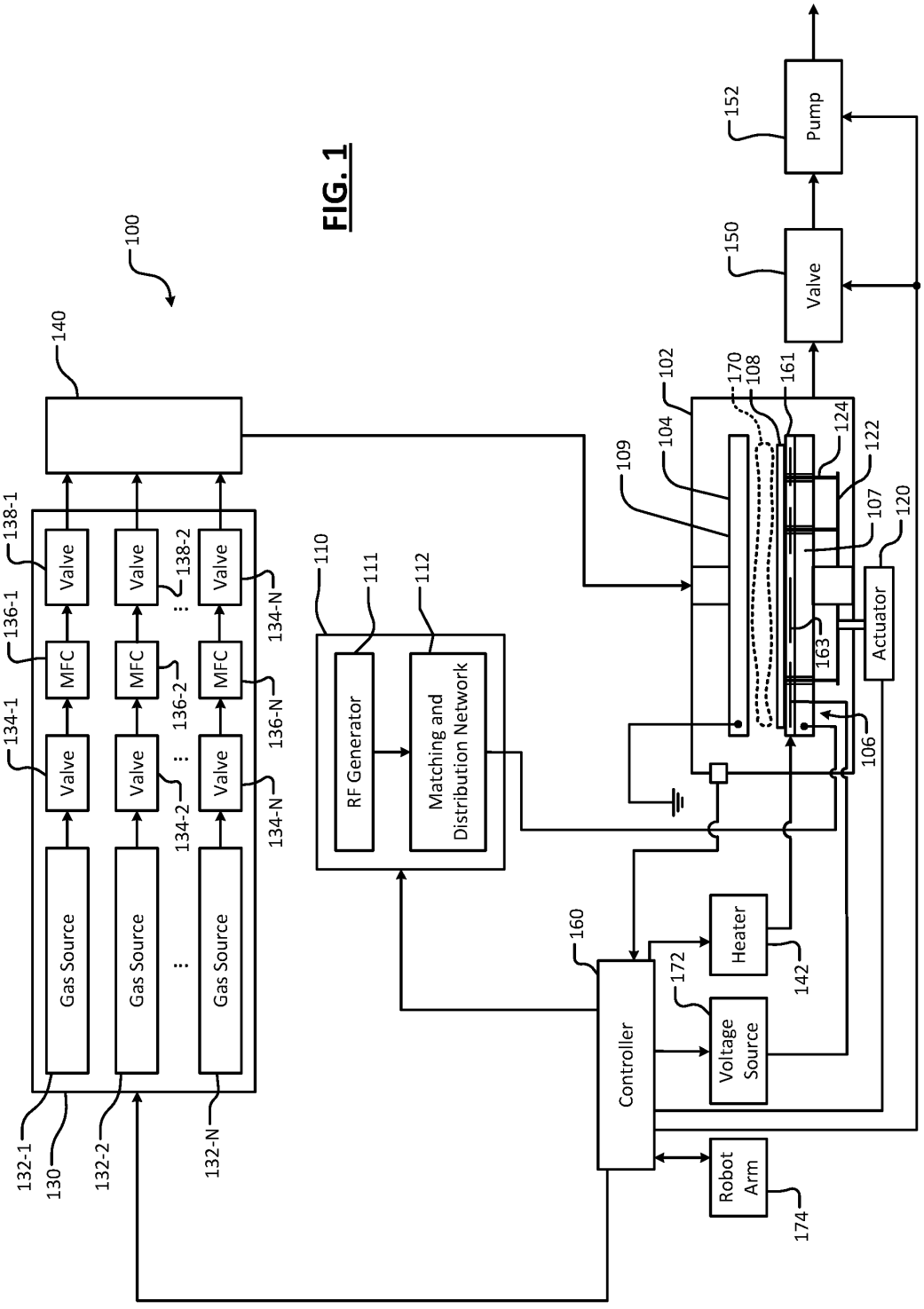
FIG. 1


100
140
138-1
138-2
136-1
136-2
136-N
134-1
134-2
134-N
Valve
MFC
Gas Source
132-1
130
132-2
132-N
110
111
112
RF Generator
Matching and Distribution Network
160
Controller
172
Voltage Source
Heater
142
Robot Arm
174
102
104
109
170
108
161
124
122
107
120
163
106
Actuator
150
Valve
152
Pump

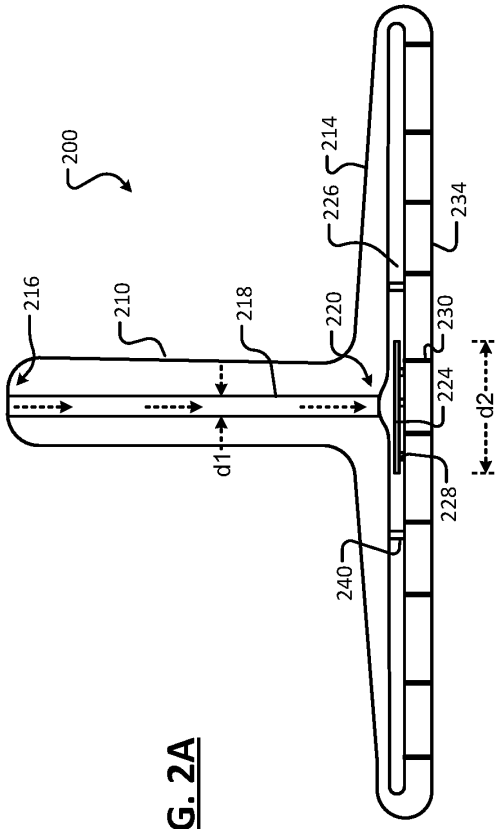

200
214
226
234
216
210
218
220
230
224
d2
d1
228
240

FIG. 2A

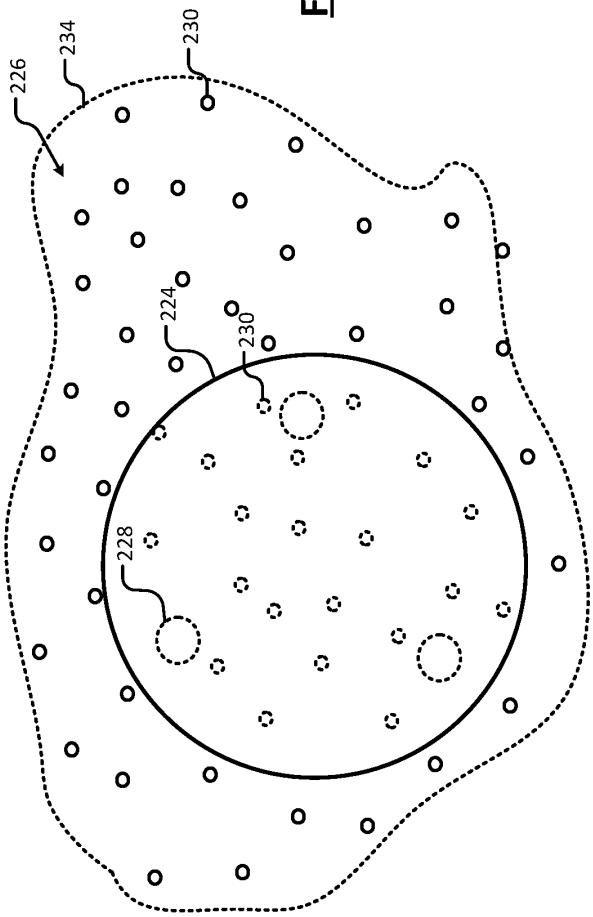

226
234
230
224
230
228

FIG. 2B

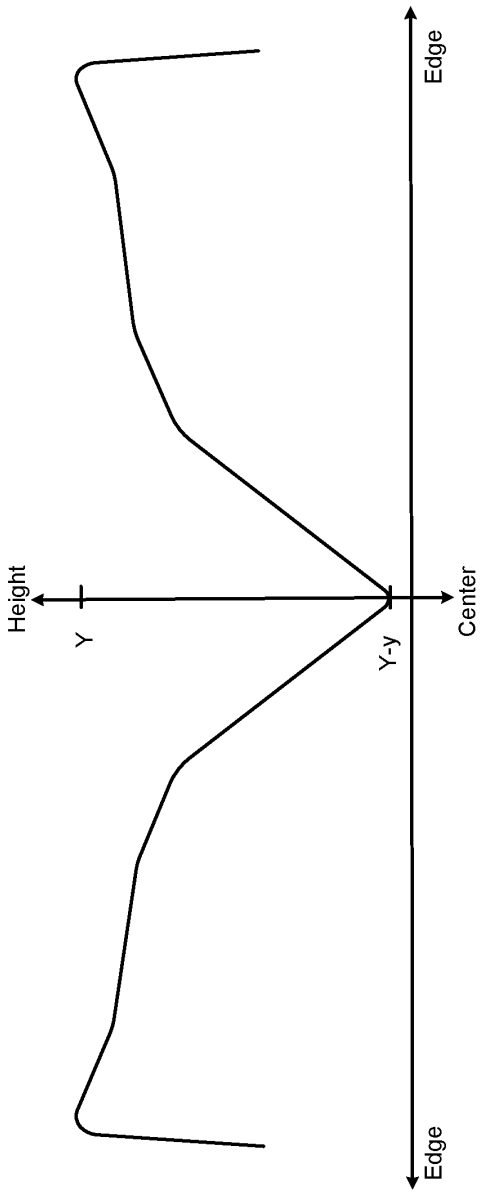


FIG. 3

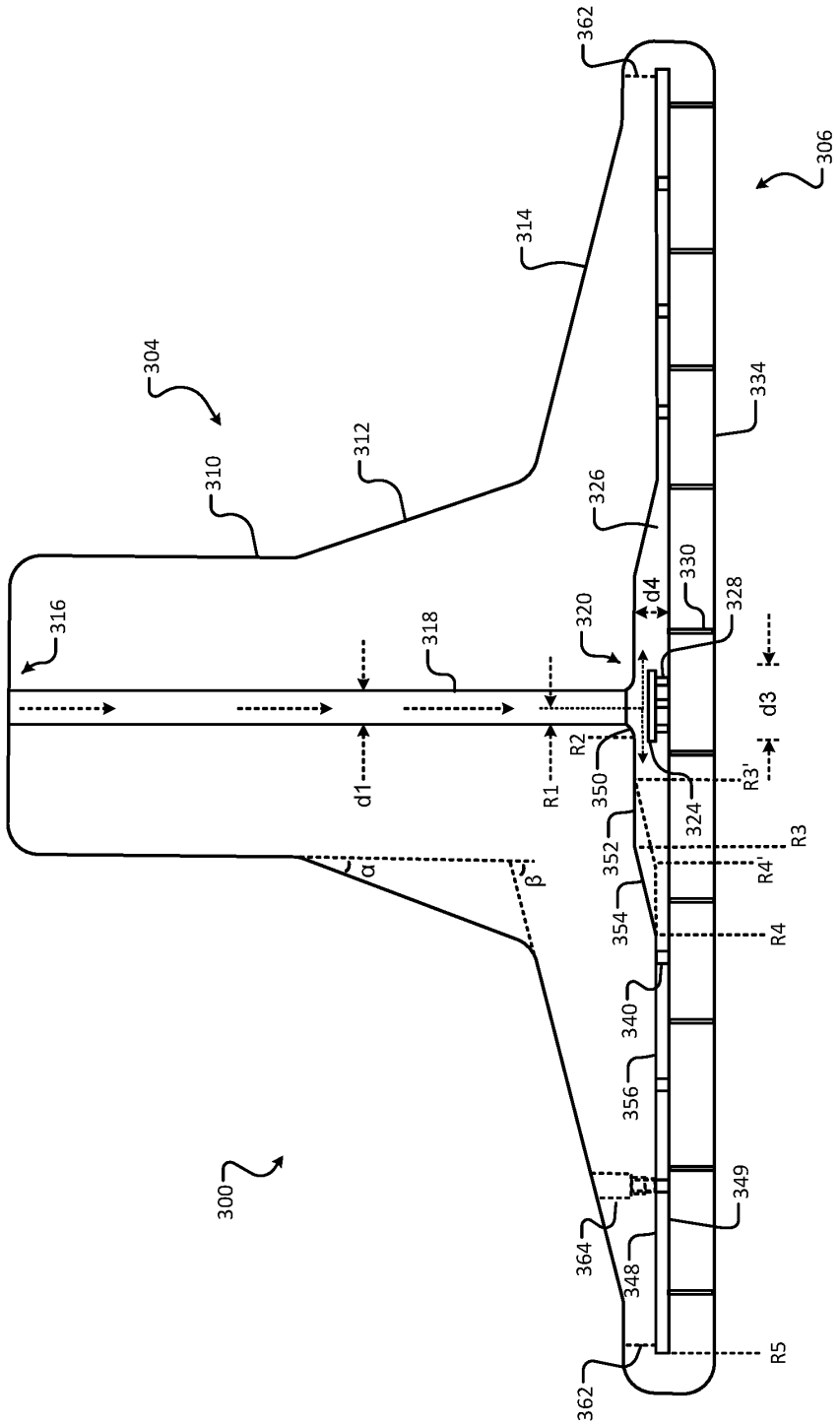

362
306
314
304
334
312
310
326
330
d4
328
316
318
320
d3
R2
R3'
d1
R1
350
324
R3
352
R4'
α
β
354
R4
340
356
300
349
364
348
R5
362

FIG. 4A

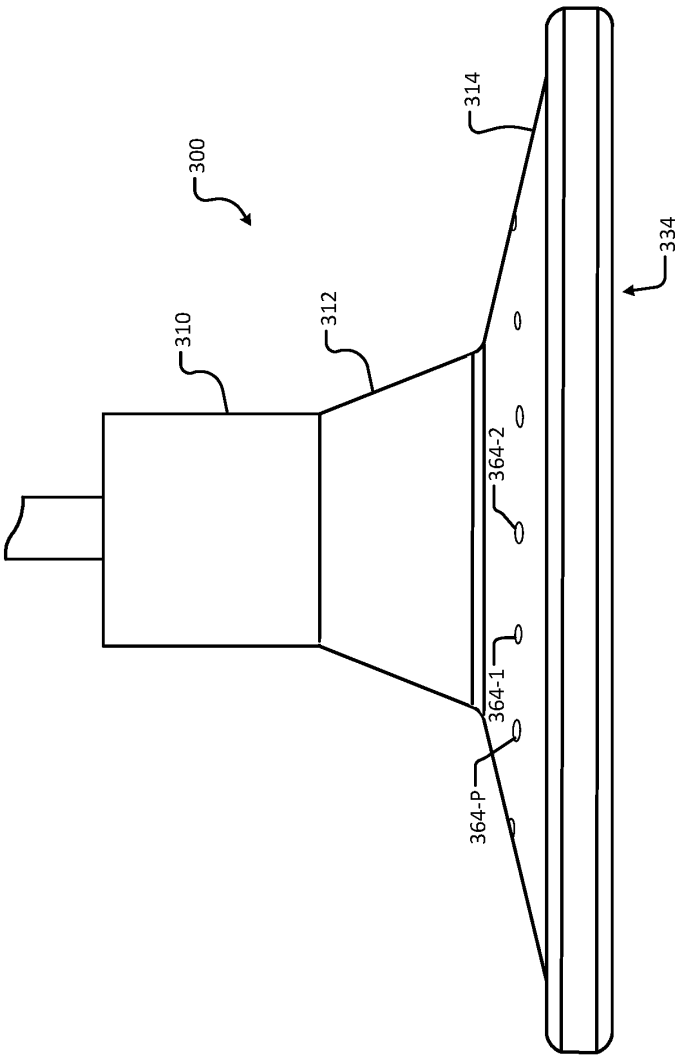


FIG. 4B

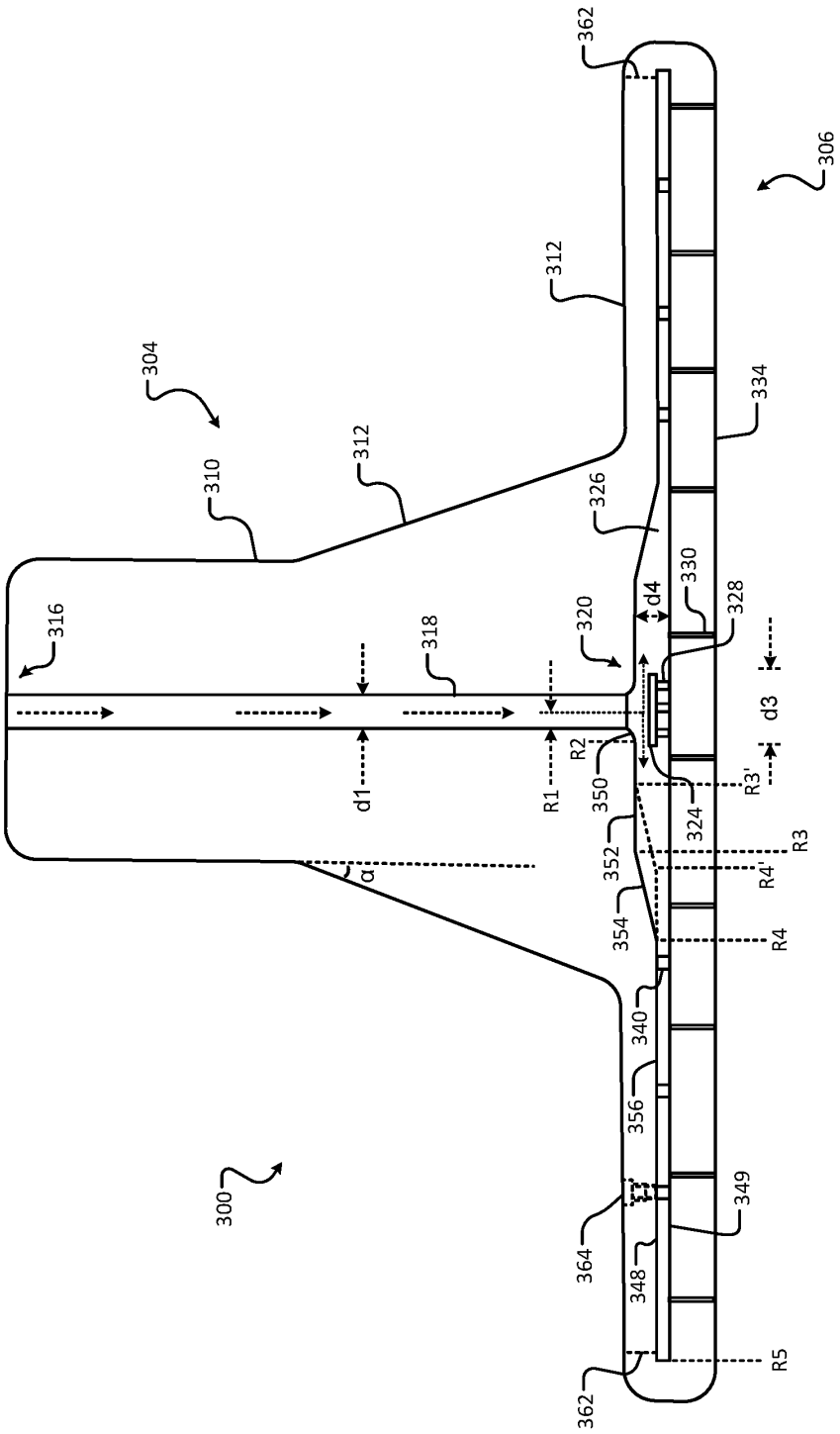

362
306
312
304
334
310
312
326
330
d4
328
316
318
320
d3
R2
R3'
d1
R1
350
324
R3
352
R4'
α
354
R4
340
356
300
349
364
348
R5
362

FIG. 4C

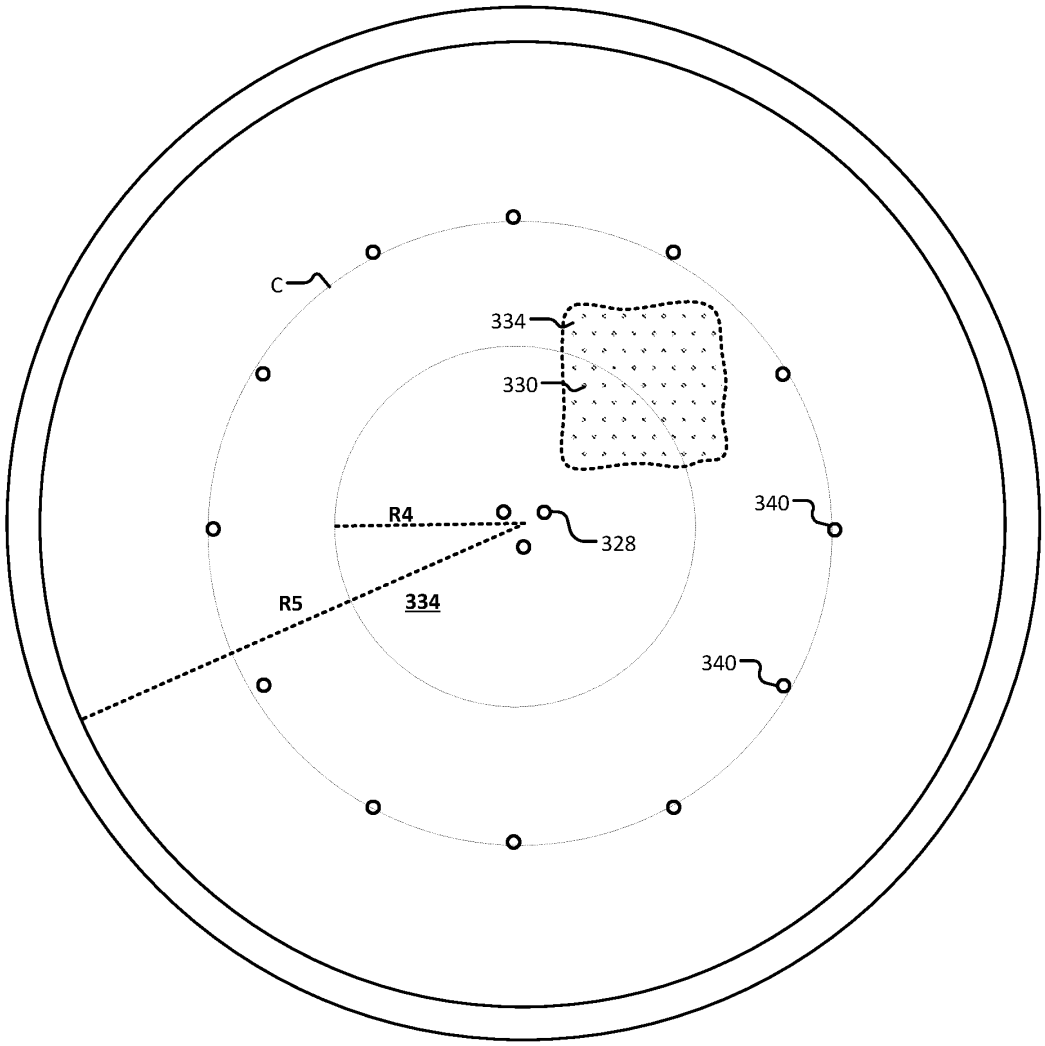


FIG. 4D

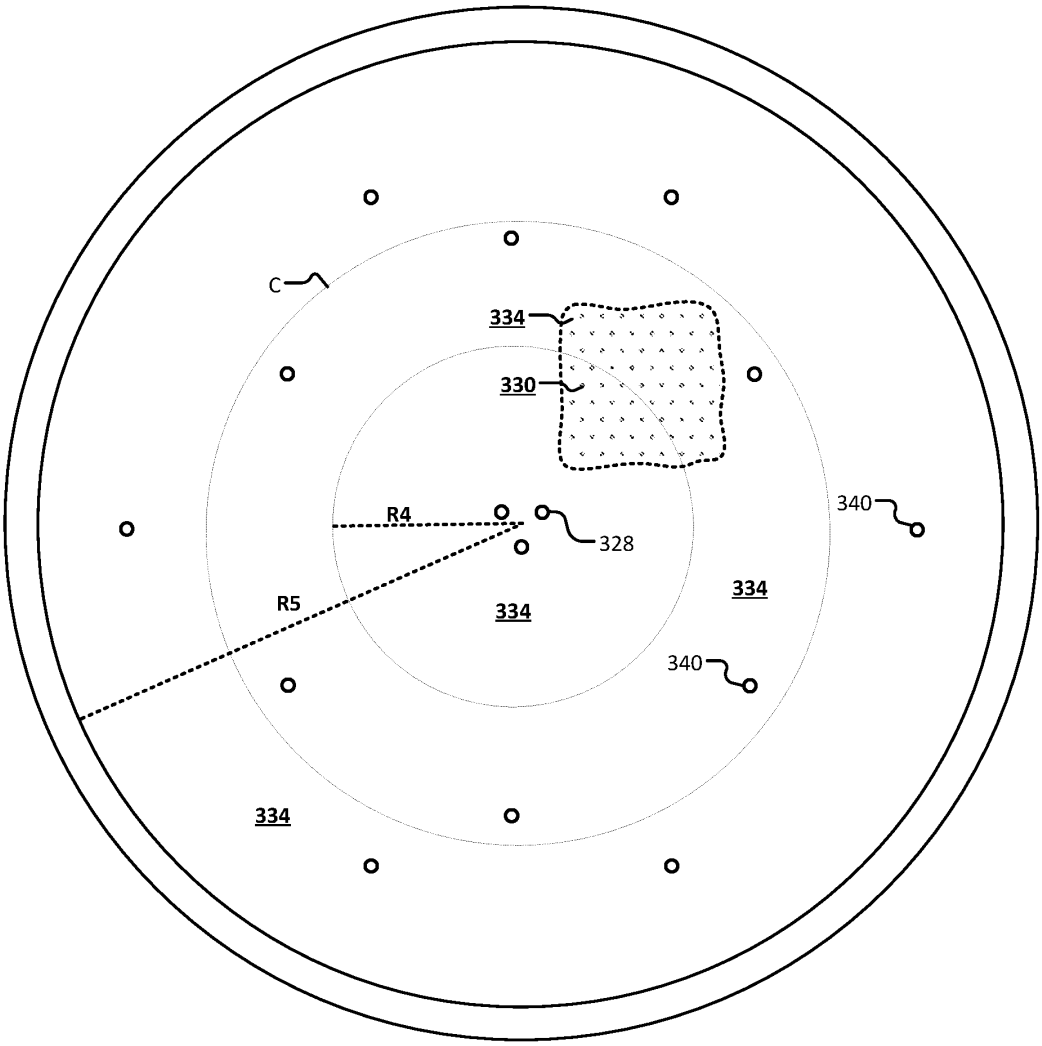


FIG. 4E

FIG. 5

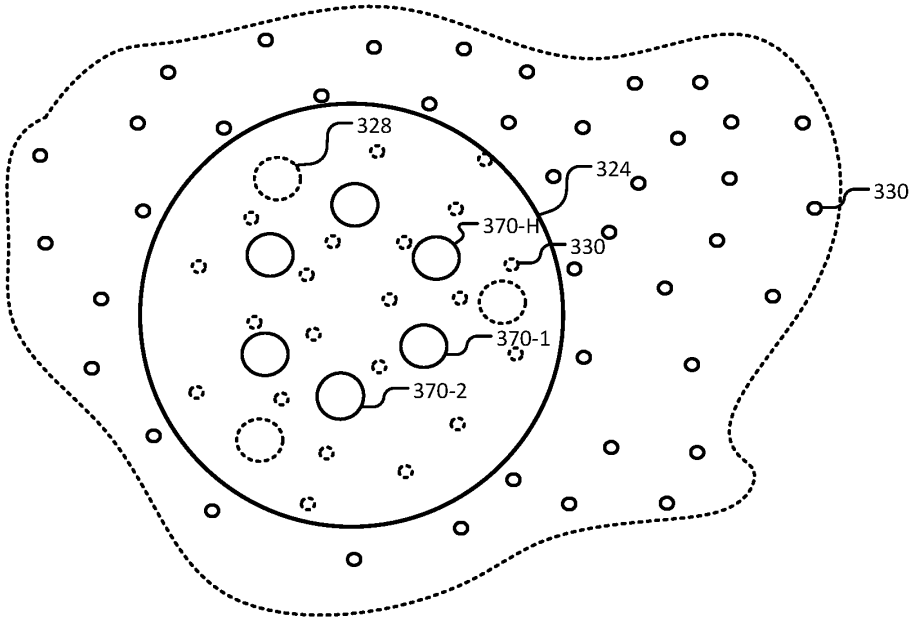

328
324
330
370-H
330
370-1
370-2

FIG. 6

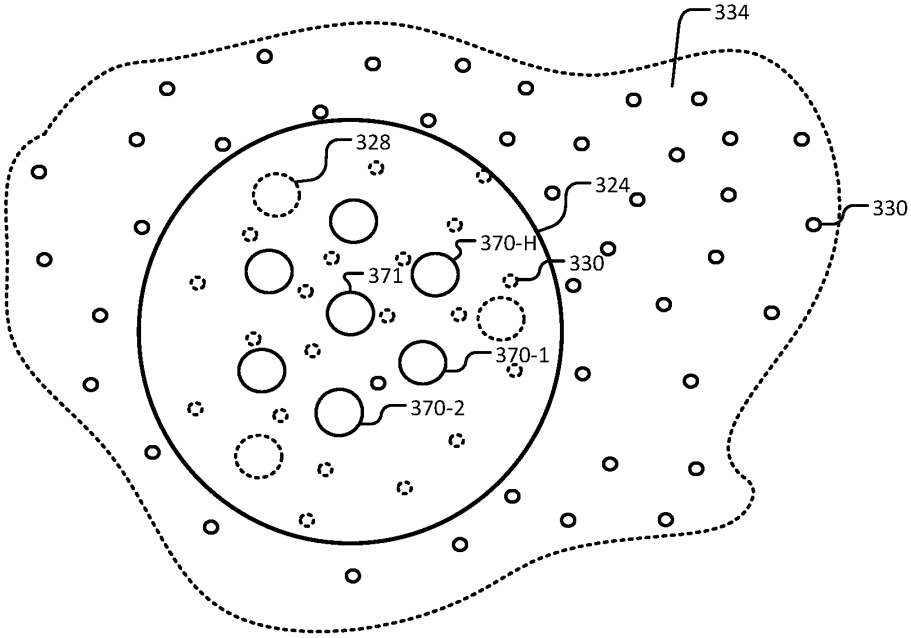

334
328
324
330
370-H
330
371
370-1
370-2

FIG. 7

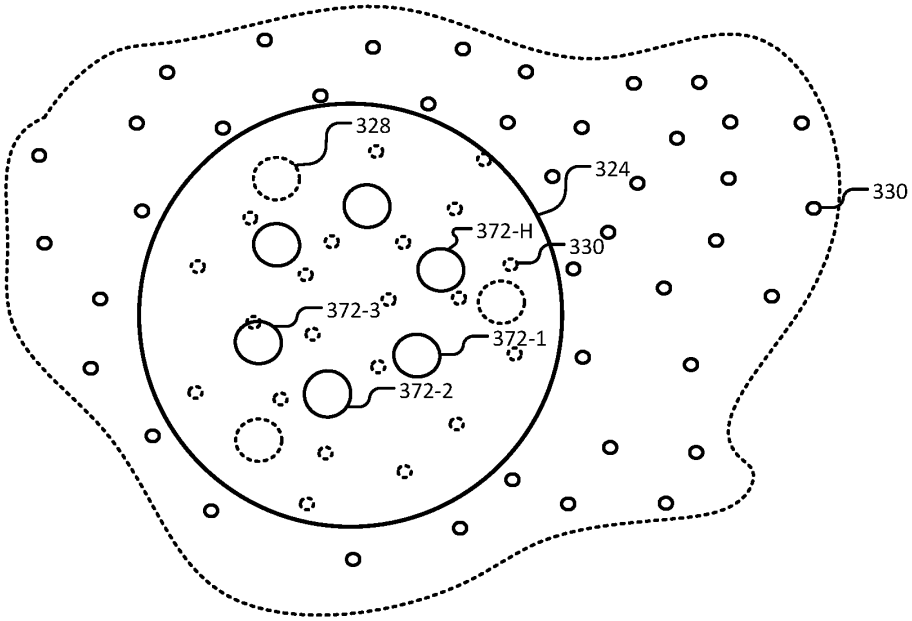

328
324
330
372-H
330
372-3
372-1
372-2

FIG. 8

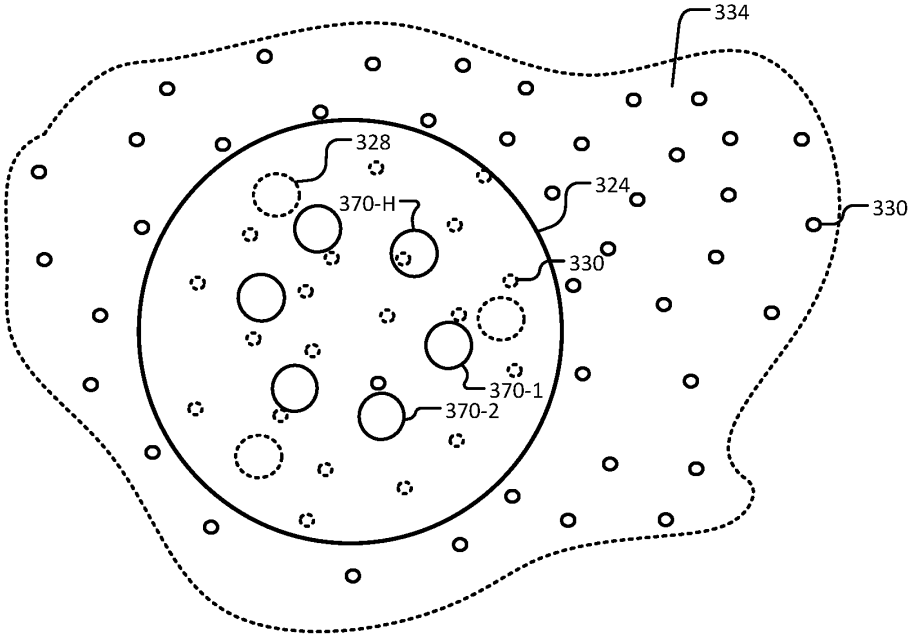
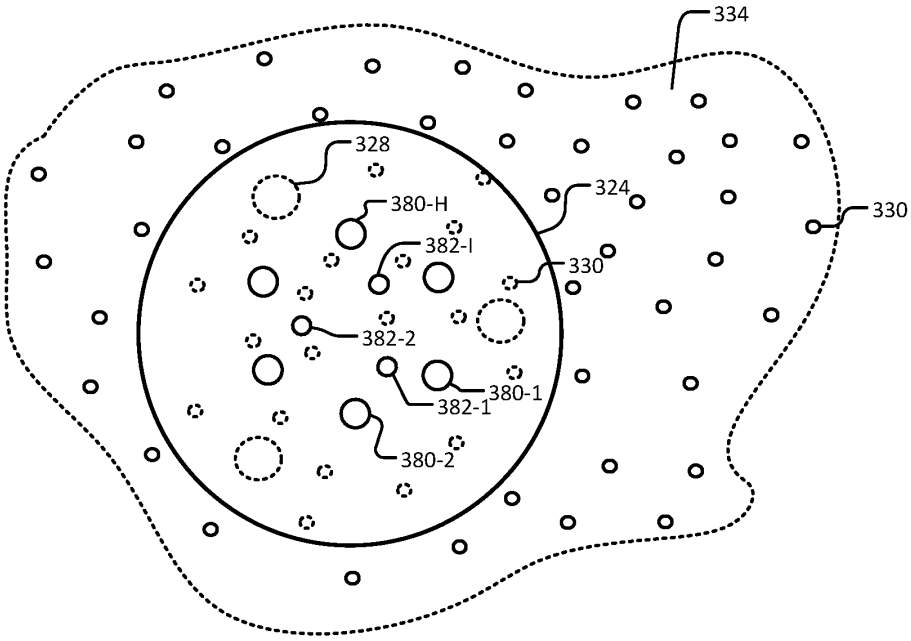

334
328
324
330
370-H
330
370-1
370-2

FIG. 9



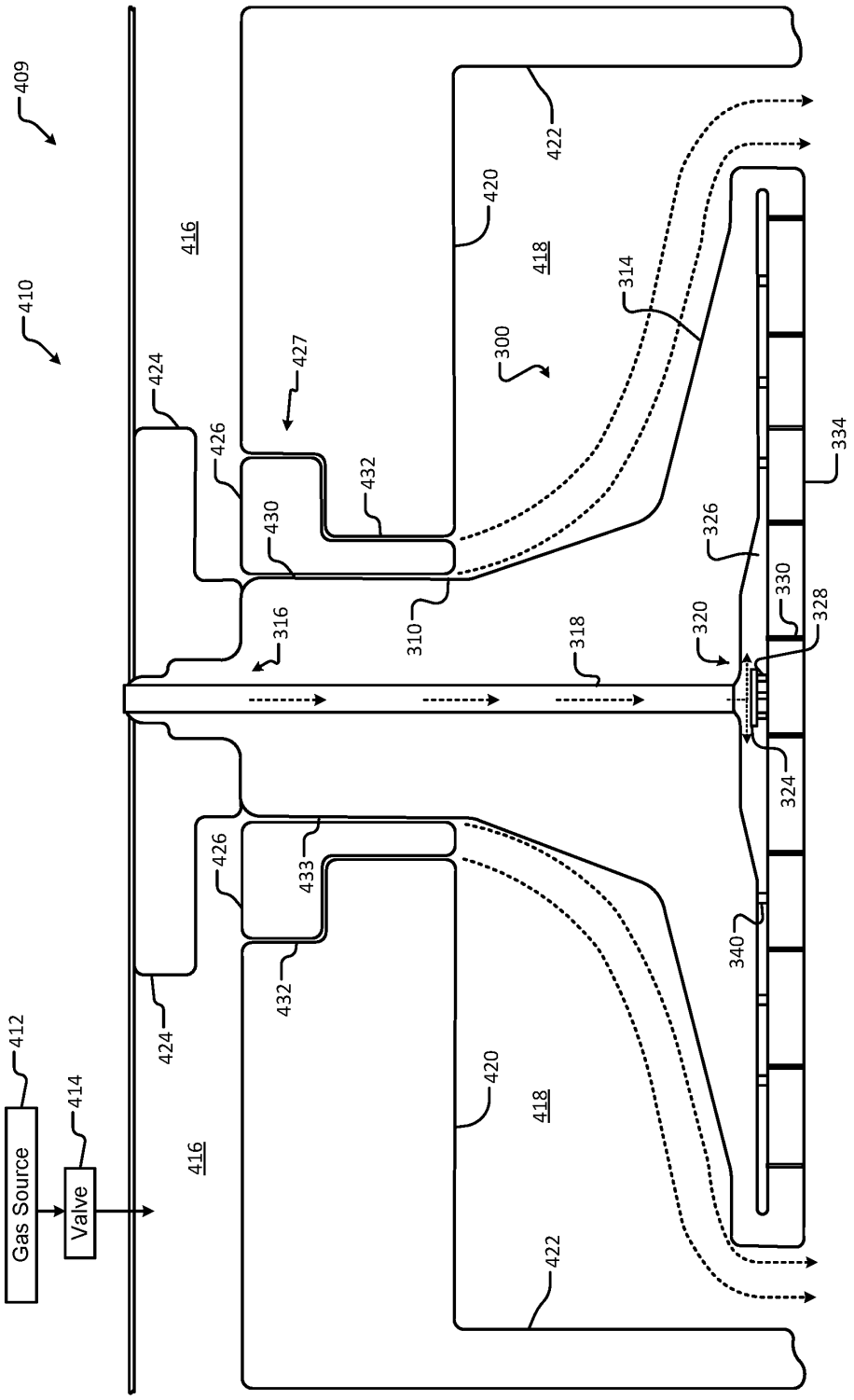

409
410
412
Gas Source
414
Valve
416
418
420
422
424
426
427
430
432
433
310
314
316
318
320
324
326
328
330
334
340
300

FIG. 10

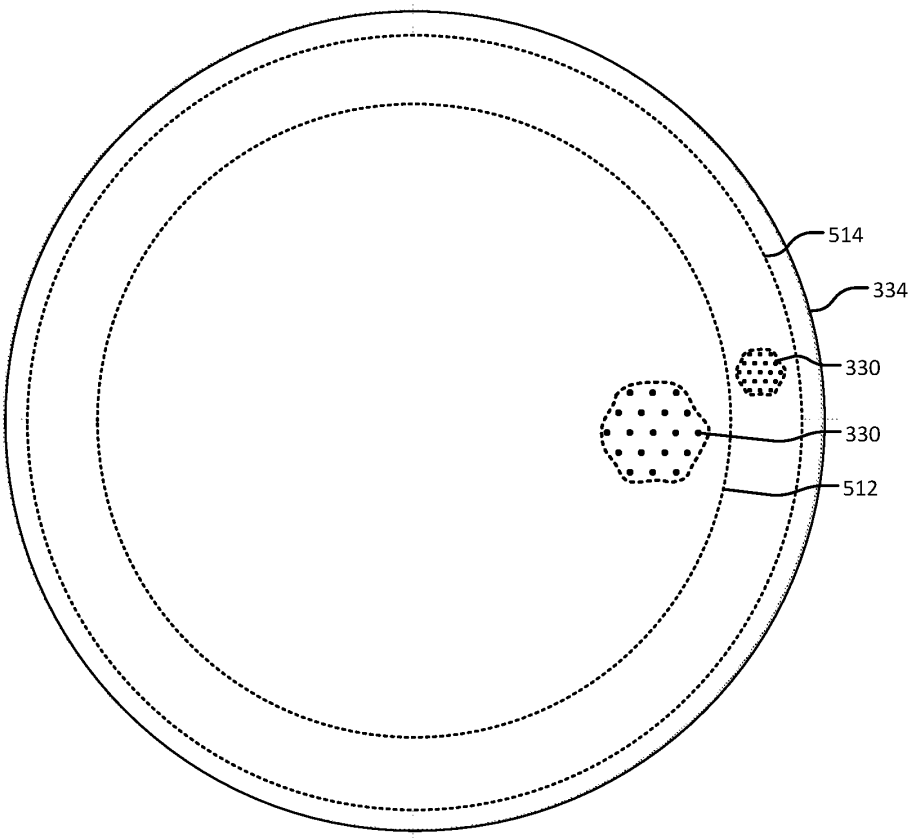


FIG. 11

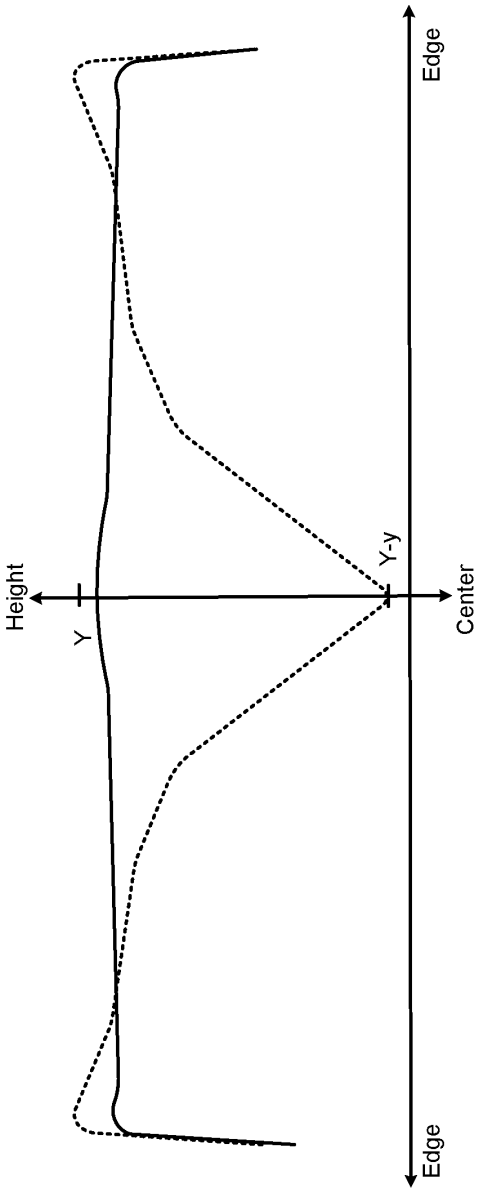


FIG. 12

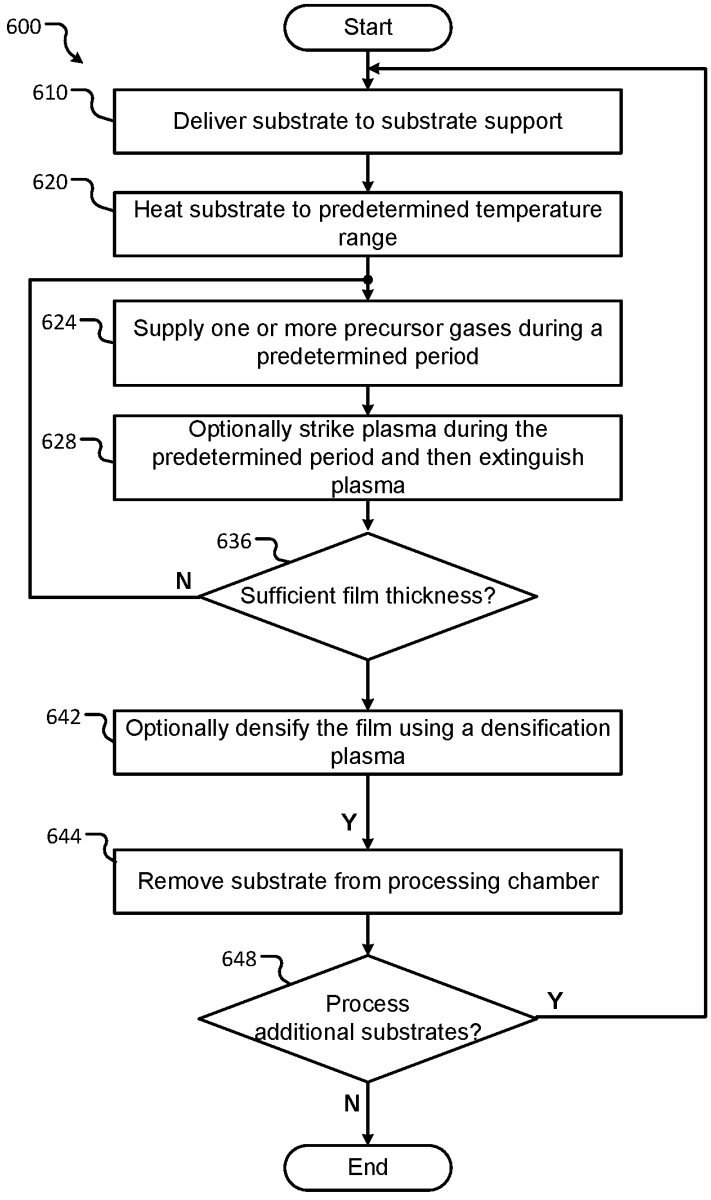

600
Start
610
Deliver substrate to substrate support
620
Heat substrate to predetermined temperature range
624
Supply one or more precursor gases during a predetermined period
628
Optionally strike plasma during the predetermined period and then extinguish plasma
636
Sufficient film thickness?
N
642
Optionally densify the film using a densification plasma
Y
644
Remove substrate from processing chamber
648
Process additional substrates?
Y
N
End

FIG. 13

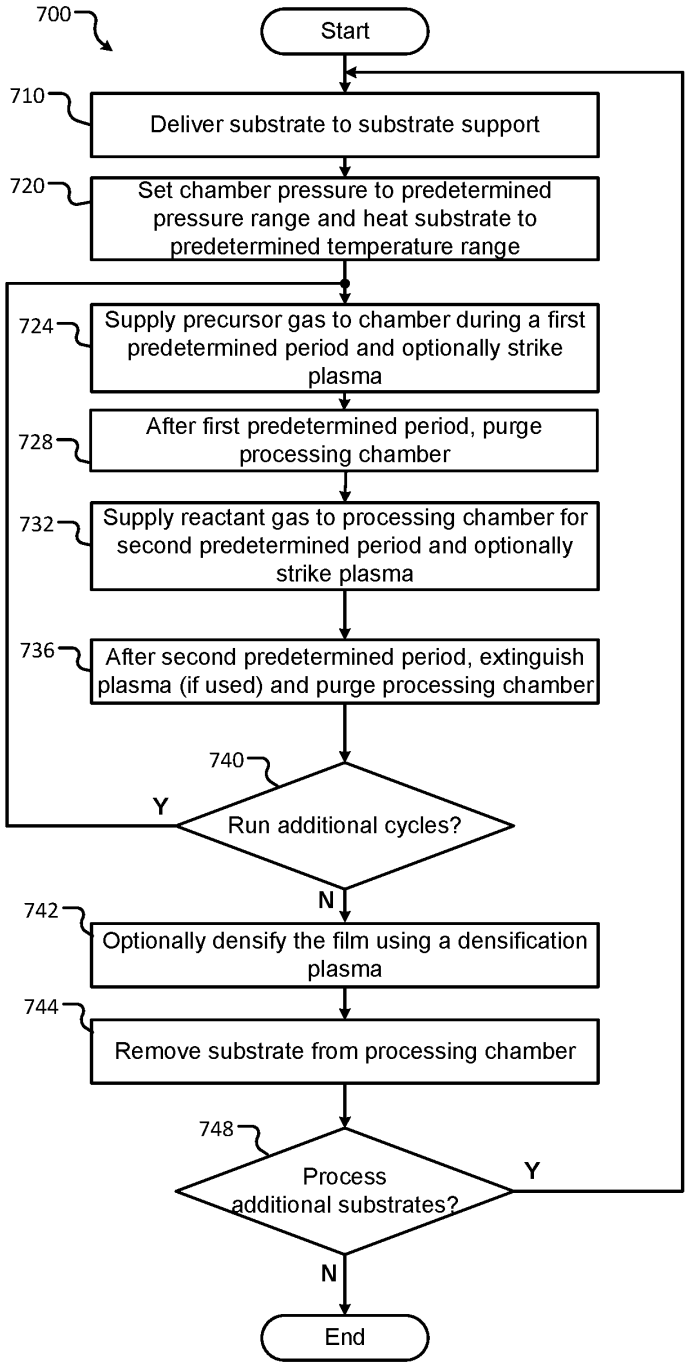

700
Start
710
Deliver substrate to substrate support
720
Set chamber pressure to predetermined pressure range and heat substrate to predetermined temperature range
724
Supply precursor gas to chamber during a first predetermined period and optionally strike plasma
728
After first predetermined period, purge processing chamber
732
Supply reactant gas to processing chamber for second predetermined period and optionally strike plasma
736
After second predetermined period, extinguish plasma (if used) and purge processing chamber
740
Run additional cycles?
Y
N
742
Optionally densify the film using a densification plasma
744
Remove substrate from processing chamber
748
Process additional substrates?
Y
N
End

FIG. 14

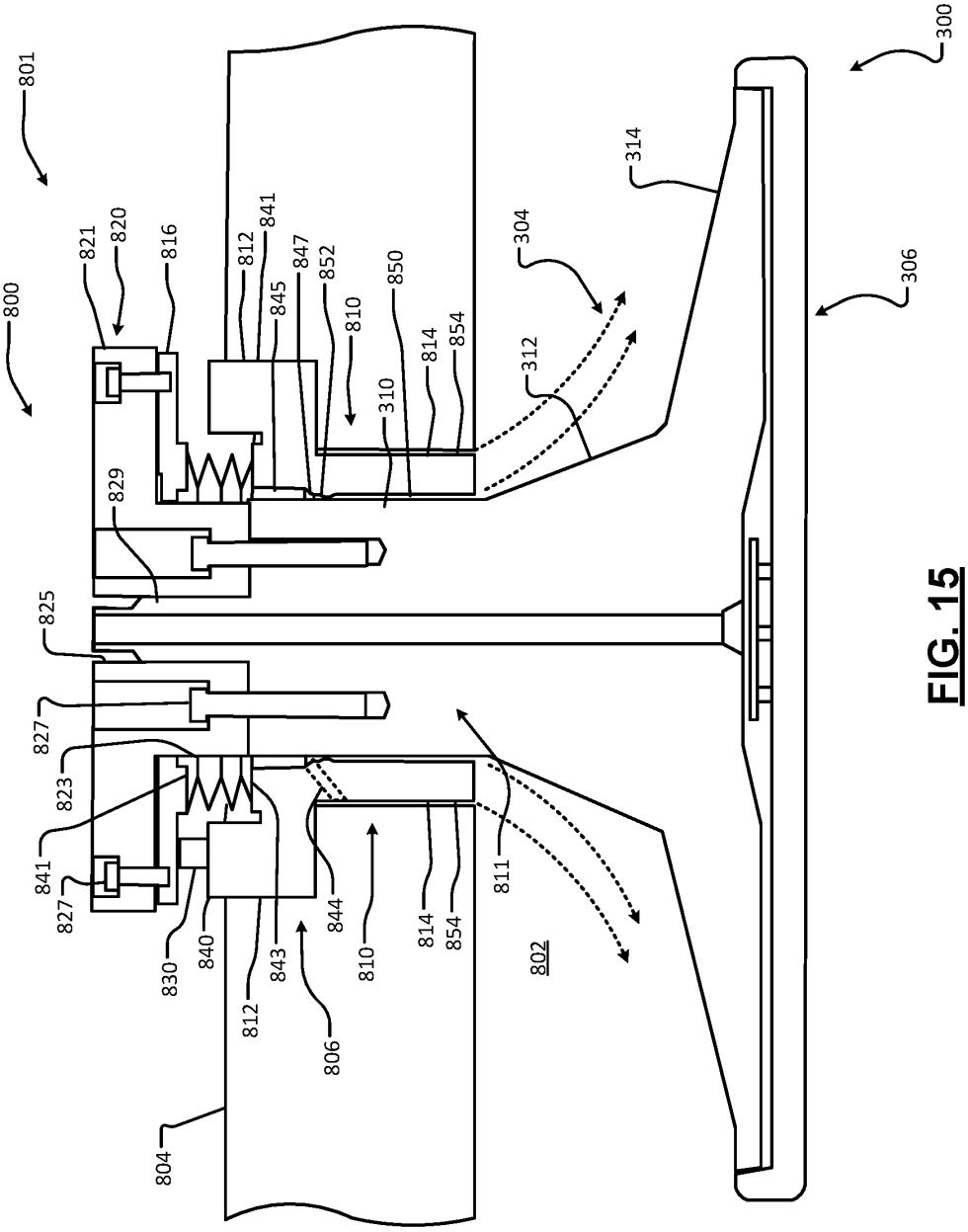

300
801
800
821
820
816
812
841
847
852
845
810
850
814
854
304
314
306
312
310
829
825
827
823
841
827
830
840
812
843
844
810
814
854
811
802
806
804

FIG. 15

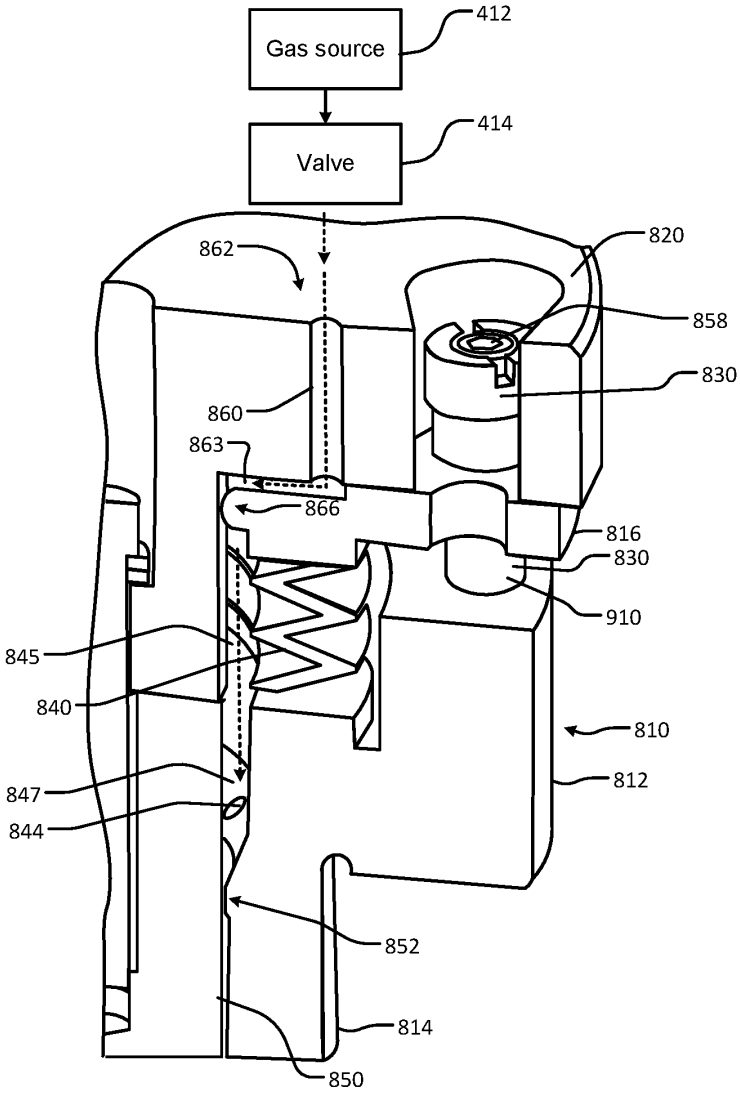

Gas source
412
Valve
414
862
820
858
830
860
863
866
816
830
910
845
840
810
812
847
844
852
814
850

FIG. 16

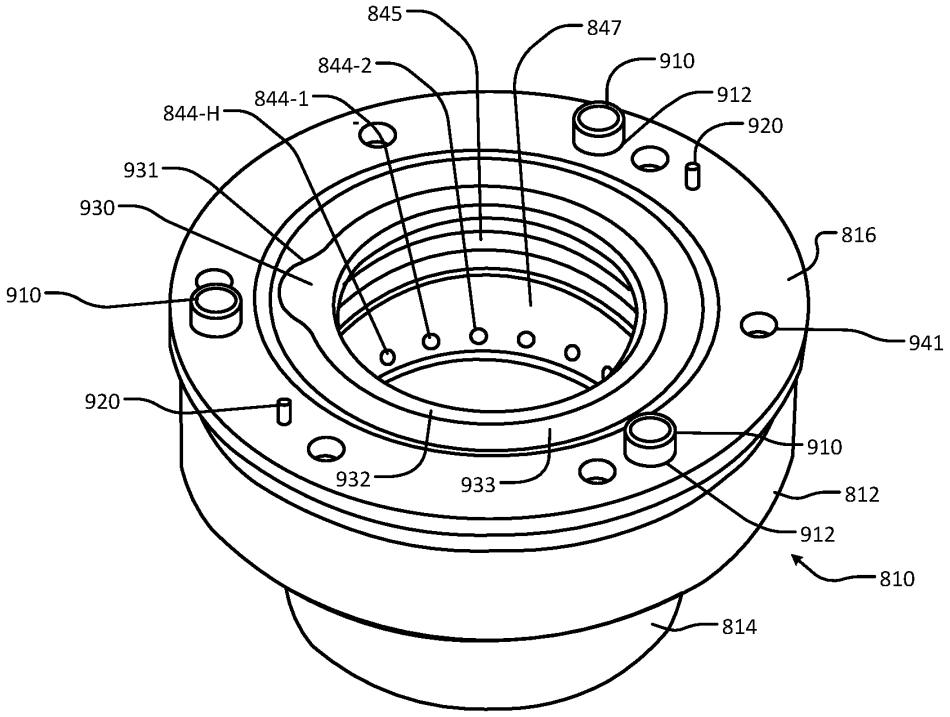

845
847
844-2
910
844-1
912
844-H
920
931
930
816
910
941
920
910
932
933
812
912
810
814

FIG. 17