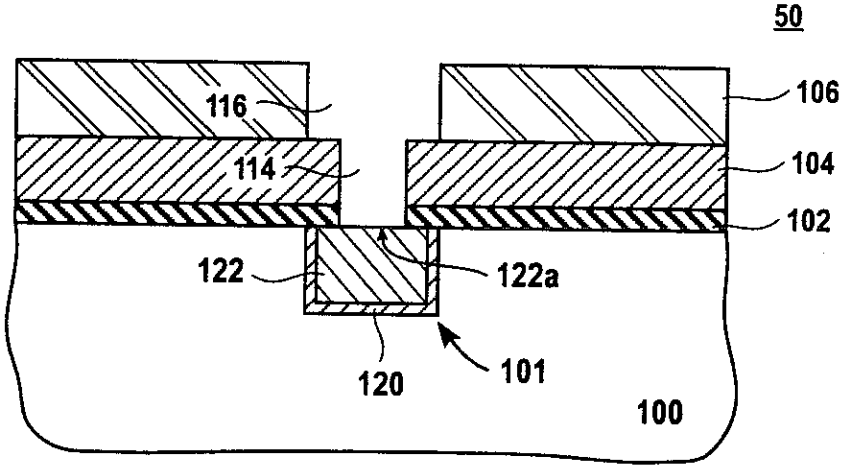

50
116
106
114
104
102
122
122a
120
101
100

FIG. 1A

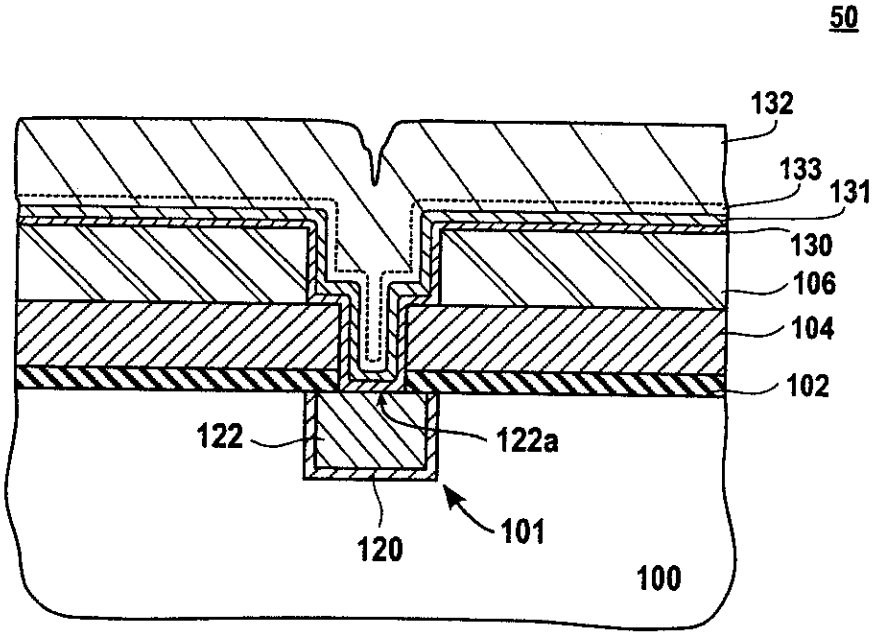

50
132
133
131
130
106
104
102
122
122a
120
101
100

FIG. 1B

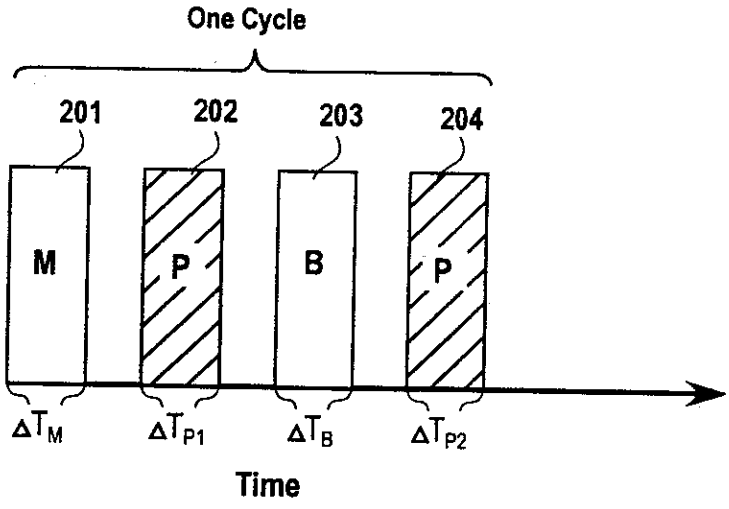

One Cycle
201
202
203
204
M
P
B
P
ΔT_M
ΔT_P1
ΔT_B
ΔT_P2
Time

FIG. 2

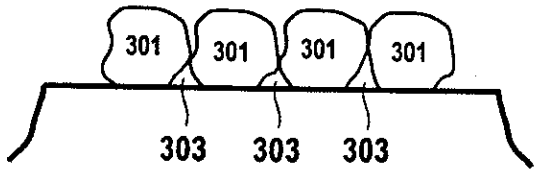

301
301
301
301
303
303
303

FIG. 3

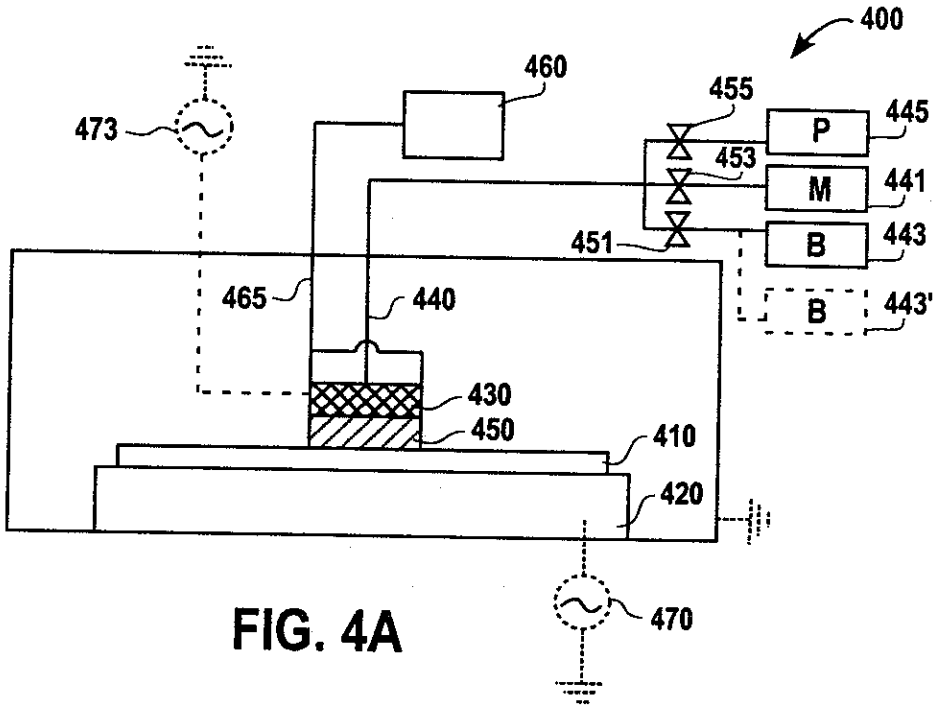

400
460
455
445
P
473
453
441
M
451
443
B
465
440
443'
B
430
450
410
420
470

FIG. 4A

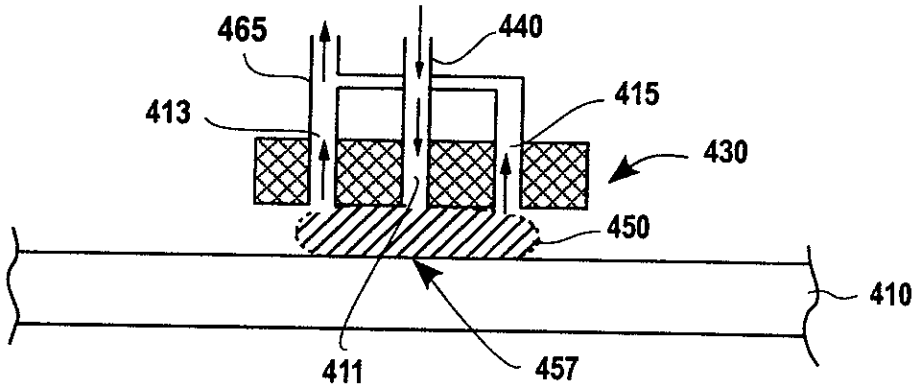

465
440
413
415
430
450
410
411
457

FIG. 4B

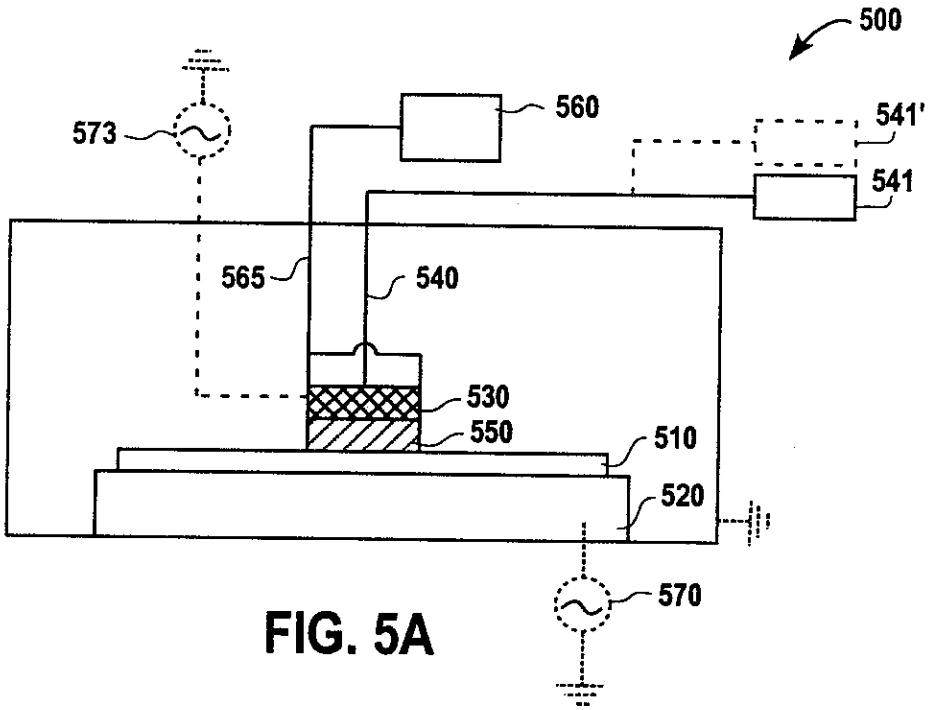

500
573
560
541'
541
565
540
530
550
510
520
570

FIG. 5A

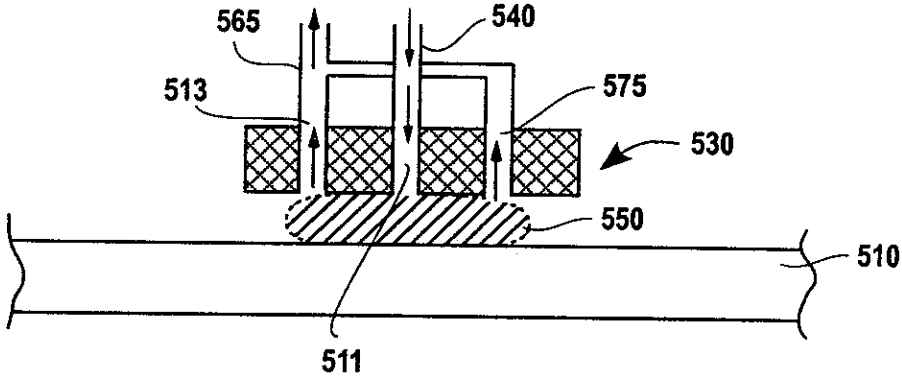

565
540
513
575
530
550
510
511

FIG. 5B

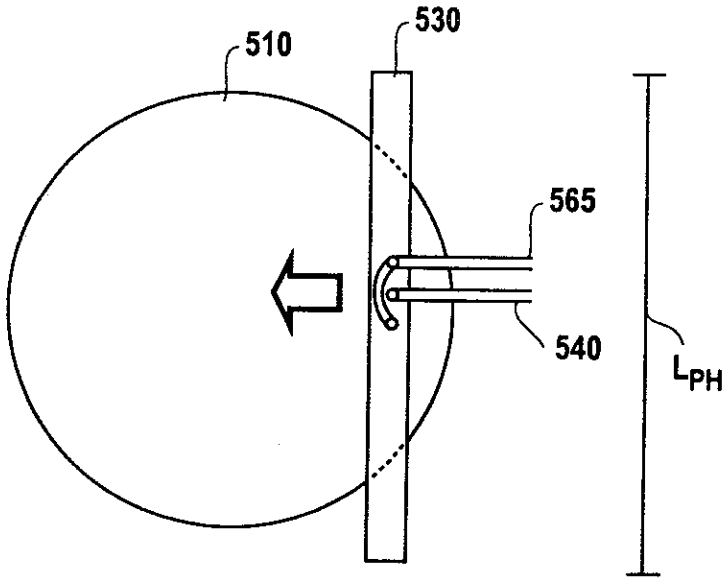

510
530
565
540
L_{PH}

FIG. 6A

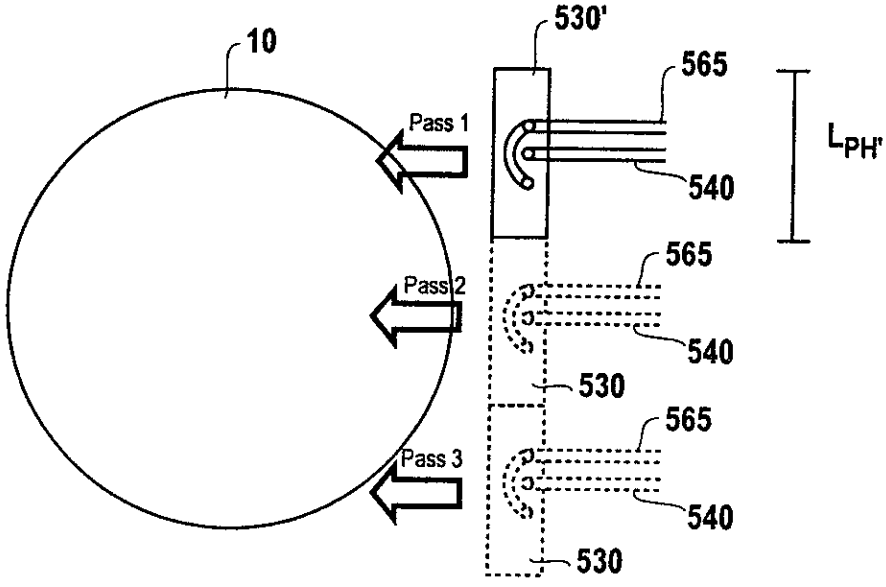

10
530'
565
Pass 1
540
$L_{PH'}$
565
Pass 2
540
530
565
Pass 3
540
530

FIG. 6B

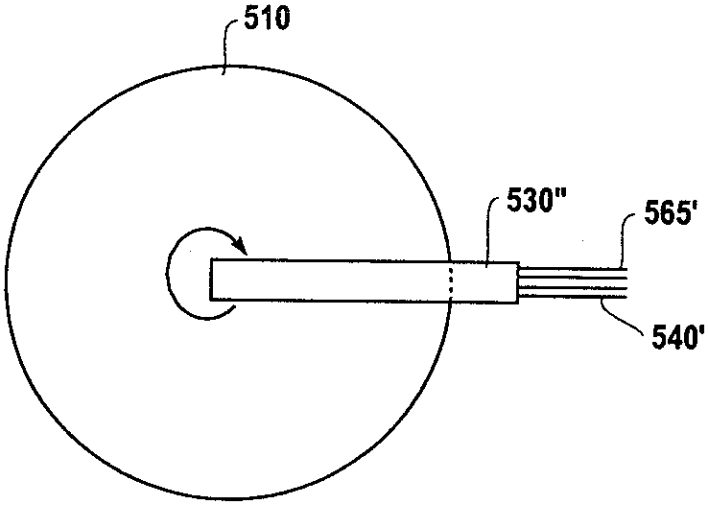


FIG. 6C

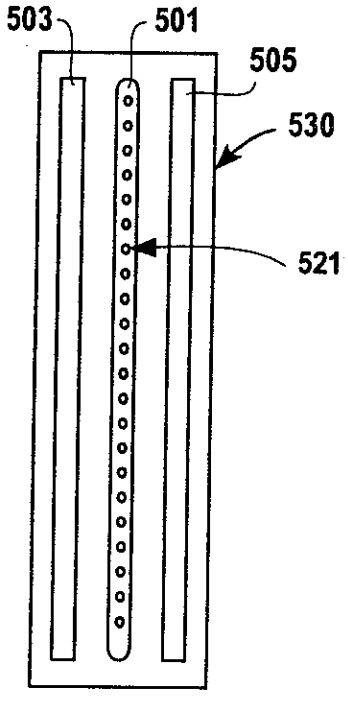


FIG. 6D

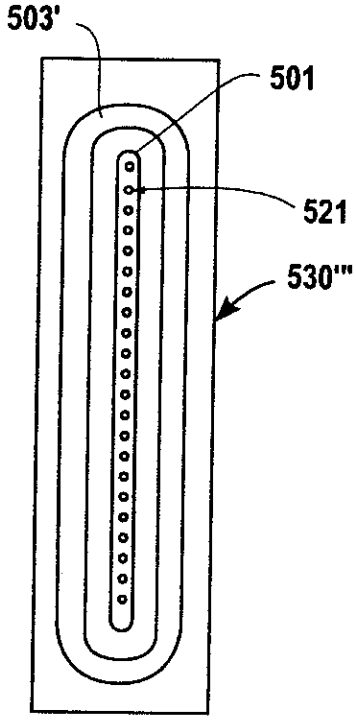


FIG. 6E

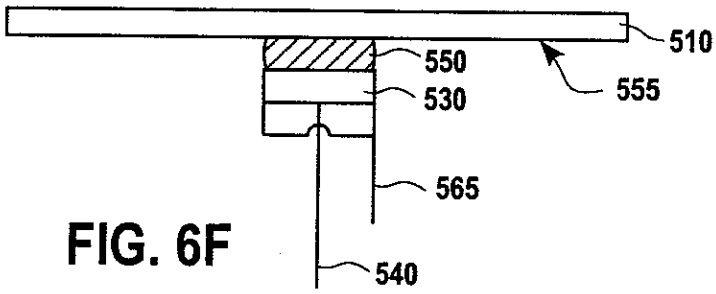


FIG. 6F

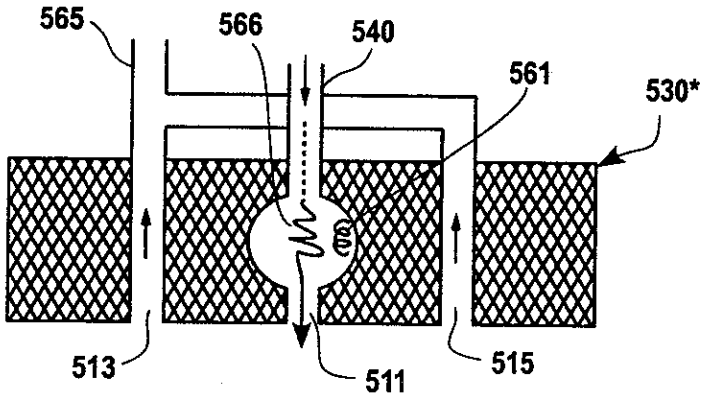


FIG. 7A

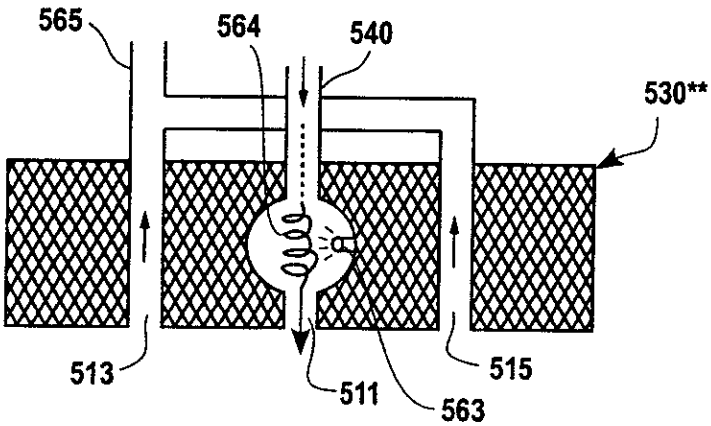


FIG. 7B

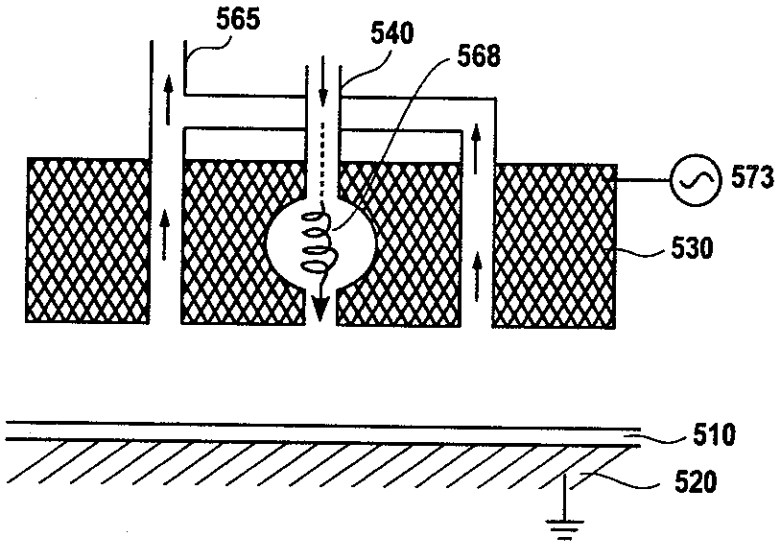


FIG. 7C

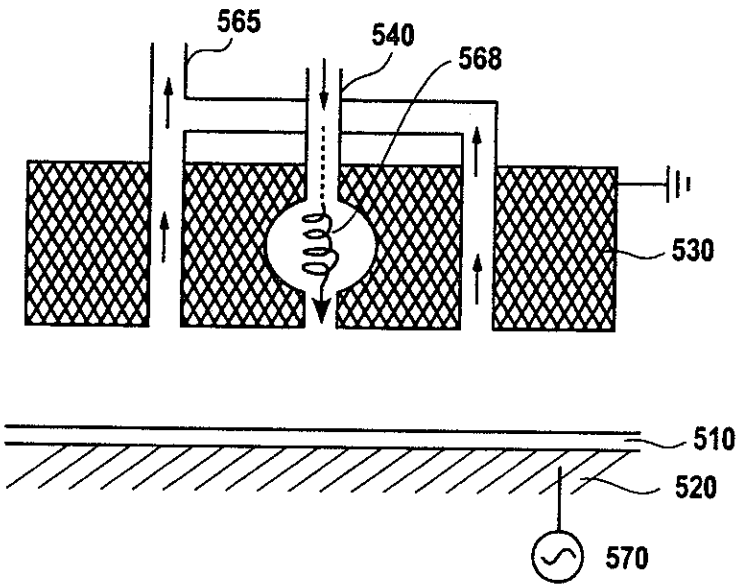


FIG. 7D

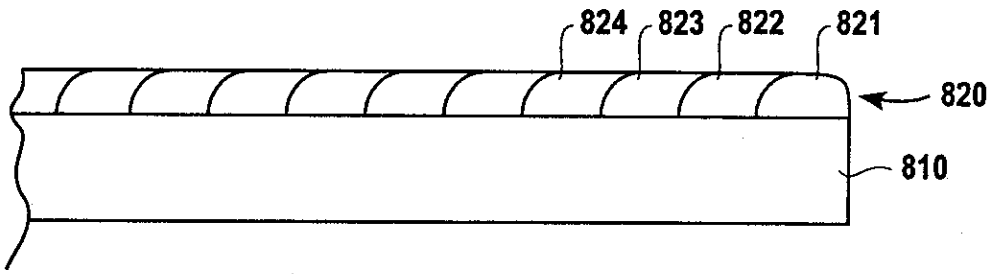


FIG. 8

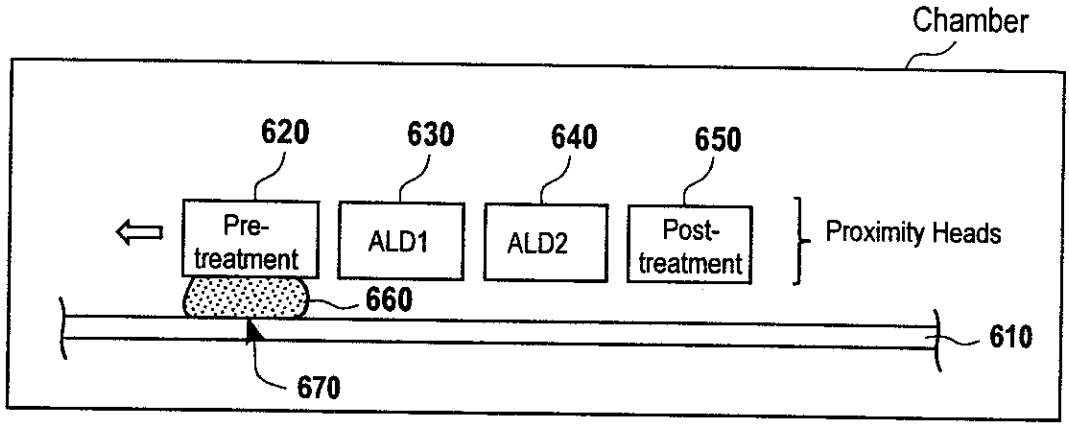

Chamber
620
630
640
650
Pre-treatment
ALD1
ALD2
Post-treatment
Proximity Heads
660
610
670

FIG. 9A

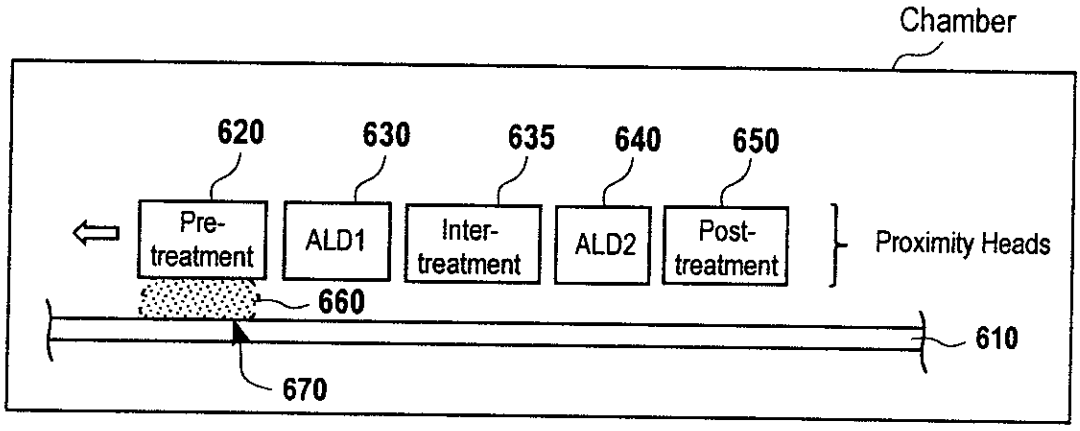

Chamber
620
630
635
640
650
Pre-treatment
ALD1
Inter-treatment
ALD2
Post-treatment
Proximity Heads
660
610
670

FIG. 9B

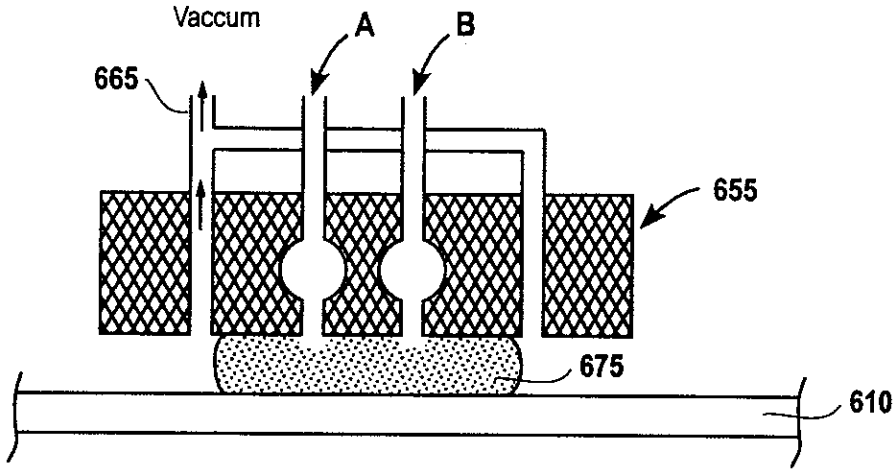

Vaccum
A
B
665
655
675
610

FIG. 9C

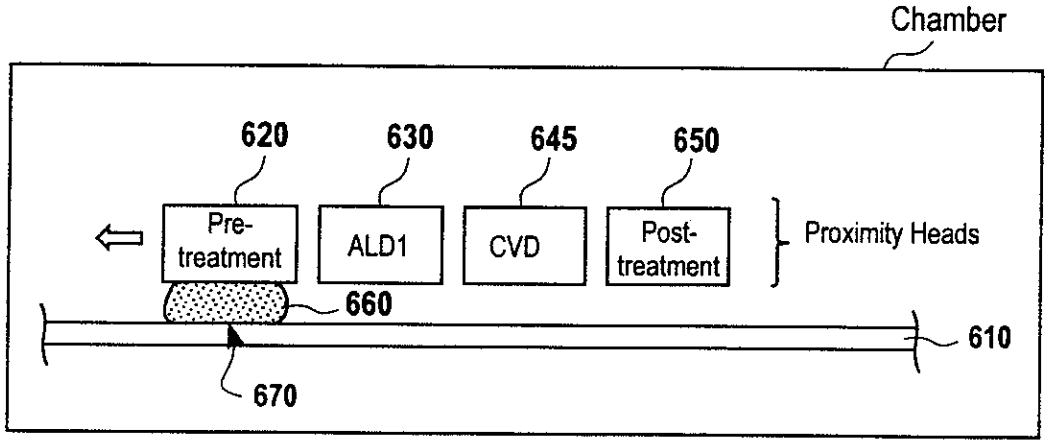

Chamber
620
630
645
650
Pre-
treatment
ALD1
CVD
Post-
treatment
Proximity Heads
660
610
670

FIG. 9D

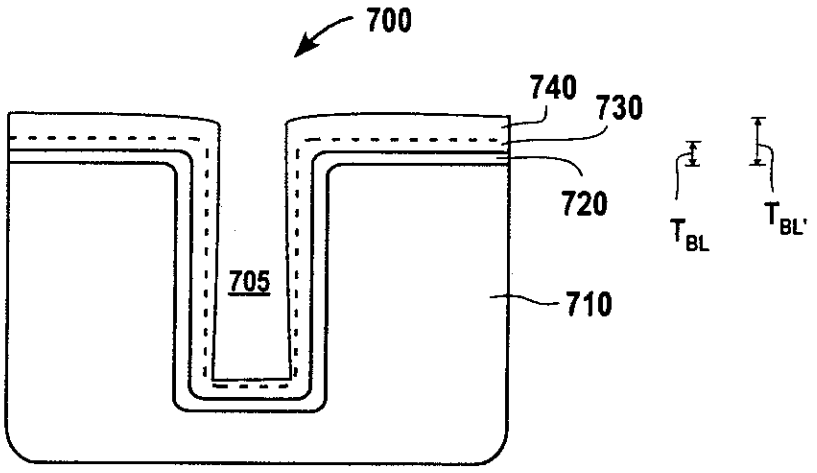


FIG. 10A

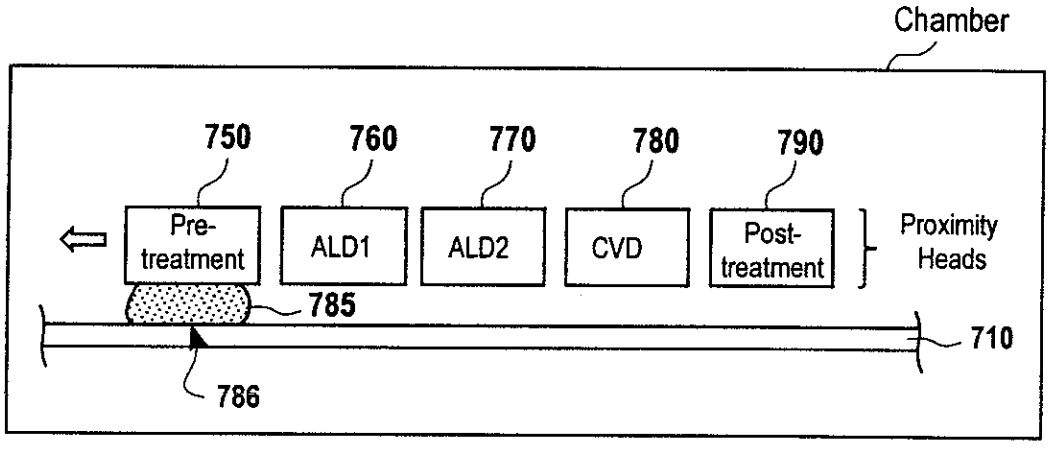


FIG. 10B

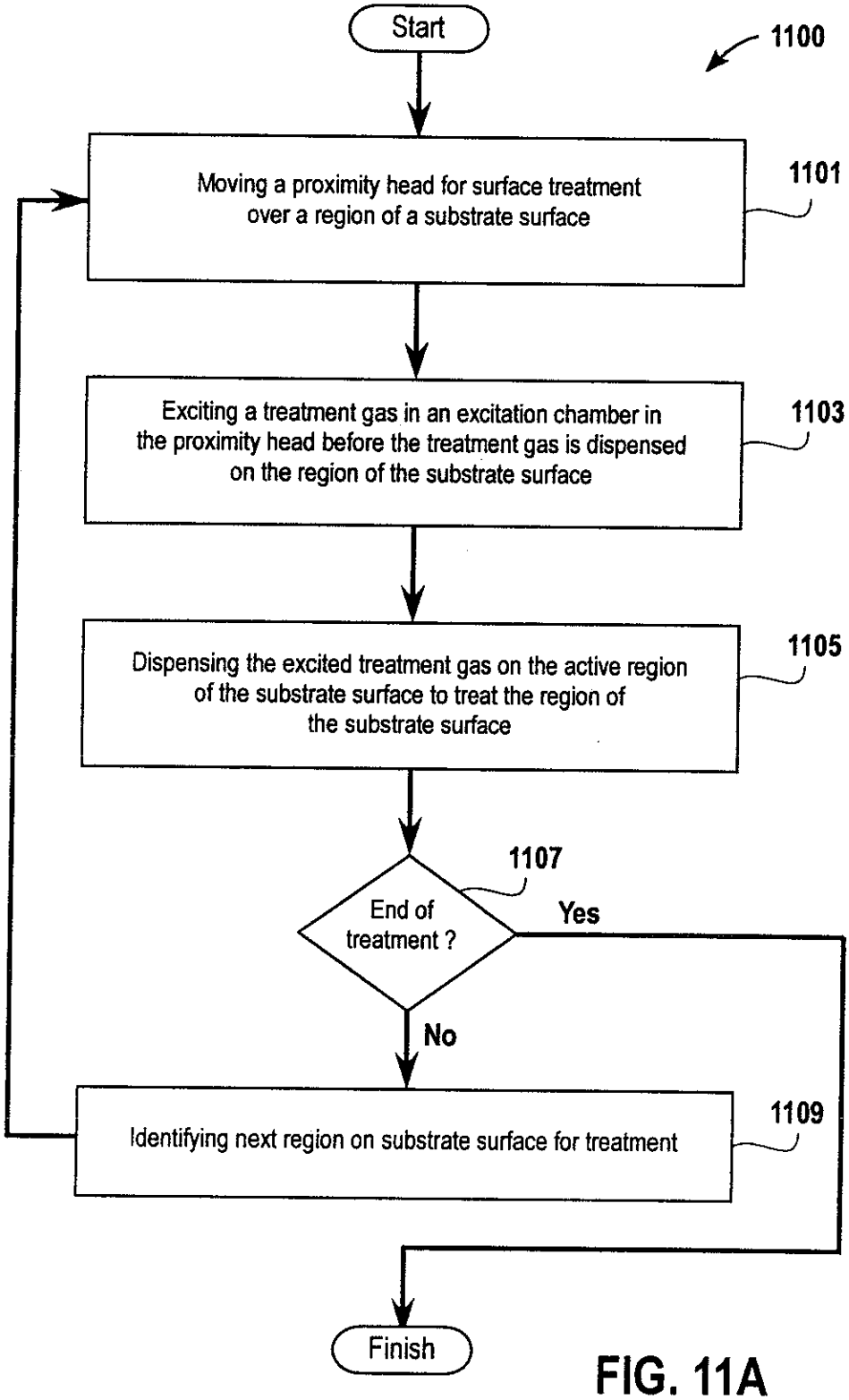

Start
1100
Moving a proximity head for surface treatment over a region of a substrate surface
1101
Exciting a treatment gas in an excitation chamber in the proximity head before the treatment gas is dispensed on the region of the substrate surface
1103
Dispensing the excited treatment gas on the active region of the substrate surface to treat the region of the substrate surface
1105
1107
End of treatment ?
Yes
No
Identifying next region on substrate surface for treatment
1109
Finish

FIG. 11A

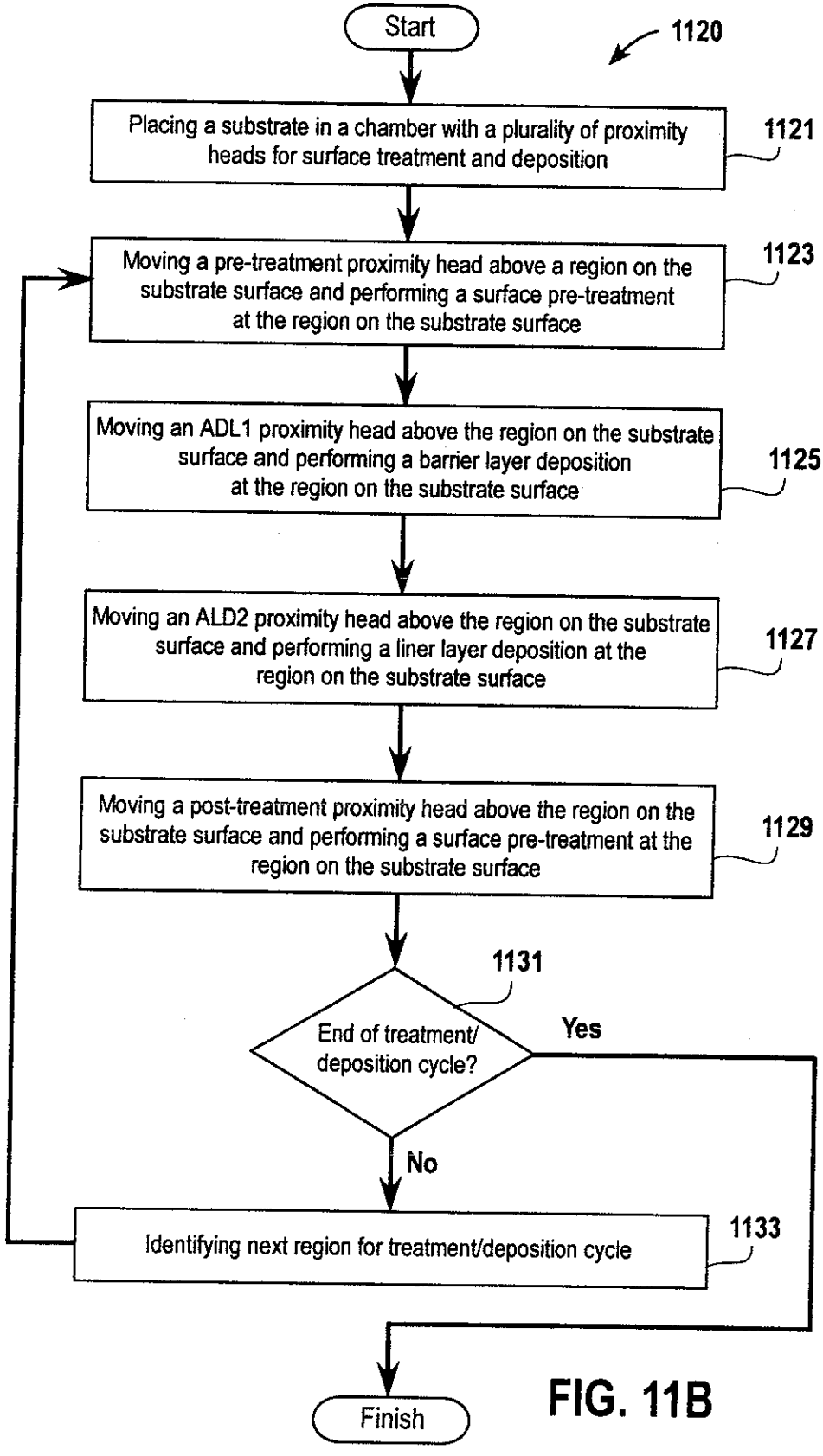

Start
1120
Placing a substrate in a chamber with a plurality of proximity heads for surface treatment and deposition
1121
Moving a pre-treatment proximity head above a region on the substrate surface and performing a surface pre-treatment at the region on the substrate surface
1123
Moving an ADL1 proximity head above the region on the substrate surface and performing a barrier layer deposition at the region on the substrate surface
1125
Moving an ALD2 proximity head above the region on the substrate surface and performing a liner layer deposition at the region on the substrate surface
1127
Moving a post-treatment proximity head above the region on the substrate surface and performing a surface pre-treatment at the region on the substrate surface
1129
1131
End of treatment/ deposition cycle?
Yes
No
Identifying next region for treatment/deposition cycle
1133
Finish

FIG. 11B

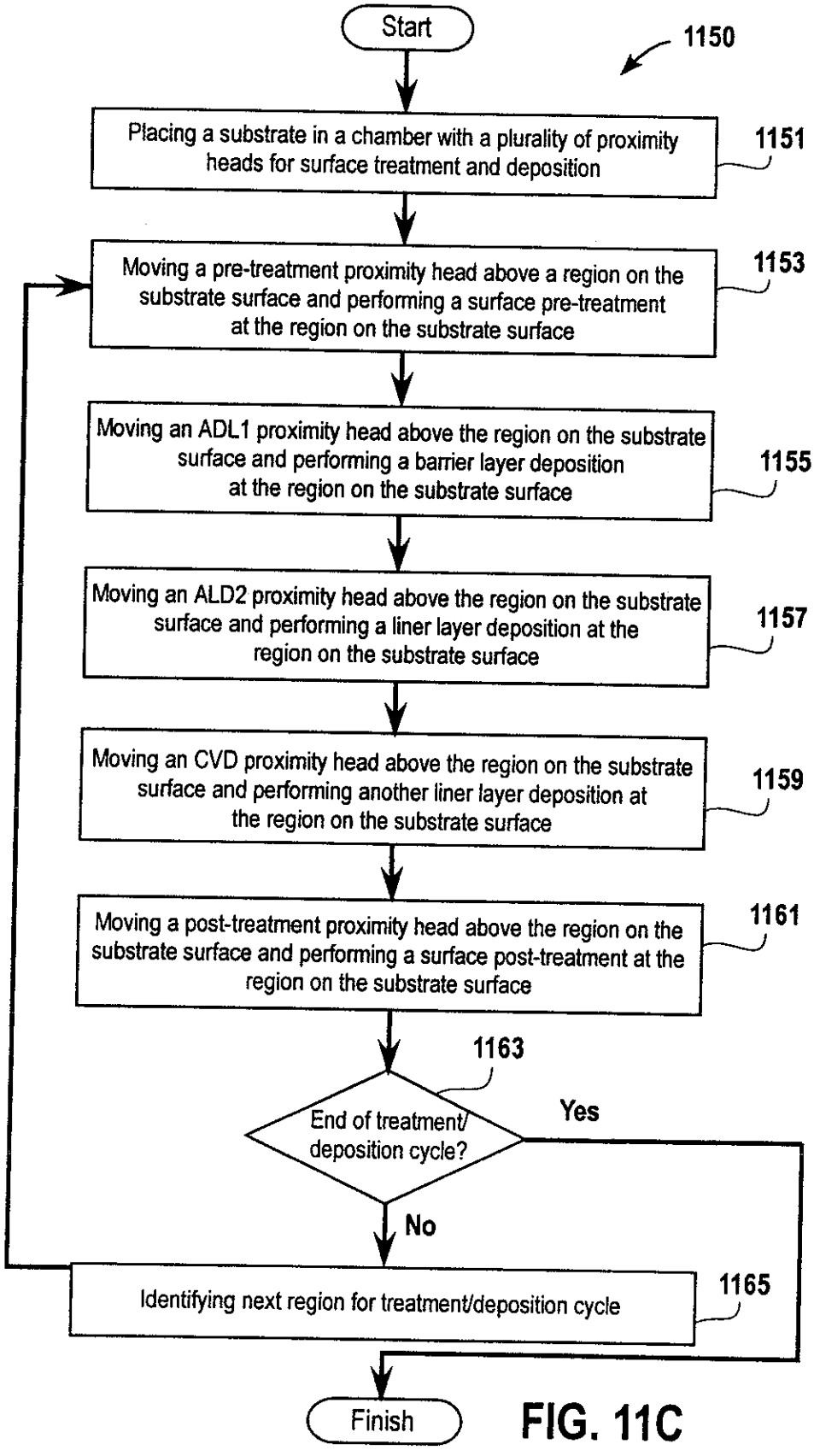

Start
1150
Placing a substrate in a chamber with a plurality of proximity heads for surface treatment and deposition
1151
Moving a pre-treatment proximity head above a region on the substrate surface and performing a surface pre-treatment at the region on the substrate surface
1153
Moving an ADL1 proximity head above the region on the substrate surface and performing a barrier layer deposition at the region on the substrate surface
1155
Moving an ALD2 proximity head above the region on the substrate surface and performing a liner layer deposition at the region on the substrate surface
1157
Moving an CVD proximity head above the region on the substrate surface and performing another liner layer deposition at the region on the substrate surface
1159
Moving a post-treatment proximity head above the region on the substrate surface and performing a surface post-treatment at the region on the substrate surface
1161
1163
End of treatment/ deposition cycle?
Yes
No
Identifying next region for treatment/deposition cycle
1165
Finish

FIG. 11C

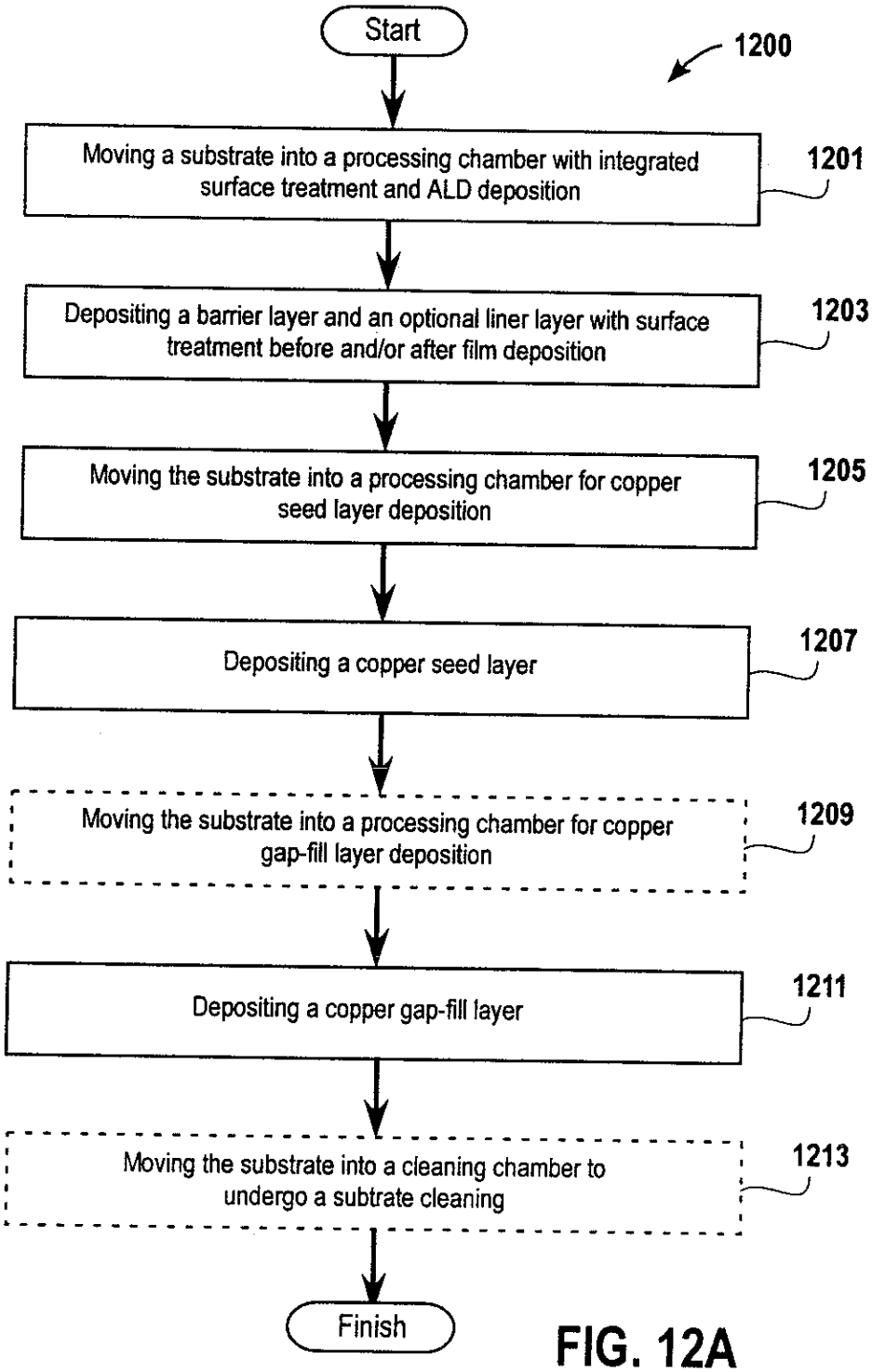

Start
1200
Moving a substrate into a processing chamber with integrated surface treatment and ALD deposition
1201
Depositing a barrier layer and an optional liner layer with surface treatment before and/or after film deposition
1203
Moving the substrate into a processing chamber for copper seed layer deposition
1205
Depositing a copper seed layer
1207
Moving the substrate into a processing chamber for copper gap-fill layer deposition
1209
Depositing a copper gap-fill layer
1211
Moving the substrate into a cleaning chamber to undergo a subtrate cleaning
1213
Finish

FIG. 12A

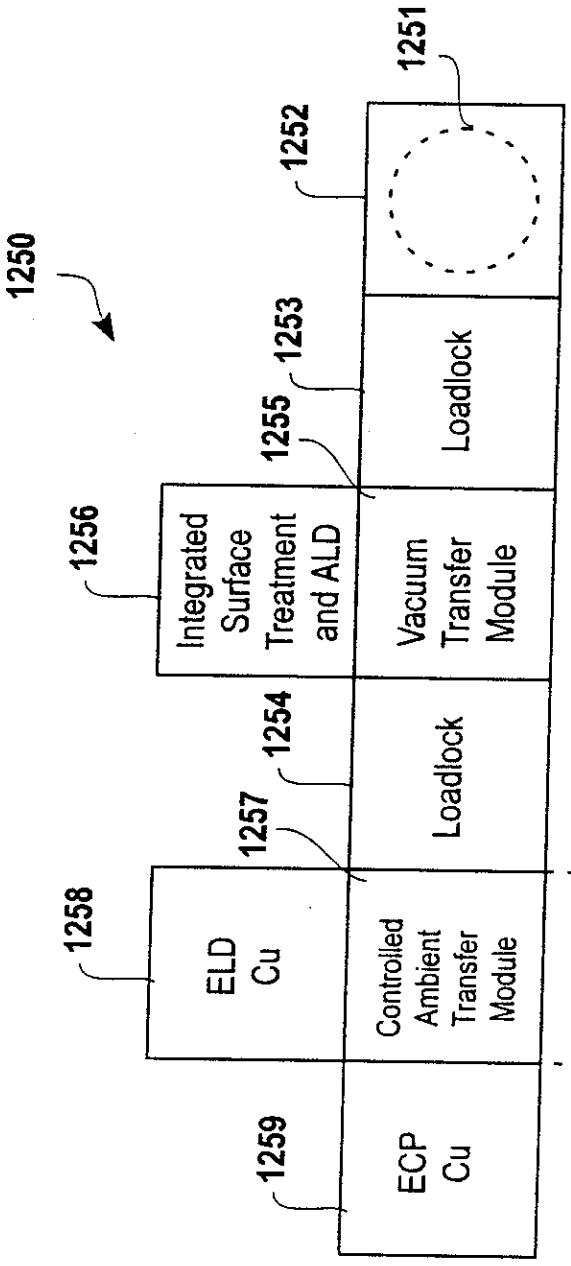

1250
1251
1252
1253
1255
1256
1254
1257
1258
1259
1261
Loadlock
Vacuum Transfer Module
Integrated Surface Treatment and ALD
Loadlock
Controlled Ambient Transfer Module
ELD Cu
ECP Cu
Clean

FIG. 12B