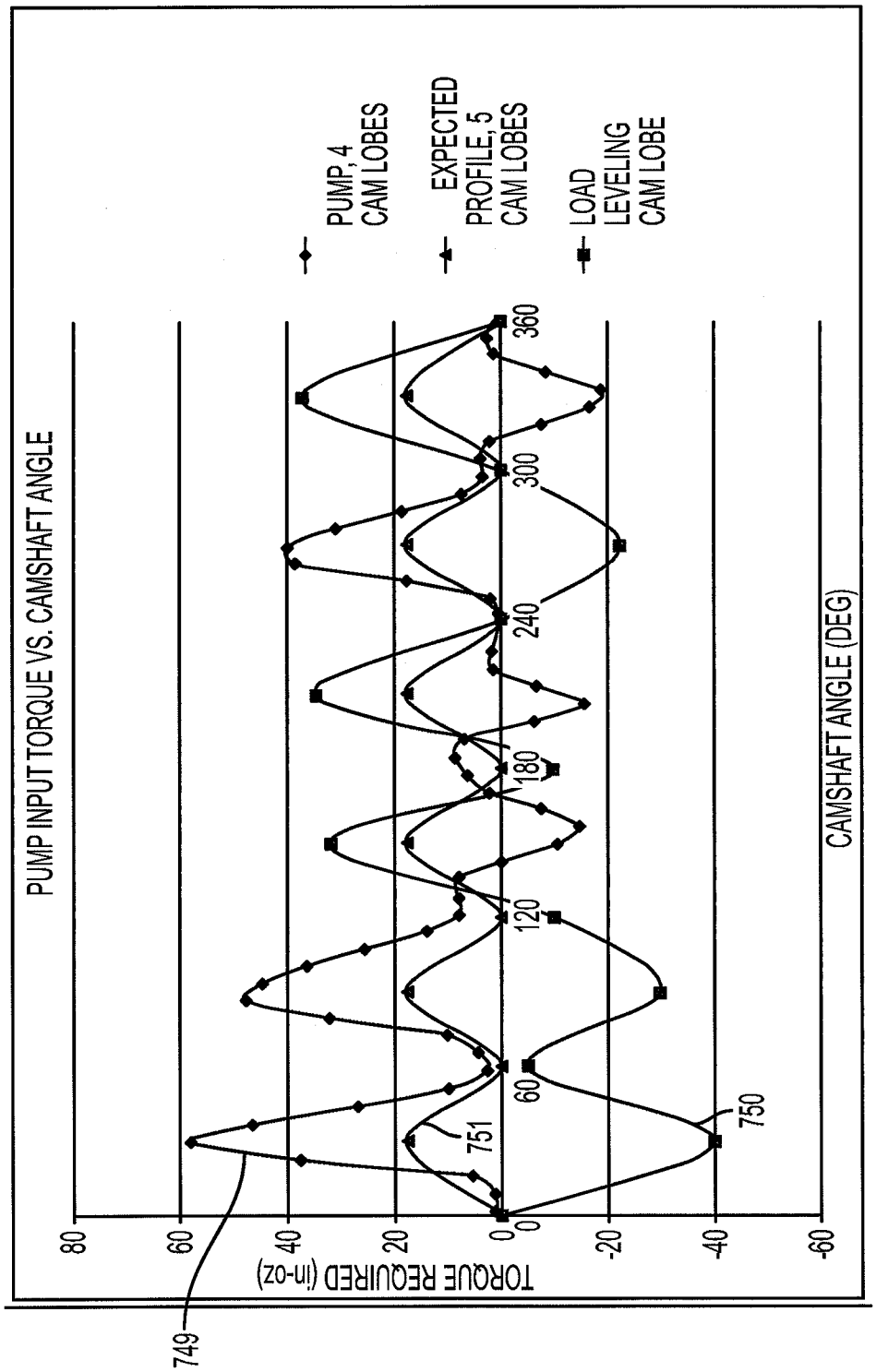

PUMP INPUT TORQUE VS. CAMSHAFT ANGLE
PUMP, 4 CAM LOBES
EXPECTED PROFILE, 5 CAM LOBES
LOAD LEVELING CAM LOBE
TORQUE REQUIRED (in-oz)
CAMSHAFT ANGLE (DEG)
80
60
40
20
0
-20
-40
-60
0
60
120
180
240
300
360
749
750
751

FIG. 196A

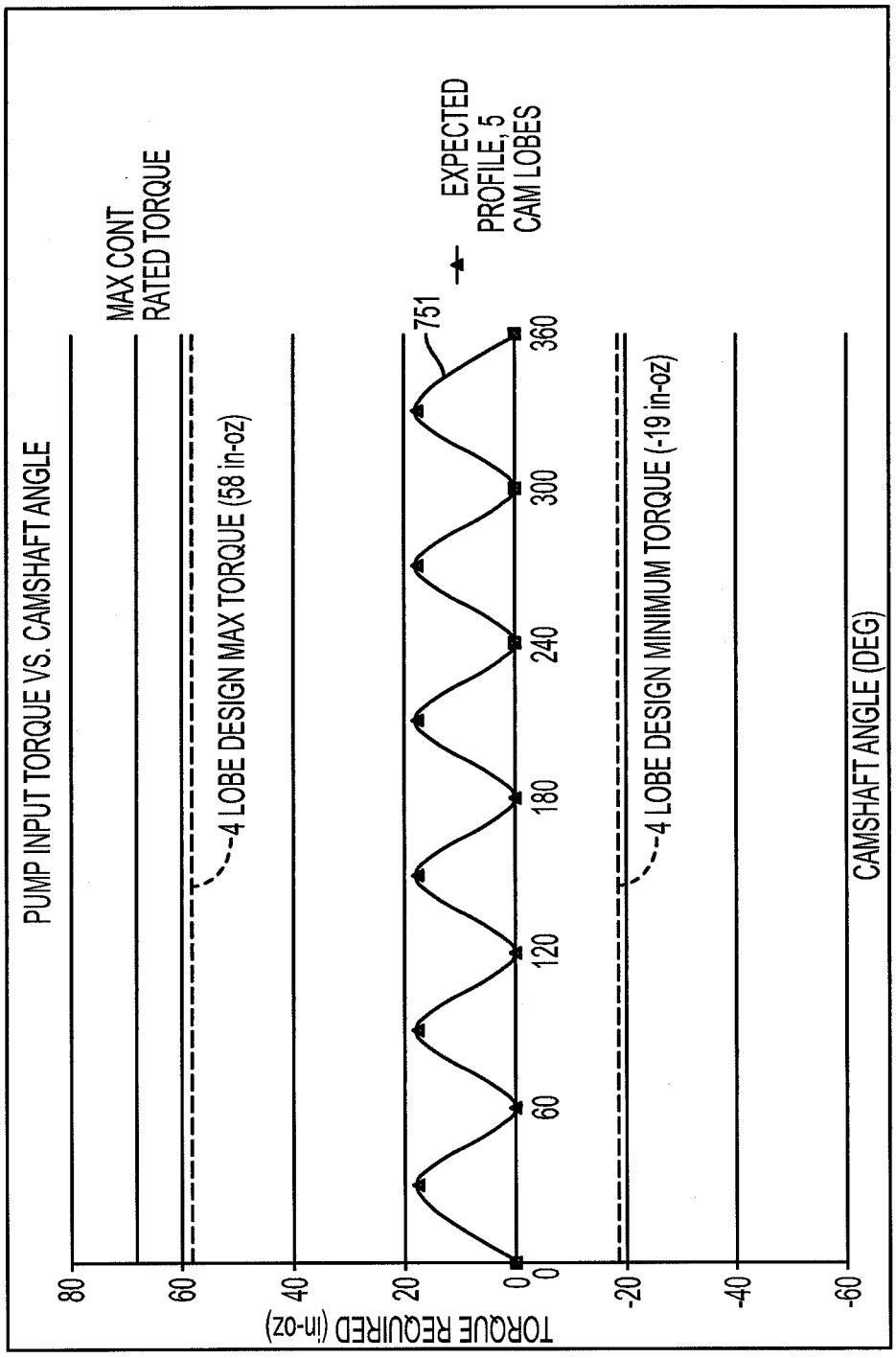

PUMP INPUT TORQUE VS. CAMSHAFT ANGLE
MAX CONT RATED TORQUE
4 LOBE DESIGN MAX TORQUE (58 in-oz)
EXPECTED PROFILE, 5 CAM LOBES
751
4 LOBE DESIGN MINIMUM TORQUE (-19 in-oz)
CAMSHAFT ANGLE (DEG)
TORQUE REQUIRED (in-oz)
80
60
40
20
0
-20
-40
-60
0
60
120
180
240
300
360

FIG. 19B

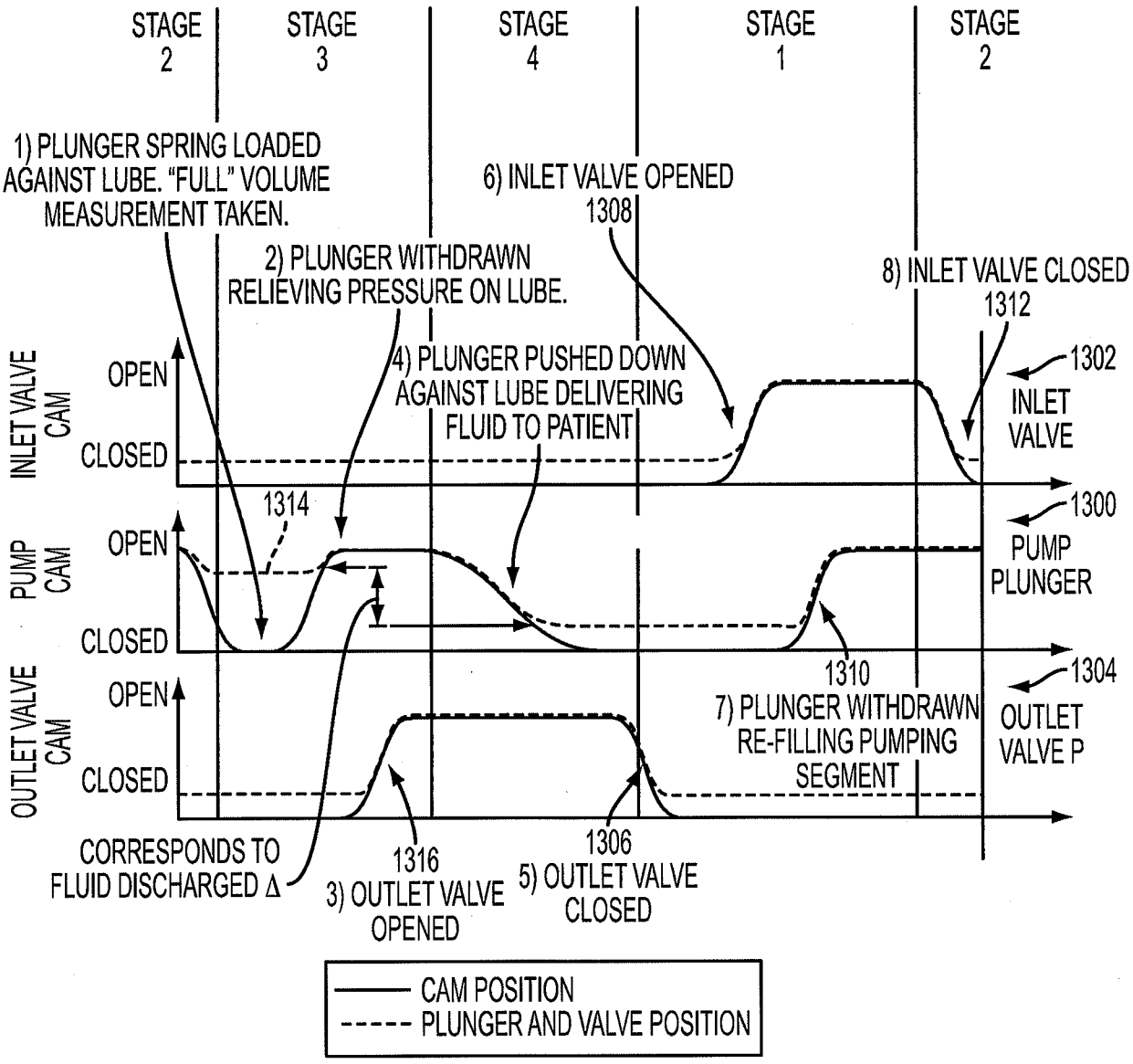

STAGE 2
STAGE 3
STAGE 4
STAGE 1
STAGE 2
1) PLUNGER SPRING LOADED AGAINST LUBE. "FULL" VOLUME MEASUREMENT TAKEN.
2) PLUNGER WITHDRAWN RELIEVING PRESSURE ON LUBE.
4) PLUNGER PUSHED DOWN AGAINST LUBE DELIVERING FLUID TO PATIENT
6) INLET VALVE OPENED
1308
8) INLET VALVE CLOSED
1312
1302
INLET VALVE
INLET VALVE CAM
OPEN
CLOSED
1314
1300
PUMP PLUNGER
PUMP CAM
OPEN
CLOSED
1310
7) PLUNGER WITHDRAWN RE-FILLING PUMPING SEGMENT
1304
OUTLET VALVE P
OUTLET VALVE CAM
OPEN
CLOSED
CORRESPONDS TO FLUID DISCHARGED Δ
1316
3) OUTLET VALVE OPENED
1306
5) OUTLET VALVE CLOSED
CAM POSITION
PLUNGER AND VALVE POSITION

FIG. ~~197~~

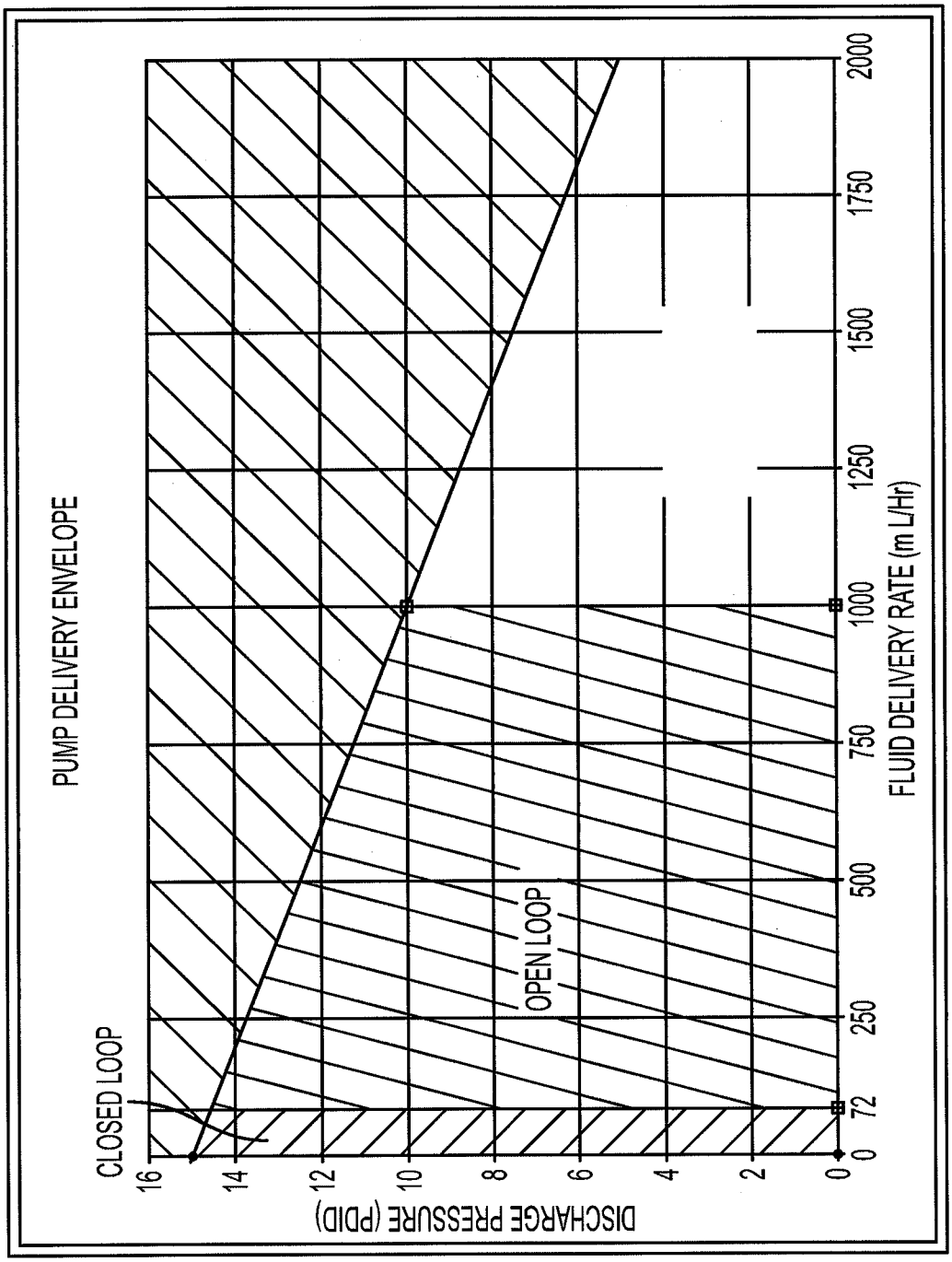

PUMP DELIVERY ENVELOPE
CLOSED LOOP
OPEN LOOP
DISCHARGE PRESSURE (PDID)
16
14
12
10
8
6
4
2
0
0
72
250
500
750
1000
1250
1500
1750
2000
FLUID DELIVERY RATE (m L/Hr)

FIG. ~~198~~

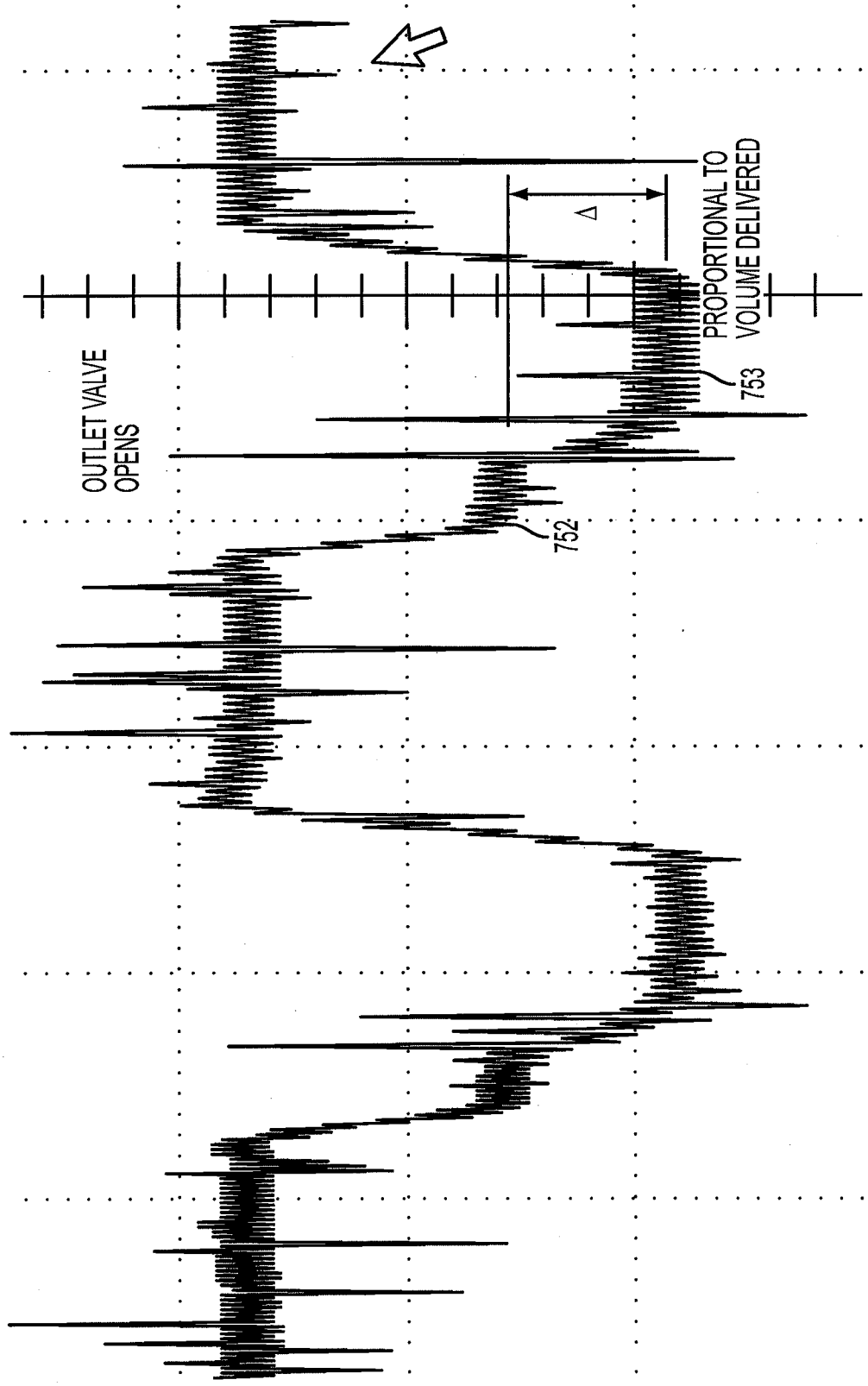

OUTLET VALVE OPENS
752
753
PROPORTIONAL TO VOLUME DELIVERED
Δ

FIG. ~~199~~

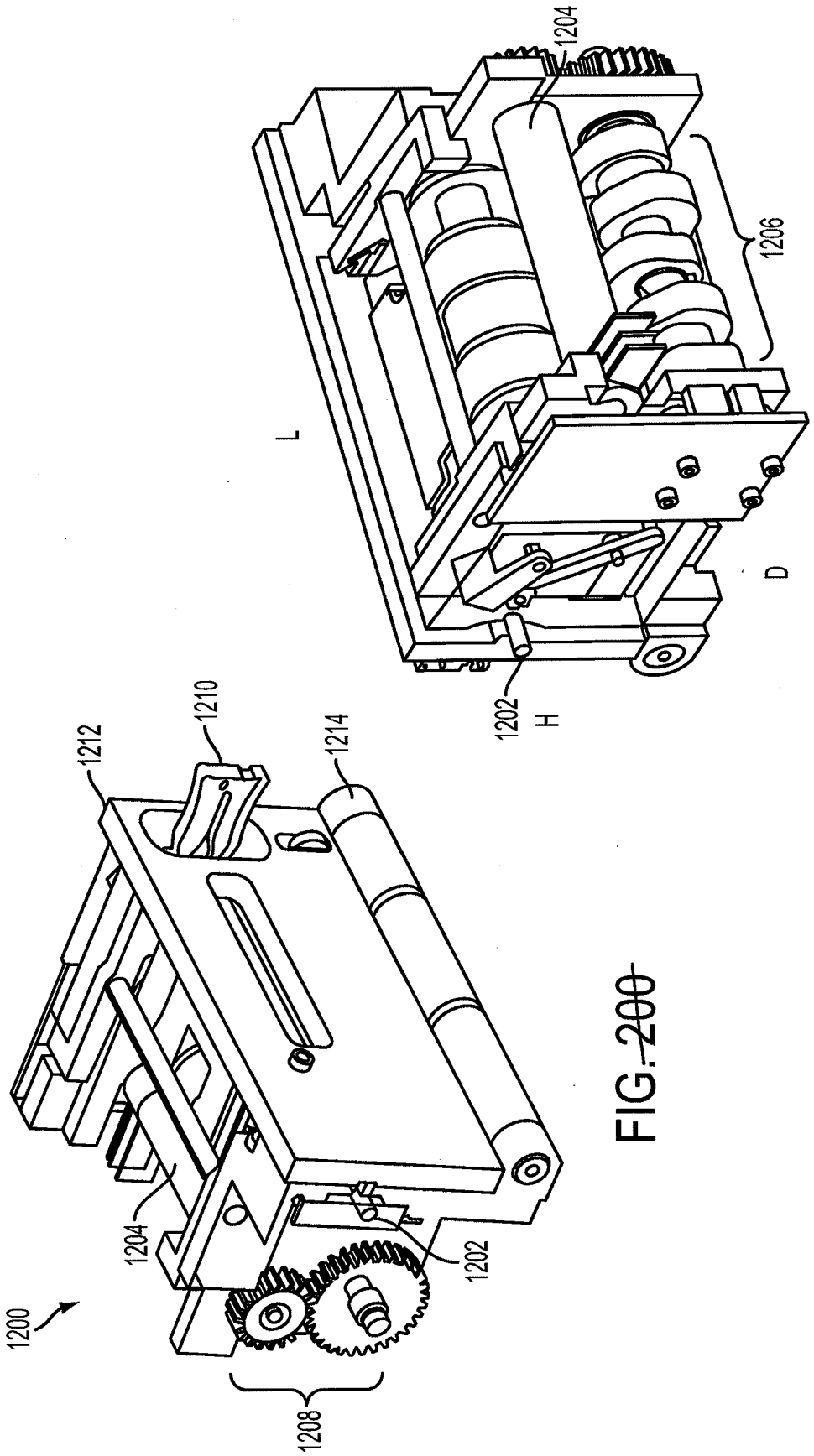


FIG. ~~200~~

FIG. ~~201~~

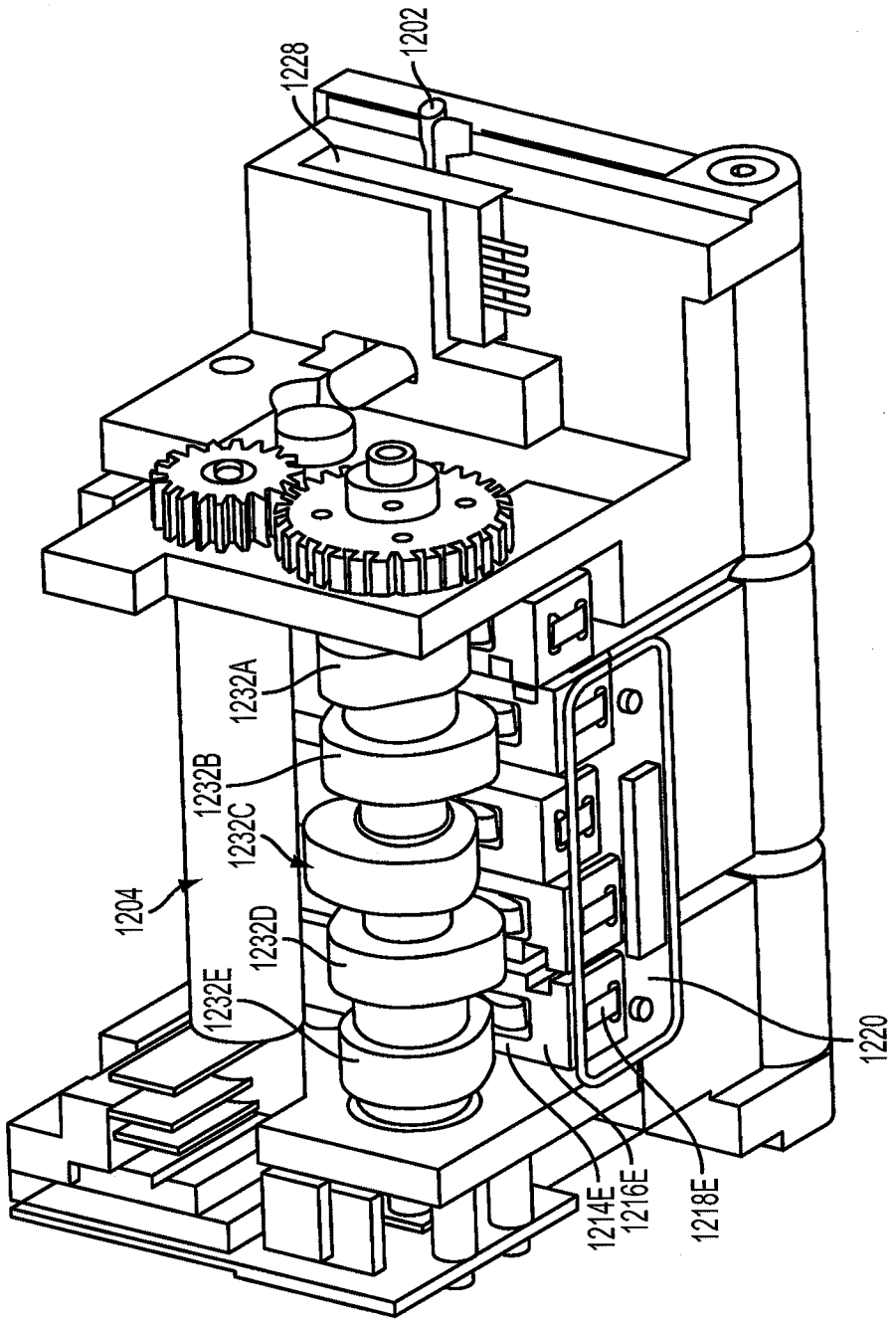

1228
1202
1232A
1232B
1232C
1204
1232D
1232E
1220
1214E
1216E
1218E

FIG. ~~202~~

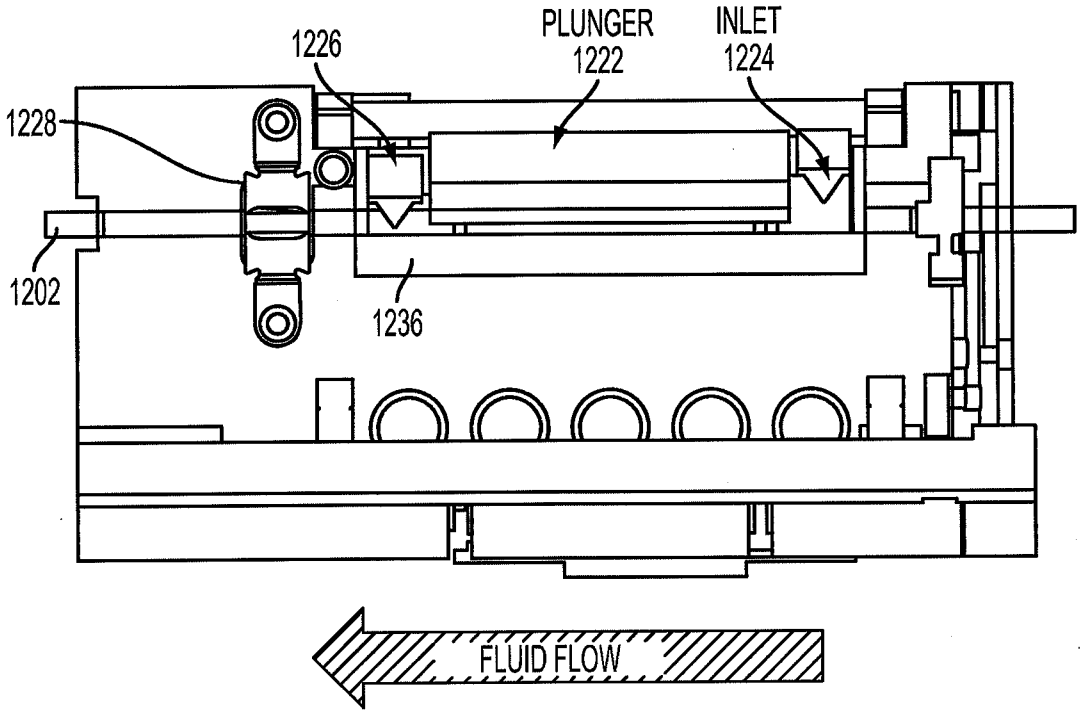


FIG. ~~203~~

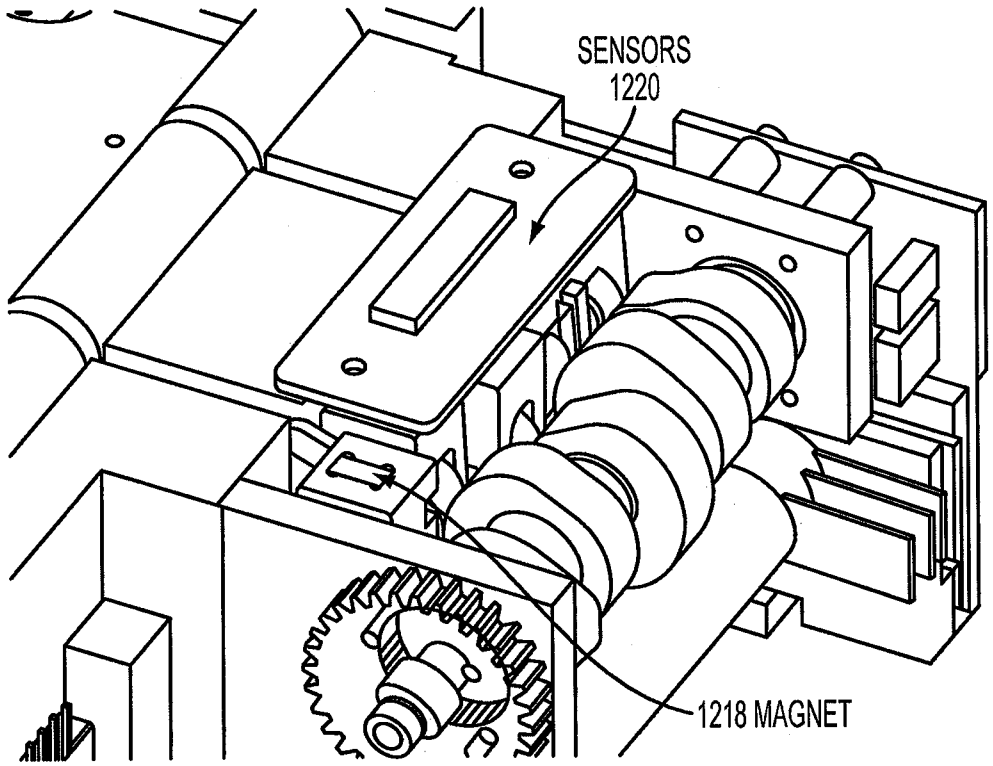


FIG. ~~204~~

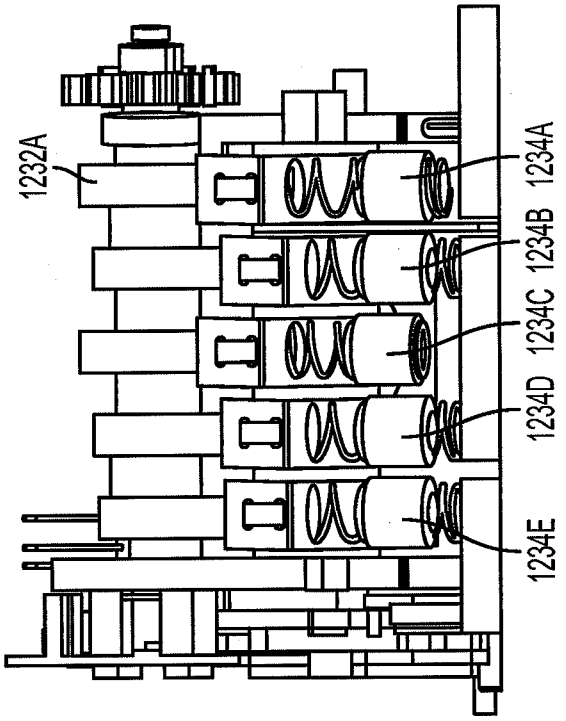


FIG. ~~206~~

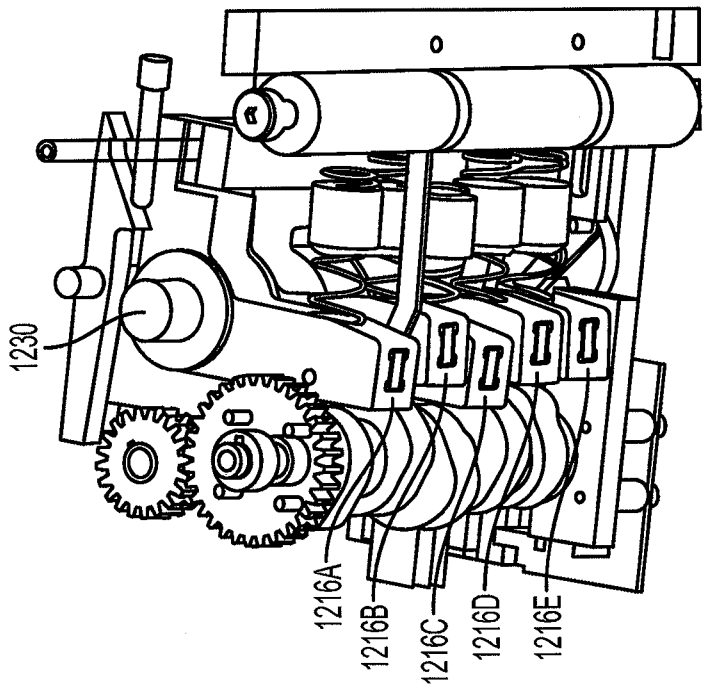


FIG. ~~205~~

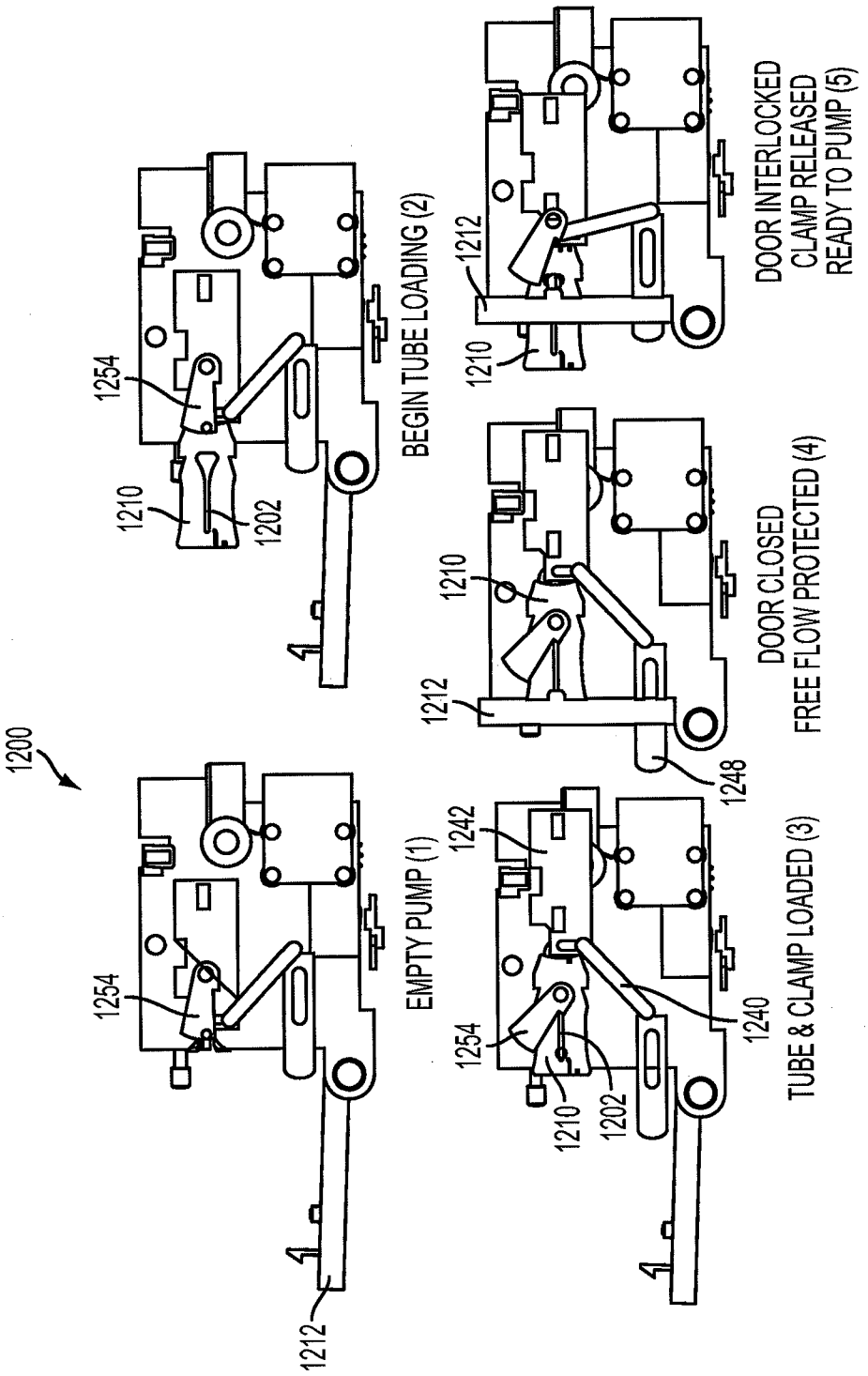

1200
1254
1212
EMPTY PUMP (1)
1254
1210
1202
BEGIN TUBE LOADING (2)
1242
1254
1210
1202
1240
TUBE & CLAMP LOADED (3)
1210
1212
1248
DOOR CLOSED
FREE FLOW PROTECTED (4)
1212
1210
DOOR INTERLOCKED
CLAMP RELEASED
READY TO PUMP (5)

FIG. ~~207~~

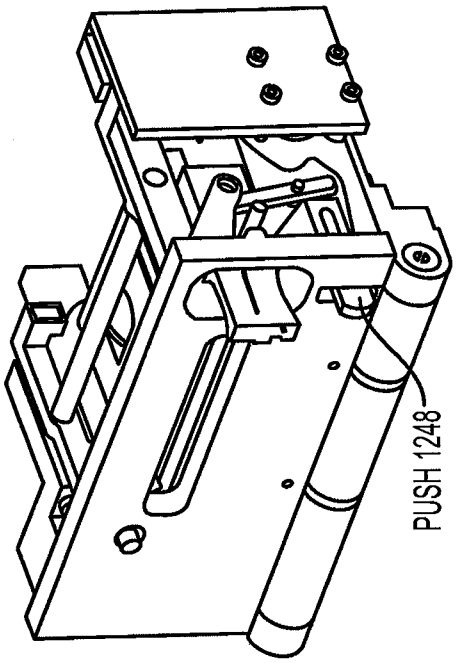


FIG. 209

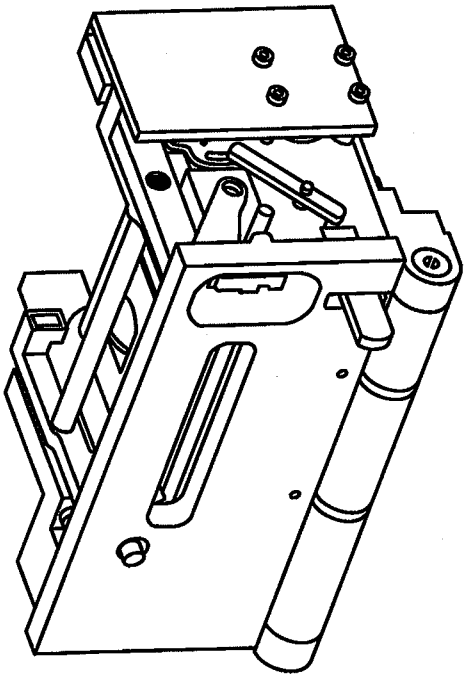


FIG. 208

SLIDE CLAMP KEY

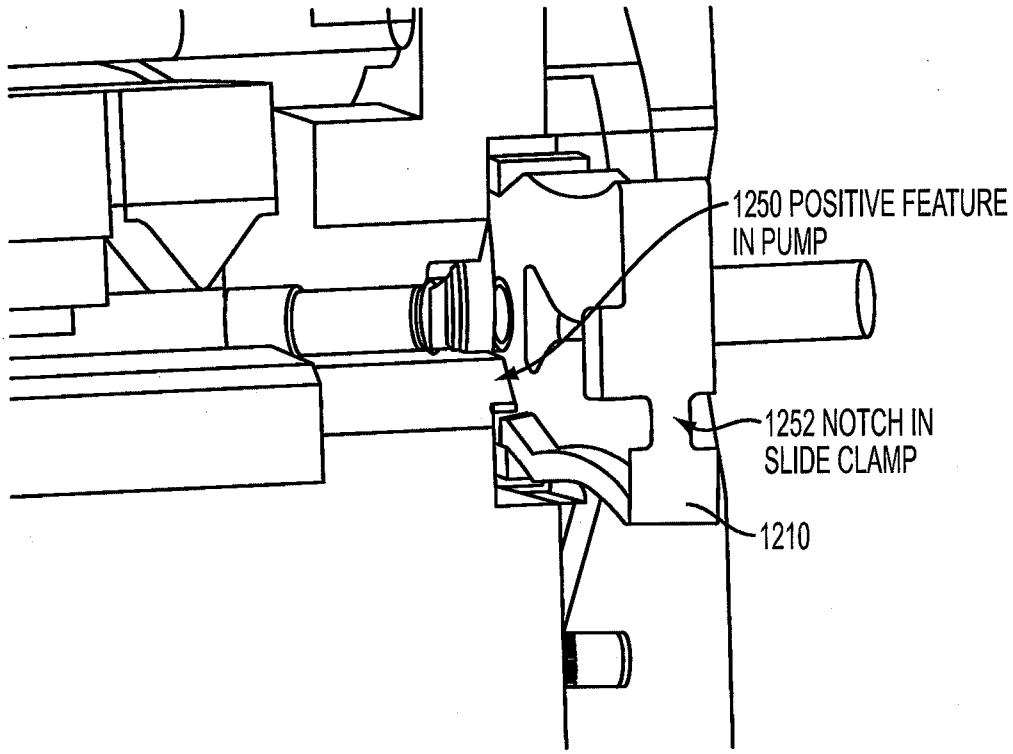


FIG. ~~210~~

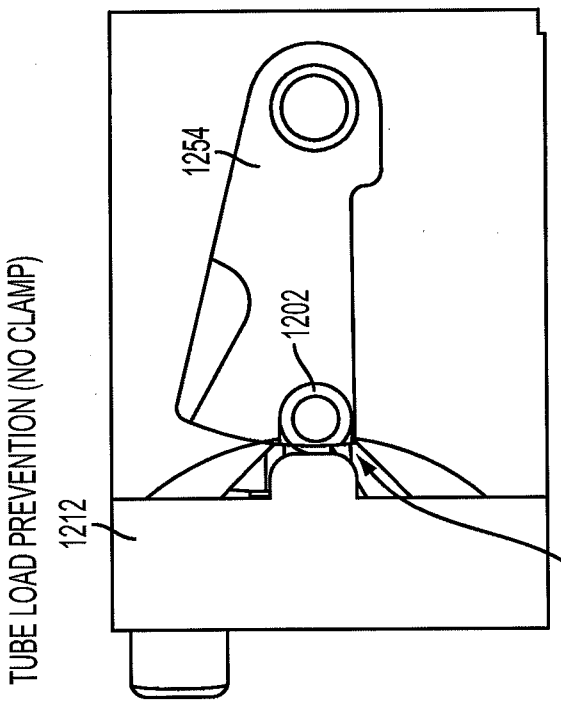


FIG. 211

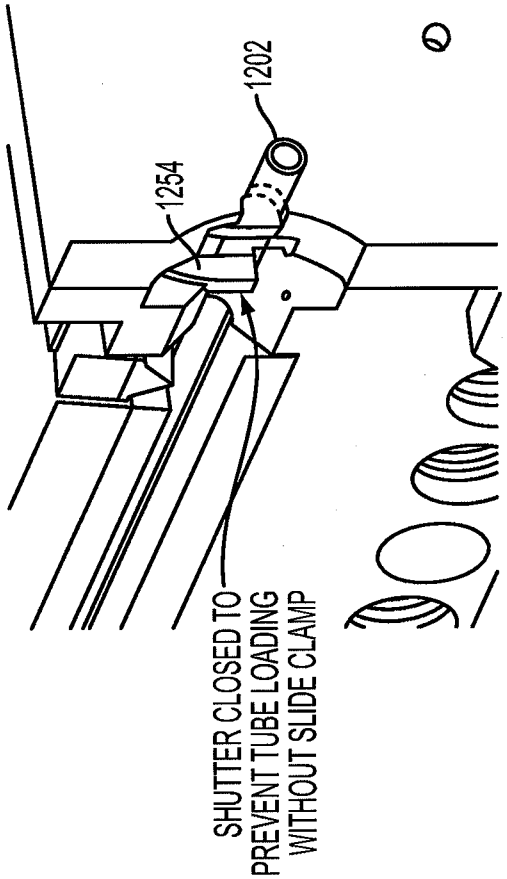


FIG. 212

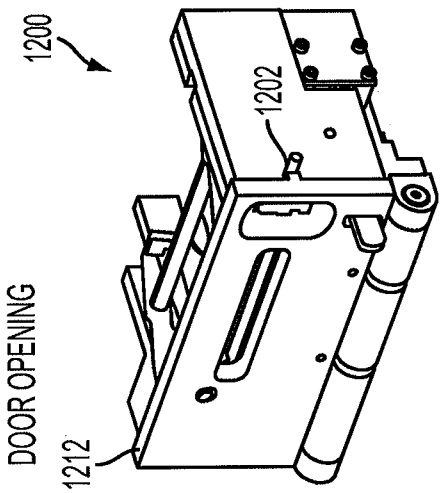


FIG. ~~213~~

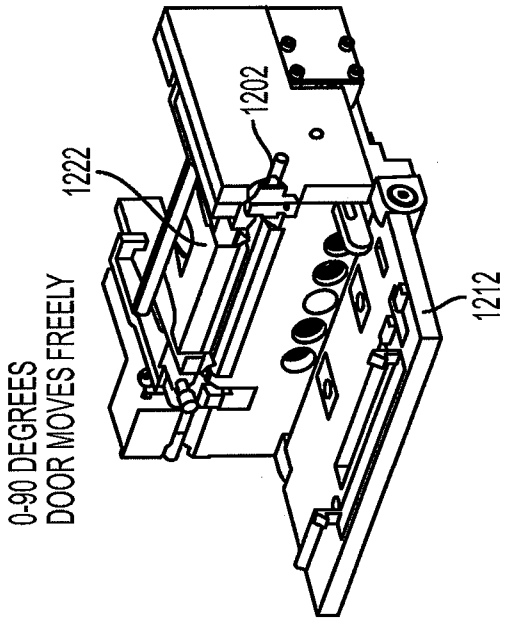


FIG. ~~214~~

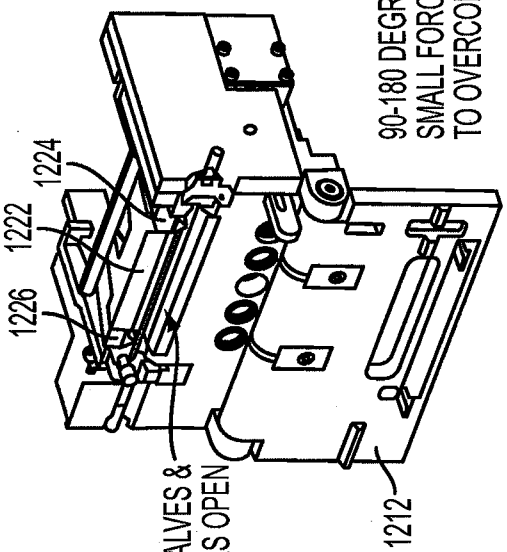


FIG. ~~215~~

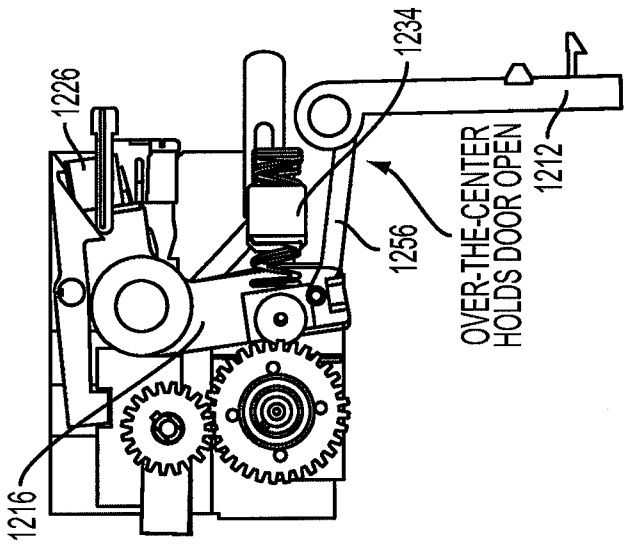


FIG. ~~218~~

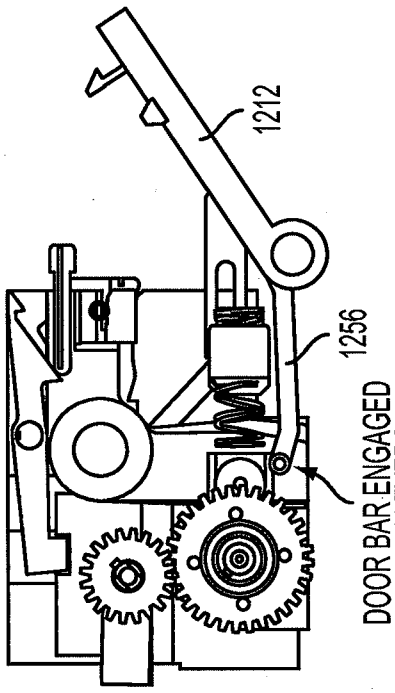


FIG. ~~217~~

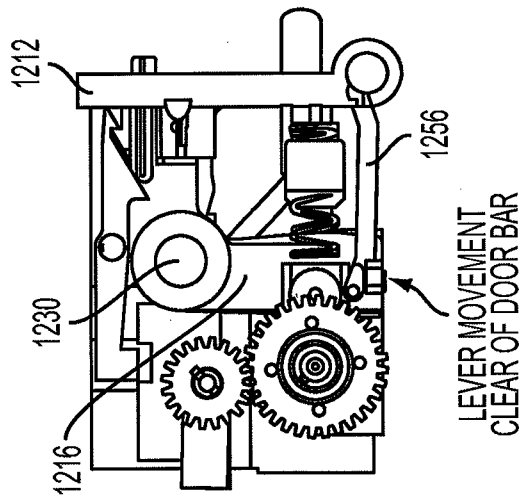


FIG. ~~216~~

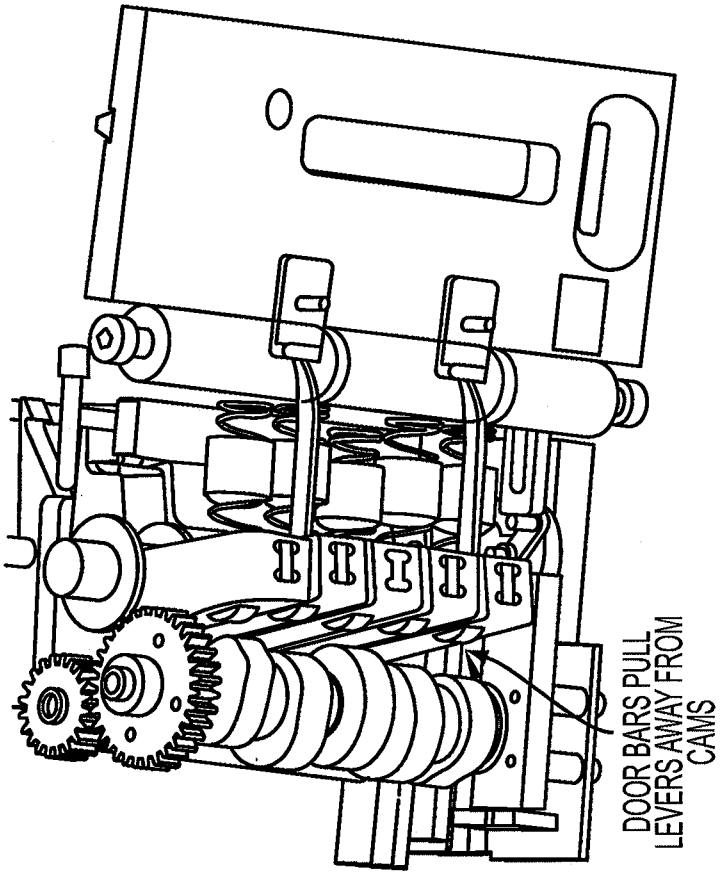


FIG. ~~220~~

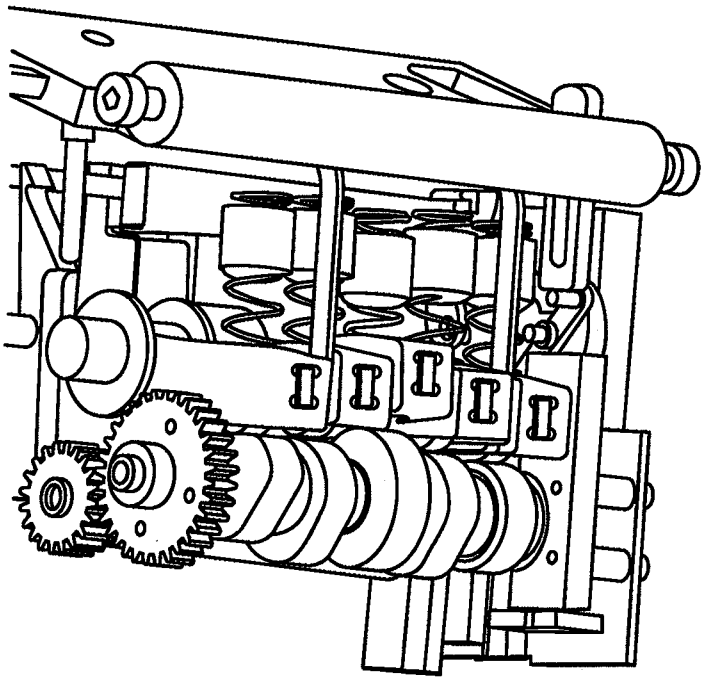


FIG. ~~219~~

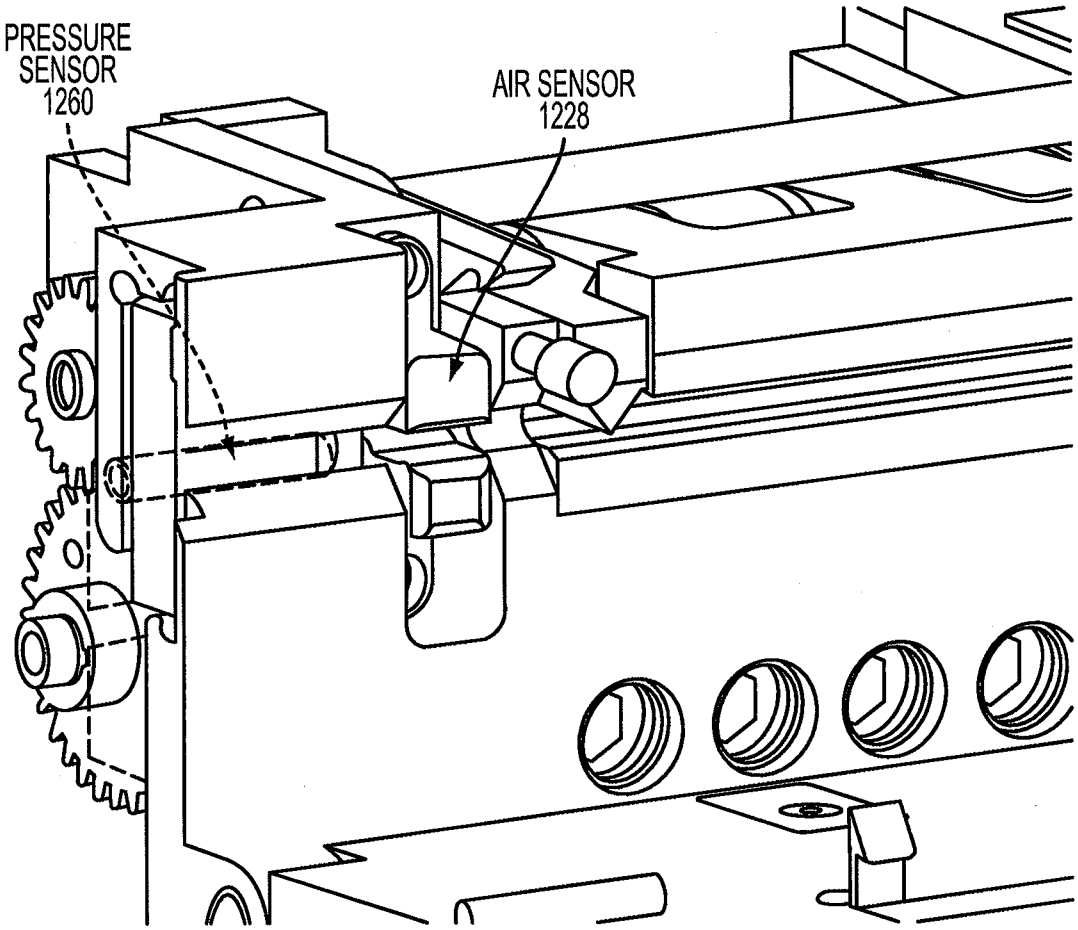


FIG. ~~221~~

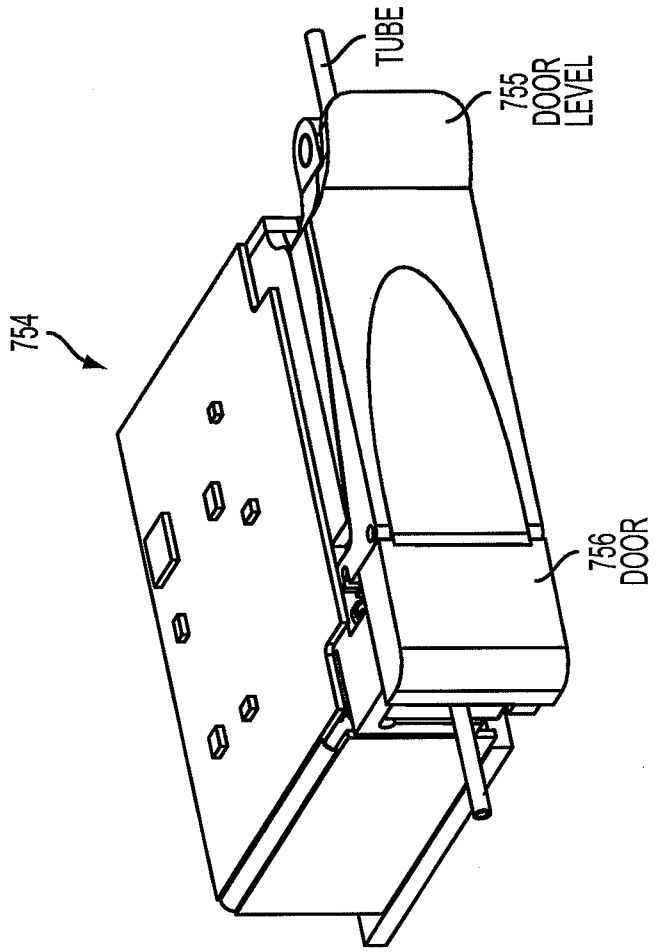


FIG. ~~222~~

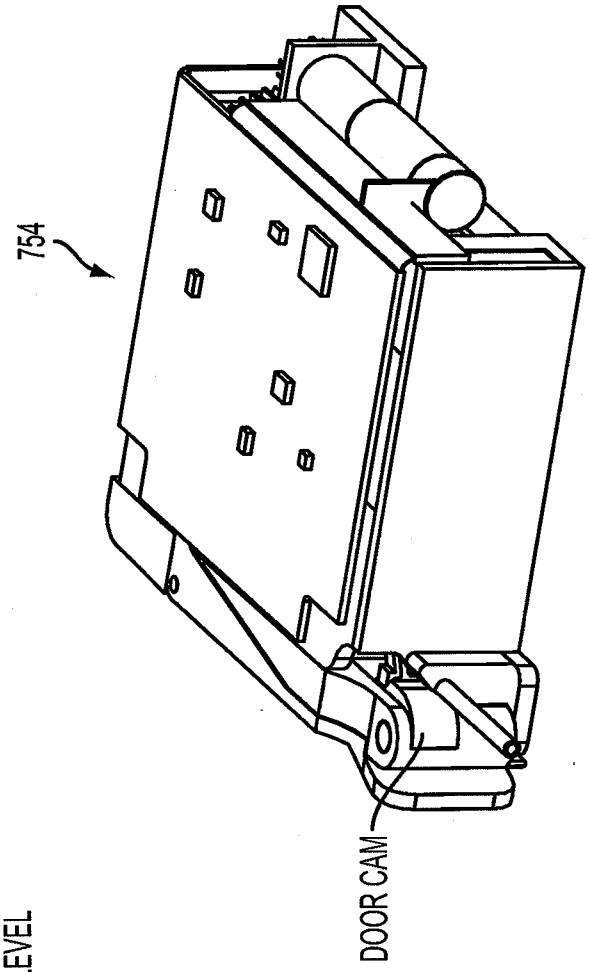


FIG. ~~223~~

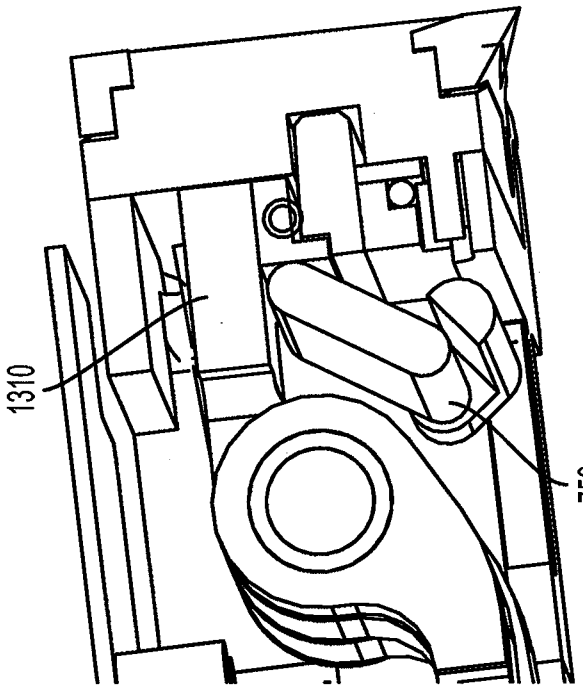


FIG. ~~225~~

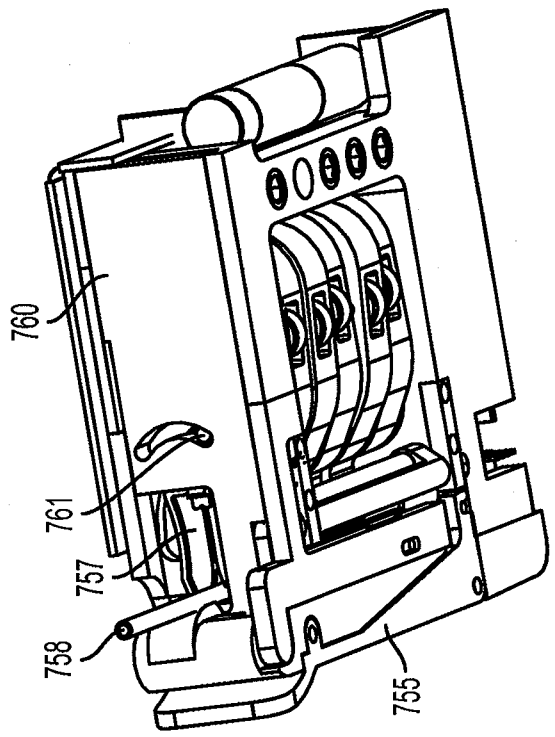


FIG. ~~224~~

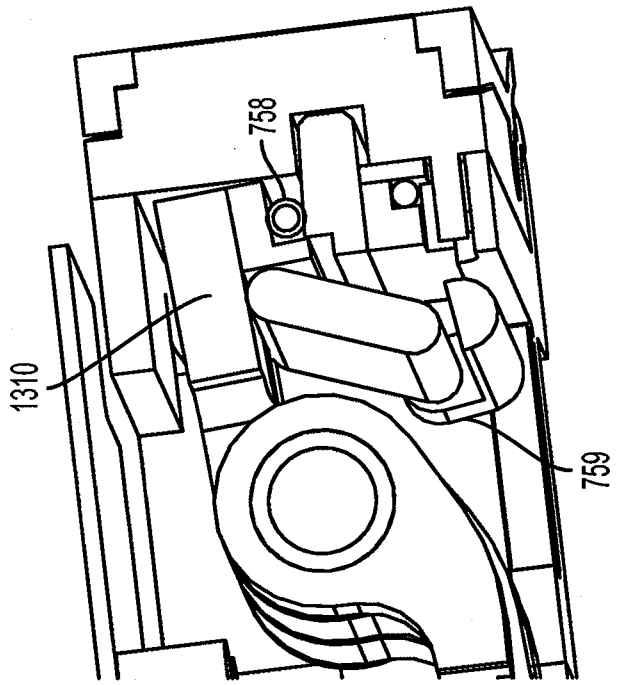


FIG. 227

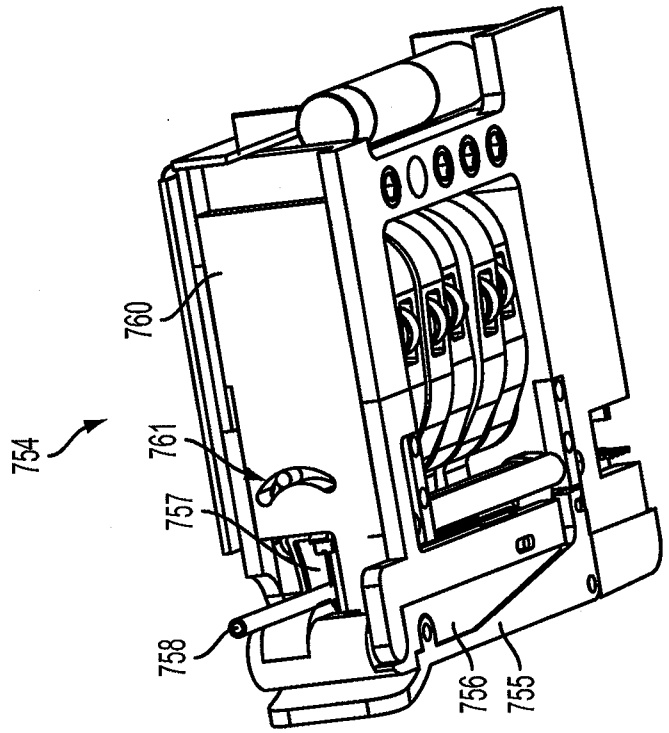


FIG. 226

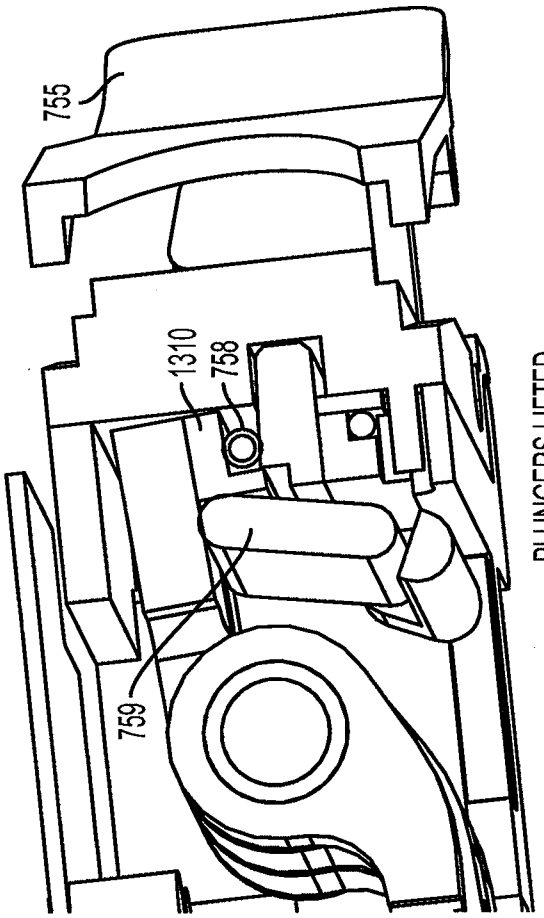


FIG. ~~229~~

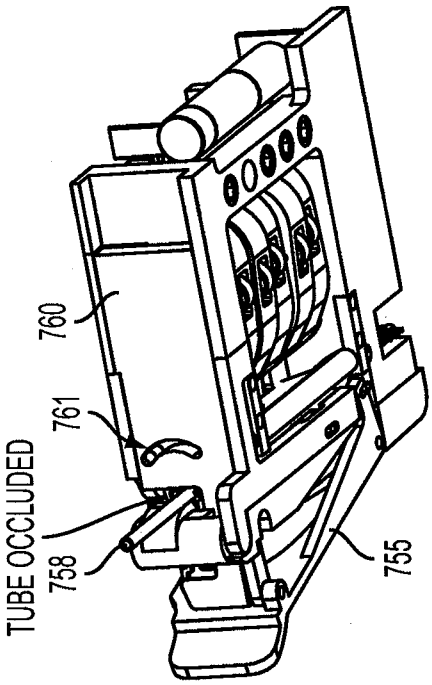


FIG. ~~228~~

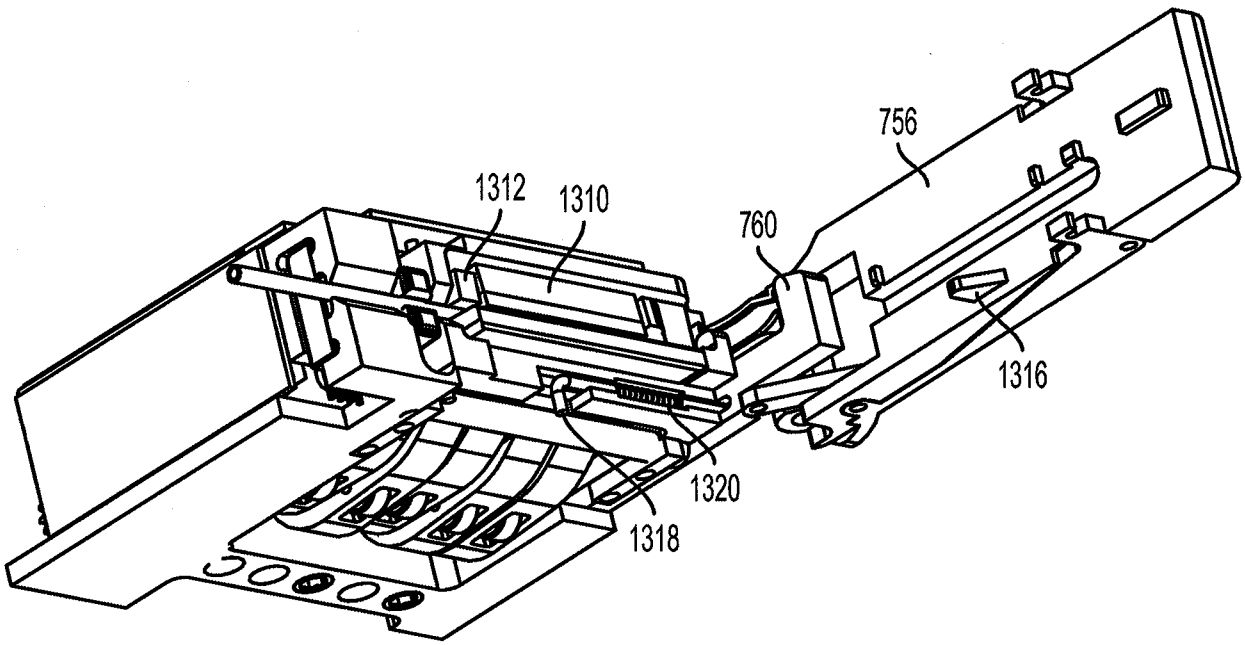


FIG. ~~230~~

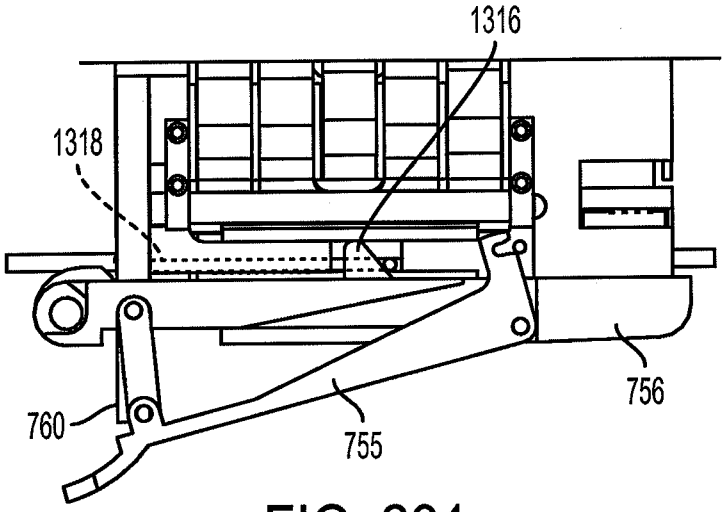


FIG. ~~231~~

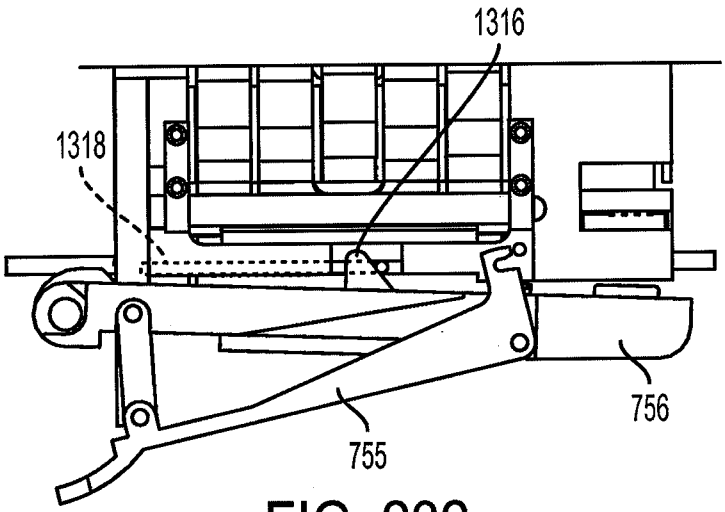


FIG. ~~232~~

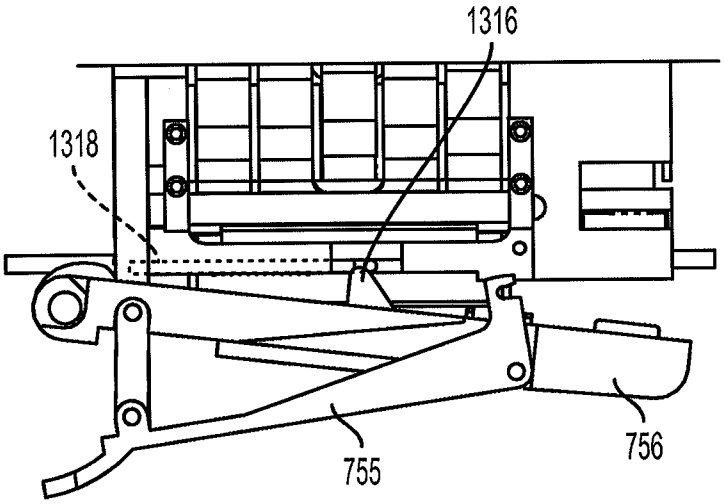


FIG. ~~233~~

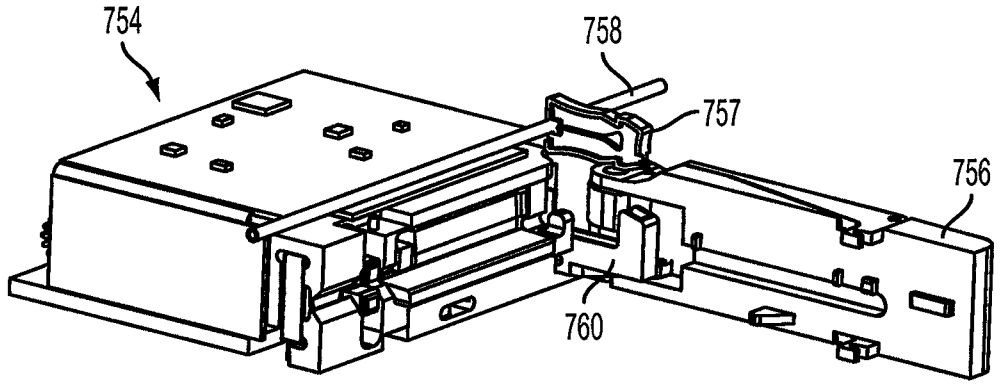


FIG. ~~234~~

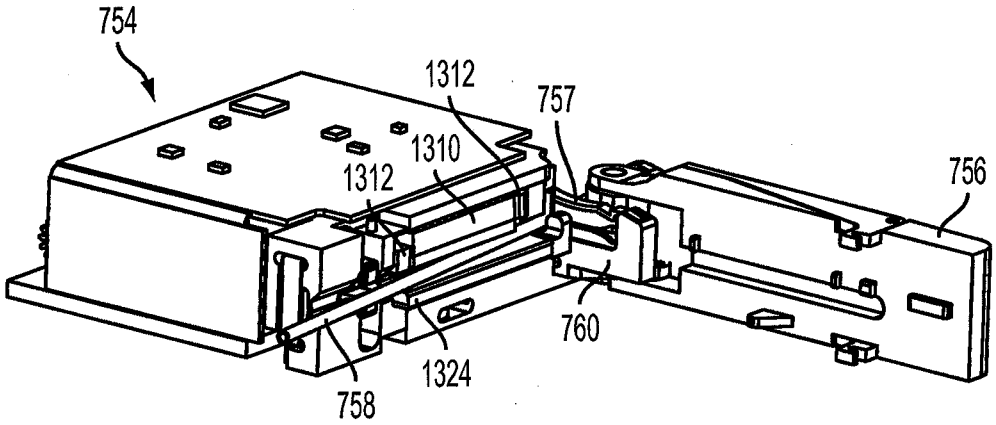


FIG. ~~235~~

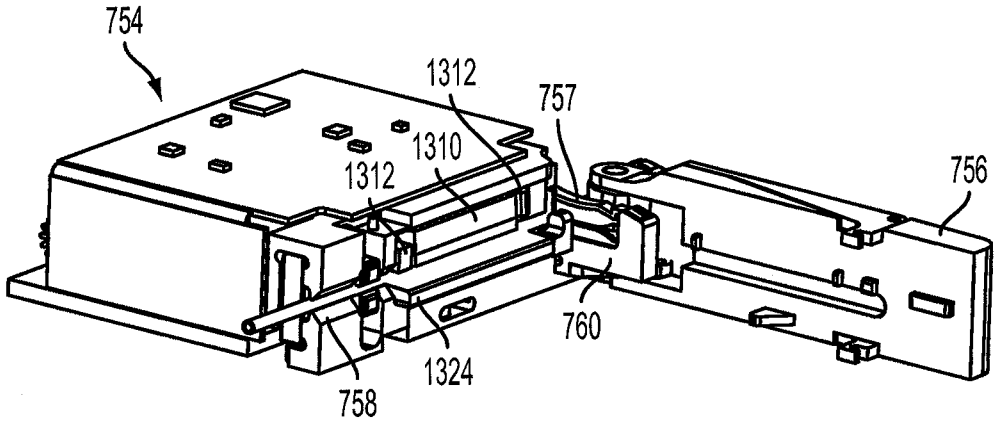


FIG. ~~236~~

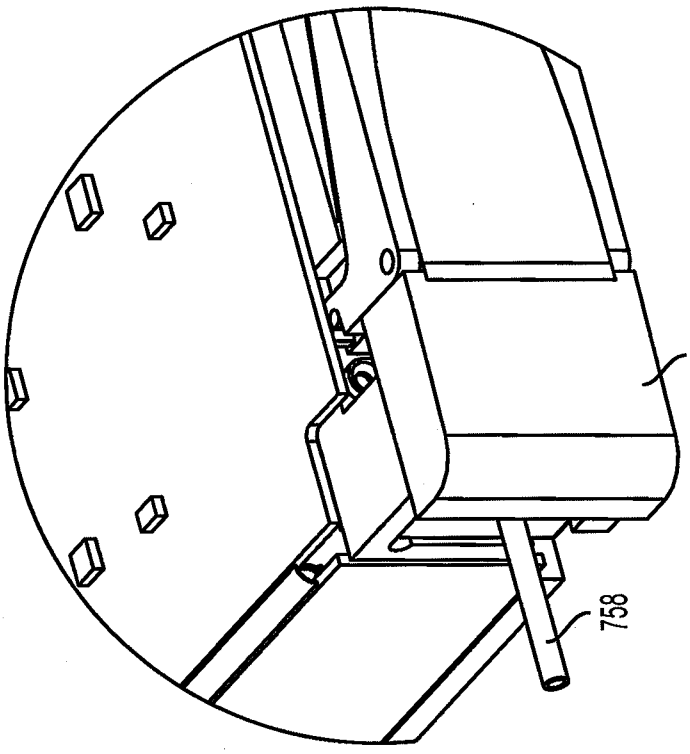


FIG. ~~238~~

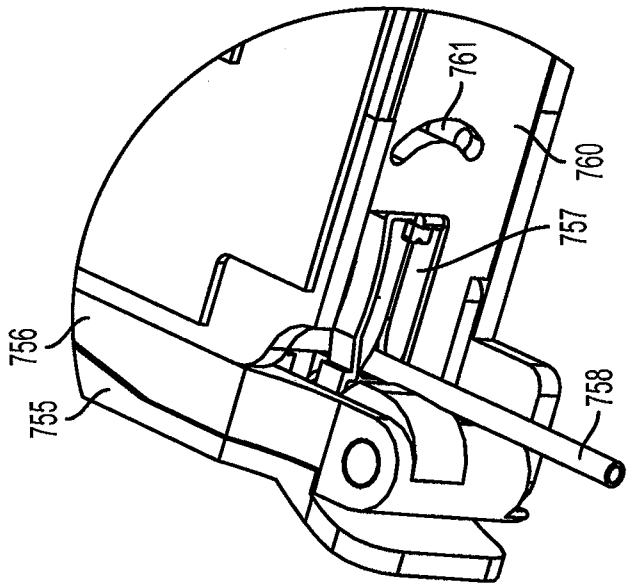


FIG. ~~237~~

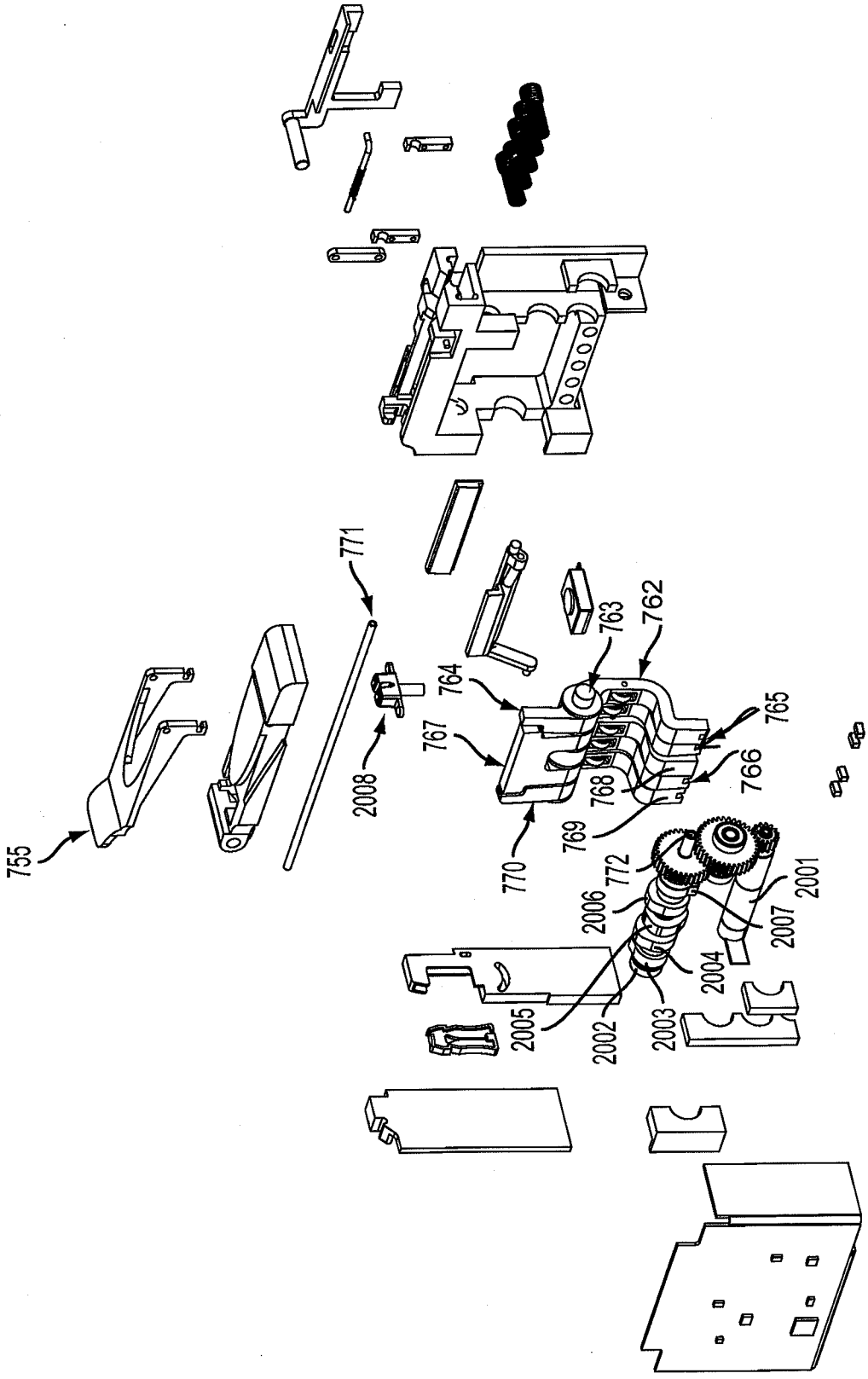

755
771
2008
767
764
763
762
765
766
768
769
770
772
2006
2005
2002
2003
2004
2007
2001

FIG. ~~239~~

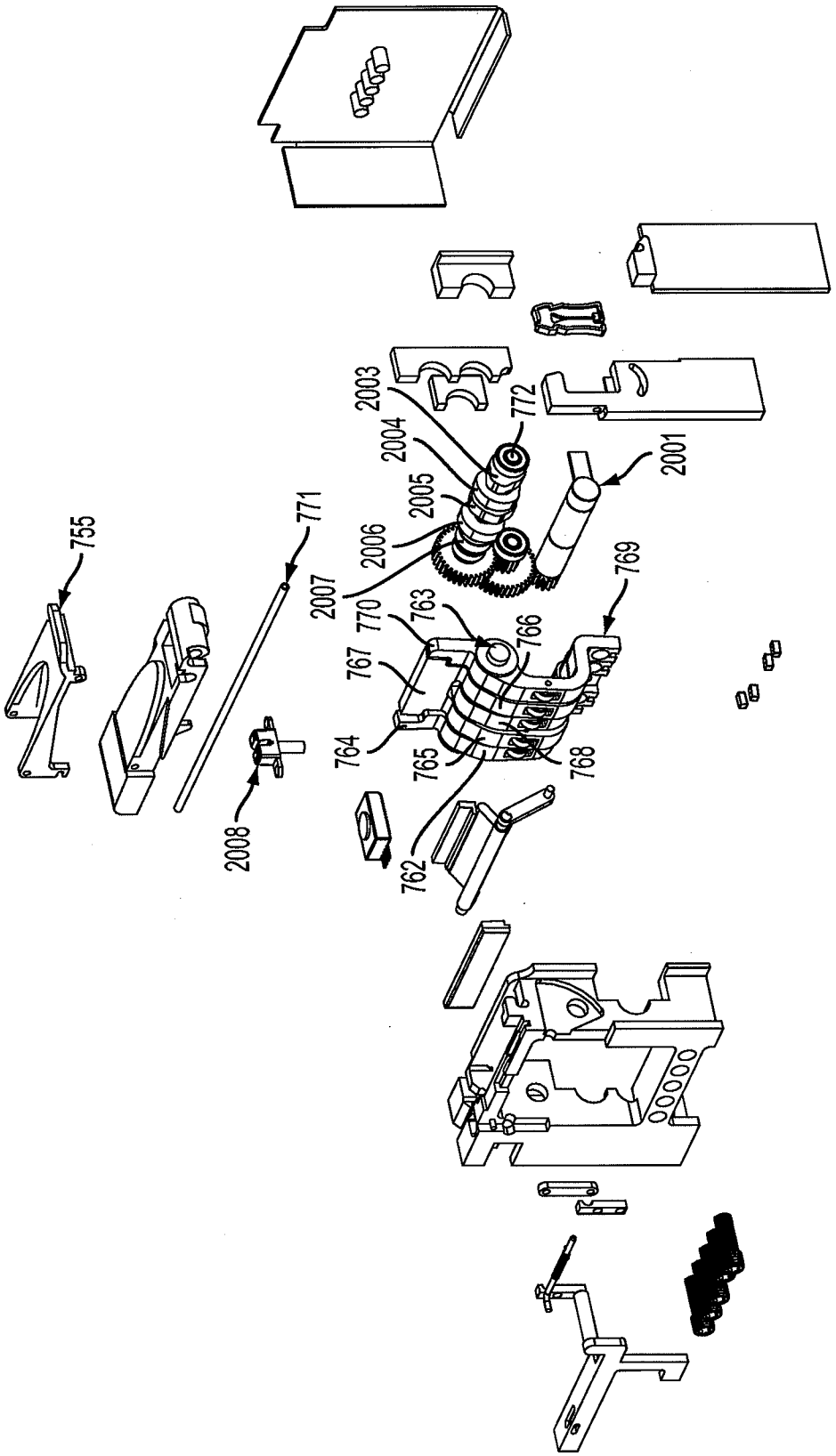

2003
772
2004
2001
2005
771
755
2006
2007
769
770
763
766
767
764
765
768
2008
762

FIG. ~~240~~

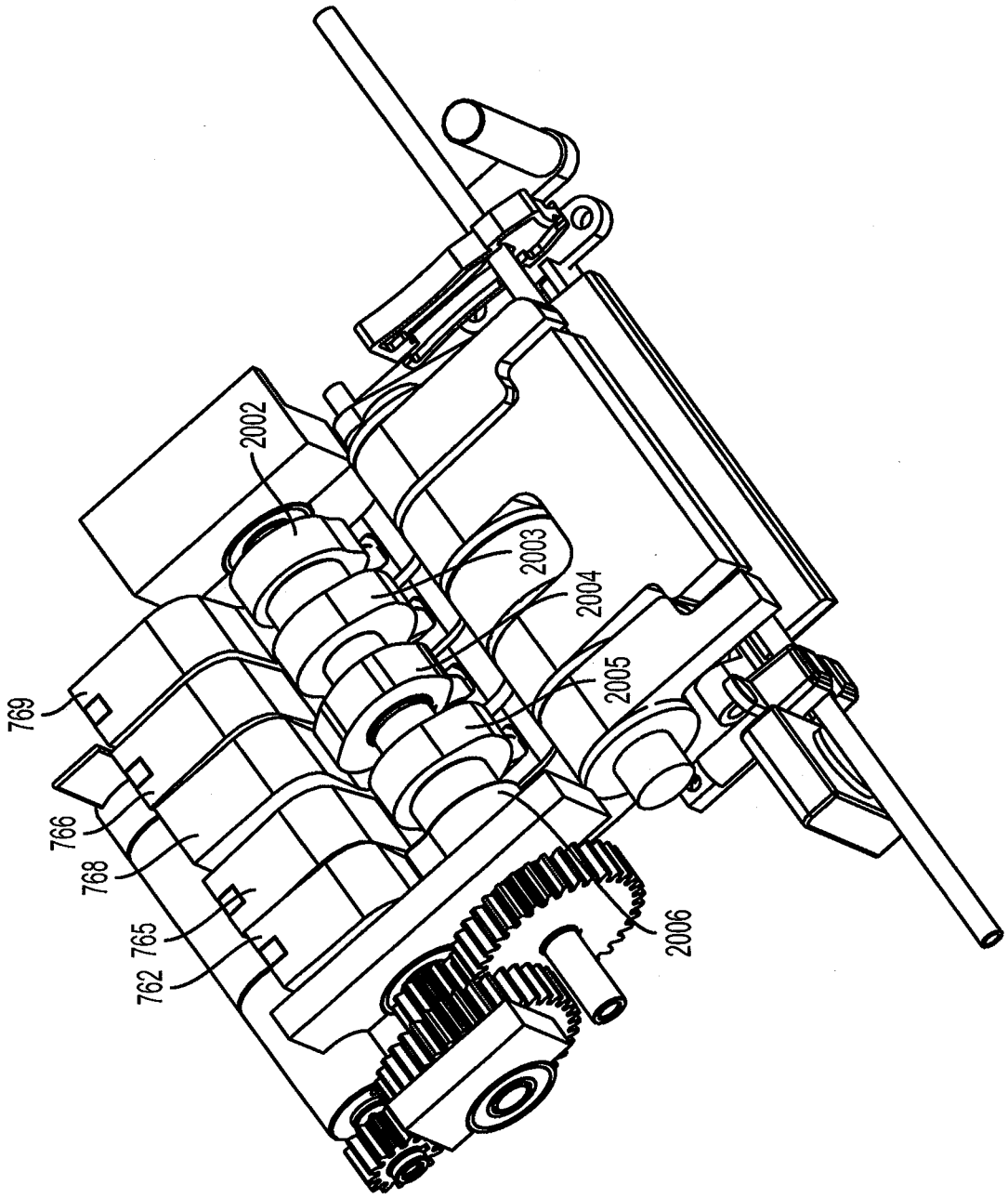


FIG. ~~241~~

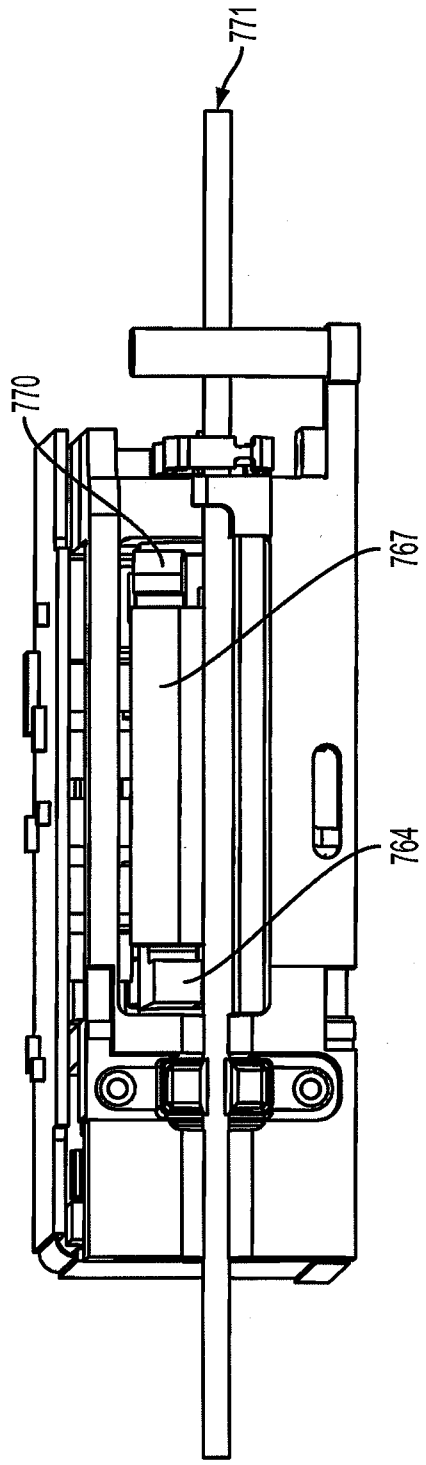


FIG. ~~242~~

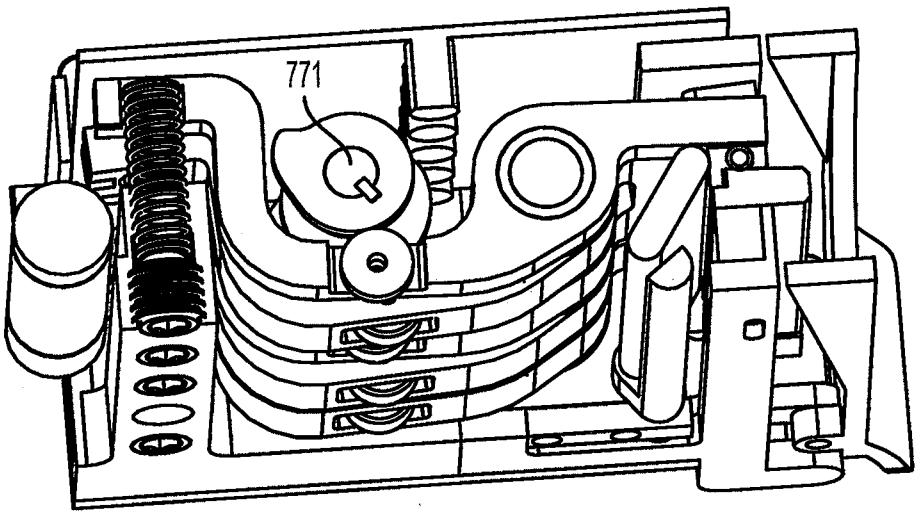


FIG. ~~243~~

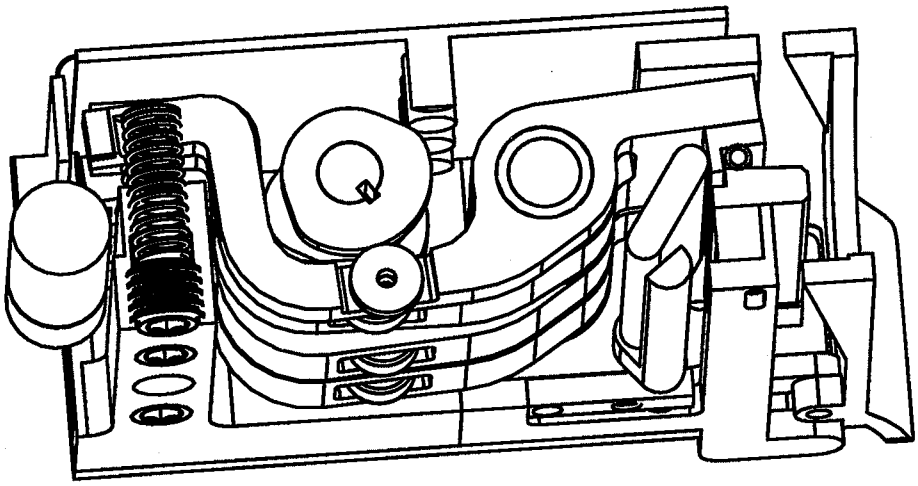


FIG. ~~244~~

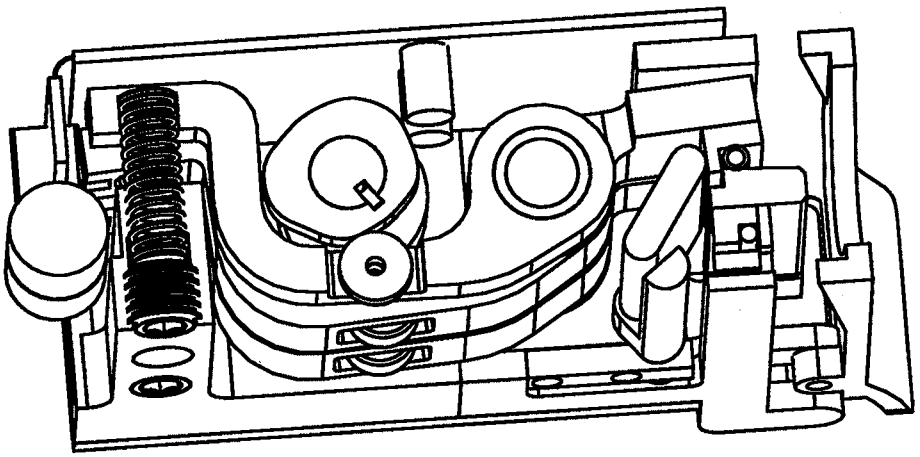


FIG. ~~245~~

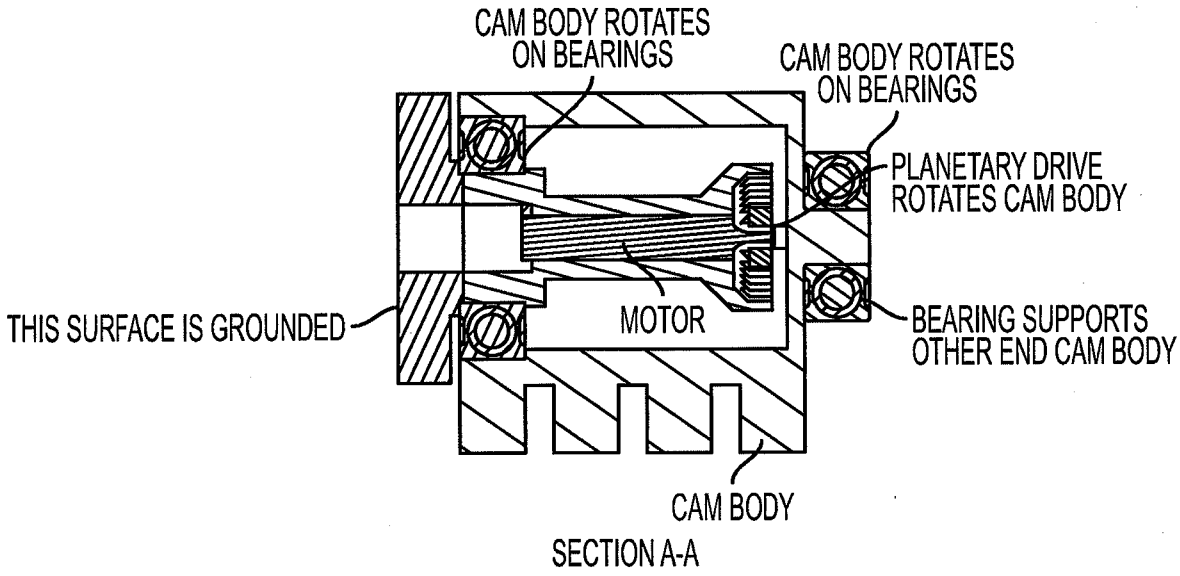

CAM BODY ROTATES ON BEARINGS
CAM BODY ROTATES ON BEARINGS
PLANETARY DRIVE ROTATES CAM BODY
THIS SURFACE IS GROUNDED
MOTOR
BEARING SUPPORTS OTHER END CAM BODY
CAM BODY
SECTION A-A

FIG. ~~246~~

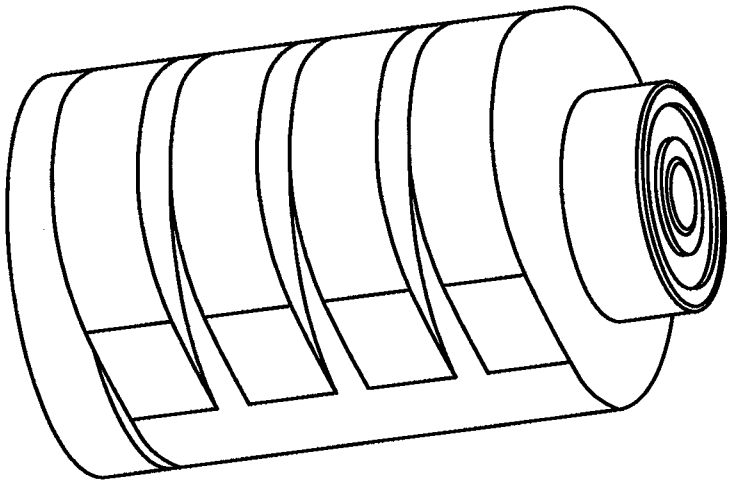


FIG. ~~247~~

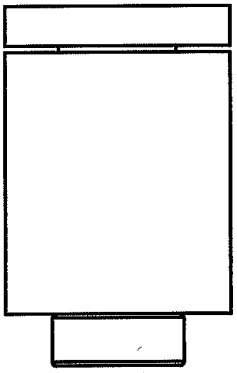


FIG. ~~250~~

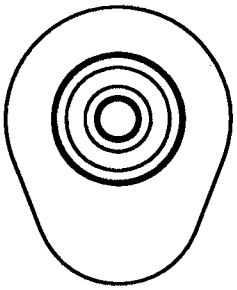


FIG. ~~249~~

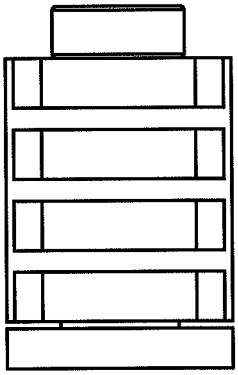


FIG. ~~248~~

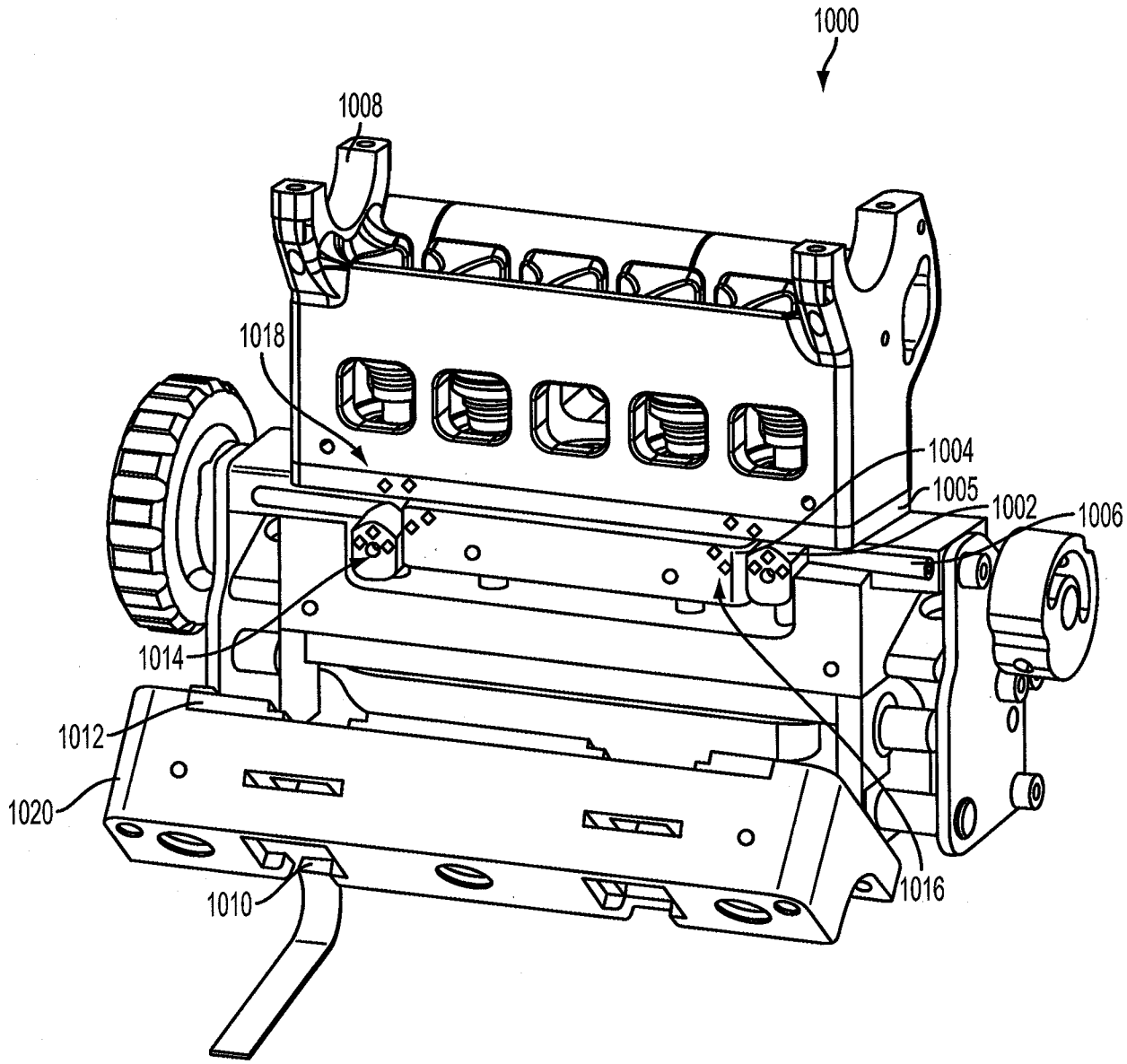


FIG. ~~251~~

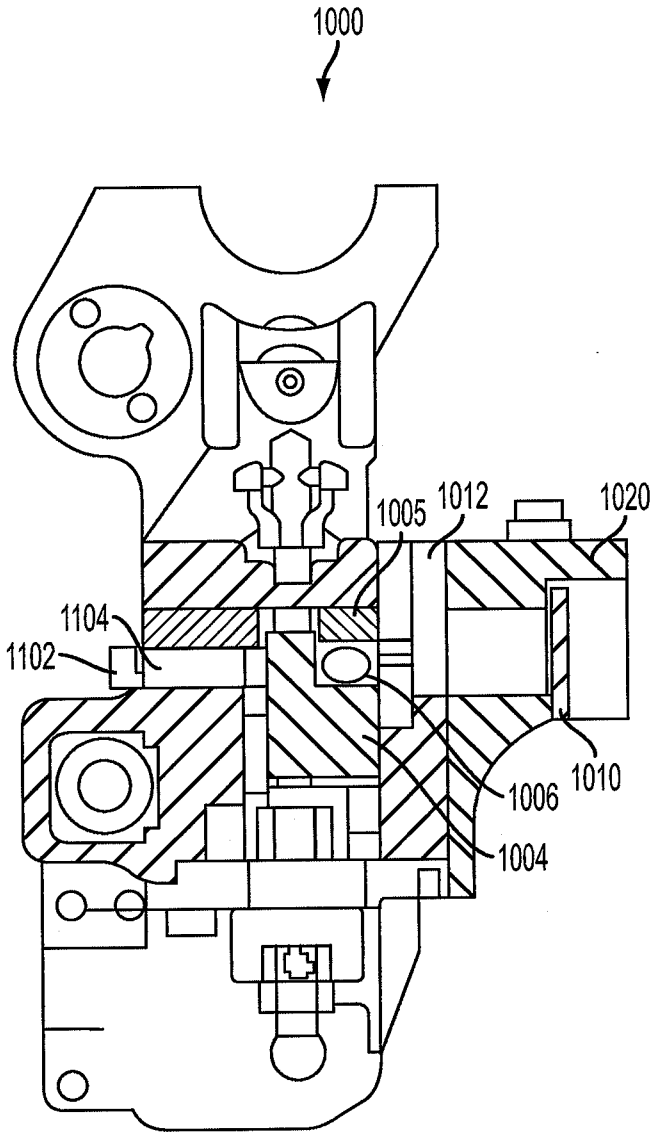


FIG. ~~252~~

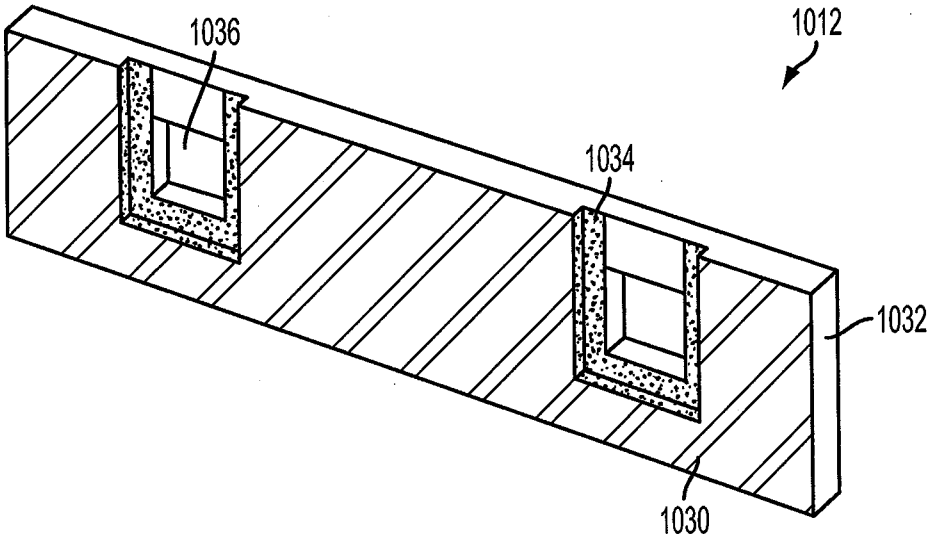


FIG. ~~253~~

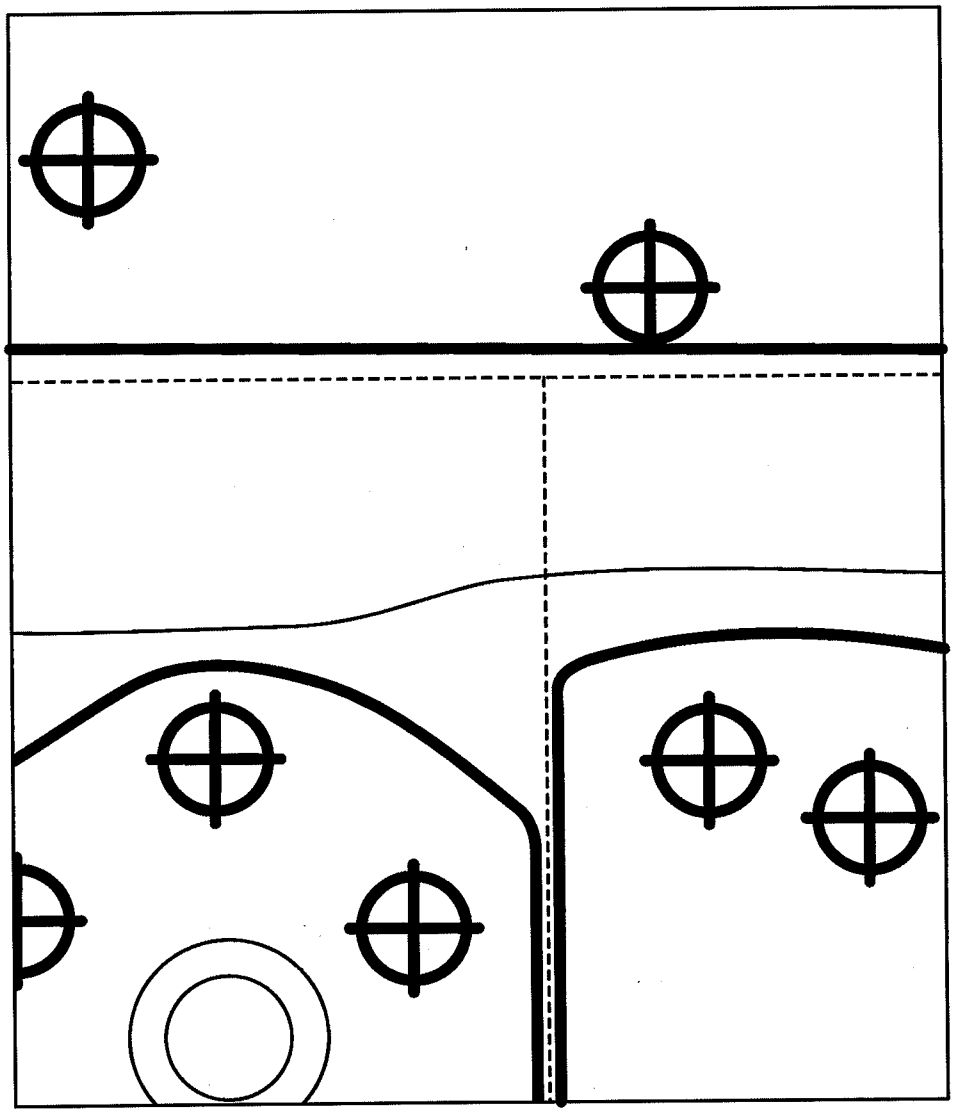


FIG. ~~254~~

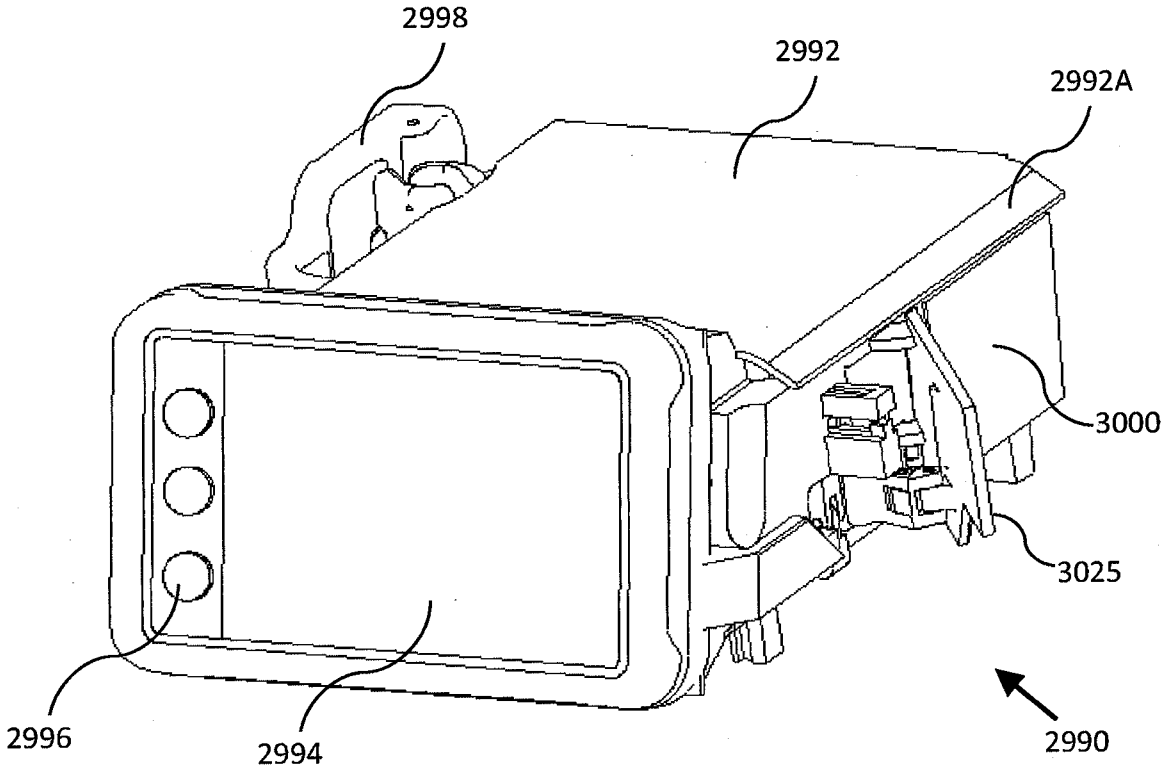


FIG. ~~255~~

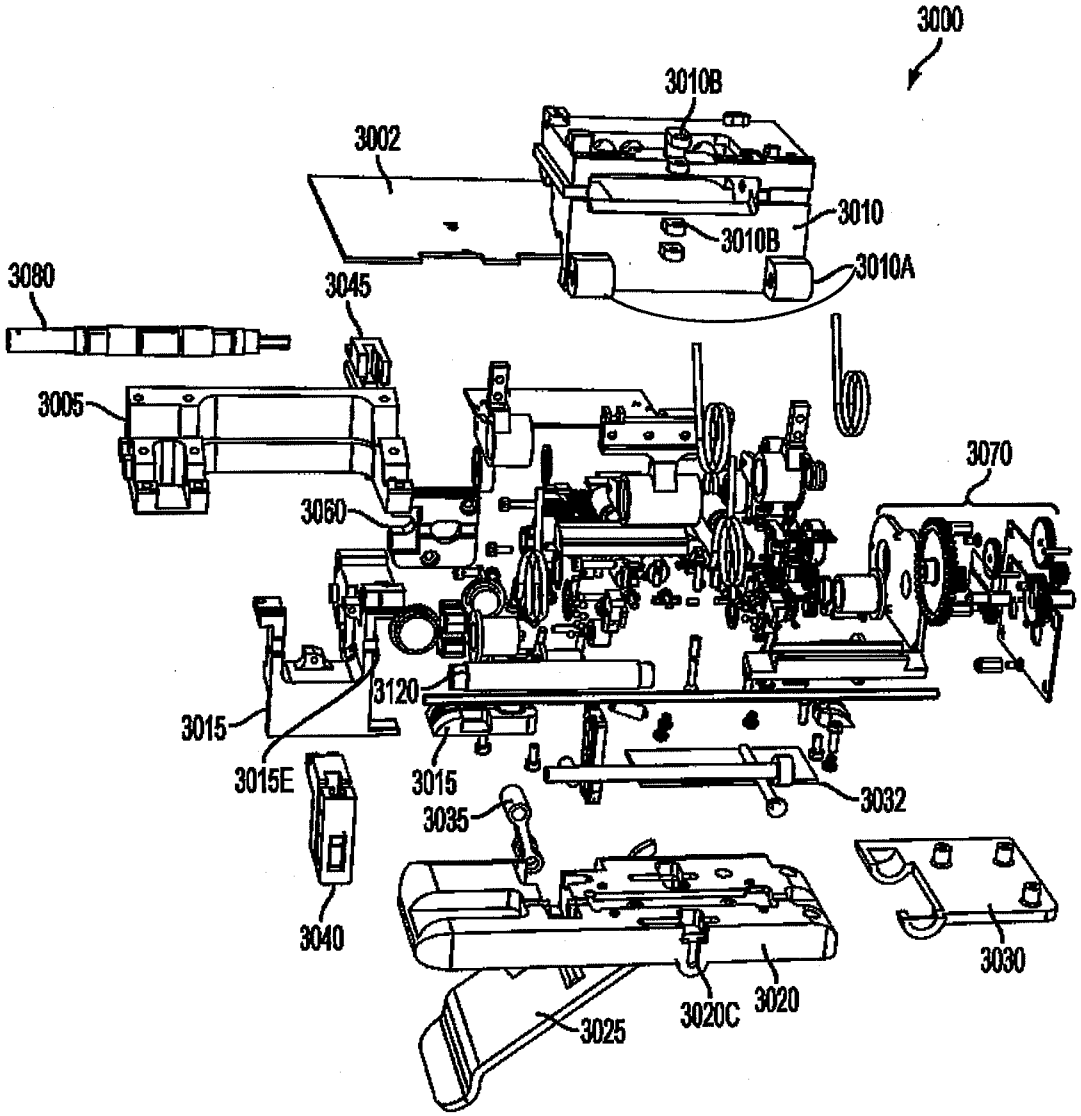

3000
3010B
3002
3010
3010B
3010A
3080
3045
3005
3070
3060
3120
3015
3015E
3015
3032
3035
3040
3030
3020C
3020
3025

FIG. ~~256A~~

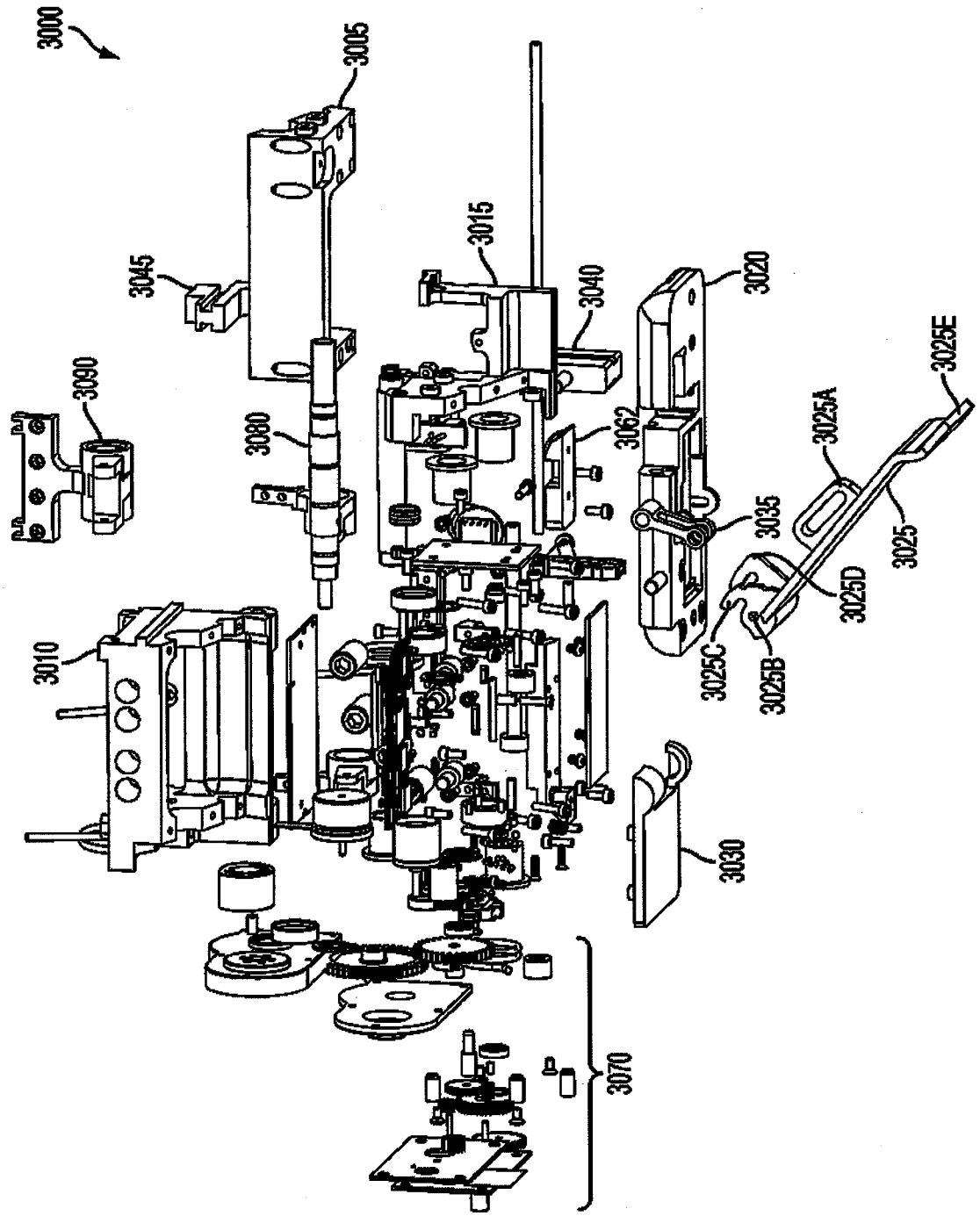

3000
3005
3015
3045
3040
3020
3090
3080
3062
3025E
3025A
3035
3025
3025D
3025C
3025B
3010
3030
3070

FIG. ~~256B~~

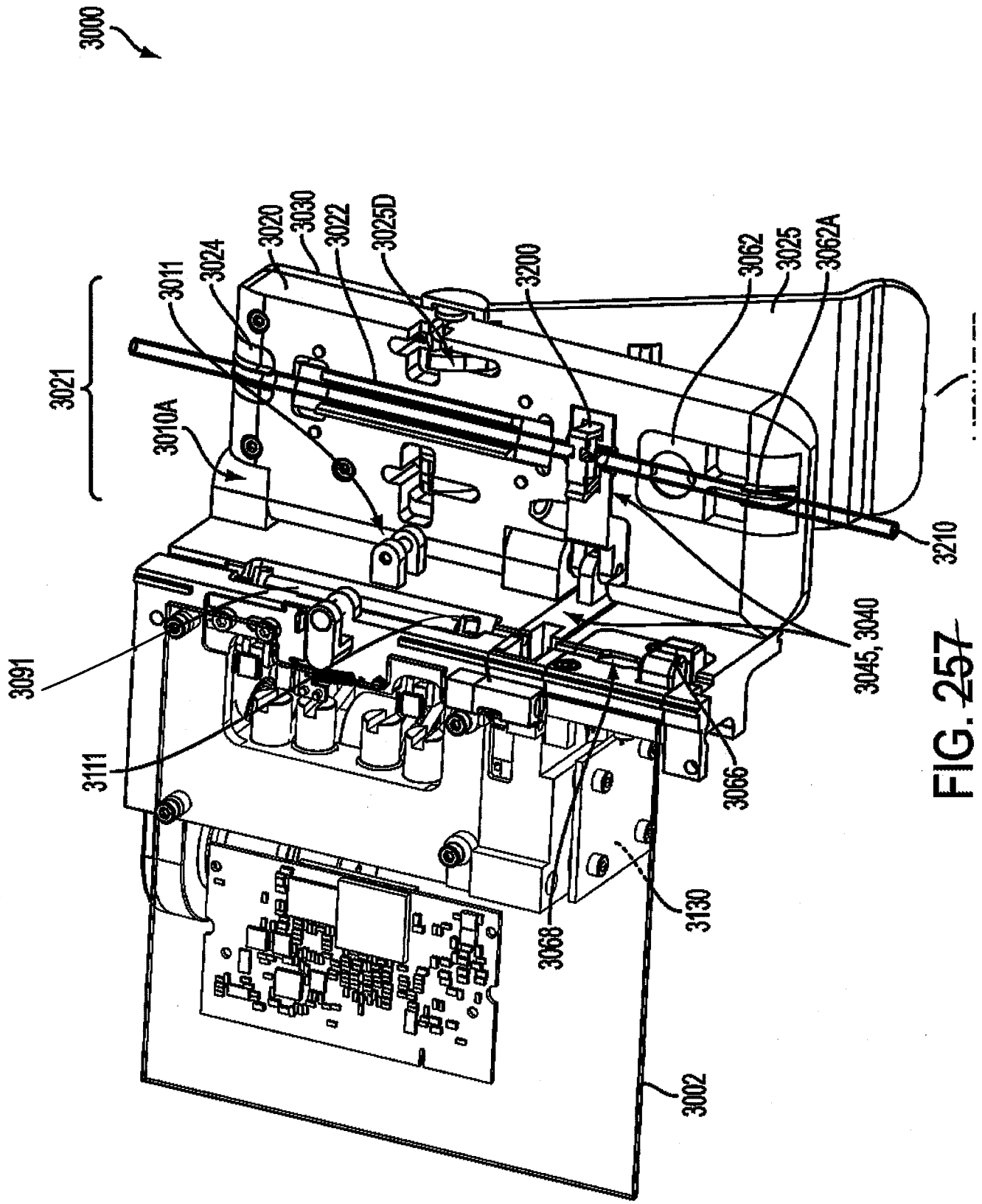

3000
3020
3030
3022
3025D
3024
3011
3200
3062
3025
3062A
3021
3010A
3210
3091
3045, 3040
3111
3066
3130
3068
3002

FIG. 257

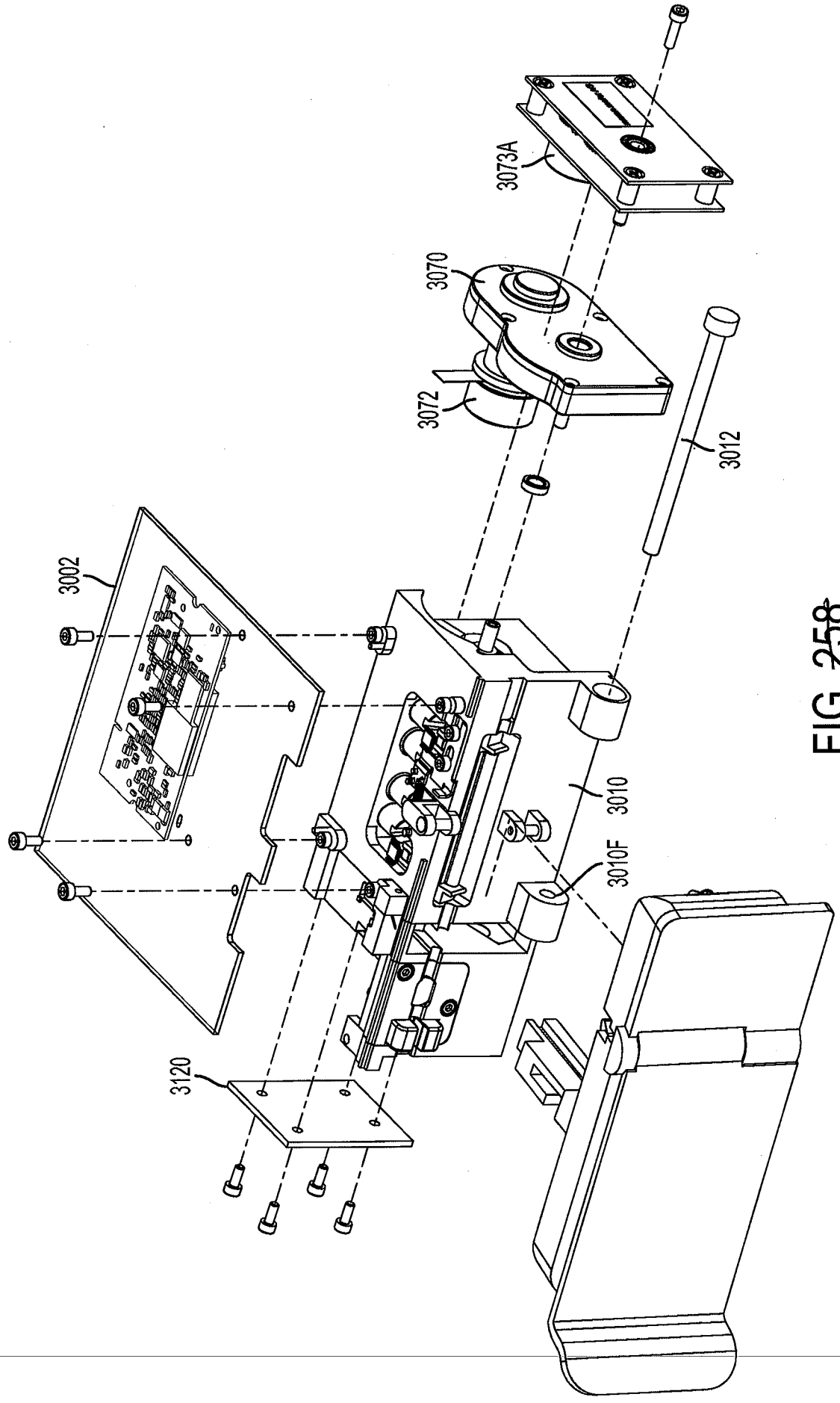


FIG. ~~258~~

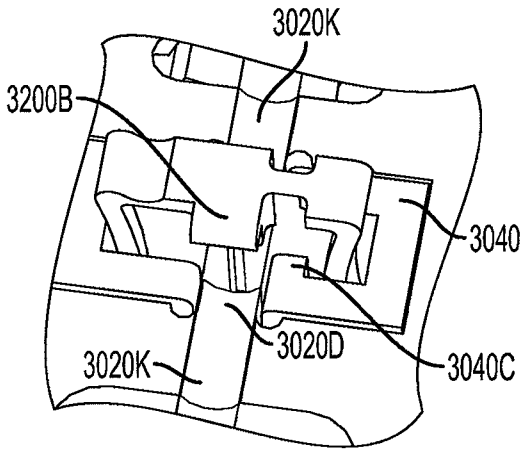


FIG. ~~259~~

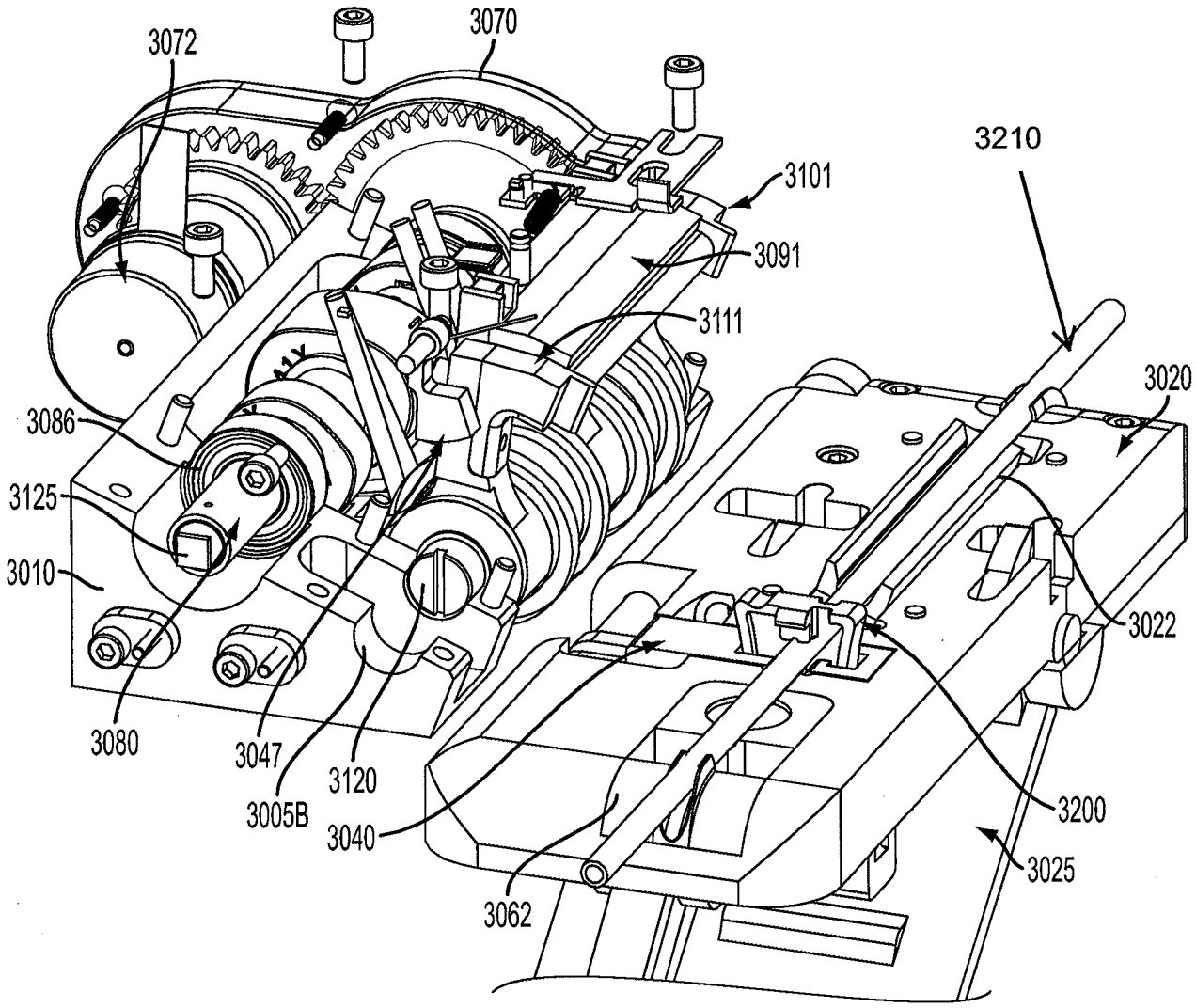

3072
3070
3210
3101
3091
3111
3020
3086
3125
3010
3022
3080
3047
3120
3005B
3040
3200
3025
3062

FIG. ~~260~~

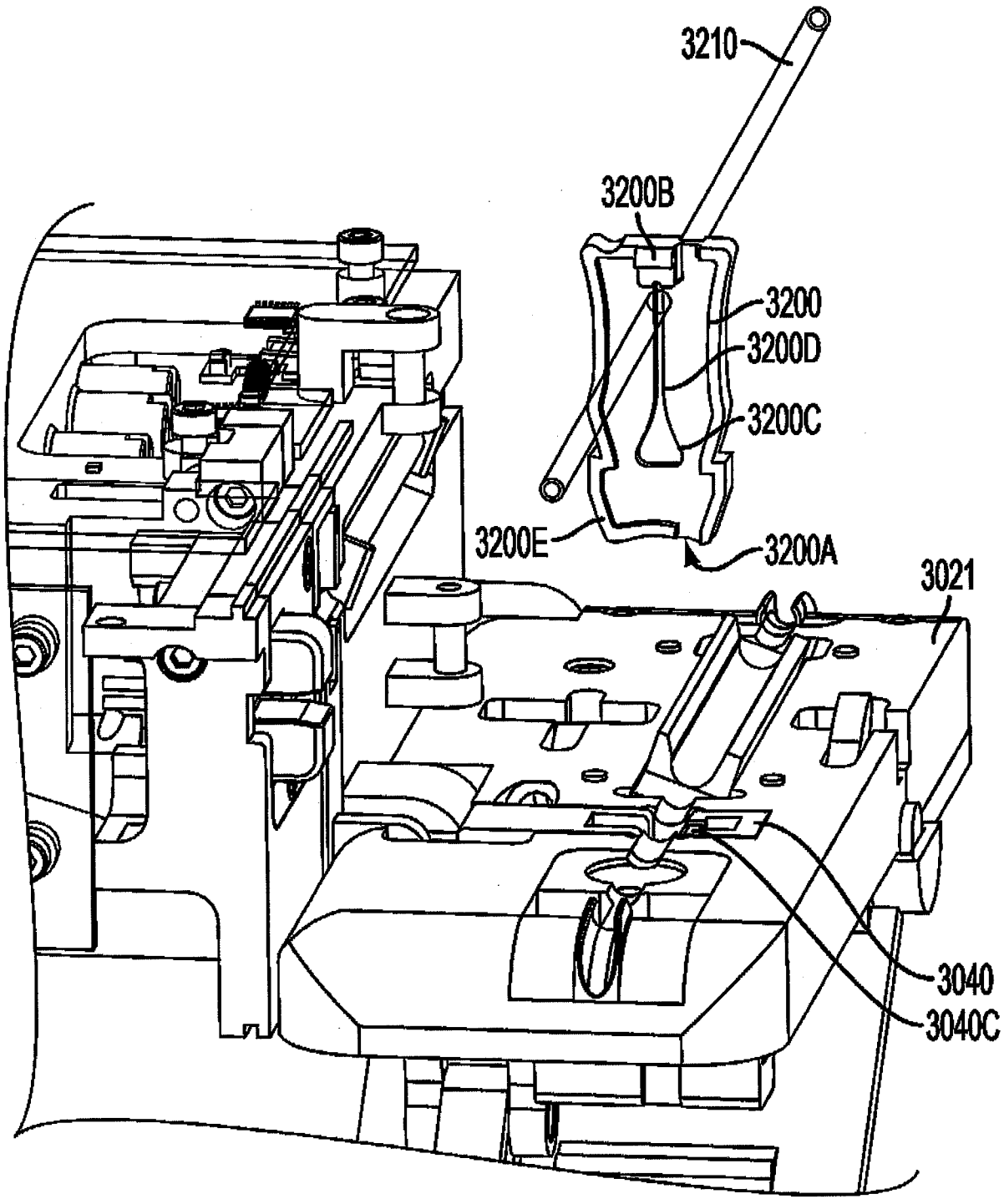


FIG. ~~261~~

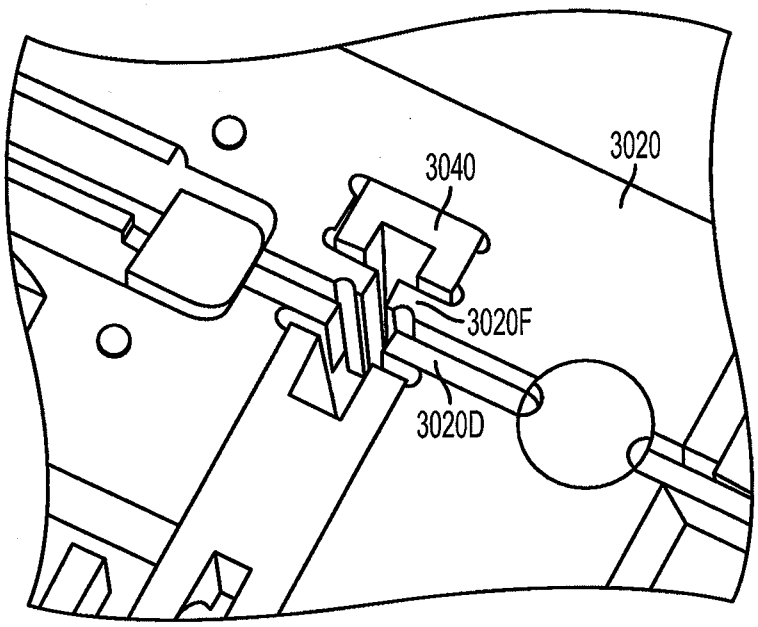


FIG. ~~262~~

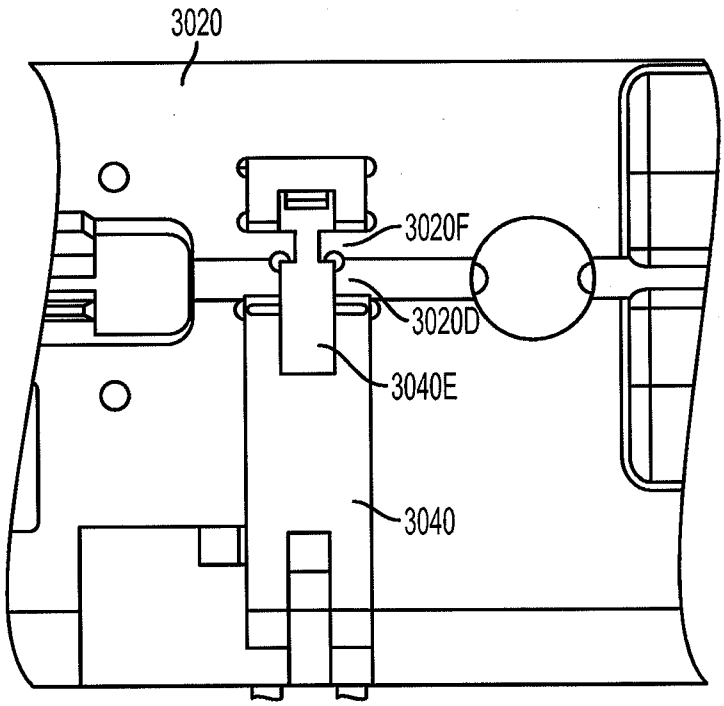


FIG. ~~263~~

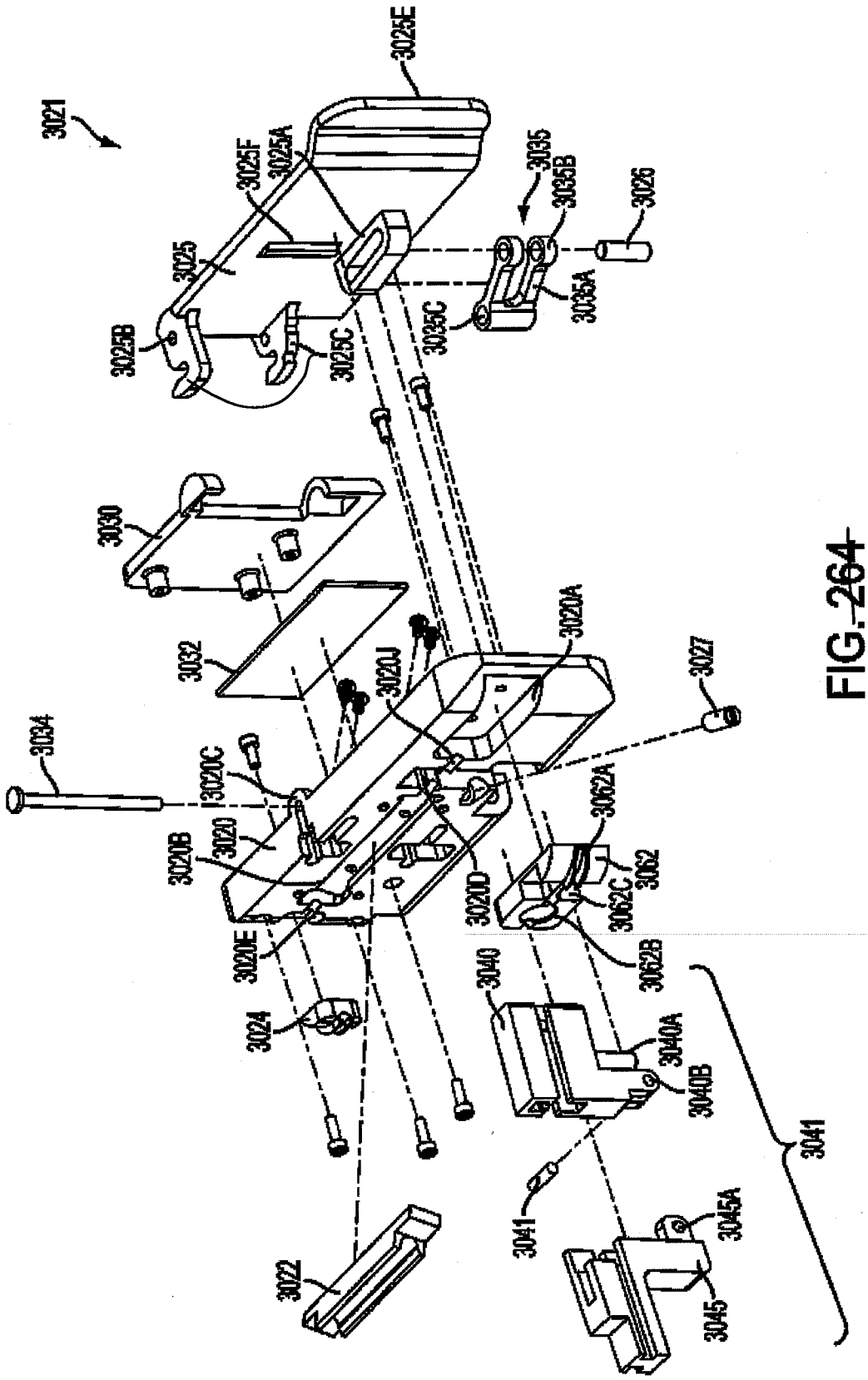

3025E
3021
3025F
3025A
3035
3036B
3026
3025
3035A
3025B
3025C
3035C
3030
3032
3020A
3020J
3027
3034
3020C
3062A
3020B
3020
3062
3020D
3062C
3020E
3062B
3040
3024
3040A
3040B
3041
3041
3045A
3022
3045

FIG. 264

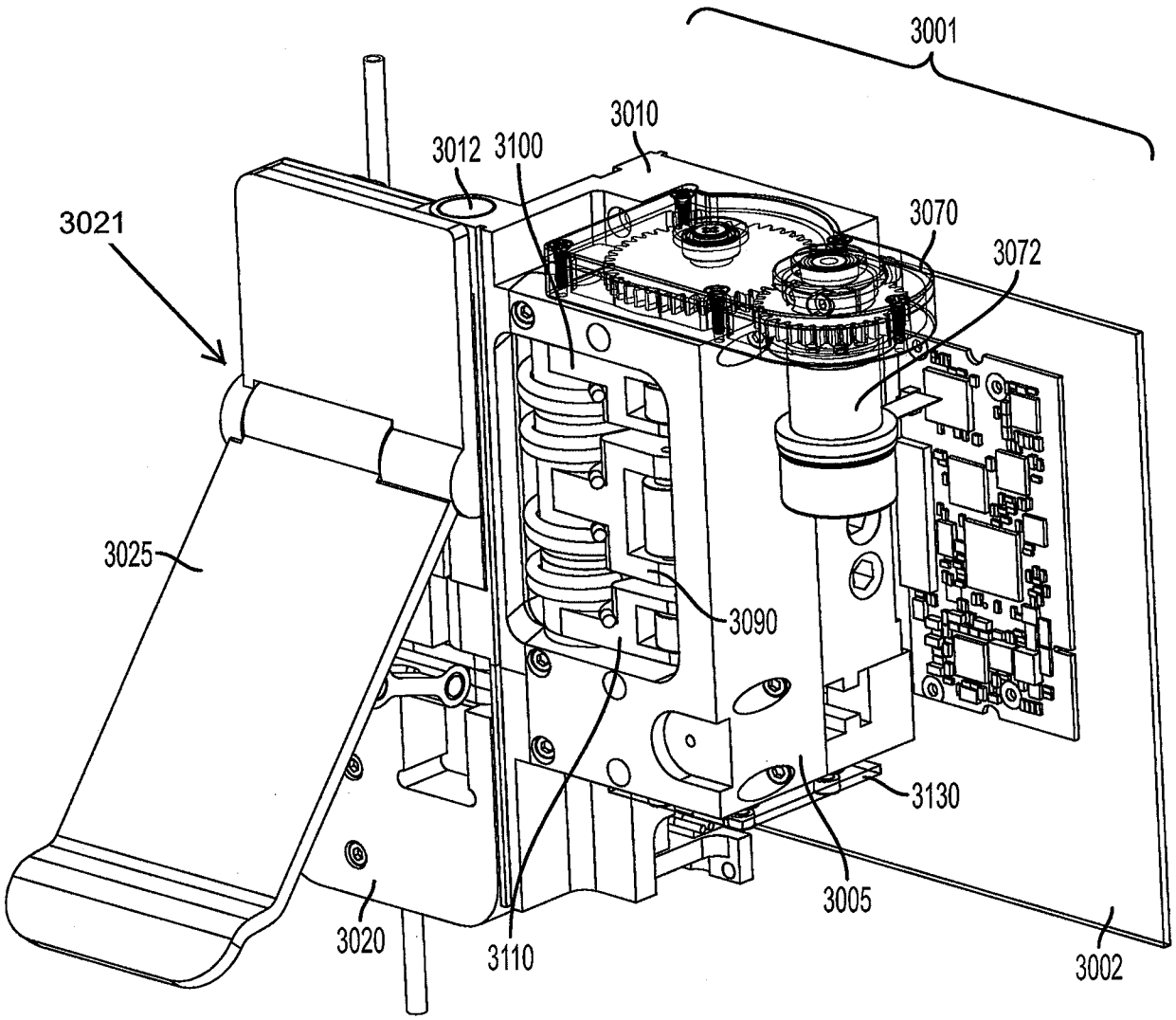

3001
3010
3012
3100
3021
3070
3072
3025
3090
3130
3005
3020
3110
3002

FIG. ~~265~~

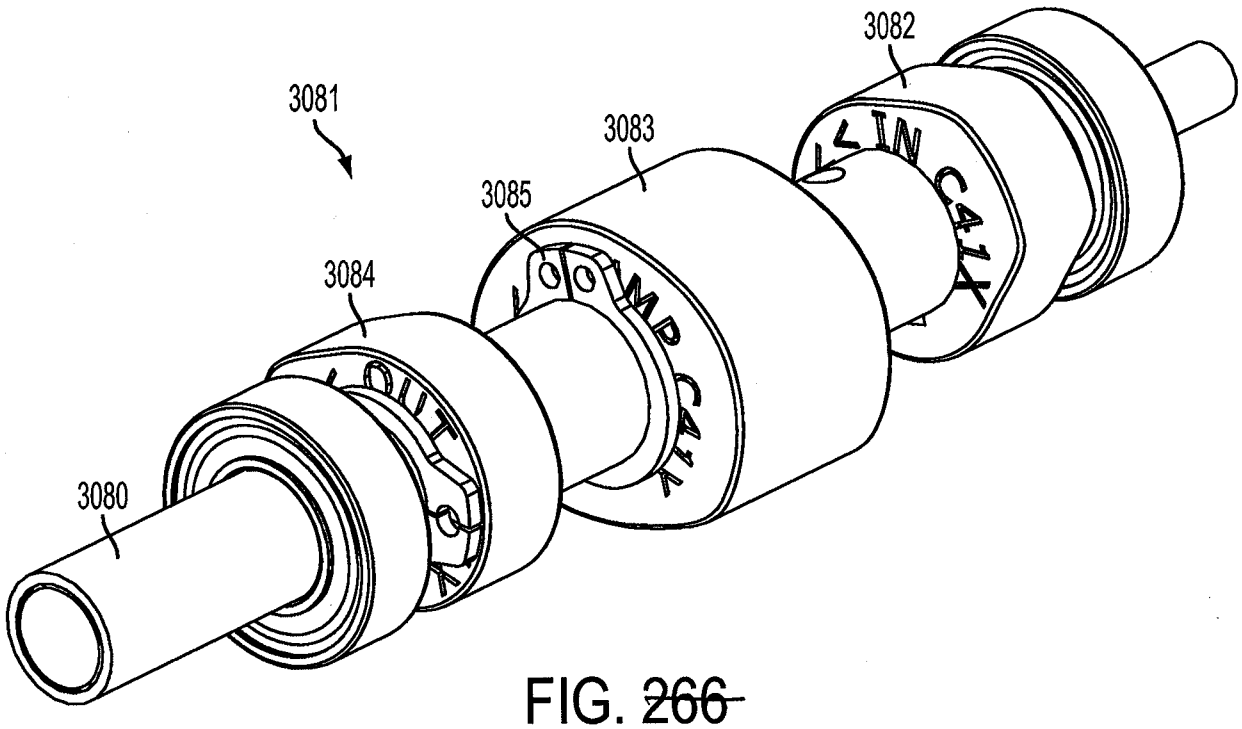


FIG. 266

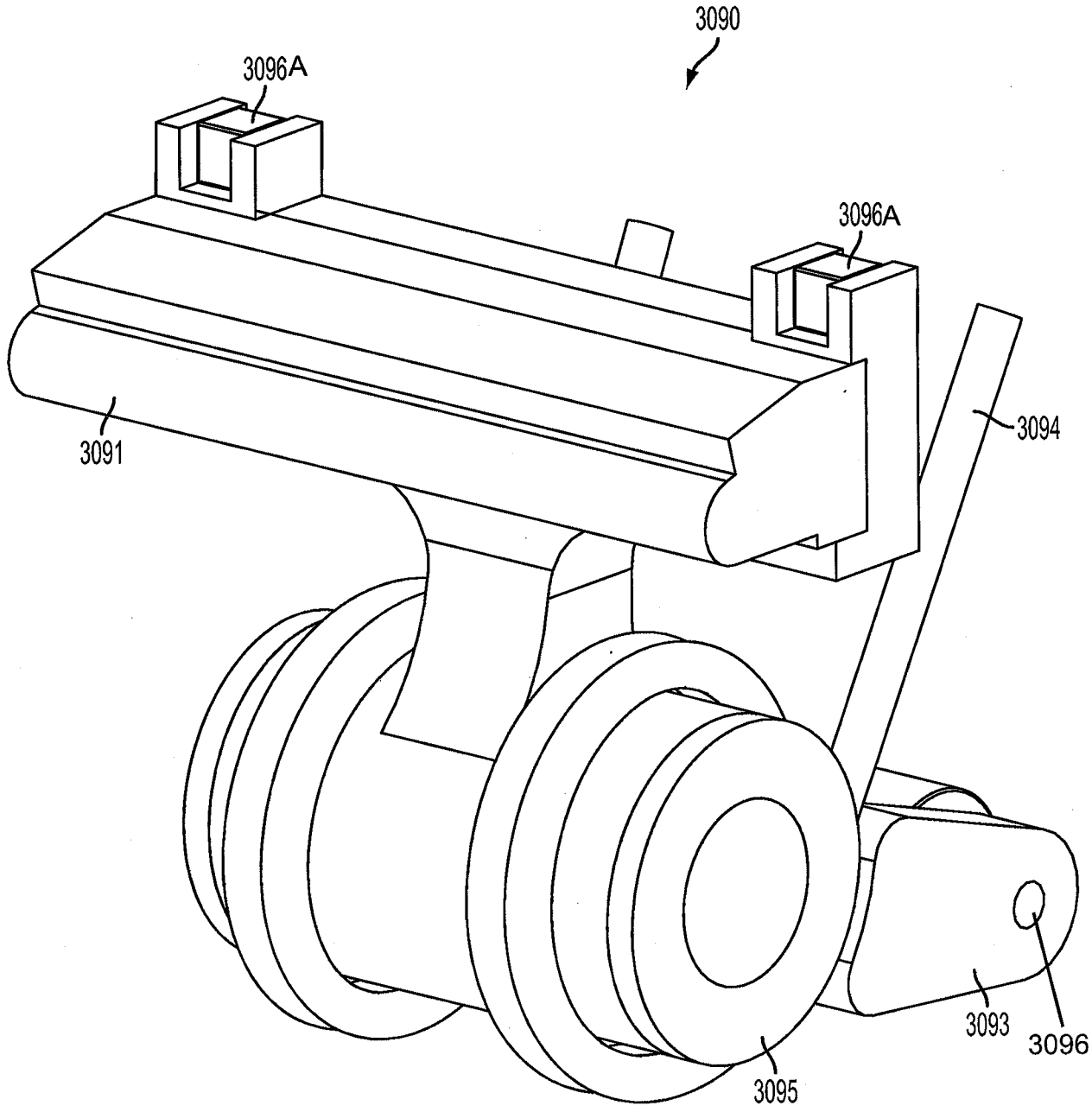


FIG. ~~267~~

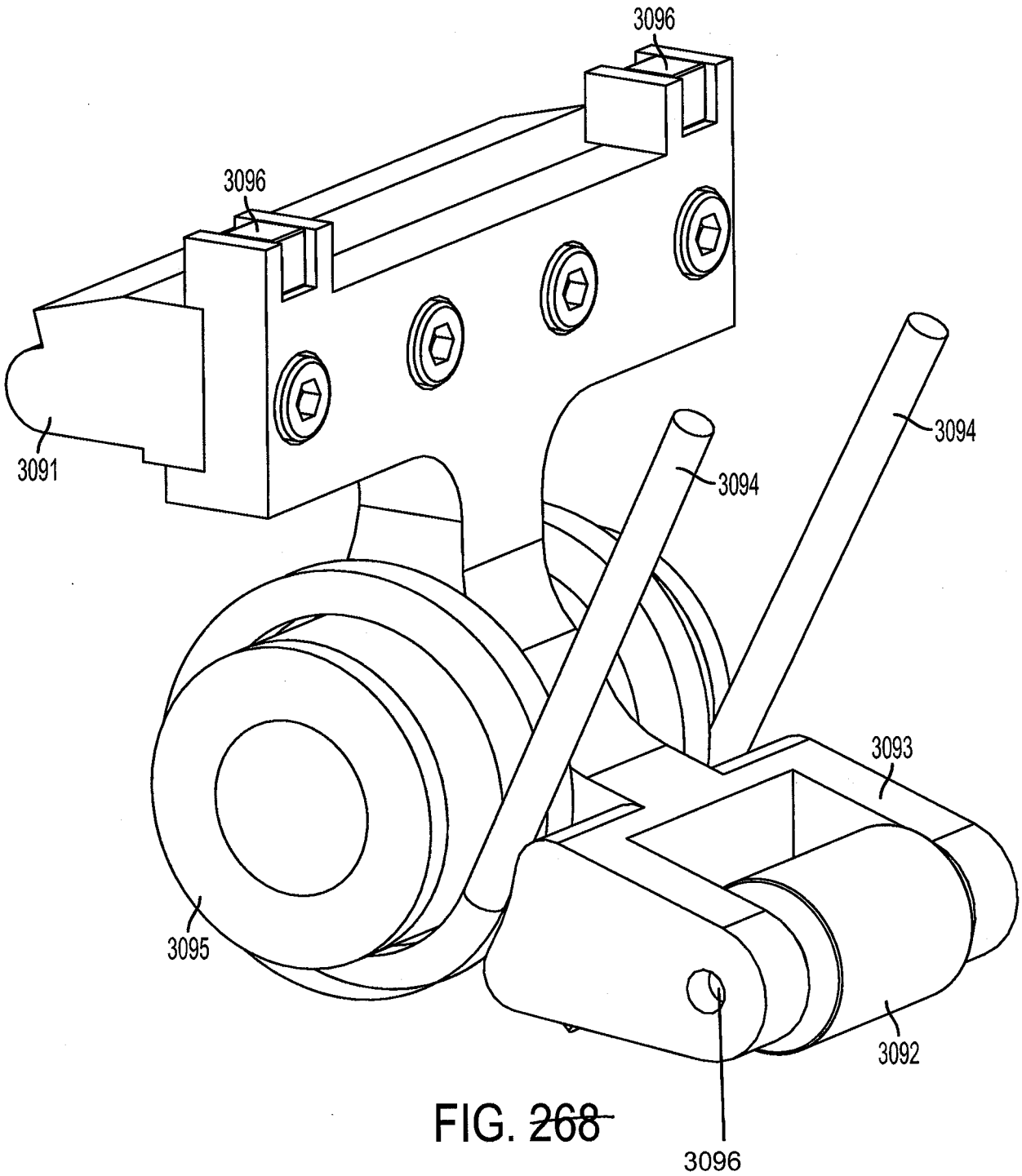


FIG. ~~268~~

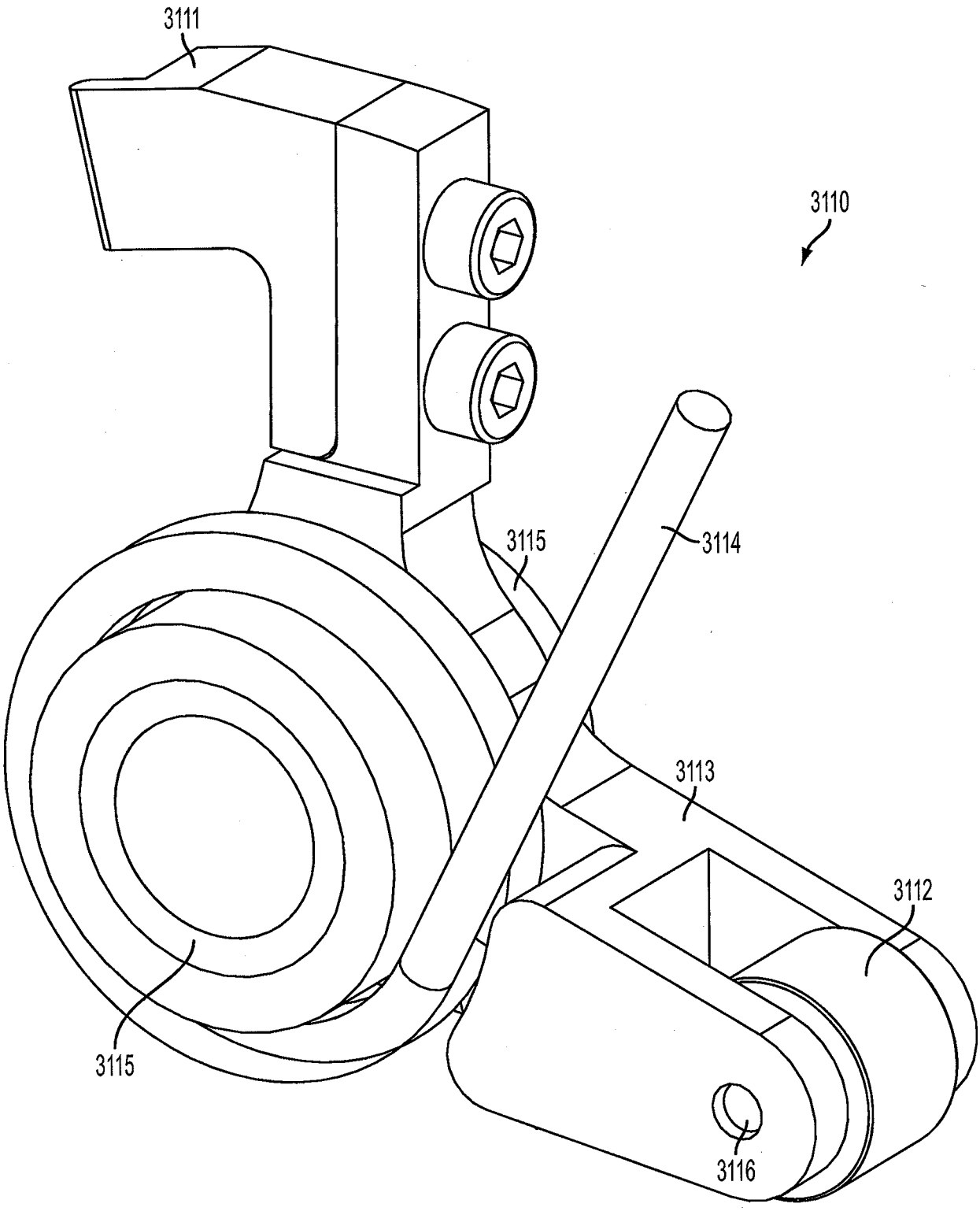


FIG. ~~269~~

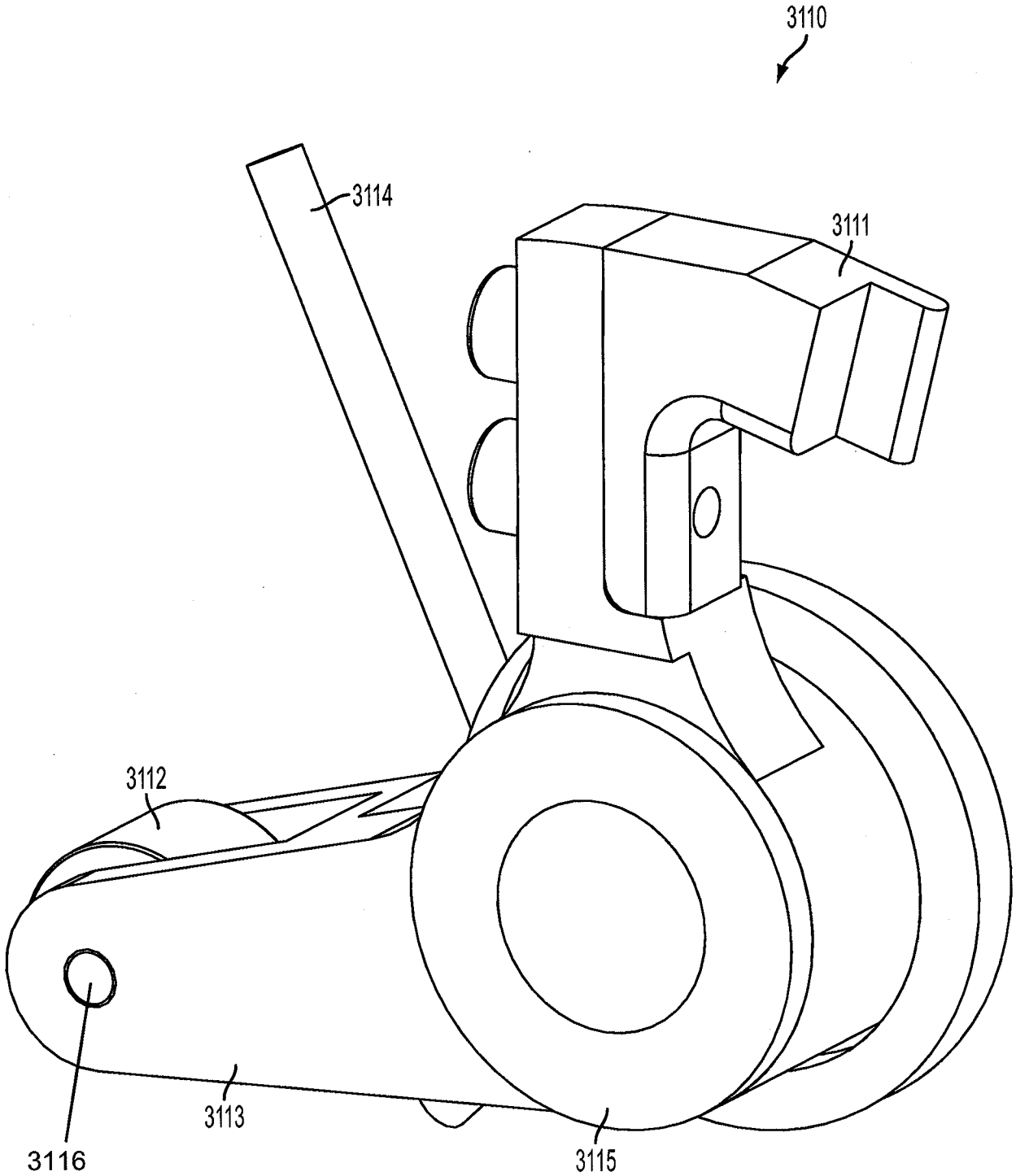


FIG. ~~270~~

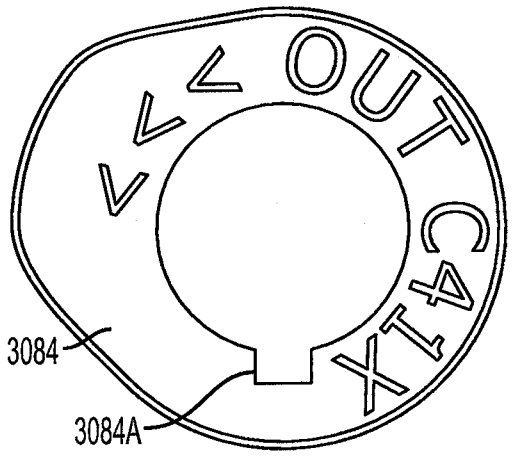


FIG. ~~271~~

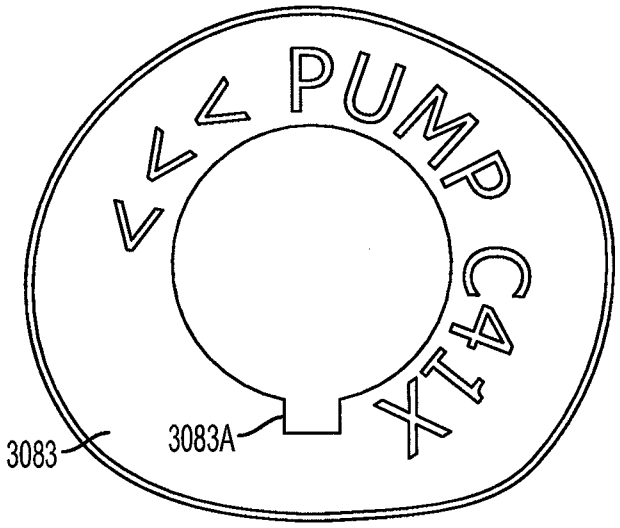


FIG. ~~272~~

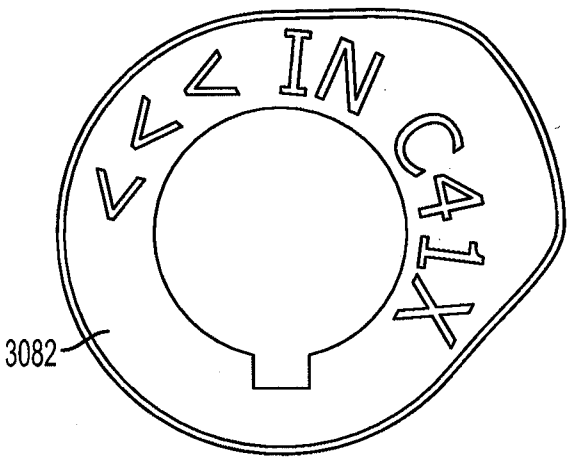


FIG. ~~273~~

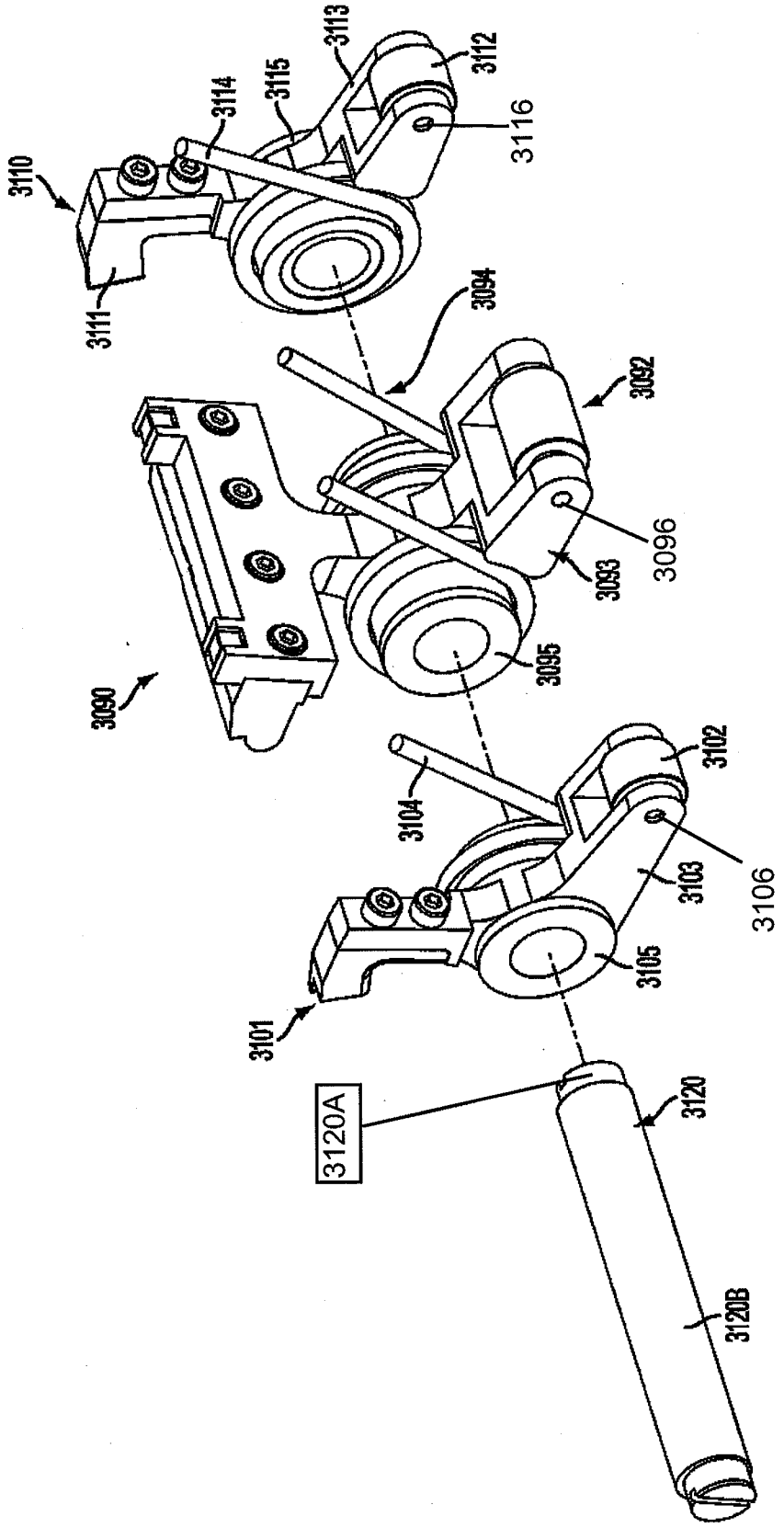

3110
3111
3114
3115
3113
3112
3116
3094
3092
3096
3093
3095
3090
3104
3102
3103
3106
3105
3101
3120A
3120
3120B

FIG. ~~274~~

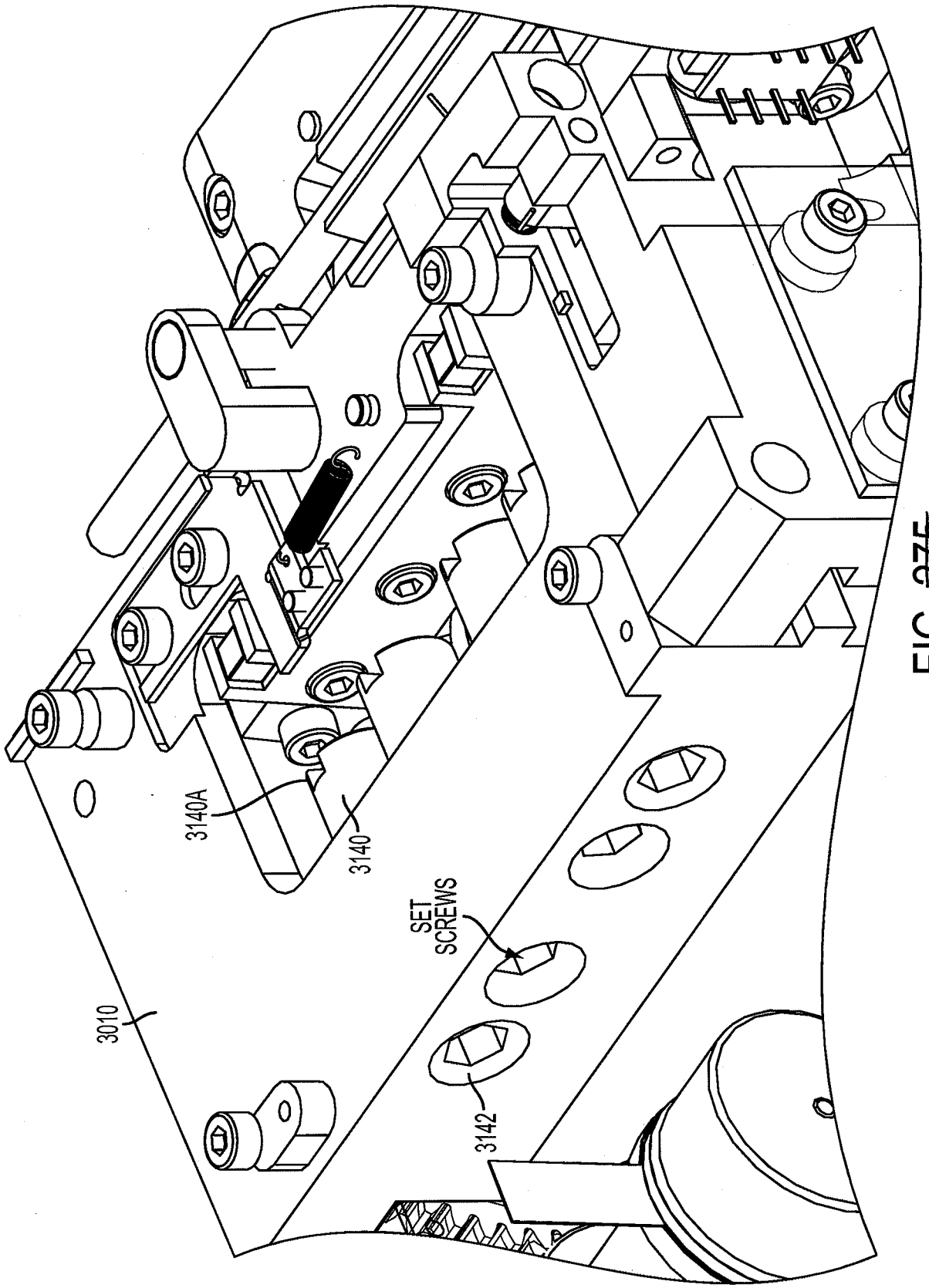


FIG. ~~275~~

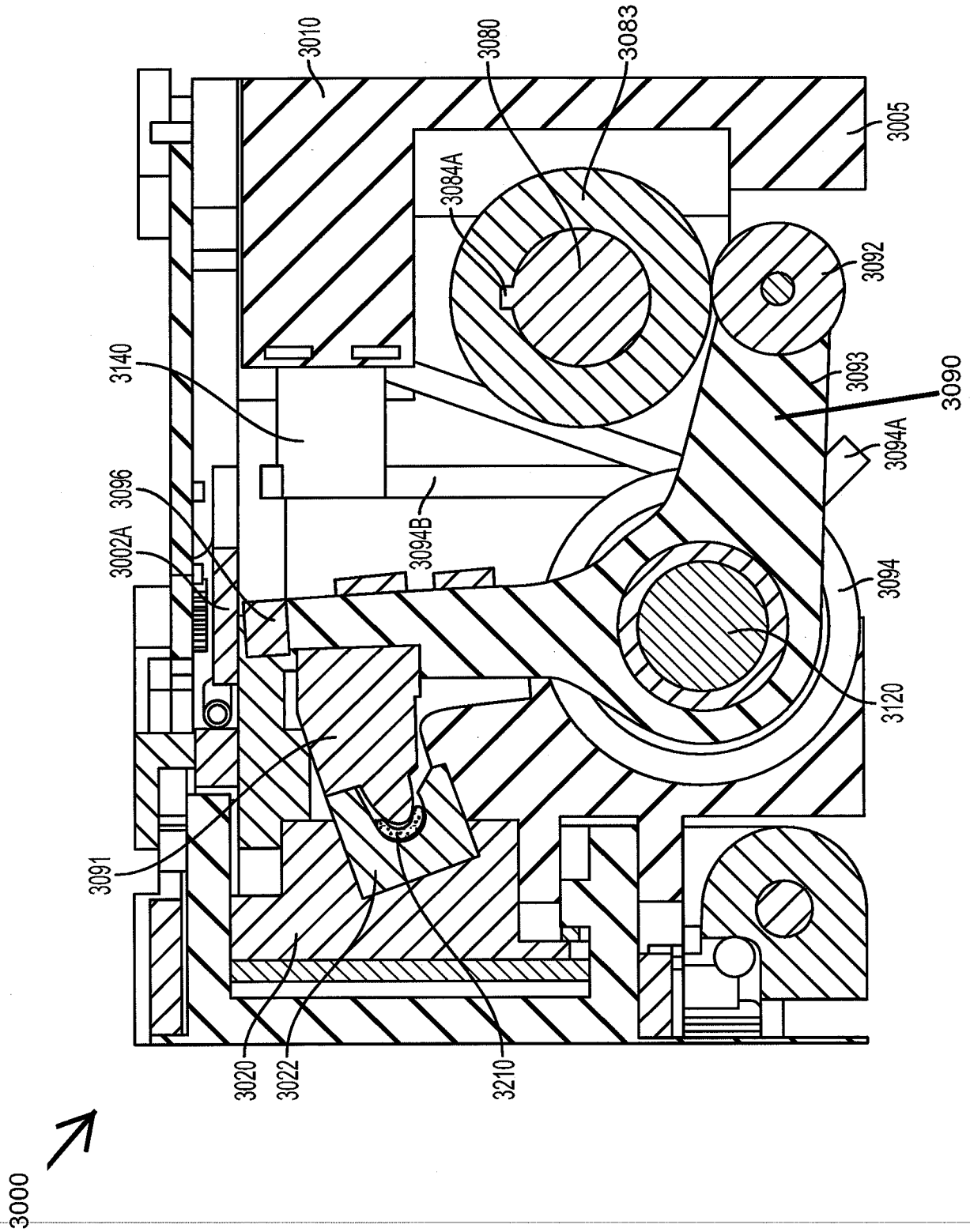

3000
3010
3080
3083
3005
3084A
3092
3140
3093
3090
3094A
3096
3002A
3094B
3094
3120
3091
3020
3022
3210

FIG. 276

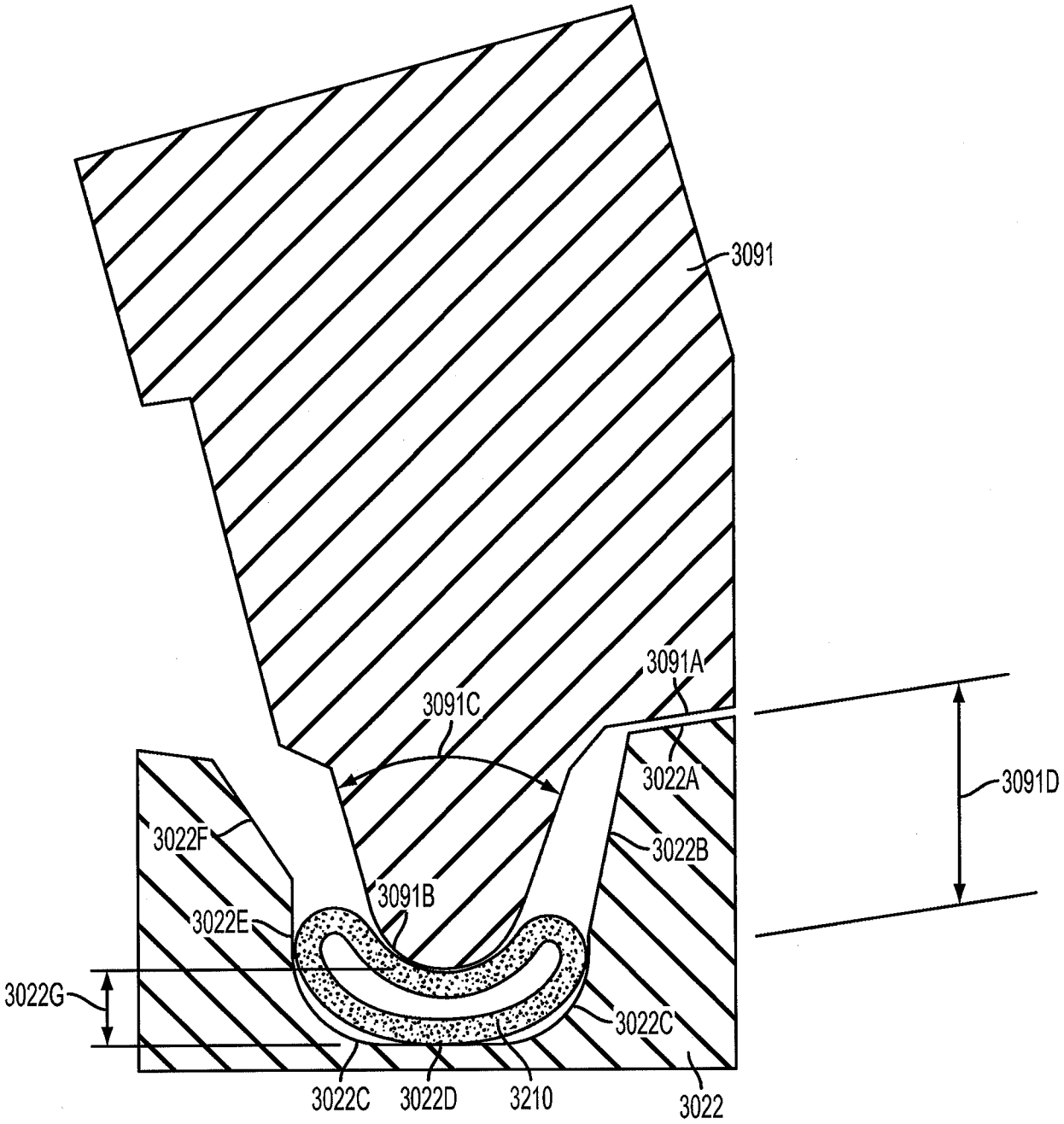

3091
3091A
3091C
3091D
3022A
3022F
3022B
3091B
3022E
3022G
3022C
3022C
3022D
3210
3022

FIG. 277

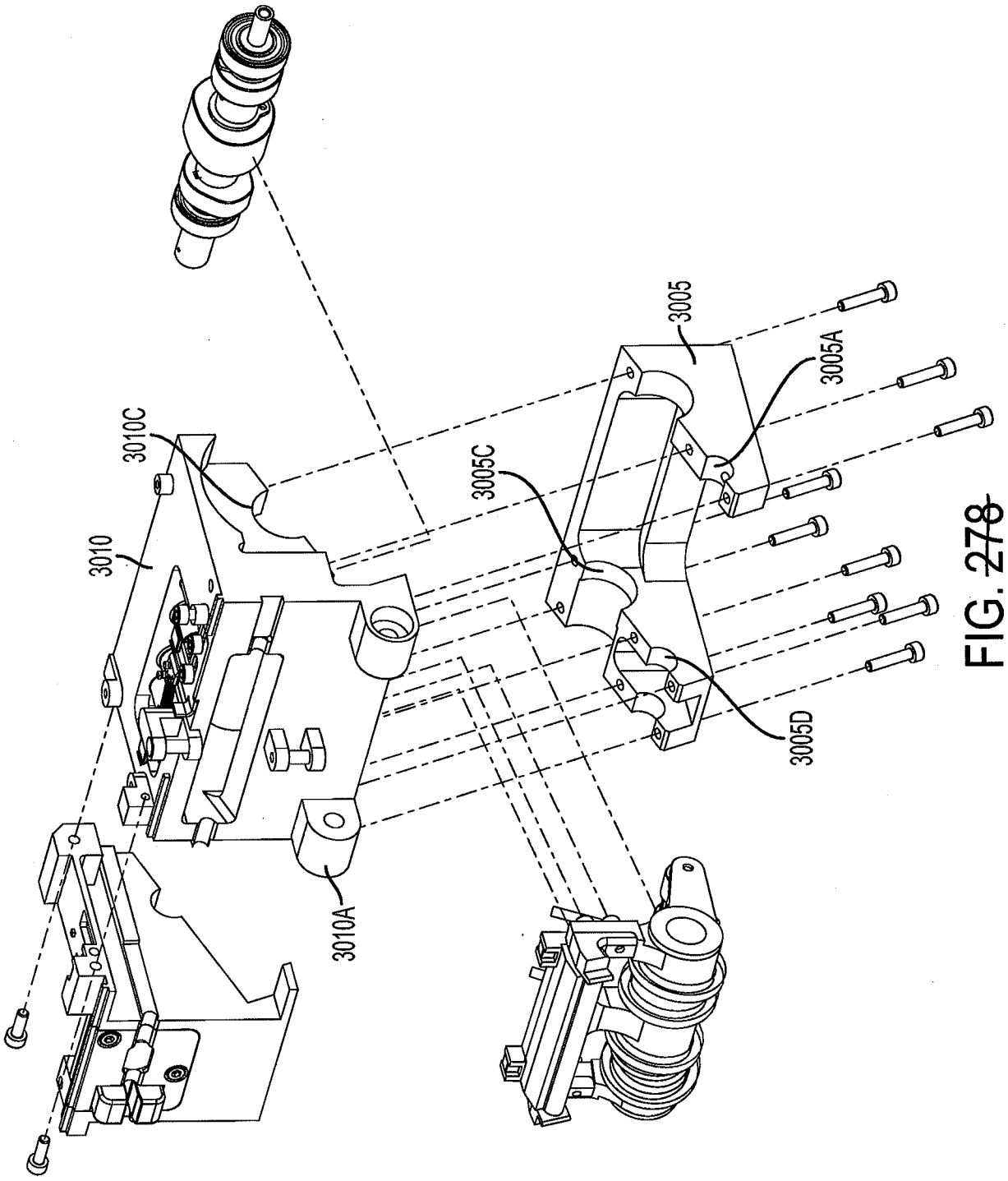


FIG. ~~278~~

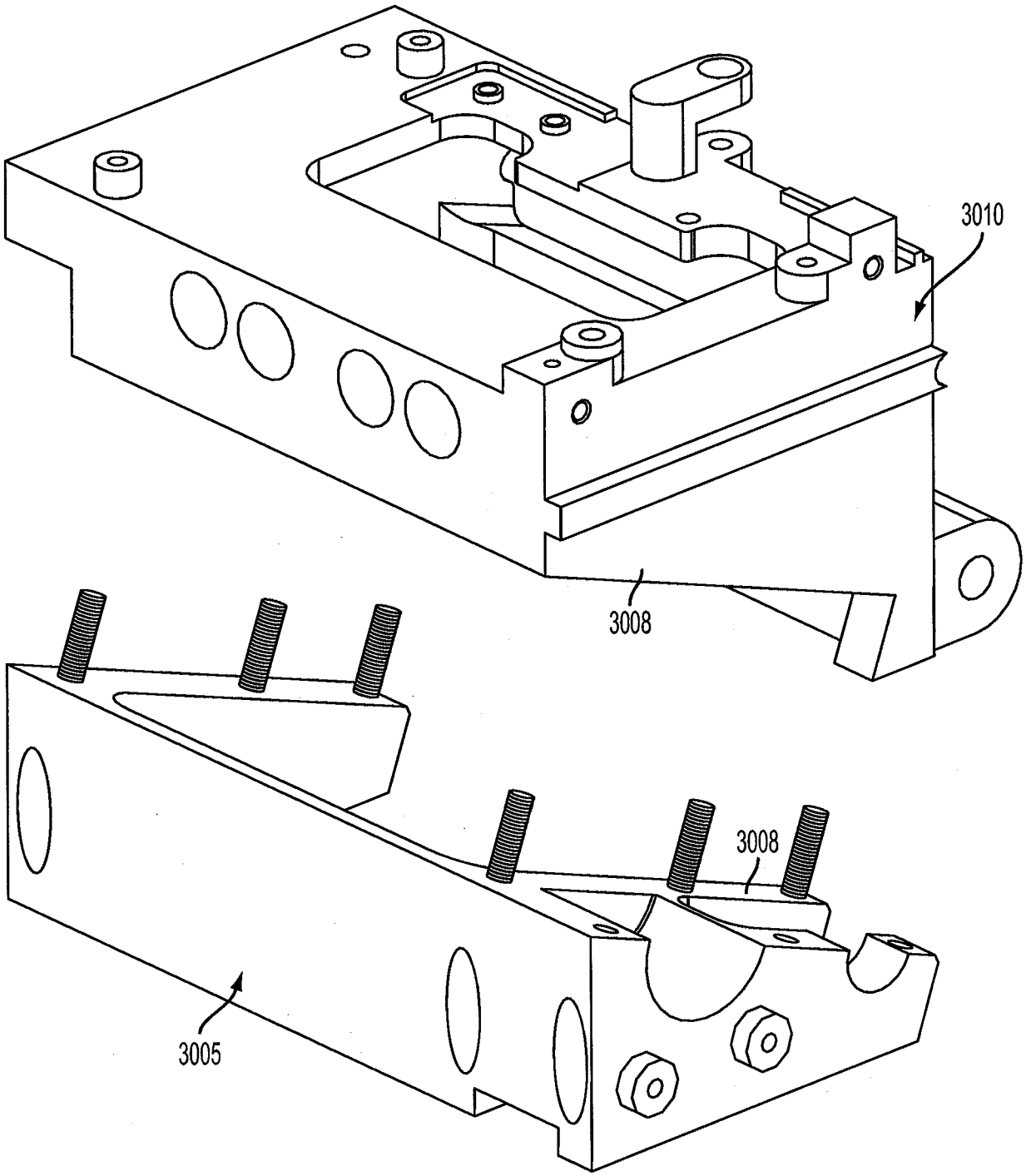


FIG. ~~279~~

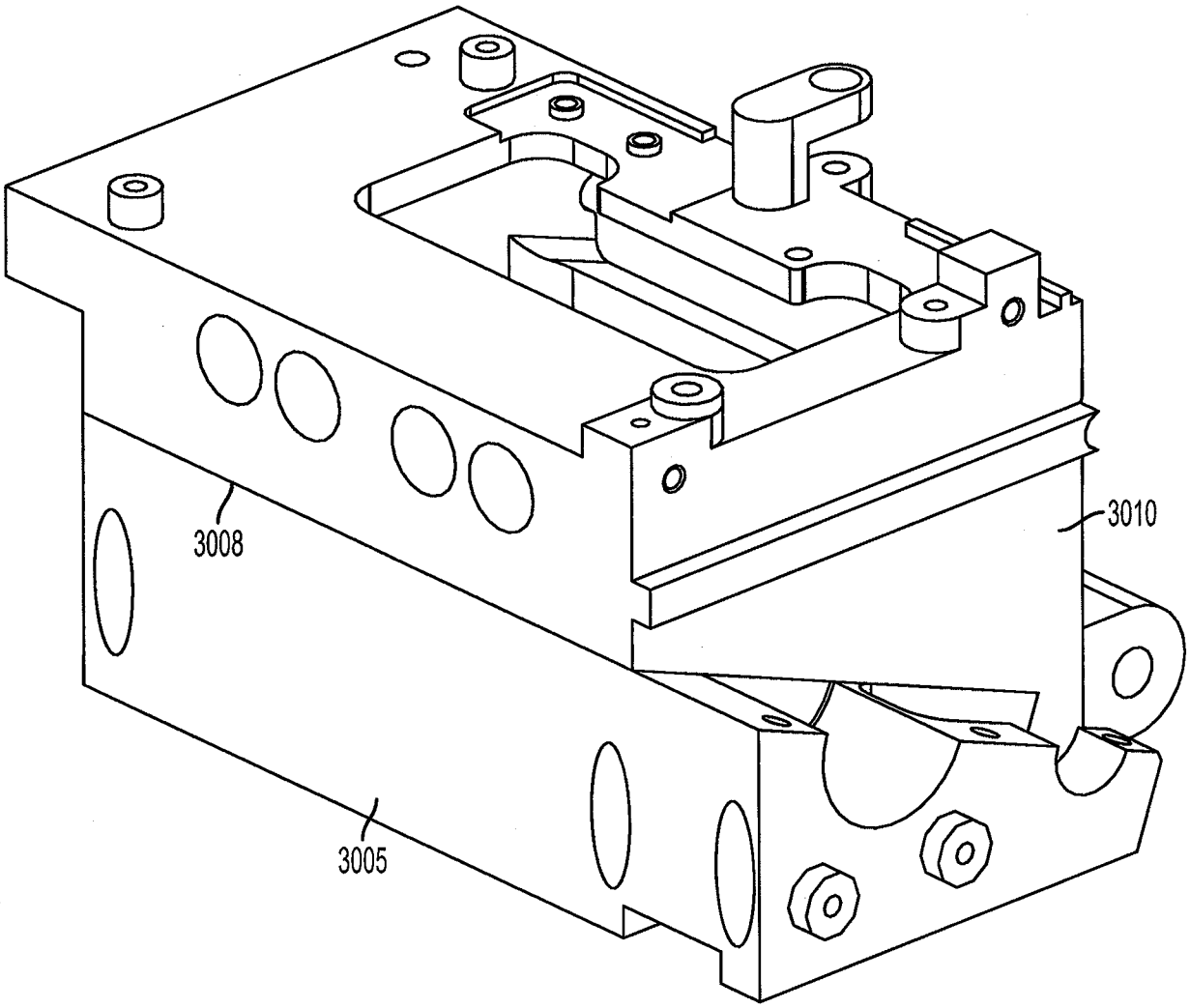


FIG. ~~280~~

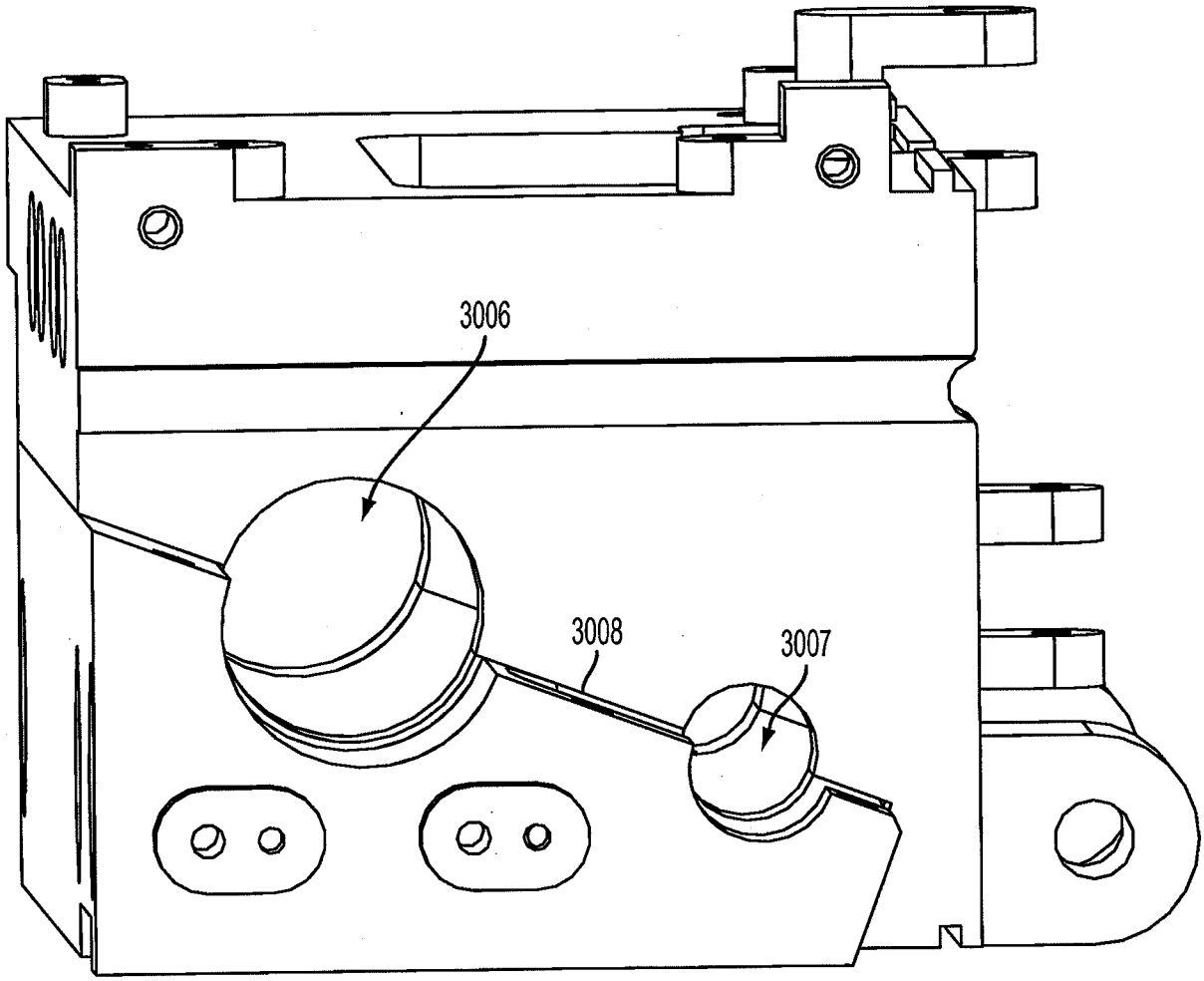


FIG. 281

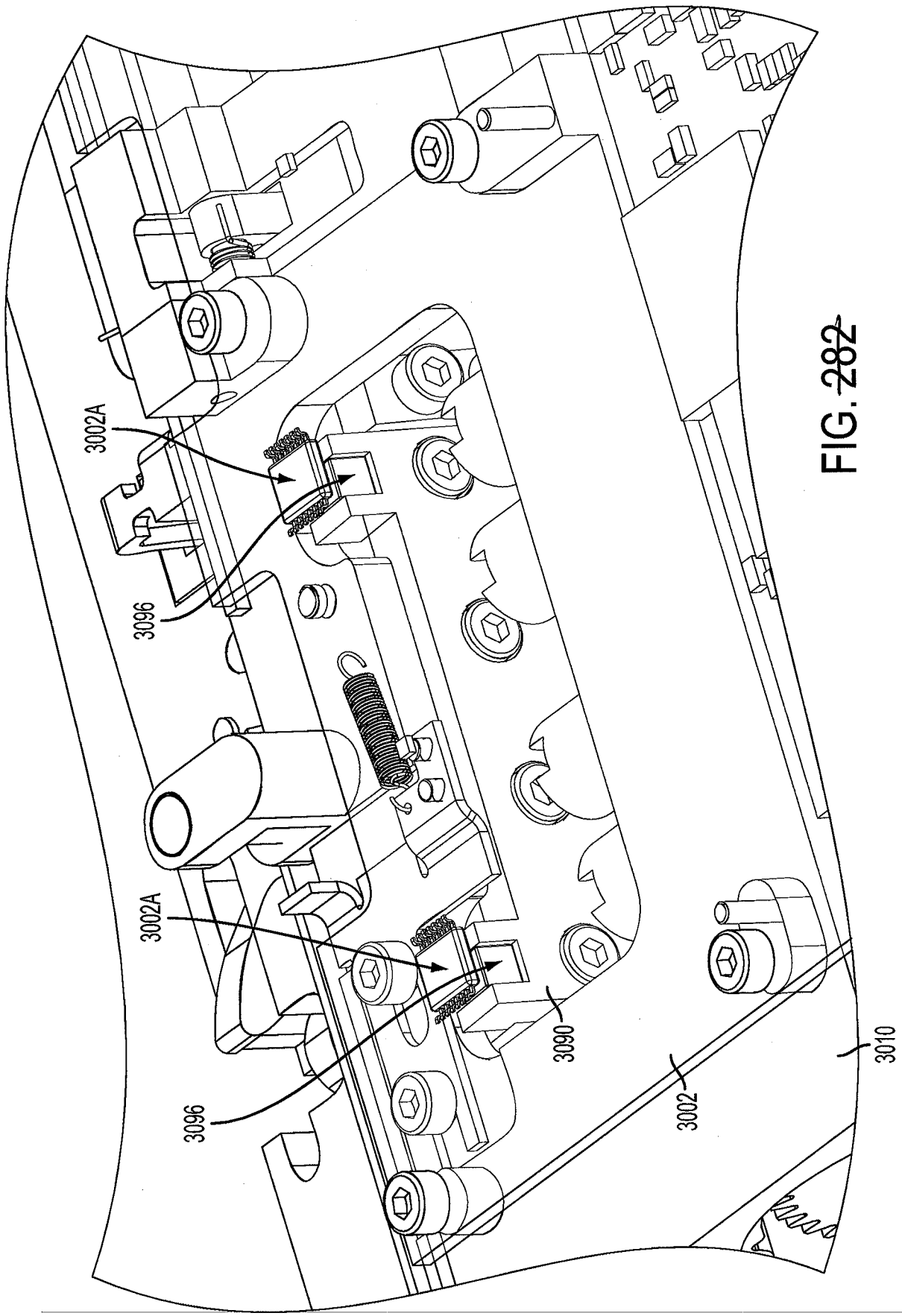


FIG. ~~282~~

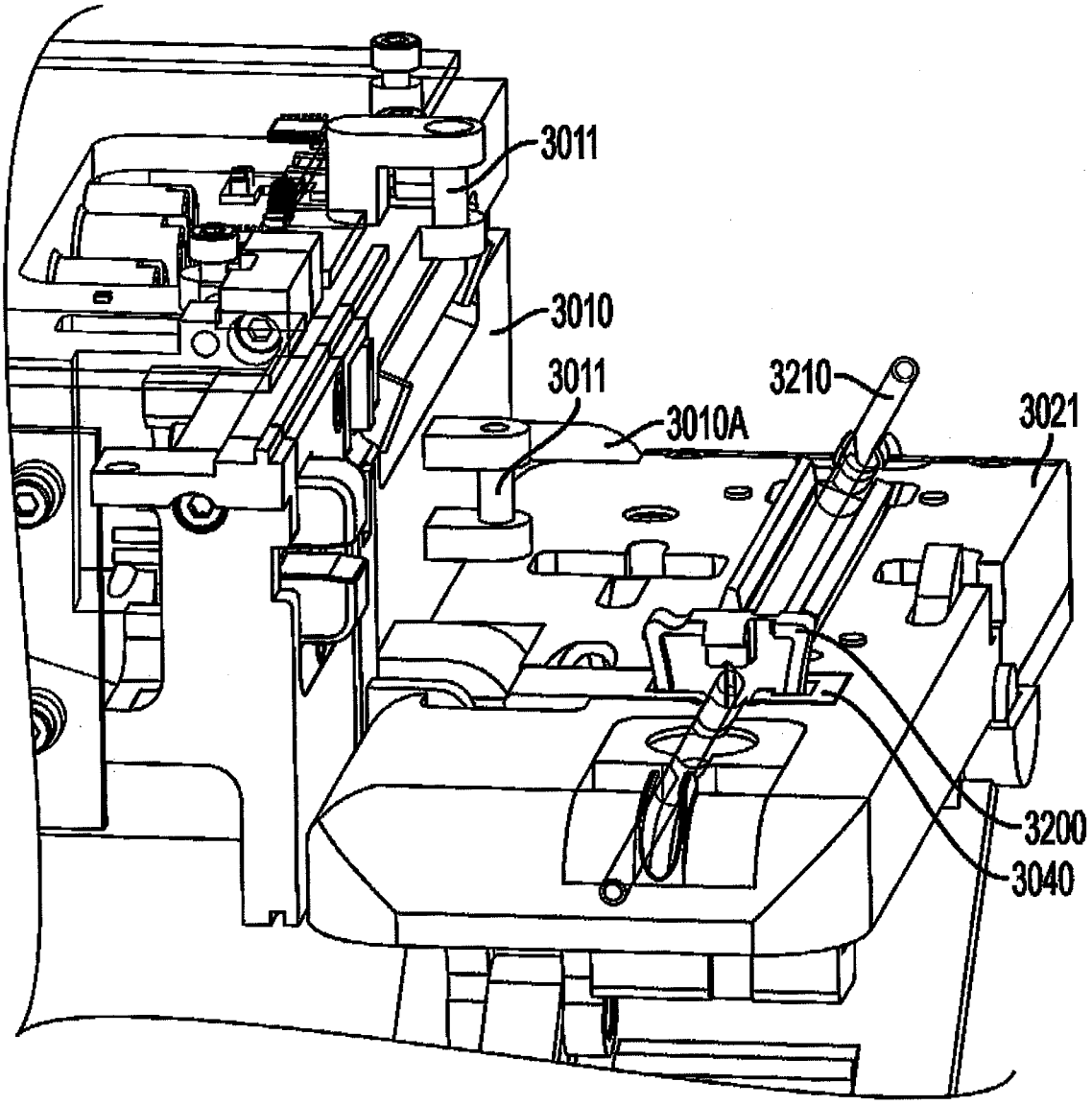


FIG. ~~283~~

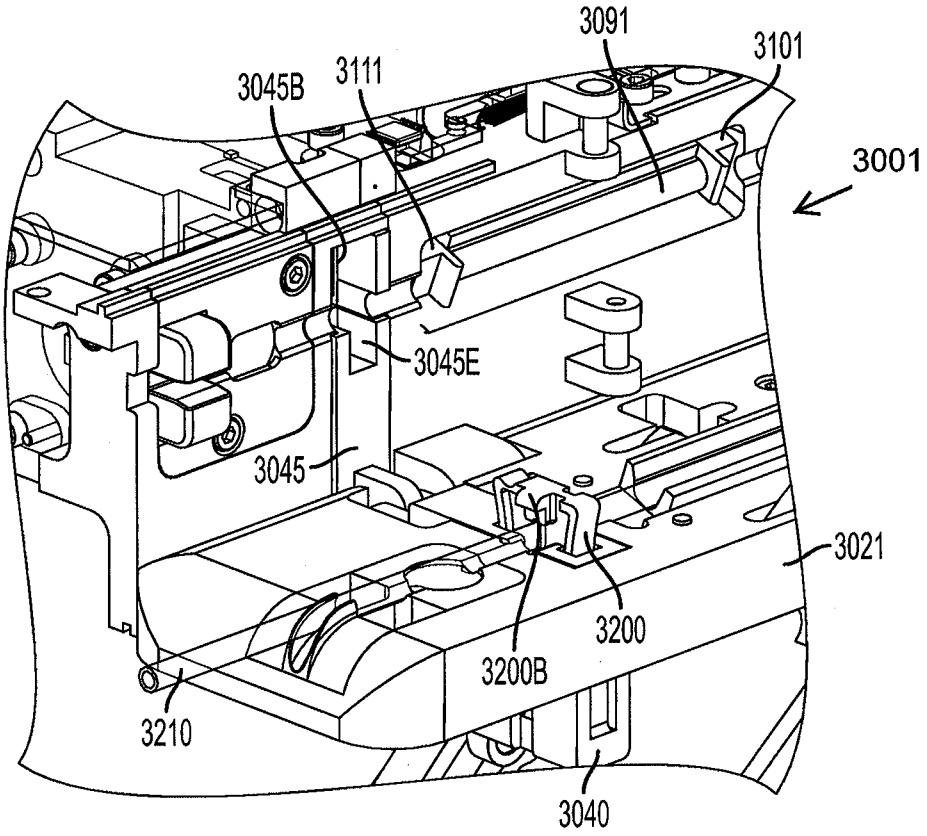

3091
3101
3111
3045B
3001
3045E
3045
3021
3200
3200B
3210
3040

FIG. ~~284~~

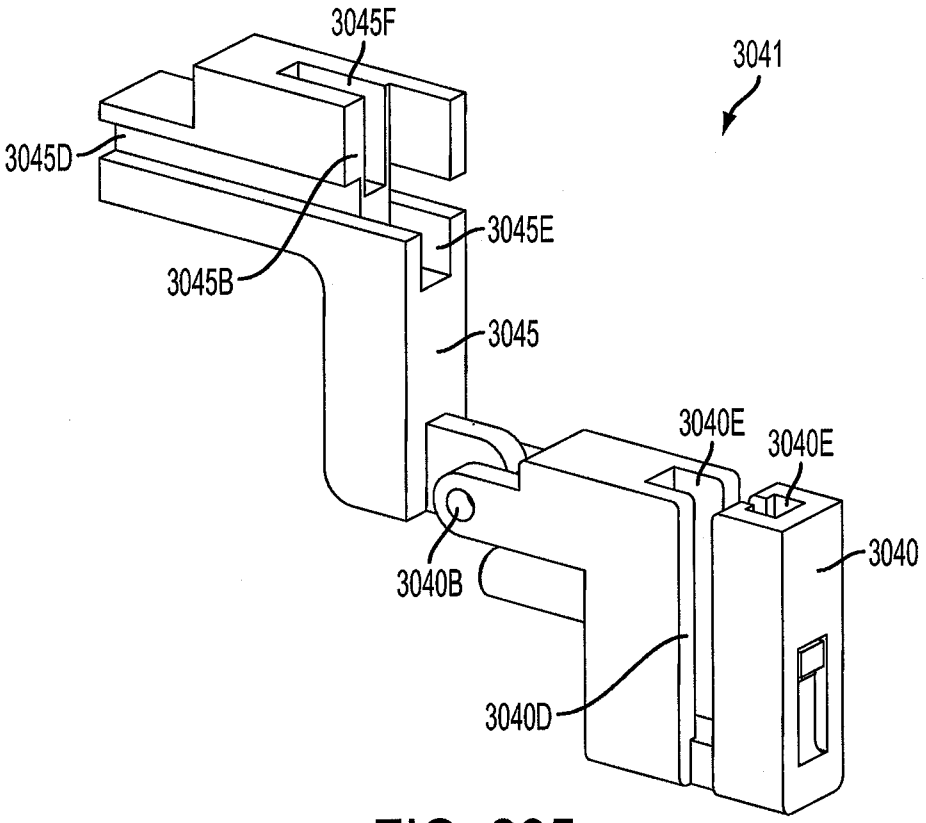


FIG. ~~285~~

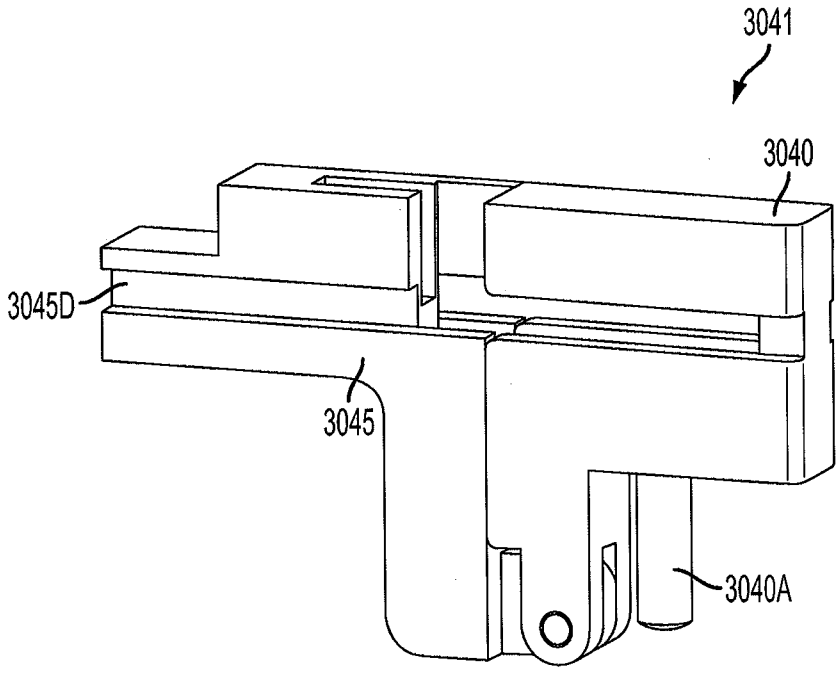


FIG. ~~286~~

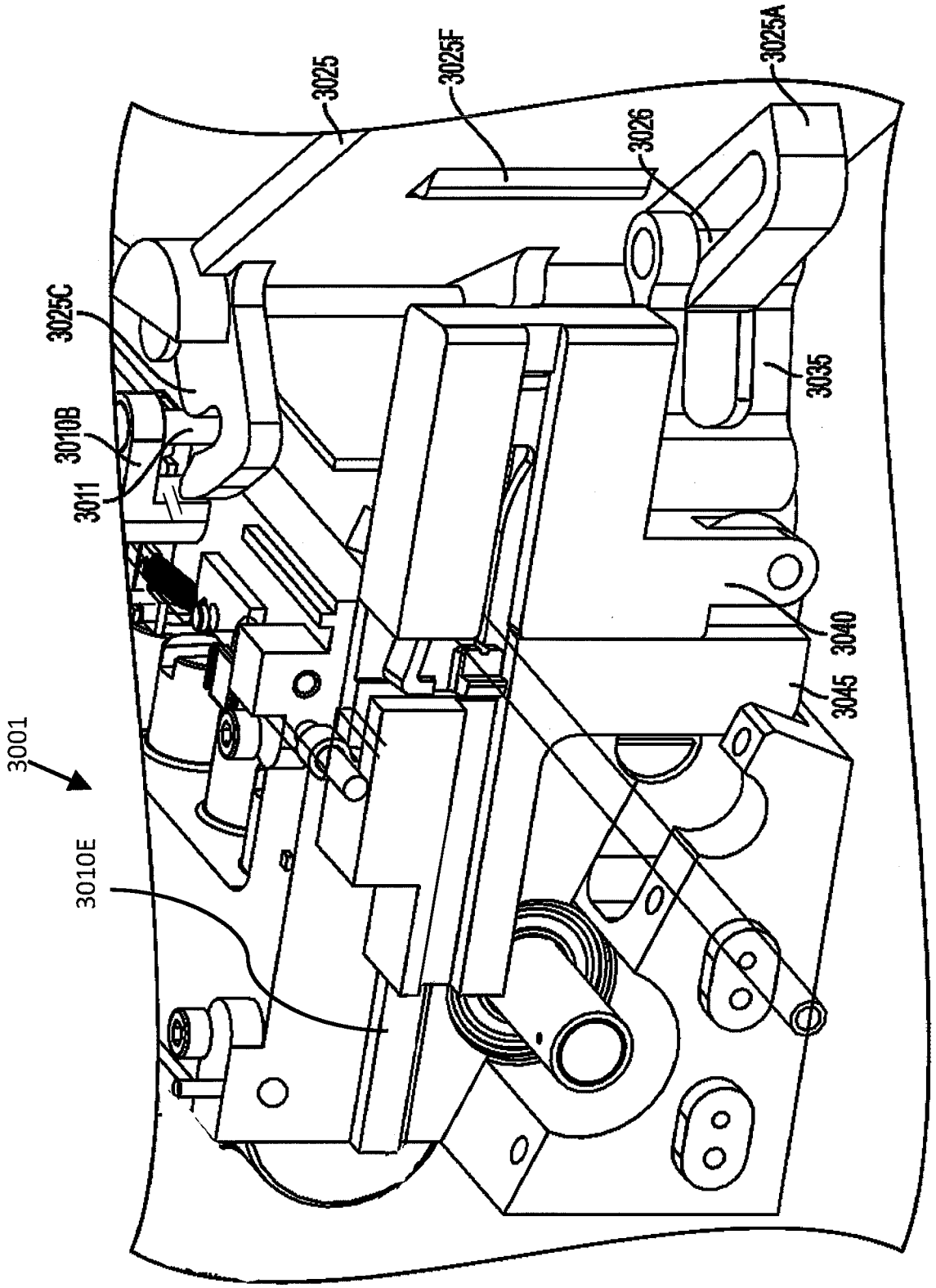

3001
3010E
3011
3010B
3025C
3025
3025F
3025A
3026
3035
3040
3045

FIG. 287

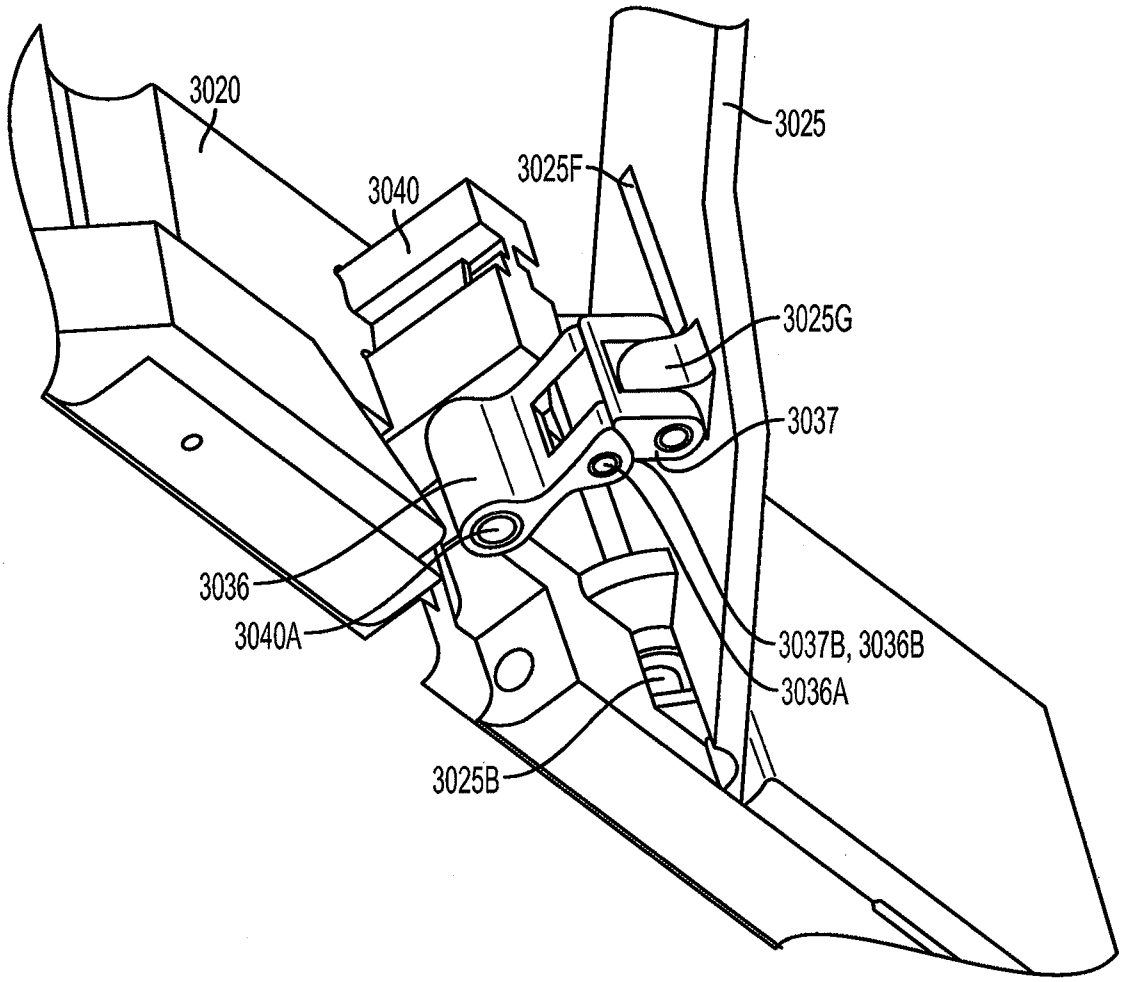

3020
3040
3025F
3025
3025G
3037
3036
3040A
3037B, 3036B
3036A
3025B

FIG. ~~288~~

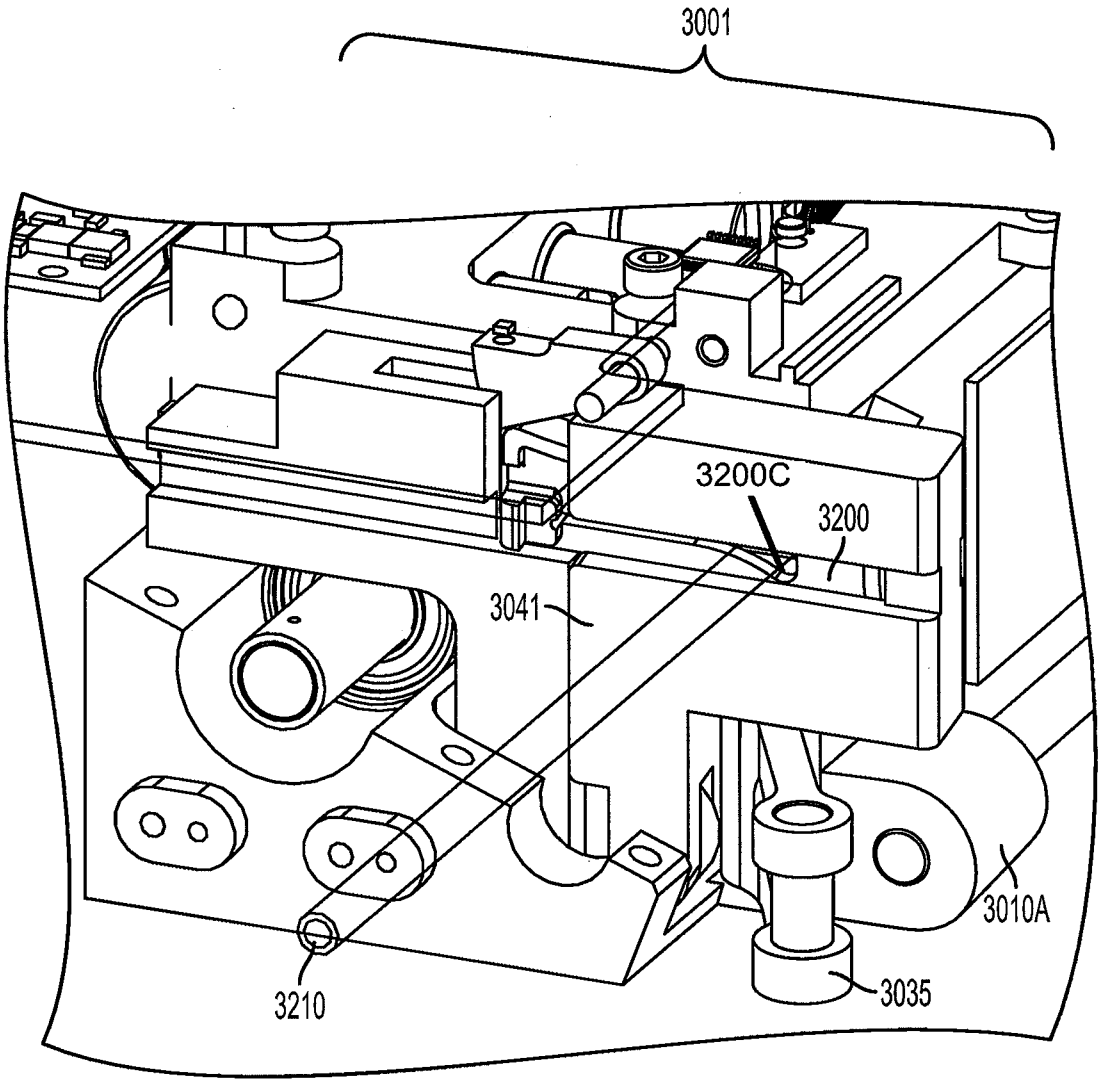


FIG. ~~289~~

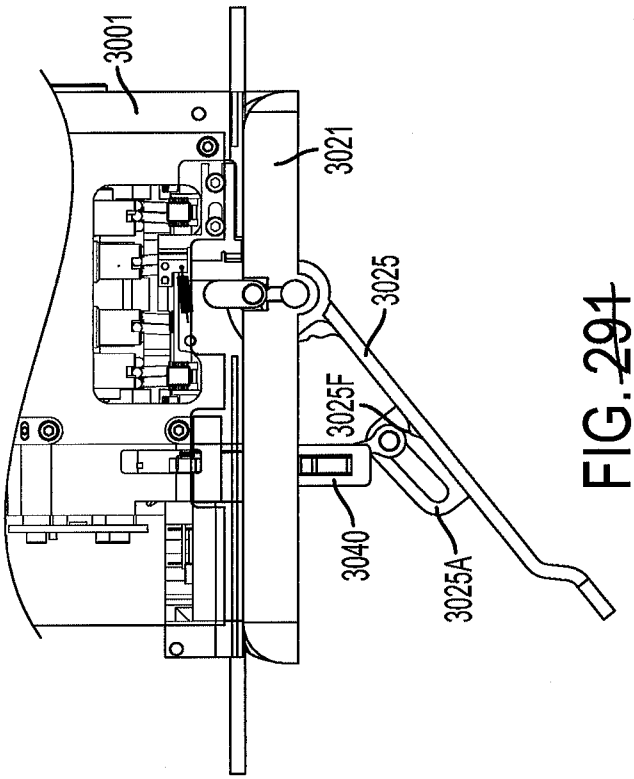


FIG. 291

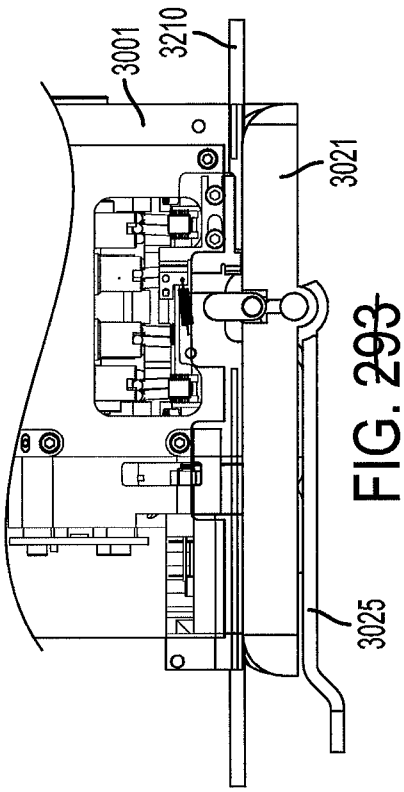


FIG. 293

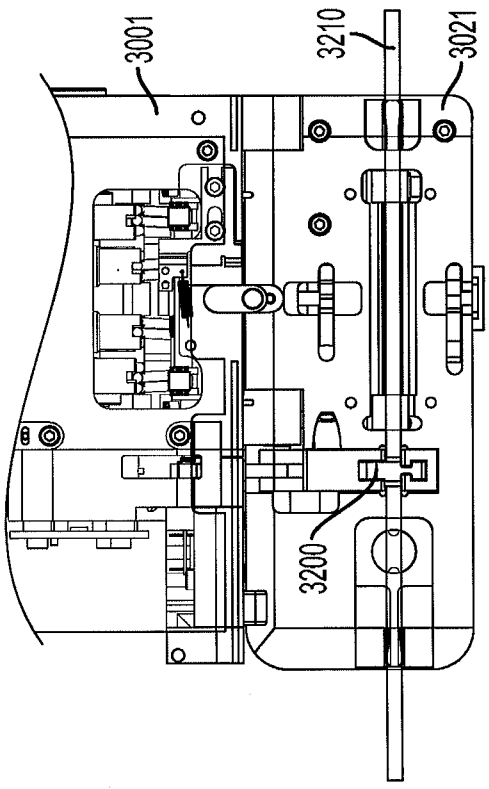


FIG. 290

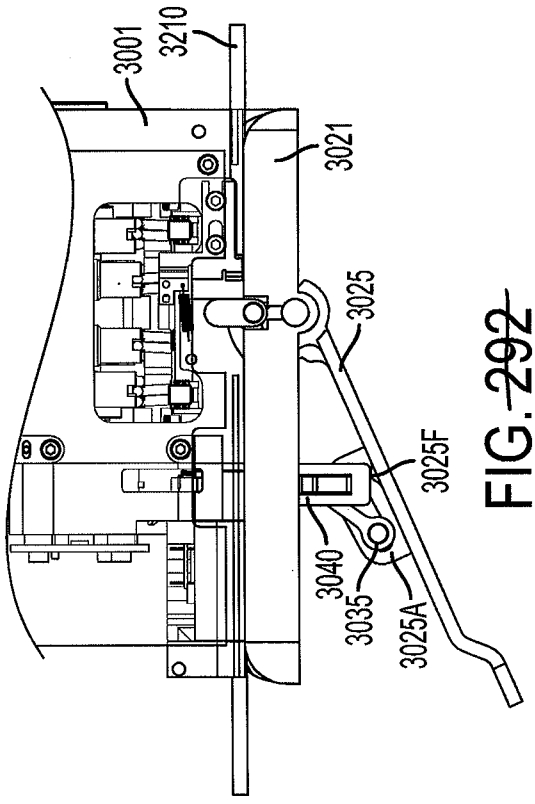


FIG. 292

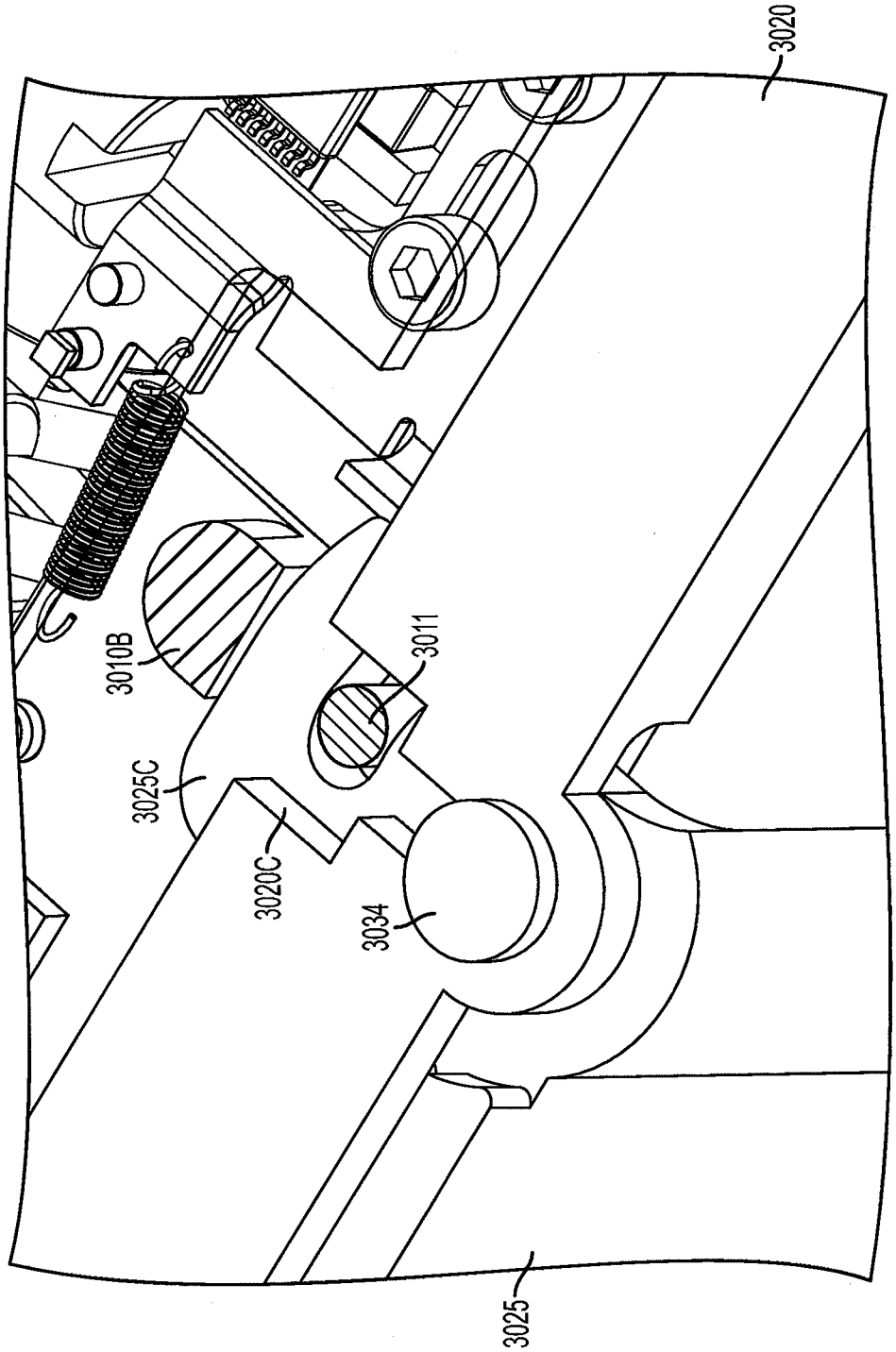


FIG. ~~294~~

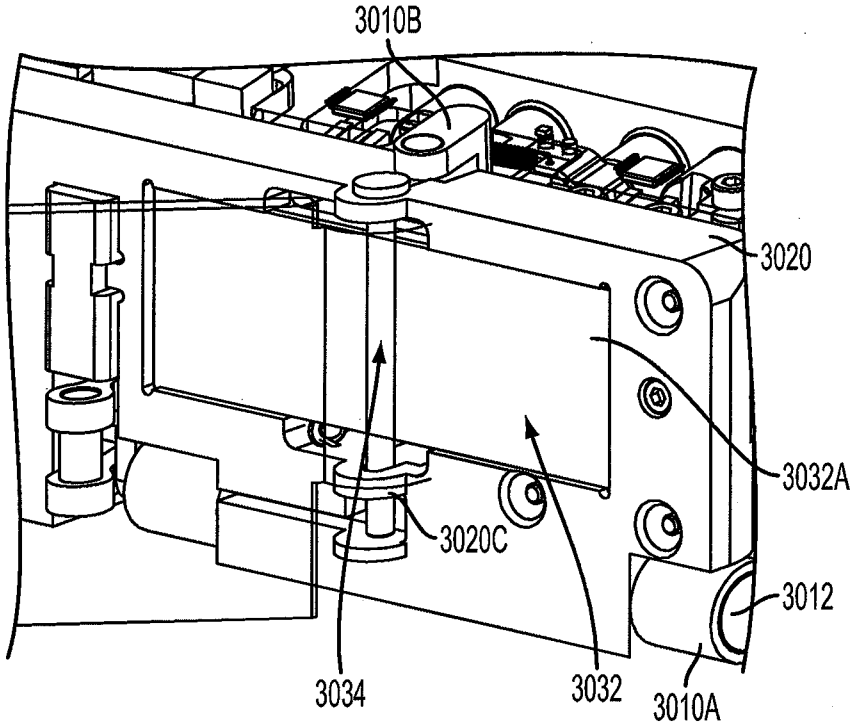


FIG. ~~295~~

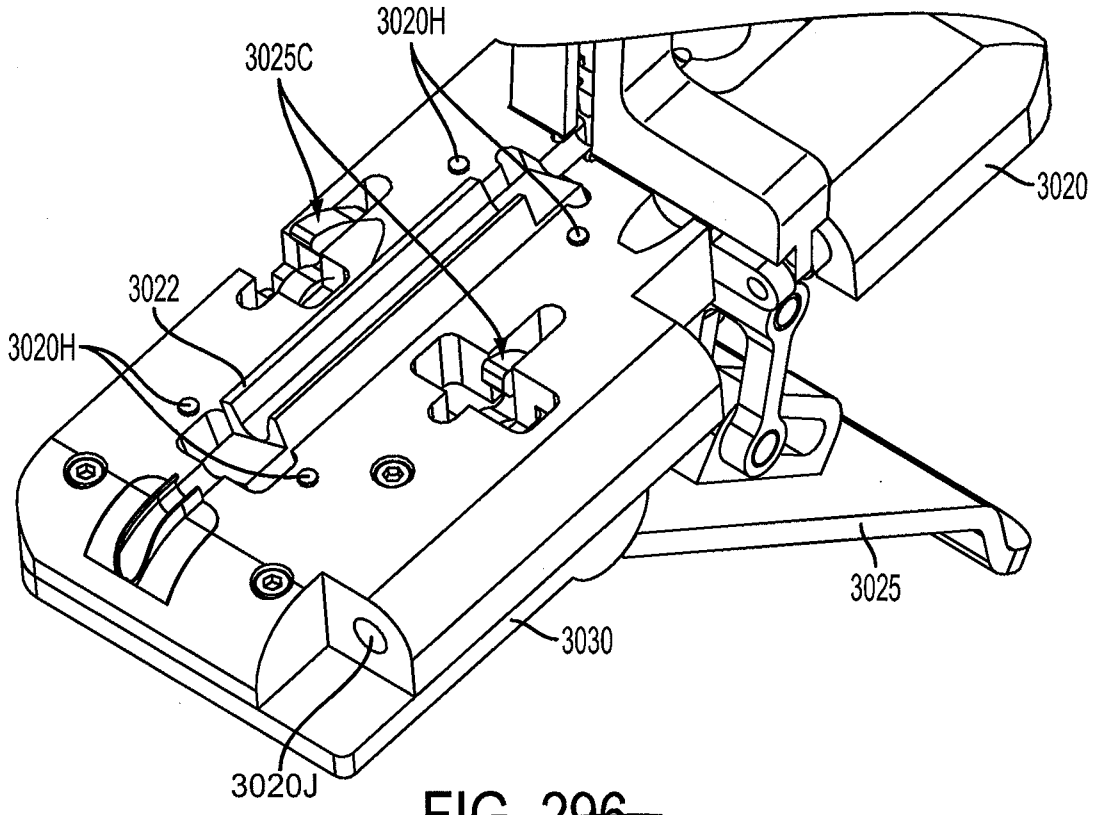


FIG. ~~296~~

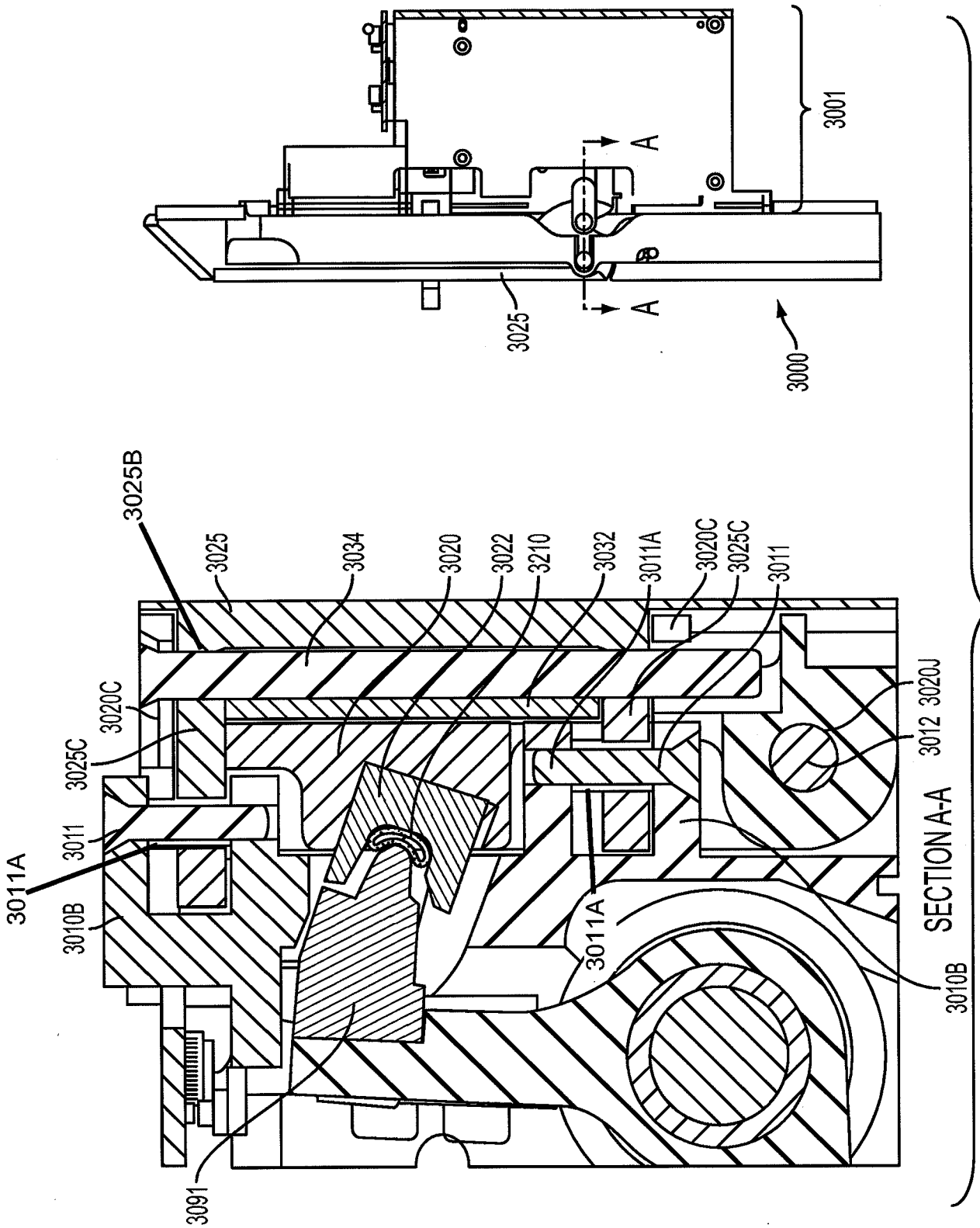

3001
A
A
3025
3000
3025B
3025
3034
3020
3022
3210
3032
3011A
3020C
3025C
3011
3020C
3025C
3011
3011A
3010B
3091
3011A
3010B
3012 3020J
SECTION A-A

FIG. ~~297~~

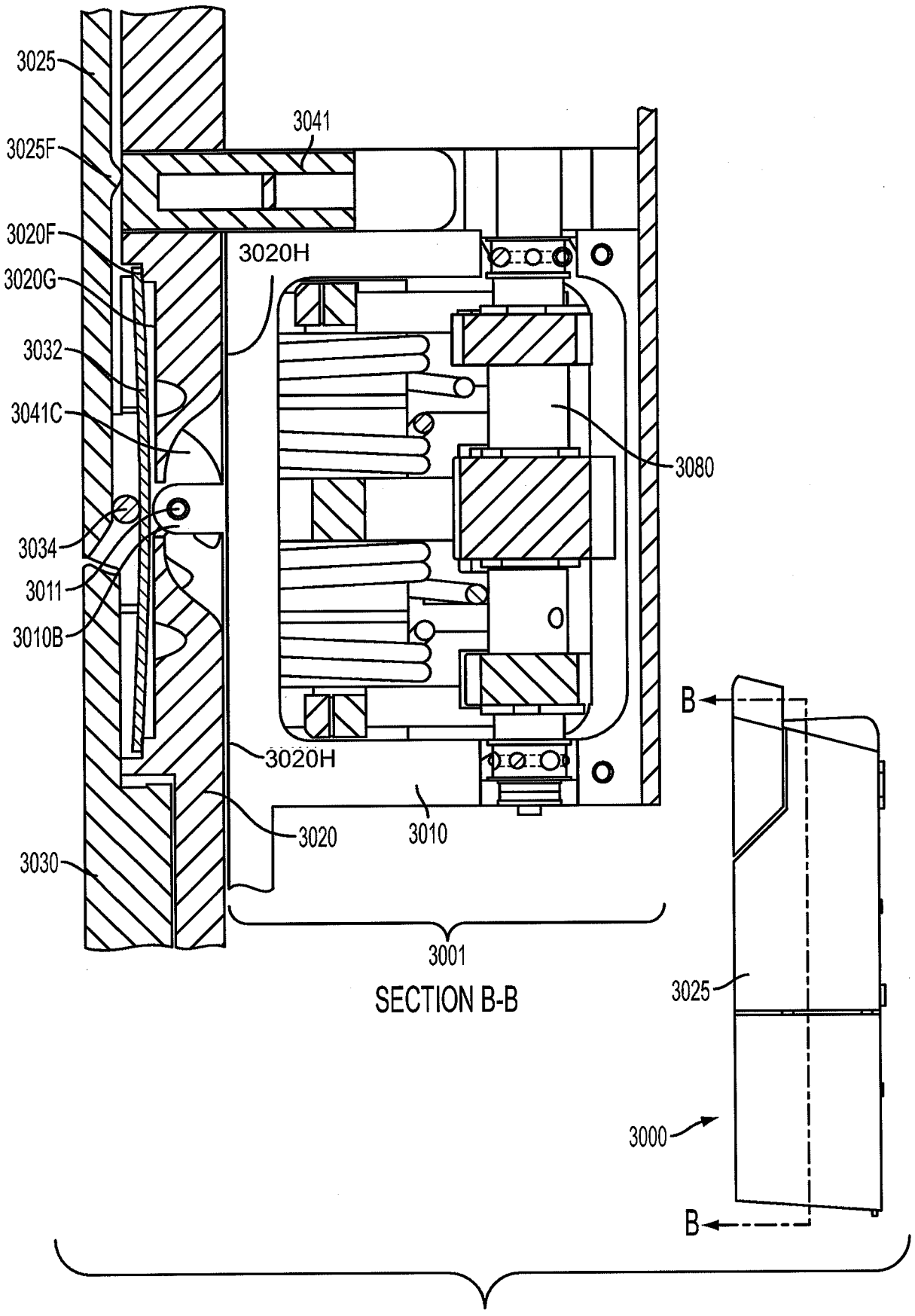

3025
3041
3025F
3020F
3020H
3020G
3032
3041C
3080
3034
3011
3010B
3020H
3020
3010
3030
3001
SECTION B-B
B
3025
3000
B

FIG. ~~298~~

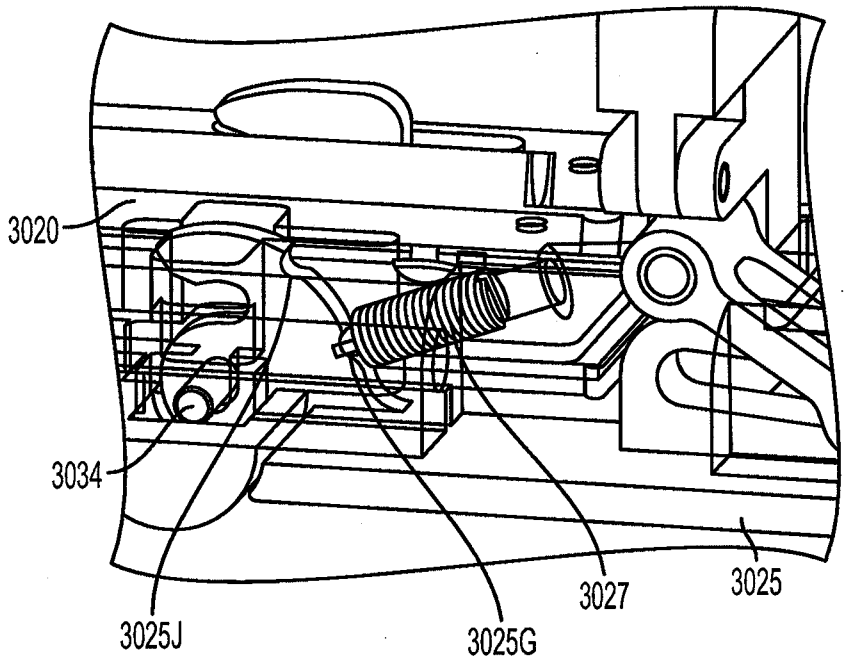


FIG. ~~299~~

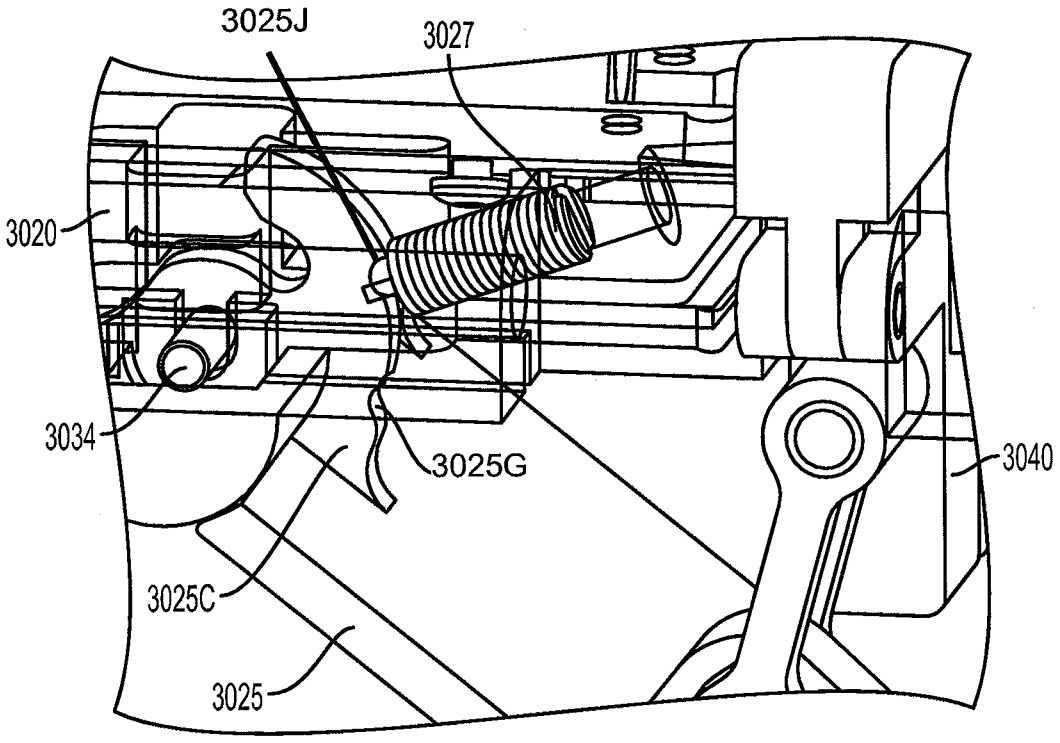


FIG. ~~300~~

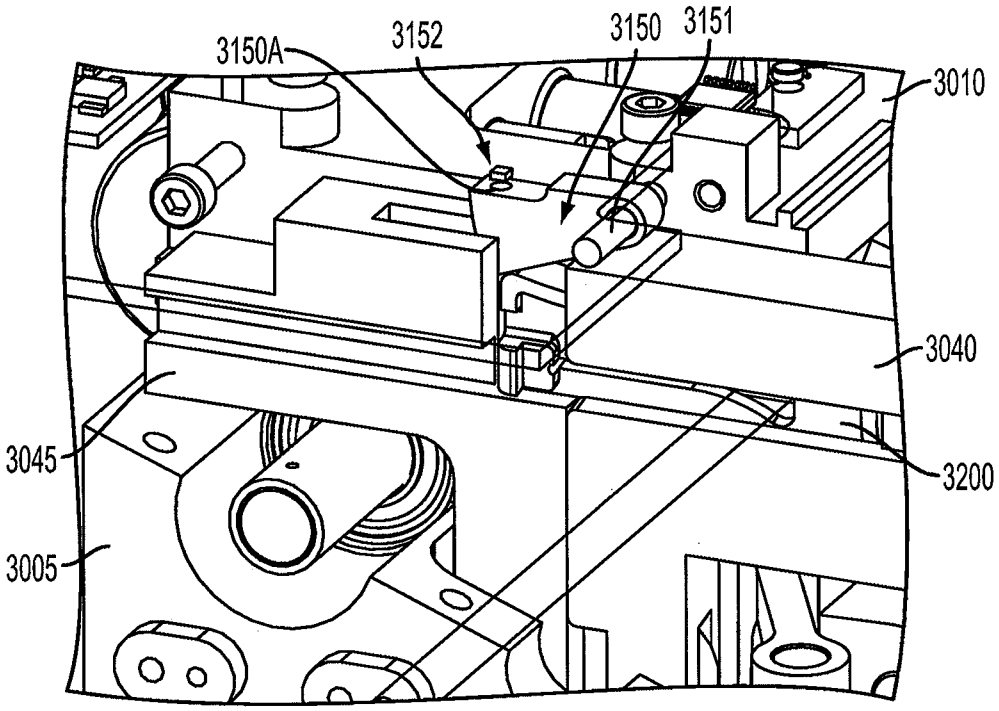


FIG. ~~301~~

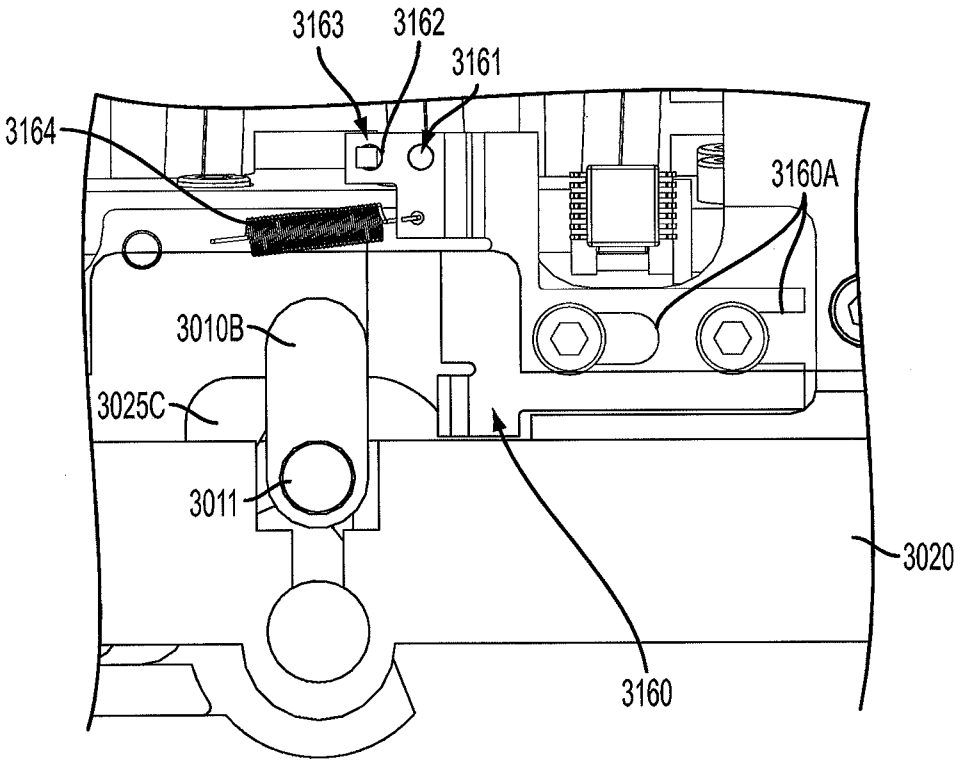


FIG. ~~302~~

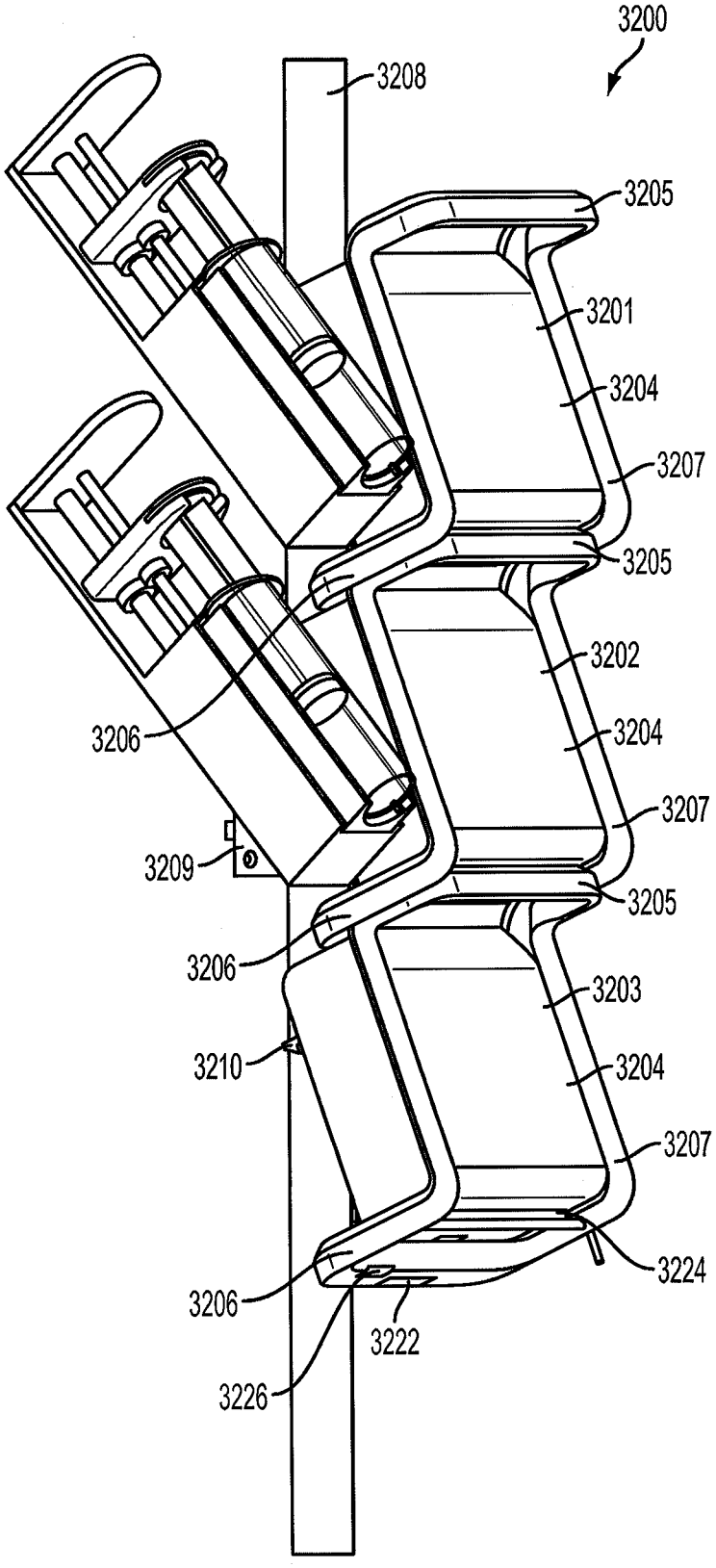

3200
3208
3205
3201
3204
3207
3205
3202
3204
3207
3205
3203
3204
3207
3224
3222
3226
3206
3206
3206
3209
3210

FIG. 303

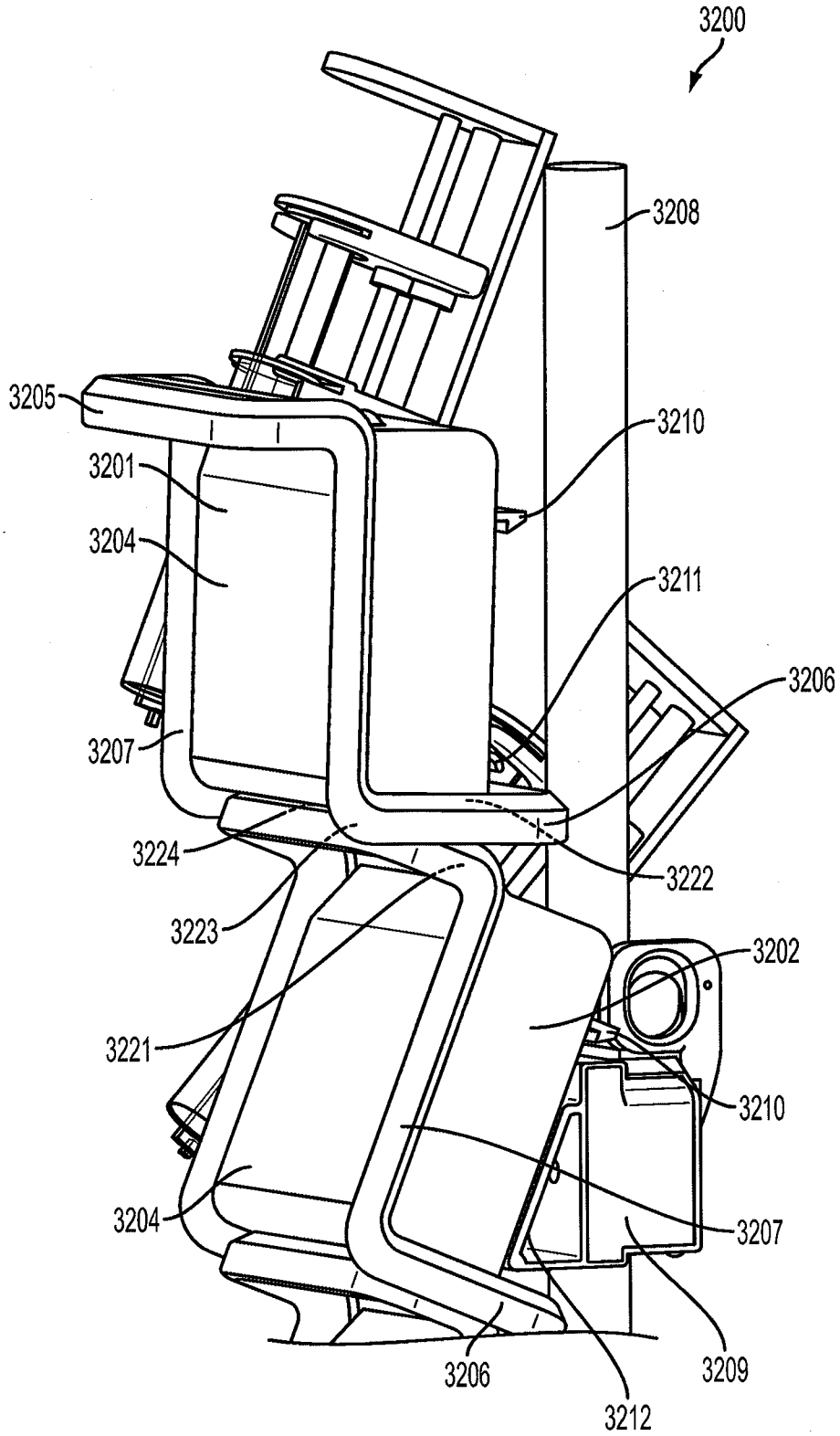

3200
3208
3205
3210
3201
3204
3211
3206
3207
3224
3222
3223
3202
3221
3210
3204
3207
3206
3209
3212

FIG. ~~304~~

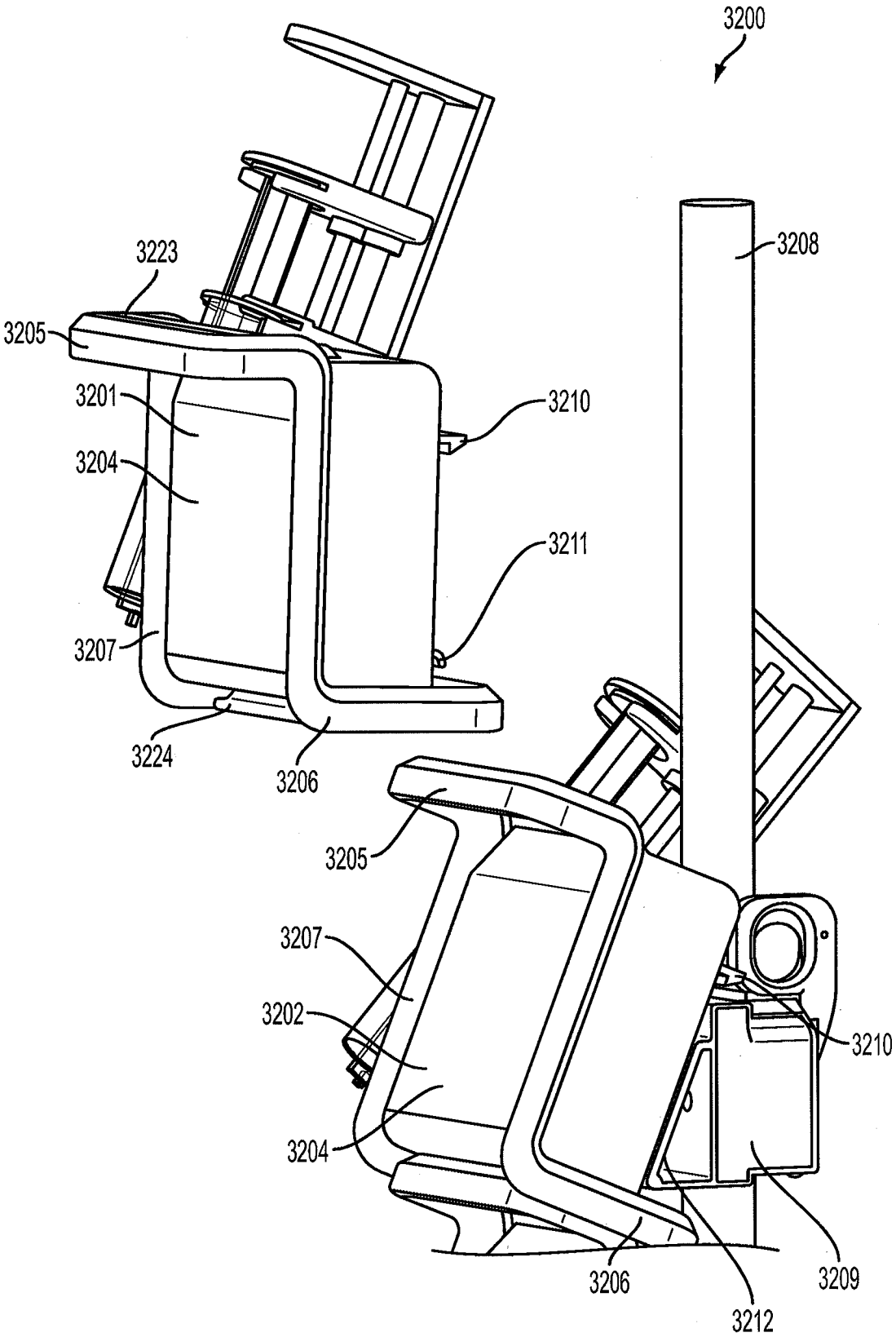

3200
3223
3205
3201
3204
3207
3224
3206
3210
3211
3208
3205
3207
3202
3204
3206
3212
3209
3210

FIG. 305

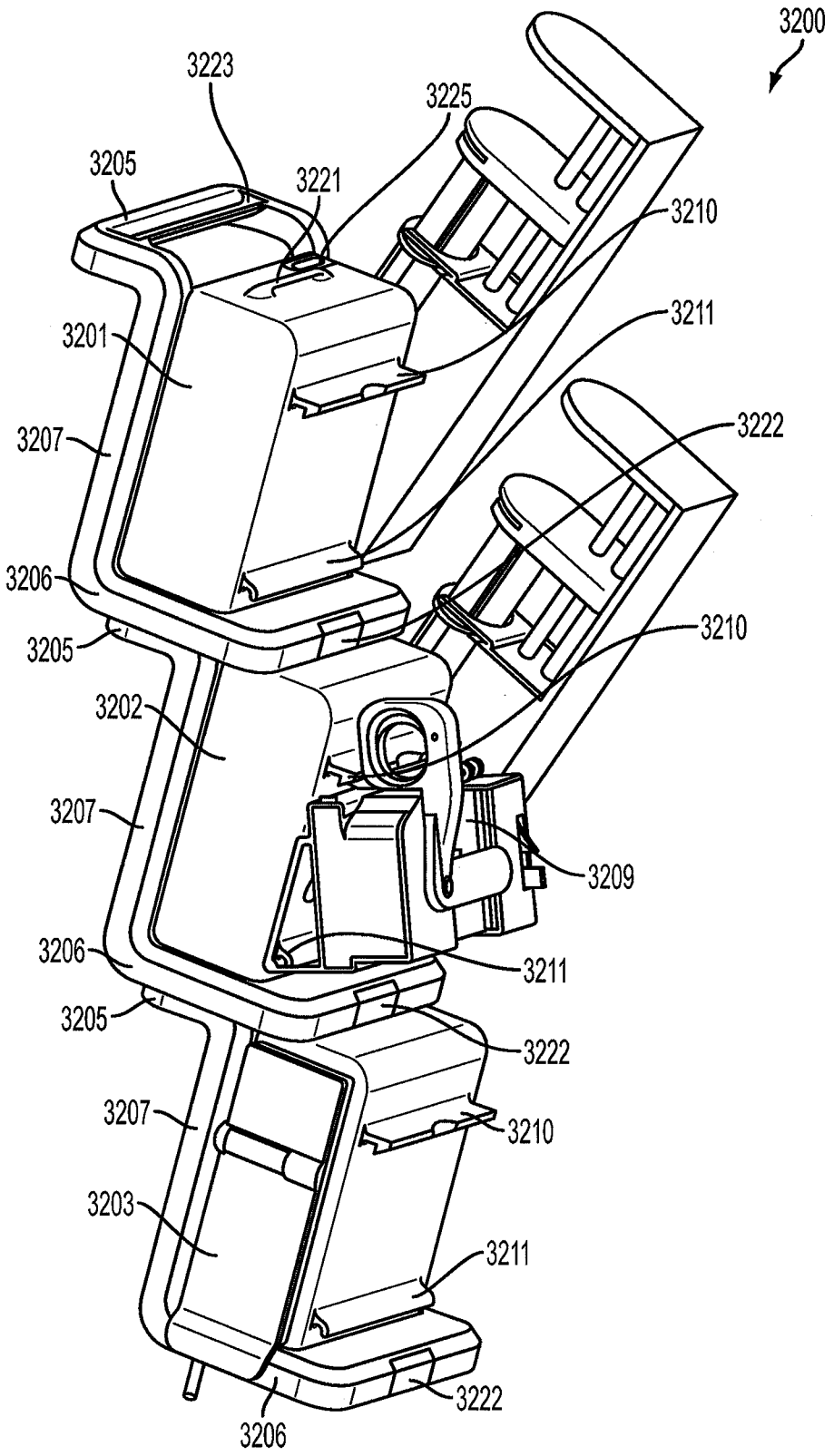

3200
3223
3225
3205
3221
3210
3211
3201
3222
3207
3206
3210
3205
3202
3207
3209
3206
3211
3205
3222
3207
3210
3203
3211
3222
3206

FIG. ~~306~~

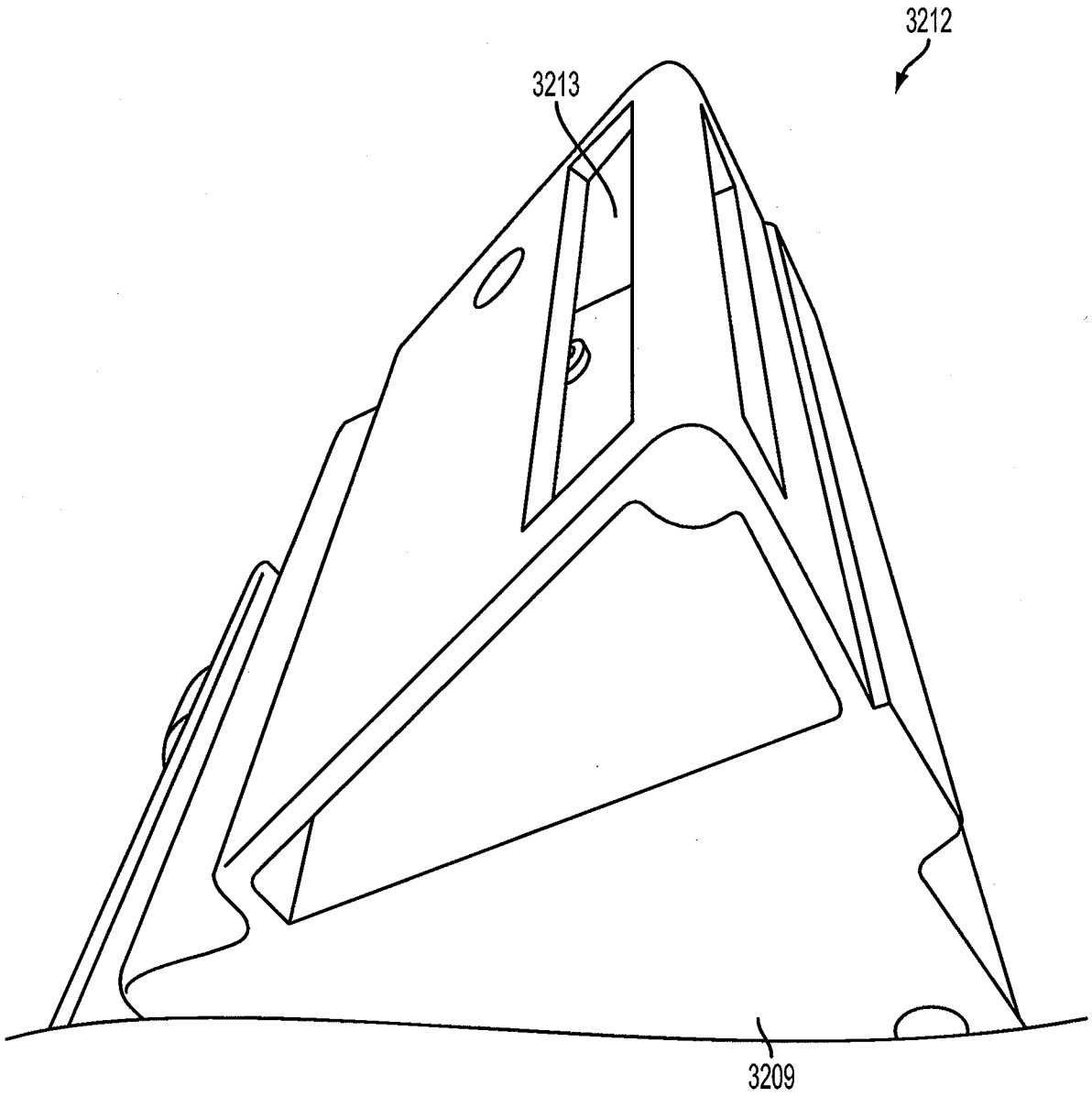


FIG. ~~307~~

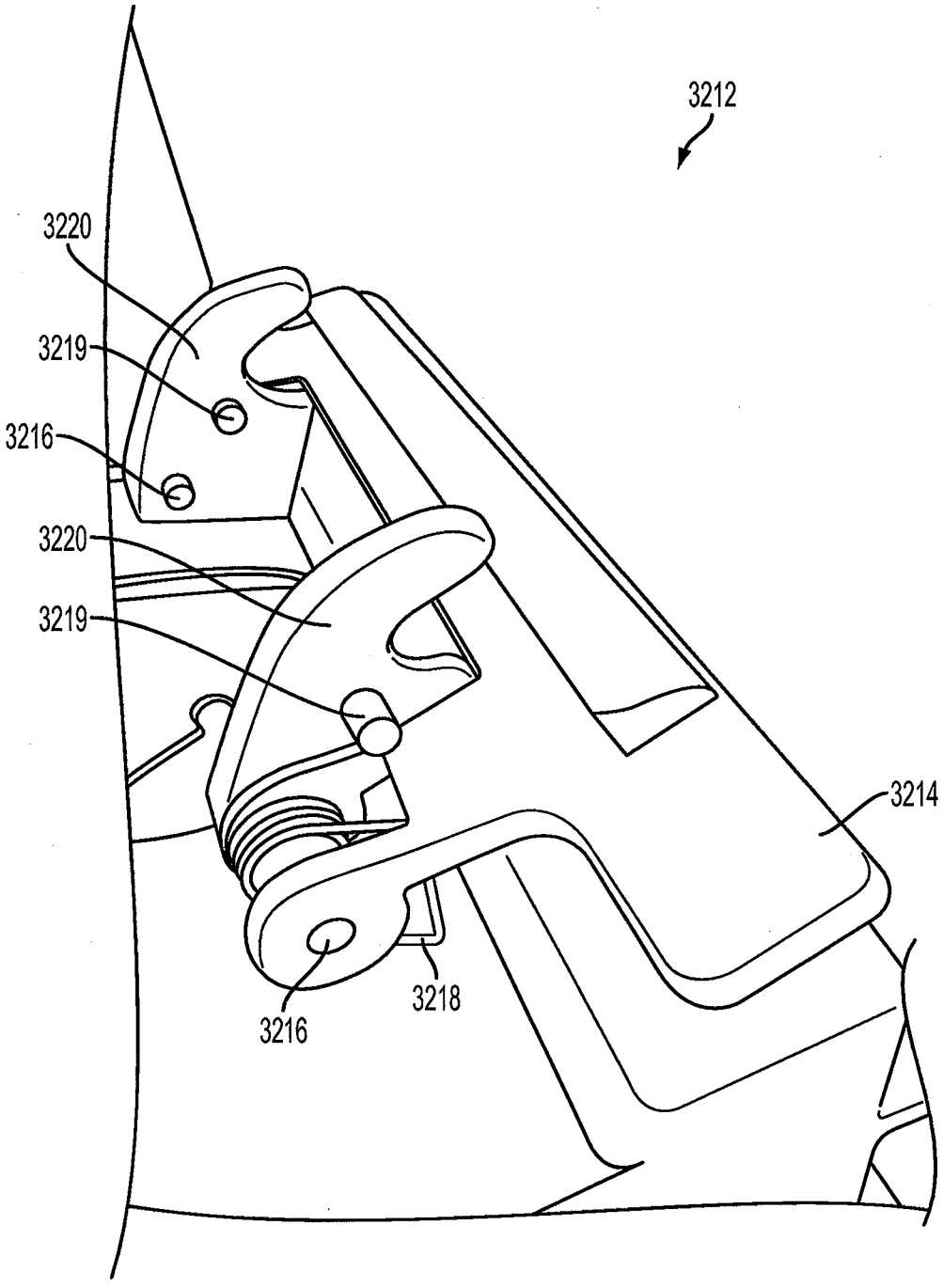


FIG. ~~308~~

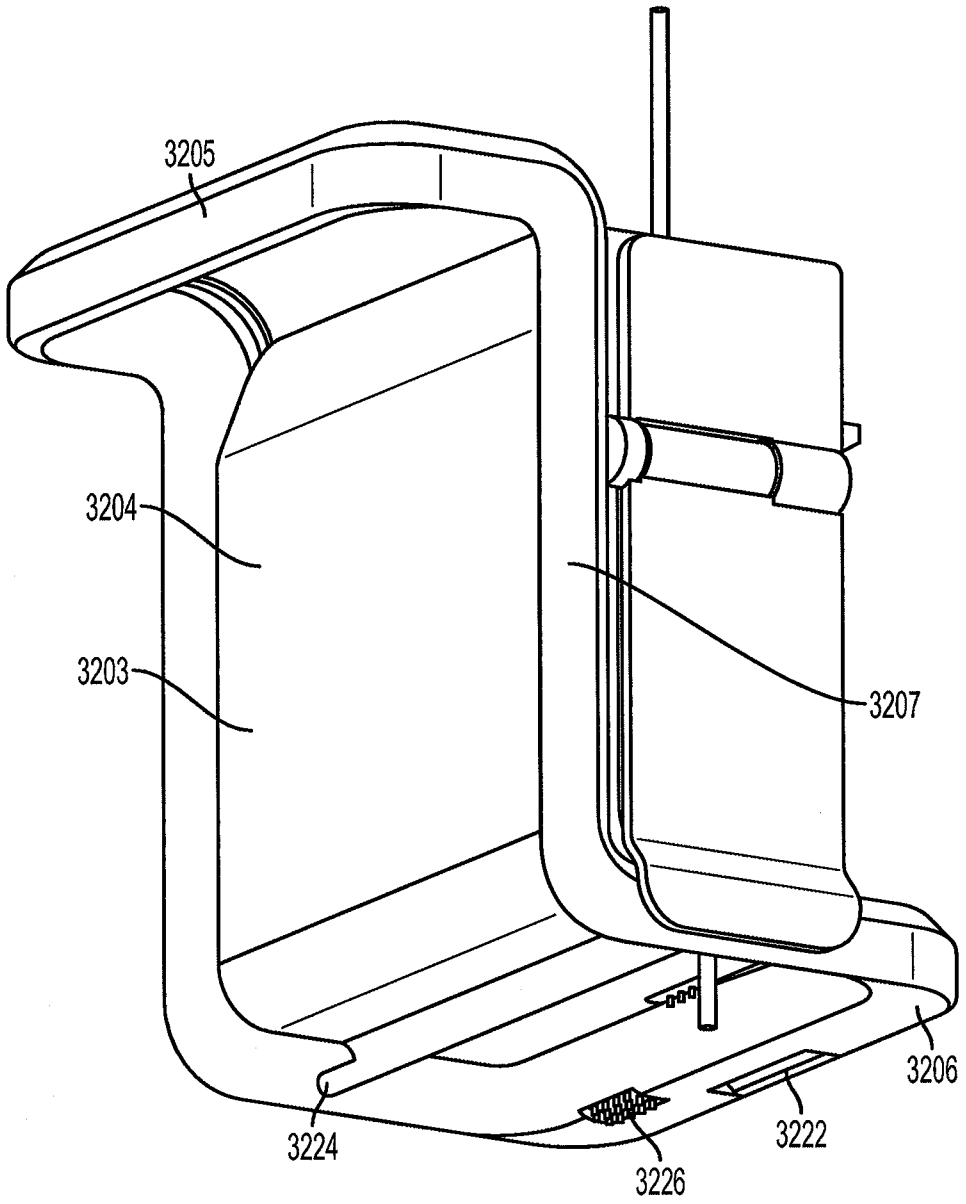


FIG. ~~309~~

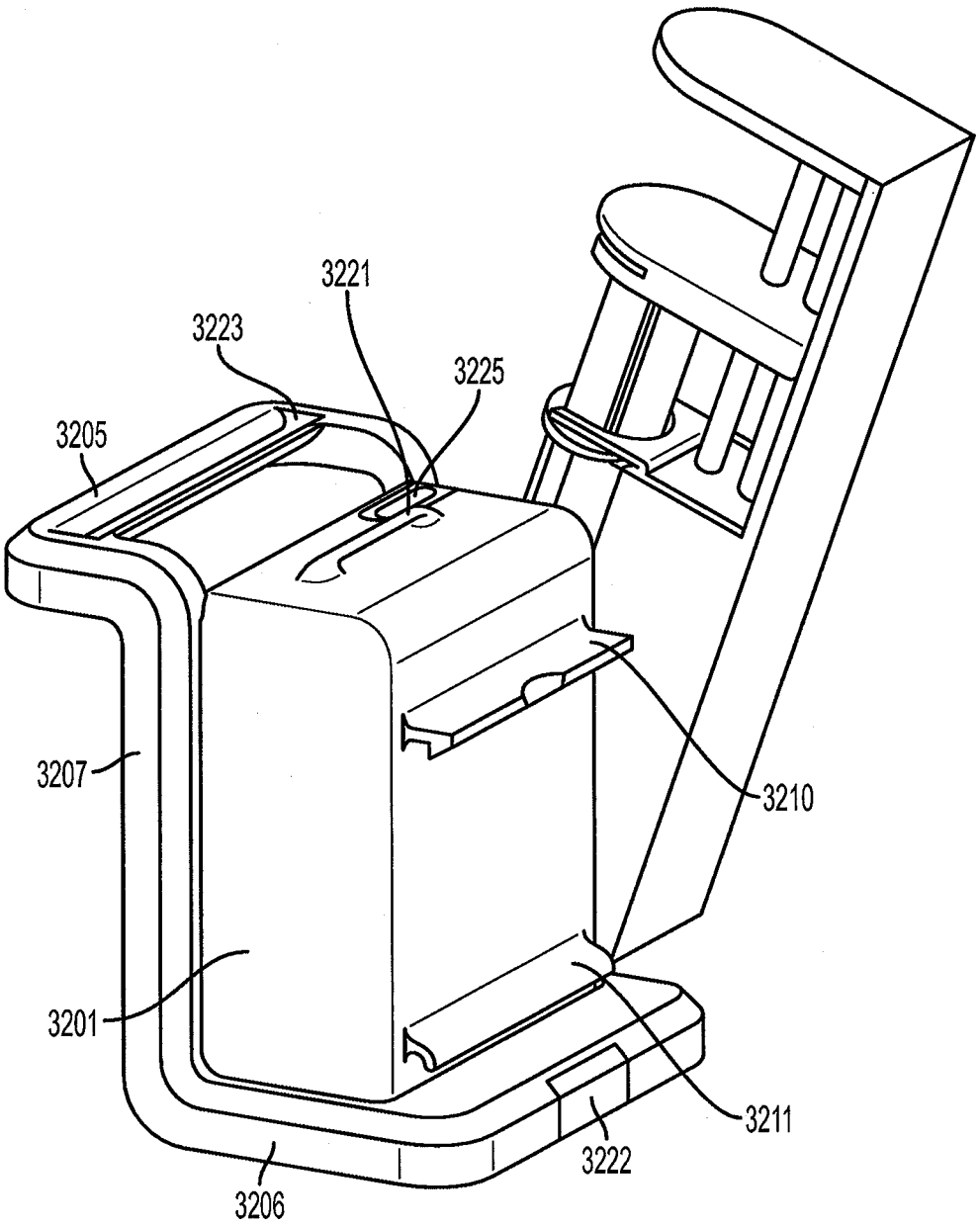


FIG. ~~310~~

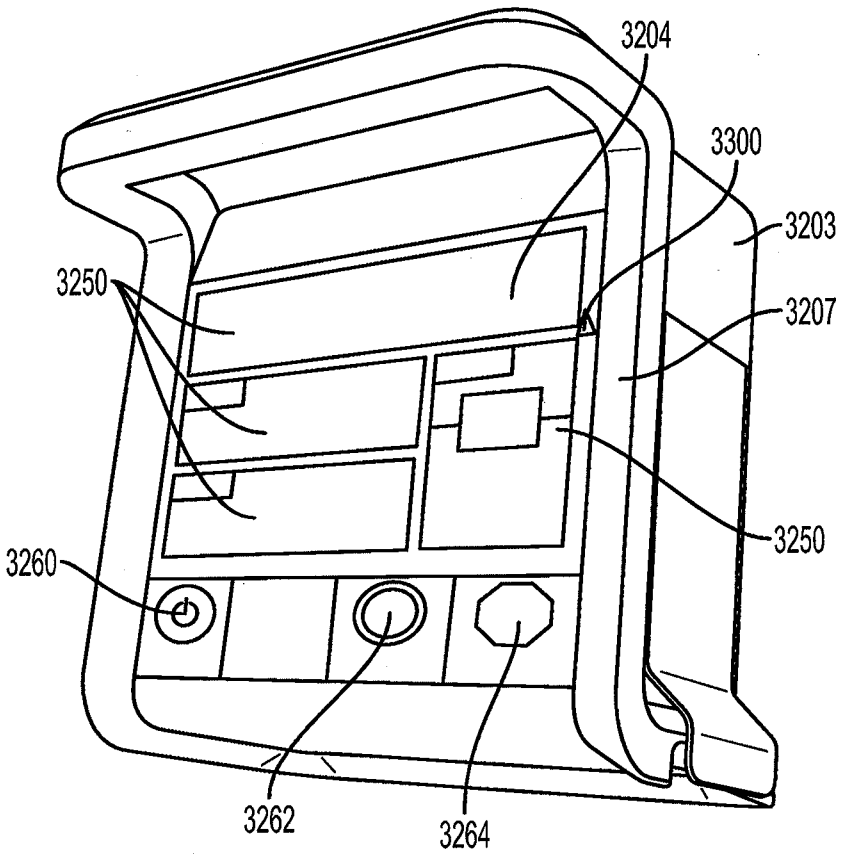


FIG. ~~311~~

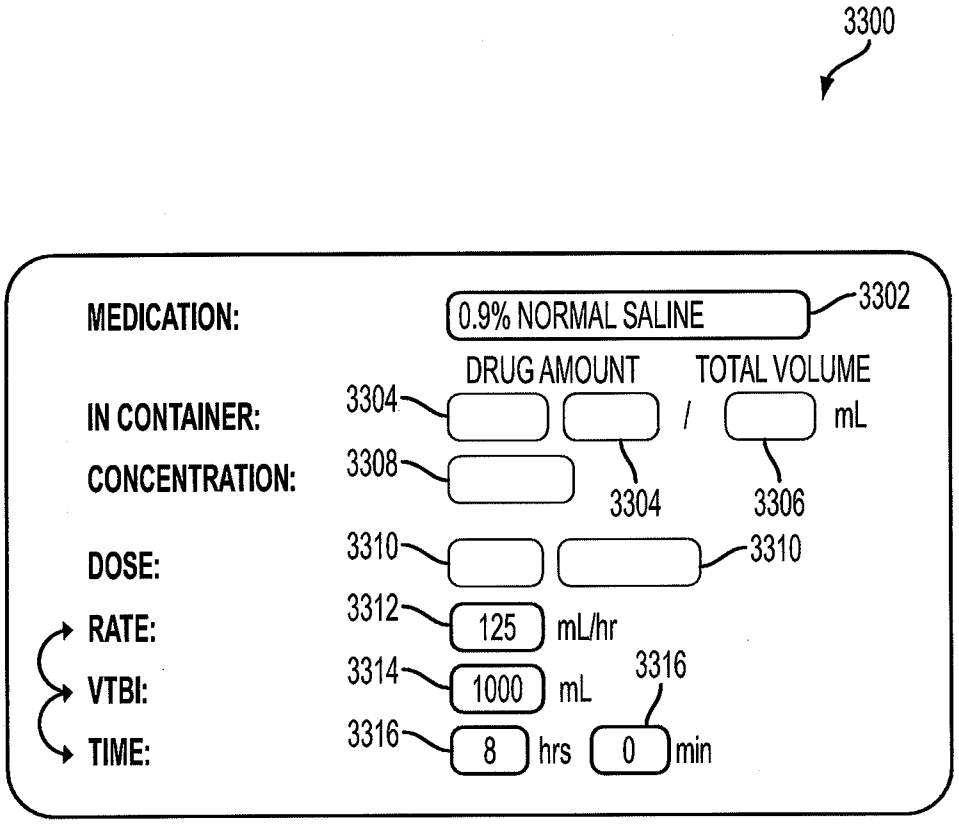

3300
MEDICATION:
0.9% NORMAL SALINE
3302
DRUG AMOUNT
TOTAL VOLUME
IN CONTAINER:
3304
/
mL
CONCENTRATION:
3308
3304
3306
DOSE:
3310
3310
RATE:
3312
125
mL/hr
VTBI:
3314
1000
mL
3316
TIME:
3316
8
hrs
0
min

FIG. ~~312~~

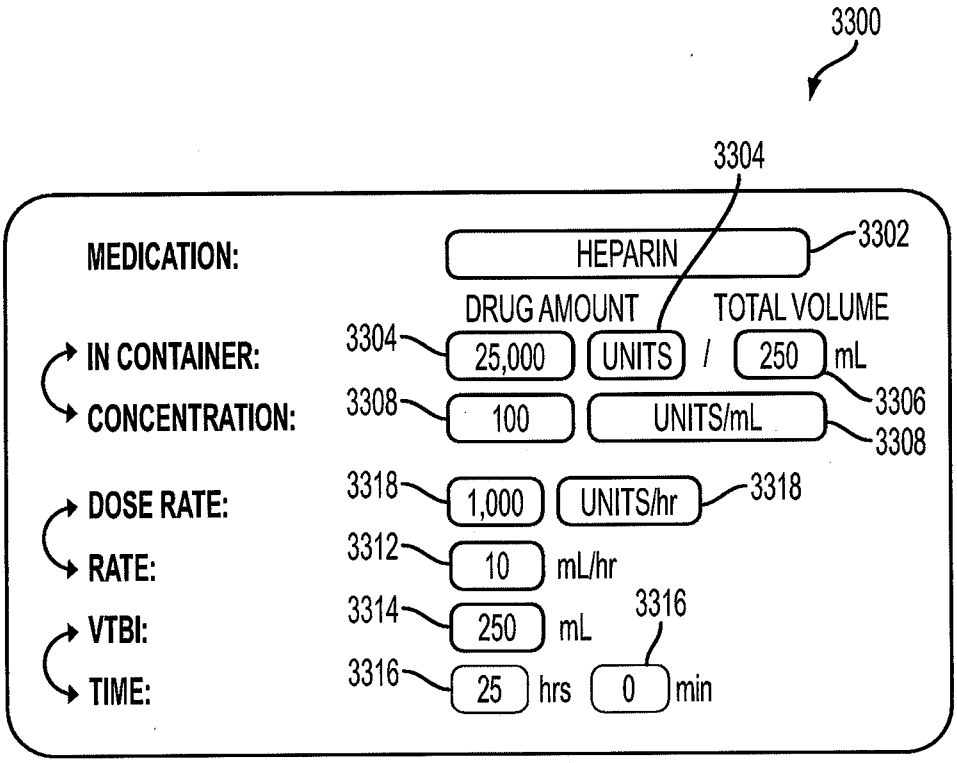

3300
3304
MEDICATION:
HEPARIN
3302
DRUG AMOUNT
TOTAL VOLUME
IN CONTAINER:
3304
25,000
UNITS
/
250
mL
3306
CONCENTRATION:
3308
100
UNITS/mL
3308
DOSE RATE:
3318
1,000
UNITS/hr
3318
RATE:
3312
10
mL/hr
VTBI:
3314
250
mL
3316
TIME:
3316
25
hrs
0
min

FIG. ~~313~~

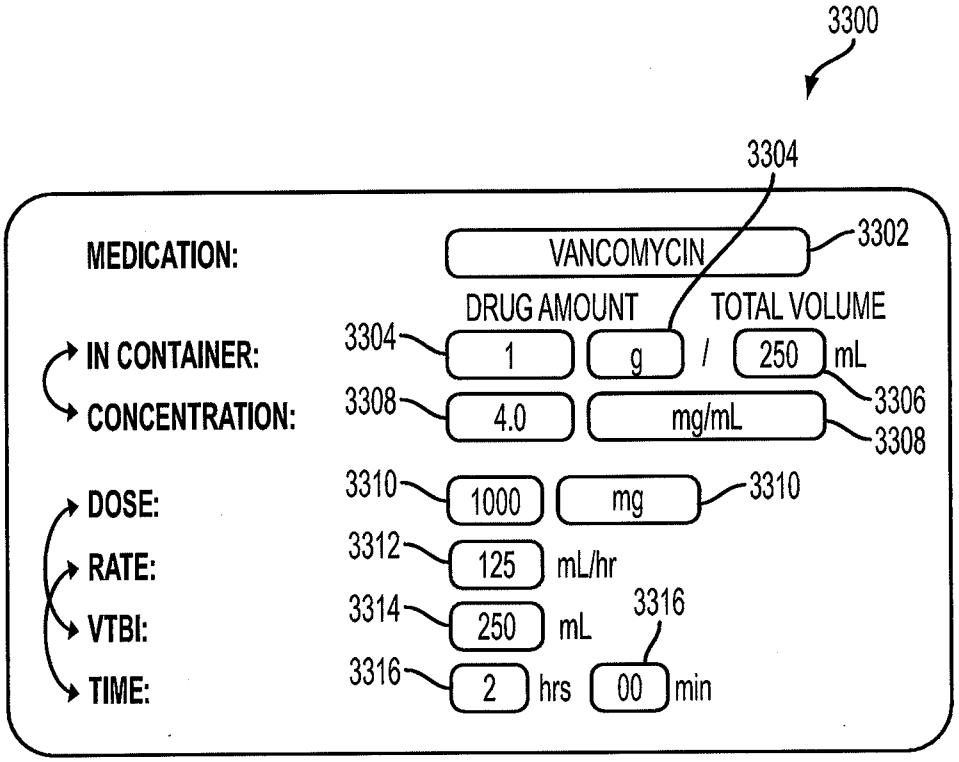

3300
3304
MEDICATION:
VANCOMYCIN
3302
DRUG AMOUNT
TOTAL VOLUME
IN CONTAINER:
3304
1
g
/
250
mL
3306
CONCENTRATION:
3308
4.0
mg/mL
3308
DOSE:
3310
1000
mg
3310
RATE:
3312
125
mL/hr
VTBI:
3314
250
mL
3316
TIME:
3316
2
hrs
00
min

FIG. 314

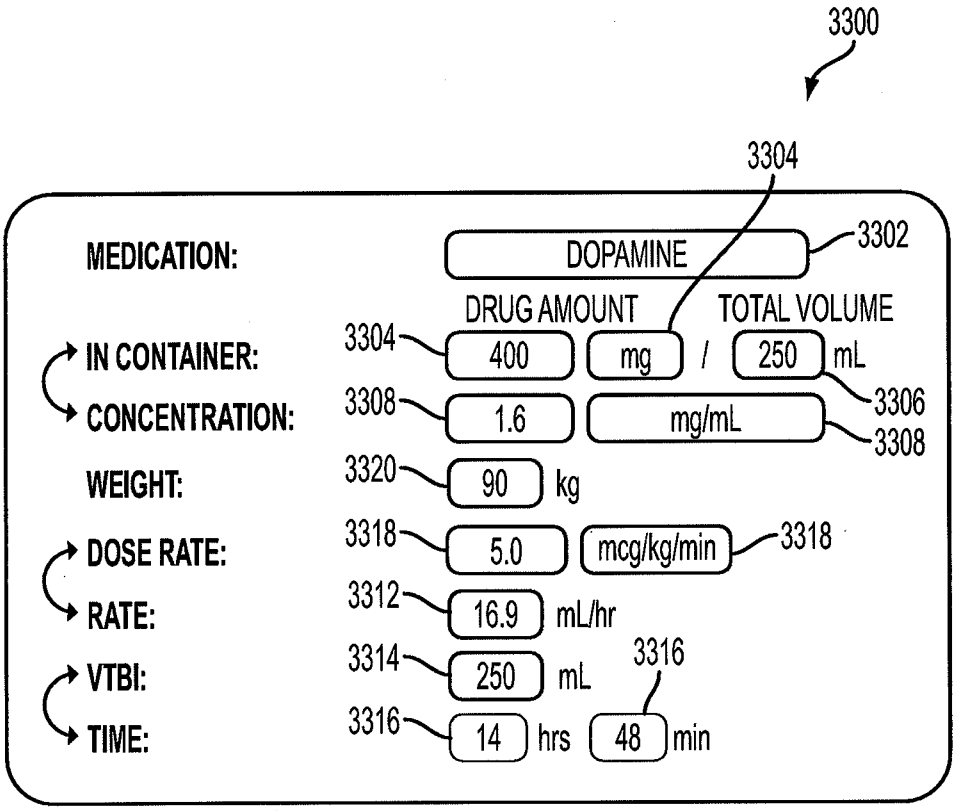

3300
3304
MEDICATION:
DOPAMINE
3302
DRUG AMOUNT
TOTAL VOLUME
IN CONTAINER:
3304
400
mg
/
250
mL
3306
CONCENTRATION:
3308
1.6
mg/mL
3308
WEIGHT:
3320
90
kg
DOSE RATE:
3318
5.0
mcg/kg/min
3318
RATE:
3312
16.9
mL/hr
VTBI:
3314
250
mL
3316
TIME:
3316
14
hrs
48
min

FIG. ~~315~~

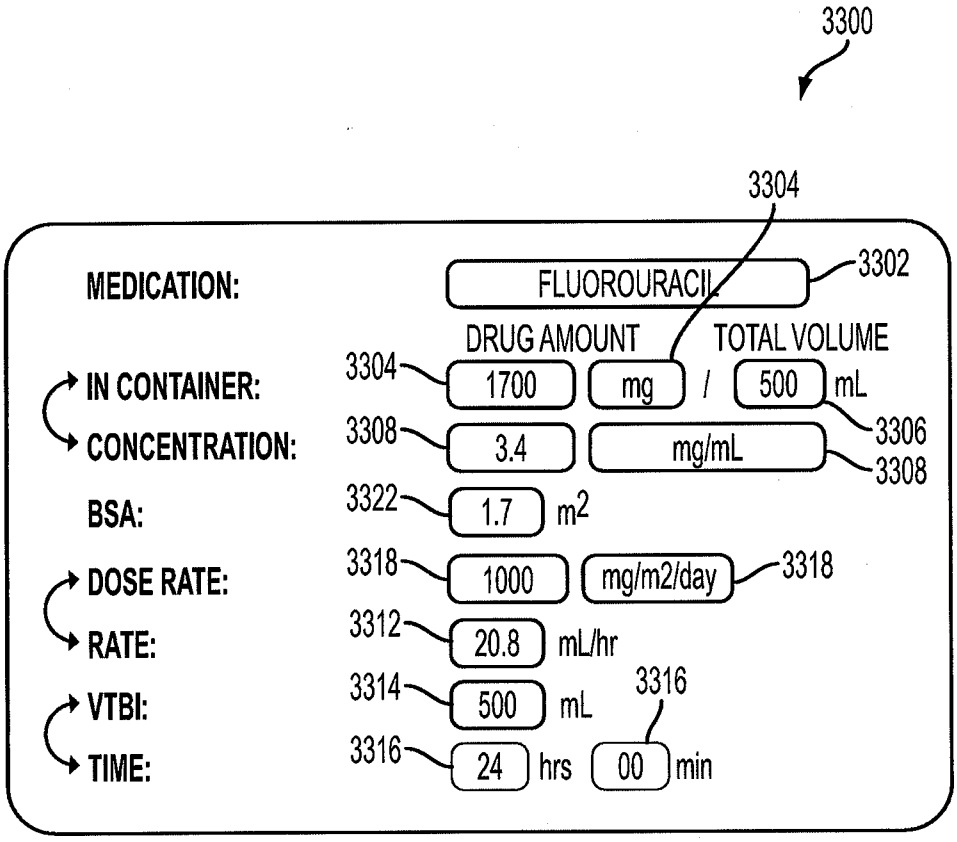

3300
3304
MEDICATION:
FLUOROURACIL
3302
DRUG AMOUNT
TOTAL VOLUME
IN CONTAINER:
3304
1700
mg
/
500
mL
3306
CONCENTRATION:
3308
3.4
mg/mL
3308
BSA:
3322
1.7
m2
DOSE RATE:
3318
1000
mg/m2/day
3318
RATE:
3312
20.8
mL/hr
VTBI:
3314
500
mL
3316
TIME:
3316
24
hrs
00
min

FIG. ~~316~~

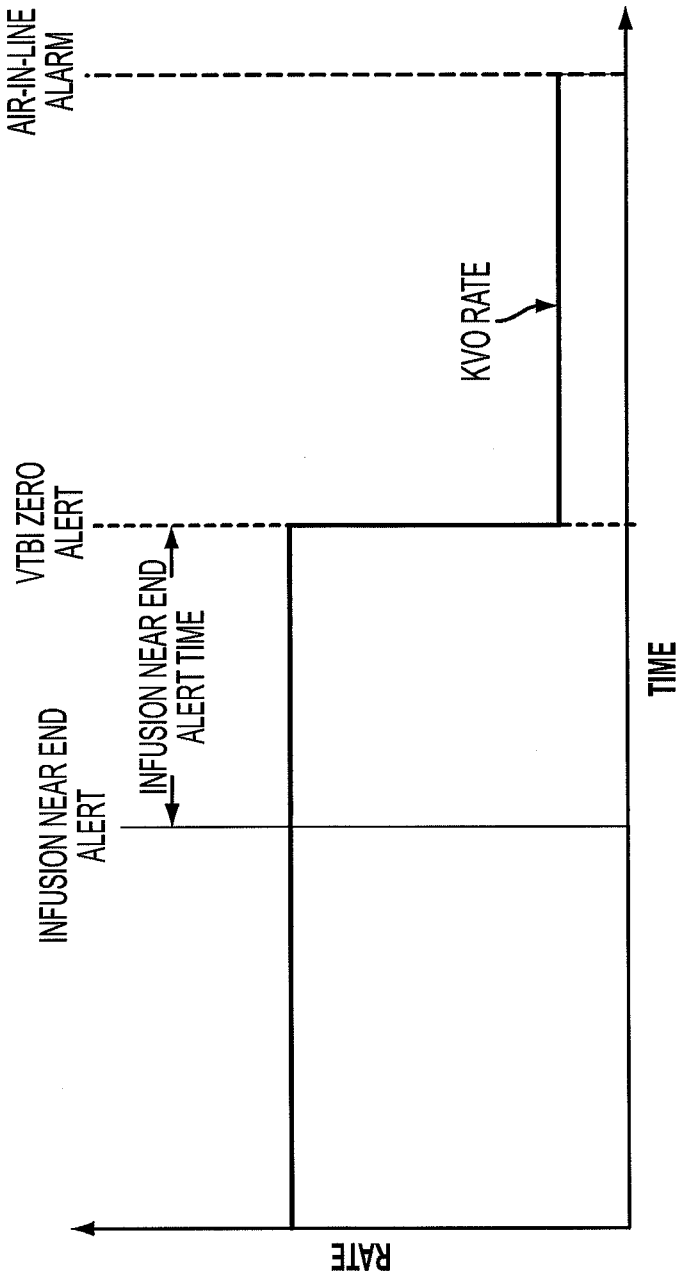

AIR-IN-LINE ALARM
KVO RATE
VTBI ZERO ALERT
INFUSION NEAR END ALERT TIME
INFUSION NEAR END ALERT
TIME
RATE

FIG. ~~317~~

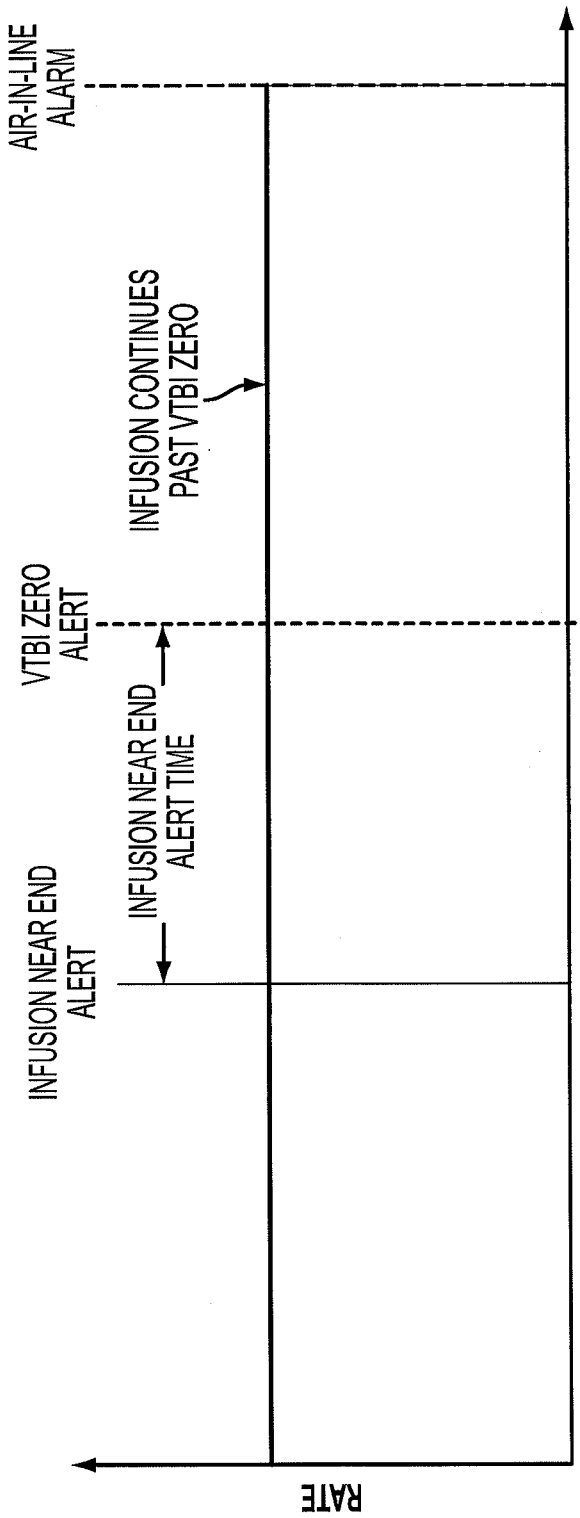

AIR-IN-LINE ALARM
INFUSION CONTINUES PAST VTBI ZERO
VTBI ZERO ALERT
INFUSION NEAR END ALERT TIME
INFUSION NEAR END ALERT
TIME
RATE

FIG. 318

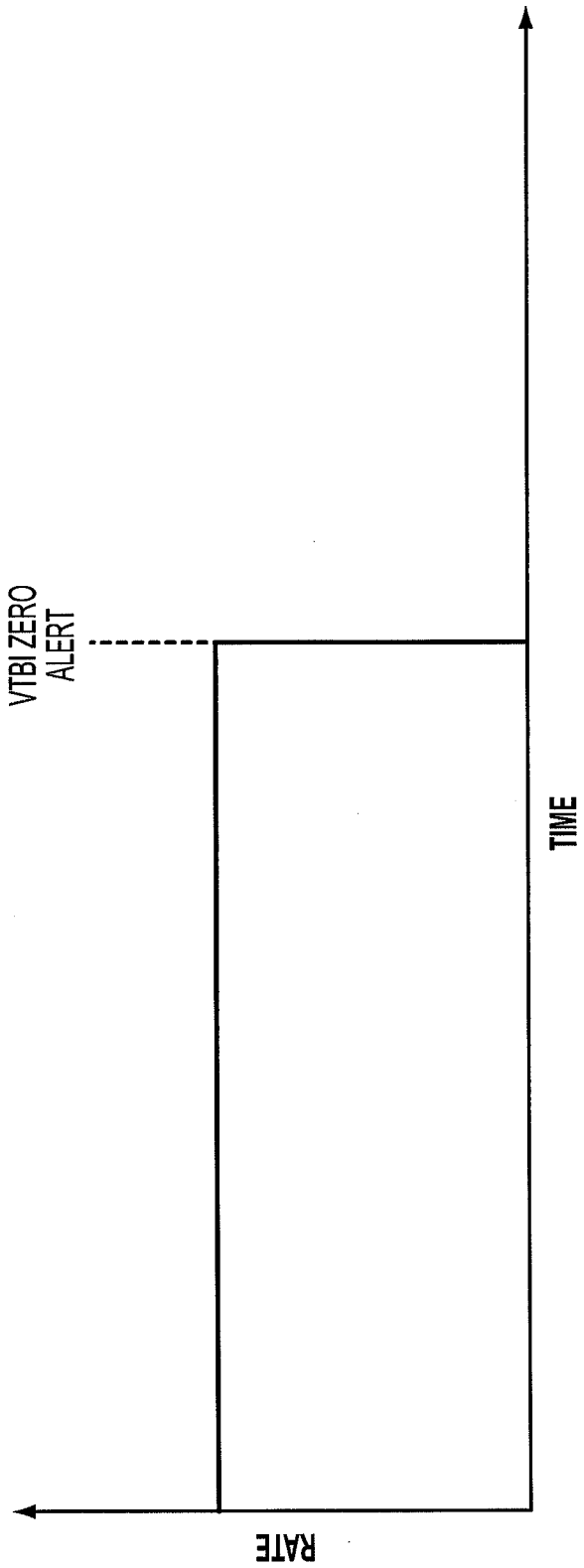


FIG. ~~319~~

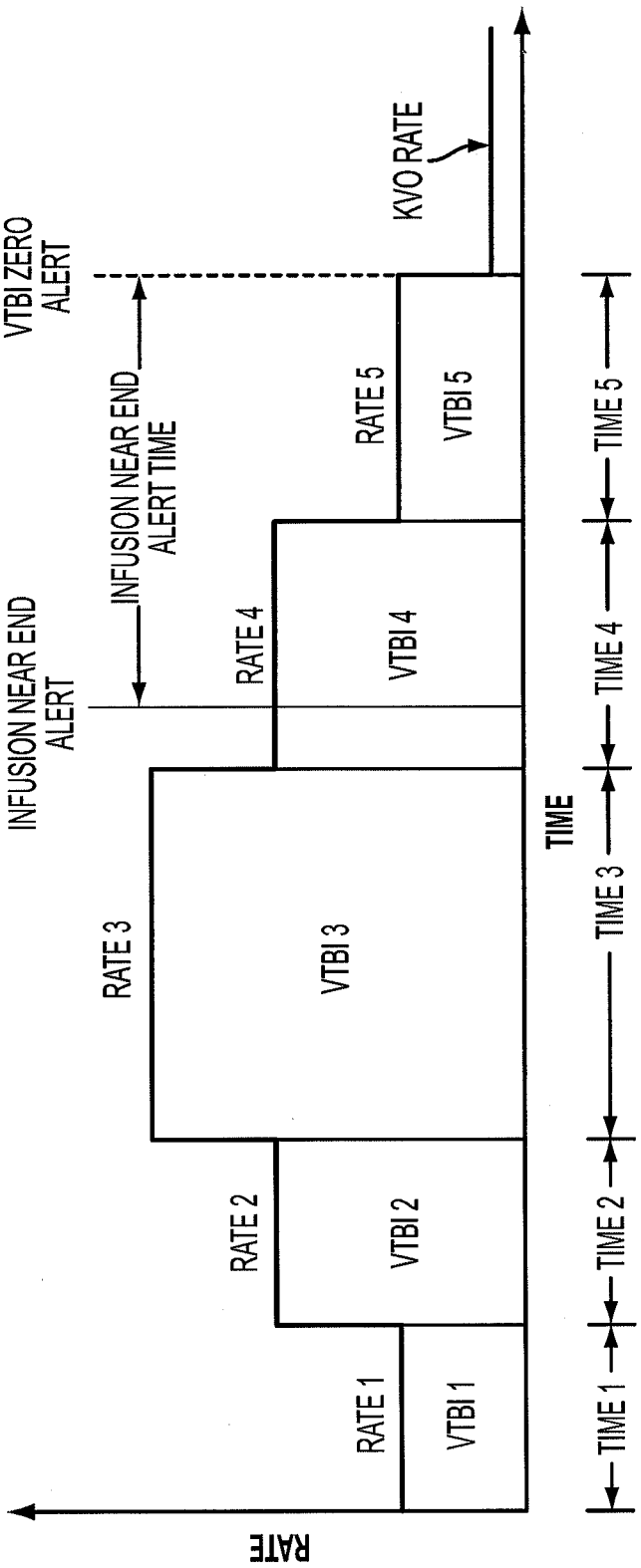

RATE
TIME
RATE 1
VTBI 1
RATE 2
VTBI 2
RATE 3
VTBI 3
RATE 4
VTBI 4
RATE 5
VTBI 5
KVO RATE
VTBI ZERO ALERT
INFUSION NEAR END ALERT TIME
INFUSION NEAR END ALERT
TIME 1
TIME 2
TIME 3
TIME 4
TIME 5

FIG. ~~321~~

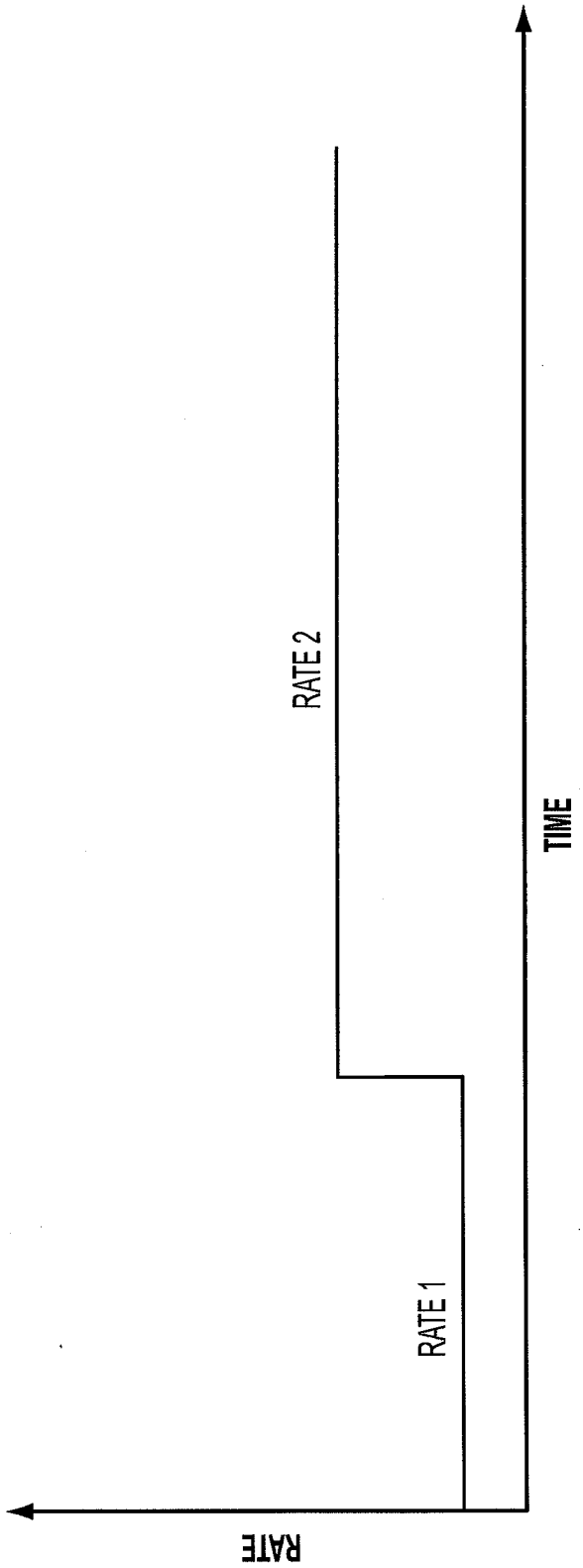


FIG. ~~320~~

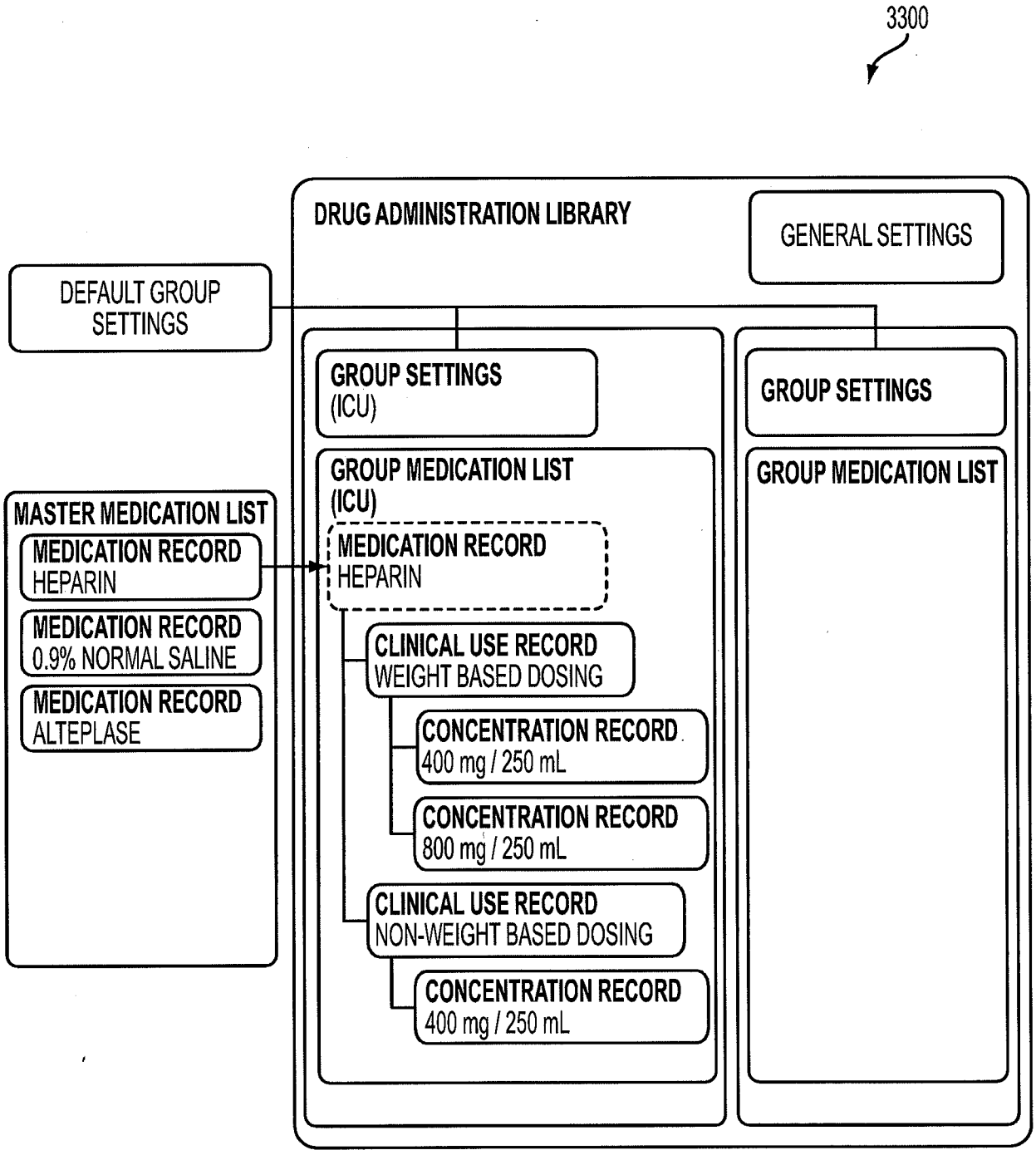

3300
DRUG ADMINISTRATION LIBRARY
GENERAL SETTINGS
DEFAULT GROUP SETTINGS
GROUP SETTINGS (ICU)
GROUP SETTINGS
GROUP MEDICATION LIST (ICU)
GROUP MEDICATION LIST
MASTER MEDICATION LIST
MEDICATION RECORD HEPARIN
MEDICATION RECORD 0.9% NORMAL SALINE
MEDICATION RECORD ALTEPLASE
MEDICATION RECORD HEPARIN
CLINICAL USE RECORD WEIGHT BASED DOSING
CONCENTRATION RECORD 400 mg / 250 mL
CONCENTRATION RECORD 800 mg / 250 mL
CLINICAL USE RECORD NON-WEIGHT BASED DOSING
CONCENTRATION RECORD 400 mg / 250 mL

FIG. ~~322~~

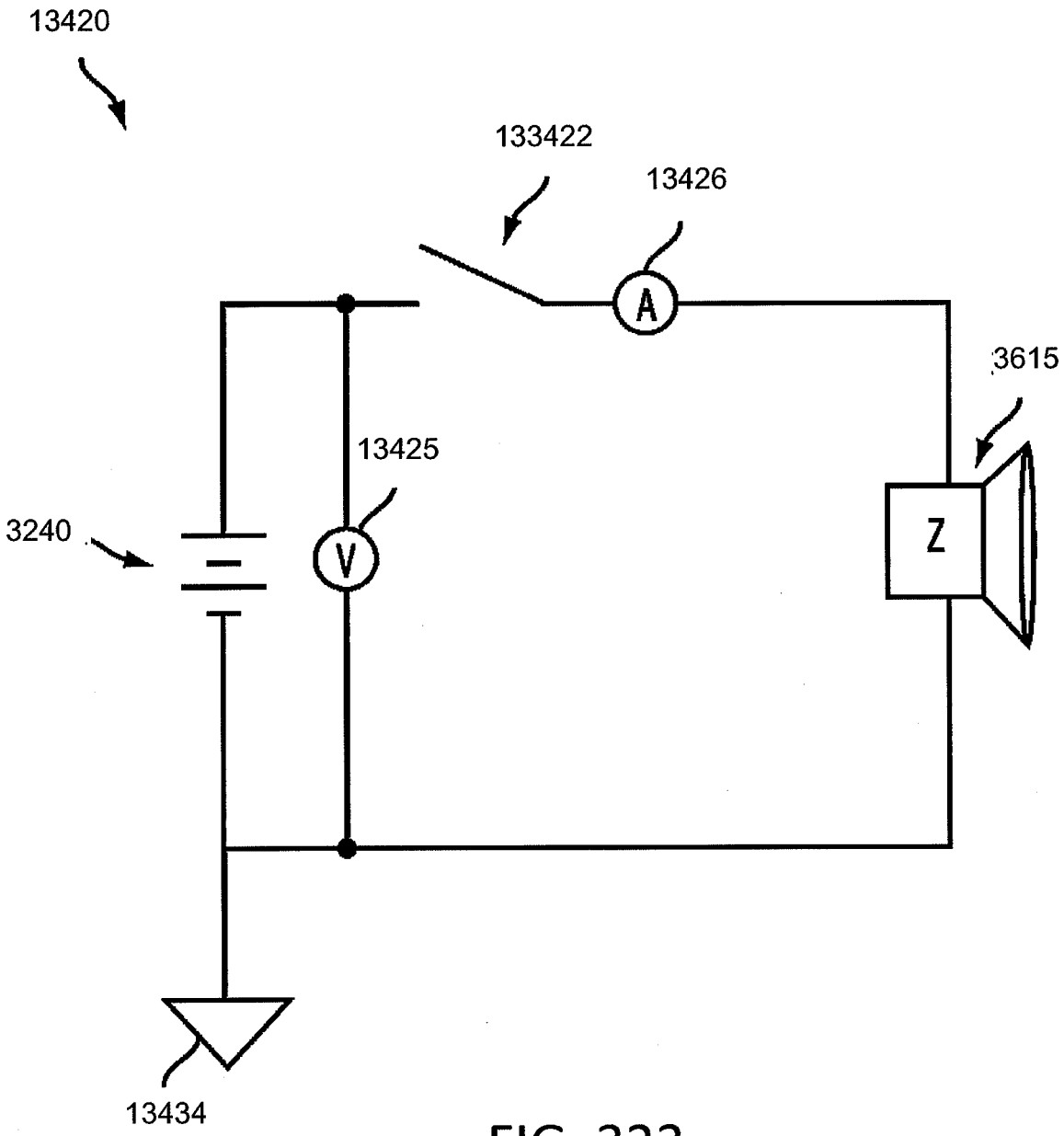


FIG. ~~323~~

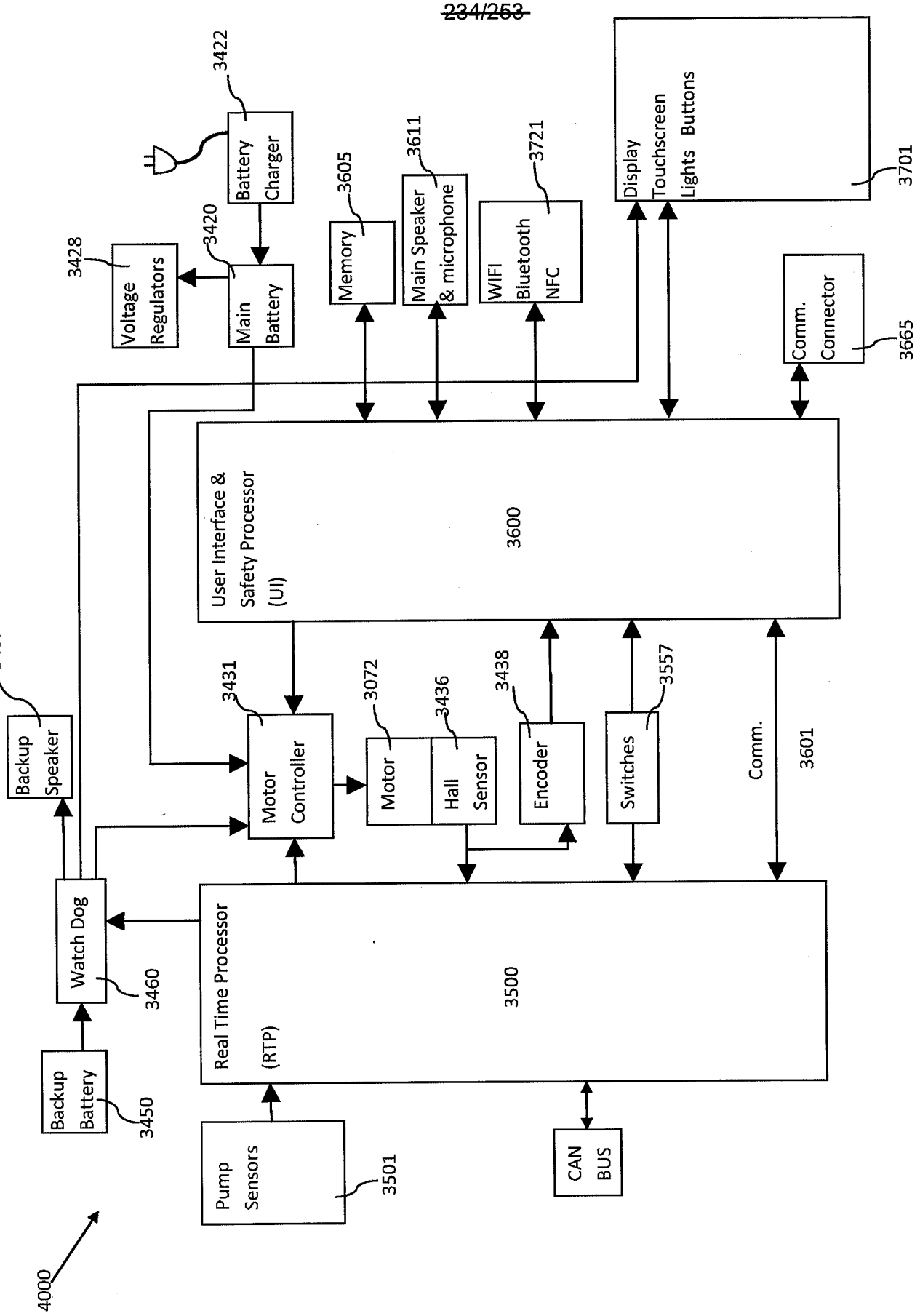

3422
Battery Charger
3420
Main Battery
3428
Voltage Regulators
3605
Memory
3611
Main Speaker & microphone
3721
WIFI Bluetooth NFC
Display Touchscreen Lights Buttons
3701
Comm. Connector
3665
User Interface & Safety Processor (UI)
3600
3467
Backup Speaker
3431
Motor Controller
3072
Motor
3436
Hall Sensor
3438
Encoder
3557
Switches
Comm.
3601
Watch Dog
3460
Real Time Processor (RTP)
3500
Backup Battery
3450
Pump Sensors
3501
CAN BUS
4000

FIG. ~~324~~

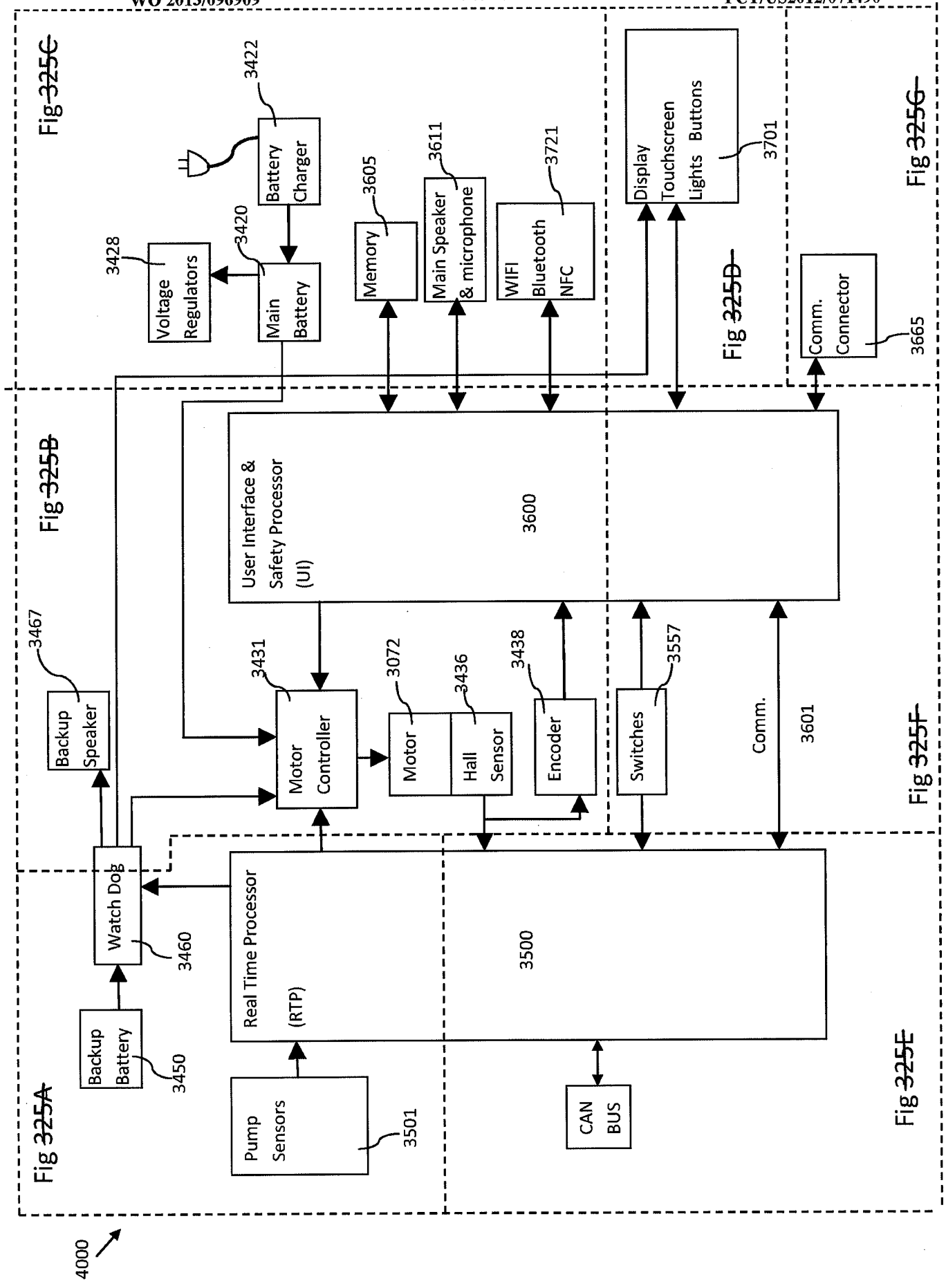

Fig 325C
Fig 325B
Fig 325D
Fig 325G
Fig 325F
Fig 325A
Fig 325E
3422
Battery Charger
3420
Main Battery
3428
Voltage Regulators
3605
Memory
3611
Main Speaker & microphone
3721
WIFI Bluetooth NFC
Display Touchscreen Lights Buttons
3701
Comm. Connector
3665
User Interface & Safety Processor (UI)
3600
3467
Backup Speaker
3431
Motor Controller
3072
Motor
3436
Hall Sensor
3438
Encoder
3557
Switches
Comm.
3601
Watch Dog
3460
Real Time Processor (RTP)
3500
Backup Battery
3450
Pump Sensors
3501
CAN BUS
4000

Fig 325

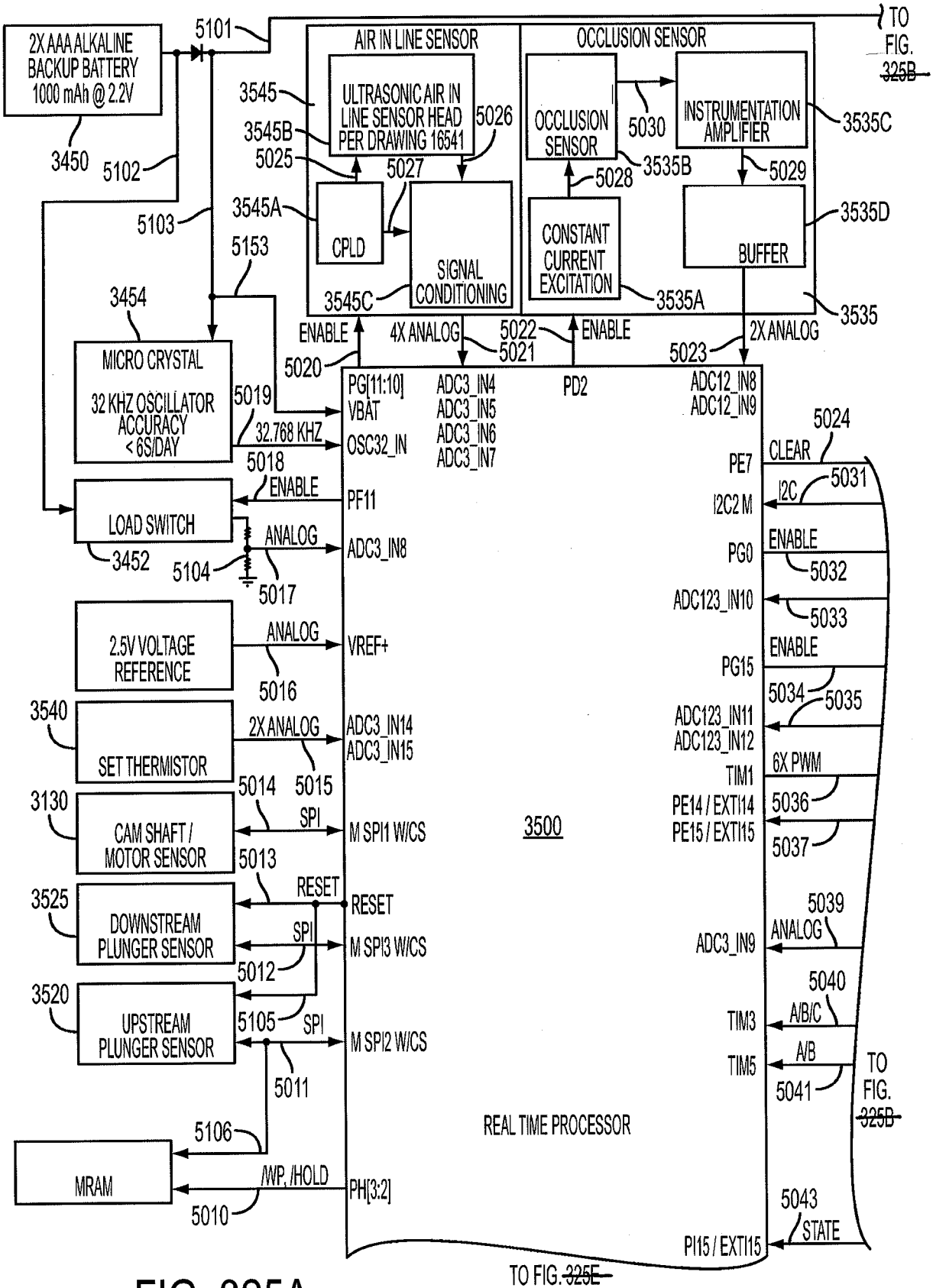

2X AAA ALKALINE BACKUP BATTERY 1000 mAh @ 2.2V
3450
5101
5102
5103
5153
AIR IN LINE SENSOR
ULTRASONIC AIR IN LINE SENSOR HEAD PER DRAWING 16541
3545
3545B
5026
5025
5027
3545A
CPLD
SIGNAL CONDITIONING
3545C
OCCLUSION SENSOR
OCCLUSION SENSOR
5030
INSTRUMENTATION AMPLIFIER
3535C
5028
3535B
5029
CONSTANT CURRENT EXCITATION
BUFFER
3535D
3535A
3535
TO FIG. 325B
3454
MICRO CRYSTAL
32 KHZ OSCILLATOR ACCURACY < 6S/DAY
5019
32.768 KHZ
5018
ENABLE
LOAD SWITCH
3452
5104
ANALOG
5017
2.5V VOLTAGE REFERENCE
ANALOG
5016
3540
SET THERMISTOR
2X ANALOG
5014
5015
3130
CAM SHAFT / MOTOR SENSOR
SPI
5013
RESET
3525
DOWNSTREAM PLUNGER SENSOR
SPI
5012
3520
UPSTREAM PLUNGER SENSOR
5105
SPI
5011
5106
MRAM
/WP, /HOLD
5010
ENABLE
4X ANALOG
5022
5021
ENABLE
2X ANALOG
5023
5020
PG[11:10]
VBAT
OSC32_IN
PF11
ADC3_IN8
VREF+
ADC3_IN14
ADC3_IN15
M SPI1 W/CS
RESET
M SPI3 W/CS
M SPI2 W/CS
PH[3:2]
ADC3_IN4
ADC3_IN5
ADC3_IN6
ADC3_IN7
PD2
ADC12_IN8
ADC12_IN9
3500
REAL TIME PROCESSOR
PE7
I2C2 M
PG0
ADC123_IN10
PG15
ADC123_IN11
ADC123_IN12
TIM1
PE14 / EXTI14
PE15 / EXTI15
ADC3_IN9
TIM3
TIM5
PI15 / EXTI15
5024
CLEAR
5031
I2C
ENABLE
5032
5033
ENABLE
5034
5035
6X PWM
5036
5037
5039
ANALOG
5040
A/B/C
A/B
5041
TO FIG. 325B
5043
STATE
TO FIG. 325E

FIG. ~~325A~~

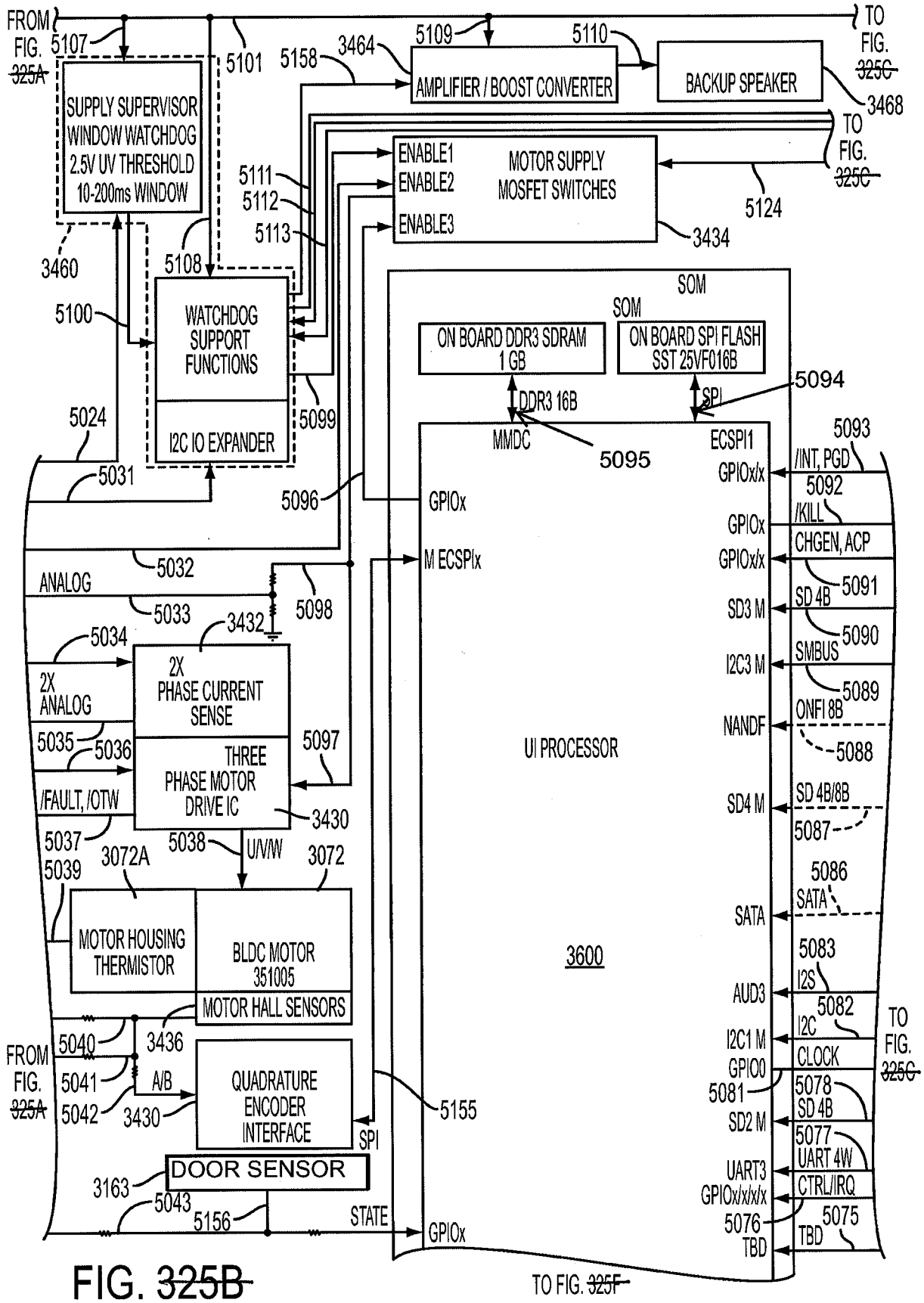

FROM FIG. 325A
5107
5101
5158
3464
5109
5110
TO FIG. 325C
AMPLIFIER / BOOST CONVERTER
BACKUP SPEAKER
3468
SUPPLY SUPERVISOR
WINDOW WATCHDOG
2.5V UV THRESHOLD
10-200ms WINDOW
ENABLE1
ENABLE2
ENABLE3
MOTOR SUPPLY
MOSFET SWITCHES
5111
5112
5113
5124
3434
3460
5108
5100
WATCHDOG
SUPPORT
FUNCTIONS
I2C IO EXPANDER
5099
5024
5031
5096
SOM
SOM
ON BOARD DDR3 SDRAM
1 GB
ON BOARD SPI FLASH
SST 25VF016B
DDR3 16B
SPI
5094
MMDC
5095
ECSPI1
5093
/INT, PGD
GPIOx/x
5092
/KILL
GPIOx
CHGEN, ACP
GPIOx/x
5091
SD 4B
SD3 M
5090
SMBUS
I2C3 M
5089
ONFI 8B
NANDF
5088
UI PROCESSOR
SD 4B/8B
SD4 M
5087
5086
SATA
SATA
3600
5083
I2S
AUD3
5082
I2C
I2C1 M
CLOCK
GPIO0
5081
5078
SD 4B
SD2 M
5077
UART 4W
CTRL/IRQ
UART3
GPIOx/x/x/x
5076
TBD
5075
TBD
TO FIG. 325C
GPIOx
M ECSPIx
5155
5032
ANALOG
5033
5098
5034
2X
ANALOG
2X
PHASE CURRENT
SENSE
3432
5035
5036
/FAULT, /OTW
THREE
PHASE MOTOR
DRIVE IC
5097
3430
5037
5039
3072A
5038
U/V/W
3072
MOTOR HOUSING
THERMISTOR
BLDC MOTOR
351005
MOTOR HALL SENSORS
FROM FIG. 325A
5040
5041
5042
3436
A/B
3430
QUADRATURE
ENCODER
INTERFACE
SPI
DOOR SENSOR
3163
5043
5156
STATE
GPIOx
TO FIG. 325F

FIG. 325B

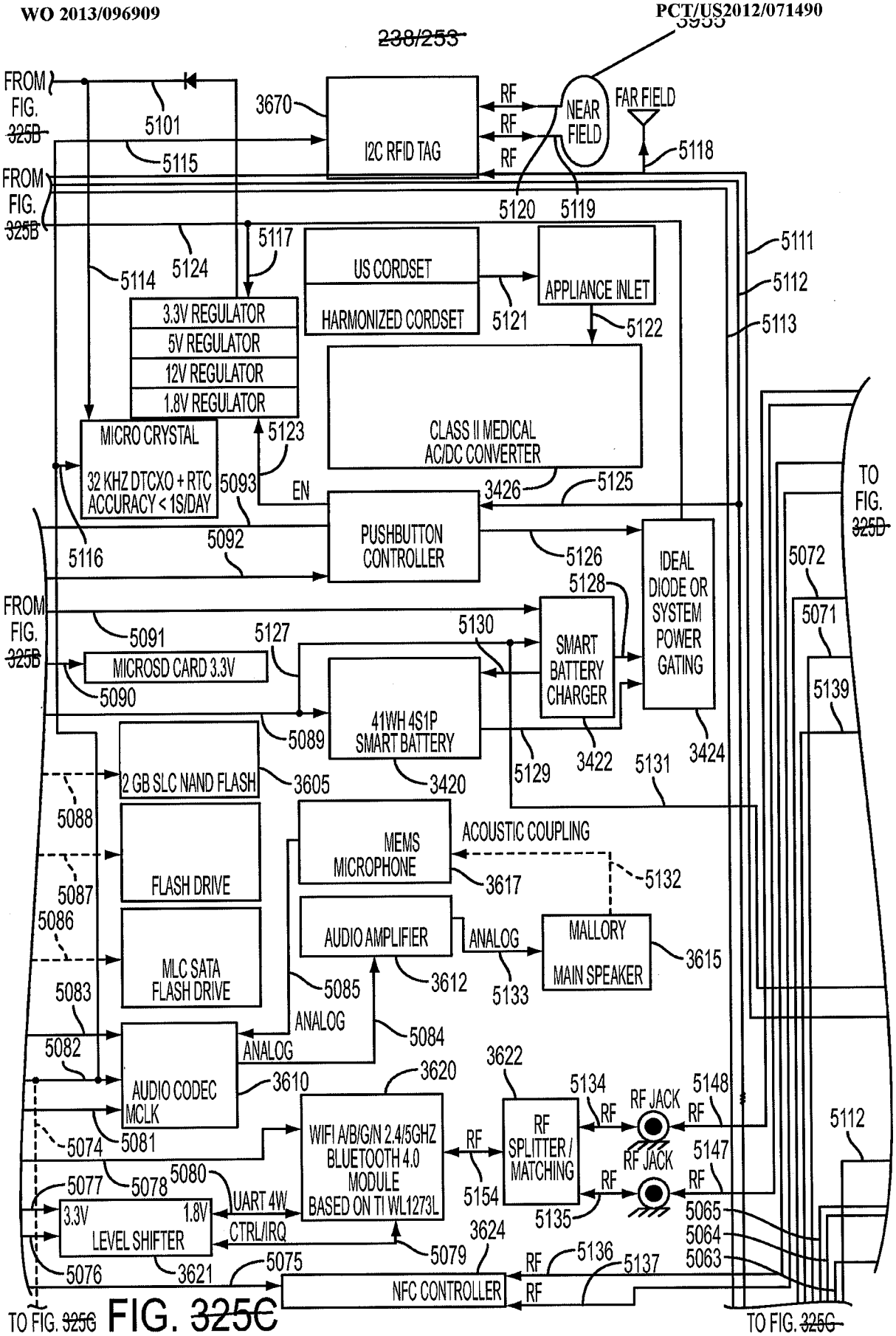

238/253
FROM FIG. 325B
5101
5115
3670
I2C RFID TAG
RF
RF
RF
NEAR FIELD
FAR FIELD
5118
5120
5119
5117
5124
5114
US CORDSET
HARMONIZED CORDSET
5121
APPLIANCE INLET
5122
5111
5112
5113
3.3V REGULATOR
5V REGULATOR
12V REGULATOR
1.8V REGULATOR
MICRO CRYSTAL
32 KHZ DTCXO + RTC
ACCURACY < 1S/DAY
5123
5093
EN
CLASS II MEDICAL
AC/DC CONVERTER
3426
5125
TO FIG. 325D
5116
5092
PUSHBUTTON CONTROLLER
5126
IDEAL DIODE OR SYSTEM POWER GATING
5072
5128
FROM FIG. 325B
5091
5127
5130
SMART BATTERY CHARGER
5071
MICROSD CARD 3.3V
5090
5139
41WH 4S1P SMART BATTERY
5089
5129
3422
5131
3424
2 GB SLC NAND FLASH
3605
3420
5088
MEMS MICROPHONE
ACOUSTIC COUPLING
3617
5132
FLASH DRIVE
5087
5086
AUDIO AMPLIFIER
ANALOG
MALLORY MAIN SPEAKER
3615
MLC SATA FLASH DRIVE
5085
3612
5133
5083
ANALOG
5084
ANALOG
5082
3622
3620
AUDIO CODEC MCLK
3610
5134
RF JACK
5148
RF
RF
5112
5074
5081
WIFI A/B/G/N 2.4/5GHZ BLUETOOTH 4.0 MODULE BASED ON TI WL1273L
RF
RF SPLITTER / MATCHING
RF JACK
5147
5077
5078
5080
UART 4W
5154
RF
RF
5135
5065
5064
5063
3.3V
1.8V
LEVEL SHIFTER
CTRL/IRQ
5079
3624
5076
3621
5075
RF
5136
5137
NFC CONTROLLER
RF
TO FIG. 325C
TO FIG. 325C

FIG. 325C

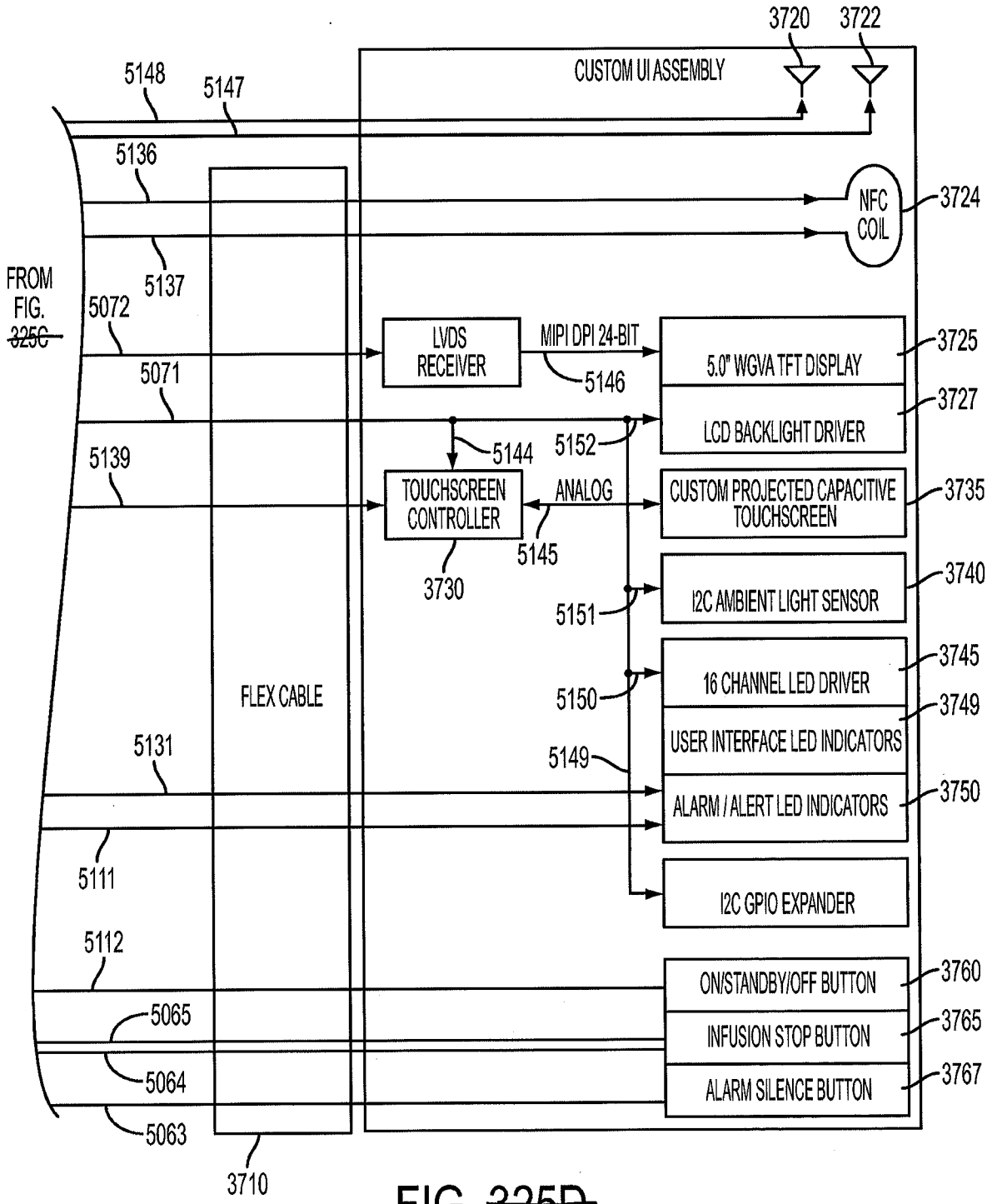

3720
3722
CUSTOM UI ASSEMBLY
5148
5147
5136
NFC COIL
3724
FROM FIG. 325C
5137
5072
5071
5139
LVDS RECEIVER
MIPI DPI 24-BIT
5146
5.0" WGVA TFT DISPLAY
3725
LCD BACKLIGHT DRIVER
3727
5144
5152
TOUCHSCREEN CONTROLLER
ANALOG
CUSTOM PROJECTED CAPACITIVE TOUCHSCREEN
3735
5145
3730
I2C AMBIENT LIGHT SENSOR
3740
5151
16 CHANNEL LED DRIVER
3745
5150
USER INTERFACE LED INDICATORS
3749
5149
ALARM / ALERT LED INDICATORS
3750
FLEX CABLE
5131
5111
I2C GPIO EXPANDER
5112
ON/STANDBY/OFF BUTTON
3760
5065
INFUSION STOP BUTTON
3765
5064
ALARM SILENCE BUTTON
3767
5063
3710

FIG. ~~325D~~

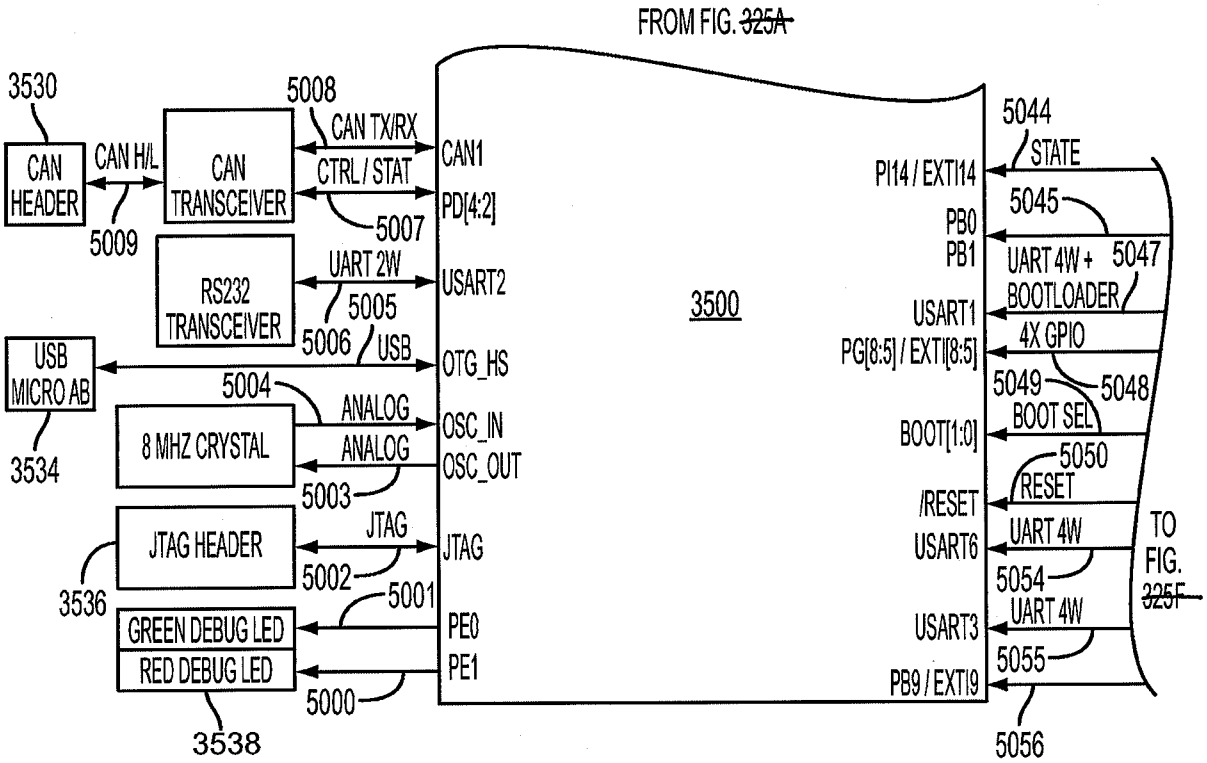

FROM FIG. ~~325A~~
3530
CAN HEADER
CAN H/L
5009
CAN TRANSCEIVER
5008
CAN TX/RX
CTRL / STAT
5007
CAN1
PD[4:2]
RS232 TRANSCEIVER
UART 2W
5005
5006
USB
USART2
OTG_HS
USB MICRO AB
3534
5004
ANALOG
ANALOG
8 MHZ CRYSTAL
5003
OSC_IN
OSC_OUT
JTAG HEADER
3536
JTAG
5002
JTAG
5001
GREEN DEBUG LED
RED DEBUG LED
3538
5000
PE0
PE1
3500
PI14 / EXTI14
PB0
PB1
USART1
PG[8:5] / EXTI[8:5]
BOOT[1:0]
/RESET
USART6
USART3
PB9 / EXTI9
5044
STATE
5045
UART 4W +
BOOTLOADER
5047
4X GPIO
5049
5048
BOOT SEL
5050
RESET
UART 4W
5054
UART 4W
5055
5056
TO FIG. ~~325F~~

FIG. ~~325E~~

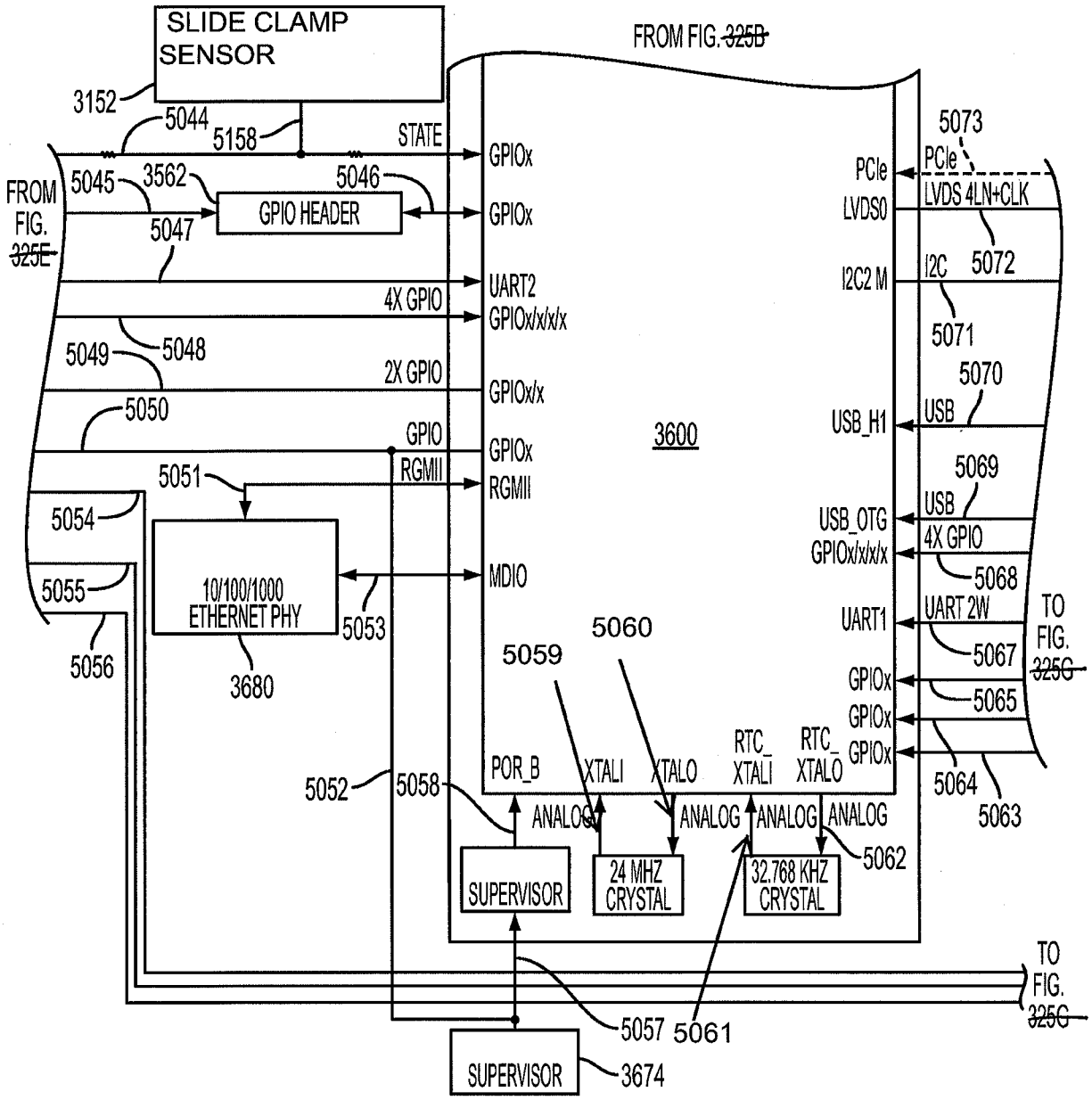

SLIDE CLAMP SENSOR
3152
5044
5158
STATE
FROM FIG. 325B
5073
PCIe
PCIe
LVDS 4LN+CLK
FROM FIG. 325E
5045
3562
5046
GPIO HEADER
5047
GPIOx
GPIOx
LVDS0
I2C2 M
I2C
5072
UART2
4X GPIO
GPIOx/x/x/x
5071
5049
5048
2X GPIO
GPIOx/x
5070
USB
USB_H1
5050
GPIO
GPIOx
3600
5069
USB
RGMII
RGMII
5051
5054
USB_OTG
4X GPIO
GPIOx/x/x/x
5068
5055
10/100/1000 ETHERNET PHY
MDIO
5053
UART1
UART 2W
TO FIG. 325G
5067
5056
3680
5060
5059
GPIOx
5065
GPIOx
RTC_ XTALI
RTC_ XTALO
GPIOx
POR_B
XTALI
XTALO
5064
5063
5052
5058
ANALOG
ANALOG
ANALOG
ANALOG
5062
SUPERVISOR
24 MHZ CRYSTAL
32.768 KHZ CRYSTAL
TO FIG. 325G
5057
5061
SUPERVISOR
3674

FIG. ~~325F~~

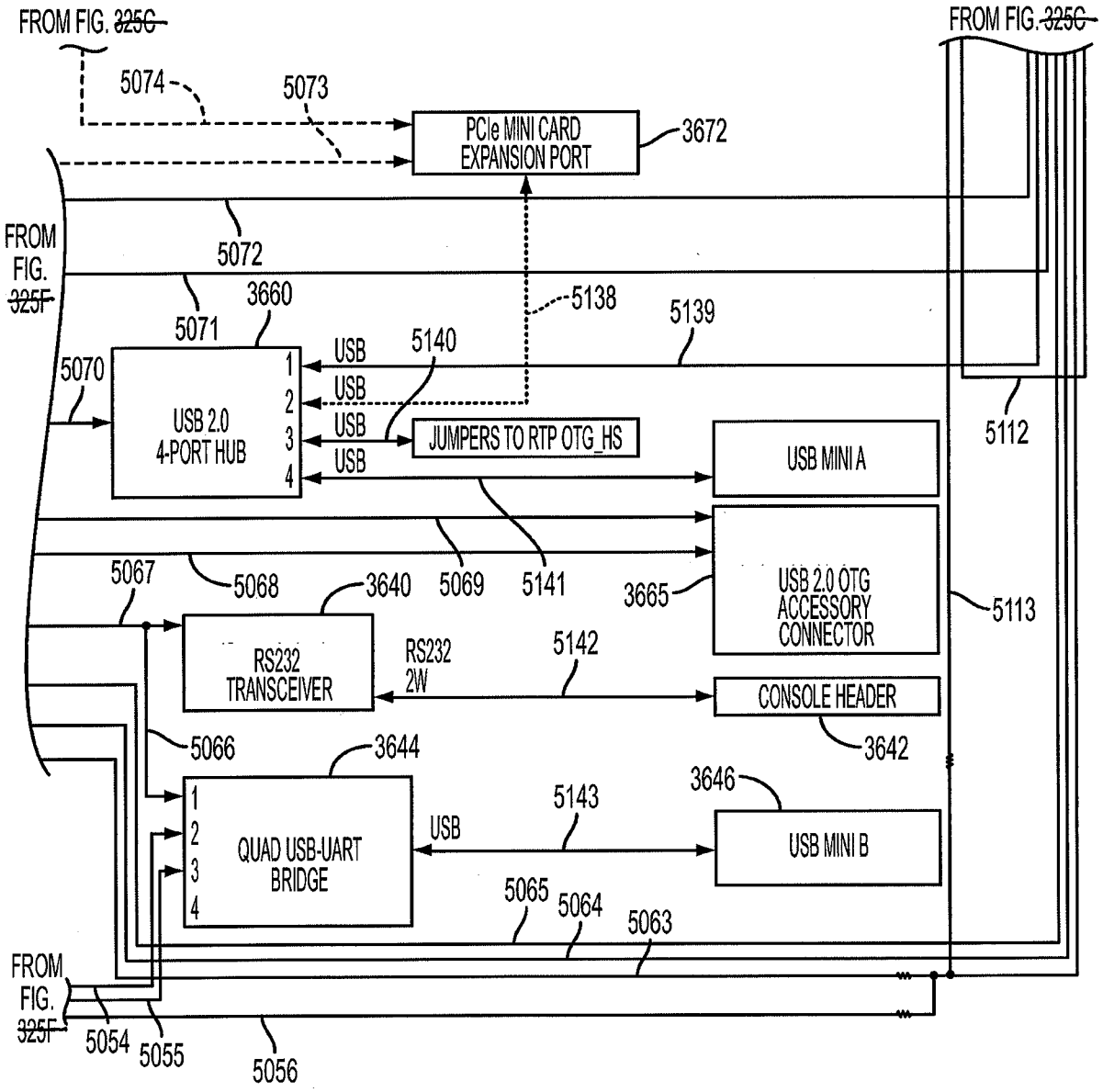

FROM FIG. 325G
FROM FIG. 325G
5074
5073
PCIe MINI CARD EXPANSION PORT
3672
FROM FIG. 325F
5072
5071
3660
5138
5139
5070
USB 2.0 4-PORT HUB
USB
USB
USB
USB
5140
JUMPERS TO RTP OTG_HS
USB MINI A
5112
5067
5068
3640
5069
5141
3665
USB 2.0 OTG ACCESSORY CONNECTOR
5113
RS232 TRANSCEIVER
RS232 2W
5142
CONSOLE HEADER
3642
5066
3644
3646
QUAD USB-UART BRIDGE
USB
5143
USB MINI B
5065
5064
5063
FROM FIG. 325F
5054
5055
5056

FIG. ~~325G~~

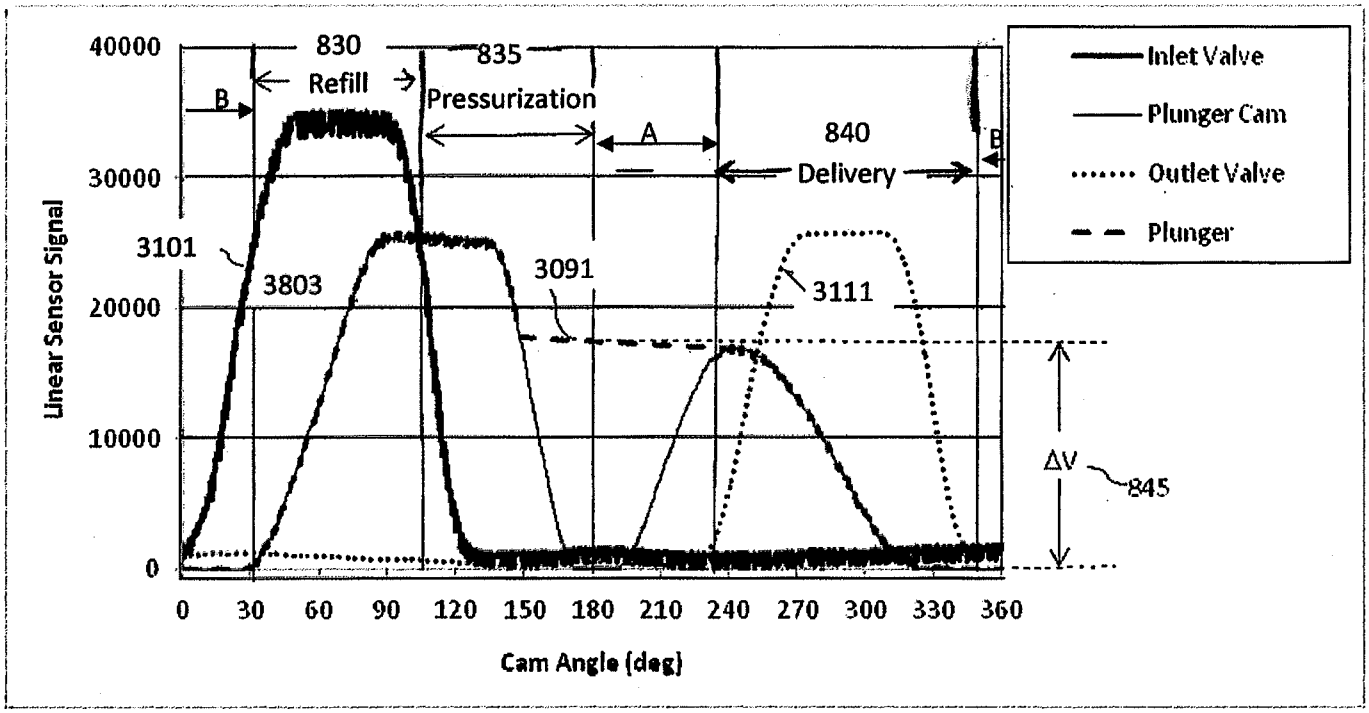

40000
30000
20000
10000
0
Linear Sensor Signal
830
Refill
835
Pressurization
840
Delivery
A
B
B
3101
3803
3091
3111
ΔV
845
Inlet Valve
Plunger Cam
Outlet Valve
Plunger
0 30 60 90 120 150 180 210 240 270 300 330 360
Cam Angle (deg)

FIG. ~~326~~

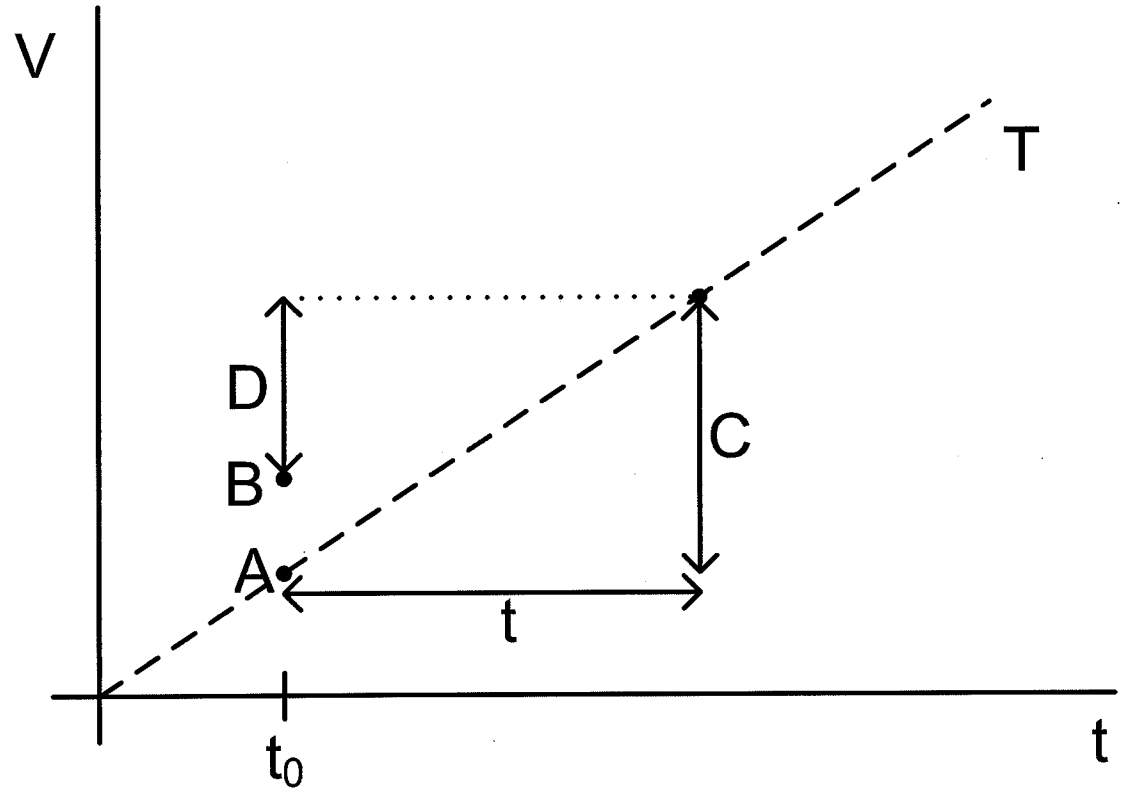


FIG. ~~327~~

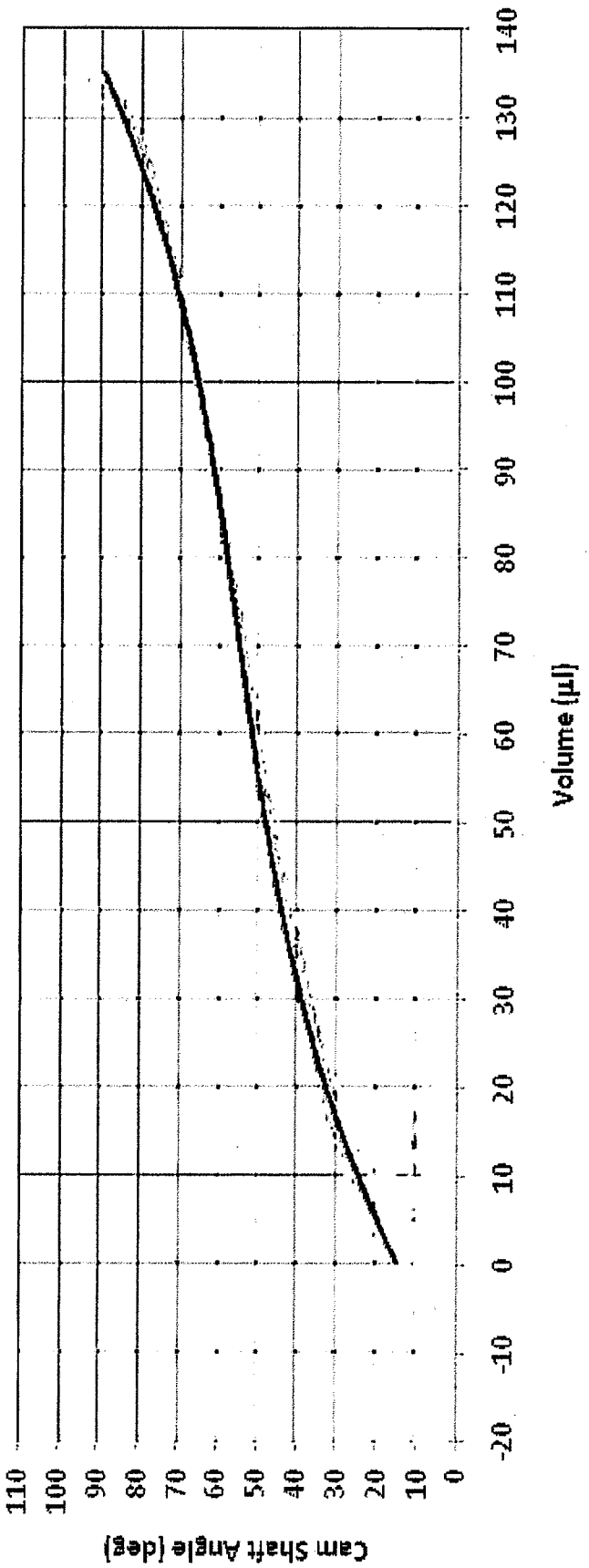

Cam Shaft Angle (deg)
110
100
90
80
70
60
50
40
30
20
10
0
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Volume (µl)

FIG. ~~328~~

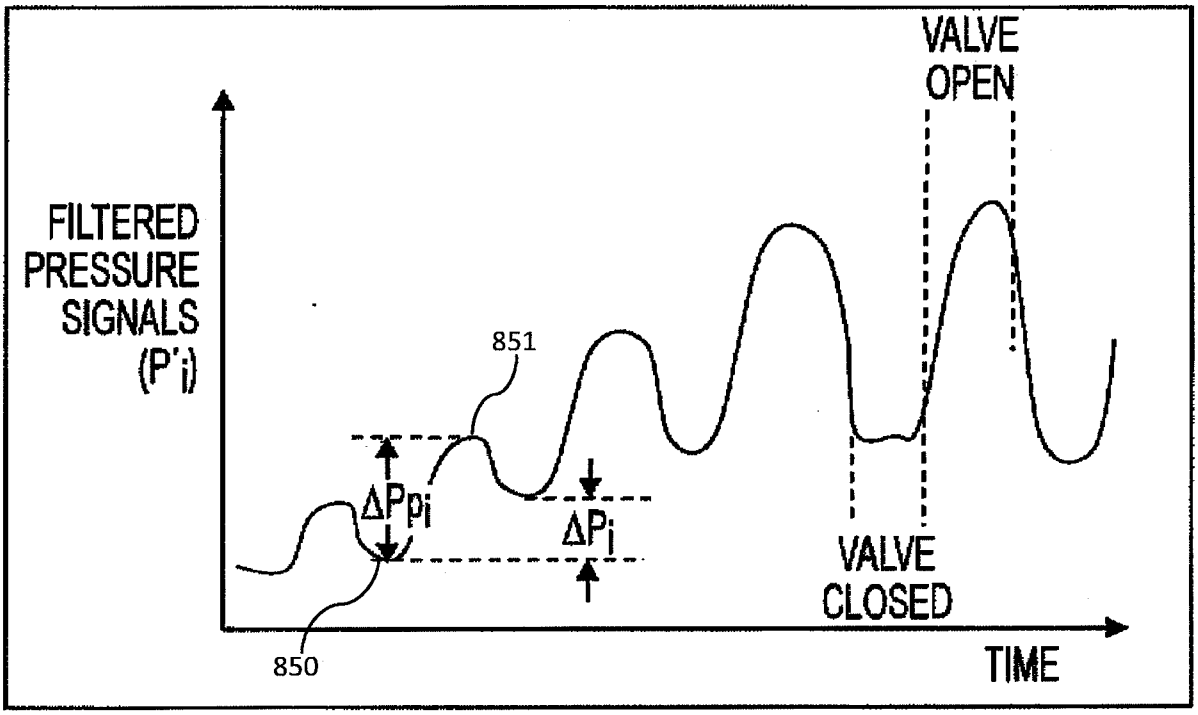

VALVE
OPEN
FILTERED
PRESSURE
SIGNALS
(P'i)
851
ΔPpi
ΔPi
VALVE
CLOSED
850
TIME

FIG. ~~329~~

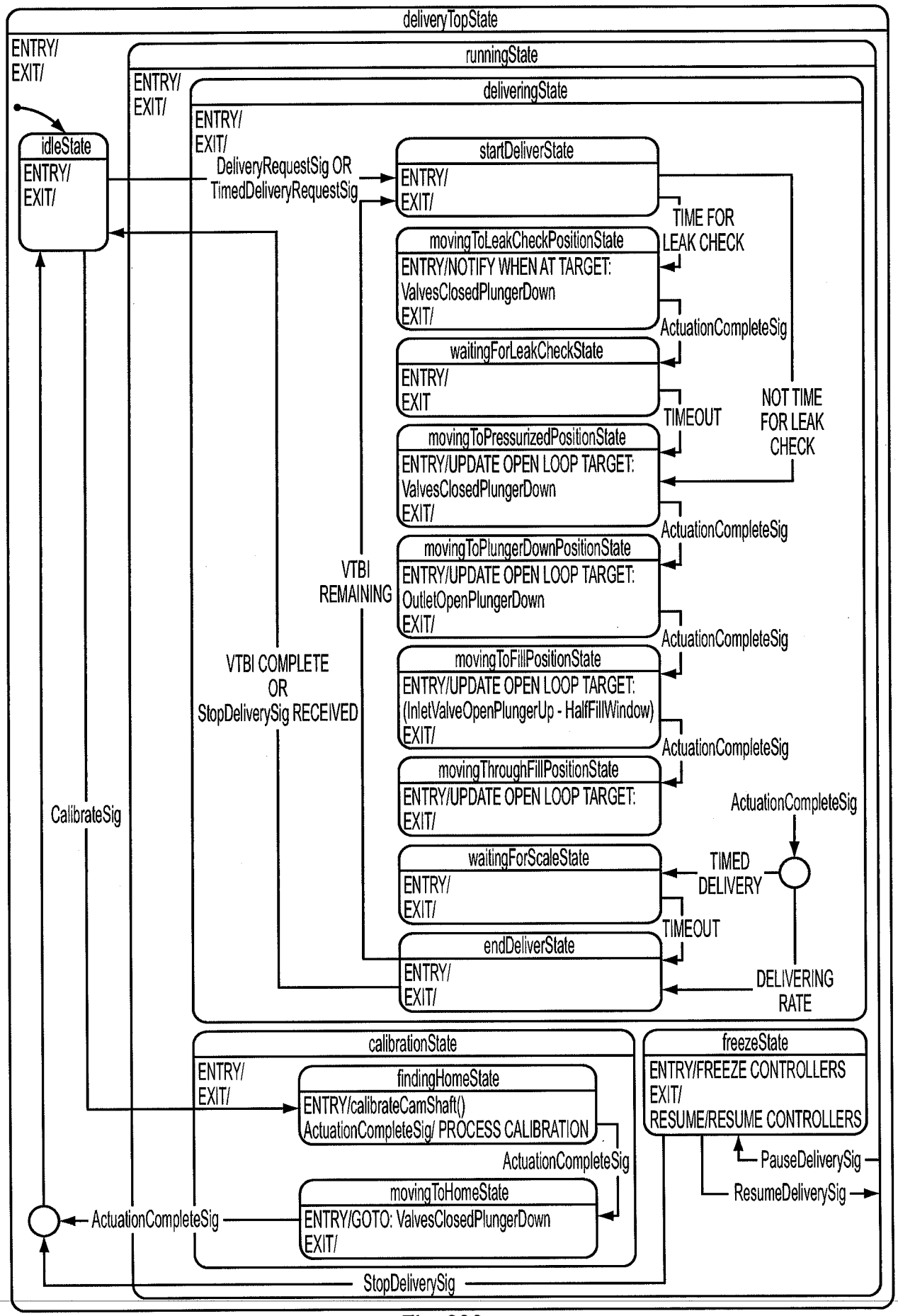

deliveryTopState
ENTRY/
EXIT/
runningState
ENTRY/
EXIT/
deliveringState
ENTRY/
EXIT/
idleState
ENTRY/
EXIT/
DeliveryRequestSig OR
TimedDeliveryRequestSig
startDeliverState
ENTRY/
EXIT/
TIME FOR
LEAK CHECK
movingToLeakCheckPositionState
ENTRY/NOTIFY WHEN AT TARGET:
ValvesClosedPlungerDown
EXIT/
ActuationCompleteSig
waitingForLeakCheckState
ENTRY/
EXIT
TIMEOUT
NOT TIME
FOR LEAK
CHECK
movingToPressurizedPositionState
ENTRY/UPDATE OPEN LOOP TARGET:
ValvesClosedPlungerDown
EXIT/
ActuationCompleteSig
movingToPlungerDownPositionState
ENTRY/UPDATE OPEN LOOP TARGET:
OutletOpenPlungerDown
EXIT/
VTBI
REMAINING
ActuationCompleteSig
movingToFillPositionState
ENTRY/UPDATE OPEN LOOP TARGET:
(InletValveOpenPlungerUp - HalfFillWindow)
EXIT/
VTBI COMPLETE
OR
StopDeliverySig RECEIVED
ActuationCompleteSig
movingThroughFillPositionState
ENTRY/UPDATE OPEN LOOP TARGET:
EXIT/
ActuationCompleteSig
CalibrateSig
waitingForScaleState
ENTRY/
EXIT/
TIMED
DELIVERY
TIMEOUT
endDeliverState
ENTRY/
EXIT/
DELIVERING
RATE
calibrationState
ENTRY/
EXIT/
findingHomeState
ENTRY/calibrateCamShaft()
ActuationCompleteSig/ PROCESS CALIBRATION
ActuationCompleteSig
movingToHomeState
ENTRY/GOTO: ValvesClosedPlungerDown
EXIT/
ActuationCompleteSig
freezeState
ENTRY/FREEZE CONTROLLERS
EXIT/
RESUME/RESUME CONTROLLERS
PauseDeliverySig
ResumeDeliverySig
StopDeliverySig

Fig. 330

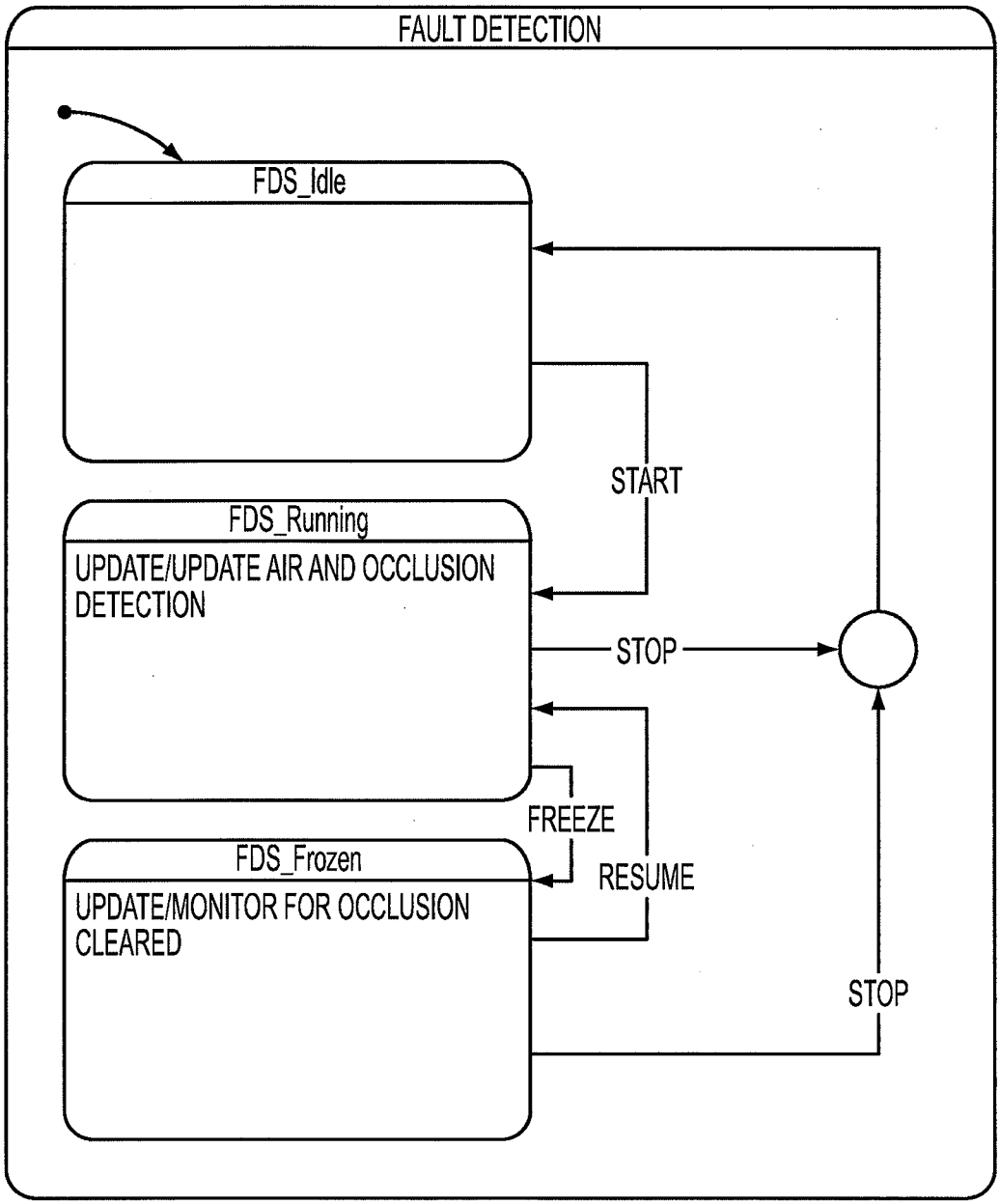

FAULT DETECTION
FDS_Idle
START
FDS_Running
UPDATE/UPDATE AIR AND OCCLUSION DETECTION
STOP
FREEZE
FDS_Frozen
RESUME
UPDATE/MONITOR FOR OCCLUSION CLEARED
STOP

Fig. ~~331~~

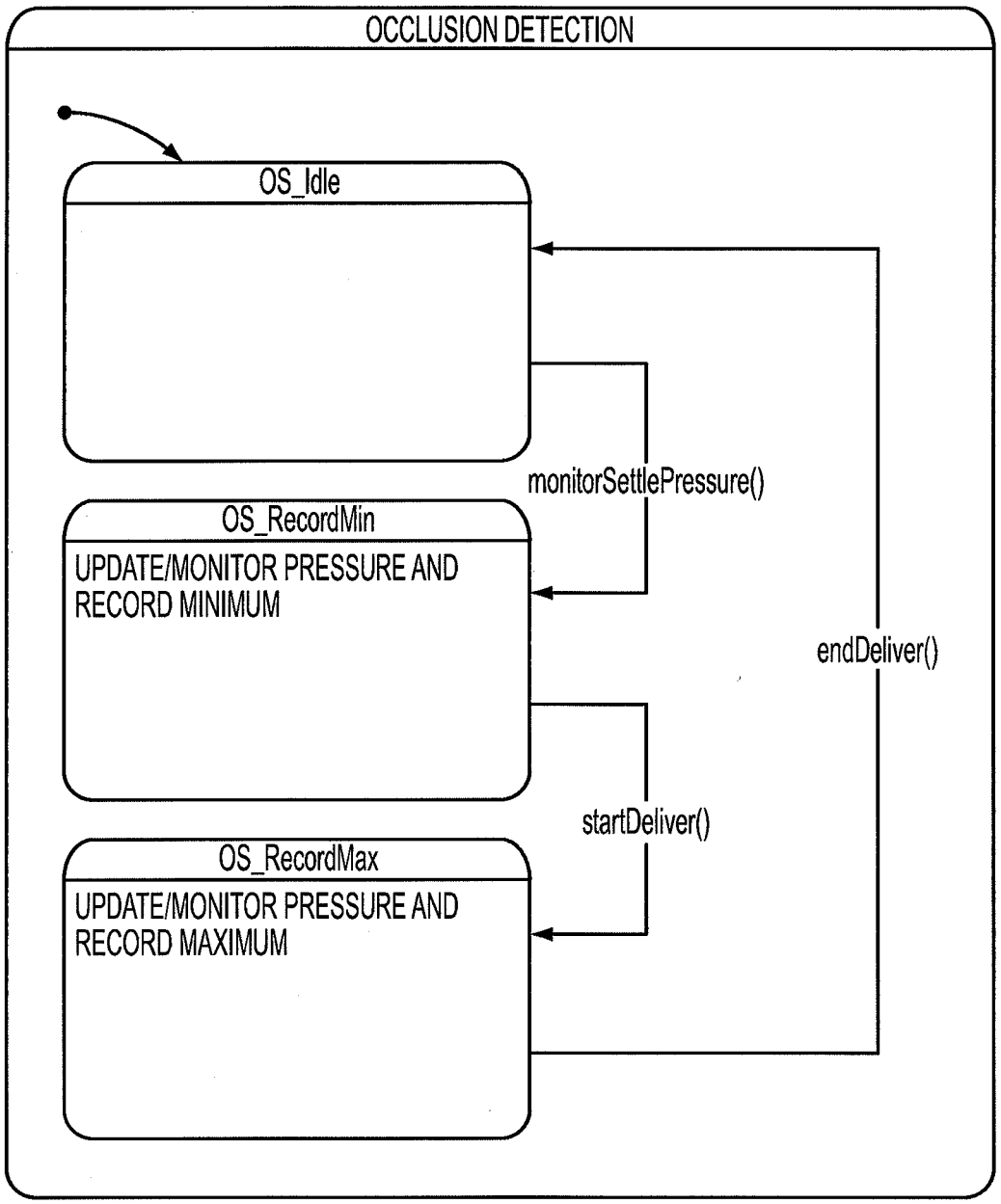

OCCLUSION DETECTION
OS_Idle
monitorSettlePressure()
OS_RecordMin
UPDATE/MONITOR PRESSURE AND RECORD MINIMUM
endDeliver()
startDeliver()
OS_RecordMax
UPDATE/MONITOR PRESSURE AND RECORD MAXIMUM

Fig. ~~332~~

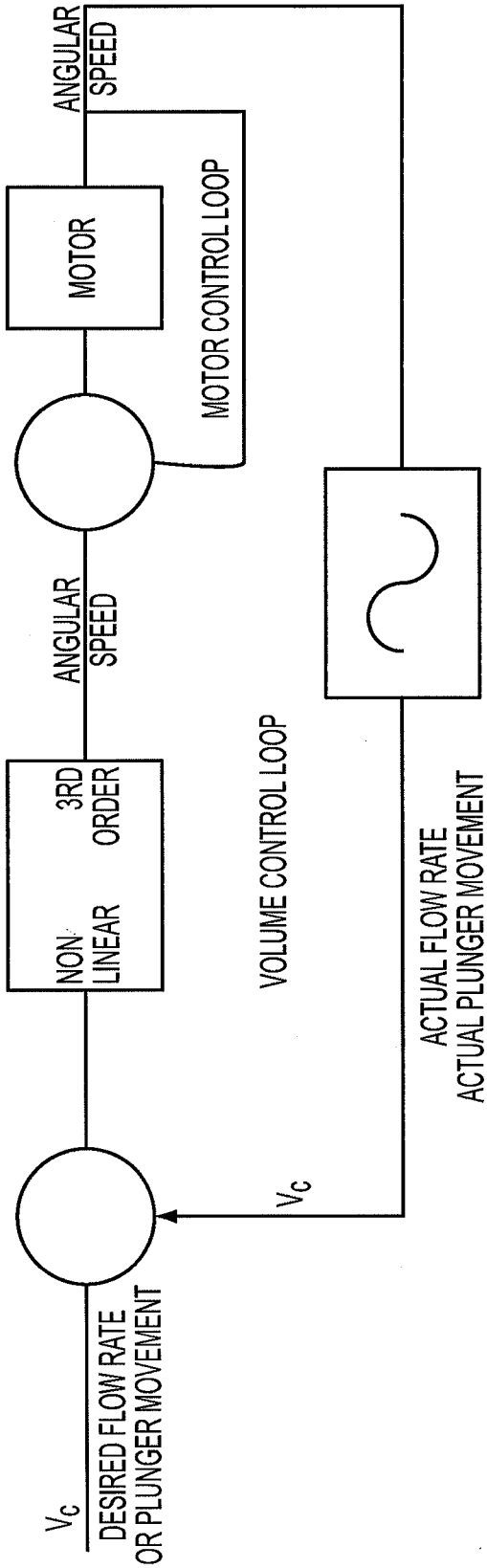

ANGULAR SPEED
MOTOR
MOTOR CONTROL LOOP
ANGULAR SPEED
3RD ORDER NON LINEAR
VOLUME CONTROL LOOP
ACTUAL FLOW RATE
ACTUAL PLUNGER MOVEMENT
V_c
V_c
DESIRED FLOW RATE
OR PLUNGER MOVEMENT

Fig. ~~333~~

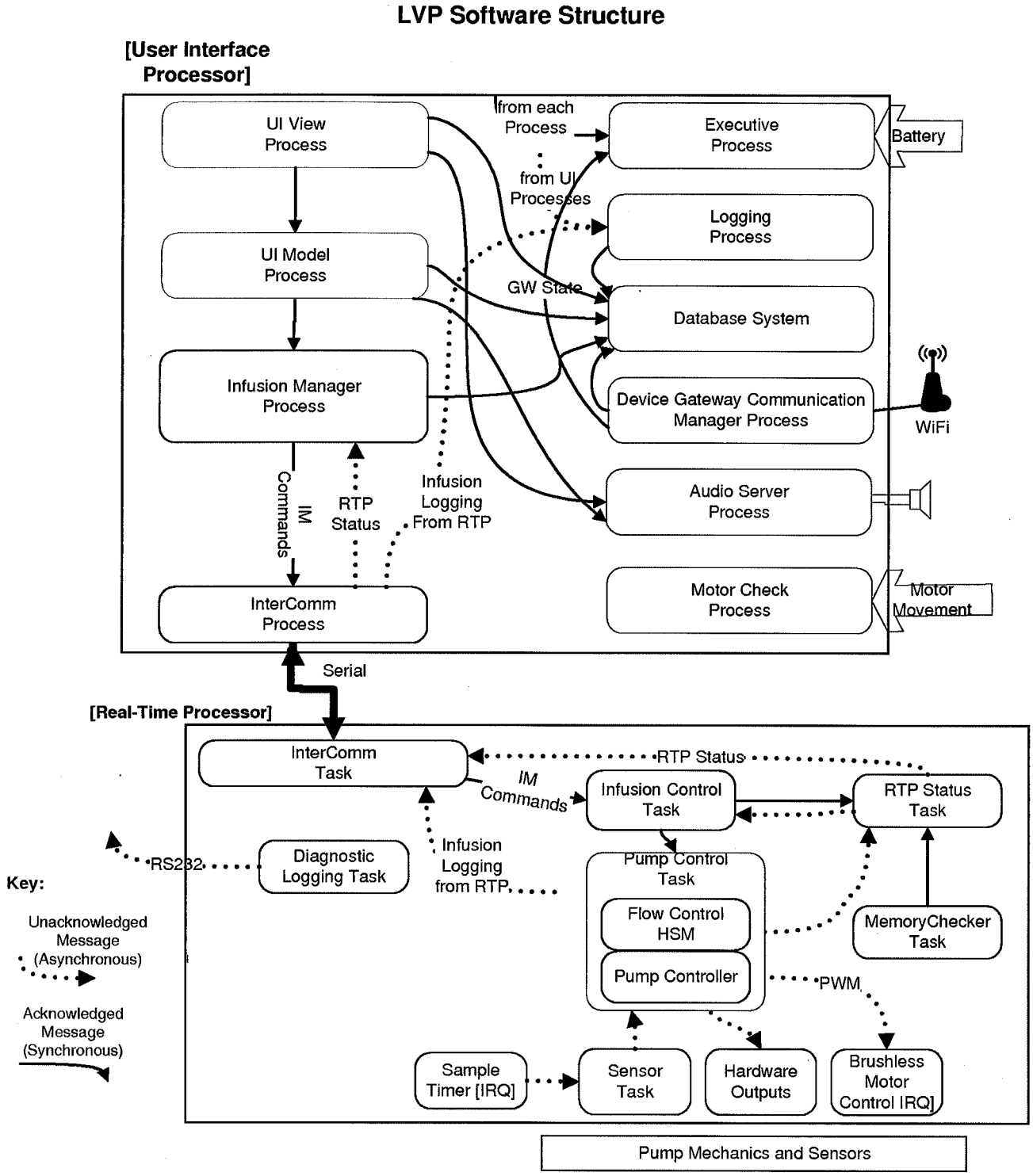
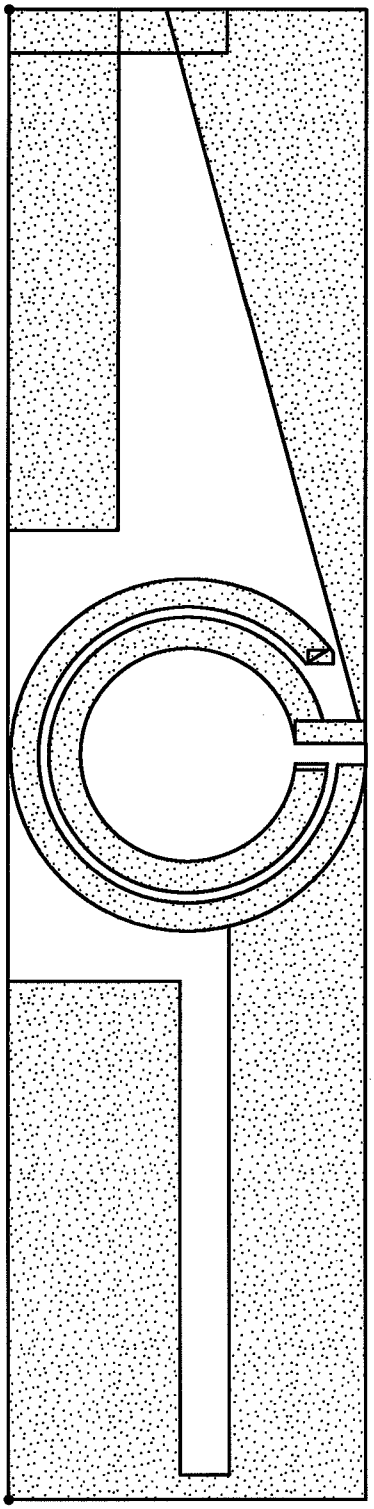

LVP Software Structure
[User Interface Processor]
UI View Process
UI Model Process
Infusion Manager Process
InterComm Process
from each Process
from UI Processes
GW State
Commands
IM
RTP Status
Infusion Logging From RTP
Executive Process
Logging Process
Database System
Device Gateway Communication Manager Process
Audio Server Process
Motor Check Process
Battery
WiFi
Motor Movement
Serial
[Real-Time Processor]
InterComm Task
RTP Status
IM Commands
Infusion Control Task
RTP Status Task
RS232
Diagnostic Logging Task
Infusion Logging from RTP
Pump Control Task
Flow Control HSM
Pump Controller
MemoryChecker Task
PWM
Sample Timer [IRQ]
Sensor Task
Hardware Outputs
Brushless Motor Control IRQ]
Pump Mechanics and Sensors
Key:
Unacknowledged Message (Asynchronous)
Acknowledged Message (Synchronous)

Fig. ~~334~~



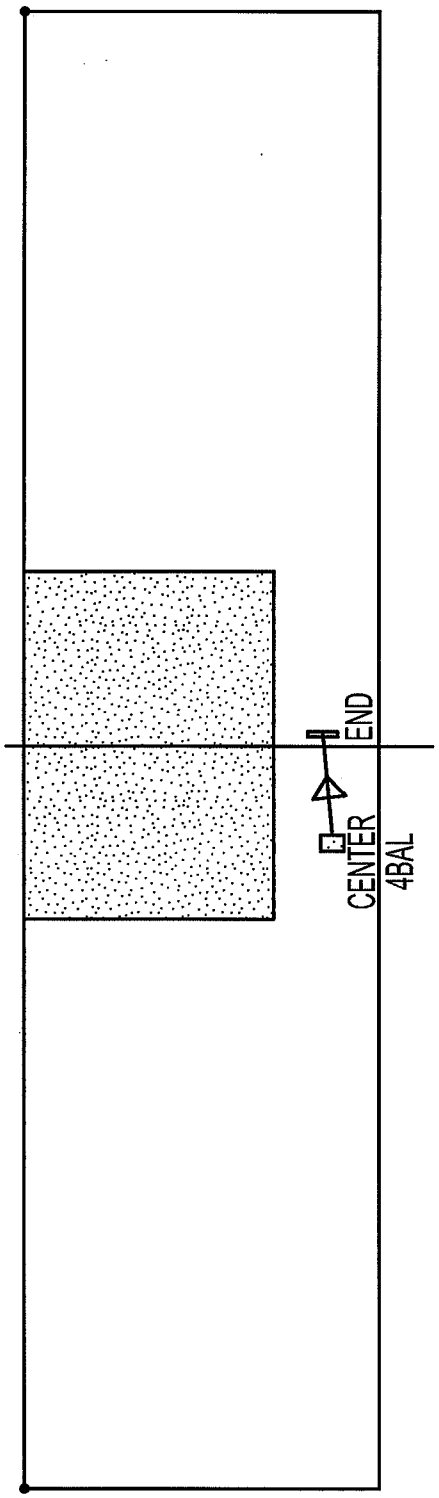


Fig. ~~335~~

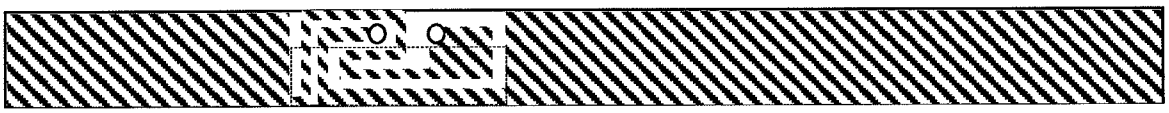


Fig. ~~336~~

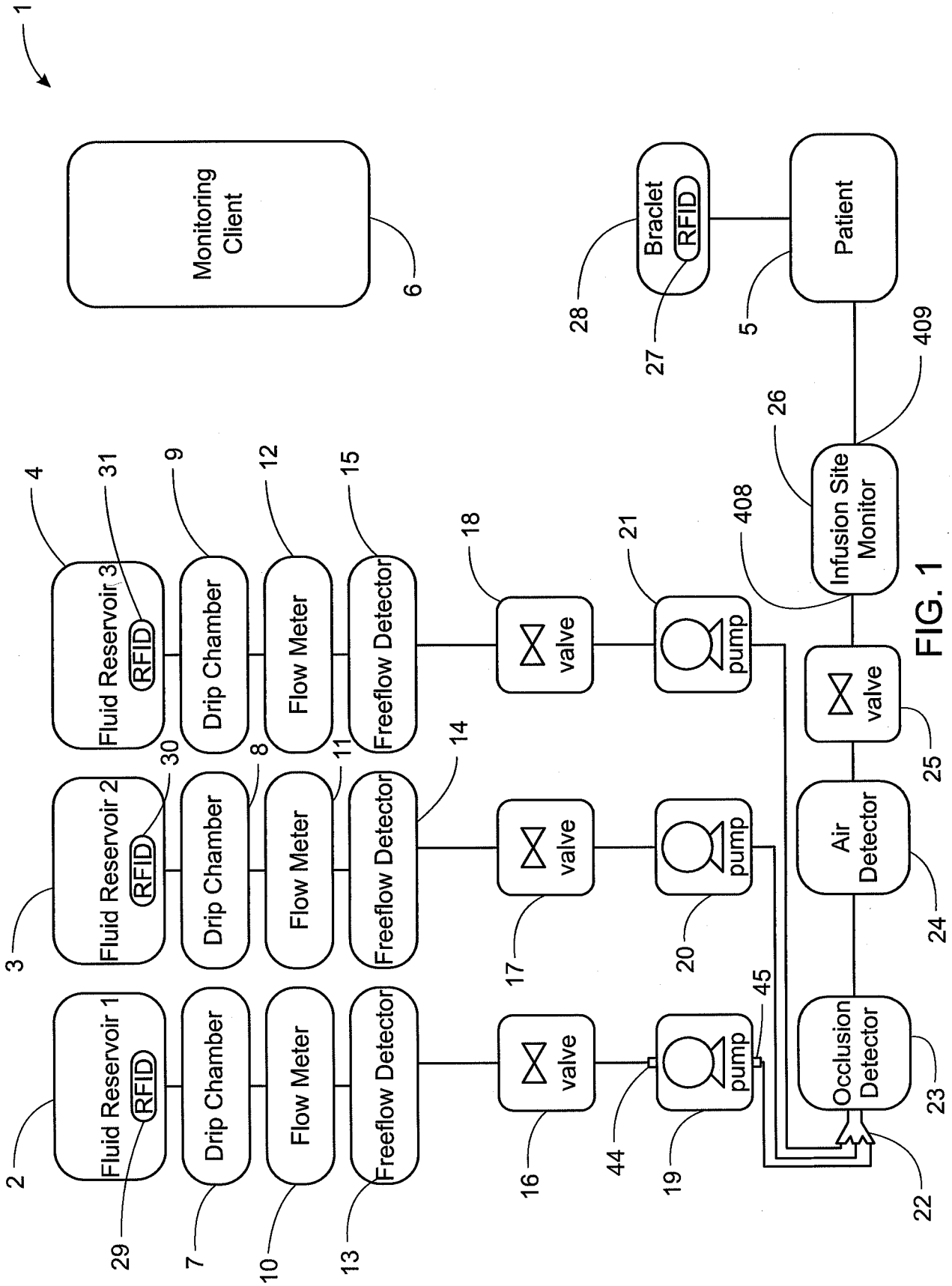

1
Monitoring Client
6
Fluid Reservoir 1
RFID
2
29
Drip Chamber
7
Flow Meter
10
Freeflow Detector
13
Fluid Reservoir 2
RFID
3
30
Drip Chamber
8
Flow Meter
11
Freeflow Detector
14
Fluid Reservoir 3
RFID
4
31
Drip Chamber
9
Flow Meter
12
Freeflow Detector
15
valve
16
valve
17
valve
18
pump
19
pump
20
pump
21
44
45
Occlusion Detector
22
Air Detector
23
24
valve
25
Infusion Site Monitor
26
408
409
Bracelet
RFID
27
28
Patient
5

FIG. 1

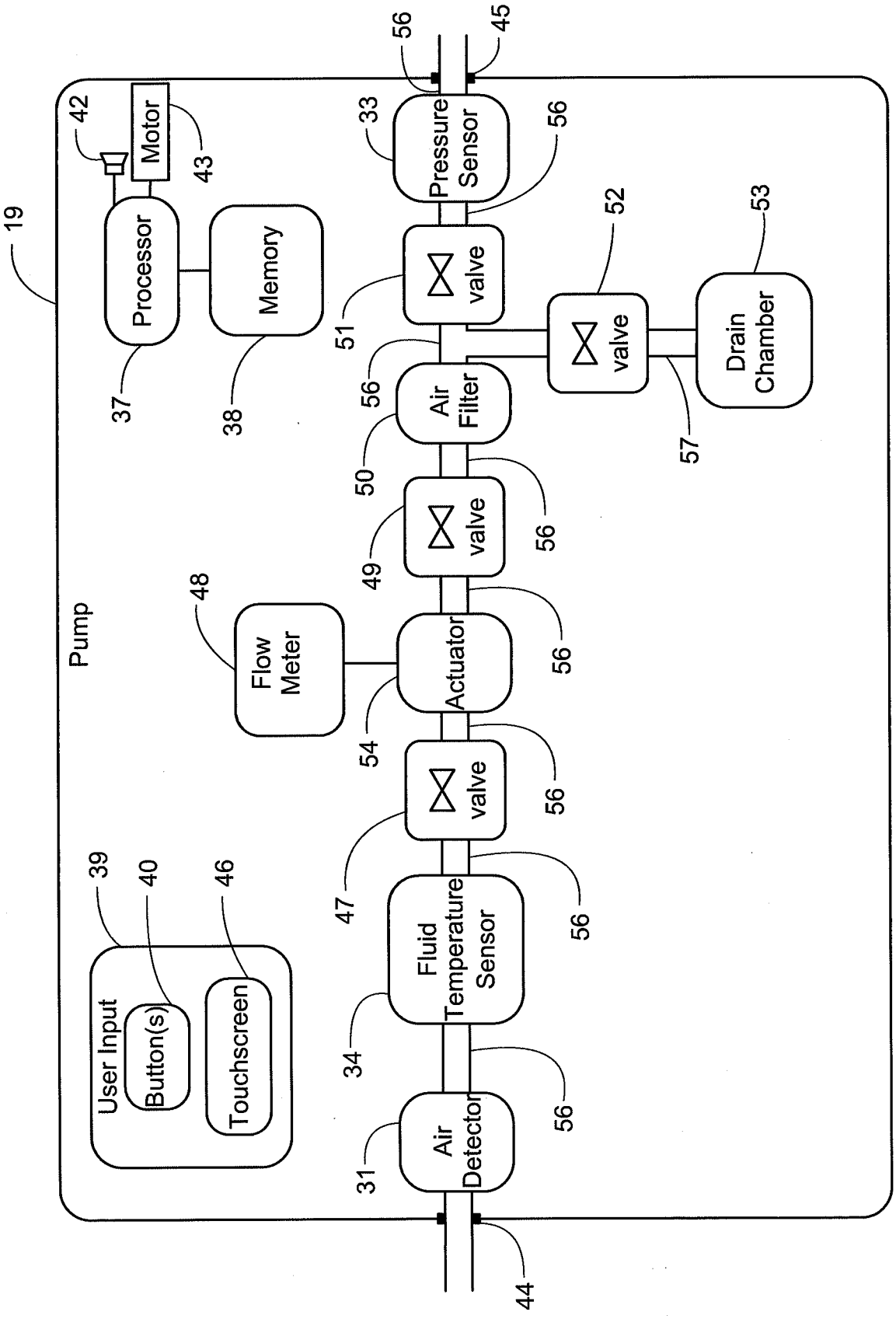

19
Pump
42
Motor
43
Processor
37
Memory
38
56
45
33
Pressure Sensor
56
52
53
51
valve
valve
Drain Chamber
56
Air Filter
50
57
49
valve
56
48
Flow Meter
Actuator
56
54
valve
56
47
39
40
46
User Input
Button(s)
Touchscreen
Fluid Temperature Sensor
56
34
56
31
Air Detector
44

FIG. 2

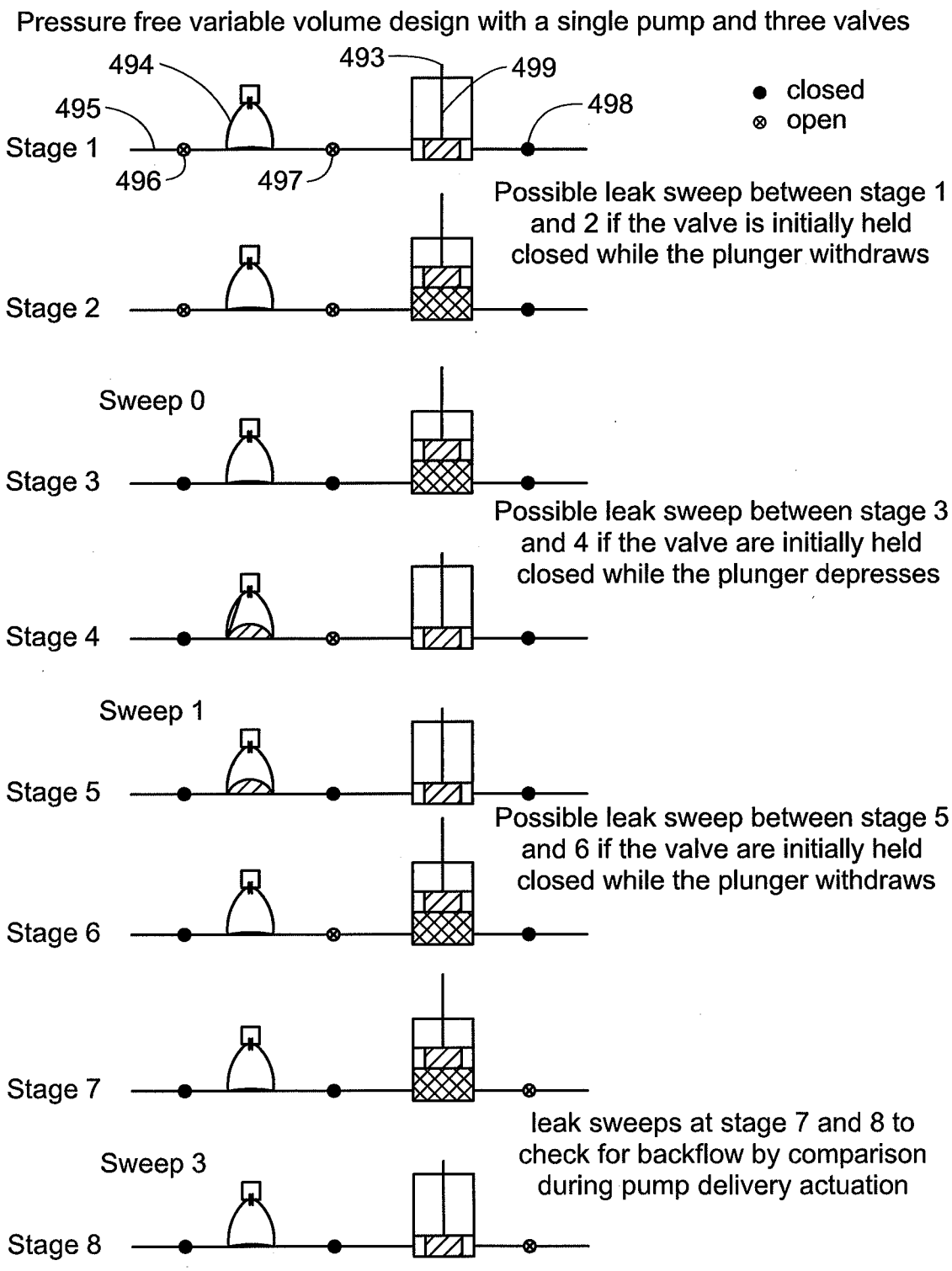

Pressure free variable volume design with a single pump and three valves
494
493
499
495
498
Stage 1
496
497
closed
open
Possible leak sweep between stage 1 and 2 if the valve is initially held closed while the plunger withdraws
Stage 2
Sweep 0
Stage 3
Possible leak sweep between stage 3 and 4 if the valve are initially held closed while the plunger depresses
Stage 4
Sweep 1
Stage 5
Possible leak sweep between stage 5 and 6 if the valve are initially held closed while the plunger withdraws
Stage 6
Stage 7
leak sweeps at stage 7 and 8 to check for backflow by comparison during pump delivery actuation
Sweep 3
Stage 8

FIG.3

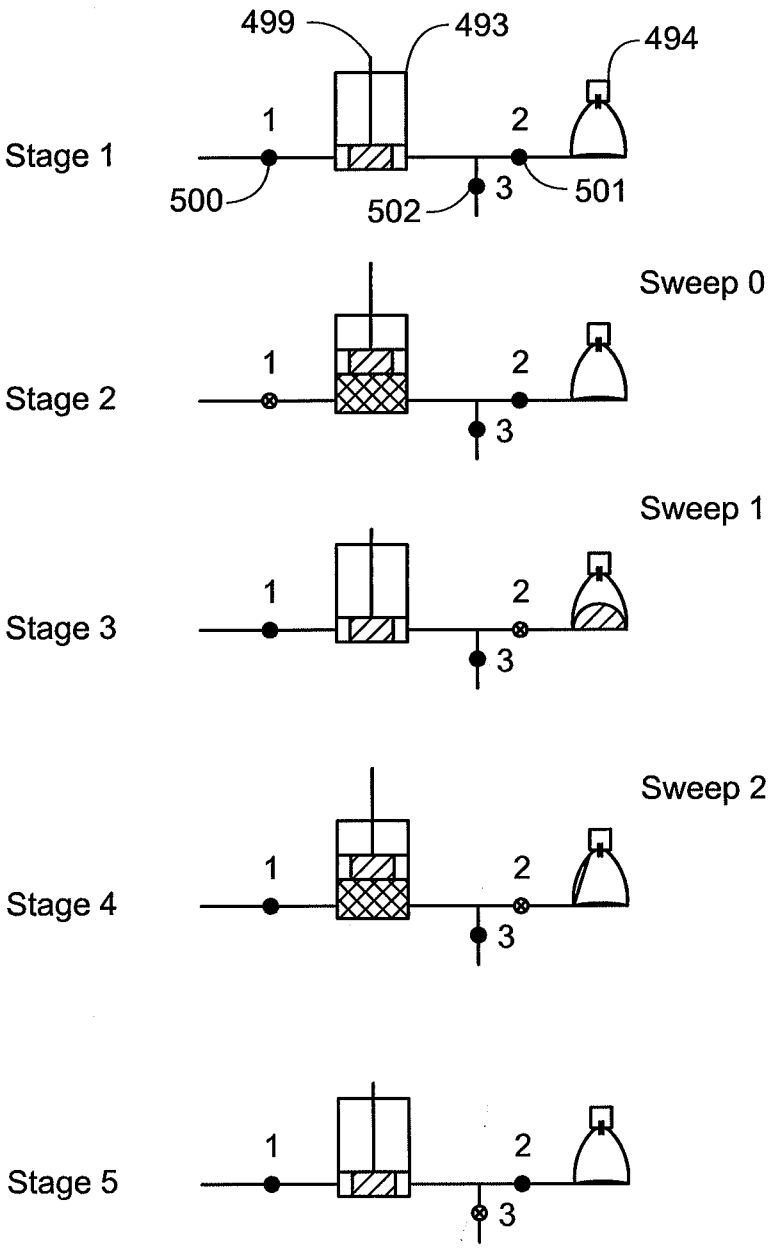

499
493
494
Stage 1
1
2
3
500
502
501
Sweep 0
Stage 2
1
2
3
Sweep 1
Stage 3
1
2
3
Sweep 2
Stage 4
1
2
3
Stage 5
1
2
3

FIG.4

Actuator in pressure-free variable volume design with a single pump and two valves

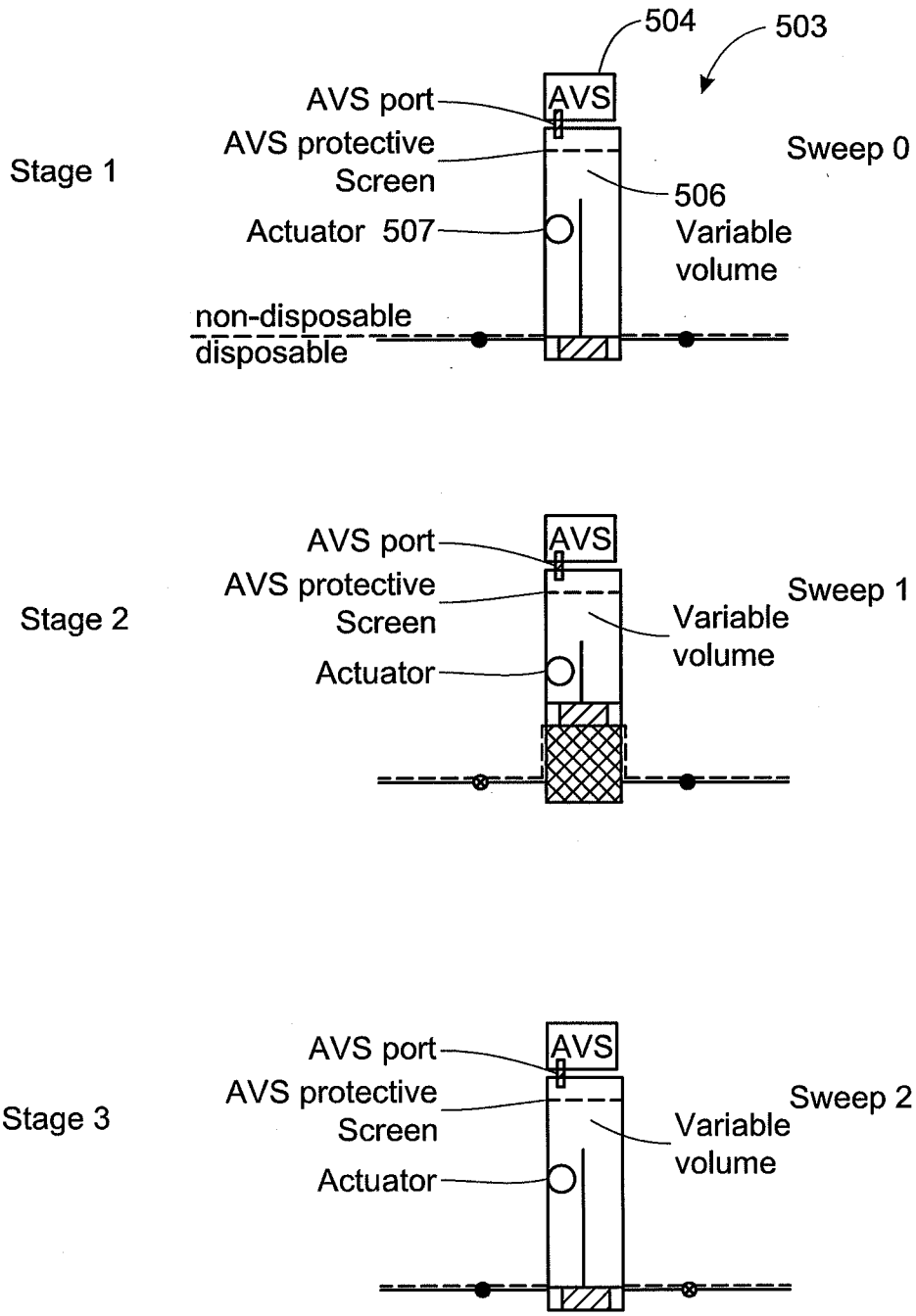


FIG.5

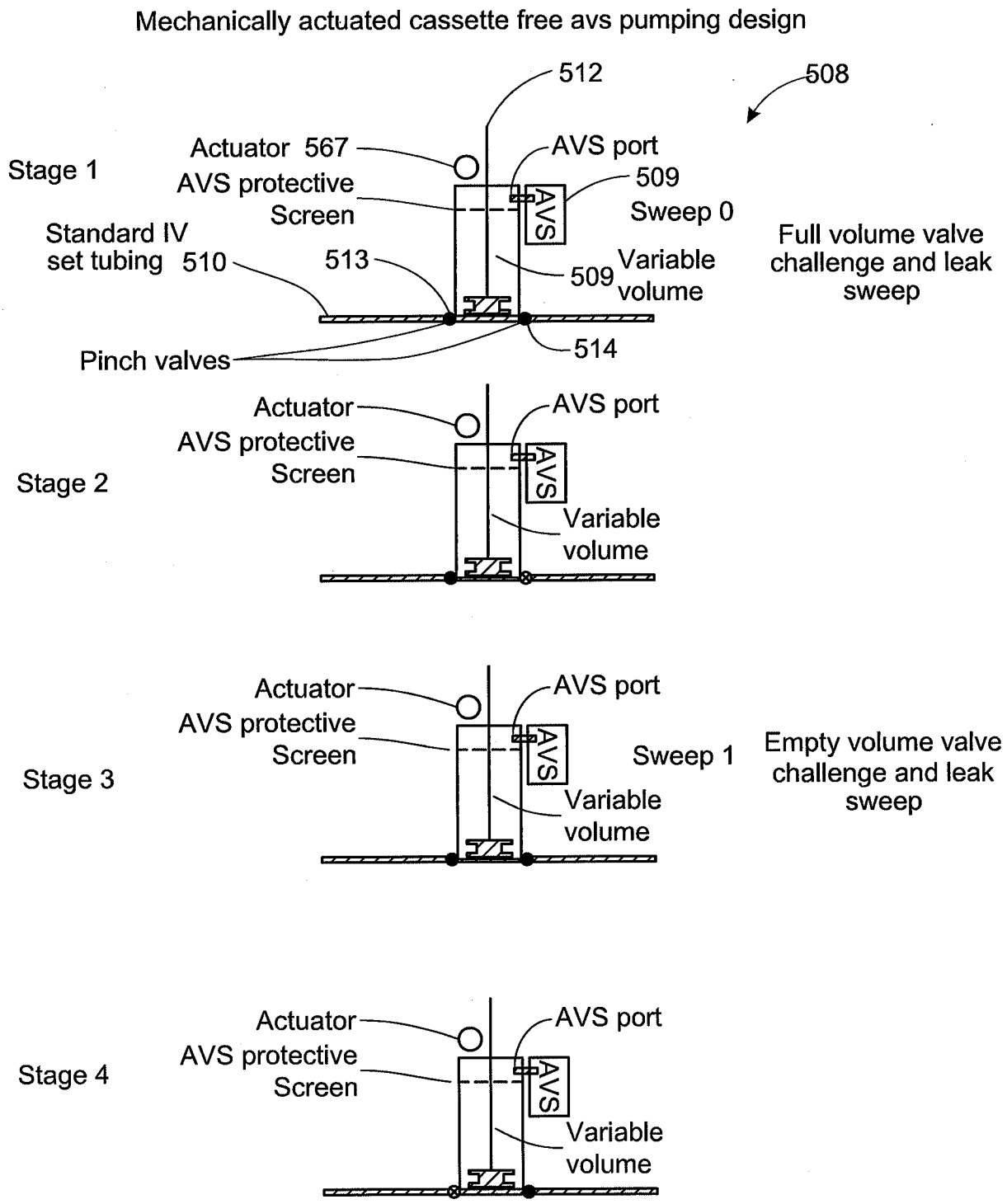

Mechanically actuated cassette free avs pumping design
512
508
Stage 1
Actuator 567
AVS protective Screen
AVS port
509
Sweep 0
Standard IV set tubing
510
513
509
Variable volume
Full volume valve challenge and leak sweep
Pinch valves
514
Stage 2
Actuator
AVS protective Screen
AVS port
Variable volume
Stage 3
Actuator
AVS protective Screen
AVS port
Sweep 1
Variable volume
Empty volume valve challenge and leak sweep
Stage 4
Actuator
AVS protective Screen
AVS port
Variable volume

FIG.6

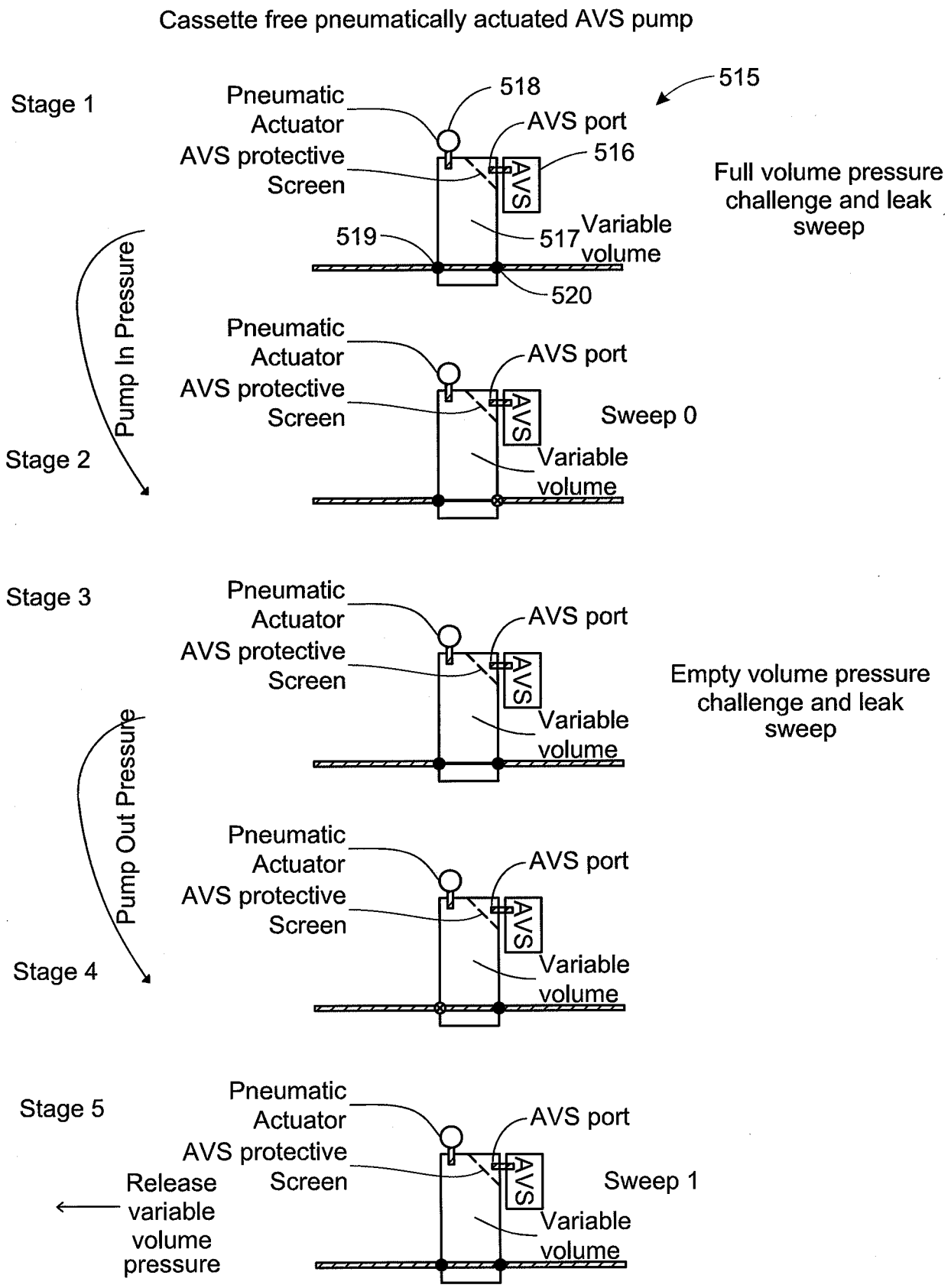

Cassette free pneumatically actuated AVS pump
Stage 1
Pneumatic Actuator
AVS protective Screen
518
515
AVS port
516
AVS
519
517
Variable volume
520
Full volume pressure challenge and leak sweep
Pump In Pressure
Stage 2
Pneumatic Actuator
AVS protective Screen
AVS port
AVS
Sweep 0
Variable volume
Stage 3
Pneumatic Actuator
AVS protective Screen
AVS port
AVS
Variable volume
Empty volume pressure challenge and leak sweep
Pump Out Pressure
Stage 4
Pneumatic Actuator
AVS protective Screen
AVS port
AVS
Variable volume
Stage 5
Pneumatic Actuator
AVS protective Screen
AVS port
AVS
Sweep 1
Variable volume
Release variable volume pressure

FIG. 7

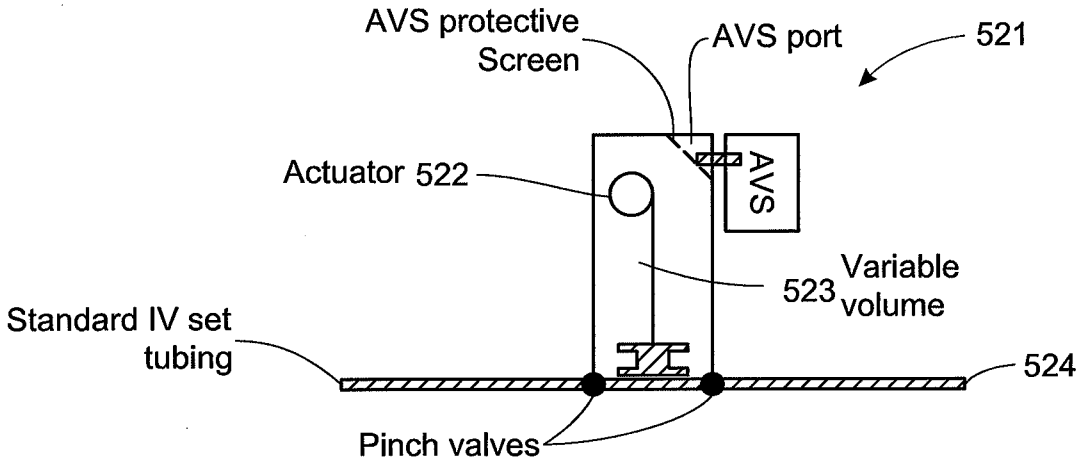

AVS protective Screen
AVS port
521
Actuator 522
AVS
523 Variable volume
Standard IV set tubing
524
Pinch valves

FIG. 8

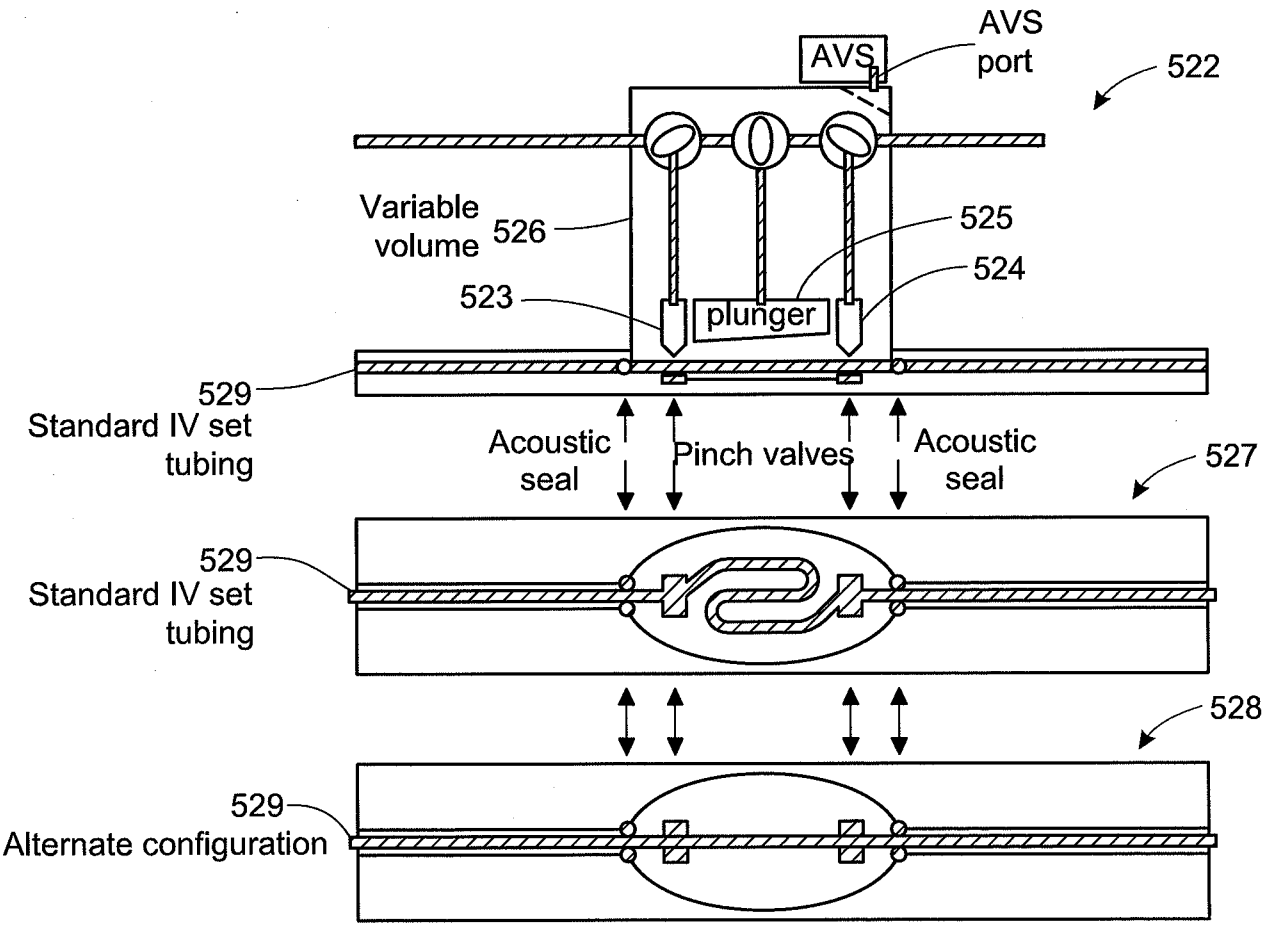

AVS
AVS port
522
Variable volume 526
525
524
523
plunger
529
Standard IV set tubing
Acoustic seal
Pinch valves
Acoustic seal
527
529
Standard IV set tubing
528
529
Alternate configuration

FIG. 9

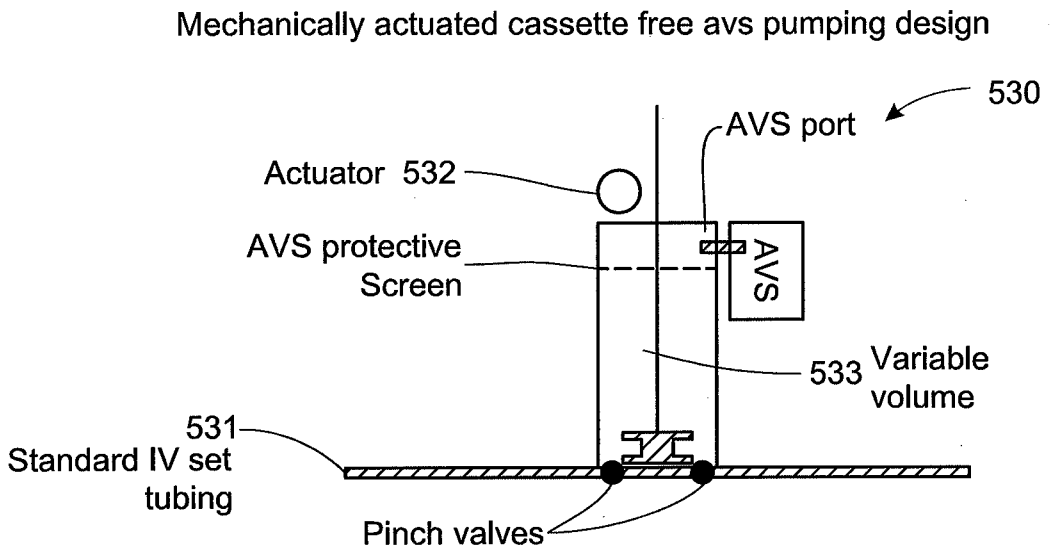

Mechanically actuated cassette free avs pumping design
530
AVS port
Actuator 532
AVS protective Screen
AVS
533 Variable volume
531 Standard IV set tubing
Pinch valves

FIG. 10

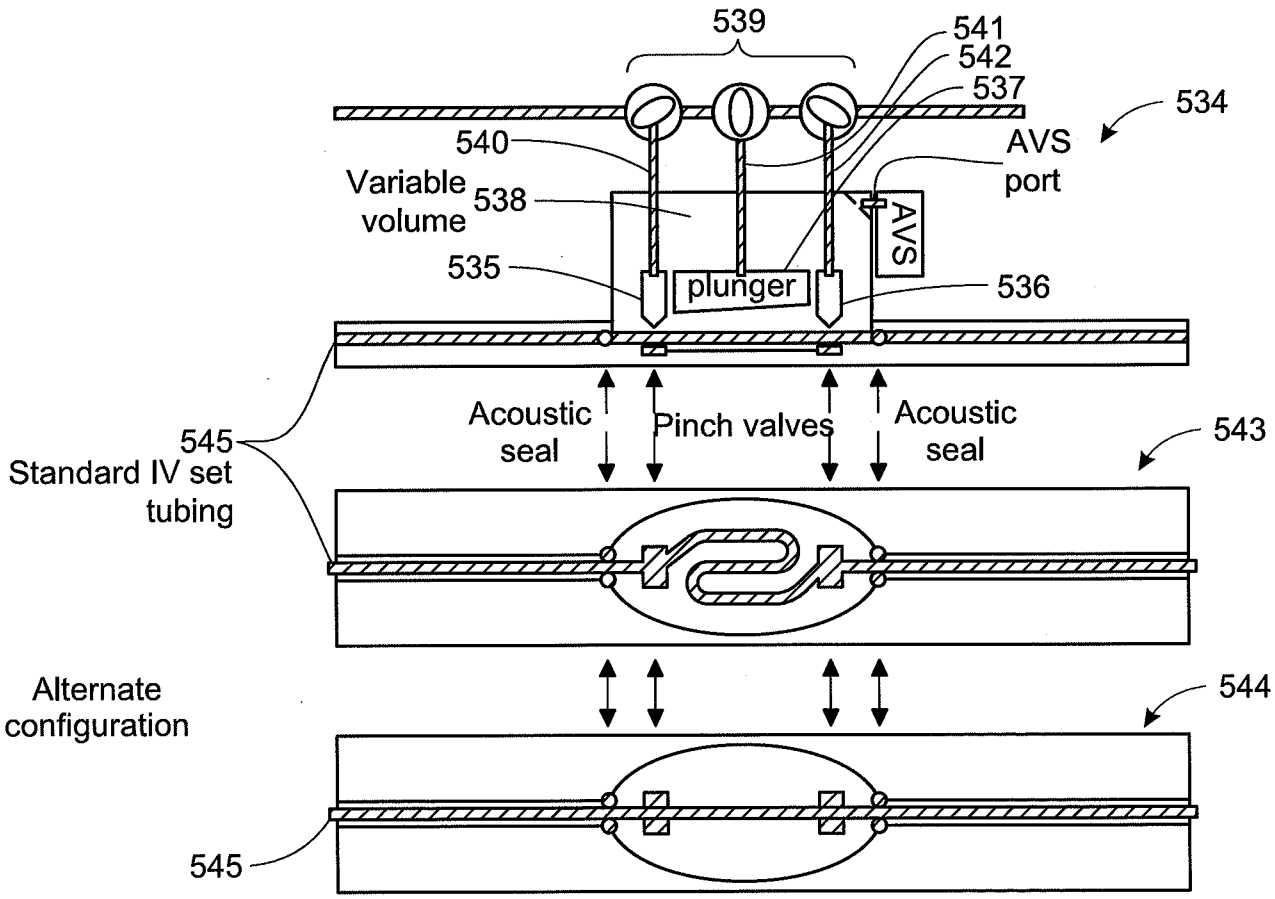

539
541
542
537
534
540
AVS port
Variable volume
538
AVS
535
plunger
536
Acoustic seal
Pinch valves
Acoustic seal
543
545 Standard IV set tubing
Alternate configuration
544
545

FIG. 11

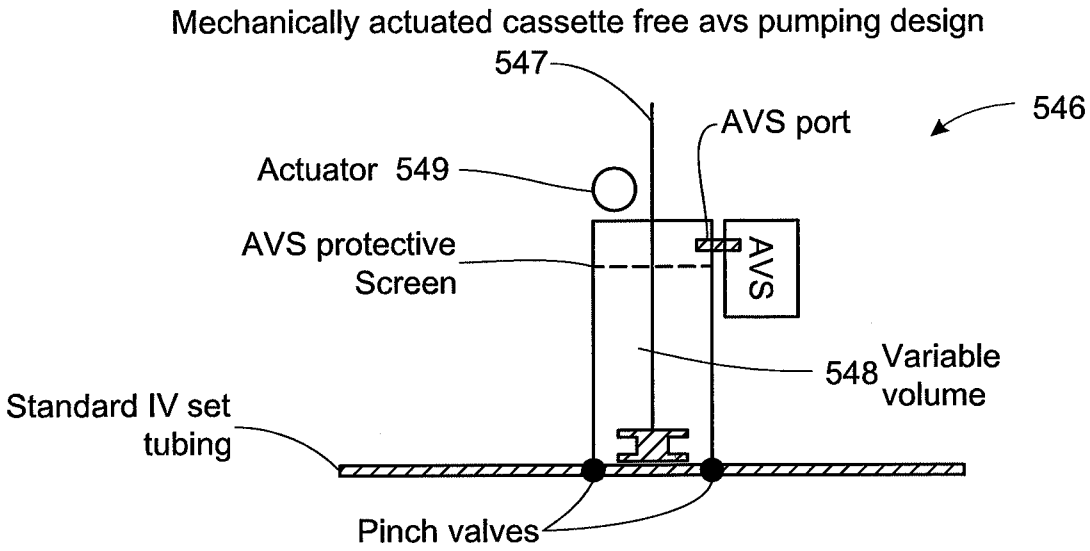

Mechanically actuated cassette free avs pumping design
547
AVS port
546
Actuator 549
AVS protective Screen
AVS
548 Variable volume
Standard IV set tubing
Pinch valves

FIG. 12

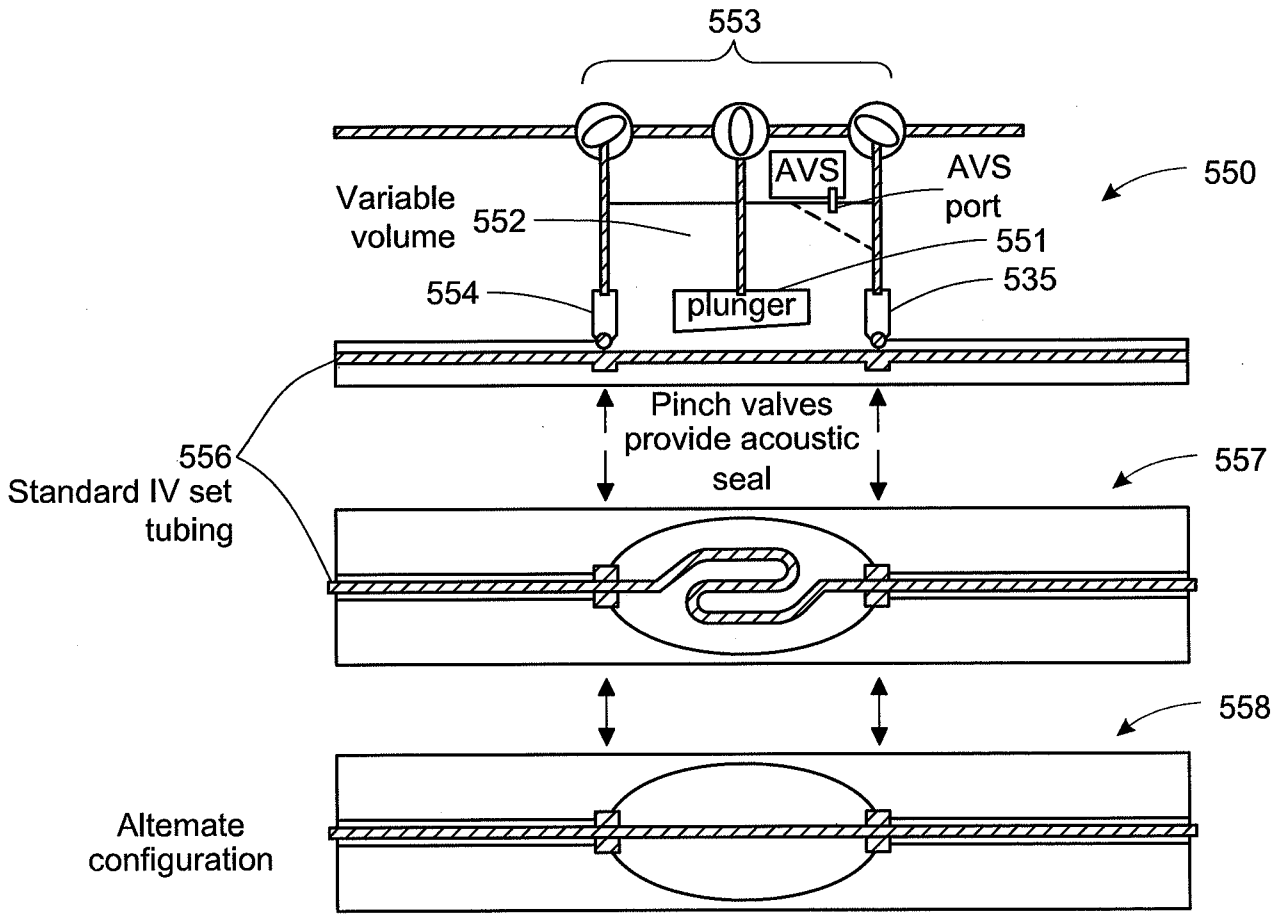

553
AVS
AVS port
550
Variable volume
552
551
554
plunger
535
Pinch valves provide acoustic seal
556
Standard IV set tubing
557
558
Altemate configuration

FIG. 13

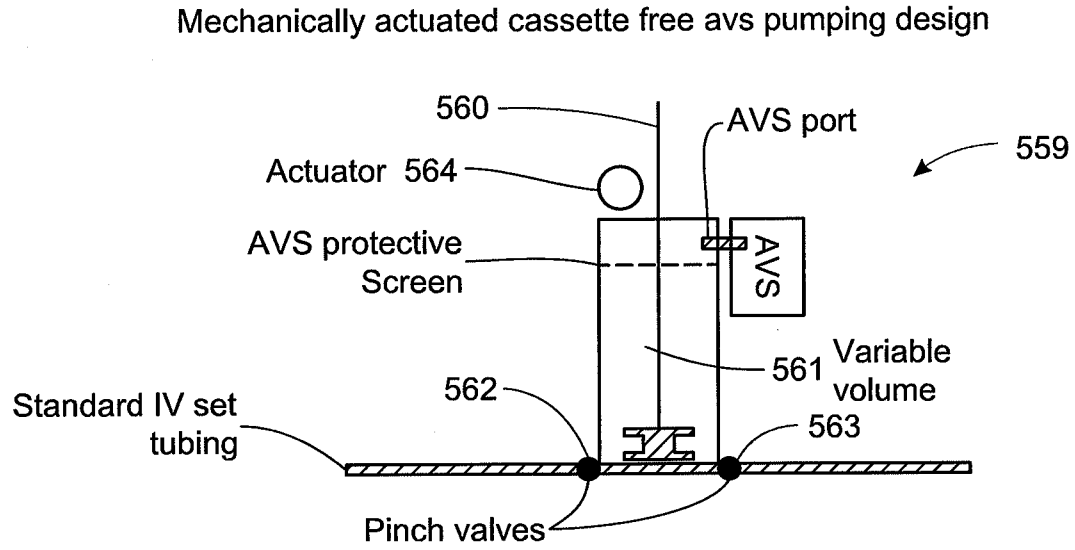

Mechanically actuated cassette free avs pumping design
560
AVS port
559
Actuator 564
AVS protective Screen
AVS
561
Variable volume
562
Standard IV set tubing
563
Pinch valves

FIG. 14

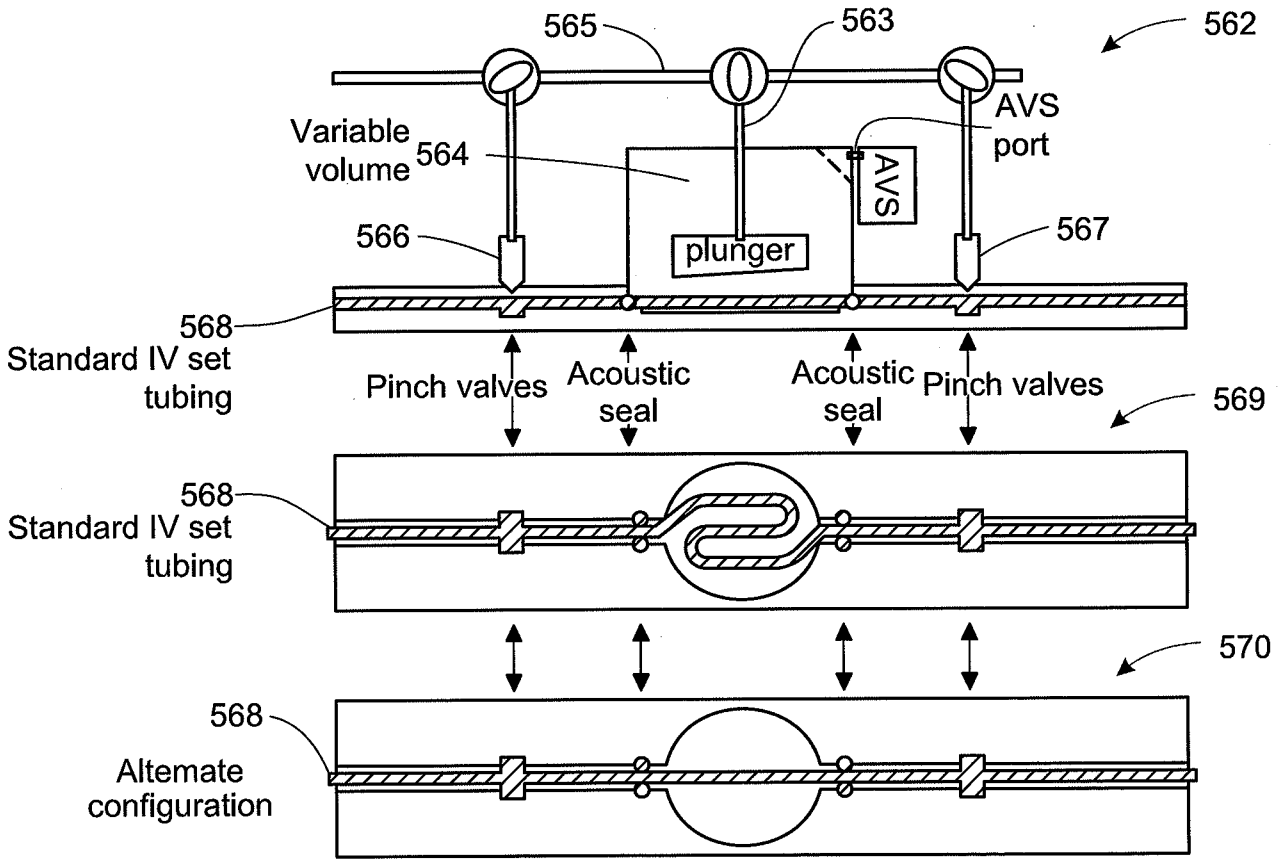

565
563
562
AVS port
Variable volume
564
AVS
plunger
566
567
568
Standard IV set tubing
Pinch valves
Acoustic seal
Acoustic seal
Pinch valves
569
568
Standard IV set tubing
570
568
Altemate configuration

FIG. 15

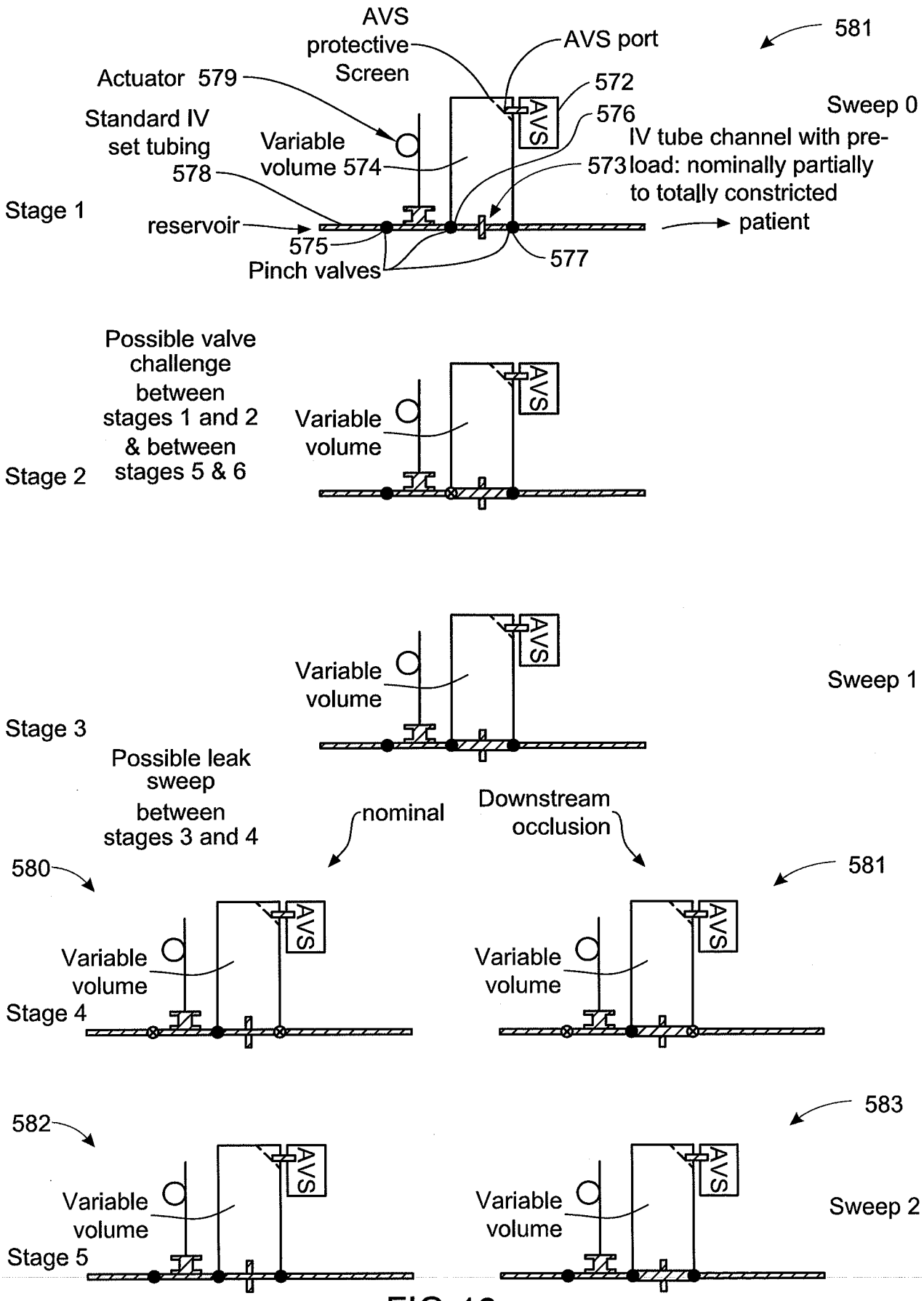

AVS protective Screen
AVS port
581
Actuator 579
572
Sweep 0
Standard IV set tubing
576
IV tube channel with pre-load: nominally partially to totally constricted
Variable volume 574
573
578
Stage 1
reservoir
patient
575
577
Pinch valves
AVS
Possible valve challenge between stages 1 and 2 & between stages 5 & 6
Variable volume
Stage 2
Variable volume
Sweep 1
Stage 3
Possible leak sweep between stages 3 and 4
nominal
Downstream occlusion
580
581
Variable volume
Stage 4
582
583
Variable volume
Stage 5
Sweep 2

FIG. 16

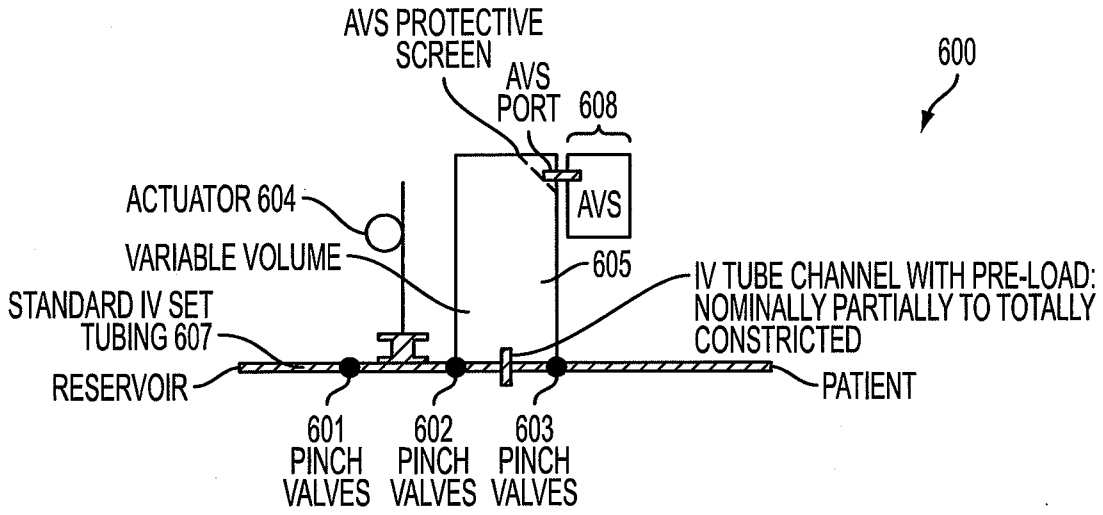


FIG. 17

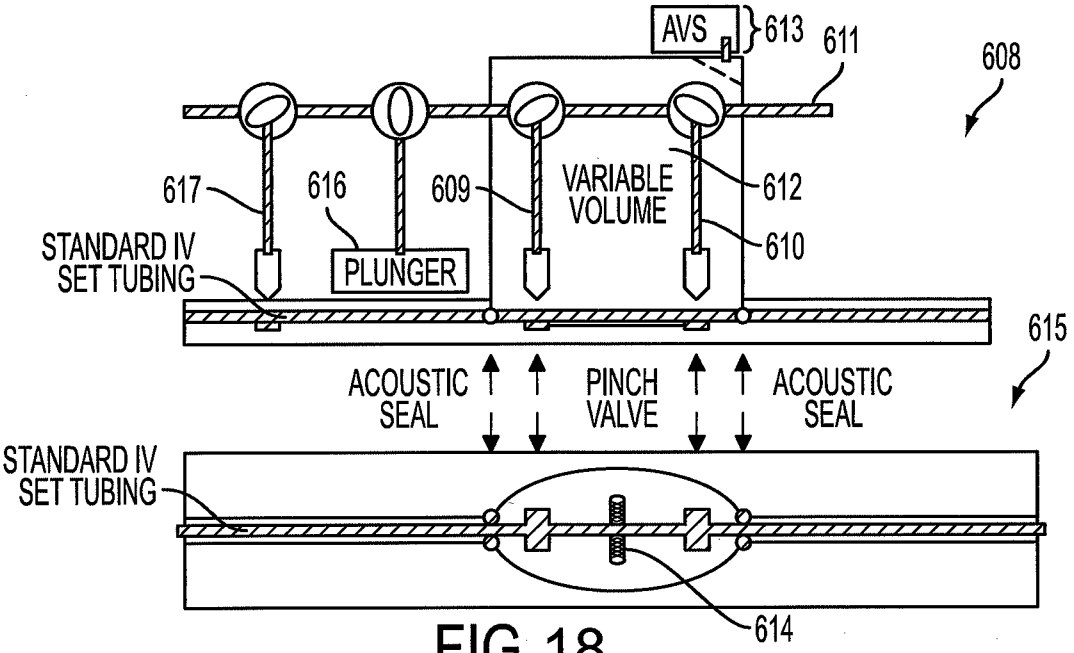


FIG. 18

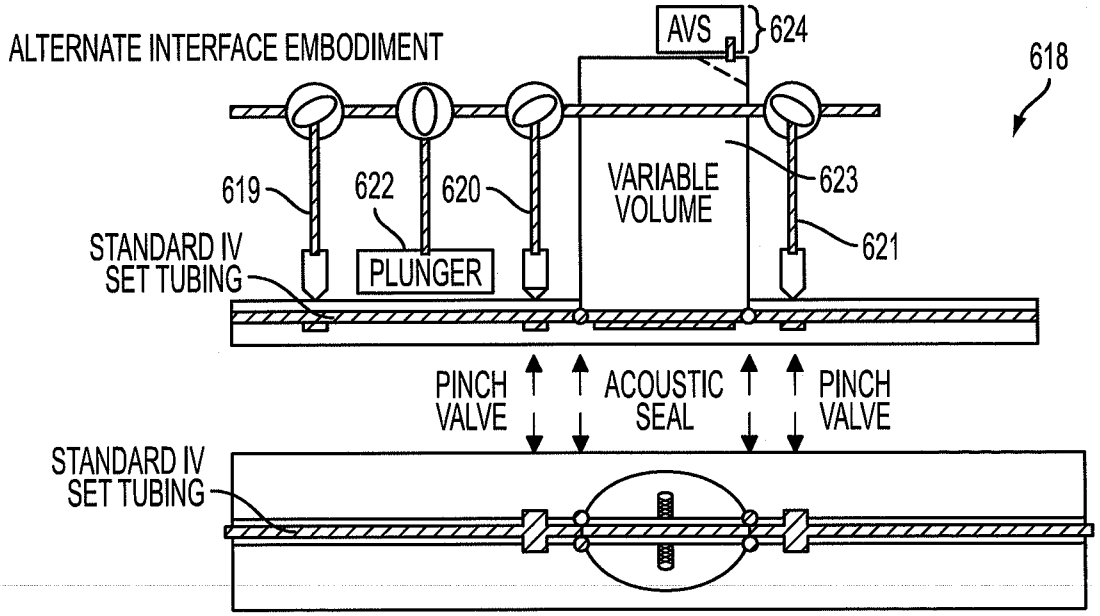


FIG. 19

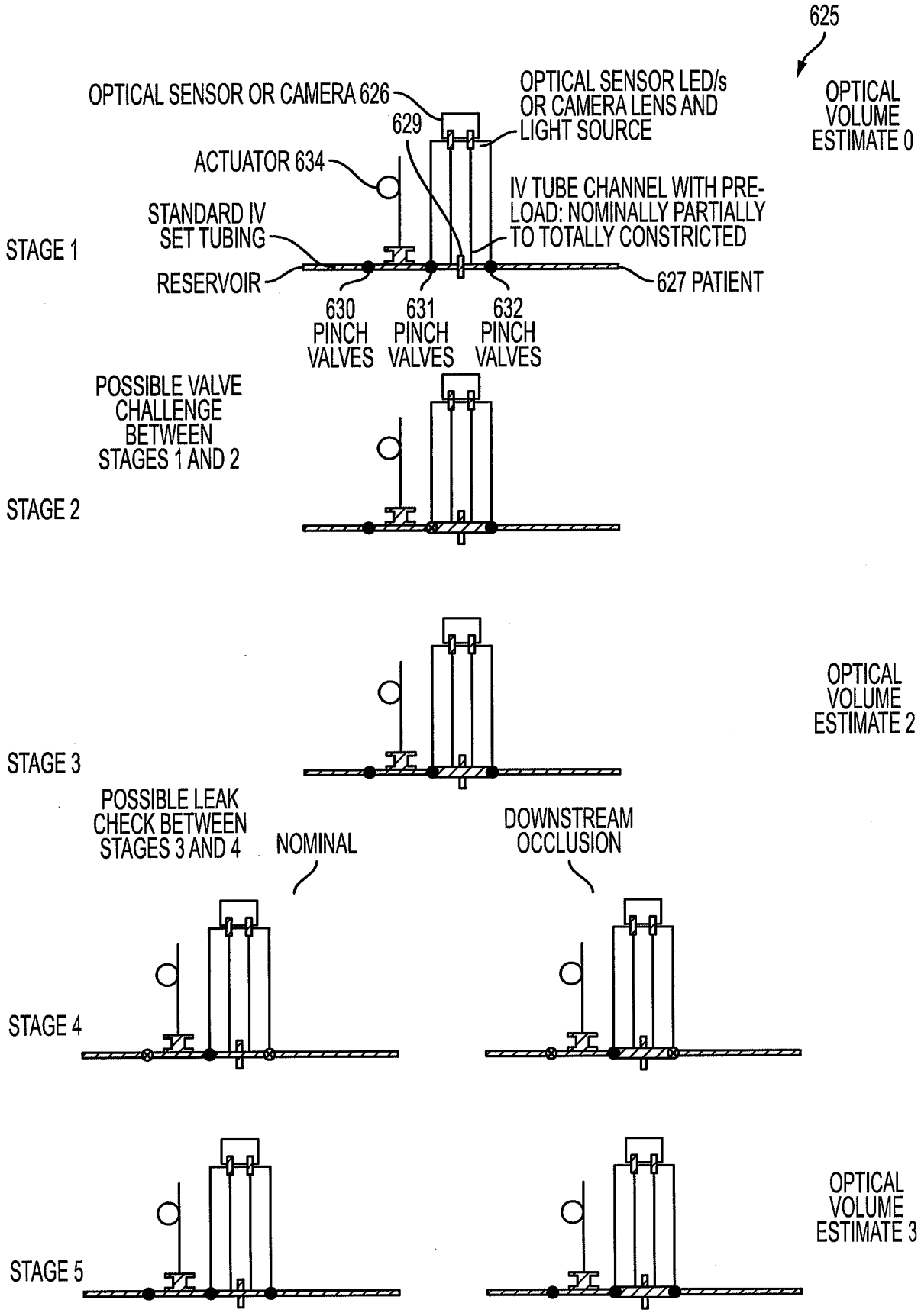

625
OPTICAL SENSOR OR CAMERA 626
629
OPTICAL SENSOR LED/s OR CAMERA LENS AND LIGHT SOURCE
OPTICAL VOLUME ESTIMATE 0
ACTUATOR 634
IV TUBE CHANNEL WITH PRE-LOAD: NOMINALLY PARTIALLY TO TOTALLY CONSTRICTED
STANDARD IV SET TUBING
STAGE 1
RESERVOIR
627 PATIENT
630 PINCH VALVES
631 PINCH VALVES
632 PINCH VALVES
POSSIBLE VALVE CHALLENGE BETWEEN STAGES 1 AND 2
STAGE 2
OPTICAL VOLUME ESTIMATE 2
STAGE 3
POSSIBLE LEAK CHECK BETWEEN STAGES 3 AND 4
NOMINAL
DOWNSTREAM OCCLUSION
STAGE 4
STAGE 5
OPTICAL VOLUME ESTIMATE 3

FIG.20

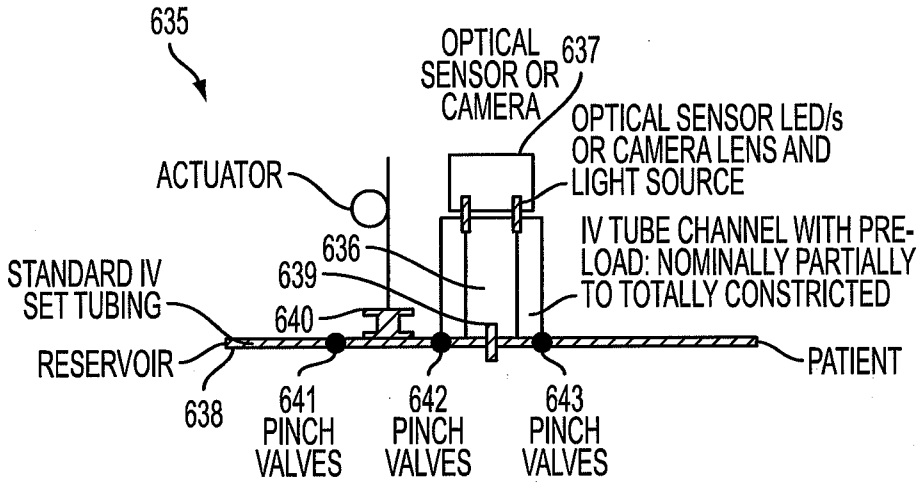

635
OPTICAL SENSOR OR CAMERA
637
OPTICAL SENSOR LED/s OR CAMERA LENS AND LIGHT SOURCE
ACTUATOR
636
IV TUBE CHANNEL WITH PRE-LOAD: NOMINALLY PARTIALLY TO TOTALLY CONSTRICTED
STANDARD IV SET TUBING
639
640
RESERVOIR
PATIENT
638
641 PINCH VALVES
642 PINCH VALVES
643 PINCH VALVES

FIG. 21

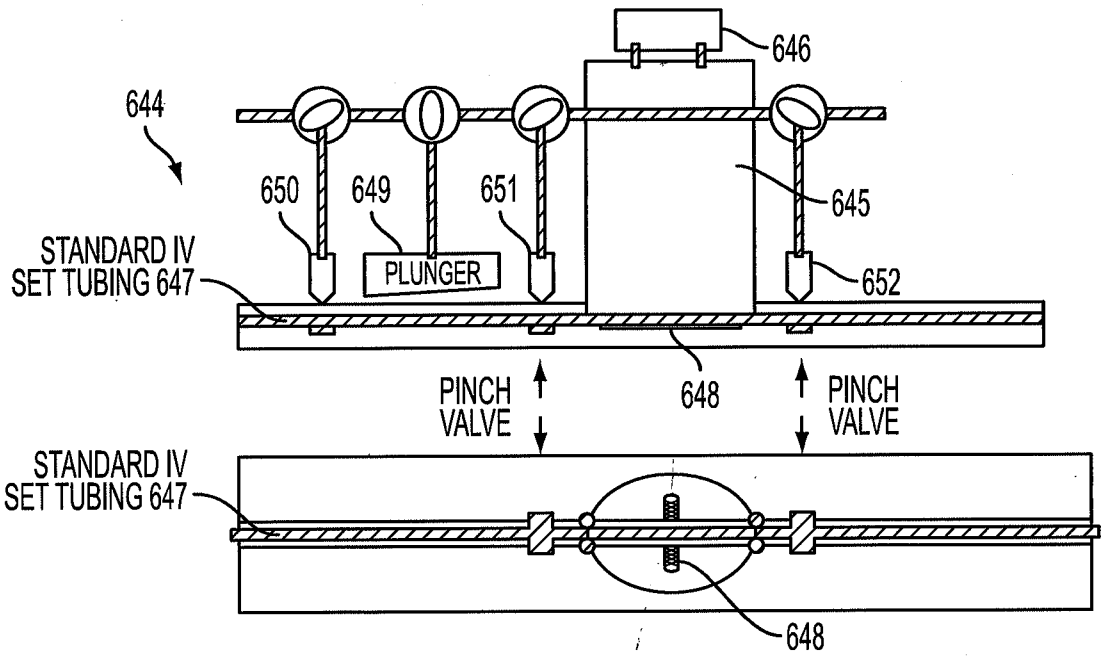

646
644
650
649
651
645
PLUNGER
STANDARD IV SET TUBING 647
652
PINCH VALVE
648
PINCH VALVE
STANDARD IV SET TUBING 647
648

FIG. 22

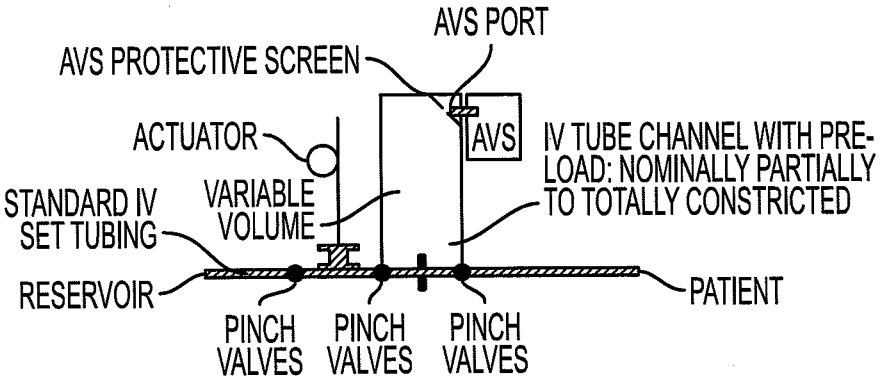


FIG. 23

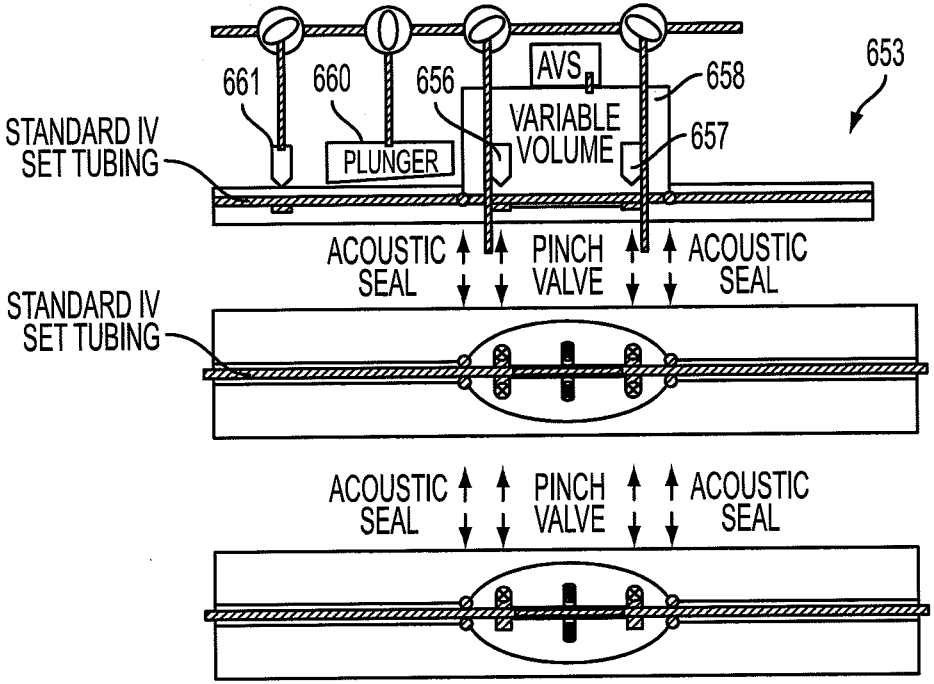


FIG. 24

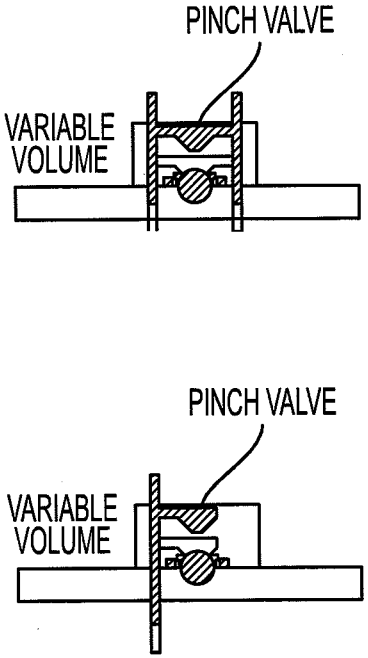


FIG. 25

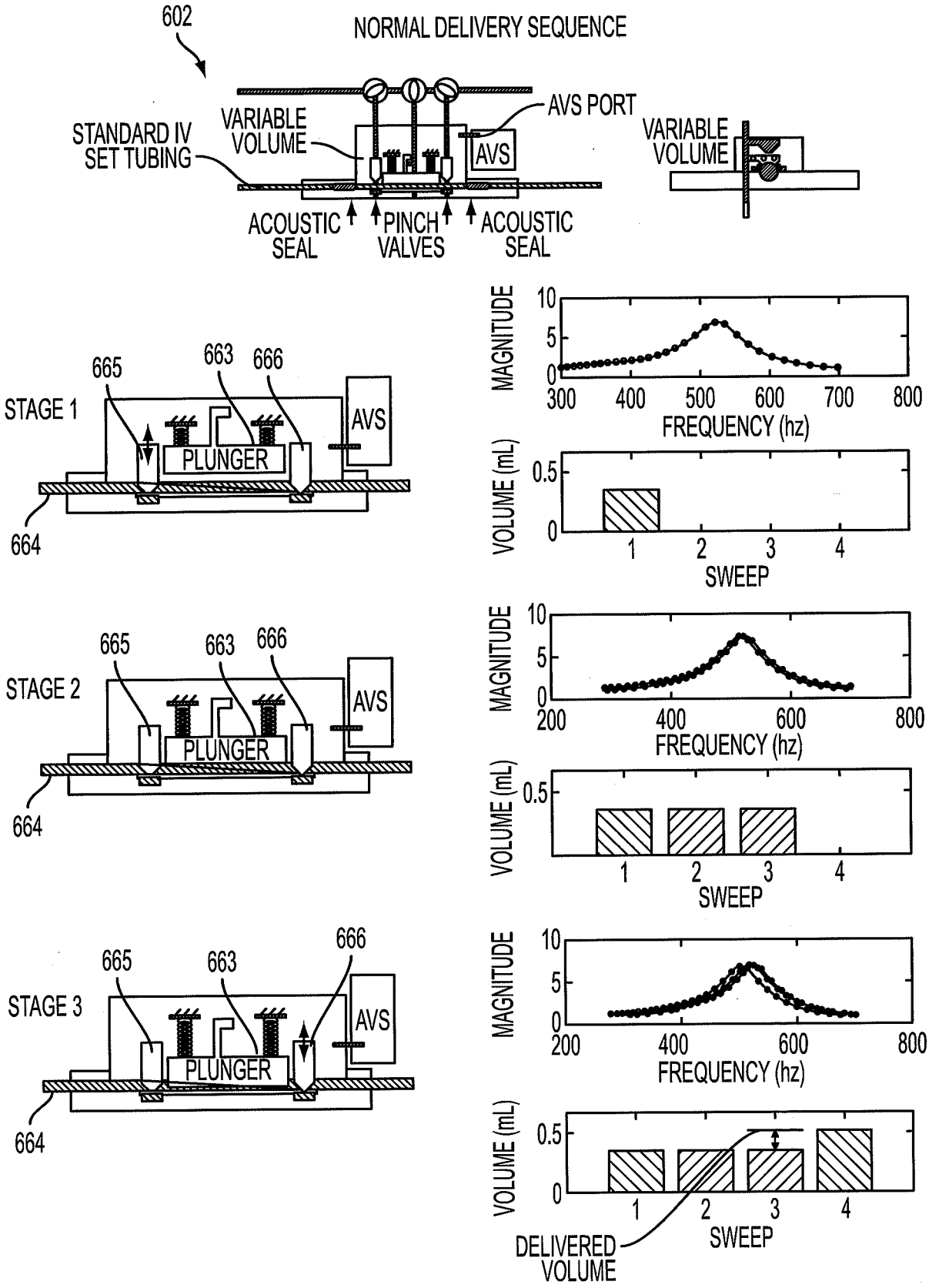

602
NORMAL DELIVERY SEQUENCE
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS PORT
AVS
VARIABLE VOLUME
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
STAGE 1
665
663
666
PLUNGER
AVS
664
MAGNITUDE
FREQUENCY (hz)
VOLUME (mL)
SWEEP
STAGE 2
STAGE 3
DELIVERED VOLUME

FIG. 26

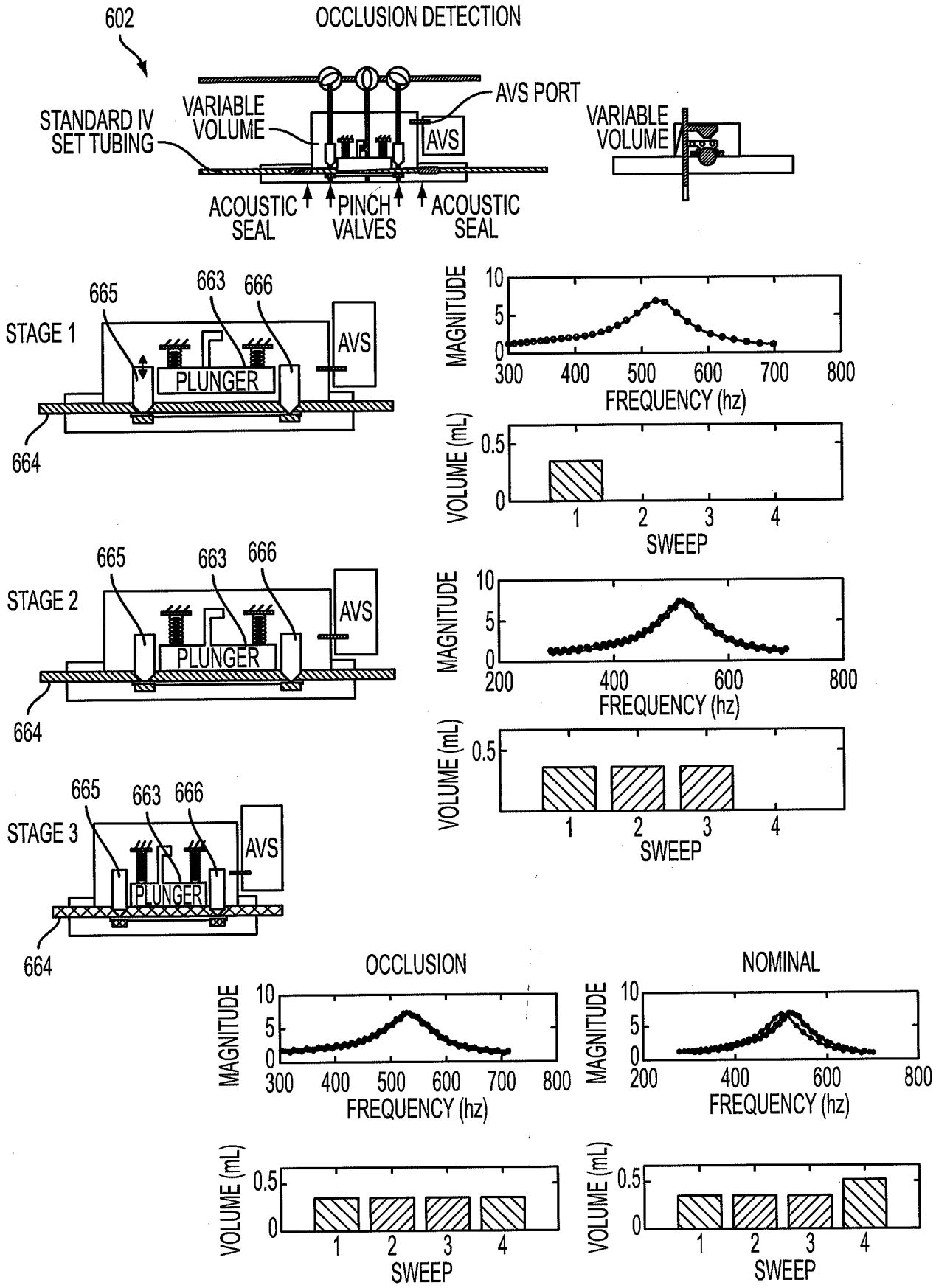

602
OCCLUSION DETECTION
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS PORT
AVS
VARIABLE VOLUME
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
STAGE 1
665
663
666
PLUNGER
AVS
664
MAGNITUDE
FREQUENCY (hz)
VOLUME (mL)
SWEEP
STAGE 2
STAGE 3
OCCLUSION
NOMINAL

FIG. 27

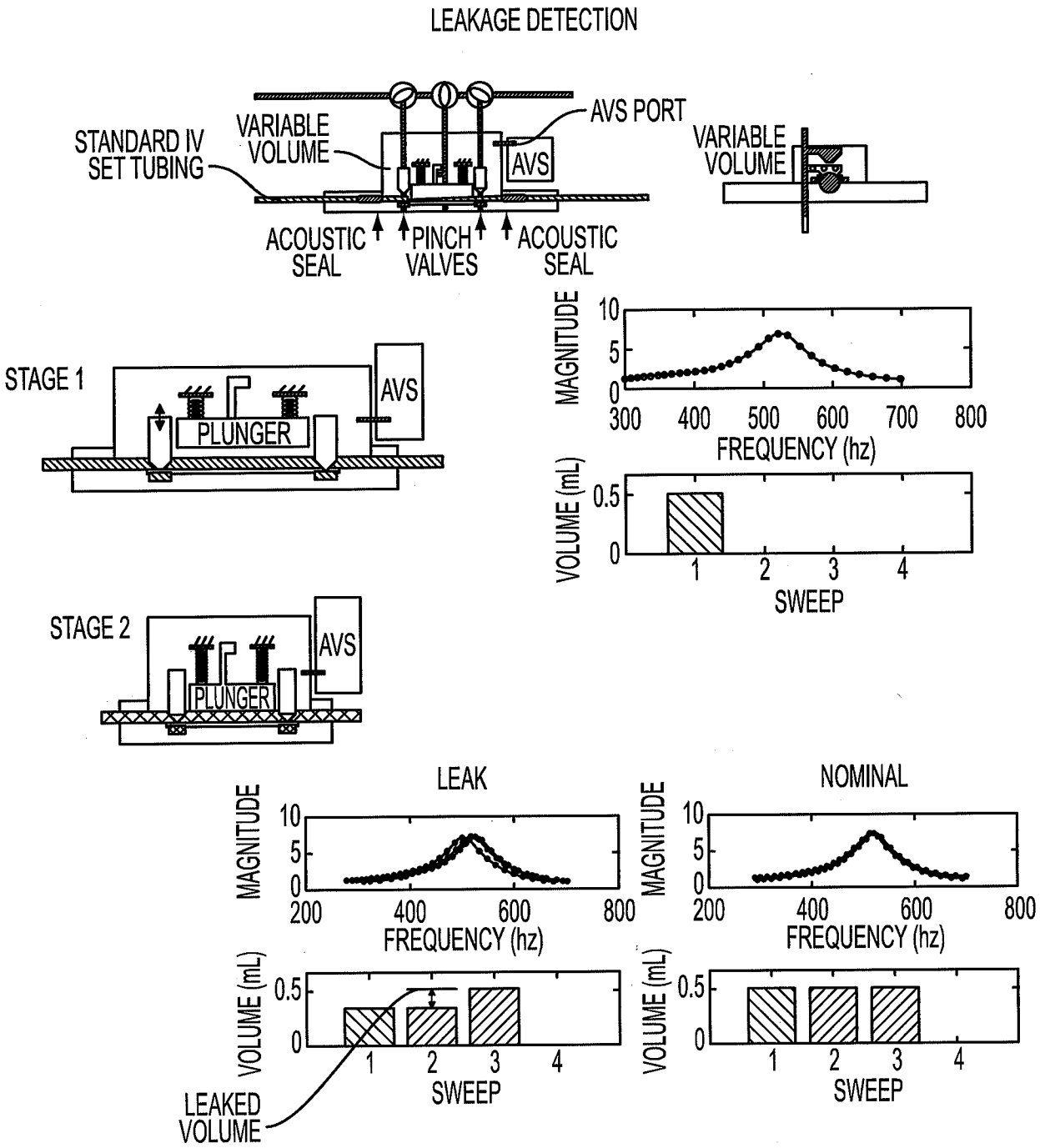

LEAKAGE DETECTION
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS PORT
AVS
VARIABLE VOLUME
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
STAGE 1
PLUNGER
AVS
MAGNITUDE
10
5
0
300
400
500
600
700
800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1
2
3
4
SWEEP
STAGE 2
PLUNGER
AVS
LEAK
NOMINAL
MAGNITUDE
10
5
0
200
400
600
800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1
2
3
4
SWEEP
LEAKED VOLUME

FIG. 28

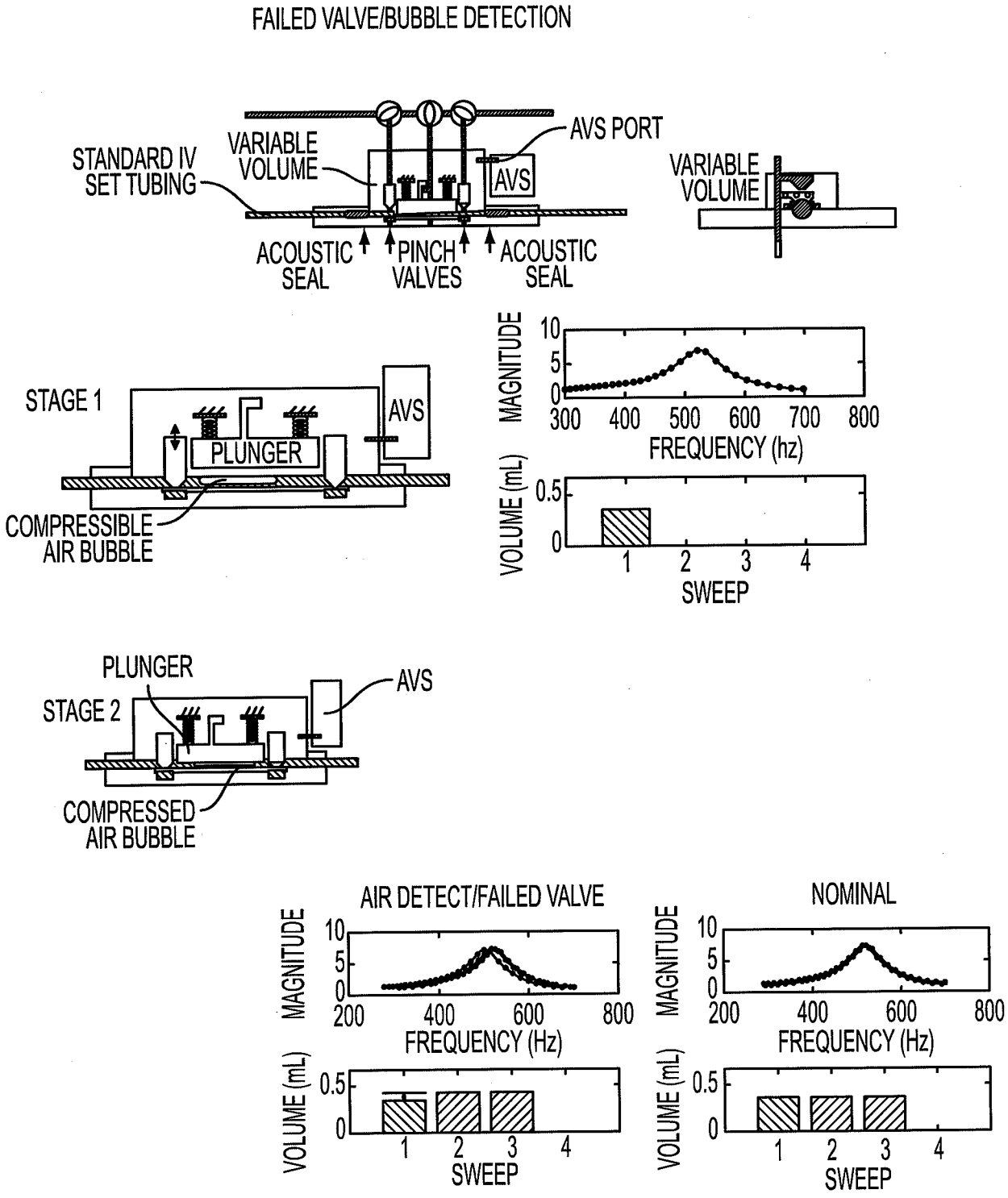
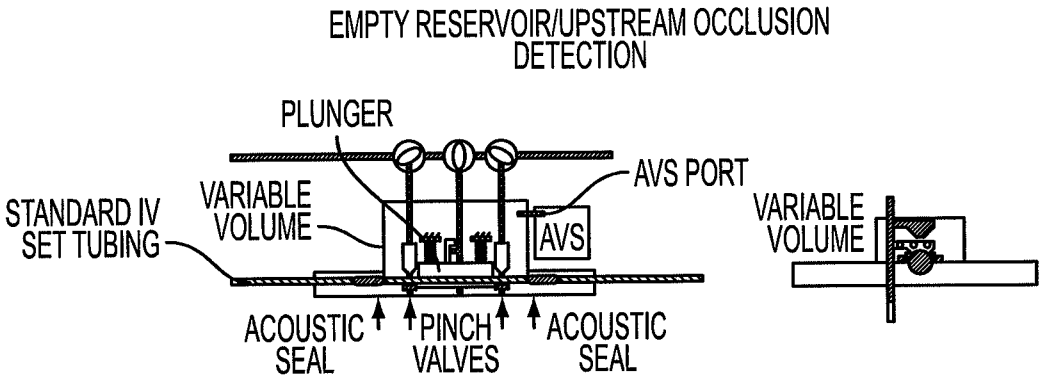
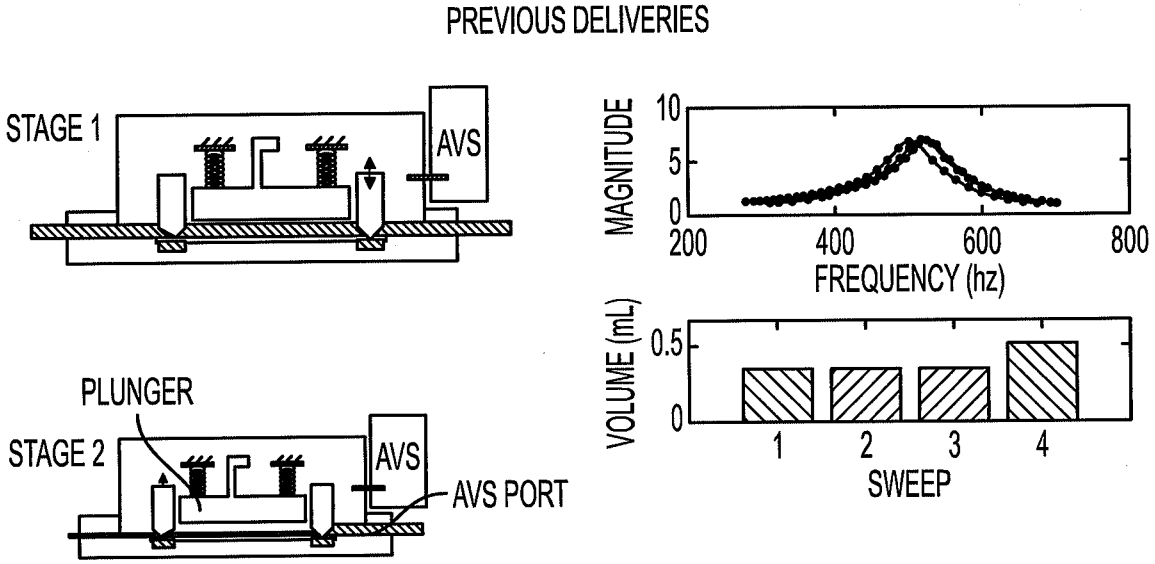

FAILED VALVE/BUBBLE DETECTION
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS PORT
AVS
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
VARIABLE VOLUME
STAGE 1
PLUNGER
AVS
COMPRESSIBLE AIR BUBBLE
MAGNITUDE
10
5
0
300 400 500 600 700 800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP
PLUNGER
STAGE 2
AVS
COMPRESSED AIR BUBBLE
AIR DETECT/FAILED VALVE
MAGNITUDE
10
5
0
200 400 600 800
FREQUENCY (Hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP
NOMINAL
MAGNITUDE
10
5
0
200 400 600 800
FREQUENCY (Hz)
VOLUME (mL)
0.5
0
1 2 3 4
SWEEP

FIG. 29


EMPTY RESERVOIR/UPSTREAM OCCLUSION DETECTION
PLUNGER
AVS PORT
VARIABLE VOLUME
STANDARD IV SET TUBING
AVS
VARIABLE VOLUME
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL


PREVIOUS DELIVERIES
STAGE 1
AVS
PLUNGER
STAGE 2
AVS
AVS PORT
MAGNITUDE
10
5
0
200
400
600
800
FREQUENCY (hz)
VOLUME (mL)
0.5
0
1
2
3
4
SWEEP

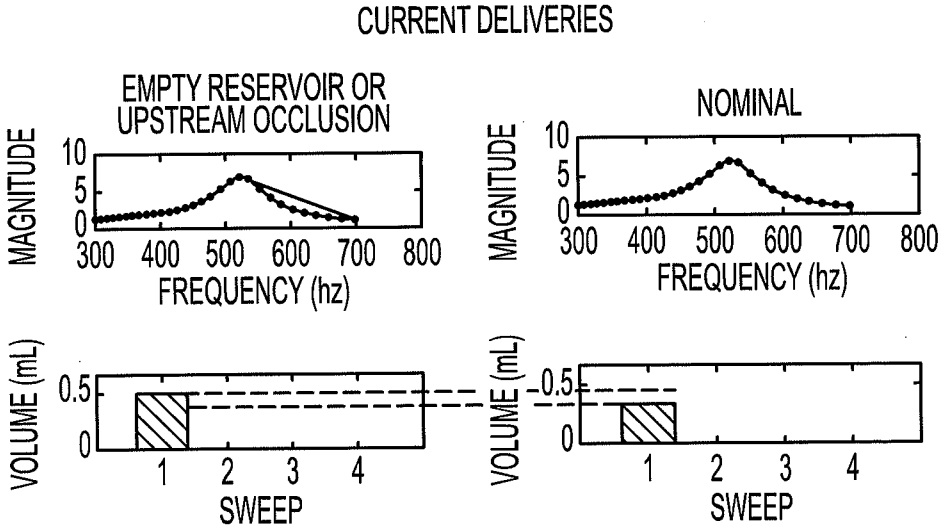

CURRENT DELIVERIES
EMPTY RESERVOIR OR UPSTREAM OCCLUSION
NOMINAL
MAGNITUDE
10
5
0
300
400
500
600
700
800
FREQUENCY (hz)
VOLUME (mL)
0.5
-0.5
0
1
2
3
4
SWEEP

FIG. 30

Free-Flow Detection

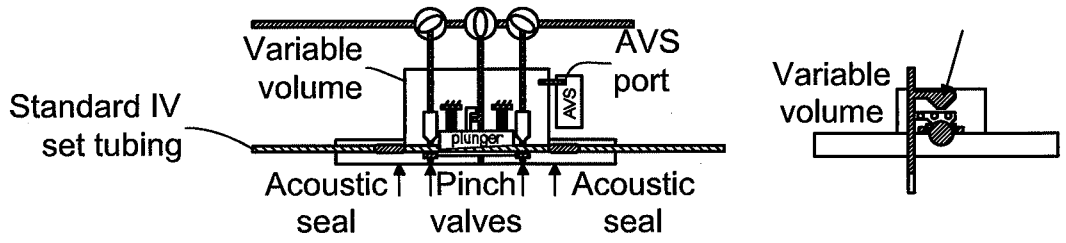


FIG. 31

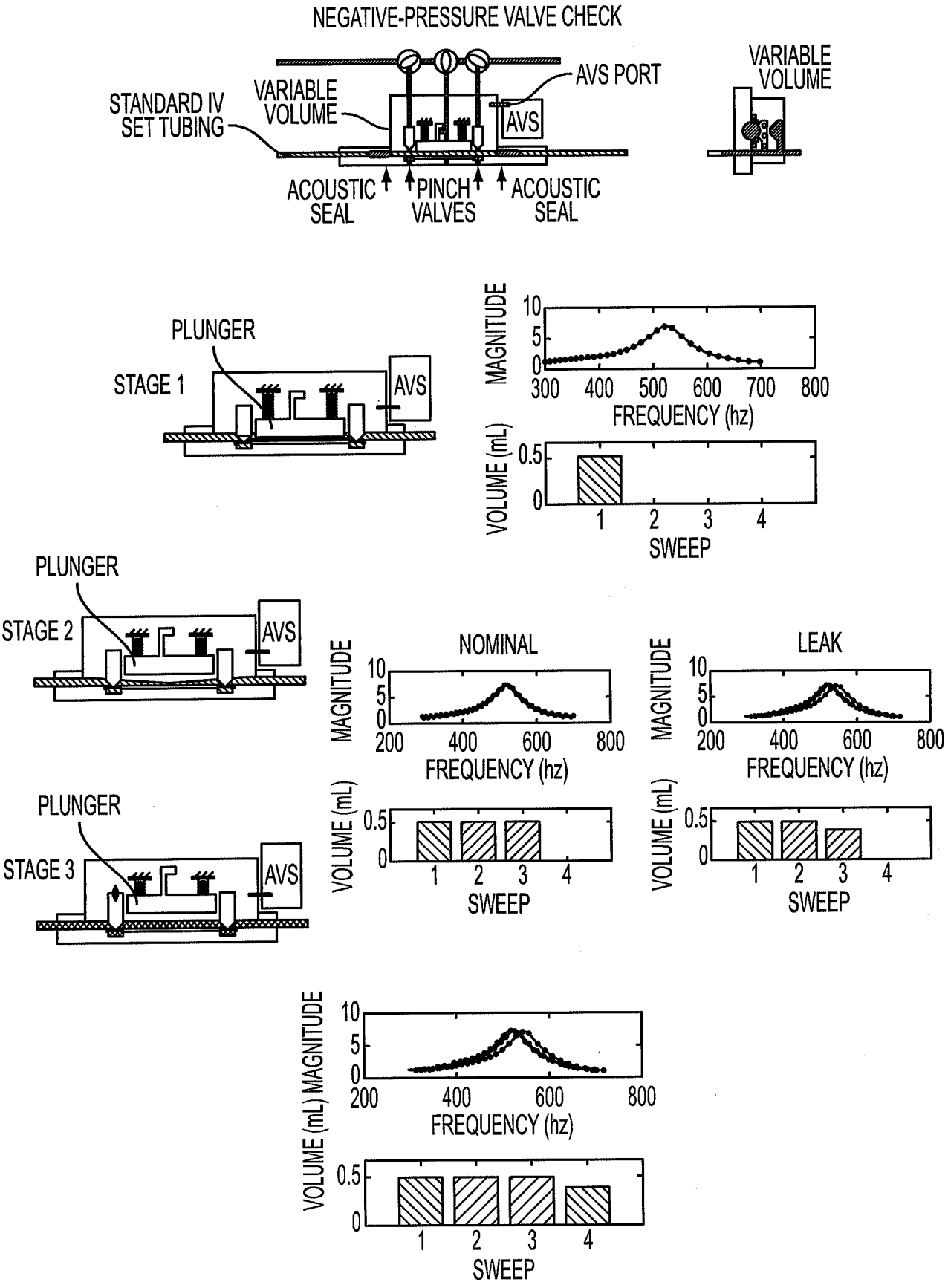

NEGATIVE-PRESSURE VALVE CHECK
STANDARD IV SET TUBING
VARIABLE VOLUME
AVS PORT
AVS
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
VARIABLE VOLUME
PLUNGER
STAGE 1
AVS
MAGNITUDE
FREQUENCY (hz)
VOLUME (mL)
SWEEP
PLUNGER
STAGE 2
AVS
NOMINAL
LEAK
PLUNGER
STAGE 3
AVS
VOLUME (mL) MAGNITUDE
FREQUENCY (hz)
SWEEP

FIG. 32

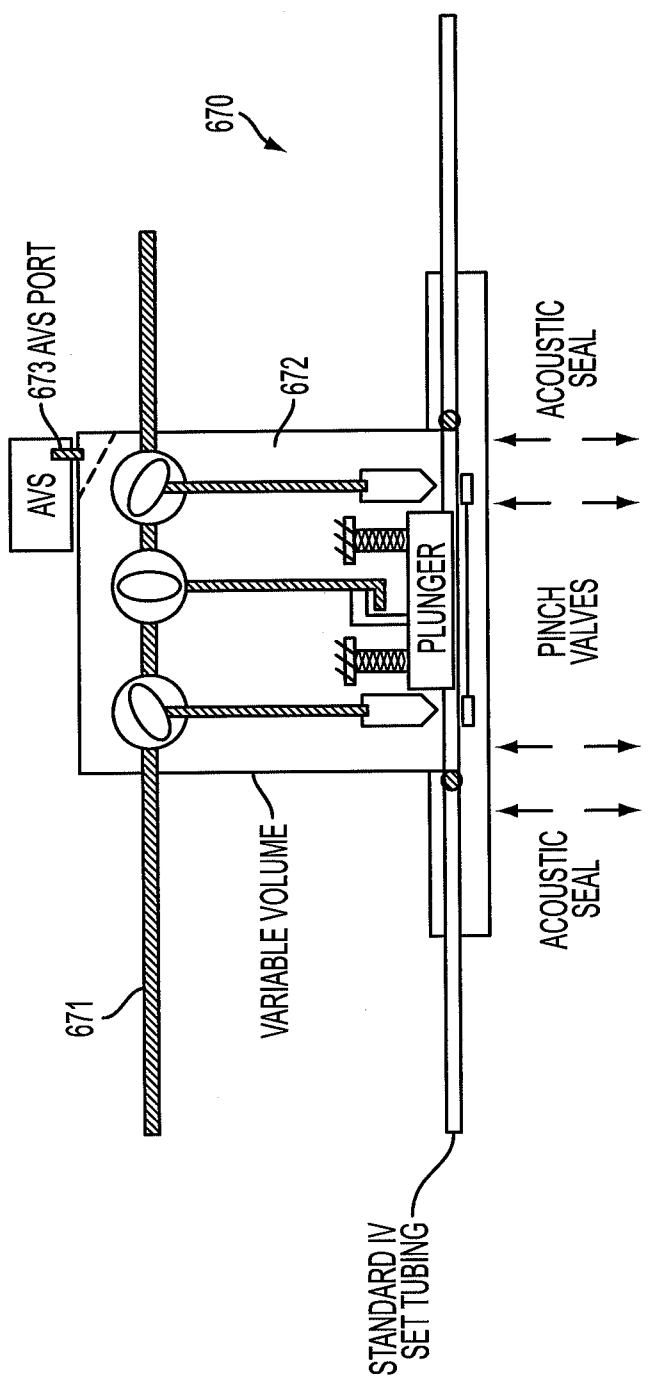

670
673 AVS PORT
672
AVS
ACOUSTIC SEAL
PLUNGER
PINCH VALVES
671
VARIABLE VOLUME
ACOUSTIC SEAL
STANDARD IV SET TUBING

FIG.33

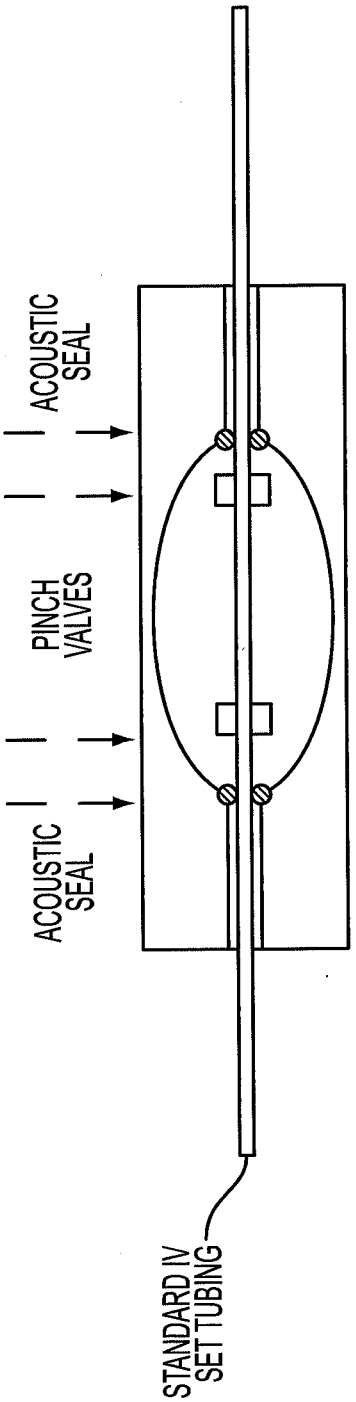
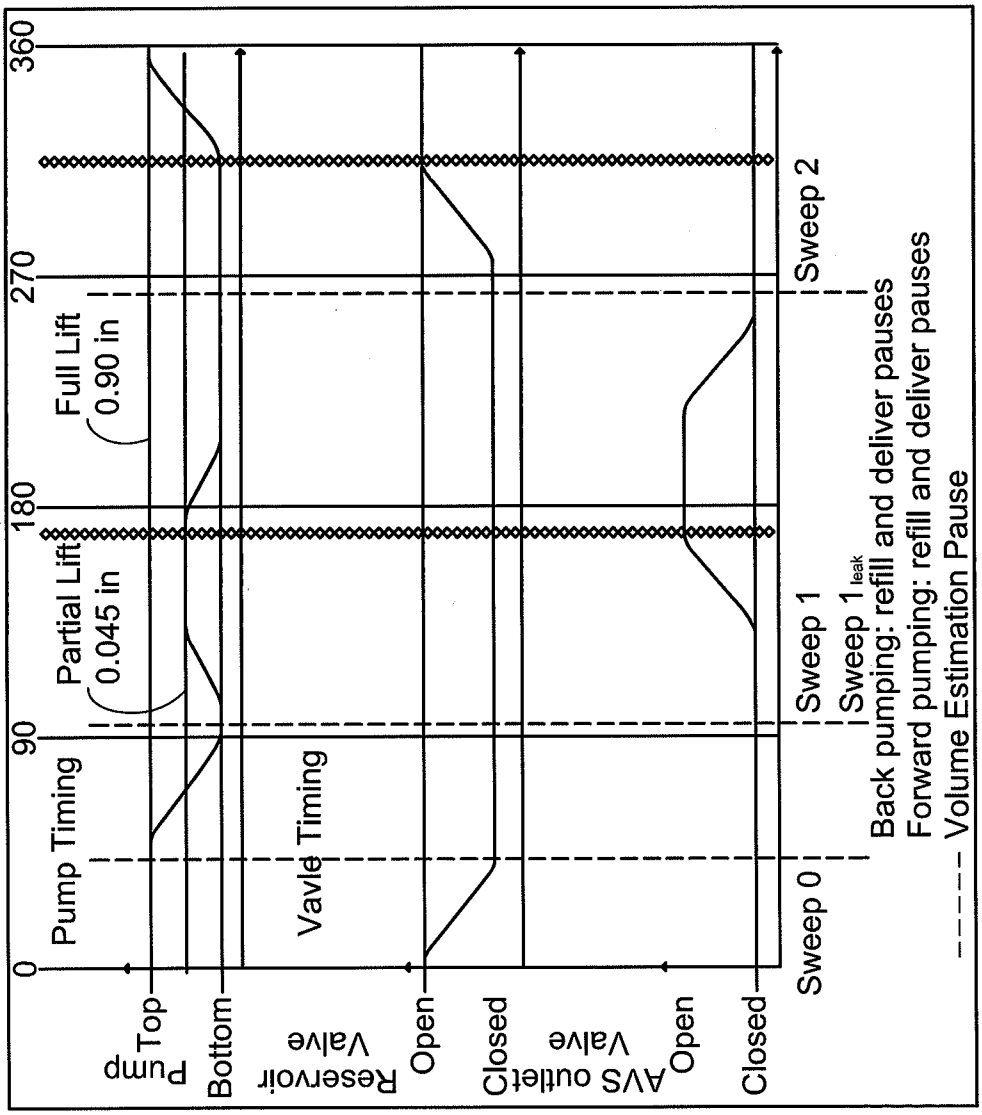

ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL
STANDARD IV SET TUBING

FIG.34



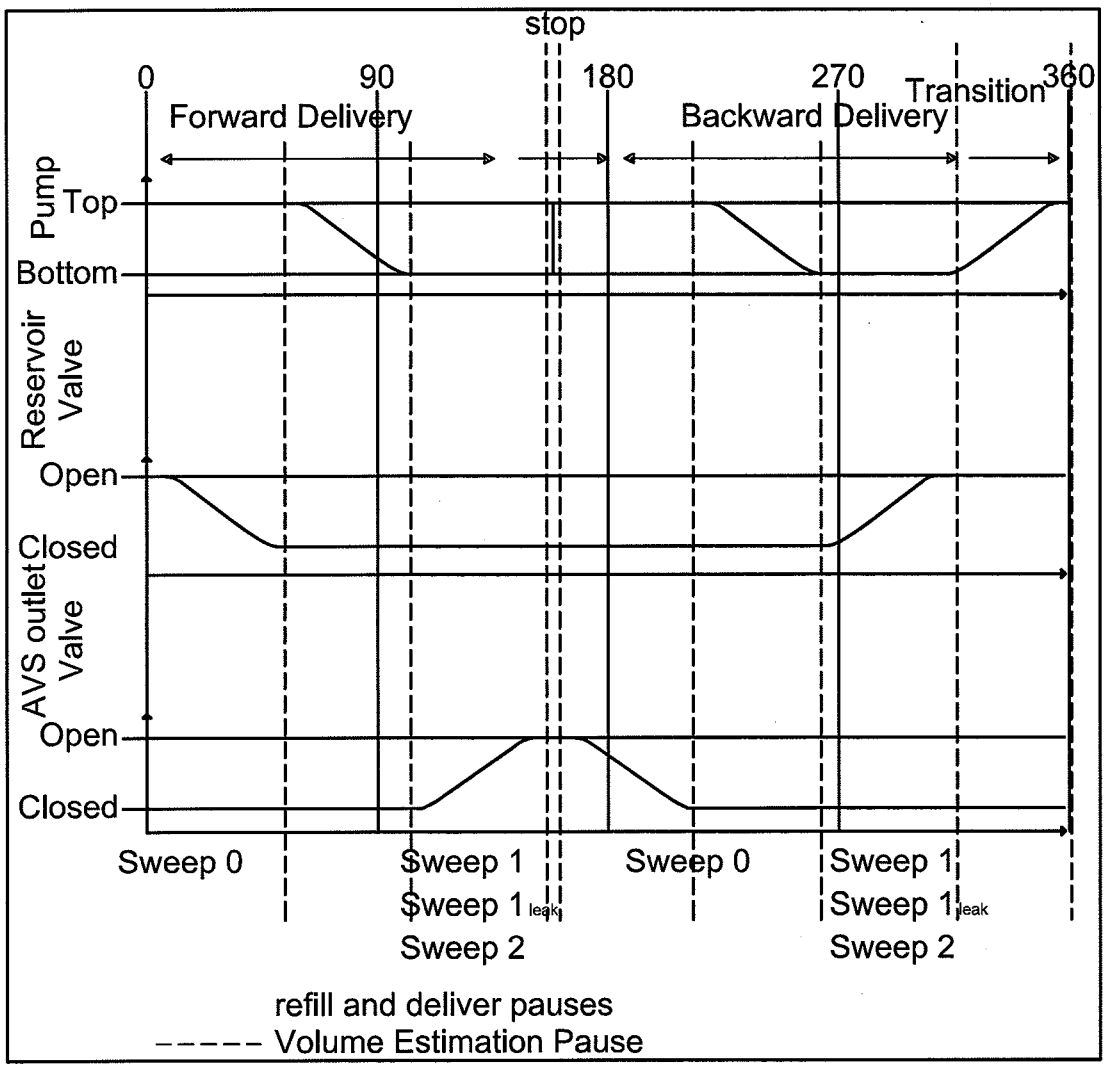
Pump Plunger			
start	stop	Degrees of Rotation	start
0	53.5	53.5	open
53.5	99.5	46	closing
99.5	104.5	5	closed
104.5	129	24.5	opening
129	180	51	partially open
180	204.5	24.5	closing
204.5	311.5	107	closed
311.5	357.5	46	opening
357.5	360	2.5	open
	sum	360	

Inlet/Reservoir Valve			
start	stop	Degrees of Rotation	start
0	2.5	2.5	open
2.5	48.5	46	closing
48.5	260.5	212	closed
260.5	306.5	46	opening
306.5	360	53.5	open
	sum	360	

Outlet Valve			
start	stop	Degrees of Rotation	start
0	129	129	closed
129	175	46	opening
175	209.5	34.5	open
209.5	255.5	46	closing
255.5	360	104.5	closed
	sum	360	

	degrees	number	total
actuation	46	6	276
partial actuation	24.5	2	49
pause	5	6	30
half pause	2.5	2	5
		sum	360

FIG. 35



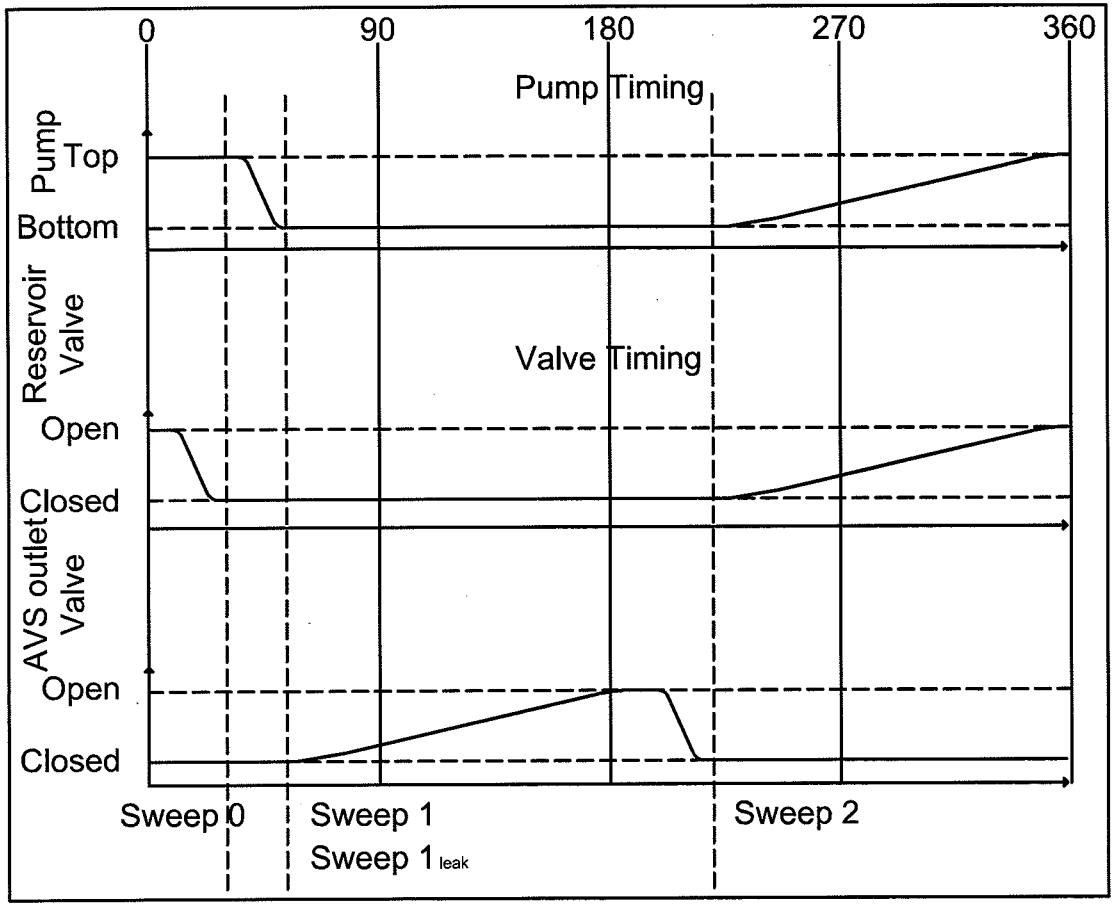
	degrees	number	total
actuation	45	7	315
stop	5	1	5
pause	5	8	40
		sum	360

Pump Plunger			
start	stop	Degrees of Rotation	start
0	55	55	open
55	100	45	closing
100	155	55	closed
155	160	5	opening
160	215	55	open
215	260	45	closing
260	315	55	closed
315	360	45	opening
	sum	360	

Inlet/Reservoir Valve			
start	stop	Degrees of Rotation	start
0	5	5	open
5	50	45	closing
50	265	215	closed
265	310	45	opening
310	360	50	open
	sum	360	

Outlet Valve			
start	stop	Degrees of Rotation	start
0	105	105	closed
105	150	45	opening
150	165	15	open
165	210	45	closing
210	360	150	closed
	sum	360	

FIG. 36



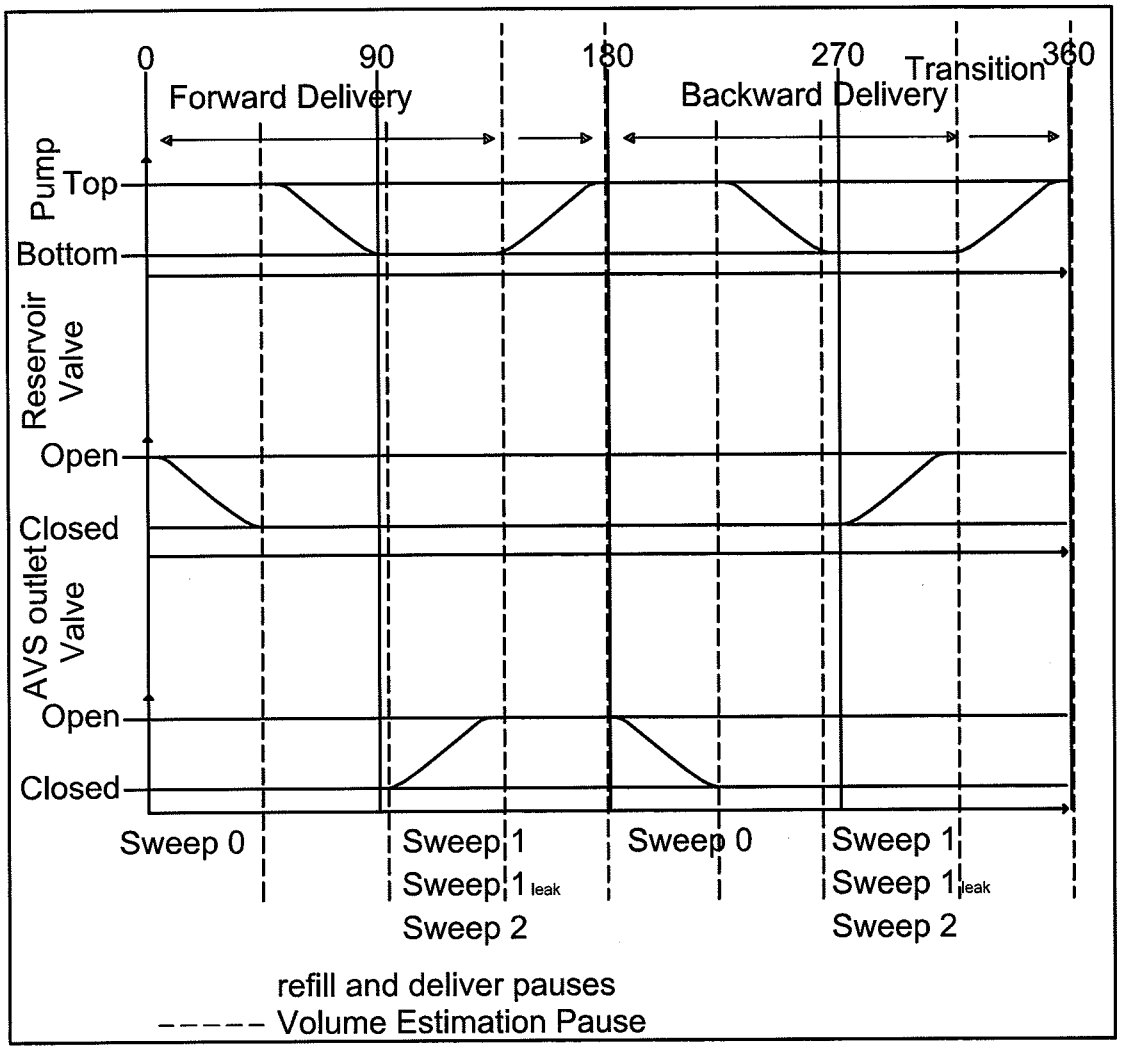
	degrees	number	total
lift actuation	135	2	270
drop actuation	15	3	45
pause	9	4	36
half pause	4.5	2	9
		sum	360

Pump Plunger			
start	stop	Degrees of Rotation	start
0	28.5	28.5	open
28.5	43.5	15	closing
43.5	220.5	177	closed
220.5	355.5	135	opening
355.5	360	4.5	open
	sum	360	

Inlet/Reservoir Valve			
start	stop	Degrees of Rotation	start
0	4.5	4.5	open
4.5	19.5	15	closing
19.5	220.5	201	closed
220.5	355.5	135	opening
355.5	360	4.5	open
	sum	360	

Outlet Valve			
start	stop	Degrees of Rotation	start
0	52.5	52.5	closed
52.5	187.5	135	opening
187.5	196.5	9	open
196.5	211.5	15	closing
211.5	360	148.5	closed
	sum	360	

FIG. 37



Pump Plunger			
start	stop	Degrees of Rotation	start
0	50	50	open
50	90	40	closing
90	140	50	closed
140	180	40	opening
180	230	50	open
230	270	40	closing
270	320	50	closed
320	360	40	opening
	sum	360	

Inlet/Reservoir Valve			
start	stop	Degrees of Rotation	start
0	5	5	open
5	45	40	closing
45	275	230	closed
275	315	40	opening
315	360	45	open
	sum	360	

Outlet/Measurement Valve			
start	stop	Degrees of Rotation	start
0	95	95	closed
95	135	40	opening
135	185	50	open
185	225	40	closing
225	360	135	closed
	sum	360	

	degrees	number	total
actuation	40	8	320
pause	5	8	40
		sum	360

0 $\longleftrightarrow$ 140 forward delivery
0 $\longleftrightarrow$ 180 downstream swish
180 $\longleftrightarrow$ 320 backward delivery
180 $\longleftrightarrow$ 360 upstream swish
0 $\longleftrightarrow$ 360 upstream & downstream
360 $\longleftrightarrow$ 0 swish

FIG.38

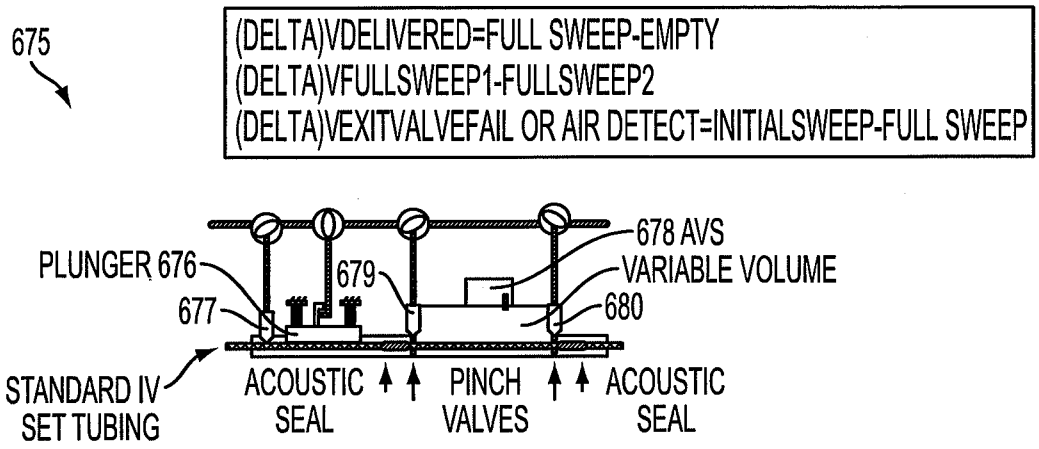

675
(DELTA)VDELIVERED=FULL SWEEP-EMPTY
(DELTA)VFULLSWEEP1-FULLSWEEP2
(DELTA)VEXITVALVEFAIL OR AIR DETECT=INITIALSWEEP-FULL SWEEP
PLUNGER 676
677
679
678 AVS
VARIABLE VOLUME
680
STANDARD IV SET TUBING
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL

FIG.39

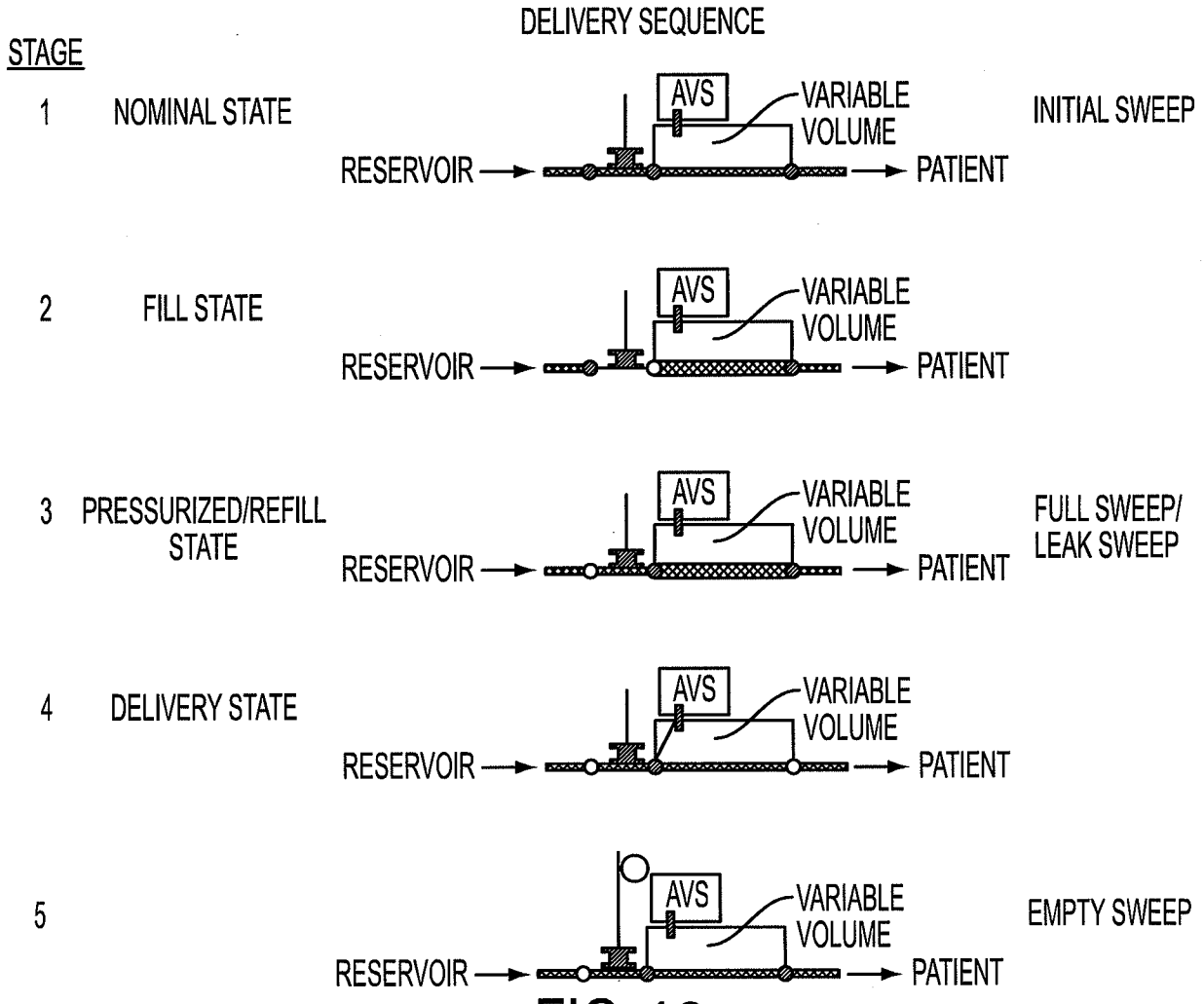

DELIVERY SEQUENCE
STAGE
1 NOMINAL STATE
AVS
VARIABLE VOLUME
RESERVOIR
PATIENT
INITIAL SWEEP
2 FILL STATE
3 PRESSURIZED/REFILL STATE
FULL SWEEP/ LEAK SWEEP
4 DELIVERY STATE
5
EMPTY SWEEP

FIG.40

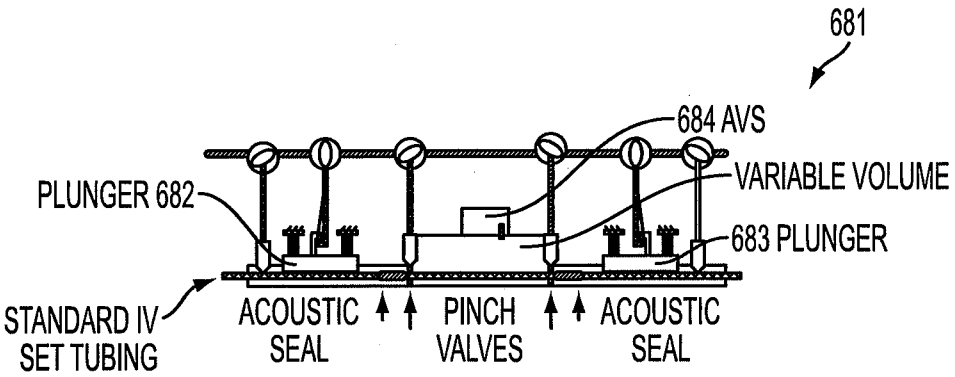

681
684 AVS
VARIABLE VOLUME
683 PLUNGER
PLUNGER 682
STANDARD IV SET TUBING
ACOUSTIC SEAL
PINCH VALVES
ACOUSTIC SEAL

FIG.41

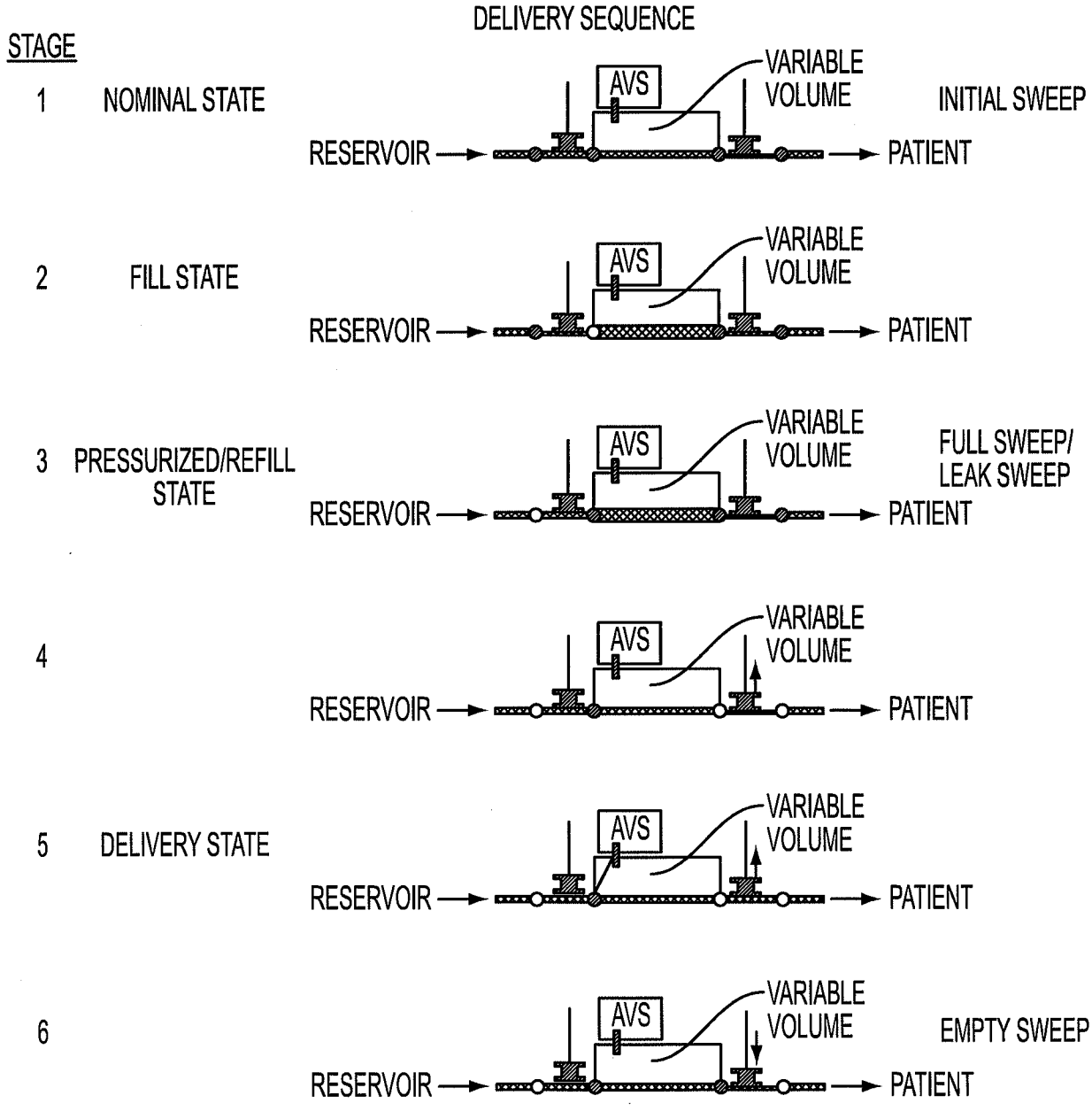

DELIVERY SEQUENCE
STAGE
1 NOMINAL STATE
AVS
VARIABLE VOLUME
INITIAL SWEEP
RESERVOIR
PATIENT
2 FILL STATE
3 PRESSURIZED/REFILL STATE
FULL SWEEP/ LEAK SWEEP
4
5 DELIVERY STATE
6
EMPTY SWEEP

FIG.42

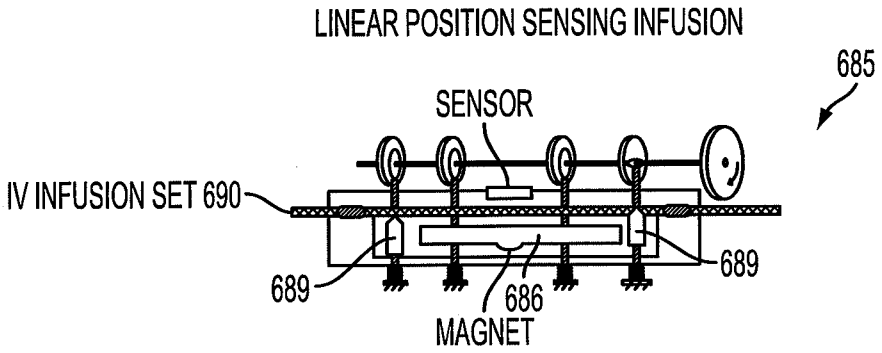

LINEAR POSITION SENSING INFUSION
685
SENSOR
IV INFUSION SET 690
689
689
686
MAGNET

FIG.43

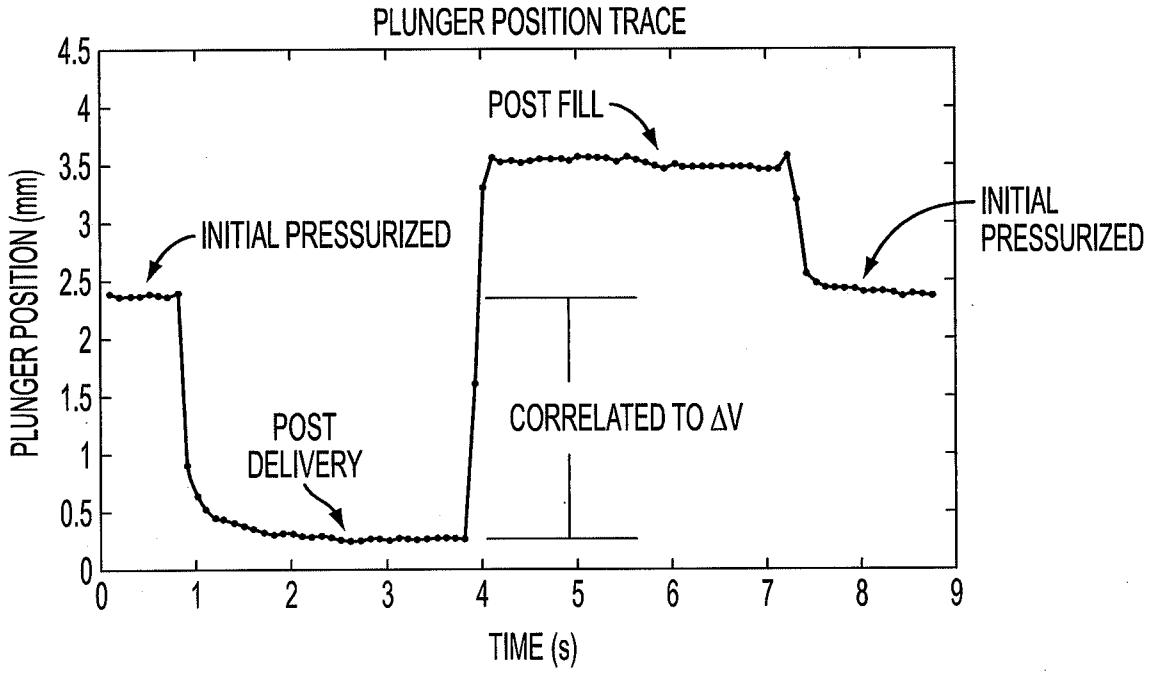

PLUNGER POSITION TRACE
PLUNGER POSITION (mm)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
7
8
9
TIME (s)
POST FILL
INITIAL PRESSURIZED
INITIAL PRESSURIZED
POST DELIVERY
CORRELATED TO ΔV

FIG.44

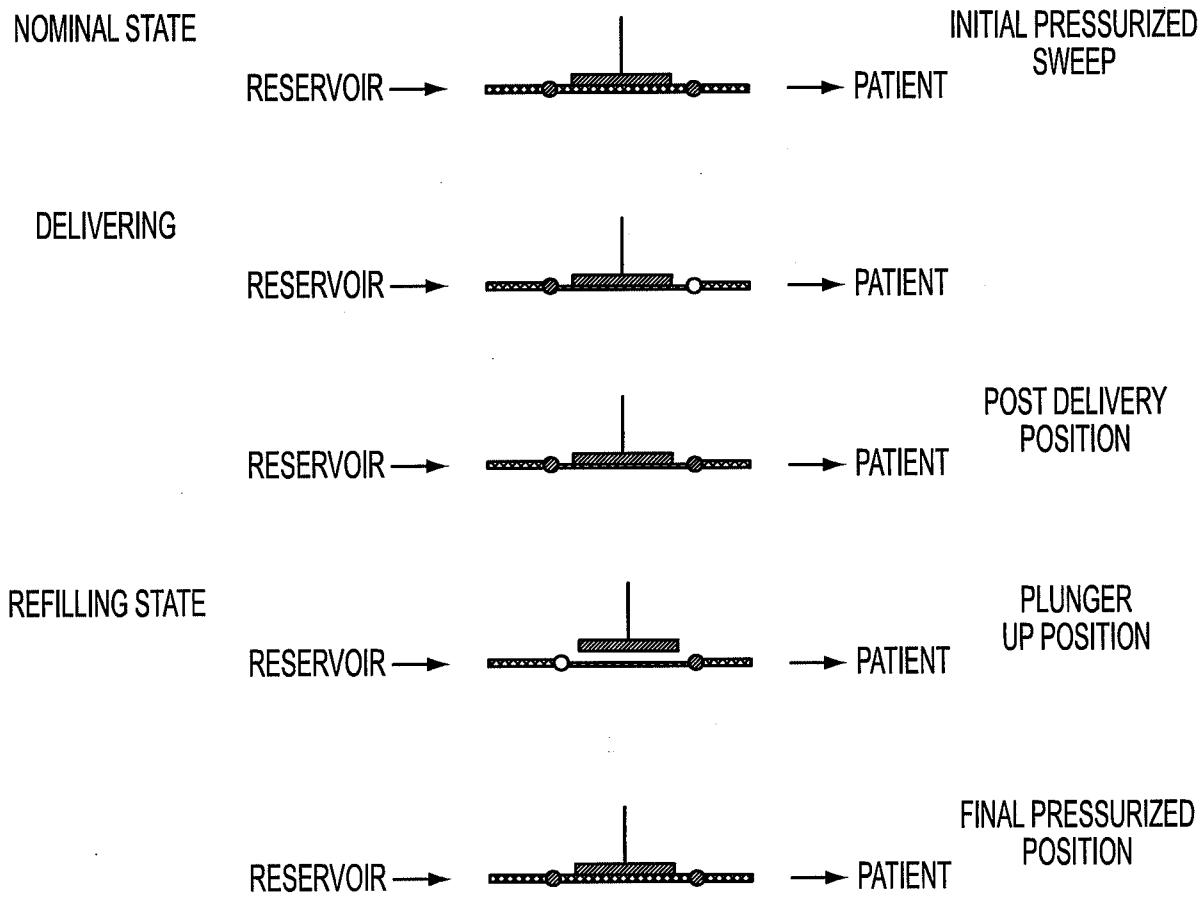

NOMINAL STATE
RESERVOIR
PATIENT
INITIAL PRESSURIZED SWEEP
DELIVERING
RESERVOIR
PATIENT
RESERVOIR
PATIENT
POST DELIVERY POSITION
REFILLING STATE
RESERVOIR
PATIENT
PLUNGER UP POSITION
RESERVOIR
PATIENT
FINAL PRESSURIZED POSITION

FIG.45

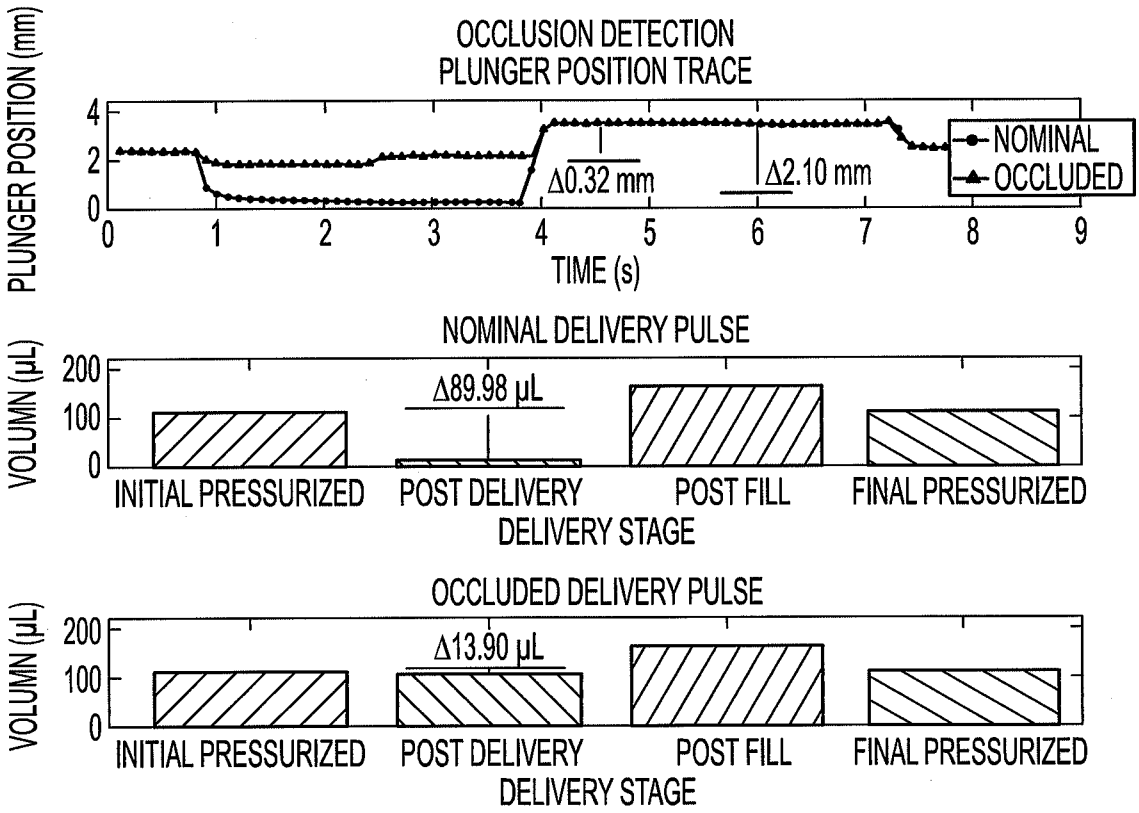

OCCLUSION DETECTION
PLUNGER POSITION TRACE
PLUNGER POSITION (mm)
4
2
0
0
1
2
3
4
5
6
7
8
9
TIME (s)
Δ0.32 mm
Δ2.10 mm
NOMINAL
OCCLUDED
NOMINAL DELIVERY PULSE
VOLUMN (µL)
200
100
0
Δ89.98 µL
INITIAL PRESSURIZED
POST DELIVERY
POST FILL
FINAL PRESSURIZED
DELIVERY STAGE
OCCLUDED DELIVERY PULSE
VOLUMN (µL)
200
100
0
Δ13.90 µL
INITIAL PRESSURIZED
POST DELIVERY
POST FILL
FINAL PRESSURIZED
DELIVERY STAGE

FIG. 46

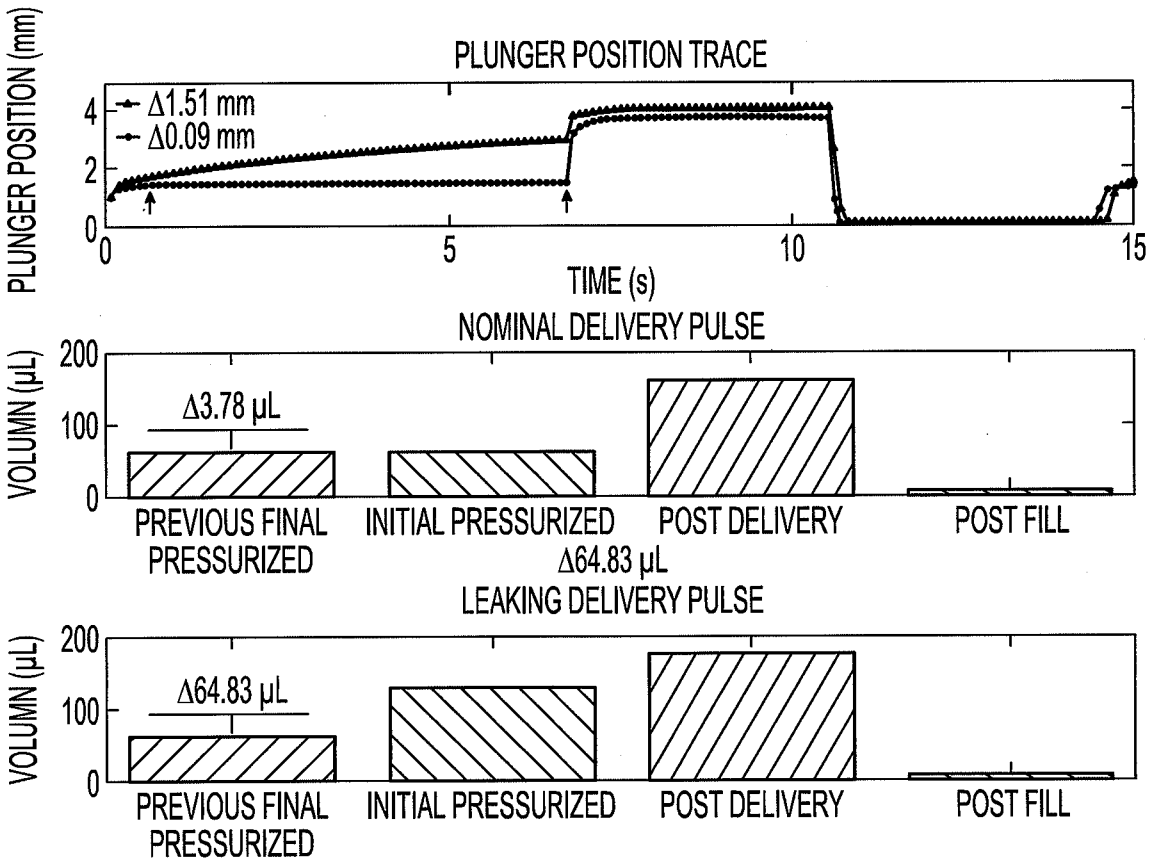

PLUNGER POSITION TRACE
PLUNGER POSITION (mm)
Δ1.51 mm
Δ0.09 mm
4
2
0
0
5
10
15
TIME (s)
NOMINAL DELIVERY PULSE
VOLUMN (μL)
200
100
0
Δ3.78 μL
PREVIOUS FINAL PRESSURIZED
INITIAL PRESSURIZED
POST DELIVERY
POST FILL
Δ64.83 μL
LEAKING DELIVERY PULSE
VOLUMN (μL)
200
100
0
Δ64.83 μL
PREVIOUS FINAL PRESSURIZED
INITIAL PRESSURIZED
POST DELIVERY
POST FILL

FIG. 47

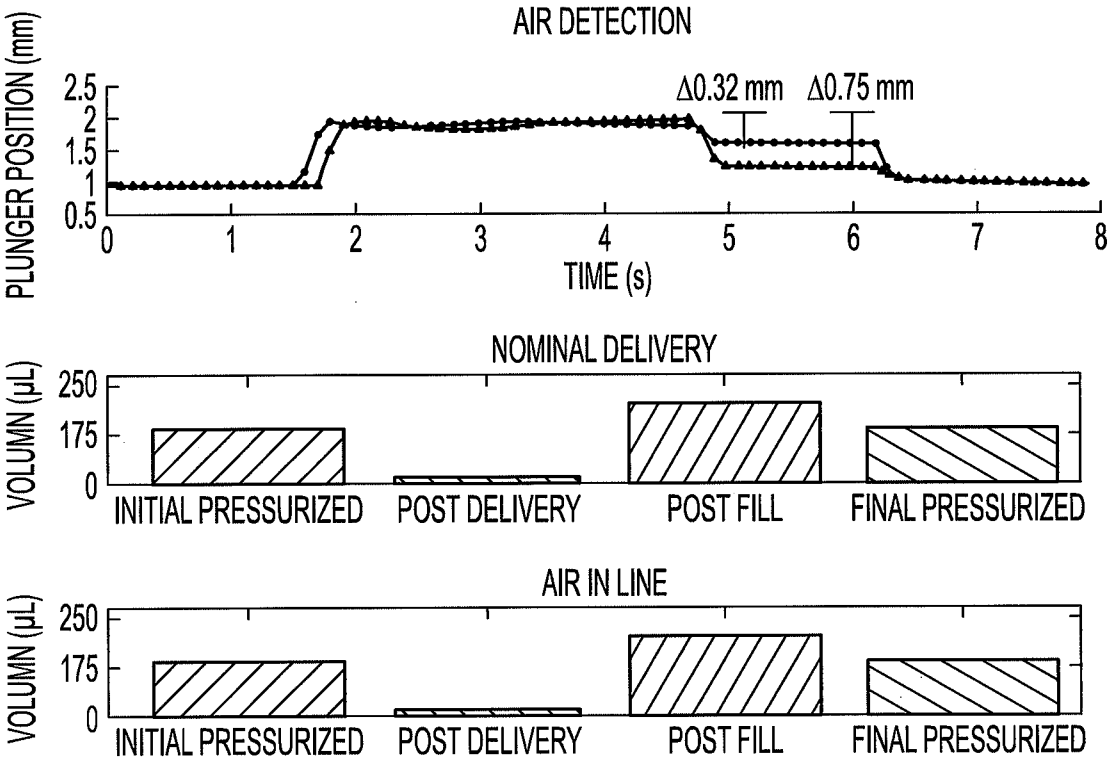

AIR DETECTION
PLUNGER POSITION (mm)
2.5
2
1.5
1
0.5
Δ0.32 mm
Δ0.75 mm
0
1
2
3
4
5
6
7
8
TIME (s)
NOMINAL DELIVERY
VOLUMN (µL)
250
175
0
INITIAL PRESSURIZED
POST DELIVERY
POST FILL
FINAL PRESSURIZED
AIR IN LINE
VOLUMN (µL)
250
175
0
INITIAL PRESSURIZED
POST DELIVERY
POST FILL
FINAL PRESSURIZED

FIG.48

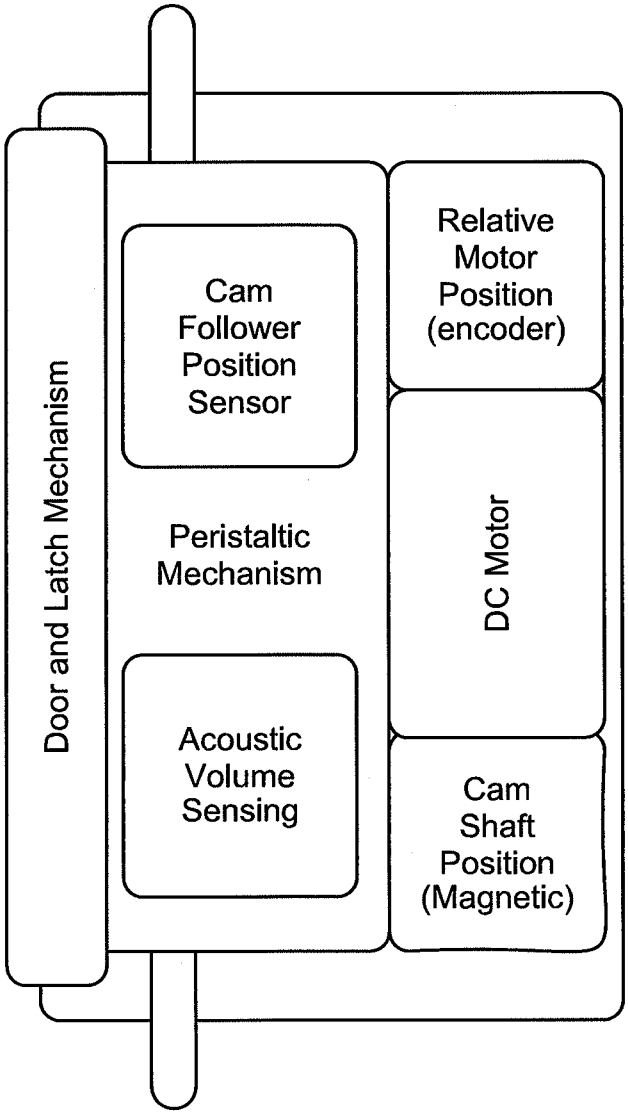

Door and Latch Mechanism
Cam Follower Position Sensor
Peristaltic Mechanism
Acoustic Volume Sensing
Relative Motor Position (encoder)
DC Motor
Cam Shaft Position (Magnetic)

FIG. 49

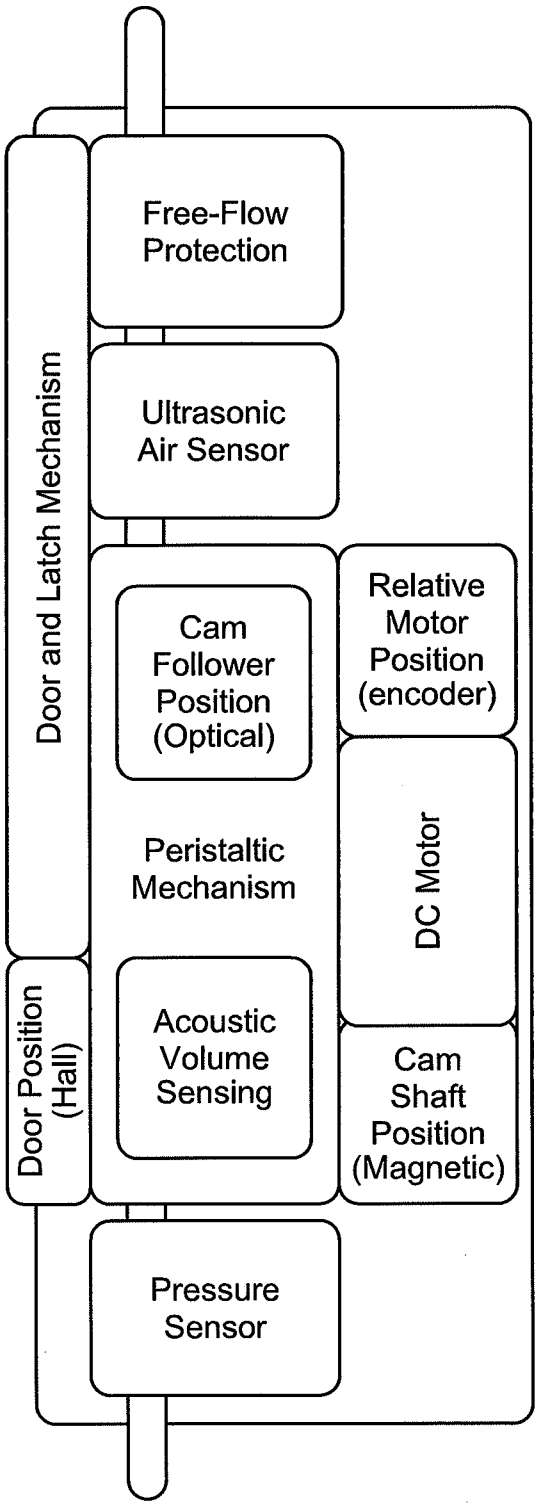

Free-Flow Protection
Ultrasonic Air Sensor
Door and Latch Mechanism
Cam Follower Position (Optical)
Relative Motor Position (encoder)
Peristaltic Mechanism
DC Motor
Door Position (Hall)
Acoustic Volume Sensing
Cam Shaft Position (Magnetic)
Pressure Sensor

FIG. 50

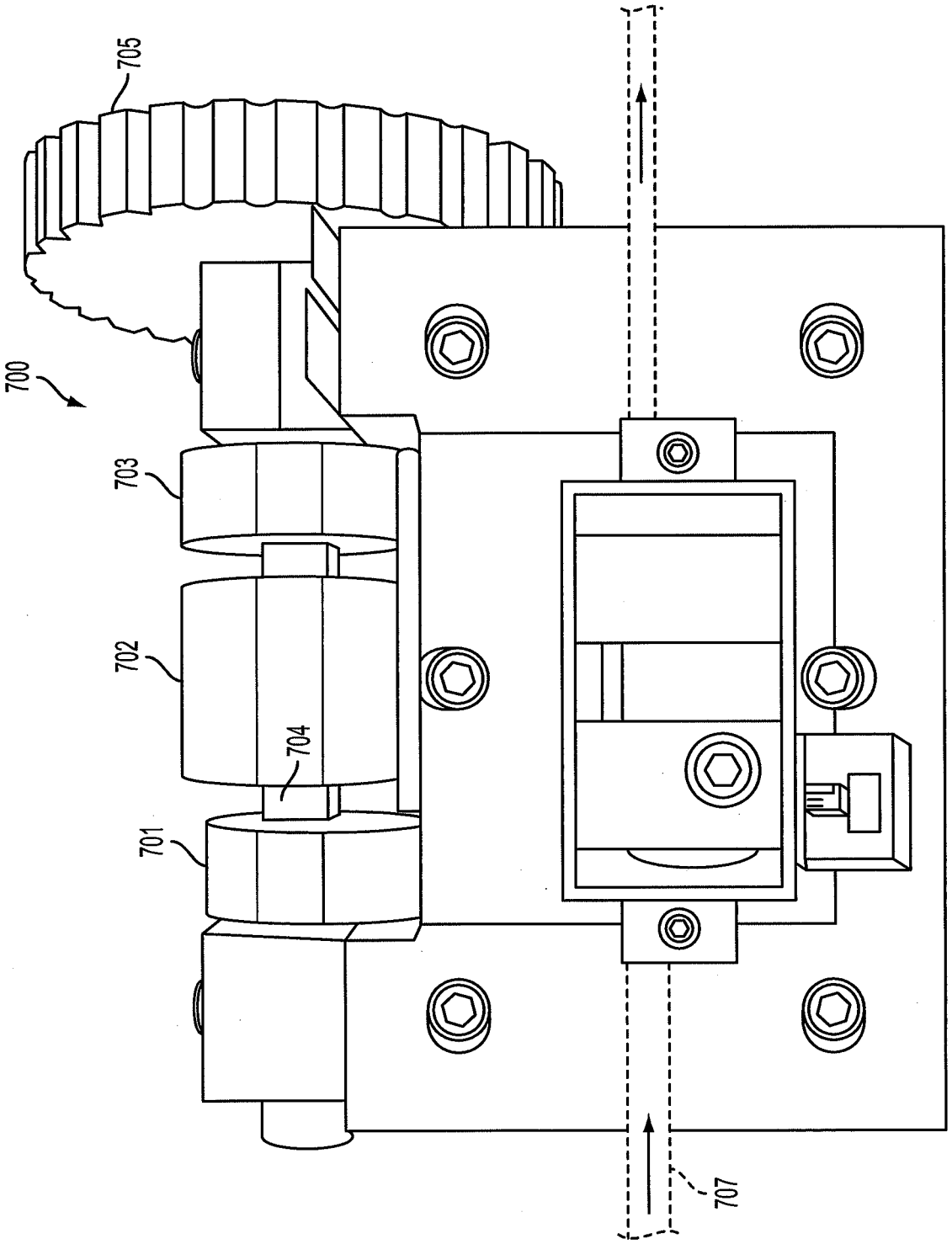


FIG. 51

Magnitude
3
2.5
2
1.5
1
0.5
0
100
1000
2000
3000
4000
Frequency (Hz)
Phase
0
-50
-100
-150
100
1000
2000
3000
4000
Frequency (Hz)

FIG. 52

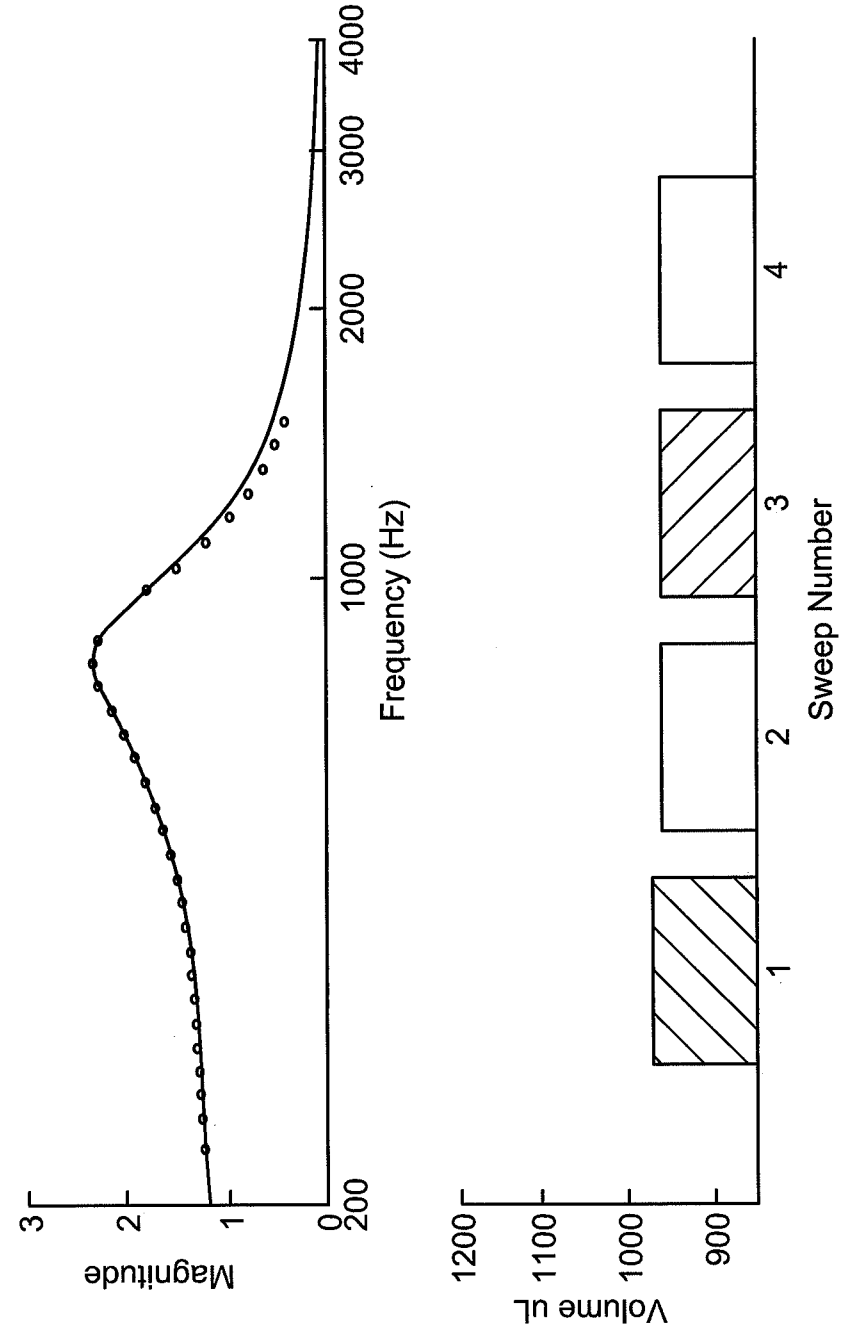

Magnitude
0
1
2
3
200
1000
2000
3000
4000
Frequency (Hz)
Volume uL
900
1000
1100
1200
1
2
3
4
Sweep Number

FIG. 53

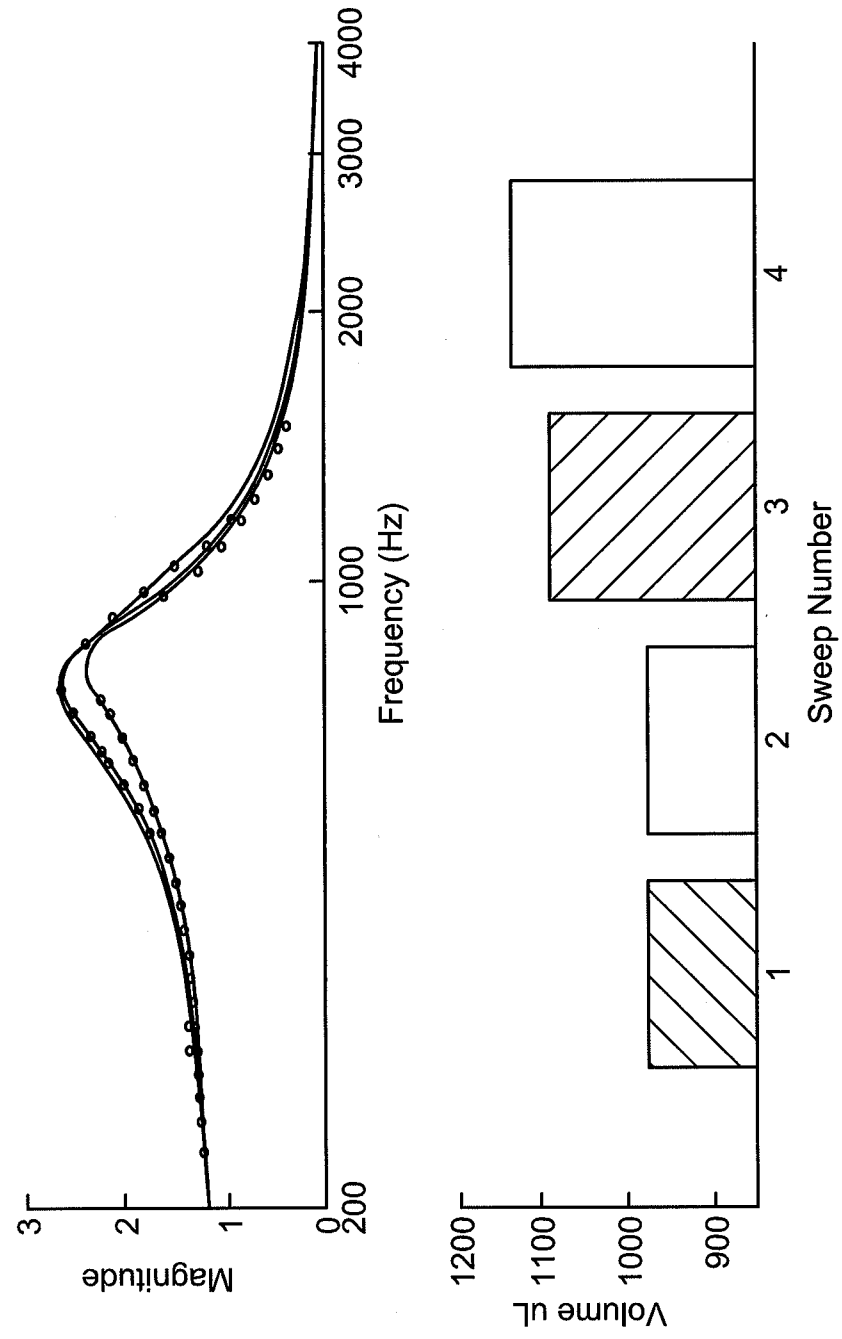

Magnitude
0
1
2
3
200
1000
2000
3000
4000
Frequency (Hz)
Volume uL
900
1000
1100
1200
1
2
3
4
Sweep Number

FIG. 54

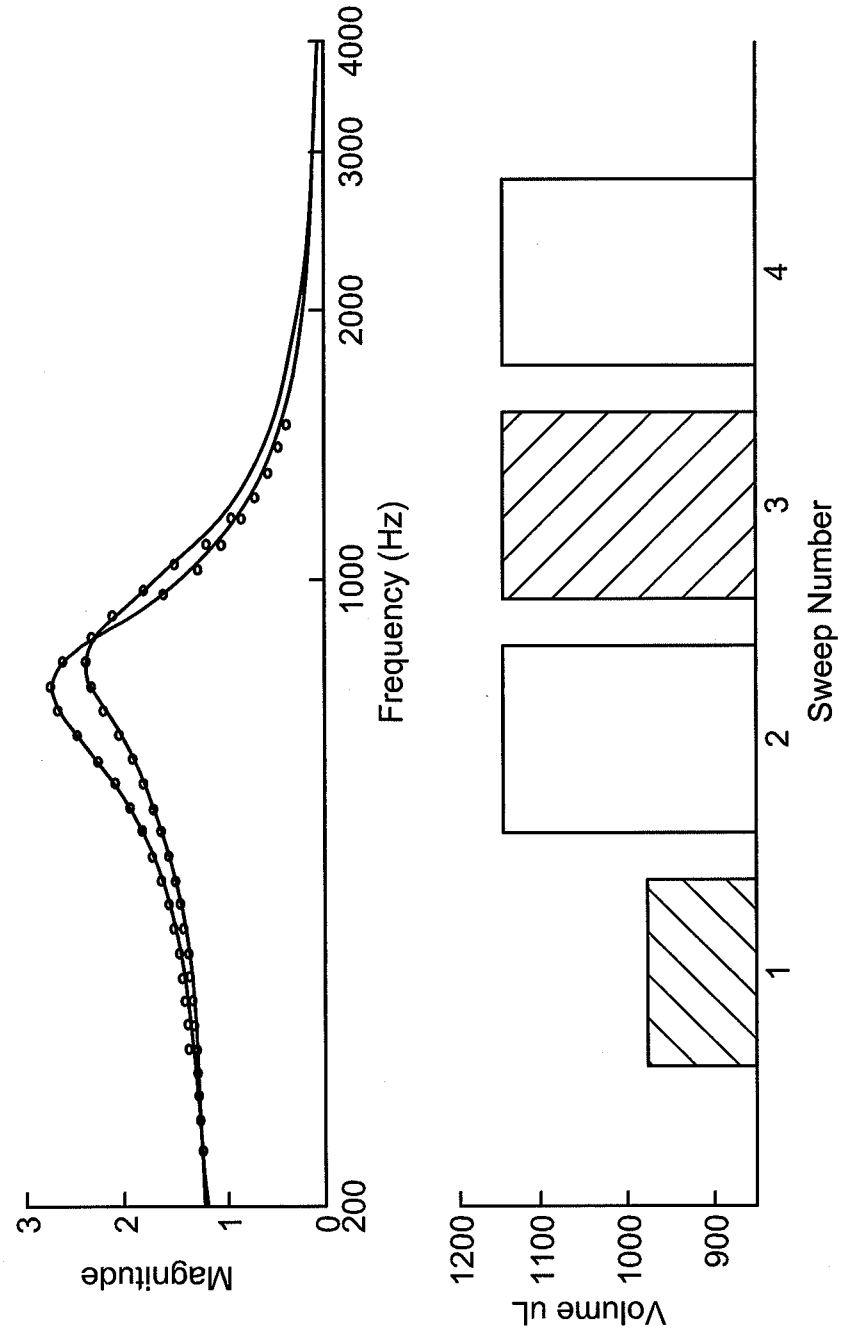

Magnitude
0
1
2
3
200
1000
2000
3000
4000
Frequency (Hz)
Volume uL
900
1000
1100
1200
1
2
3
4
Sweep Number

FIG.55

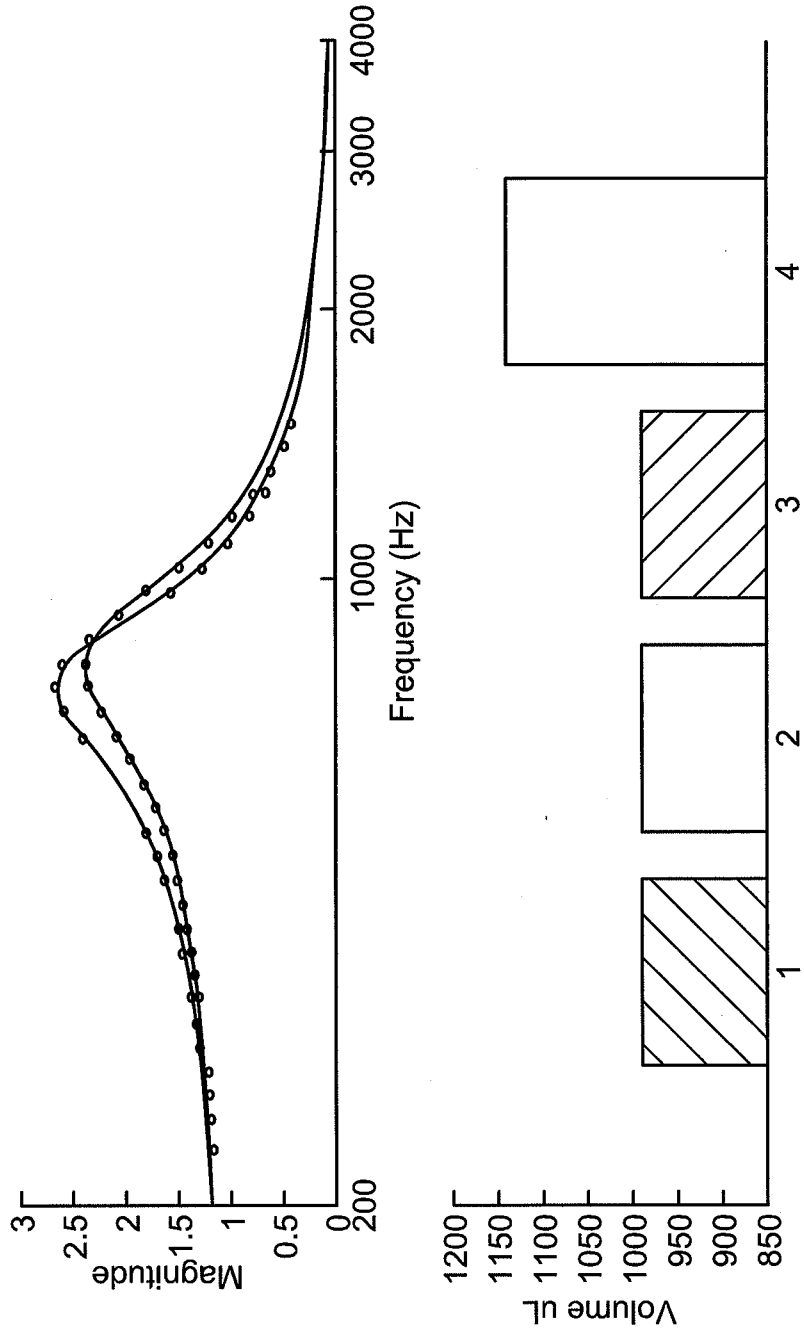

Magnitude
3
2.5
2
1.5
1
0.5
0
200
1000
2000
3000
4000
Frequency (Hz)
Volume uL
1200
1150
1100
1050
1000
950
900
850
1
2
3
4
Sweep Number

FIG. 56

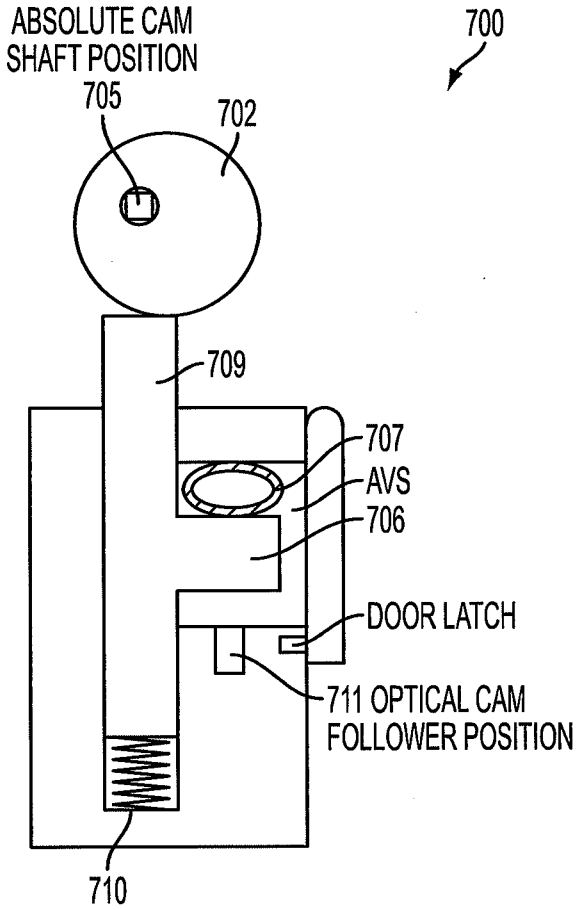

ABSOLUTE CAM
SHAFT POSITION
705
702
700
709
707
AVS
706
DOOR LATCH
711 OPTICAL CAM
FOLLOWER POSITION
710

FIG.57

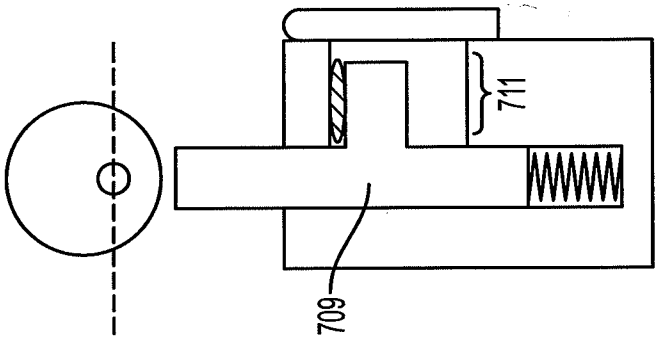


FIG. 58C

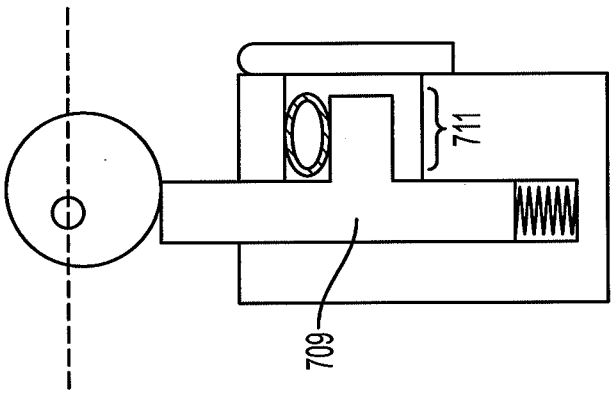


FIG. 58B

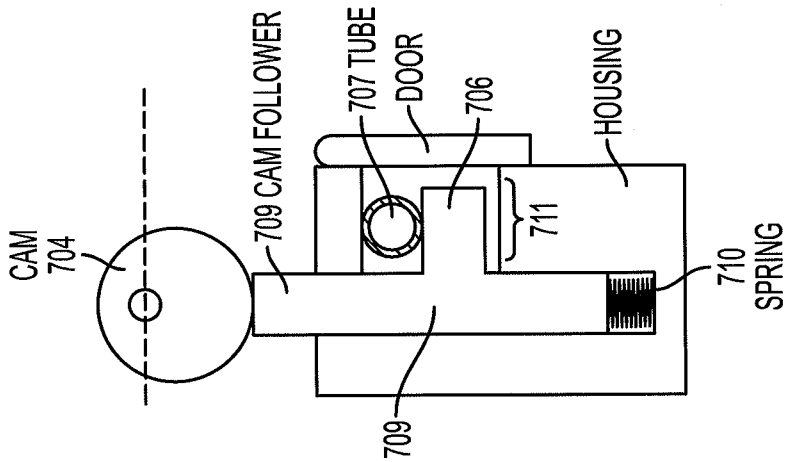


FIG. 58A

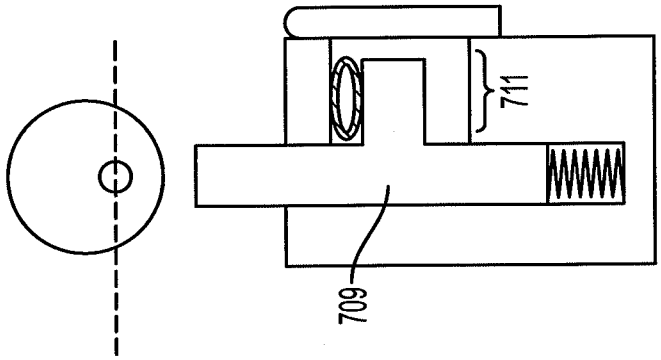


FIG. 59C

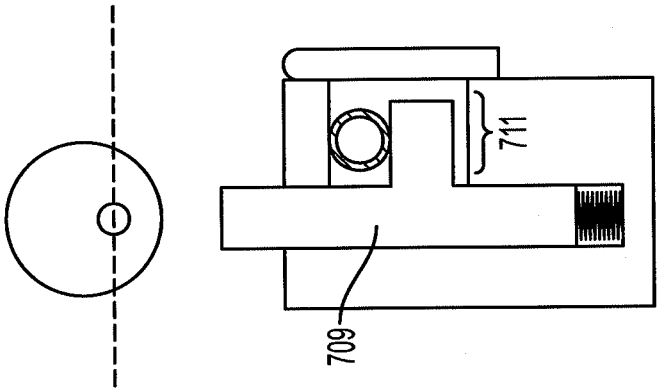


FIG. 59B

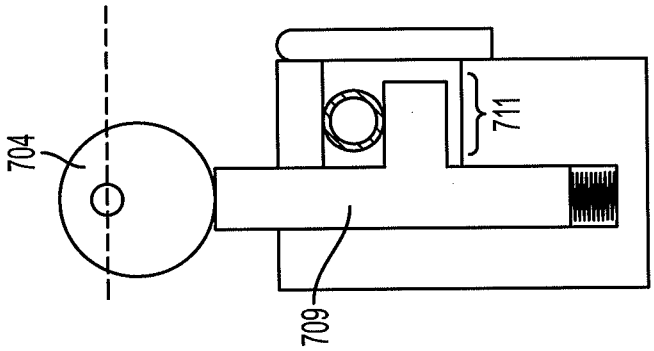


FIG. 59A

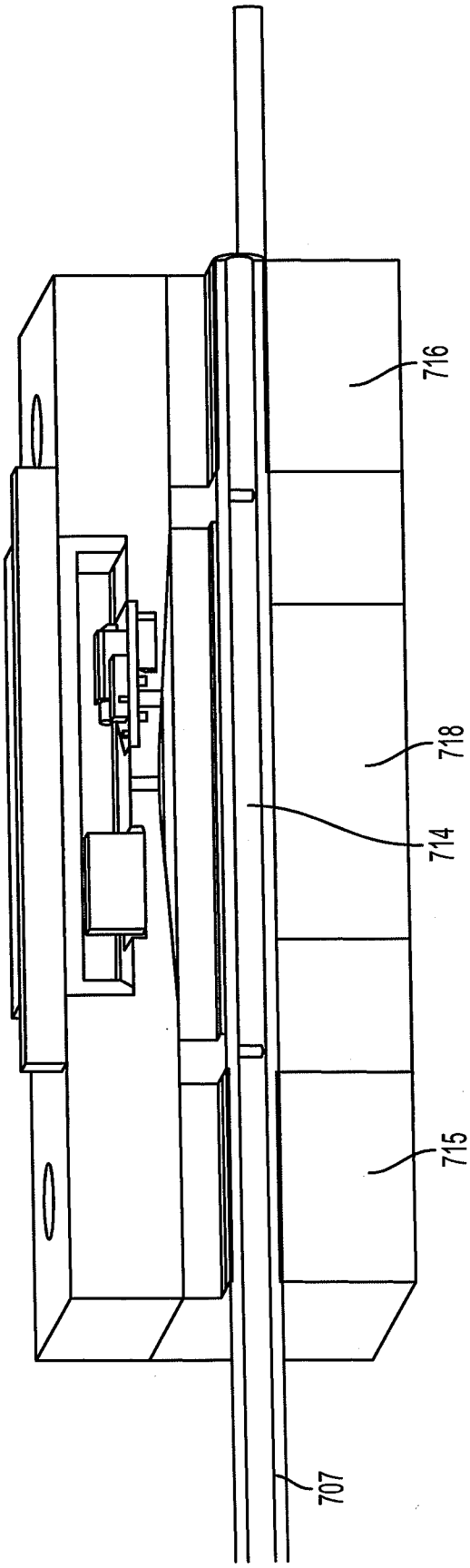


FIG. 60

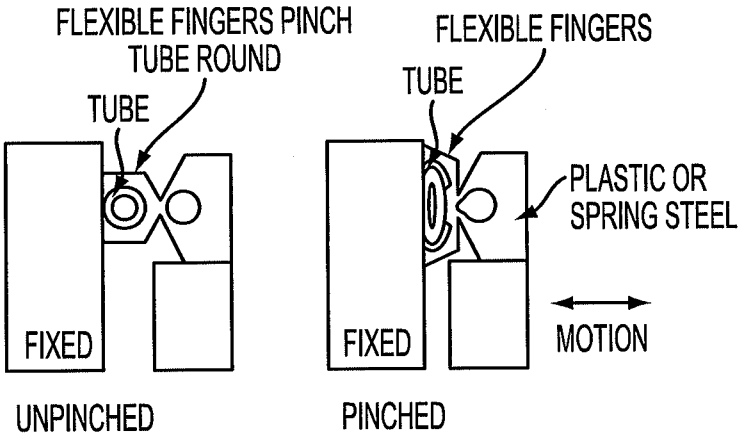

FLEXIBLE FINGERS PINCH TUBE ROUND
TUBE
FIXED
UNPINCHED
FLEXIBLE FINGERS
TUBE
PLASTIC OR SPRING STEEL
FIXED
MOTION
PINCHED

FIG.61

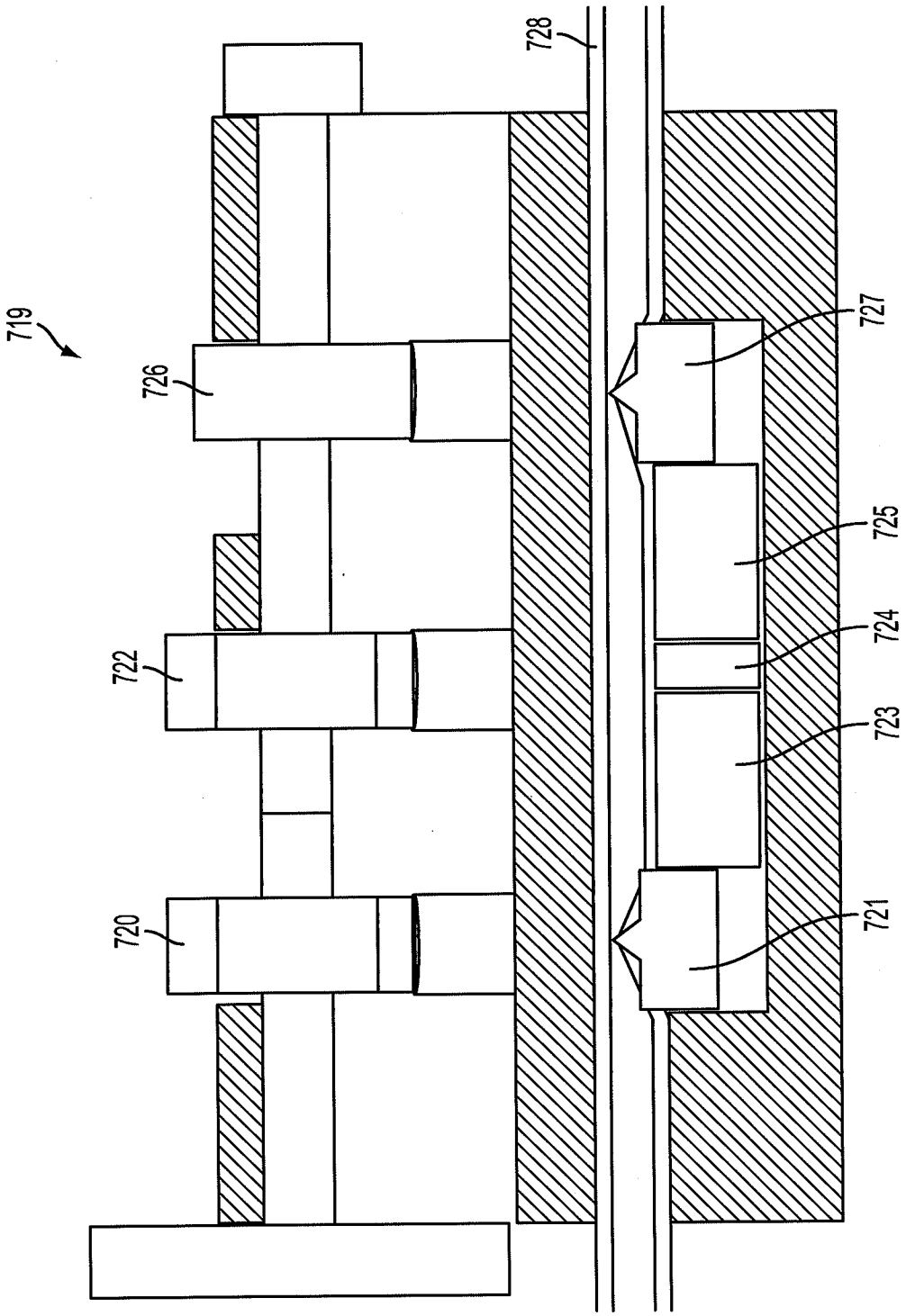


FIG. 62

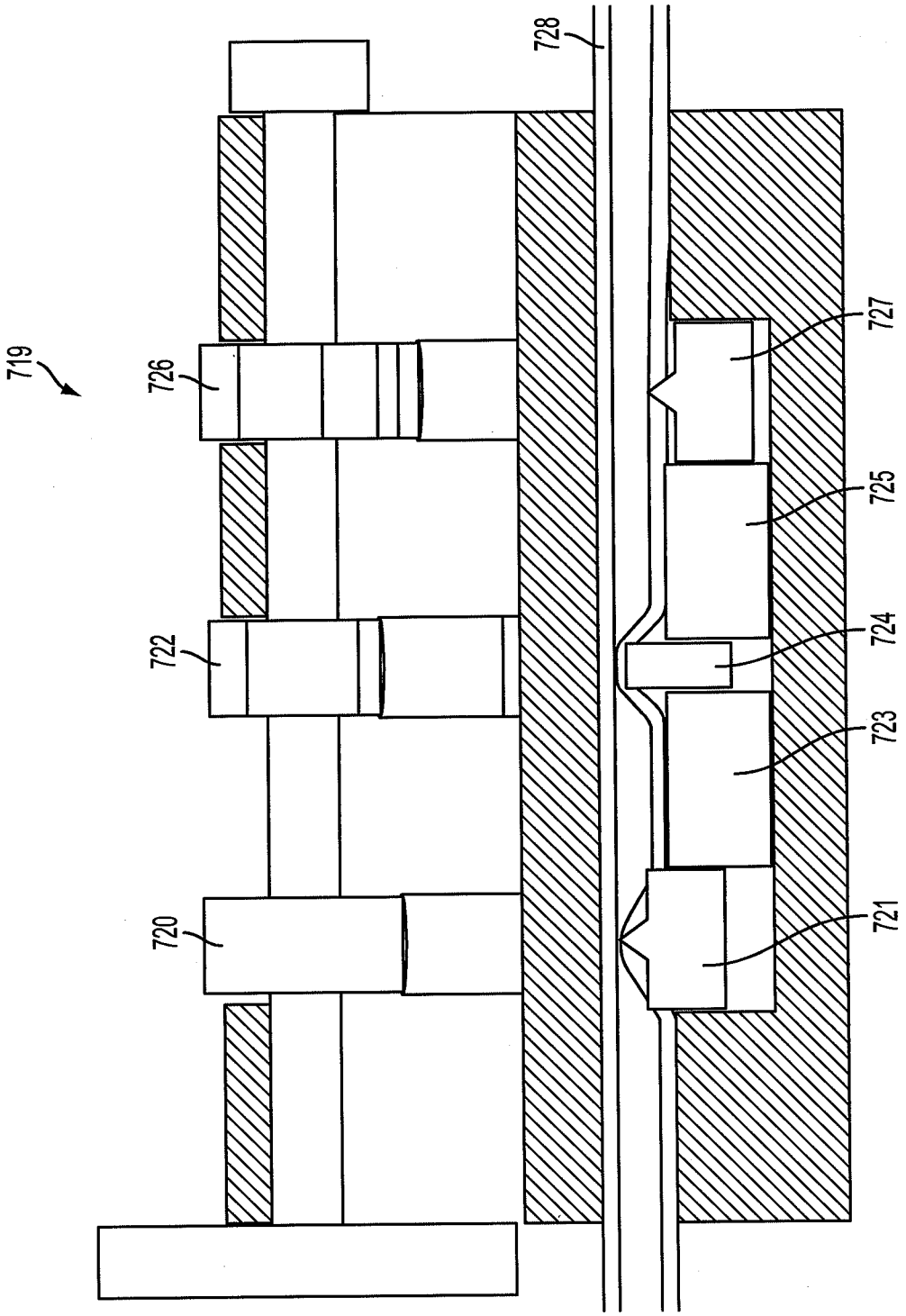


FIG.63

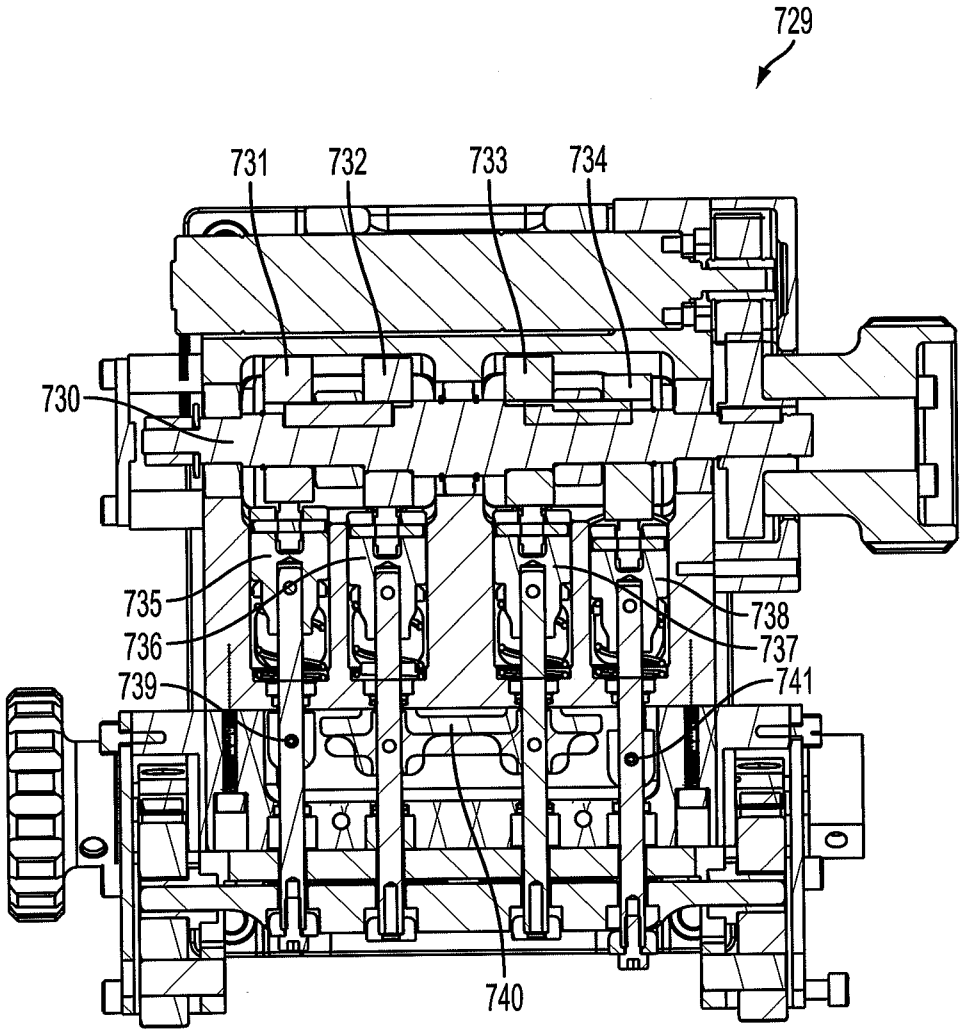


FIG.64

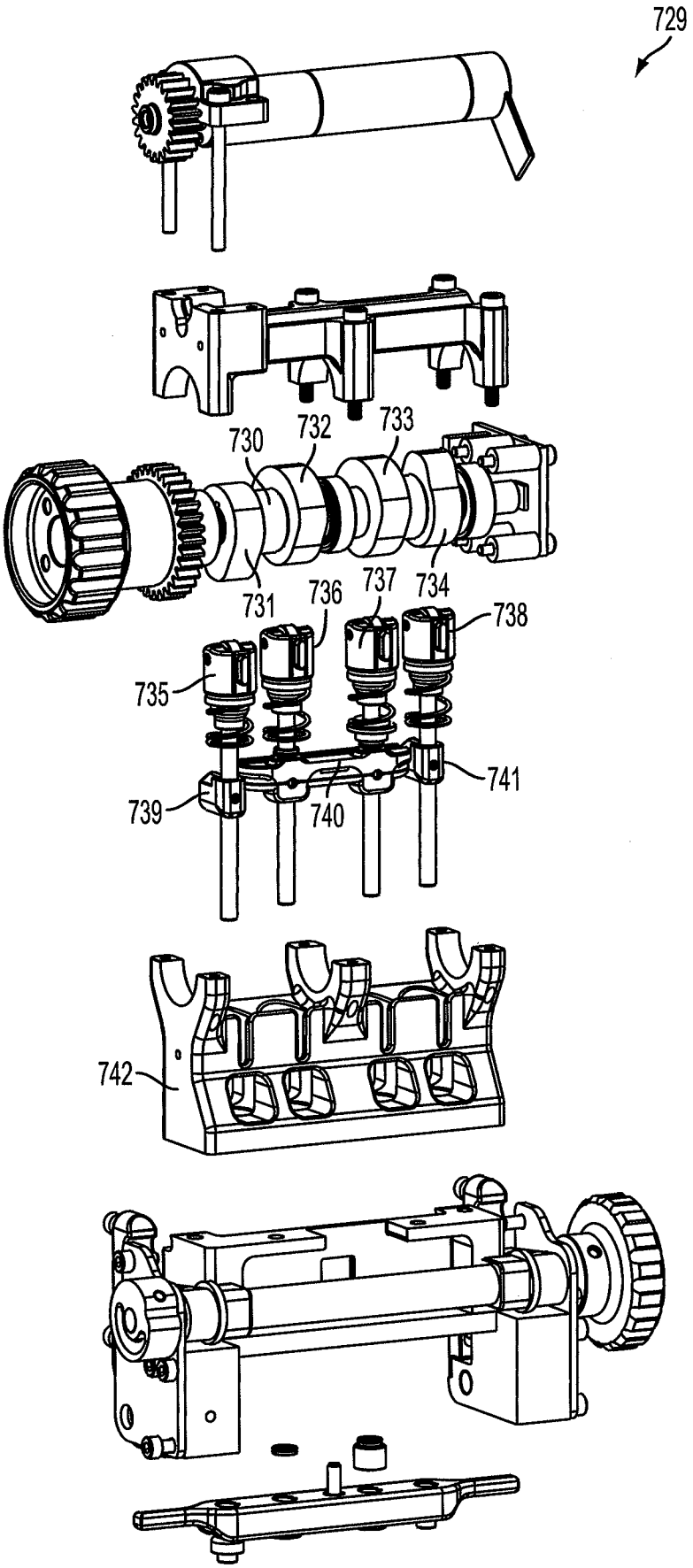


FIG. 65

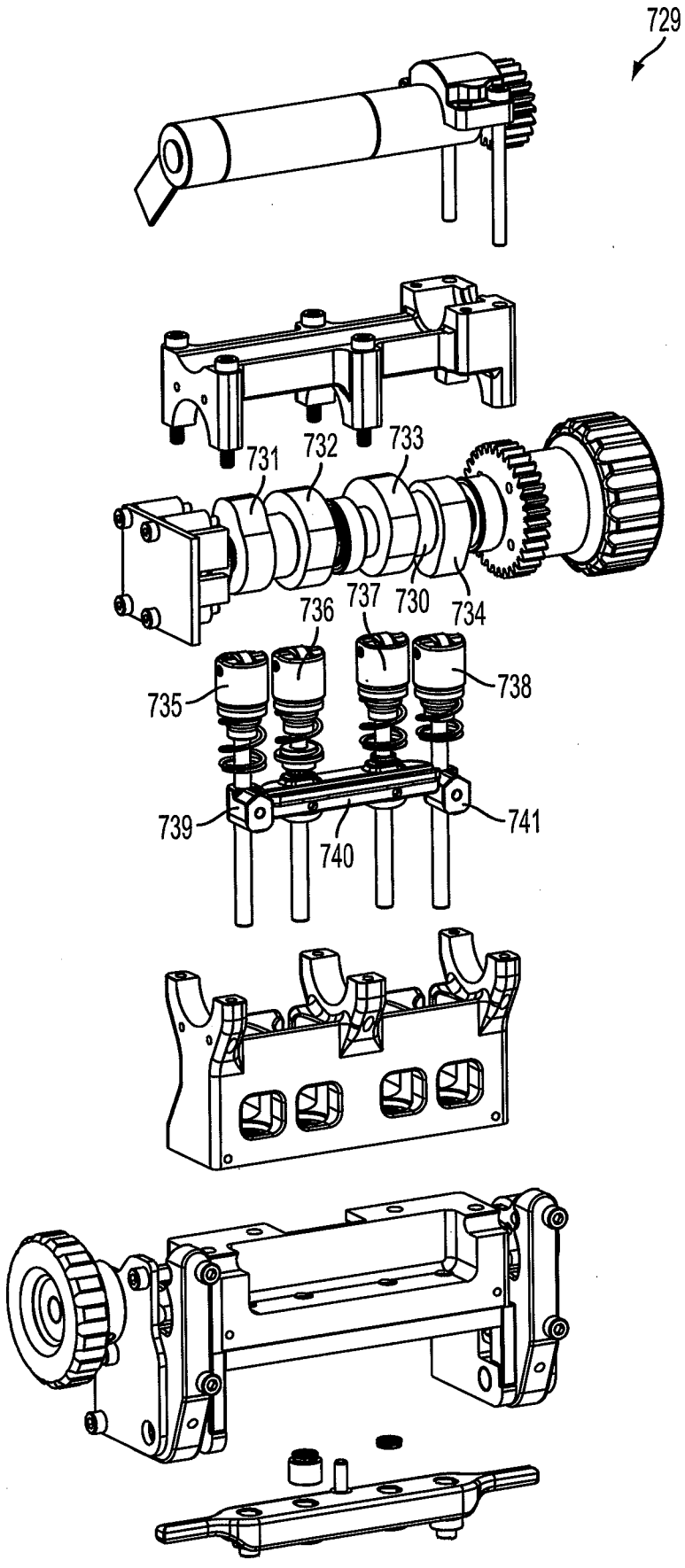


FIG. 66A

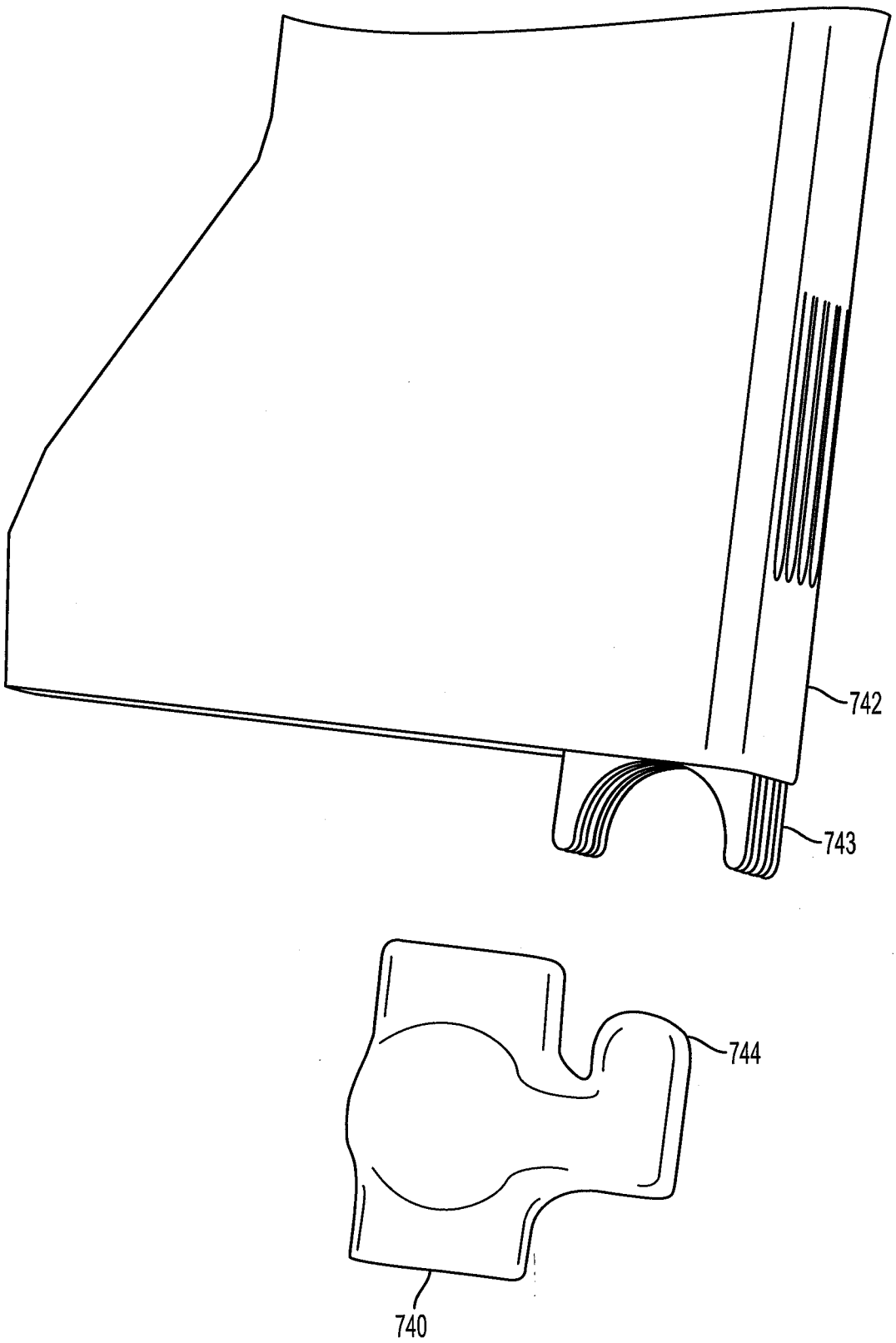


FIG. 66B

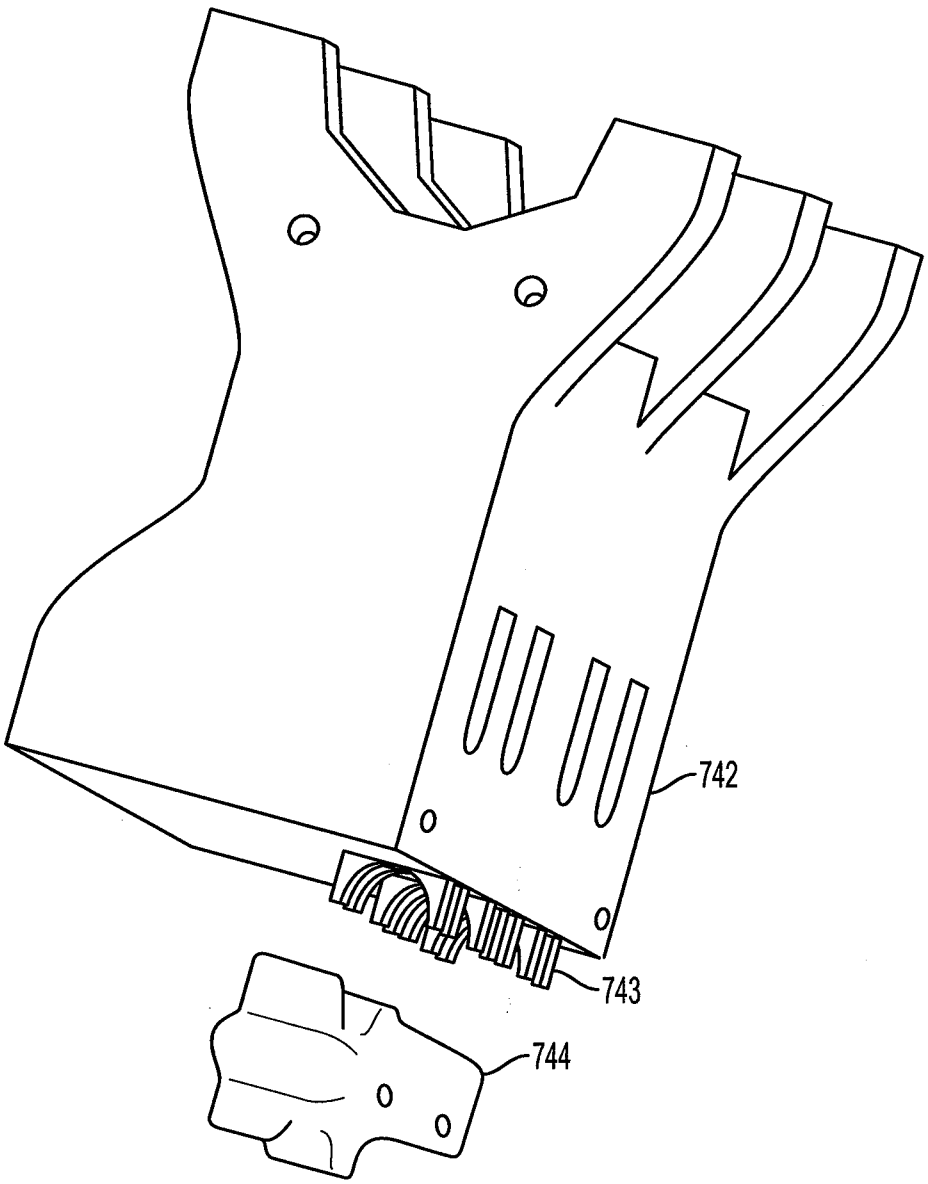


FIG. 66C

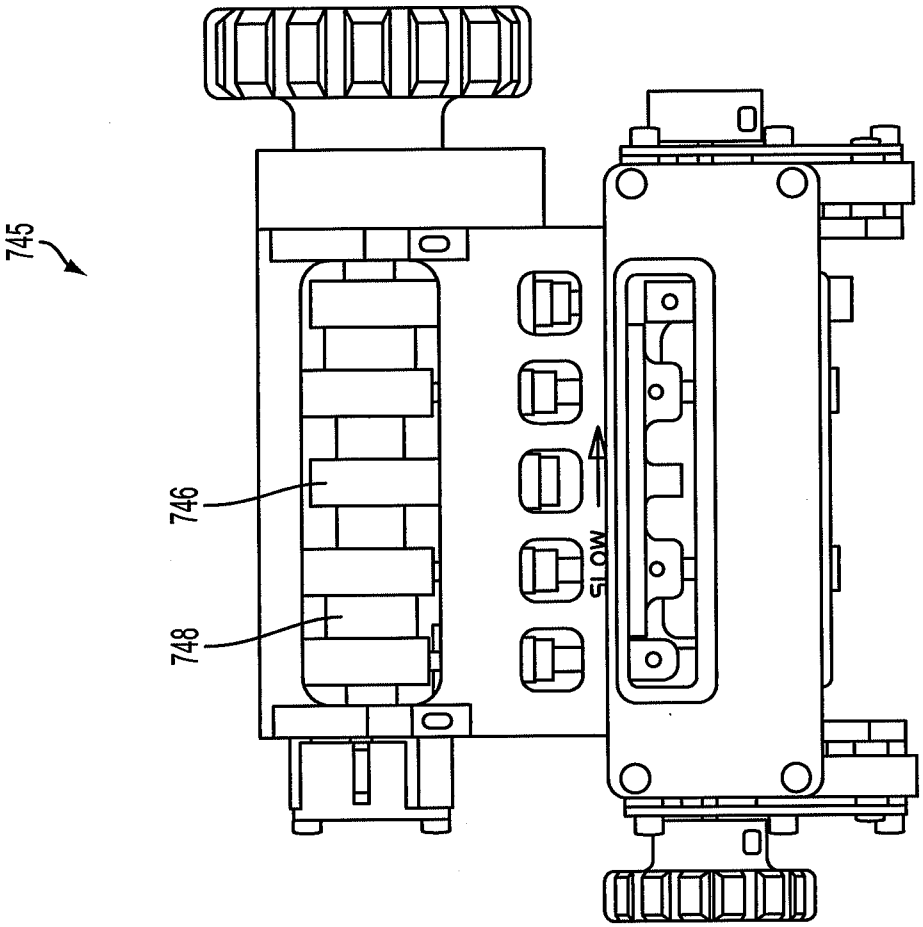


FIG. 68

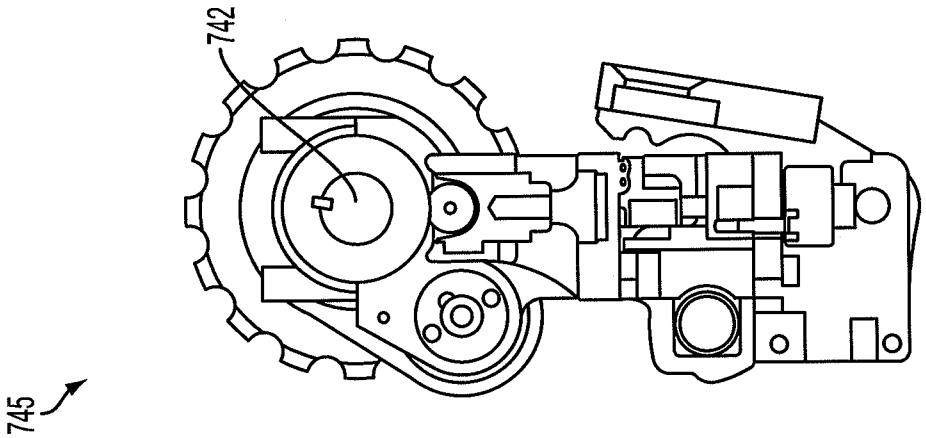


FIG. 67

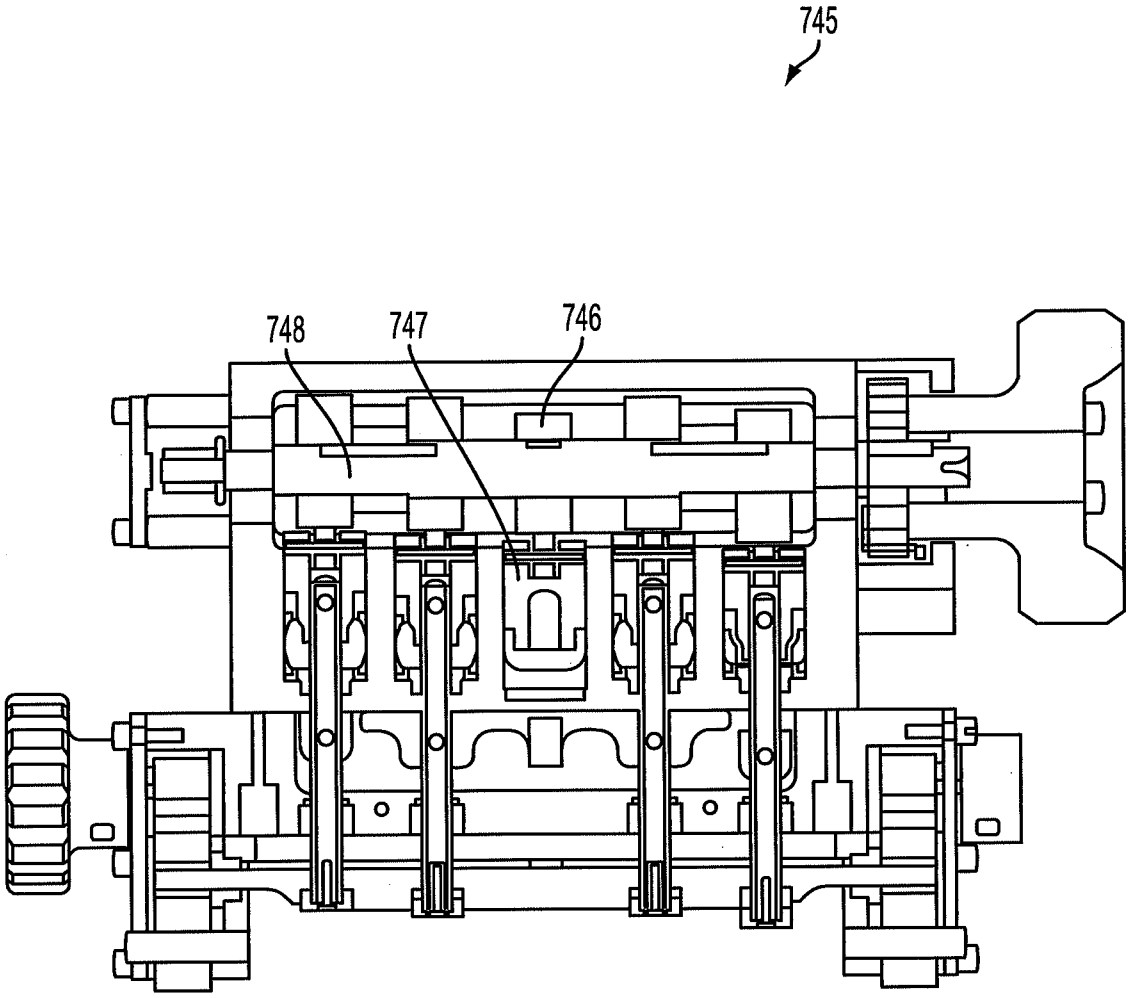


FIG. 69

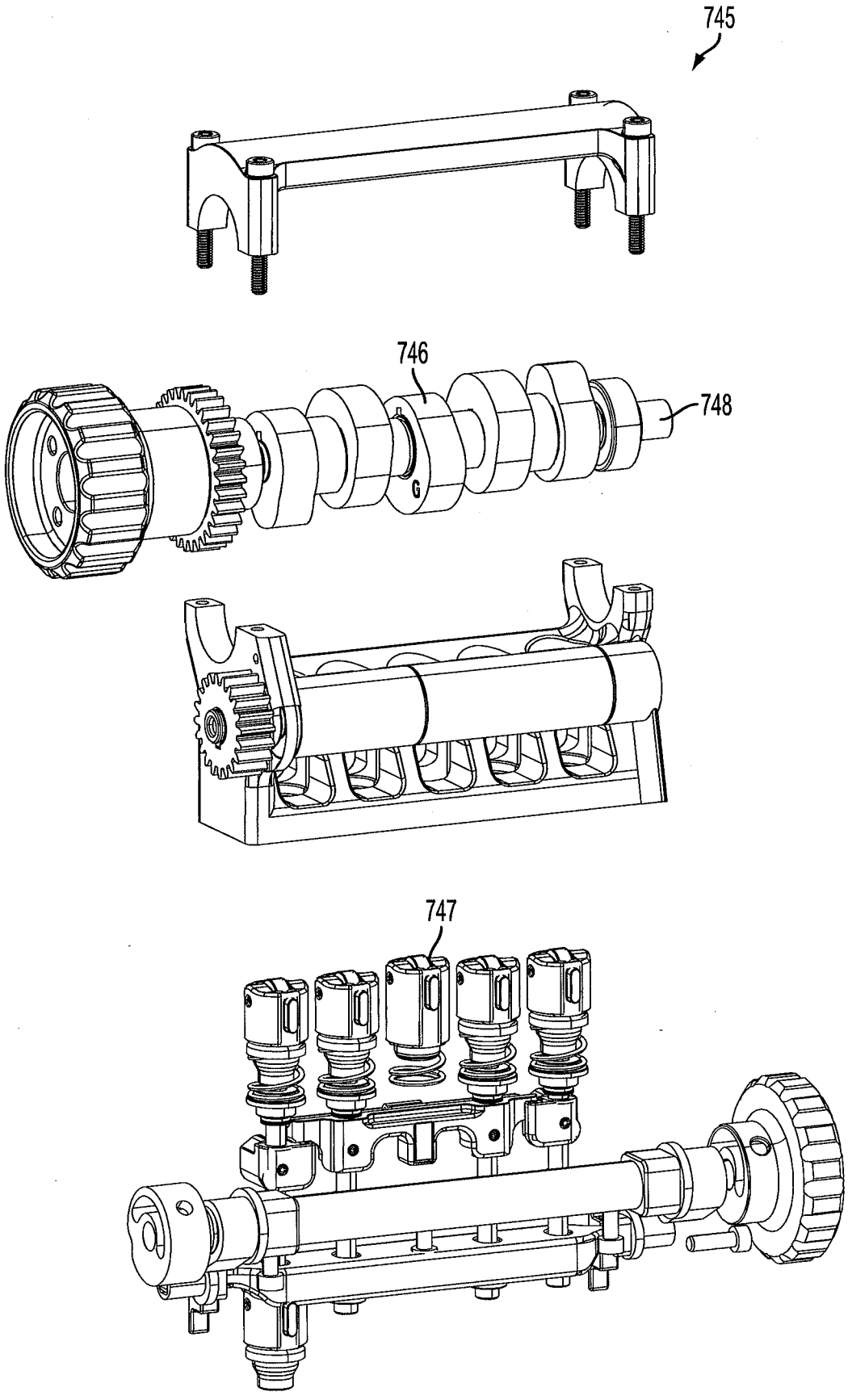


FIG. 70

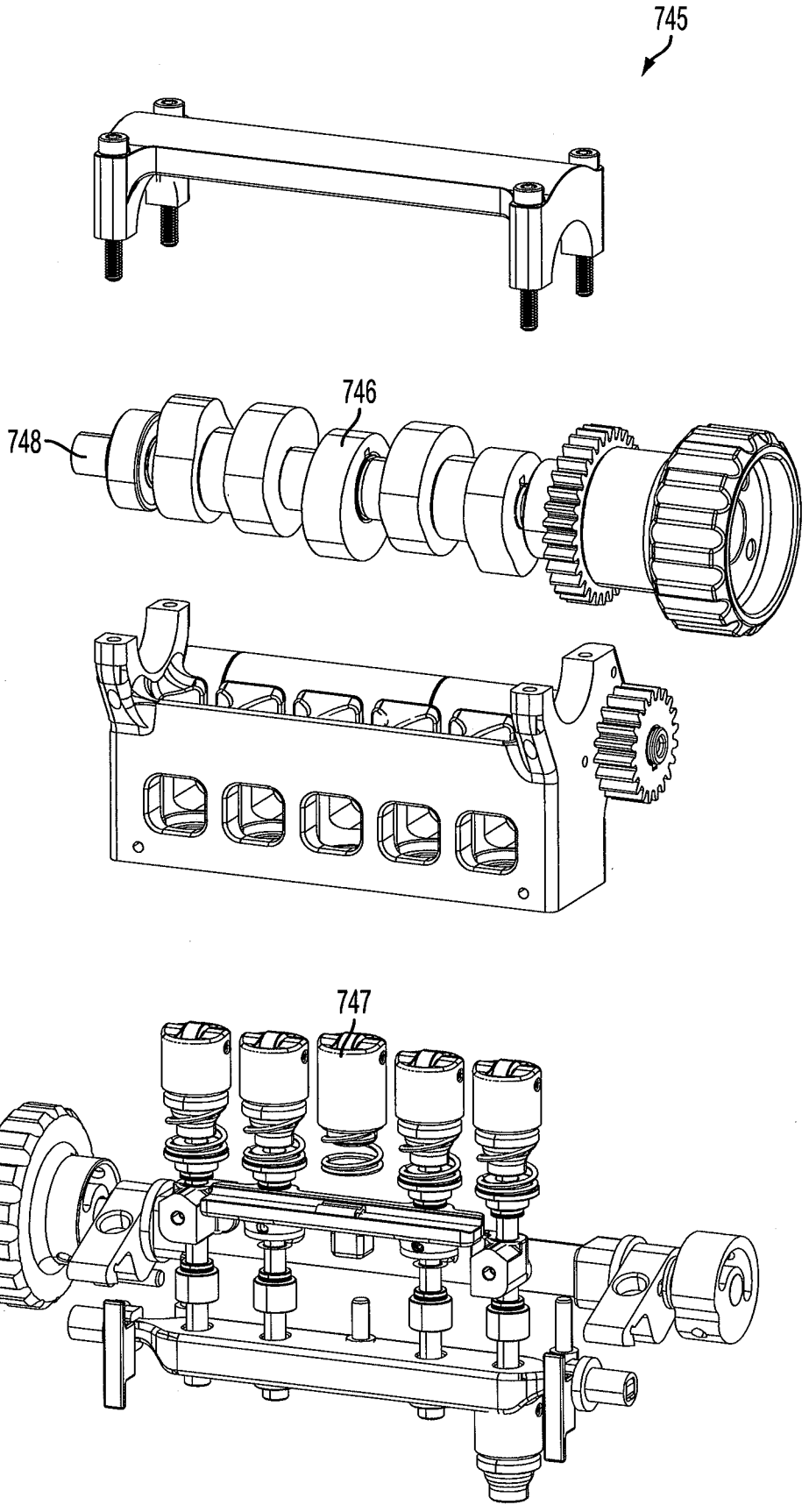


FIG. 71

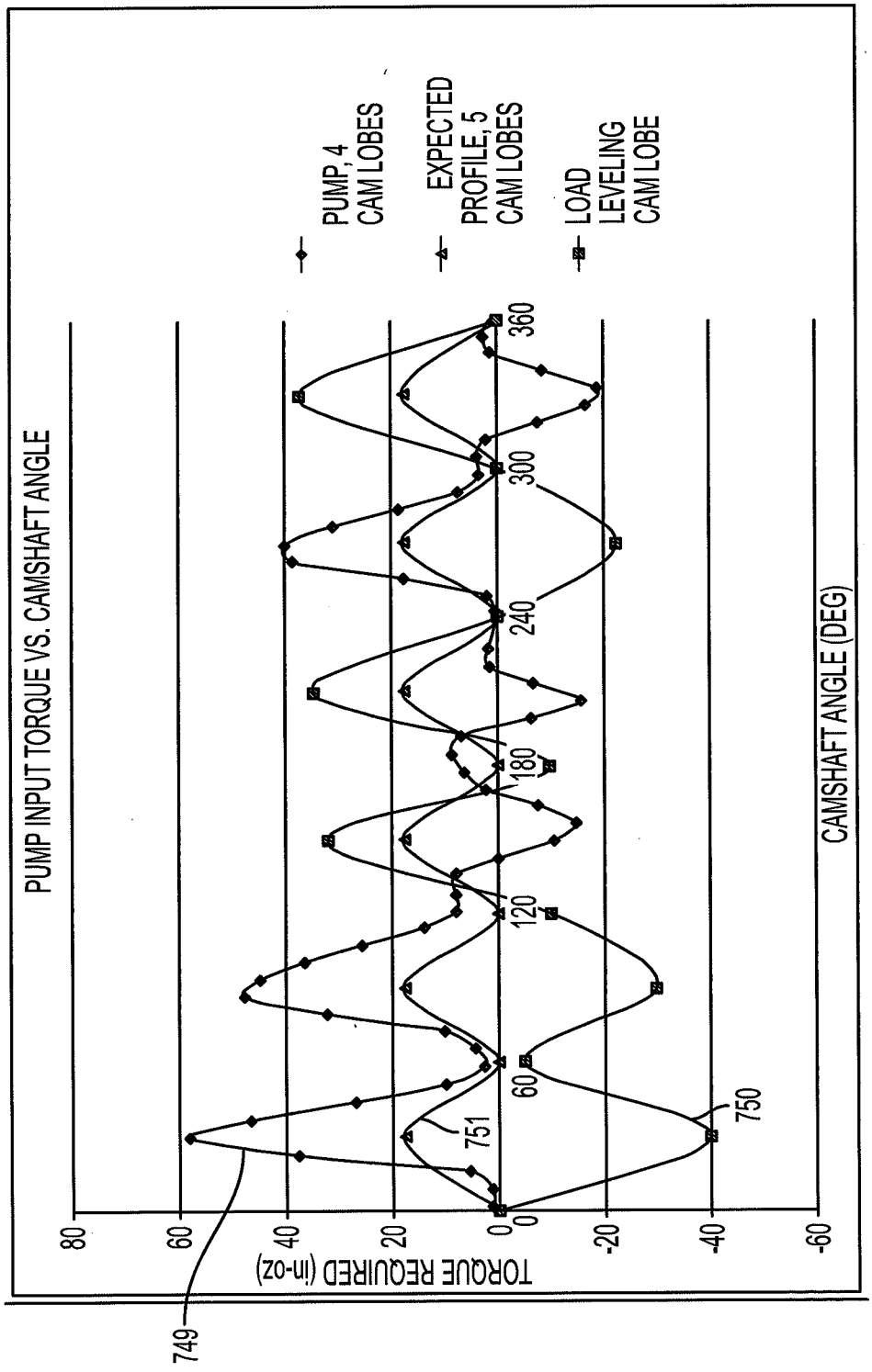

PUMP INPUT TORQUE VS. CAMSHAFT ANGLE
PUMP, 4 CAM LOBES
EXPECTED PROFILE, 5 CAM LOBES
LOAD LEVELING CAM LOBE
TORQUE REQUIRED (in-oz)
CAMSHAFT ANGLE (DEG)
80
60
40
20
0
-20
-40
-60
0
60
120
180
240
300
360
749
751
750

FIG. 72A

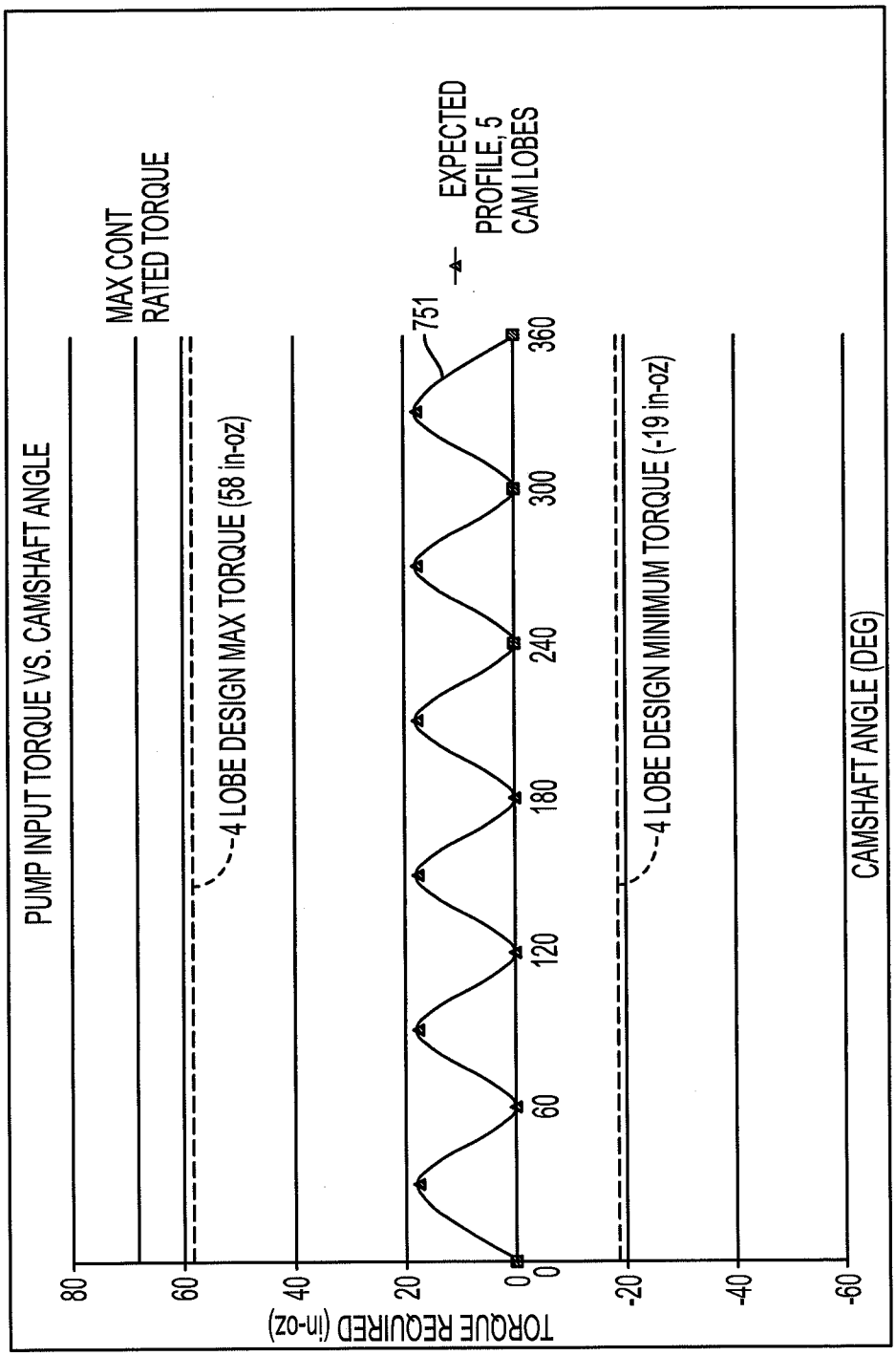

PUMP INPUT TORQUE VS. CAMSHAFT ANGLE
MAX CONT
RATED TORQUE
4 LOBE DESIGN MAX TORQUE (58 in-oz)
751
EXPECTED
PROFILE, 5
CAM LOBES
4 LOBE DESIGN MINIMUM TORQUE (-19 in-oz)
CAMSHAFT ANGLE (DEG)
TORQUE REQUIRED (in-oz)
80
60
40
20
0
-20
-40
-60
0
60
120
180
240
300
360

FIG. 72B

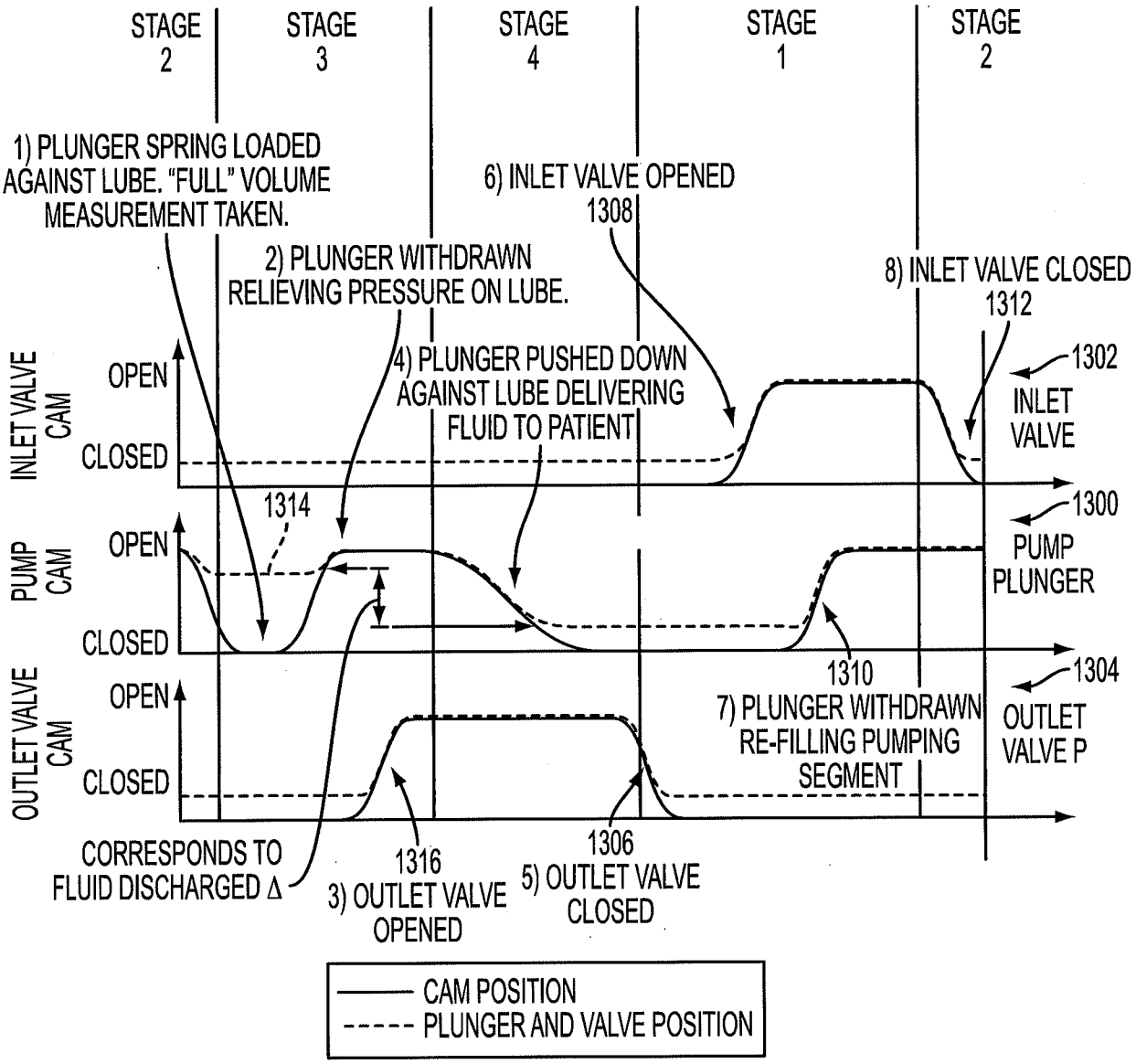

STAGE 2
STAGE 3
STAGE 4
STAGE 1
STAGE 2
1) PLUNGER SPRING LOADED AGAINST LUBE. "FULL" VOLUME MEASUREMENT TAKEN.
2) PLUNGER WITHDRAWN RELIEVING PRESSURE ON LUBE.
6) INLET VALVE OPENED
1308
8) INLET VALVE CLOSED
1312
4) PLUNGER PUSHED DOWN AGAINST LUBE DELIVERING FLUID TO PATIENT
INLET VALVE CAM
OPEN
CLOSED
1302
INLET VALVE
1314
PUMP CAM
OPEN
CLOSED
1300
PUMP PLUNGER
1310
OUTLET VALVE CAM
OPEN
CLOSED
1304
OUTLET VALVE P
7) PLUNGER WITHDRAWN RE-FILLING PUMPING SEGMENT
CORRESPONDS TO FLUID DISCHARGED Δ
1316
3) OUTLET VALVE OPENED
1306
5) OUTLET VALVE CLOSED
CAM POSITION
PLUNGER AND VALVE POSITION

FIG.73

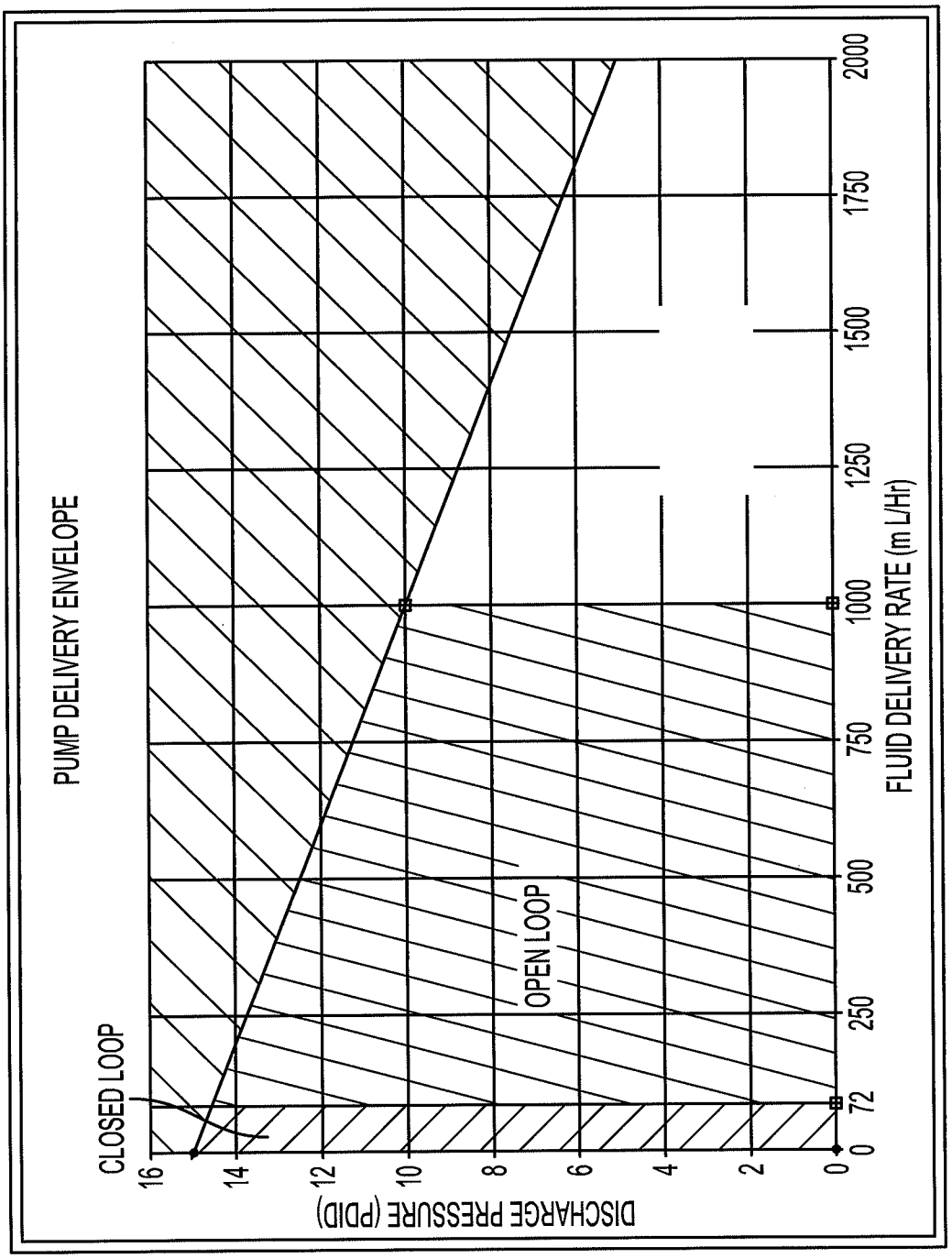

PUMP DELIVERY ENVELOPE
CLOSED LOOP
OPEN LOOP
DISCHARGE PRESSURE (PDID)
0
2
4
6
8
10
12
14
16
FLUID DELIVERY RATE (m L/Hr)
0
72
250
500
750
1000
1250
1500
1750
2000

FIG. 74

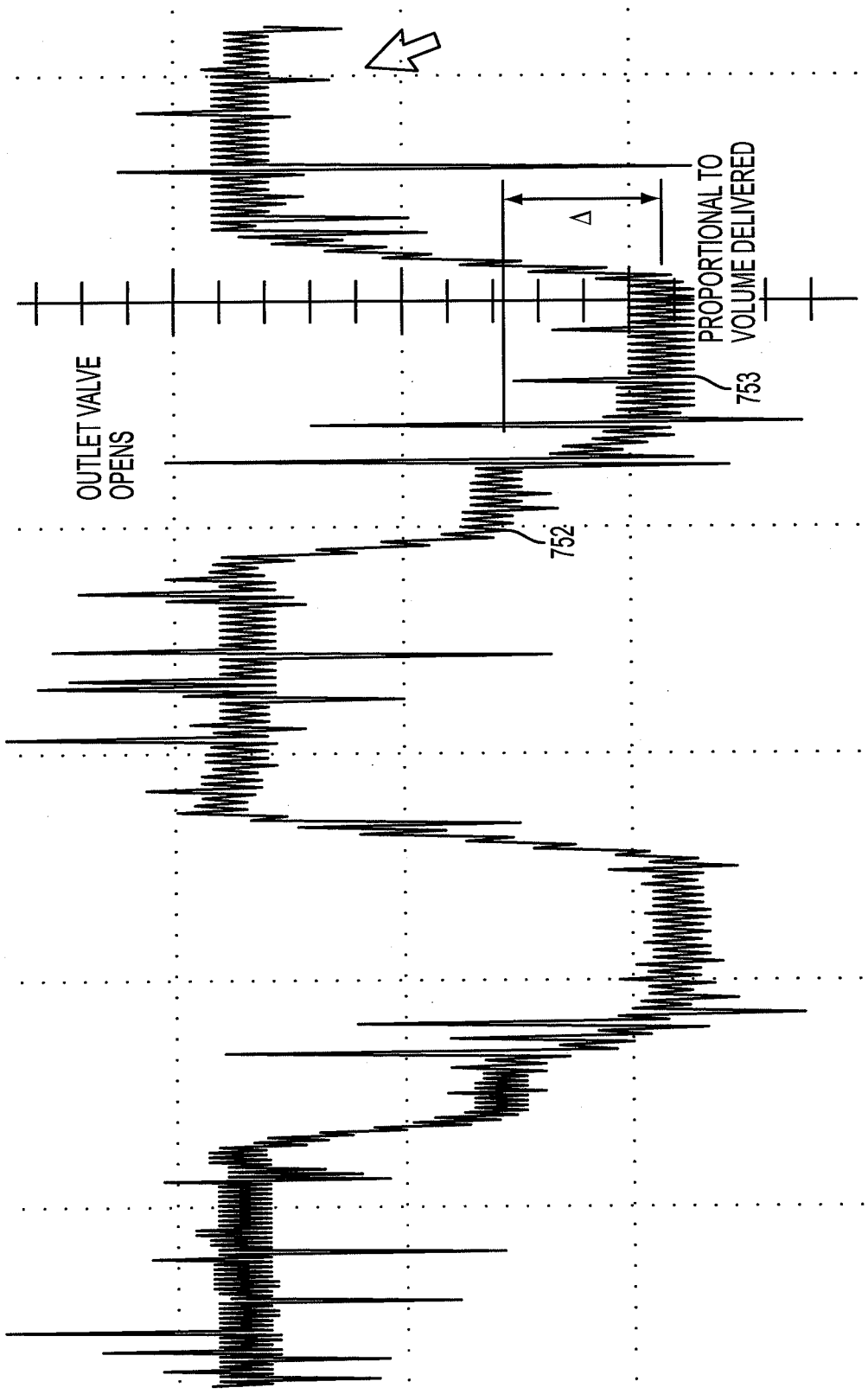

OUTLET VALVE OPENS
752
753
Δ
PROPORTIONAL TO VOLUME DELIVERED

FIG.75

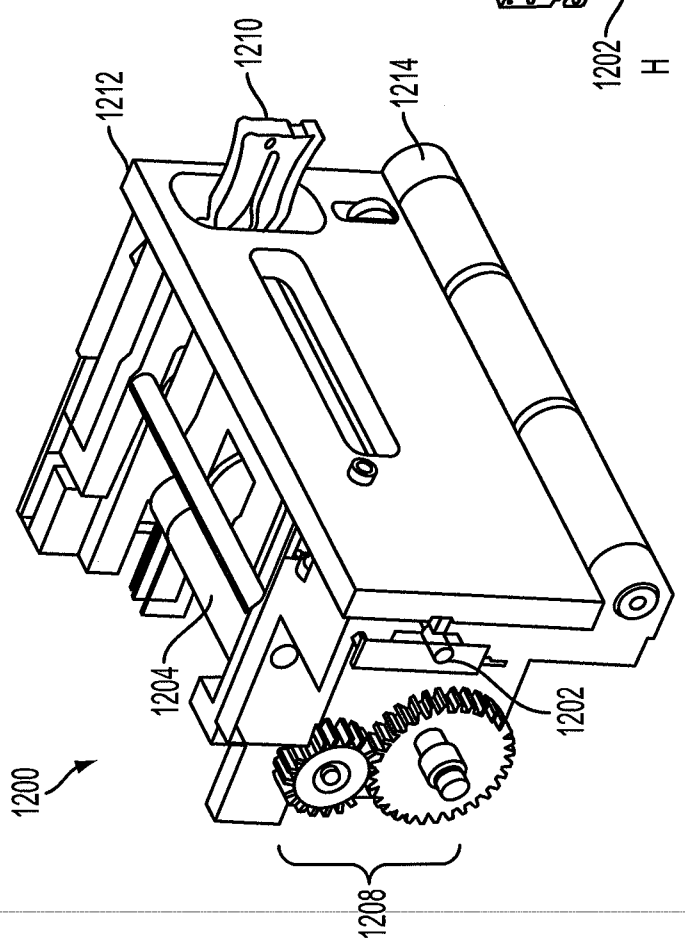


FIG. 76

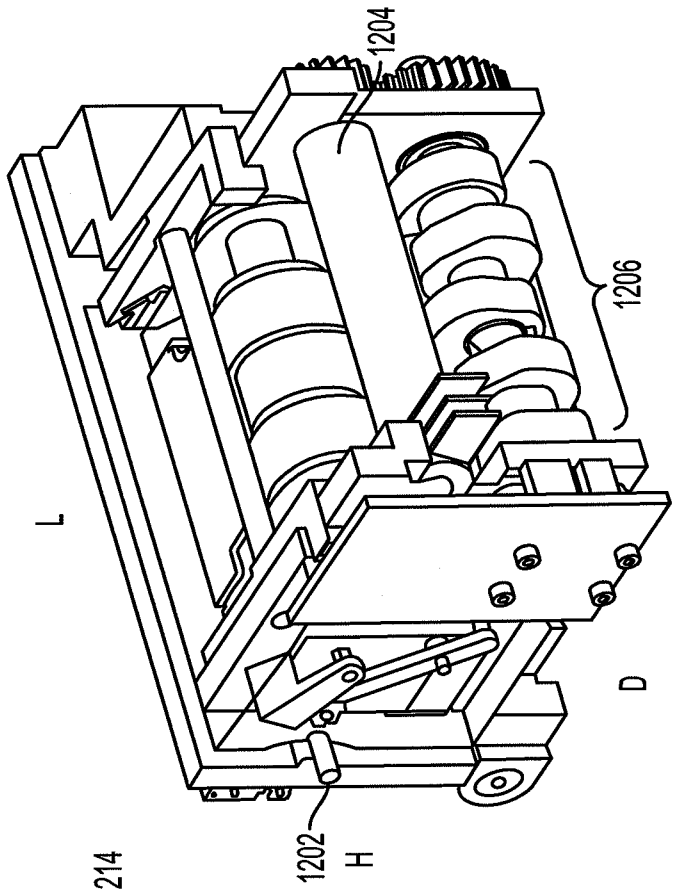


FIG. 77

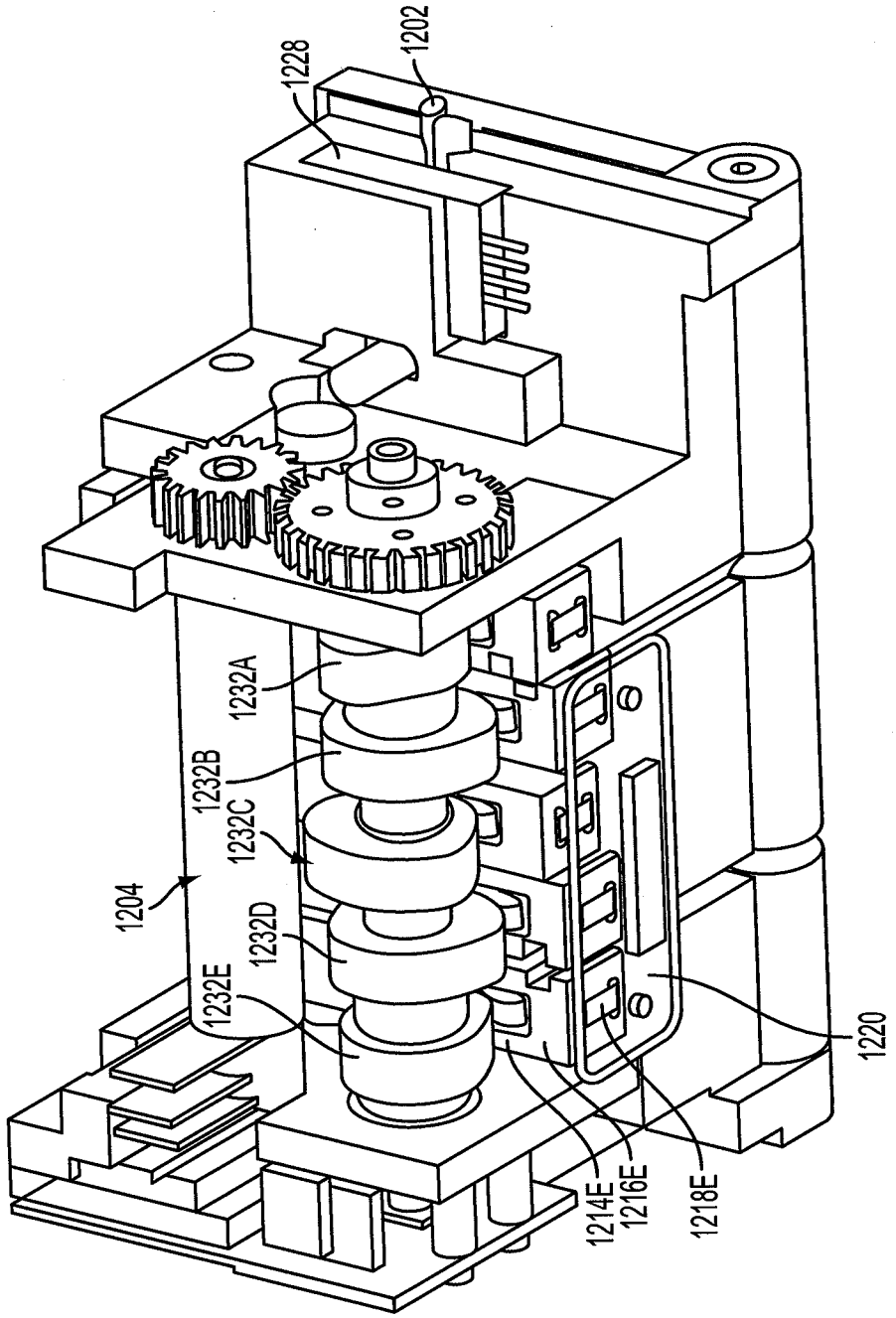

1228
1202
1232A
1232B
1232C
1204
1232D
1232E
1220
1214E
1216E
1218E

FIG. 78

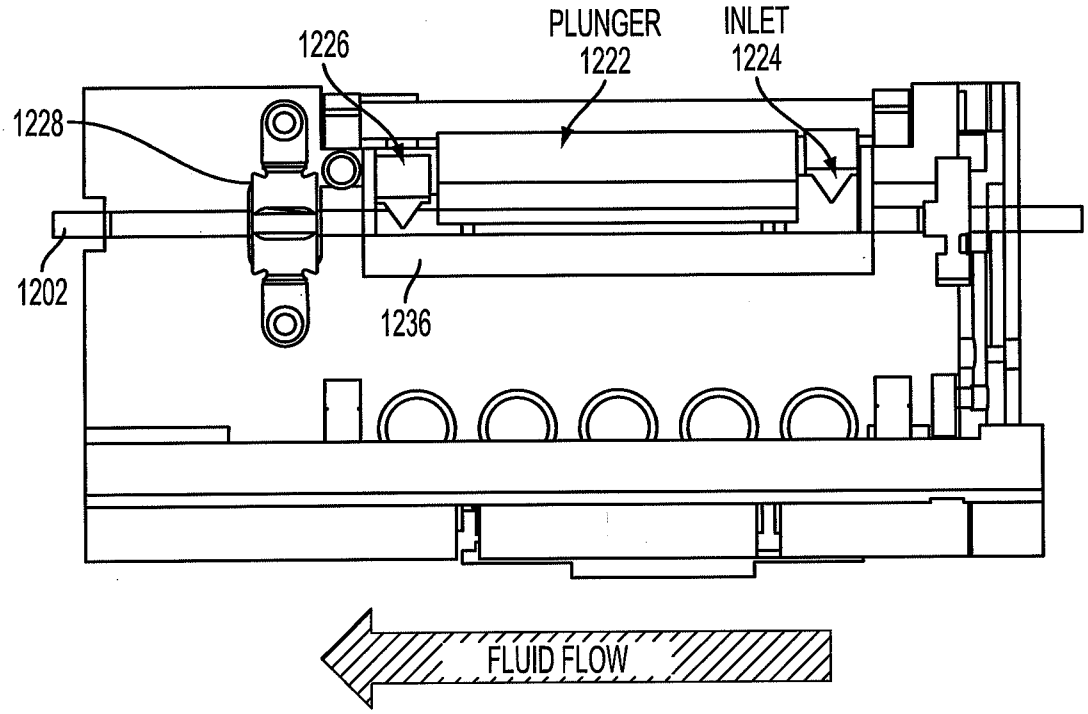


FIG. 79

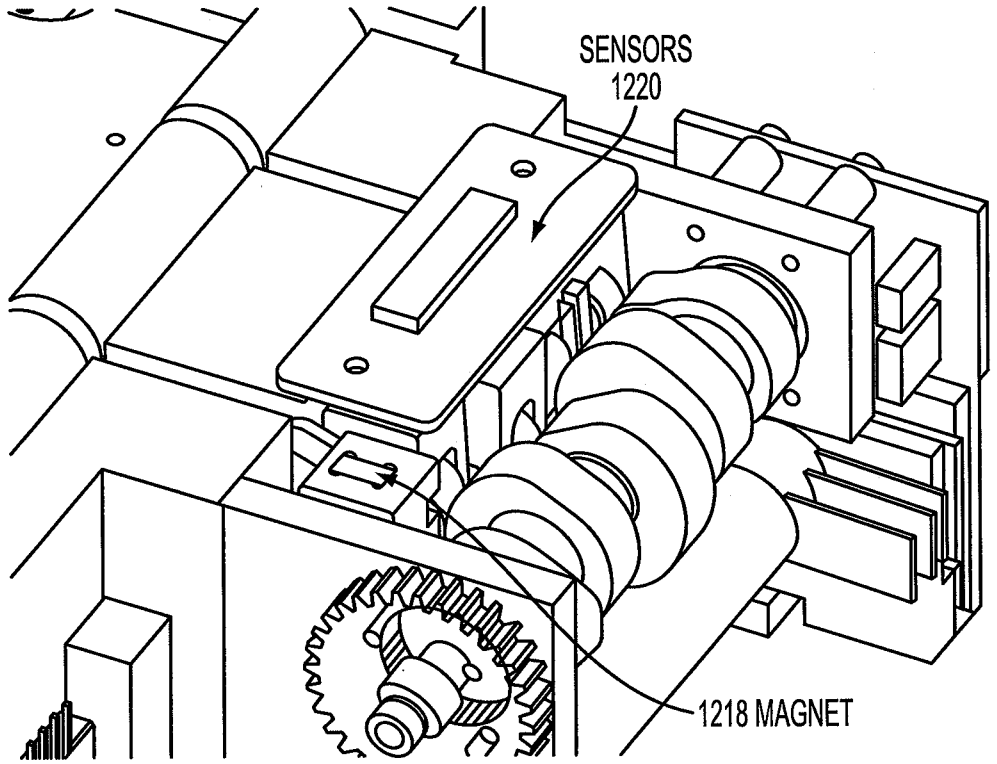


FIG. 80

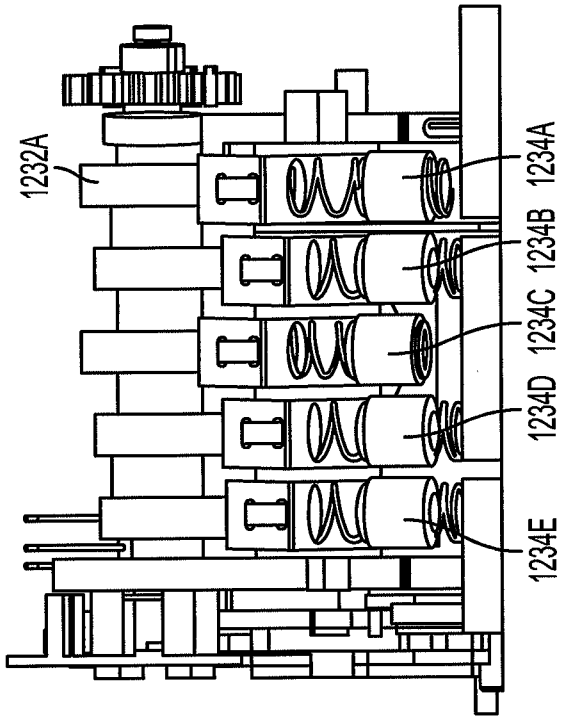

1232A
1234A
1234B
1234C
1234D
1234E

FIG. 82

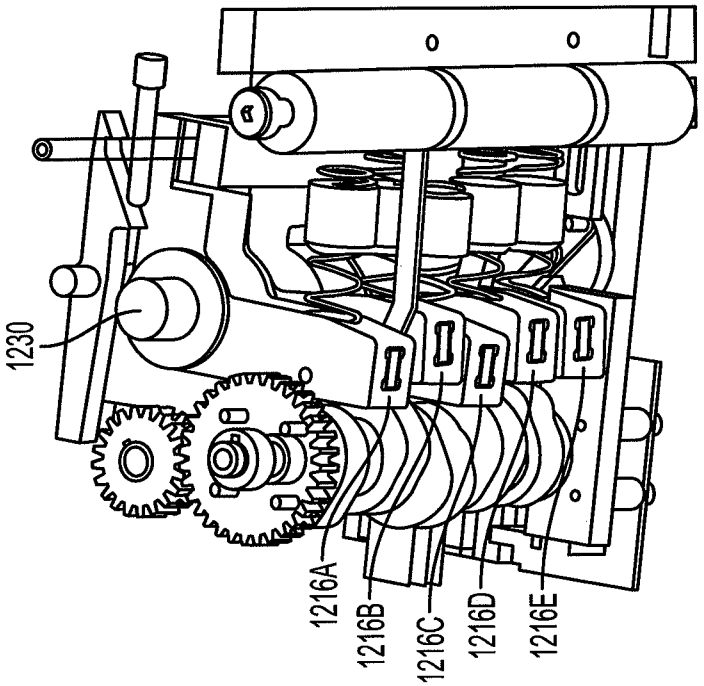

1230
1216A
1216B
1216C
1216D
1216E

FIG. 81

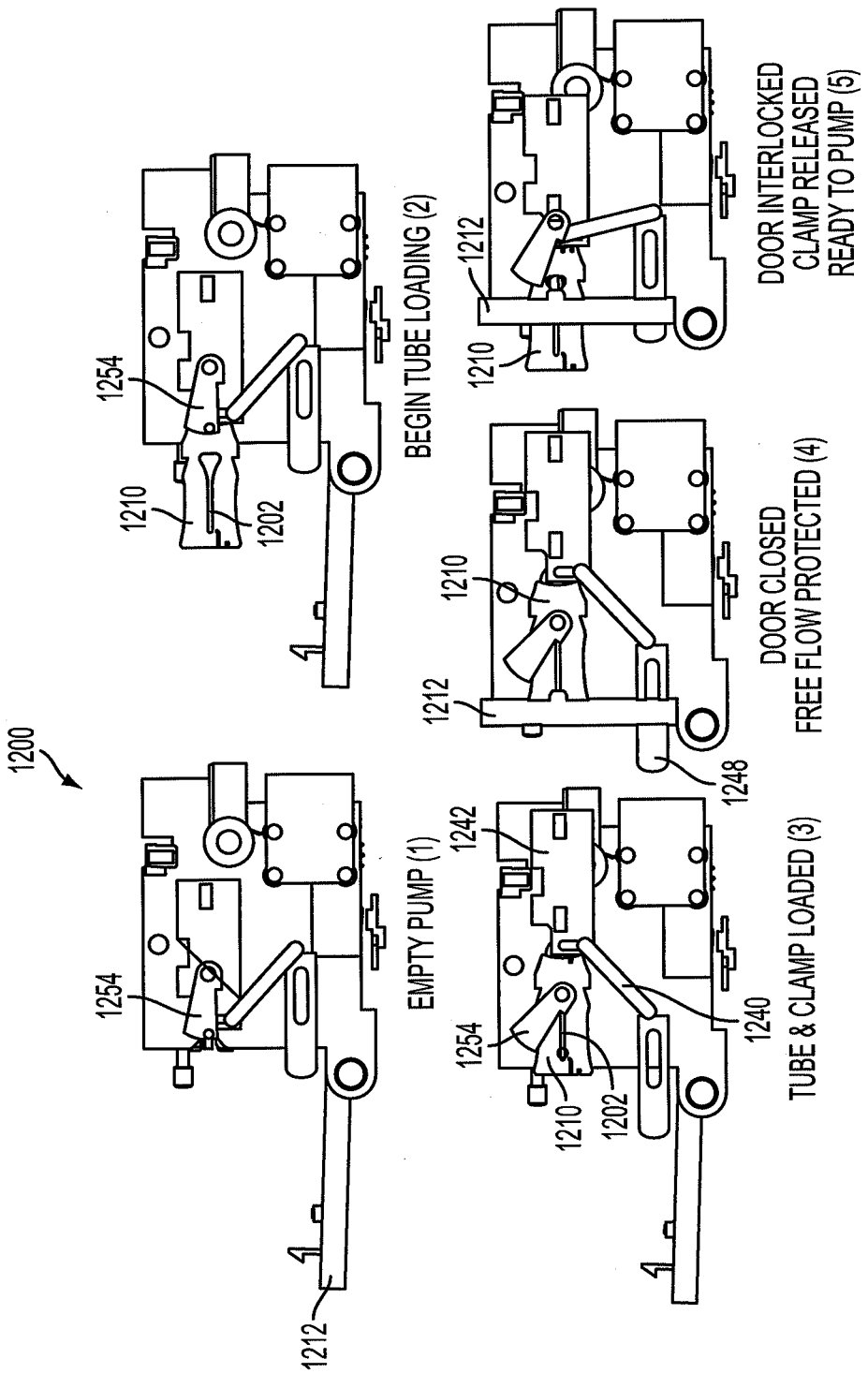

1200
1254
1212
EMPTY PUMP (1)
1254
1210
1202
BEGIN TUBE LOADING (2)
1242
1254
1210
1202
1240
TUBE & CLAMP LOADED (3)
1210
1212
1248
DOOR CLOSED
FREE FLOW PROTECTED (4)
1212
1210
DOOR INTERLOCKED
CLAMP RELEASED
READY TO PUMP (5)

FIG. 83

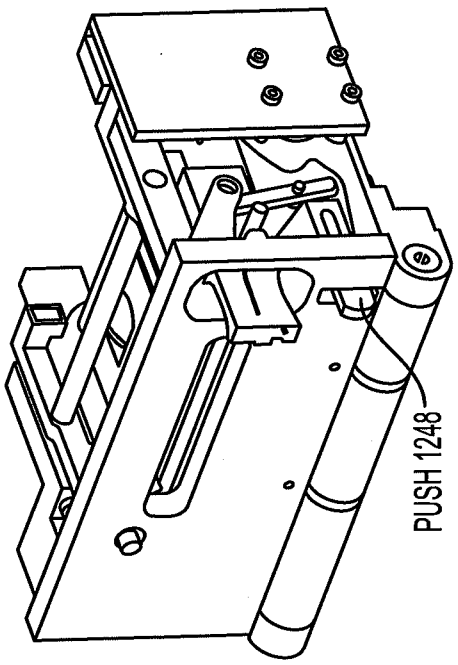


FIG. 85

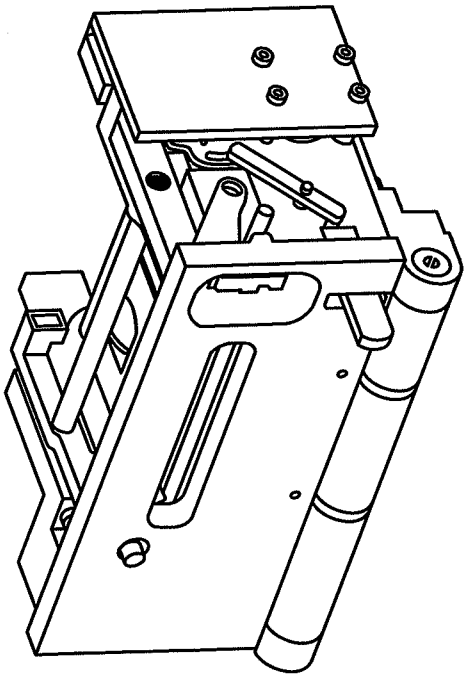


FIG. 84

SLIDE CLAMP KEY

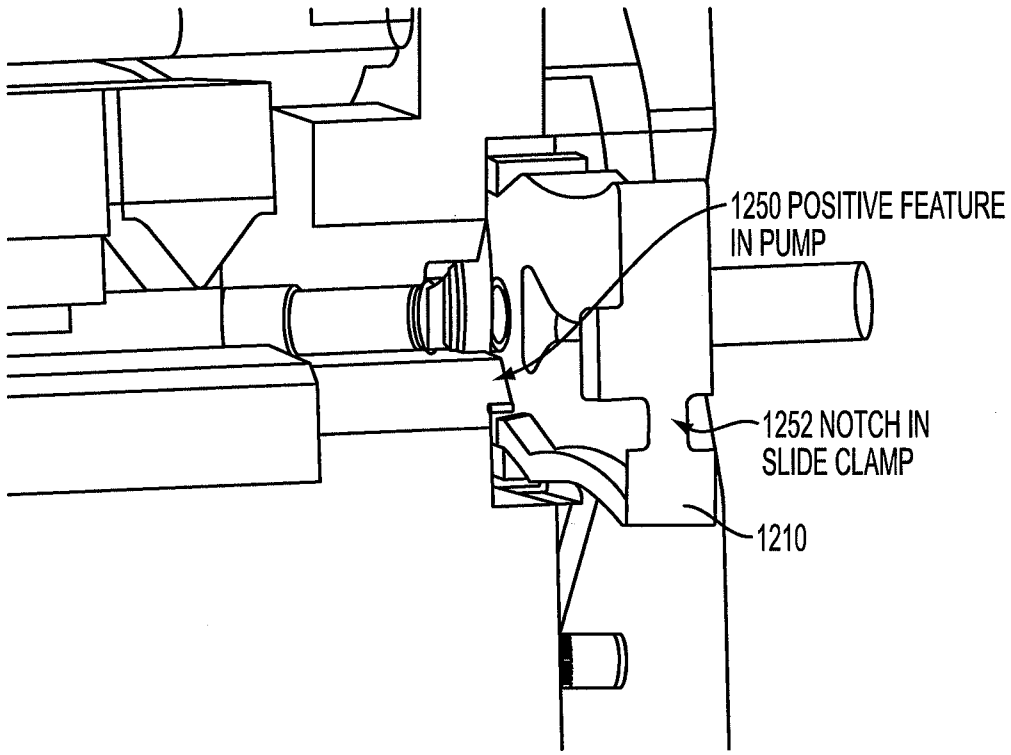


FIG.86

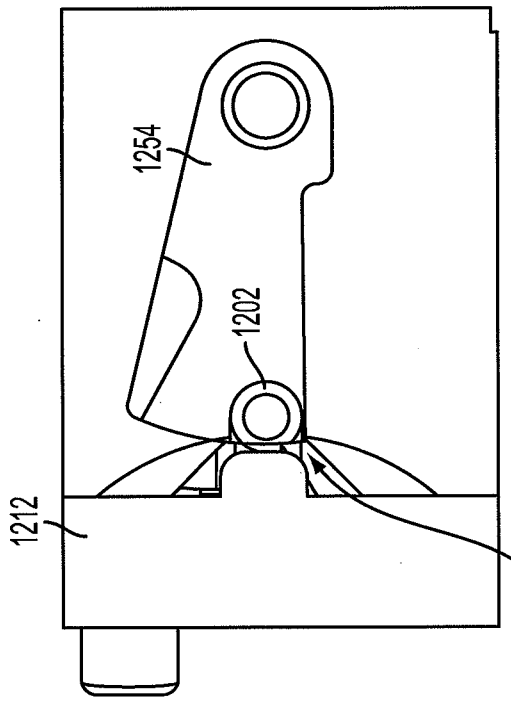

1212
1254
1202
INSUFFICIENT CLEARANCE
TO CLOSE DOOR WITH TUBE
PRESENT

FIG. 87

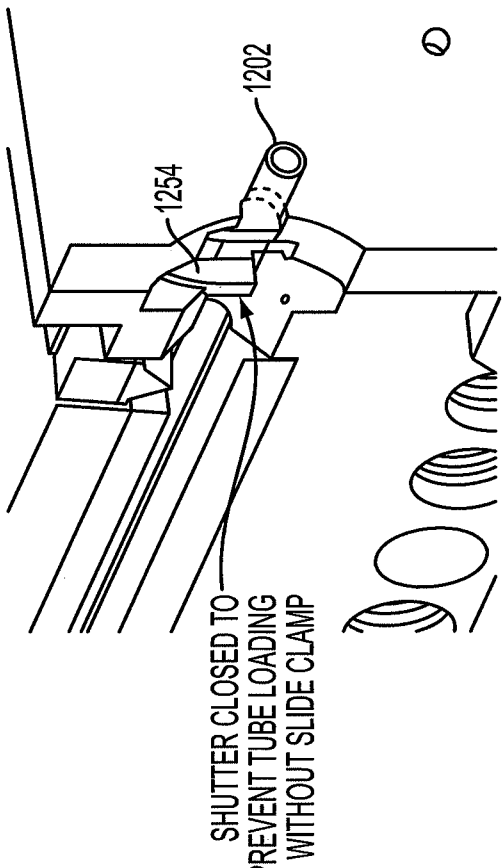

1202
1254
SHUTTER CLOSED TO
PREVENT TUBE LOADING
WITHOUT SLIDE CLAMP

FIG. 88

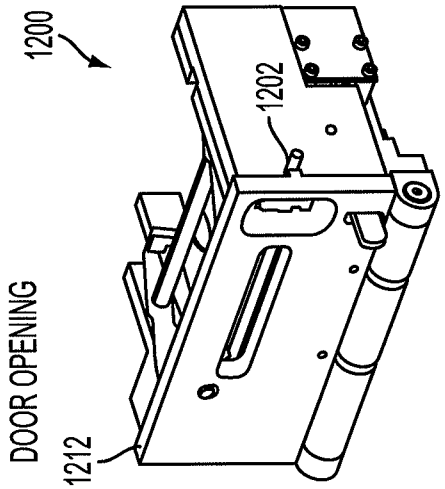


FIG. 89

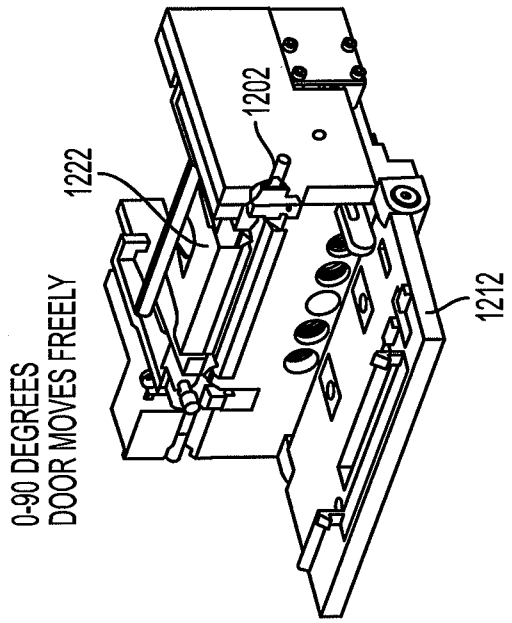


FIG. 90

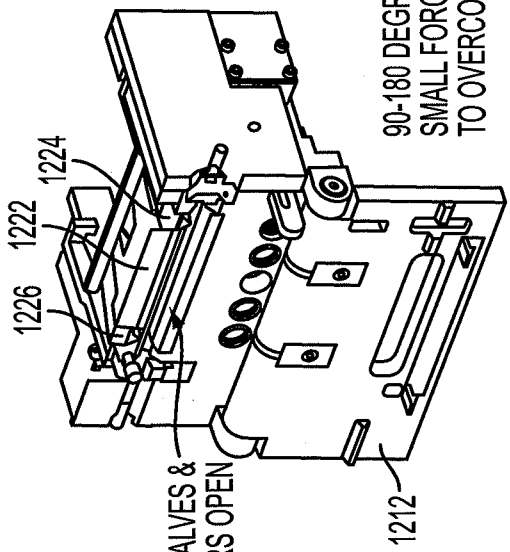


FIG. 91

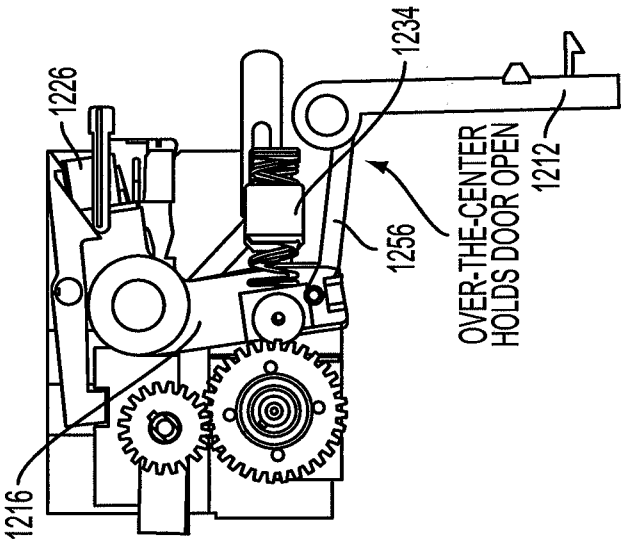


FIG. 94

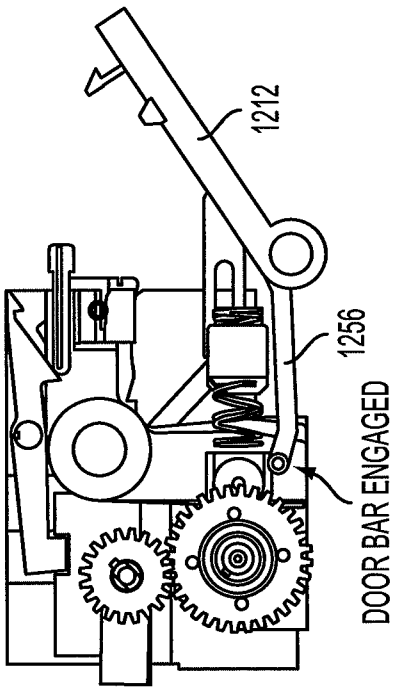


FIG. 93

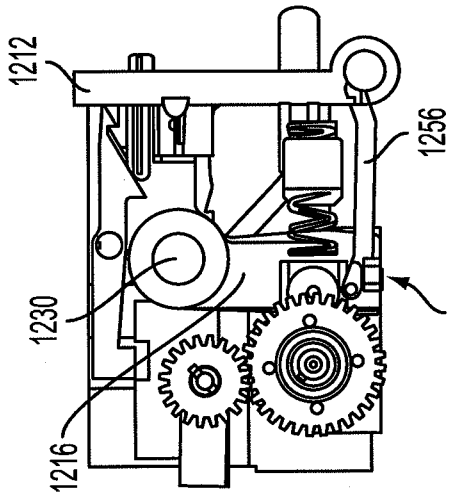


FIG. 92

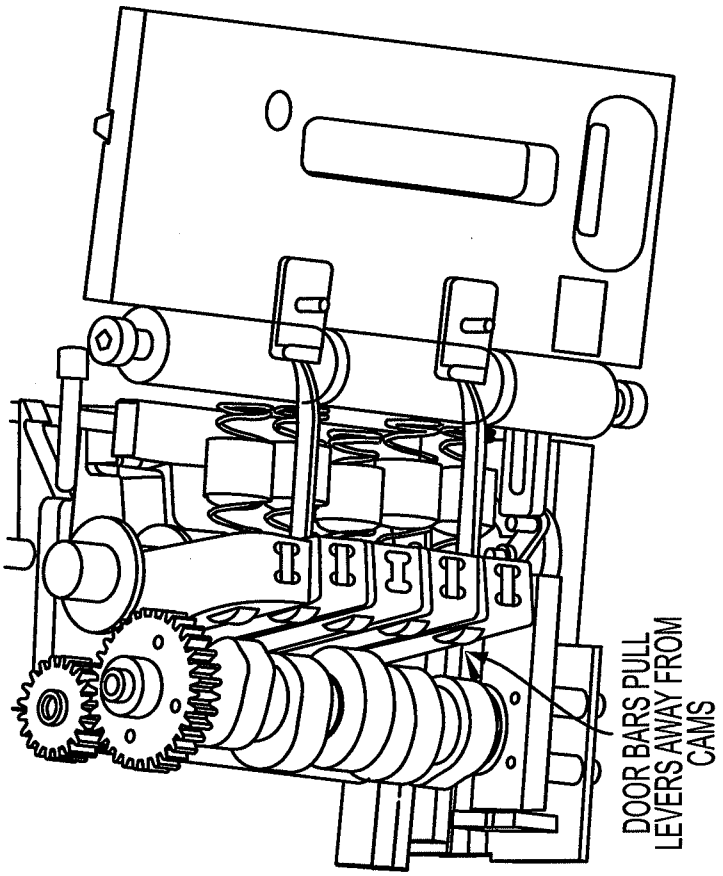


FIG. 96

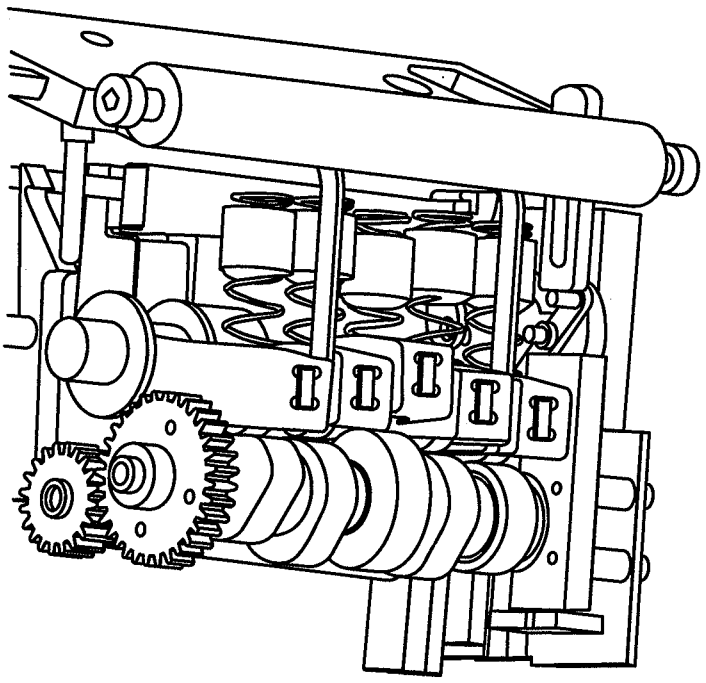


FIG. 95

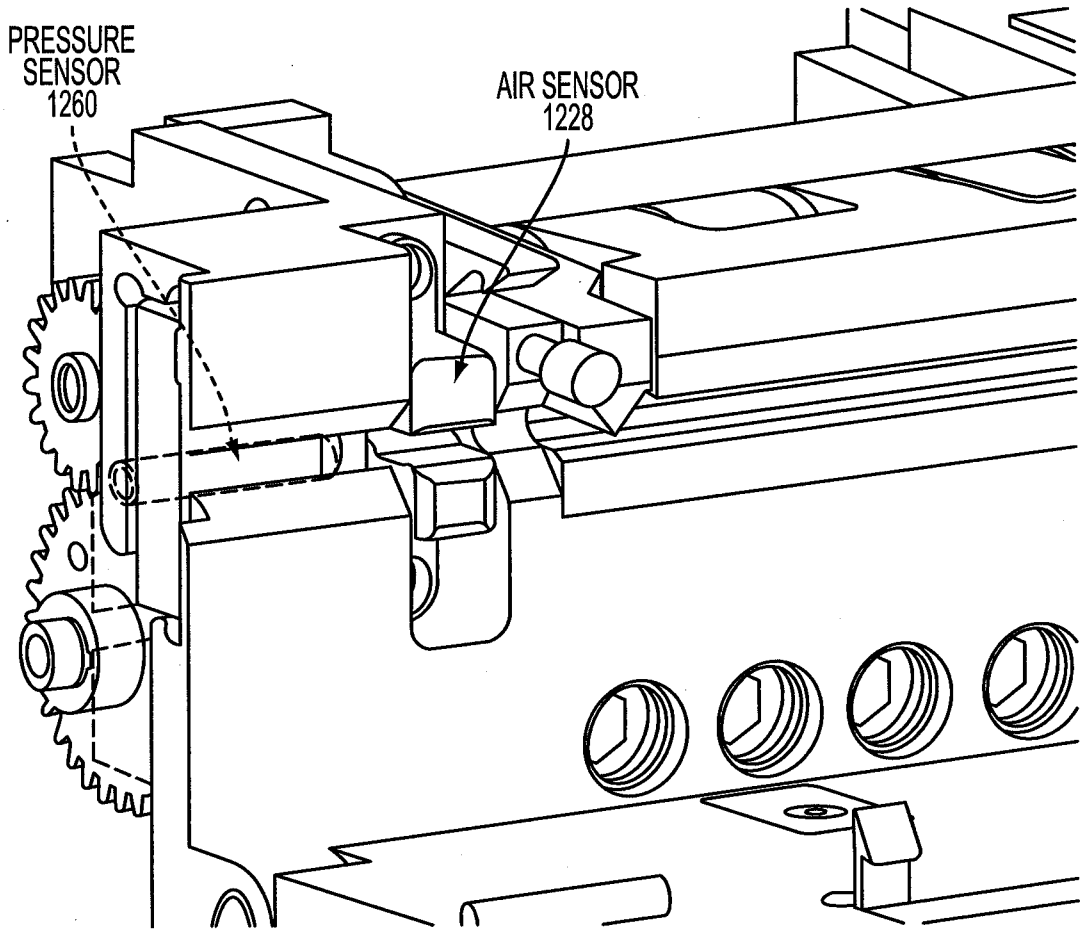


FIG. 97

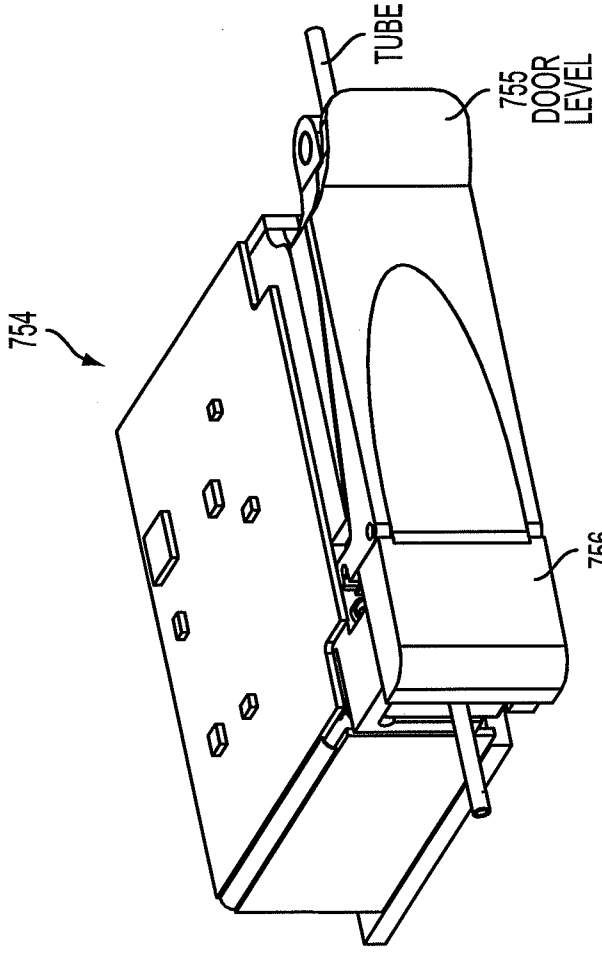


FIG. 98

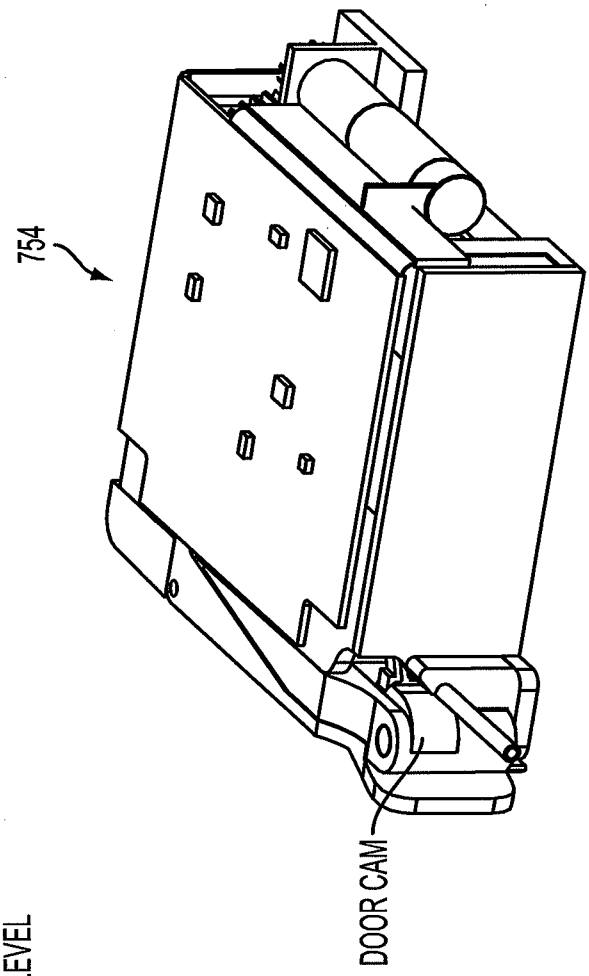


FIG. 99

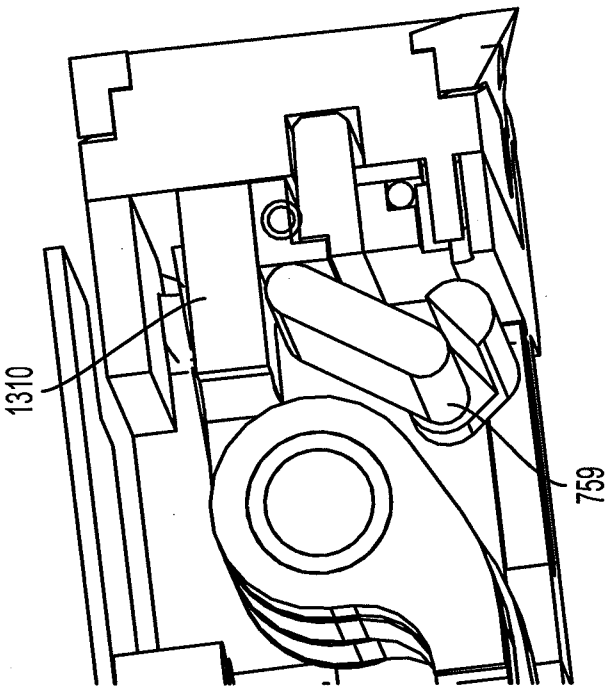


FIG. 1011

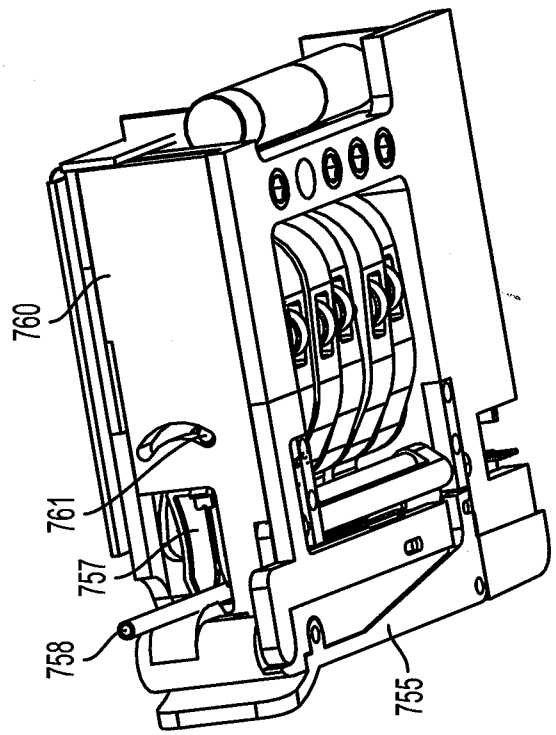


FIG. 100

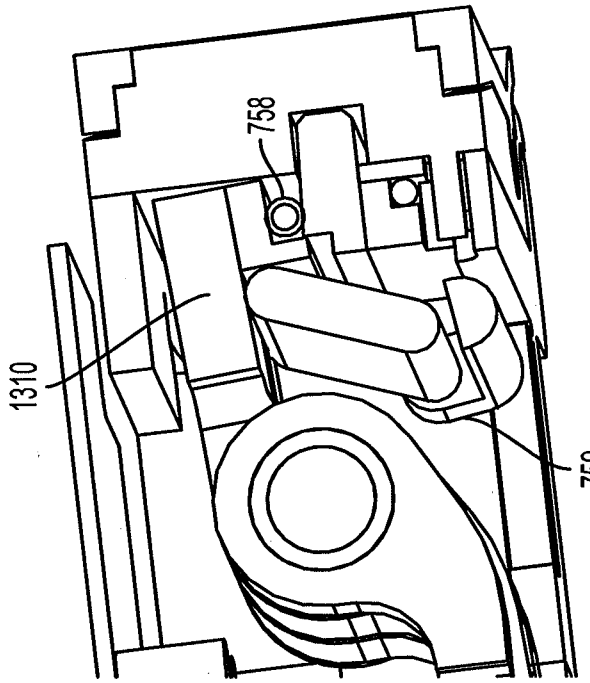


FIG. 103

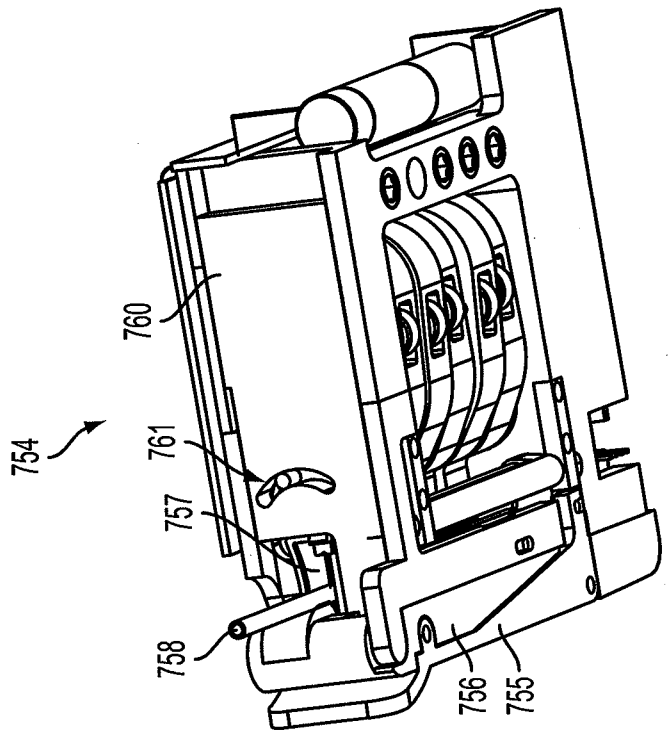


FIG. 102

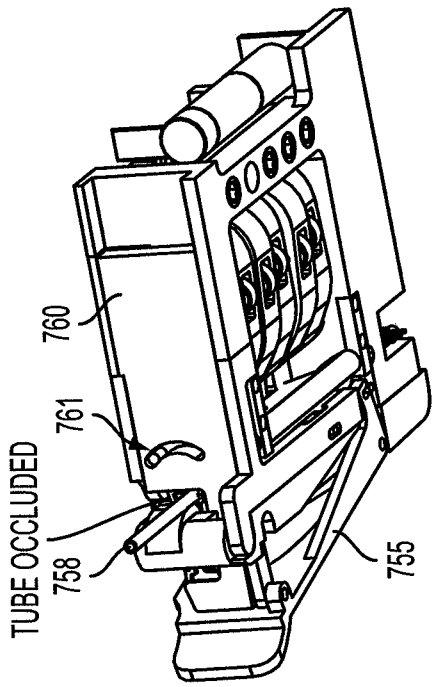


FIG. 104

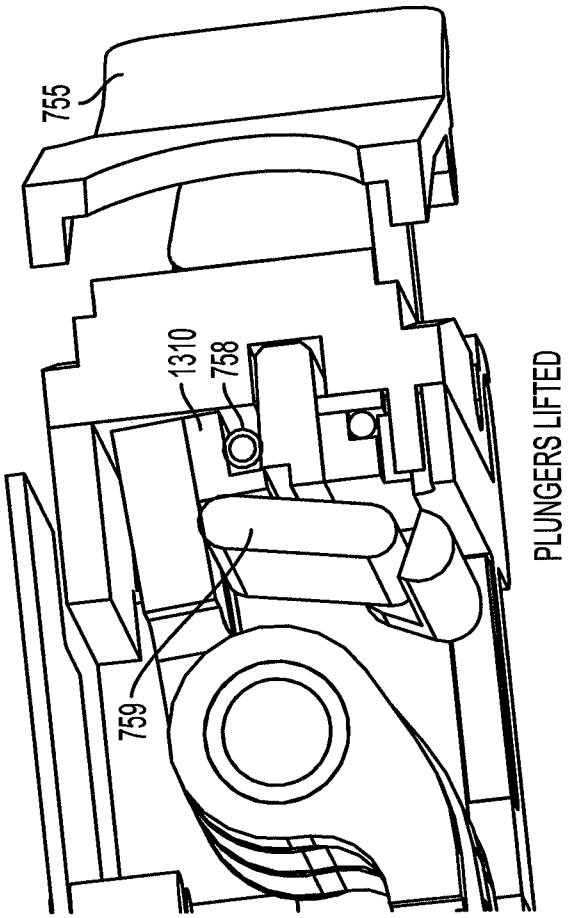


FIG. 105

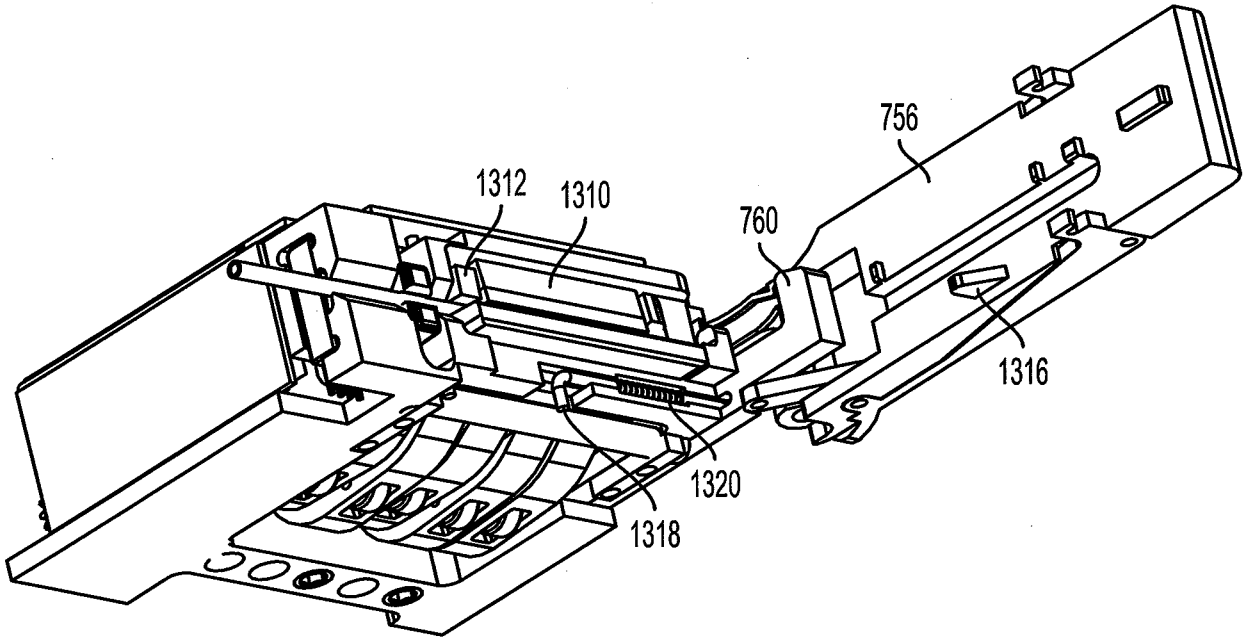


FIG. 106

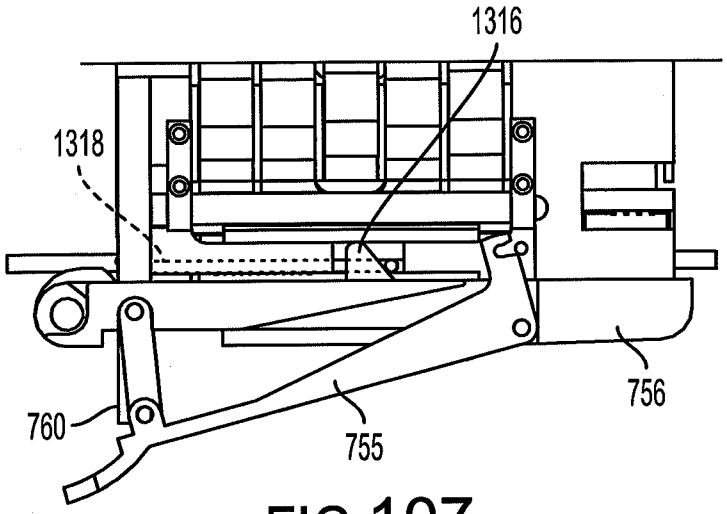


FIG. 107

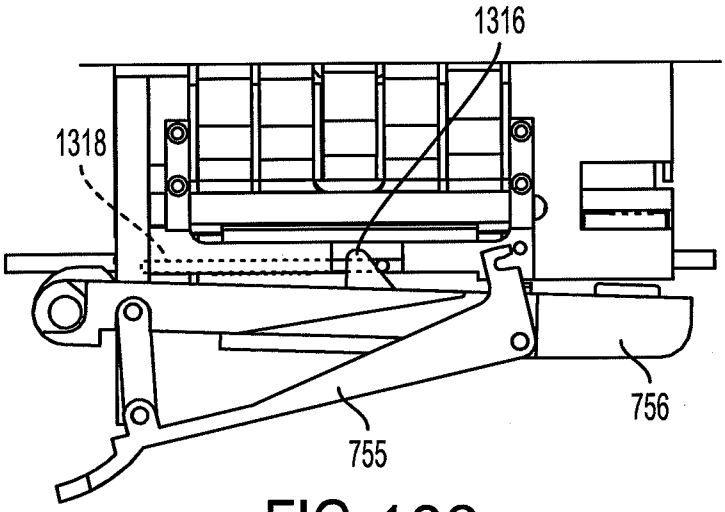


FIG. 108

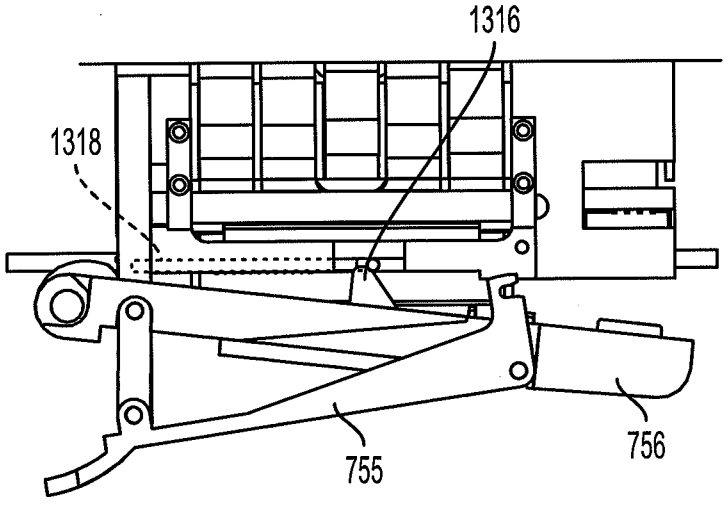


FIG. 109

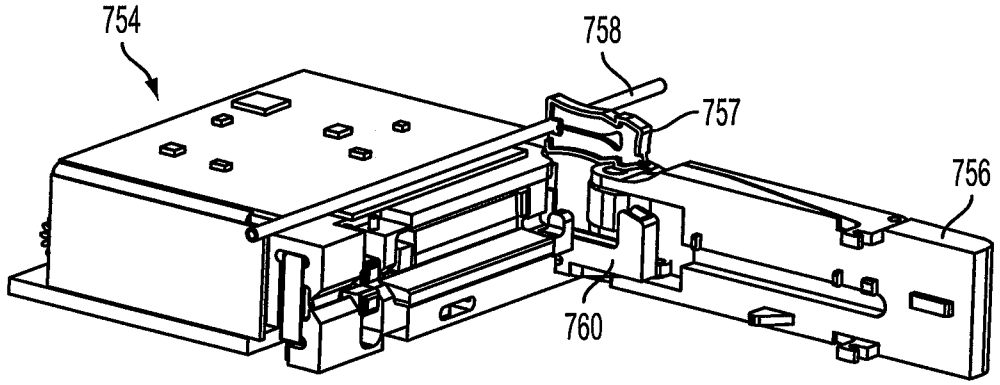


FIG. 110

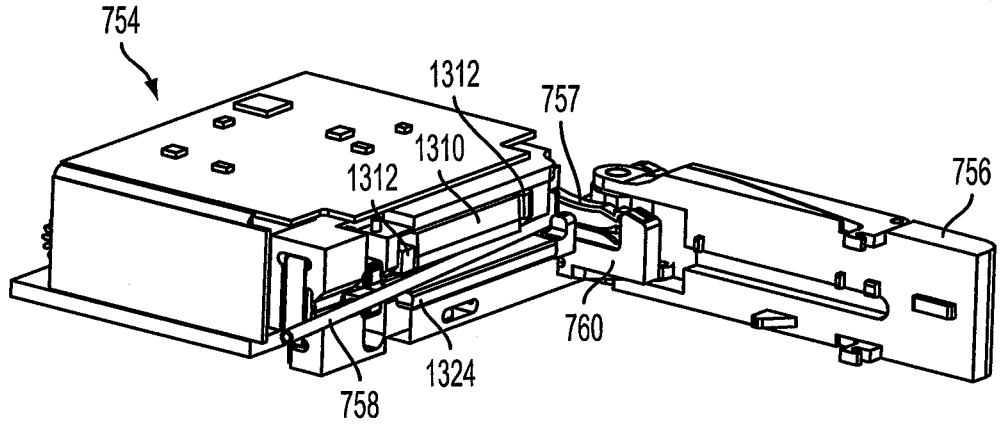


FIG. 111

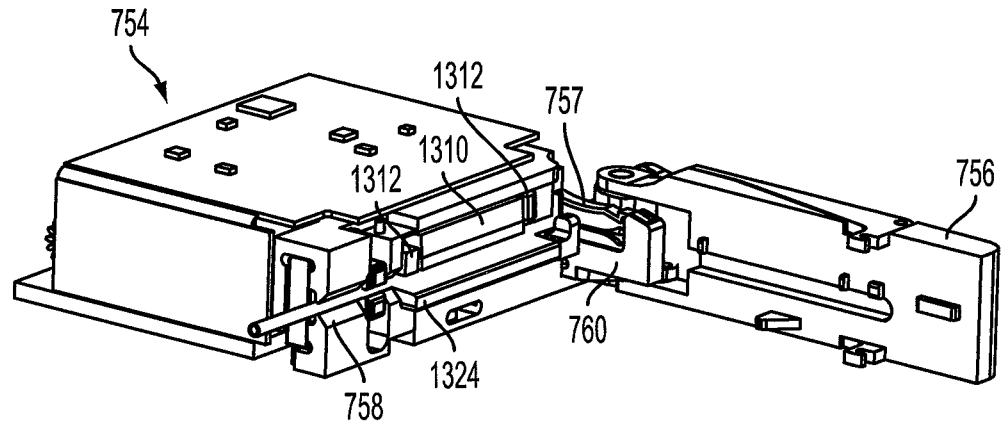


FIG. 112

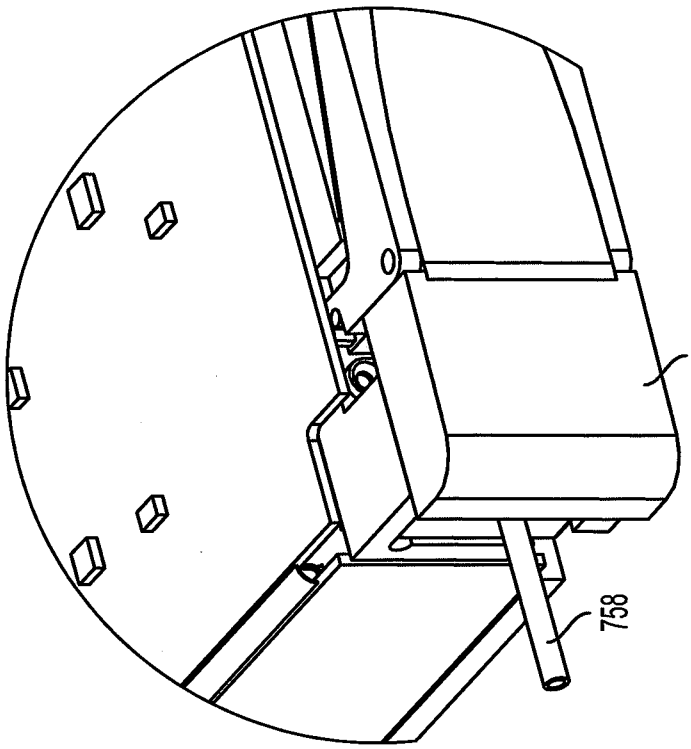


FIG. 114

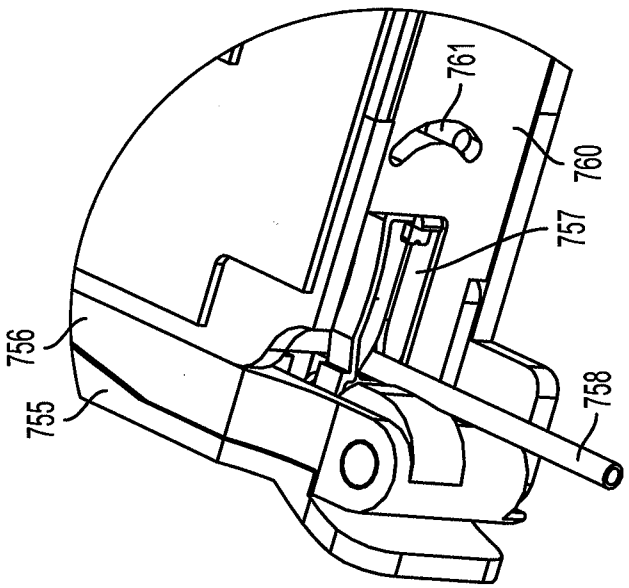


FIG.113

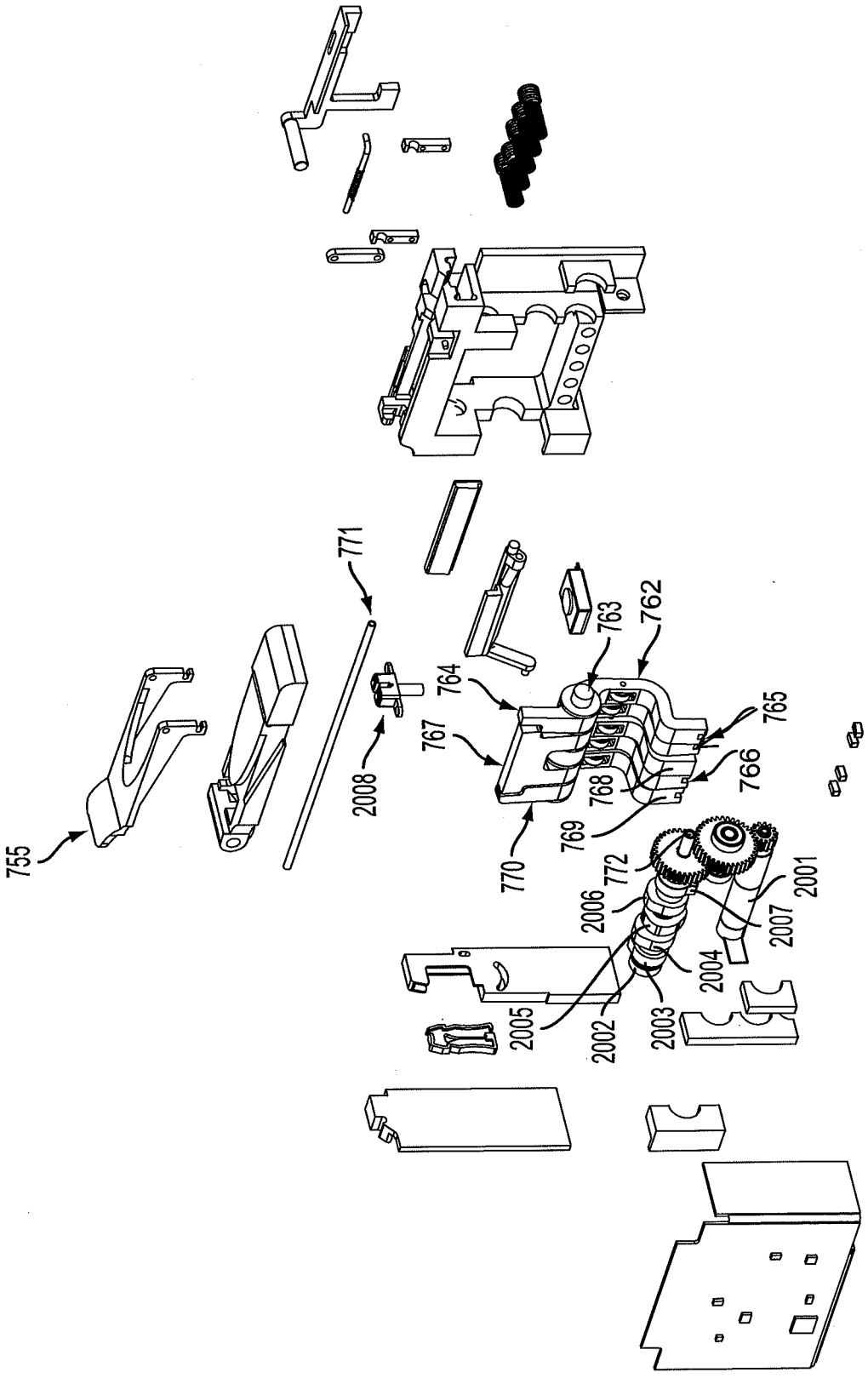

771
763
762
764
765
767
766
2008
768
769
770
755
772
2001
2006
2007
2004
2005
2002
2003

FIG.115

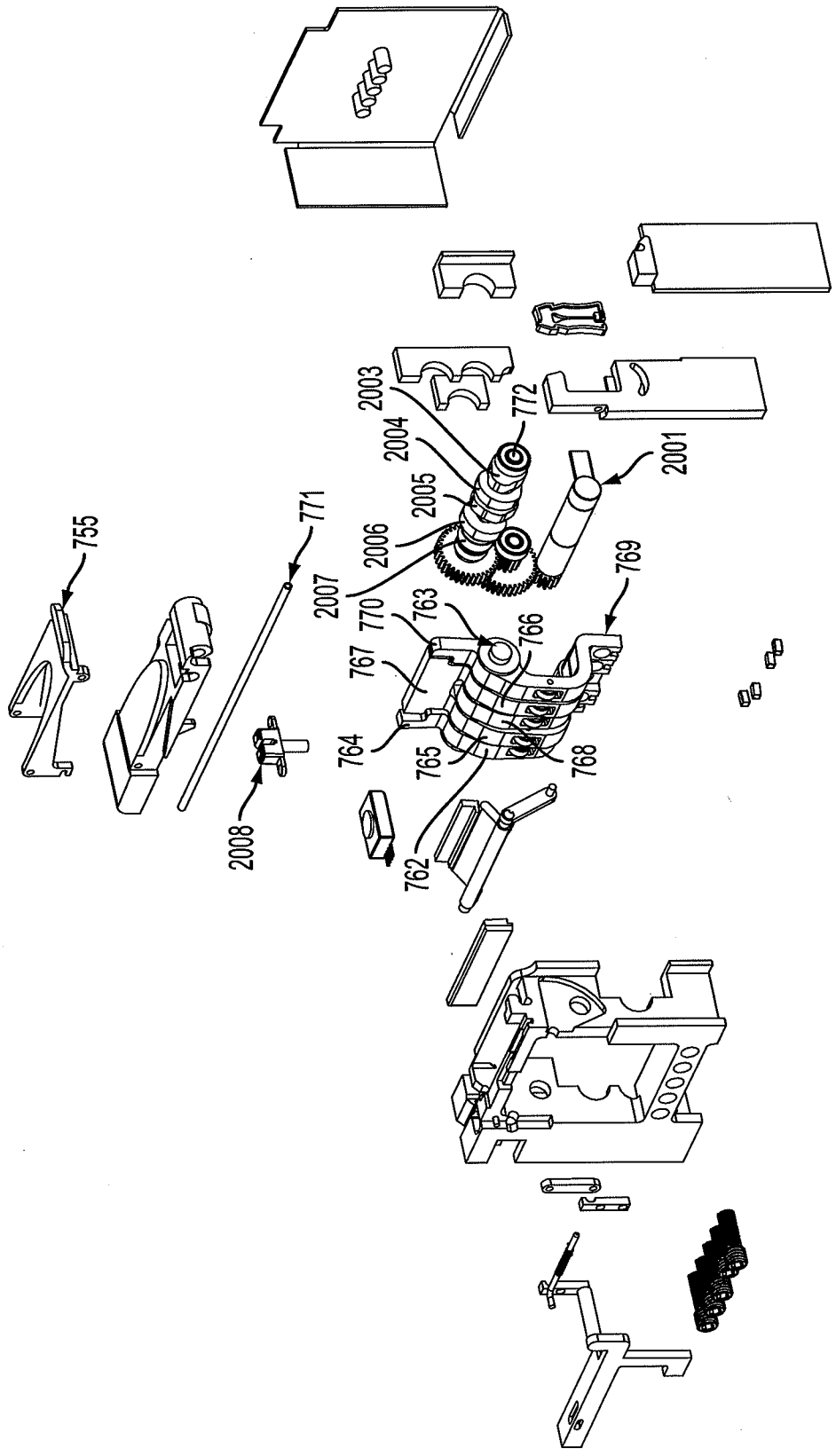

755
771
2003
772
2004
2001
2005
2006
2007
769
770
763
766
767
764
765
768
2008
762

FIG. 116

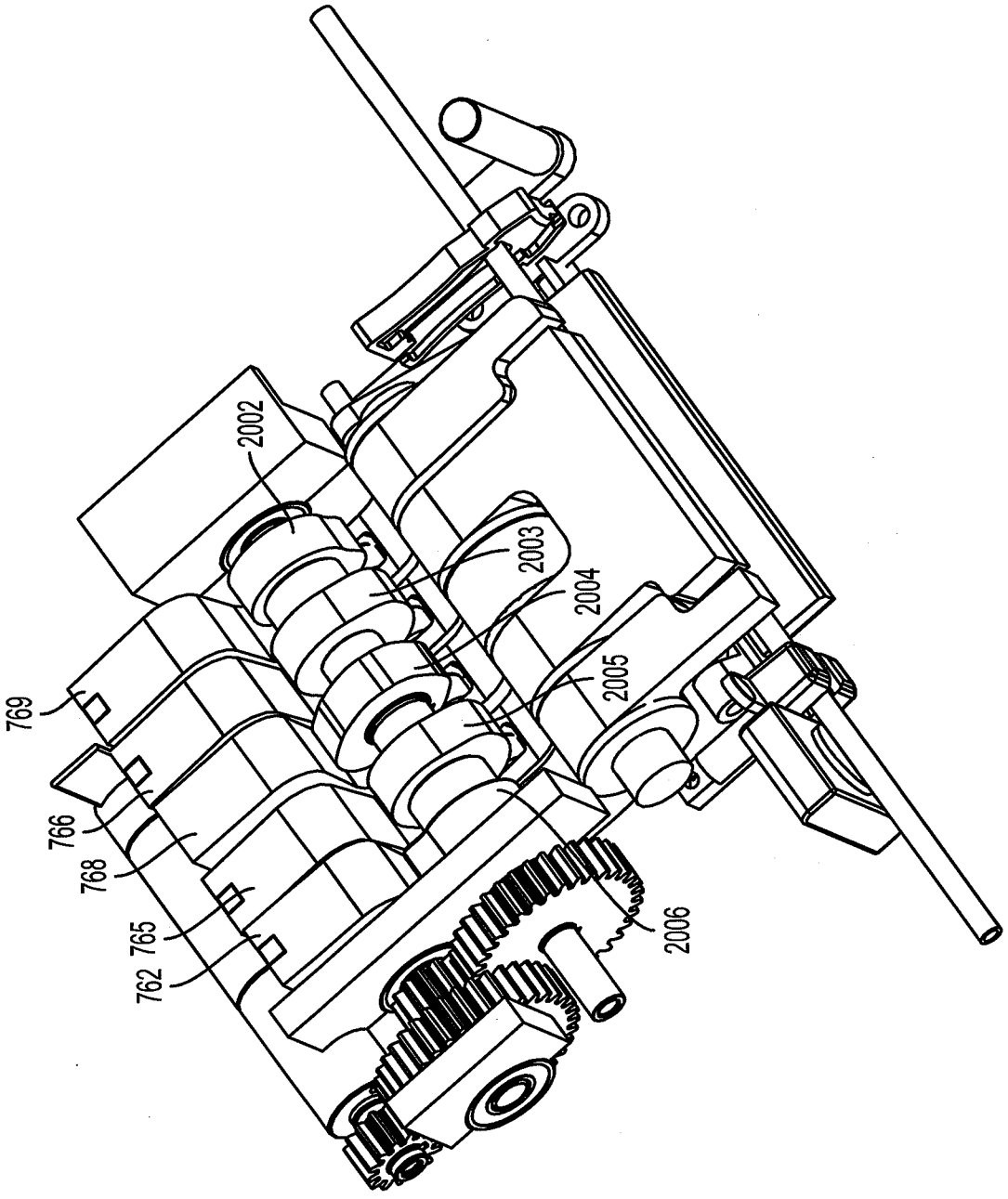


FIG. 117

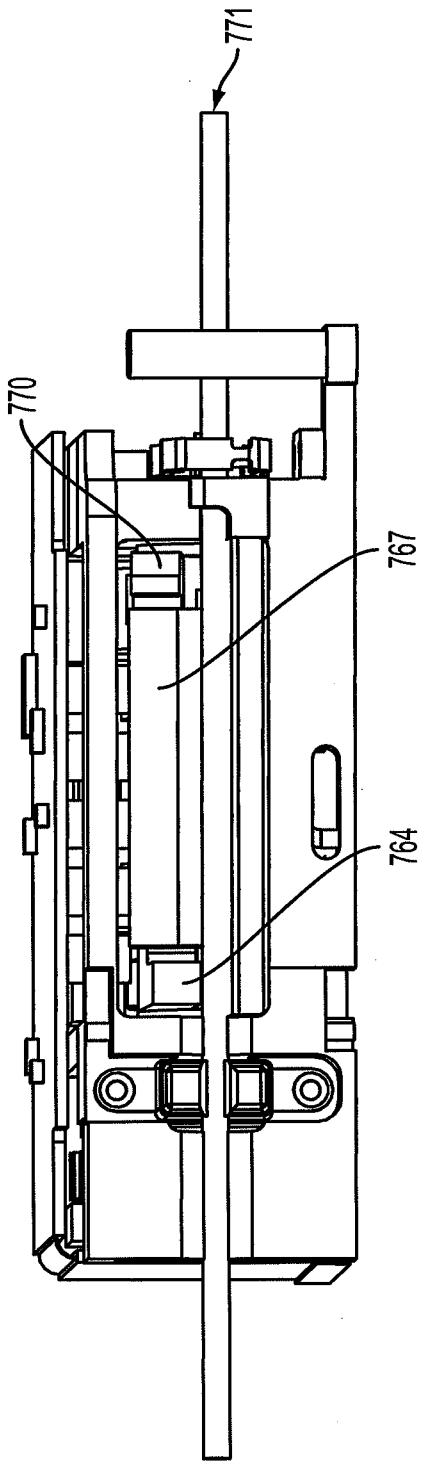


FIG. 118

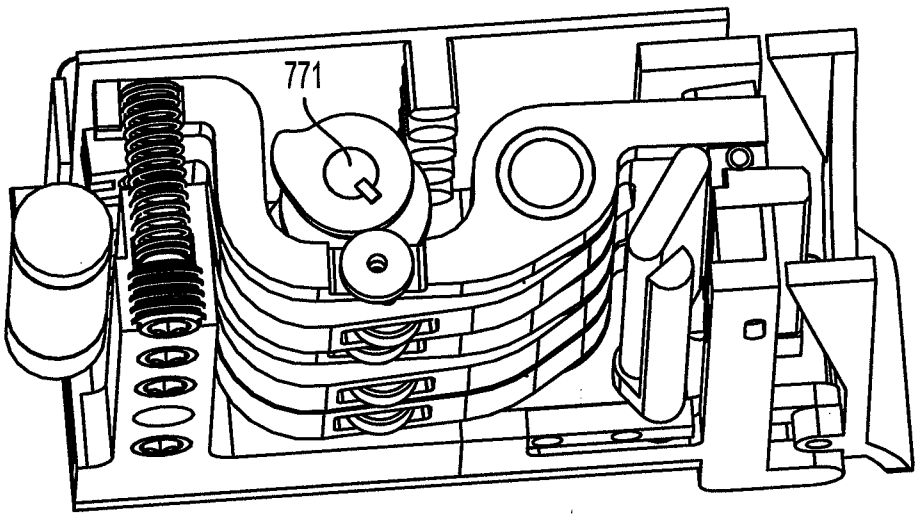


FIG. 119

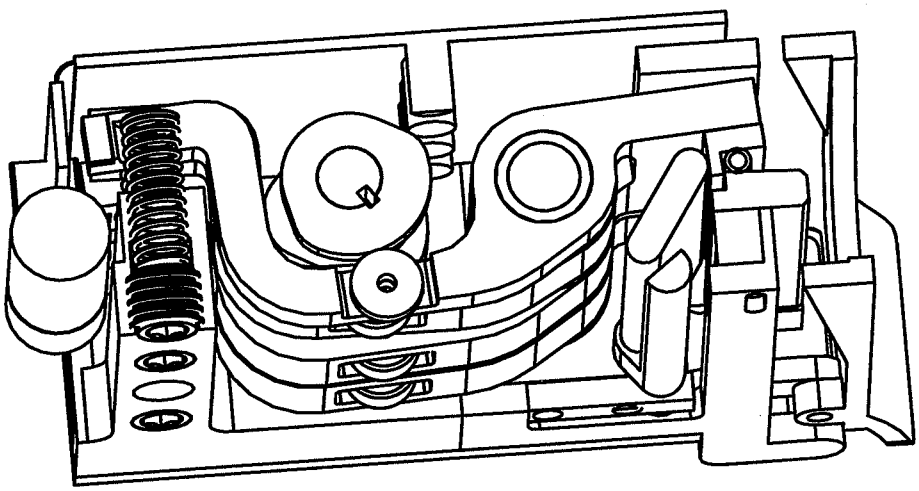


FIG. 120

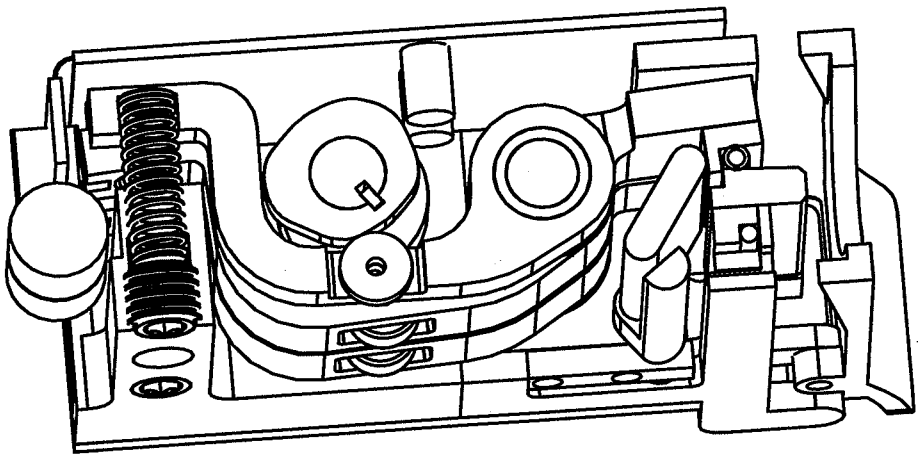


FIG. 121

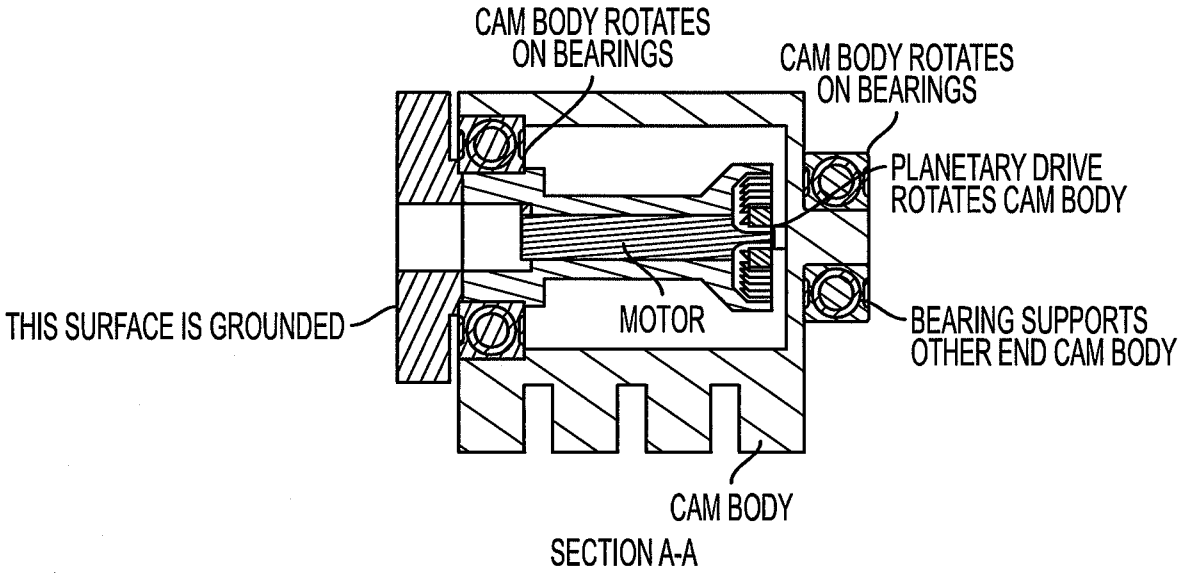

CAM BODY ROTATES
ON BEARINGS
CAM BODY ROTATES
ON BEARINGS
PLANETARY DRIVE
ROTATES CAM BODY
THIS SURFACE IS GROUNDED
MOTOR
BEARING SUPPORTS
OTHER END CAM BODY
CAM BODY
SECTION A-A

FIG. 122

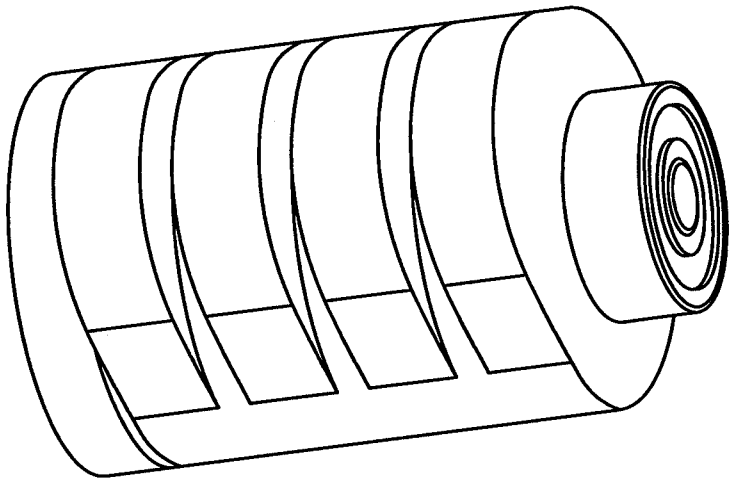


FIG. 123

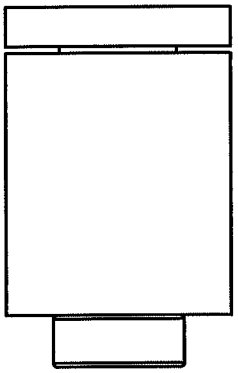


FIG. 126

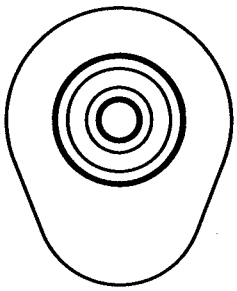


FIG. 125

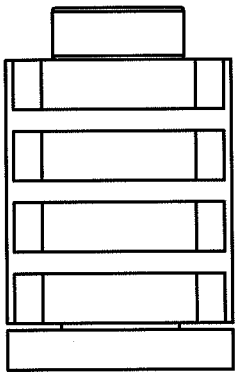


FIG. 124

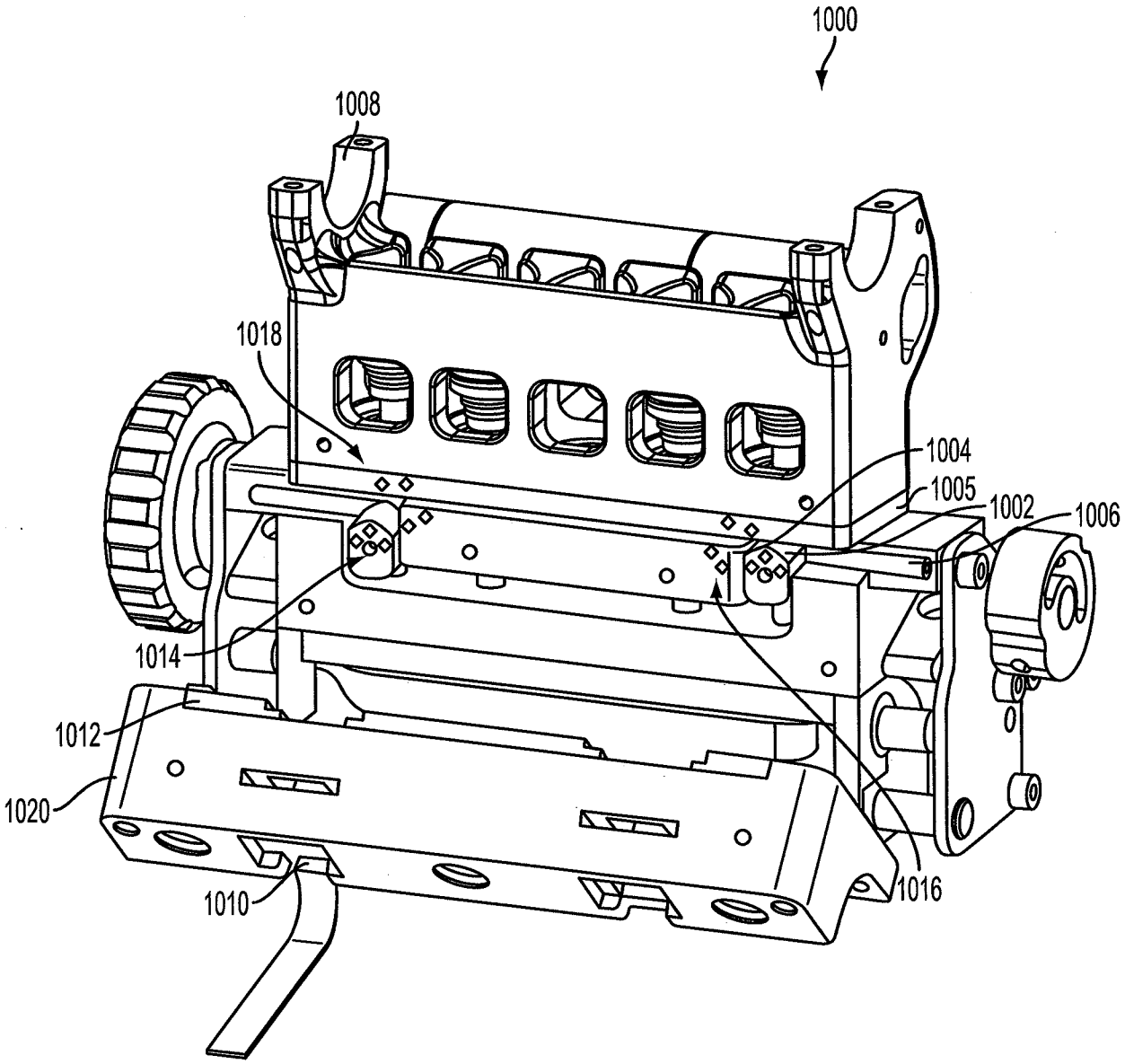


FIG. 127

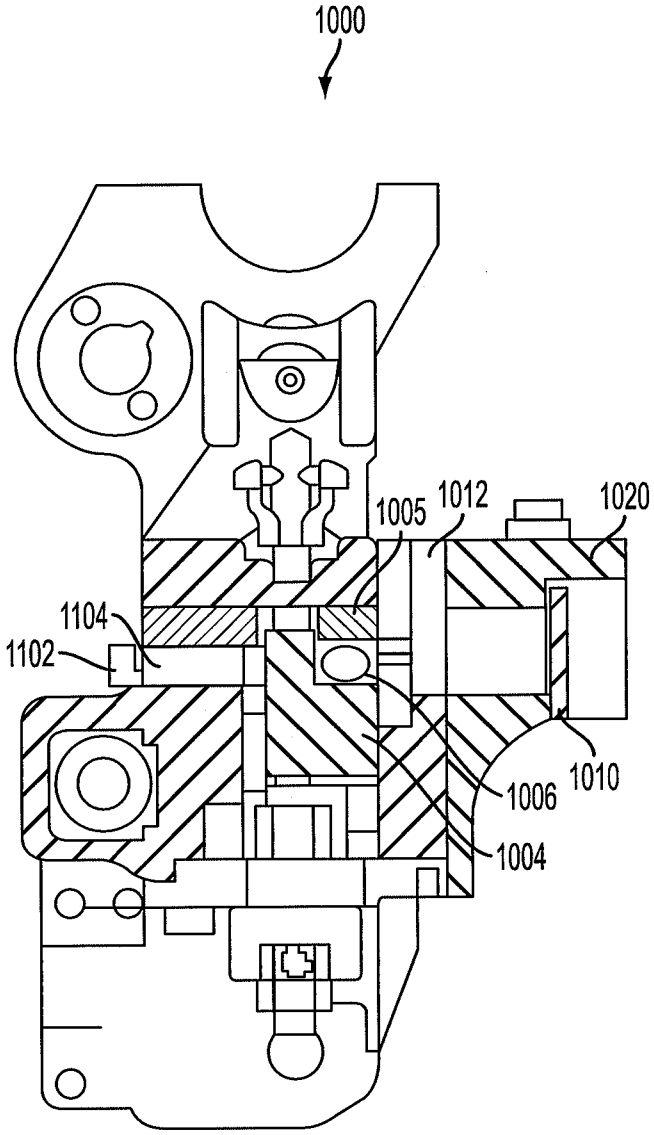


FIG. 128

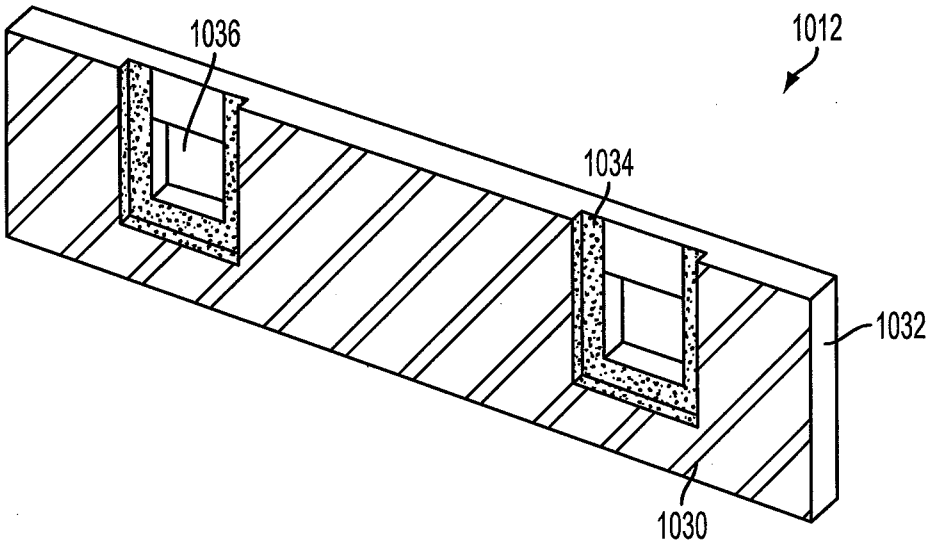


FIG. 129

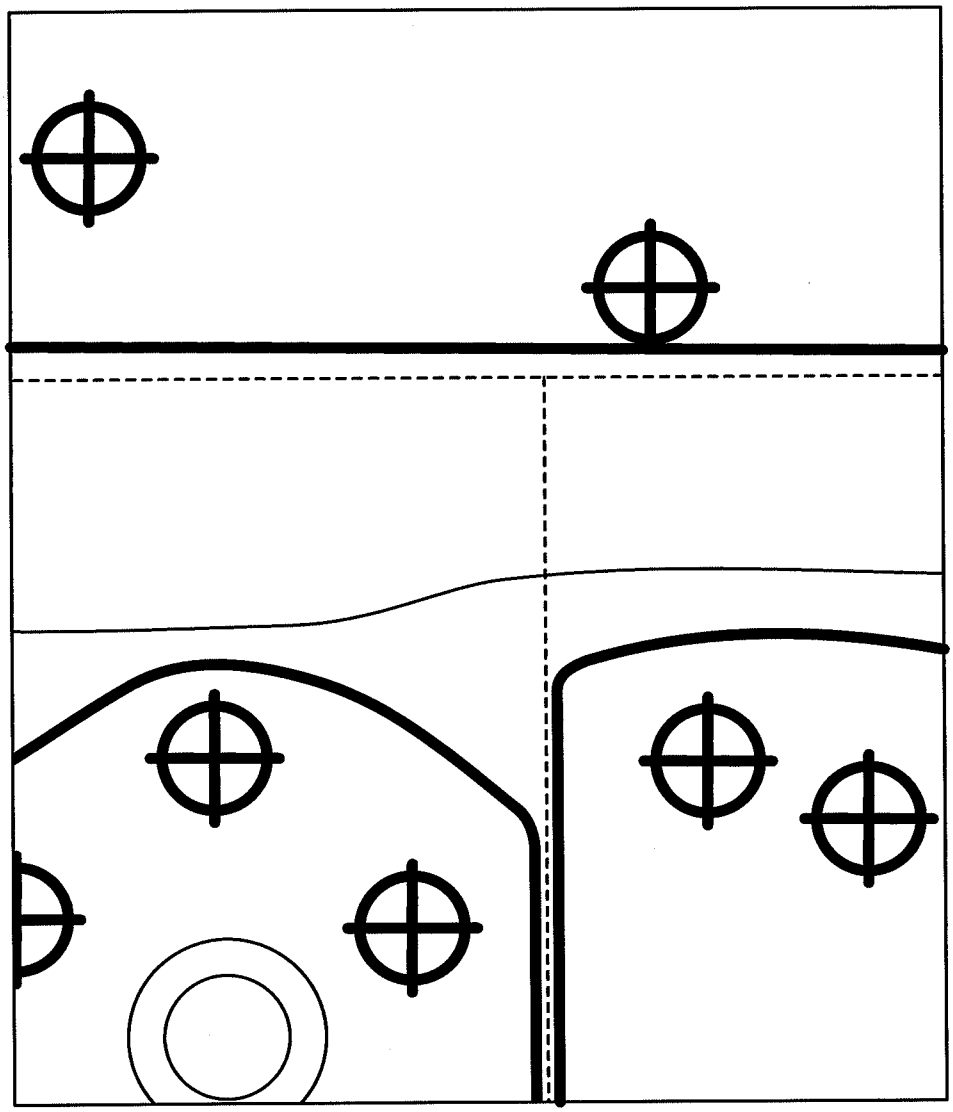


FIG. 130

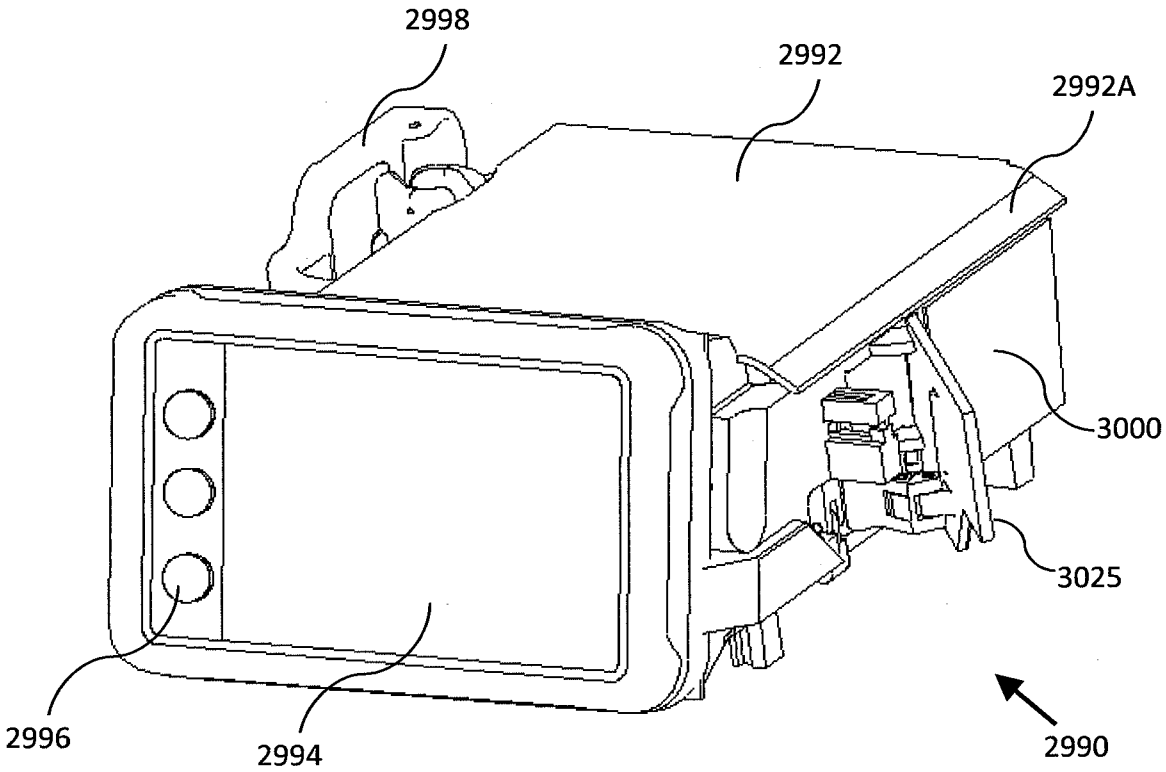


FIG. 131

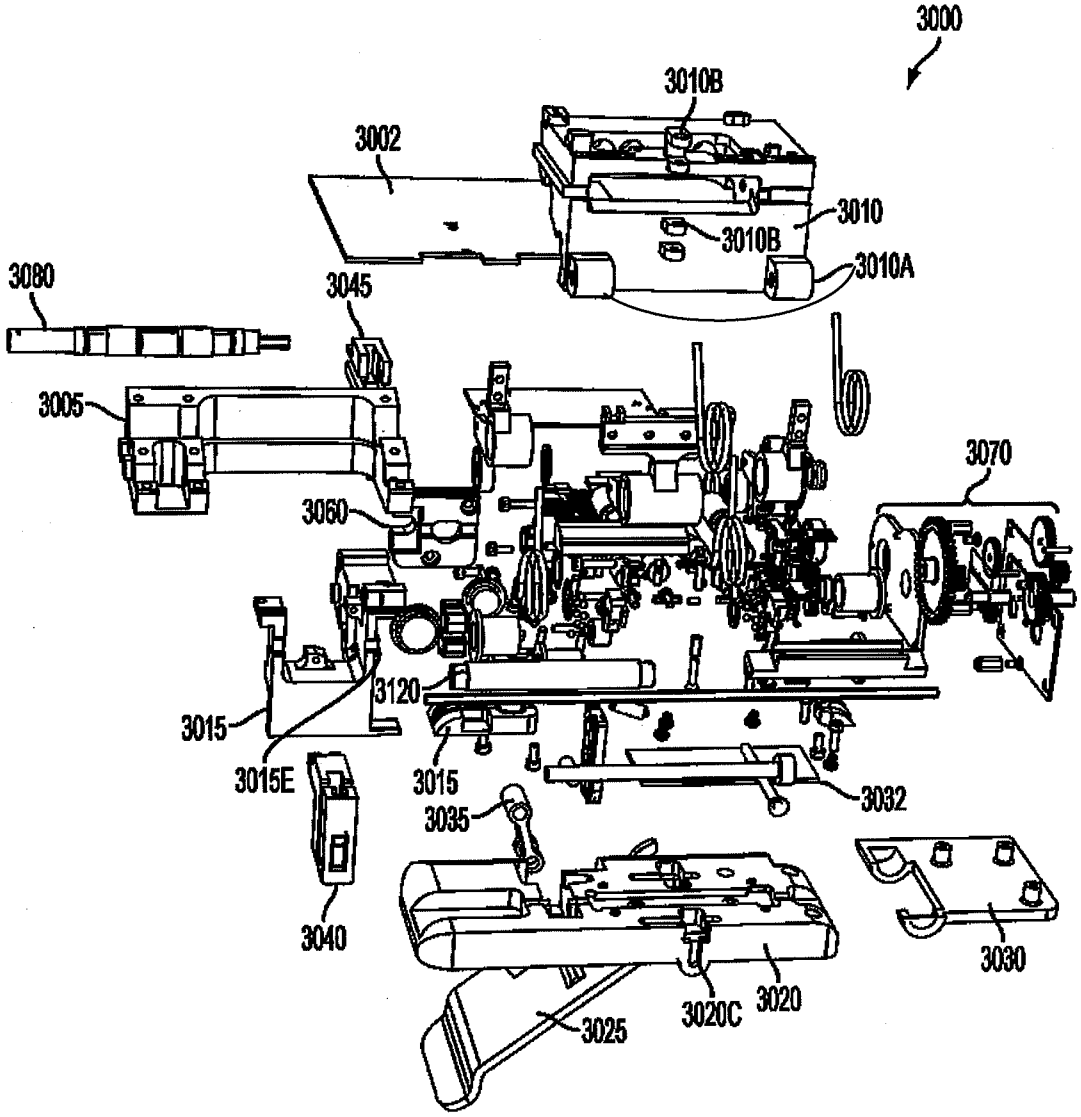

3000
3010B
3002
3010
3010B
3010A
3080
3045
3005
3070
3060
3120
3015
3015E
3015
3032
3035
3040
3030
3020C
3020
3025

FIG. 132A

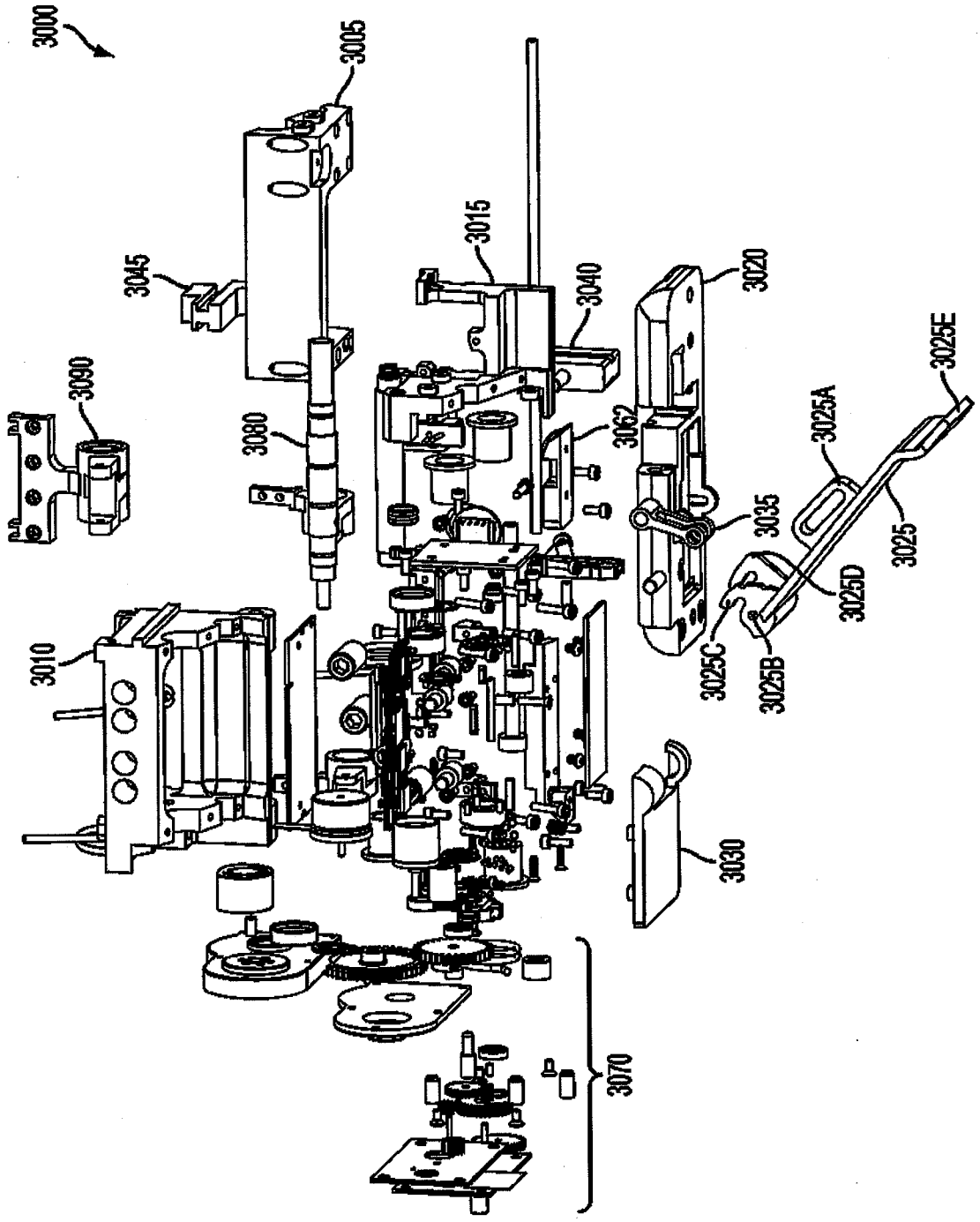

3000
3005
3015
3045
3040
3020
3090
3080
3062
3025E
3025A
3035
3025
3025D
3010
3025C
3025B
3030
3070

FIG.132B

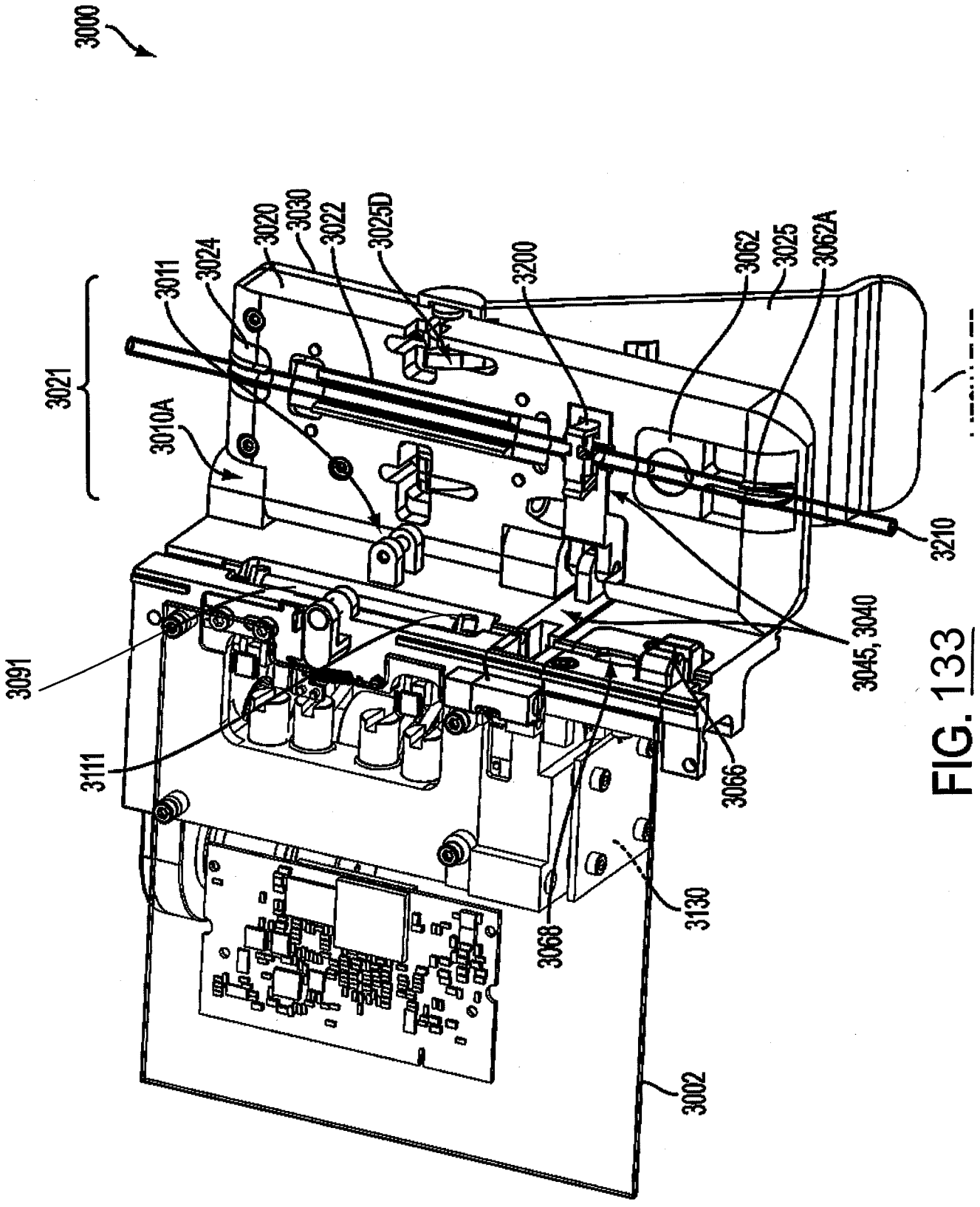

3000
3020
3030
3022
3025D
3024
3011
3200
3062
3025
3062A
3021
3010A
3210
3091
3045, 3040
3111
3066
3130
3068
3002

FIG. 133

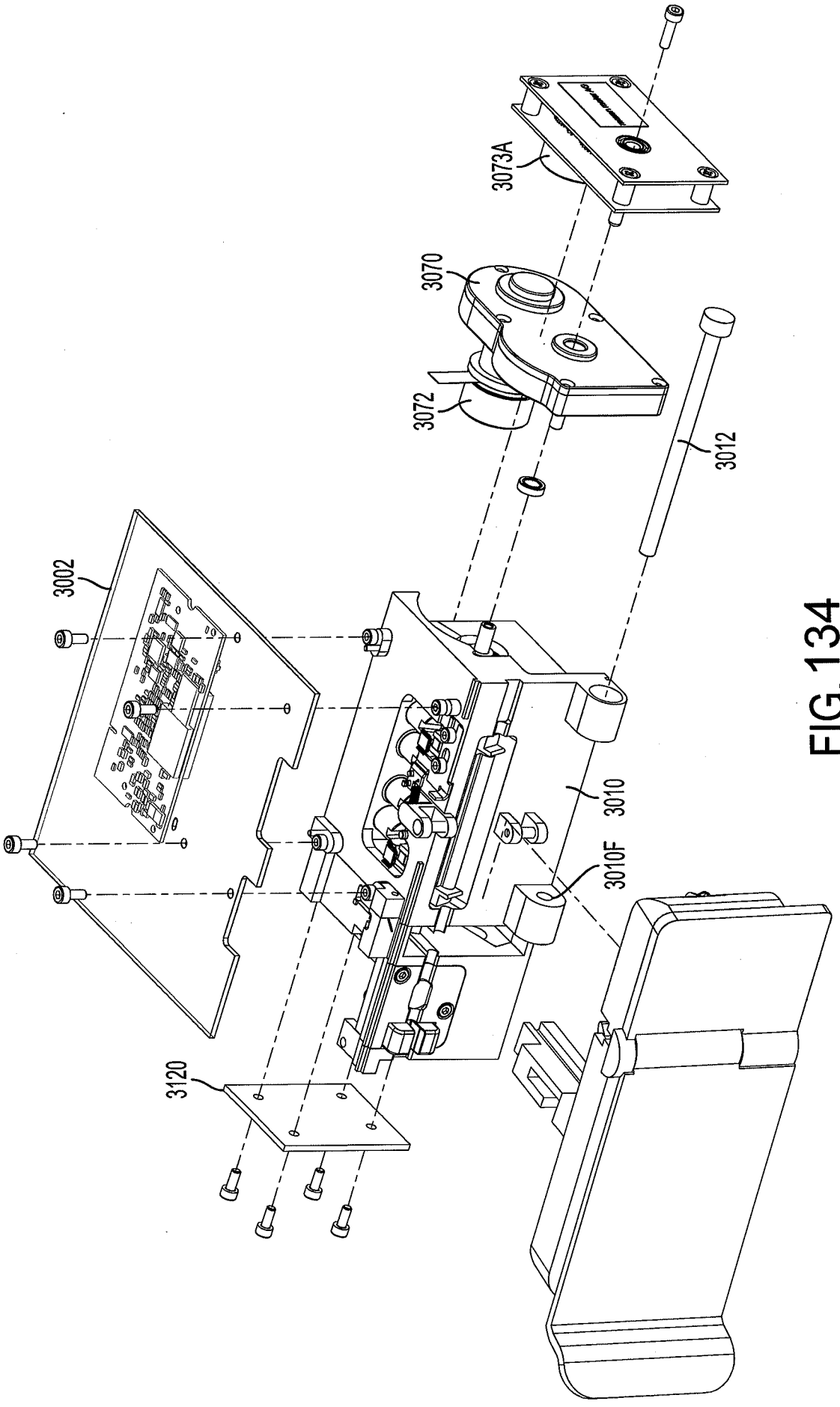


FIG. 134

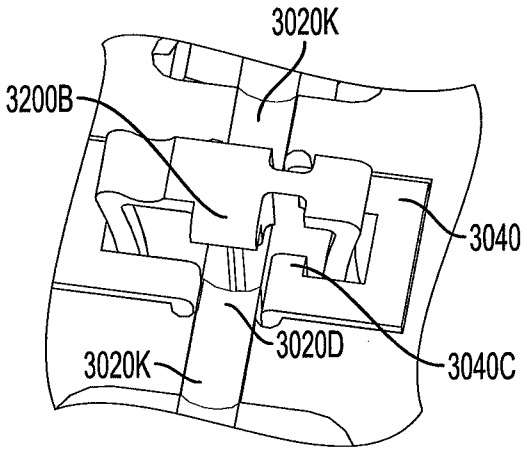


FIG. 135

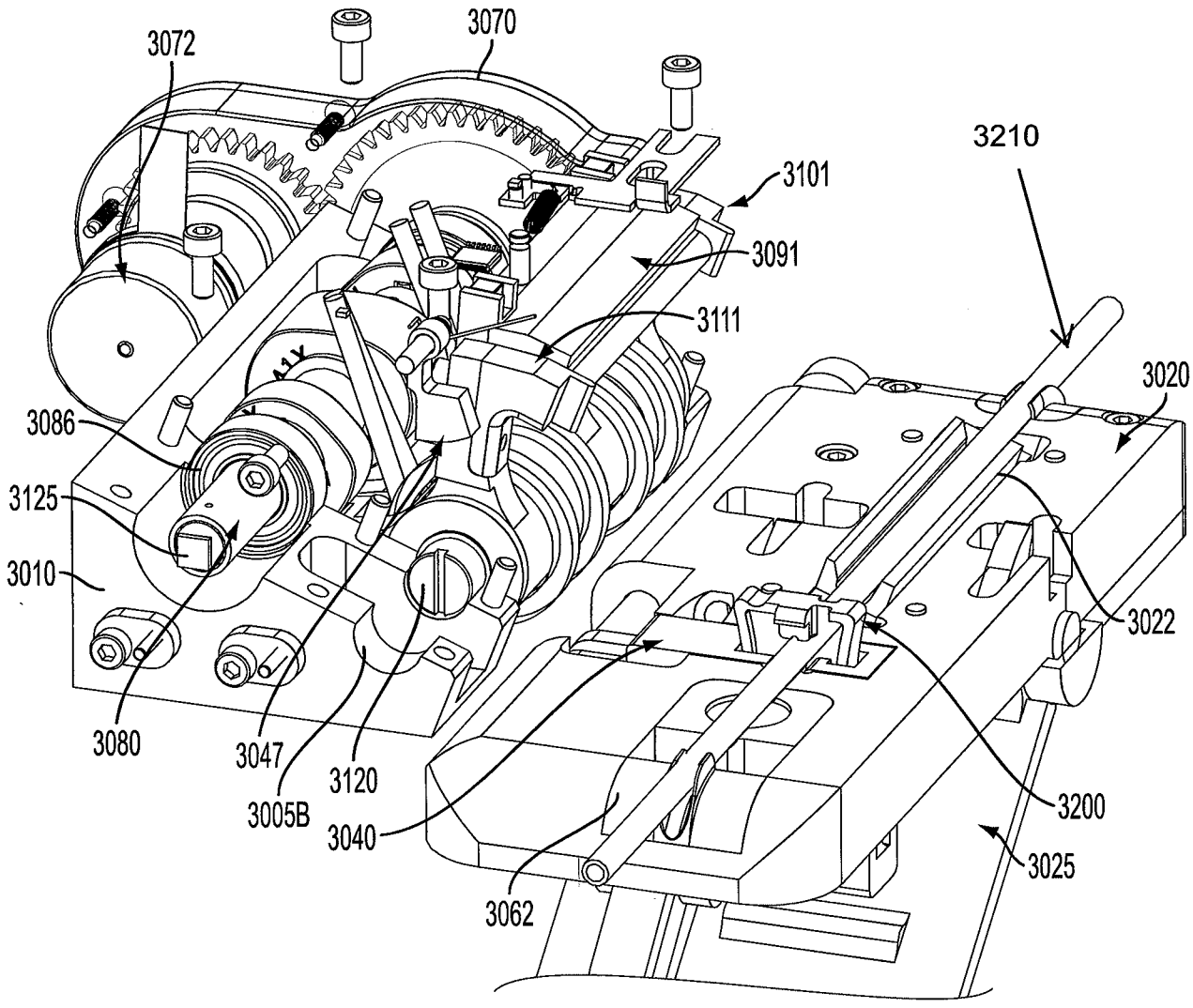

3072
3070
3210
3101
3091
3111
3020
3086
3125
3010
3022
3080
3047
3120
3005B
3040
3200
3025
3062

FIG.136

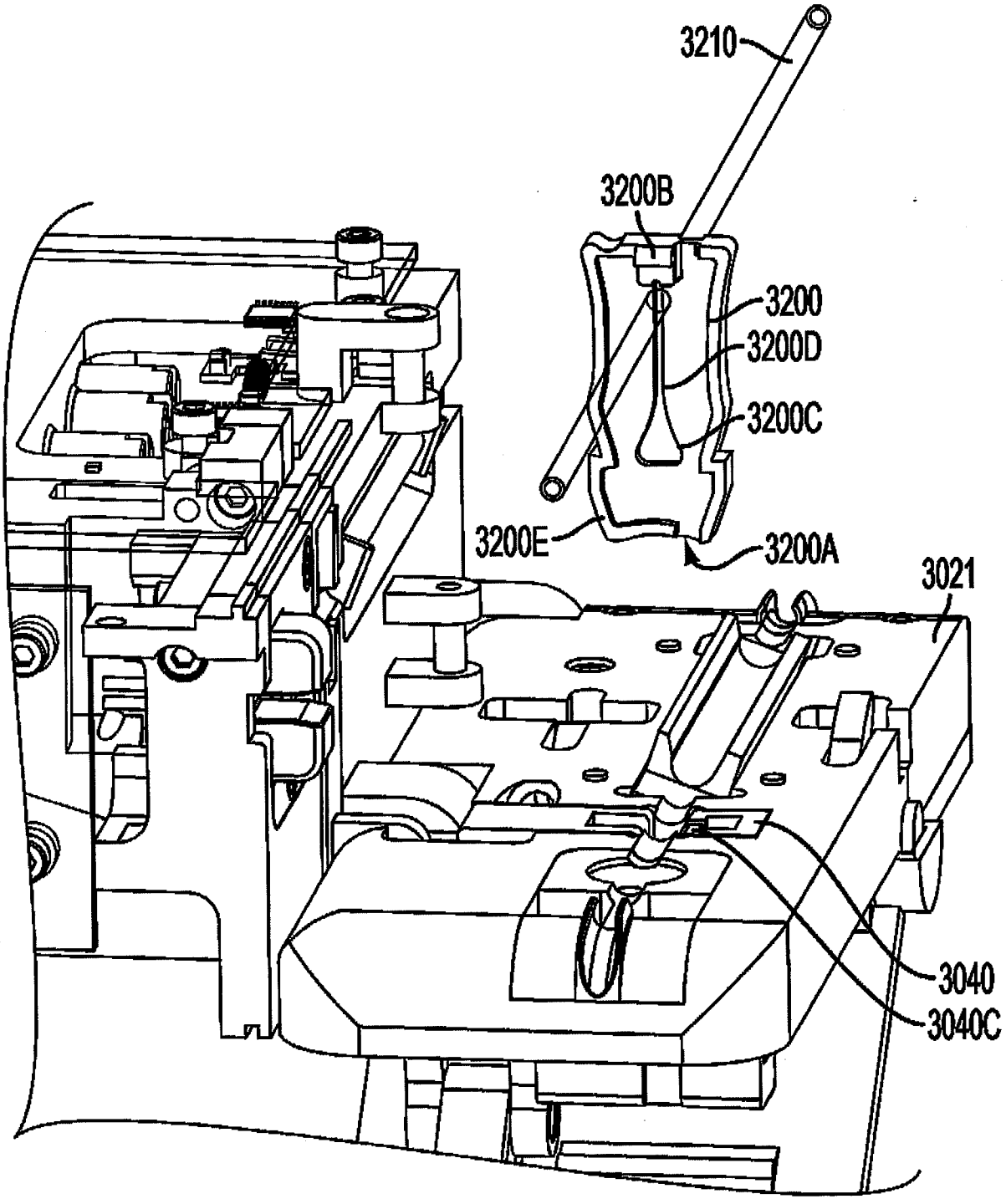


FIG. 137

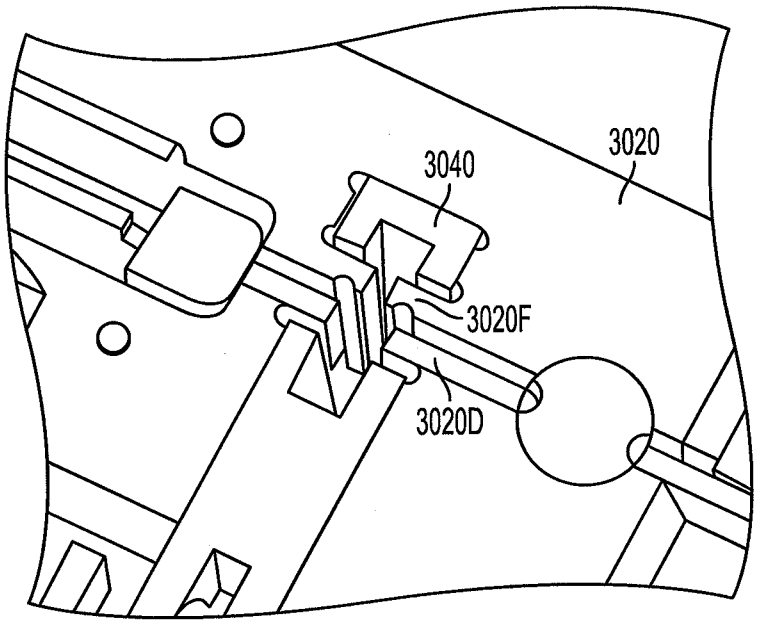


FIG. 138

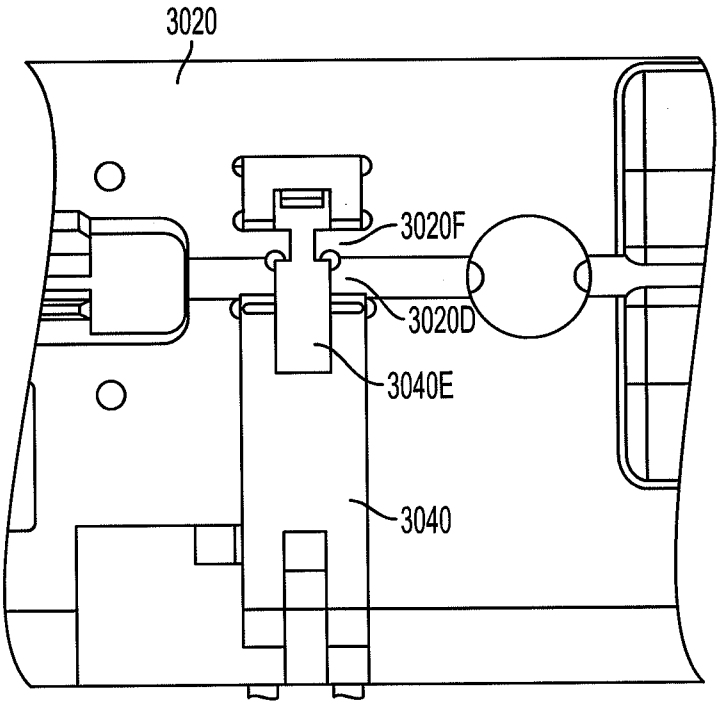


FIG. 139

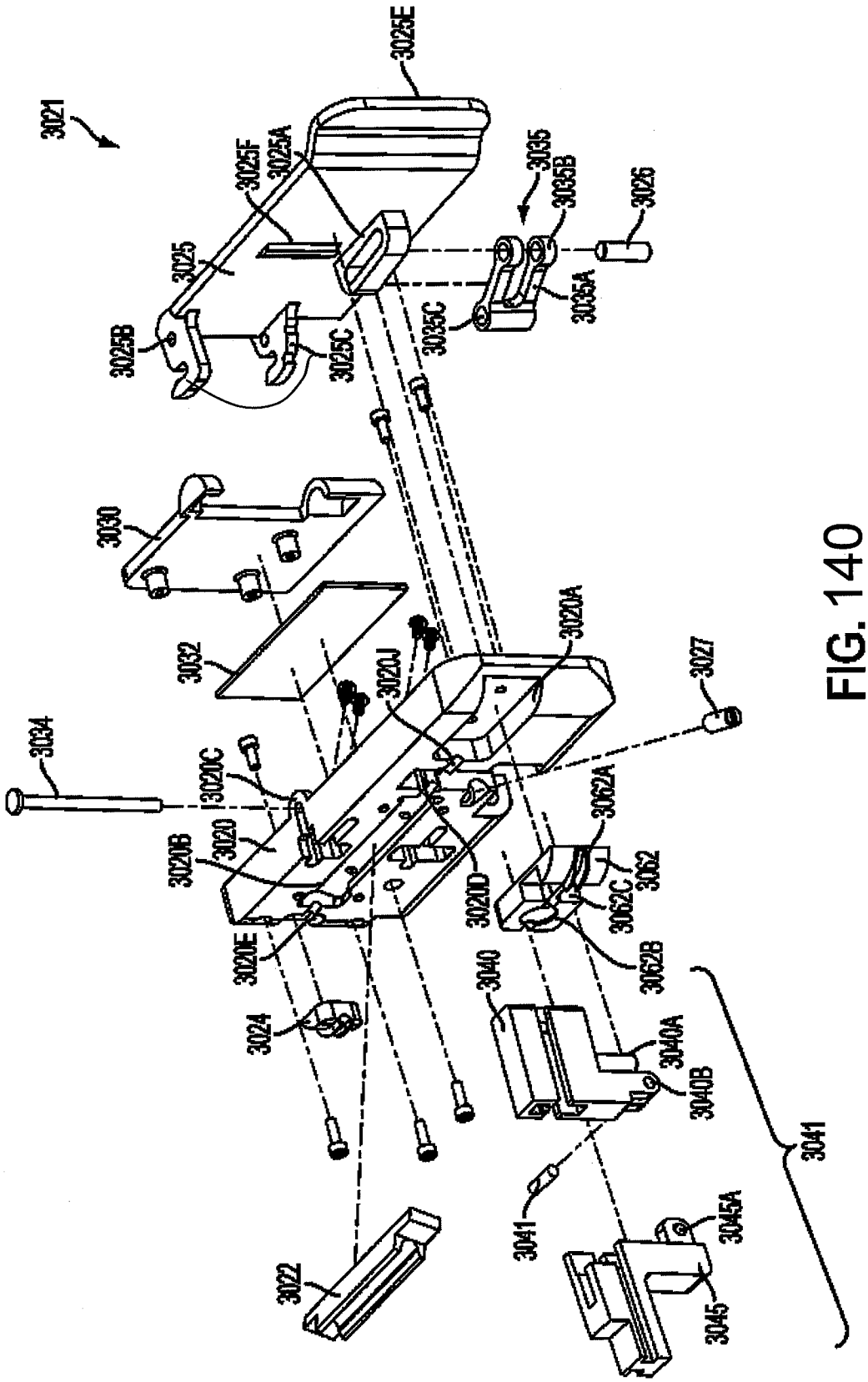

3021
3025E
3025F
3025A
3035
3035B
3026
3025
3035A
3025B
3025C
3035C
3030
3032
3020A
3027
3034
3020C
3020
3020B
3062A
3062
3062C
3062B
3020D
3020E
3040
3040A
3040B
3024
3041
3045A
3045
3022

FIG. 140

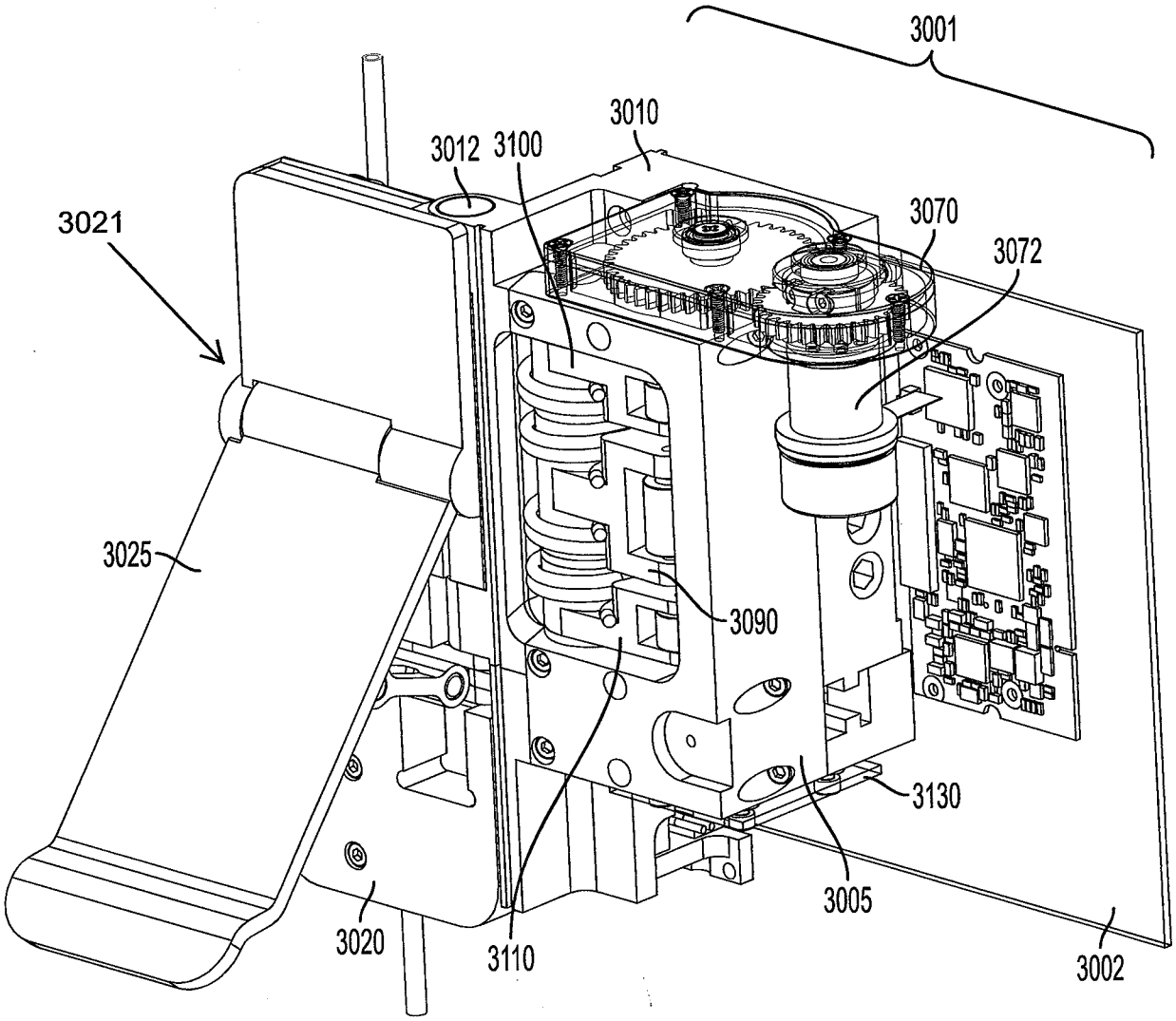

3001
3010
3012
3100
3021
3070
3072
3025
3090
3130
3005
3020
3110
3002

FIG. 141

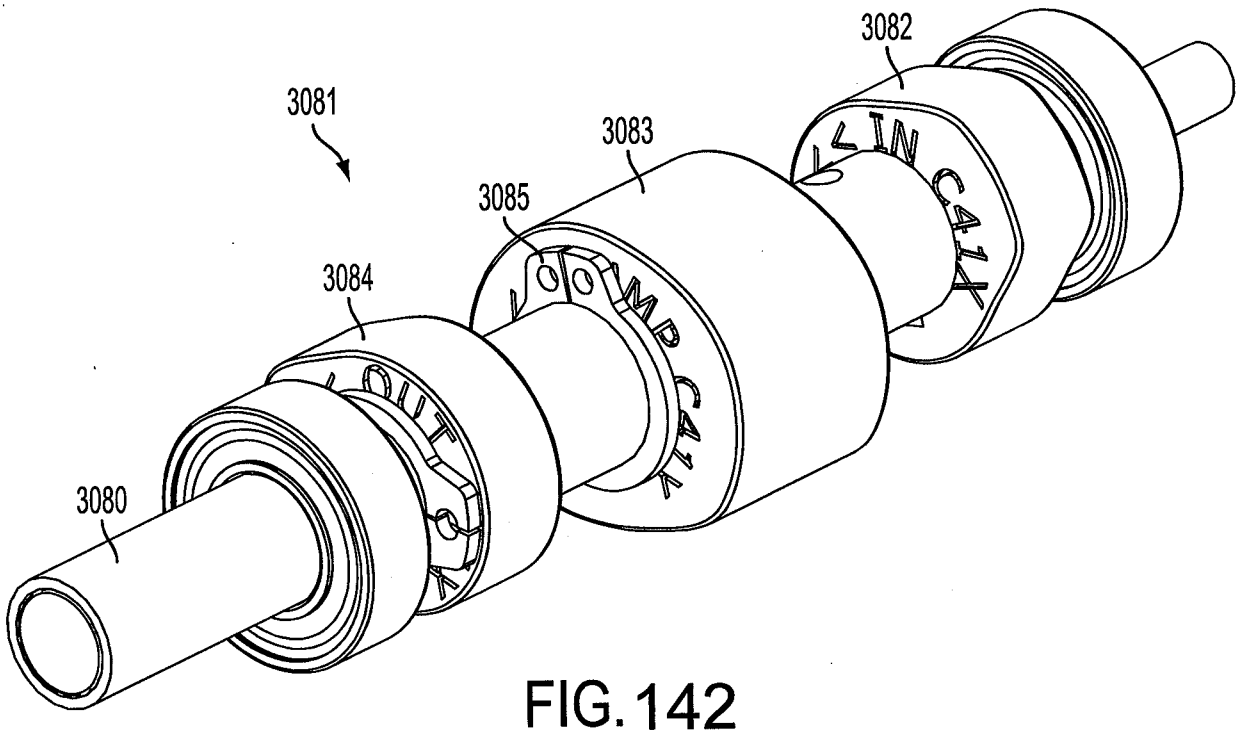


FIG. 142

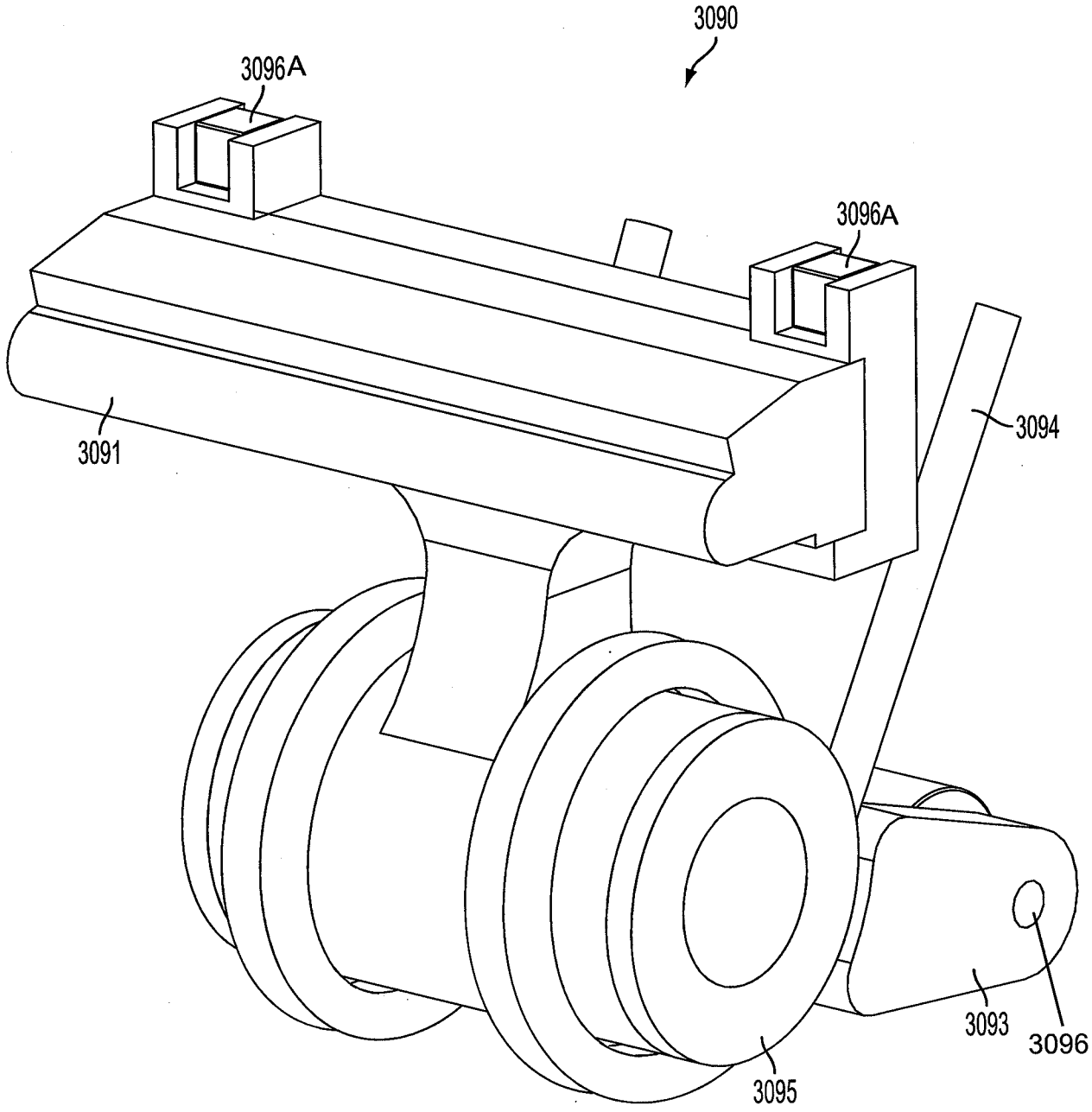


FIG. 143

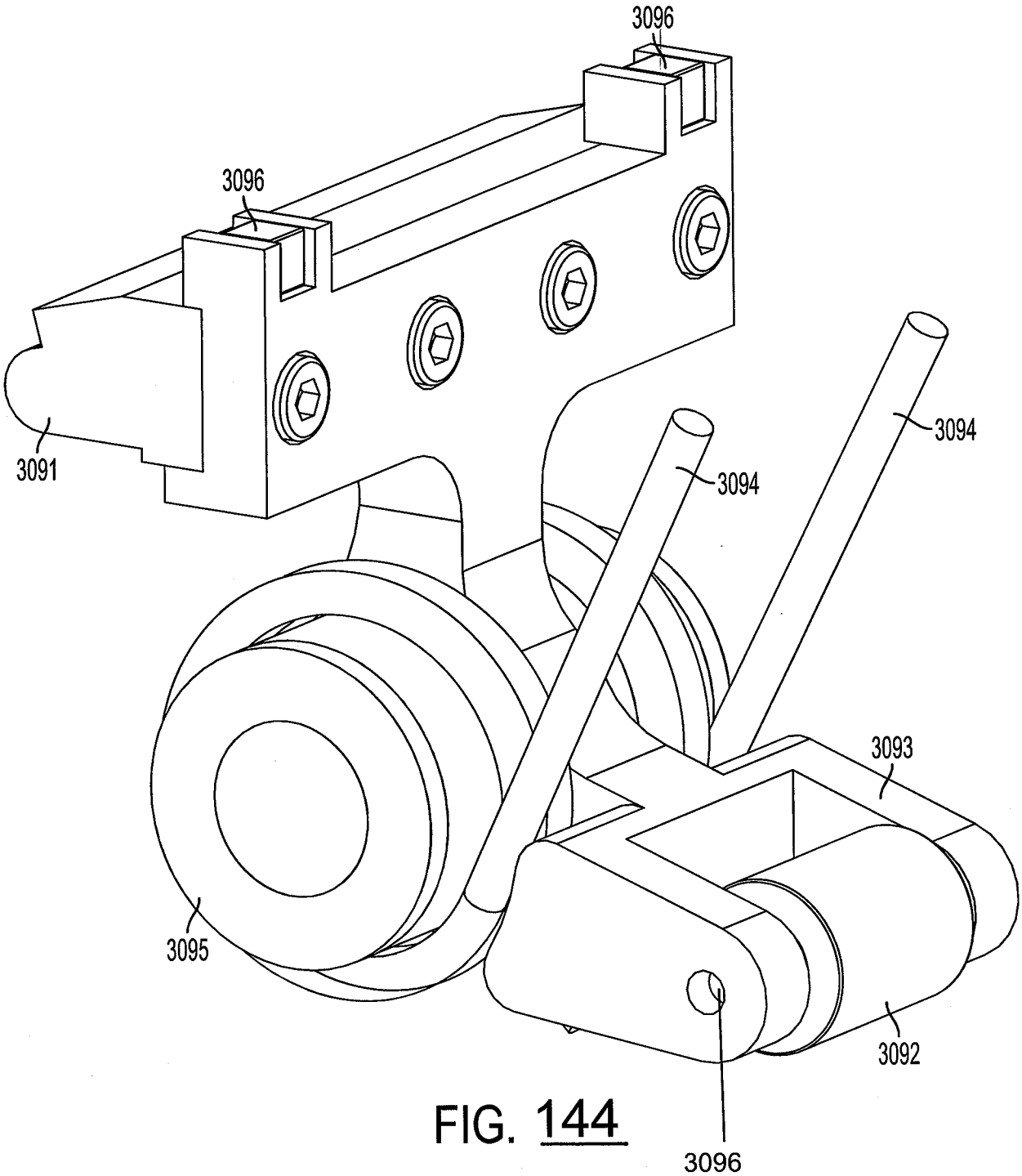


FIG. 144

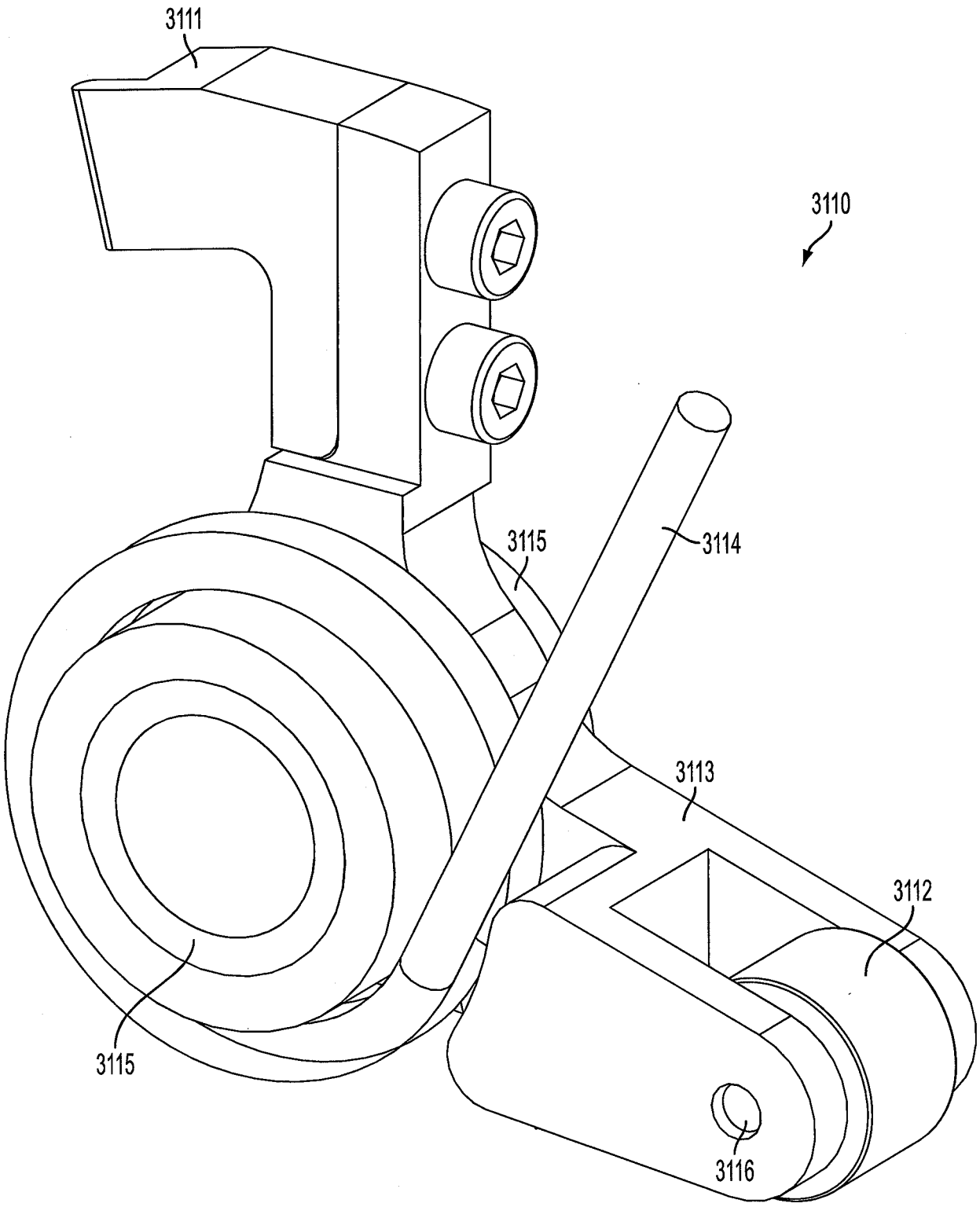


FIG.145

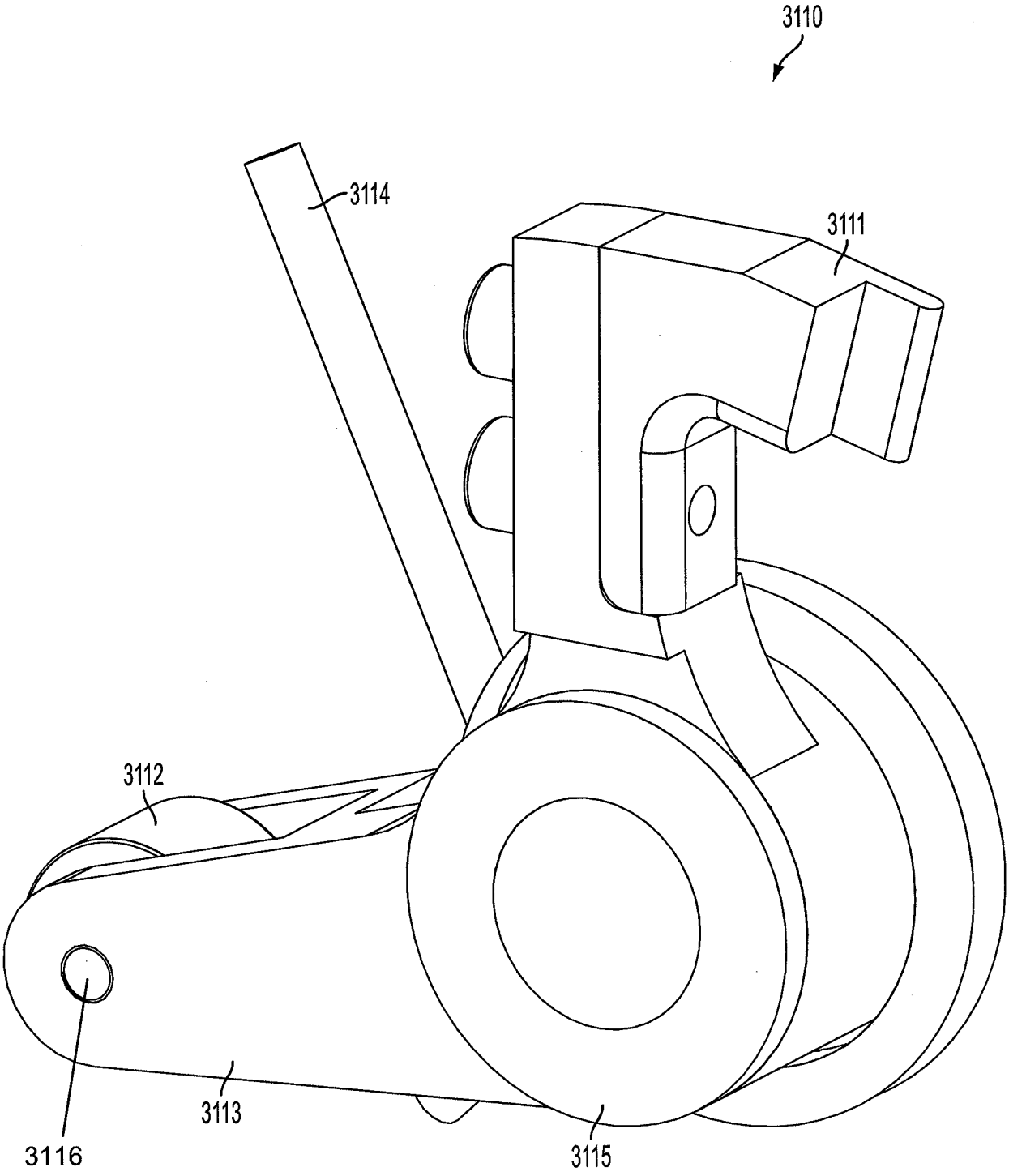


FIG. 146

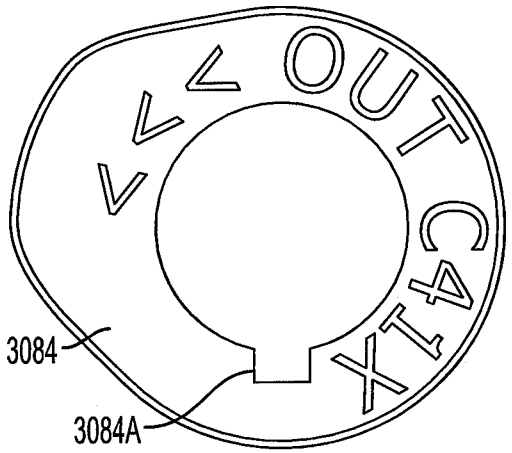


FIG.147

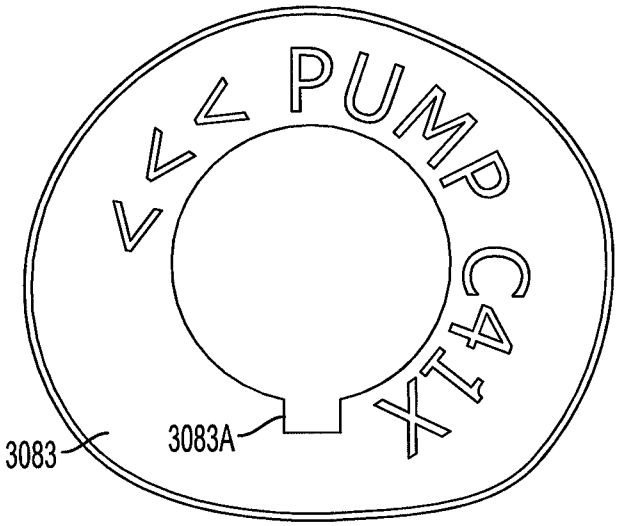


FIG.148

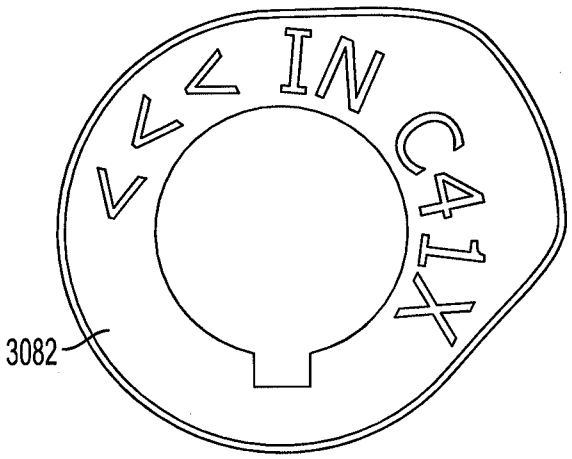


FIG.149

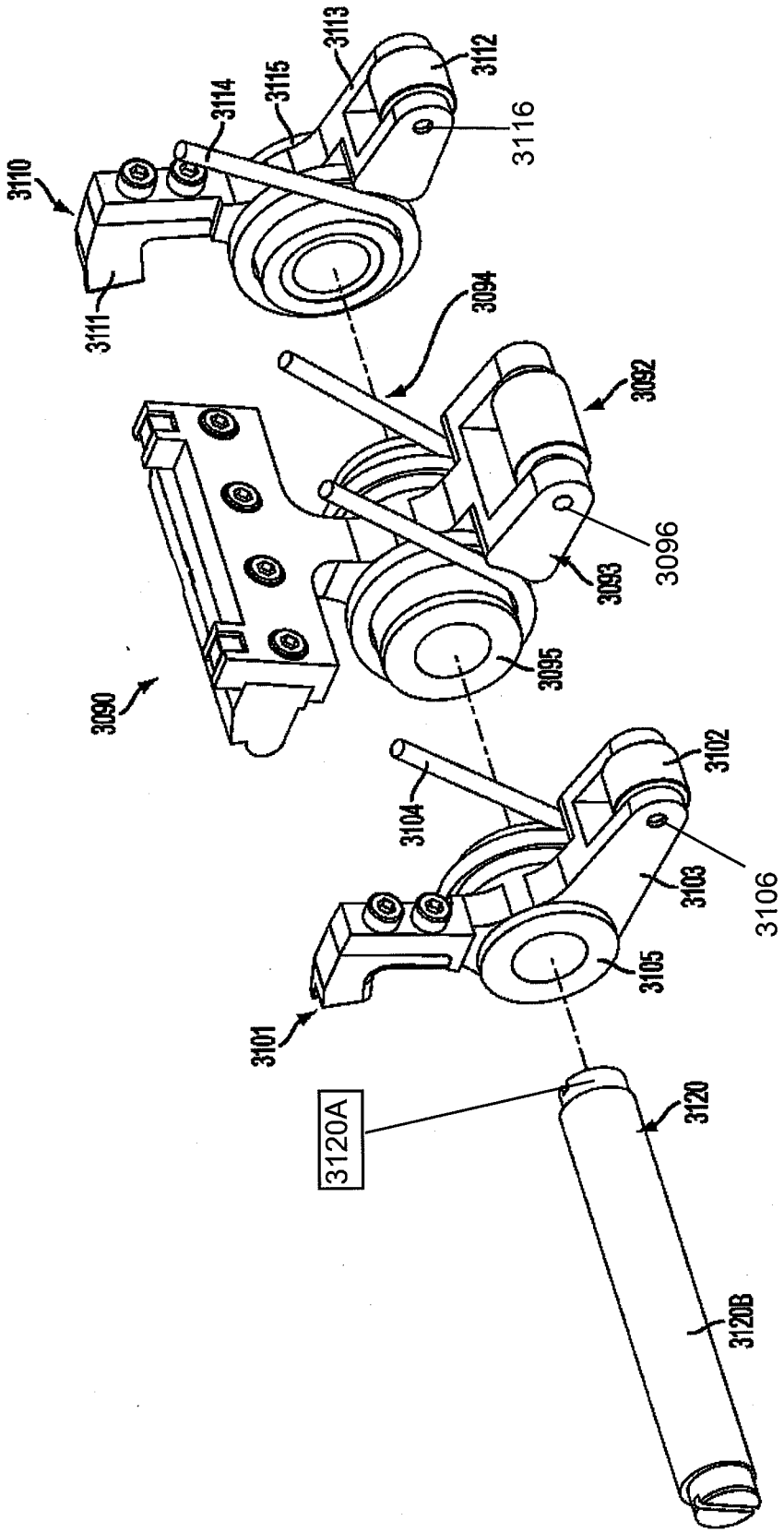

3110
3111
3114
3115
3113
3112
3116
3094
3092
3096
3093
3095
3090
3104
3102
3103
3106
3105
3101
3120A
3120
3120B

FIG. 150

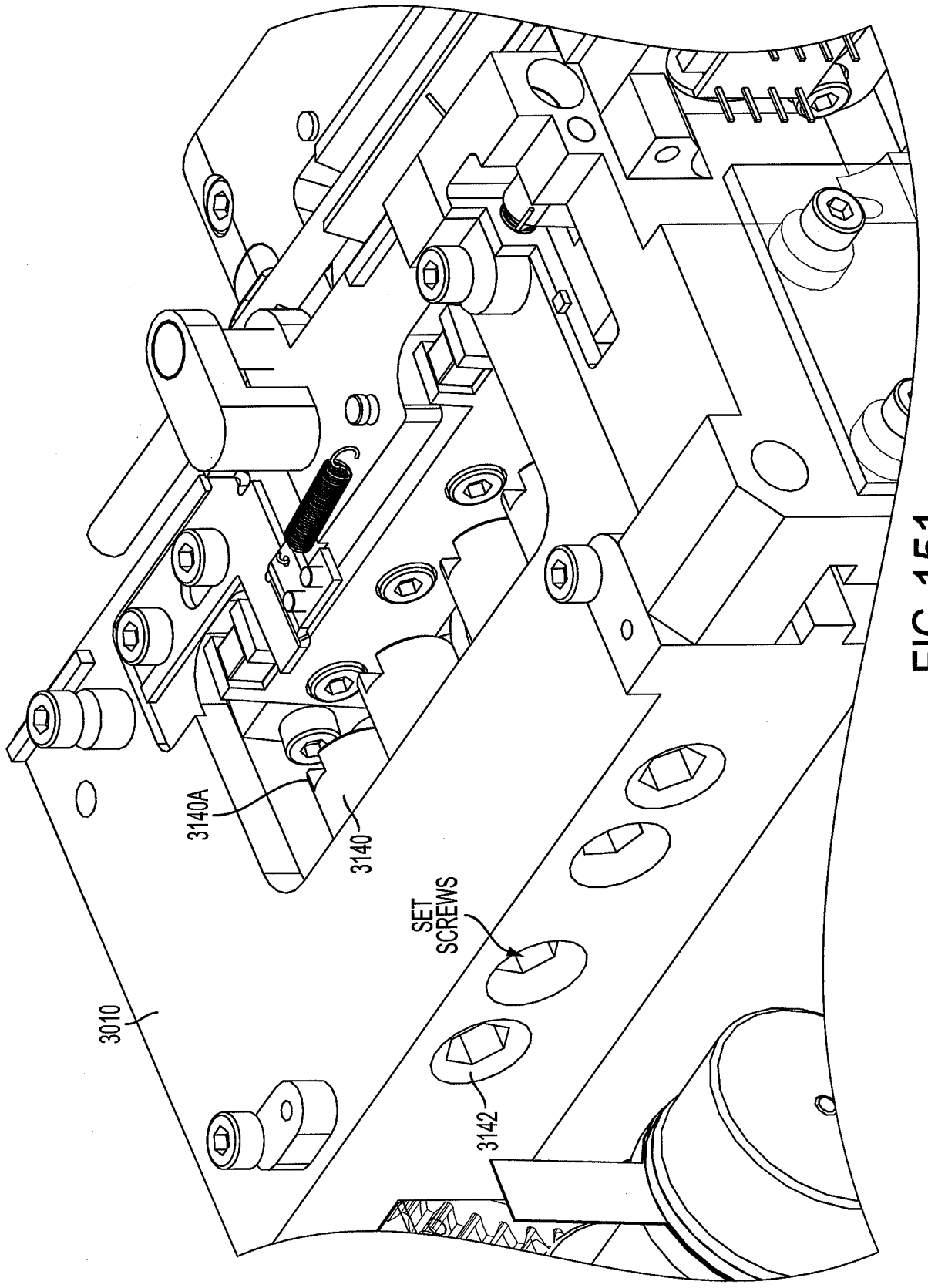


FIG. 151

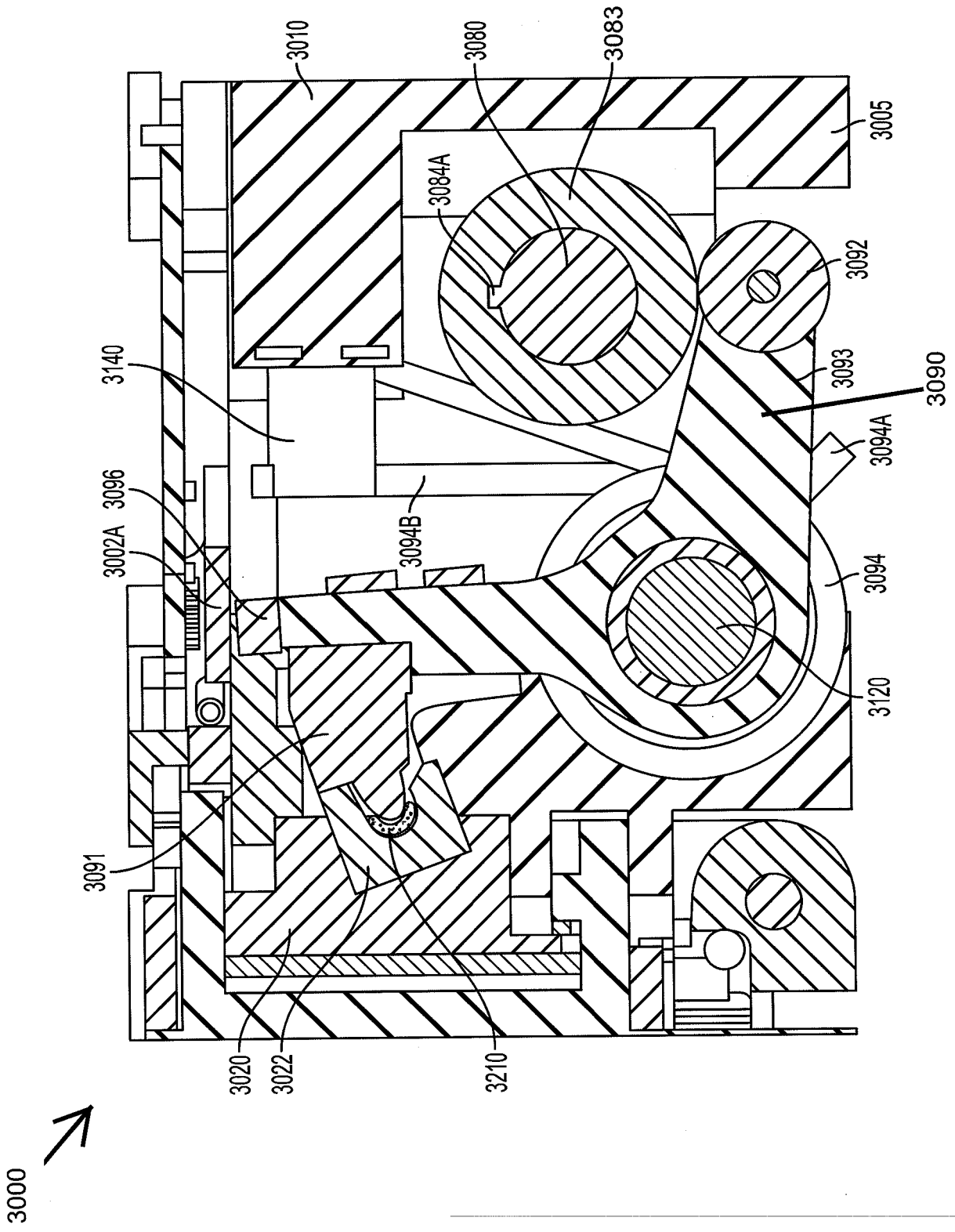

3000
3010
3080
3083
3005
3084A
3092
3140
3093
3090
3094A
3096
3002A
3094B
3094
3120
3091
3020
3022
3210

FIG. 152

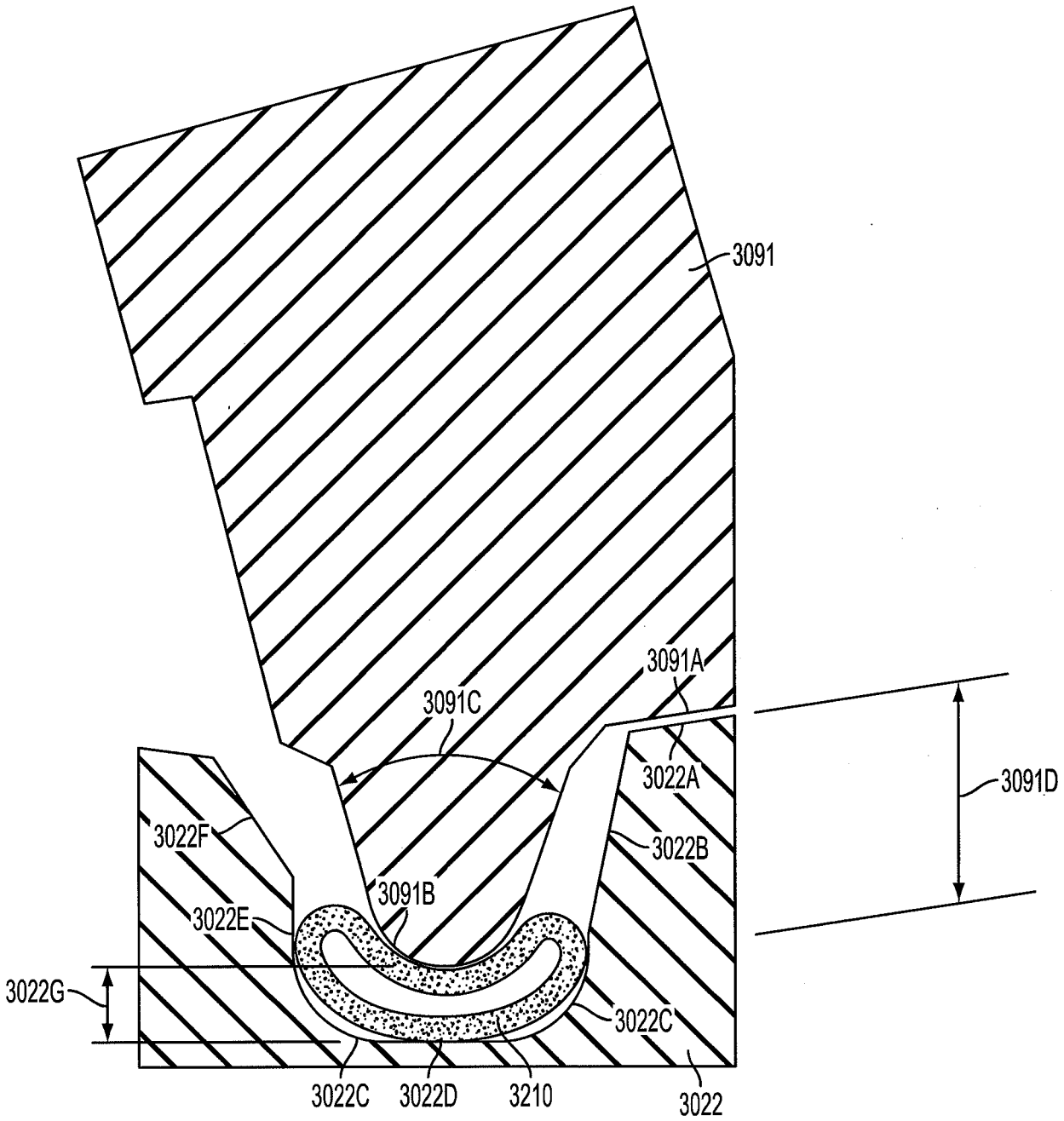

3091
3091A
3091C
3091D
3022A
3022F
3022B
3091B
3022E
3022G
3022C
3022C
3022D
3210
3022

FIG. 153

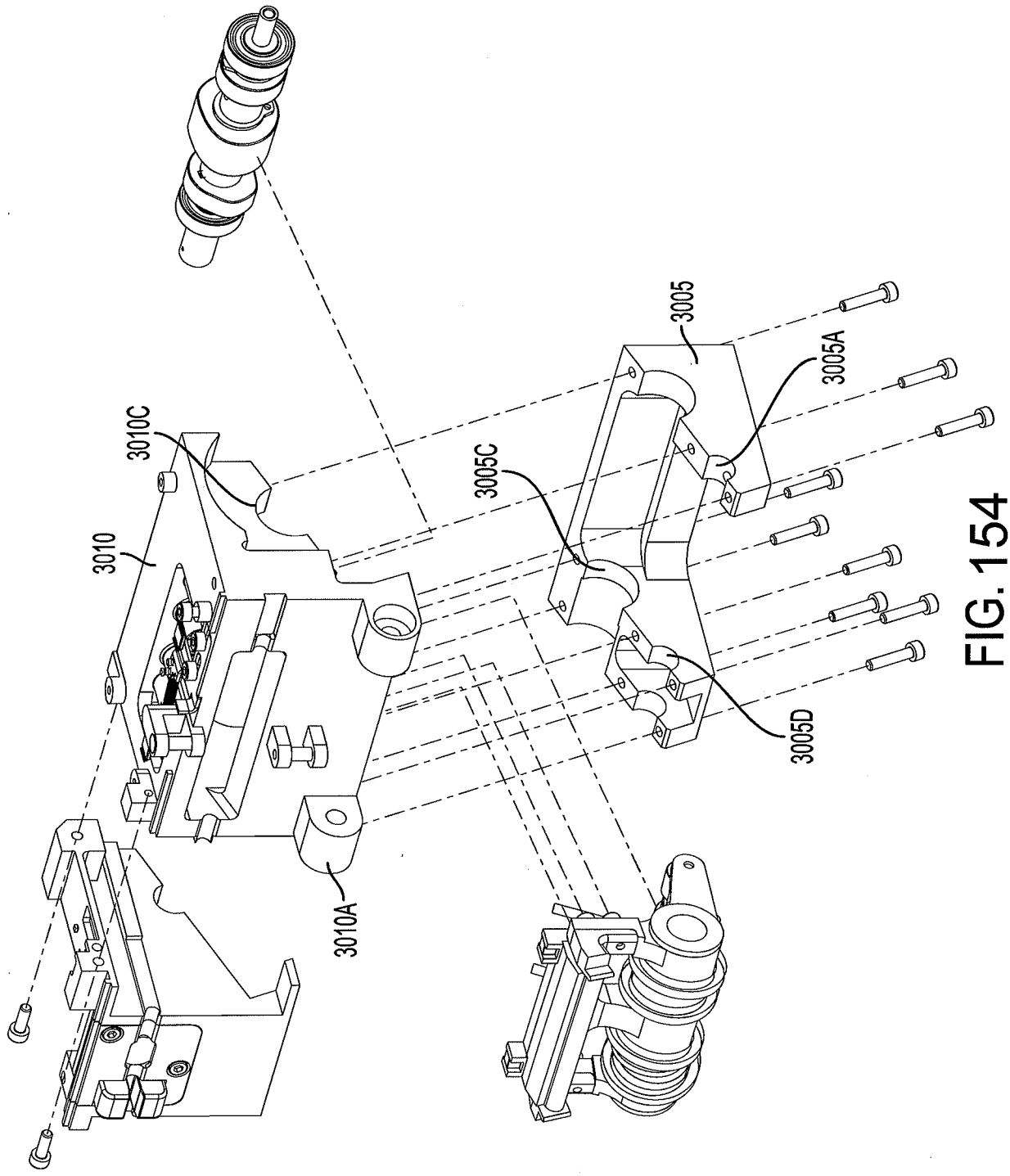


FIG. 154

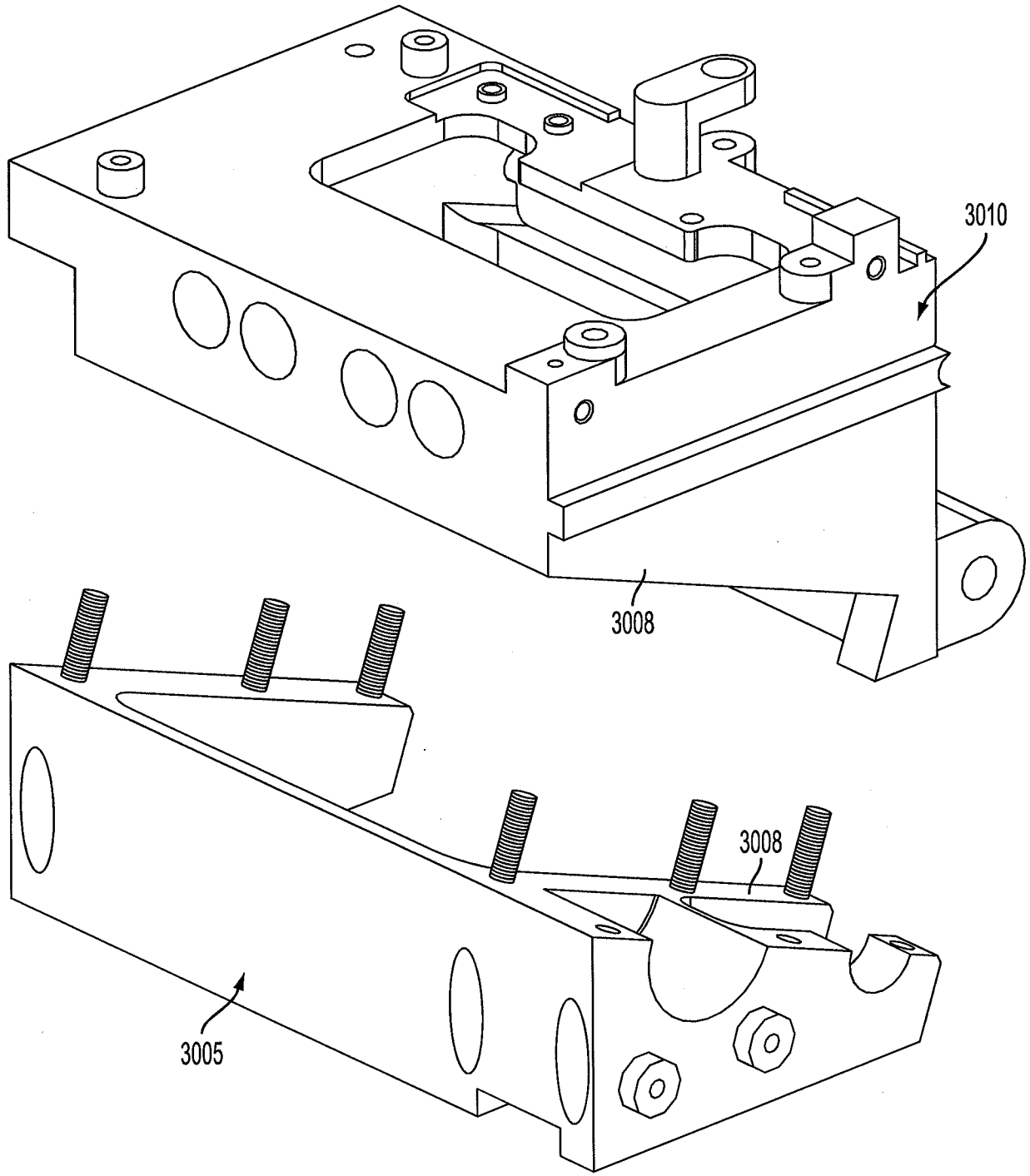


FIG. 155

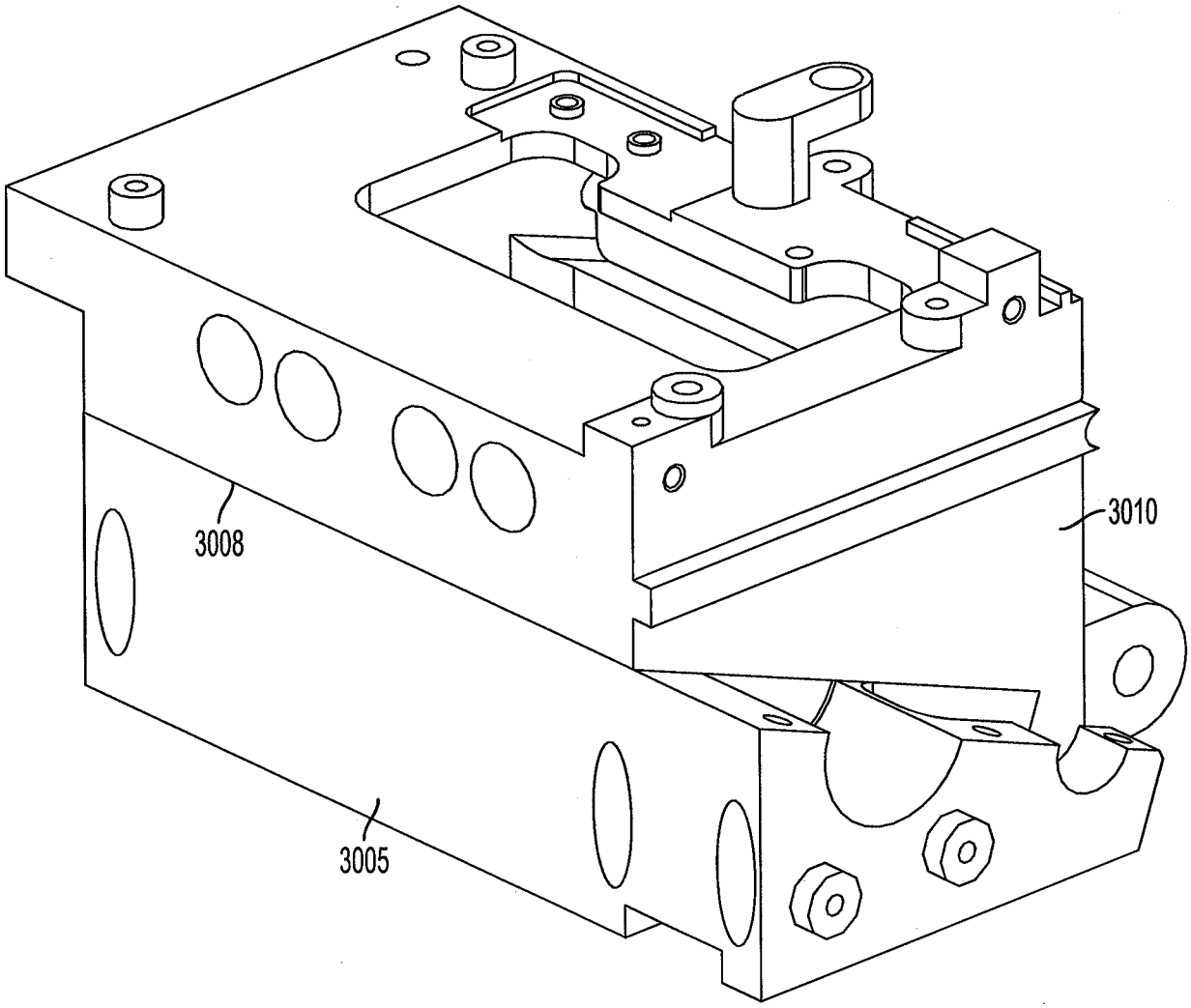


FIG. 156

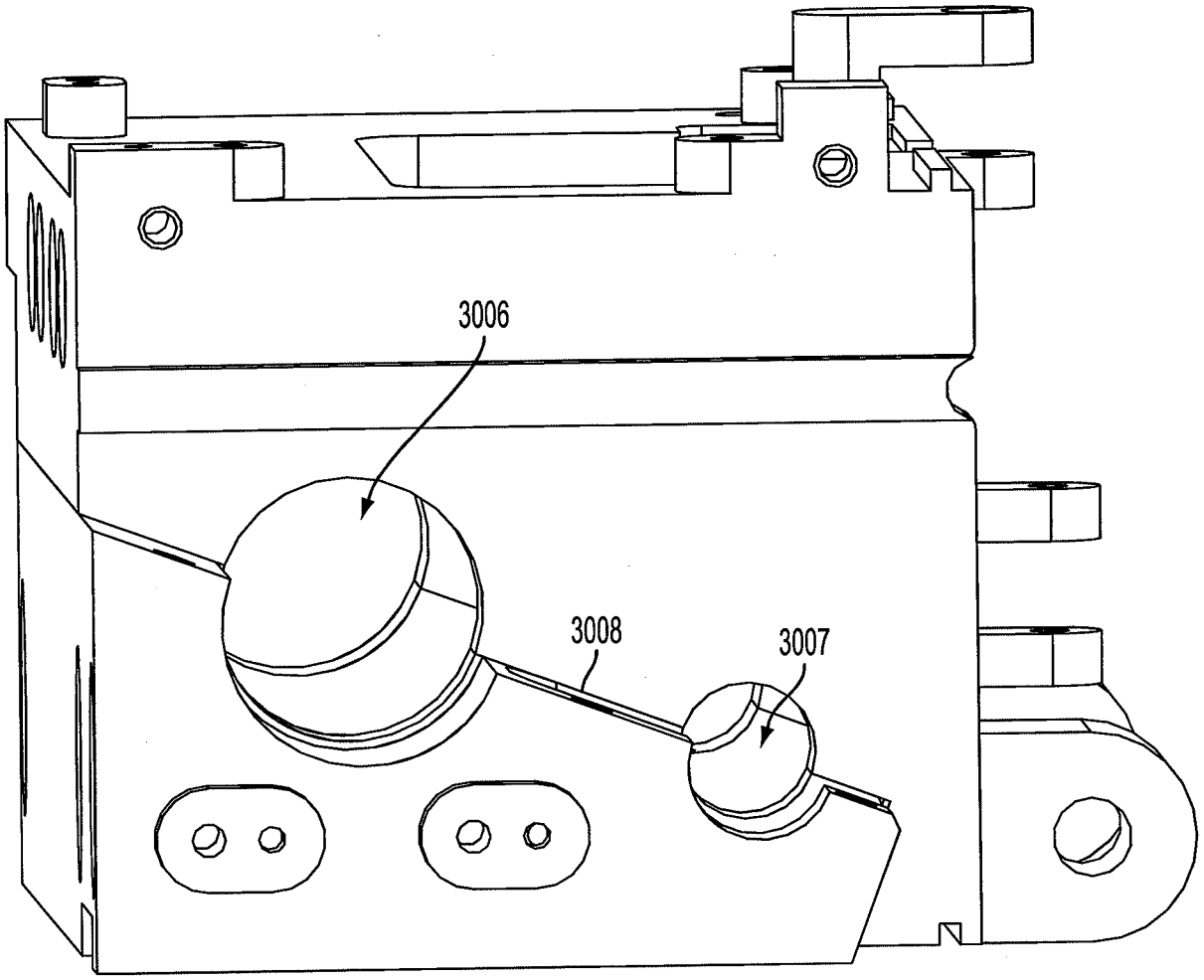


FIG. 157

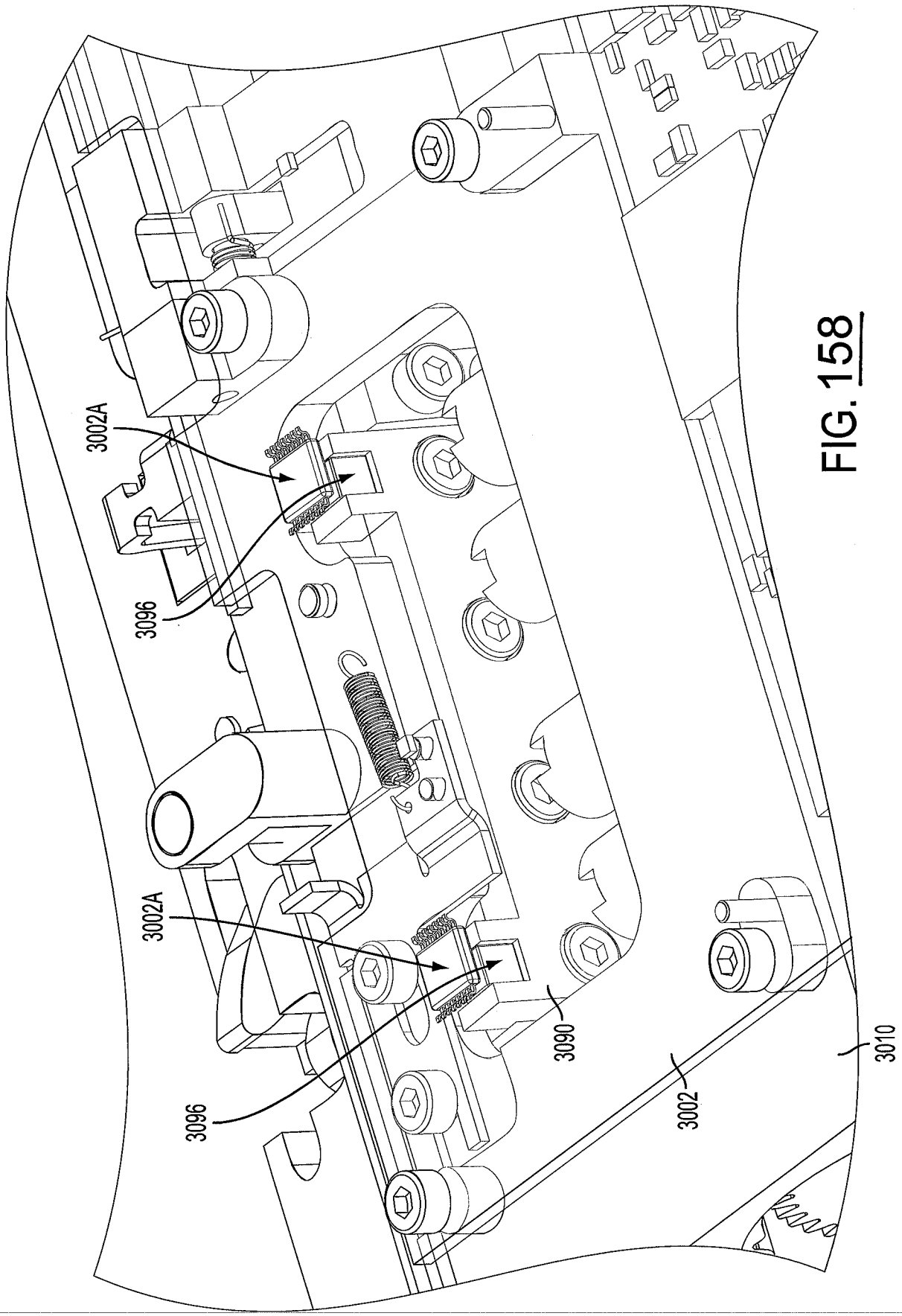


FIG. 158

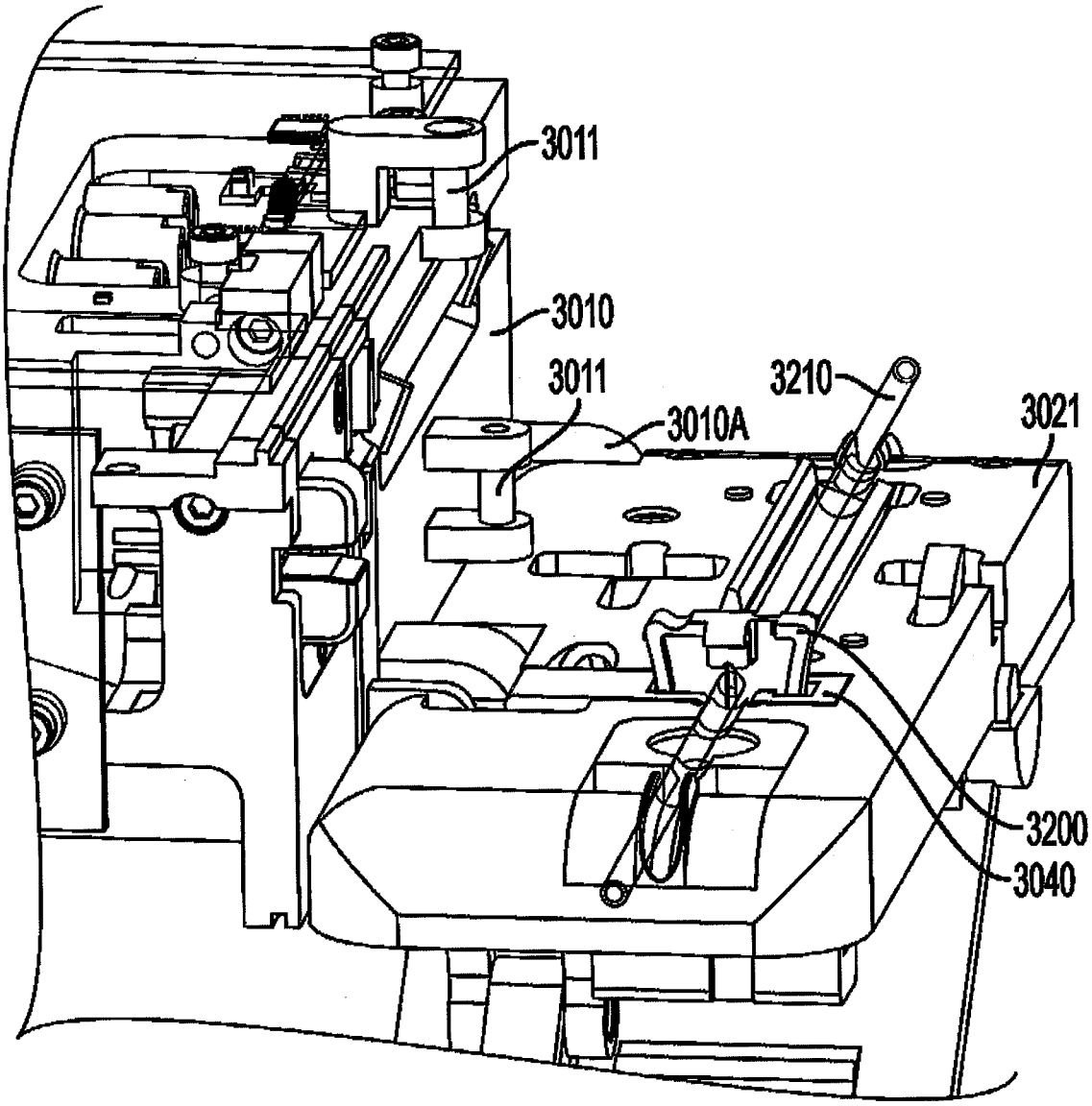


FIG. 159

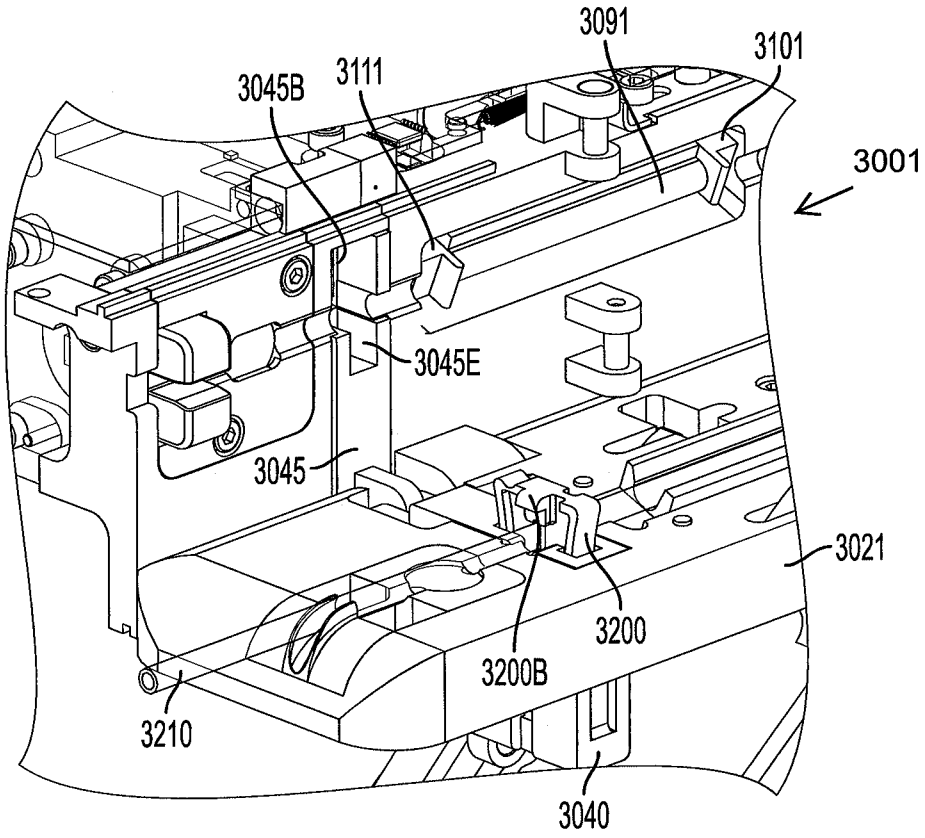

3091
3101
3111
3045B
3001
3045E
3045
3021
3200
3200B
3210
3040

FIG.160

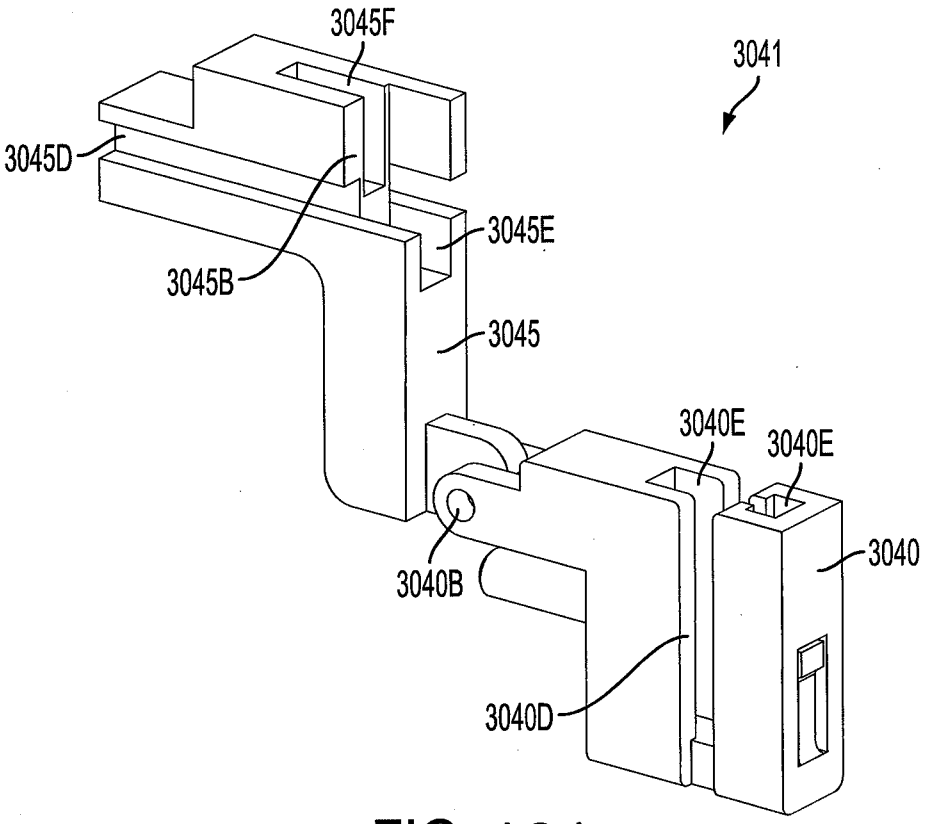


FIG. 161

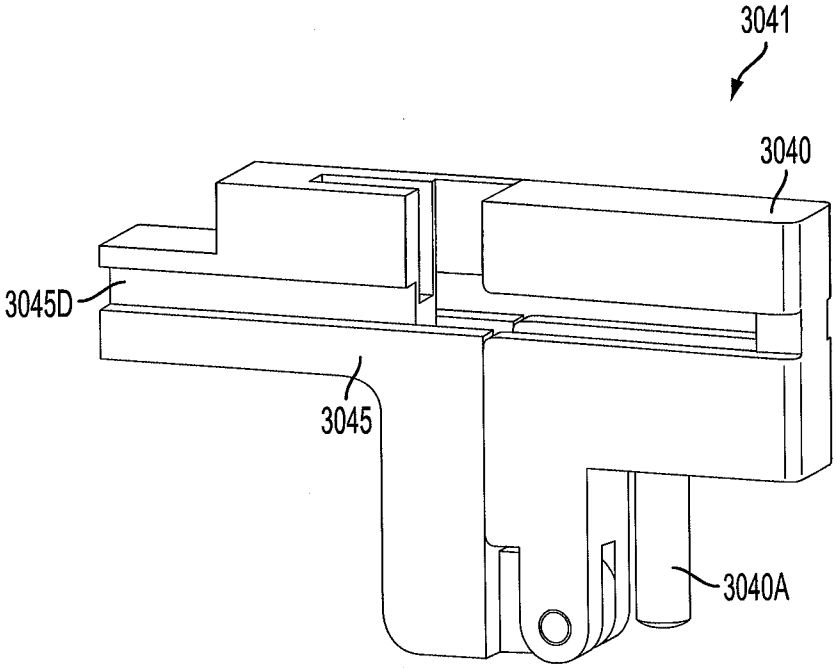


FIG. 162

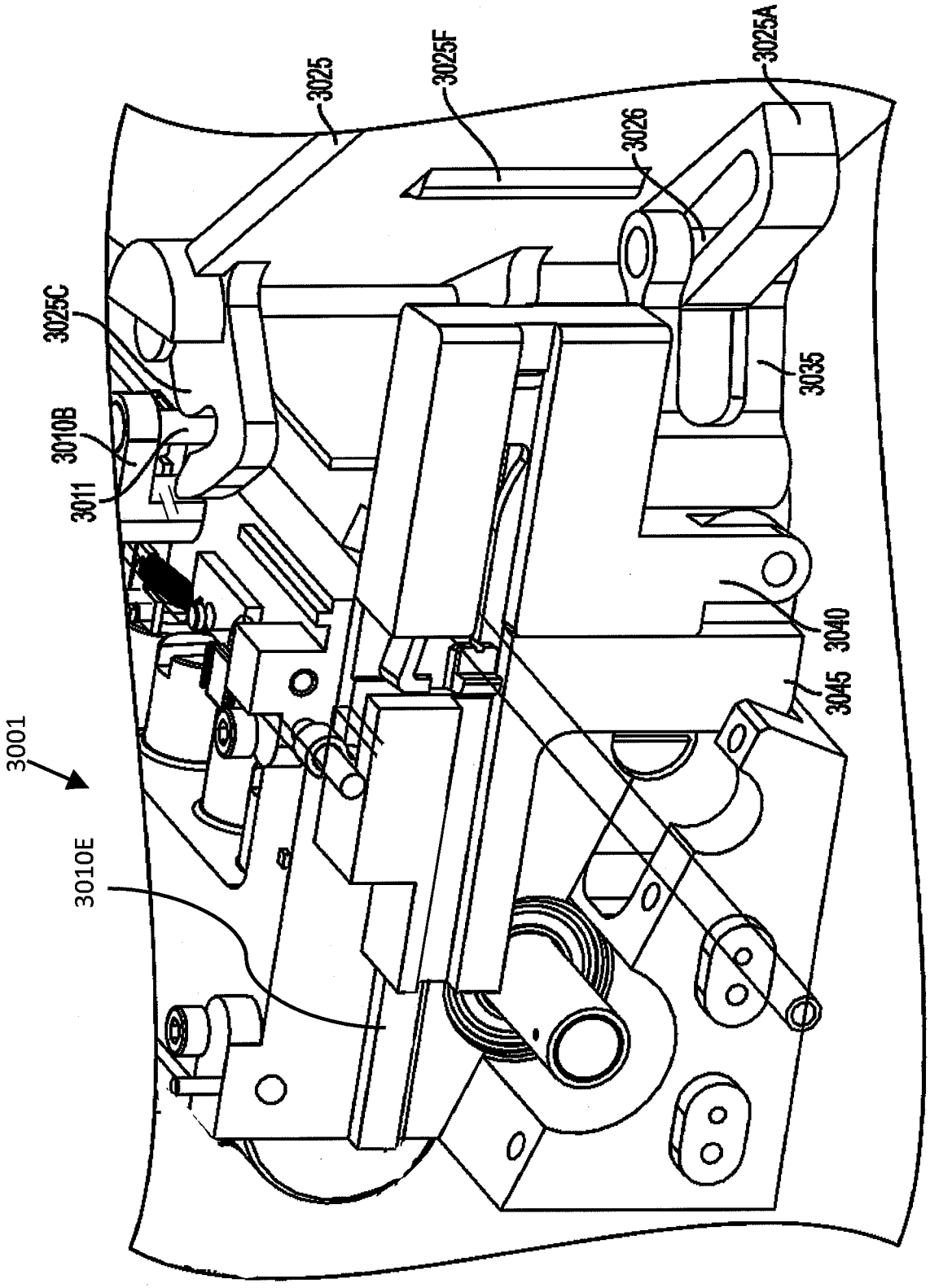

3001
3010E
3011
3010B
3025C
3025
3025F
3026
3025A
3035
3040
3045

FIG. 163

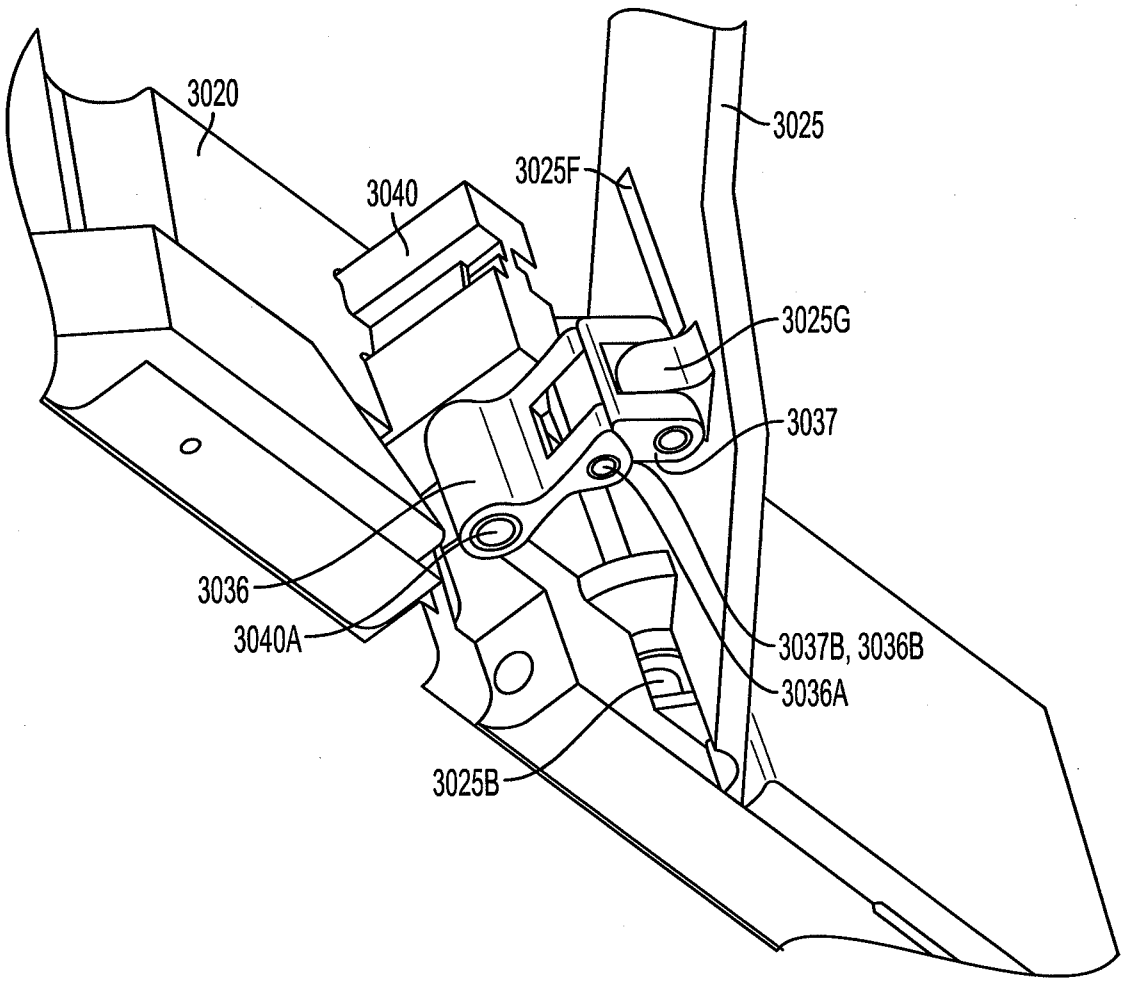

3020
3040
3025F
3025
3025G
3037
3036
3040A
3037B, 3036B
3036A
3025B

FIG. 164

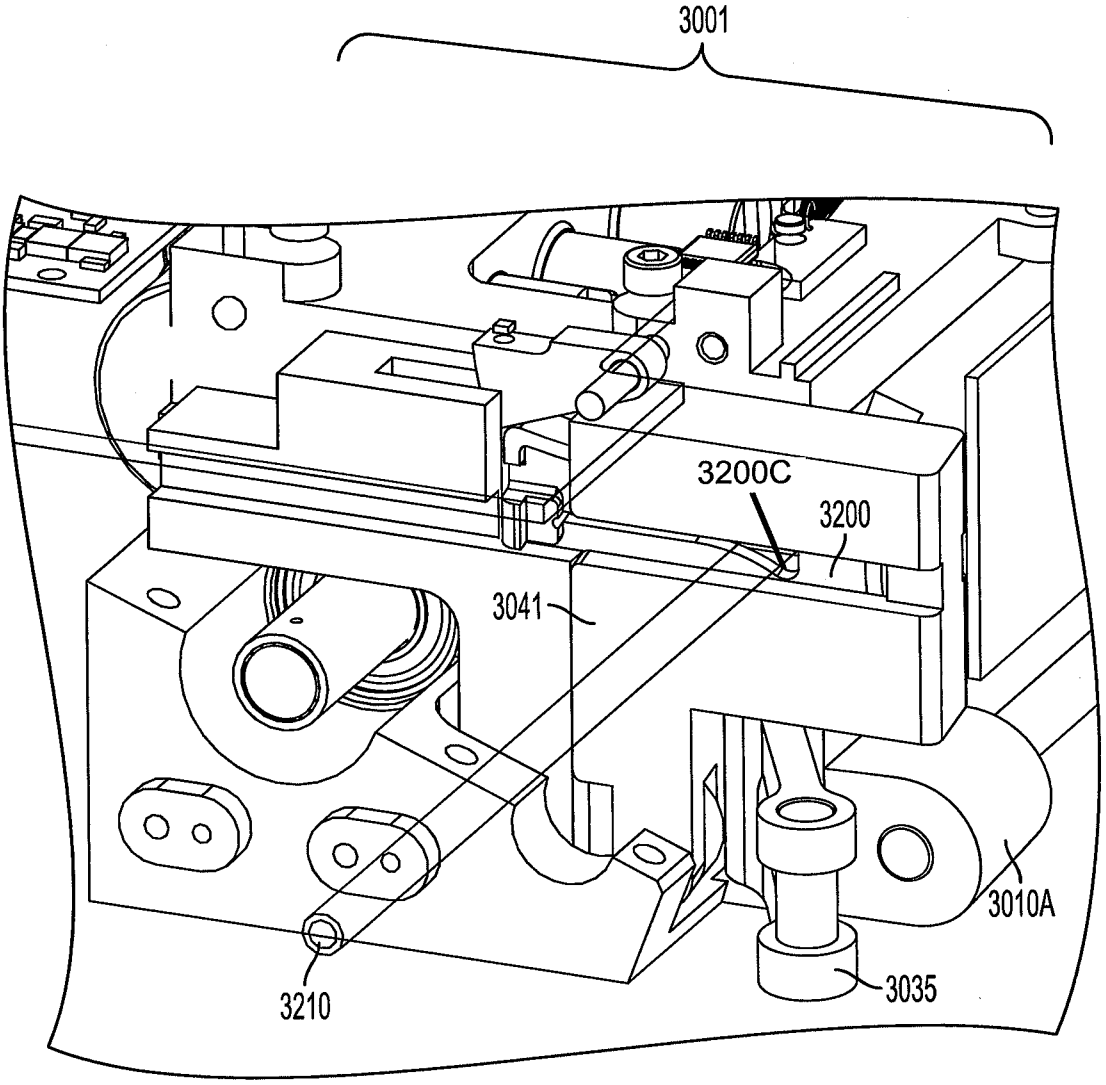


FIG. 165

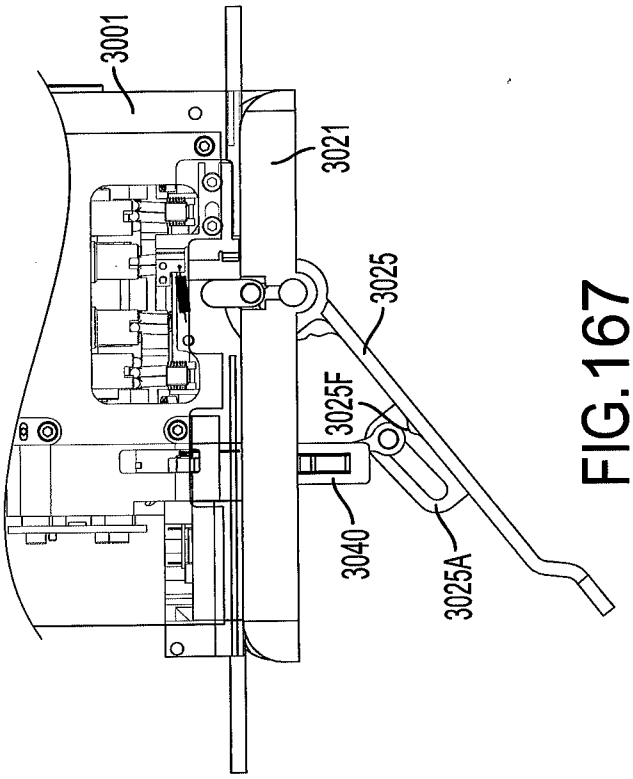


FIG. 167

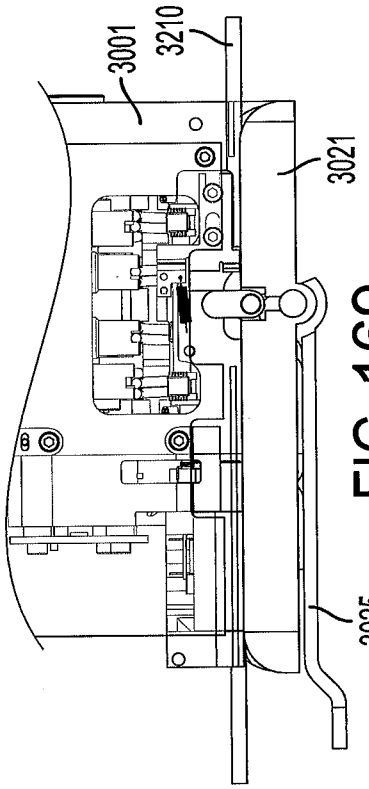


FIG. 169

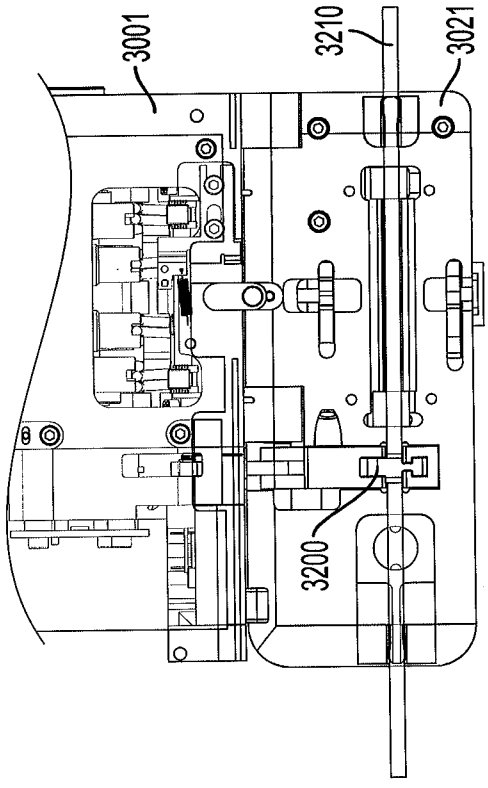


FIG. 166

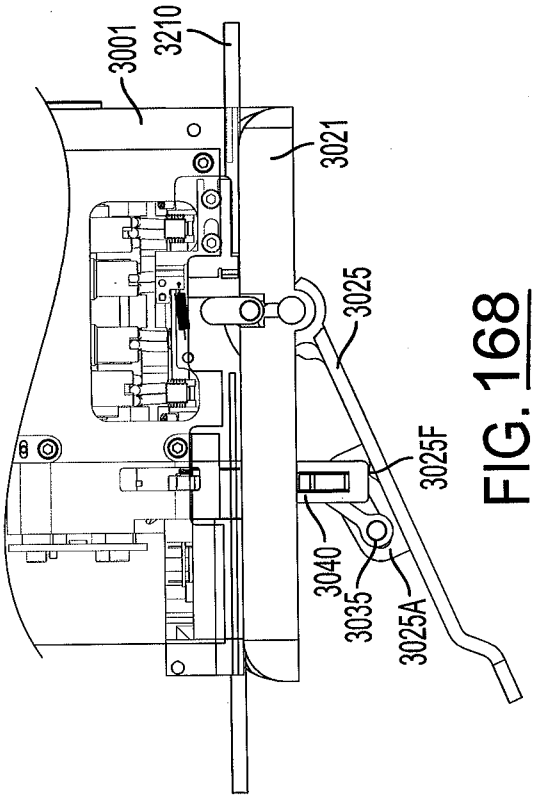


FIG. 168

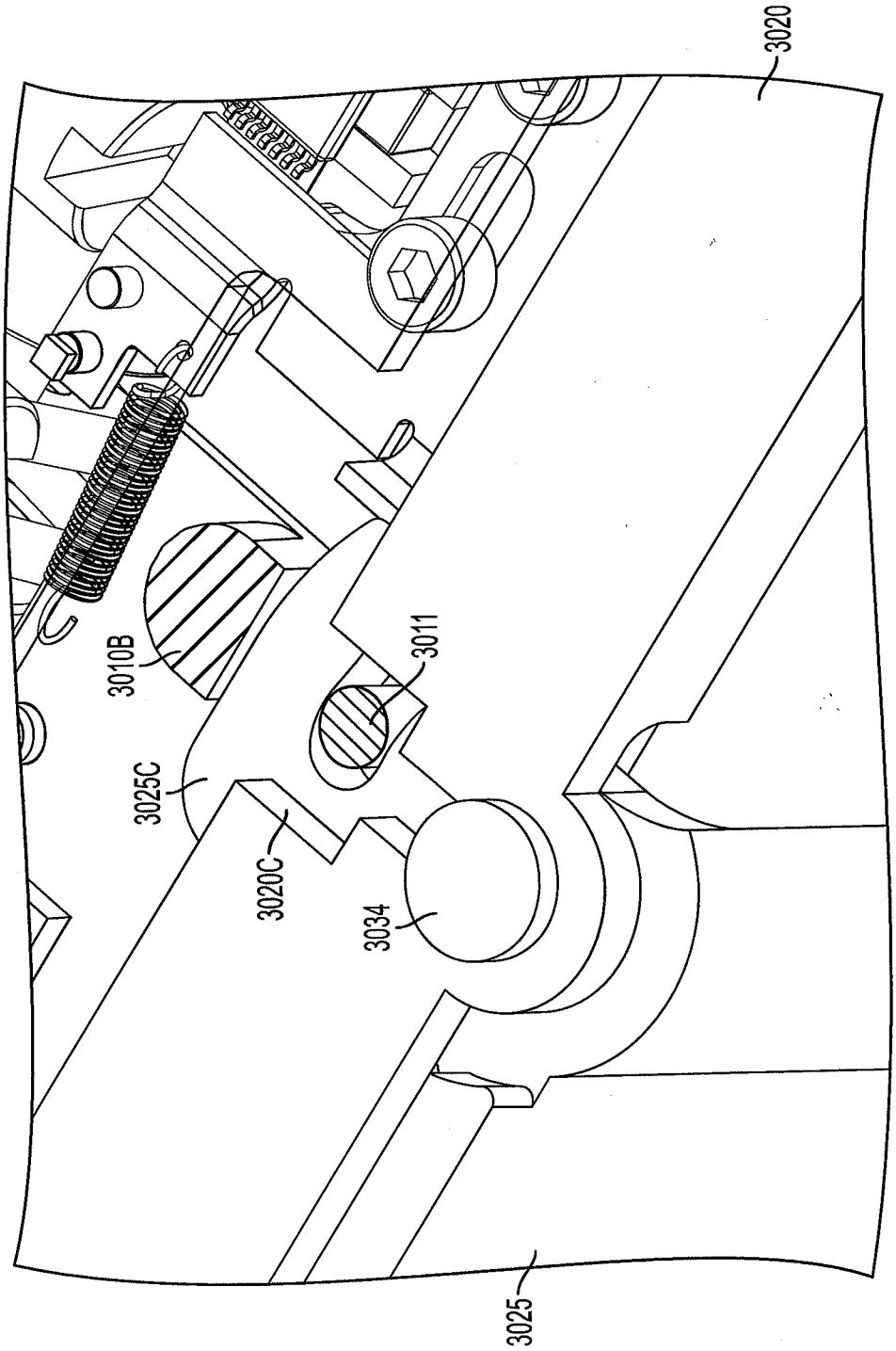


FIG. 170

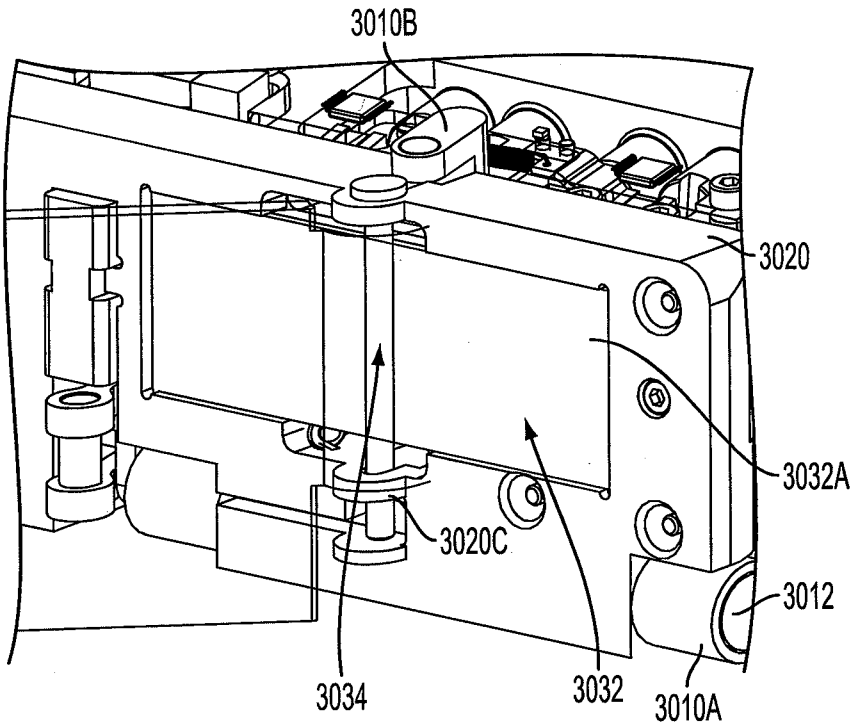


FIG. 171

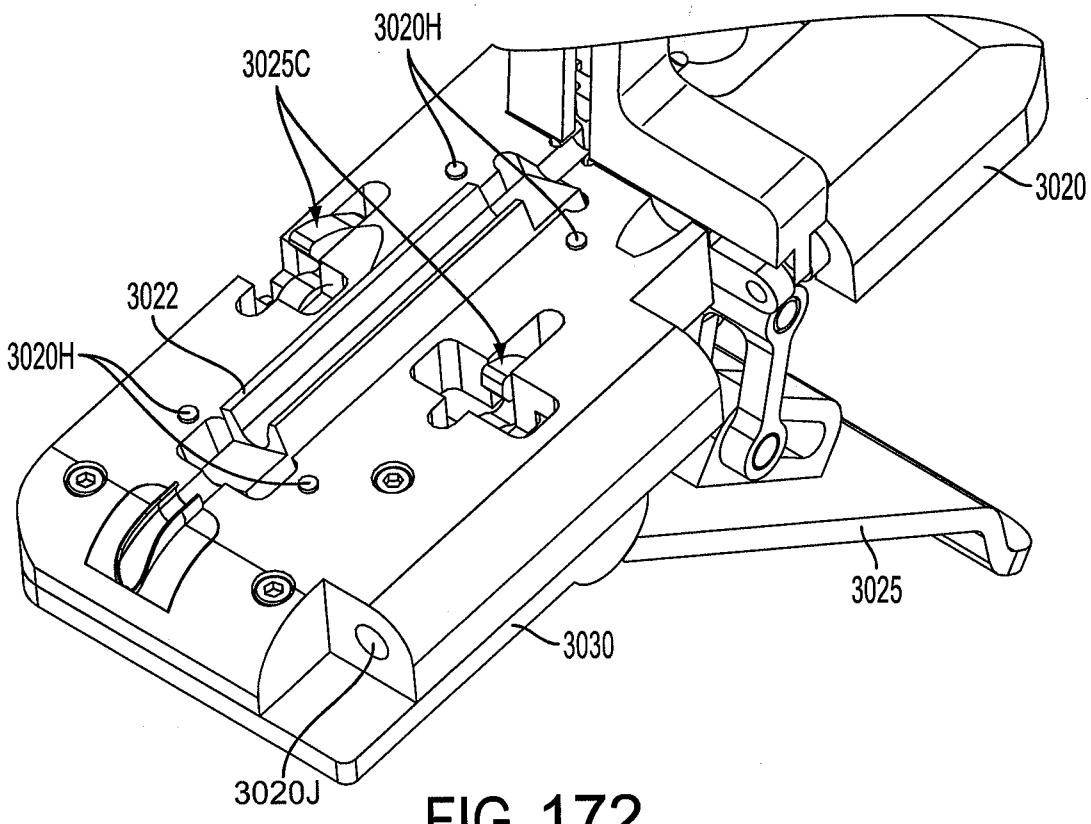


FIG. 172

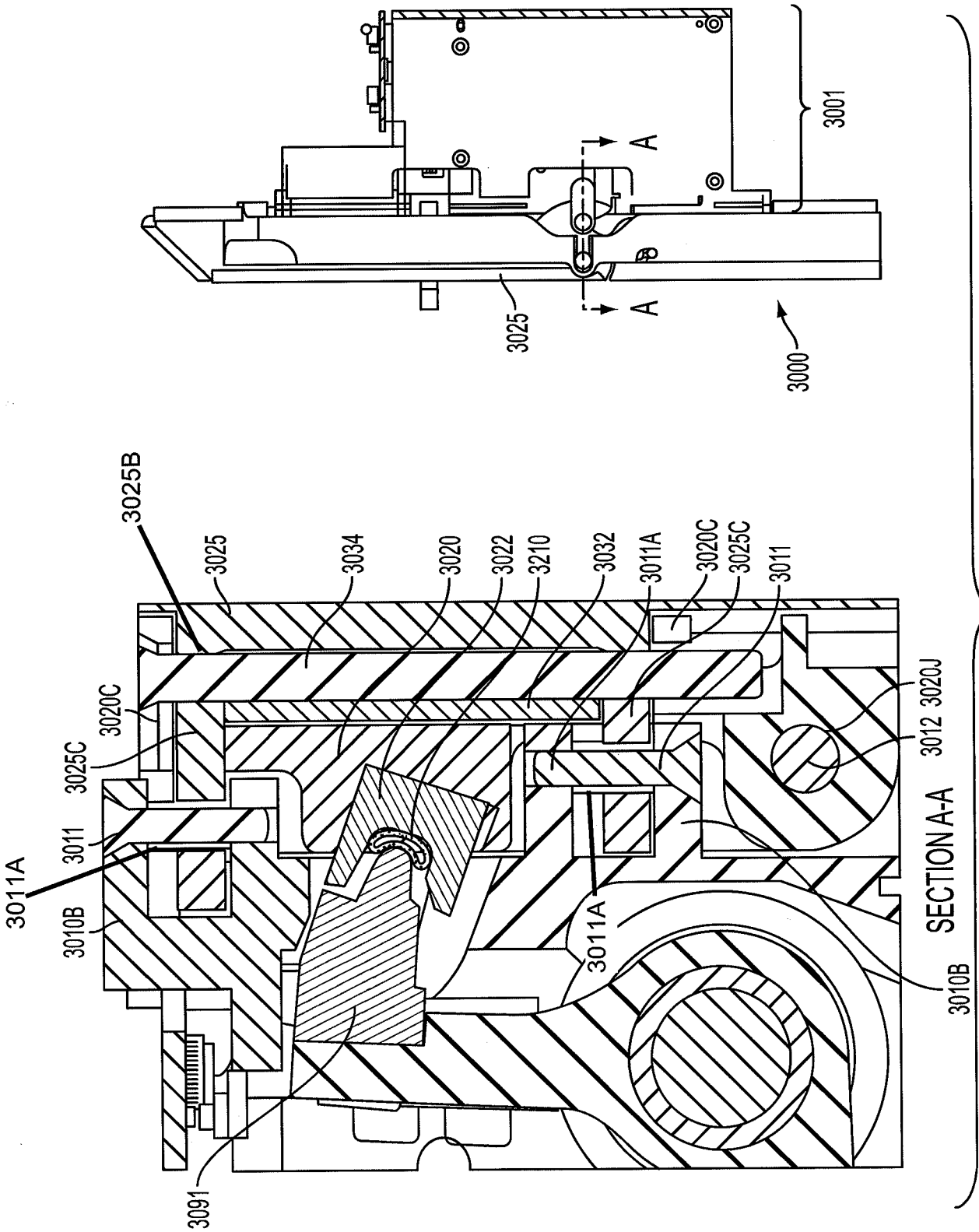

3001
A
A
3025
3000
3025B
3025
3034
3020
3022
3210
3032
3011A
3020C
3025C
3011
3020C
3025C
3011
3011A
3010B
3091
3011A
3012 3020J
SECTION A-A
3010B

FIG. 173

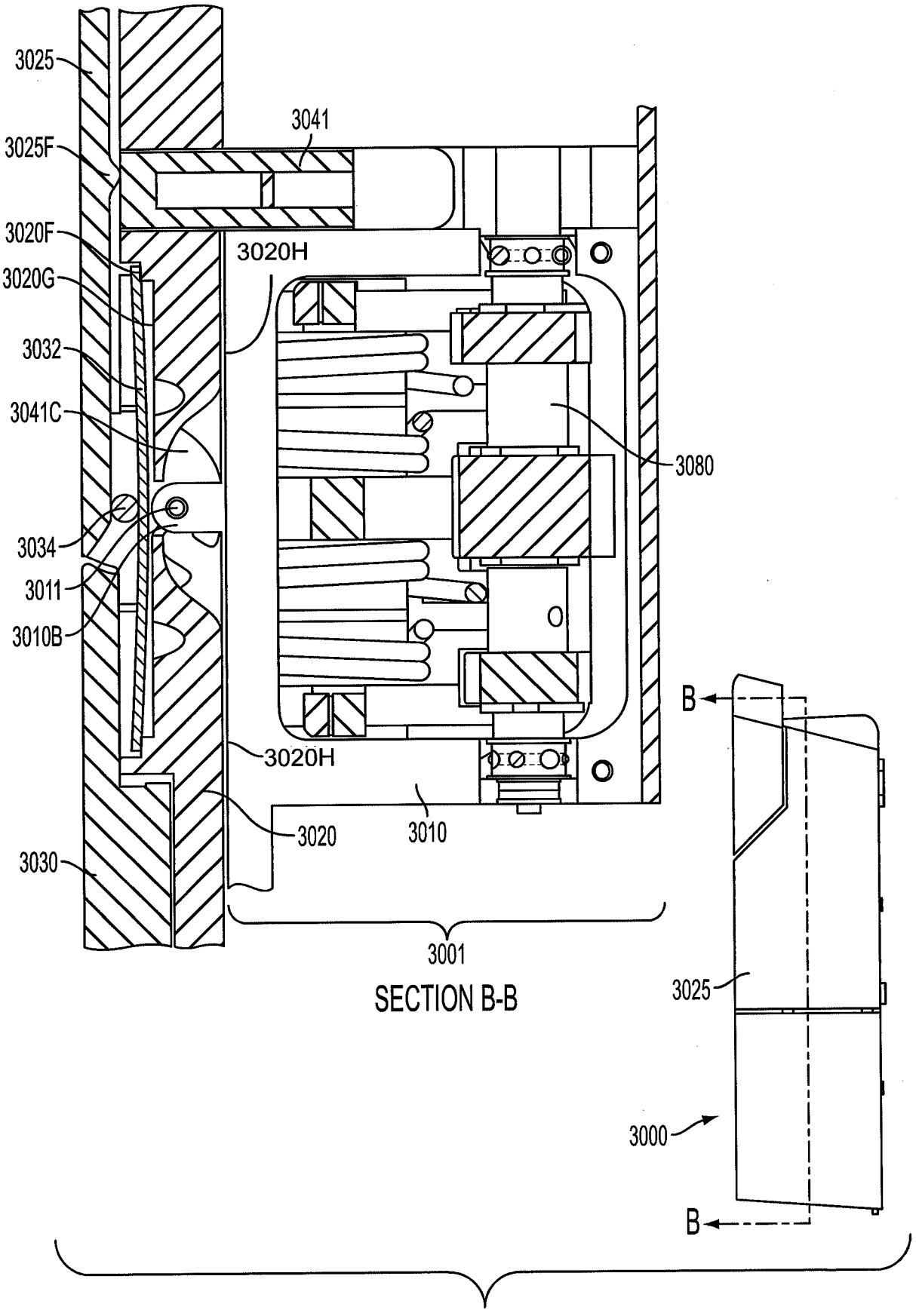

3025
3041
3025F
3020F
3020H
3020G
3032
3041C
3080
3034
3011
3010B
3020H
3020
3010
3030
3001
SECTION B-B
B
3025
3000
B

FIG. 174

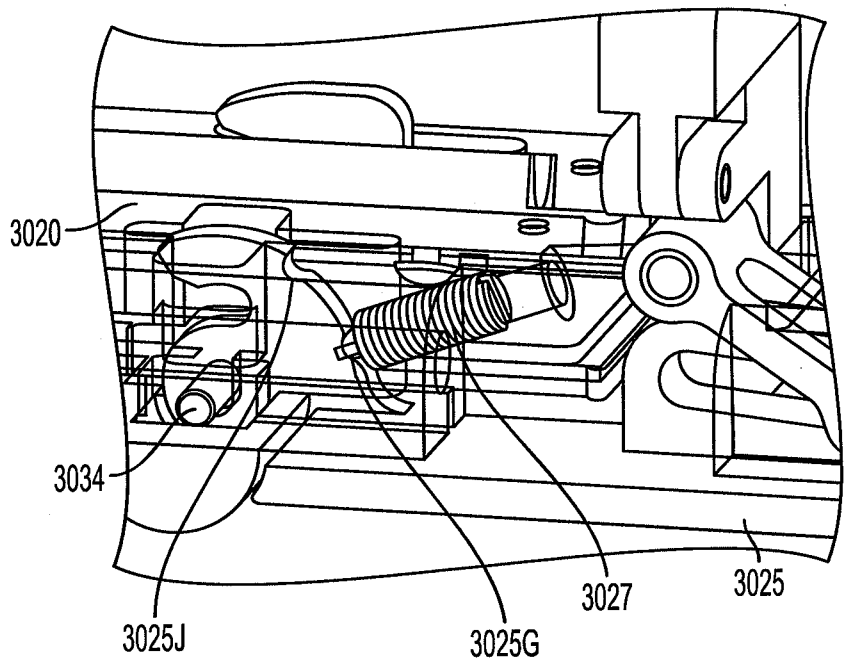


FIG. 175

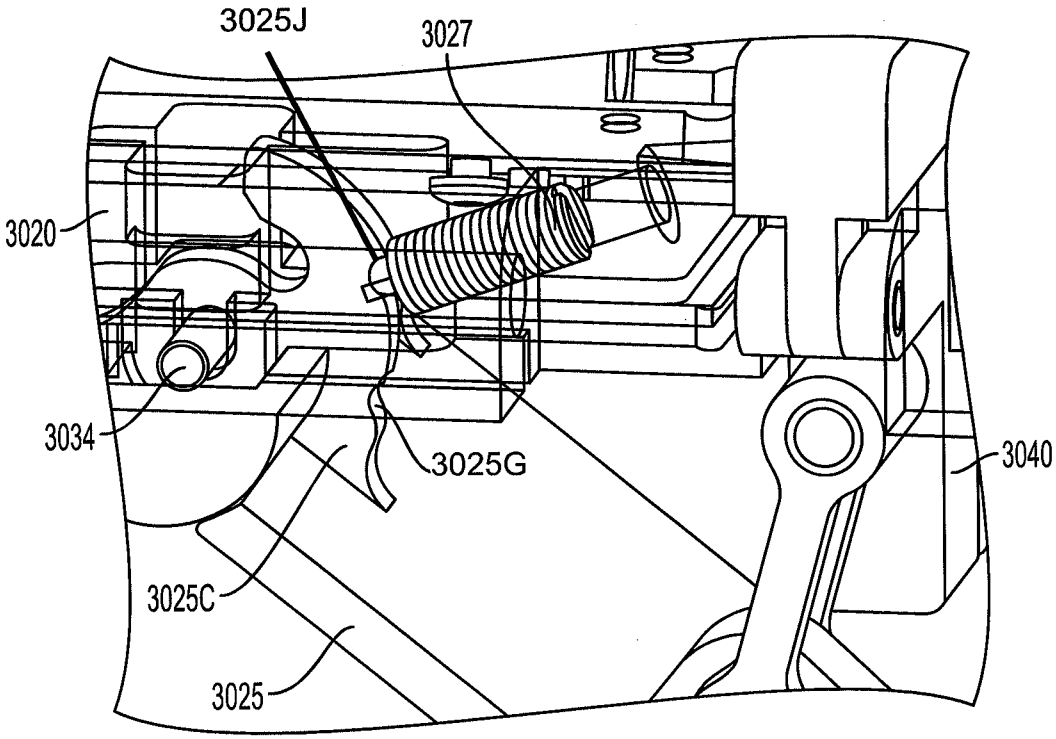


FIG. 176

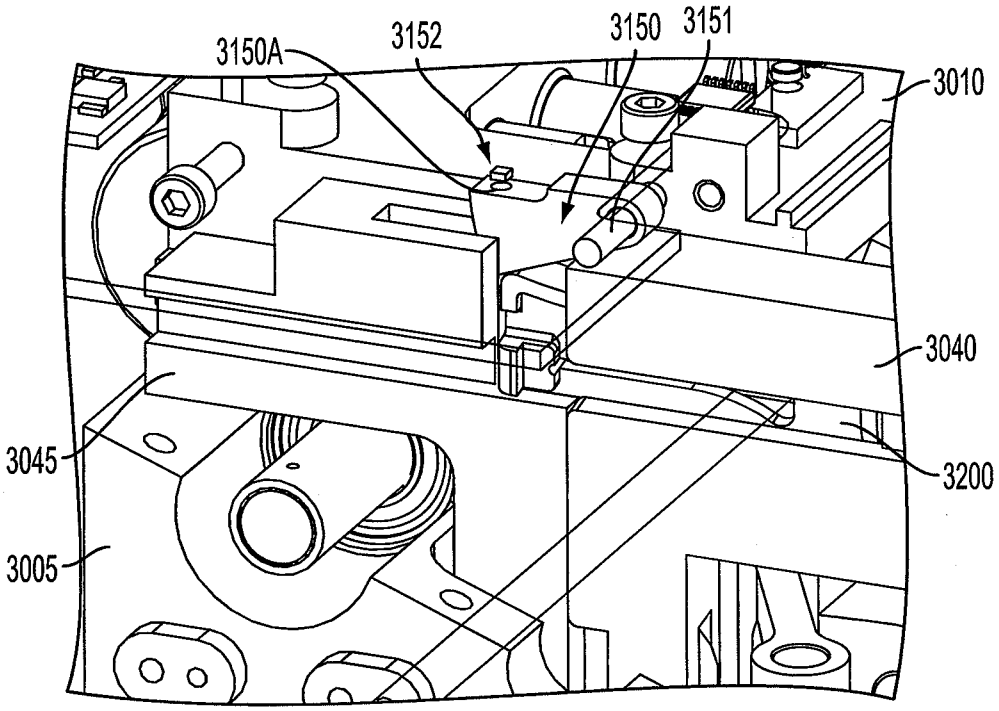


FIG. 177

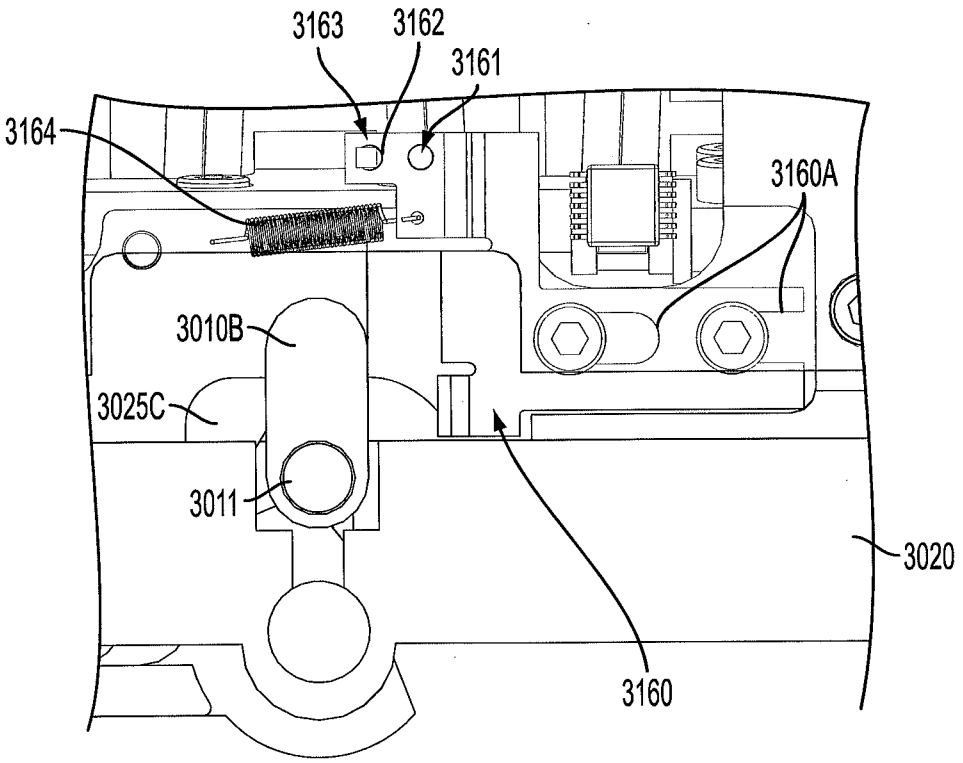


FIG. 178

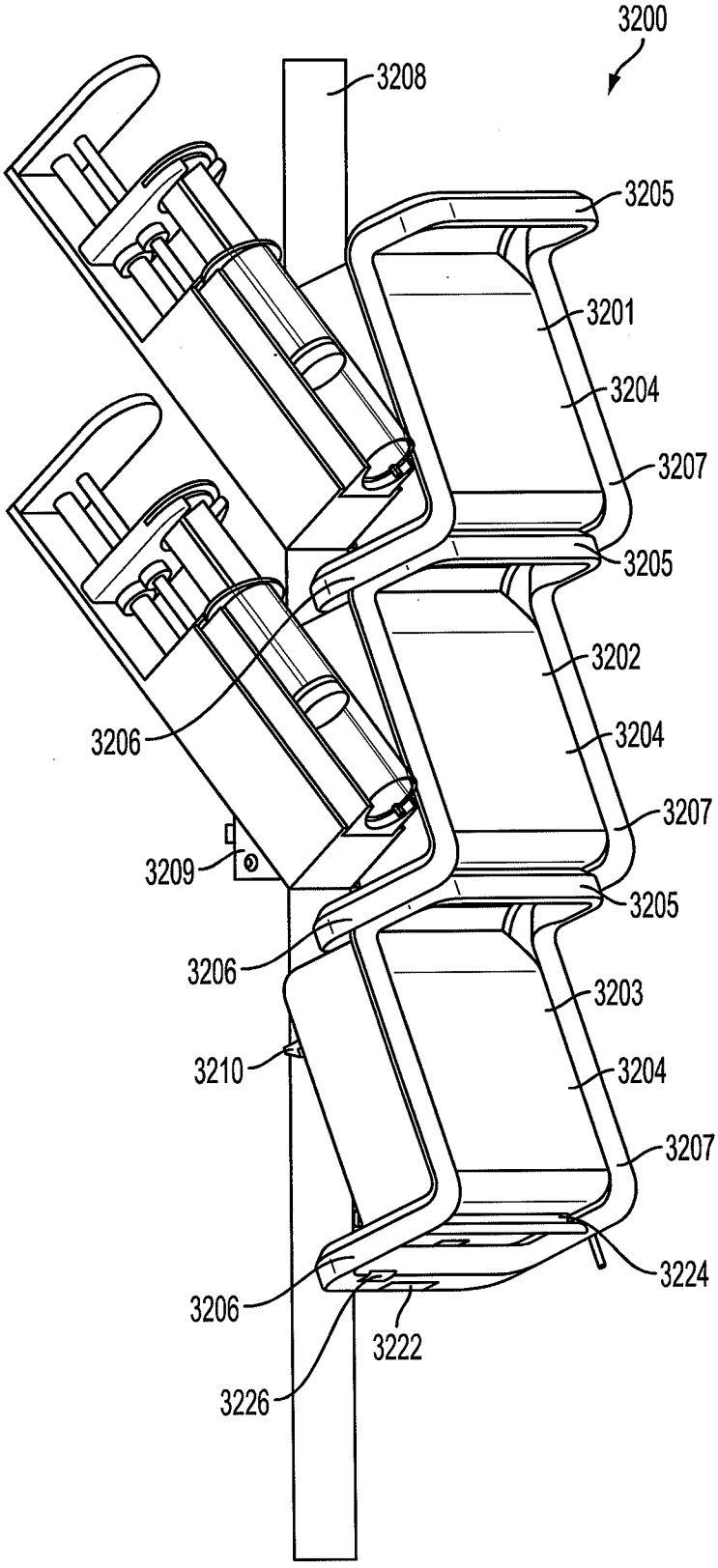

3200
3208
3205
3201
3204
3207
3205
3202
3204
3207
3205
3203
3204
3207
3224
3222
3226
3206
3206
3206
3209
3210

FIG. 179

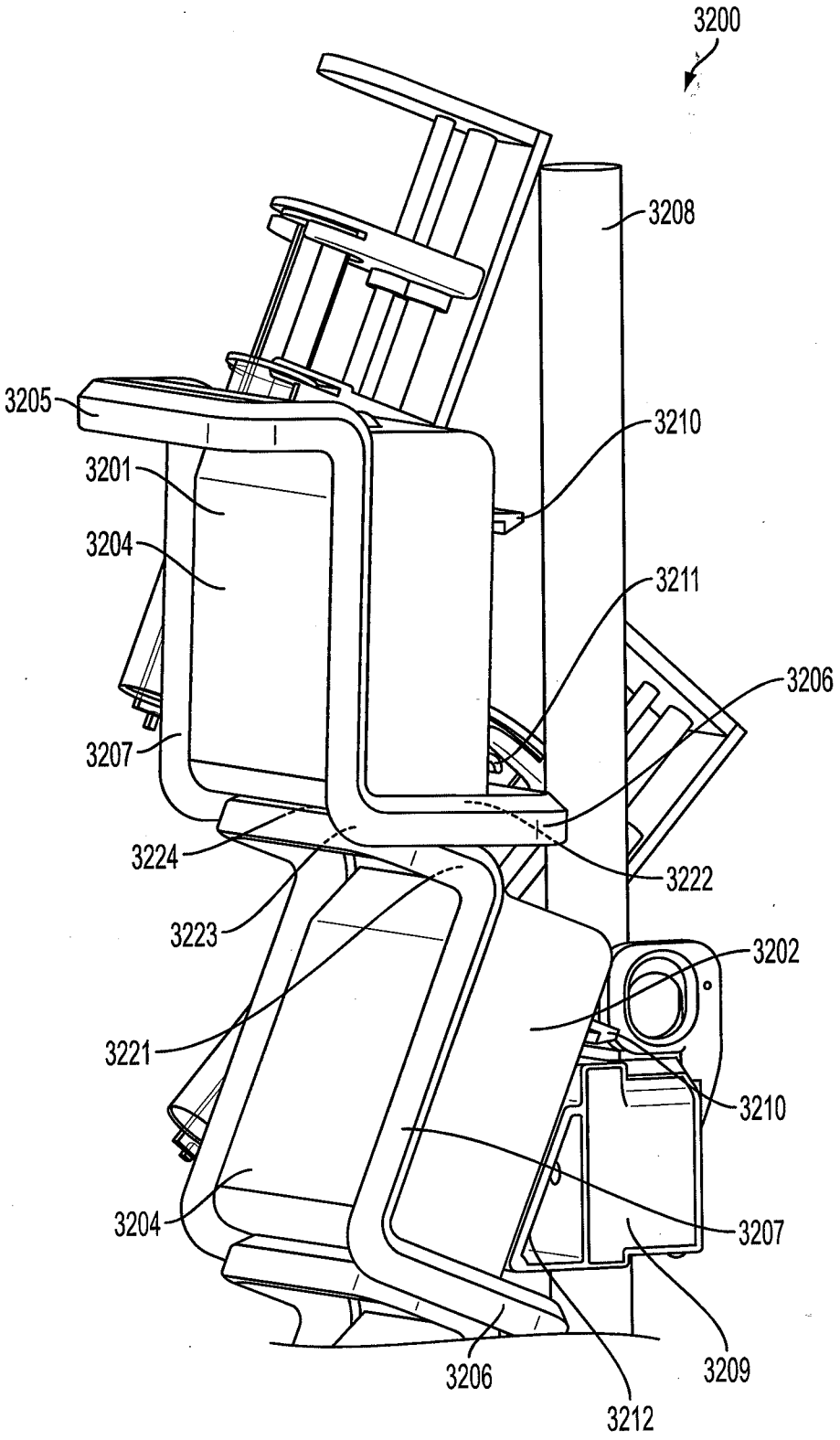

3200
3208
3205
3210
3201
3204
3211
3206
3207
3224
3222
3223
3202
3221
3210
3204
3207
3206
3209
3212

FIG.180

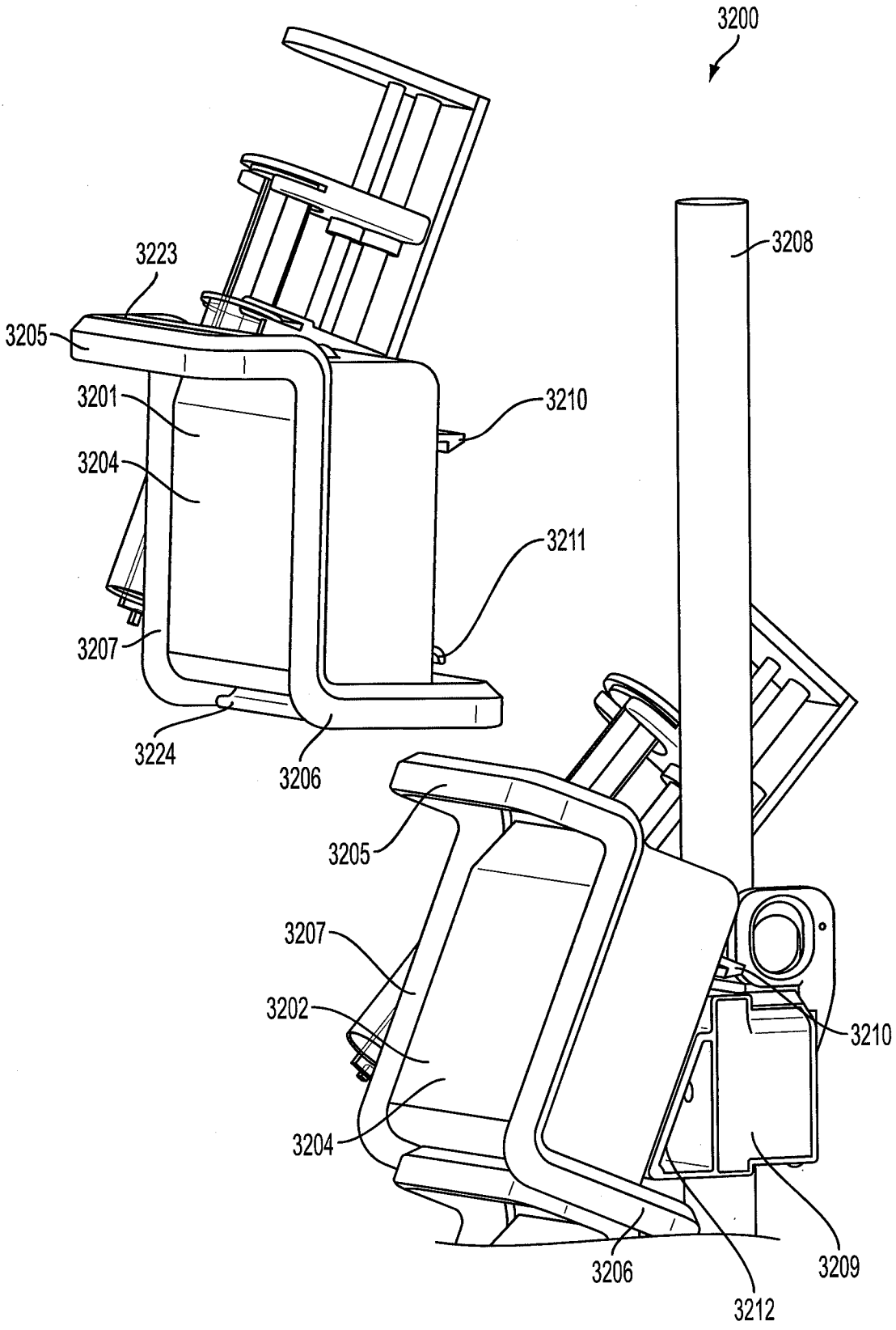

3200
3223
3205
3201
3204
3207
3224
3206
3210
3211
3208
3205
3207
3202
3204
3206
3212
3209
3210

FIG. 181

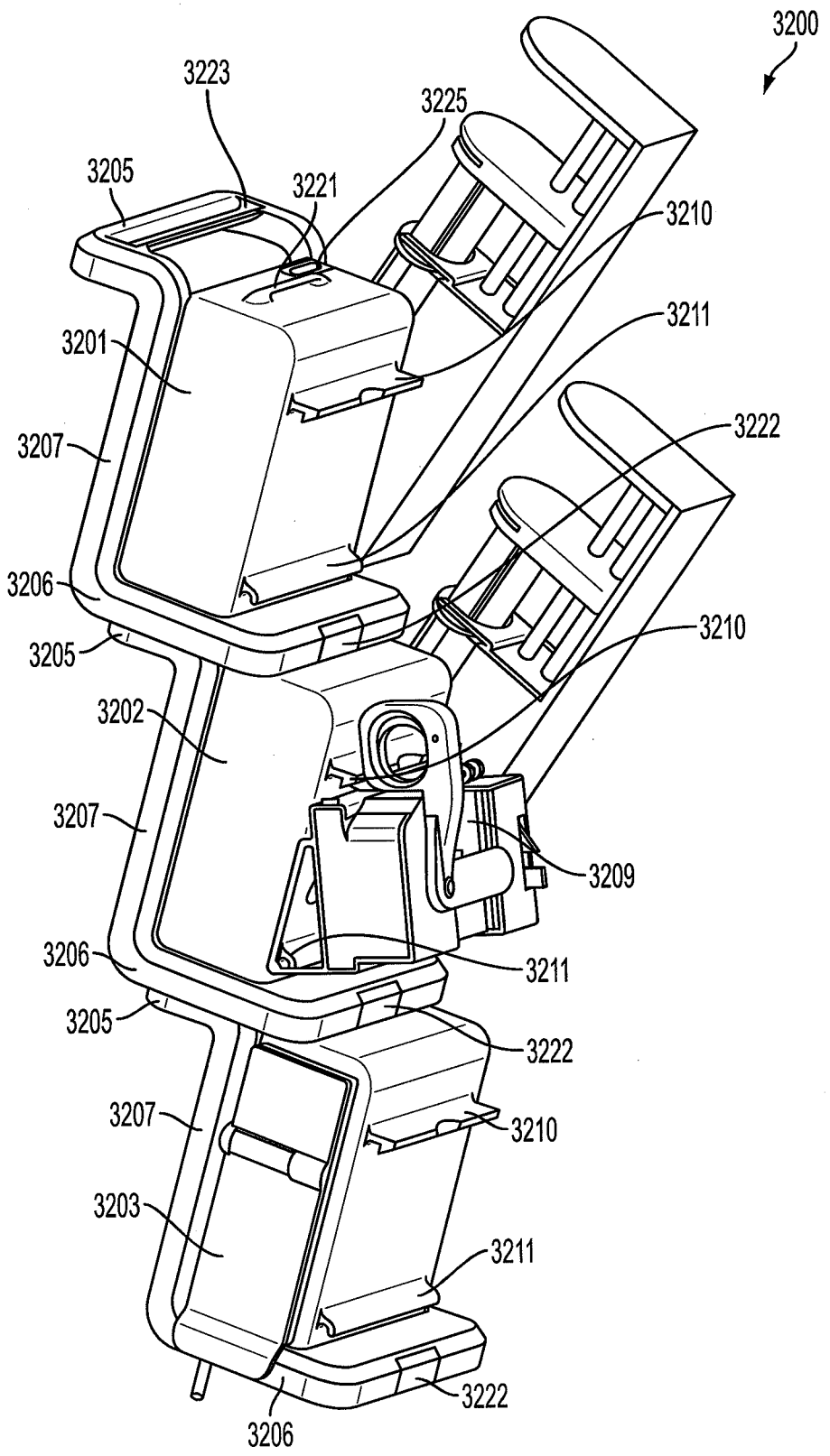

3200
3223
3225
3205
3221
3210
3211
3201
3222
3207
3206
3210
3205
3202
3207
3209
3206
3211
3205
3222
3207
3210
3203
3211
3222
3206

FIG. 182

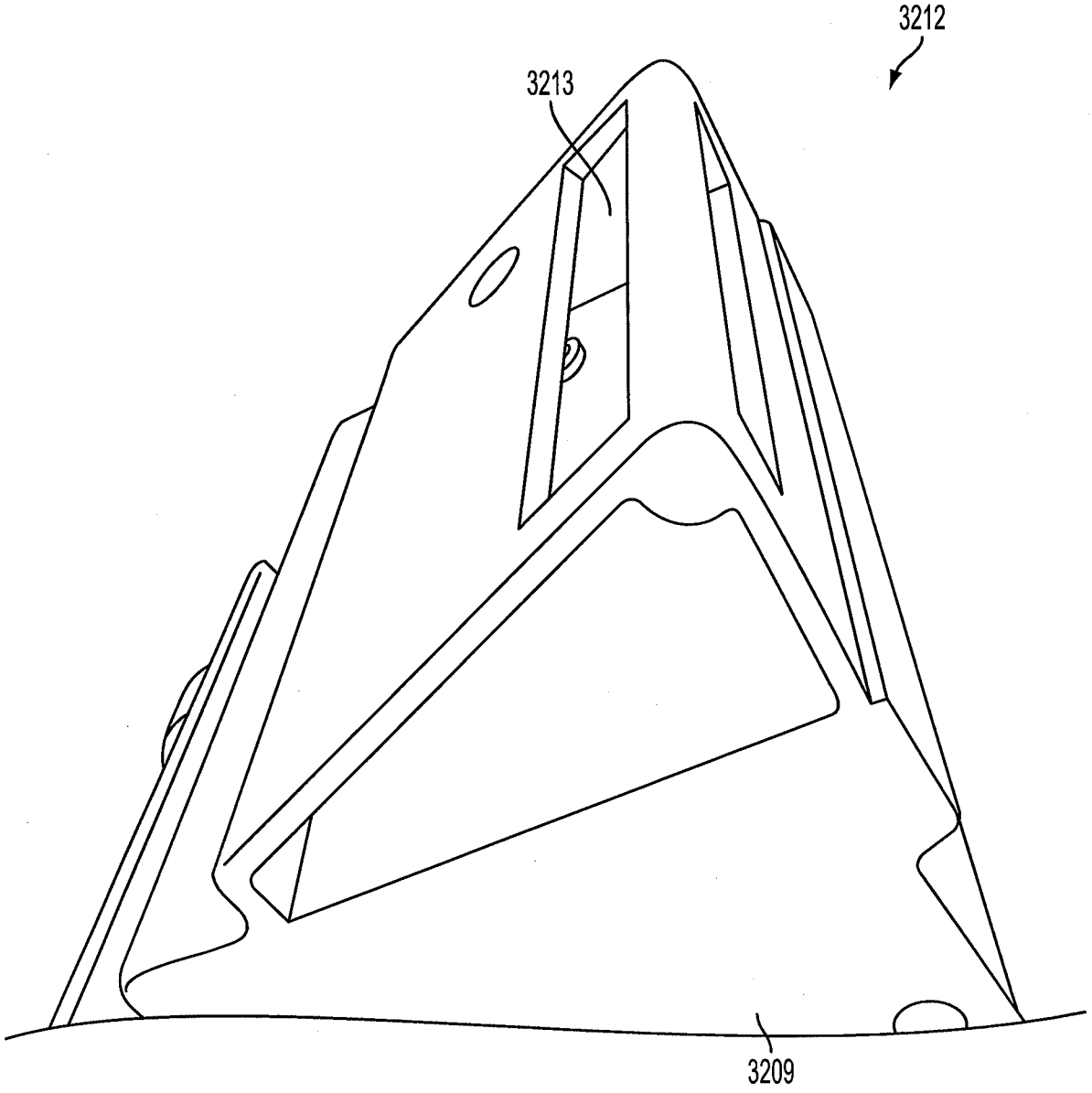


FIG. 183

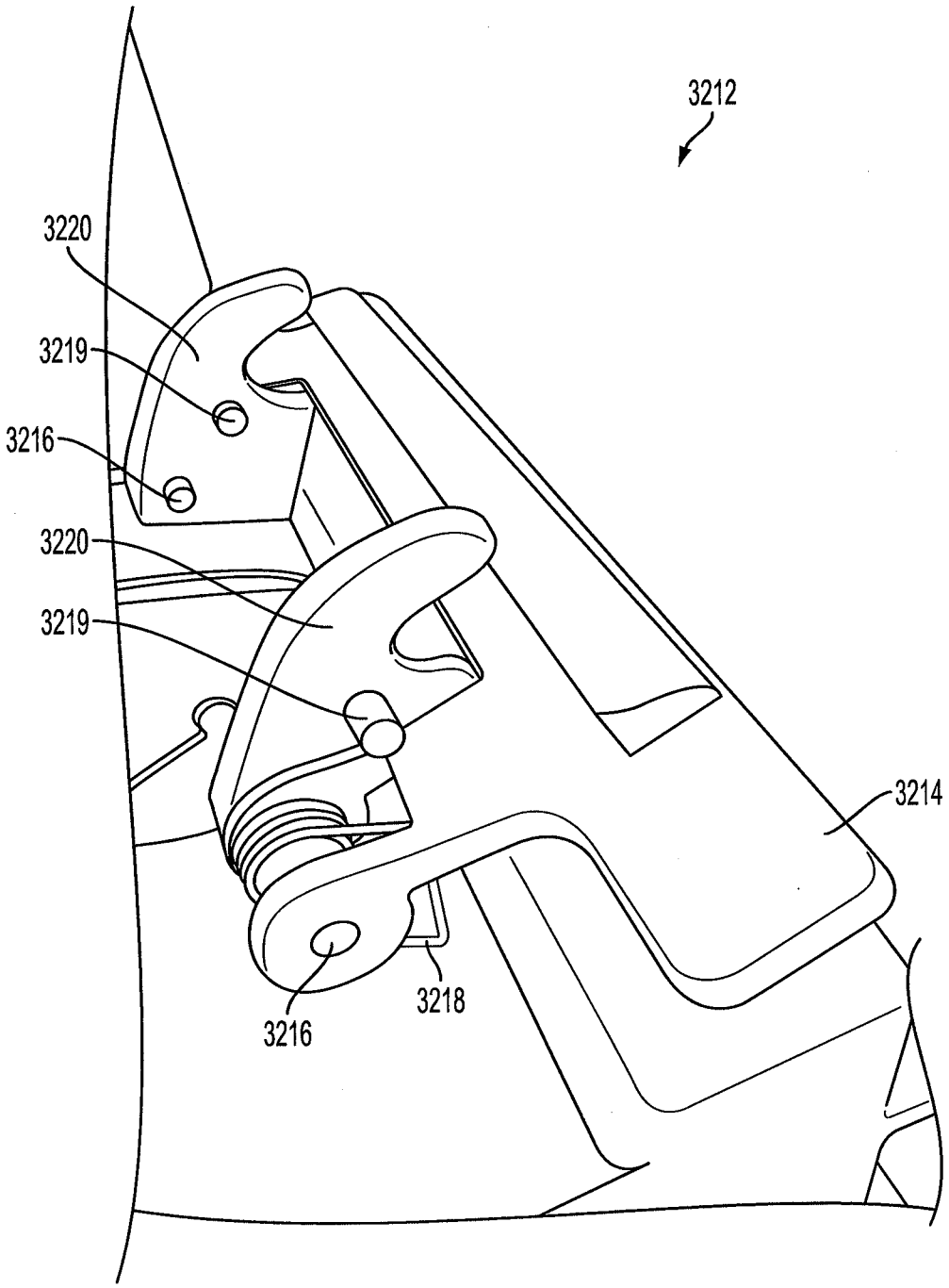


FIG. 184

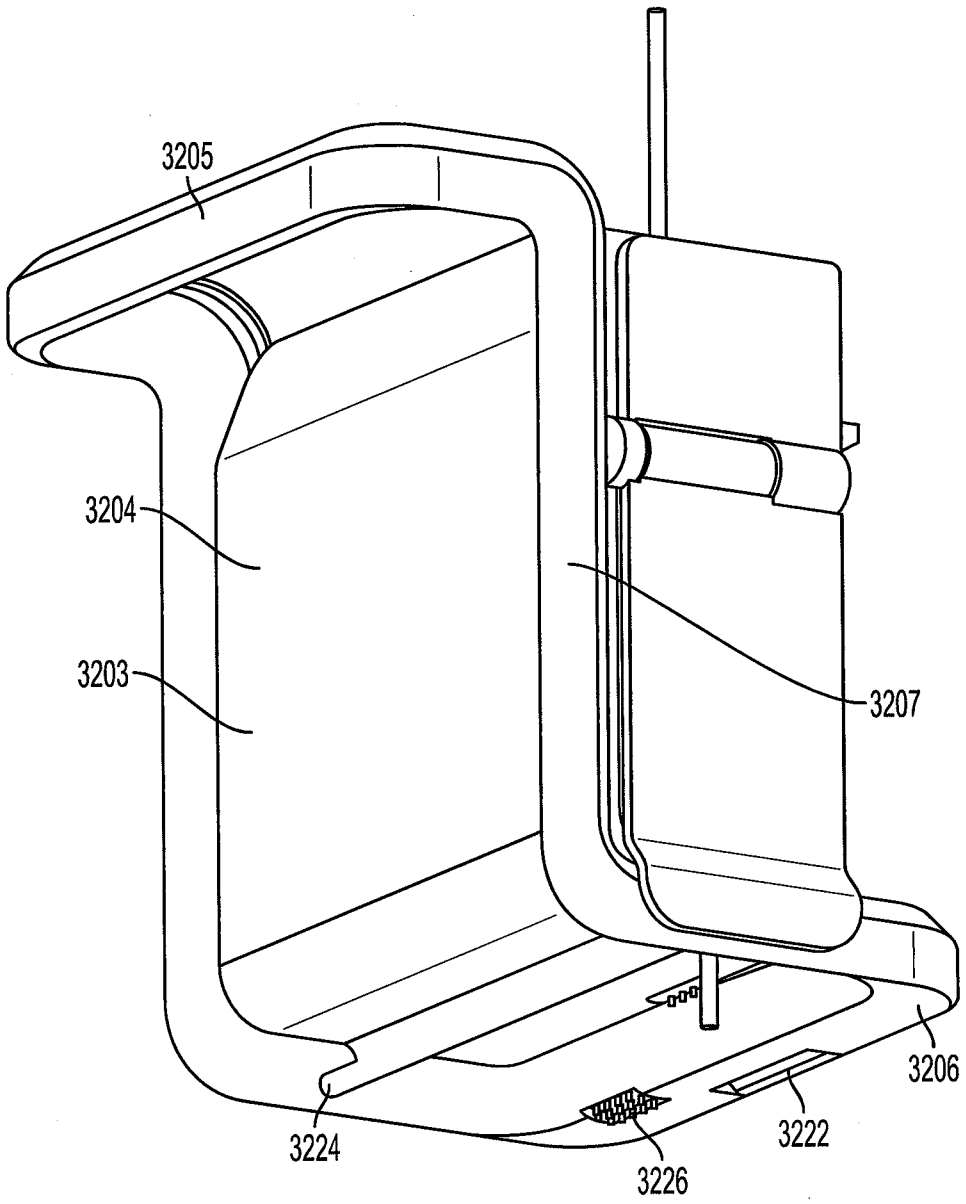


FIG. 185

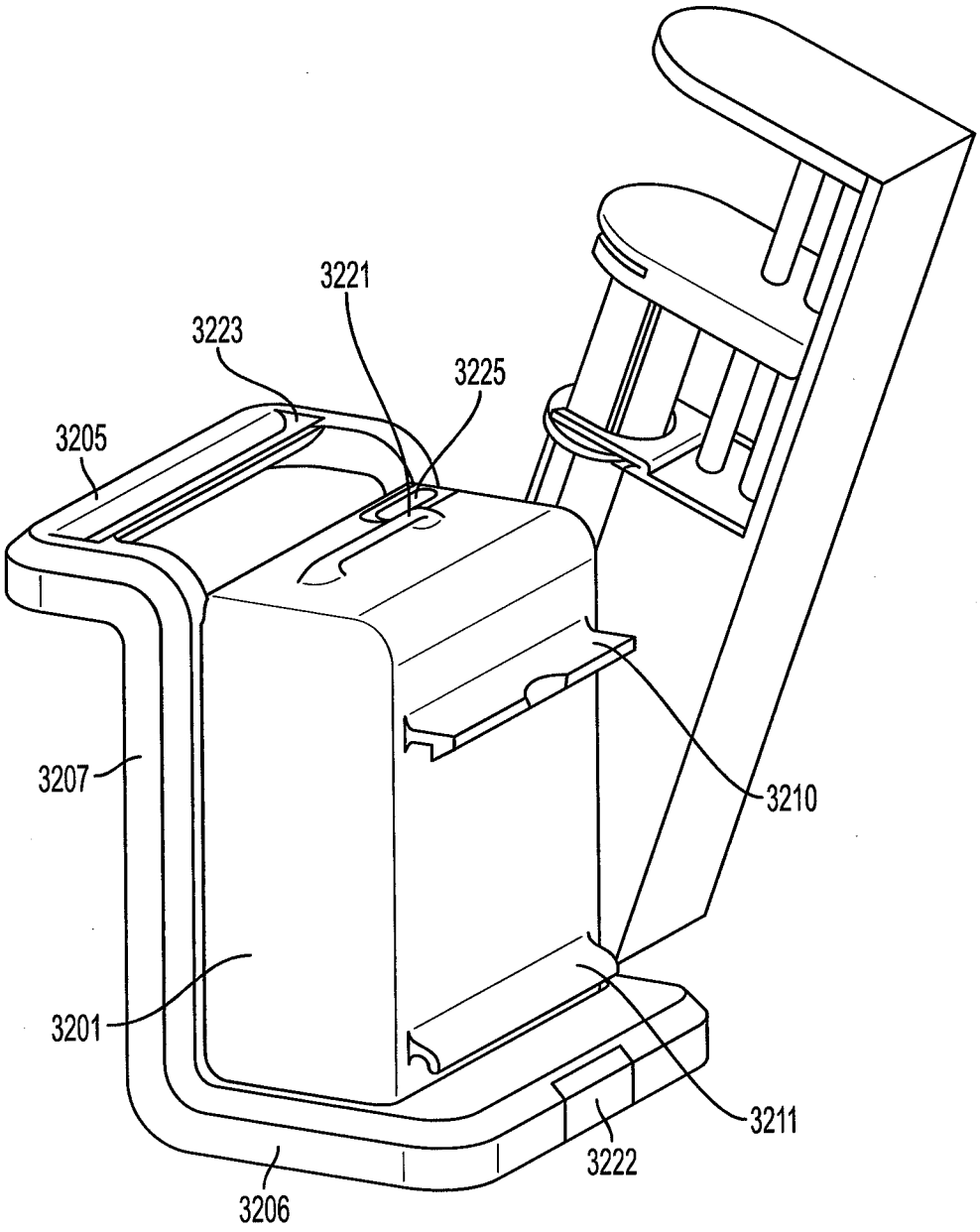


FIG. 186

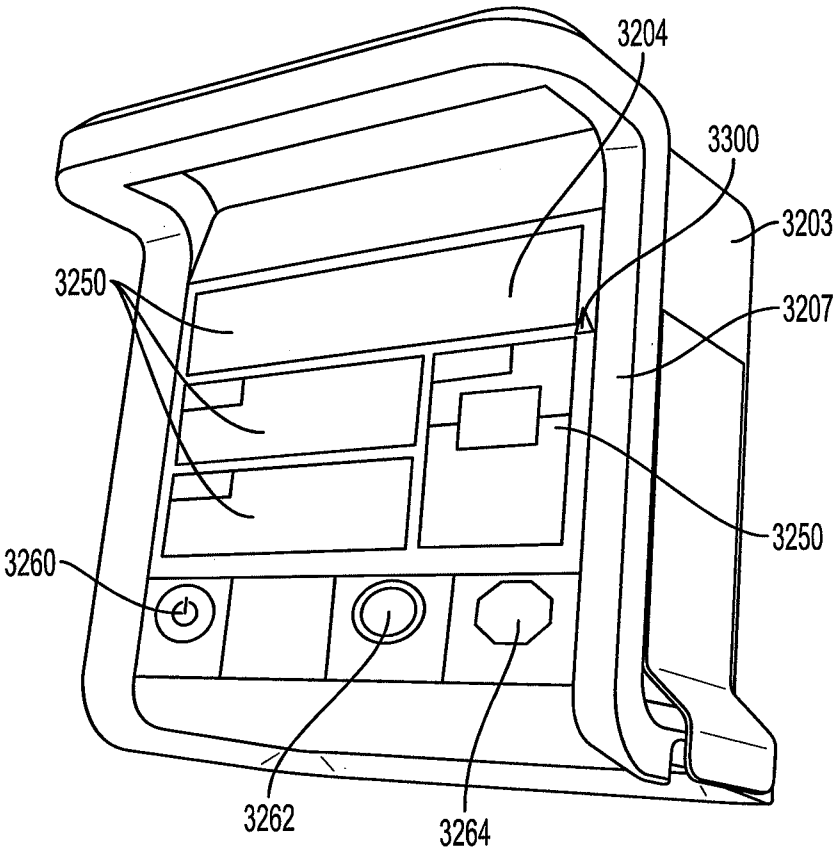


FIG. 187

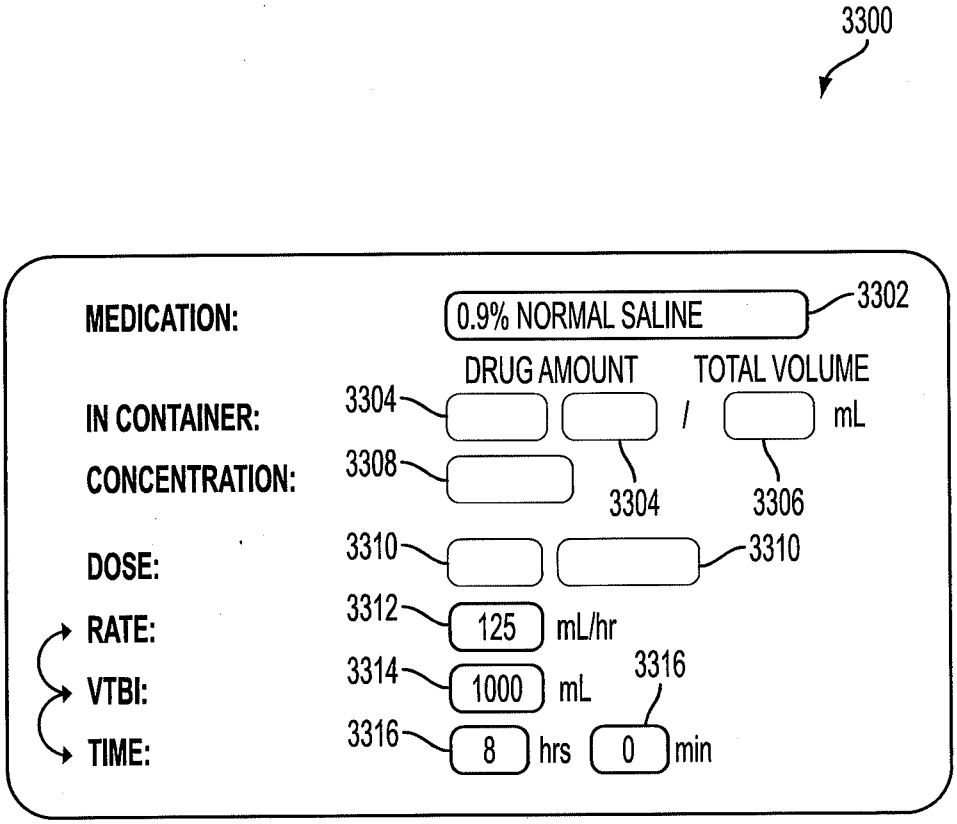

3300
MEDICATION:
0.9% NORMAL SALINE
3302
DRUG AMOUNT
TOTAL VOLUME
IN CONTAINER:
3304
/
mL
CONCENTRATION:
3308
3304
3306
DOSE:
3310
3310
RATE:
3312
125
mL/hr
VTBI:
3314
1000
mL
3316
TIME:
3316
8
hrs
0
min

FIG. 188

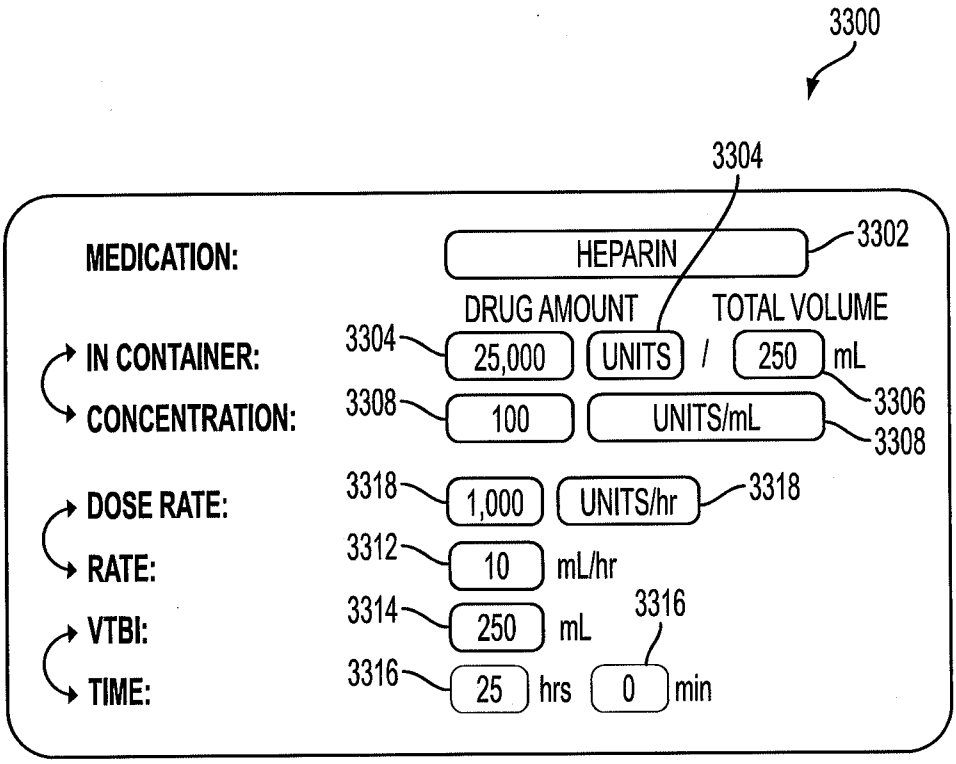

3300
3304
MEDICATION:
HEPARIN
3302
DRUG AMOUNT
TOTAL VOLUME
IN CONTAINER:
3304
25,000
UNITS
/
250
mL
3306
CONCENTRATION:
3308
100
UNITS/mL
3308
DOSE RATE:
3318
1,000
UNITS/hr
3318
RATE:
3312
10
mL/hr
VTBI:
3314
250
mL
3316
TIME:
3316
25
hrs
0
min

FIG. 189

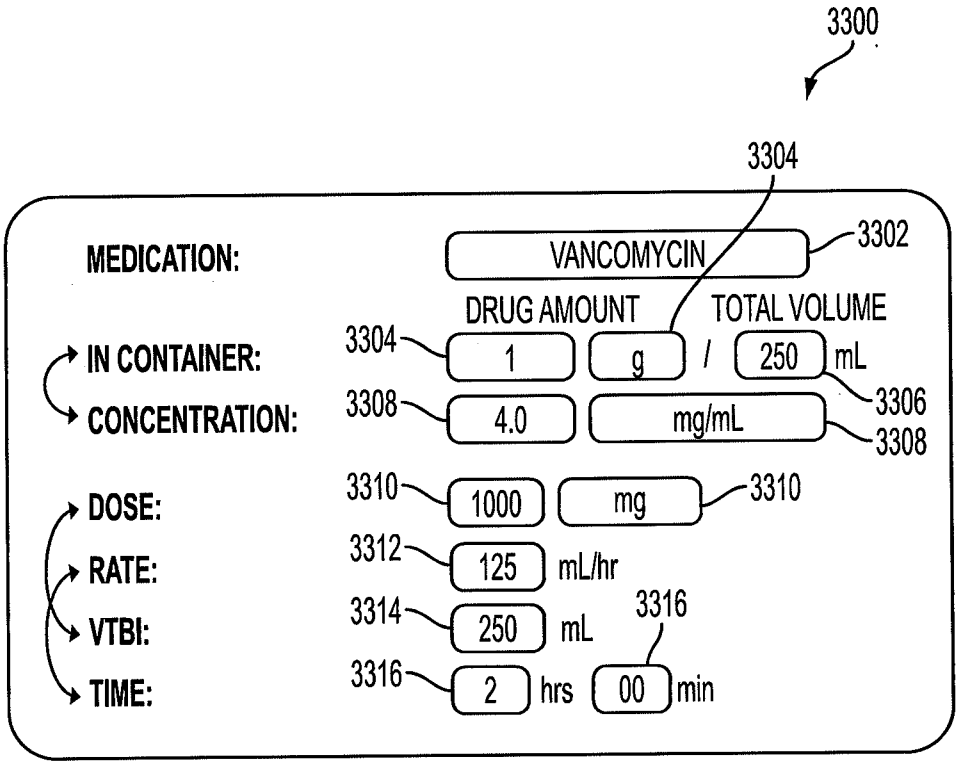

3300
3304
MEDICATION:
VANCOMYCIN
3302
DRUG AMOUNT
TOTAL VOLUME
IN CONTAINER:
3304
1
g
/
250
mL
3306
CONCENTRATION:
3308
4.0
mg/mL
3308
DOSE:
3310
1000
mg
3310
RATE:
3312
125
mL/hr
VTBI:
3314
250
mL
3316
TIME:
3316
2
hrs
00
min

FIG. 190

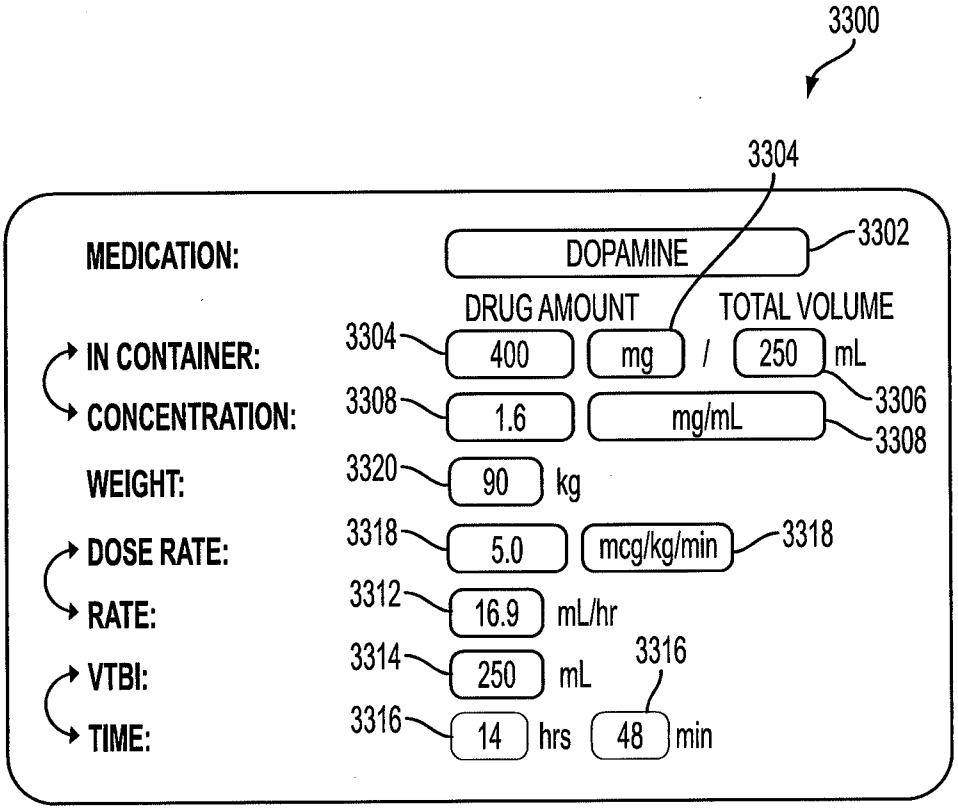

3300
3304
MEDICATION:
DOPAMINE
3302
DRUG AMOUNT
TOTAL VOLUME
IN CONTAINER:
3304
400
mg
/
250
mL
CONCENTRATION:
3308
1.6
mg/mL
3306
3308
WEIGHT:
3320
90
kg
DOSE RATE:
3318
5.0
mcg/kg/min
3318
RATE:
3312
16.9
mL/hr
VTBI:
3314
250
mL
3316
TIME:
3316
14
hrs
48
min

FIG. 191

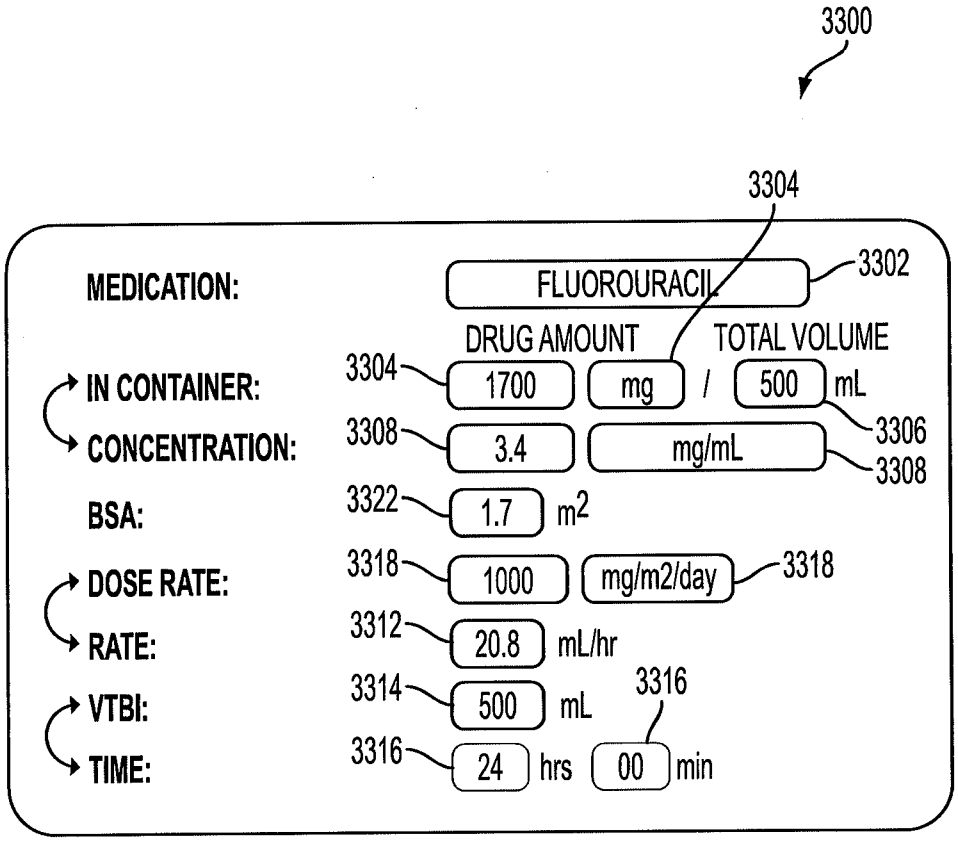

3300
3304
MEDICATION:
FLUOROURACIL
3302
DRUG AMOUNT
TOTAL VOLUME
IN CONTAINER:
3304
1700
mg
/
500
mL
3306
CONCENTRATION:
3308
3.4
mg/mL
3308
BSA:
3322
1.7
m2
DOSE RATE:
3318
1000
mg/m2/day
3318
RATE:
3312
20.8
mL/hr
VTBI:
3314
500
mL
3316
TIME:
3316
24
hrs
00
min

FIG. 192

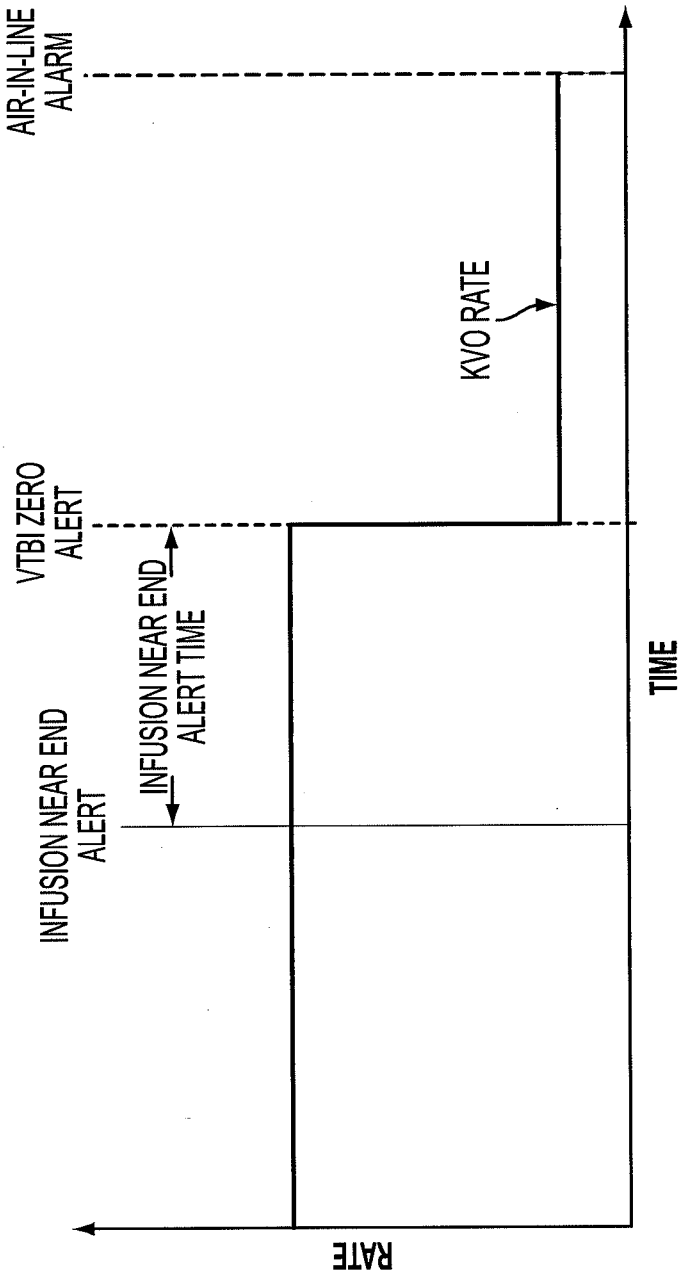

AIR-IN-LINE ALARM
KVO RATE
VTBI ZERO ALERT
INFUSION NEAR END ALERT TIME
INFUSION NEAR END ALERT
TIME
RATE

FIG. 193

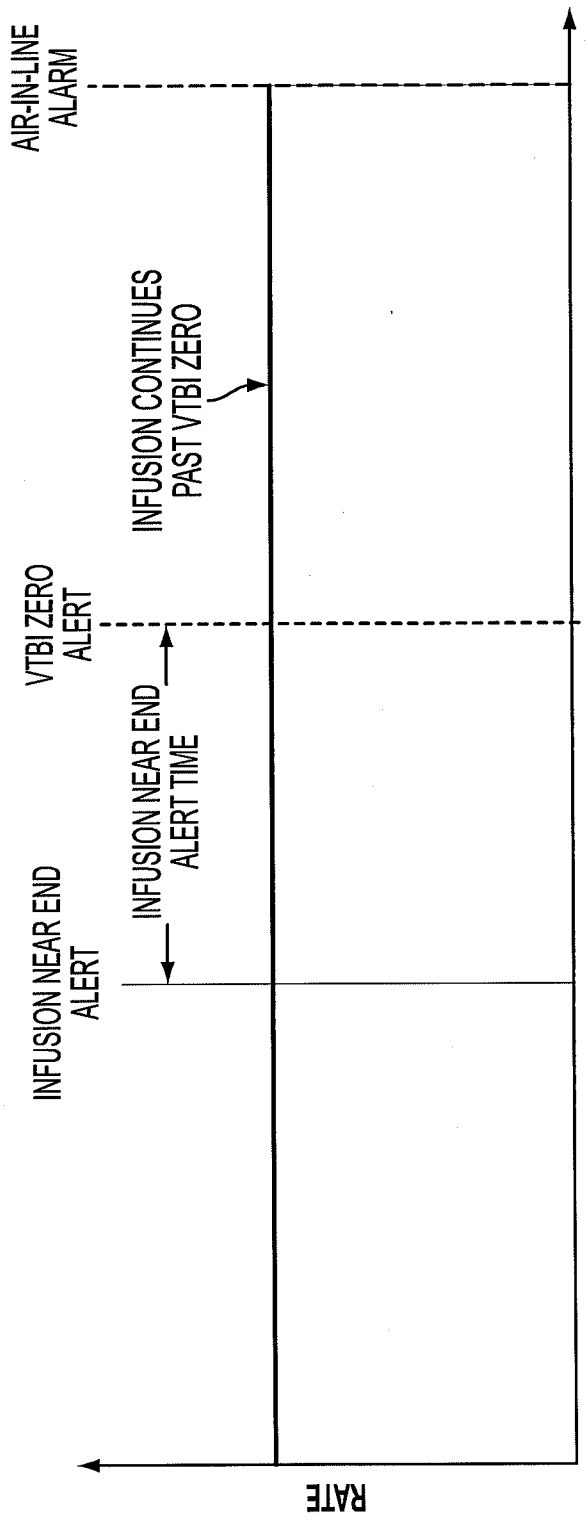

AIR-IN-LINE ALARM
INFUSION CONTINUES PAST VTBI ZERO
VTBI ZERO ALERT
INFUSION NEAR END ALERT TIME
INFUSION NEAR END ALERT
TIME
RATE

FIG. 194

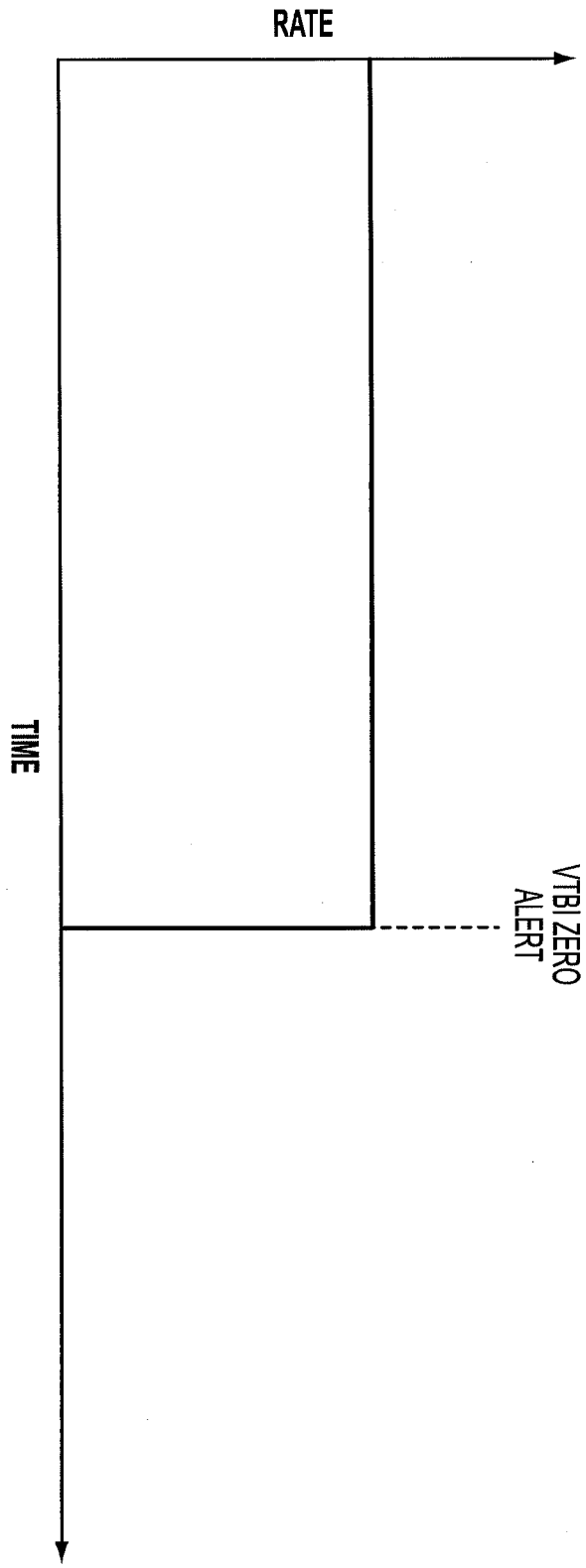


FIG. 195

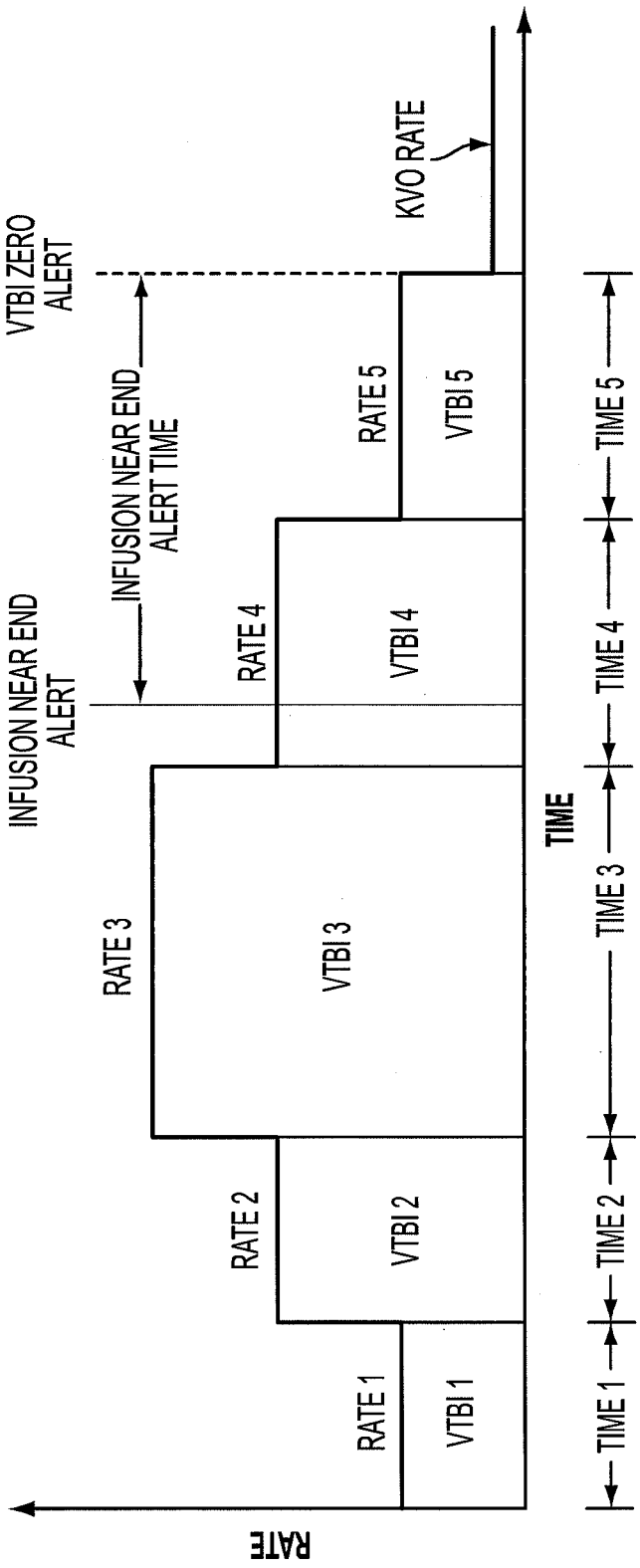

RATE
TIME
RATE 1
VTBI 1
RATE 2
VTBI 2
RATE 3
VTBI 3
RATE 4
VTBI 4
RATE 5
VTBI 5
KVO RATE
VTBI ZERO ALERT
INFUSION NEAR END ALERT TIME
INFUSION NEAR END ALERT
TIME 1
TIME 2
TIME 3
TIME 4
TIME 5

FIG. 196

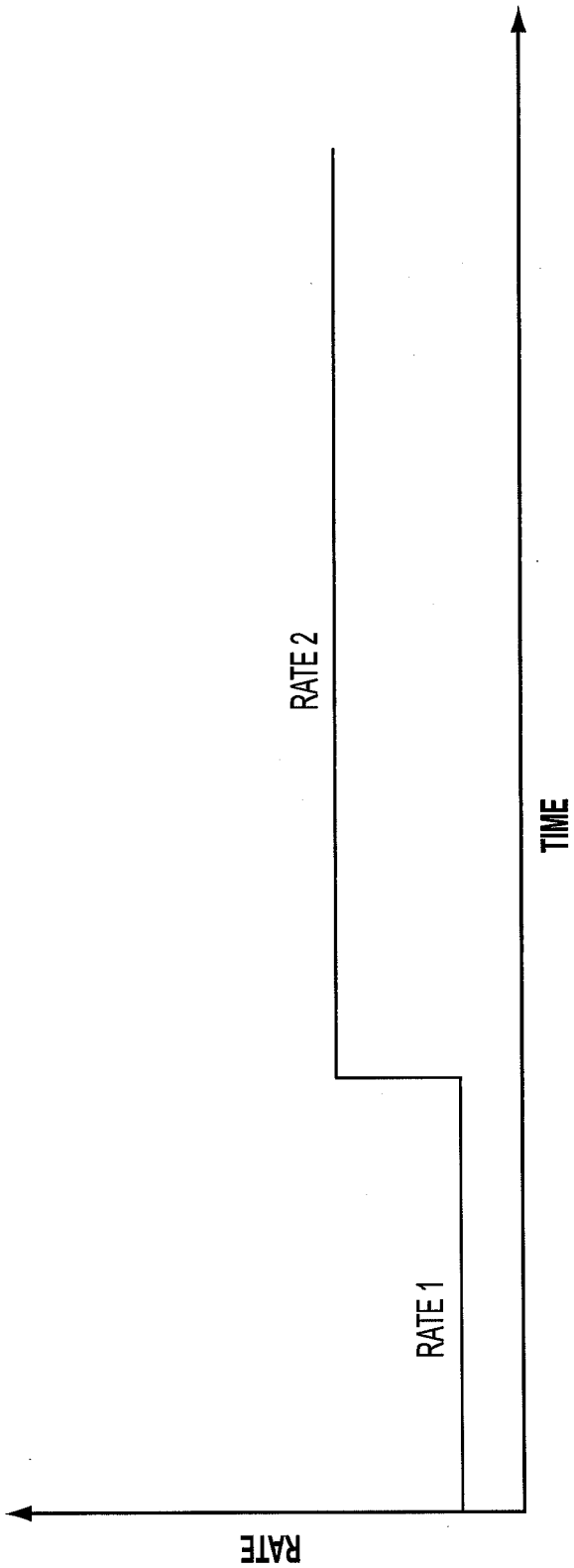


FIG. 197

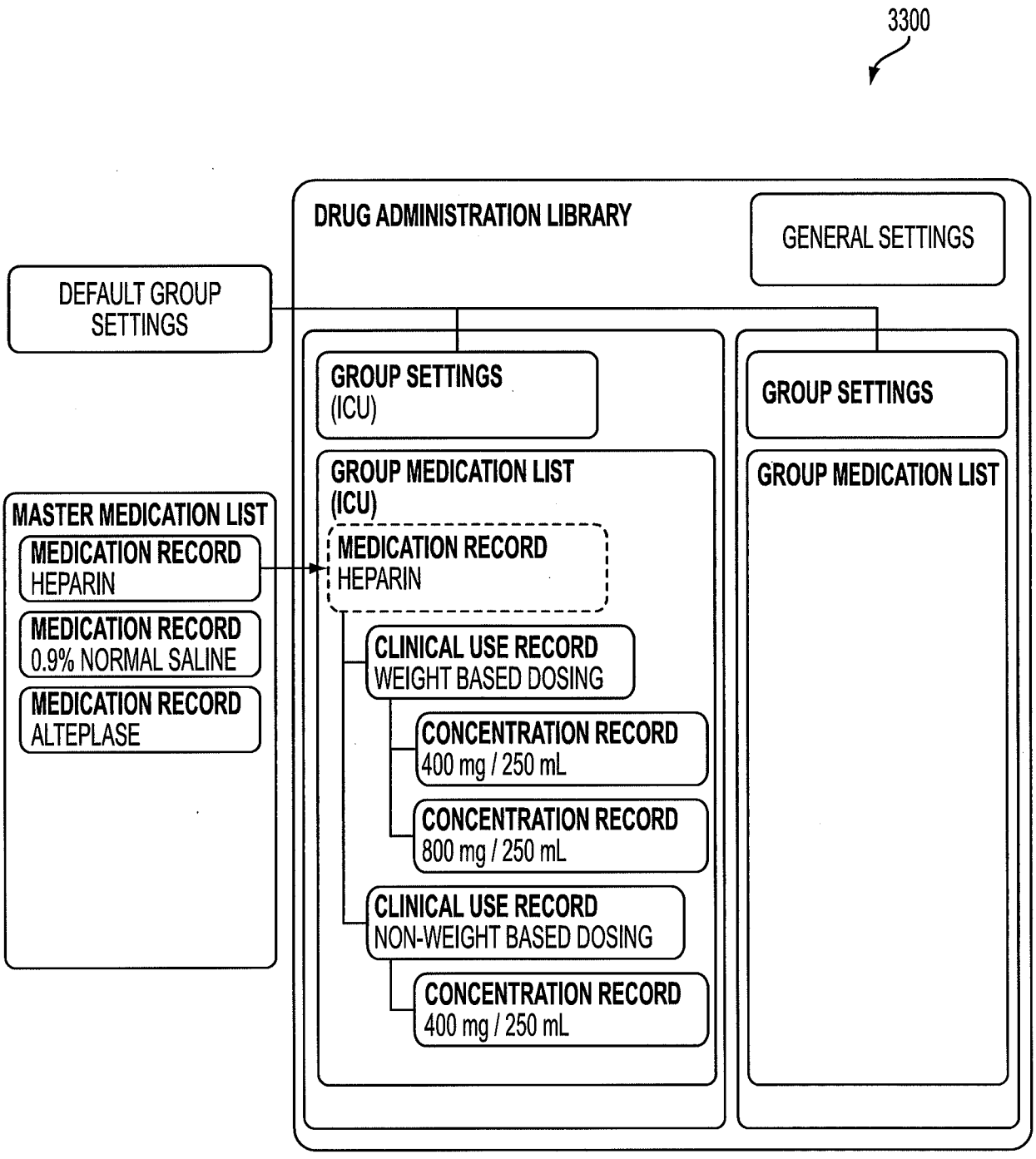

3300
DRUG ADMINISTRATION LIBRARY
GENERAL SETTINGS
DEFAULT GROUP SETTINGS
GROUP SETTINGS (ICU)
GROUP SETTINGS
GROUP MEDICATION LIST (ICU)
GROUP MEDICATION LIST
MASTER MEDICATION LIST
MEDICATION RECORD HEPARIN
MEDICATION RECORD 0.9% NORMAL SALINE
MEDICATION RECORD ALTEPLASE
MEDICATION RECORD HEPARIN
CLINICAL USE RECORD WEIGHT BASED DOSING
CONCENTRATION RECORD 400 mg / 250 mL
CONCENTRATION RECORD 800 mg / 250 mL
CLINICAL USE RECORD NON-WEIGHT BASED DOSING
CONCENTRATION RECORD 400 mg / 250 mL

FIG. 198

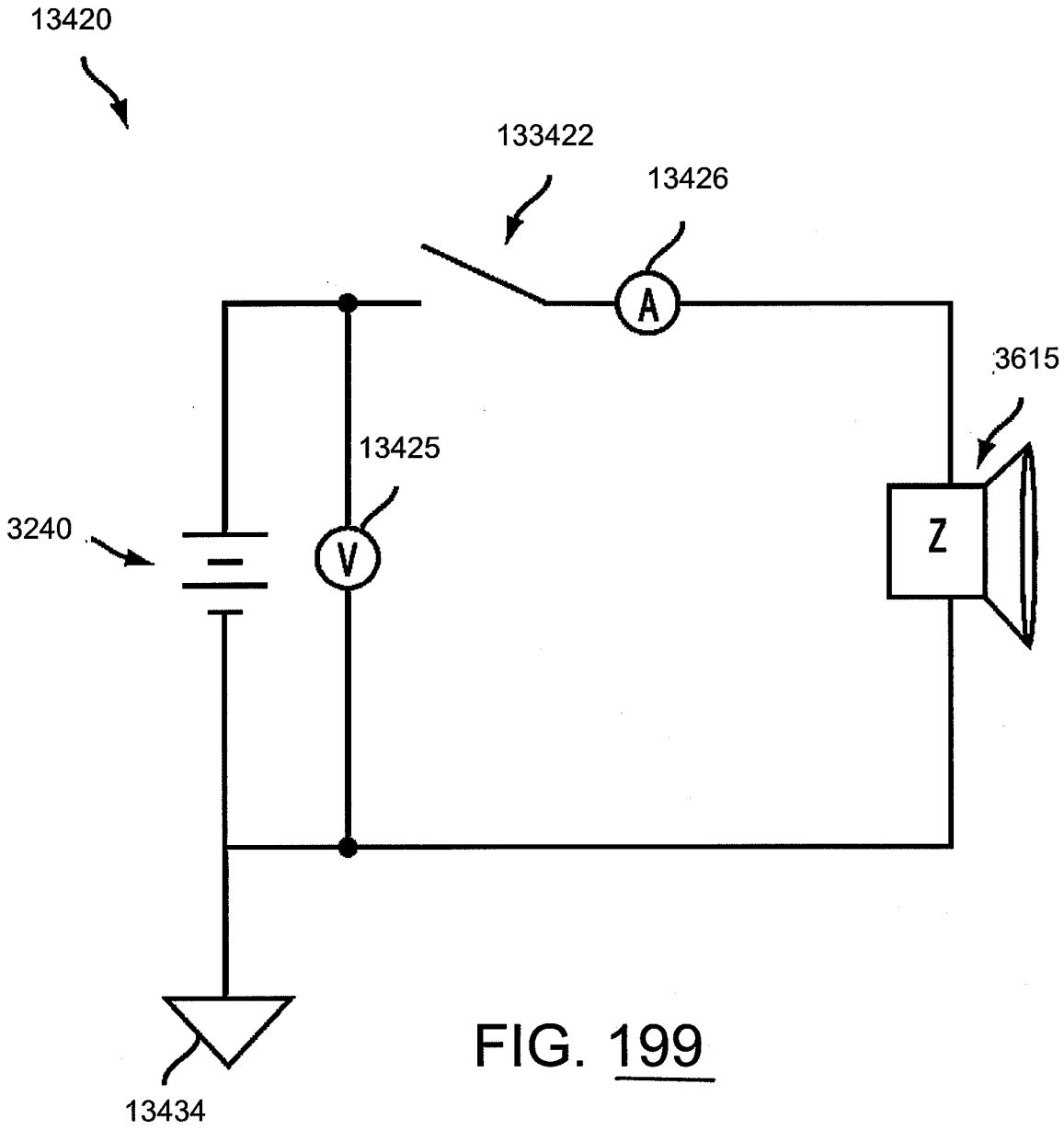


FIG. 199

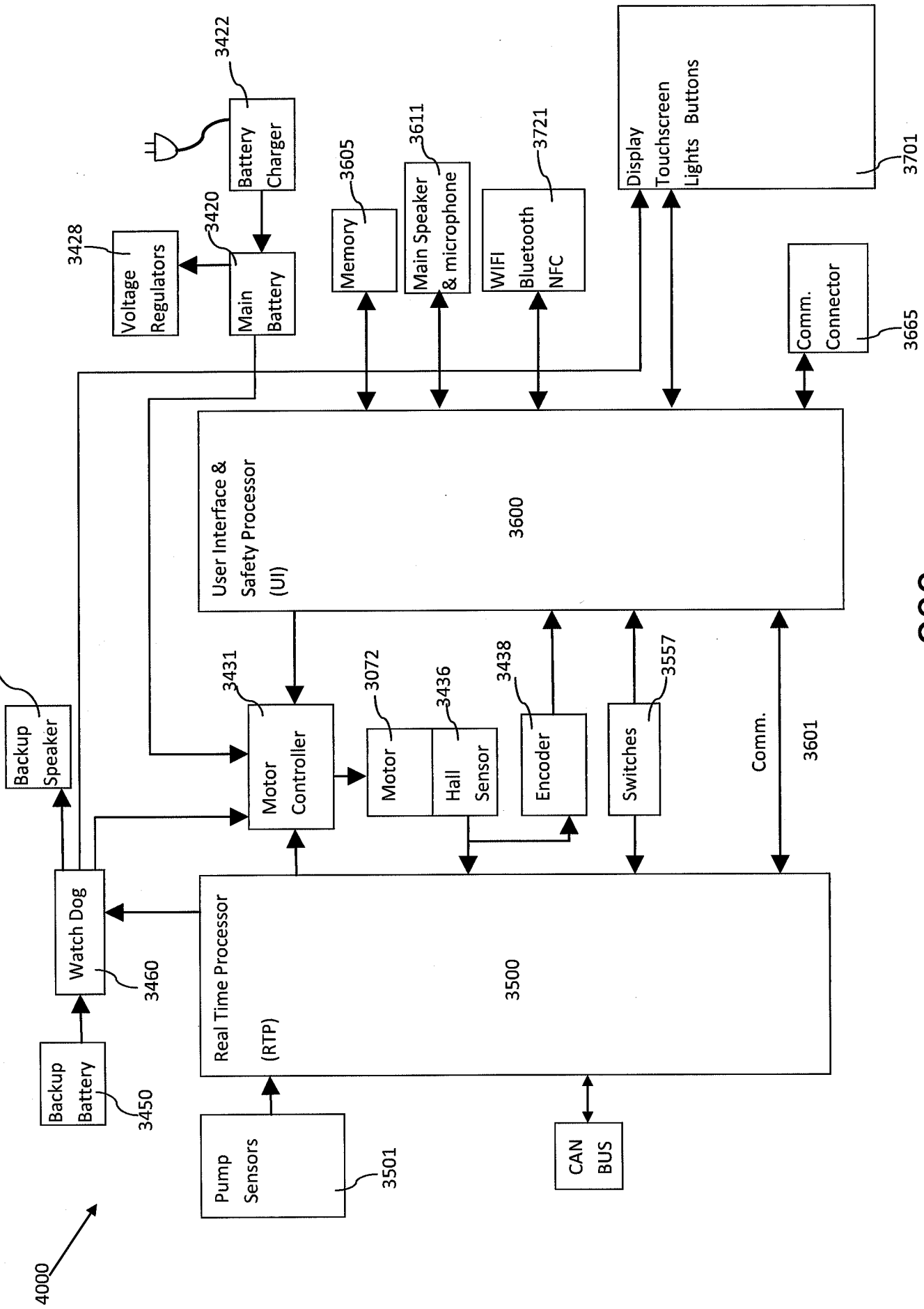

4000
Backup Battery
3450
Pump Sensors
3501
Watch Dog
3460
Real Time Processor (RTP)
3500
CAN BUS
Backup Speaker
3467
Motor Controller
3431
Motor
3072
Hall Sensor
3436
Encoder
3438
Switches
3557
Comm.
3601
User Interface & Safety Processor (UI)
3600
Voltage Regulators
3428
Main Battery
3420
Battery Charger
3422
Memory
3605
Main Speaker & microphone
3611
WIFI Bluetooth NFC
3721
Display Touchscreen Lights Buttons
3701
Comm. Connector
3665

FIG. 200

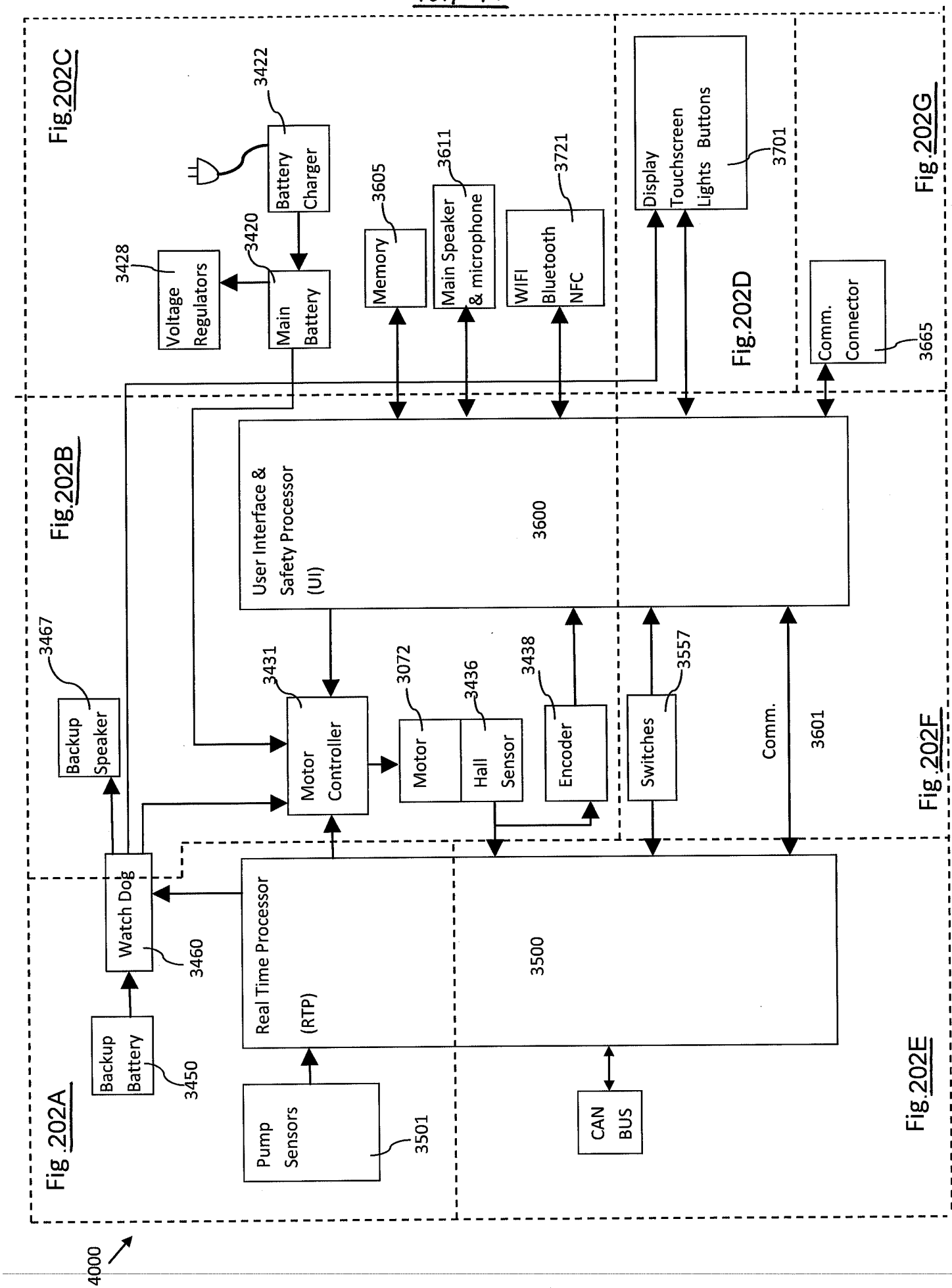

Fig.202C
Fig.202B
Fig.202D
Fig.202G
Fig.202F
Fig.202E
Fig.202A
4000
3422
Battery Charger
3420
Main Battery
3428
Voltage Regulators
3605
Memory
3611
Main Speaker & microphone
3721
WIFI Bluetooth NFC
Display Touchscreen Lights Buttons
3701
Comm. Connector
3665
User Interface & Safety Processor (UI)
3600
3467
Backup Speaker
3431
Motor Controller
3072
Motor
3436
Hall Sensor
3438
Encoder
3557
Switches
Comm.
3601
Watch Dog
3460
Real Time Processor (RTP)
3500
Backup Battery
3450
Pump Sensors
3501
CAN BUS

Fig.201

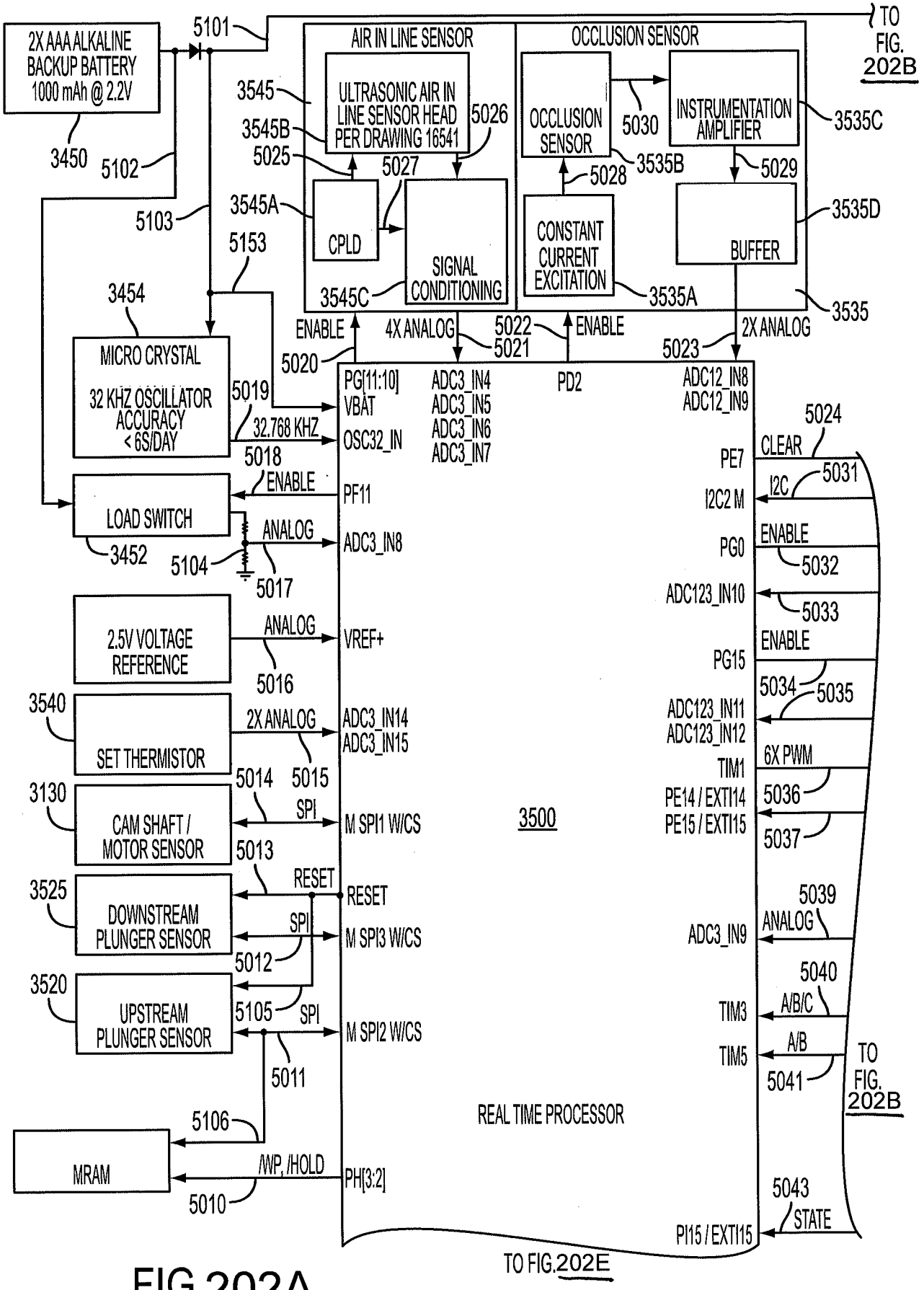

2X AAA ALKALINE BACKUP BATTERY 1000 mAh @ 2.2V
3450
5102
5101
5103
5153
3454
MICRO CRYSTAL 32 KHZ OSCILLATOR ACCURACY < 6S/DAY
5019
32.768 KHZ
5018
ENABLE
LOAD SWITCH
3452
5104
ANALOG
5017
2.5V VOLTAGE REFERENCE
ANALOG
5016
3540
SET THERMISTOR
2X ANALOG
5015
5014
3130
CAM SHAFT / MOTOR SENSOR
SPI
5013
RESET
3525
DOWNSTREAM PLUNGER SENSOR
SPI
5012
3520
UPSTREAM PLUNGER SENSOR
5105
SPI
5011
5106
MRAM
/WP, /HOLD
5010
AIR IN LINE SENSOR
3545
ULTRASONIC AIR IN LINE SENSOR HEAD PER DRAWING 16541
5026
3545B
5025
5027
3545A
CPLD
SIGNAL CONDITIONING
3545C
OCCLUSION SENSOR
OCCLUSION SENSOR
5030
INSTRUMENTATION AMPLIFIER
3535C
5028
3535B
5029
CONSTANT CURRENT EXCITATION
BUFFER
3535D
3535A
3535
ENABLE
4X ANALOG
5022
5021
ENABLE
2X ANALOG
5023
5020
PG[11:10]
VBAT
OSC32_IN
PF11
ADC3_IN8
VREF+
ADC3_IN14
ADC3_IN15
M SPI1 W/CS
RESET
M SPI3 W/CS
M SPI2 W/CS
PH[3:2]
ADC3_IN4
ADC3_IN5
ADC3_IN6
ADC3_IN7
PD2
3500
REAL TIME PROCESSOR
ADC12_IN8
ADC12_IN9
PE7
I2C2 M
PG0
ADC123_IN10
PG15
ADC123_IN11
ADC123_IN12
TIM1
PE14 / EXTI14
PE15 / EXTI15
ADC3_IN9
TIM3
TIM5
PI15 / EXTI15
5024
CLEAR
5031
I2C
ENABLE
5032
5033
ENABLE
5034
5035
6X PWM
5036
5037
5039
ANALOG
5040
A/B/C
A/B
5041
5043
STATE
TO FIG. 202B
TO FIG. 202B
TO FIG. 202E

FIG. 202A

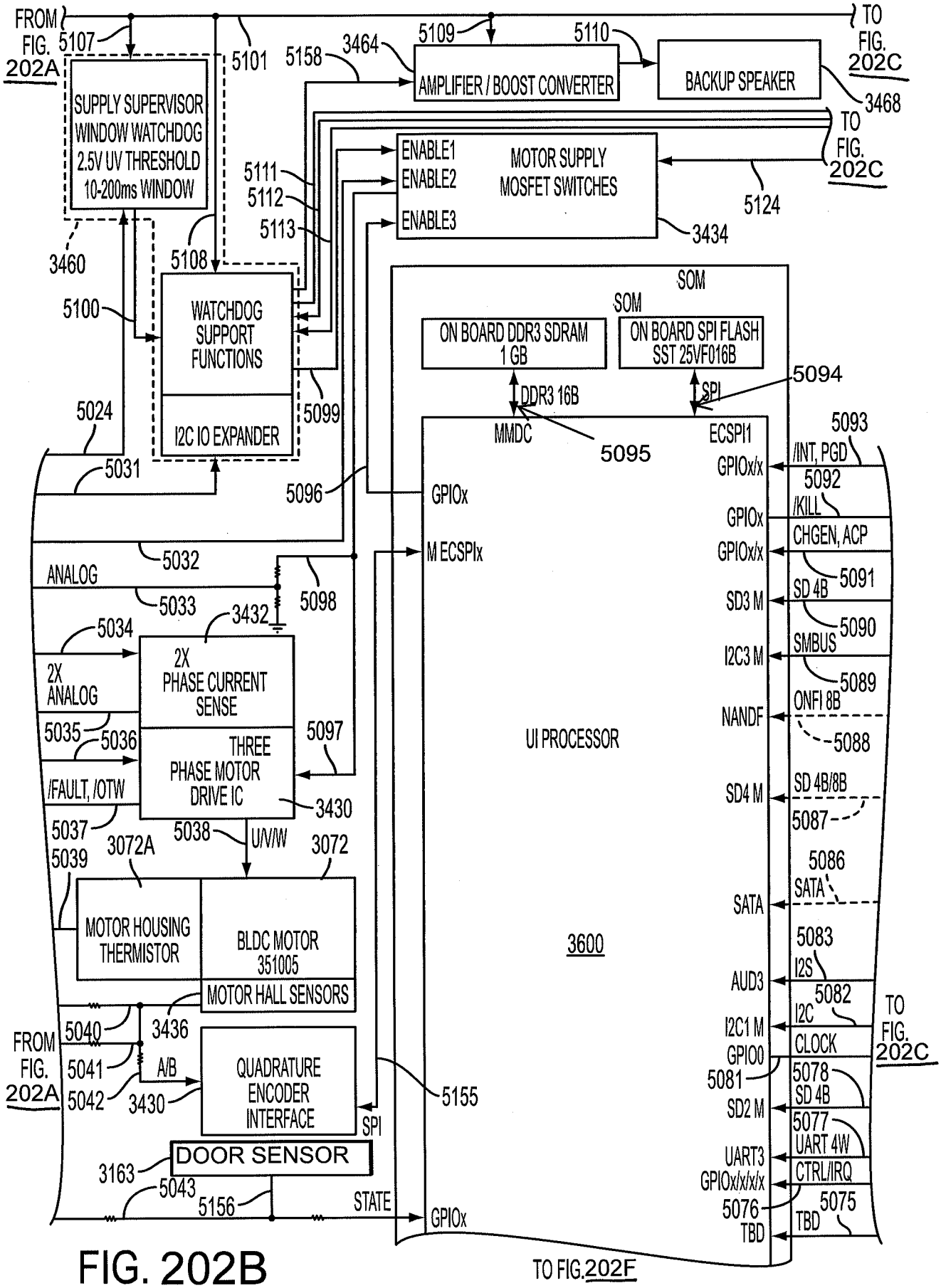

FROM FIG. 202A
TO FIG. 202C
5107
5101
5158
3464
5109
5110
AMPLIFIER / BOOST CONVERTER
BACKUP SPEAKER
3468
SUPPLY SUPERVISOR
WINDOW WATCHDOG
2.5V UV THRESHOLD
10-200ms WINDOW
ENABLE1
ENABLE2
ENABLE3
MOTOR SUPPLY
MOSFET SWITCHES
5111
5112
5113
5124
3434
3460
5108
5100
WATCHDOG
SUPPORT
FUNCTIONS
I2C IO EXPANDER
5099
5024
5031
5096
SOM
ON BOARD DDR3 SDRAM
1 GB
ON BOARD SPI FLASH
SST 25VF016B
DDR3 16B
SPI
5094
MMDC
5095
ECSPI1
5093
/INT, PGD
GPIOx/x
5092
/KILL
GPIOx
CHGEN, ACP
GPIOx/x
5091
SD 4B
SD3 M
5090
SMBUS
I2C3 M
5089
ONFI 8B
NANDF
5088
GPIOx
M ECSPIx
UI PROCESSOR
SD4 M
SD 4B/8B
5087
5086
SATA
SATA
3600
5083
I2S
AUD3
5082
I2C
I2C1 M
CLOCK
GPIO0
5081
5078
SD 4B
SD2 M
5077
UART 4W
UART3
CTRL/IRQ
GPIOx/x/x/x
5076
TBD
5075
TBD
ANALOG
5033
5032
5098
5034
2X
ANALOG
2X
PHASE CURRENT
SENSE
3432
5035
5036
/FAULT, /OTW
THREE
PHASE MOTOR
DRIVE IC
5097
3430
5037
5038
U/V/W
3072A
3072
5039
MOTOR HOUSING
THERMISTOR
BLDC MOTOR
351005
MOTOR HALL SENSORS
FROM FIG. 202A
5040
5041
5042
3436
A/B
3430
QUADRATURE
ENCODER
INTERFACE
5155
SPI
DOOR SENSOR
3163
5043
5156
STATE
GPIOx
TO FIG. 202C
TO FIG. 202F

FIG. 202B

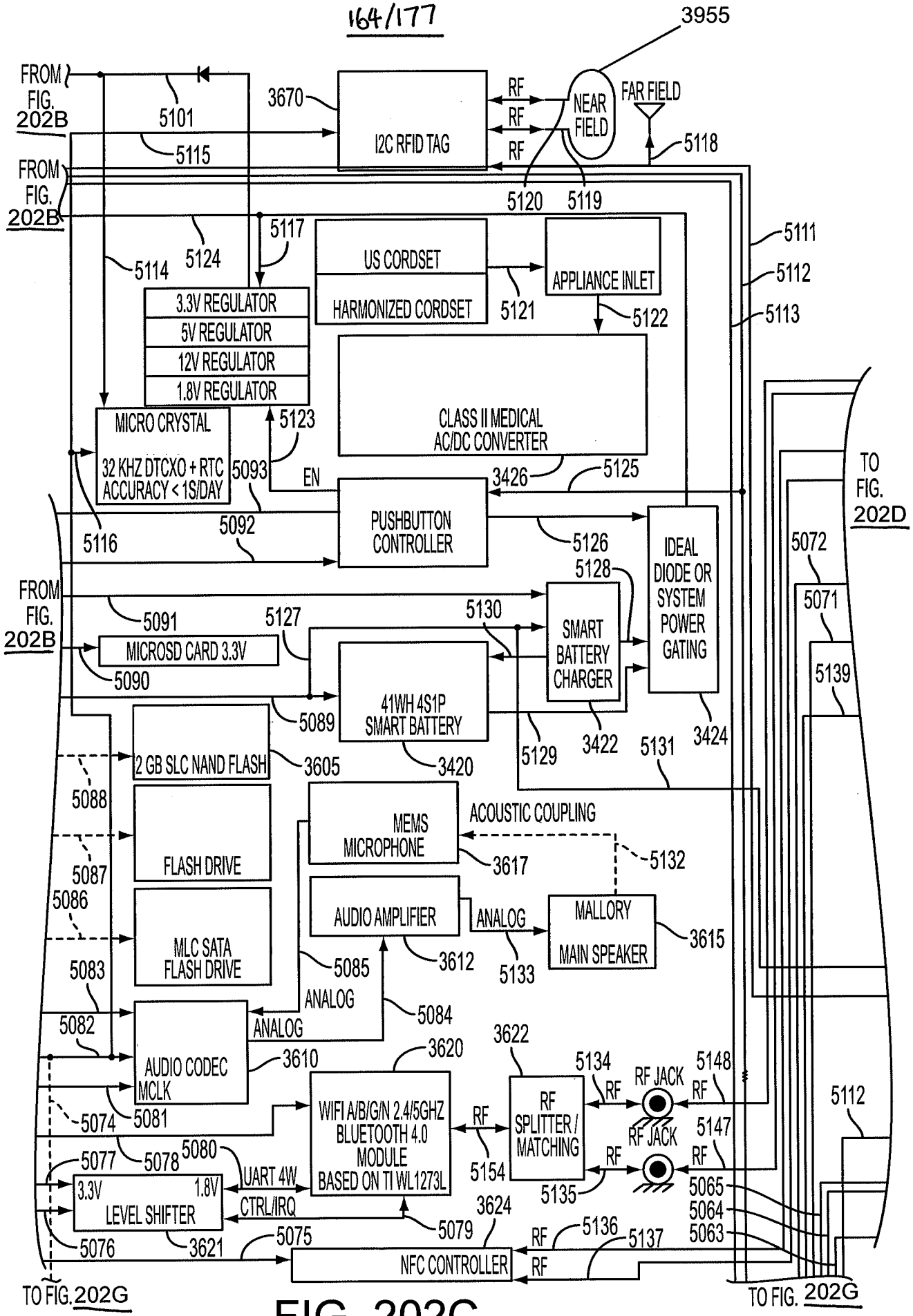

3955
FROM FIG. 202B
5101
3670
I2C RFID TAG
RF
RF
RF
NEAR FIELD
FAR FIELD
5118
5115
FROM FIG. 202B
5120
5119
5111
5117
5124
5114
US CORDSET
HARMONIZED CORDSET
APPLIANCE INLET
5121
5122
5112
5113
3.3V REGULATOR
5V REGULATOR
12V REGULATOR
1.8V REGULATOR
MICRO CRYSTAL
32 KHZ DTCXO + RTC
ACCURACY < 1S/DAY
5123
CLASS II MEDICAL
AC/DC CONVERTER
5093
EN
3426
5125
TO FIG. 202D
5116
5092
PUSHBUTTON CONTROLLER
5126
IDEAL DIODE OR SYSTEM POWER GATING
5072
5128
FROM FIG. 202B
5091
5127
5130
SMART BATTERY CHARGER
5071
MICROSD CARD 3.3V
5090
5139
41WH 4S1P SMART BATTERY
5089
5129
3422
5131
3424
2 GB SLC NAND FLASH
3605
3420
5088
MEMS MICROPHONE
ACOUSTIC COUPLING
3617
5132
FLASH DRIVE
5087
5086
AUDIO AMPLIFIER
ANALOG
MALLORY MAIN SPEAKER
3615
MLC SATA FLASH DRIVE
5085
3612
5133
5083
ANALOG
5084
ANALOG
5082
3622
5134
5148
RF JACK
AUDIO CODEC MCLK
3610
3620
WIFI A/B/G/N 2.4/5GHZ BLUETOOTH 4.0 MODULE BASED ON TI WL1273L
RF
RF SPLITTER / MATCHING
RF
RF
5112
5074
5081
5147
RF JACK
5077
5078
5080
UART 4W
5154
RF
RF
5135
5065
3.3V
1.8V
LEVEL SHIFTER
CTRL/IRQ
5079
3624
5064
5063
5076
3621
5075
RF
5136
5137
NFC CONTROLLER
RF
TO FIG. 202G
TO FIG. 202G

FIG. 202C

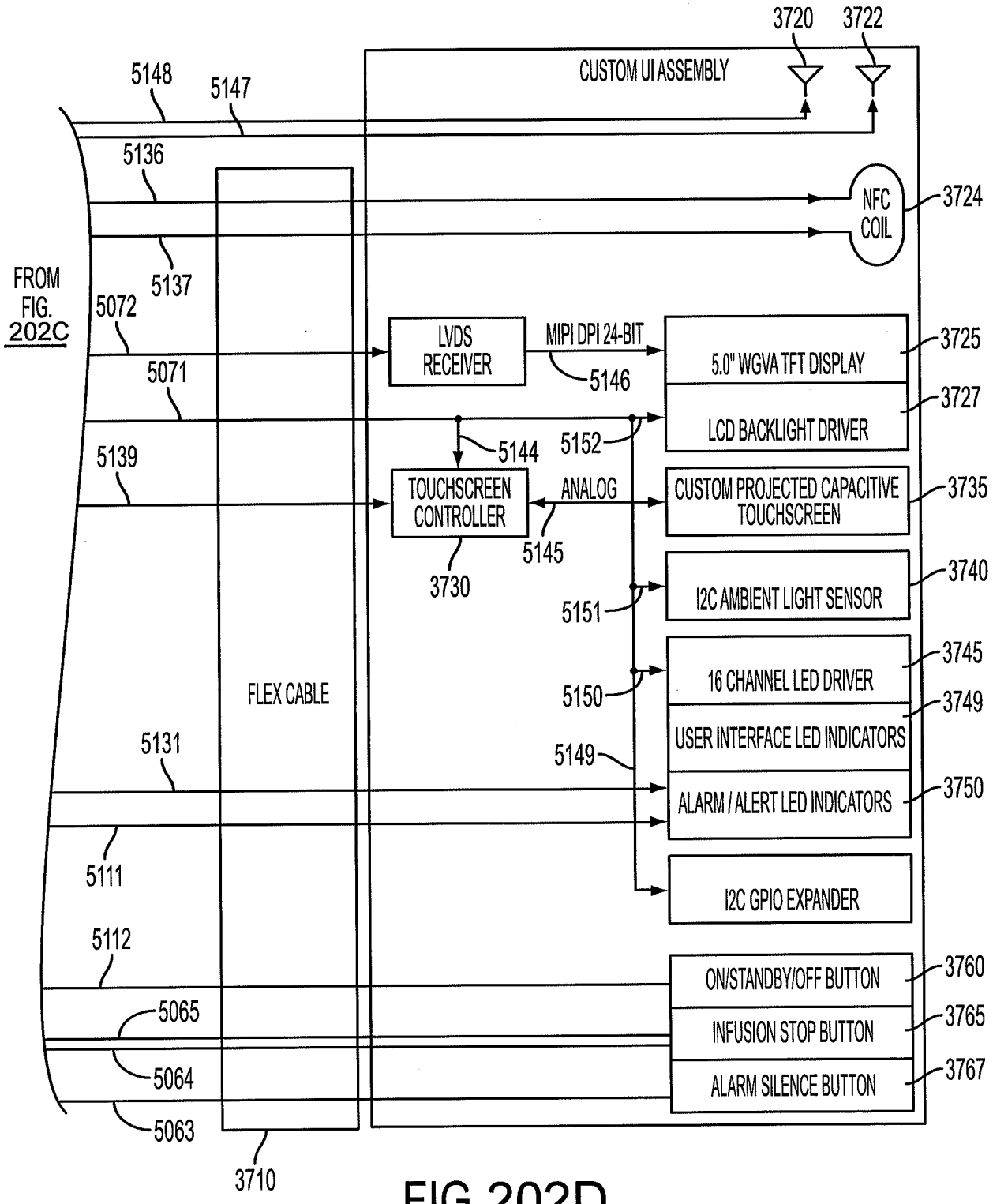

3720
3722
CUSTOM UI ASSEMBLY
5148
5147
5136
NFC COIL
3724
FROM FIG. 202C
5137
5072
LVDS RECEIVER
MIPI DPI 24-BIT
5146
5.0" WGVA TFT DISPLAY
3725
5071
LCD BACKLIGHT DRIVER
3727
5144
5152
5139
TOUCHSCREEN CONTROLLER
ANALOG
CUSTOM PROJECTED CAPACITIVE TOUCHSCREEN
3735
5145
3730
I2C AMBIENT LIGHT SENSOR
3740
5151
3745
16 CHANNEL LED DRIVER
5150
3749
USER INTERFACE LED INDICATORS
FLEX CABLE
5131
5149
ALARM / ALERT LED INDICATORS
3750
5111
I2C GPIO EXPANDER
5112
ON/STANDBY/OFF BUTTON
3760
5065
INFUSION STOP BUTTON
3765
5064
ALARM SILENCE BUTTON
3767
5063
3710

FIG. 202D

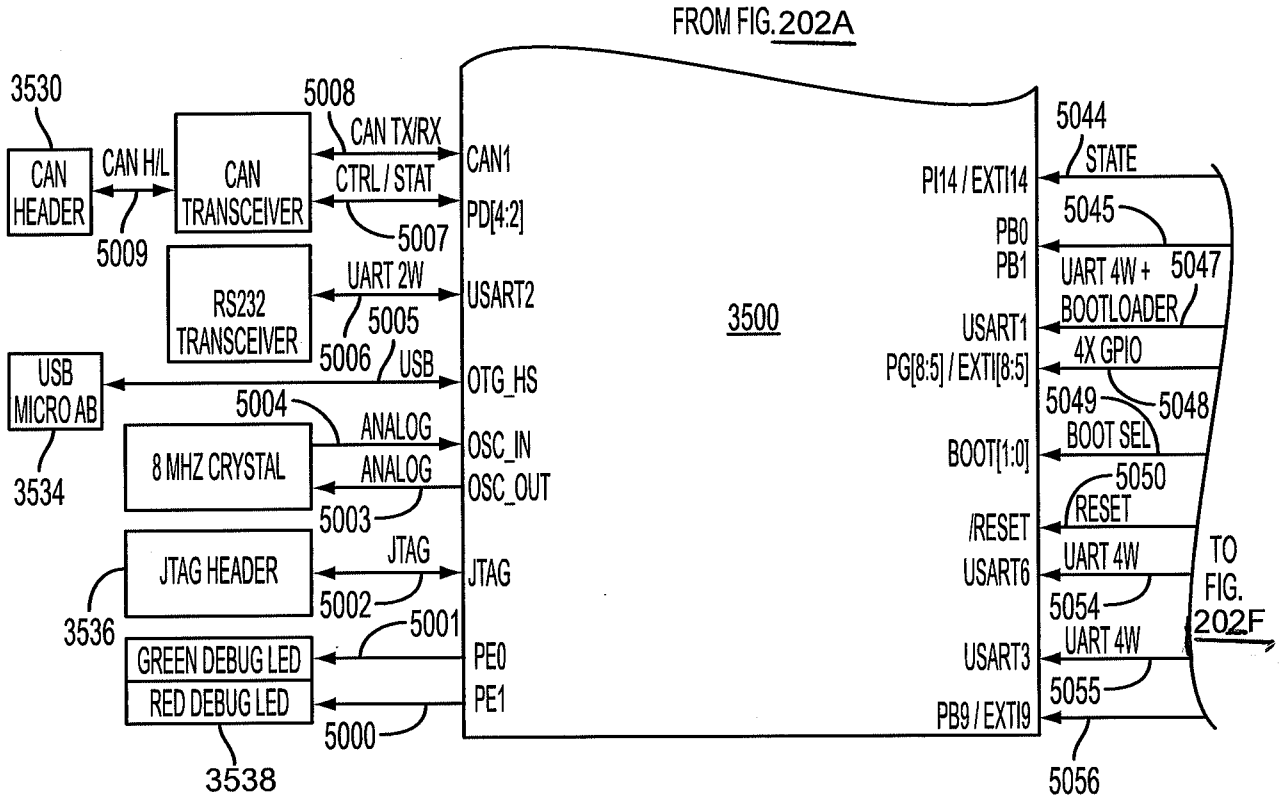

FROM FIG. 202A
3530
CAN HEADER
CAN H/L
5009
CAN TRANSCEIVER
5008
CAN TX/RX
CTRL / STAT
5007
CAN1
PD[4:2]
RS232 TRANSCEIVER
UART 2W
5005
5006
USB
USART2
OTG_HS
USB MICRO AB
3534
5004
8 MHZ CRYSTAL
ANALOG
ANALOG
5003
OSC_IN
OSC_OUT
JTAG HEADER
3536
JTAG
5002
JTAG
5001
GREEN DEBUG LED
RED DEBUG LED
5000
PE0
PE1
3538
3500
PI14 / EXTI14
PB0
PB1
USART1
PG[8:5] / EXTI[8:5]
BOOT[1:0]
/RESET
USART6
USART3
PB9 / EXTI9
5044
STATE
5045
UART 4W + BOOTLOADER
5047
4X GPIO
5049
5048
BOOT SEL
5050
RESET
UART 4W
5054
UART 4W
5055
5056
TO FIG. 202F

FIG. 202E

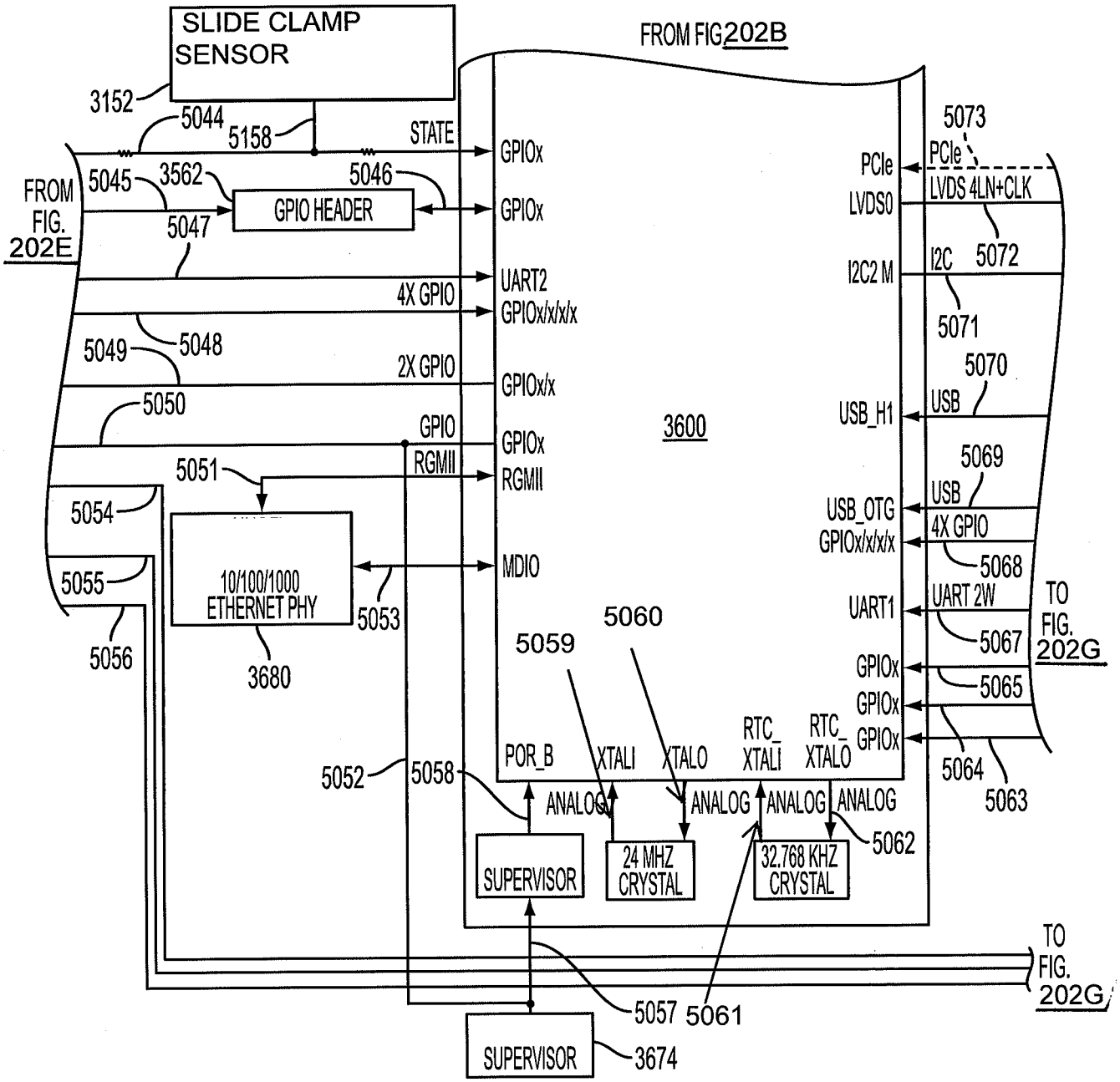

SLIDE CLAMP SENSOR
3152
5044
5158
STATE
FROM FIG. 202E
5045
3562
5046
GPIO HEADER
5047
4X GPIO
5049
5048
2X GPIO
5050
GPIO
RGMII
5051
5054
5055
5056
10/100/1000 ETHERNET PHY
3680
5053
MDIO
FROM FIG 202B
GPIOx
GPIOx
UART2
GPIOx/x/x/x
GPIOx/x
GPIOx
RGMII
3600
5060
5059
POR_B
XTALI
XTALO
RTC_ XTALI
RTC_ XTALO
5052
5058
ANALOG
ANALOG
ANALOG
ANALOG
SUPERVISOR
24 MHZ CRYSTAL
32.768 KHZ CRYSTAL
5062
SUPERVISOR
3674
5057
5061
5073
PCIe
PCIe
LVDS 4LN+CLK
LVDS0
I2C
5072
I2C2 M
5071
5070
USB
USB_H1
5069
USB
USB_OTG
4X GPIO
GPIOx/x/x/x
5068
UART 2W
UART1
5067
GPIOx
5065
GPIOx
GPIOx
5064
5063
TO FIG. 202G
TO FIG. 202G

FIG. 202F

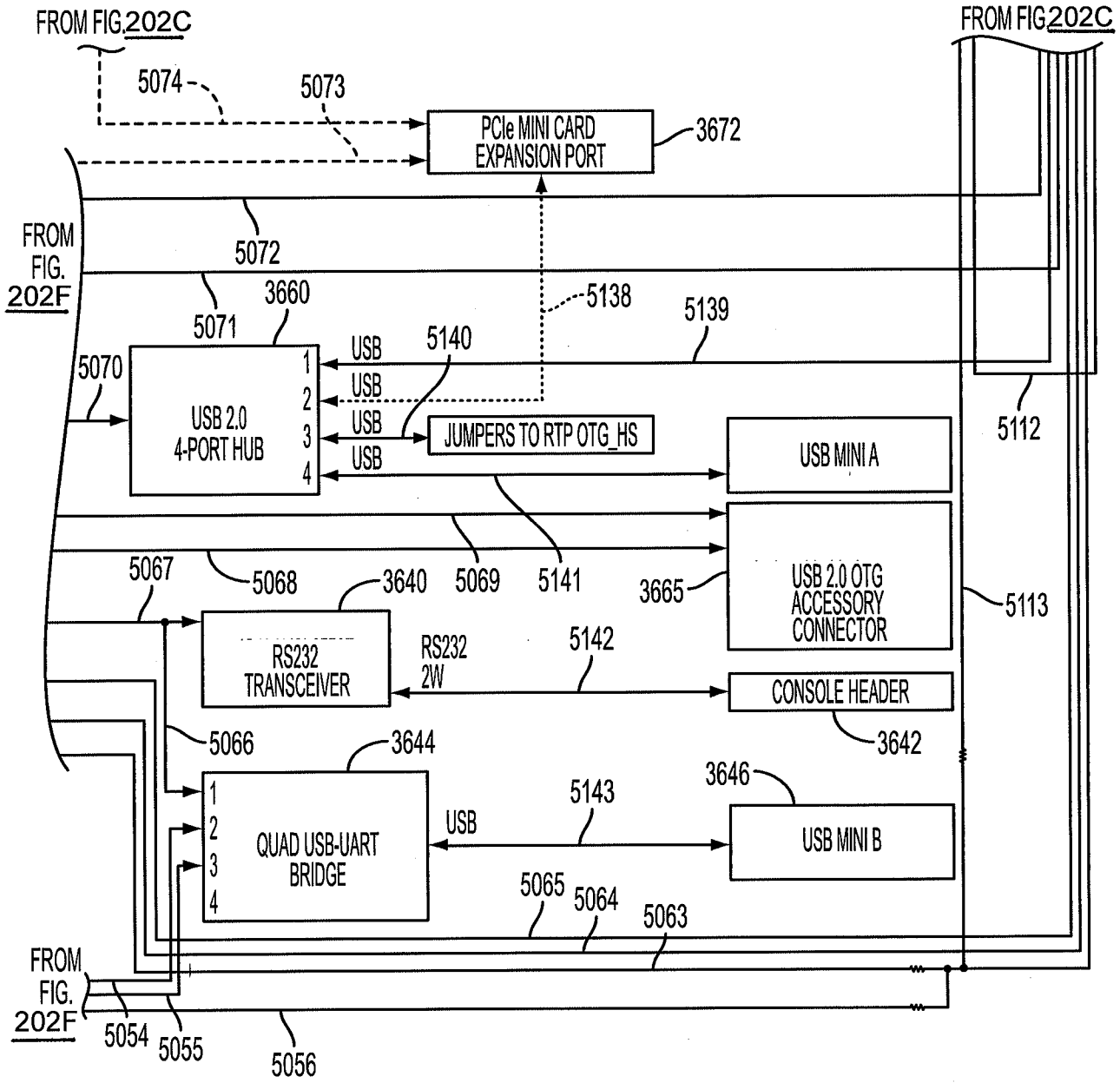

FROM FIG.202C
FROM FIG.202C
5074
5073
PCIe MINI CARD EXPANSION PORT
3672
FROM FIG. 202F
5072
5071
3660
5138
5139
5070
USB 2.0 4-PORT HUB
USB
USB
USB
USB
5140
JUMPERS TO RTP OTG_HS
USB MINI A
5112
5067
5068
3640
5069
5141
3665
USB 2.0 OTG ACCESSORY CONNECTOR
5113
RS232 TRANSCEIVER
RS232 2W
5142
CONSOLE HEADER
3642
5066
3644
3646
QUAD USB-UART BRIDGE
USB
5143
USB MINI B
5065
5064
5063
FROM FIG. 202F
5054
5055
5056

FIG. 202G

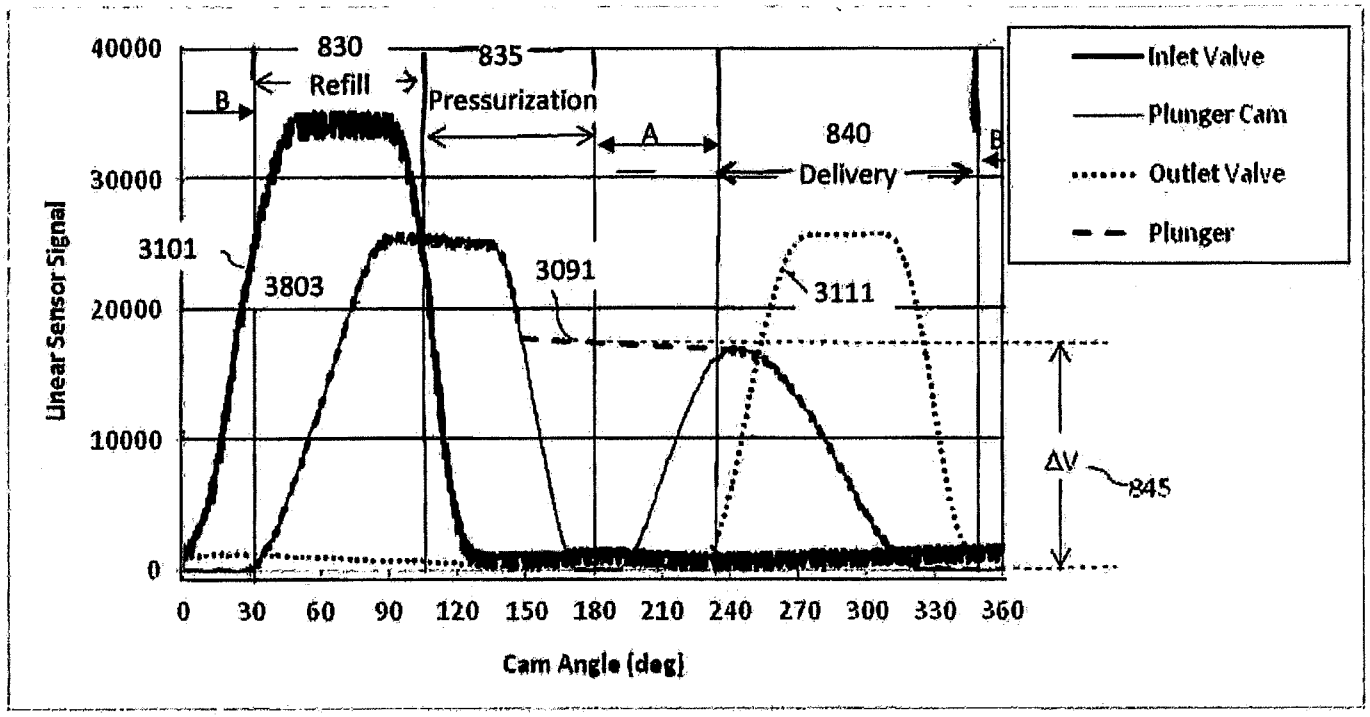

40000
30000
20000
10000
0
Linear Sensor Signal
830
Refill
835
Pressurization
A
840
Delivery
B
B
3101
3803
3091
3111
ΔV
845
Inlet Valve
Plunger Cam
Outlet Valve
Plunger
0
30
60
90
120
150
180
210
240
270
300
330
360
Cam Angle (deg)

FIG. 203

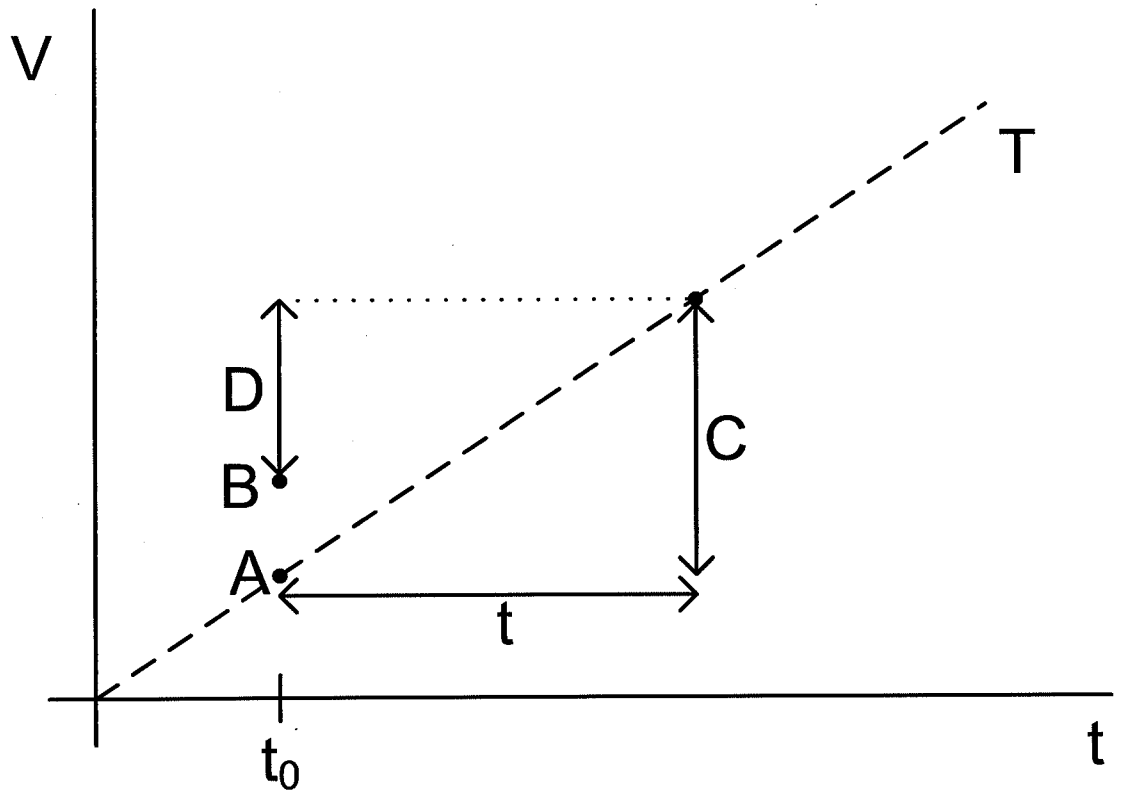


FIG. 204

Cam Shaft Angle (deg)
110
100
90
80
70
60
50
40
30
20
10
0
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Volume (µl)

FIG. 205

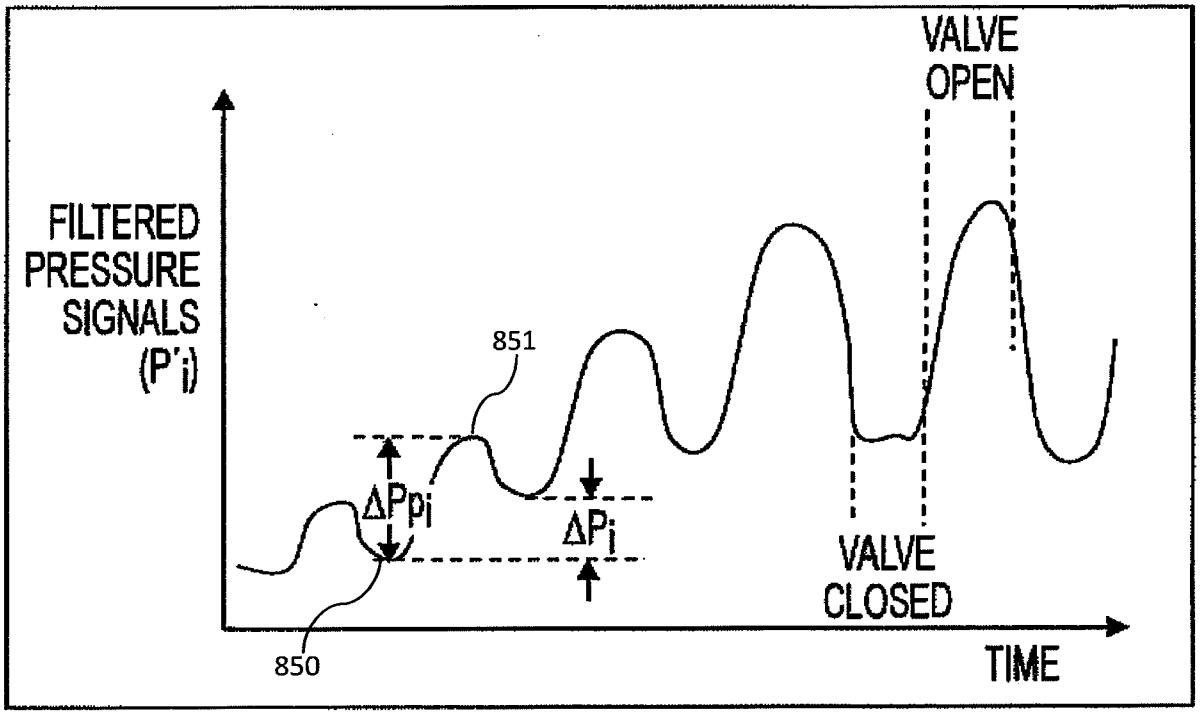

VALVE
OPEN
FILTERED
PRESSURE
SIGNALS
(P'i)
851
ΔPpi
ΔPi
VALVE
CLOSED
850
TIME

FIG. 206

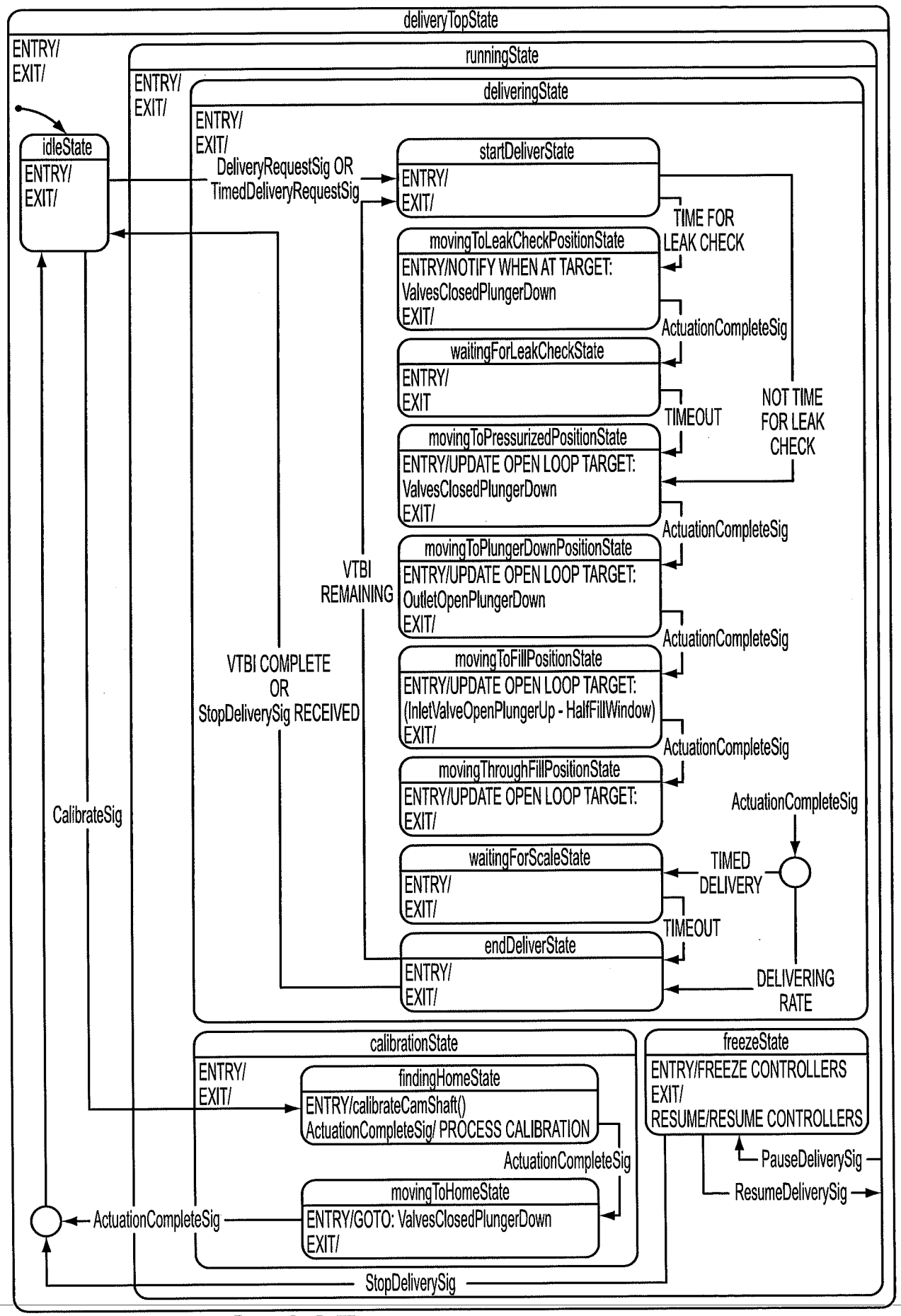

deliveryTopState
ENTRY/
EXIT/
runningState
ENTRY/
EXIT/
deliveringState
ENTRY/
EXIT/
idleState
ENTRY/
EXIT/
DeliveryRequestSig OR
TimedDeliveryRequestSig
startDeliverState
ENTRY/
EXIT/
TIME FOR
LEAK CHECK
movingToLeakCheckPositionState
ENTRY/NOTIFY WHEN AT TARGET:
ValvesClosedPlungerDown
EXIT/
ActuationCompleteSig
waitingForLeakCheckState
ENTRY/
EXIT
TIMEOUT
NOT TIME
FOR LEAK
CHECK
movingToPressurizedPositionState
ENTRY/UPDATE OPEN LOOP TARGET:
ValvesClosedPlungerDown
EXIT/
ActuationCompleteSig
movingToPlungerDownPositionState
ENTRY/UPDATE OPEN LOOP TARGET:
OutletOpenPlungerDown
EXIT/
VTBI
REMAINING
ActuationCompleteSig
movingToFillPositionState
ENTRY/UPDATE OPEN LOOP TARGET:
(InletValveOpenPlungerUp - HalfFillWindow)
EXIT/
VTBI COMPLETE
OR
StopDeliverySig RECEIVED
ActuationCompleteSig
movingThroughFillPositionState
ENTRY/UPDATE OPEN LOOP TARGET:
EXIT/
ActuationCompleteSig
CalibrateSig
waitingForScaleState
ENTRY/
EXIT/
TIMED
DELIVERY
TIMEOUT
endDeliverState
ENTRY/
EXIT/
DELIVERING
RATE
calibrationState
ENTRY/
EXIT/
findingHomeState
ENTRY/calibrateCamShaft()
ActuationCompleteSig/ PROCESS CALIBRATION
ActuationCompleteSig
movingToHomeState
ENTRY/GOTO: ValvesClosedPlungerDown
EXIT/
ActuationCompleteSig
freezeState
ENTRY/FREEZE CONTROLLERS
EXIT/
RESUME/RESUME CONTROLLERS
PauseDeliverySig
ResumeDeliverySig
StopDeliverySig

FIG. 207

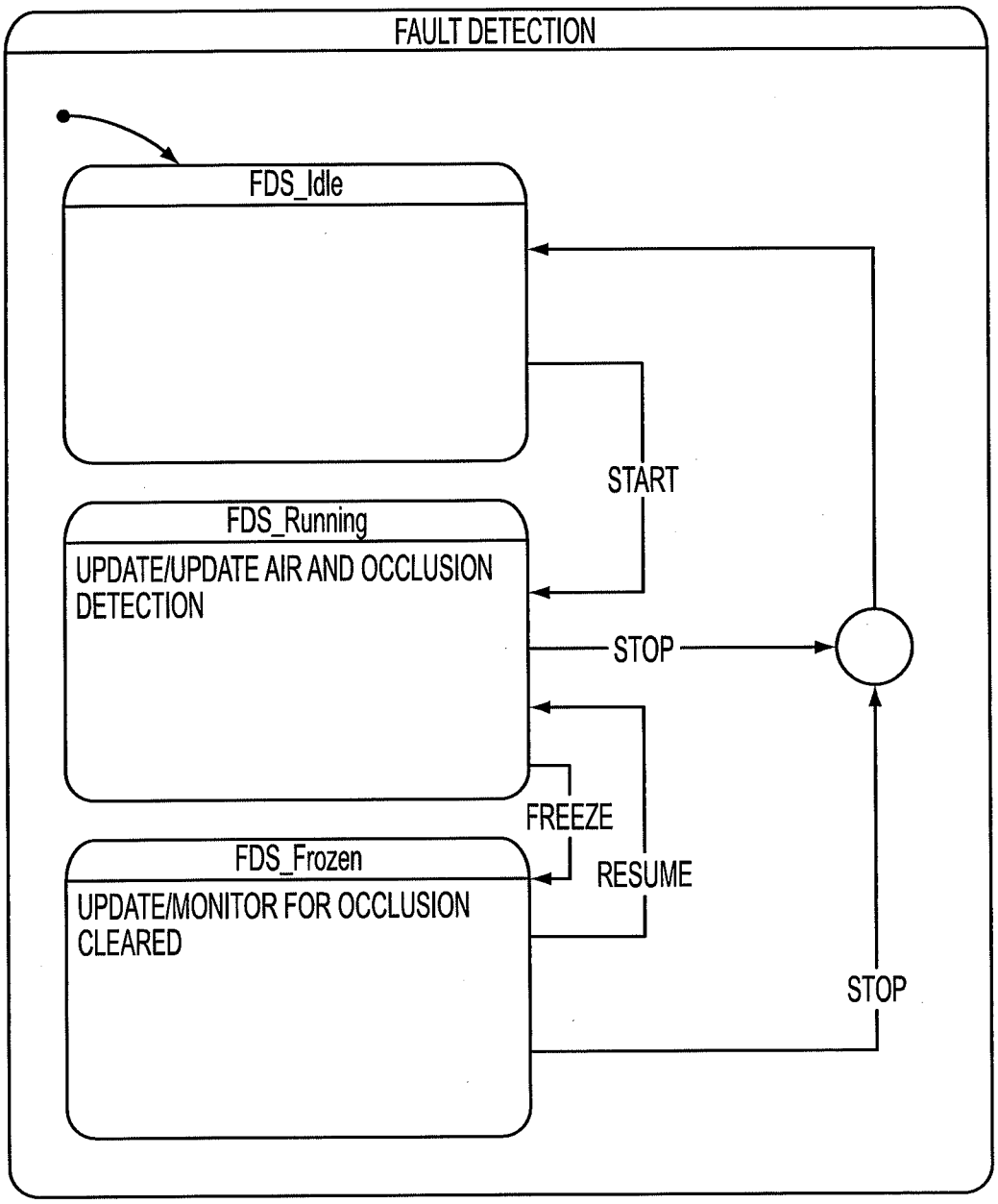

FAULT DETECTION
FDS_Idle
START
FDS_Running
UPDATE/UPDATE AIR AND OCCLUSION DETECTION
STOP
FREEZE
FDS_Frozen
RESUME
UPDATE/MONITOR FOR OCCLUSION CLEARED
STOP

FIG. 208

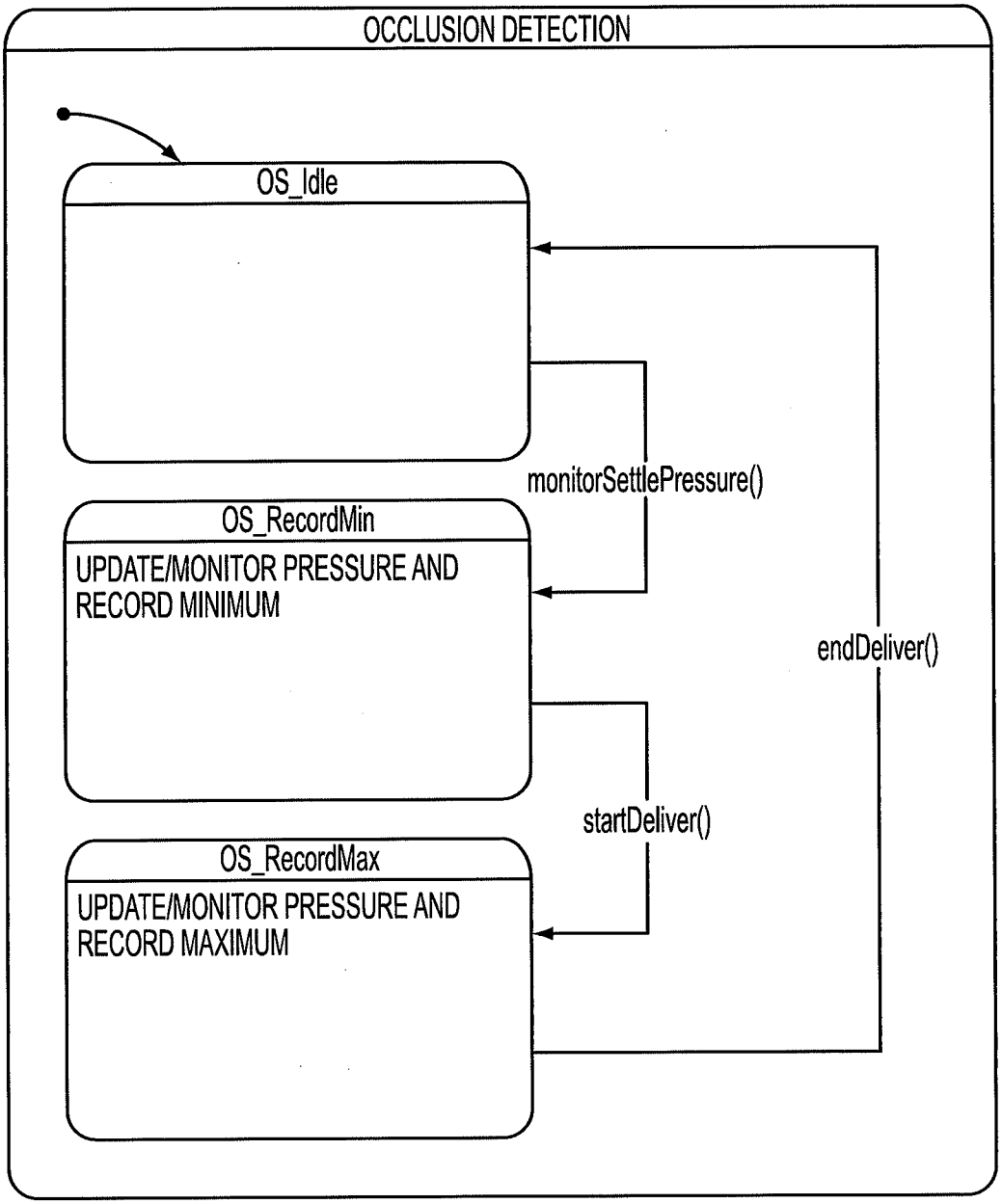

OCCLUSION DETECTION
OS_Idle
monitorSettlePressure()
OS_RecordMin
UPDATE/MONITOR PRESSURE AND RECORD MINIMUM
endDeliver()
startDeliver()
OS_RecordMax
UPDATE/MONITOR PRESSURE AND RECORD MAXIMUM

FIG. 209

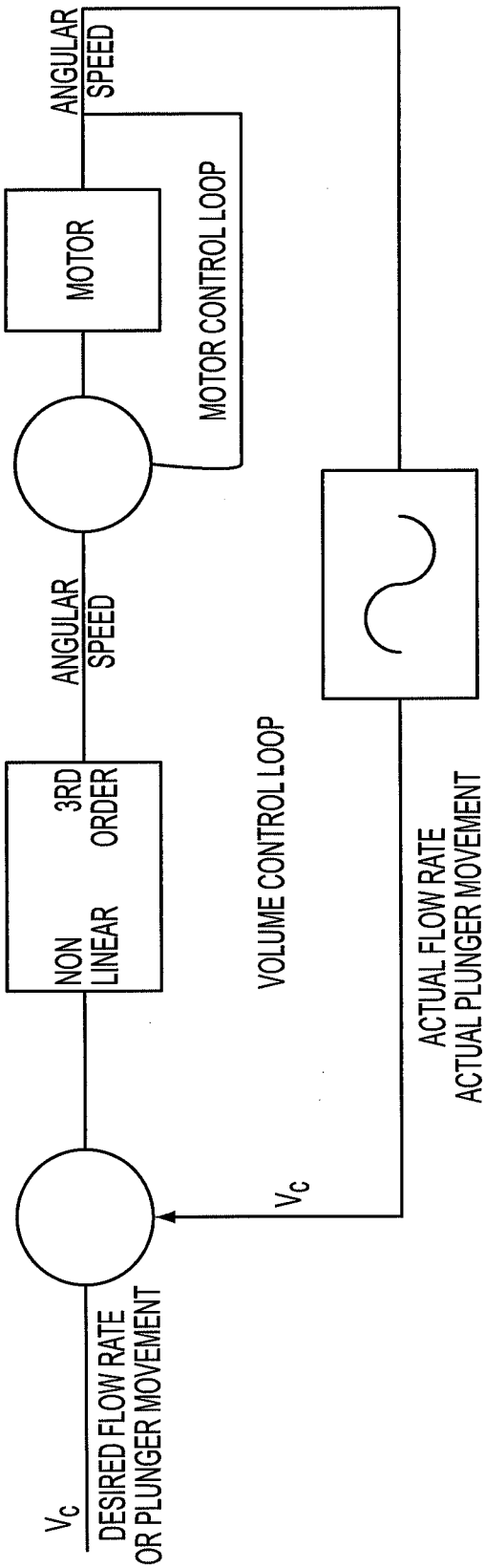

V_c
DESIRED FLOW RATE
OR PLUNGER MOVEMENT
NON LINEAR 3RD ORDER
ANGULAR SPEED
MOTOR
ANGULAR SPEED
MOTOR CONTROL LOOP
VOLUME CONTROL LOOP
V_c
ACTUAL FLOW RATE
ACTUAL PLUNGER MOVEMENT

FIG. 210

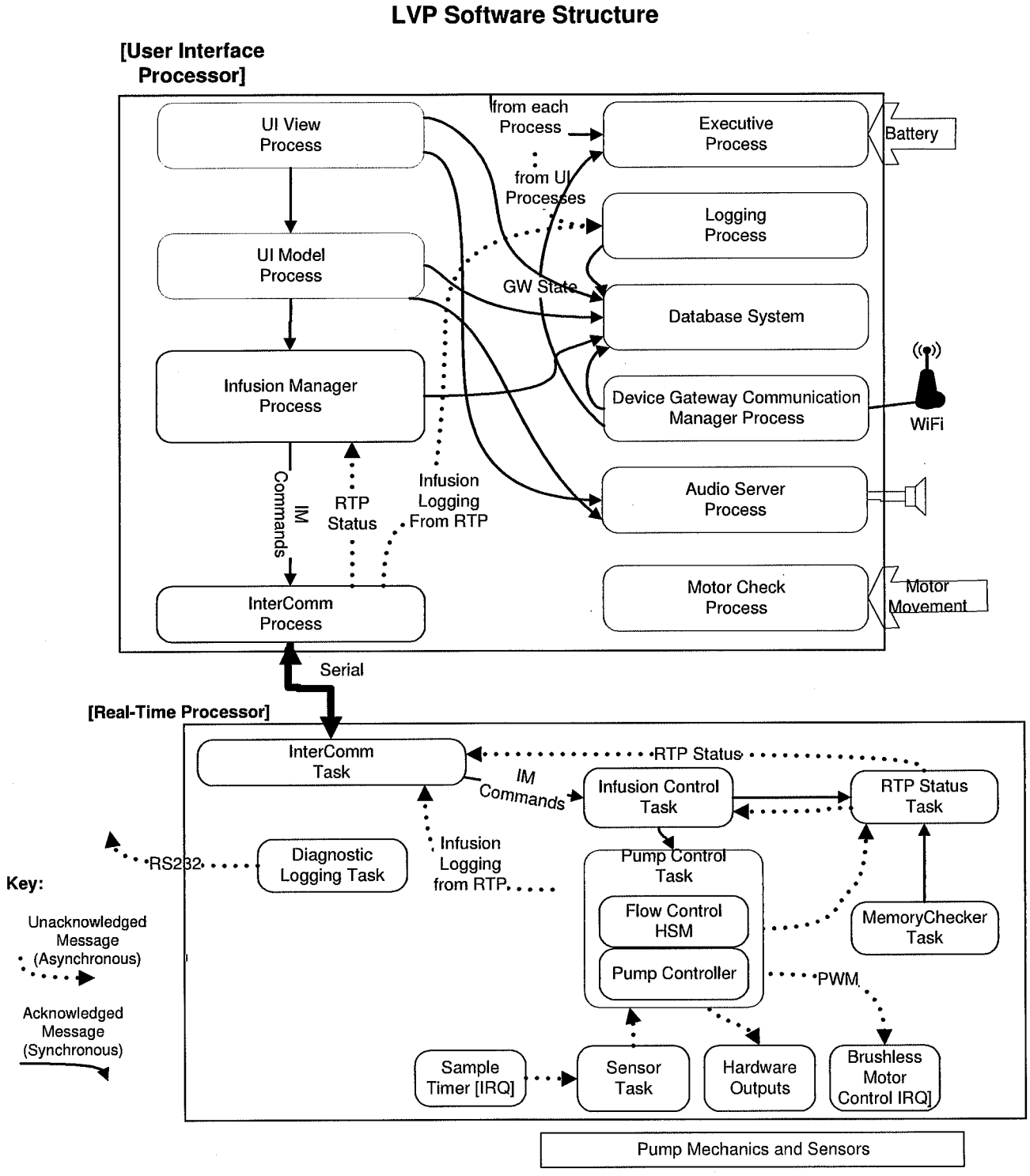

LVP Software Structure
[User Interface Processor]
UI View Process
UI Model Process
Infusion Manager Process
InterComm Process
from each Process
from UI Processes
GW State
Commands
IM
RTP Status
Infusion Logging From RTP
Executive Process
Logging Process
Database System
Device Gateway Communication Manager Process
Audio Server Process
Motor Check Process
Battery
WiFi
Motor Movement
Serial
[Real-Time Processor]
InterComm Task
RTP Status
IM Commands
Infusion Control Task
RTP Status Task
Diagnostic Logging Task
RS232
Infusion Logging from RTP
Pump Control Task
Flow Control HSM
Pump Controller
MemoryChecker Task
PWM
Sample Timer [IRQ]
Sensor Task
Hardware Outputs
Brushless Motor Control IRQ]
Pump Mechanics and Sensors
Key:
Unacknowledged Message (Asynchronous)
Acknowledged Message (Synchronous)

FIG. 211