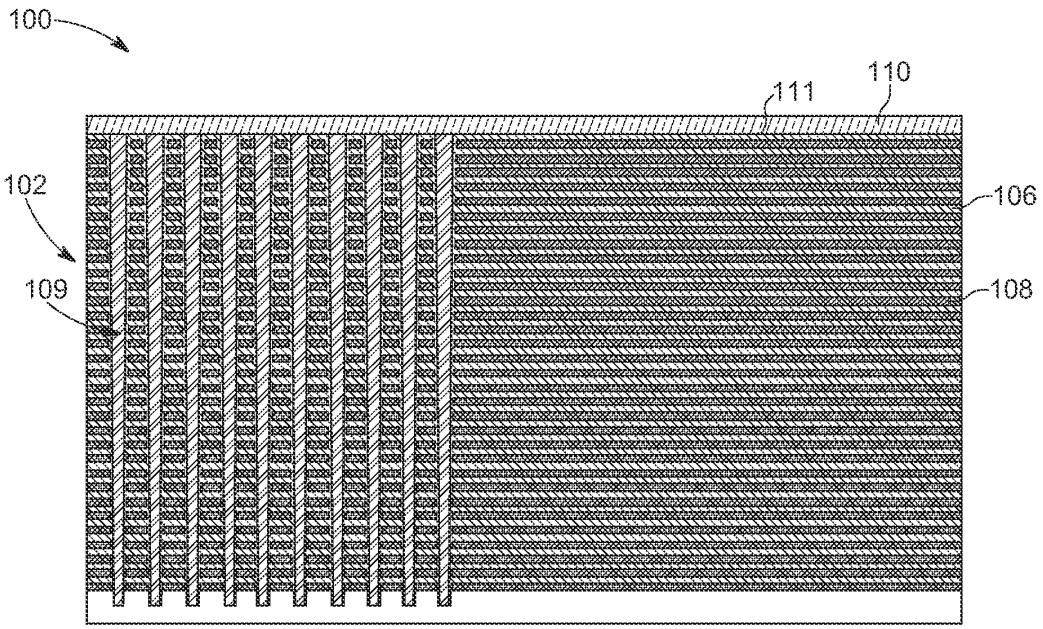

FIG. 1A

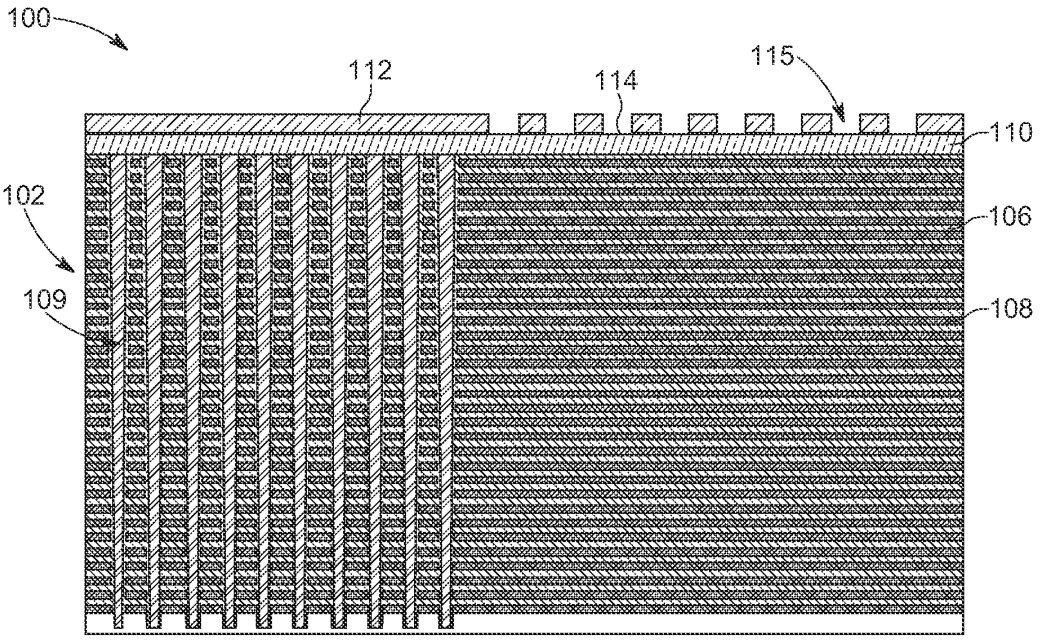

FIG. 1B

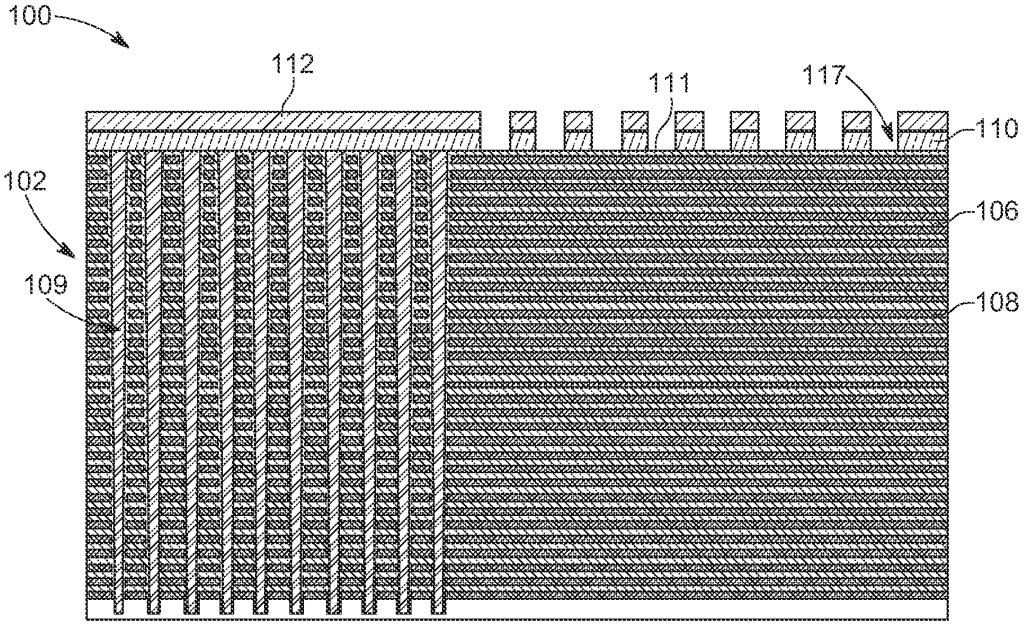
100
112
111
117
110
102
106
109
108

FIG. 1C

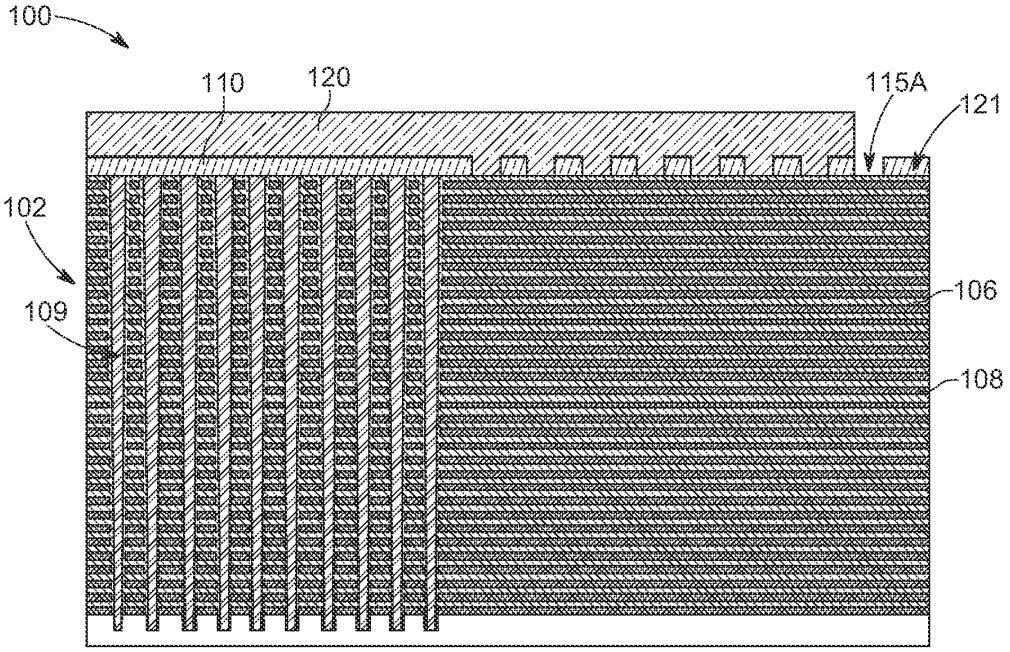
100
110
120
115A
121
102
106
109
108

FIG. 1D

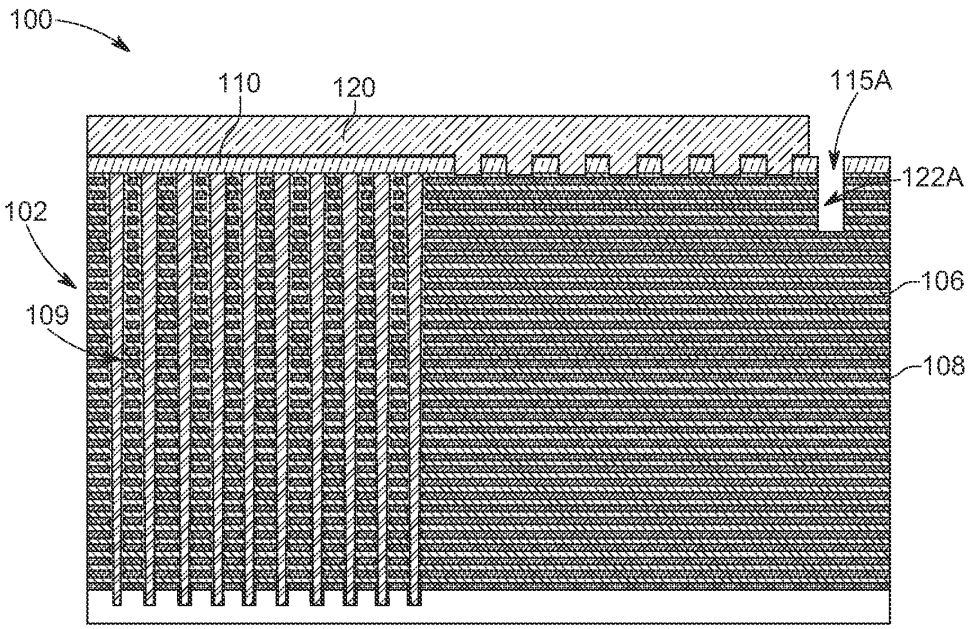
100
110
120
115A
122A
102
106
109
108

FIG. 1E

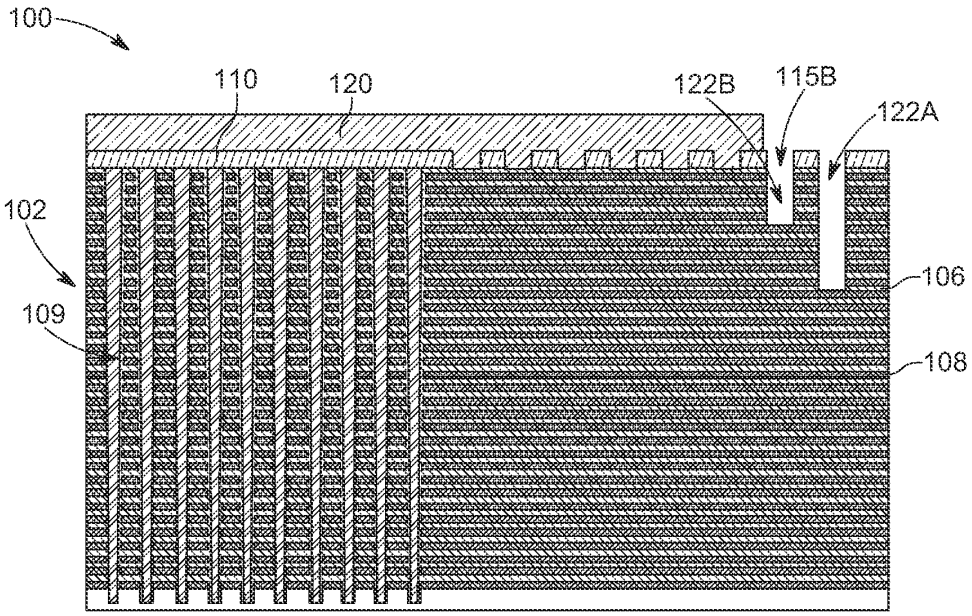
100
110
120
122B
115B
122A
102
106
109
108

FIG. 1F

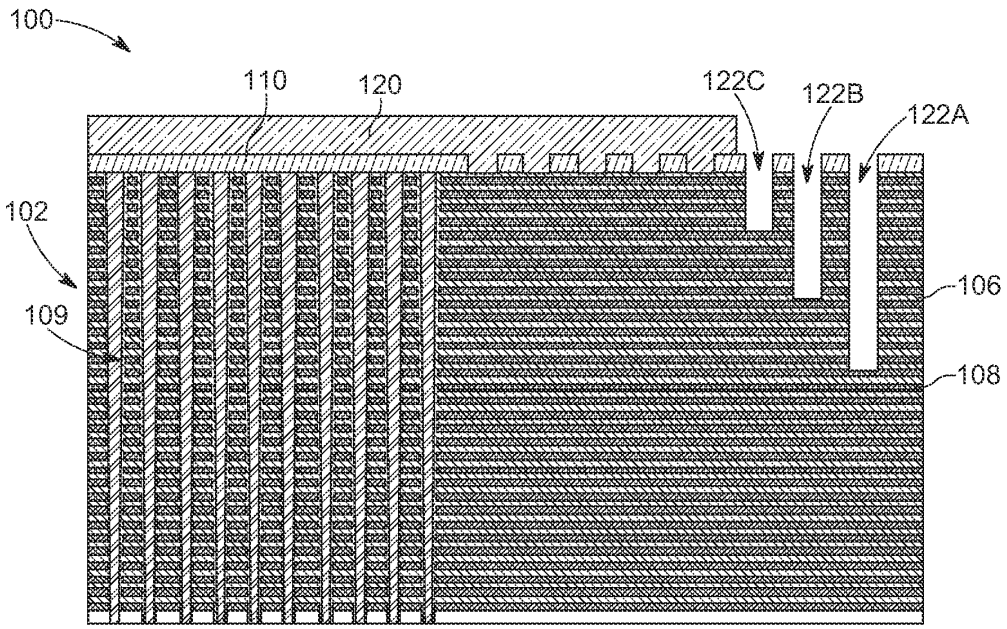
100
110
120
122C
122B
122A
102
109
106
108

FIG. 1G

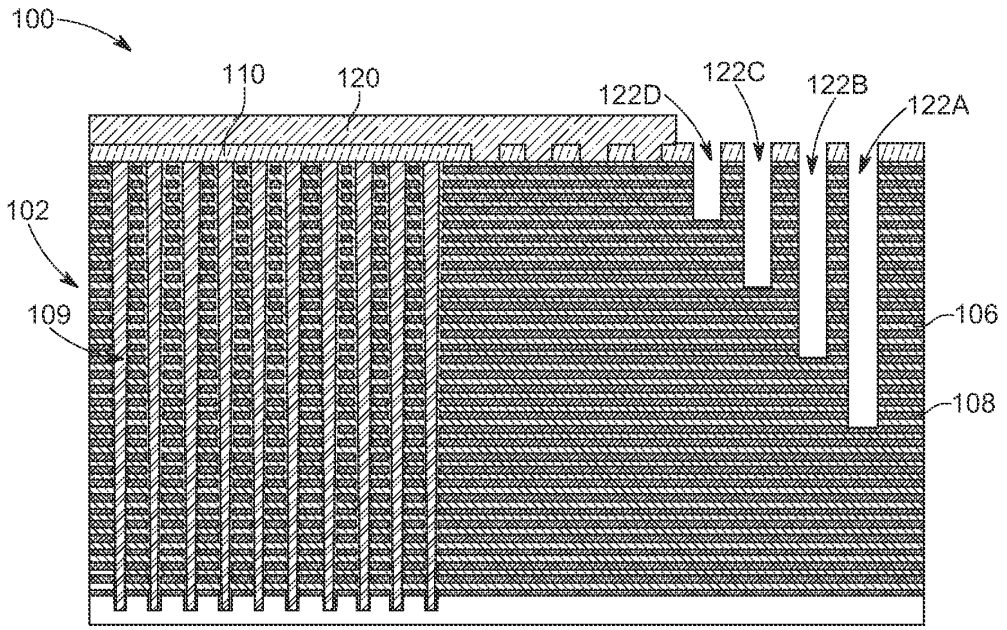
100
110
120
122D
122C
122B
122A
102
109
106
108

FIG. 1H

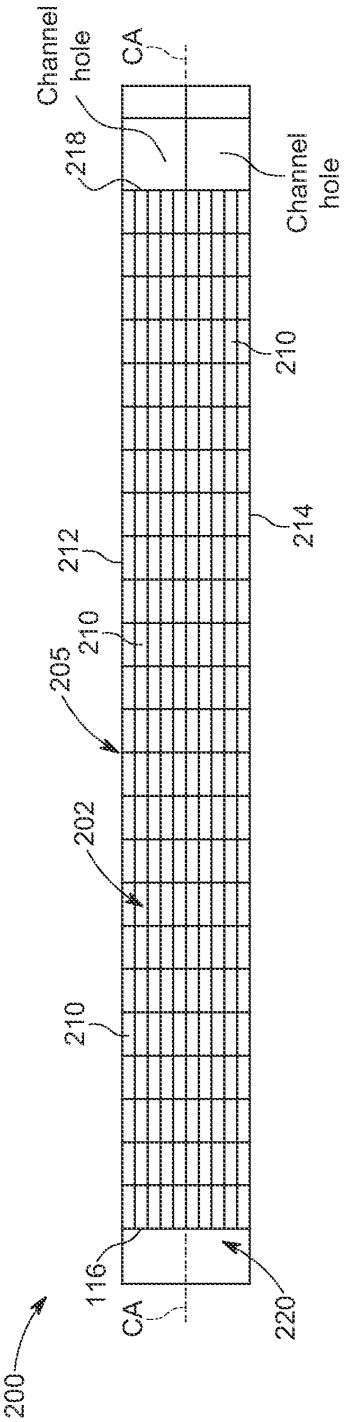
200
116
CA
220
210
202
205
210
212
214
210
218
Channel hole
CA
Channel hole

FIG. 2A

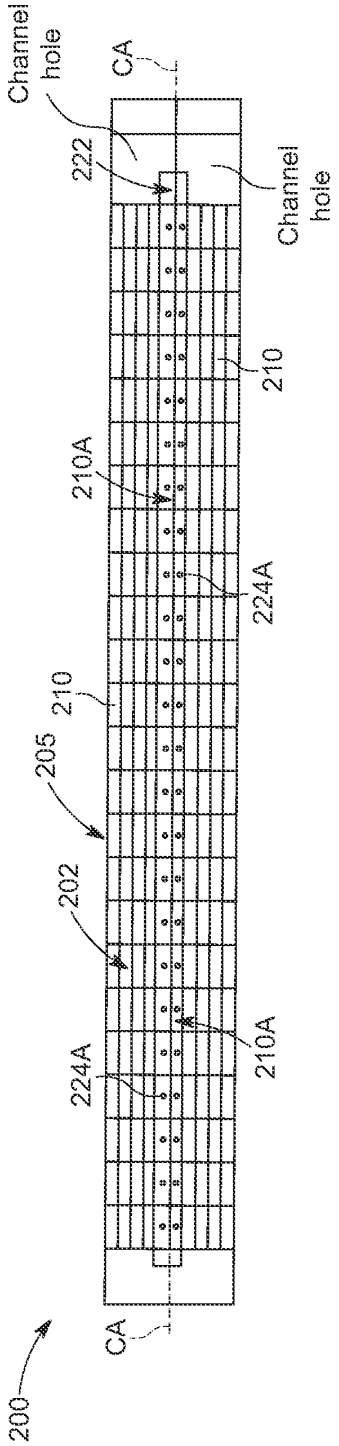
200
CA
224A
210A
202
205
210
224A
210A
210
222
Channel hole
CA
Channel hole

FIG. 2B

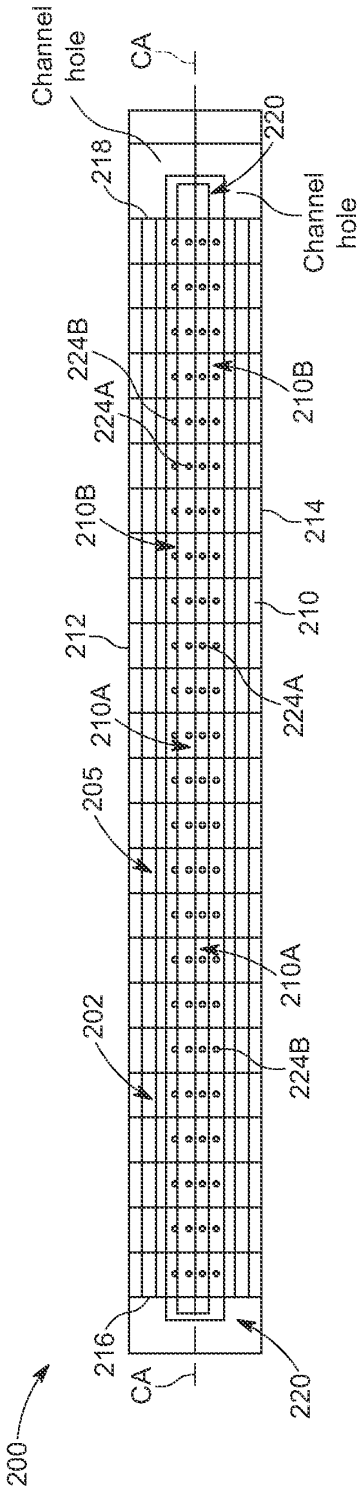
Channel hole
CA
218
220
Channel hole
224B
224A
210B
210B
214
210
212
224A
210A
205
210A
202
224B
216
CA
220
200

FIG. 2C

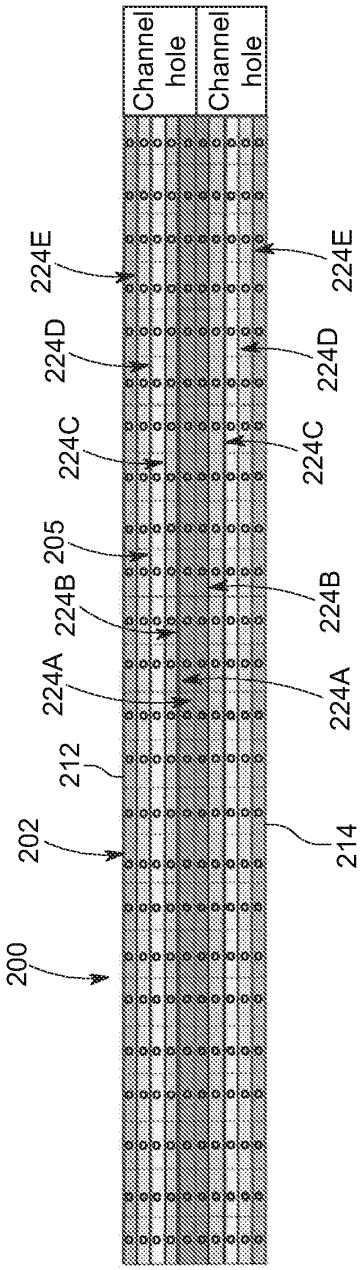
Channel hole
Channel hole
224E
224E
224D
224D
224C
224C
205
224B
224B
224A
224A
212
214
202
200

FIG. 2D

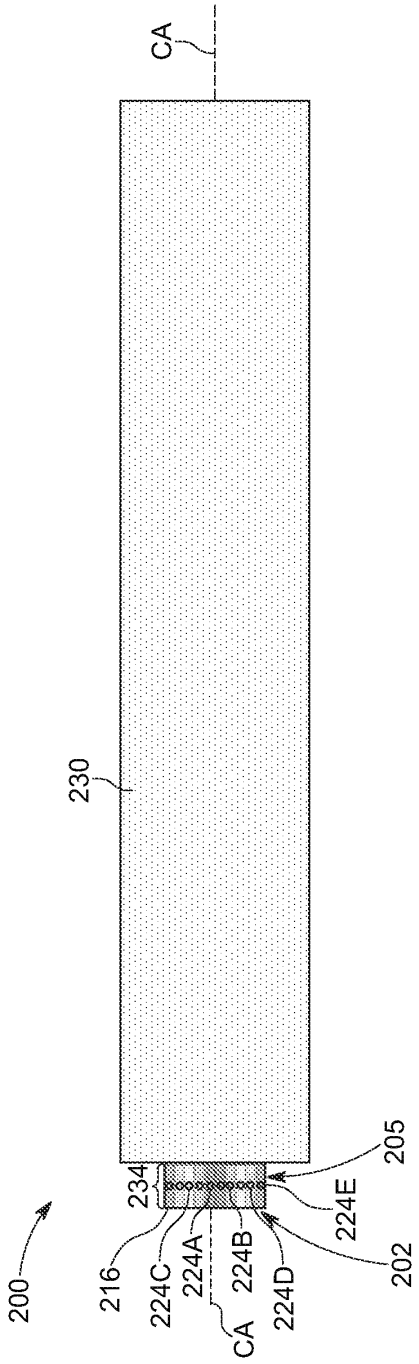
CA
230
234
205
224E
202
200
216
224C
224A
224B
224D
CA

FIG. 2E

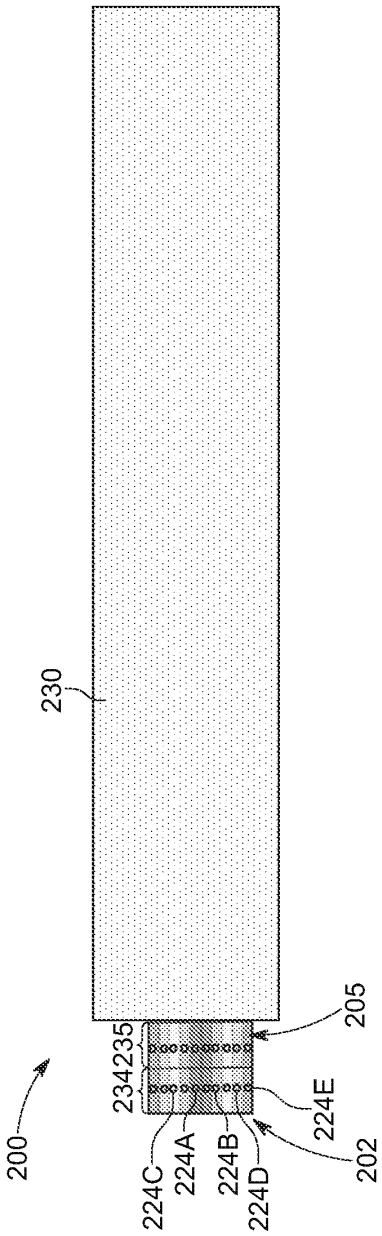
230
205
234235
224E
202
200
224C
224A
224B
224D

FIG. 2F

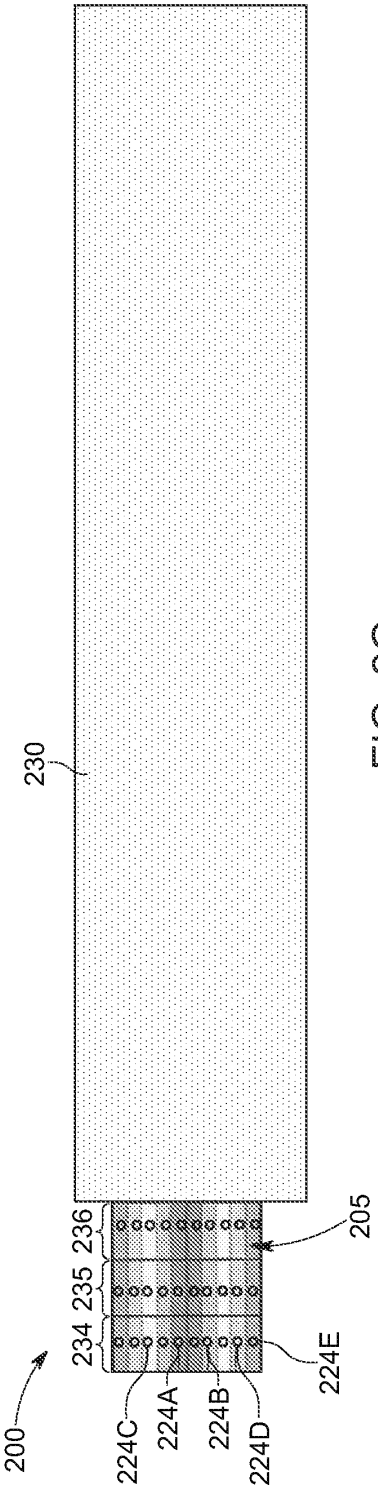
230
236
235
234
205
224E
200
224C
224A
224B
224D

FIG. 2G

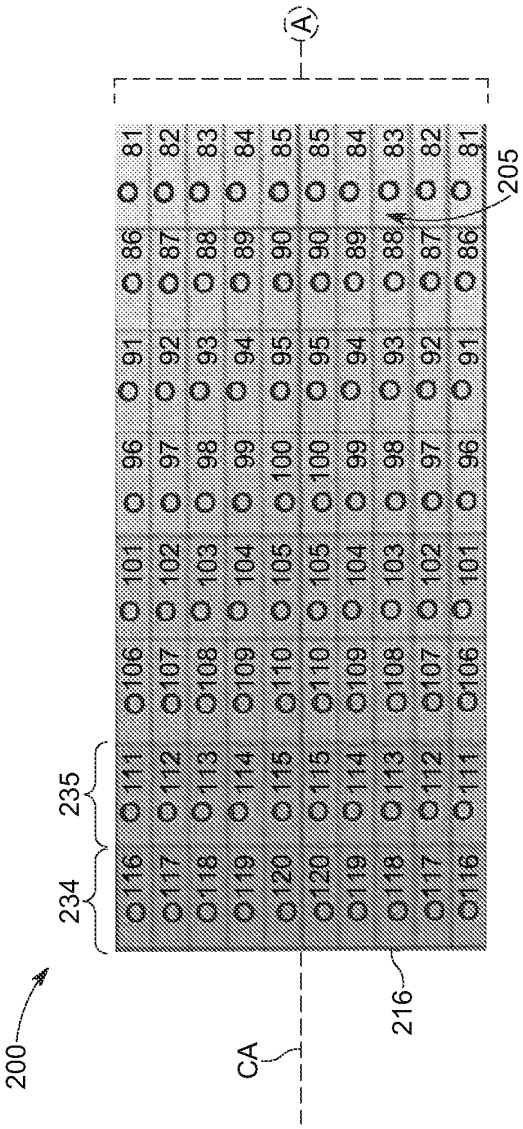
A
81 82 83 84 85 85 84 83 82 81
86 87 88 89 90 90 89 88 87 86
205
91 92 93 94 95 95 94 93 92 91
96 97 98 99 100 100 99 98 97 96
101 102 103 104 105 105 104 103 102 101
106 107 108 109 110 110 109 108 107 106
111 112 113 114 115 115 114 113 112 111
116 117 118 119 120 120 119 118 117 116
235
234
200
CA
216

FIG. 2H

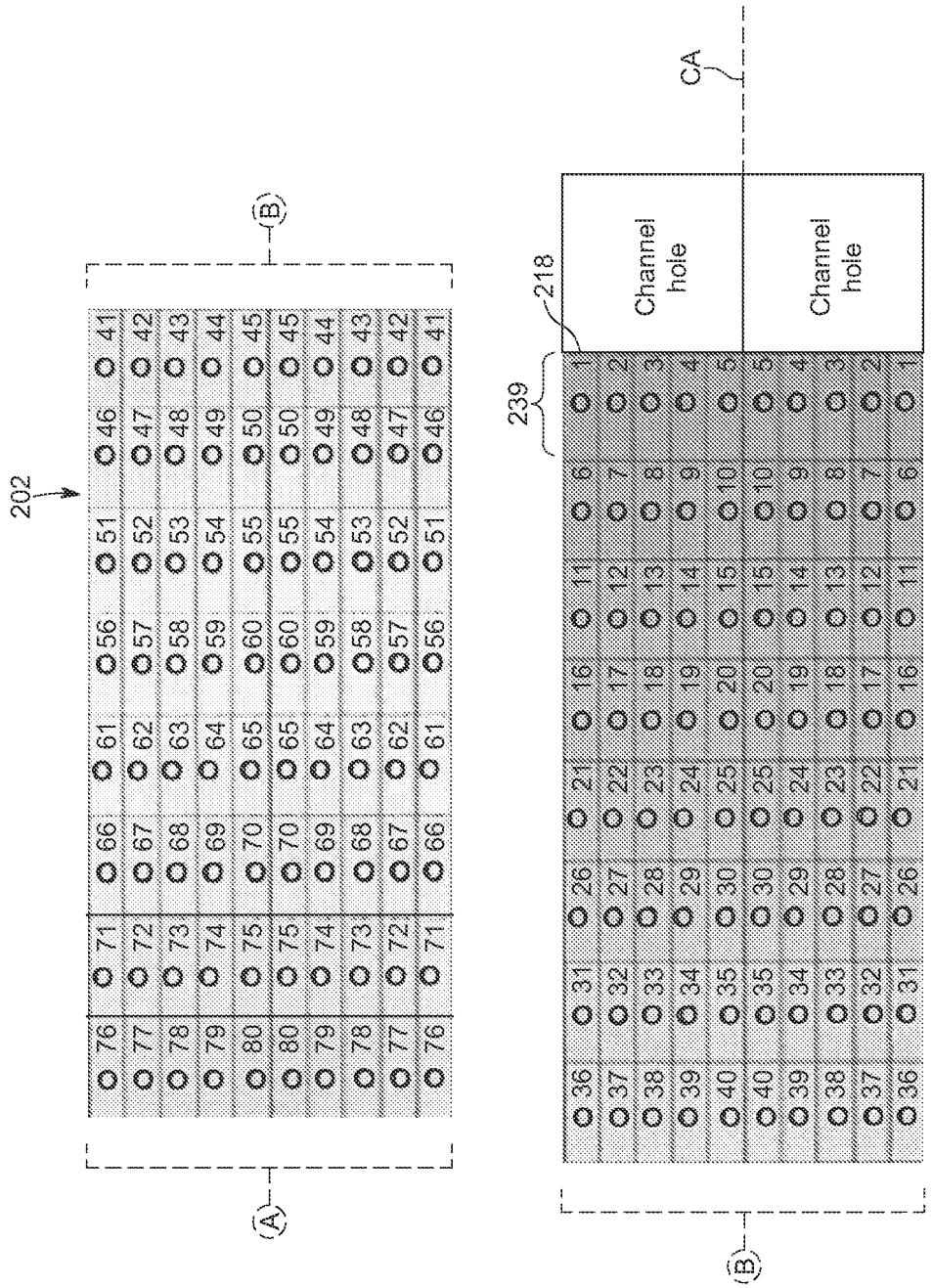

FIG. 2H (Continued)

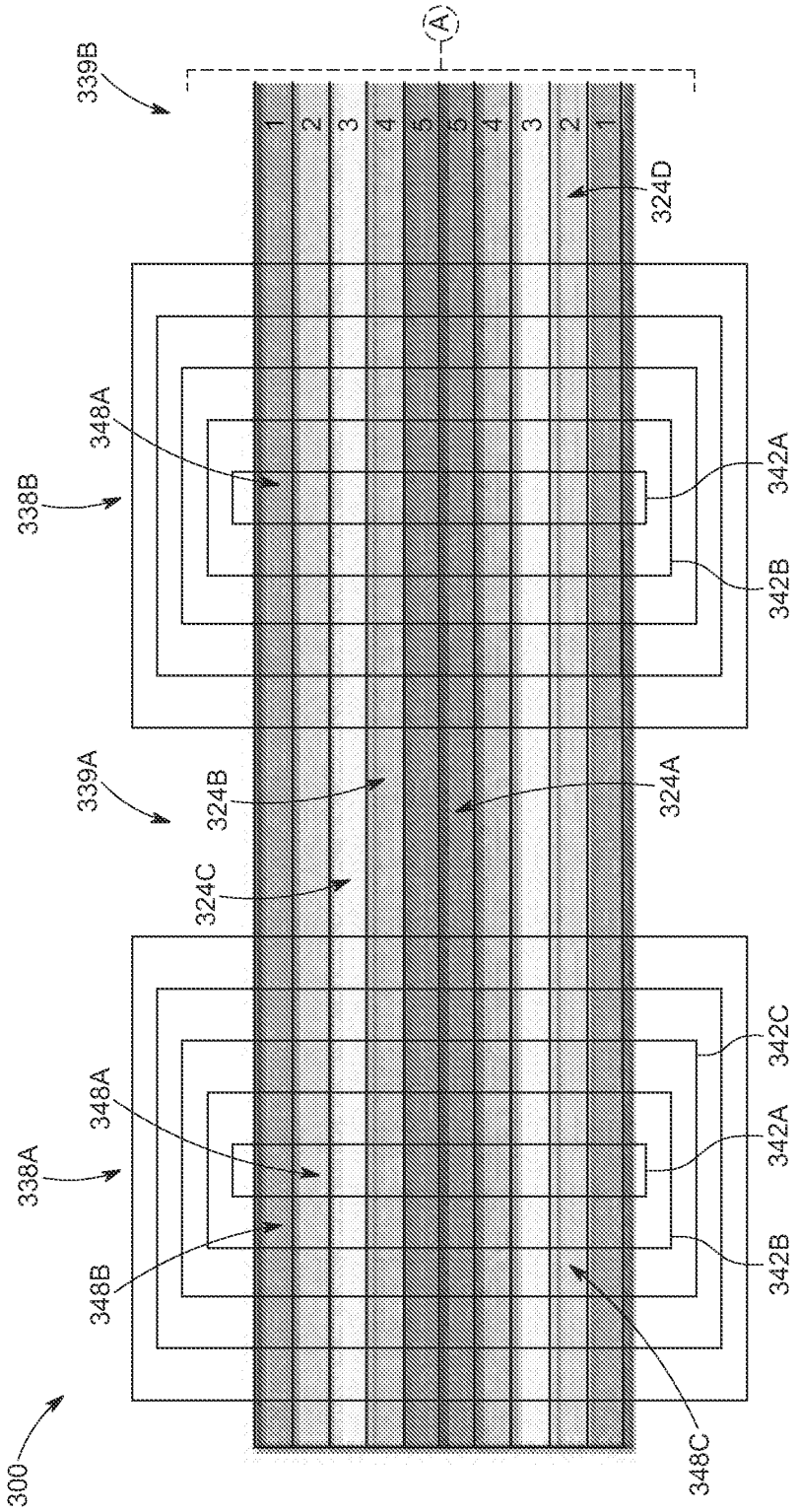
339B
A
1
2
3
4
5
6
4
3
2
1
324D
348A
338B
342A
342B
339A
324B
324A
324C
342C
348A
338A
342A
348B
342B
348C
300

FIG. 3A

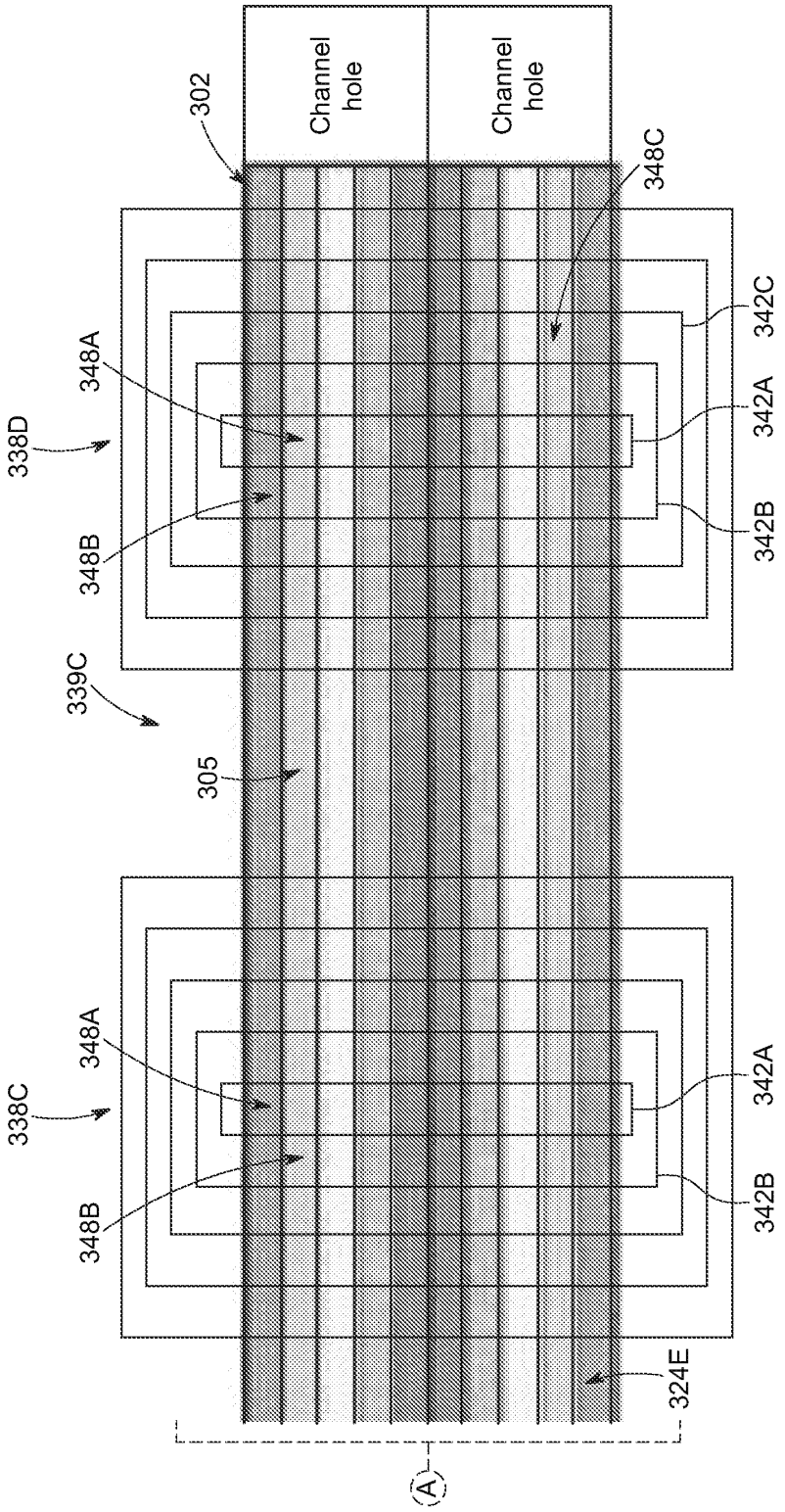

FIG. 3A (Continued)

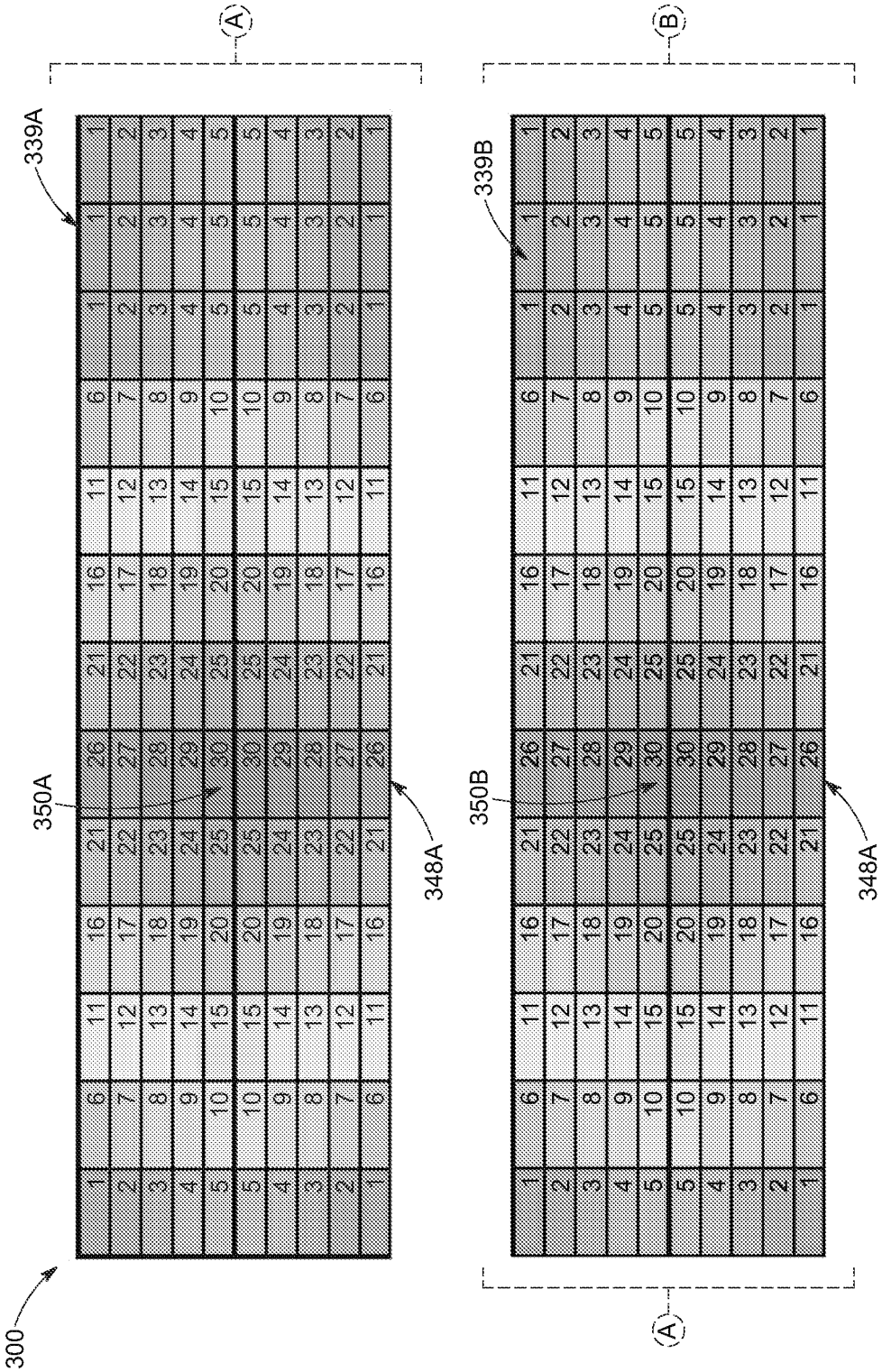

FIG. 3B

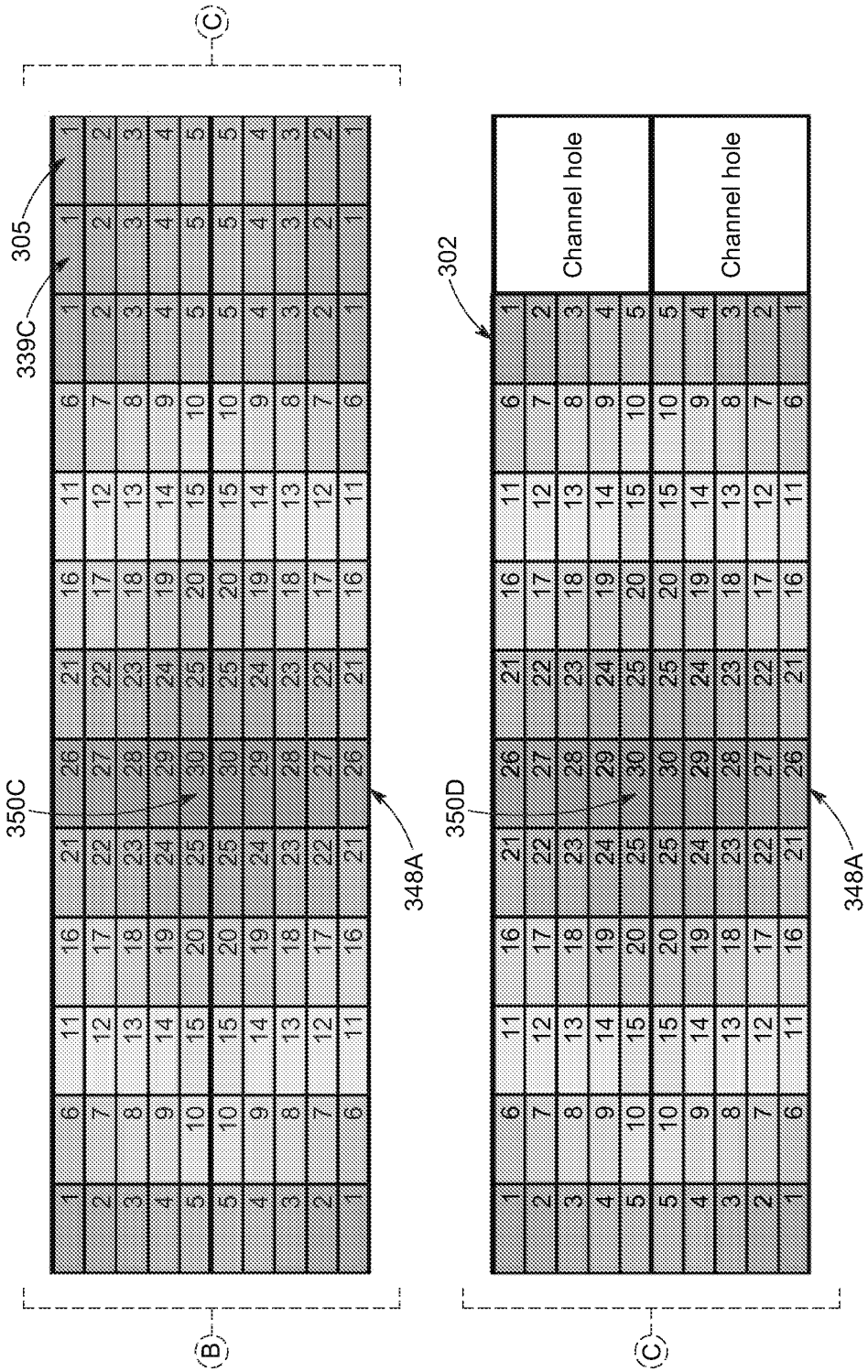

FIG. 3B (Continued)

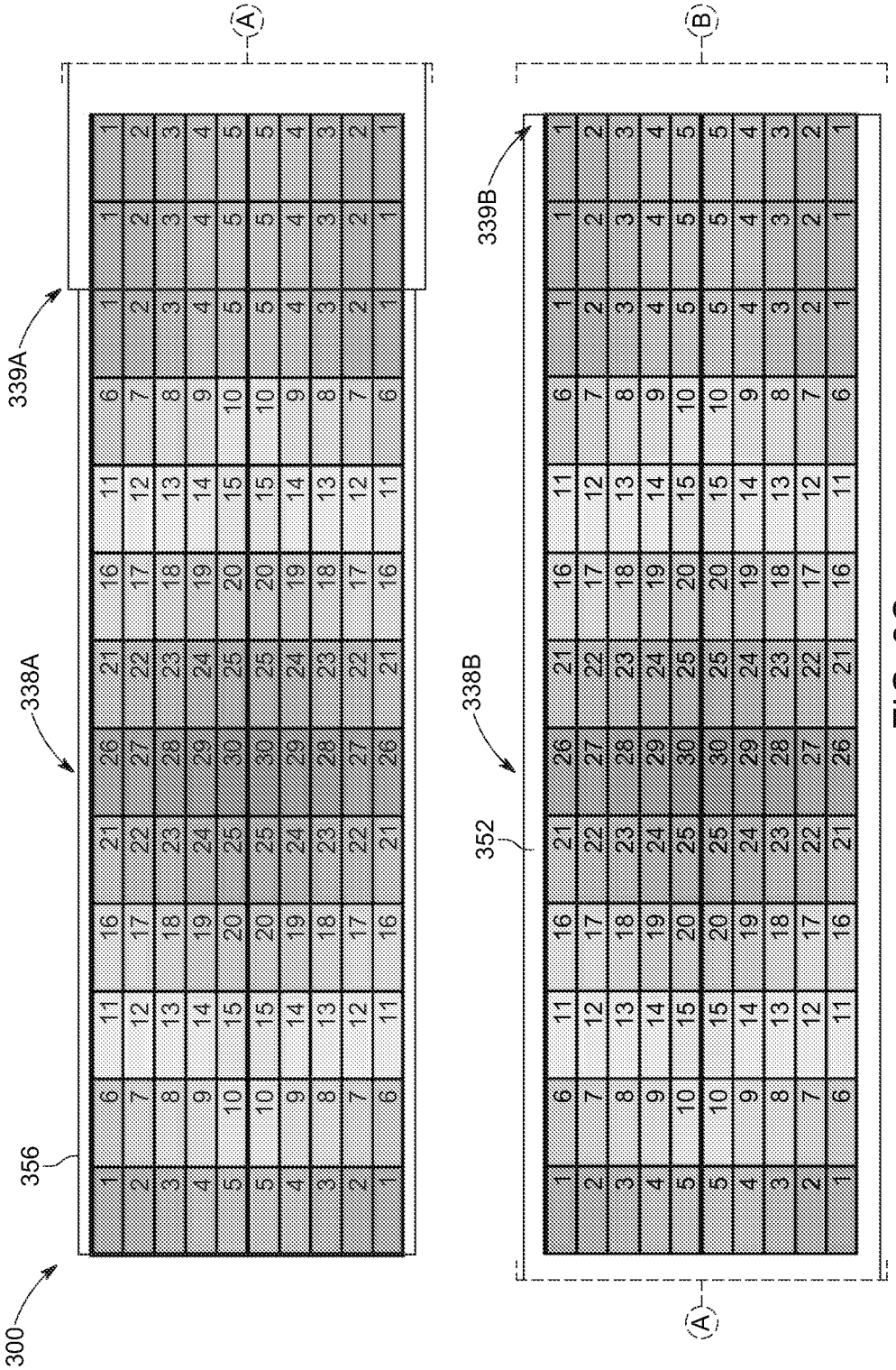

FIG. 3C

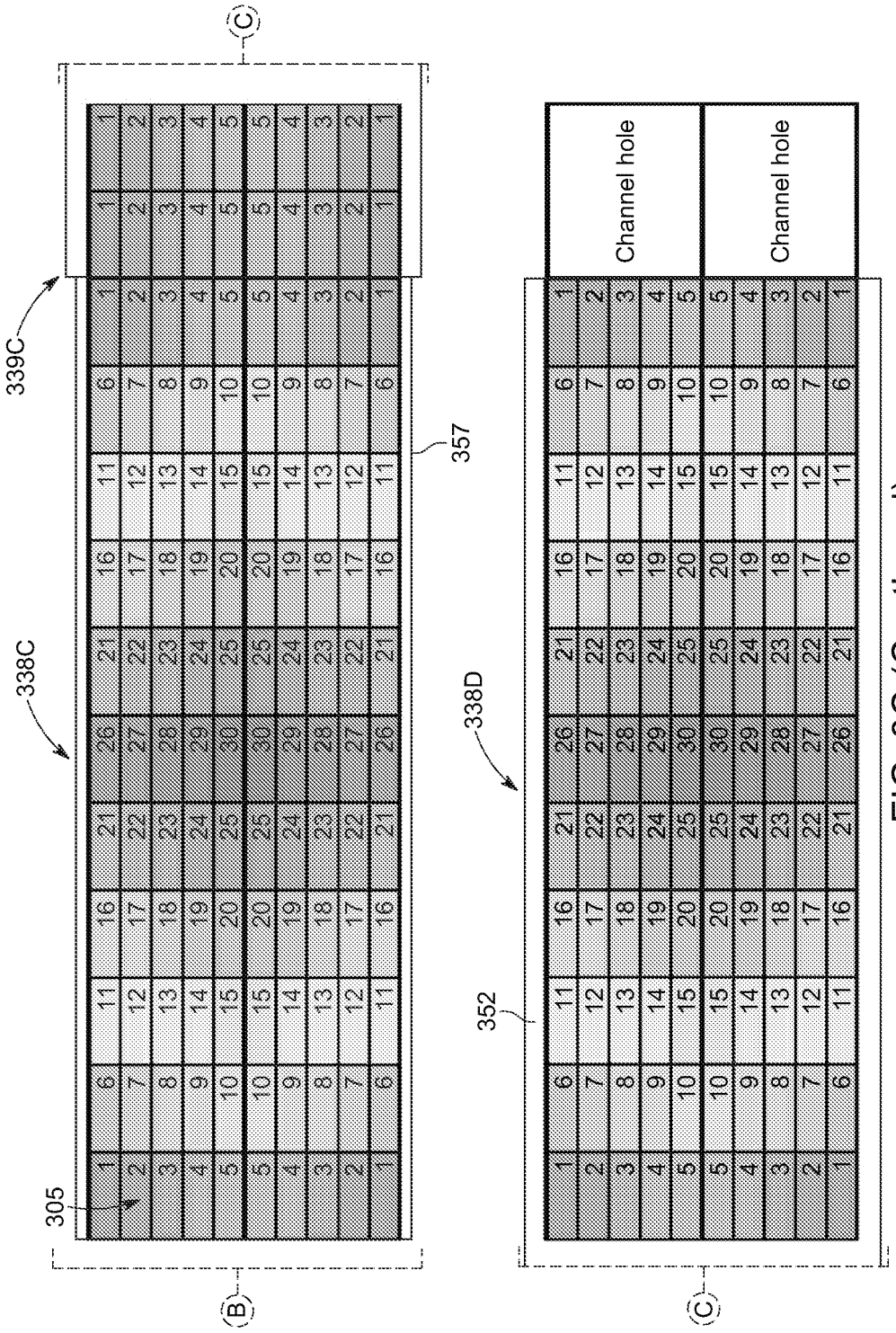

FIG. 3C (Continued)

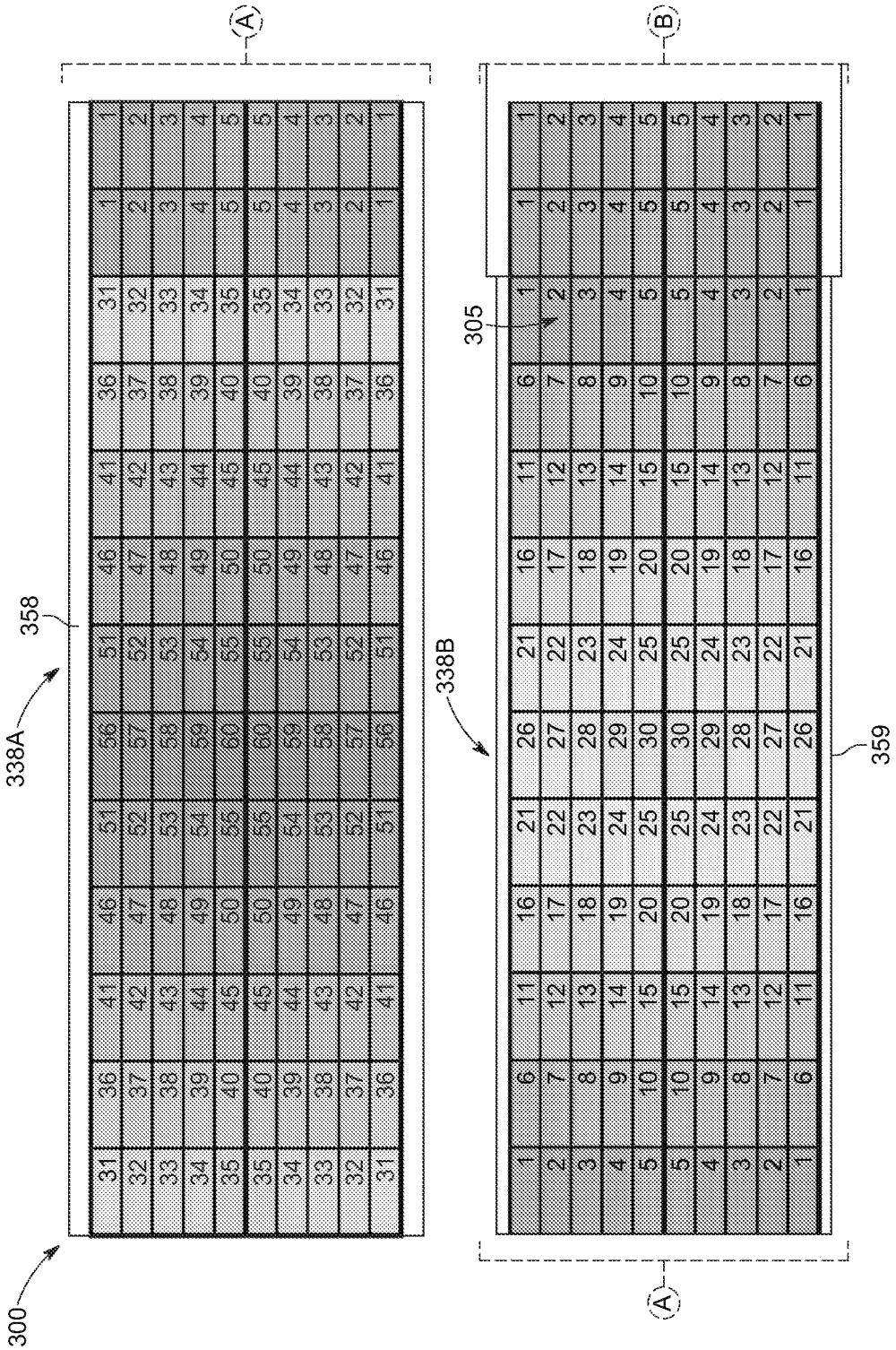

FIG. 3D

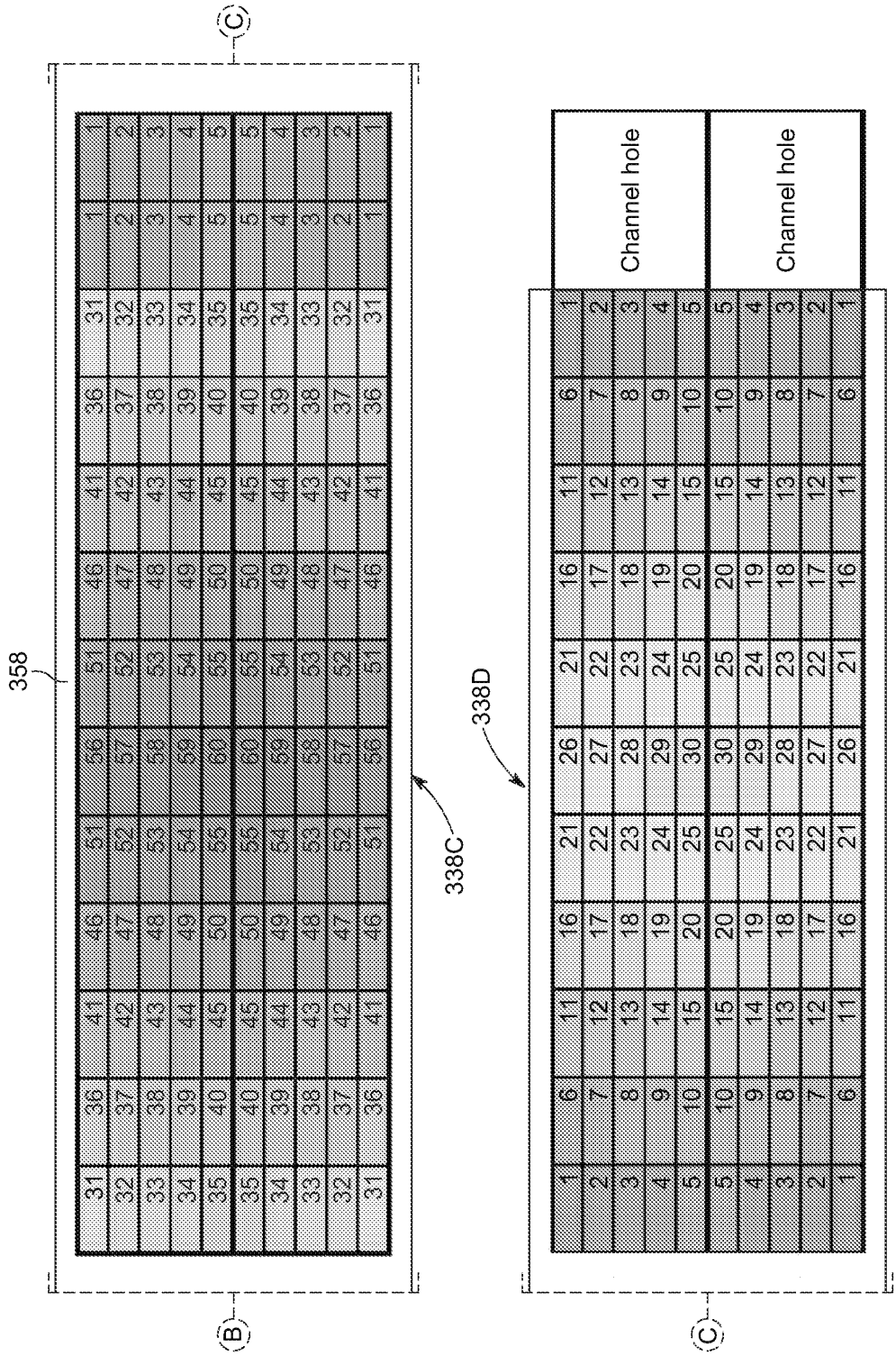

FIG. 3D (Continued)

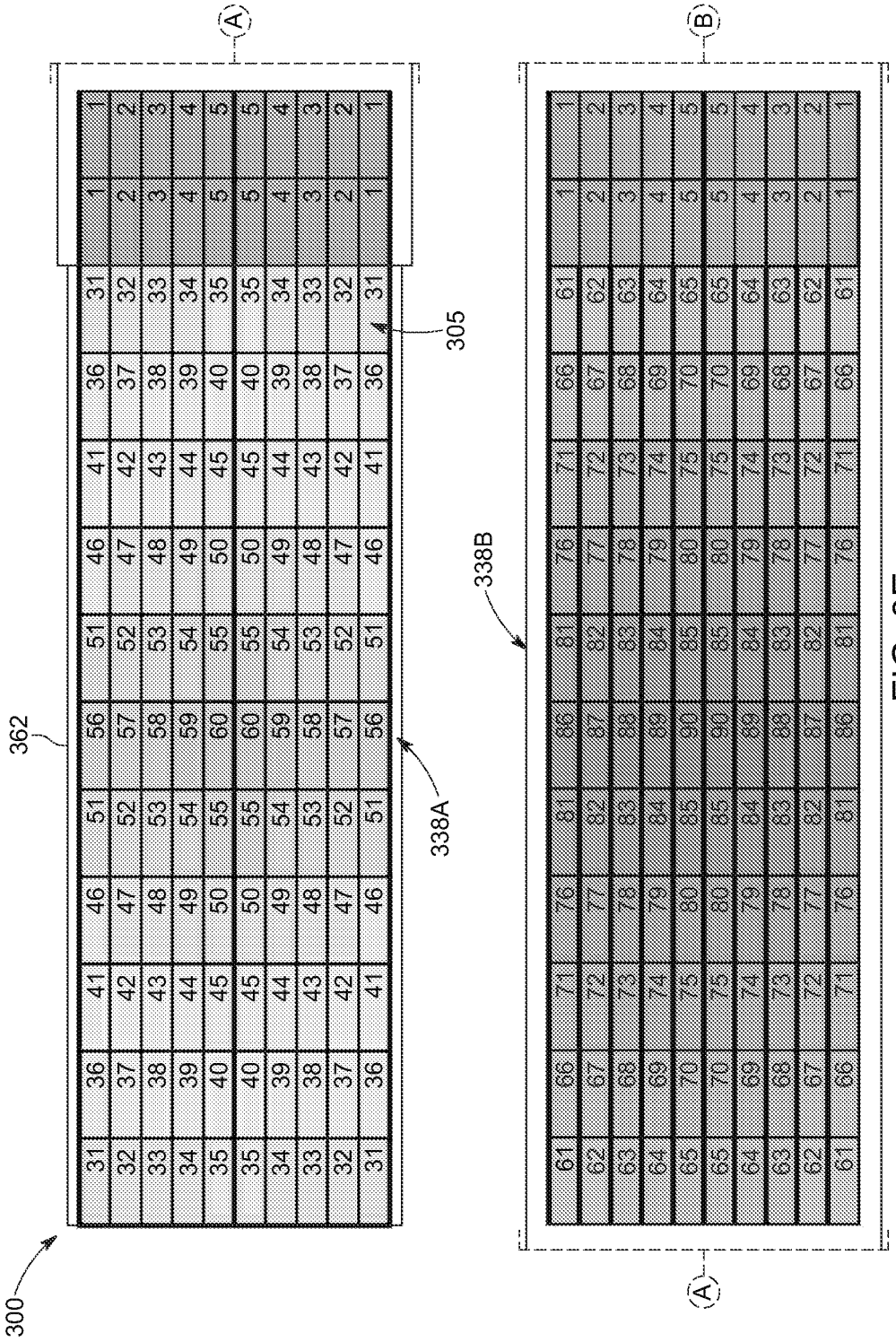

FIG. 3E

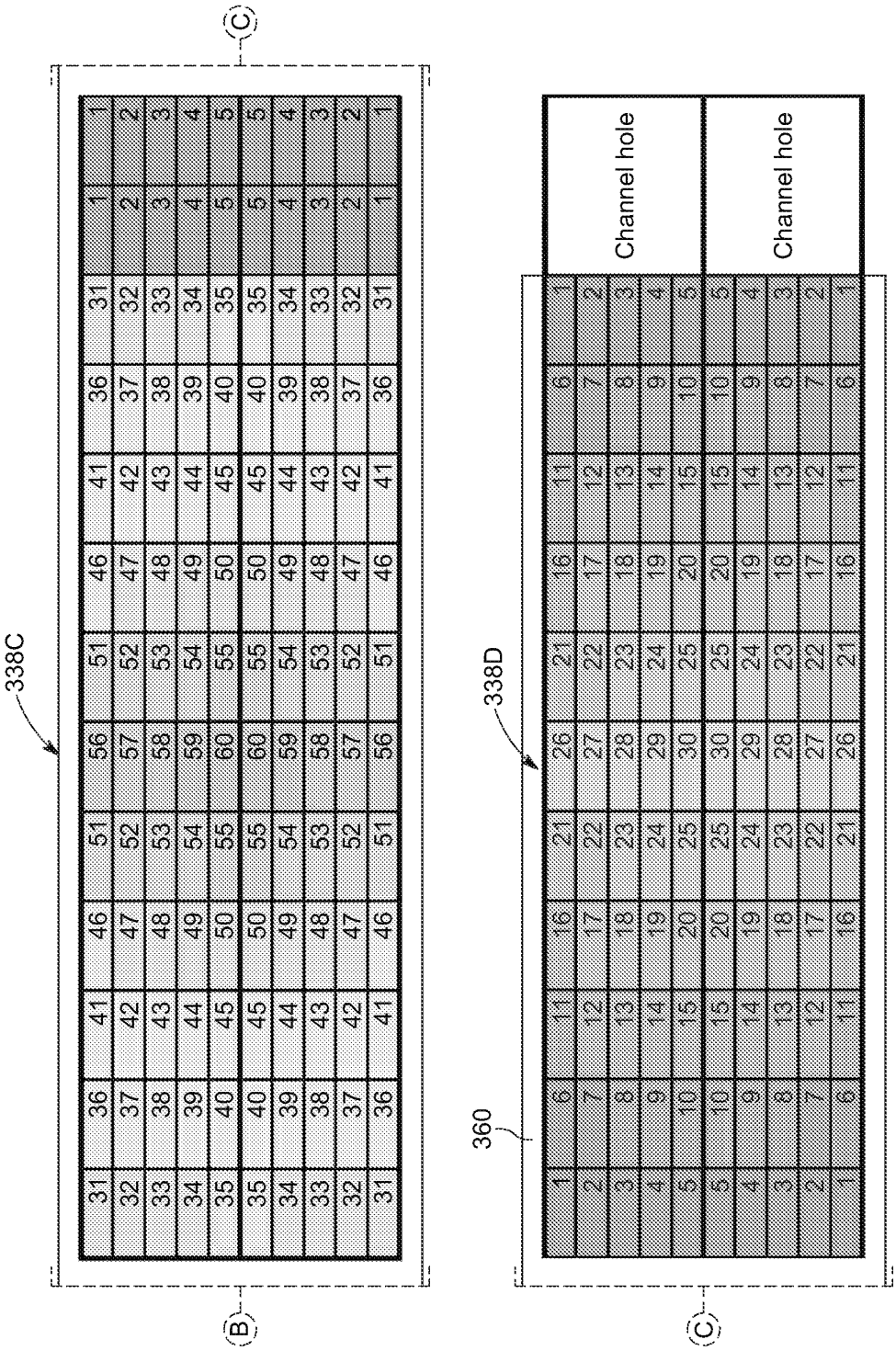

FIG. 3E (Continued)

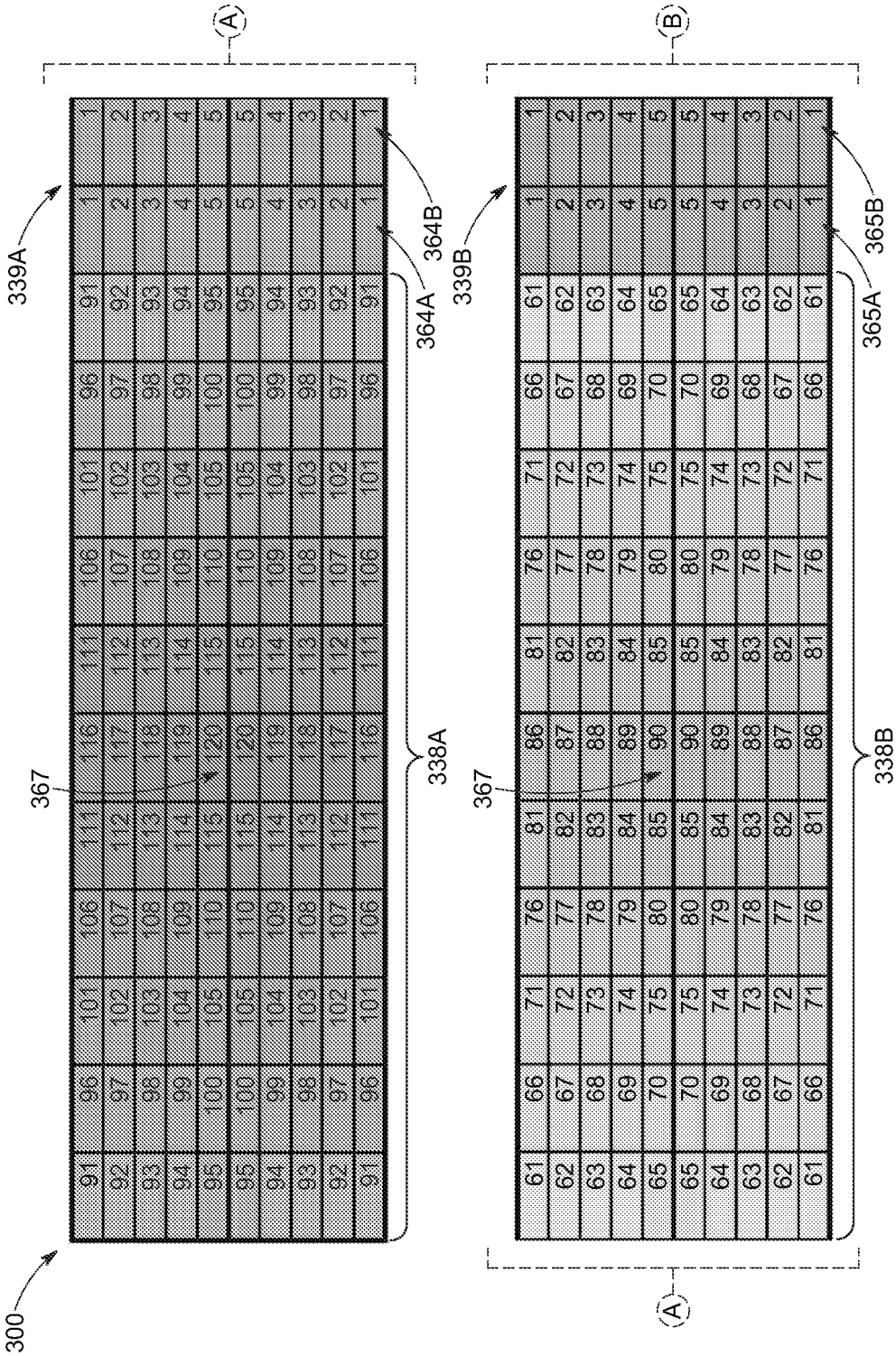

FIG. 3F

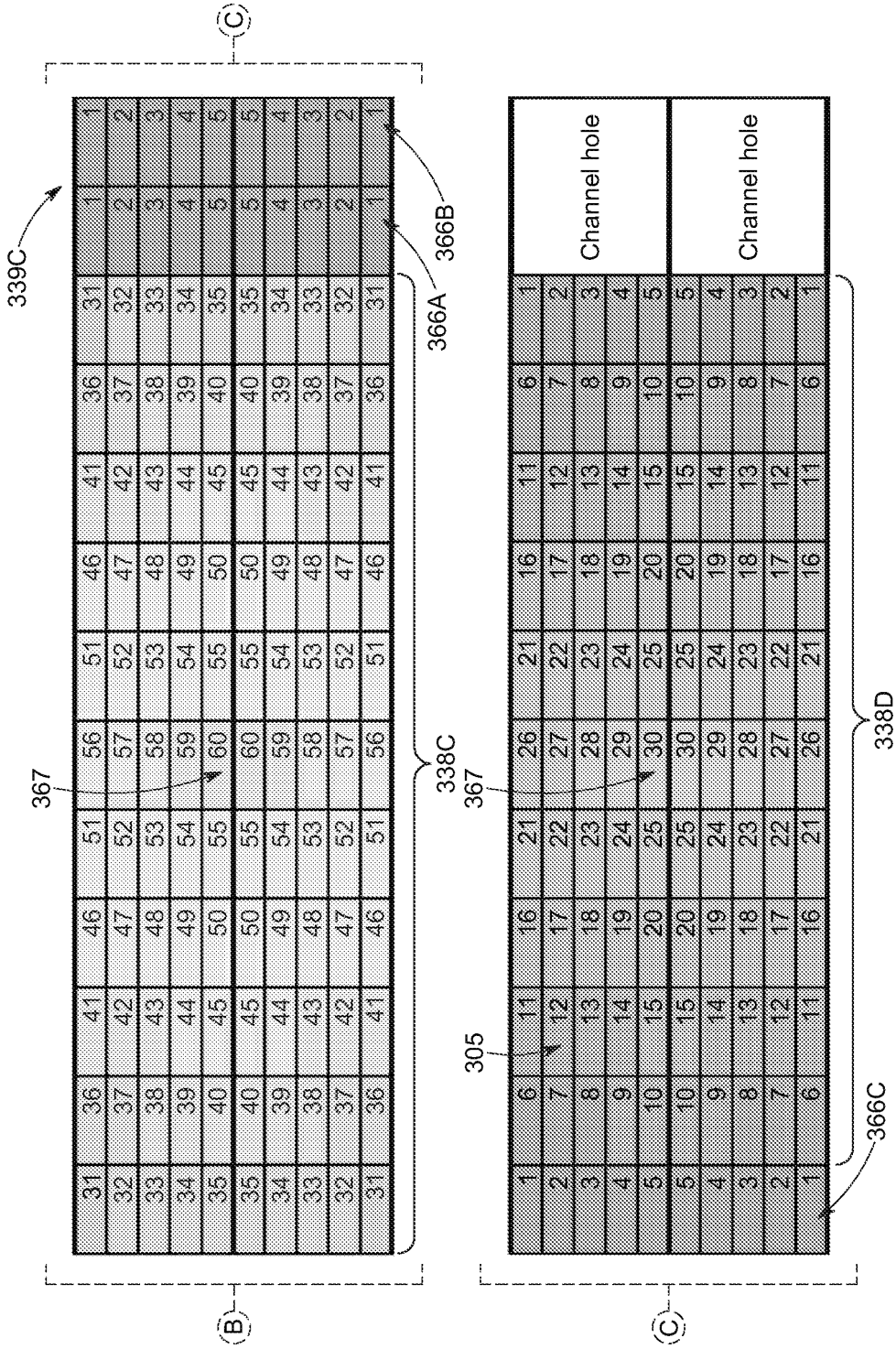

FIG. 3F (Continued)

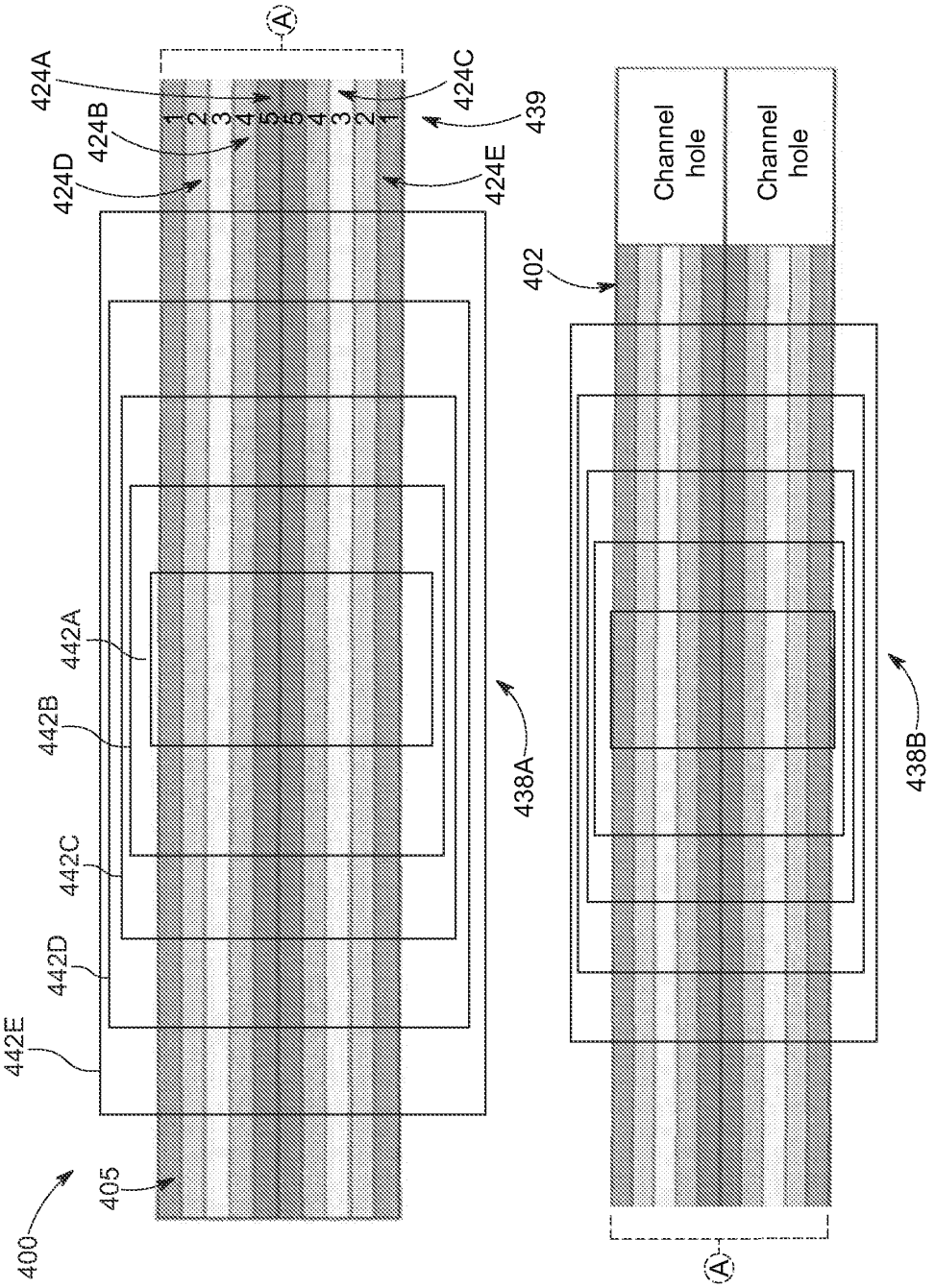
A
424A
424B
424D
424C
439
424E
1 2 3 4 5 5 4 3 2 1
442A
442B
442C
442D
442E
438A
405
400
Channel hole
Channel hole
402
438B
A

FIG. 4A

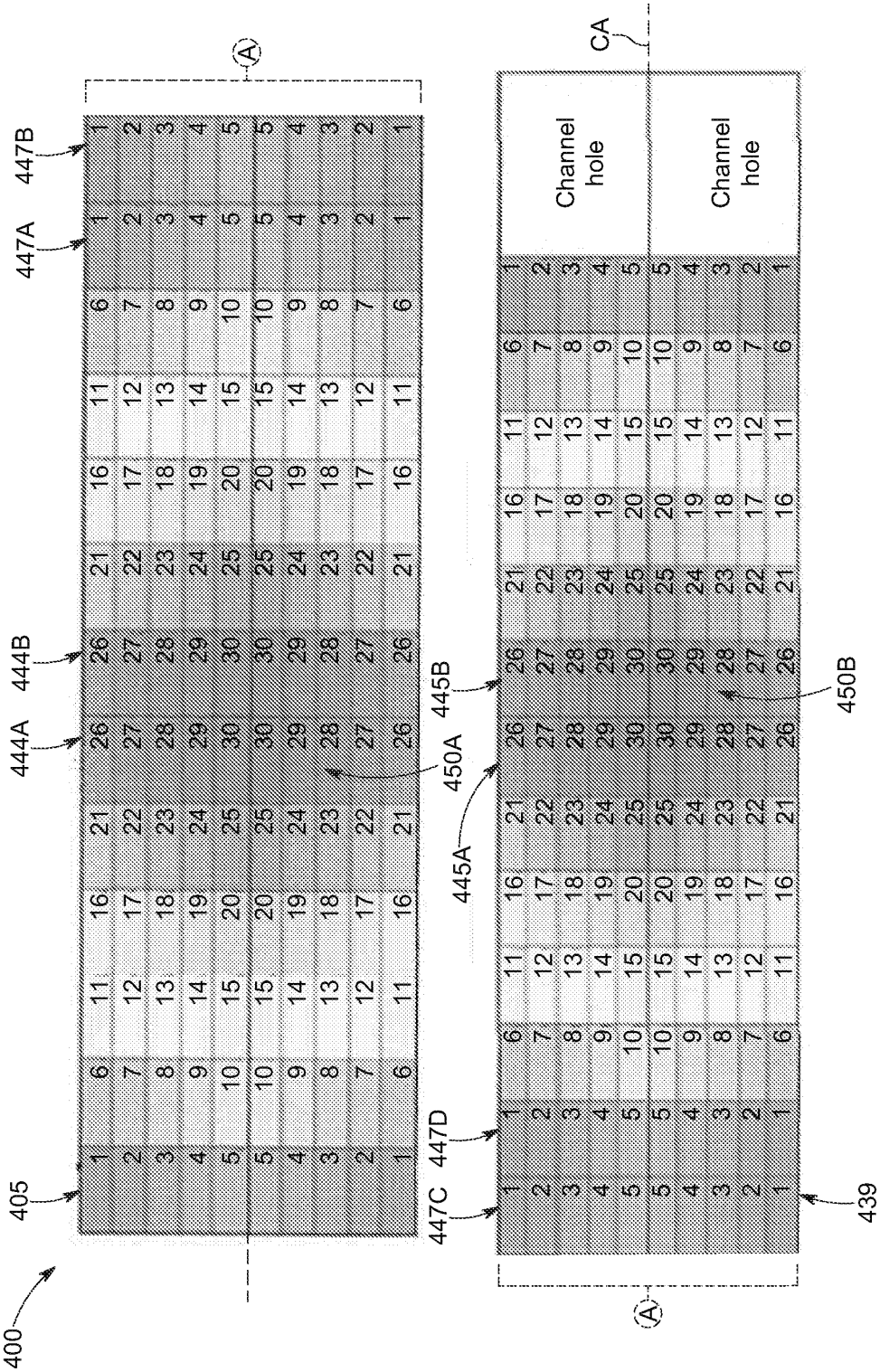
400
405
447B
447A
444B
444A
450A
447D
447C
445B
445A
450B
439
CA
A
A
Channel hole
Channel hole

FIG. 4B

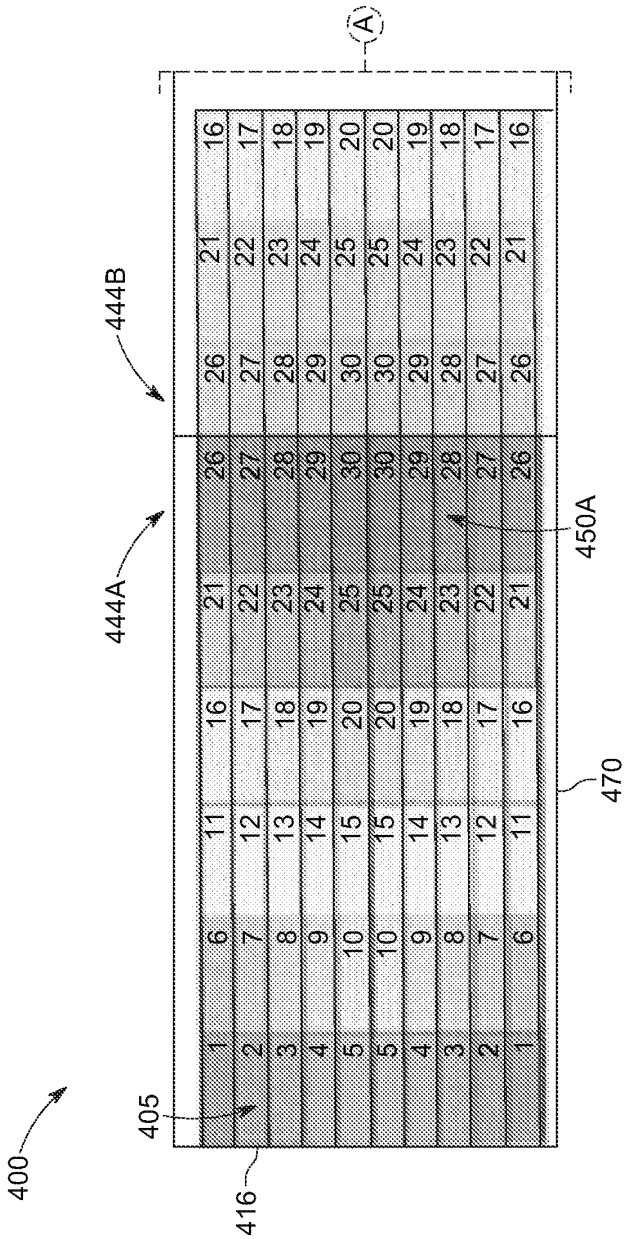

FIG. 4C

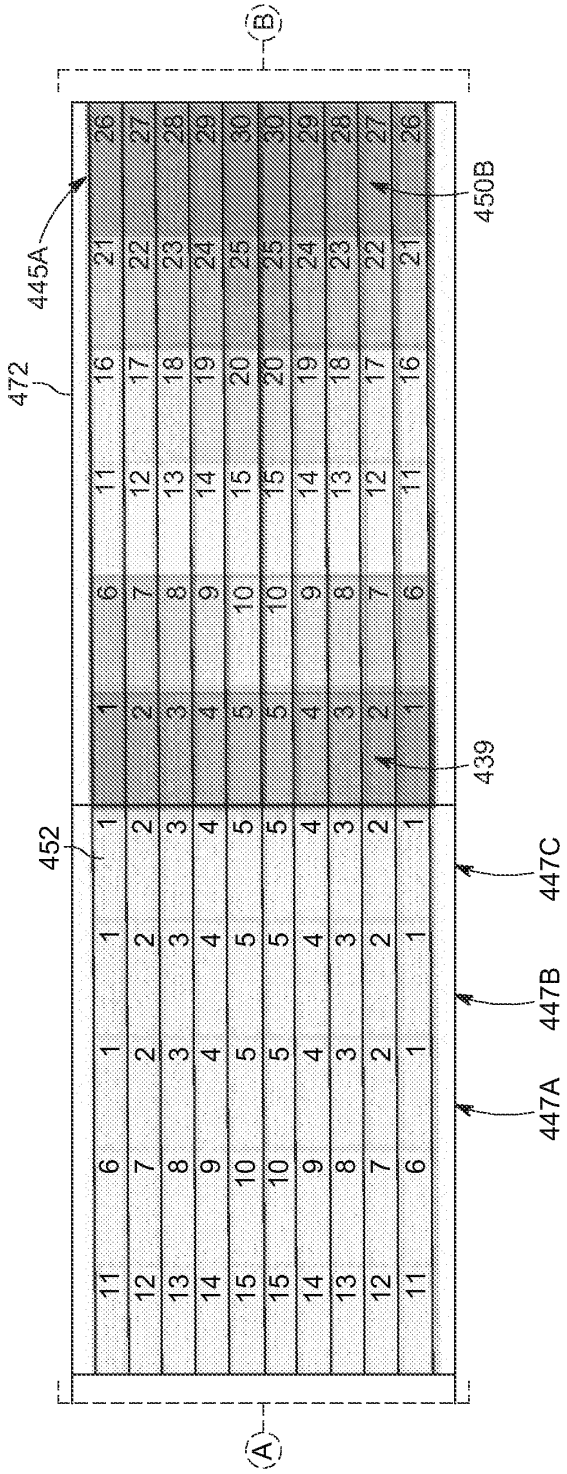

FIG. 4C (Continued)

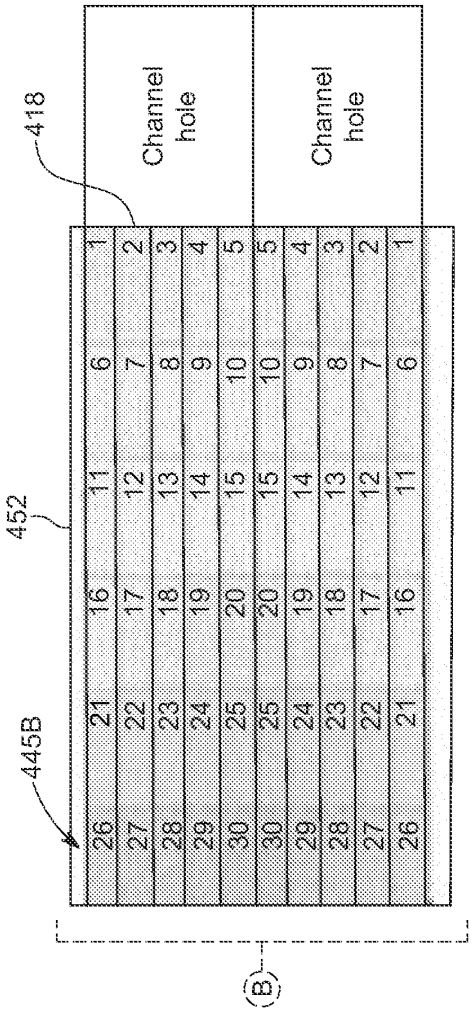

FIG. 4C (Continued)

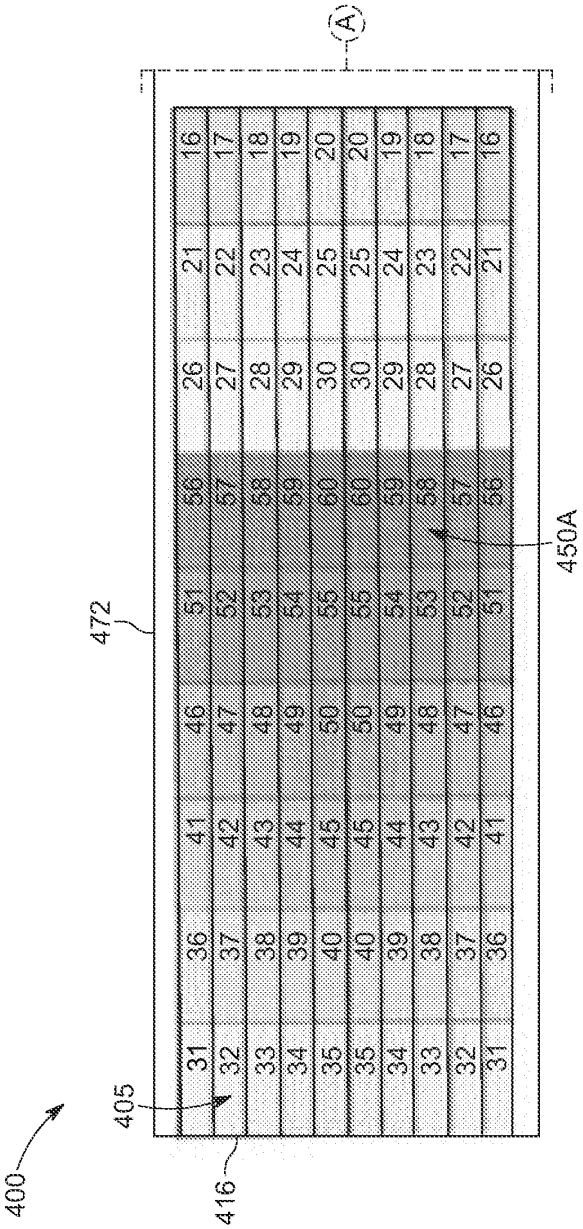
400
405
416
472
450A
A
31 32 33 34 35 35 34 33 32 31
36 37 38 39 40 40 39 38 37 36
41 42 43 44 45 45 44 43 42 41
46 47 48 49 50 50 49 48 47 46
51 52 53 54 55 55 54 53 52 51
56 57 58 59 60 60 59 58 57 56
26 27 28 29 30 30 29 28 27 26
21 22 23 24 25 25 24 23 22 21
16 17 18 19 20 20 19 18 17 16

FIG. 4D

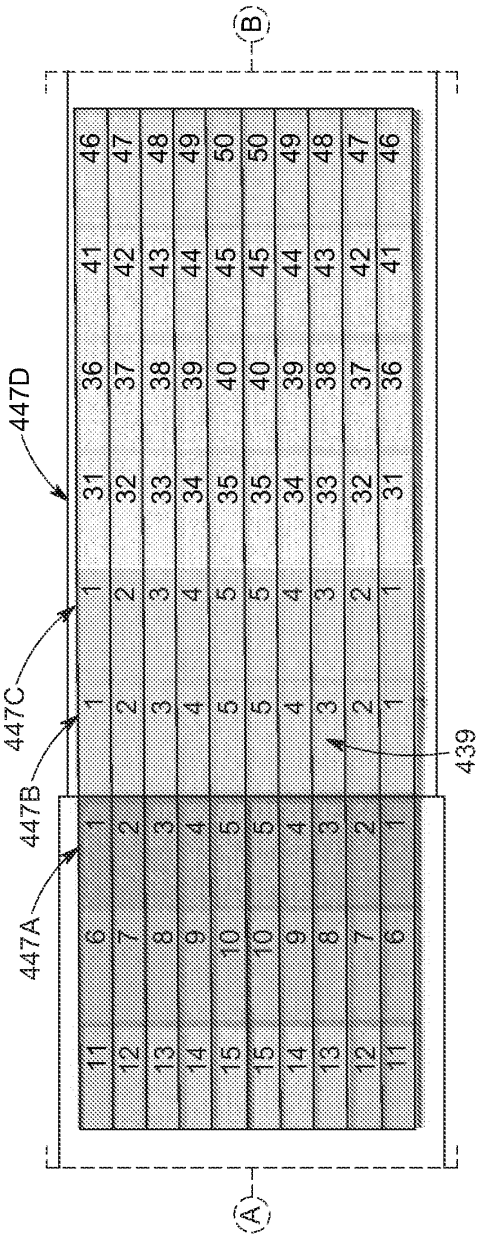

FIG. 4D (Continued)

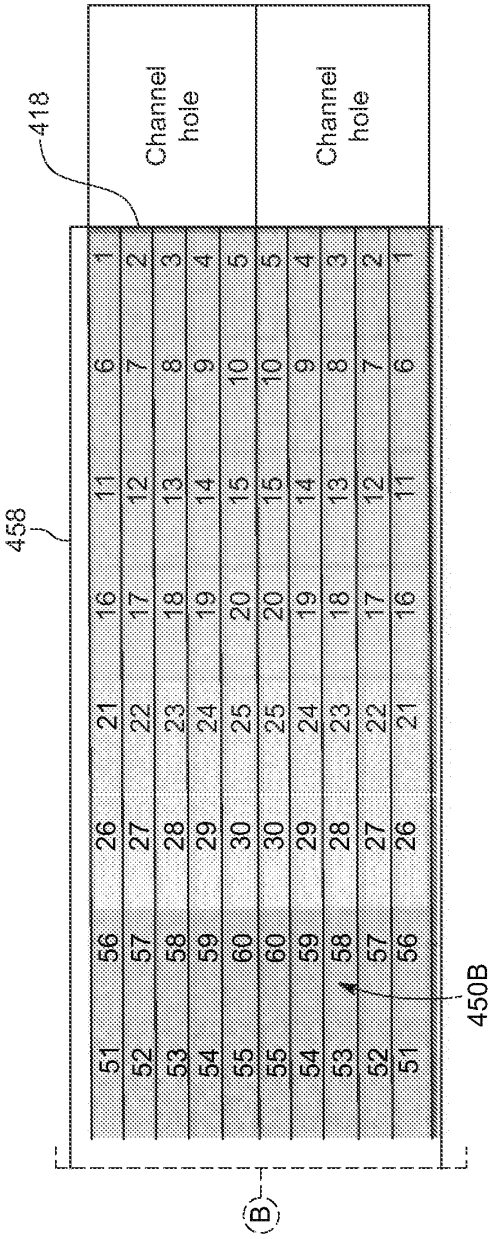

FIG. 4D (Continued)

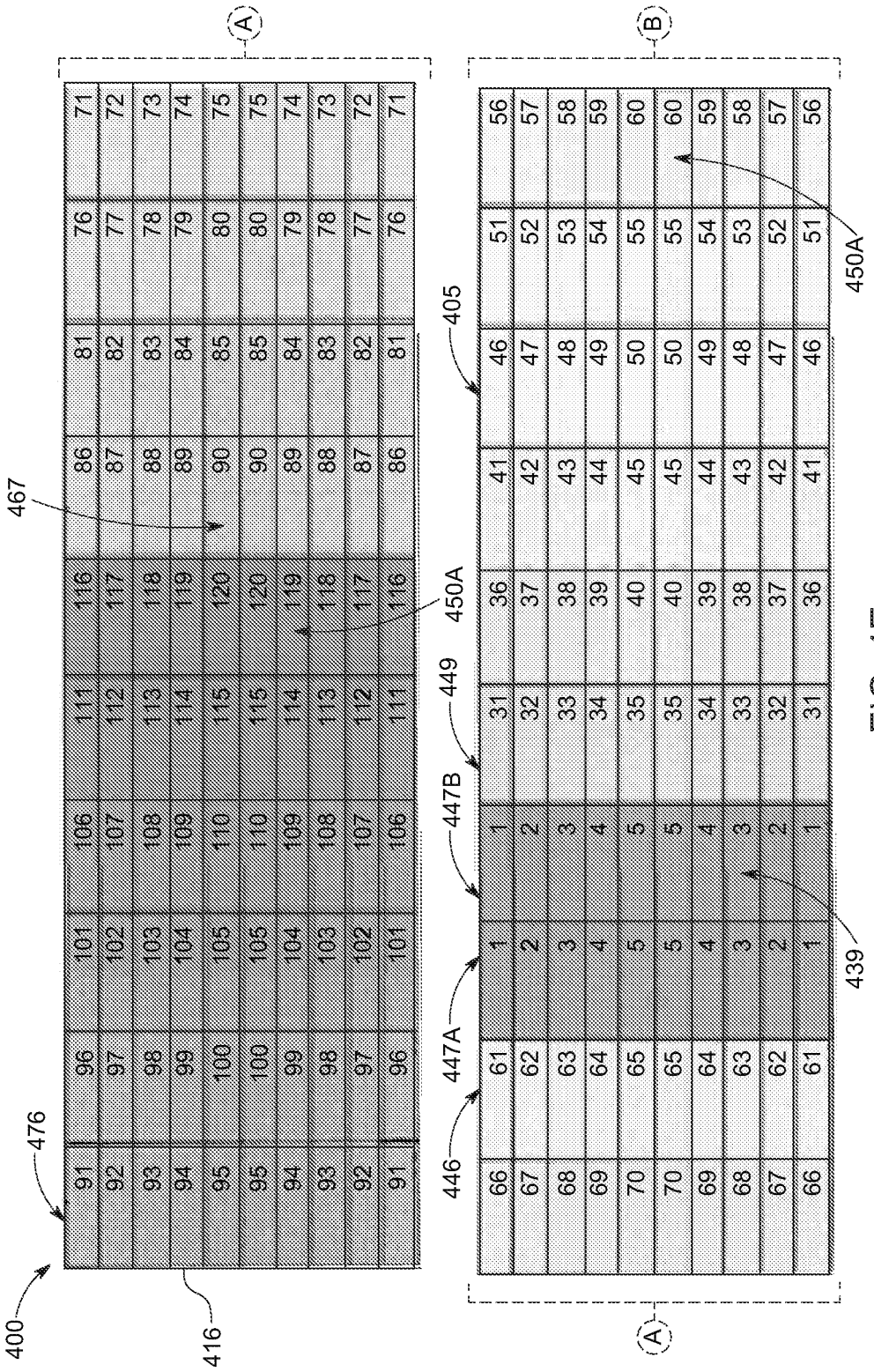

FIG. 4E

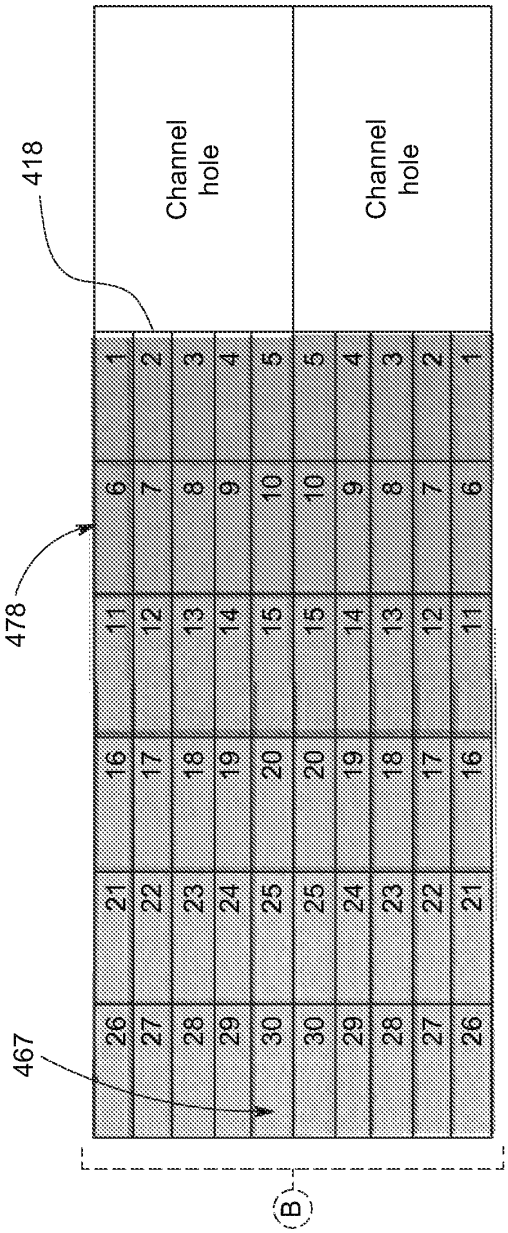

FIG. 4E (Continued)

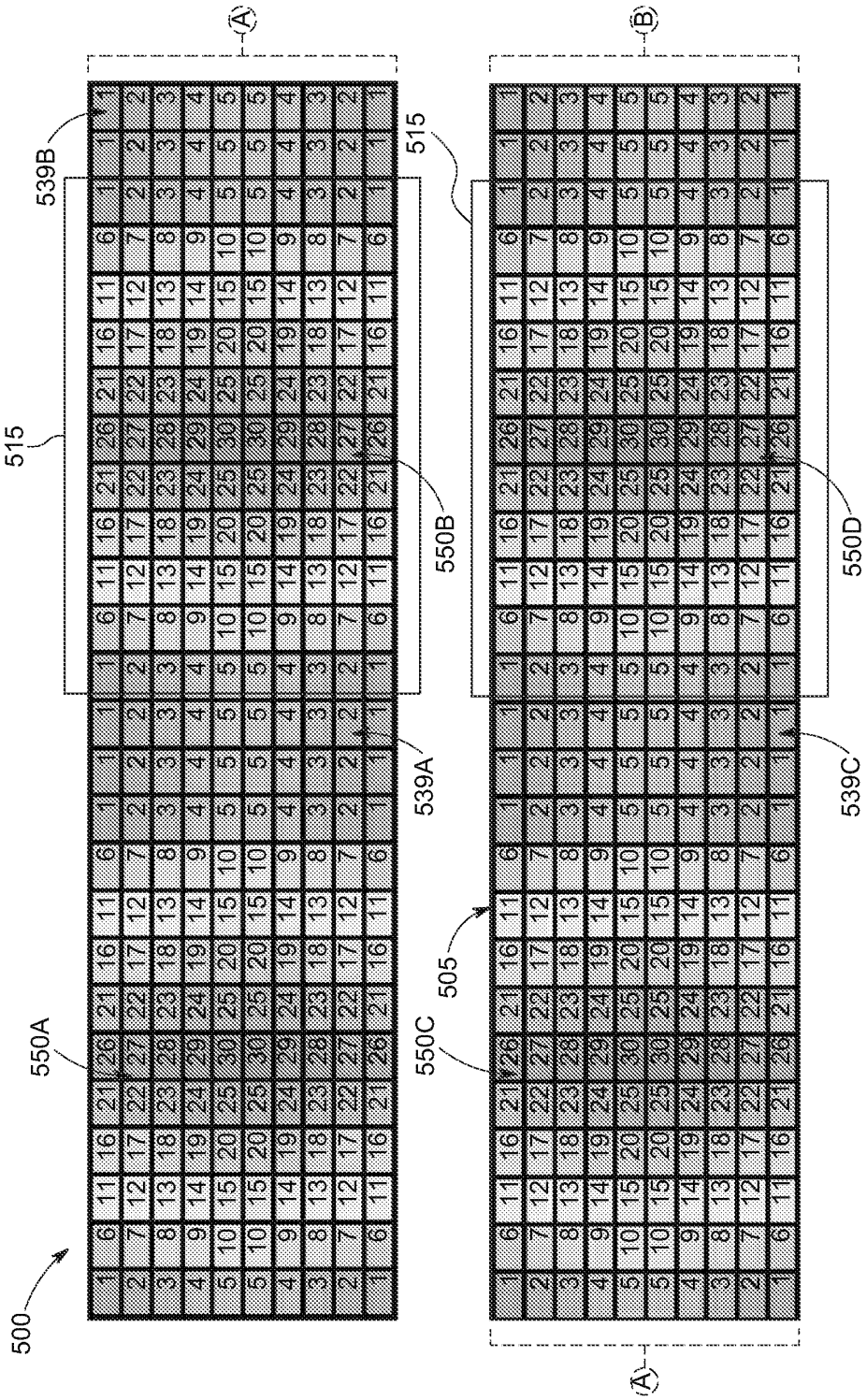

FIG. 5A

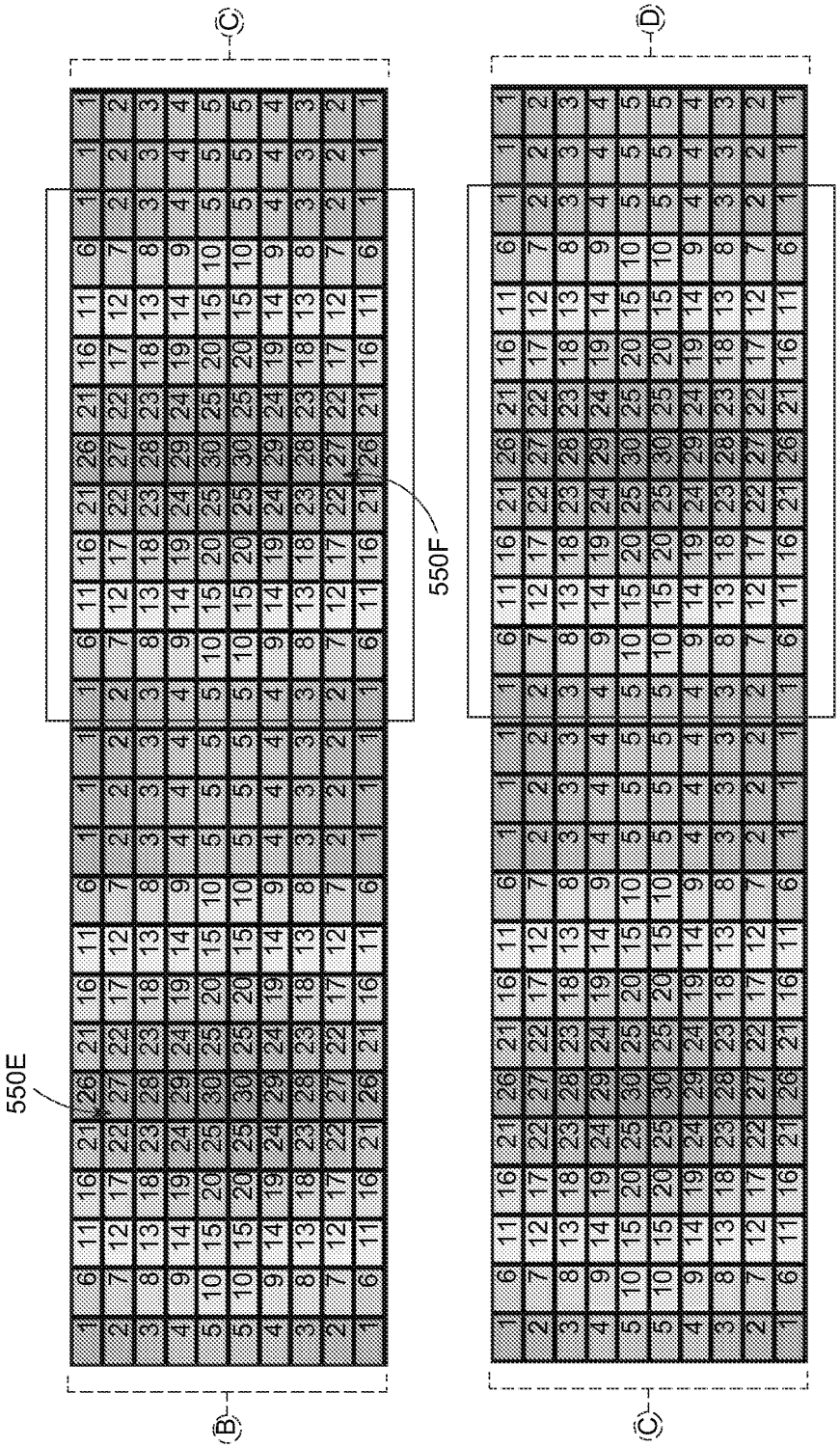

FIG. 5A (Continued)

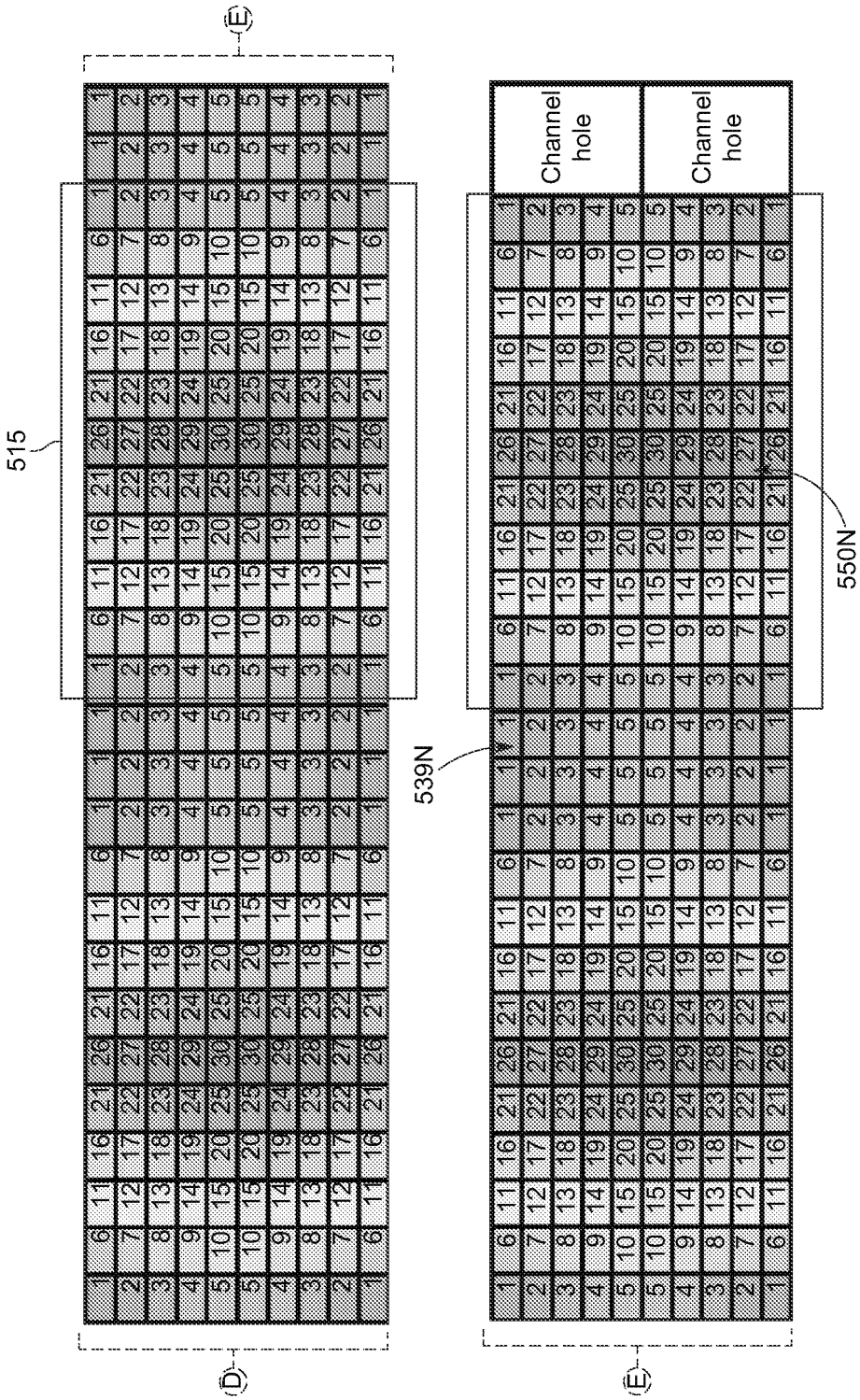

FIG. 5A (Continued)

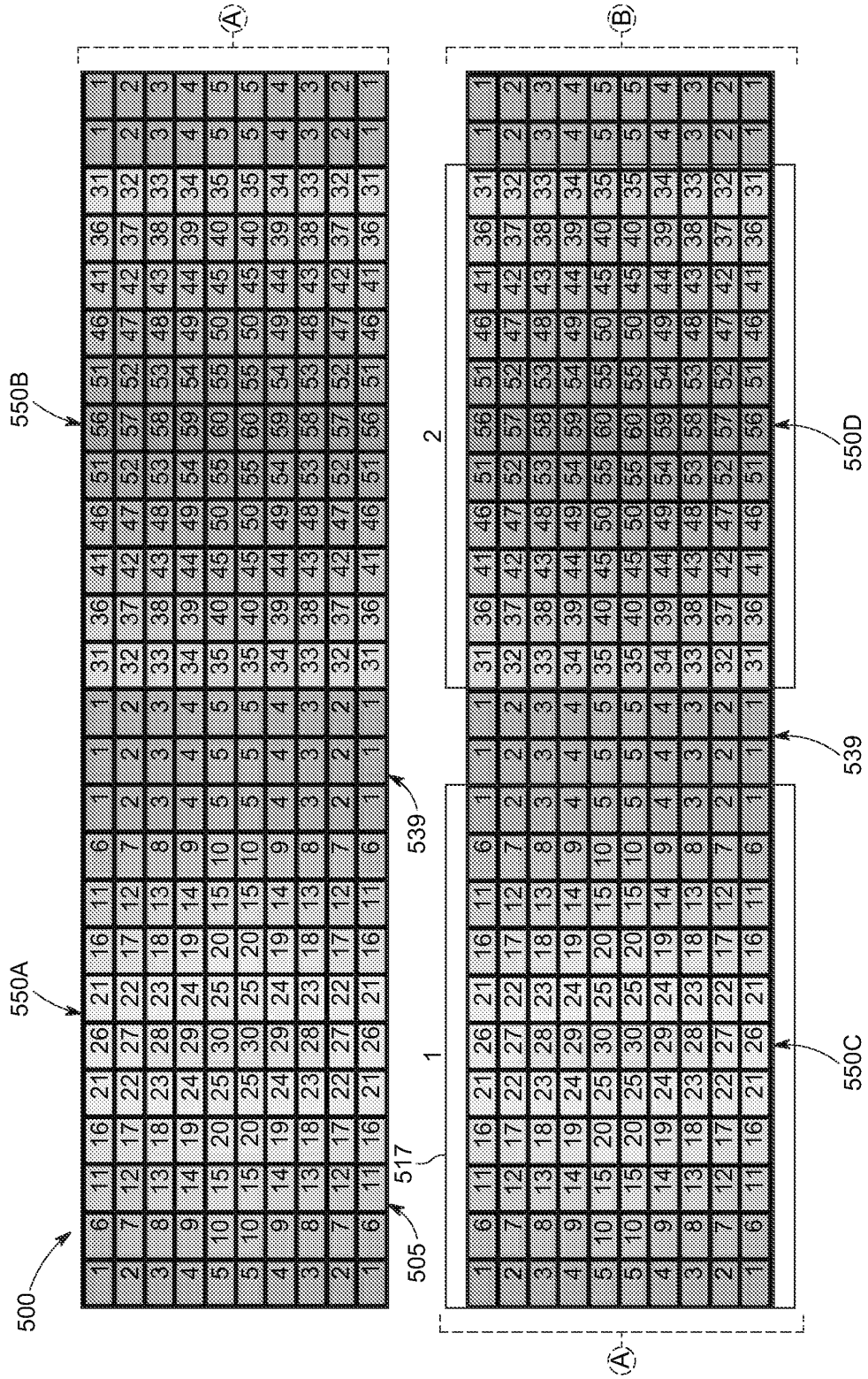

FIG. 5B

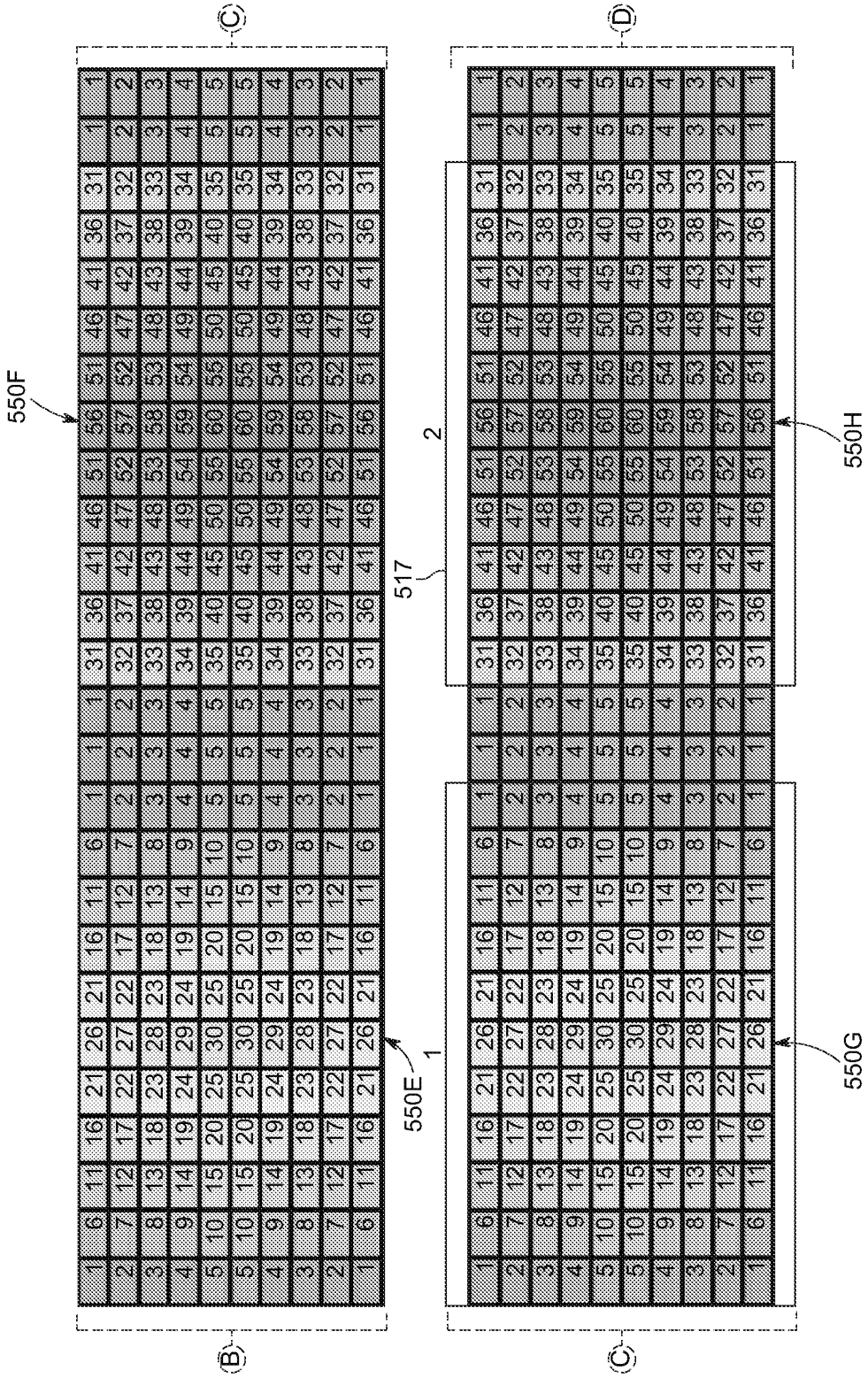

FIG. 5B (Continued)

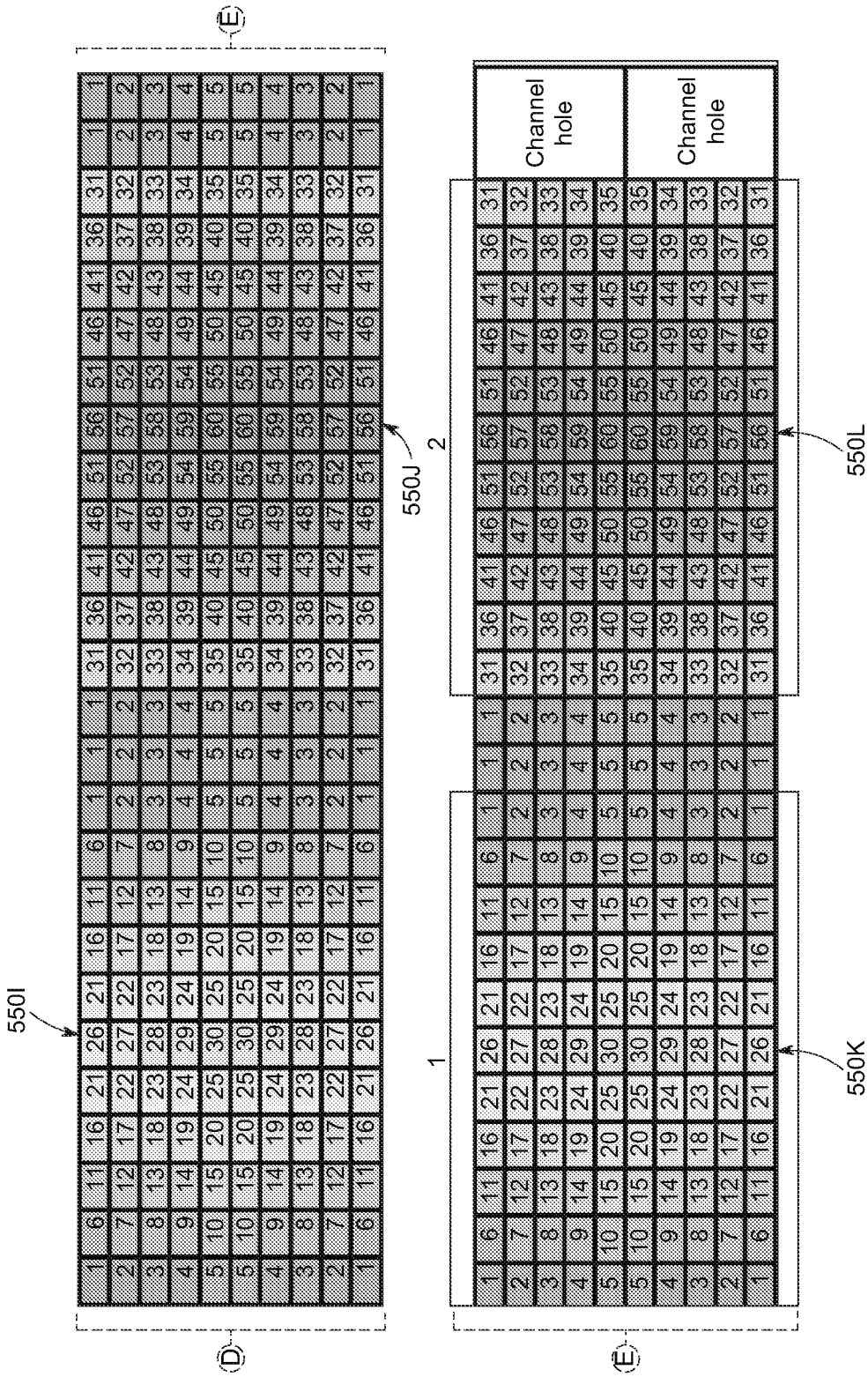

FIG. 5B (Continued)

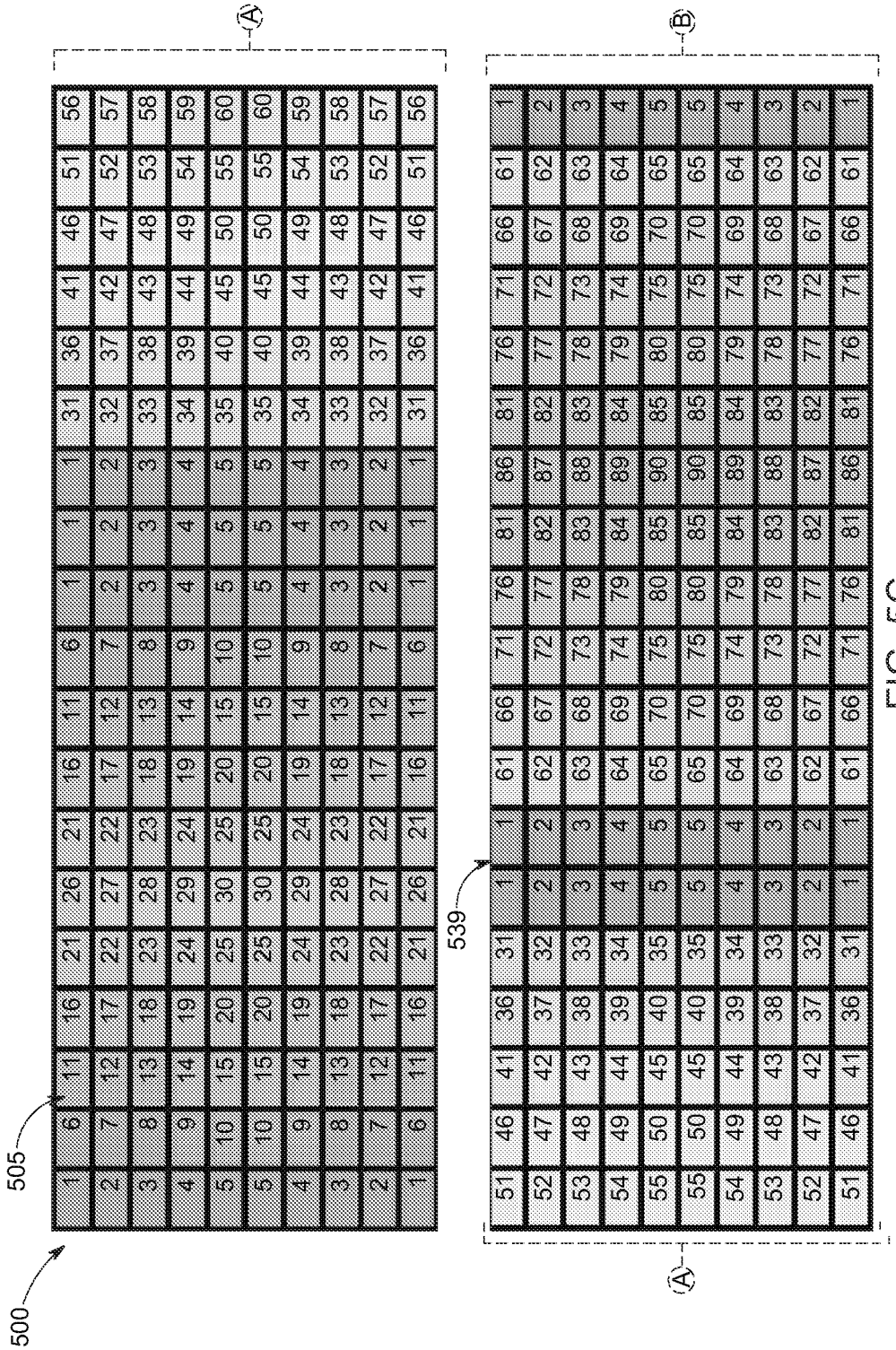

FIG. 5C

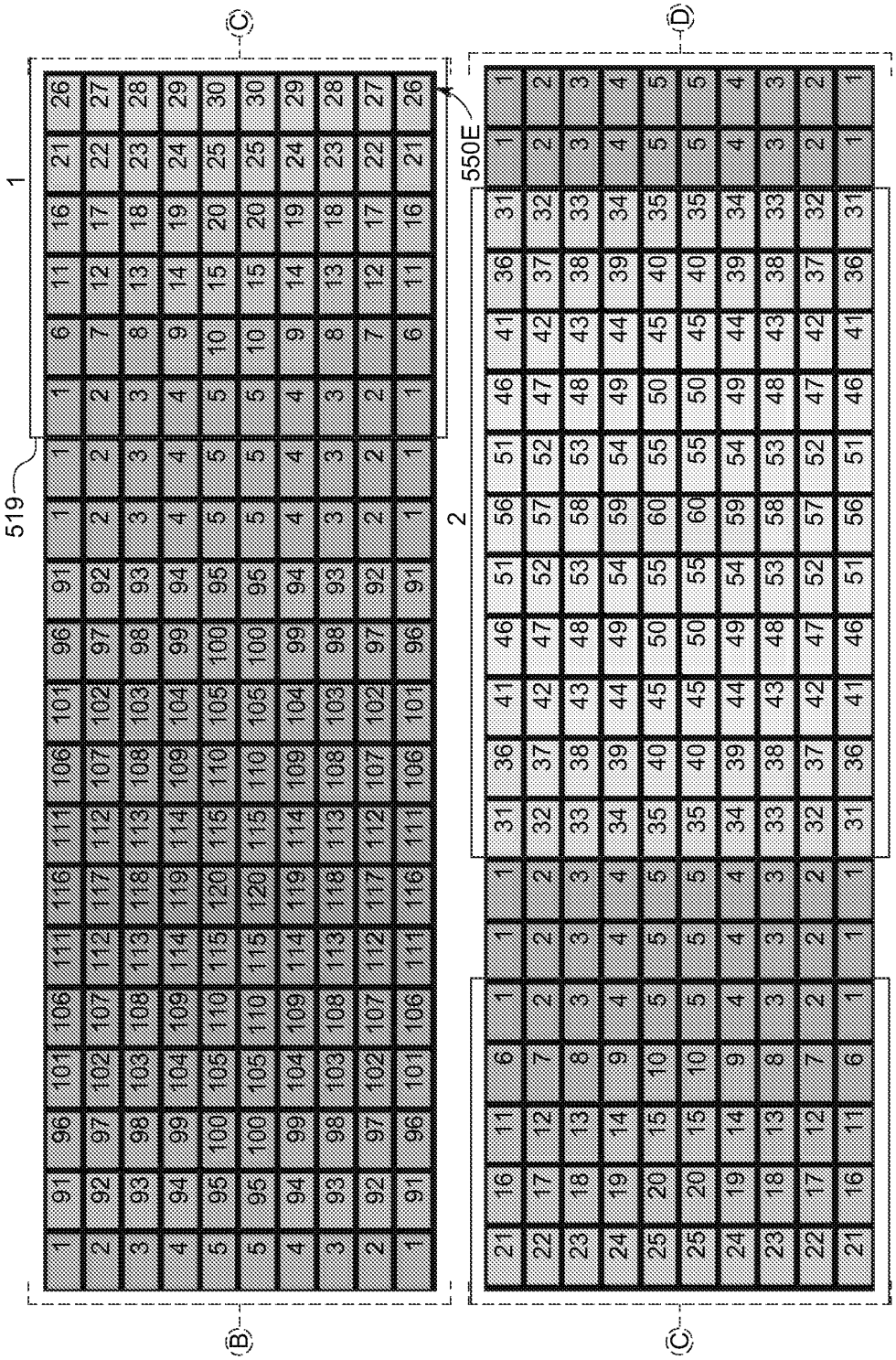

FIG. 5C (Continued)

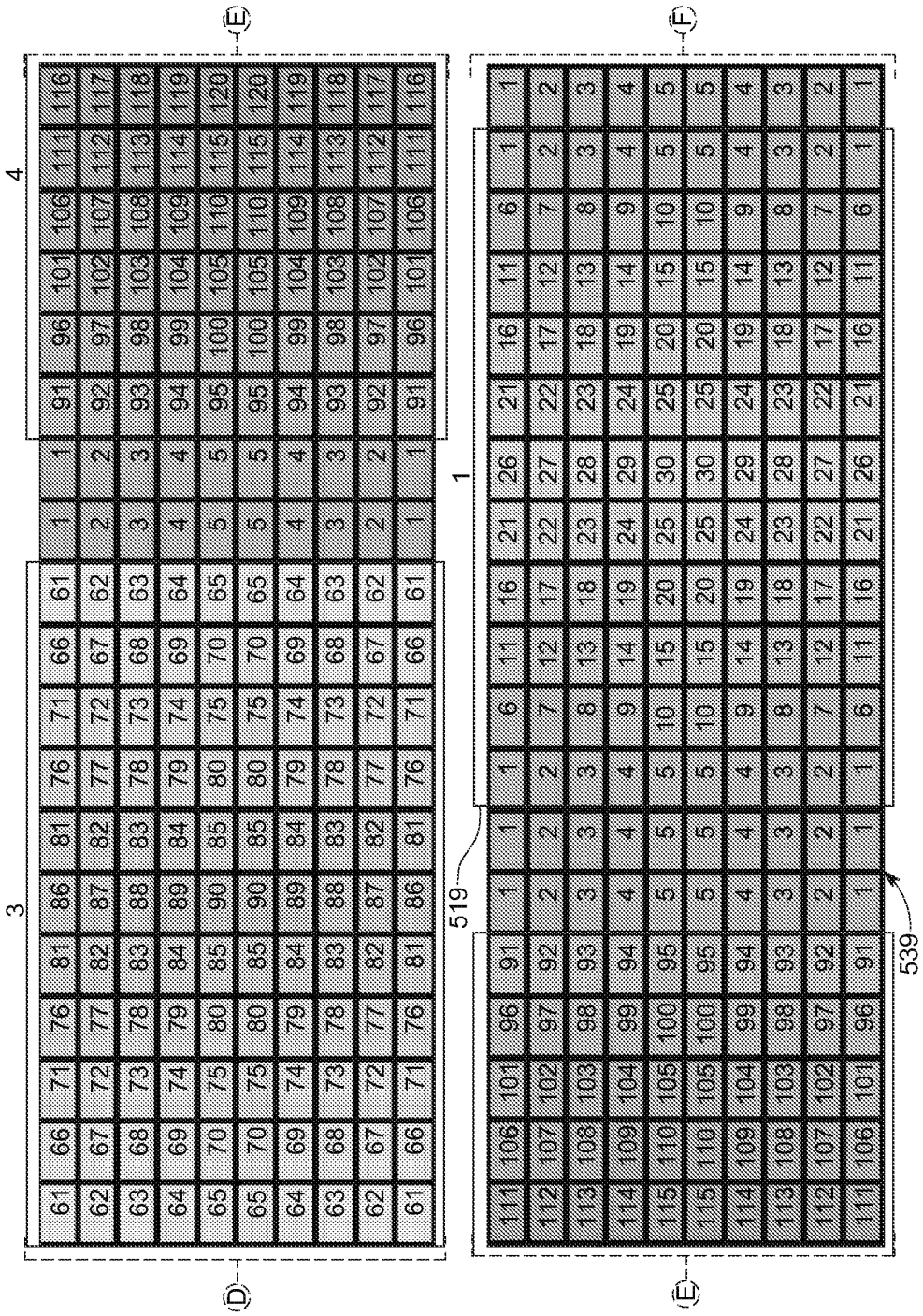

FIG. 5C (Continued)

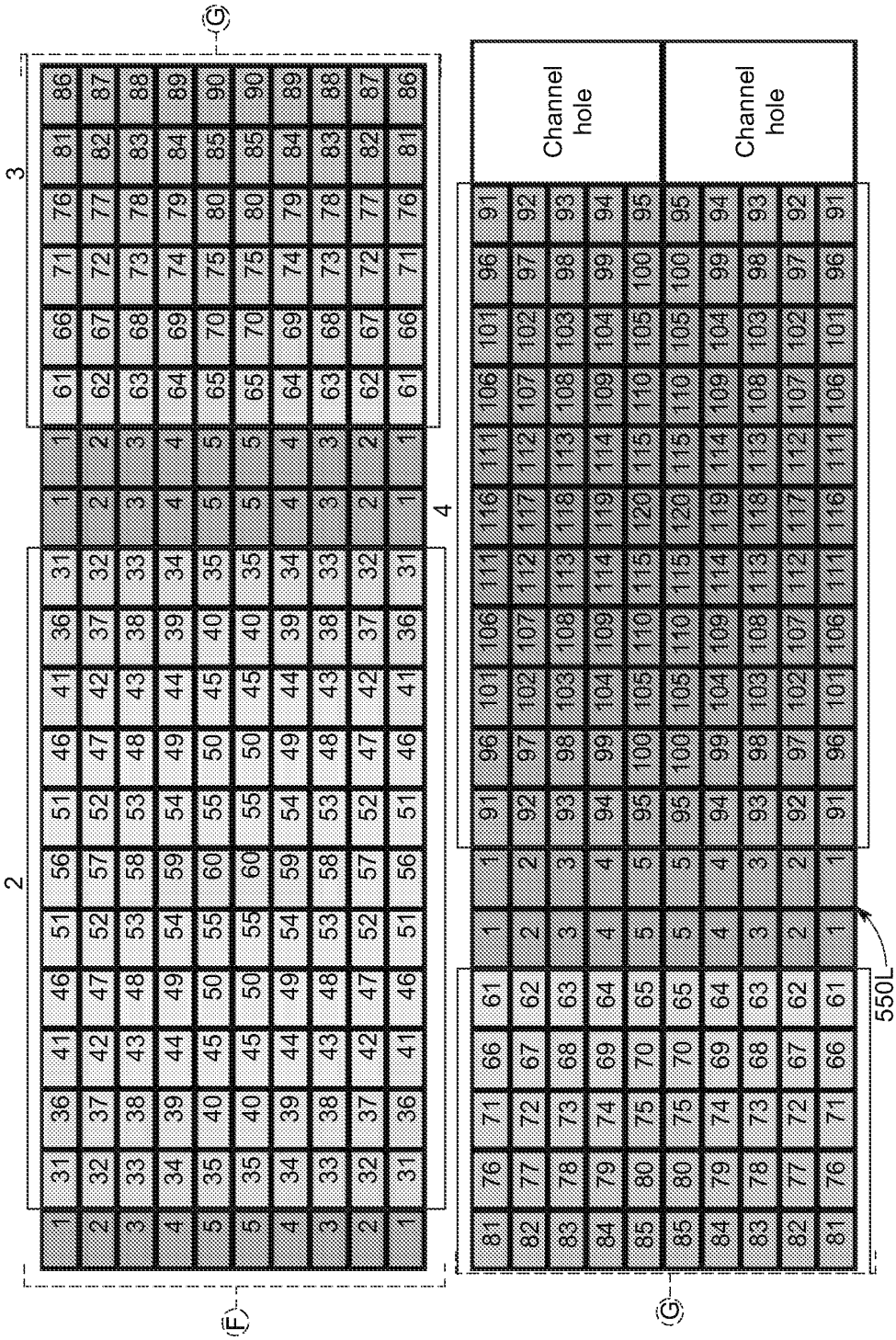

FIG. 5C (Continued)

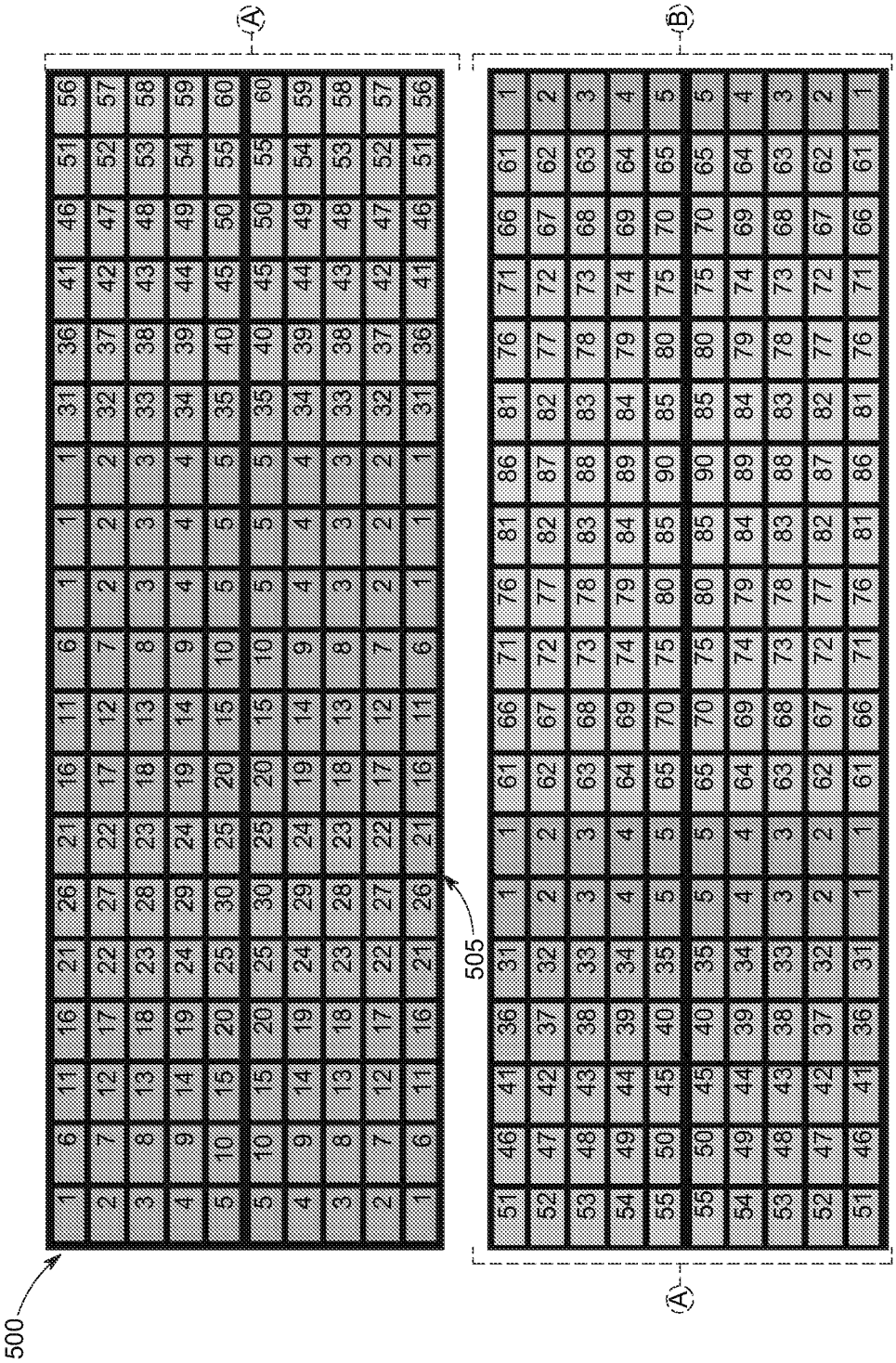

FIG. 5D

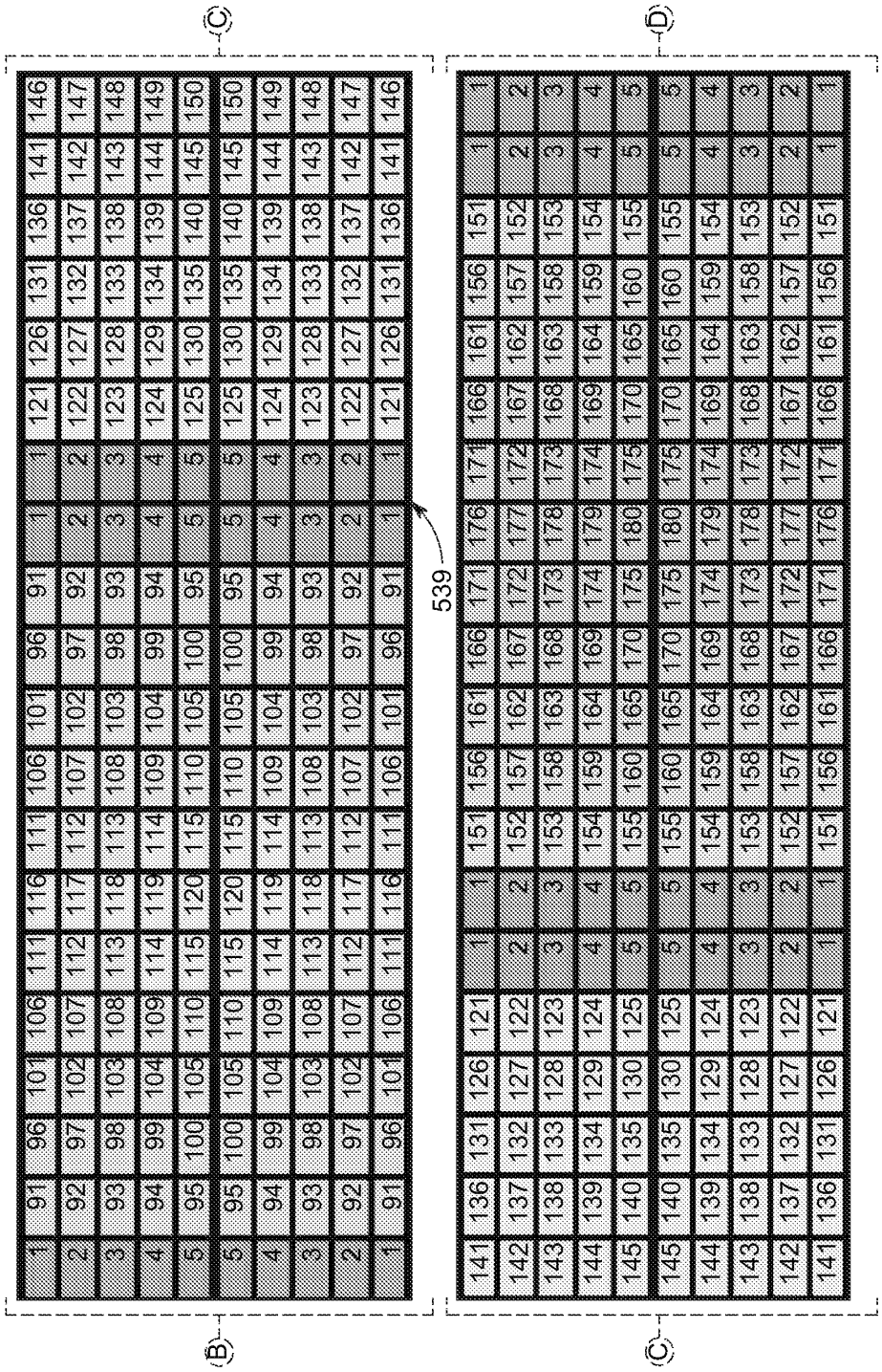

FIG. 5D (Continued)

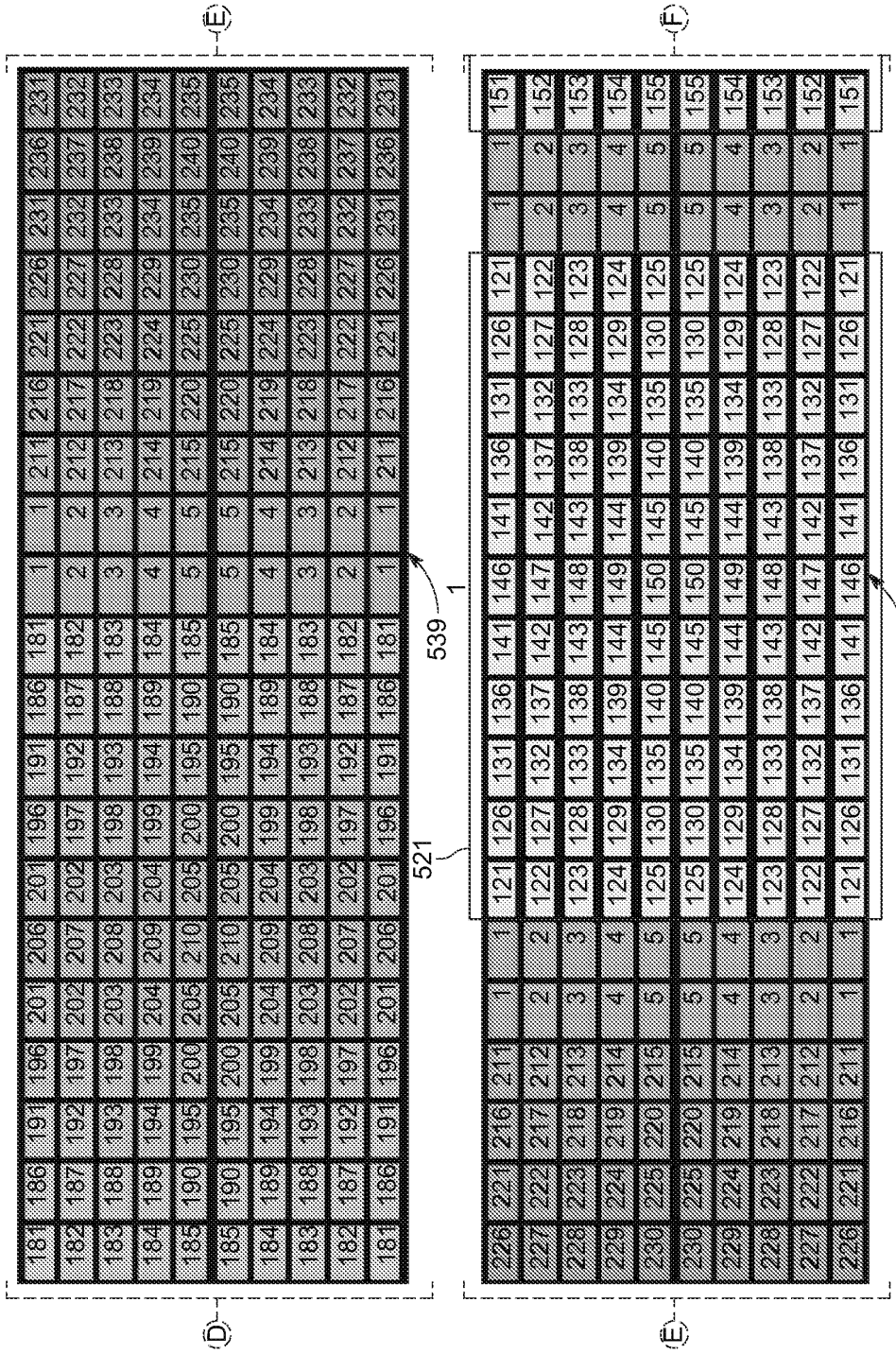

FIG. 5D (Continued)

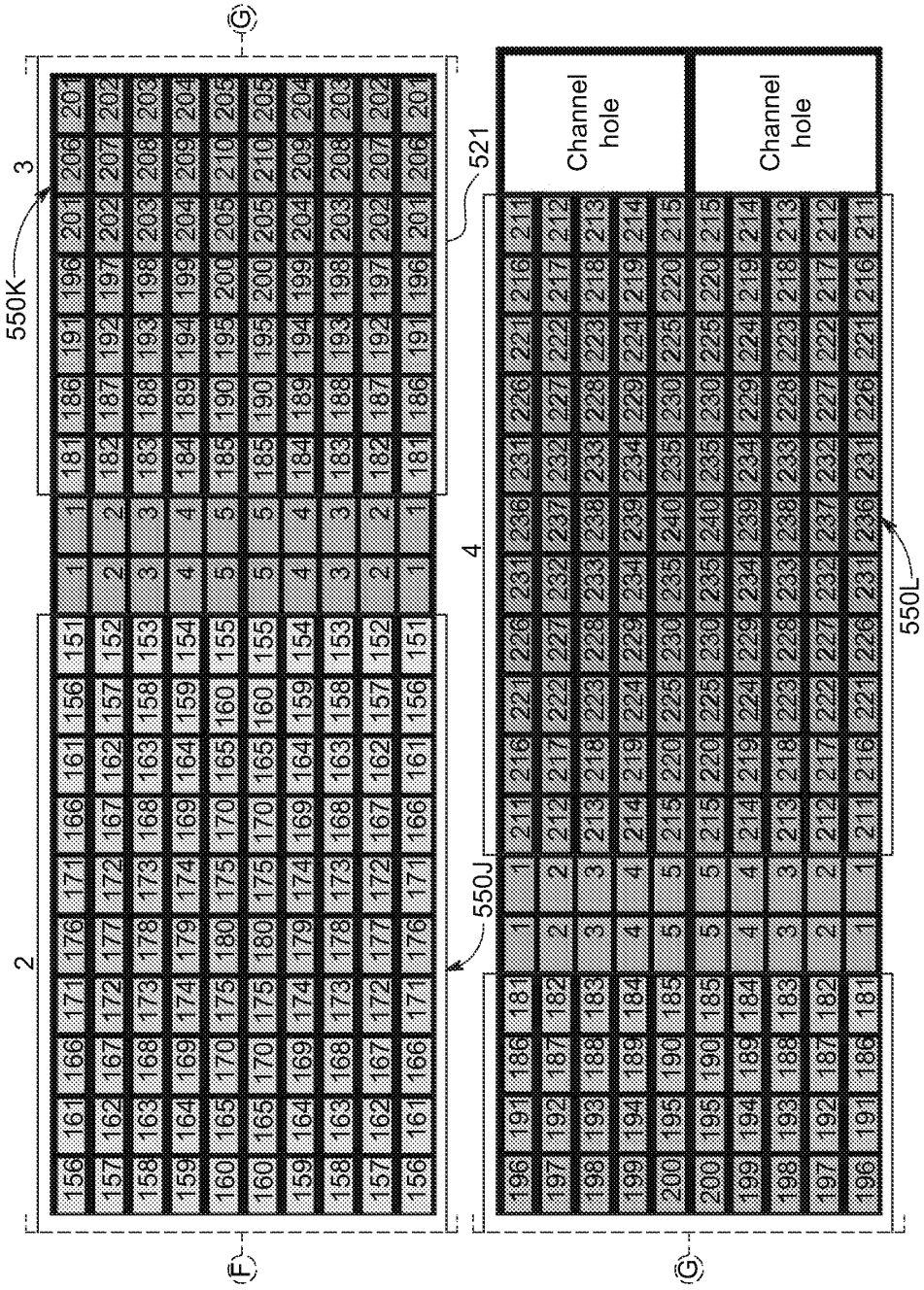

FIG. 5D (Continued)

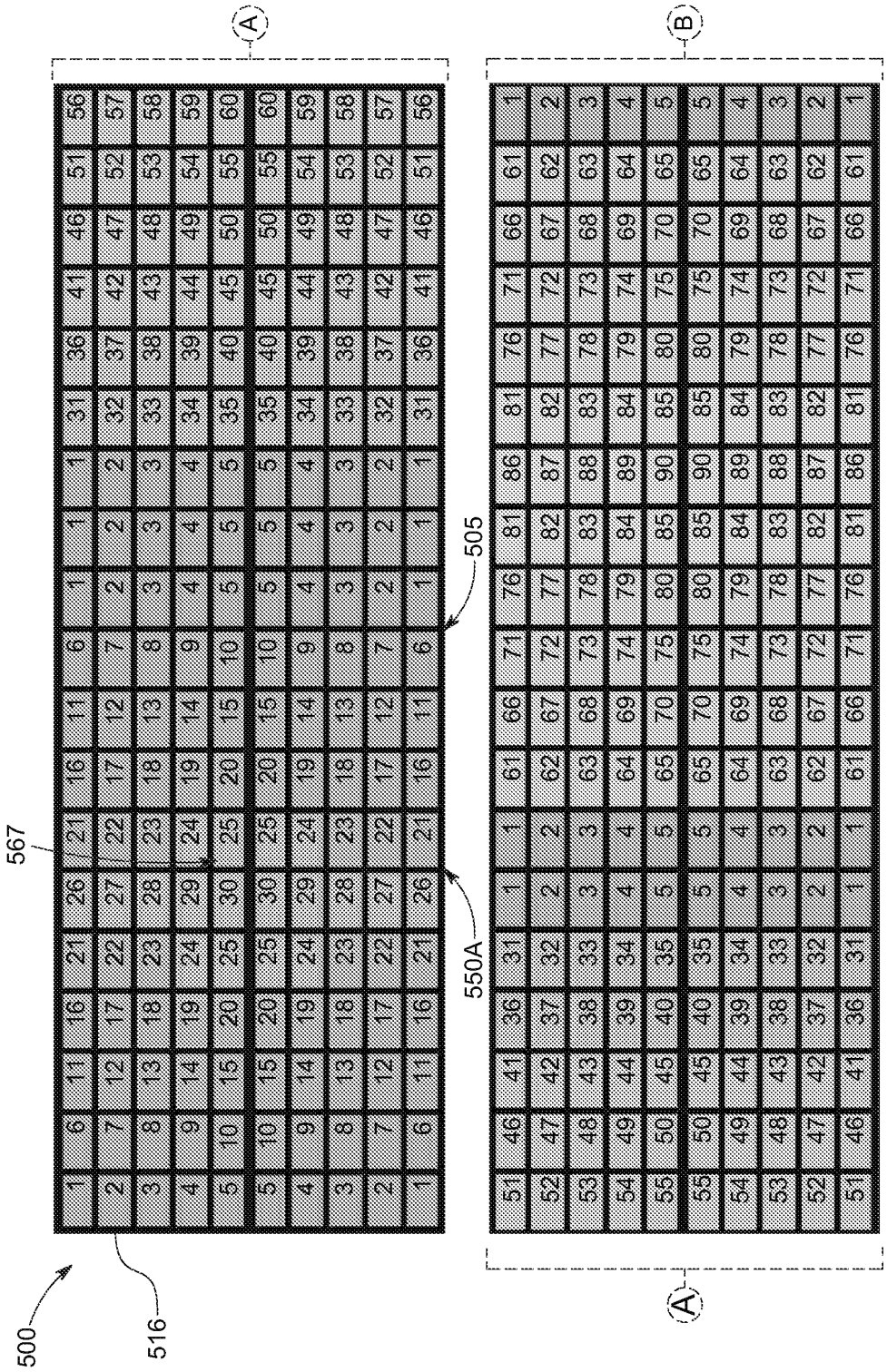

FIG. 5E

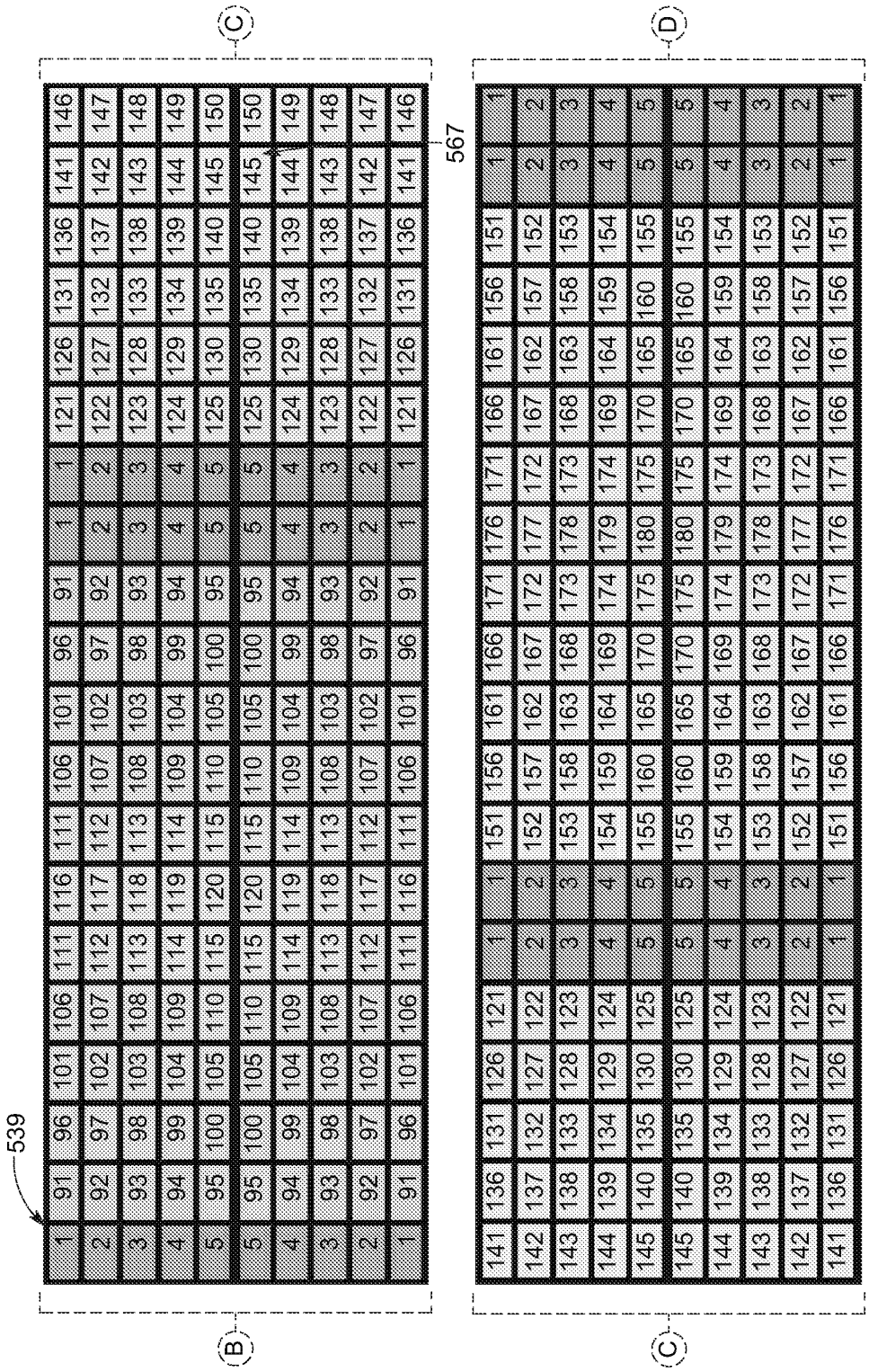

FIG. 5E (Continued)

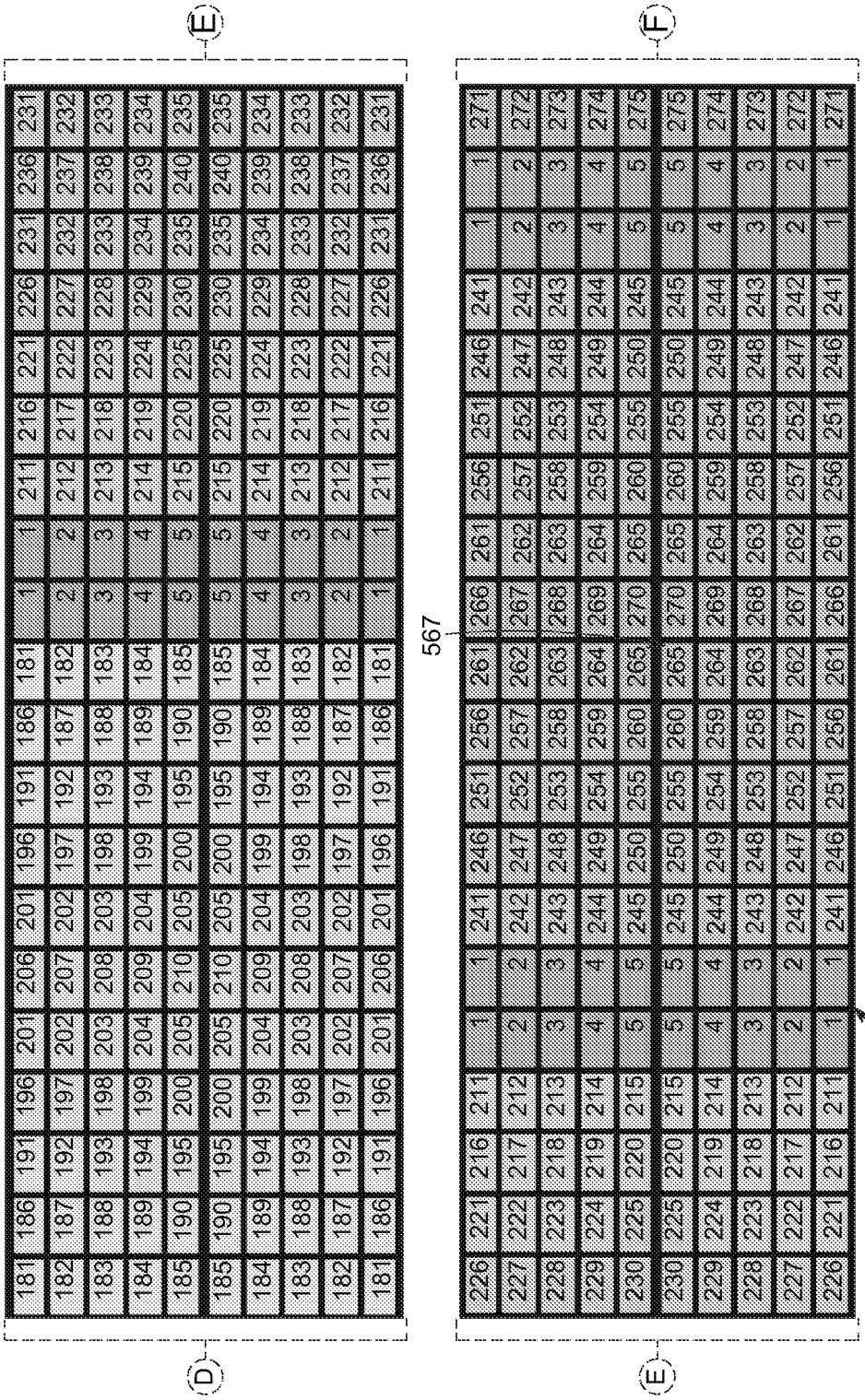

FIG. 5E (Continued)

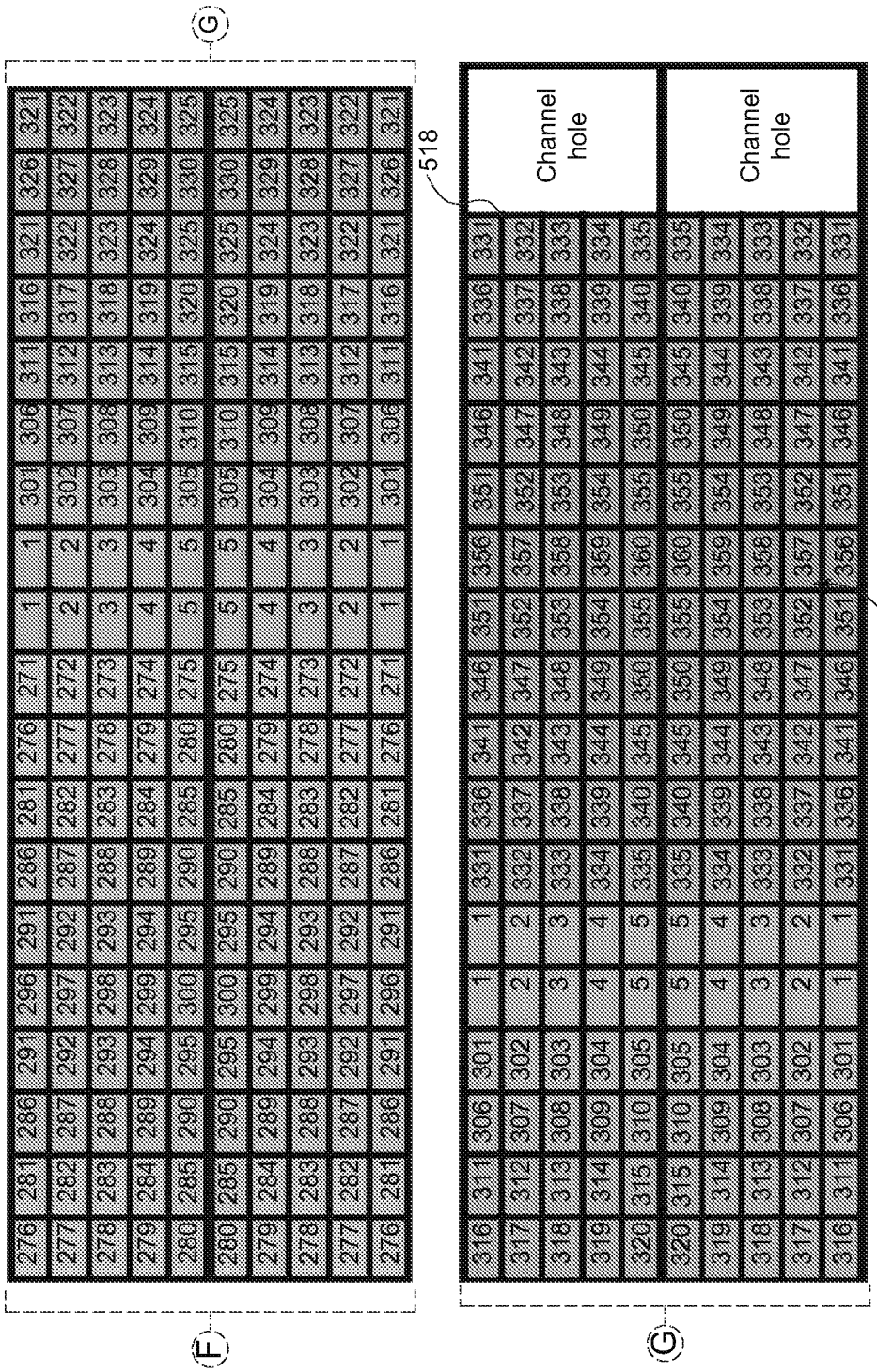

FIG. 5E (Continued)

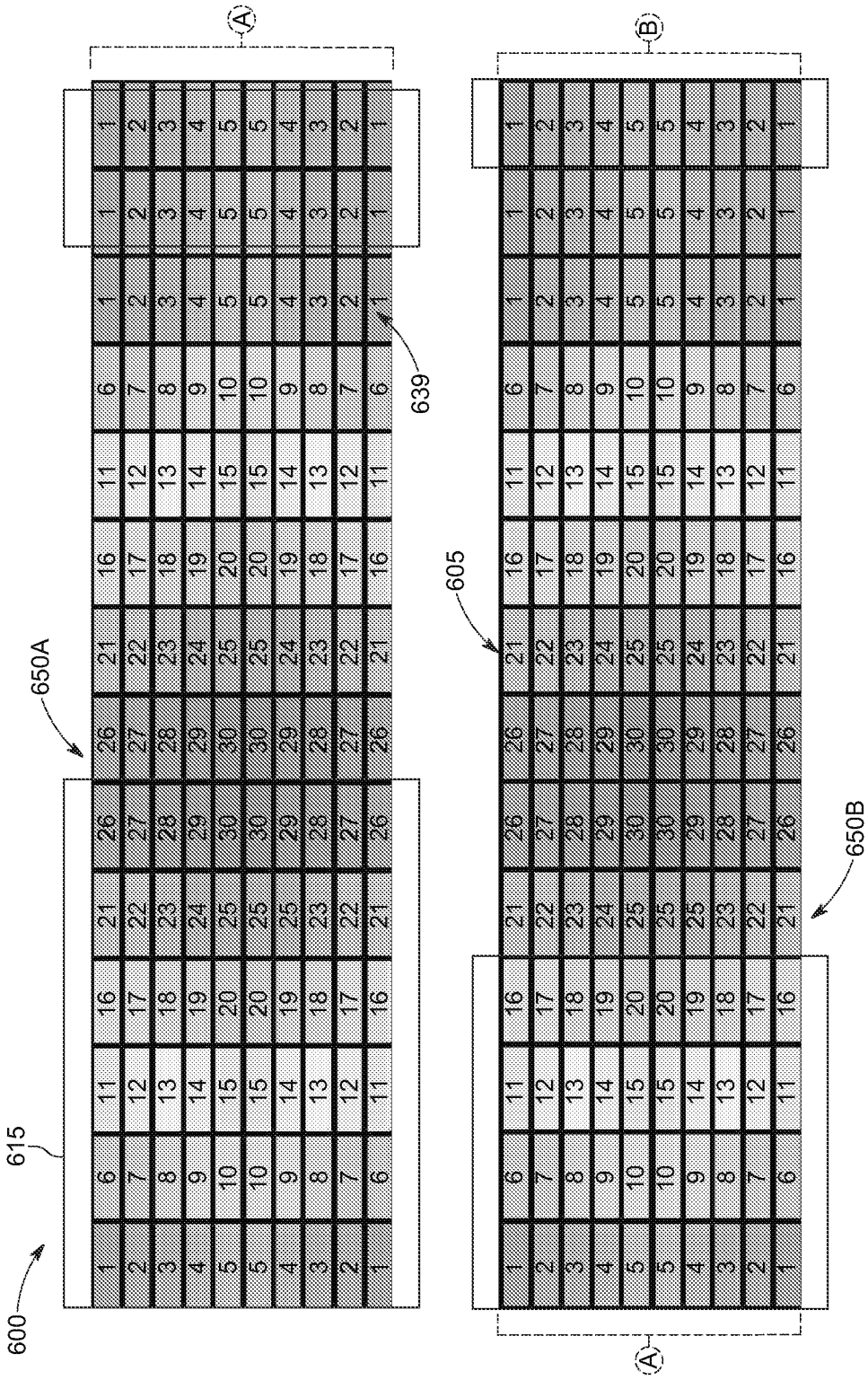

FIG. 6A

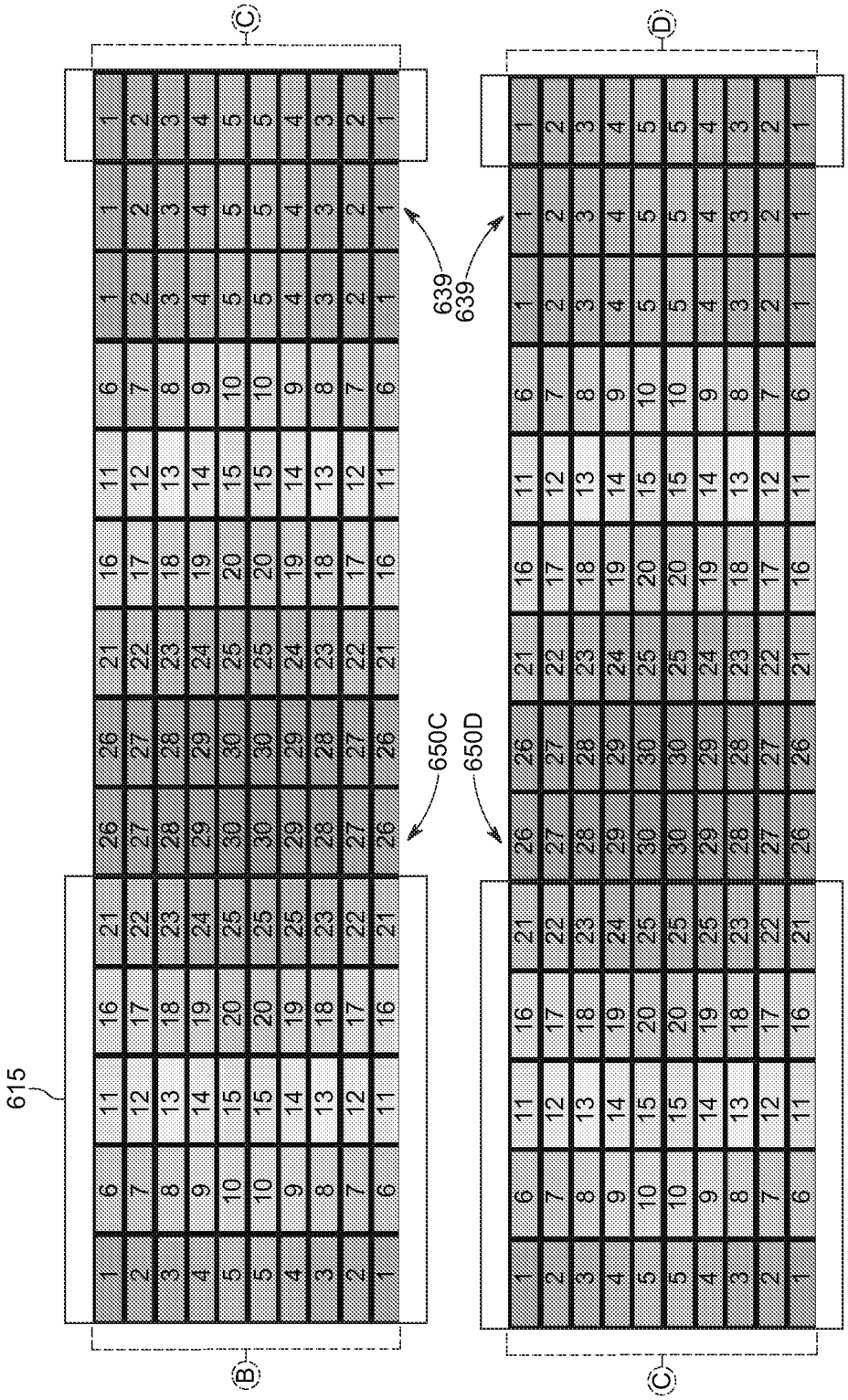

FIG. 6A (Continued)

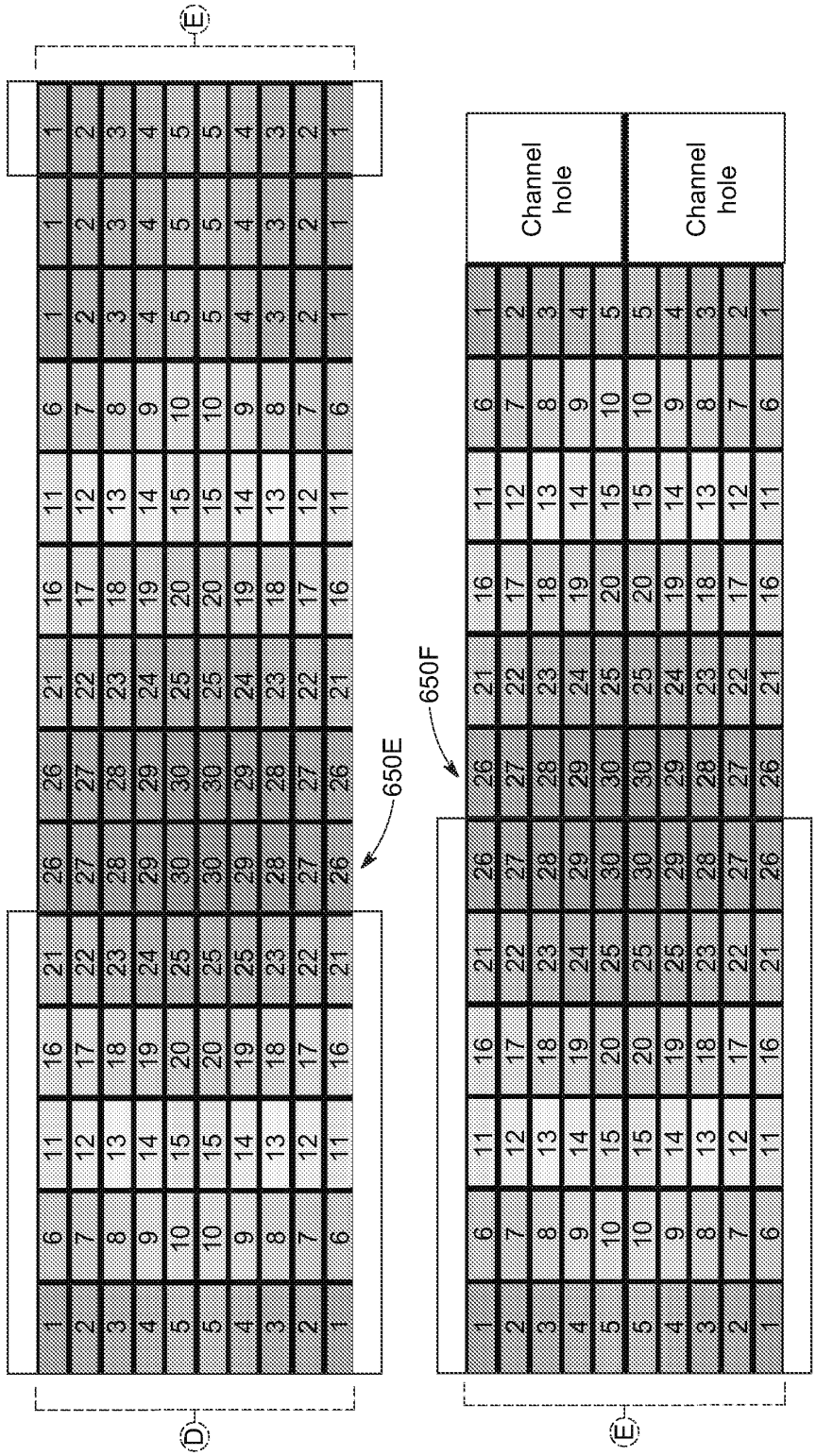

FIG. 6A (Continued)

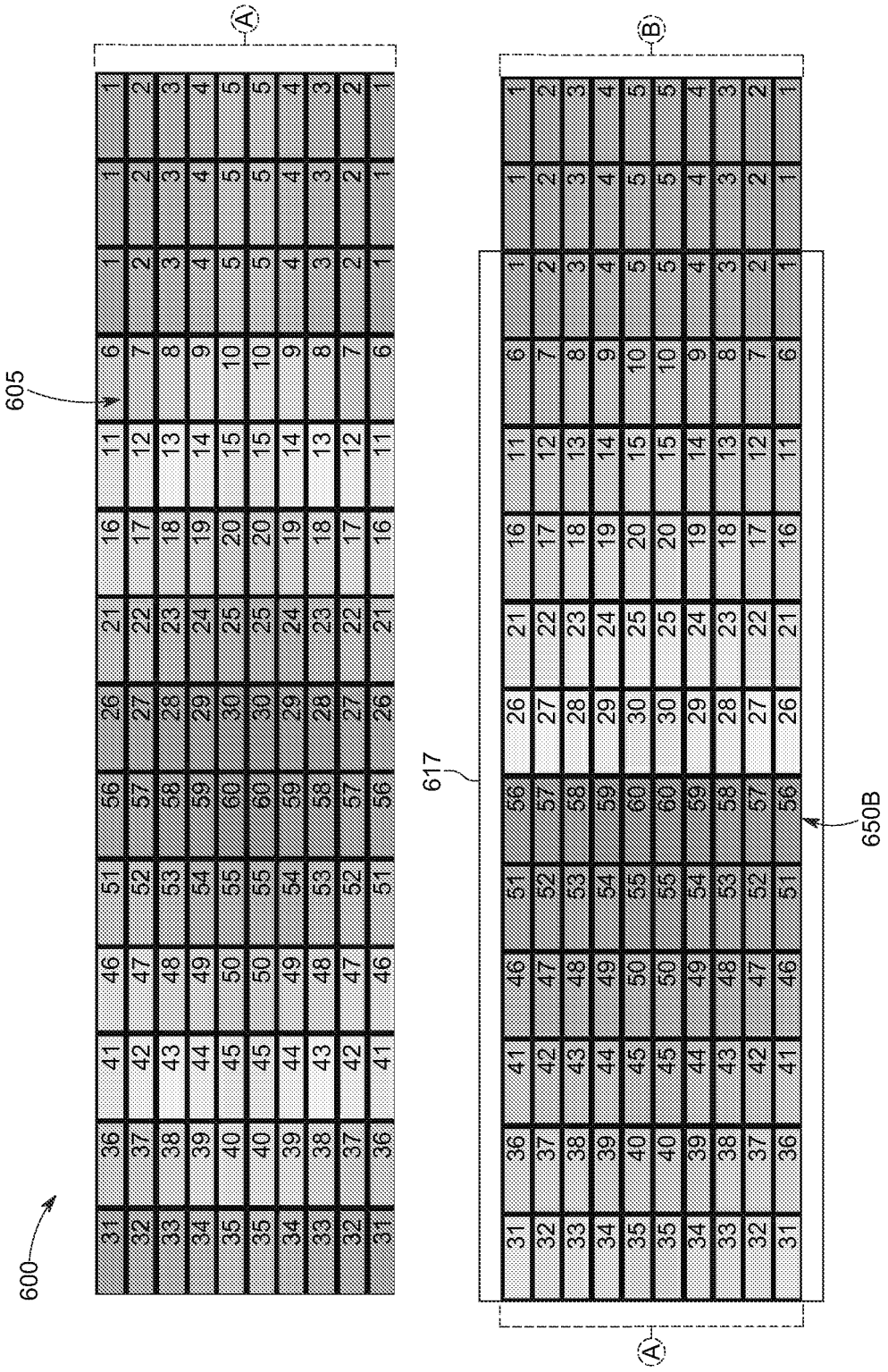

FIG. 6B

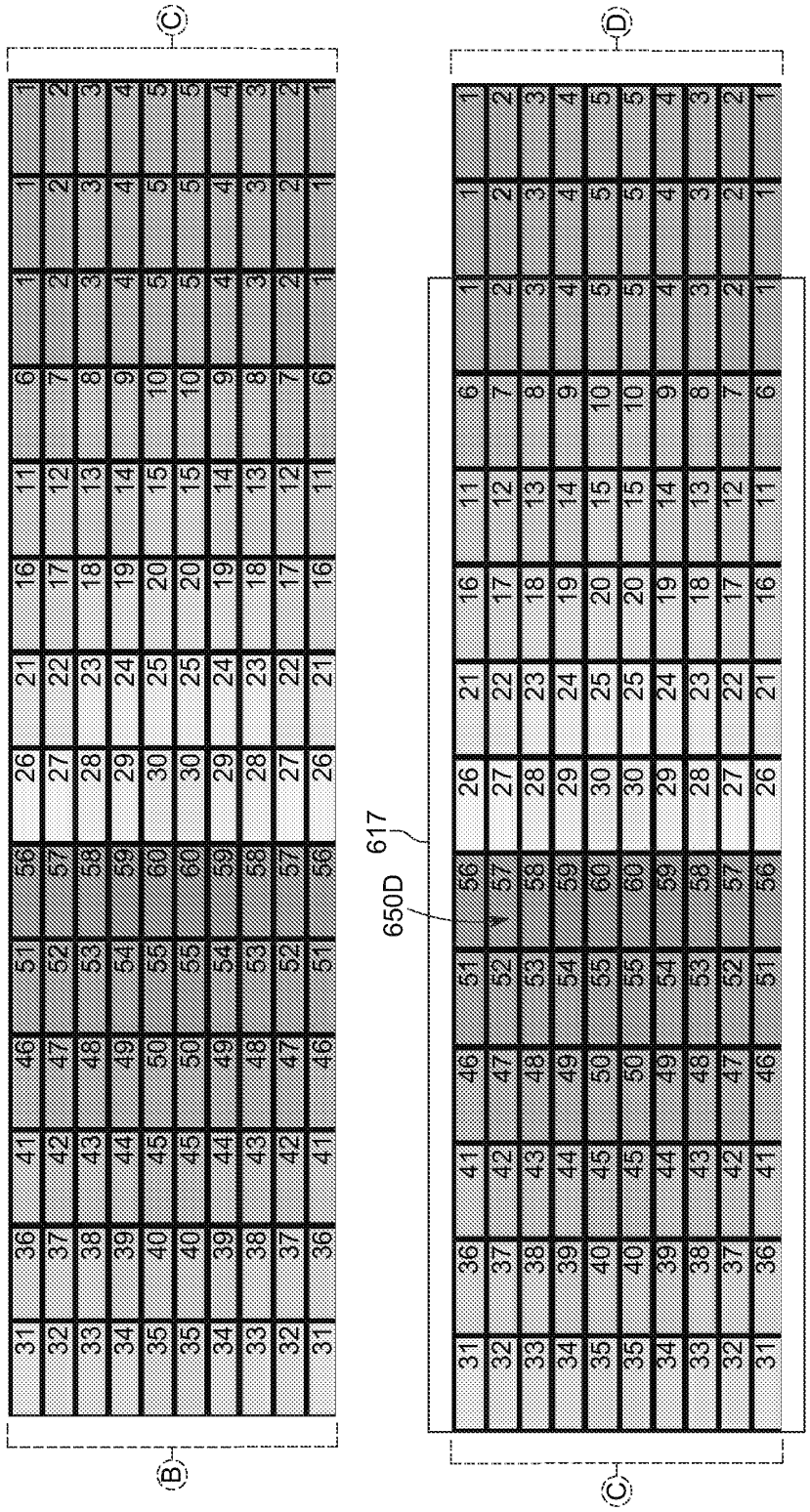

FIG. 6B (Continued)

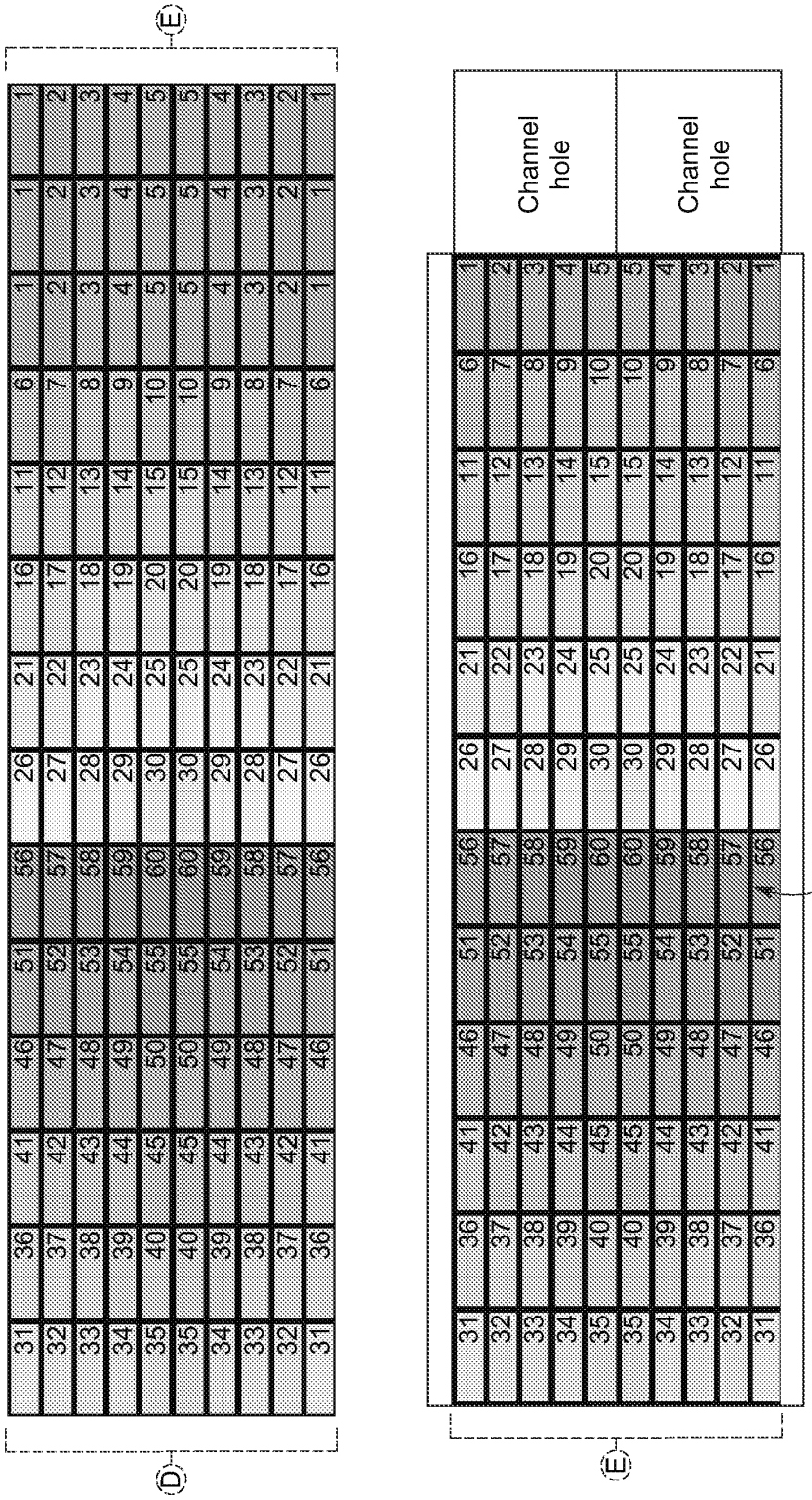

FIG. 6B (Continued)

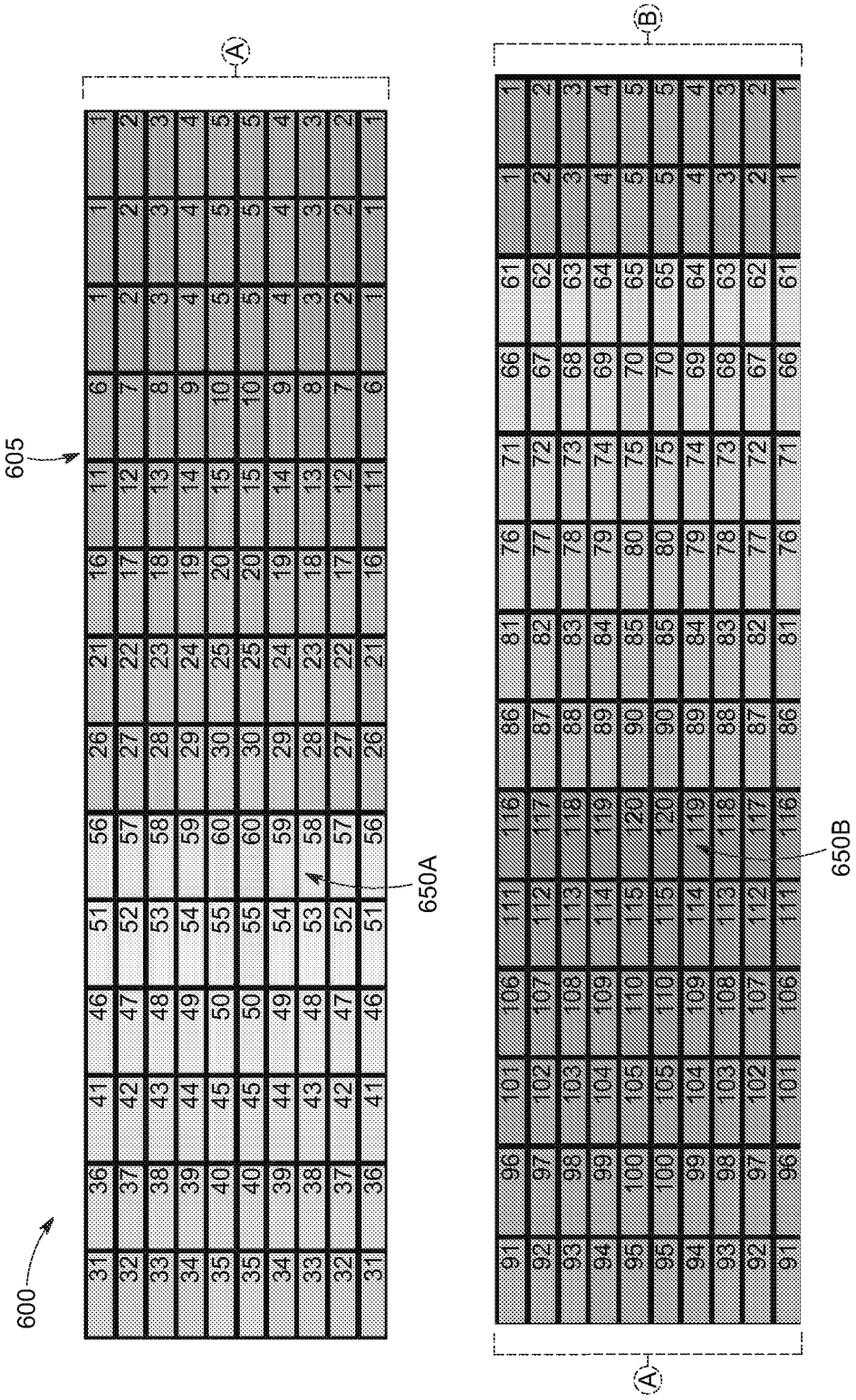

FIG. 6C

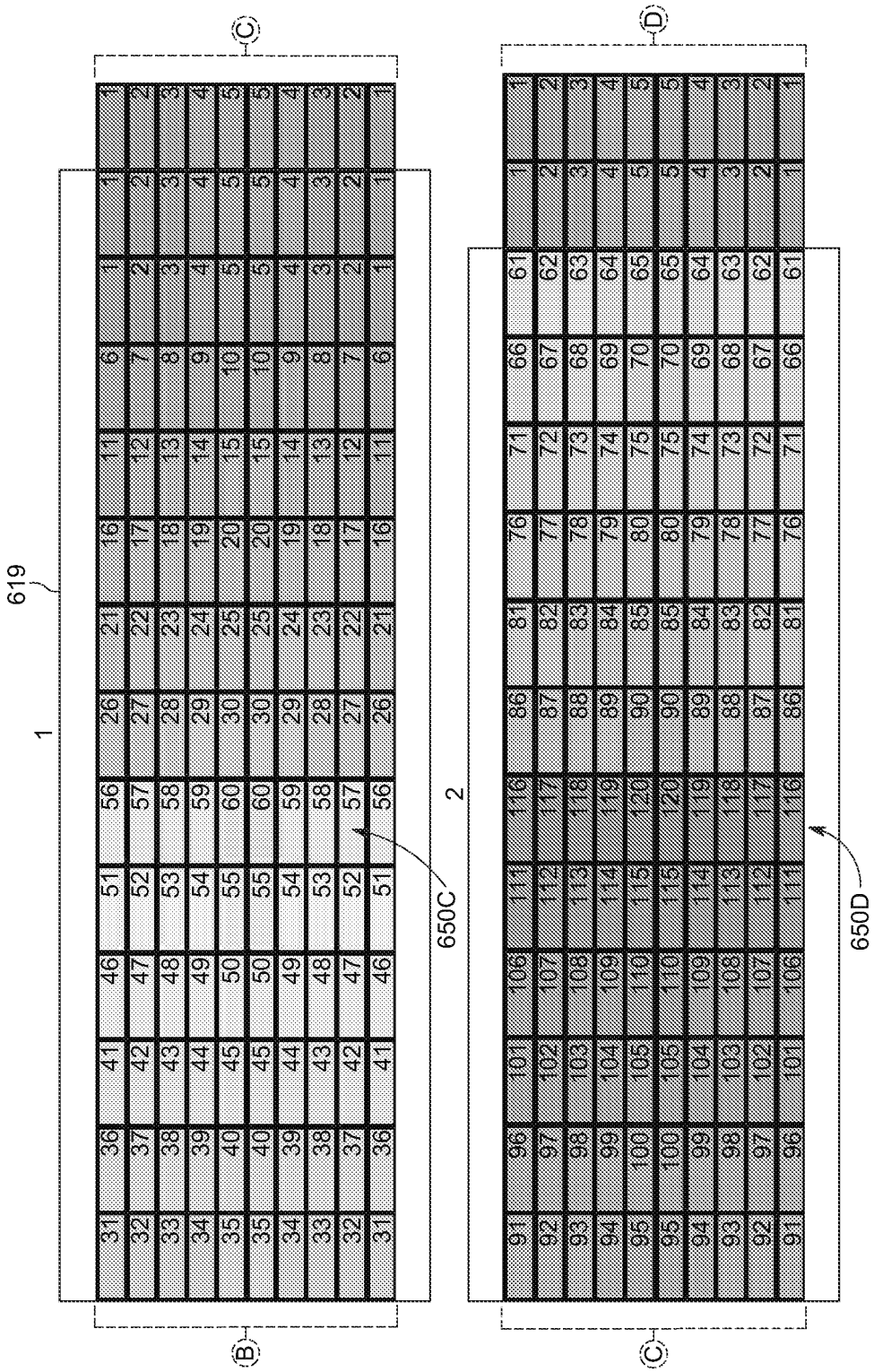

FIG. 6C (Continued)

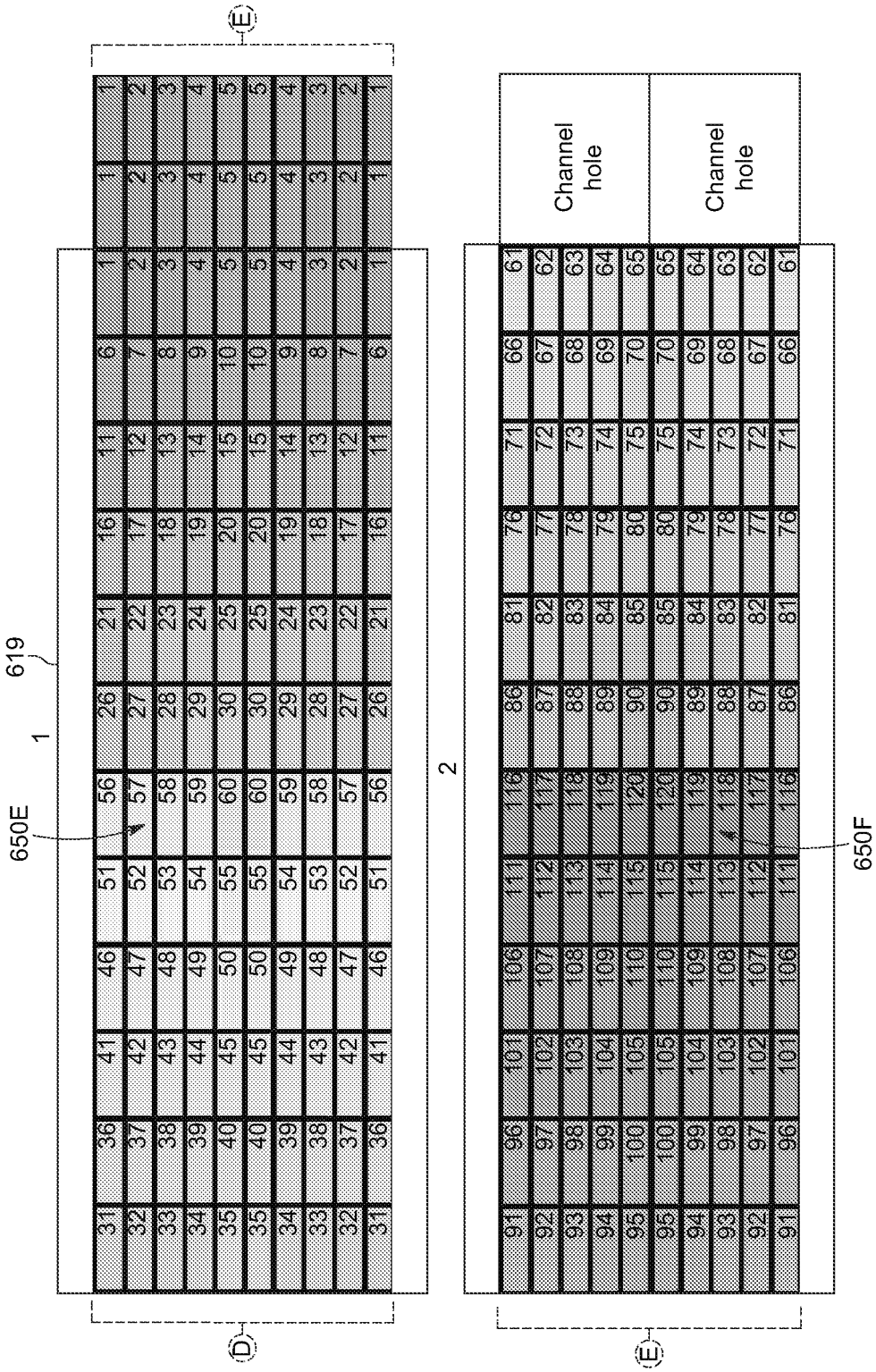

FIG. 6C (Continued)

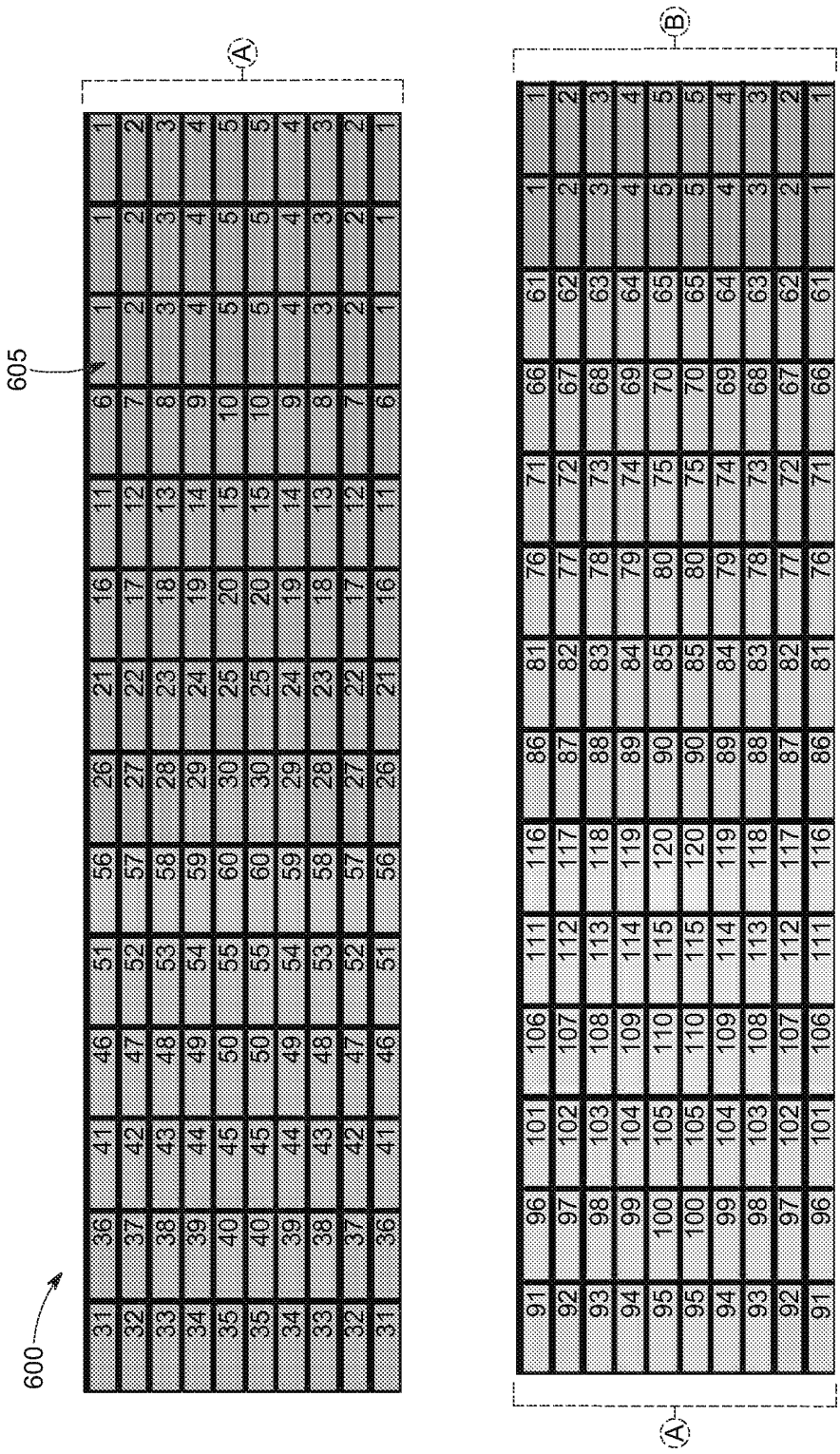

FIG. 6D

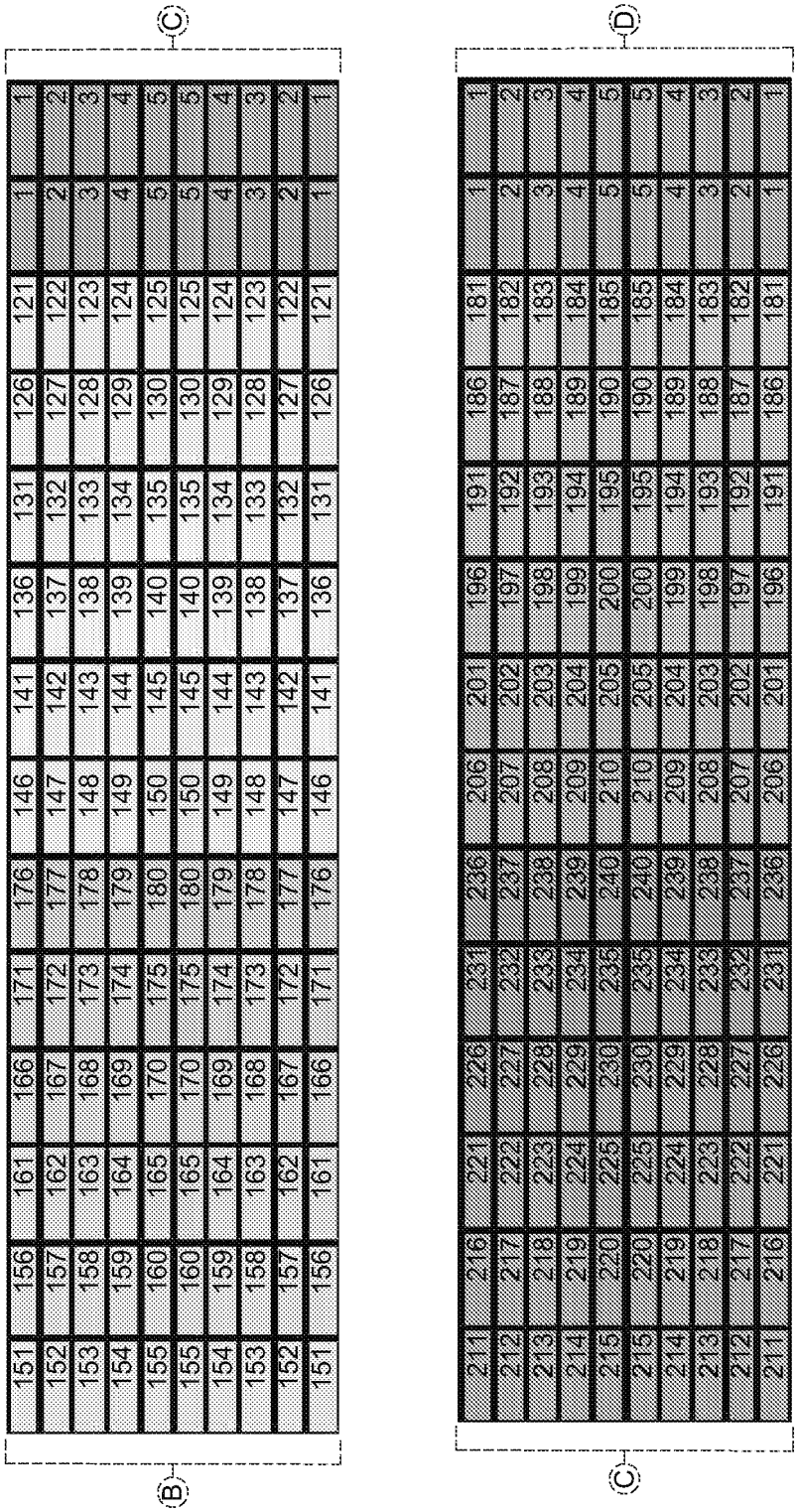

FIG. 6D (Continued)

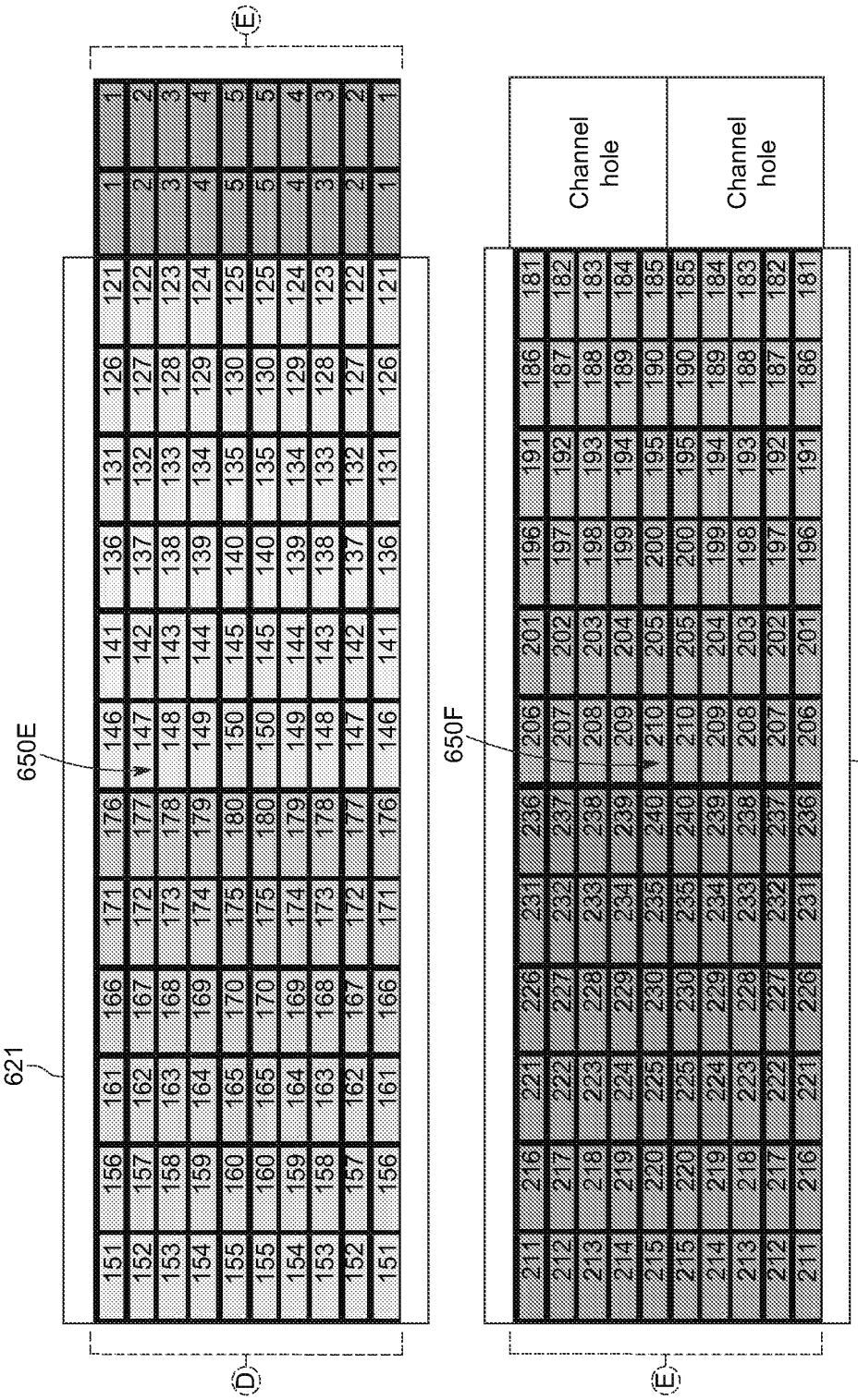

FIG. 6D (Continued)

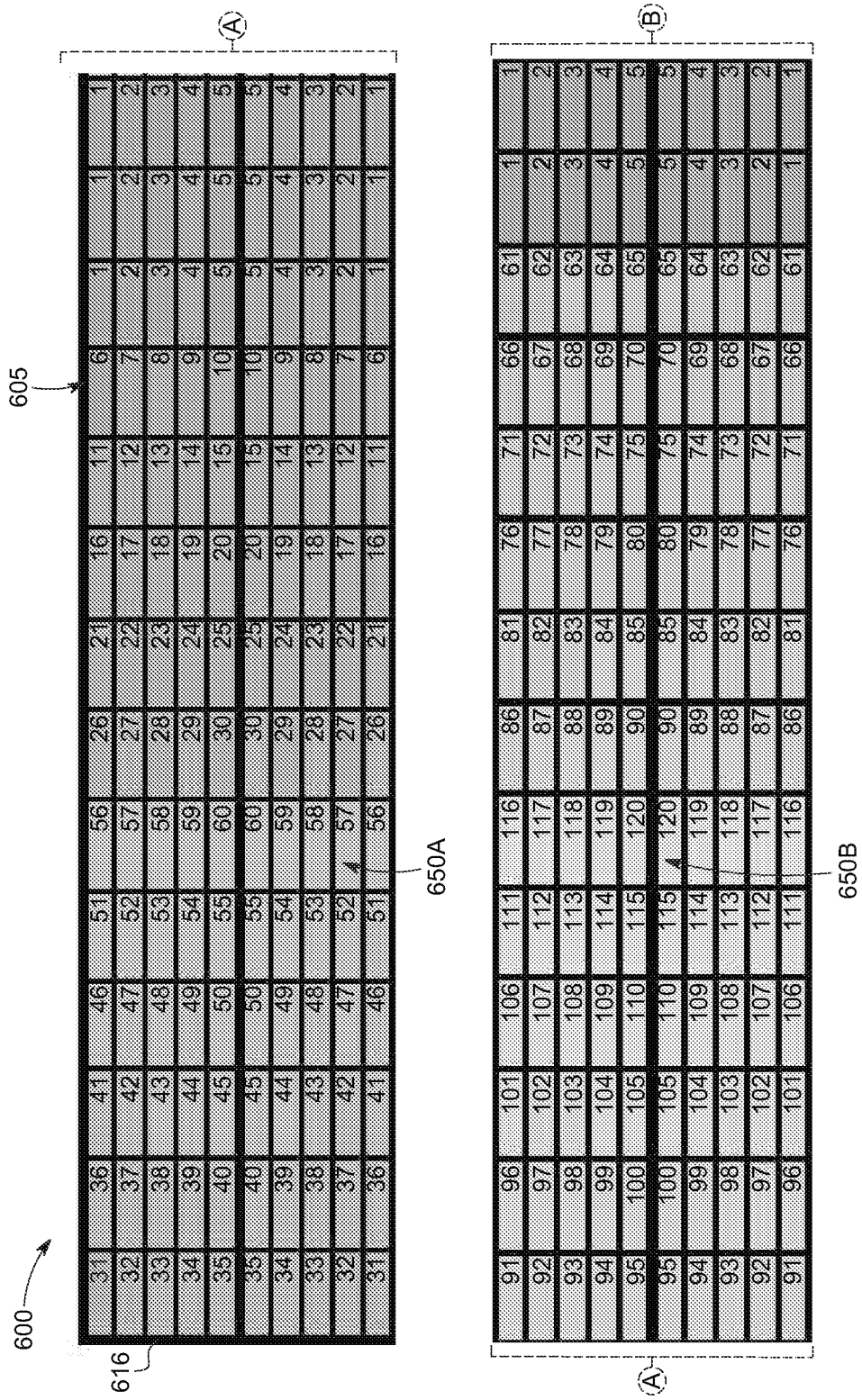

FIG. 6E

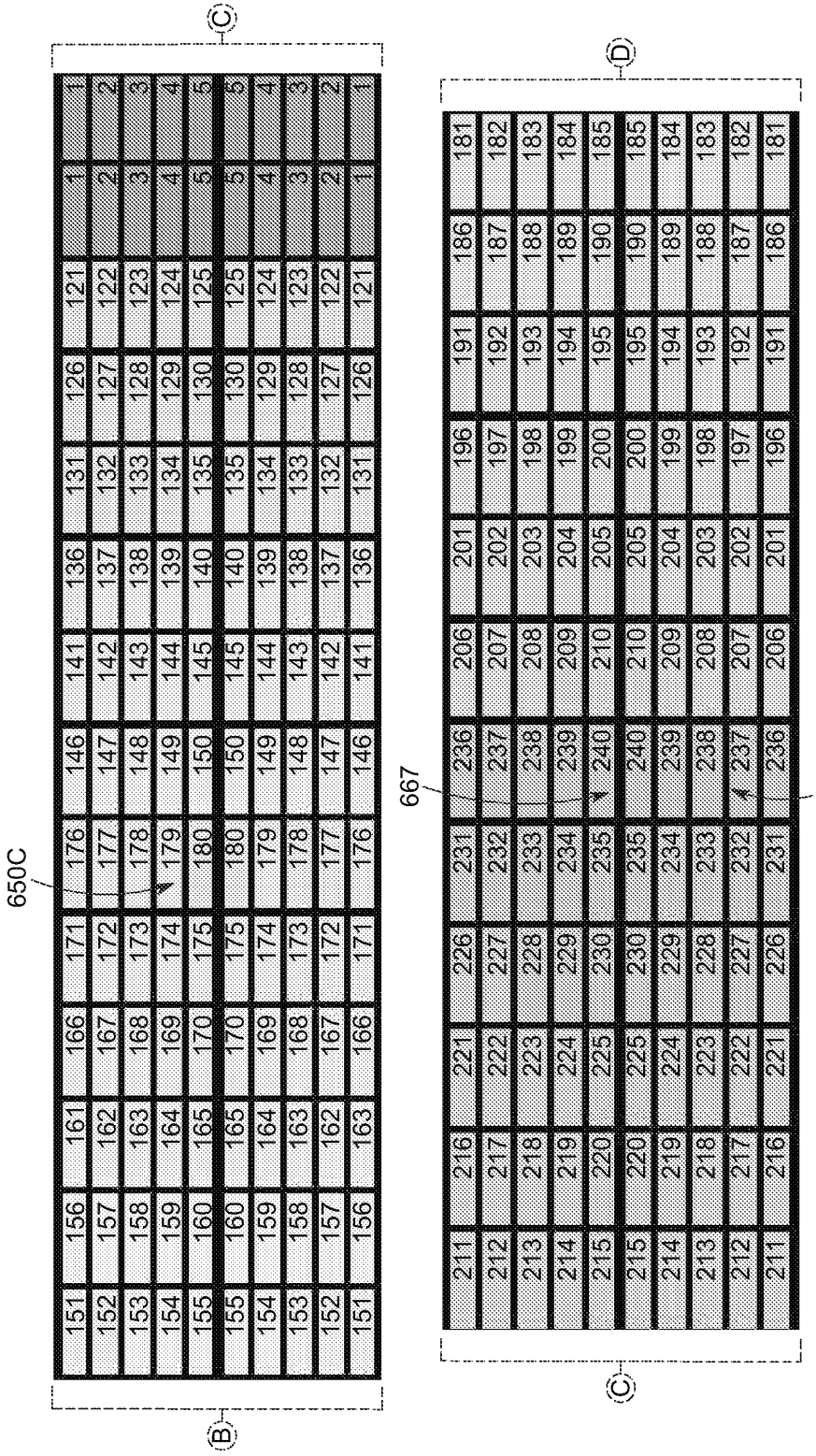

FIG. 6E (Continued)

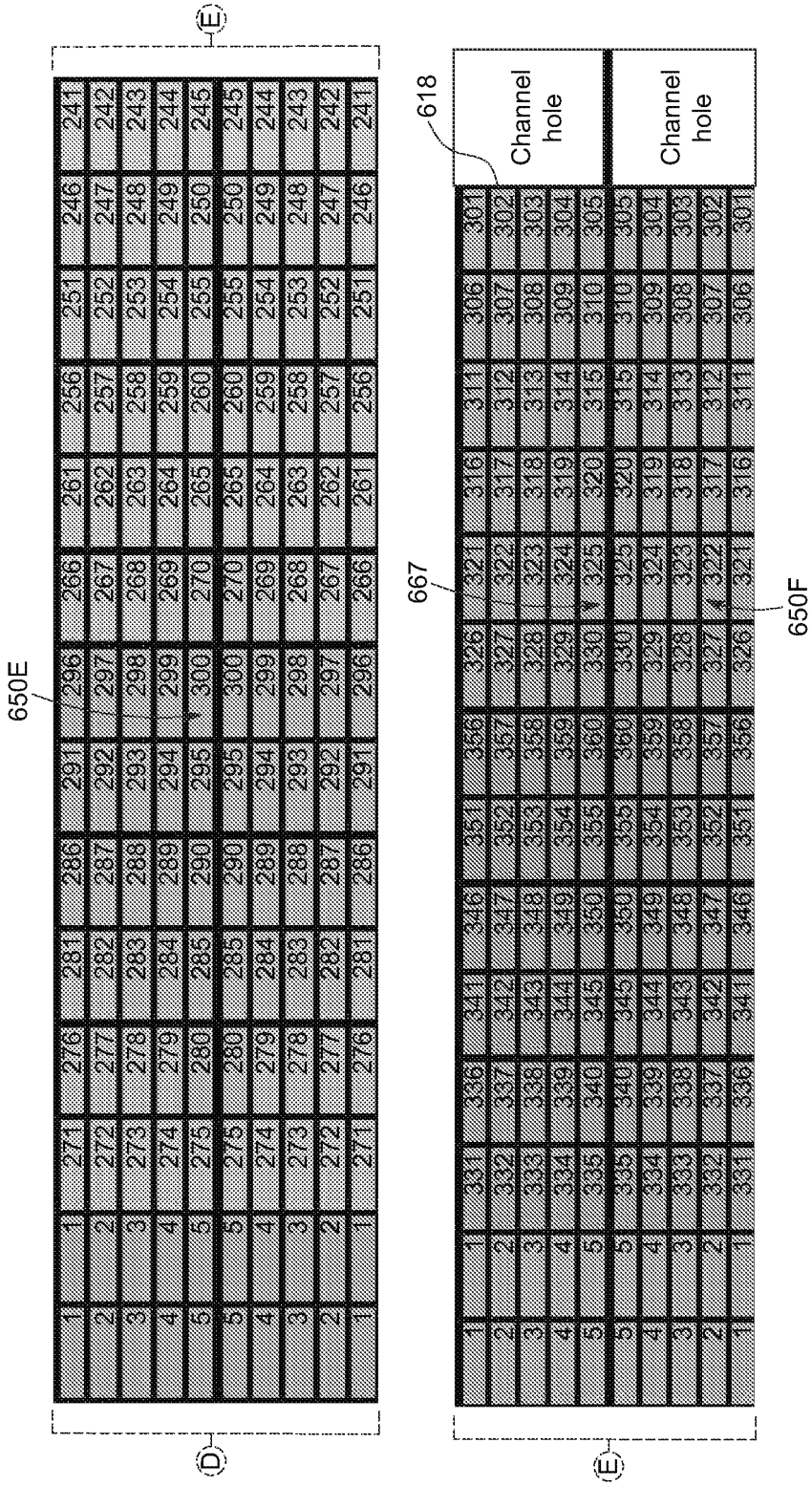

FIG. 6E (Continued)

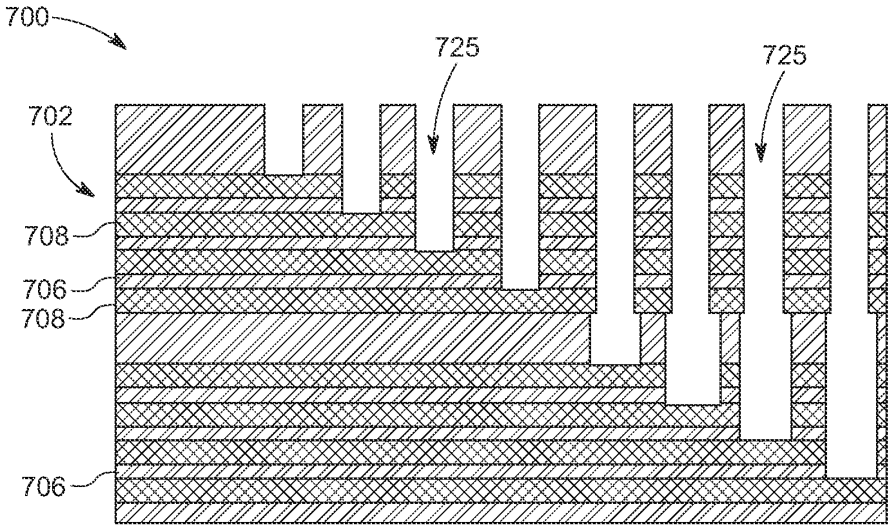

FIG. 7A

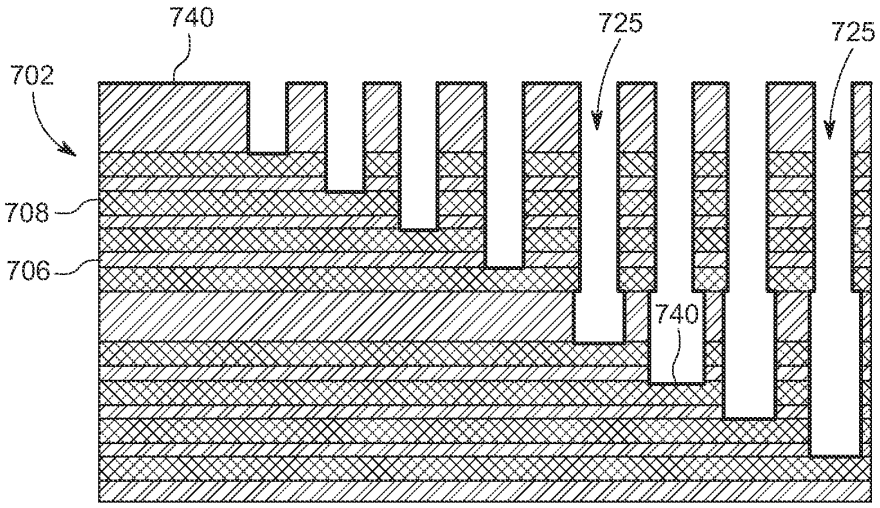

FIG. 7B

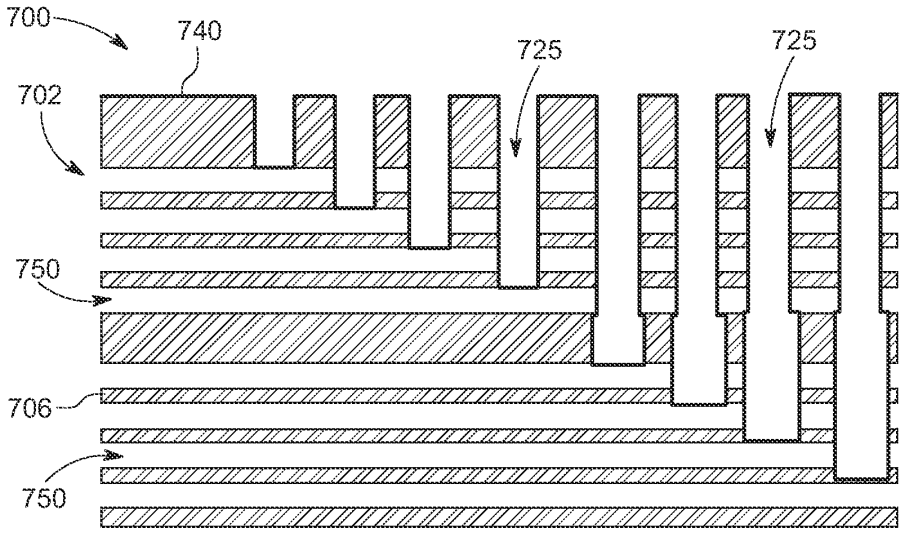

FIG. 7C

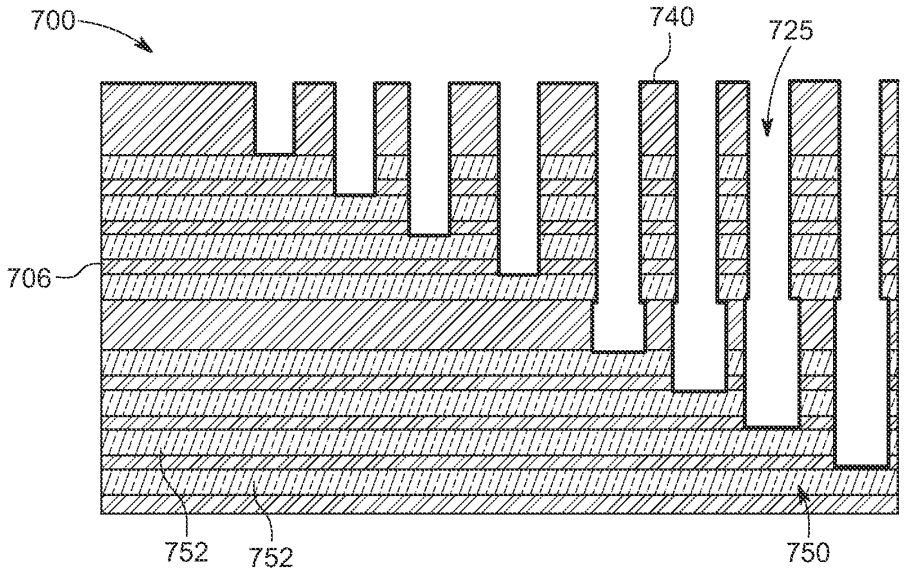

FIG. 7D

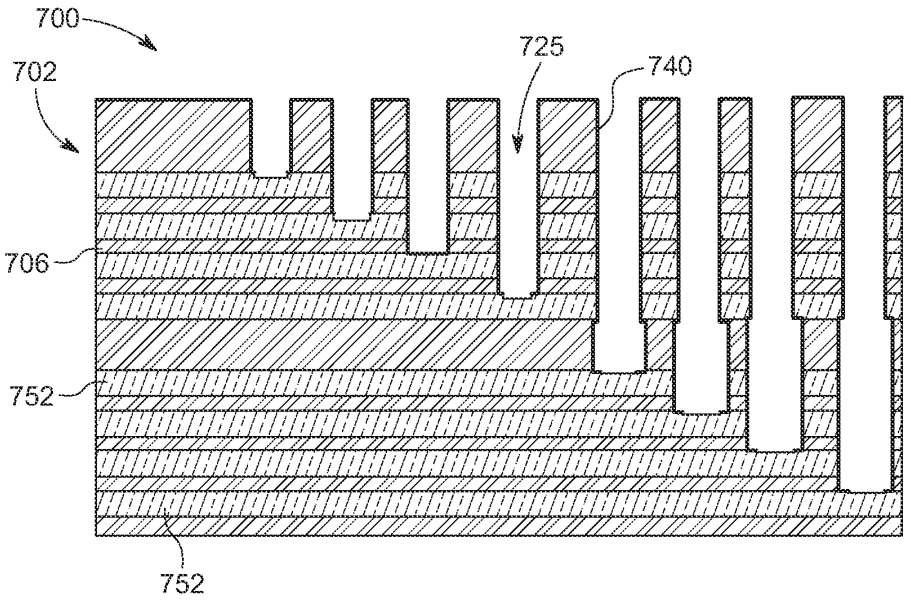
700
702
725
740
706
752
752

FIG. 7E

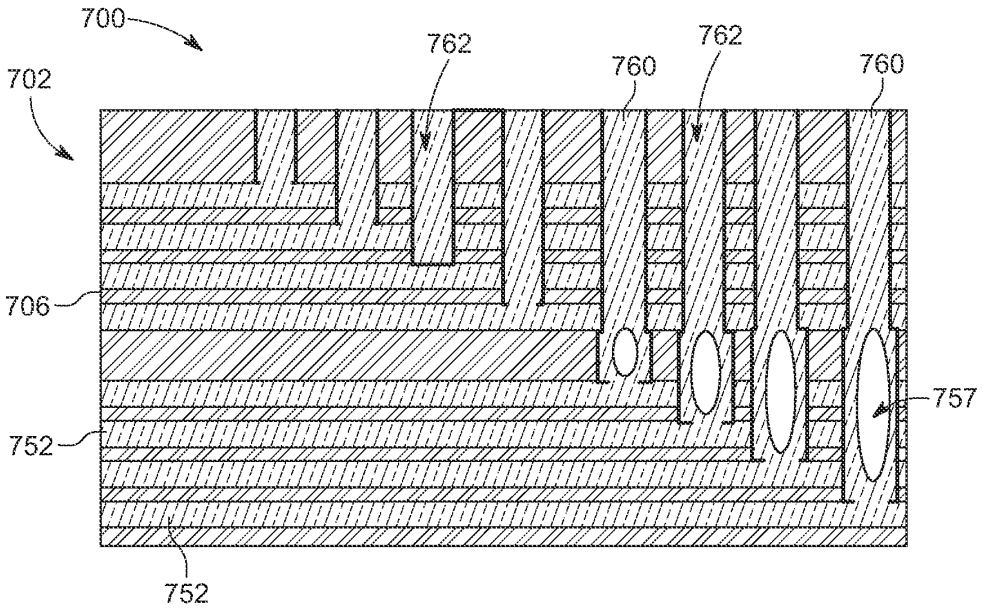
700
702
762
760
762
760
706
757
752
752

FIG. 7F

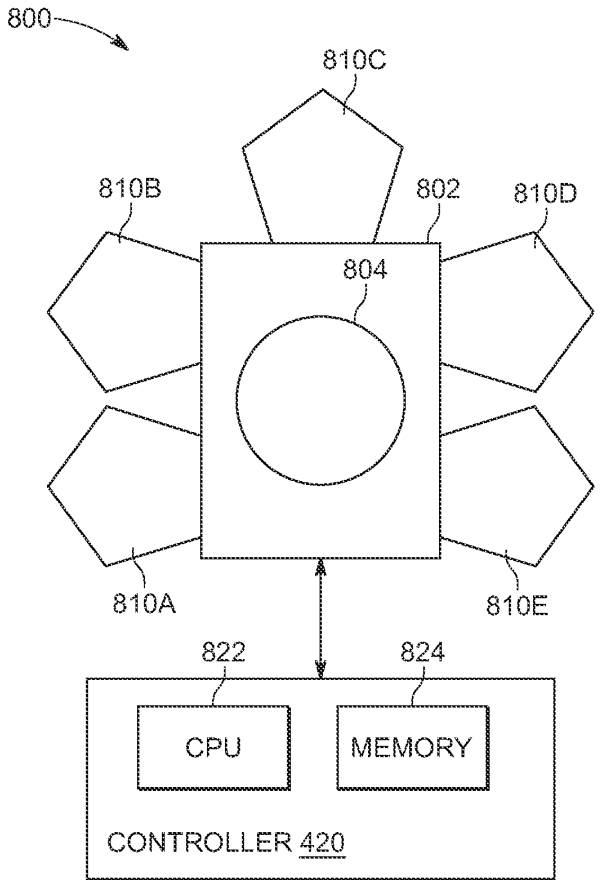
800
810C
810B
802
810D
804
810A
810E
822
824
CPU
MEMORY
CONTROLLER 420

FIG. 8

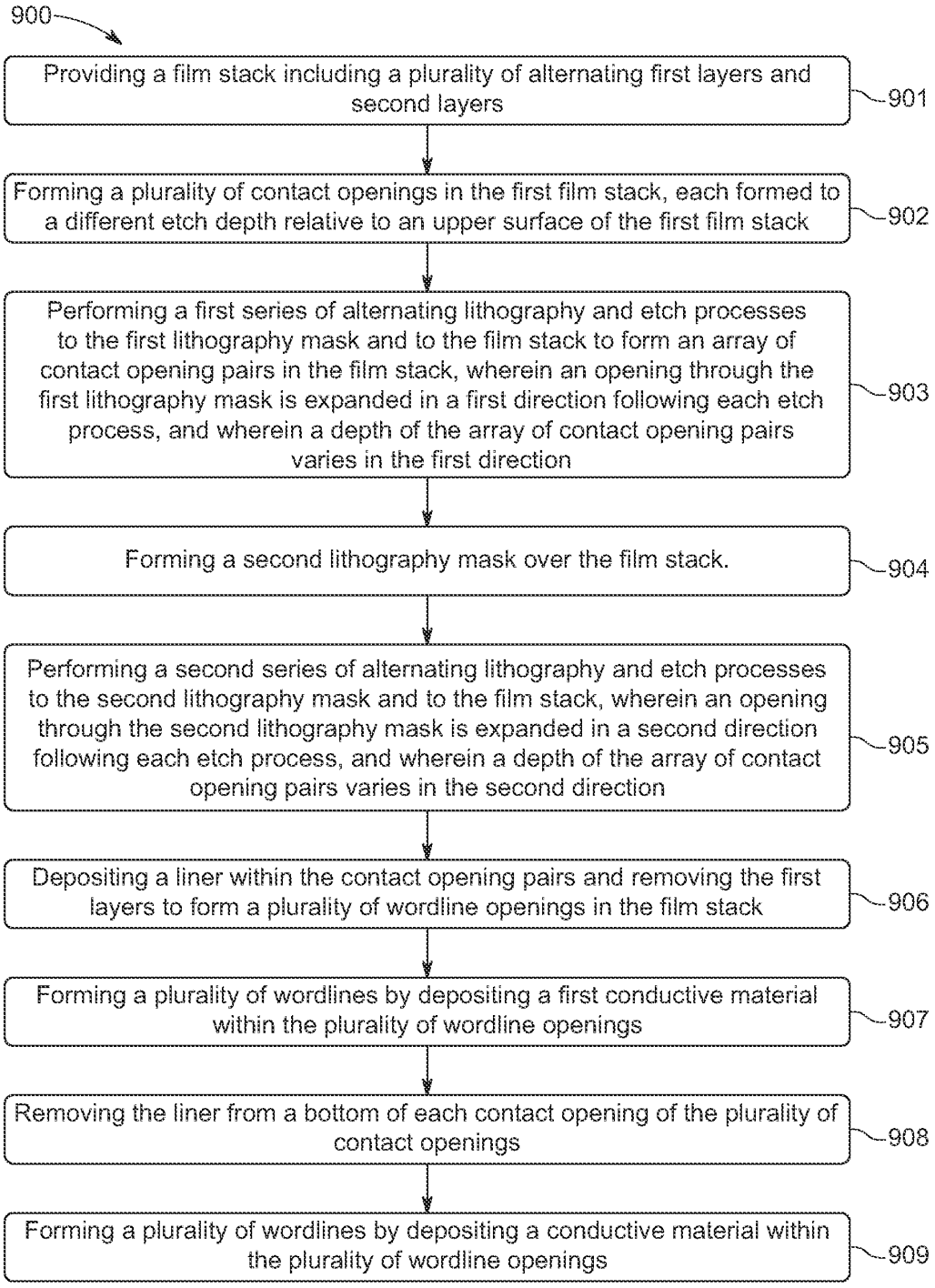
900
Providing a film stack including a plurality of alternating first layers and second layers
901
Forming a plurality of contact openings in the first film stack, each formed to a different etch depth relative to an upper surface of the first film stack
902
Performing a first series of alternating lithography and etch processes to the first lithography mask and to the film stack to form an array of contact opening pairs in the film stack, wherein an opening through the first lithography mask is expanded in a first direction following each etch process, and wherein a depth of the array of contact opening pairs varies in the first direction
903
Forming a second lithography mask over the film stack.
904
Performing a second series of alternating lithography and etch processes to the second lithography mask and to the film stack, wherein an opening through the second lithography mask is expanded in a second direction following each etch process, and wherein a depth of the array of contact opening pairs varies in the second direction
905
Depositing a liner within the contact opening pairs and removing the first layers to form a plurality of wordline openings in the film stack
906
Forming a plurality of wordlines by depositing a first conductive material within the plurality of wordline openings
907
Removing the liner from a bottom of each contact opening of the plurality of contact openings
908
Forming a plurality of wordlines by depositing a conductive material within the plurality of wordline openings
909

FIG. 9