US007710534B2

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Byun et al.

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(45) Date of Patent: May 4, 2010

(54) **SYSTEM AND METHOD FOR MANUFACTURING LIQUID CRYSTAL DISPLAY DEVICES**

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(73) Assignee: **LG Display Co., Ltd.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 251 days.

(21) Appl. No.: **11/806,525**

(22) Filed: **May 31, 2007**

(65) **Prior Publication Data**

US 2008/0170197 A1 Jul. 17, 2008

Related U.S. Application Data

(63) Continuation of application No. 10/184,096, filed on Jun. 28, 2002, now Pat. No. 7,295,279.

(51) **Int. Cl.**
G02F 1/1339 (2006.01)

(52) **U.S. Cl.** **349/189**; 349/187; 349/86

(58) **Field of Classification Search** 349/187, 349/189, 86
See application file for complete search history.

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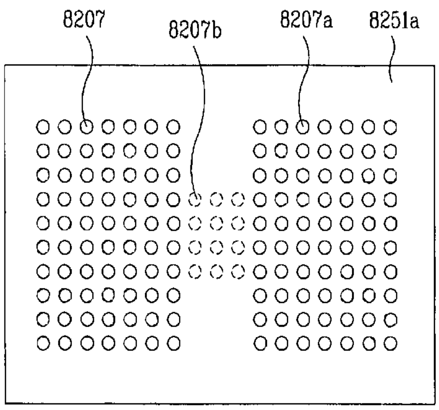
Primary Examiner—David Nelms
Assistant Examiner—Thanh-Nhan P Nguyen
(74) *Attorney, Agent, or Firm*—McKenna Long & Aldridge

(57) **ABSTRACT**

Disclosed is a system for fabricating a liquid crystal display using liquid crystal dropping and a method of fabricating a liquid crystal display using the same. The present invention includes a liquid crystal forming line dropping liquid crystals on the first substrate, a sealant forming line forming the sealant on the second substrate, and a bonding and hardening line bonding the two substrates to each other and hardening the sealant, printing a sealant, bonding the substrates each other, and hardening the sealant and an inspection process line of cutting the bonded substrates into panel units and grinding and inspecting the unit panels. And, the GAP process line includes And, the present invention includes the processes of dropping LC on a first substrate using a dispenser, forming a main UV hardening sealant on a second substrate, bonding the first and second substrates to each other in a vacuum state, UV-hardening the main UV hardening sealant, cutting the bonded substrates into cell units, grinding the cut substrates, and inspecting the grinded substrates finally.

24 Claims, 265 Drawing Sheets



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KR	2000-0035302	A1	6/2000

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FIG. 1

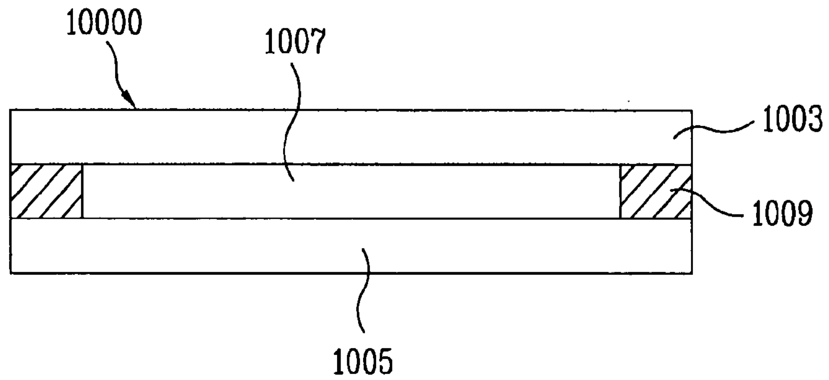

10000
1007
1003
1009
1005

FIG. 2

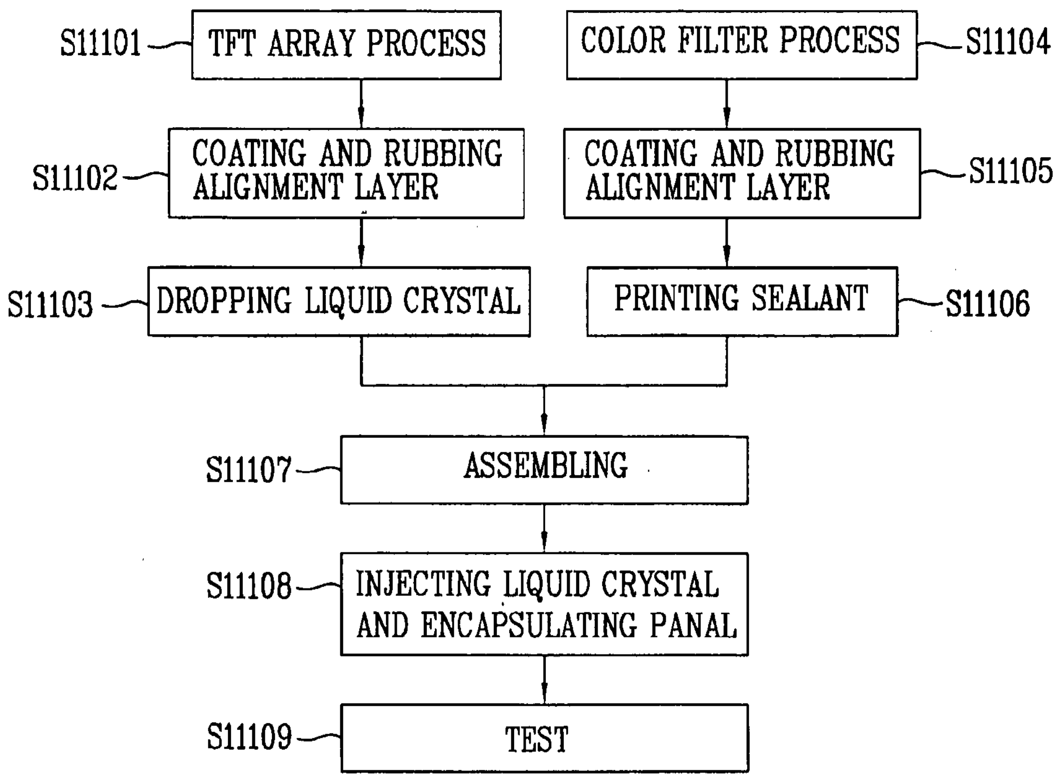

S11101
TFT ARRAY PROCESS
COLOR FILTER PROCESS
S11104
S11102
COATING AND RUBBING ALIGNMENT LAYER
COATING AND RUBBING ALIGNMENT LAYER
S11105
S11103
DROPPING LIQUID CRYSTAL
PRINTING SEALANT
S11106
S11107
ASSEMBLING
S11108
INJECTING LIQUID CRYSTAL AND ENCAPSULATING PANAL
S11109
TEST

FIG. 3

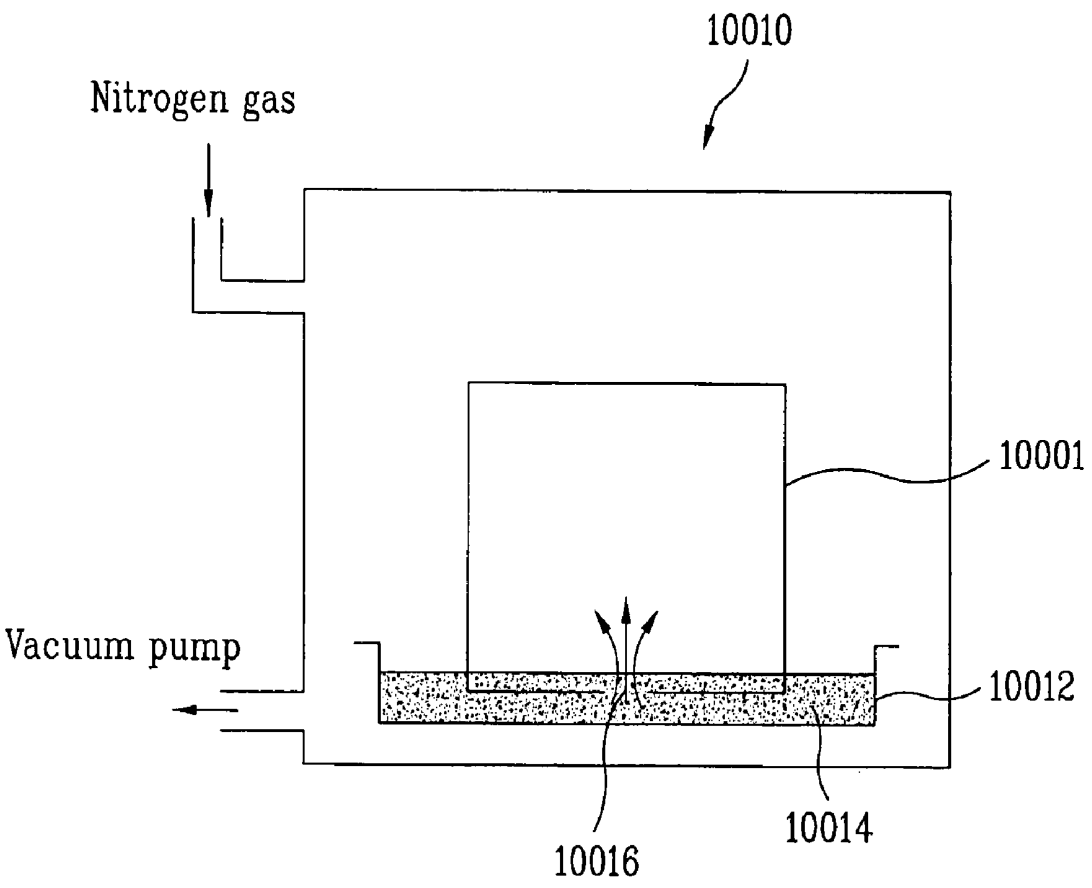


FIG. 4

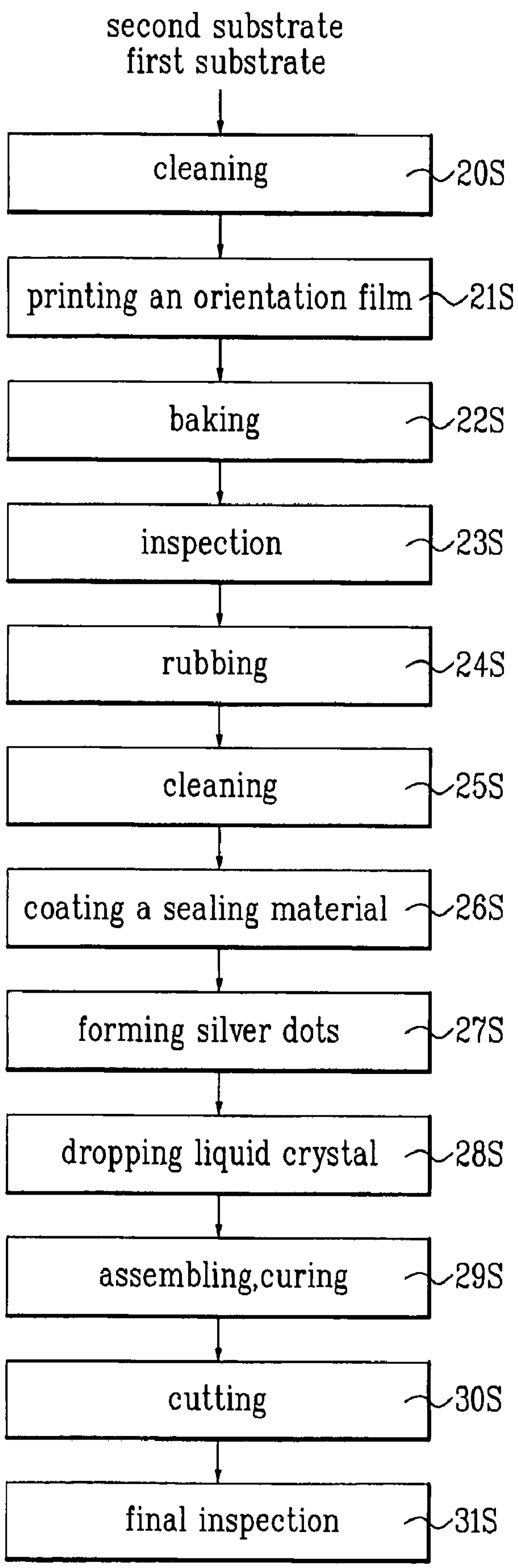

second substrate
first substrate
cleaning
20S
printing an orientation film
21S
baking
22S
inspection
23S
rubbing
24S
cleaning
25S
coating a sealing material
26S
forming silver dots
27S
dropping liquid crystal
28S
assembling,curing
29S
cutting
30S
final inspection
31S

FIG. 5

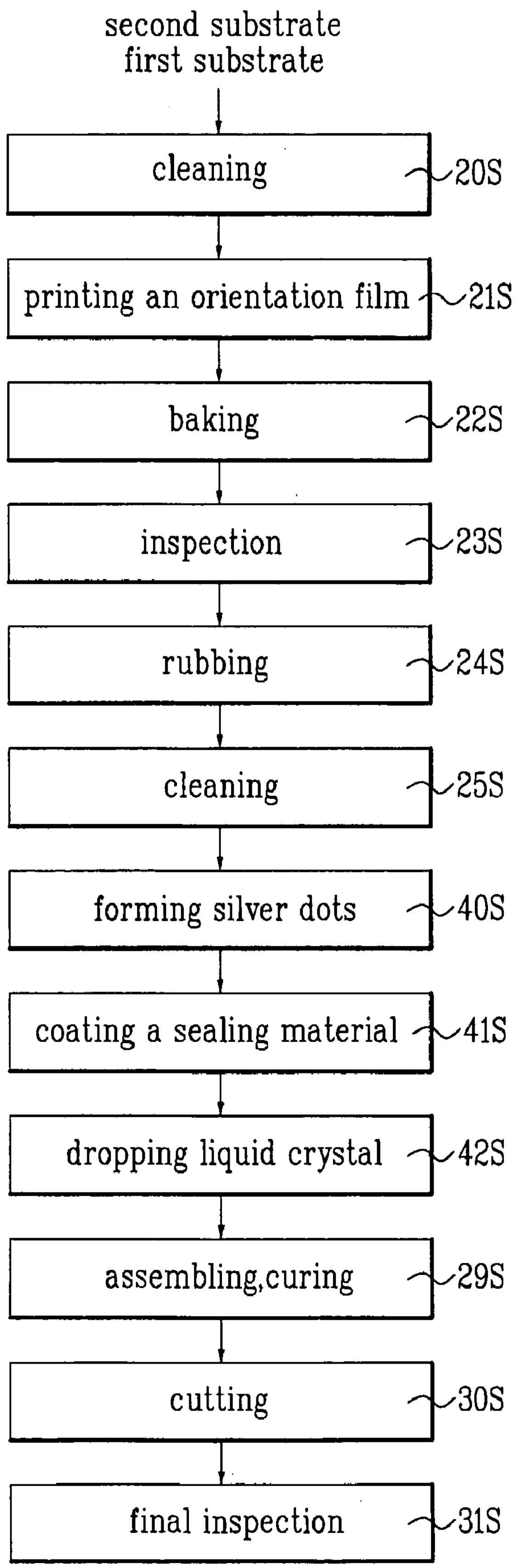

second substrate
first substrate
cleaning
20S
printing an orientation film
21S
baking
22S
inspection
23S
rubbing
24S
cleaning
25S
forming silver dots
40S
coating a sealing material
41S
dropping liquid crystal
42S
assembling,curing
29S
cutting
30S
final inspection
31S

FIG. 6

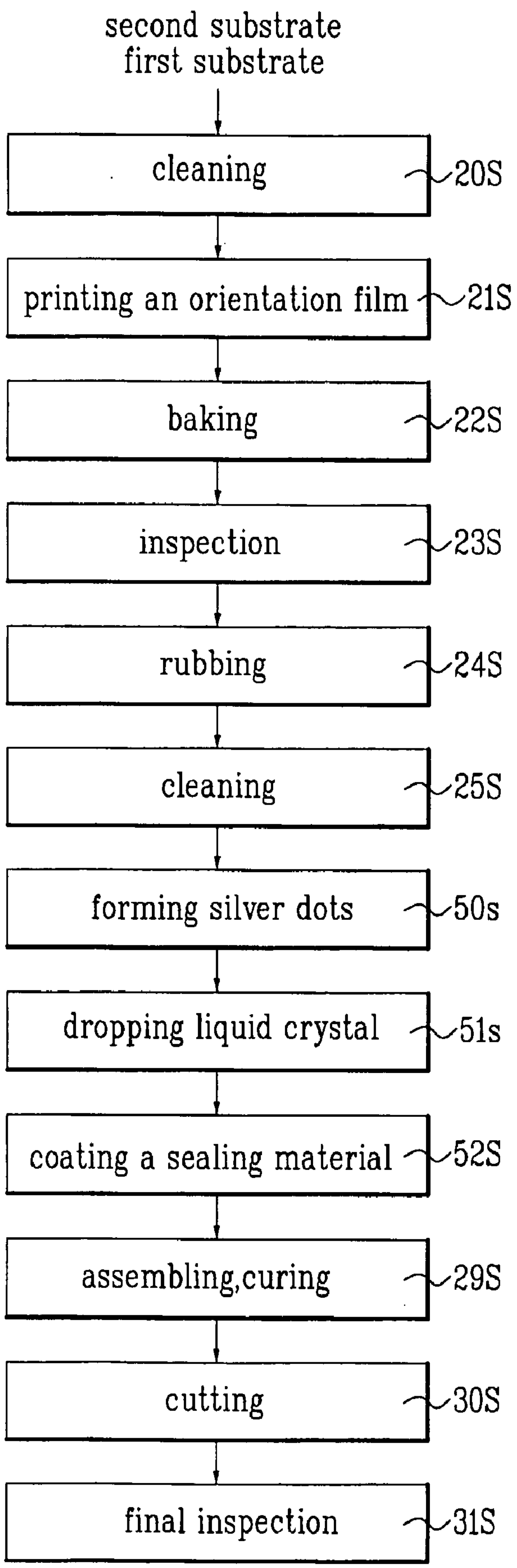

second substrate
first substrate
cleaning
20S
printing an orientation film
21S
baking
22S
inspection
23S
rubbing
24S
cleaning
25S
forming silver dots
50s
dropping liquid crystal
51s
coating a sealing material
52S
assembling,curing
29S
cutting
30S
final inspection
31S

FIG. 7A

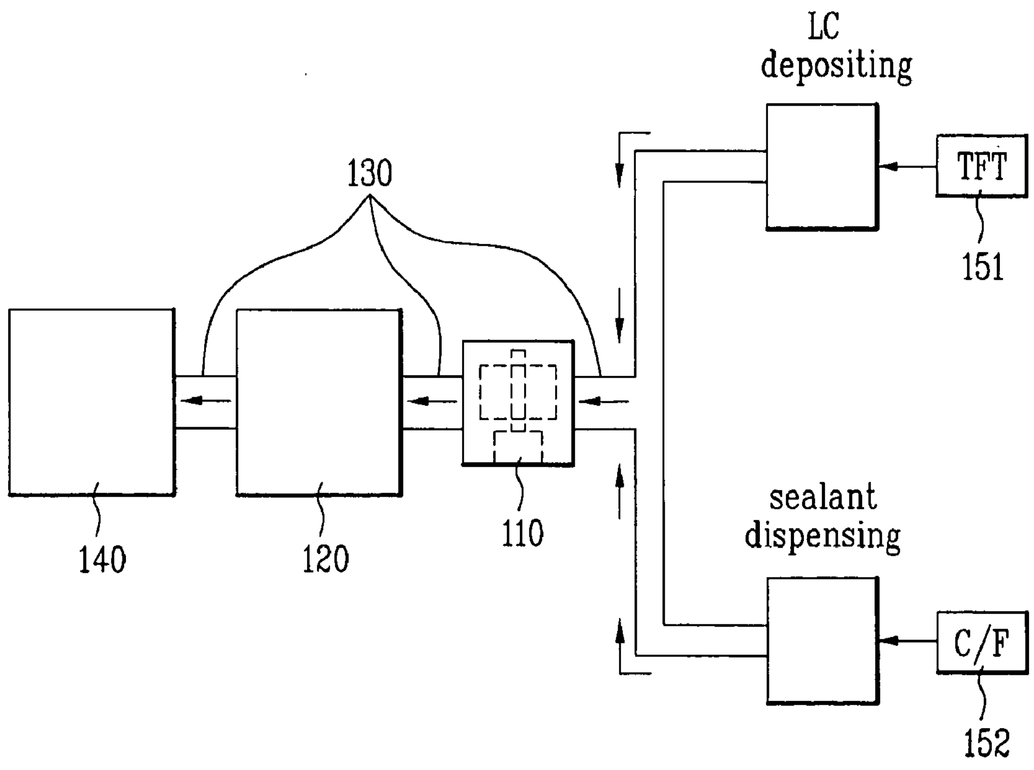

LC
depositing
TFT
151
130
140
120
110
sealant
dispensing
C/F
152

FIG. 7B

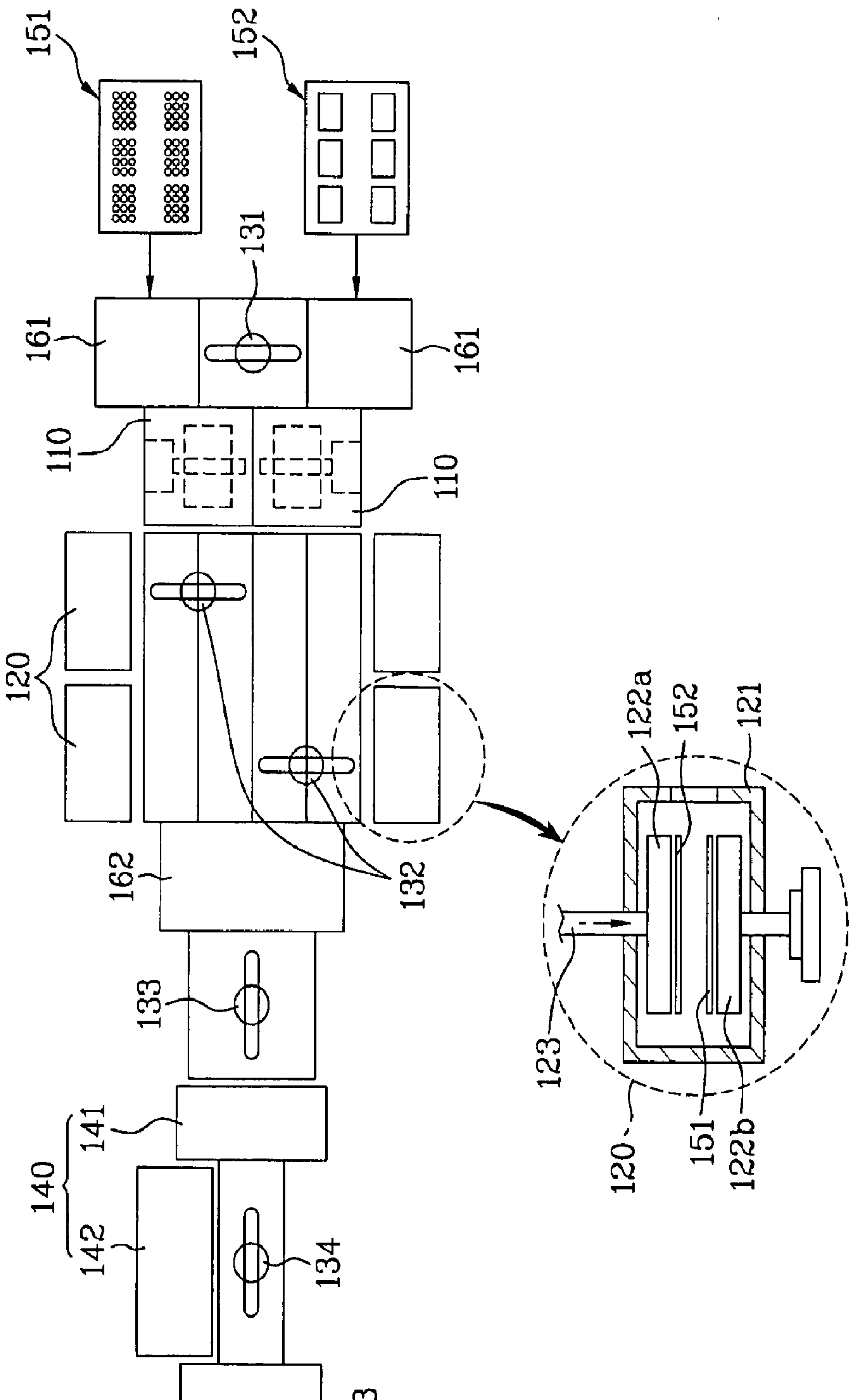

151
152
131
161
161
110
110
120
122a
152
121
132
162
133
123
141
140
142
134
163
120
151
122b

FIG. 8

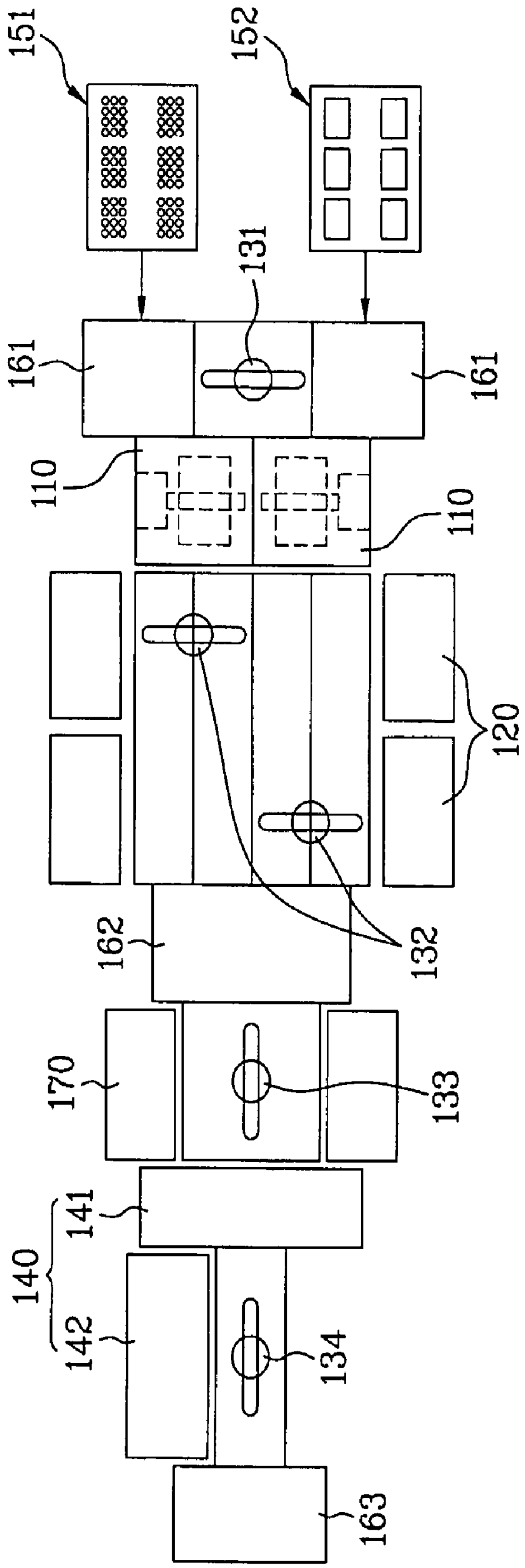
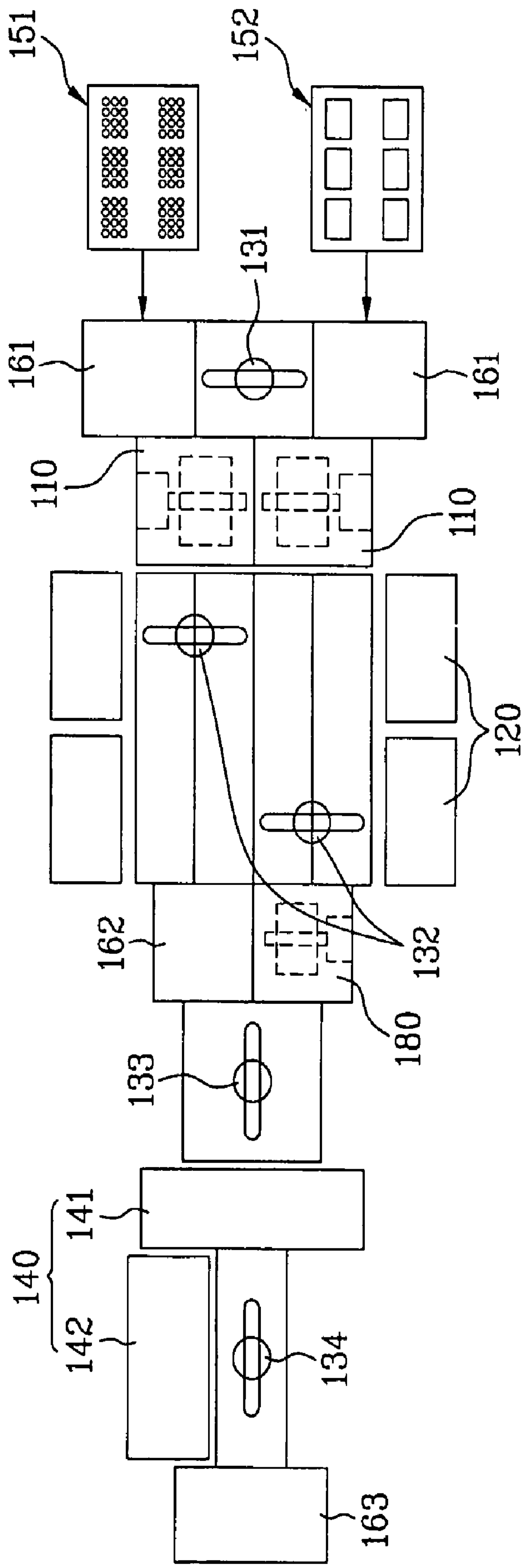

151
152
131
161
161
110
110
120
162
132
170
133
141
140
142
134
163

FIG. 9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152
131
161
161
110
110
120
132
162
180
133
141
140
142
134
163

FIG. 10A

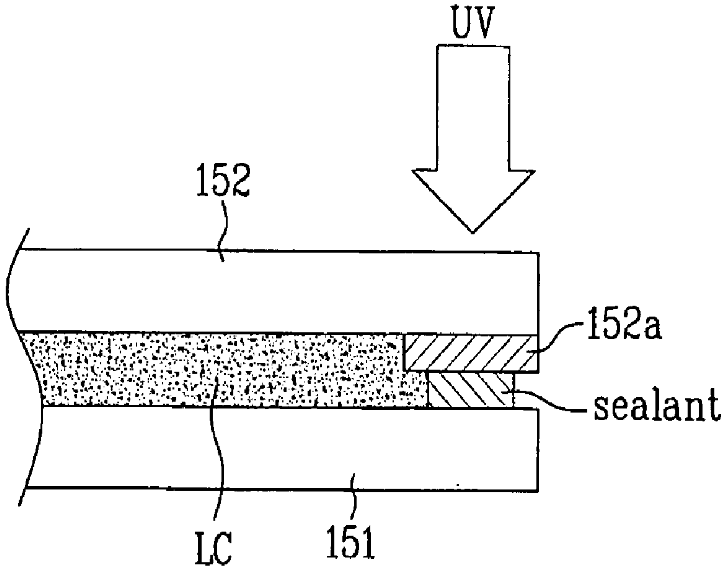


FIG. 10B

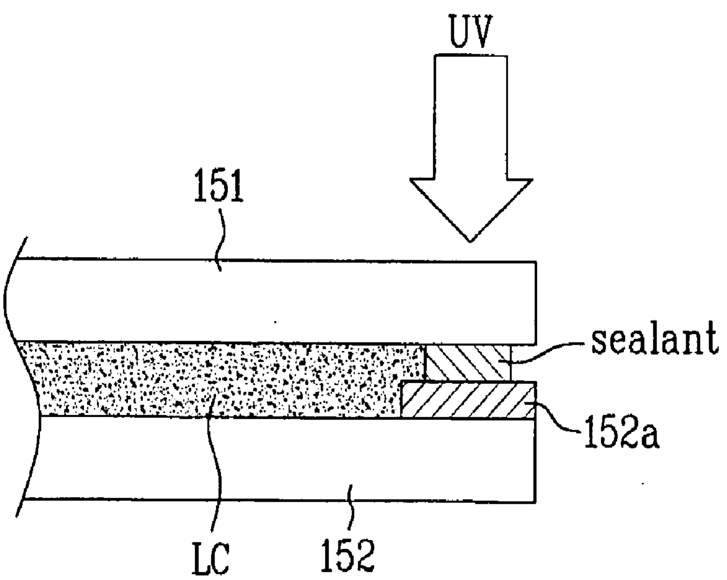
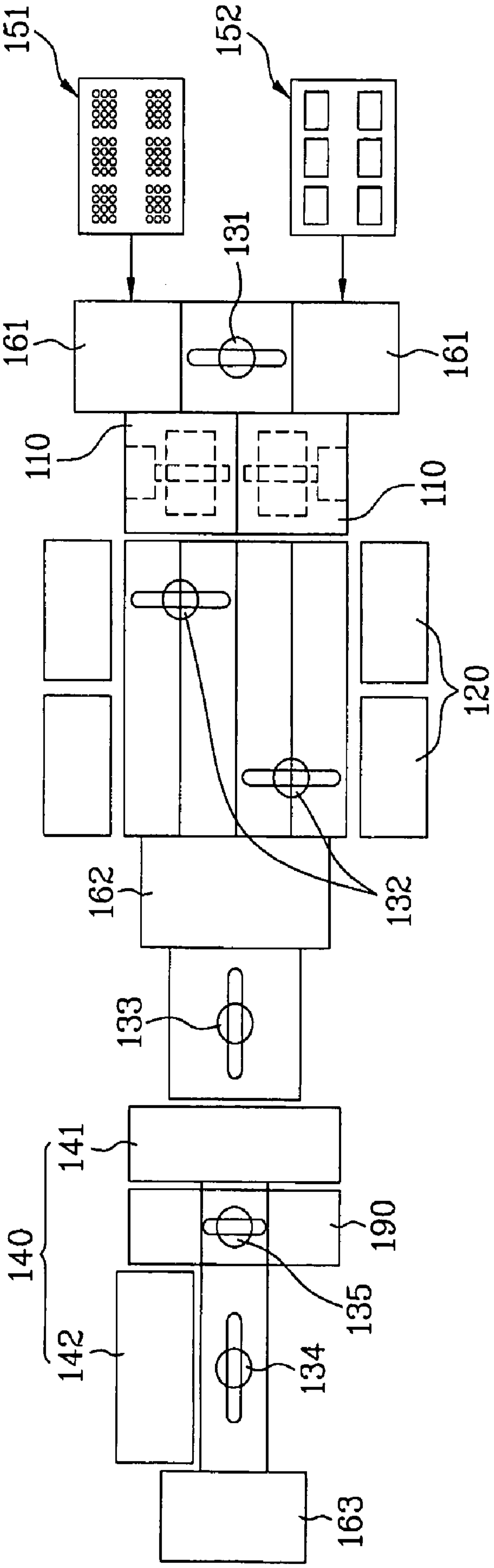


FIG. 11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152
131
161
161
110
110
120
132
162
133
141
140
190
135
142
134
163

FIG. 12

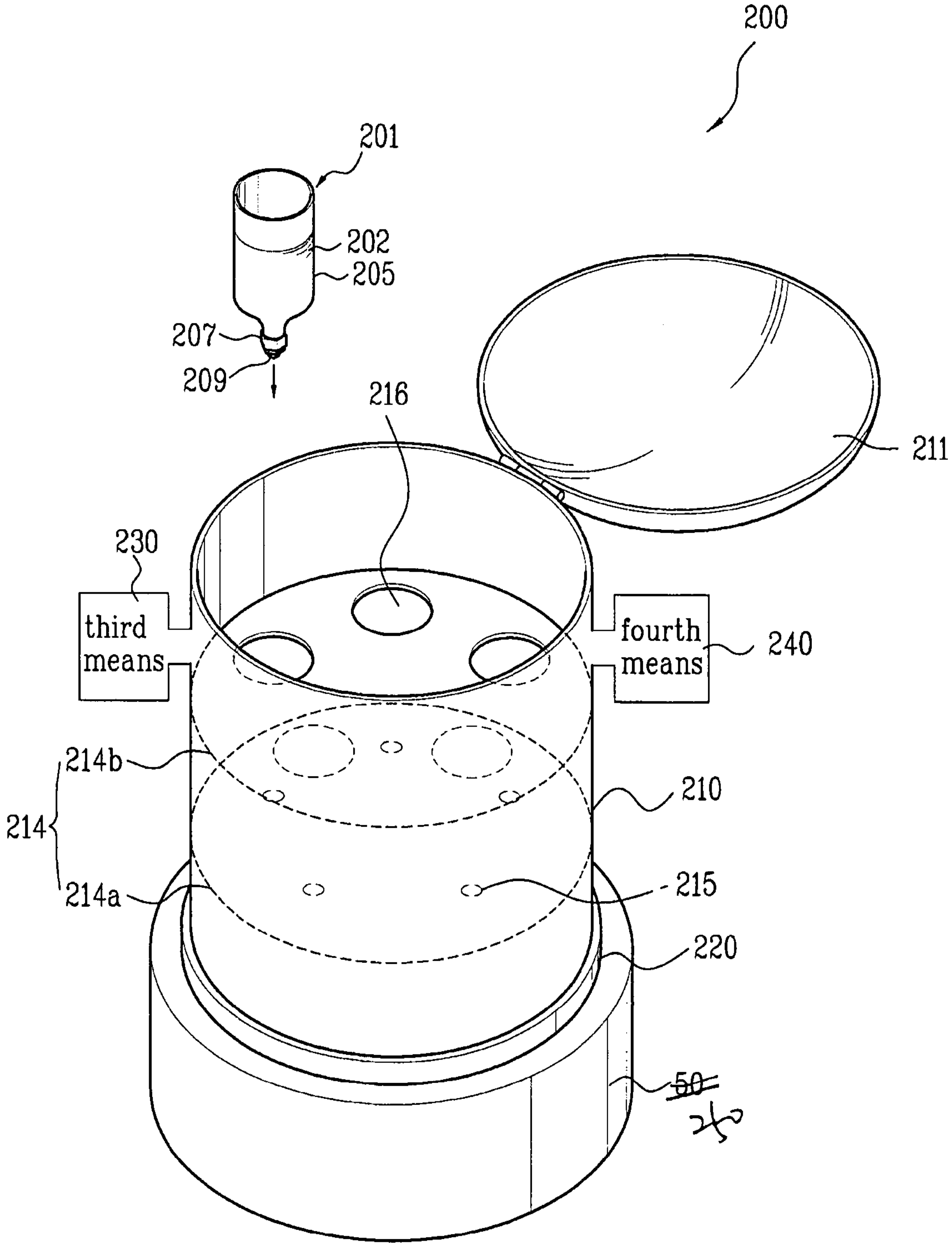
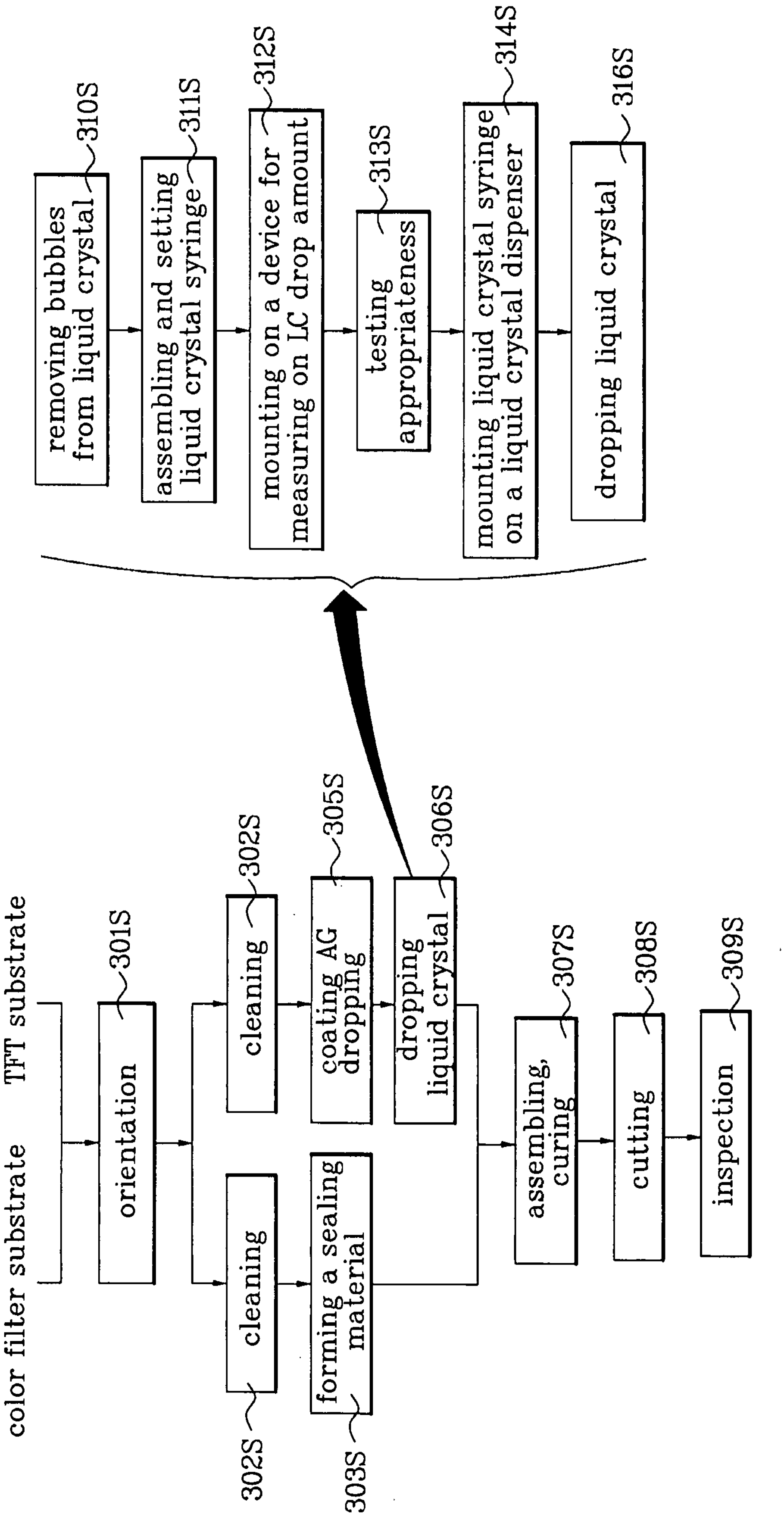

200
201
202
205
207
209
216
211
230
third means
fourth means
240
214b
214
214a
210
215
220
50
250

FIG. 13



color filter substrate
TFT substrate
orientation
301S
cleaning
302S
cleaning
302S
forming a sealing material
303S
coating AG dropping
305S
dropping liquid crystal
306S
assembling, curing
307S
cutting
308S
inspection
309S
removing bubbles from liquid crystal
310S
assembling and setting liquid crystal syringe
311S
mounting on a device for measuring on LC drop amount
312S
testing appropriateness
313S
mounting liquid crystal syringe on a liquid crystal dispenser
314S
dropping liquid crystal
316S

FIG. 14

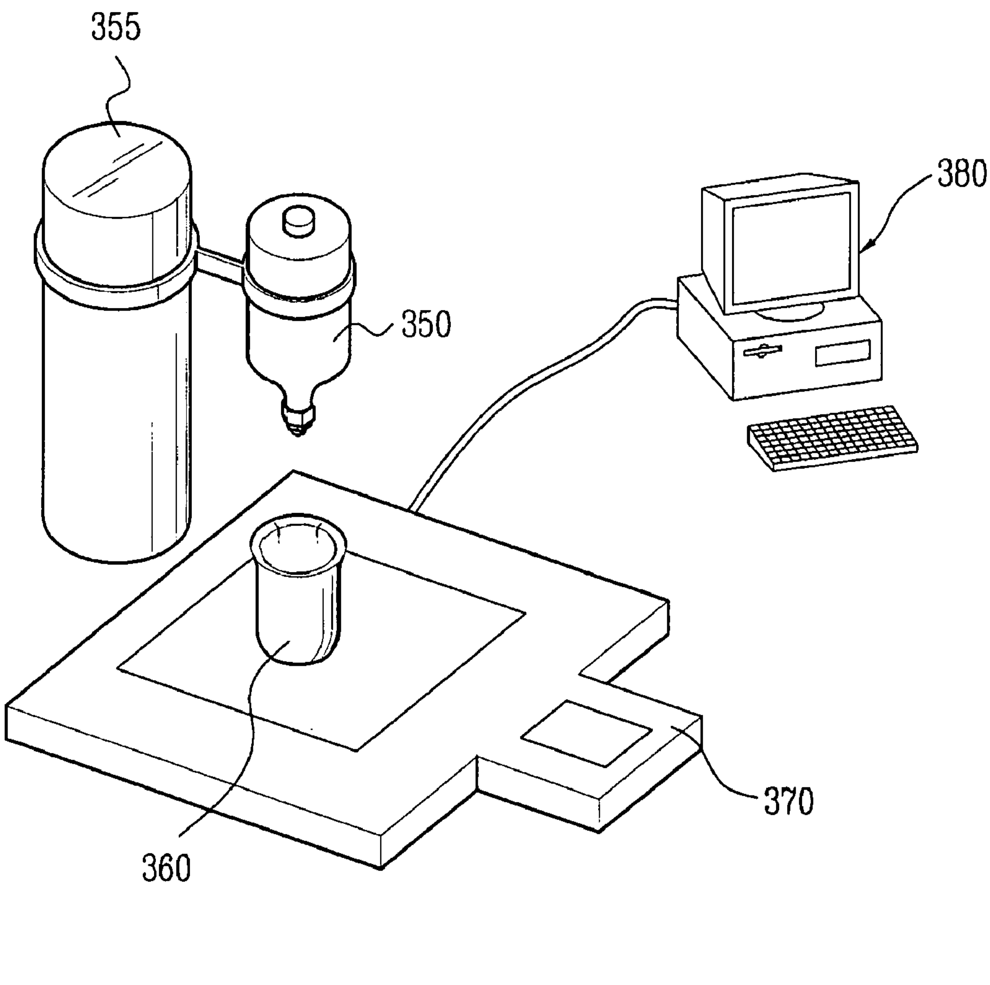


FIG. 15

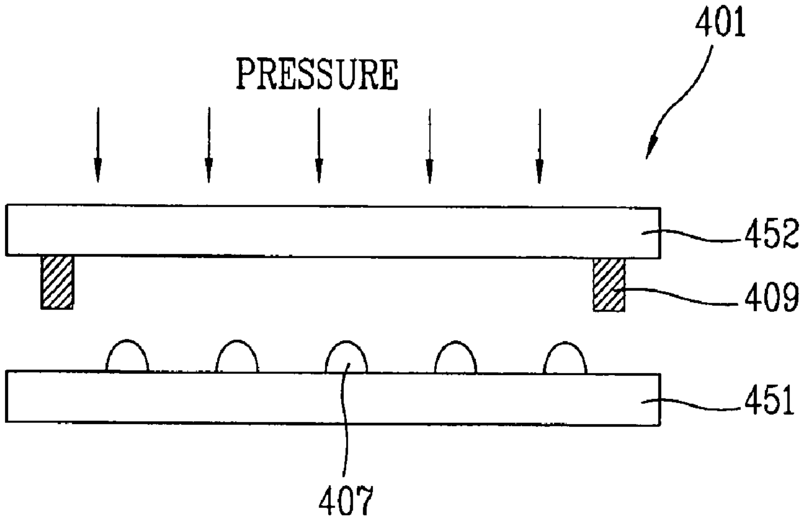


FIG. 16

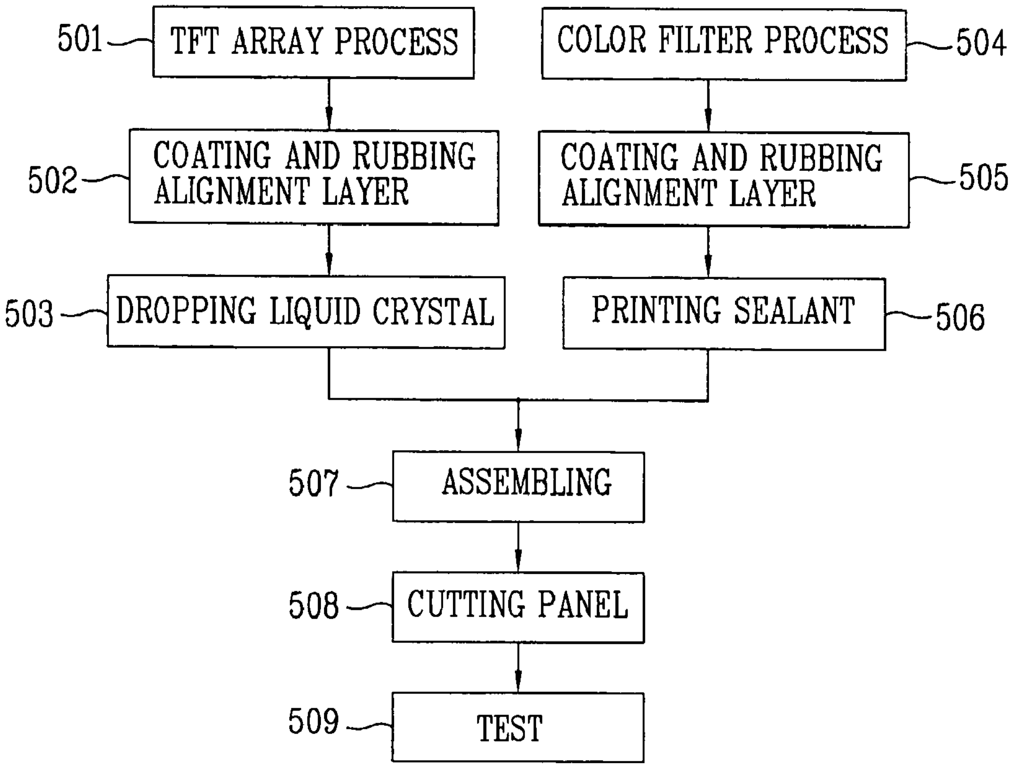

501
TFT ARRAY PROCESS
504
COLOR FILTER PROCESS
502
COATING AND RUBBING ALIGNMENT LAYER
505
COATING AND RUBBING ALIGNMENT LAYER
503
DROPPING LIQUID CRYSTAL
506
PRINTING SEALANT
507
ASSEMBLING
508
CUTTING PANEL
509
TEST

FIG. 17

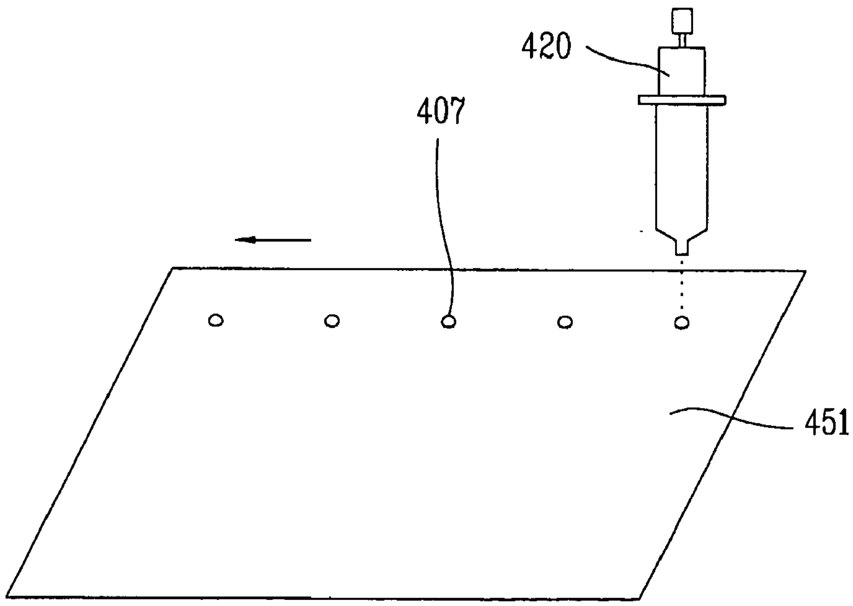

420
407
451

FIG. 18A

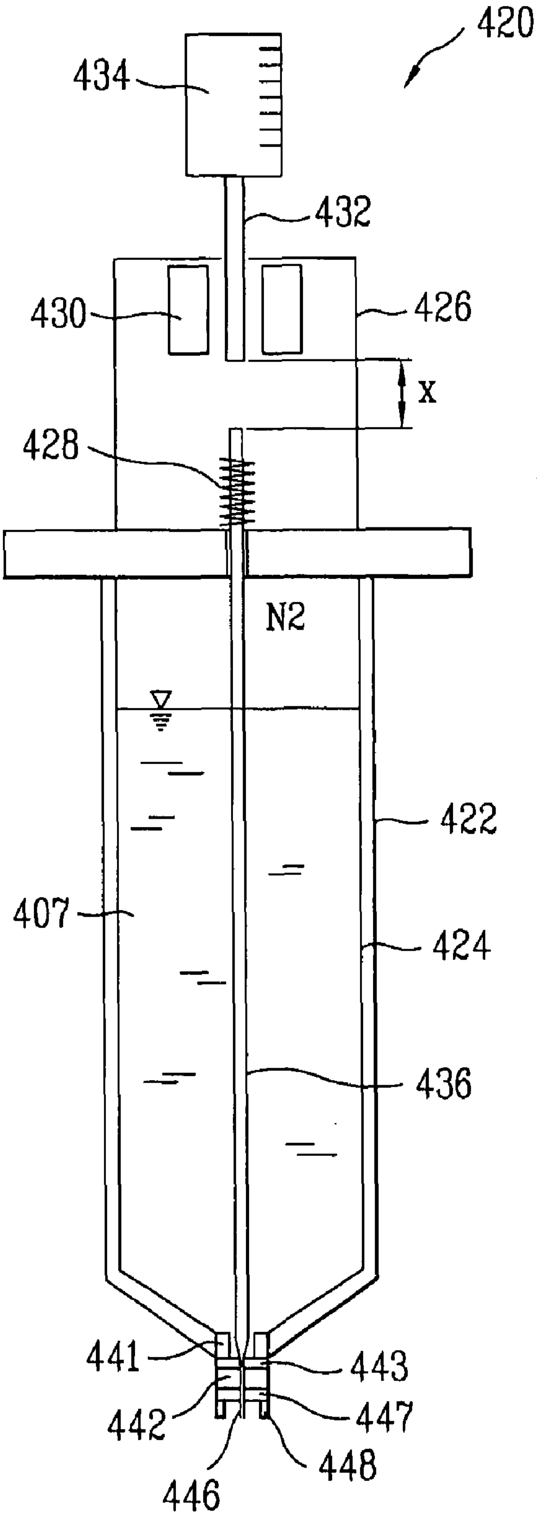

420
434
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FIG. 18B

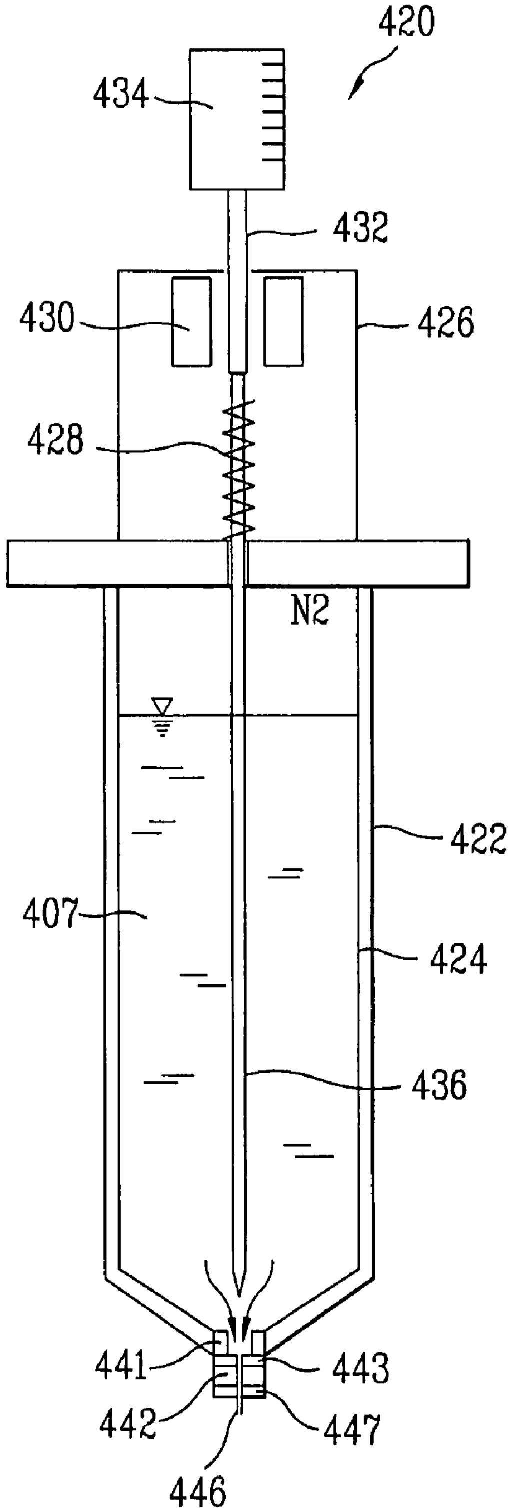


FIG. 19

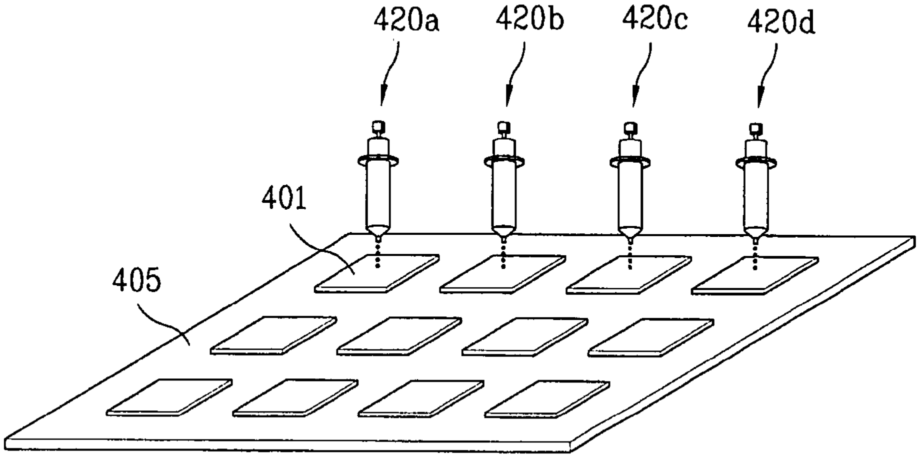


FIG. 20

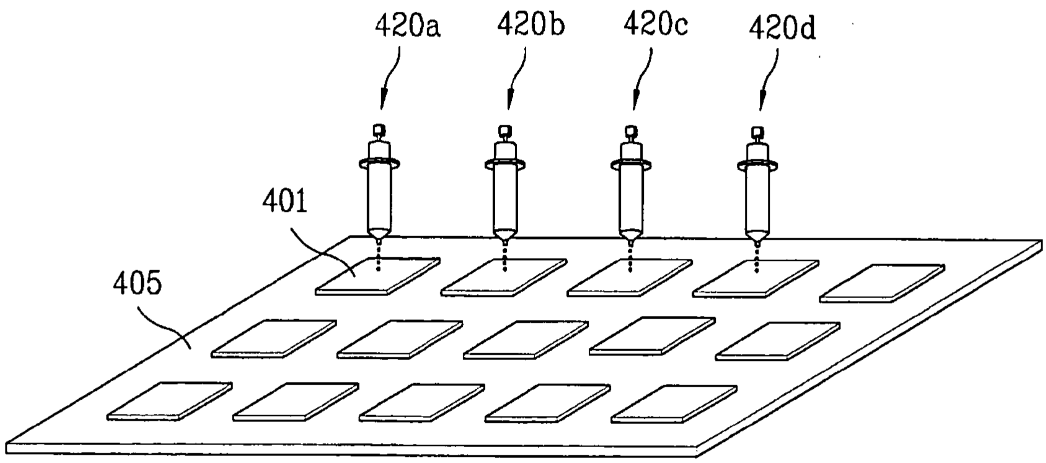


FIG. 21A

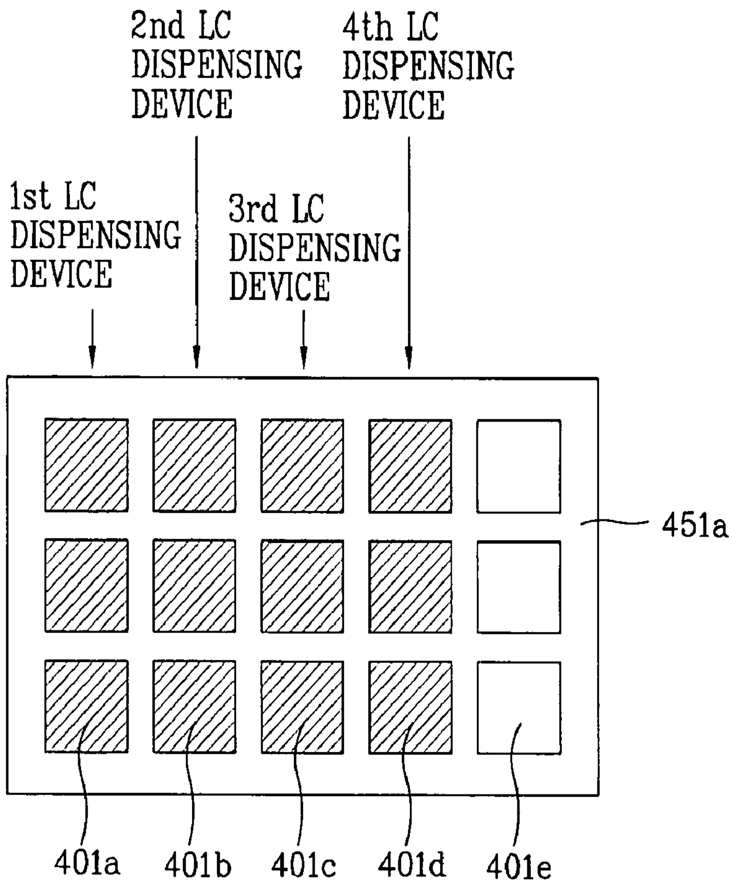


FIG. 21B

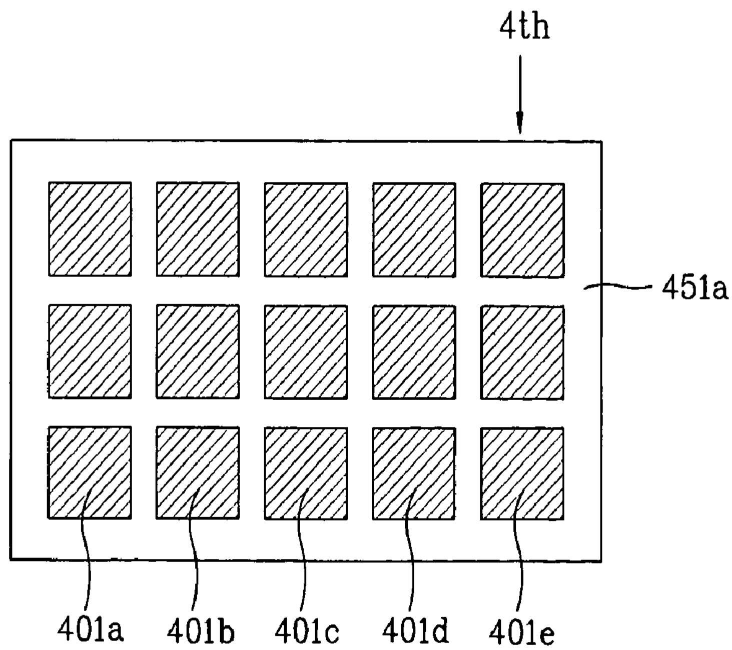


FIG. 22A

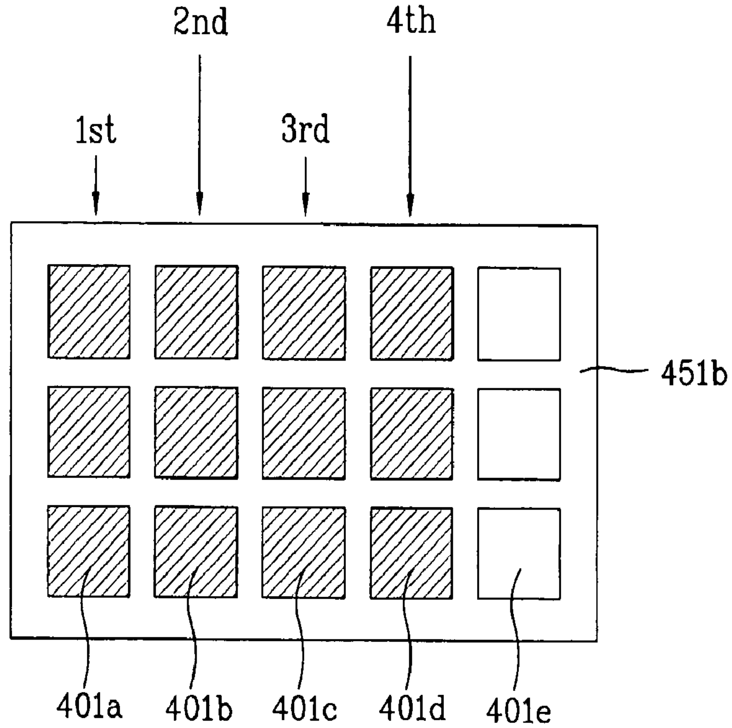


FIG. 22B

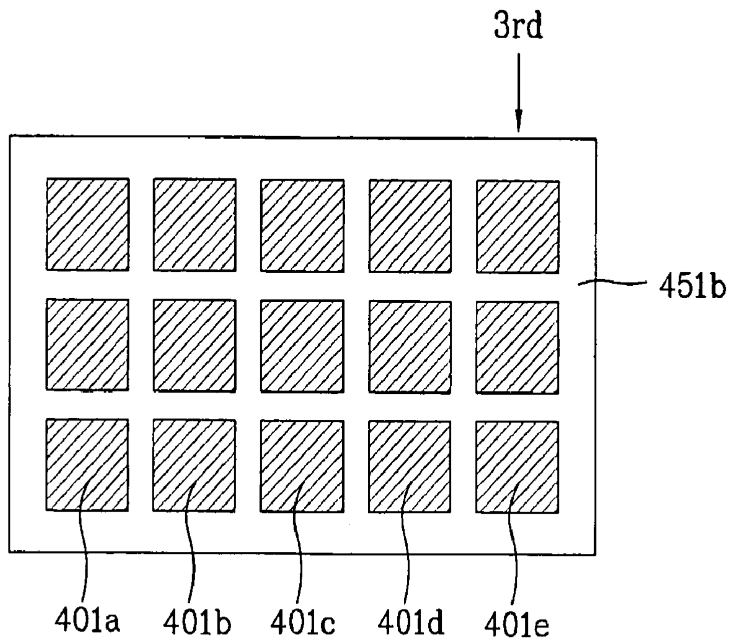


FIG. 23A

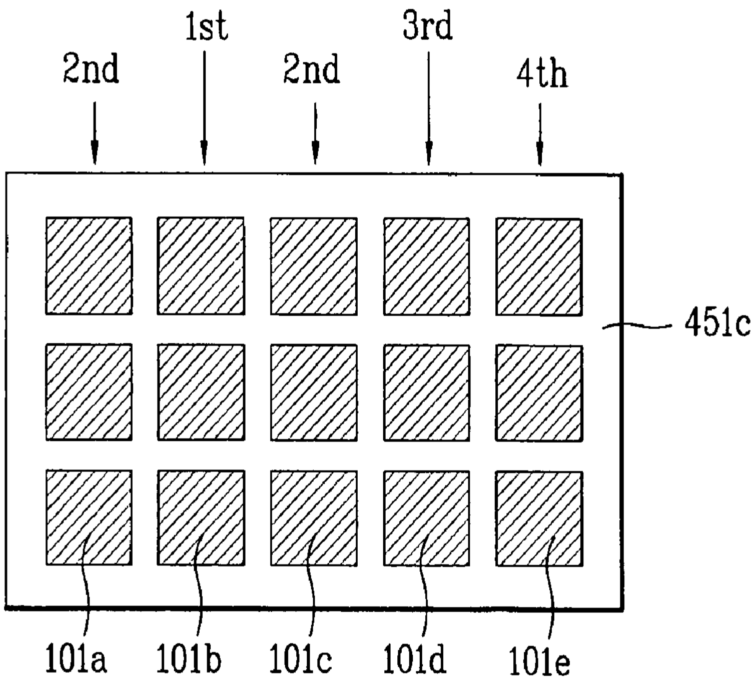


FIG. 23B

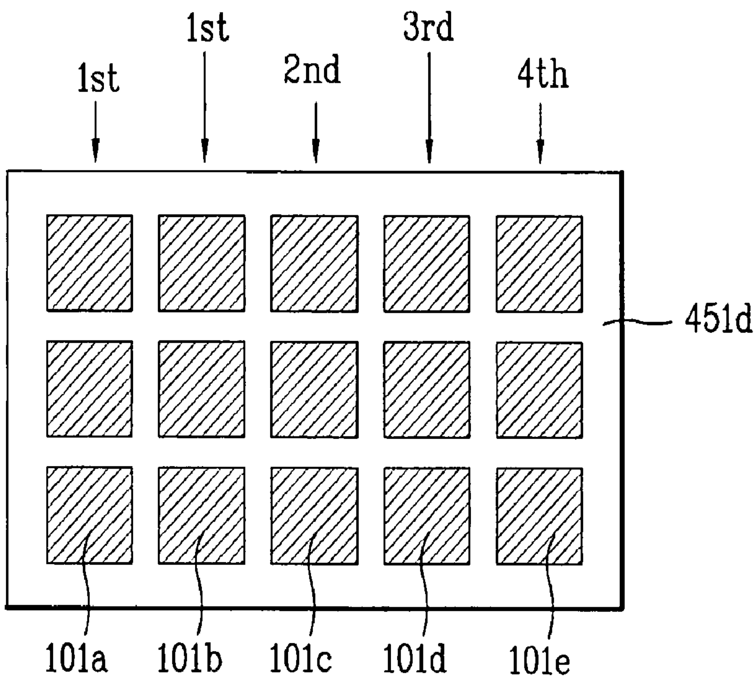


FIG. 24A

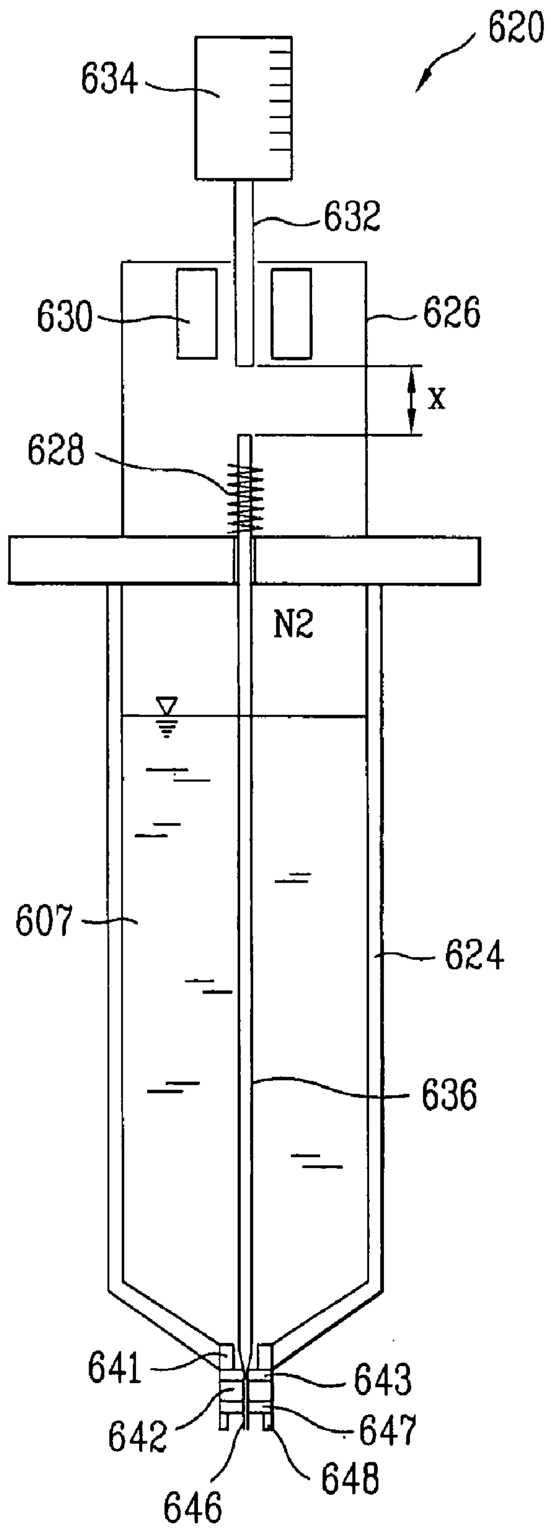


FIG. 24B

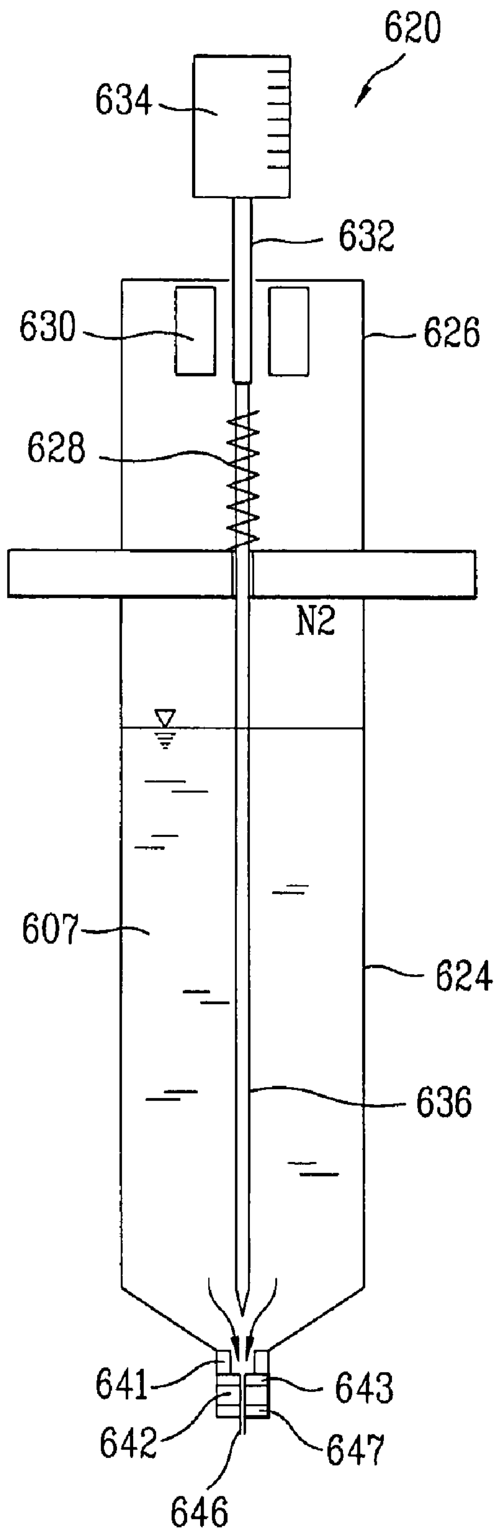


FIG. 25

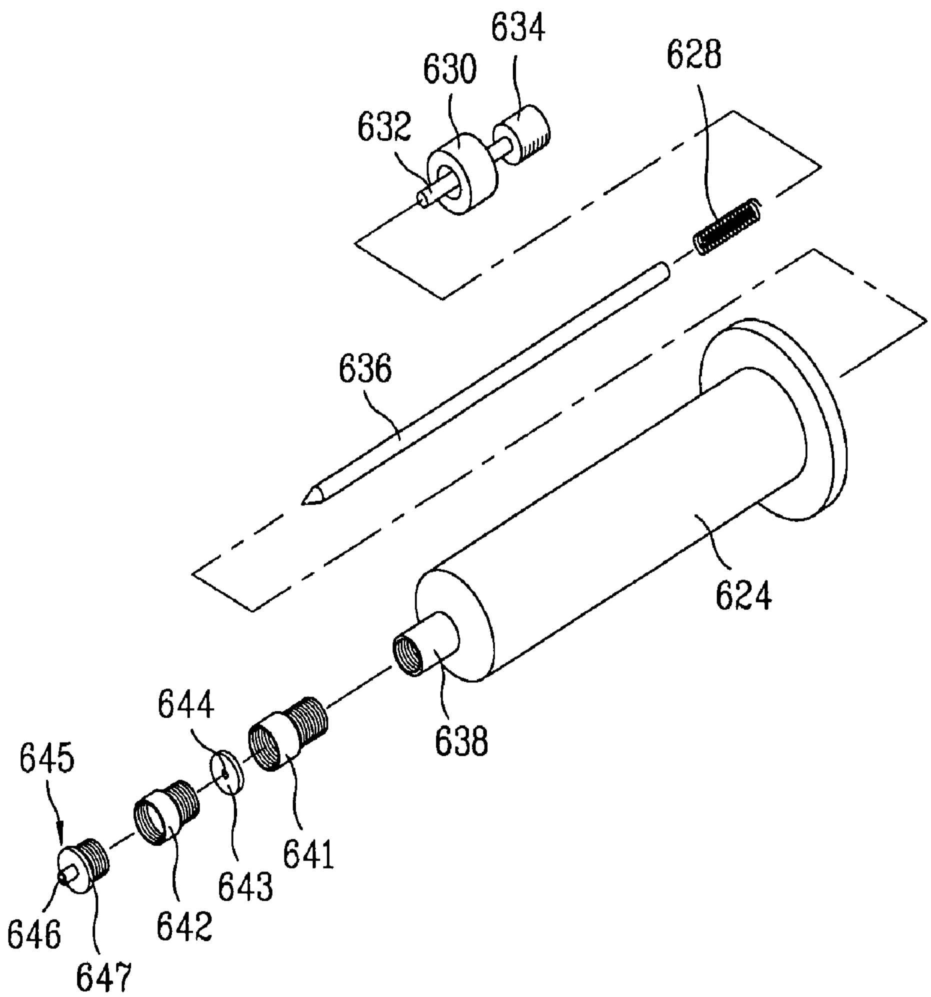


FIG. 26

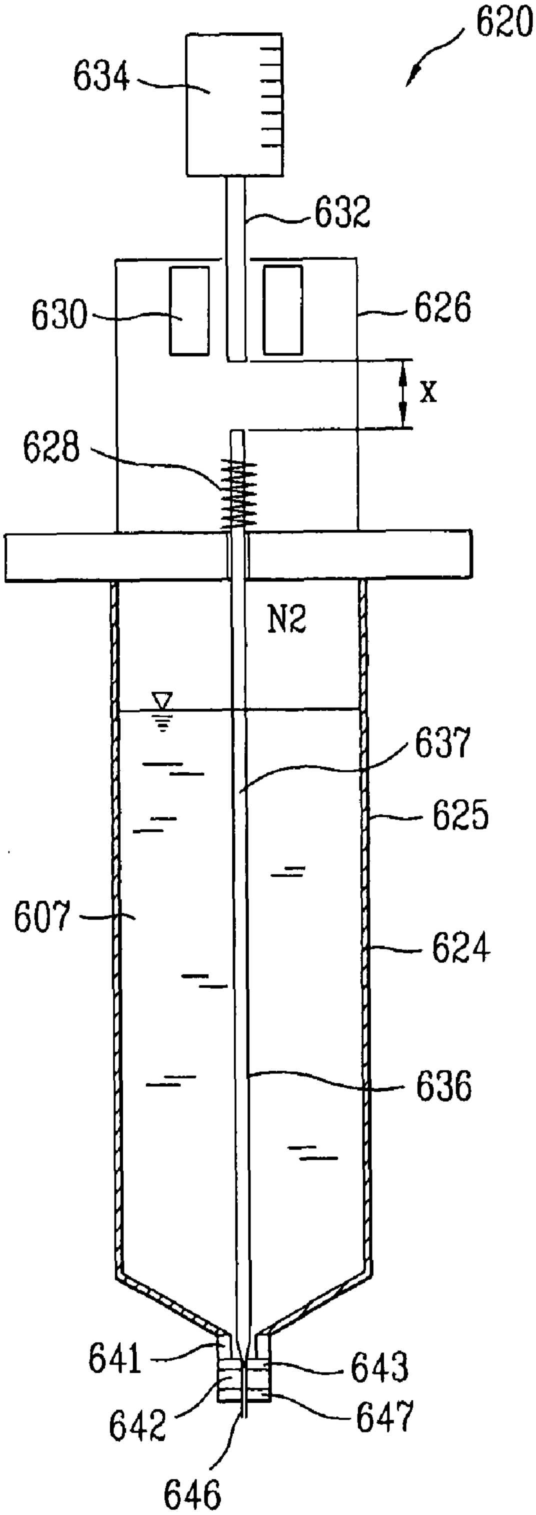

620
634
632
630
626
X
628
N2
637
625
607
624
636
641
643
642
647
646

FIG. 27A

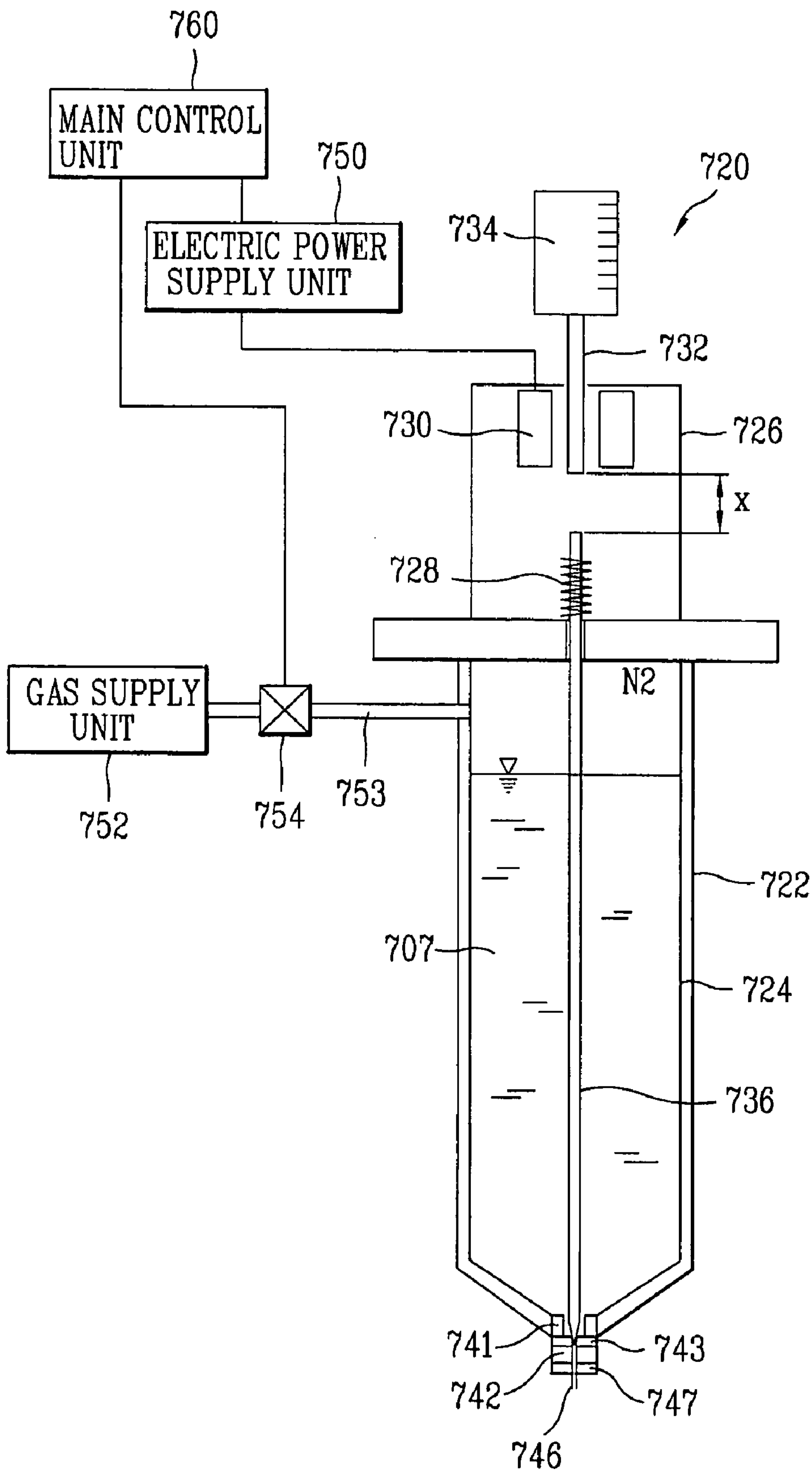

760
MAIN CONTROL UNIT
750
ELECTRIC POWER SUPPLY UNIT
720
734
732
730
726
X
728
GAS SUPPLY UNIT
N2
752
754
753
722
707
724
736
741
743
742
747
746

FIG. 27B

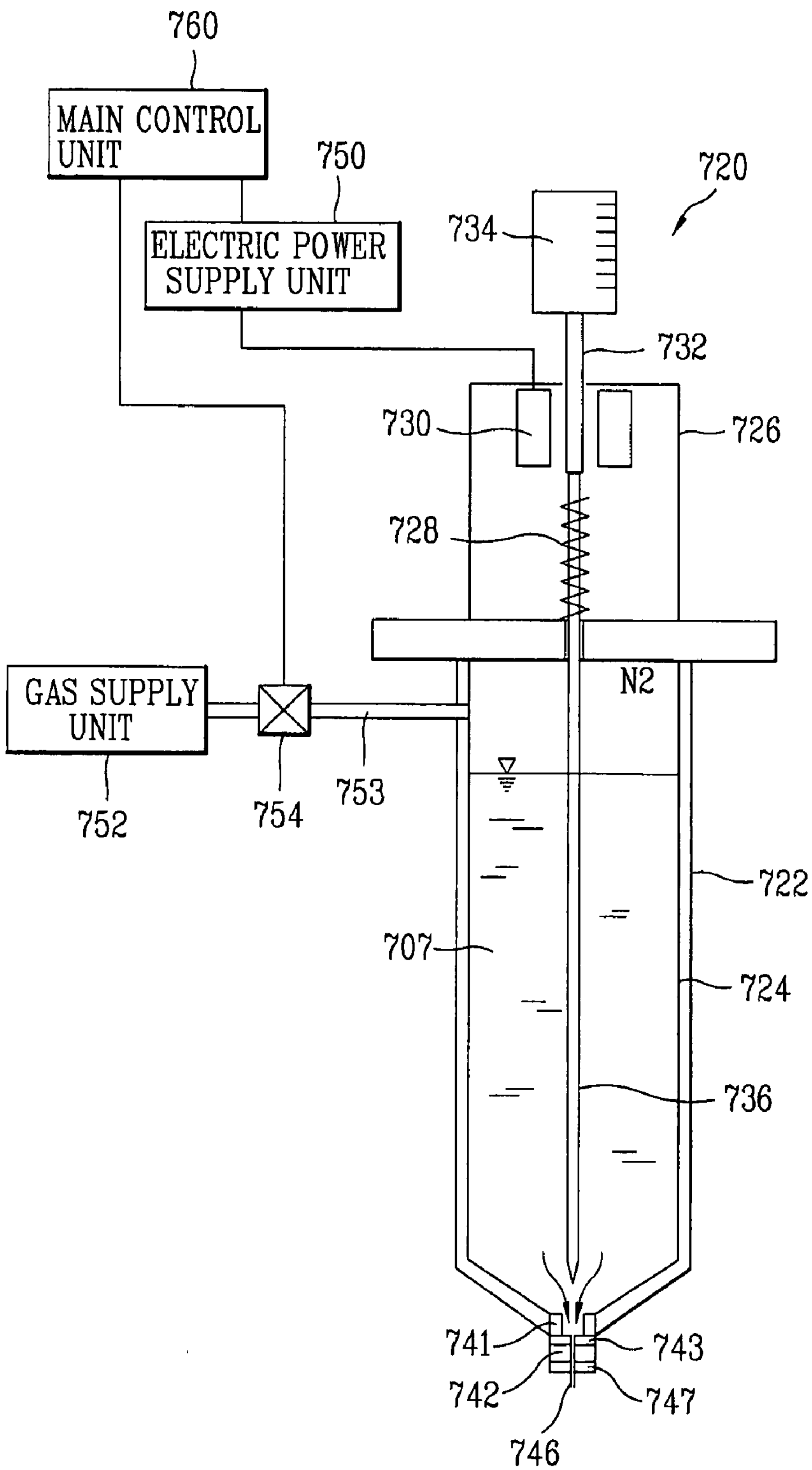

760
MAIN CONTROL UNIT
750
ELECTRIC POWER SUPPLY UNIT
720
734
732
730
726
728
N2
GAS SUPPLY UNIT
752
754
753
722
707
724
736
741
743
742
747
746

FIG. 27C

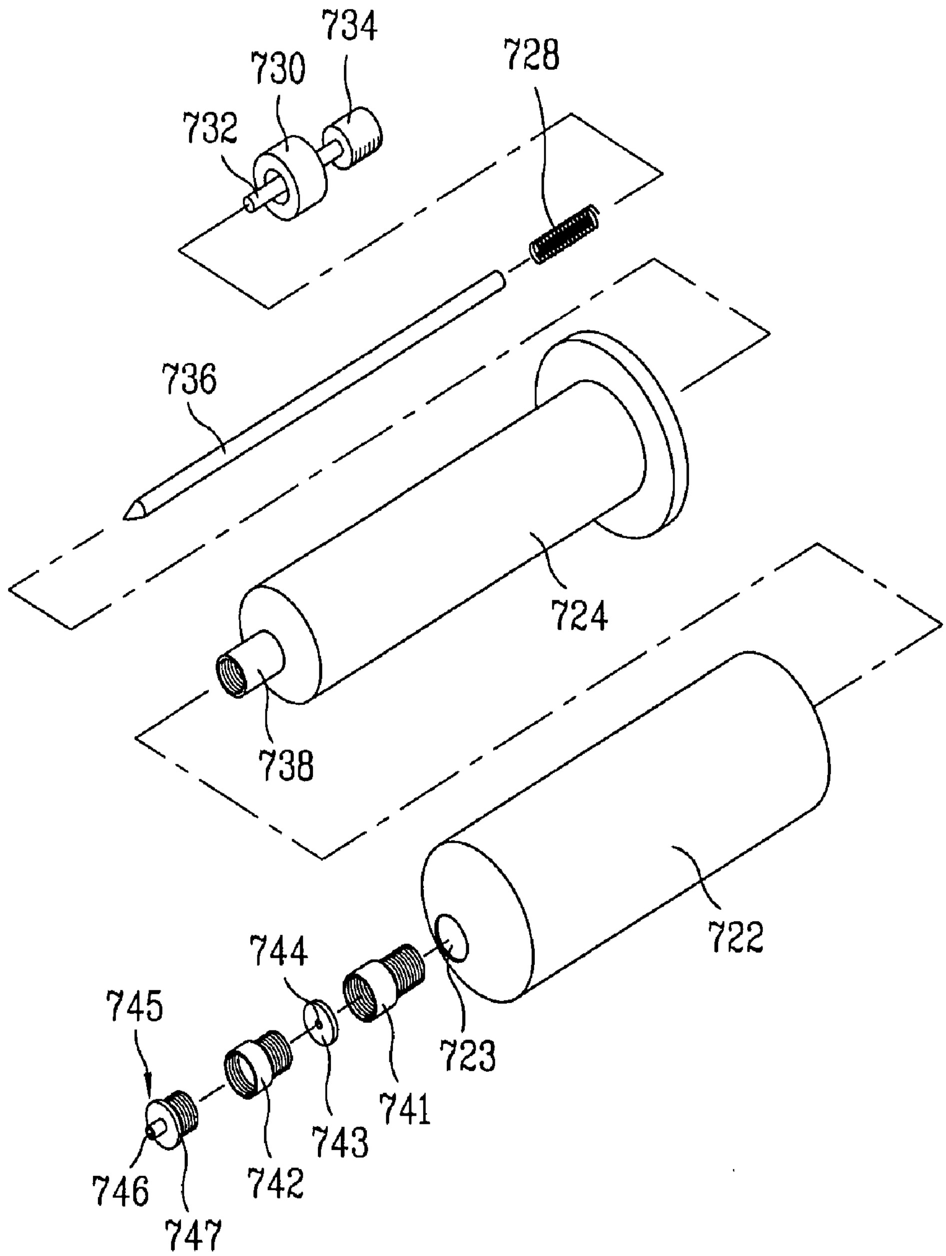


FIG. 28

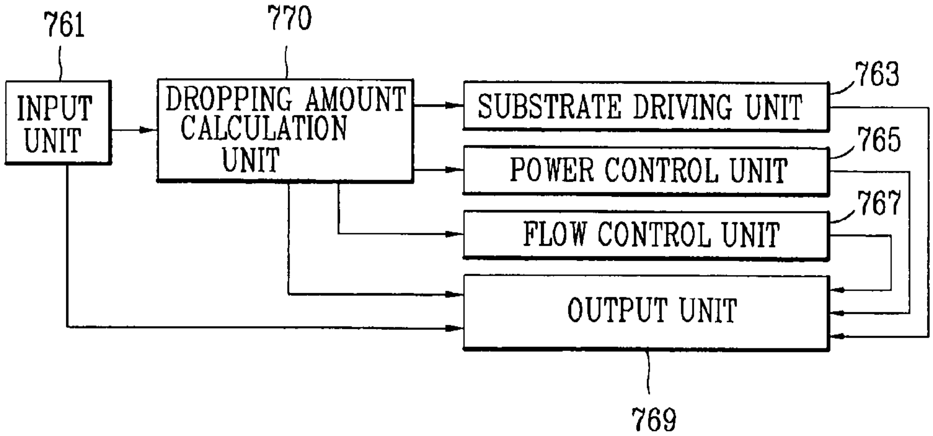

761
770
INPUT UNIT
DROPPING AMOUNT CALCULATION UNIT
SUBSTRATE DRIVING UNIT
763
POWER CONTROL UNIT
765
FLOW CONTROL UNIT
767
OUTPUT UNIT
769

FIG. 29

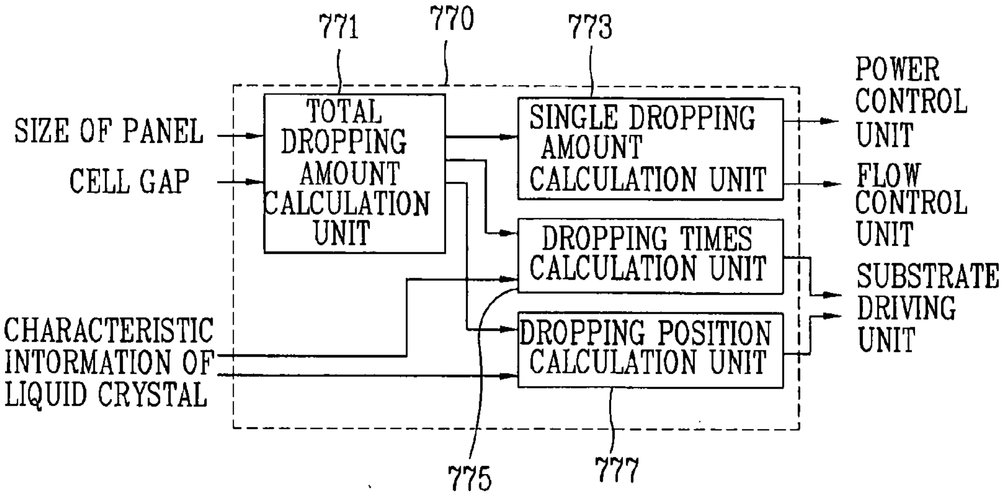

771
770
773
SIZE OF PANEL
CELL GAP
TOTAL DROPPING AMOUNT CALCULATION UNIT
SINGLE DROPPING AMOUNT CALCULATION UNIT
DROPPING TIMES CALCULATION UNIT
DROPPING POSITION CALCULATION UNIT
CHARACTERISTIC INTORMATION OF LIQUID CRYSTAL
POWER CONTROL UNIT
FLOW CONTROL UNIT
SUBSTRATE DRIVING UNIT
775
777

FIG. 30

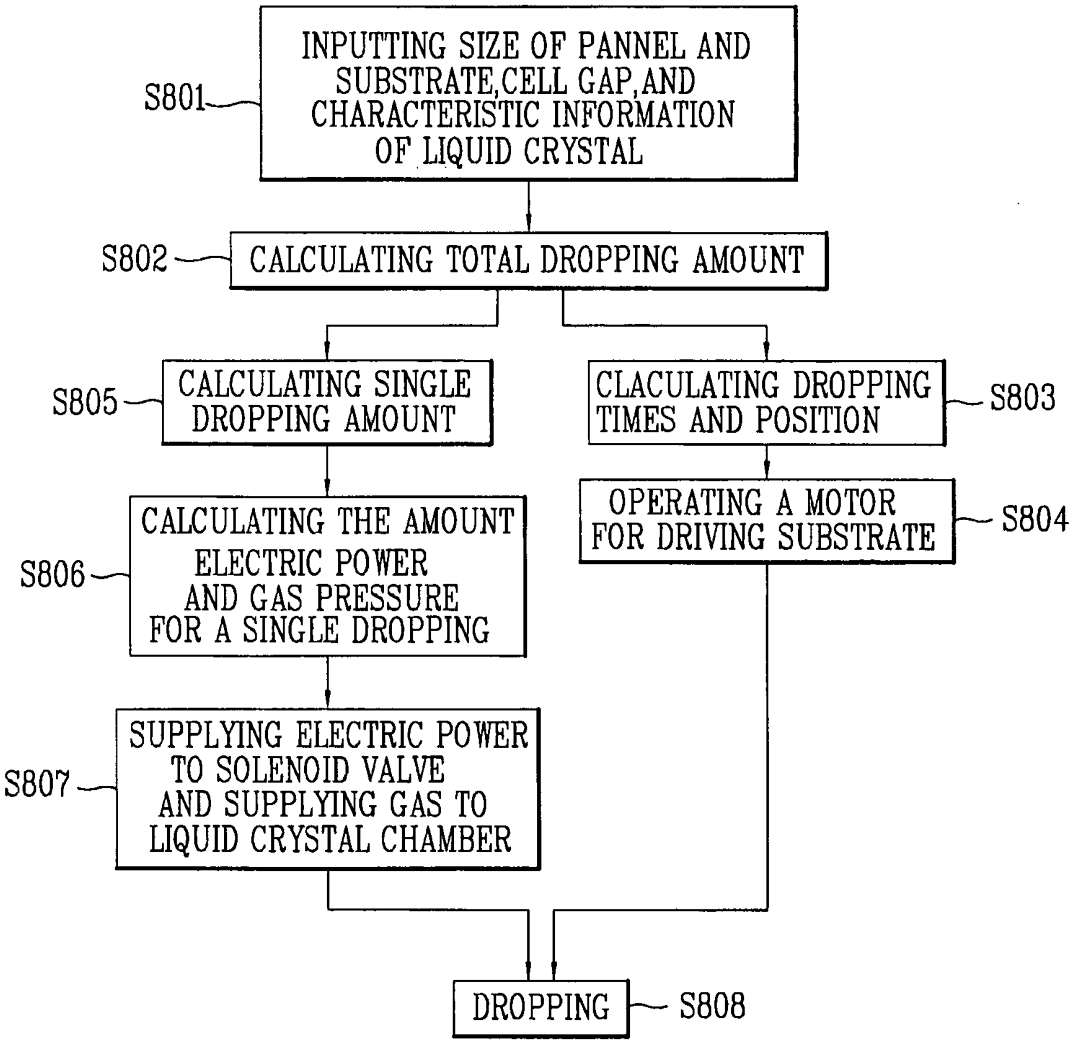

INPUTTING SIZE OF PANNEL AND SUBSTRATE,CELL GAP,AND CHARACTERISTIC INFORMATION OF LIQUID CRYSTAL
S801
CALCULATING TOTAL DROPPING AMOUNT
S802
CALCULATING SINGLE DROPPING AMOUNT
S805
CLACULATING DROPPING TIMES AND POSITION
S803
CALCULATING THE AMOUNT ELECTRIC POWER AND GAS PRESSURE FOR A SINGLE DROPPING
S806
OPERATING A MOTOR FOR DRIVING SUBSTRATE
S804
SUPPLYING ELECTRIC POWER TO SOLENOID VALVE AND SUPPLYING GAS TO LIQUID CRYSTAL CHAMBER
S807
DROPPING
S808

FIG. 31

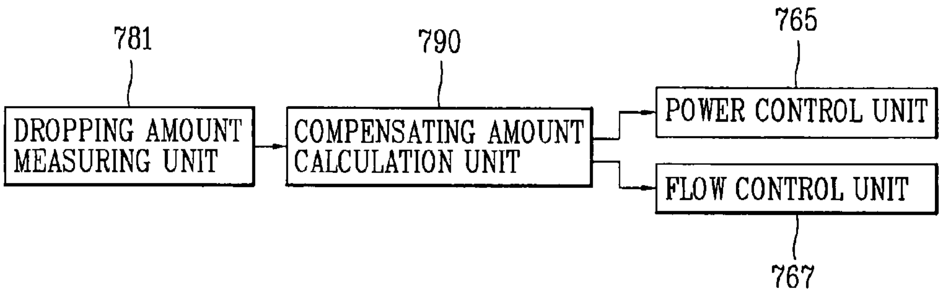

781
790
765
DROPPING AMOUNT MEASURING UNIT
COMPENSATING AMOUNT CALCULATION UNIT
POWER CONTROL UNIT
FLOW CONTROL UNIT
767

FIG. 32

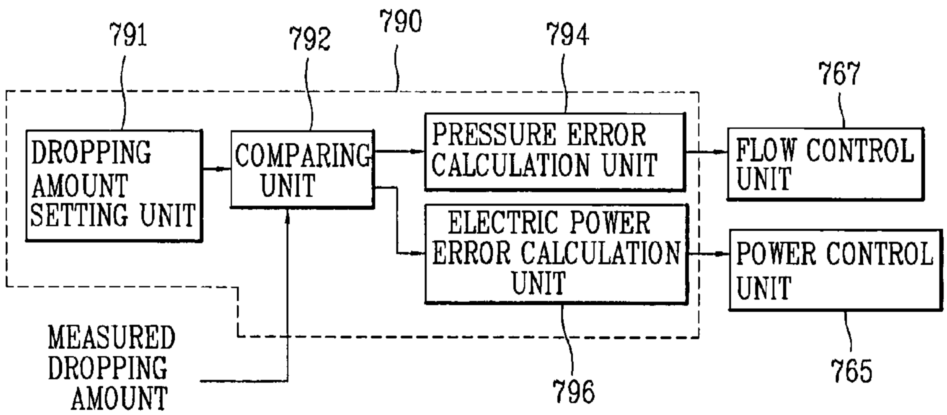

791
792
790
794
767
DROPPING AMOUNT SETTING UNIT
COMPARING UNIT
PRESSURE ERROR CALCULATION UNIT
FLOW CONTROL UNIT
ELECTRIC POWER ERROR CALCULATION UNIT
POWER CONTROL UNIT
MEASURED DROPPING AMOUNT
796
765

FIG. 33

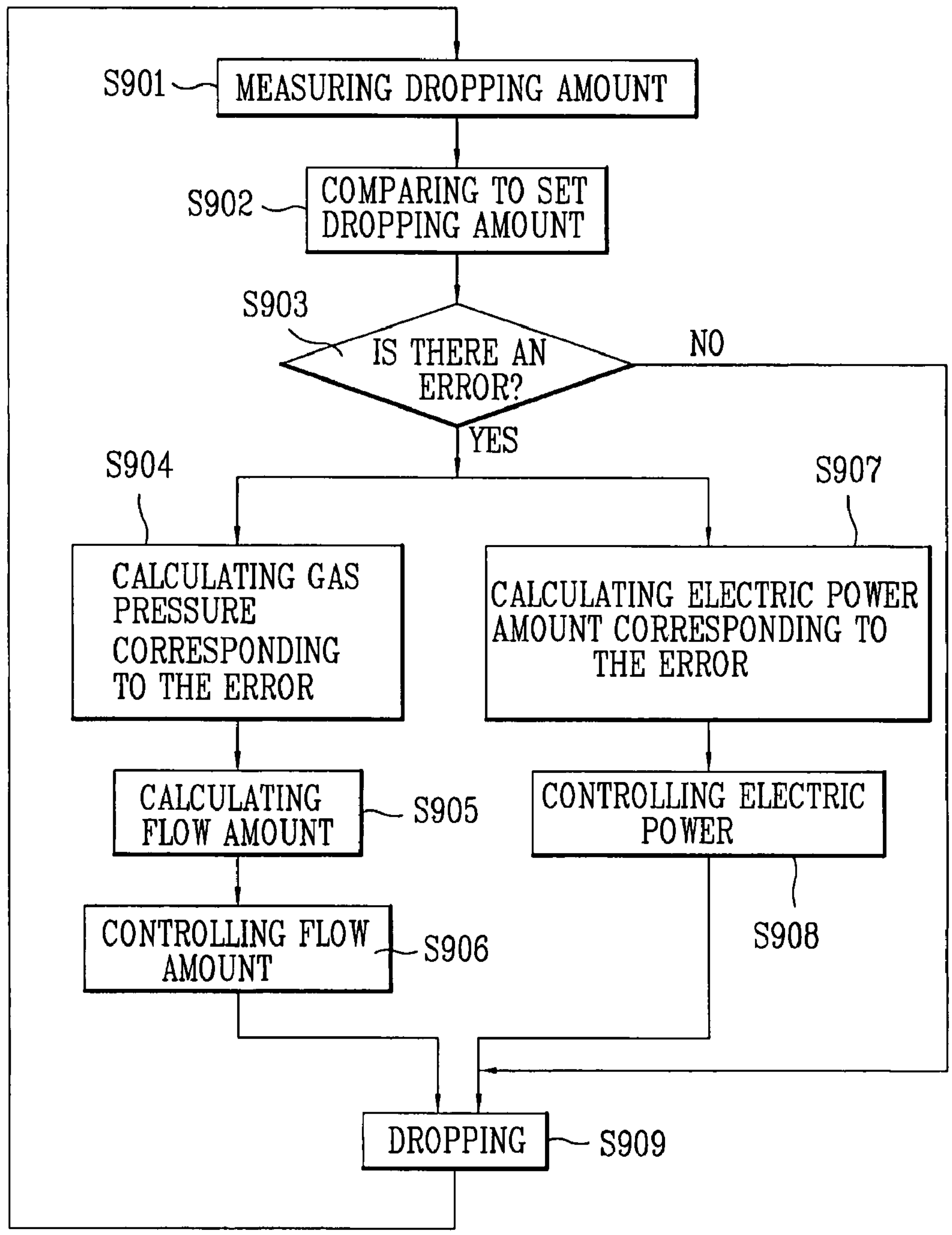

S901
MEASURING DROPPING AMOUNT
S902
COMPARING TO SET DROPPING AMOUNT
S903
IS THERE AN ERROR?
NO
YES
S904
CALCULATING GAS PRESSURE CORRESPONDING TO THE ERROR
S907
CALCULATING ELECTRIC POWER AMOUNT CORRESPONDING TO THE ERROR
CALCULATING FLOW AMOUNT
S905
CONTROLLING ELECTRIC POWER
S908
CONTROLLING FLOW AMOUNT
S906
DROPPING
S909

FIG. 34

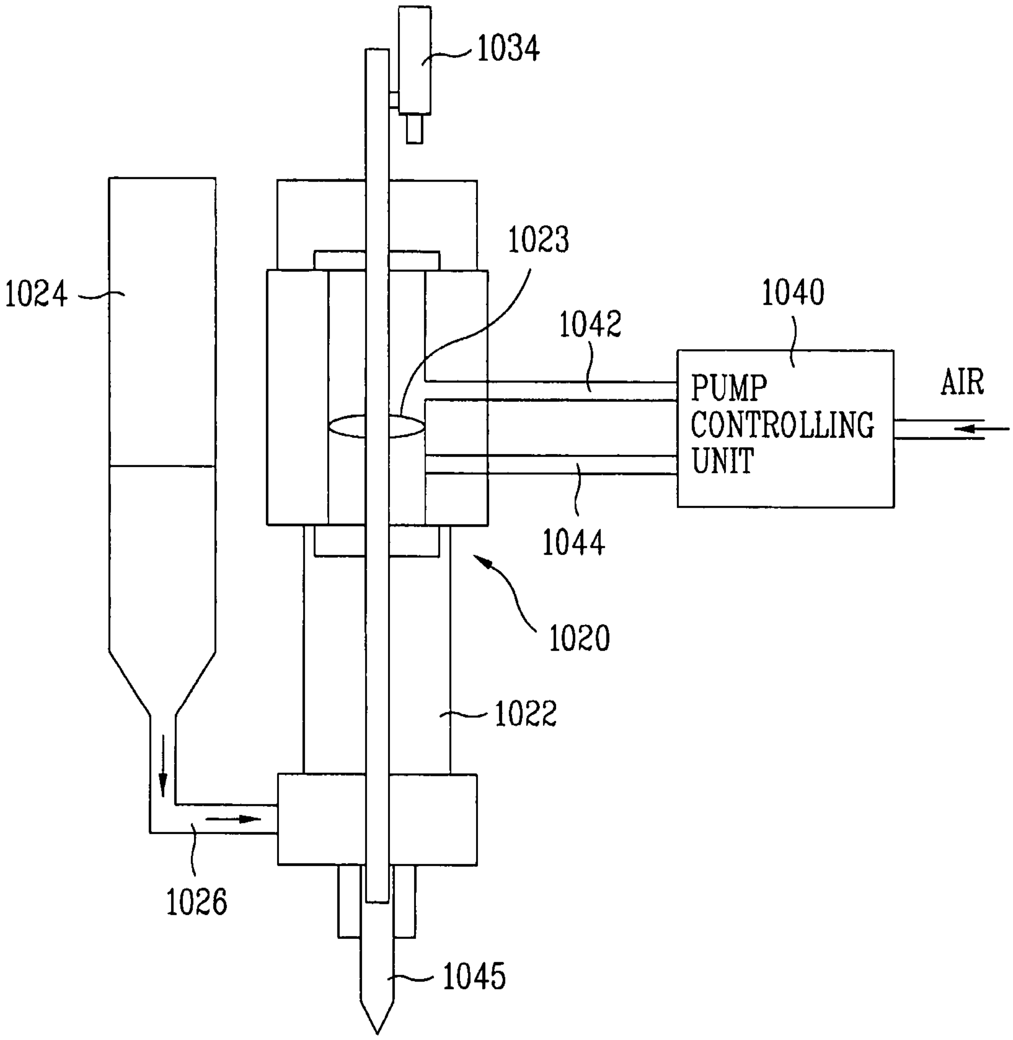

1034
1023
1024
1040
1042
PUMP
CONTROLLING
UNIT
AIR
1044
1020
1022
1026
1045

FIG. 35A

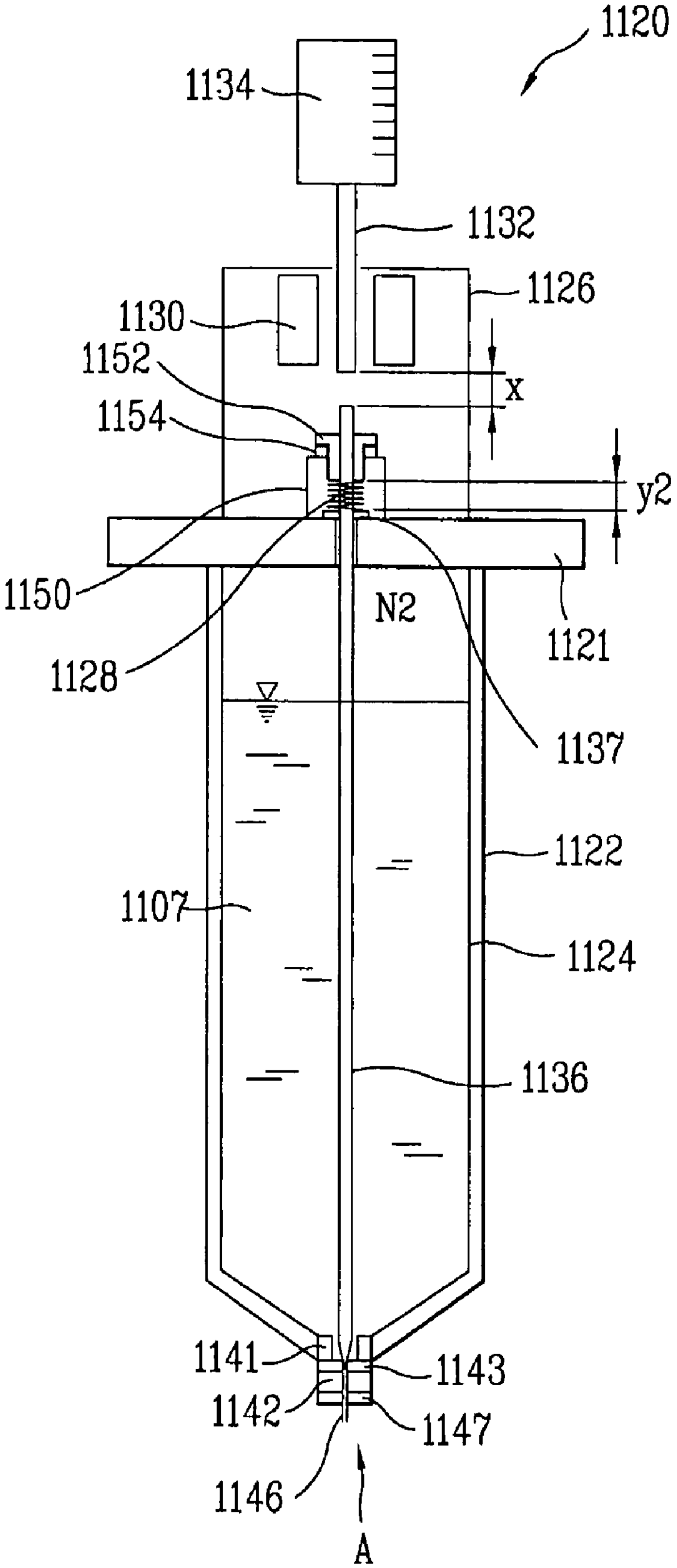

1120
1134
1132
1126
1130
1152
1154
x
y2
1150
1121
N2
1128
1137
1122
1107
1124
1136
1141
1143
1142
1147
1146
A

FIG. 35B

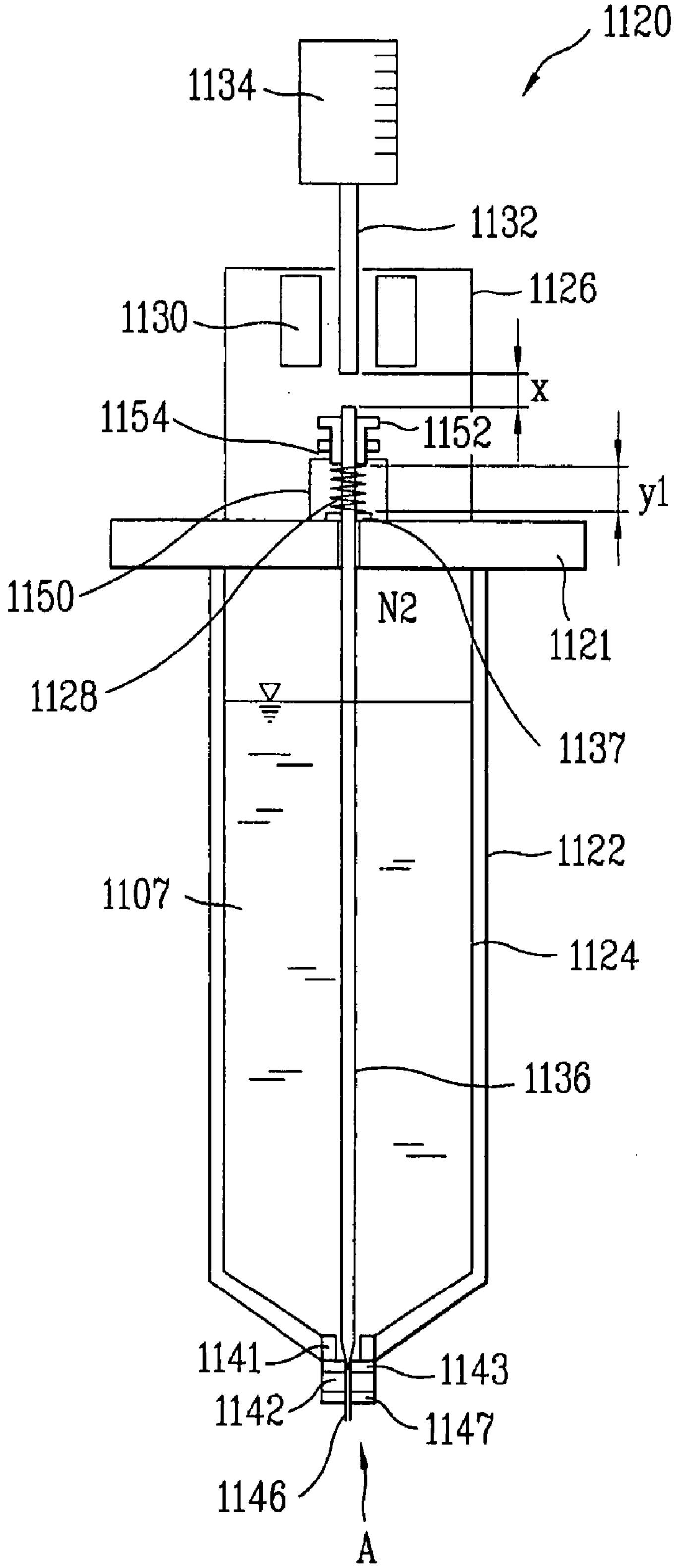

1120
1134
1132
1126
1130
X
1154
1152
y1
1150
N2
1121
1128
1137
1122
1107
1124
1136
1141
1143
1142
1147
1146
A

FIG. 36

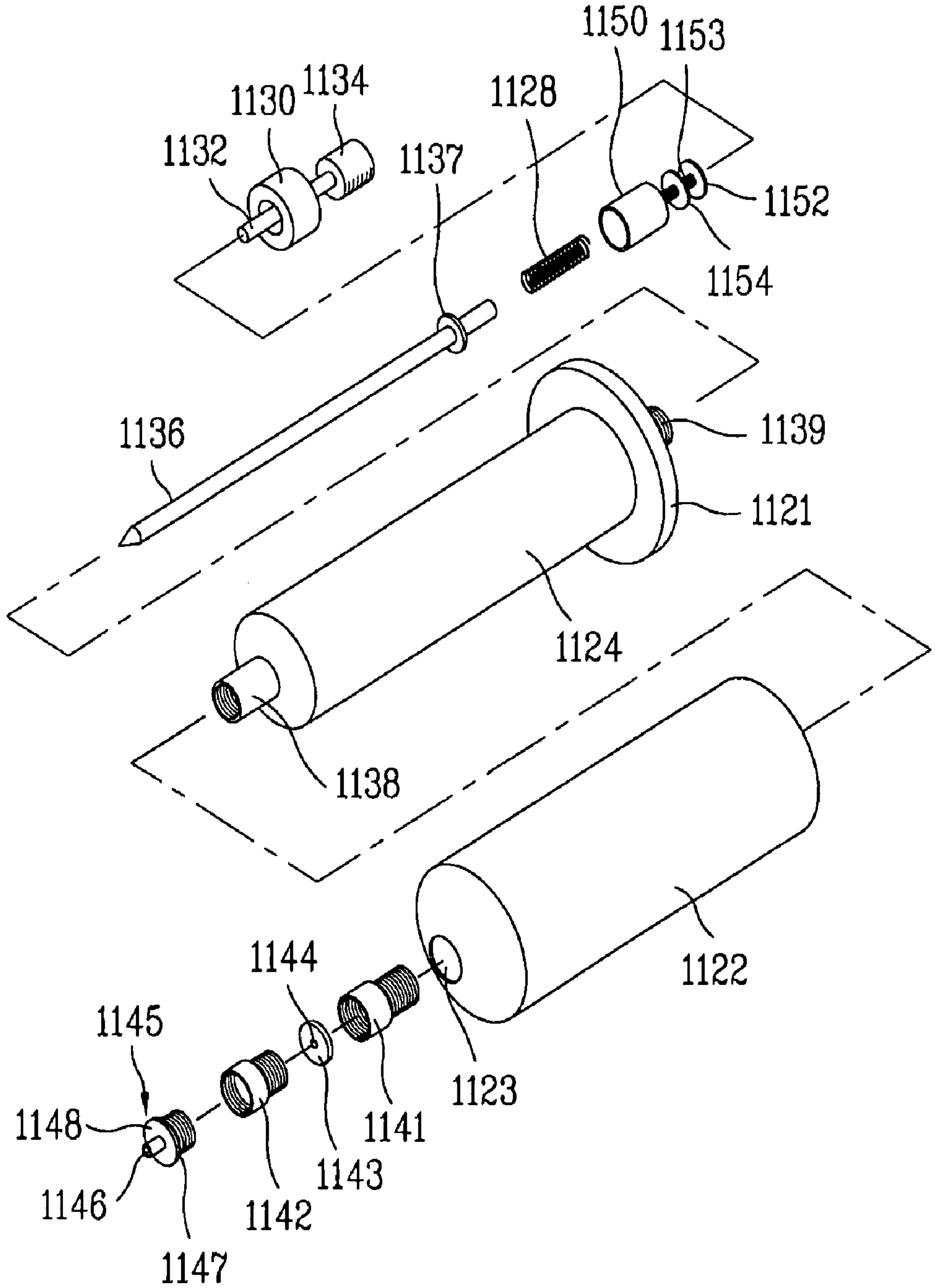

1150
1153
1134
1130
1128
1132
1137
1152
1154
1139
1136
1121
1124
1138
1122
1144
1145
1123
1148
1141
1143
1146
1142
1147

FIG. 37

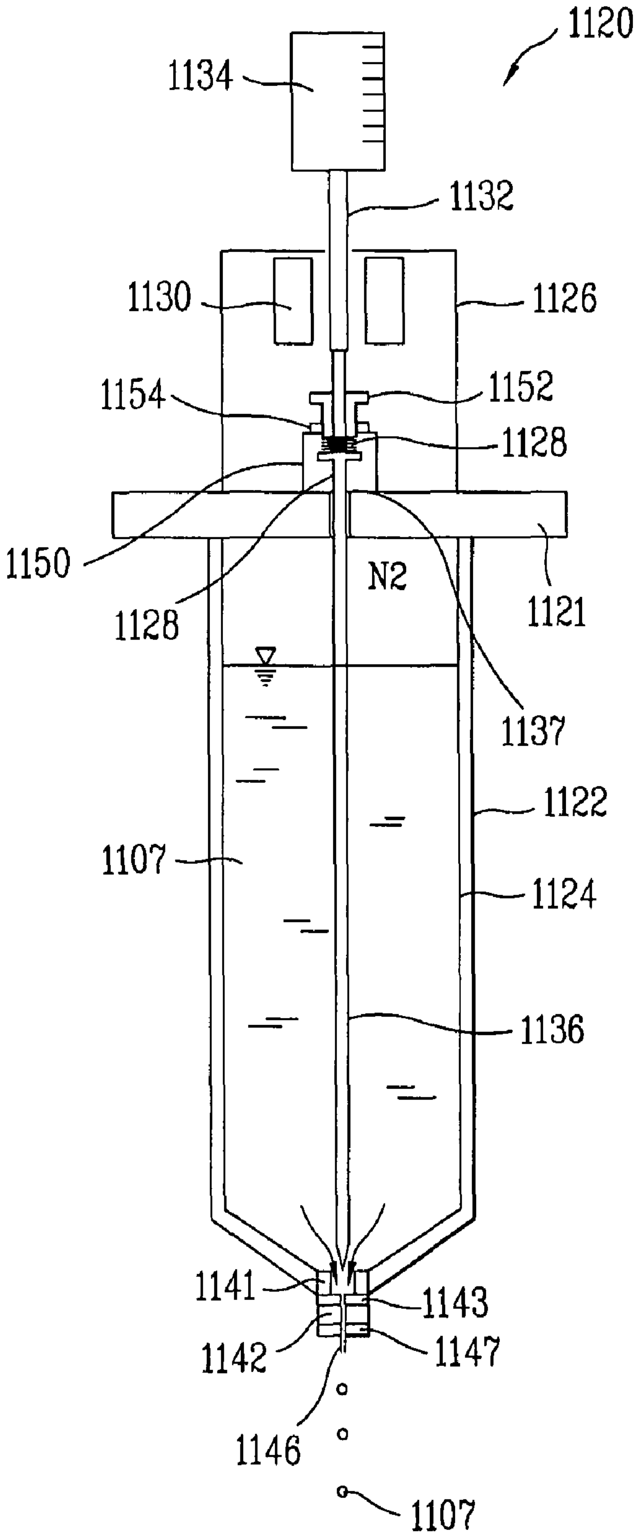

1120
1134
1132
1130
1126
1154
1152
1128
1150
1128
N2
1121
1137
1122
1107
1124
1136
1141
1143
1142
1147
1146
1107

FIG. 38A

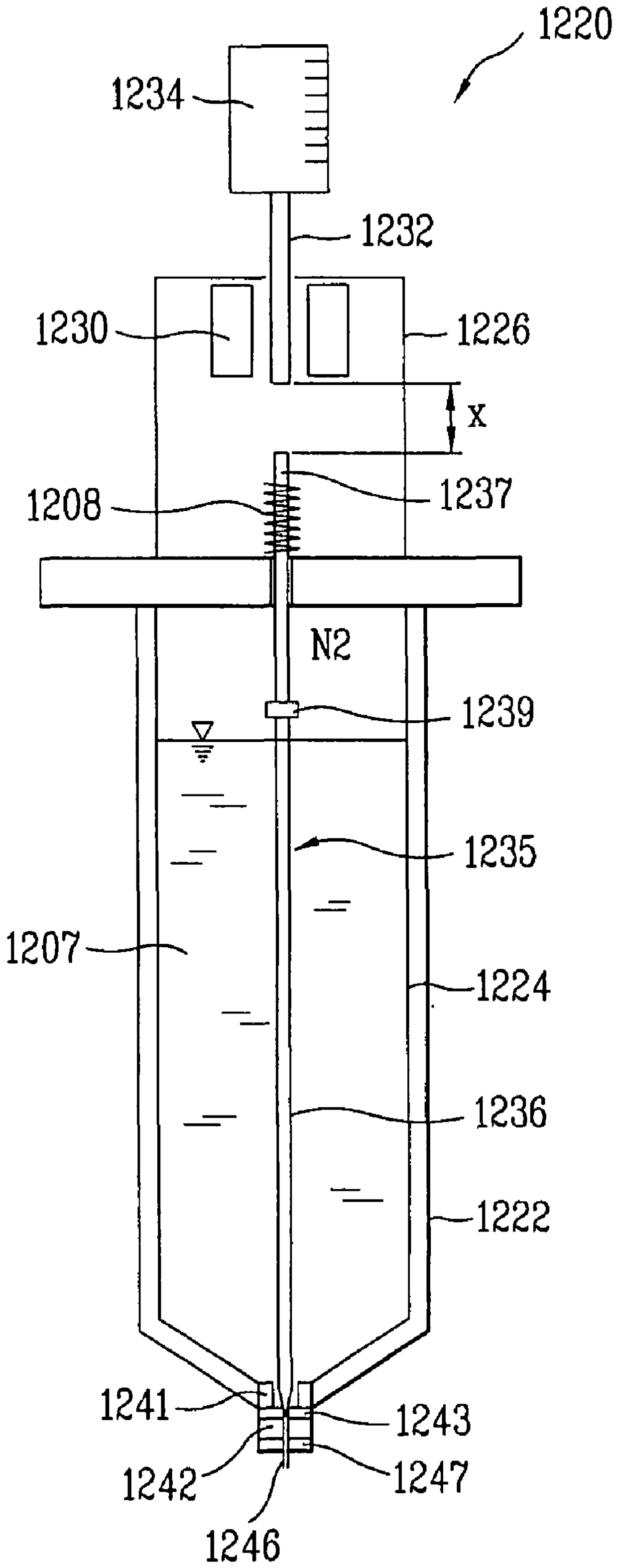

1220
1234
1232
1230
1226
X
1208
1237
N2
1239
1235
1207
1224
1236
1222
1241
1243
1242
1247
1246

FIG. 38B

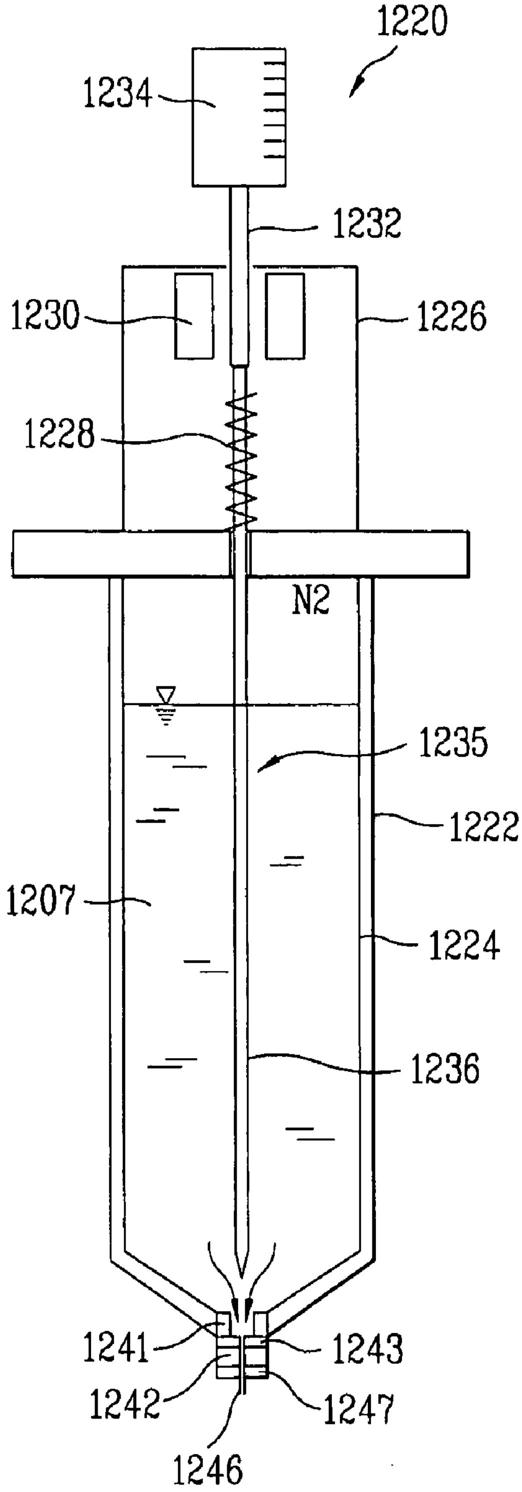

1220
1234
1232
1230
1226
1228
N2
1235
1222
1207
1224
1236
1241
1243
1242
1247
1246

FIG. 39

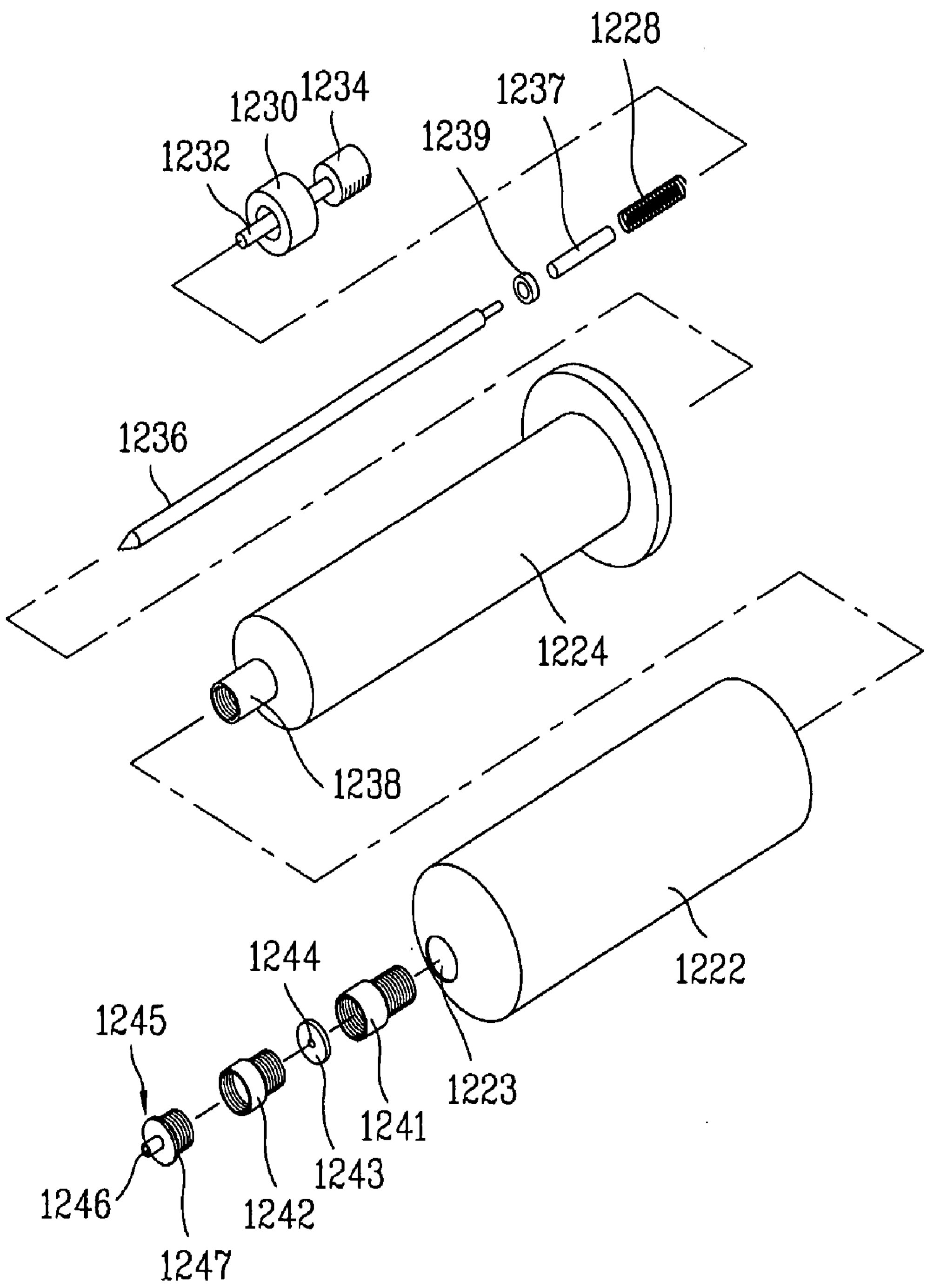

1228
1234
1230
1237
1232
1239
1236
1224
1238
1222
1244
1245
1223
1241
1243
1246
1242
1247

FIG. 40

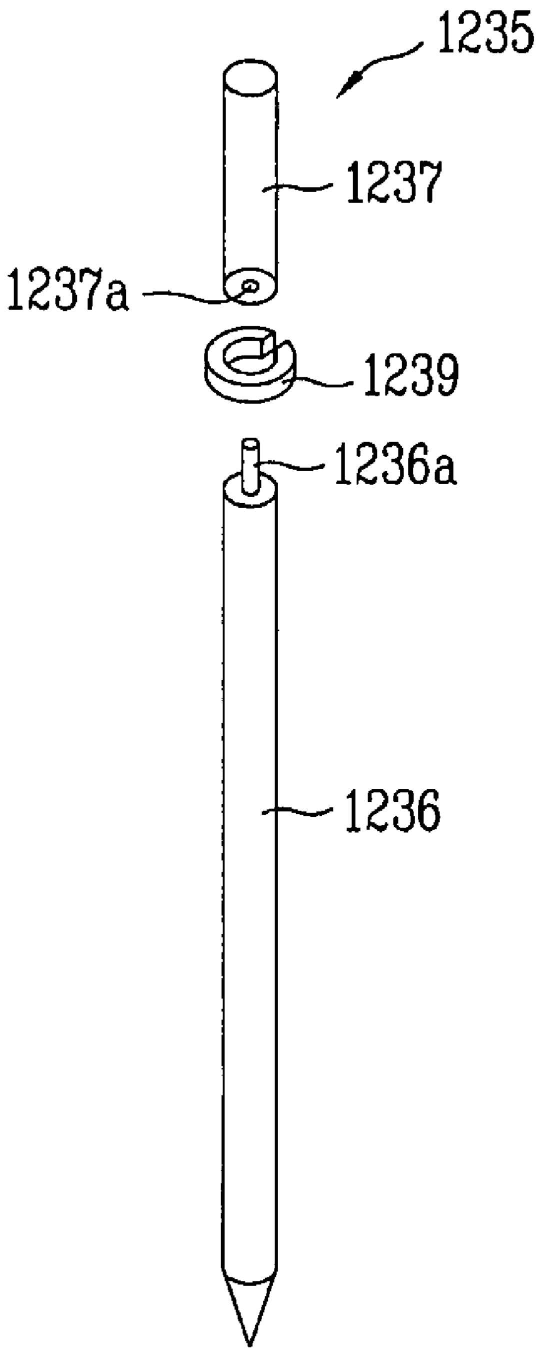
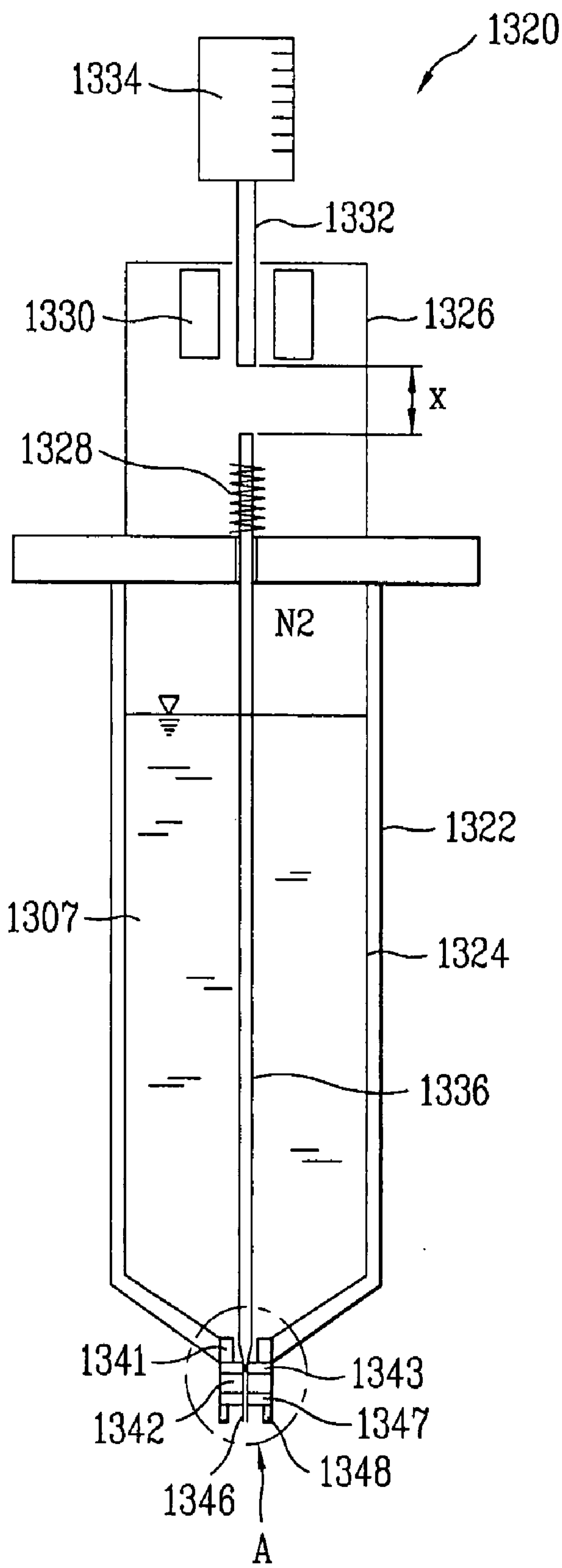


FIG. 41A



1320
1334
1332
1330
1326
X
1328
N2
1322
1307
1324
1336
1341
1343
1342
1347
1348
1346
A

FIG. 41B

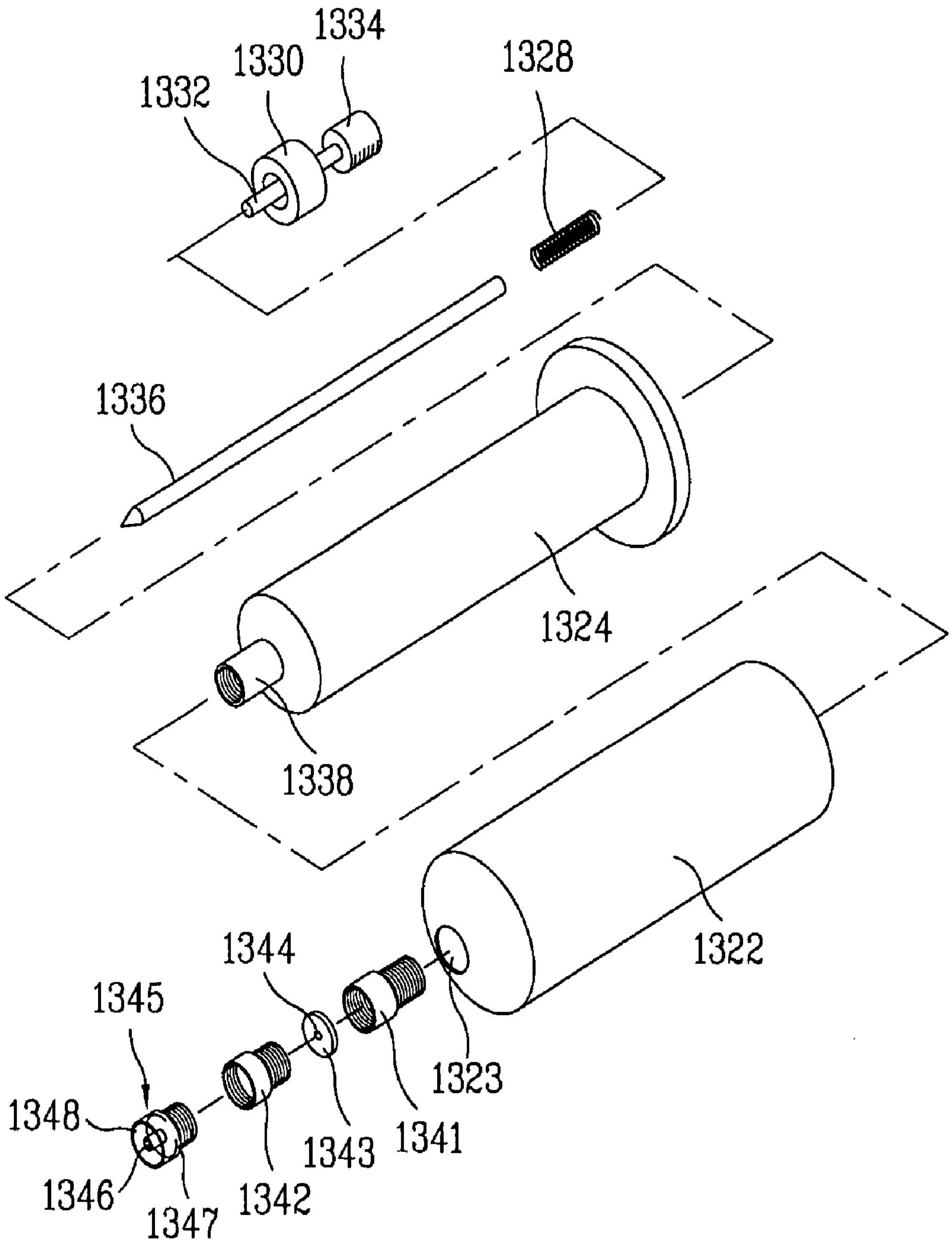

1334
1330
1332
1328
1336
1324
1338
1322
1344
1345
1348
1346
1347
1342
1343
1341
1323

FIG. 42

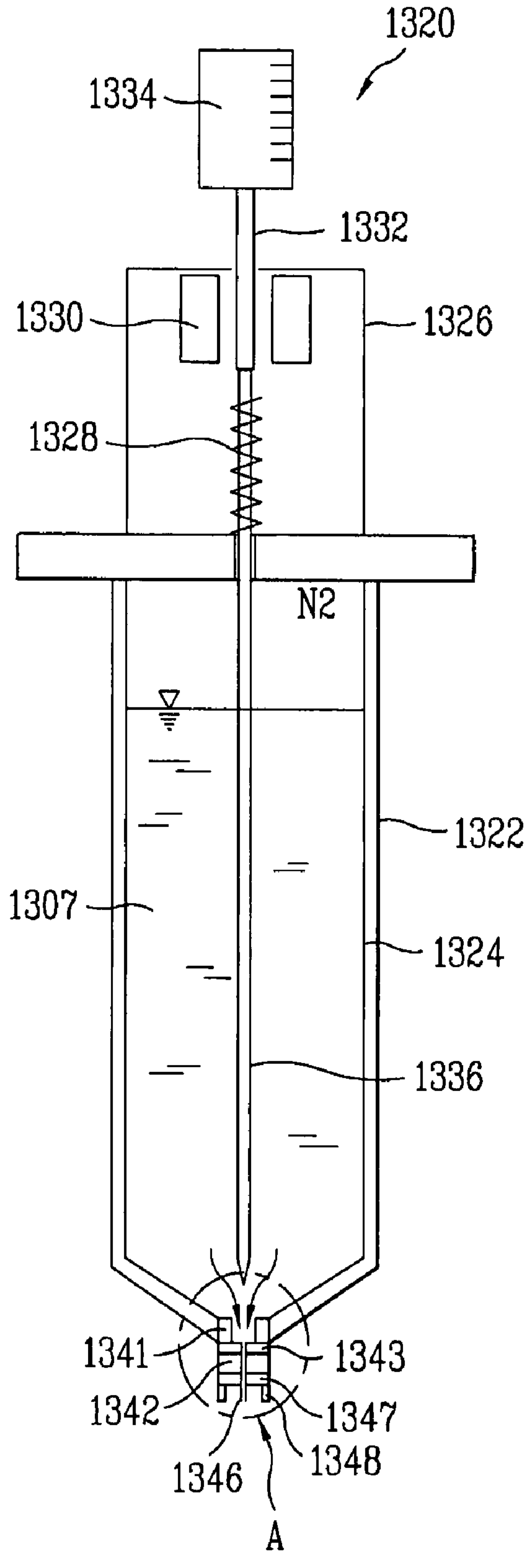

1320
1334
1332
1330
1326
1328
N2
1322
1307
1324
1336
1341
1343
1342
1347
1346
1348
A

FIG. 43A

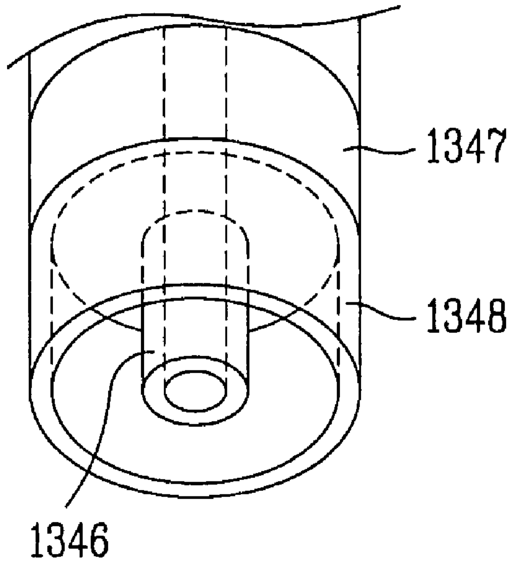


FIG. 43B

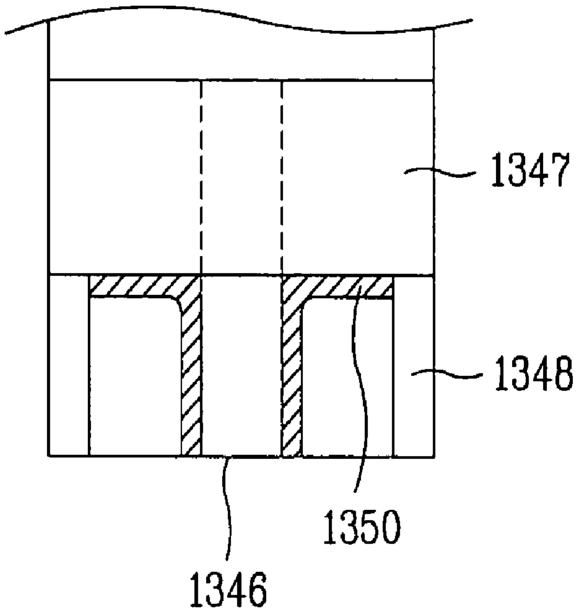


FIG. 44

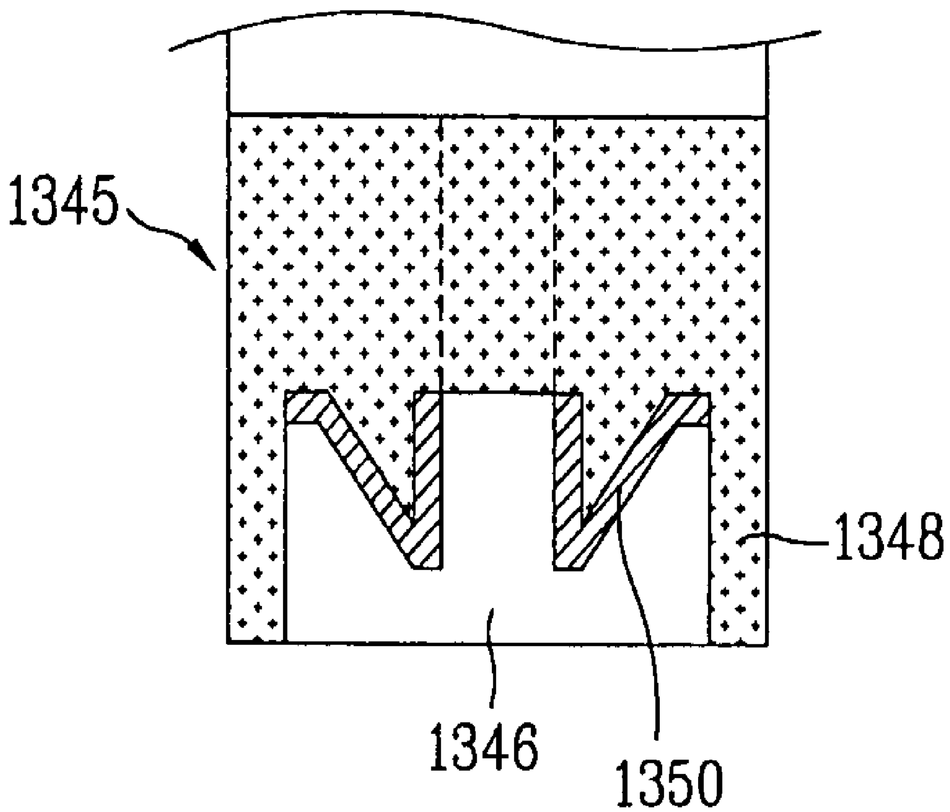


FIG. 45

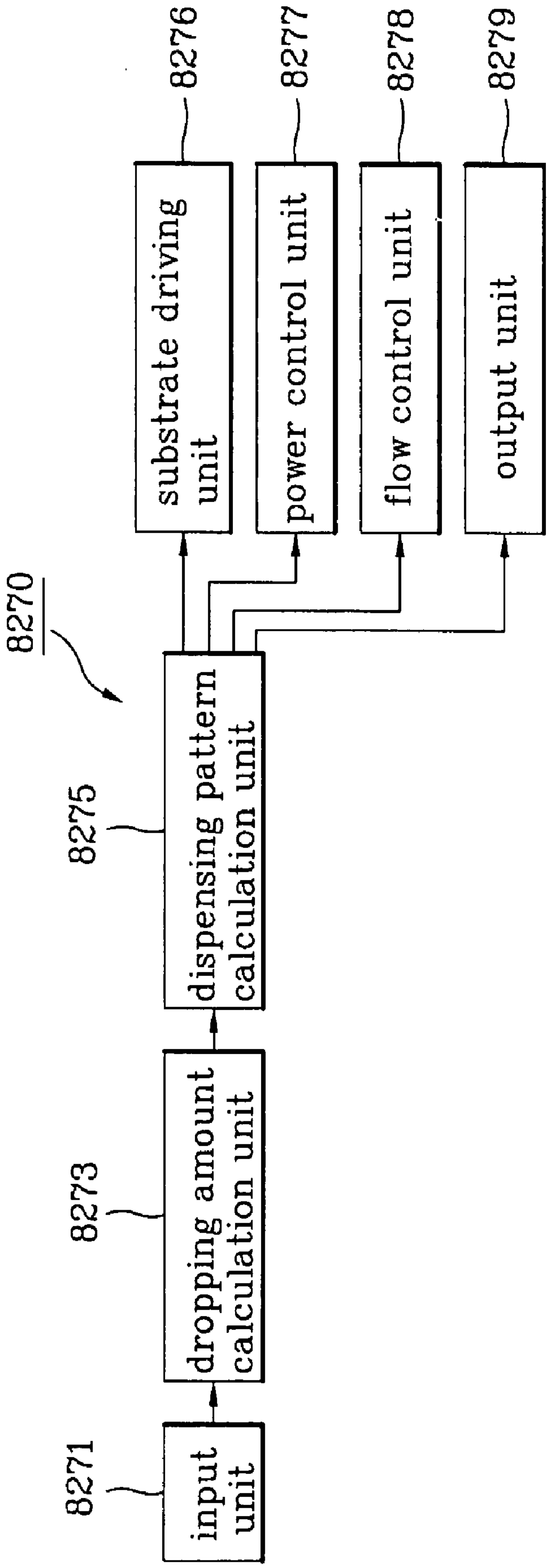

8270
8271
input unit
8273
dropping amount calculation unit
8275
dispensing pattern calculation unit
8276
substrate driving unit
8277
power control unit
8278
flow control unit
8279
output unit

FIG. 46

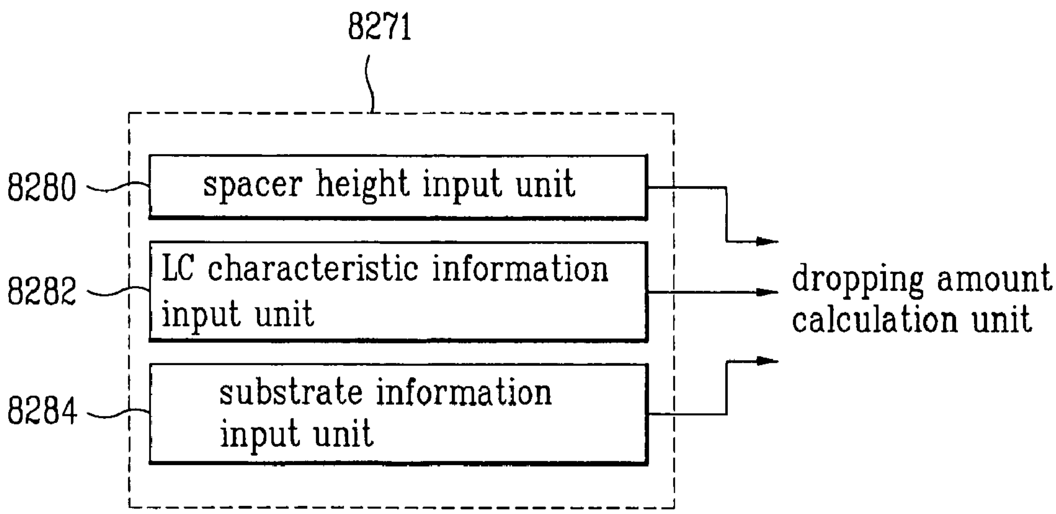

8271
8280
spacer height input unit
8282
LC characteristic information input unit
8284
substrate information input unit
dropping amount calculation unit

FIG. 47

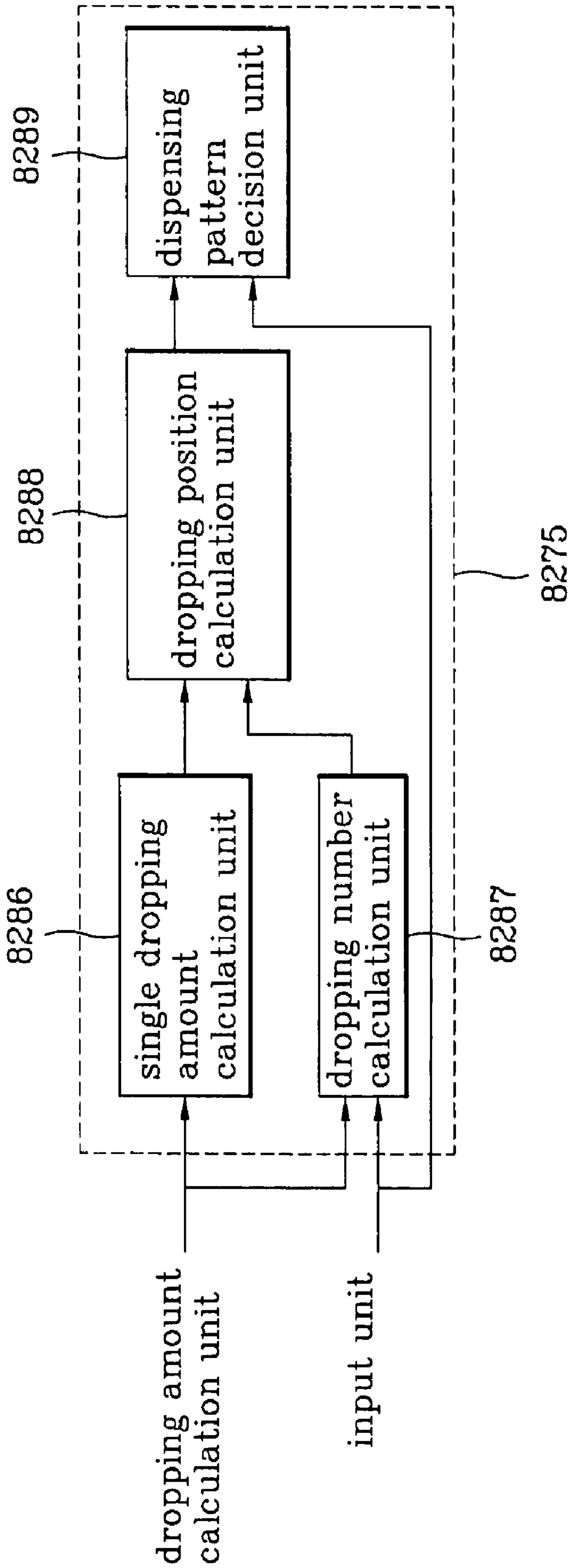

8289
dispensing pattern decision unit
8288
dropping position calculation unit
8275
8286
single dropping amount calculation unit
dropping number calculation unit
8287
dropping amount calculation unit
input unit

FIG. 48

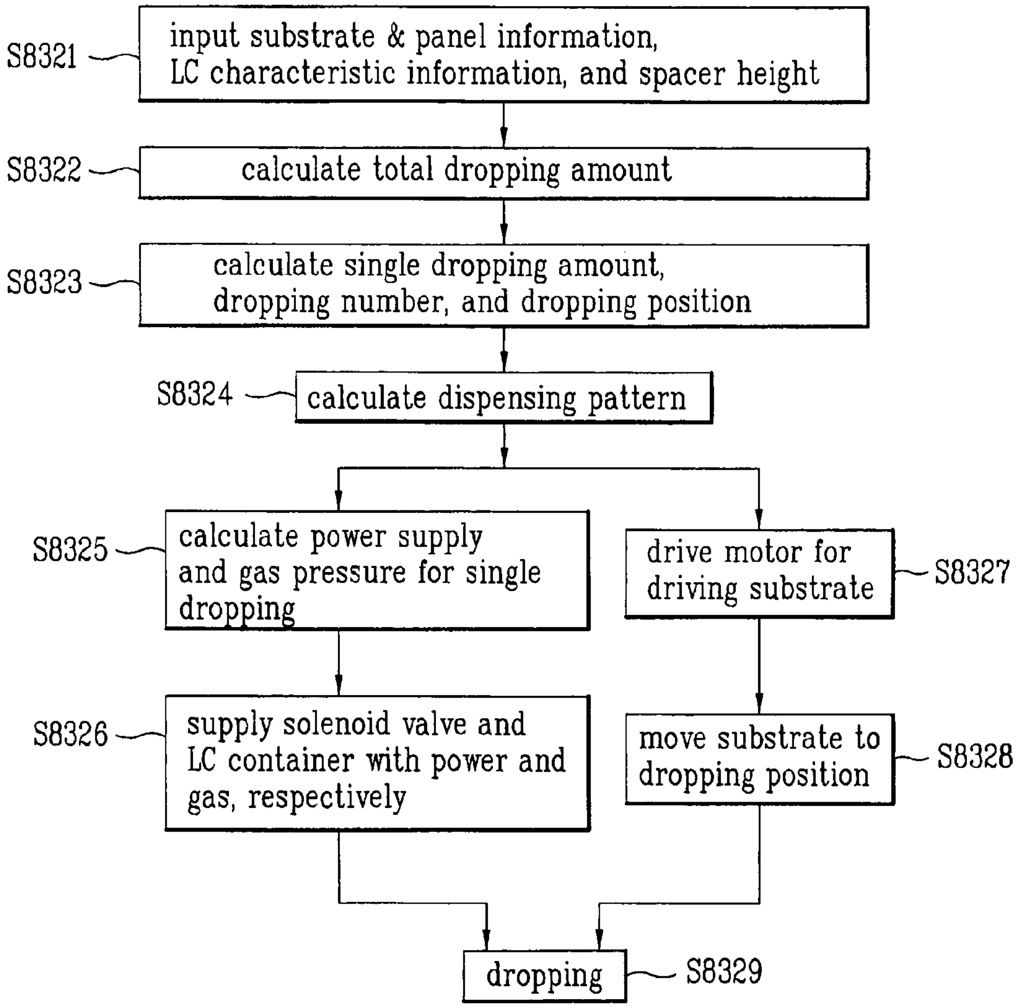

S8321
input substrate & panel information, LC characteristic information, and spacer height
S8322
calculate total dropping amount
S8323
calculate single dropping amount, dropping number, and dropping position
S8324
calculate dispensing pattern
S8325
calculate power supply and gas pressure for single dropping
S8327
drive motor for driving substrate
S8326
supply solenoid valve and LC container with power and gas, respectively
S8328
move substrate to dropping position
dropping
S8329

FIG. 49

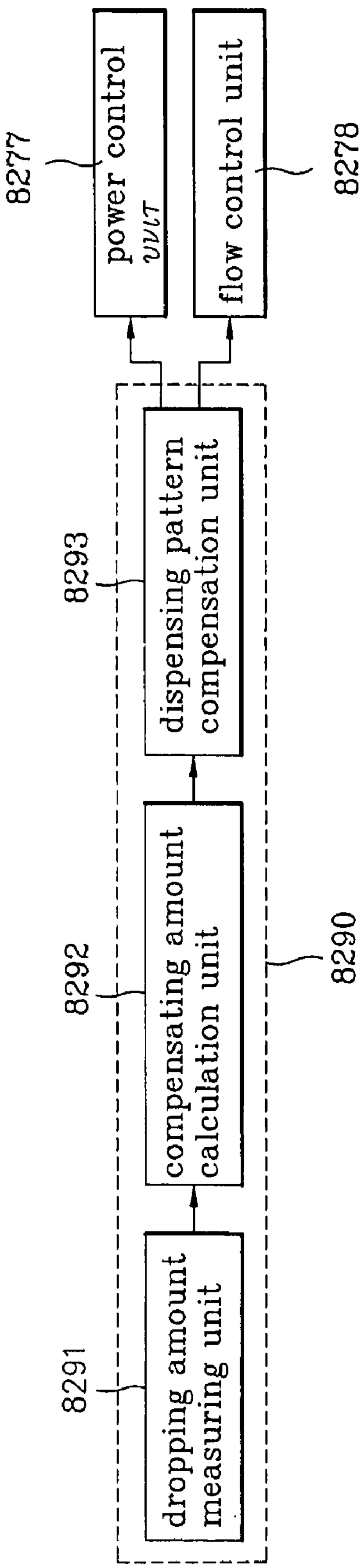

dropping amount measuring unit
8291
compensating amount calculation unit
8292
dispensing pattern compensation unit
8293
8290
power control unit
8277
flow control unit
8278

FIG. 50

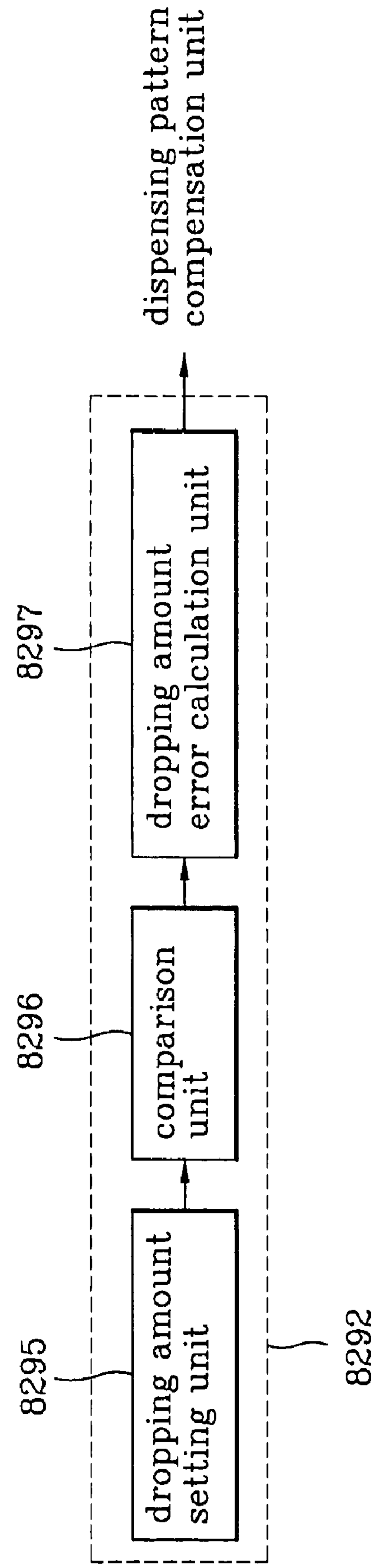

dropping amount setting unit
8295
comparison unit
8296
dropping amount error calculation unit
8297
8292
dispensing pattern compensation unit

FIG. 51

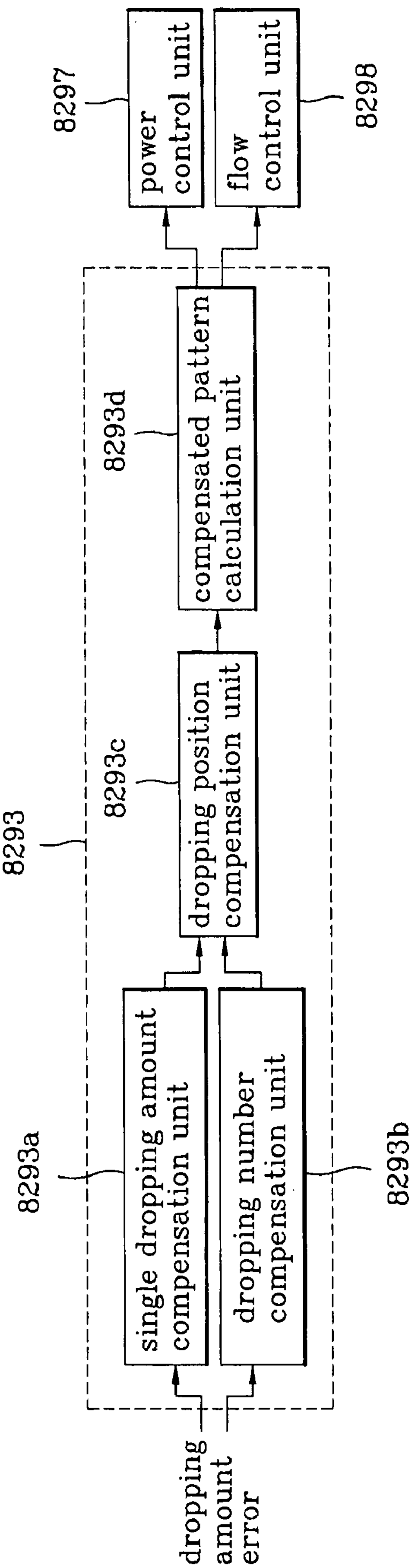

dropping amount error
8293
8293a
single dropping amount compensation unit
8293b
dropping number compensation unit
8293c
dropping position compensation unit
8293d
compensated pattern calculation unit
8297
power control unit
8298
flow control unit

FIG. 52

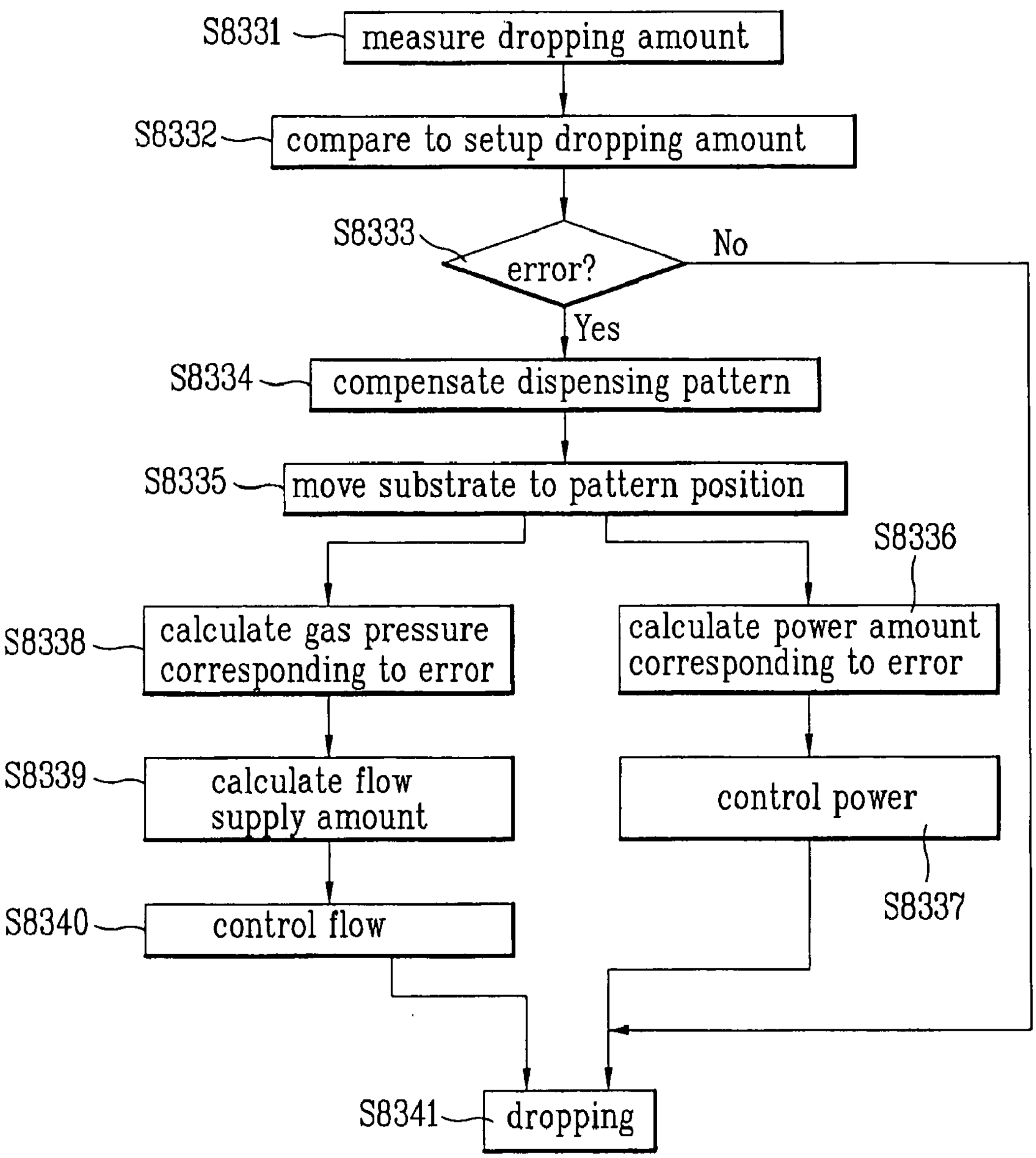

S8331
measure dropping amount
S8332
compare to setup dropping amount
S8333
error?
No
Yes
S8334
compensate dispensing pattern
S8335
move substrate to pattern position
S8336
S8338
calculate gas pressure corresponding to error
calculate power amount corresponding to error
S8339
calculate flow supply amount
control power
S8337
S8340
control flow
S8341
dropping

FIG. 53A

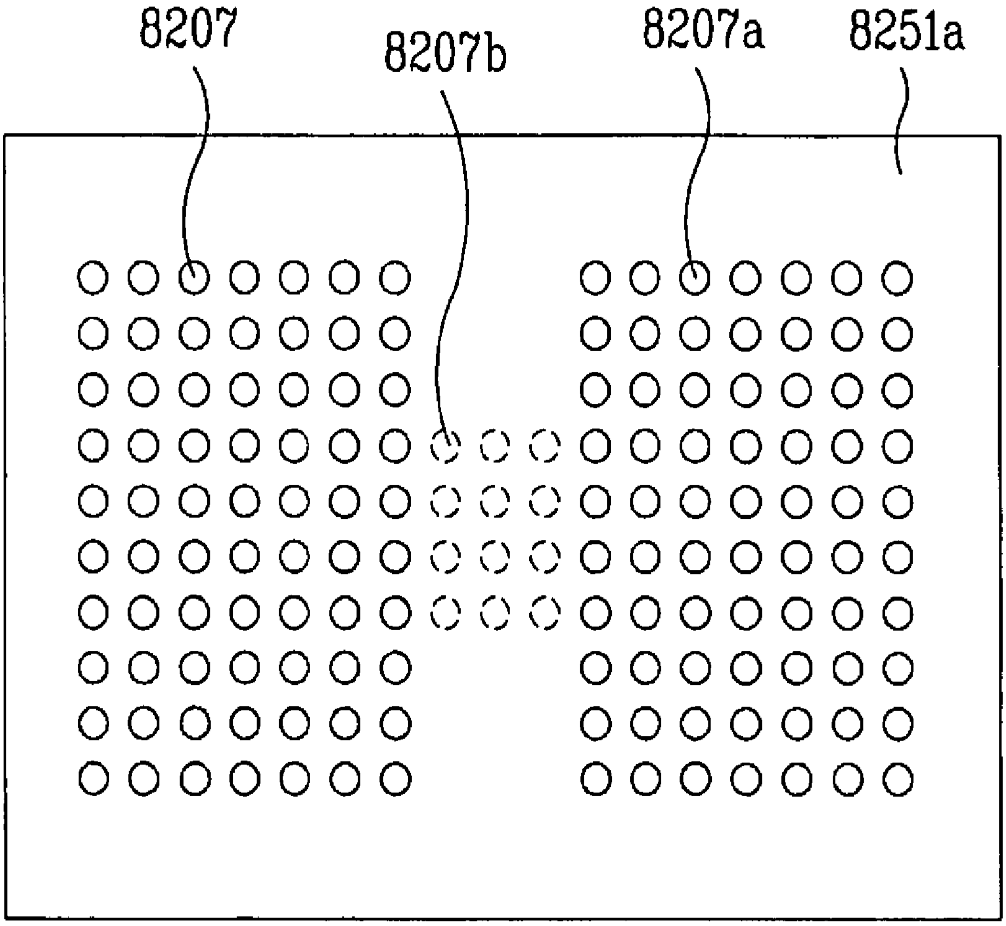


FIG. 53B

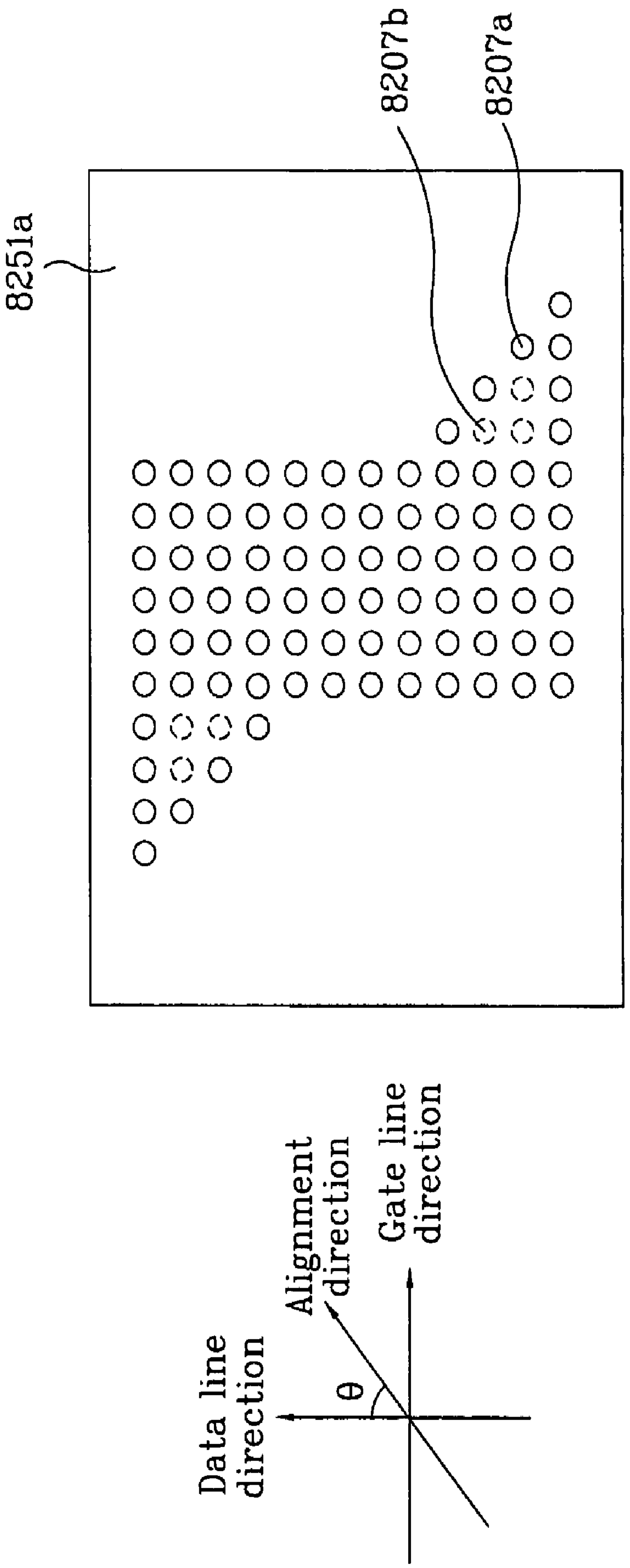

8207b
8207a
8251a
Alignment direction
Gate line direction
Data line direction
θ

FIG. 53C

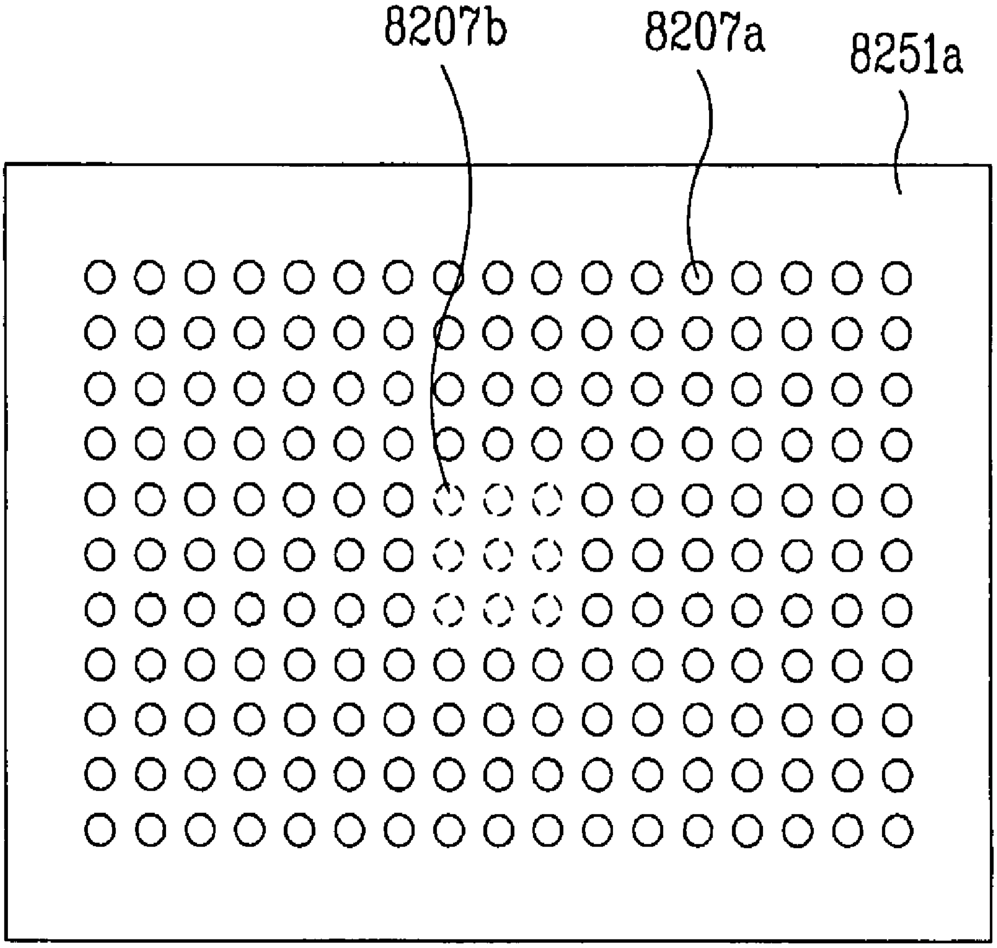


FIG. 53D

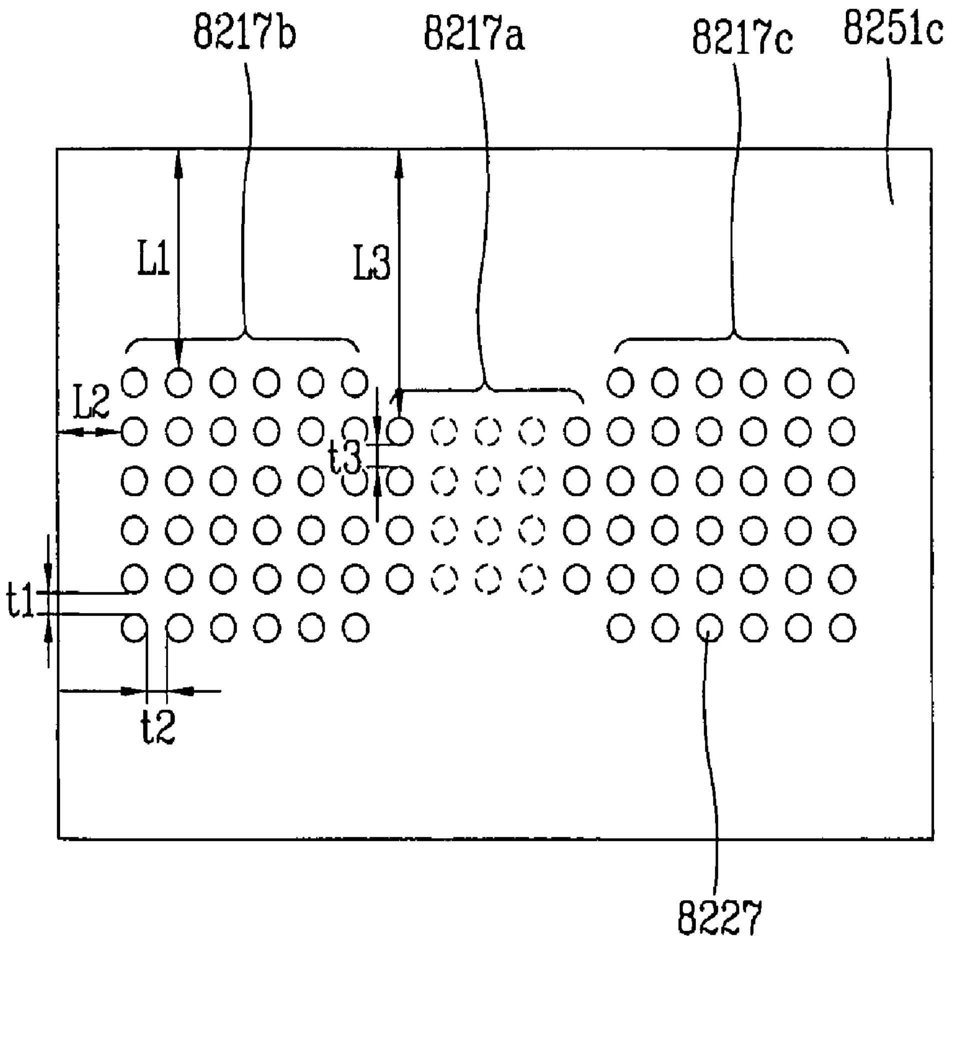


FIG. 53E

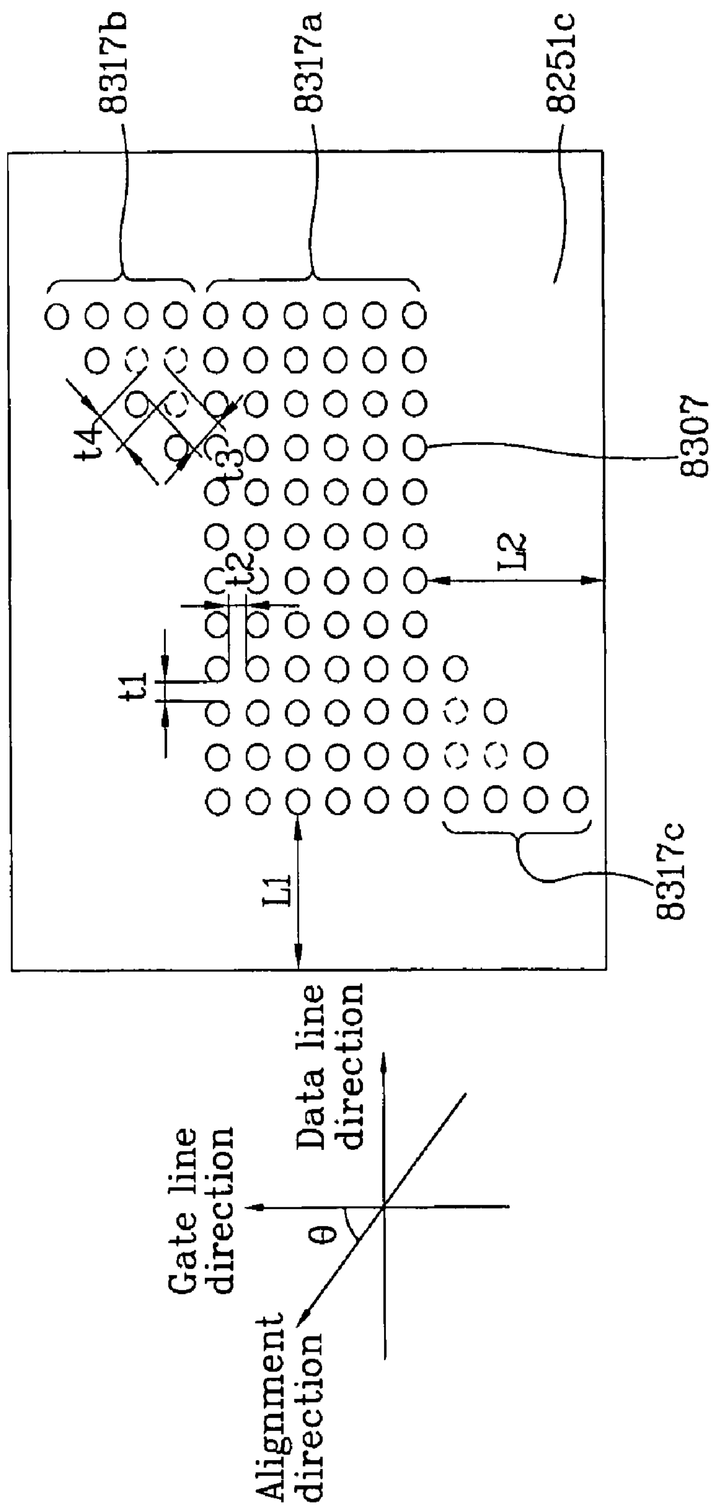

8317b
8317a
8251c
8307
t4
t3
t2
t1
L2
L1
8317c
Data line direction
Gate line direction
θ
Alignment direction

FIG. 53F

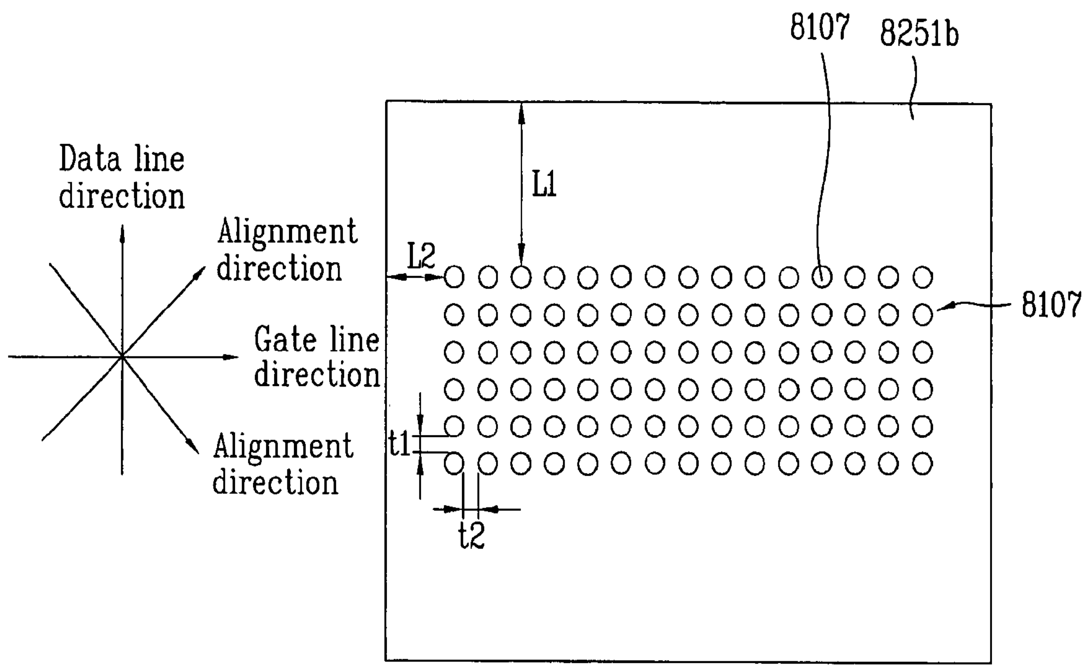

8107
8251b
Data line direction
Alignment direction
L1
L2
8107
Gate line direction
t1
Alignment direction
t2

FIG. 53G

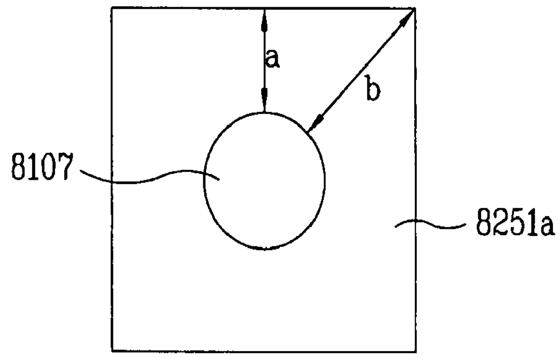


FIG. 53H

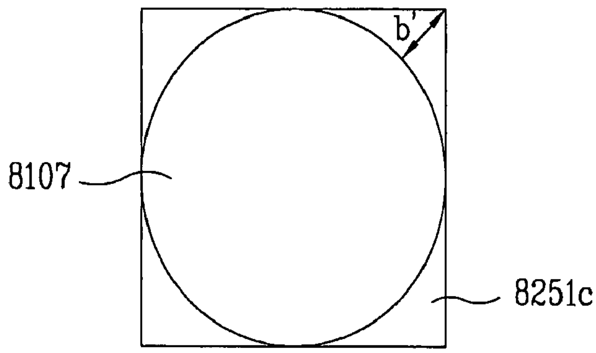


FIG. 53I

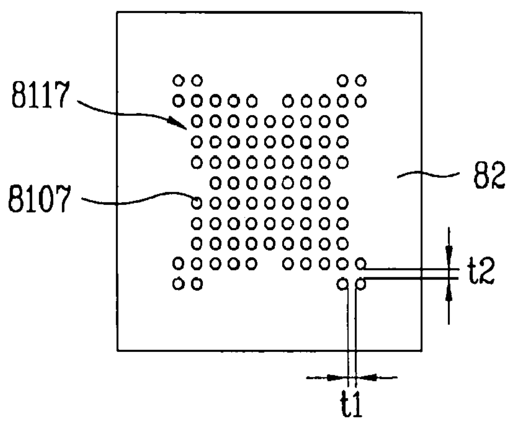


FIG. 53J

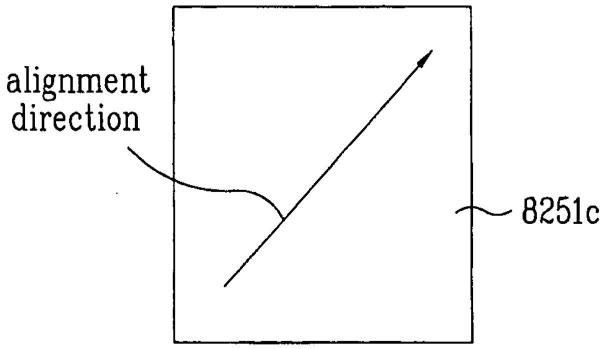


FIG. 53K

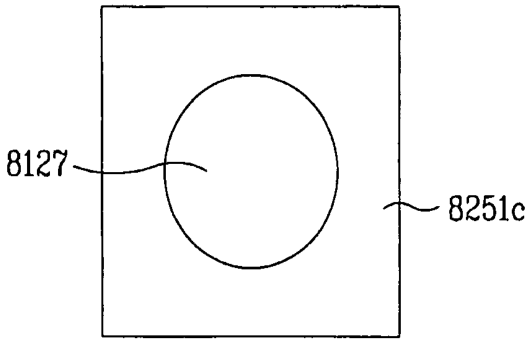


FIG. 53L

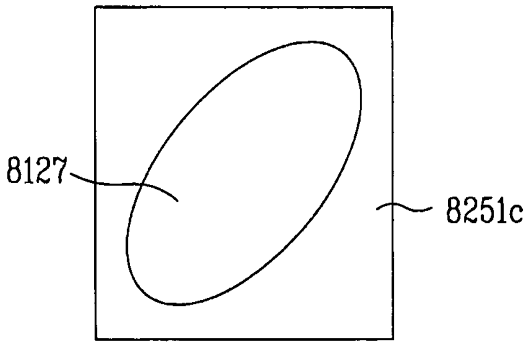


FIG. 53M

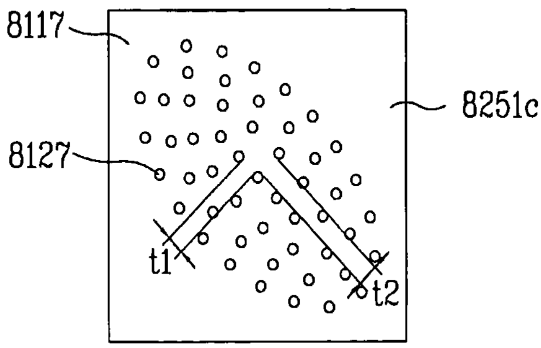


FIG. 53N

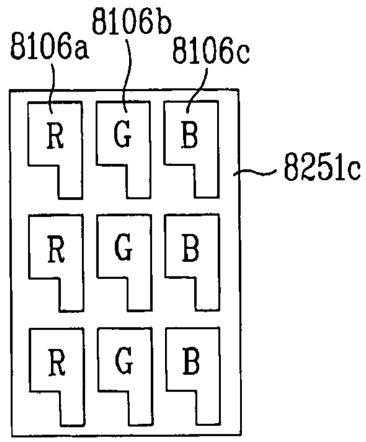


FIG. 53O

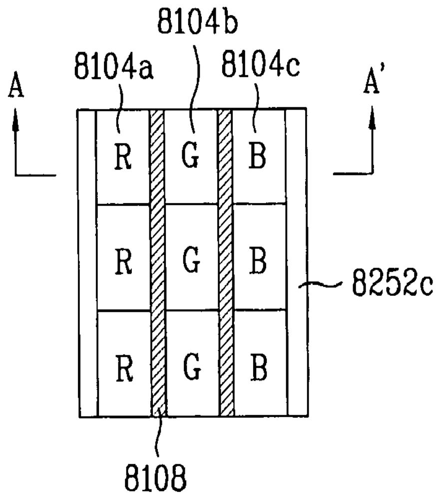


FIG. 53P

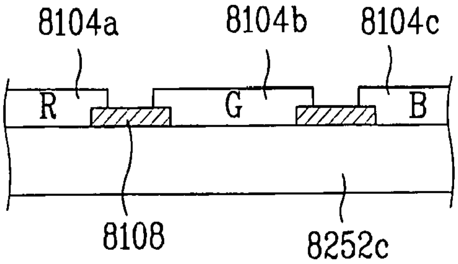


FIG. 53Q

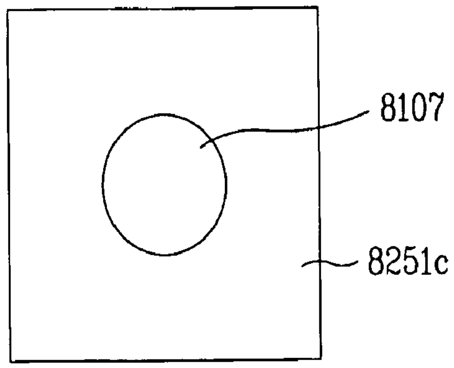


FIG. 53R

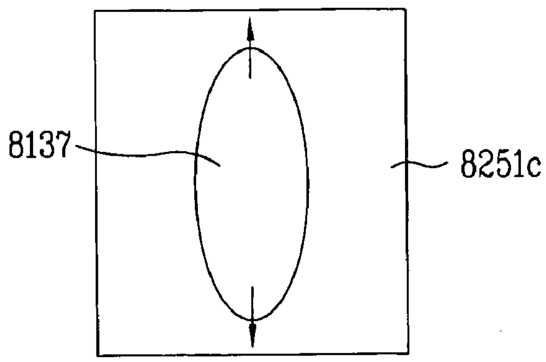


FIG. 53S

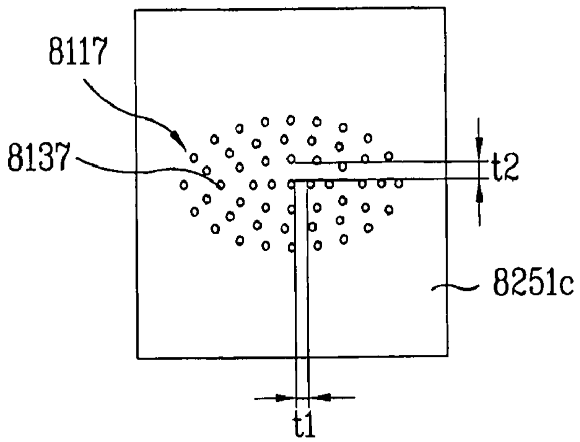


FIG. 53T

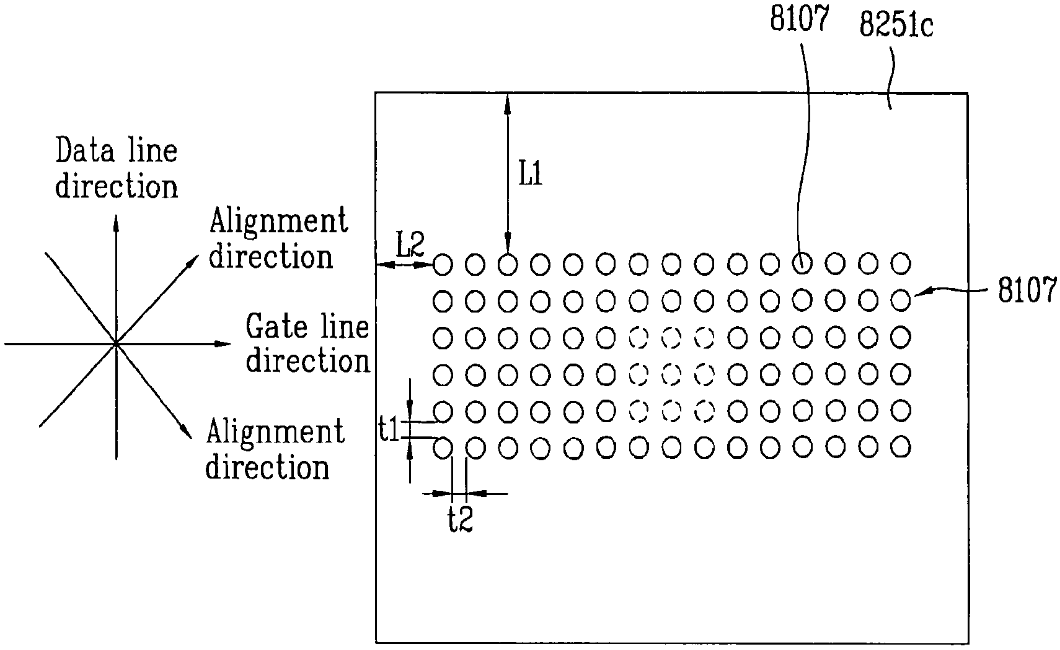


FIG. 53U

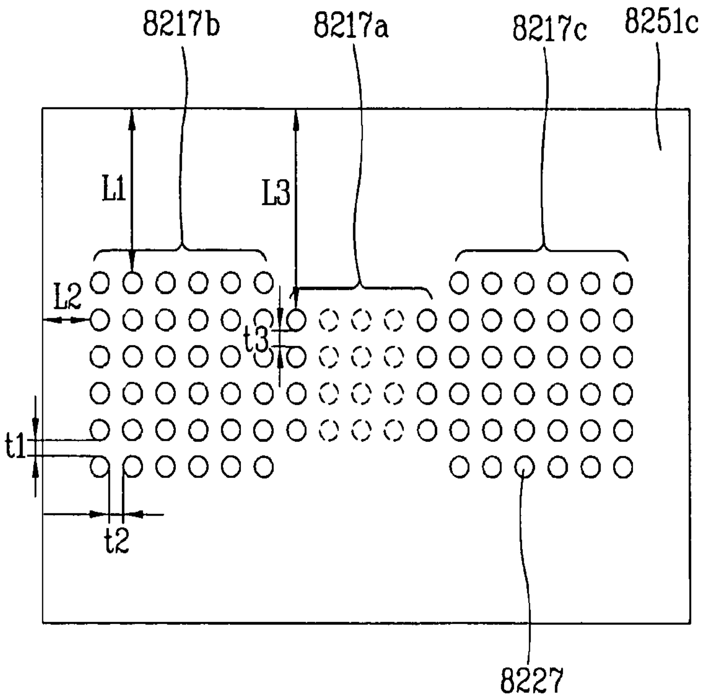


FIG. 53V

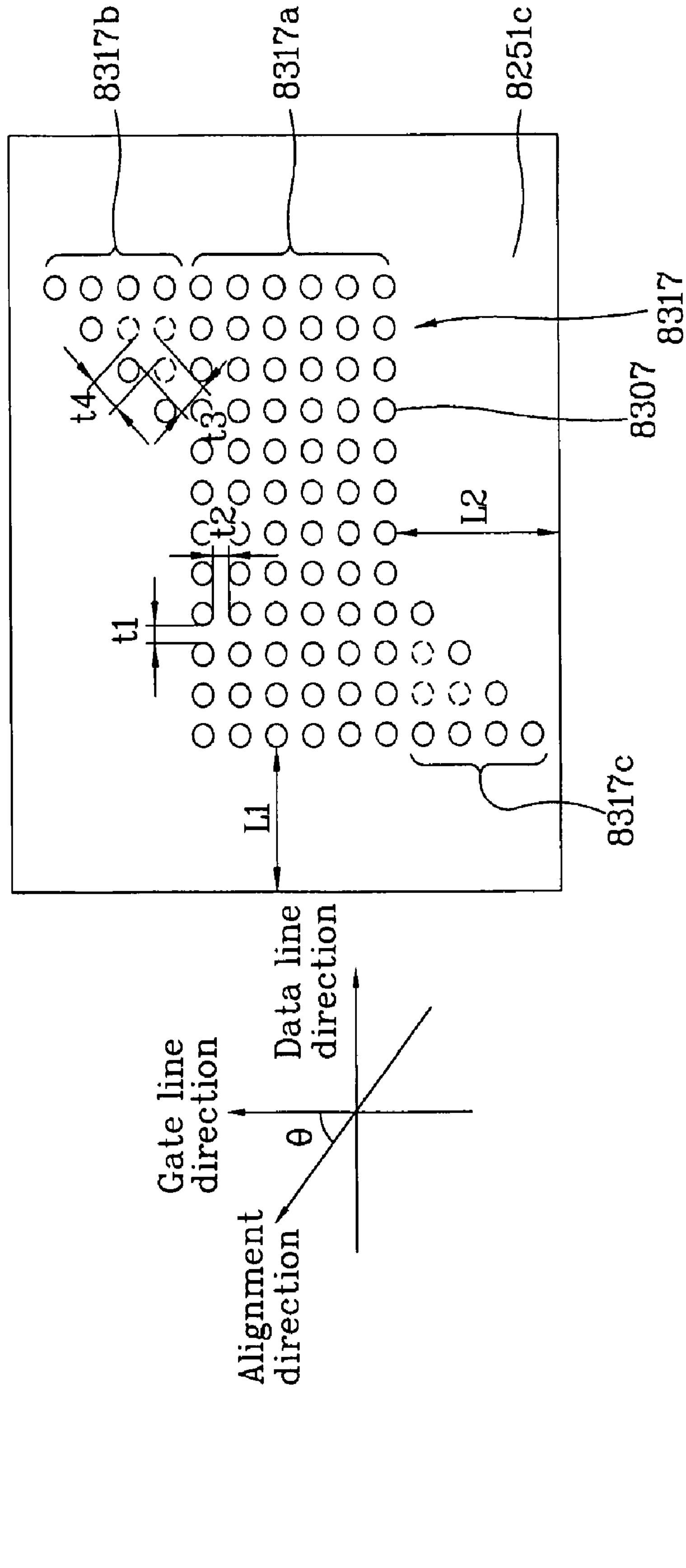

8317b
8317a
8251c
8317
8307
t4
t3
t2
t1
L2
L1
8317c
Gate line direction
Data line direction
θ
Alignment direction

FIG. 54A

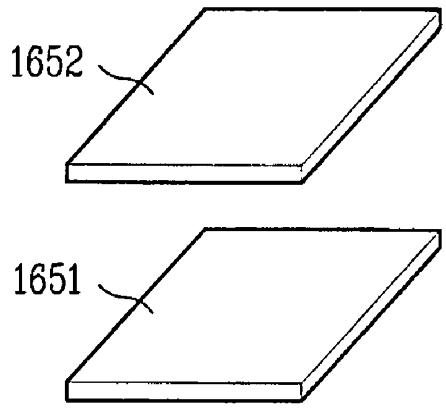


FIG. 54B

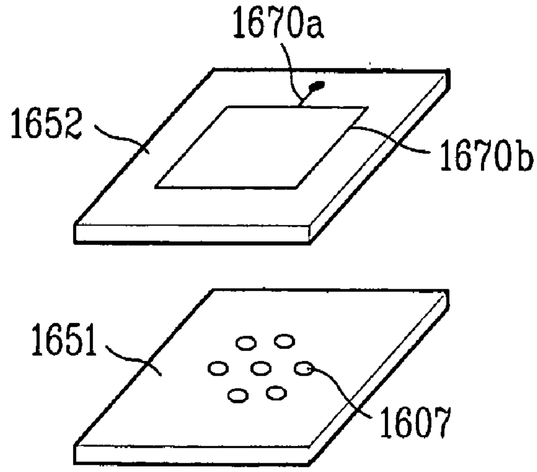


FIG. 54C

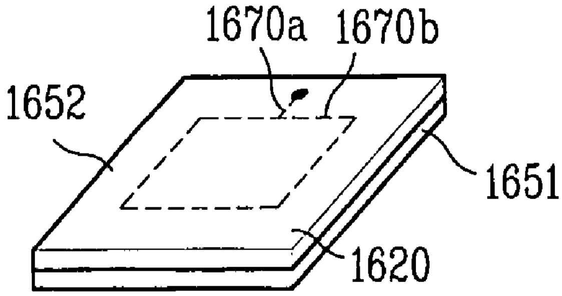


FIG. 54D

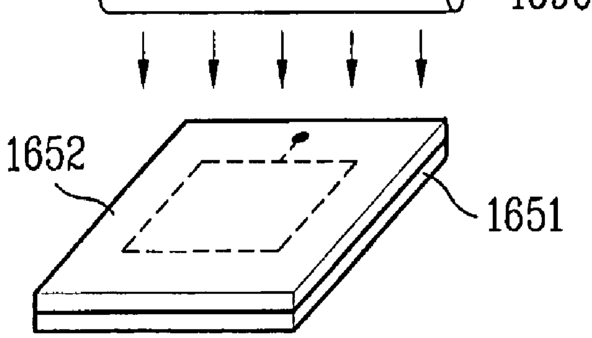


FIG. 55A

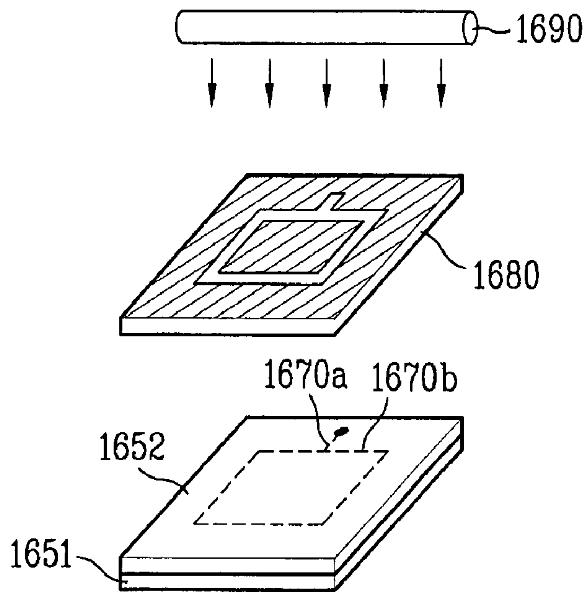


FIG. 55B

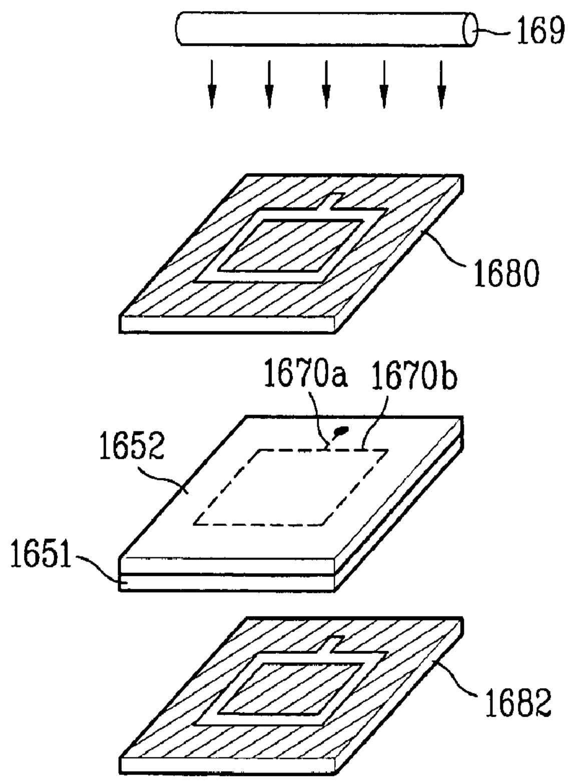


FIG. 55C

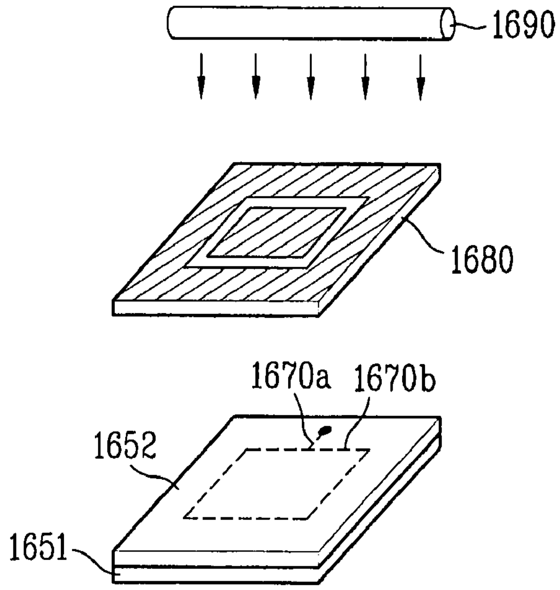


FIG. 55D

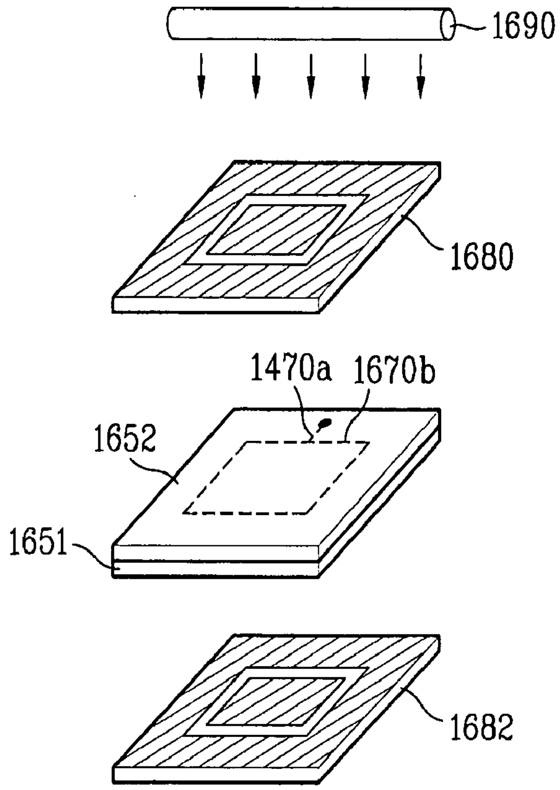


FIG. 56A

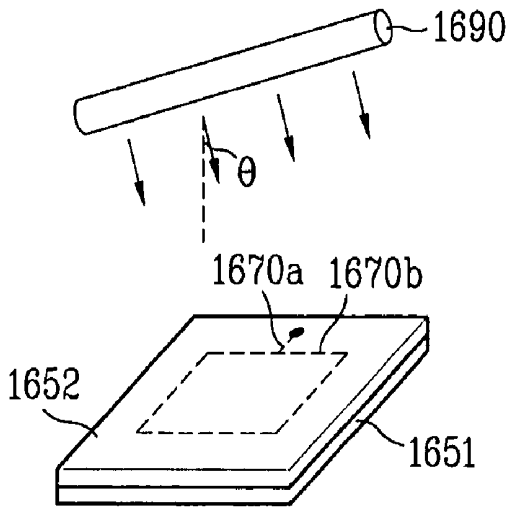


FIG. 56B

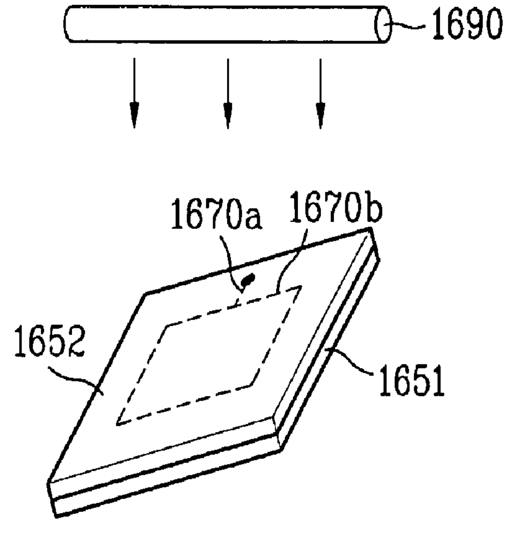


FIG. 57

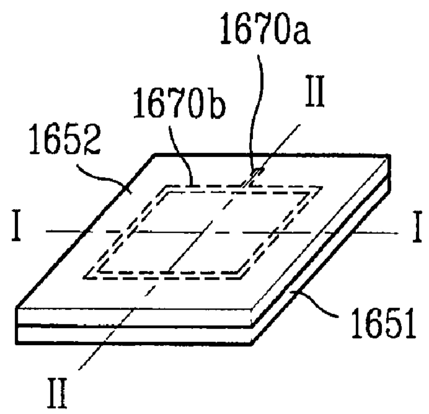


FIG. 58A

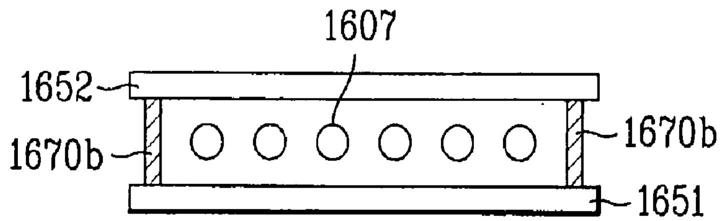


FIG. 58B

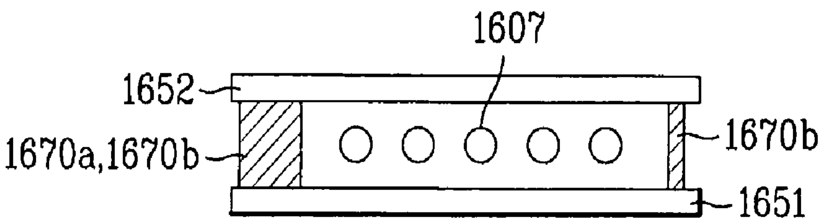


FIG. 59A

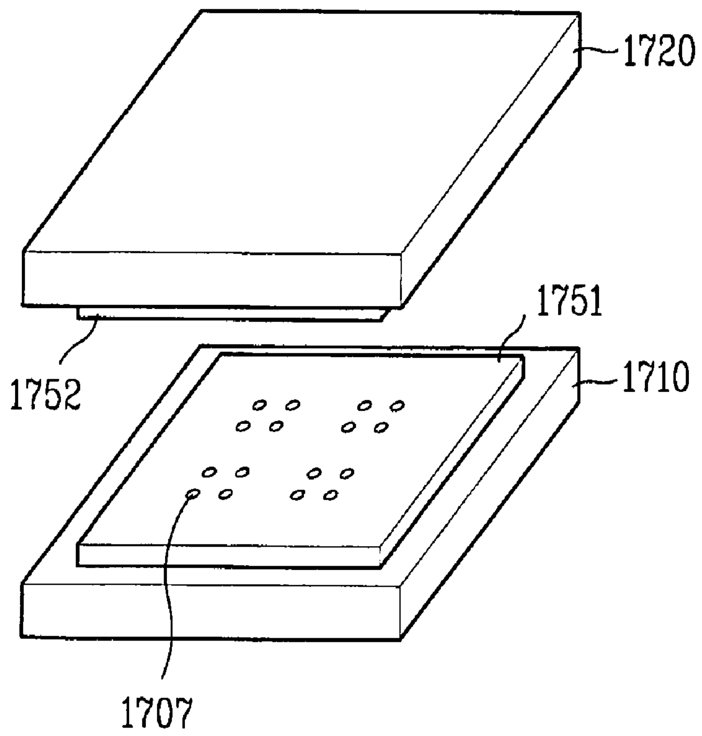


FIG. 59B

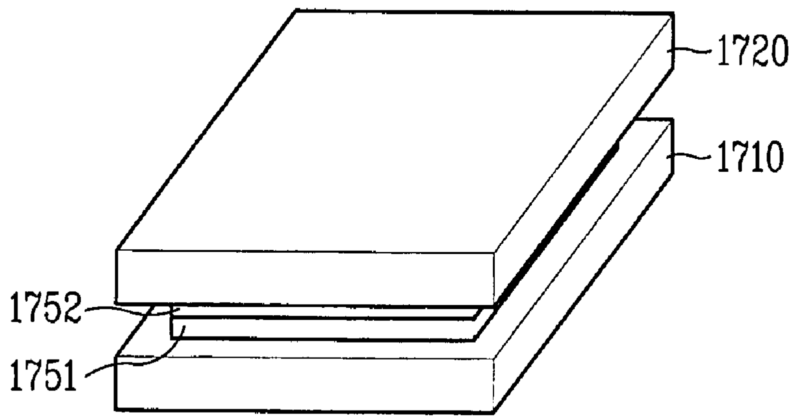


FIG. 59C

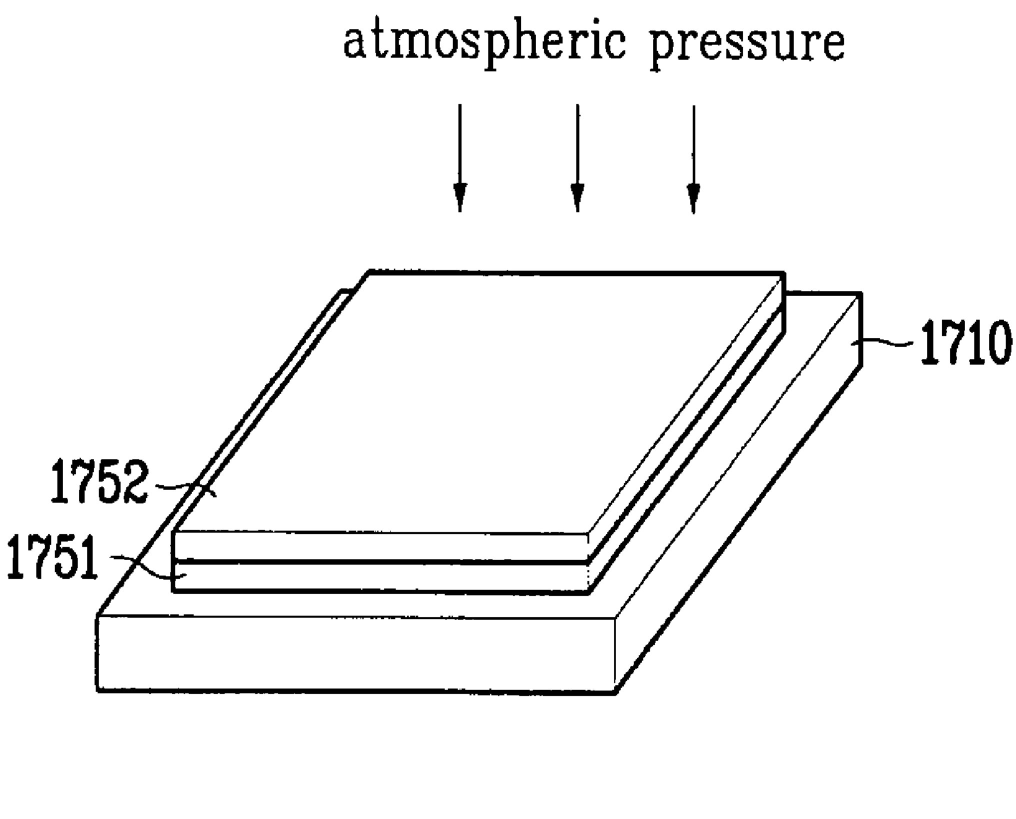


FIG. 60A

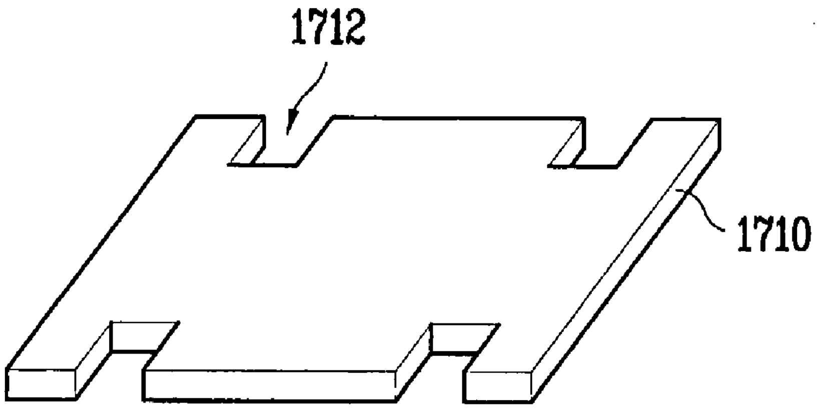


FIG. 60B

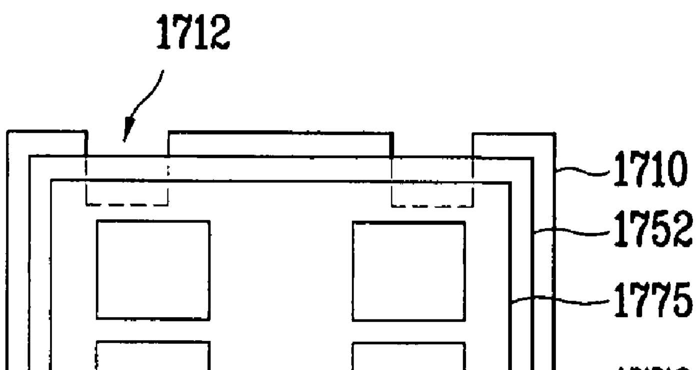


FIG. 61A

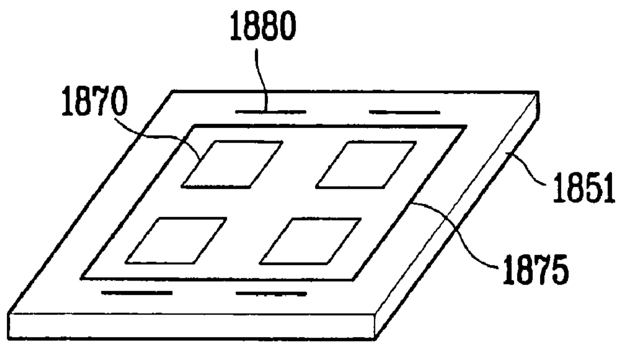


FIG. 61B

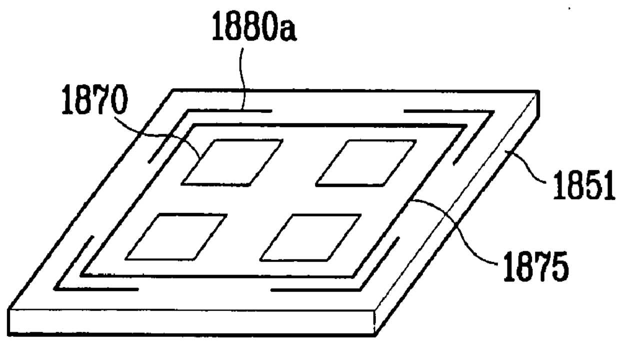


FIG. 61C

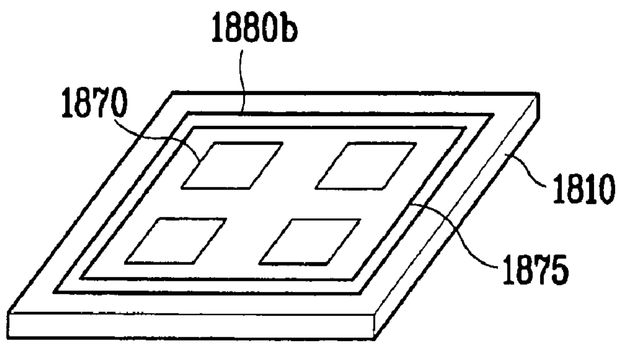


FIG. 62A

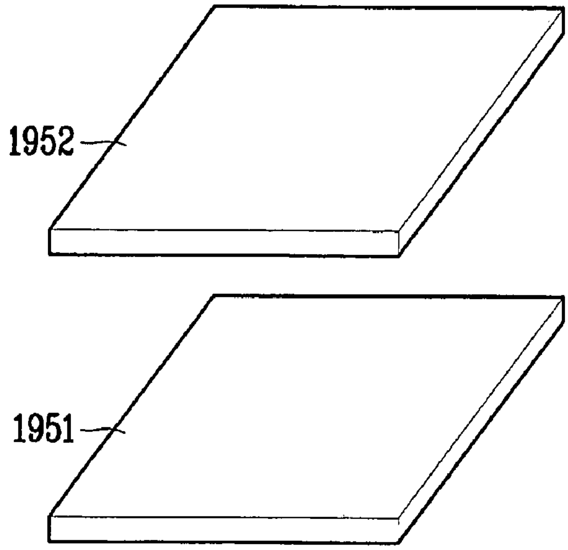


FIG. 62B

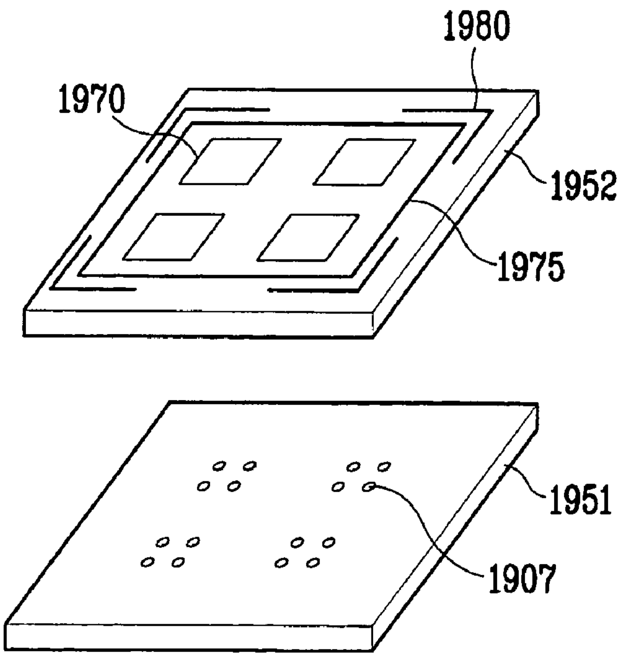


FIG. 62C

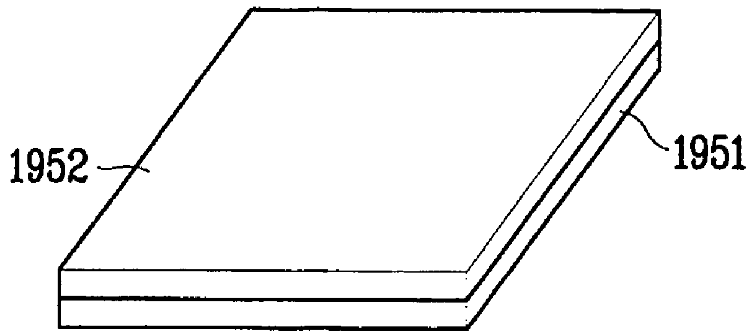


FIG. 62D

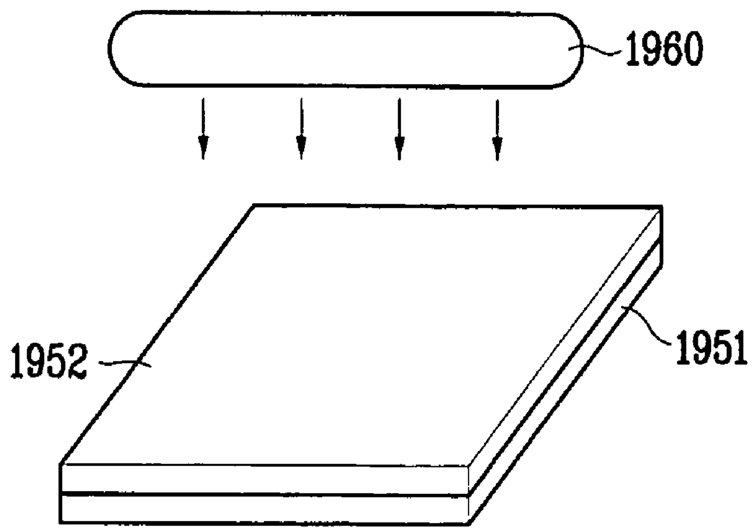


FIG. 62E

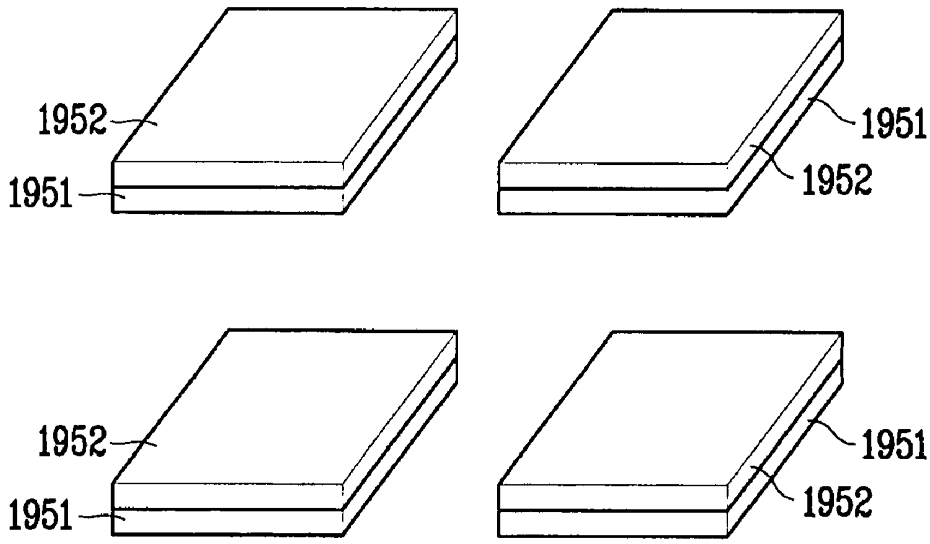


FIG. 63

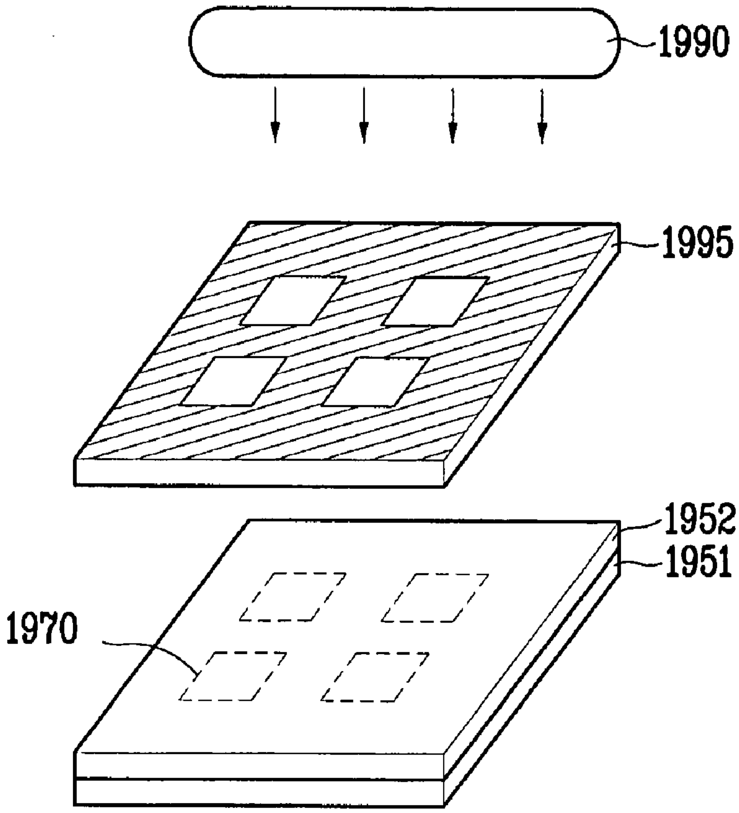


FIG. 64

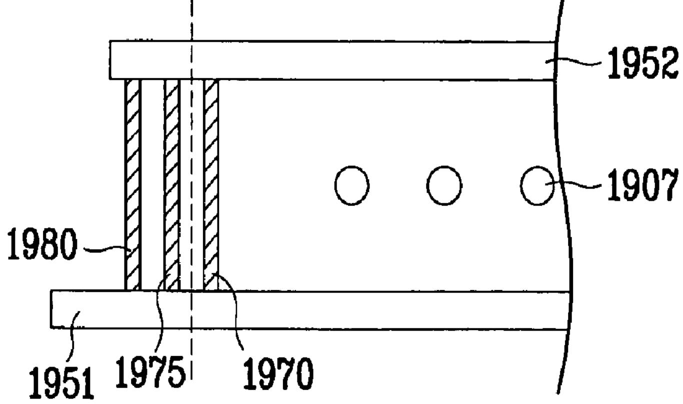


FIG. 65A

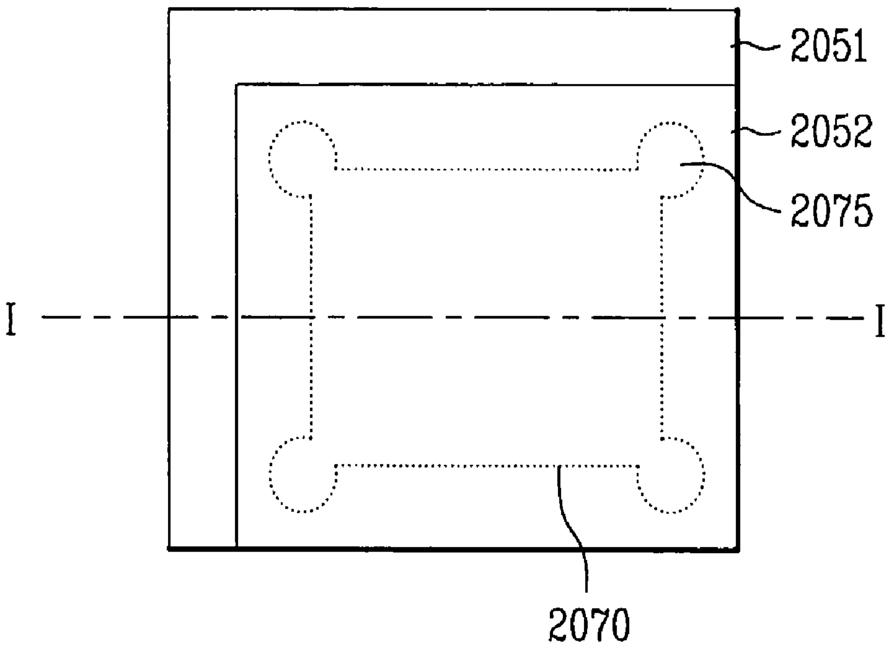


FIG. 65B

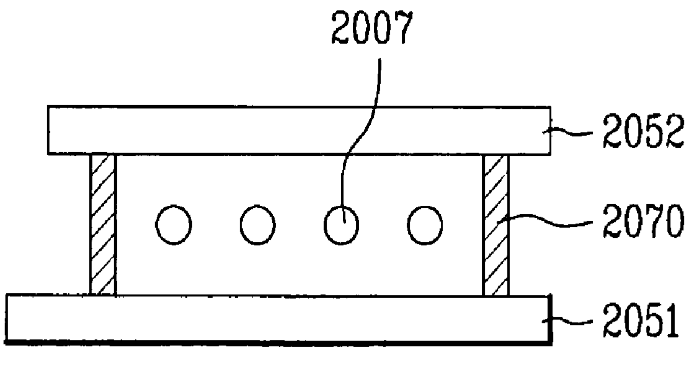


FIG. 66A

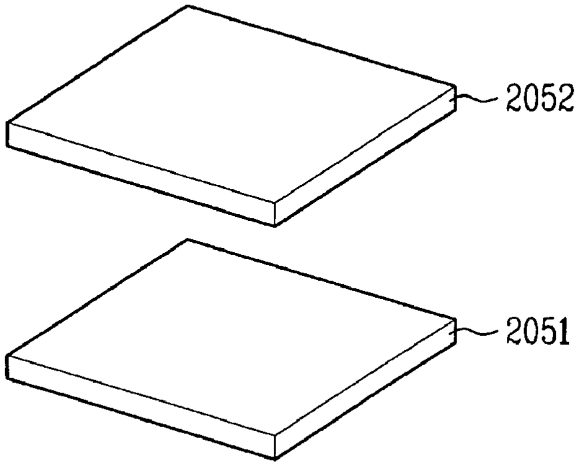


FIG. 66B

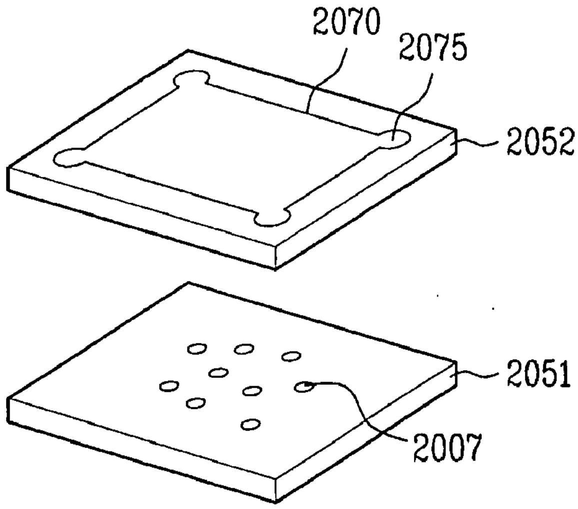


FIG. 66C

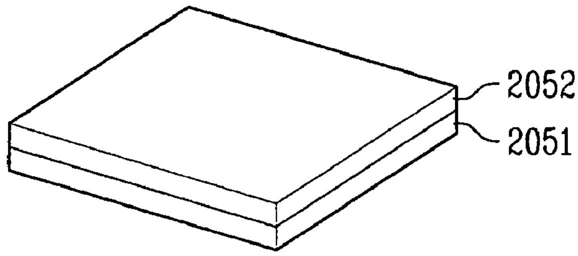


FIG. 66D

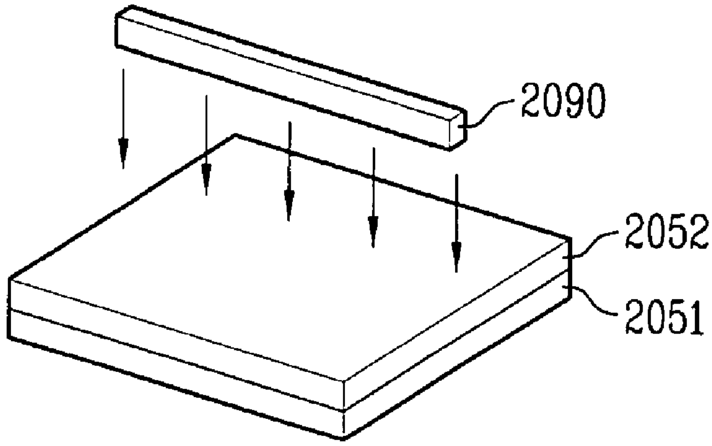


FIG. 67

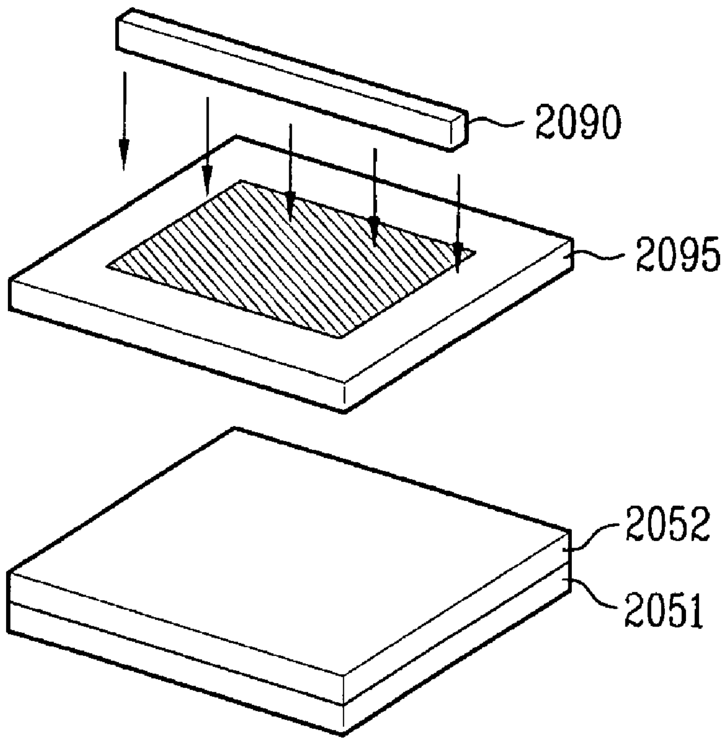


FIG. 68

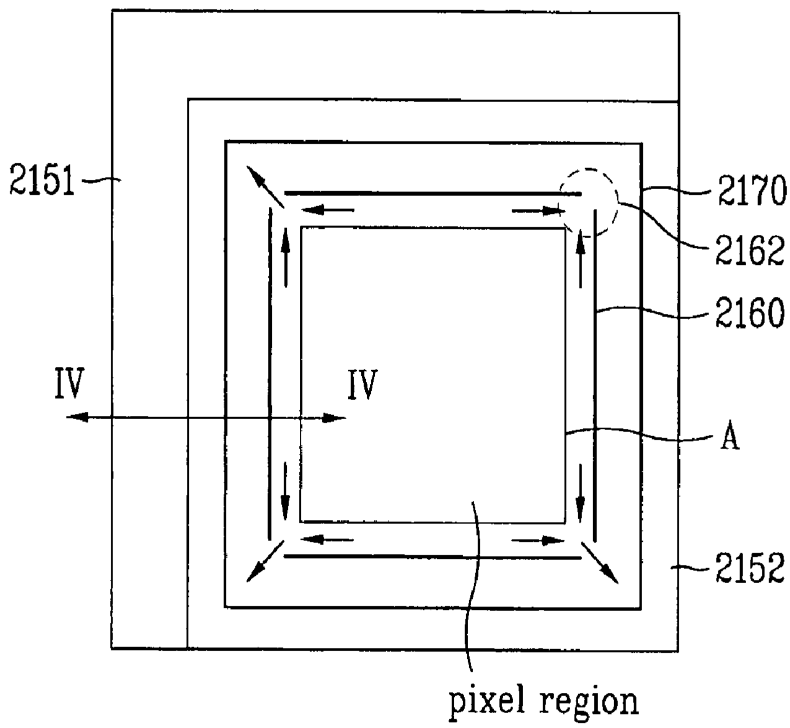


FIG. 69A

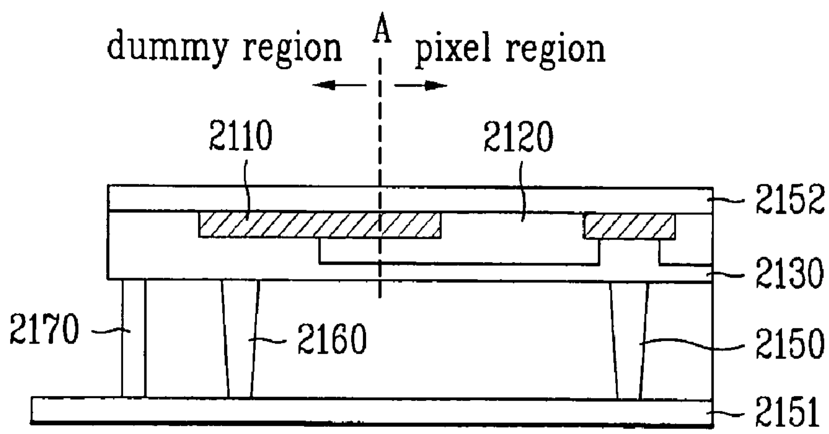


FIG. 69B

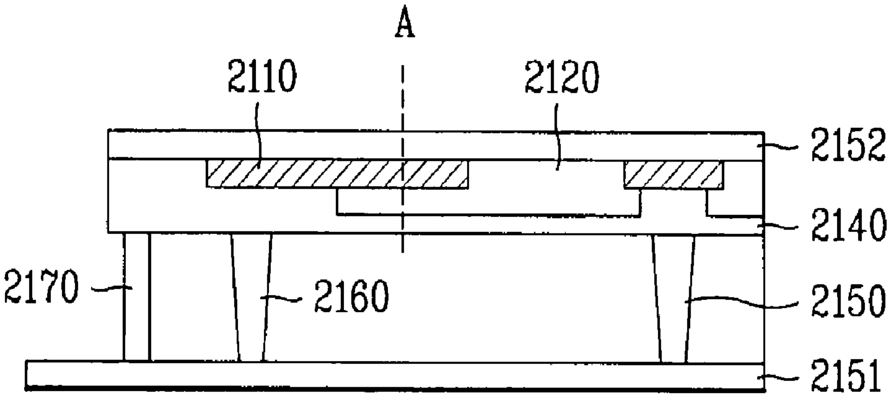


FIG. 69C

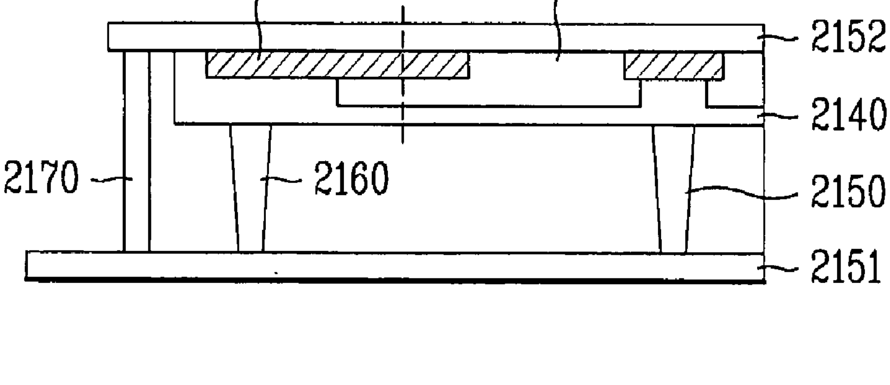


FIG. 70

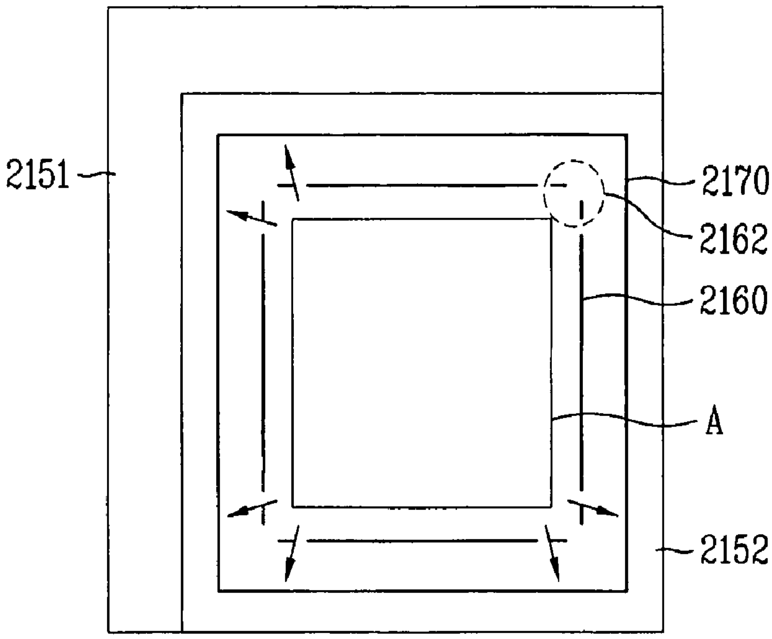

2151
2170
2162
2160
A
2152

FIG. 71

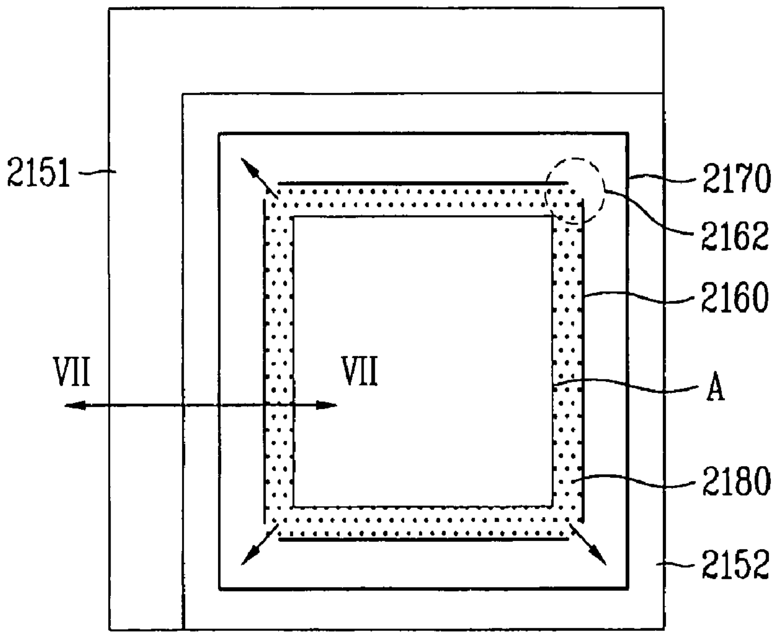

2151
2170
2162
2160
VII
VII
A
2180
2152

FIG. 72A

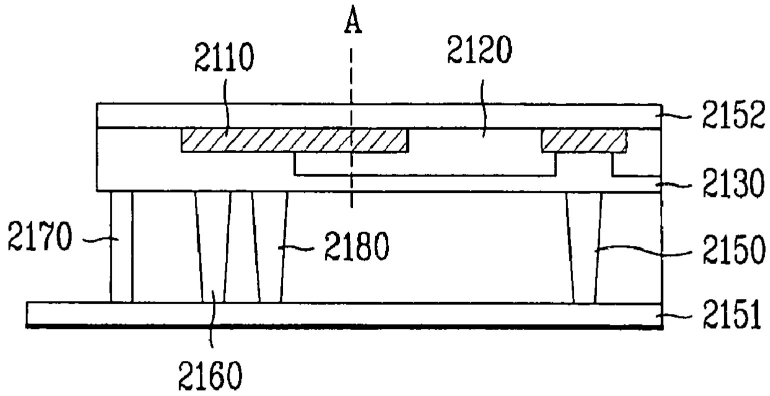


FIG. 72B

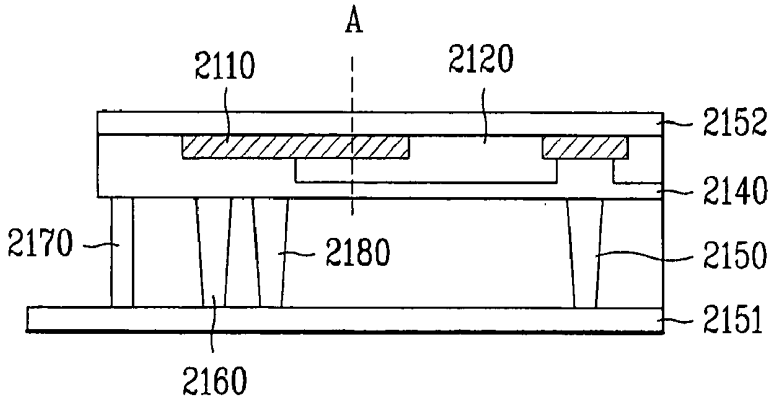


FIG. 72C

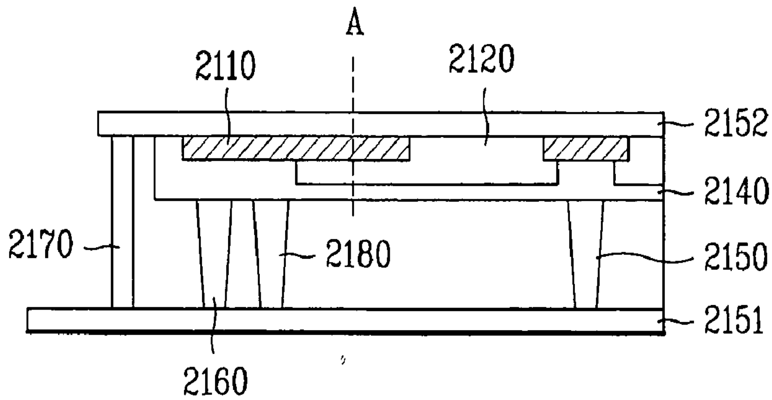


FIG. 73

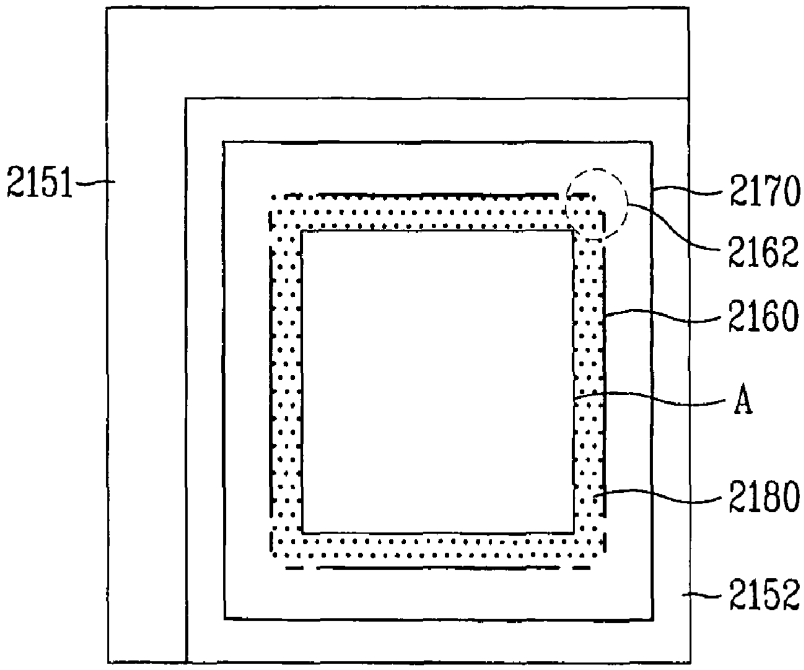

2151
2170
2162
2160
A
2180
2152

FIG. 74

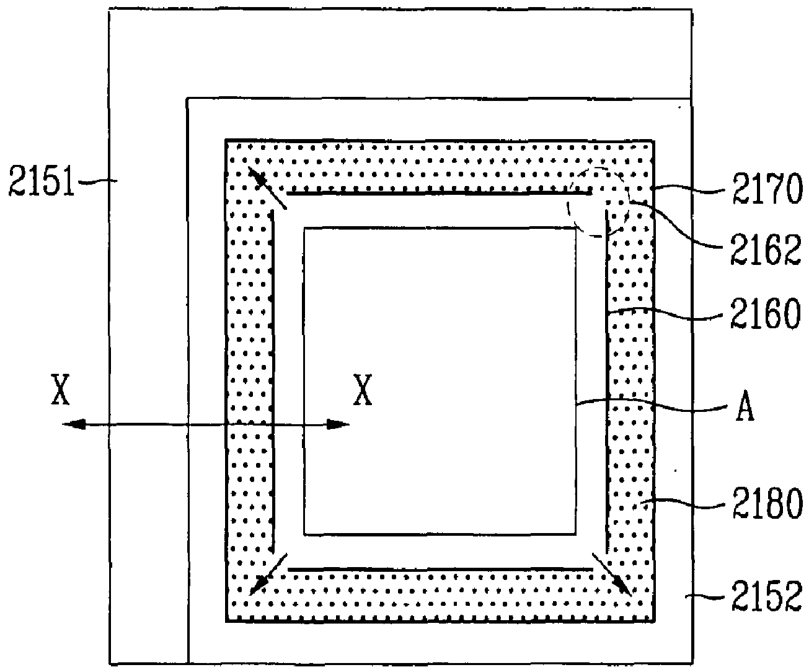

2151
2170
2162
2160
X
X
A
2180
2152

FIG. 75A

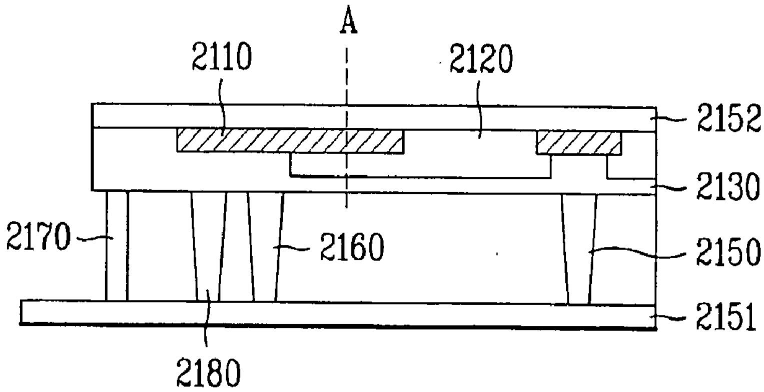


FIG. 75B

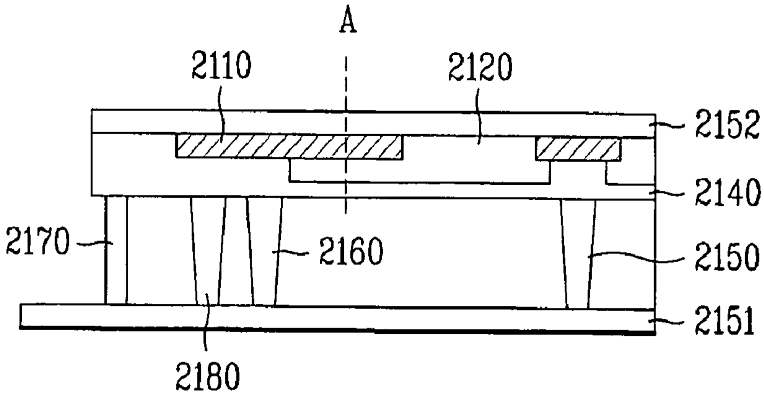


FIG. 75C

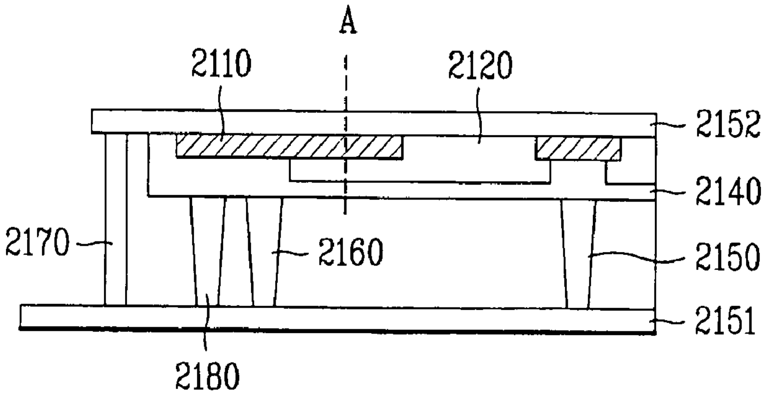


FIG. 76

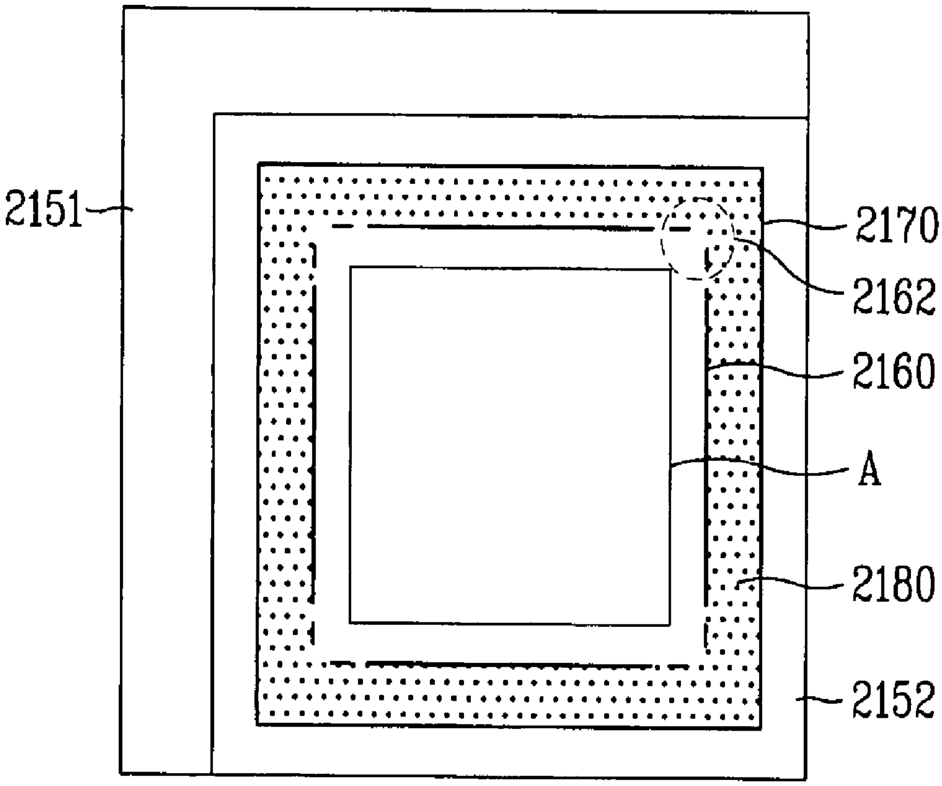


FIG. 77A

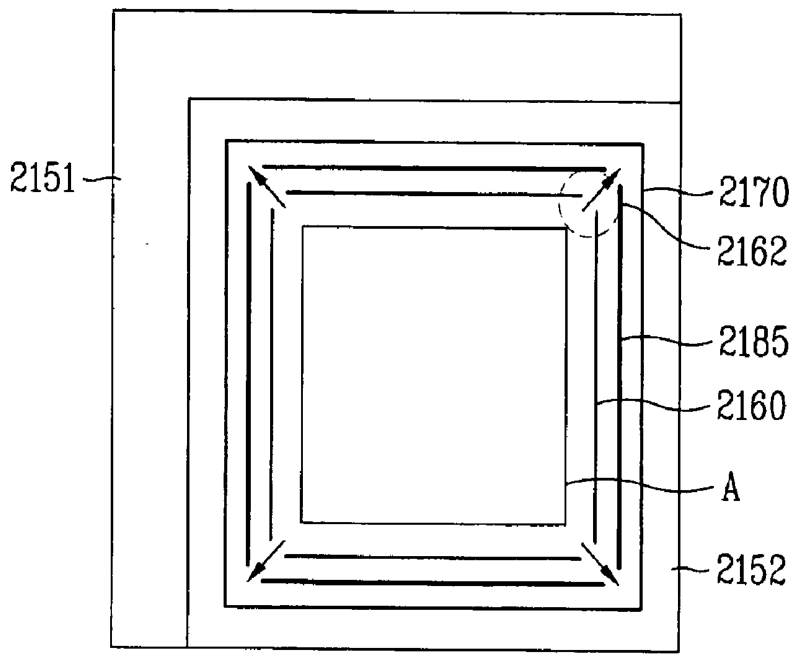


FIG. 77B

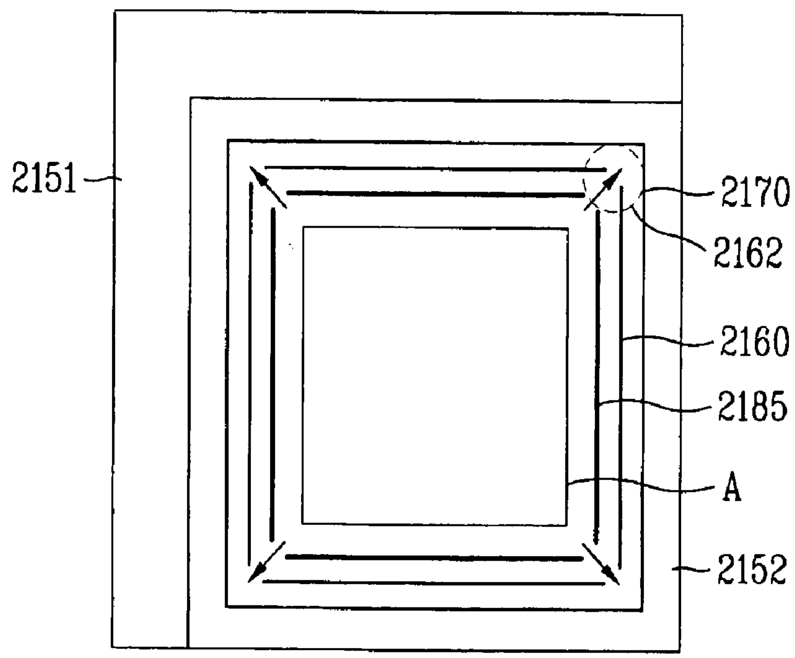


FIG. 78A

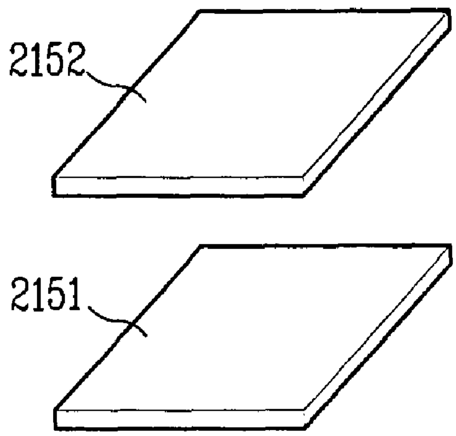


FIG. 78B

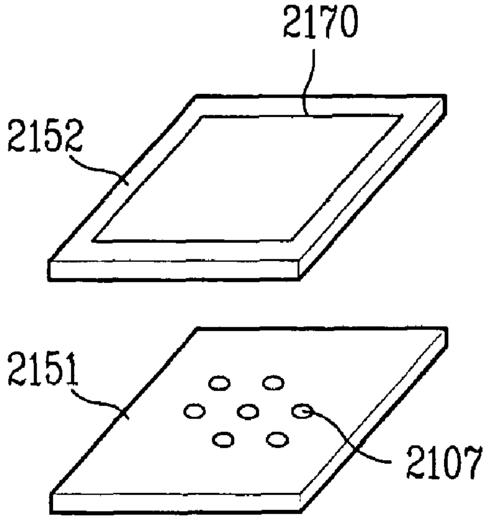


FIG. 78C

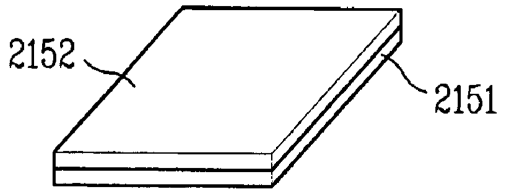


FIG. 78D

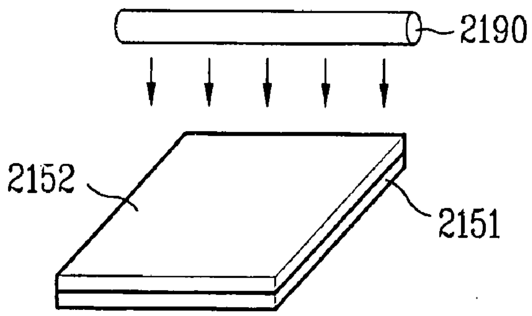


FIG. 79

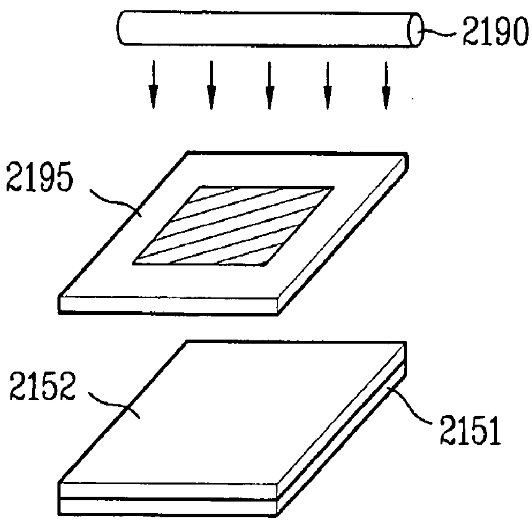


FIG. 80

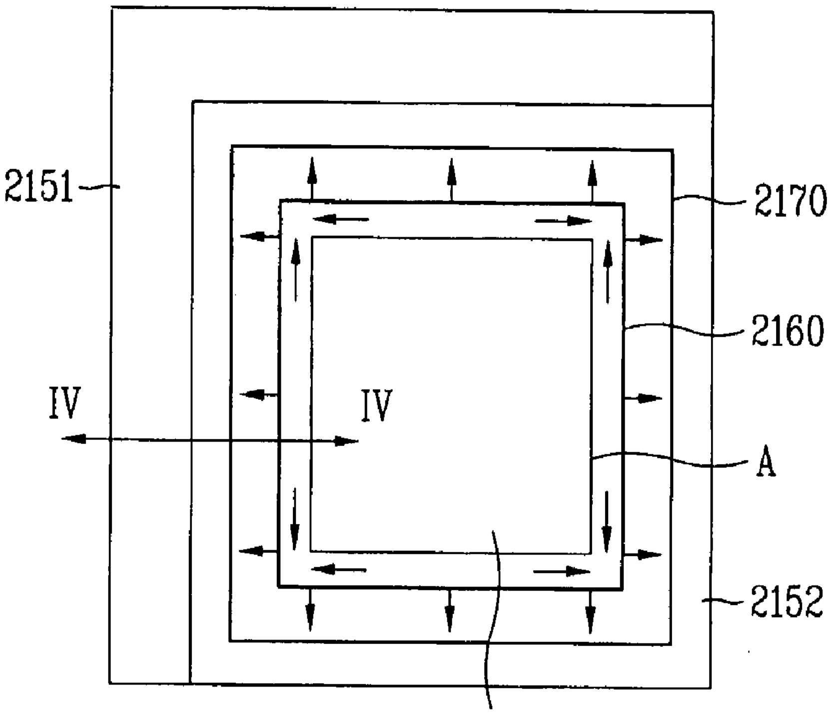


FIG. 81A

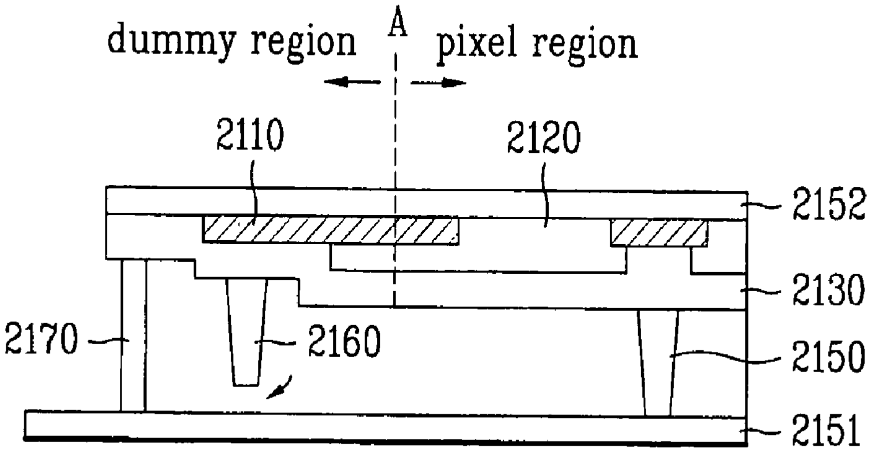


FIG. 81B

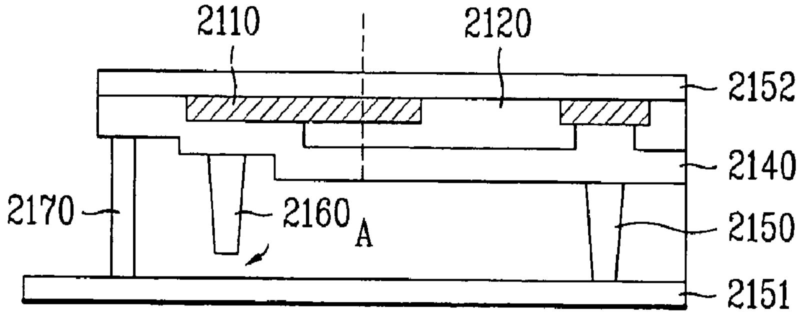


FIG. 81C

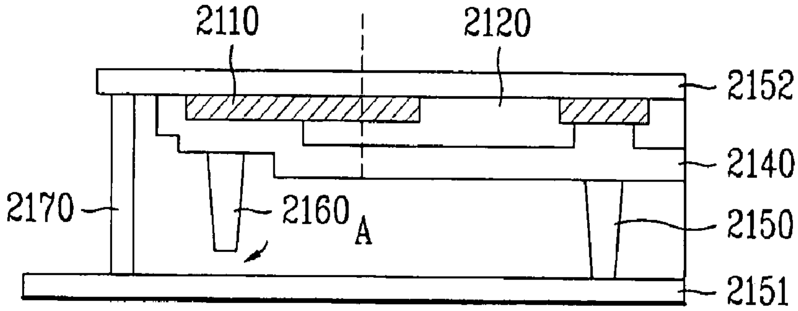


FIG. 81D

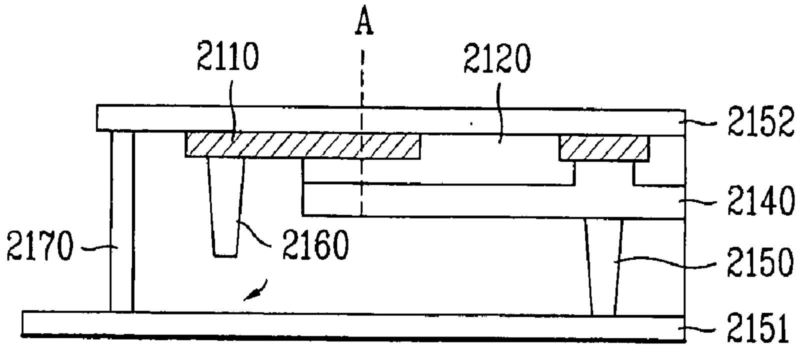


FIG. 82A

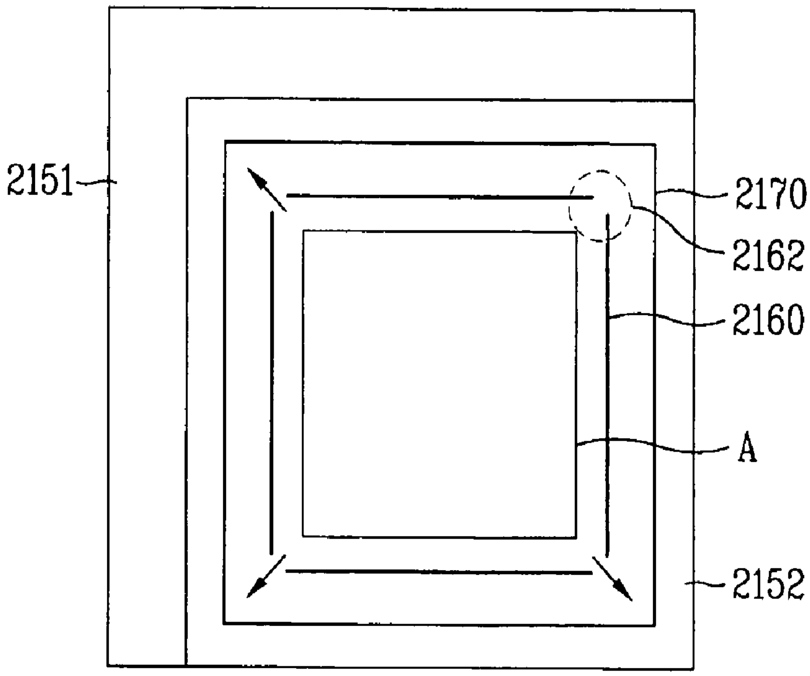


FIG. 82B

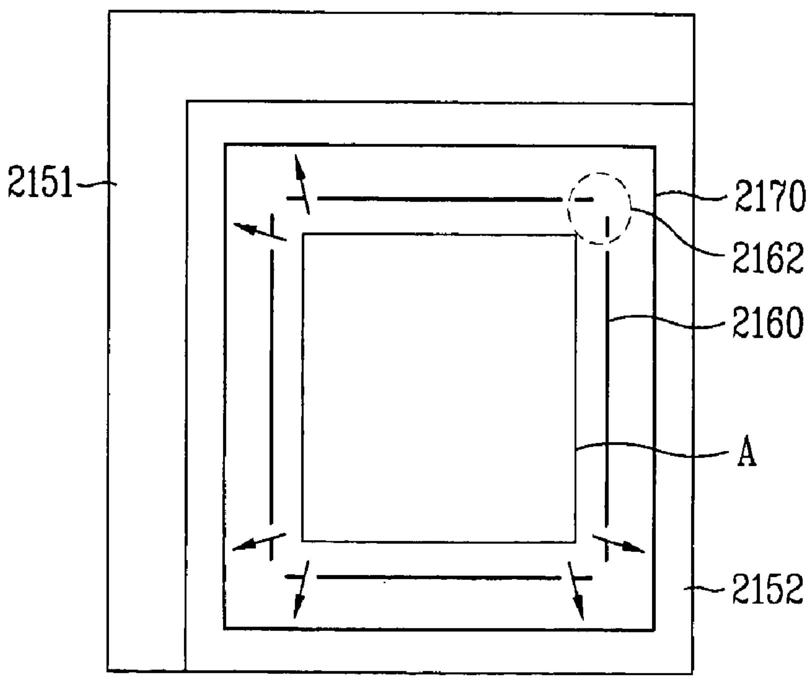


FIG. 83

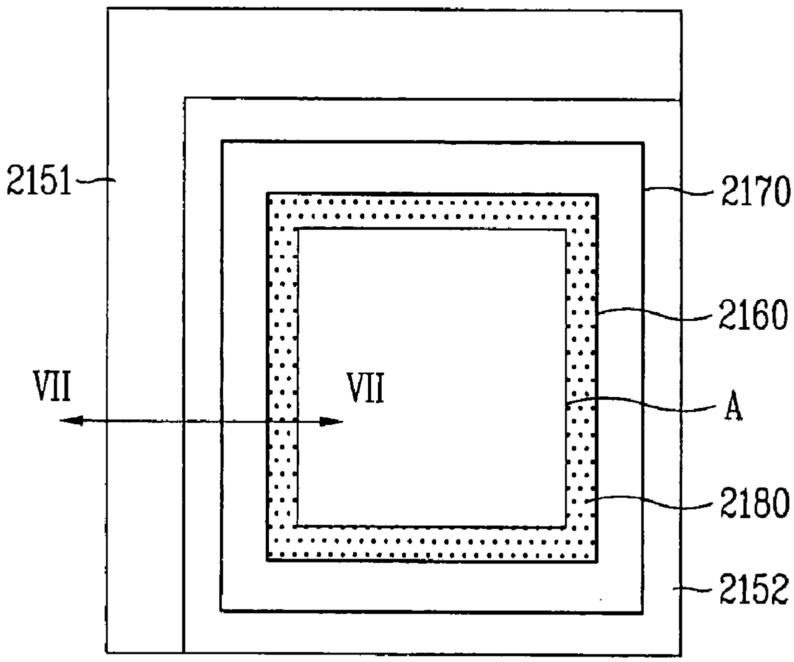


FIG. 84A

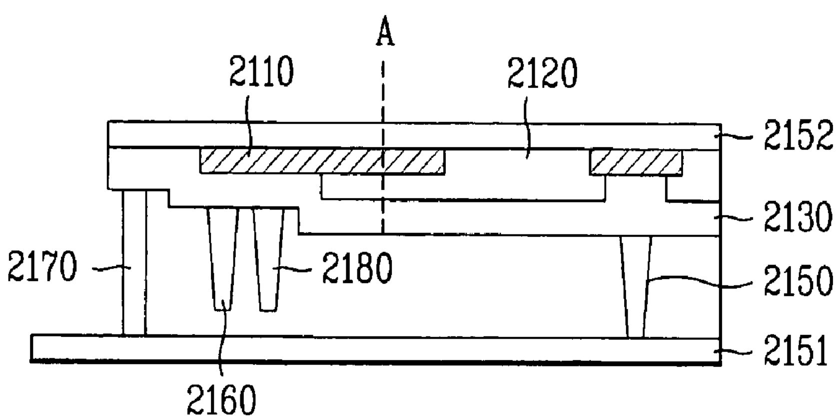


FIG. 84B

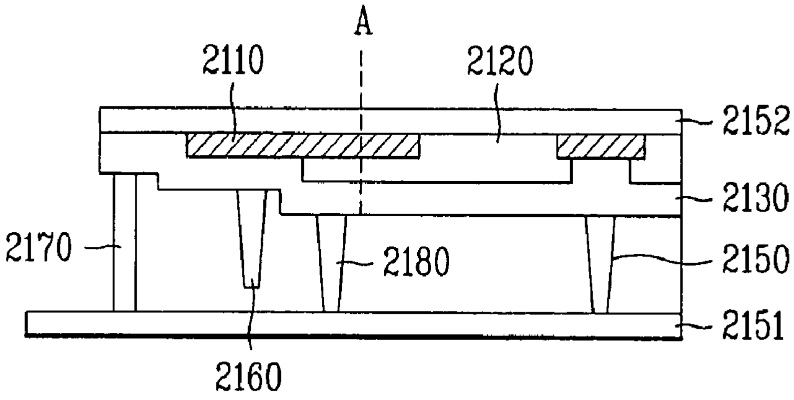


FIG. 84C

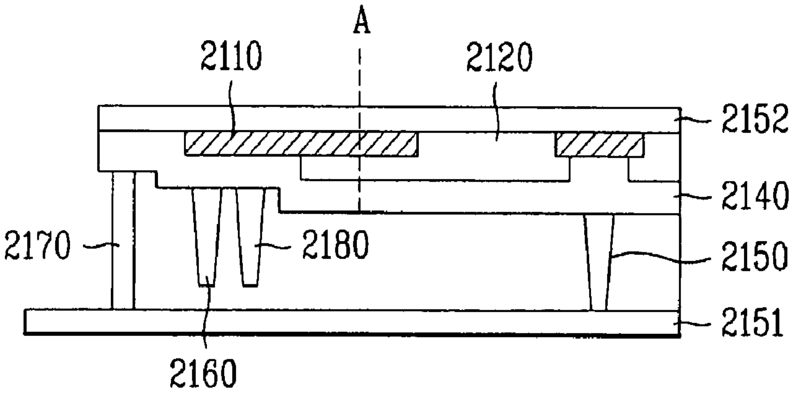


FIG. 84D

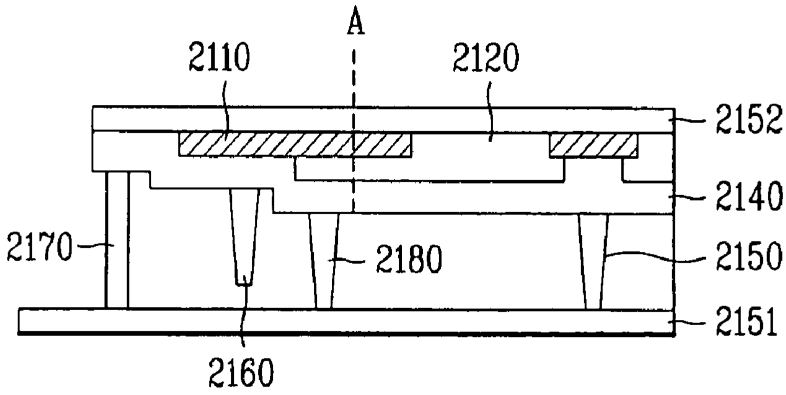


FIG. 84E

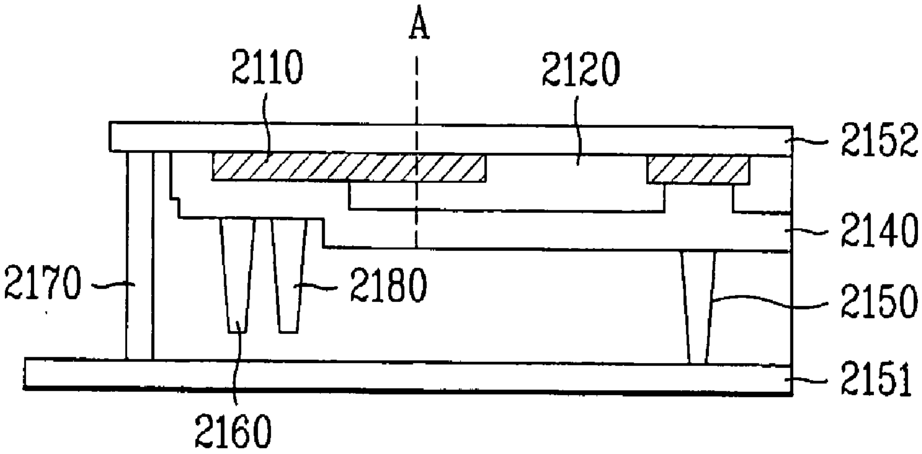


FIG. 84F

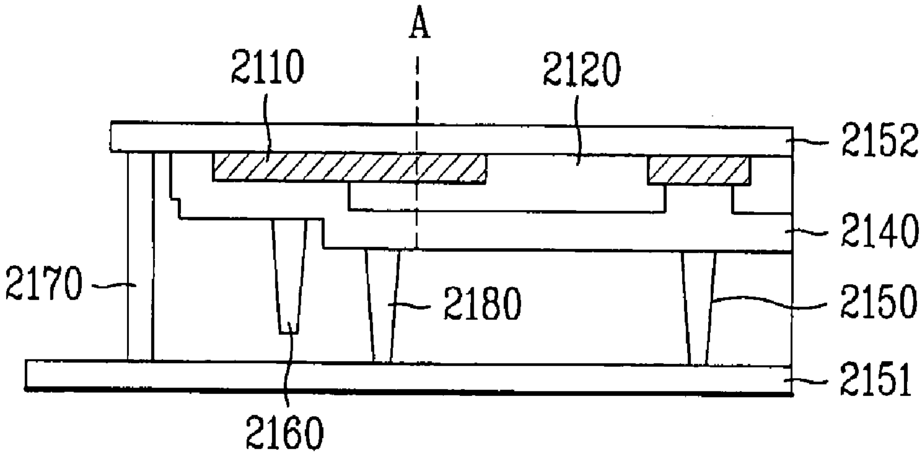


FIG. 84G

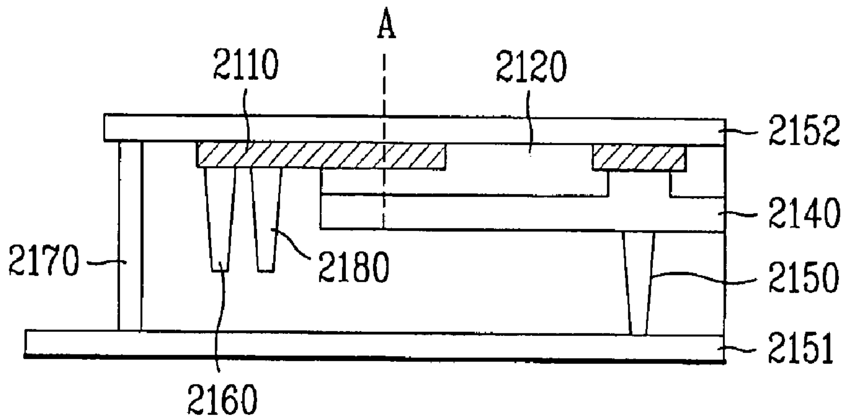


FIG. 84H

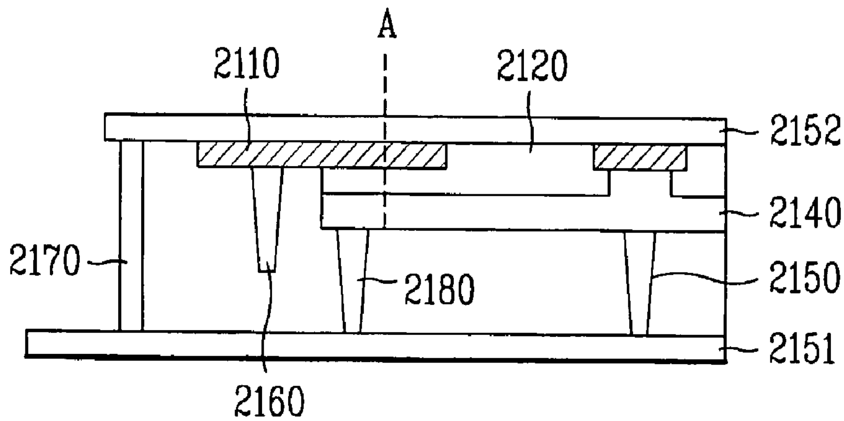


FIG. 85A

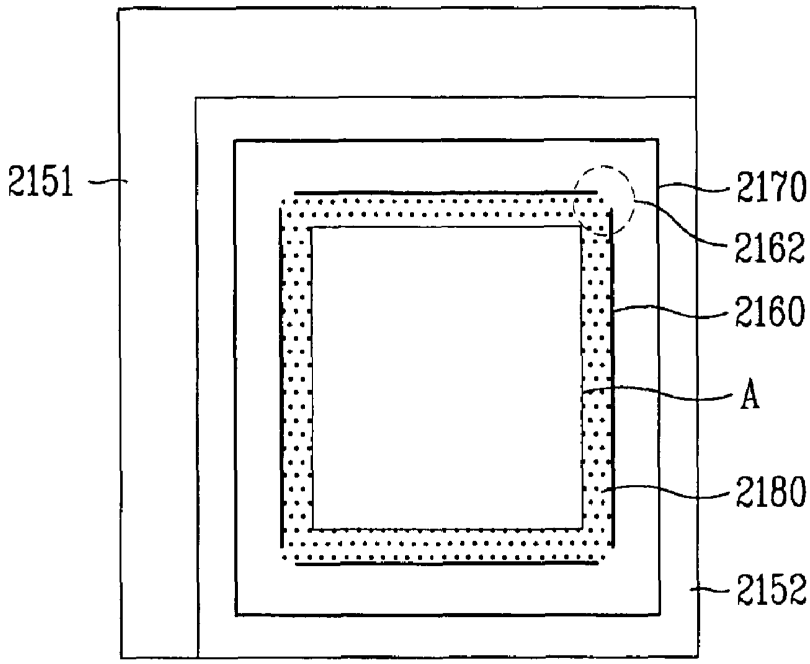


FIG. 85B

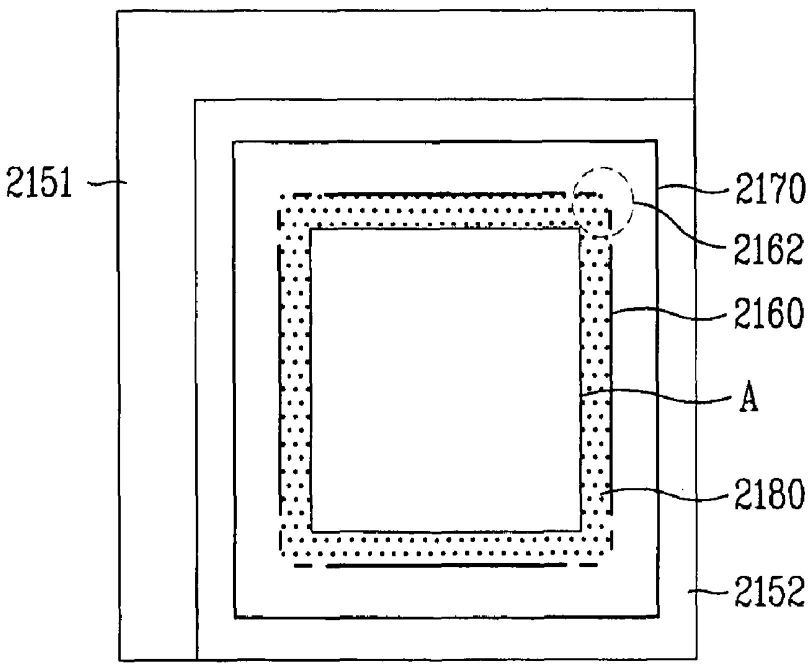


FIG. 86

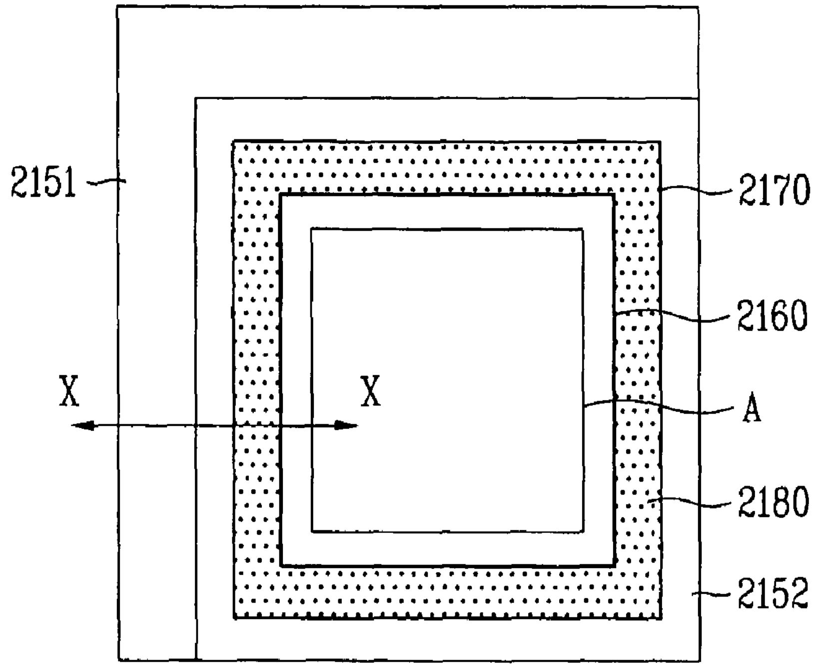


FIG. 87A

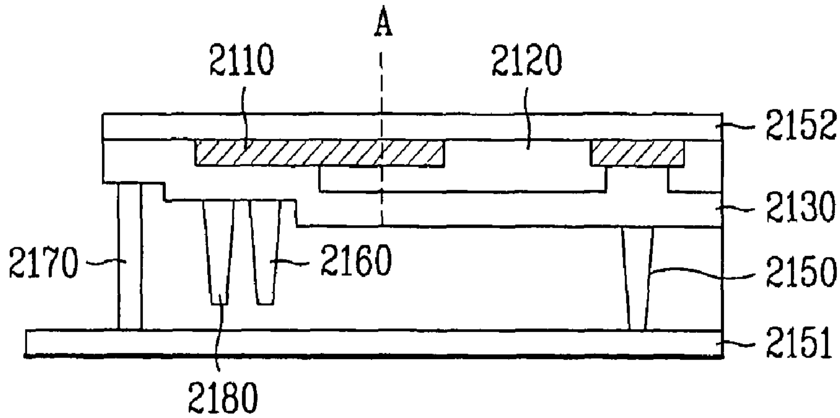


FIG. 87B

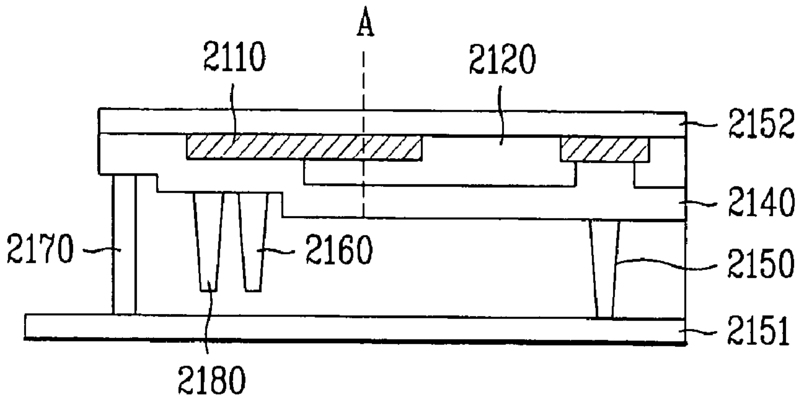


FIG. 87C

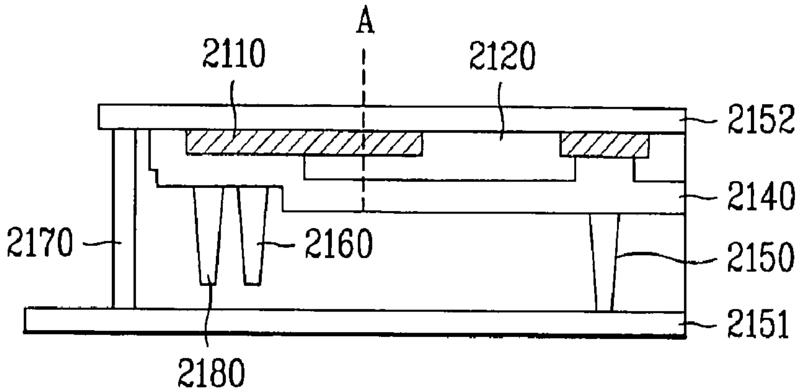


FIG. 87D

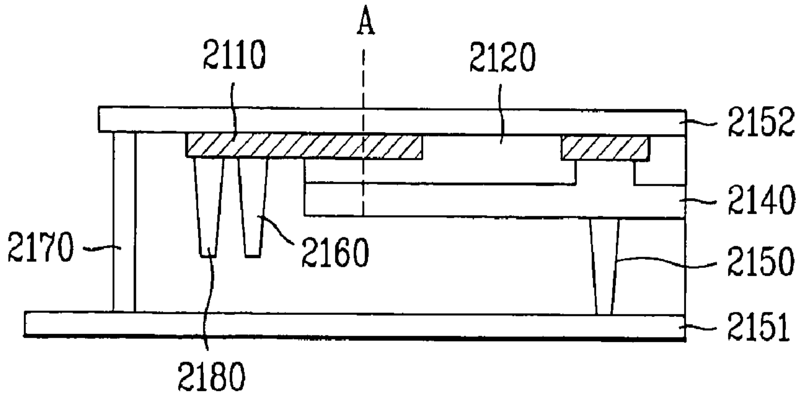


FIG. 88A

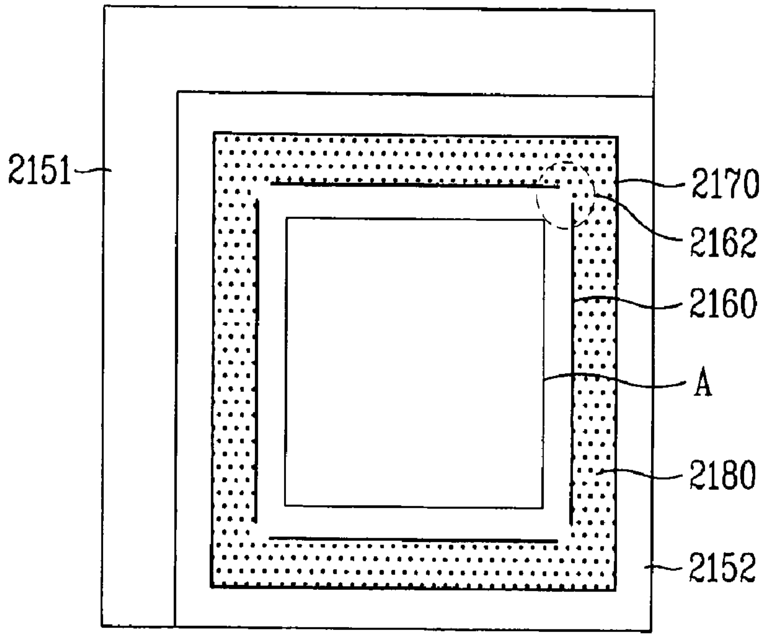


FIG. 88B

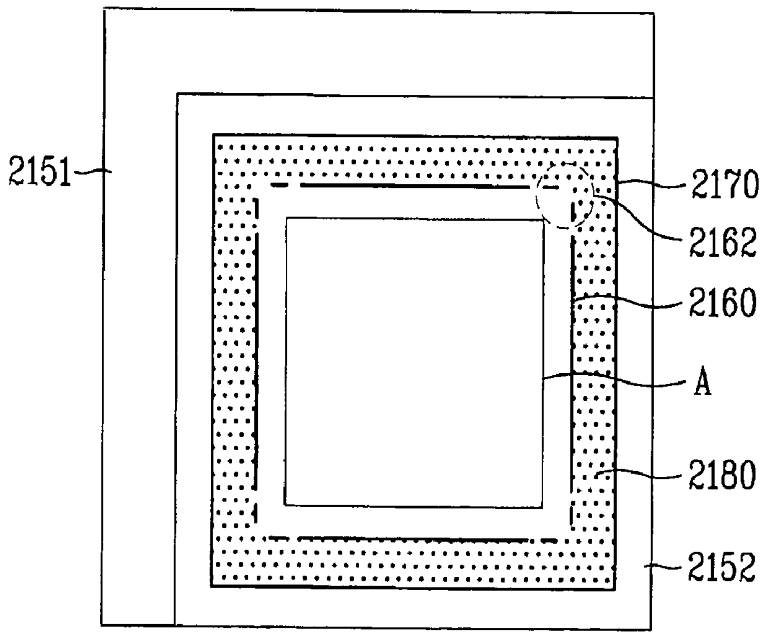


FIG. 89A

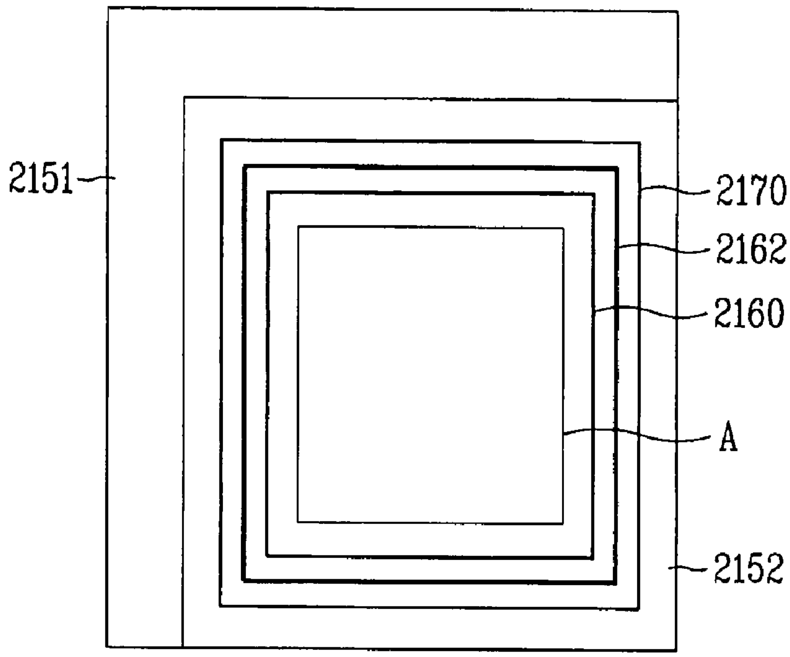


FIG. 89B

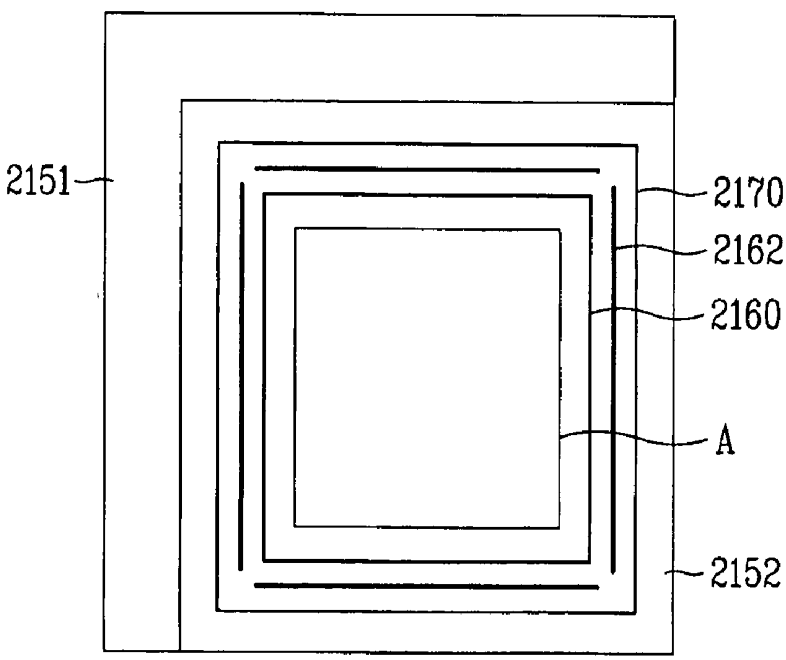


FIG. 89C

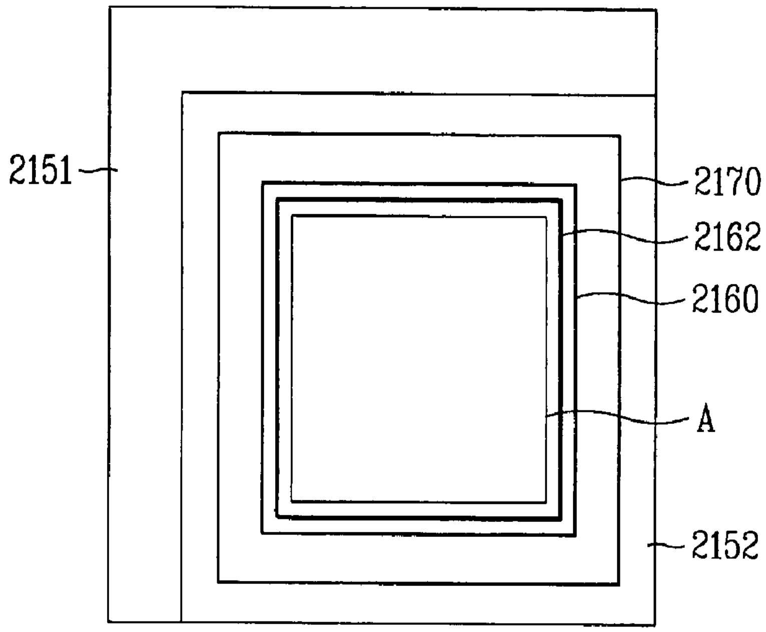


FIG. 89D

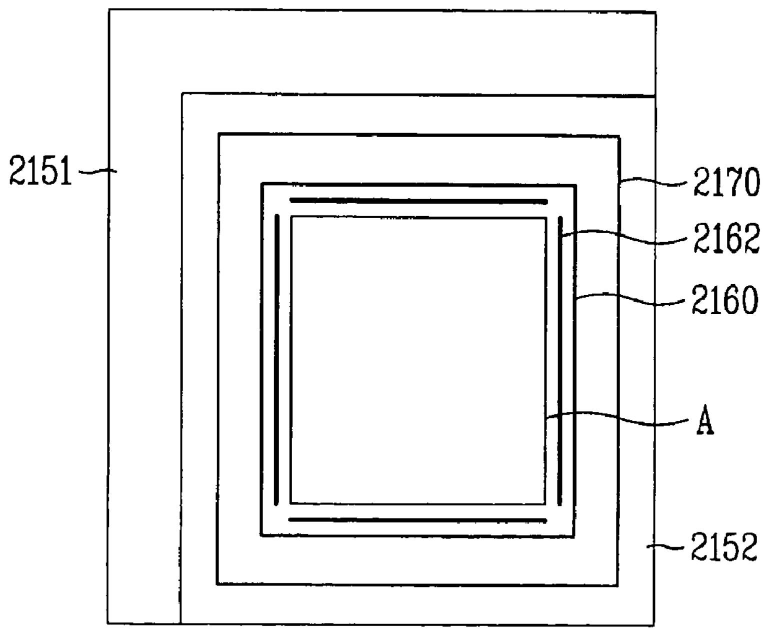


FIG. 90A

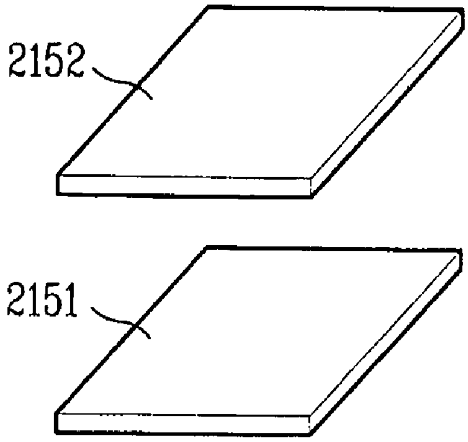


FIG. 90B

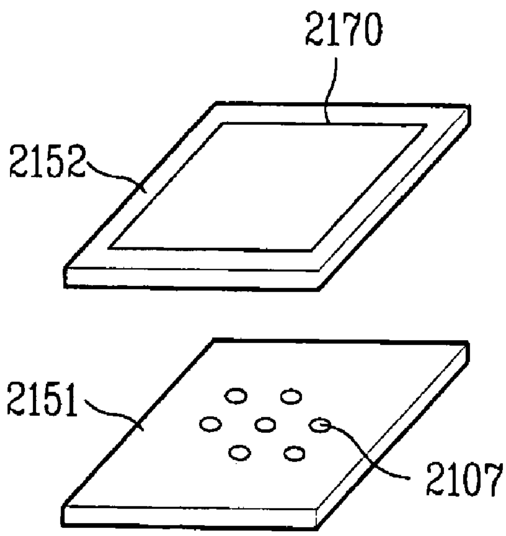


FIG. 90C

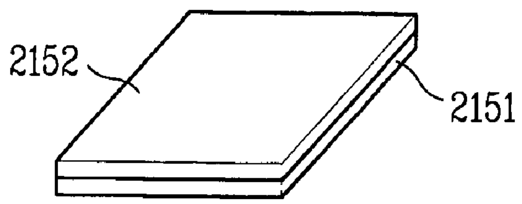


FIG. 90D

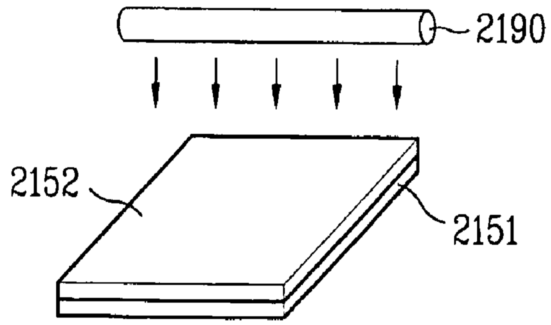


FIG. 91

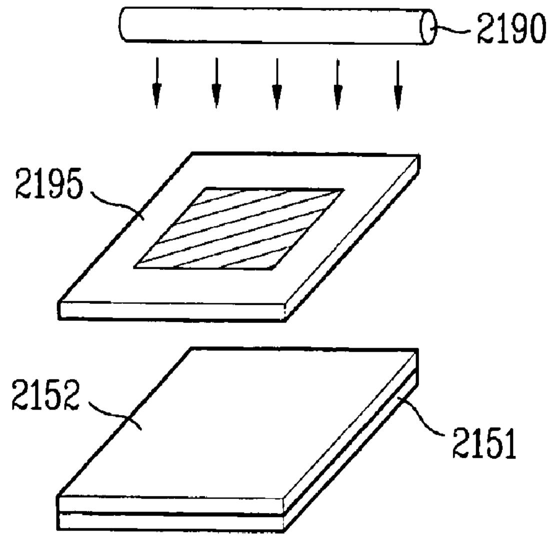
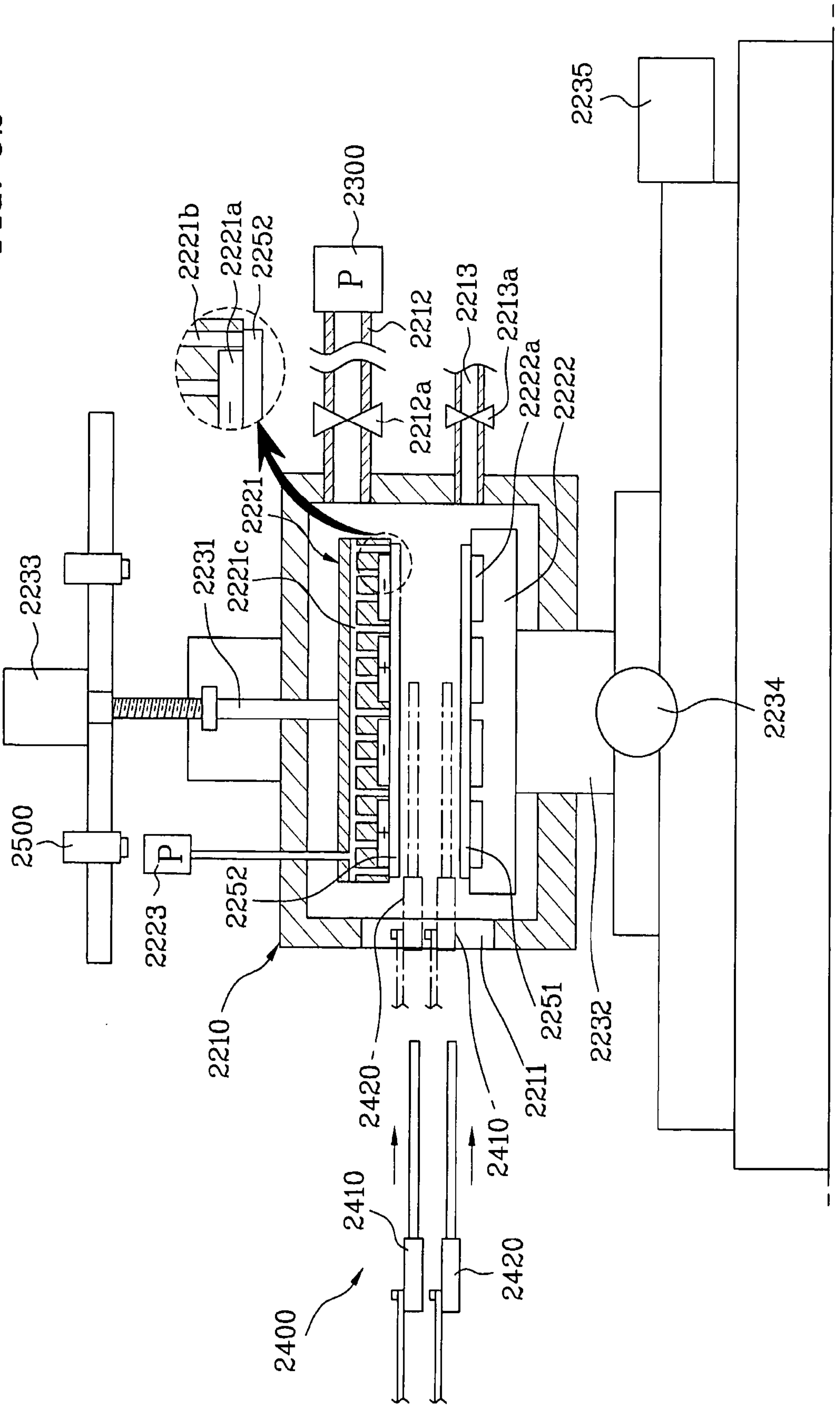


FIG. 92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2212a
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2222
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2233
2231
2221c
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P
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2252
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2410
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2251
2232
2234
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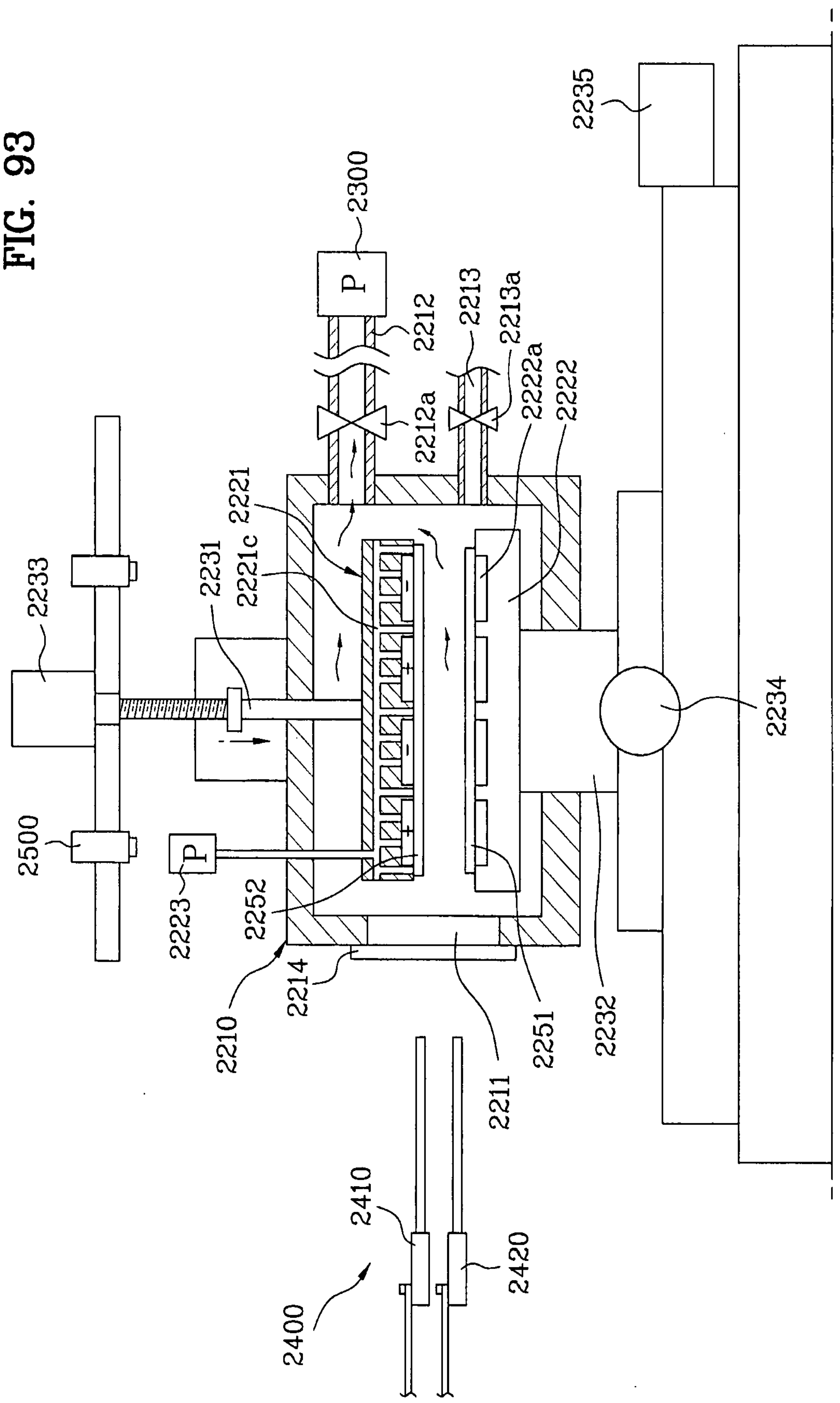
2420
2400

FIG. 93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2221c
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2211
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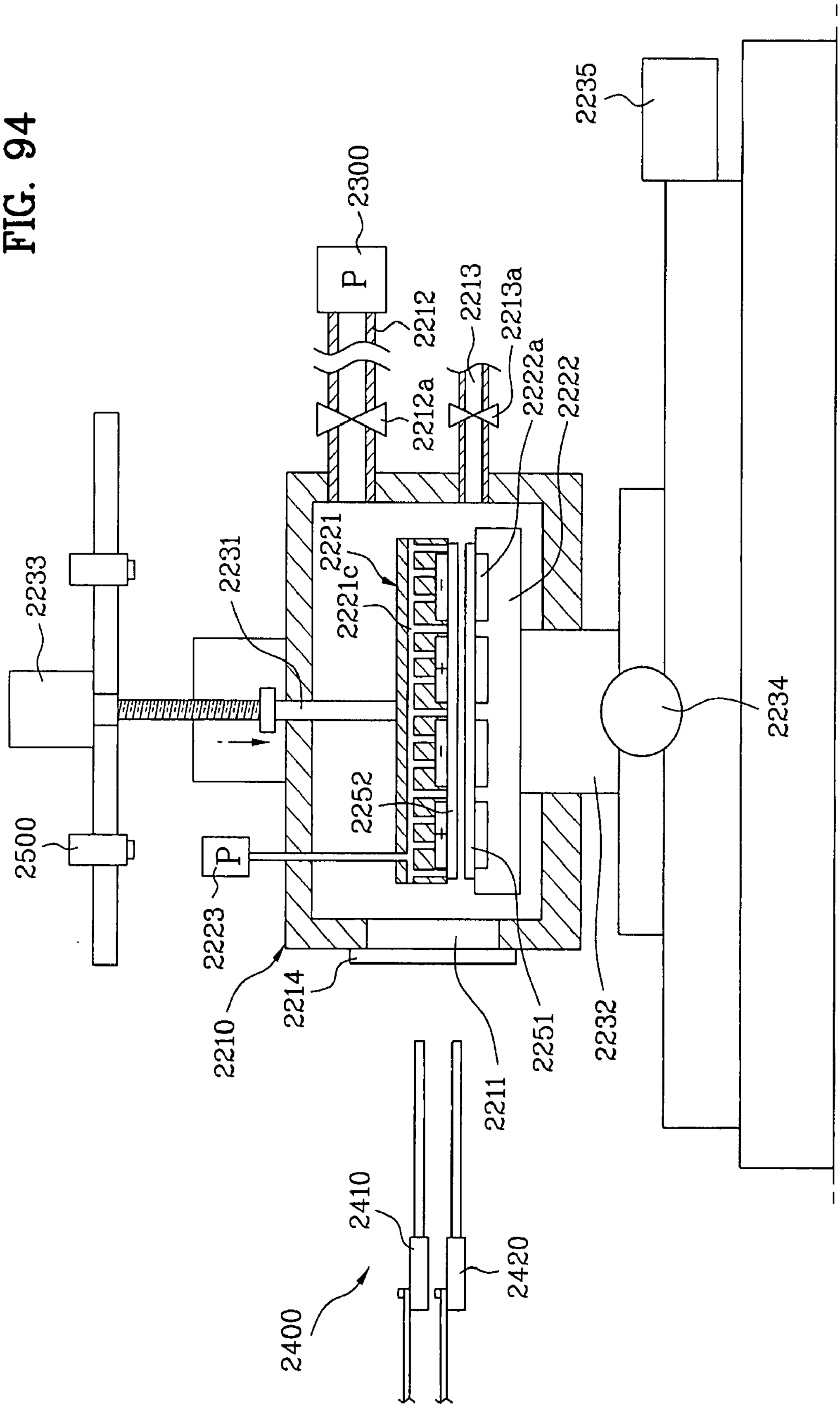
FIG. 94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2222
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2221
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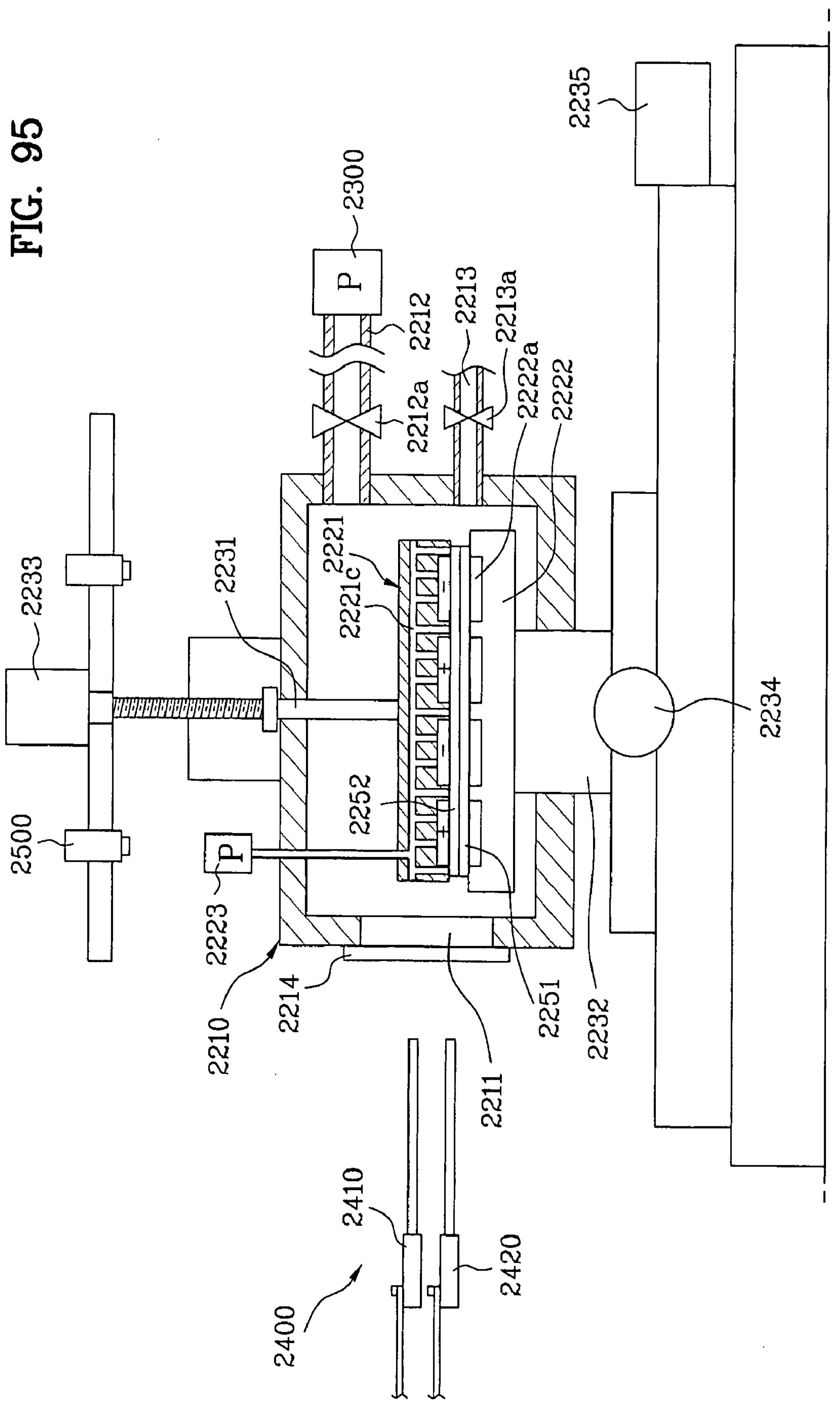
P
2223
2210
2214
2211
2251
2232
2410
2420
2400

FIG. 95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2210
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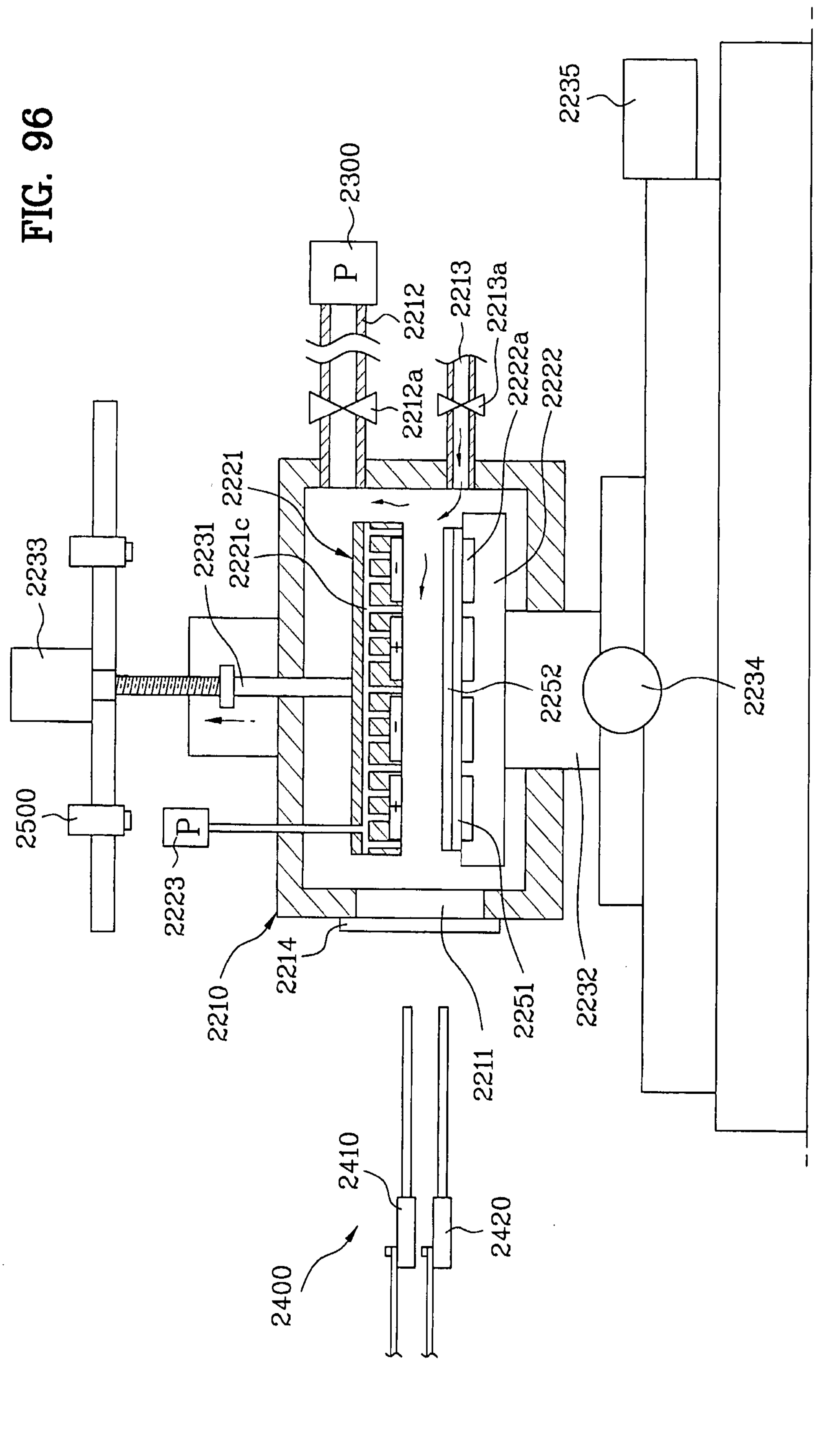
2420
2400

FIG. 96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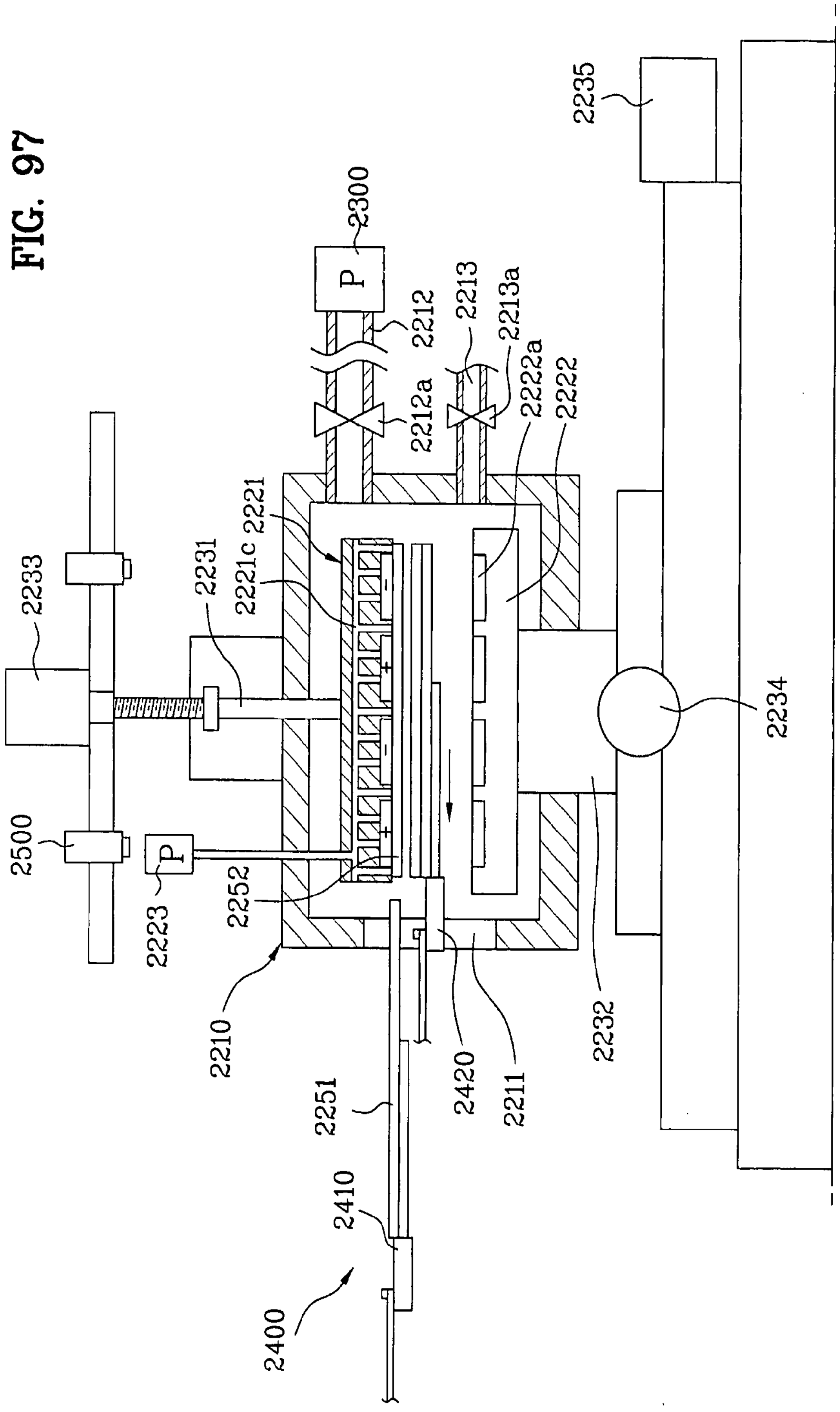
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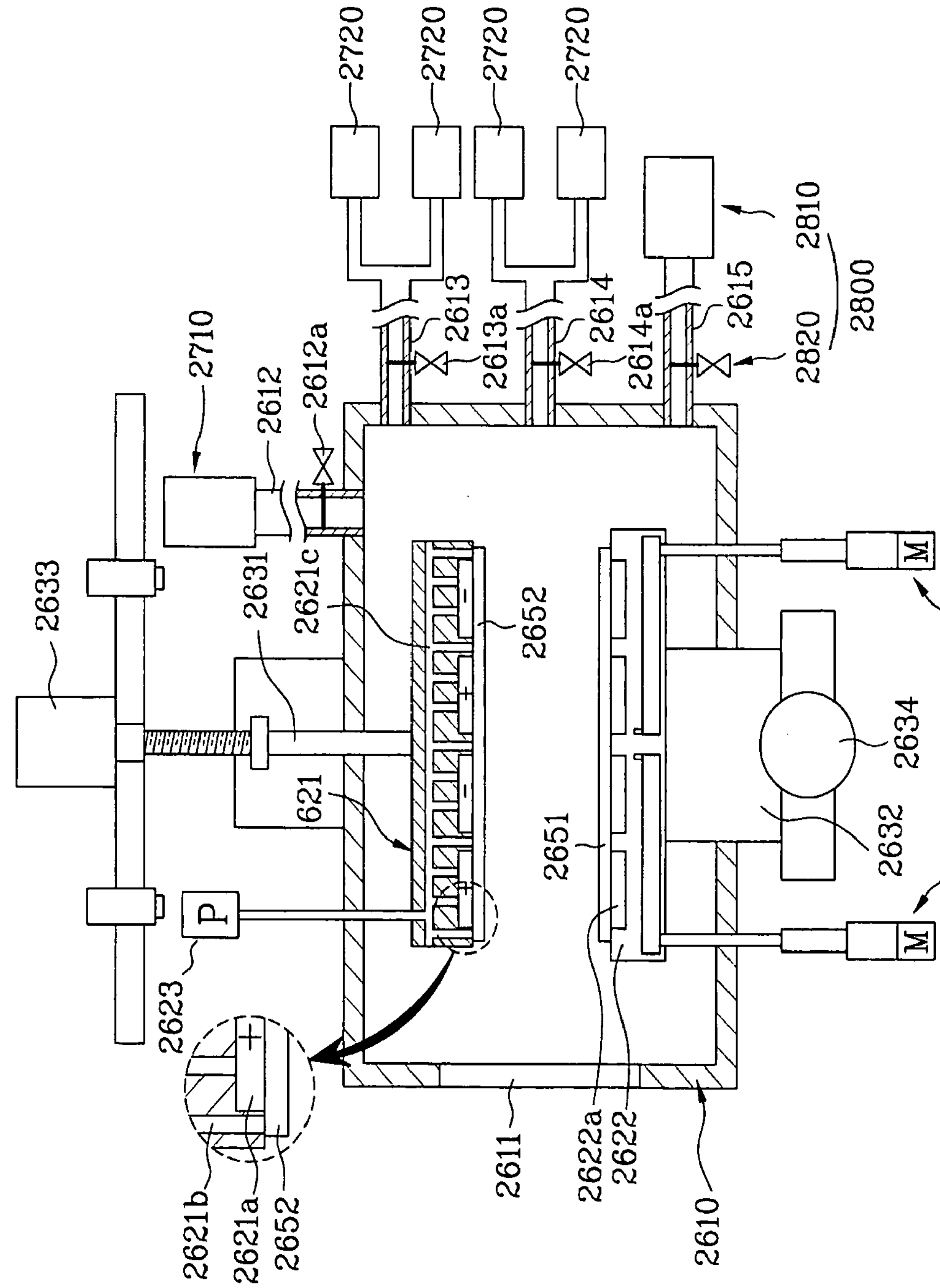
FIG. 97

FIG. 98A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2631
2621c
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2652
621
P
2623
2651
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2900
2621b
2621a
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2611
2622a
2622
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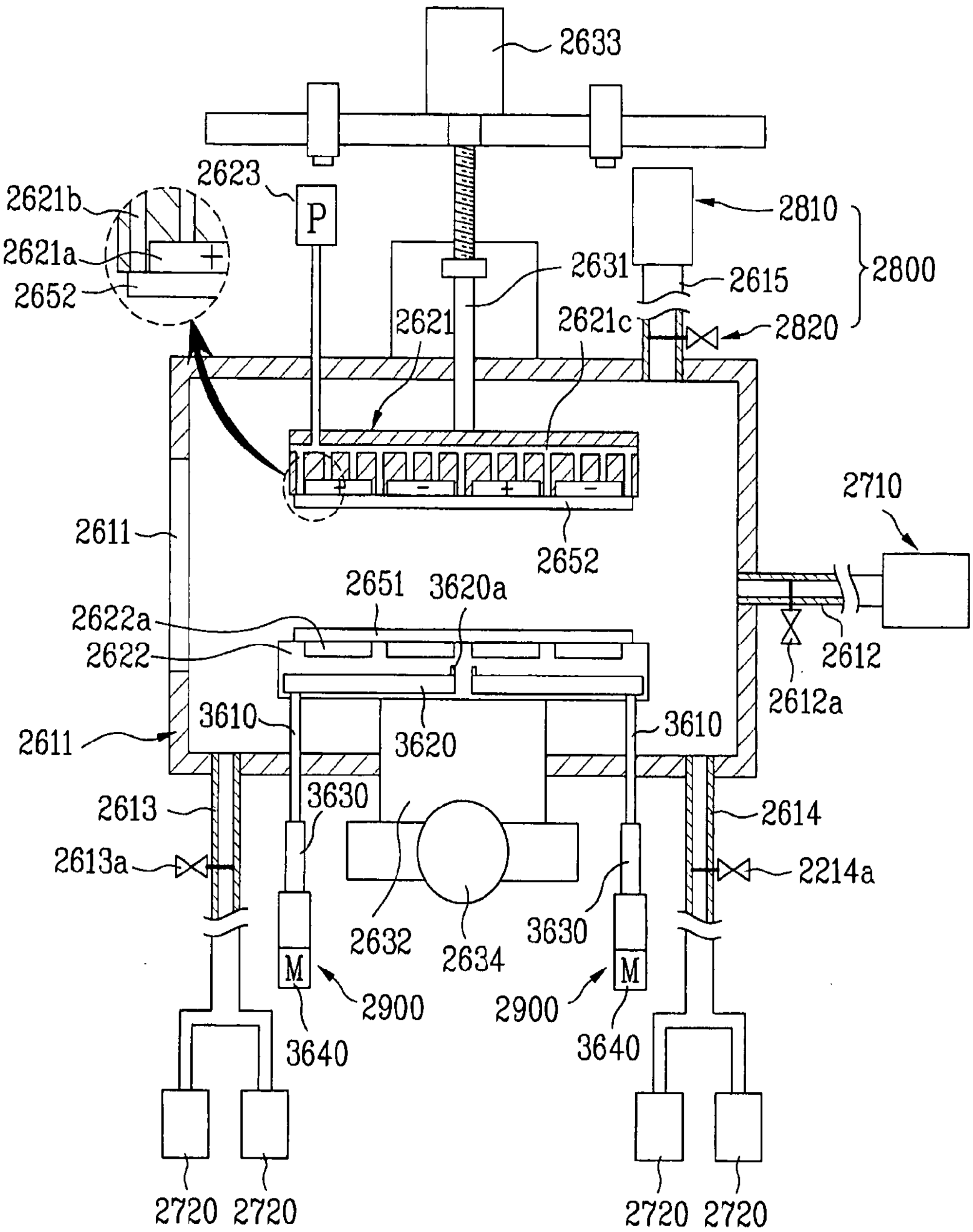
FIG. 98B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2622a
2622
2612
2612a
3610
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2611
3620
2613
3630
2614
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2632
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2720
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FIG. 99A

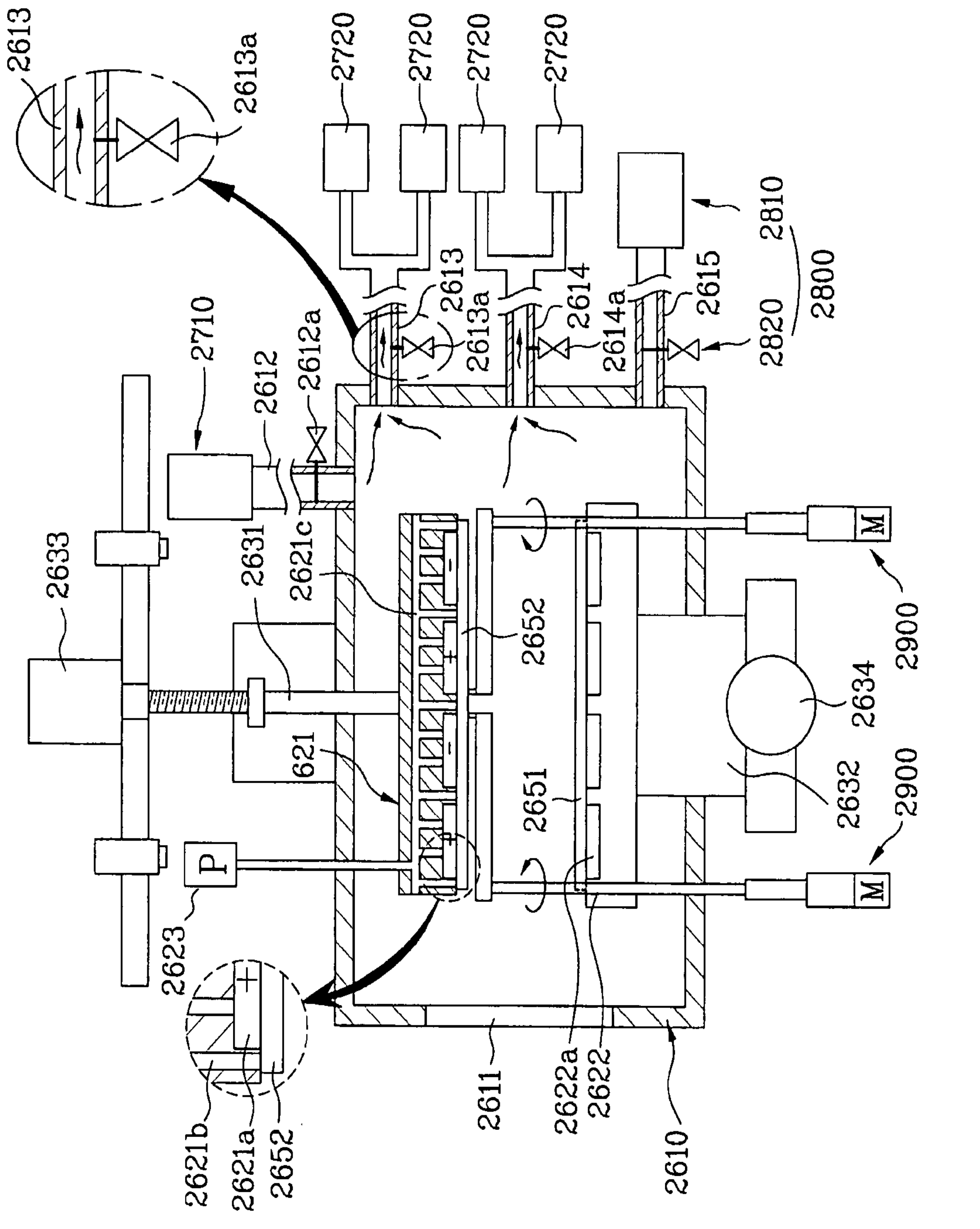
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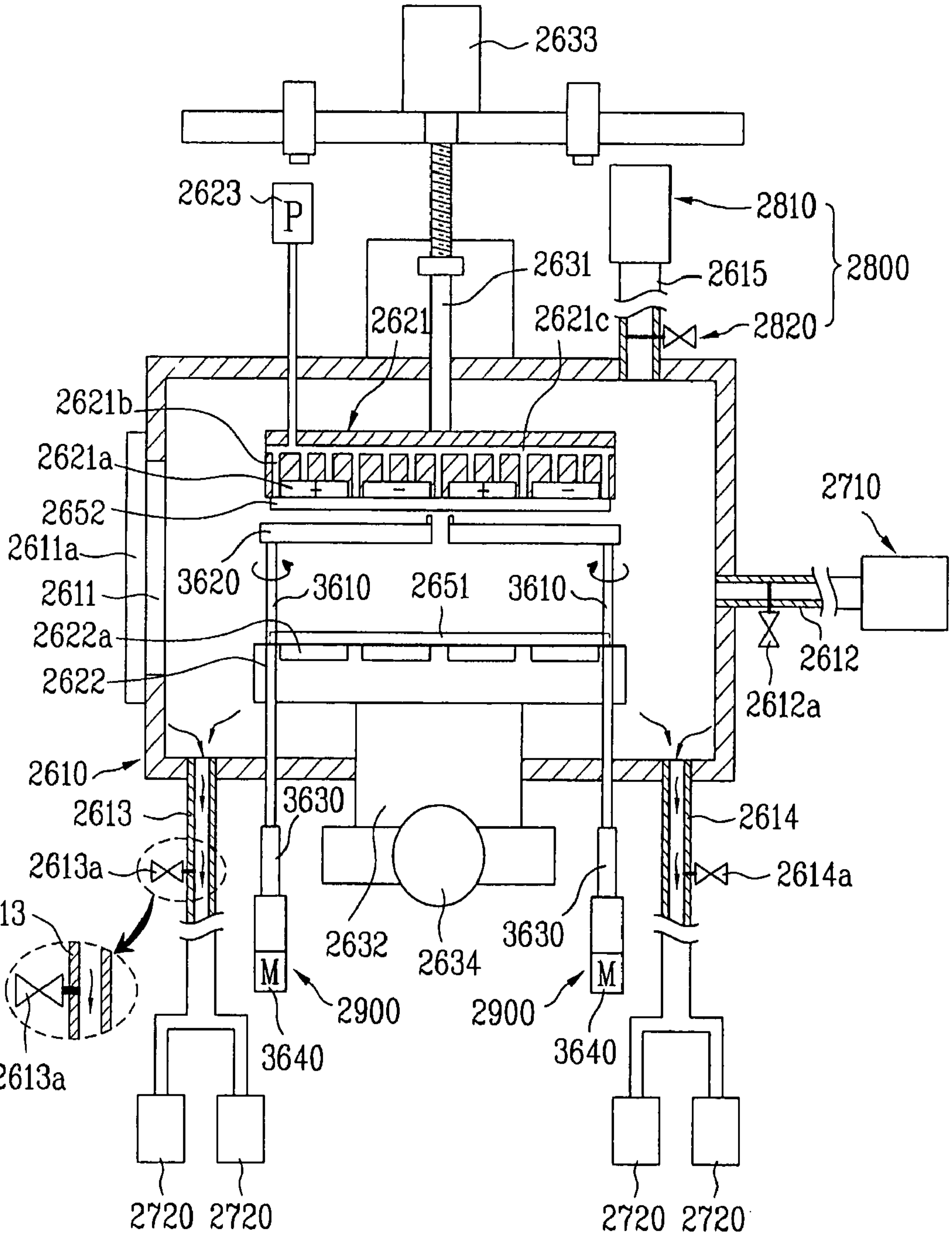
FIG. 99B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2720 2720

FIG. 100A

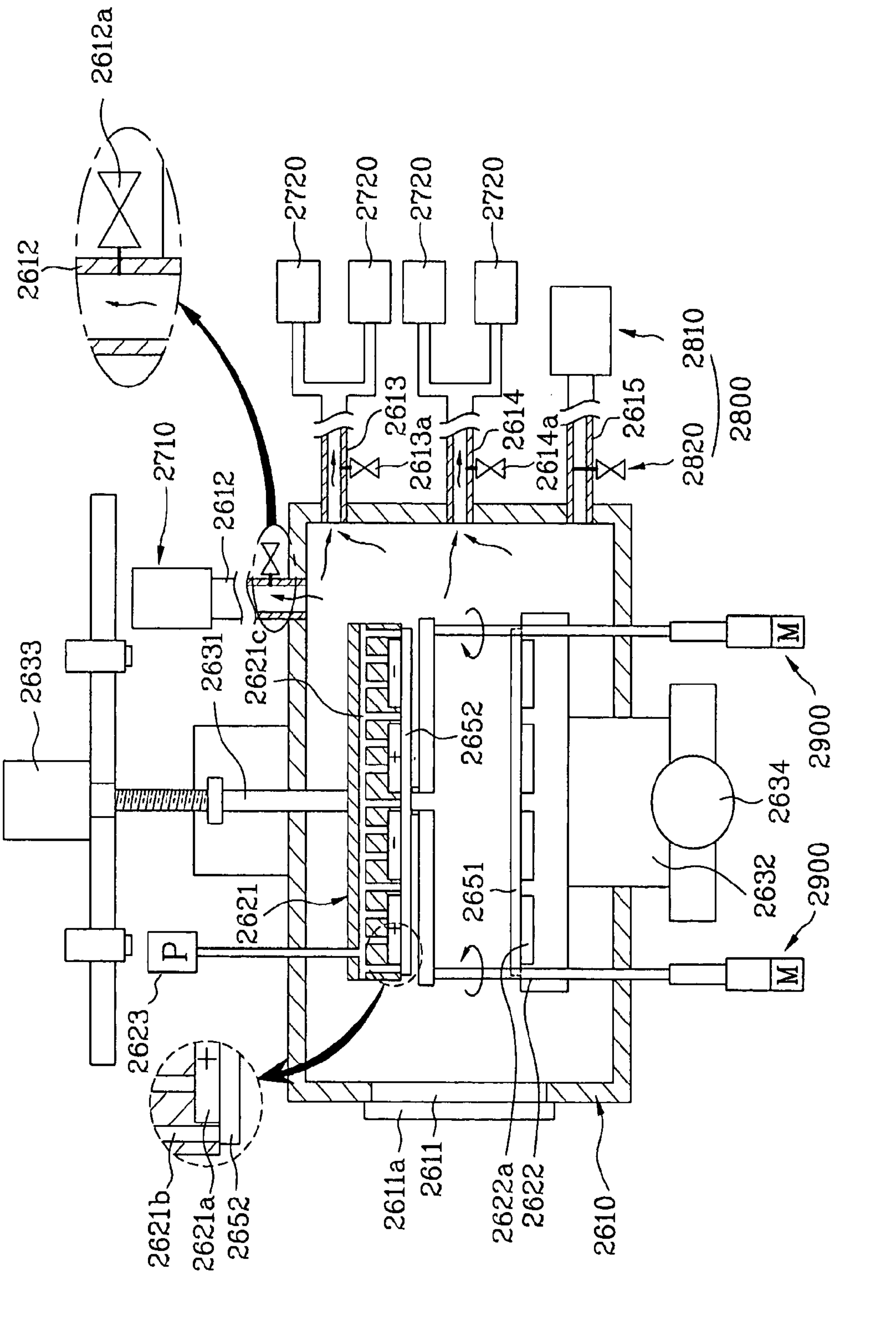
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FIG. 100B

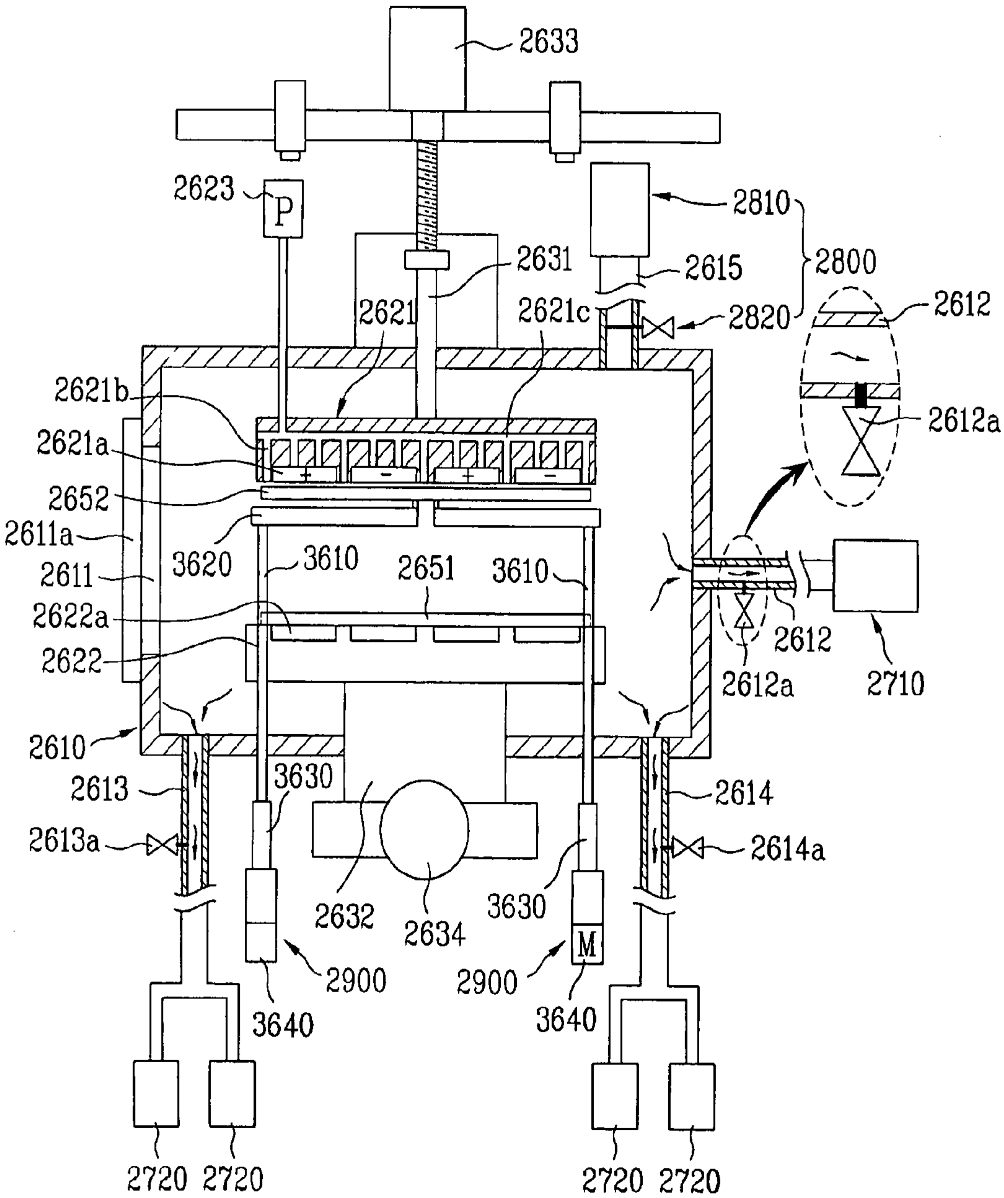
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FIG. 101A

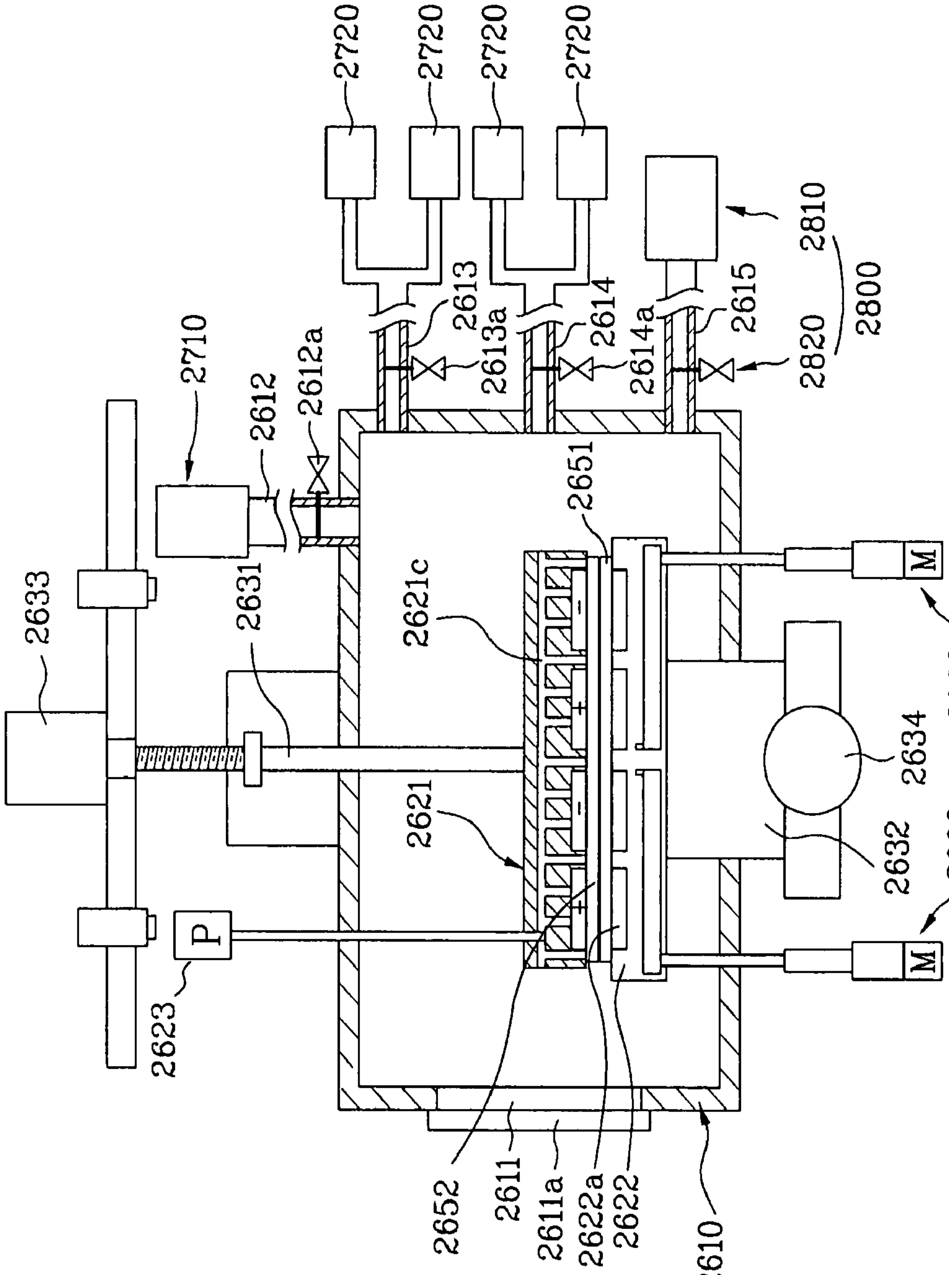
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FIG. 101B

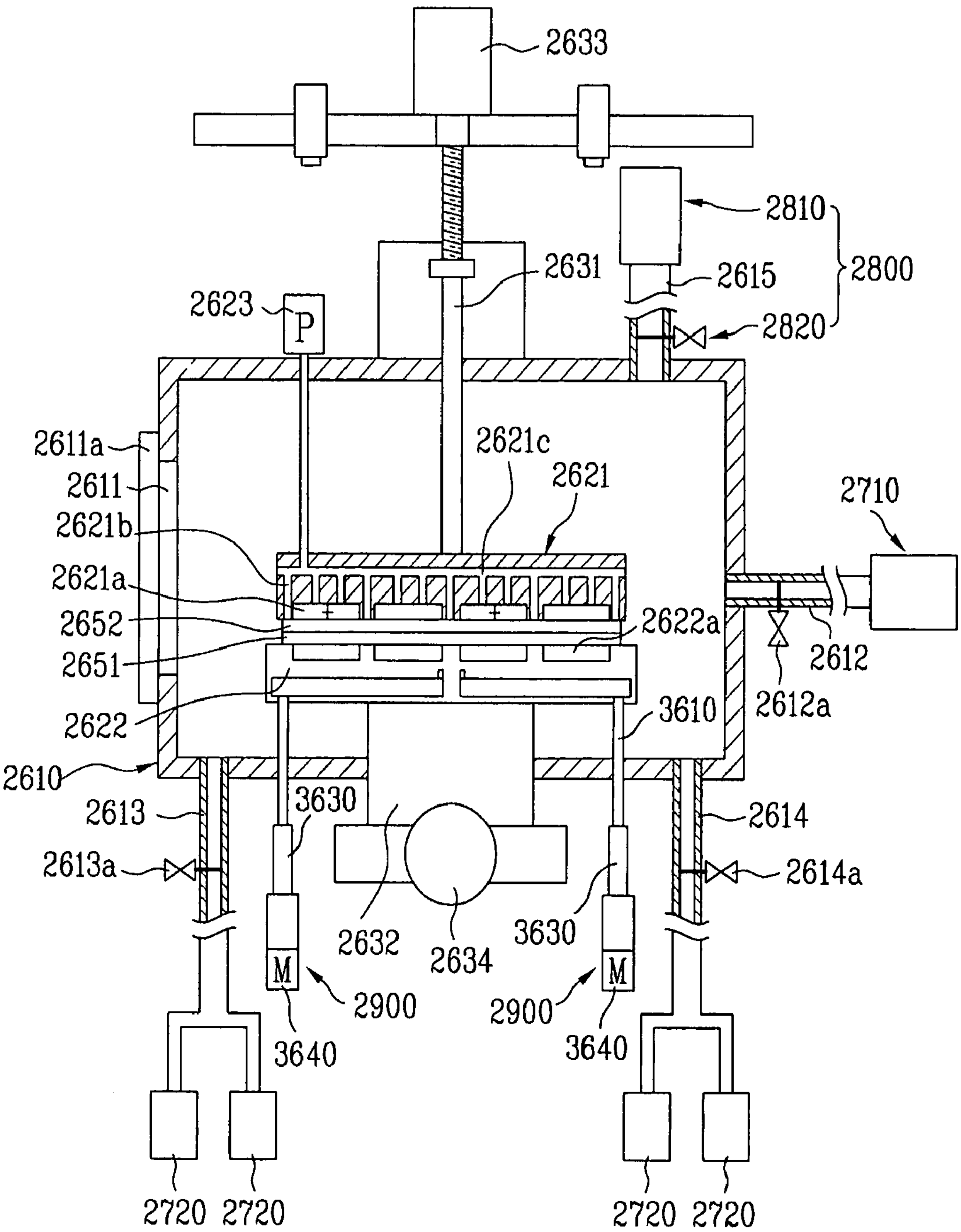
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FIG. 102A

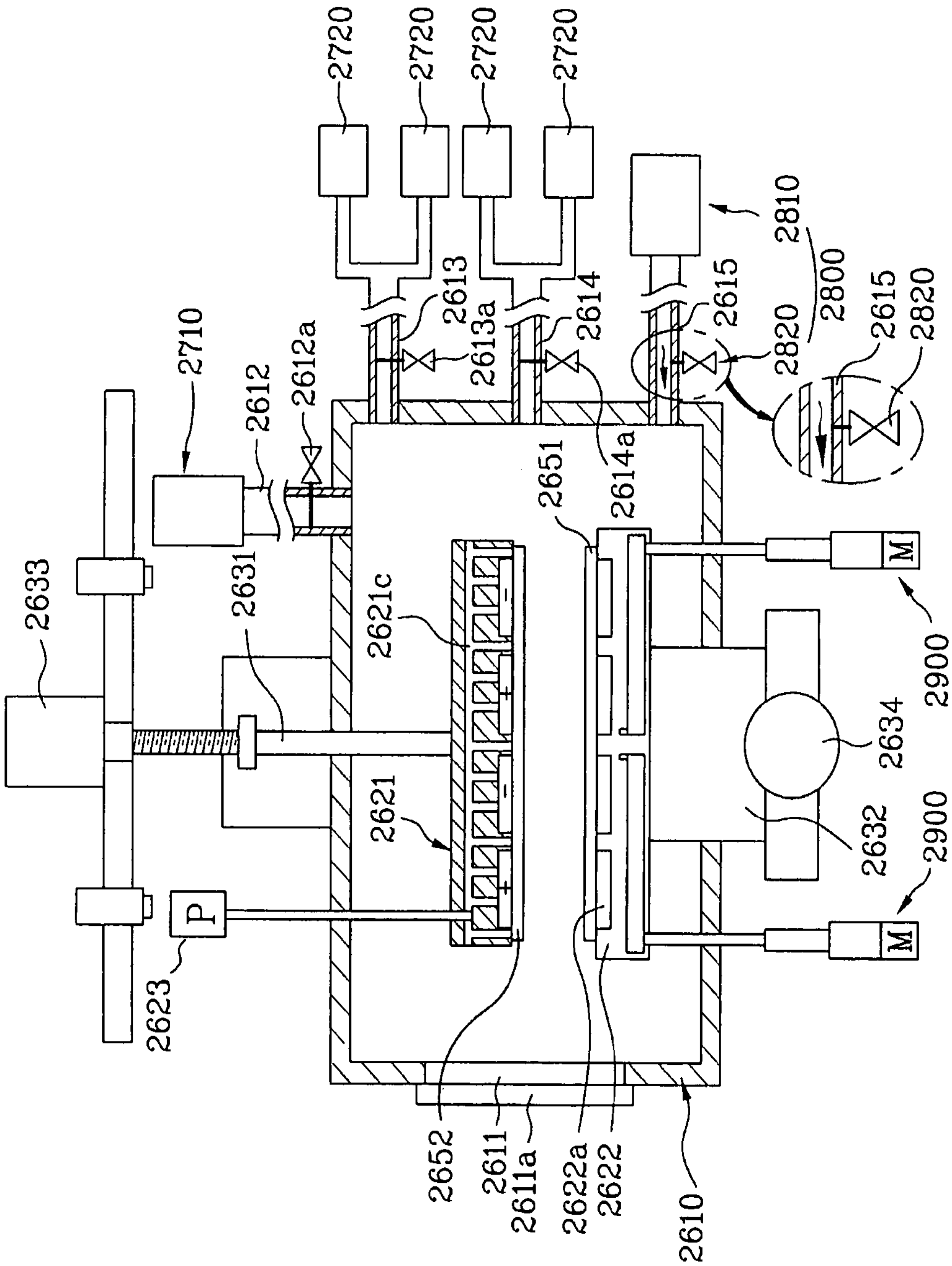
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FIG. 102B

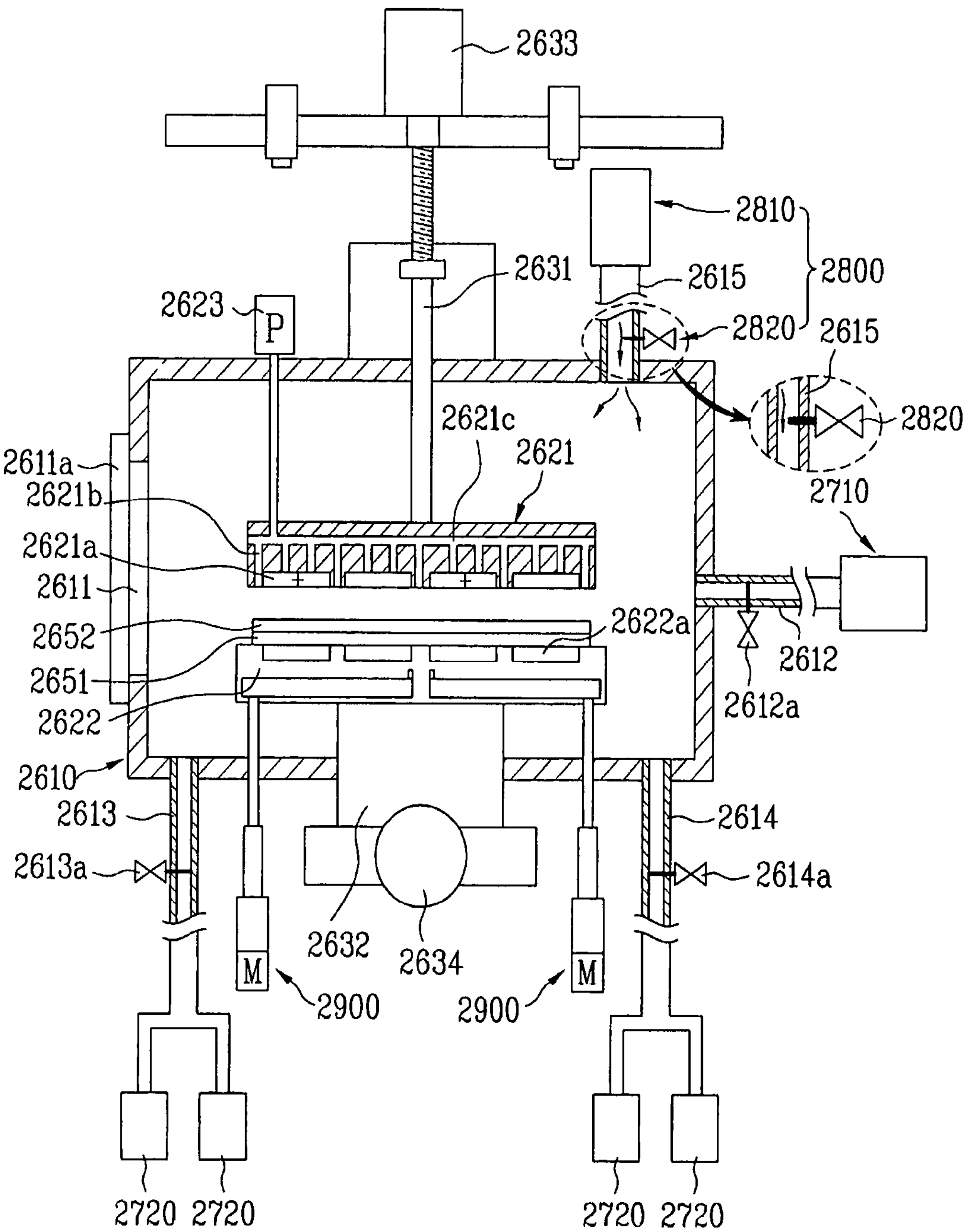
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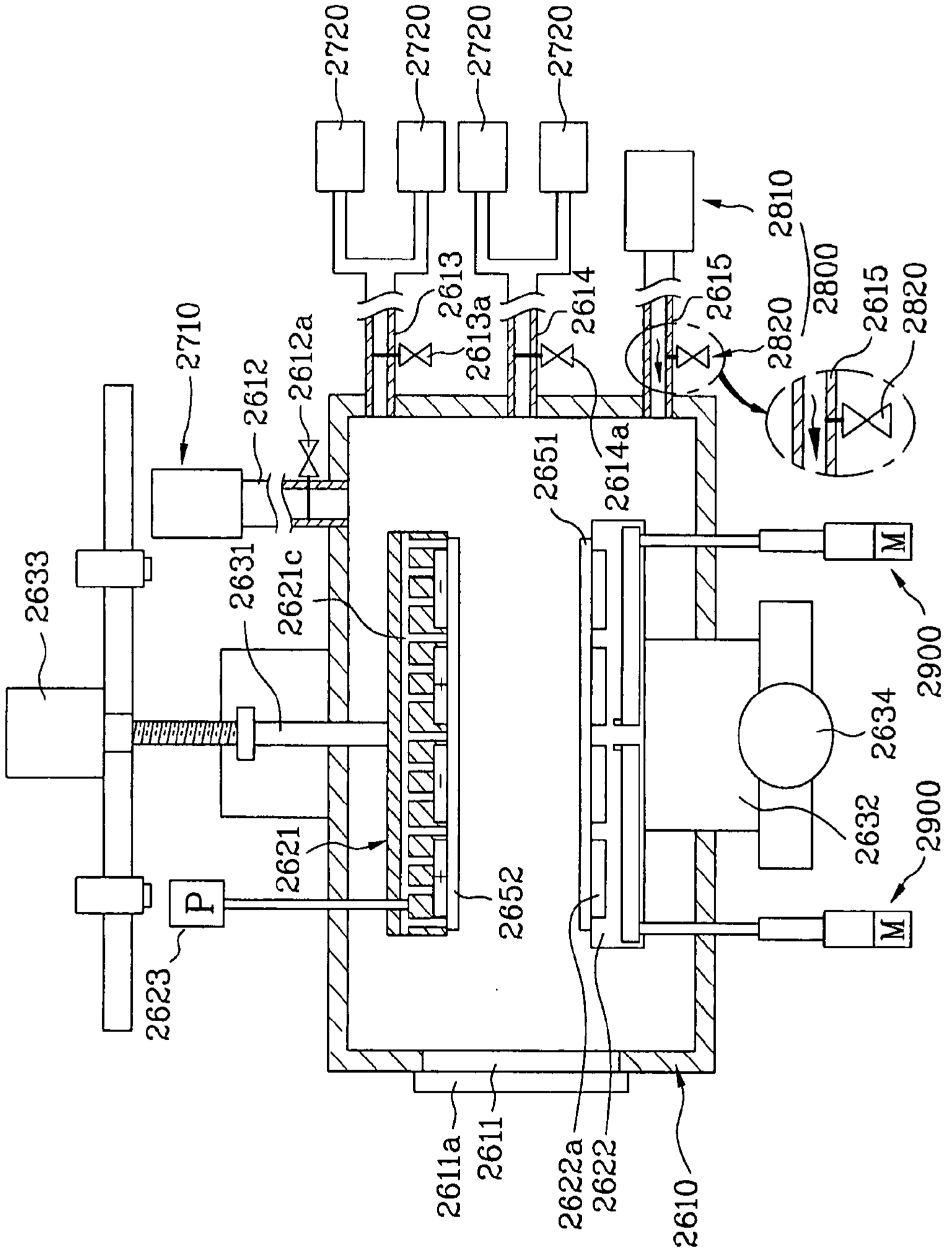
FIG. 103A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2621c
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FIG. 103B

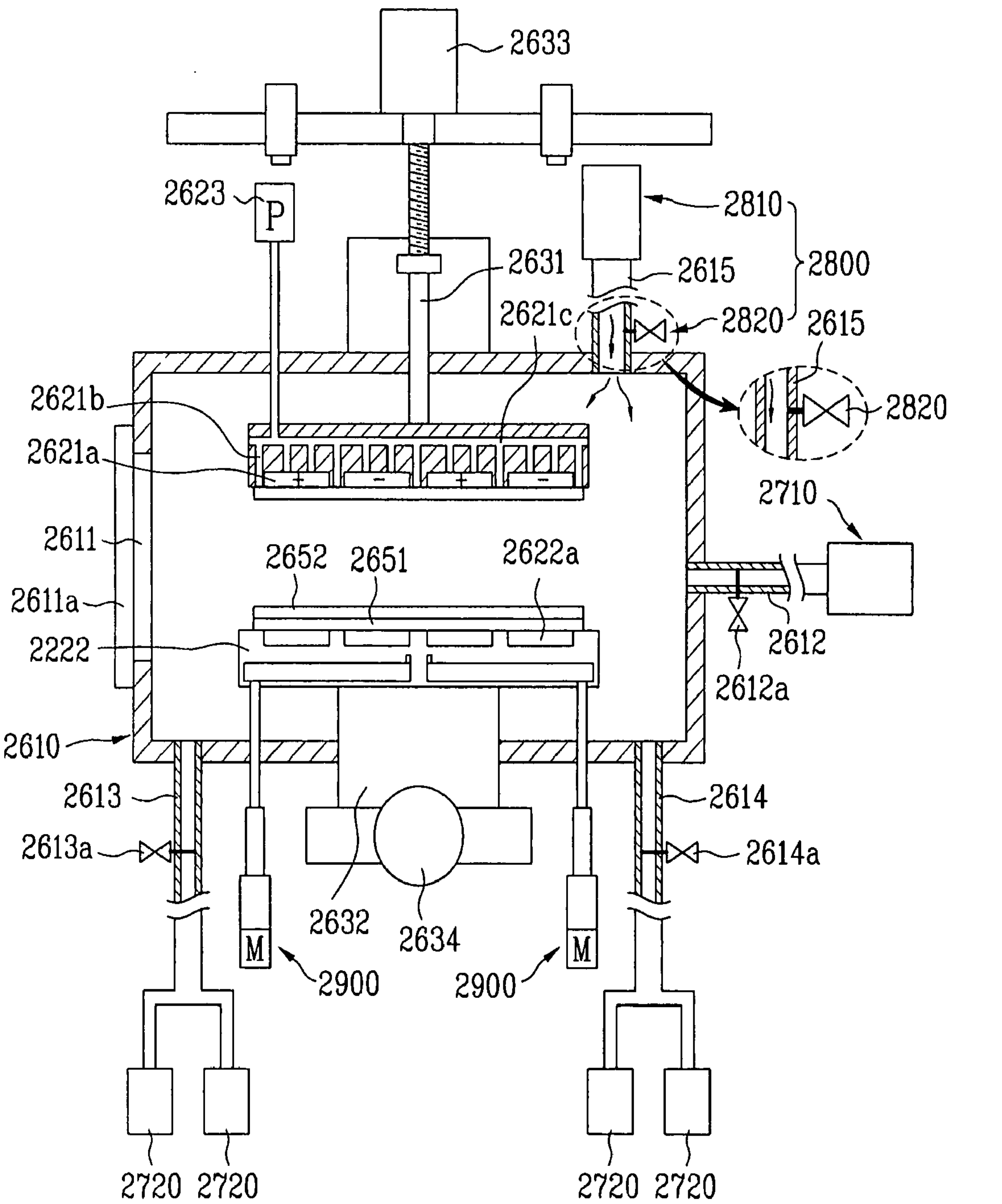

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FIG. 104A

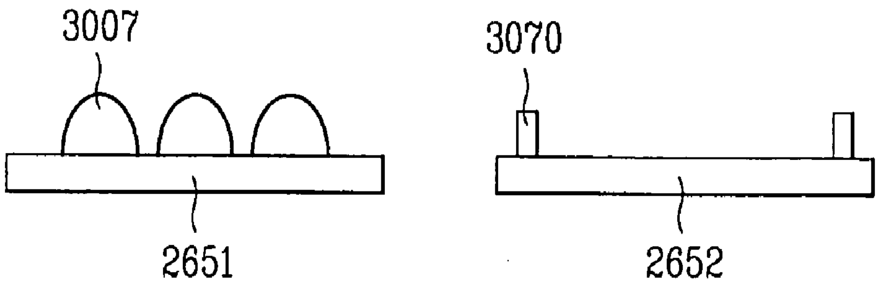


FIG. 104B

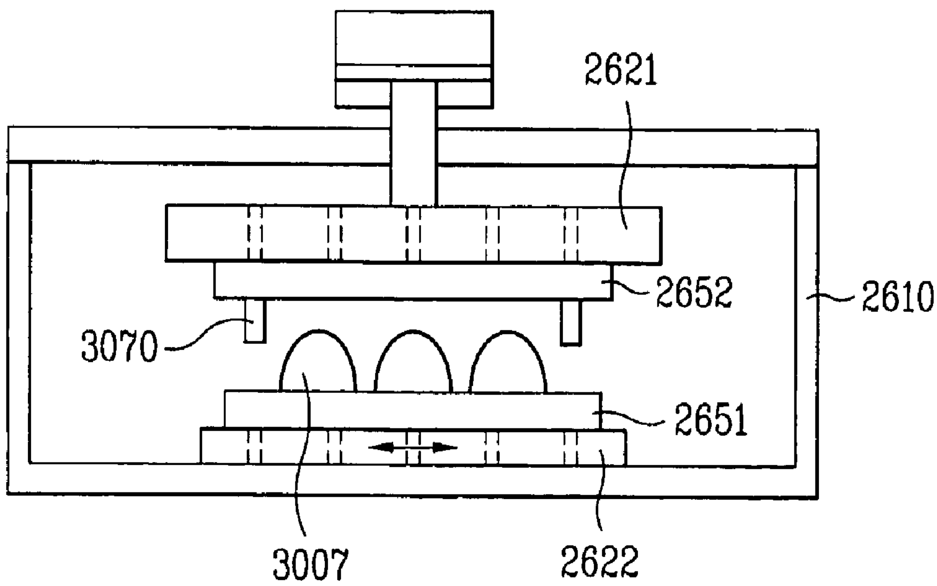


FIG. 104C

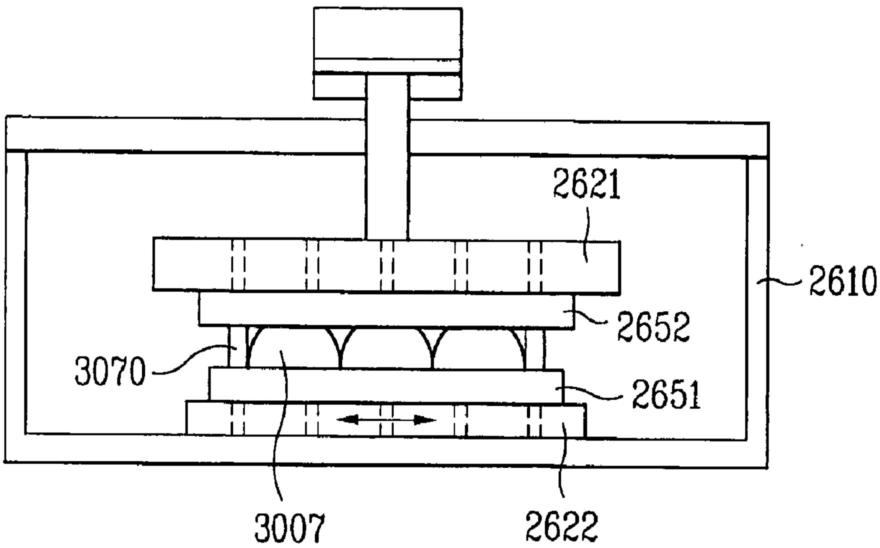


FIG. 104D

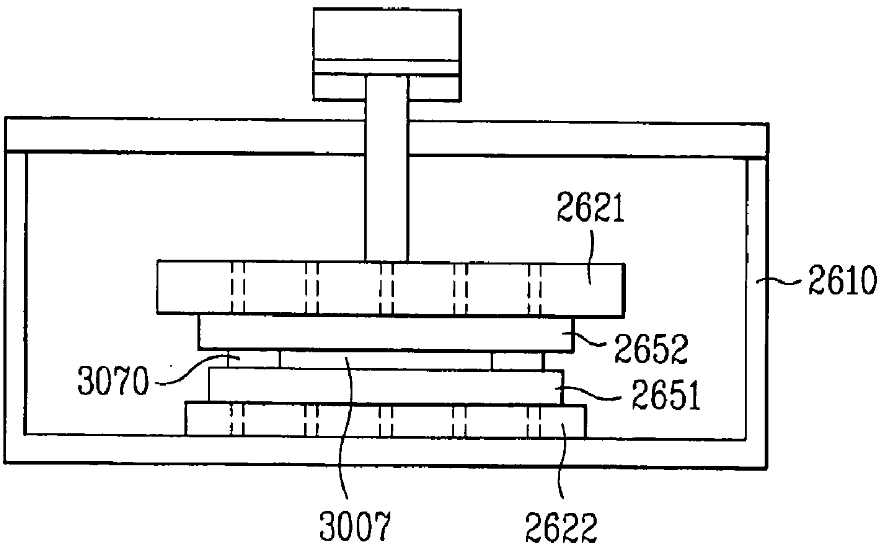


FIG. 104E

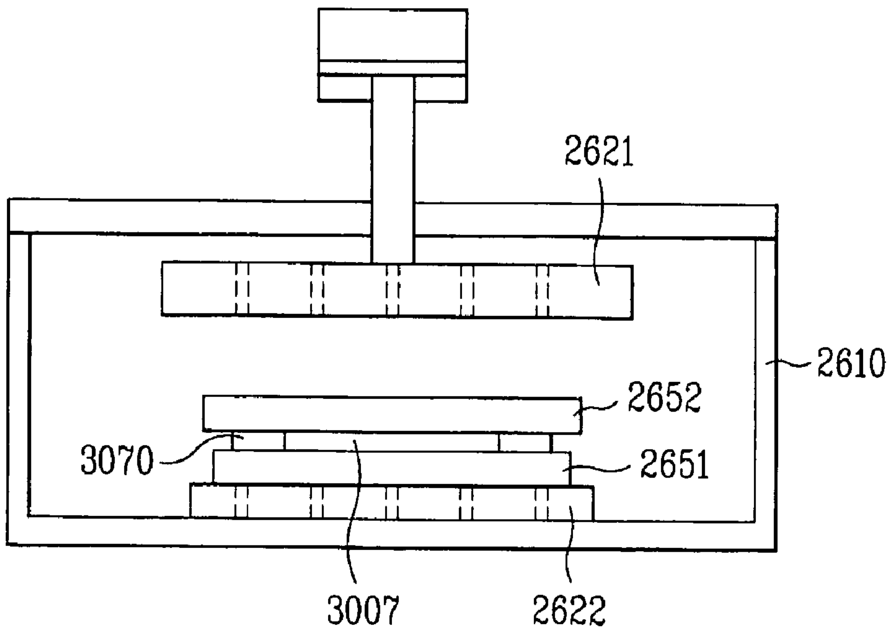


FIG. 105

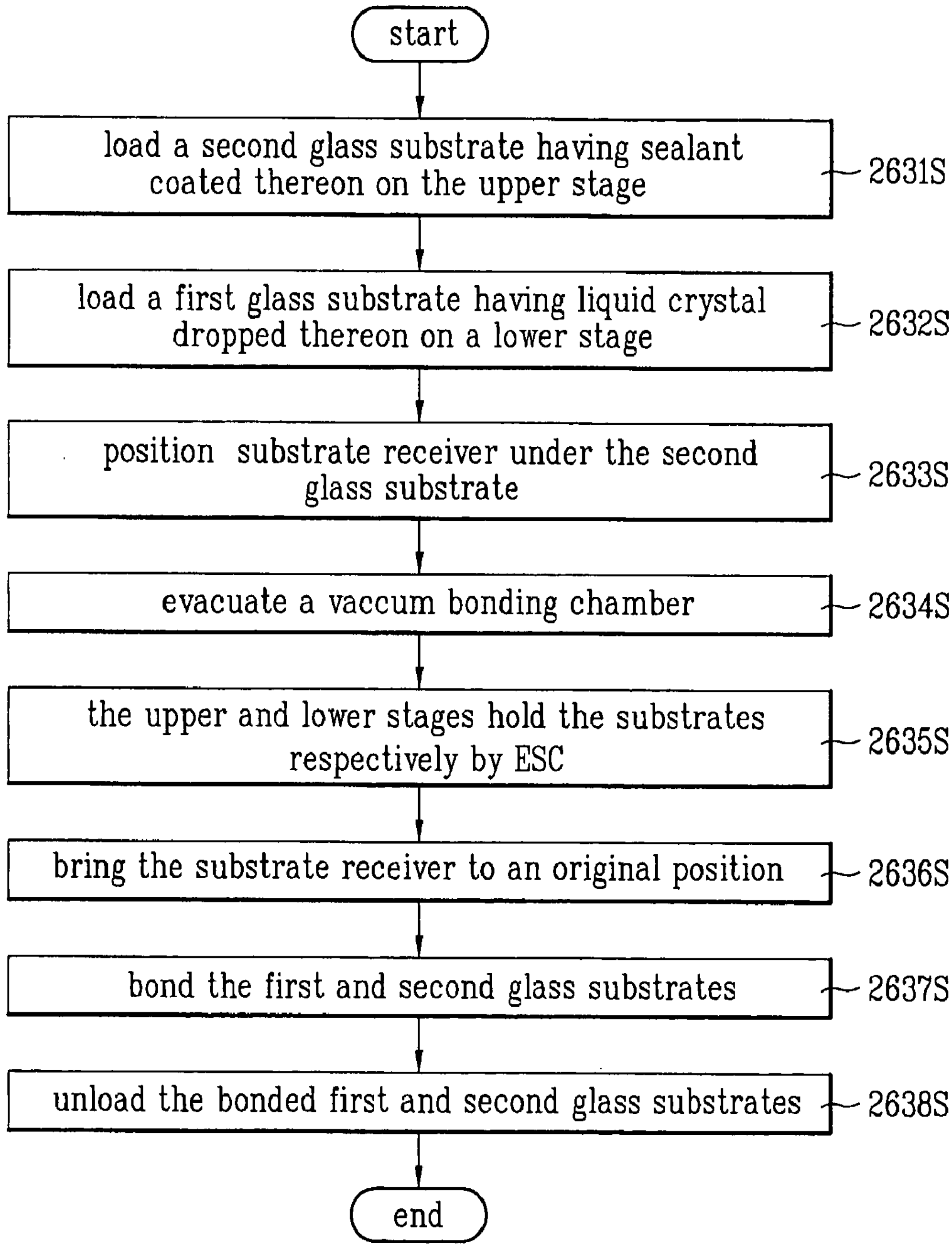

start
load a second glass substrate having sealant coated thereon on the upper stage
2631S
load a first glass substrate having liquid crystal dropped thereon on a lower stage
2632S
position substrate receiver under the second glass substrate
2633S
evacuate a vaccum bonding chamber
2634S
the upper and lower stages hold the substrates respectively by ESC
2635S
bring the substrate receiver to an original position
2636S
bond the first and second glass substrates
2637S
unload the bonded first and second glass substrates
2638S
end

FIG. 106

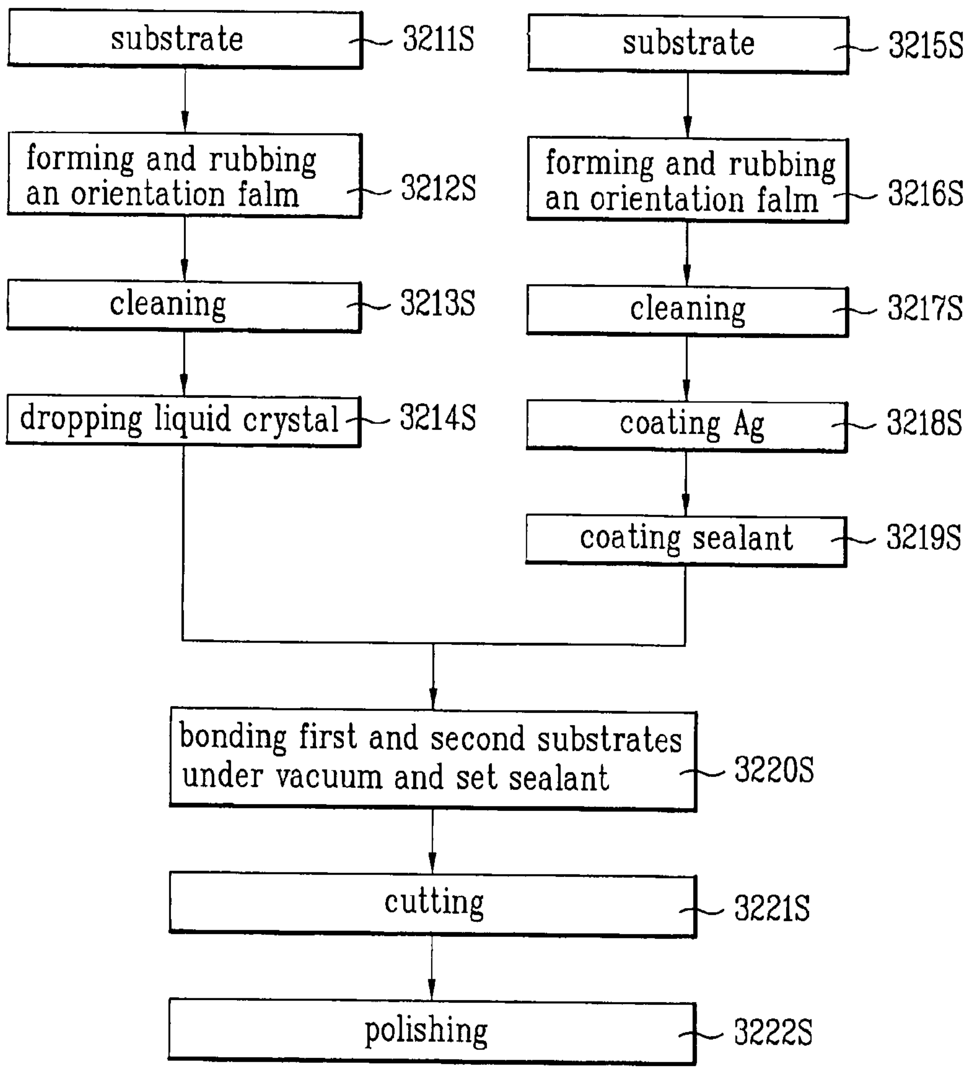

substrate
3211S
forming and rubbing an orientation falm
3212S
cleaning
3213S
dropping liquid crystal
3214S
substrate
3215S
forming and rubbing an orientation falm
3216S
cleaning
3217S
coating Ag
3218S
coating sealant
3219S
bonding first and second substrates under vacuum and set sealant
3220S
cutting
3221S
polishing
3222S

FIG. 107A

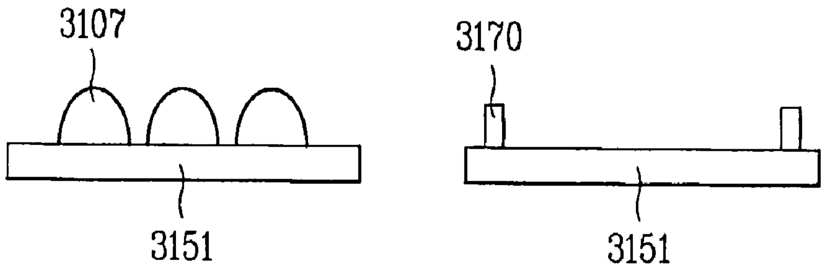


FIG. 107B

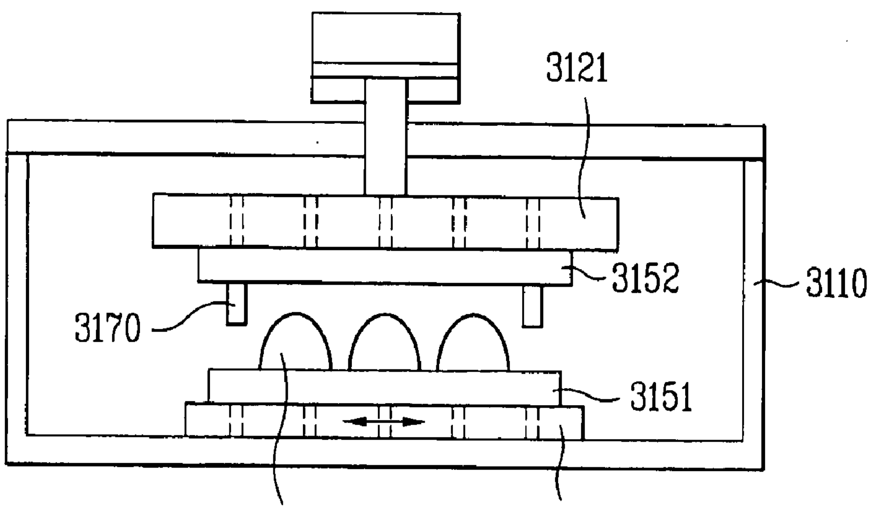


FIG. 107C

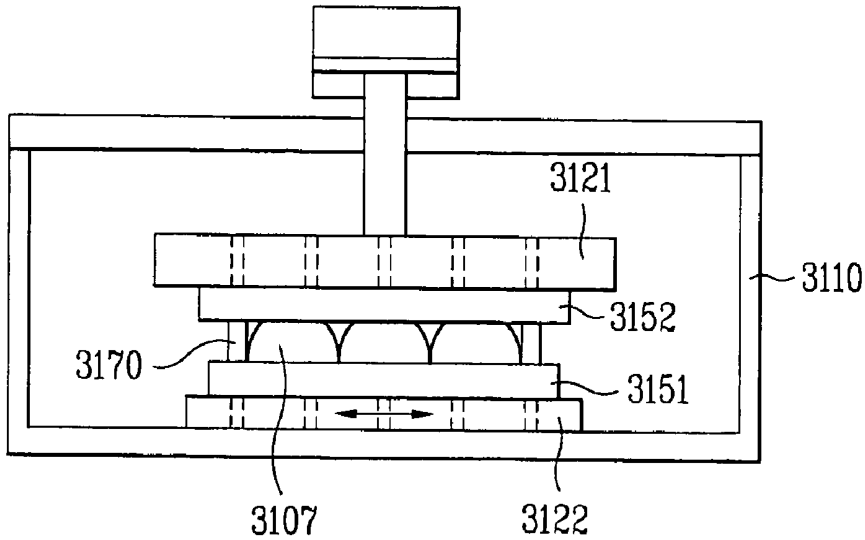


FIG. 107D

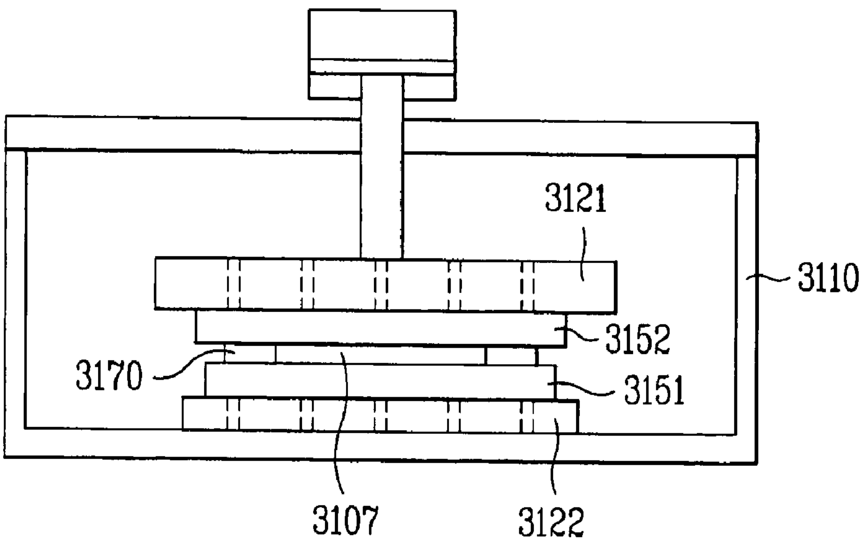


FIG. 107E

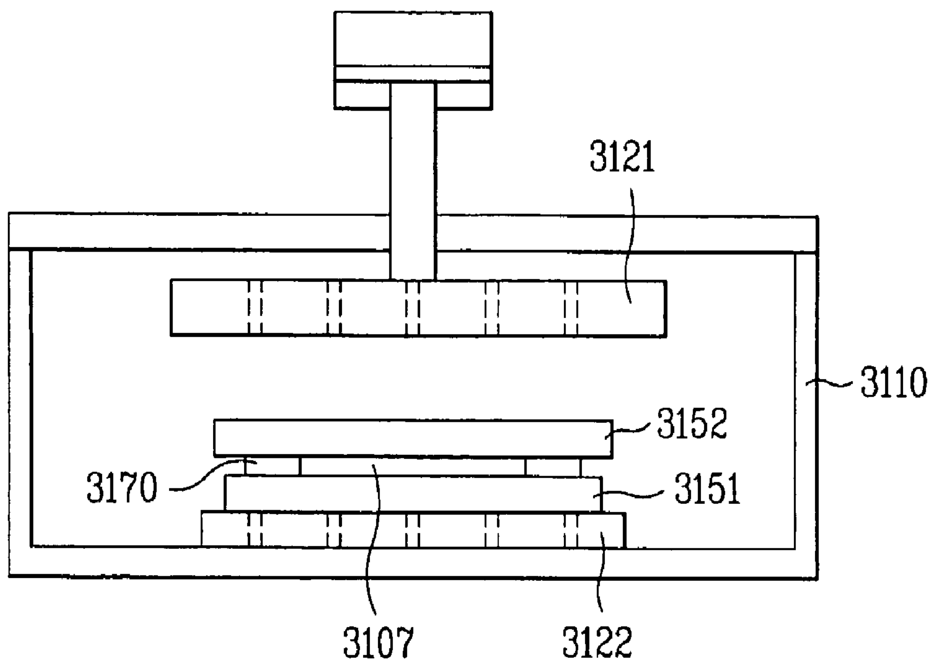


FIG. 108

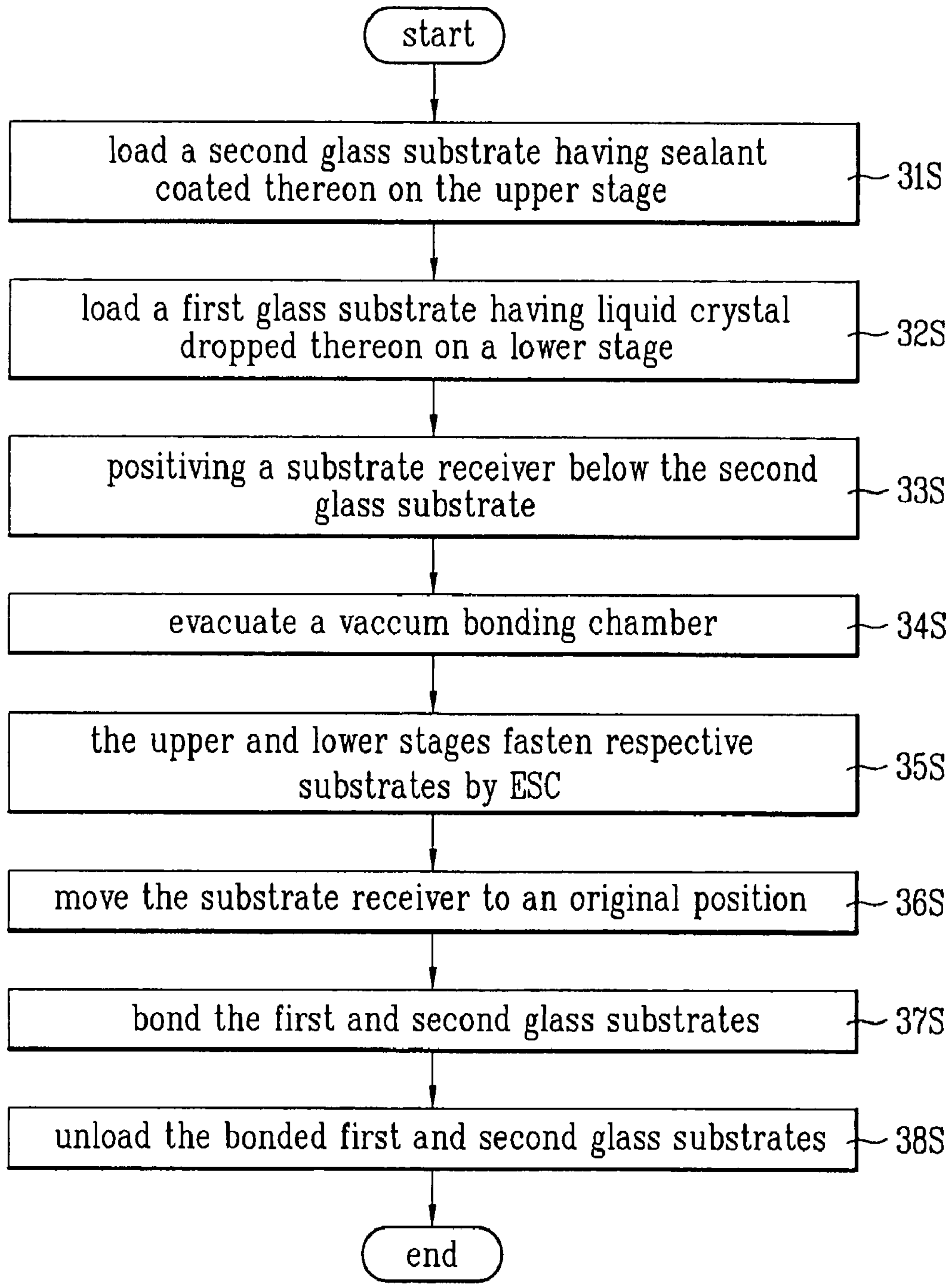

start
load a second glass substrate having sealant coated thereon on the upper stage
31S
load a first glass substrate having liquid crystal dropped thereon on a lower stage
32S
positiving a substrate receiver below the second glass substrate
33S
evacuate a vaccum bonding chamber
34S
the upper and lower stages fasten respective substrates by ESC
35S
move the substrate receiver to an original position
36S
bond the first and second glass substrates
37S
unload the bonded first and second glass substrates
38S
end

FIG. 109

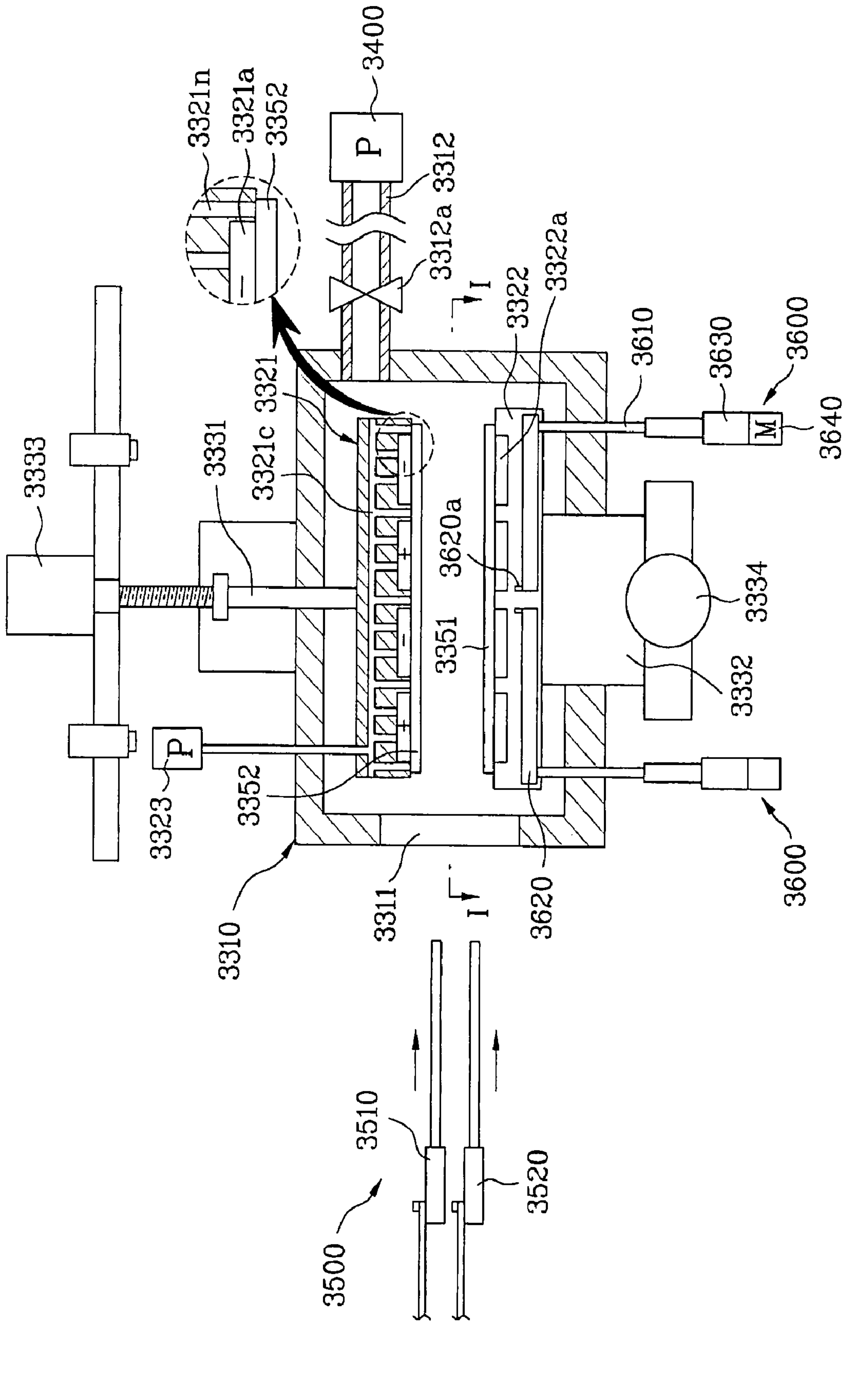

3400
3321n
3321a
3352
P
3312
3312a
3322
3322a
3610
3630
3600
3640
M
3333
3331
3321c
3321
3620a
3351
3334
3332
P
3323
3352
3310
3311
3620
3600
3500
3510
3520
I
I

FIG. 110A

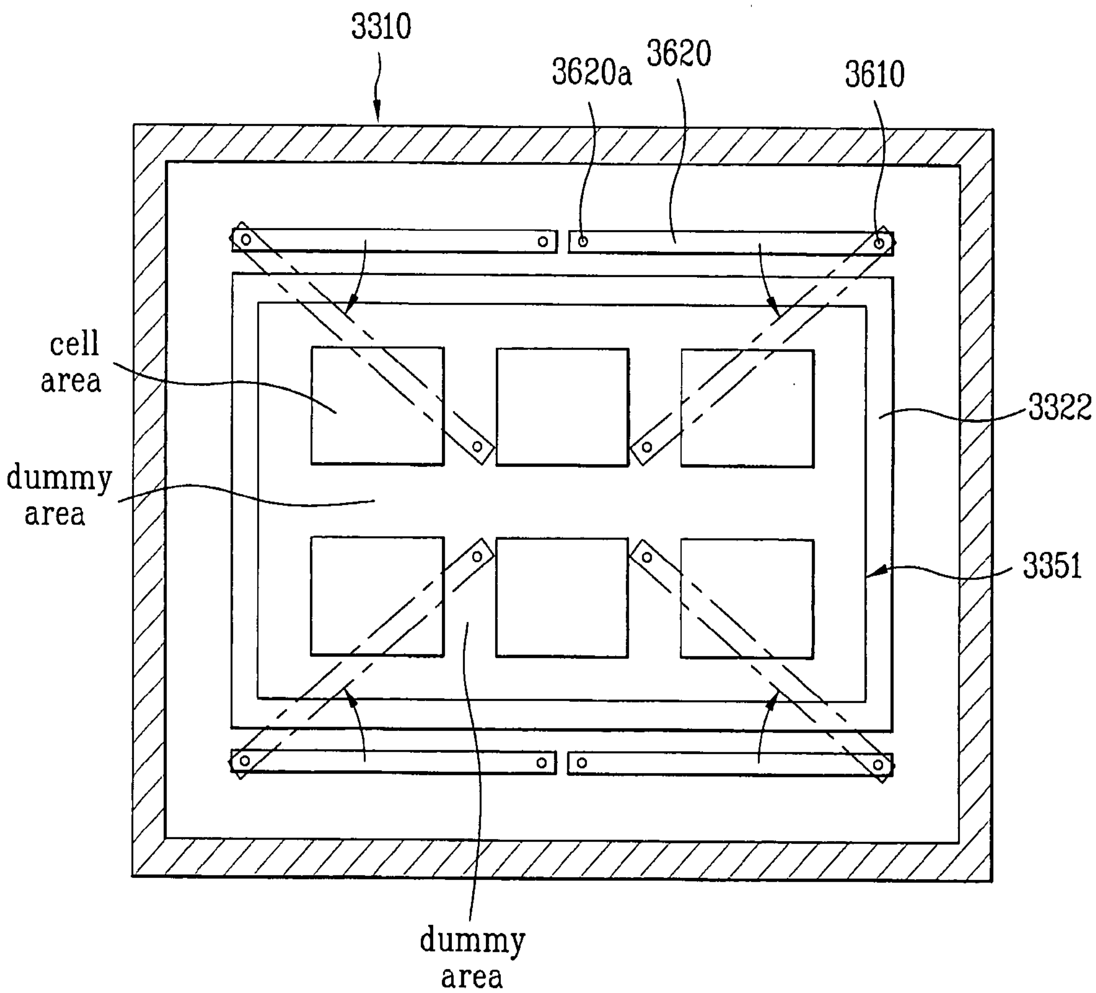

3310
3620a
3620
3610
cell area
dummy area
3322
3351
dummy area

FIG. 110B

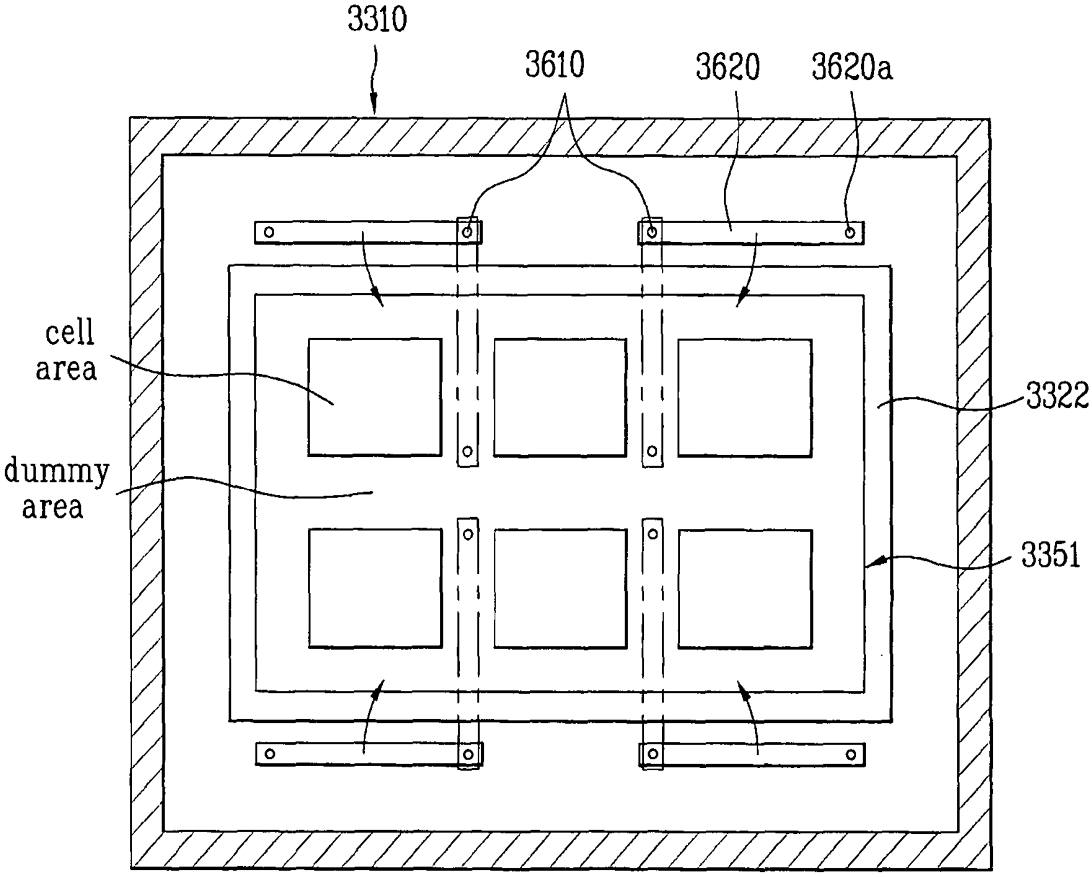


FIG. 111A

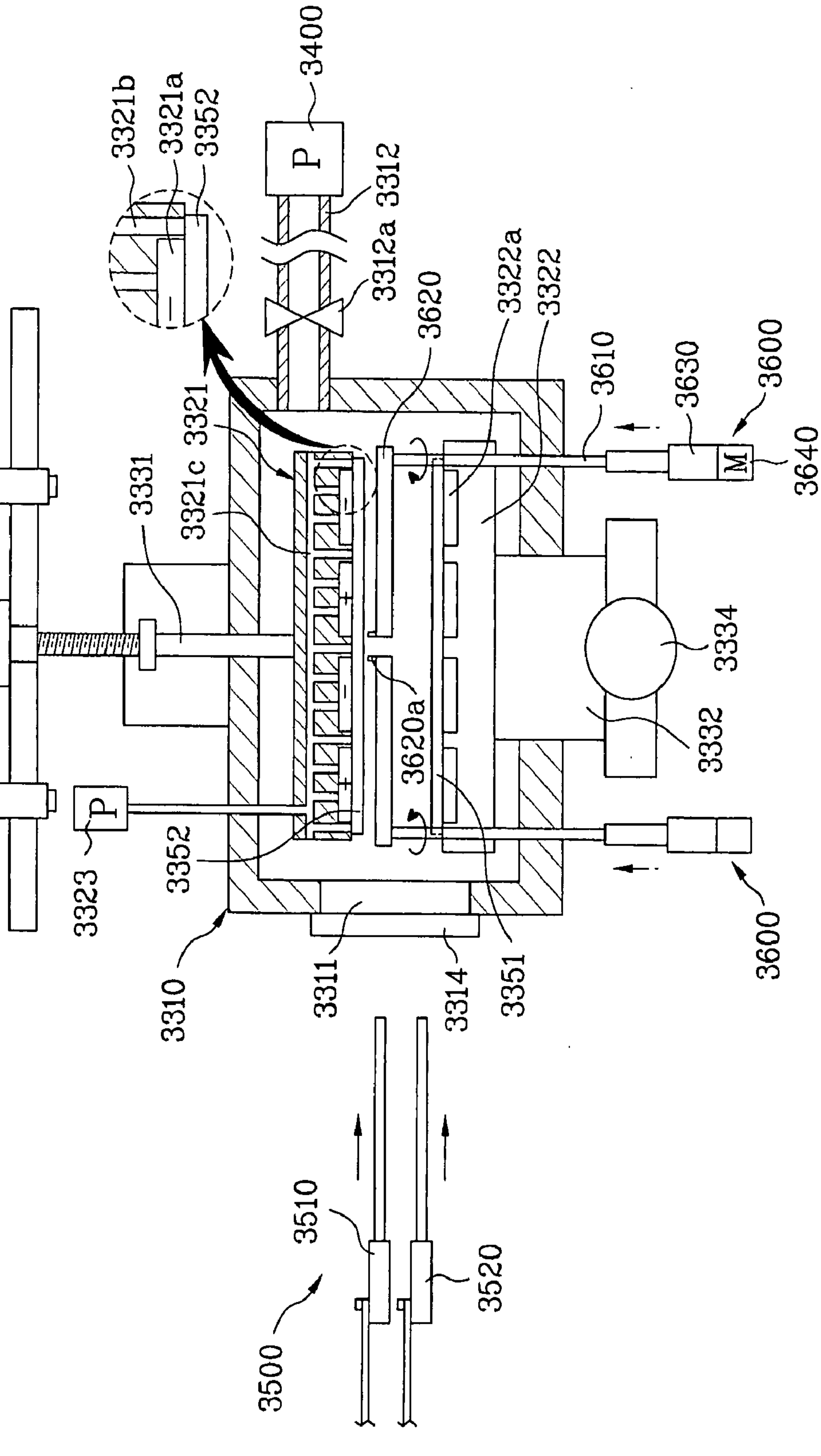

3400
P
3321b
3321a
3352
3312
3312a
3620
3322a
3322
3610
3630
3600
M
3640
3321
3321c
3331
3333
3334
3332
3620a
P
3352
3323
3310
3311
3314
3351
3600
3510
3520
3500

FIG. 111B

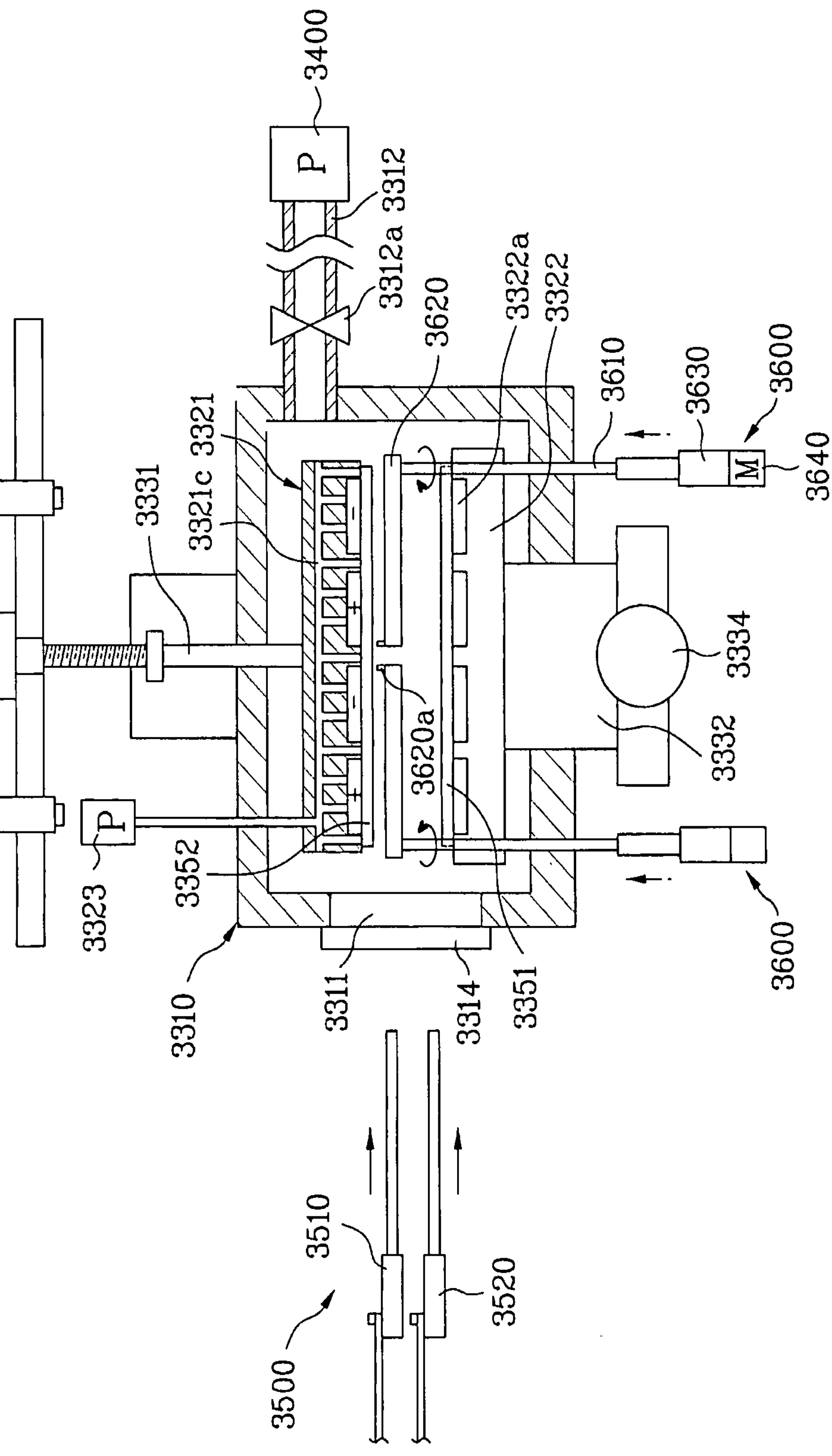

3400
P
3312
3312a
3620
3322a
3322
3610
3630
3600
M
3640
3333
3331
3321c
3321
3334
3332
3620a
P
3323
3352
3310
3311
3314
3351
3600
3510
3520
3500

FIG. 112

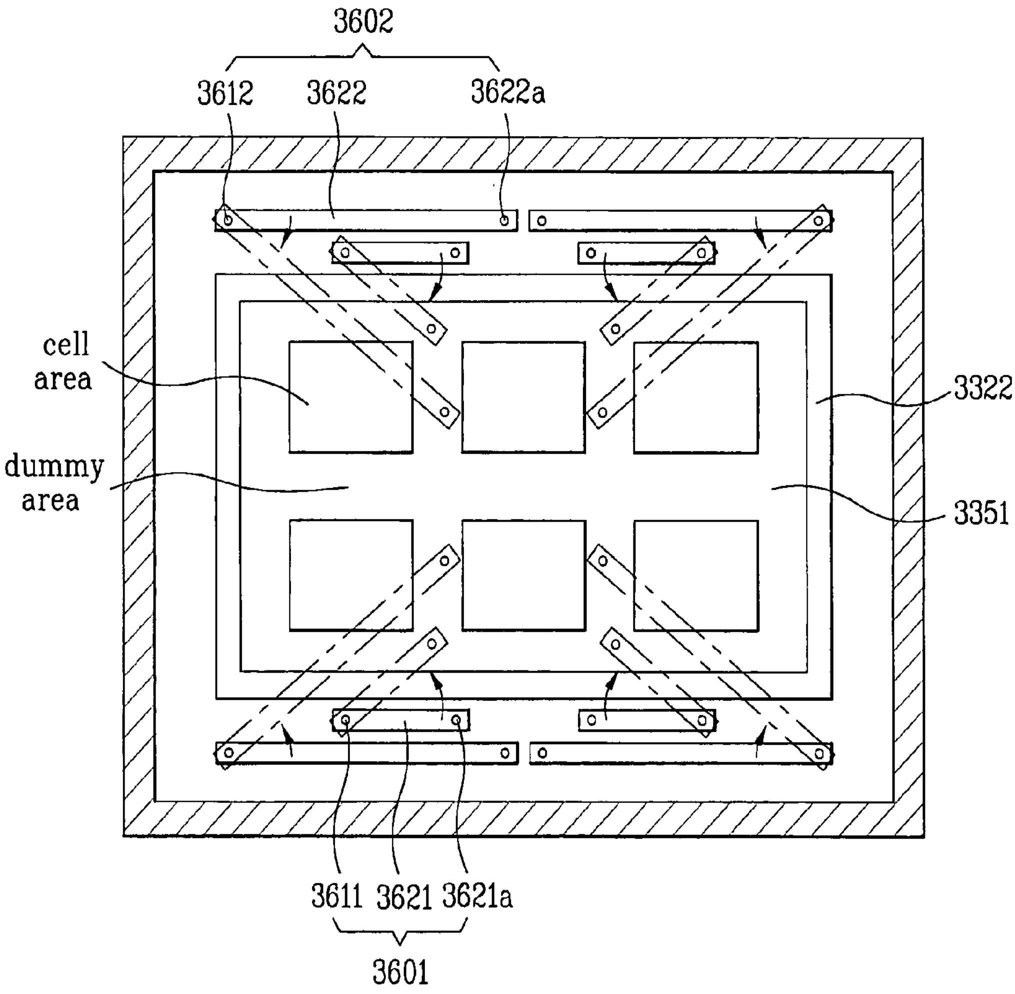

3602
3612
3622
3622a
cell
area
dummy
area
3322
3351
3611
3621
3621a
3601

FIG. 113

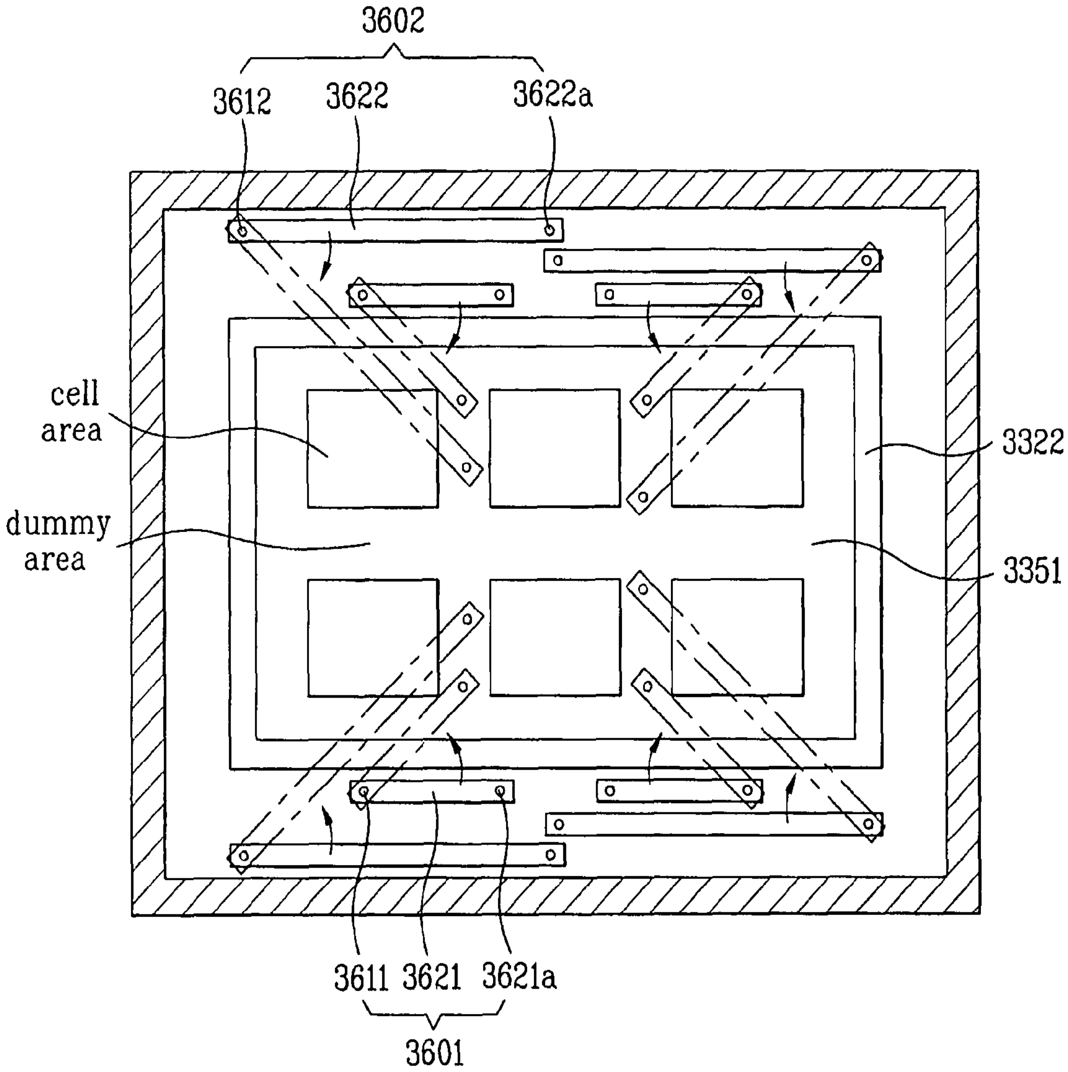

3602
3612
3622
3622a
cell area
dummy area
3322
3351
3611
3621
3621a
3601

FIG. 114

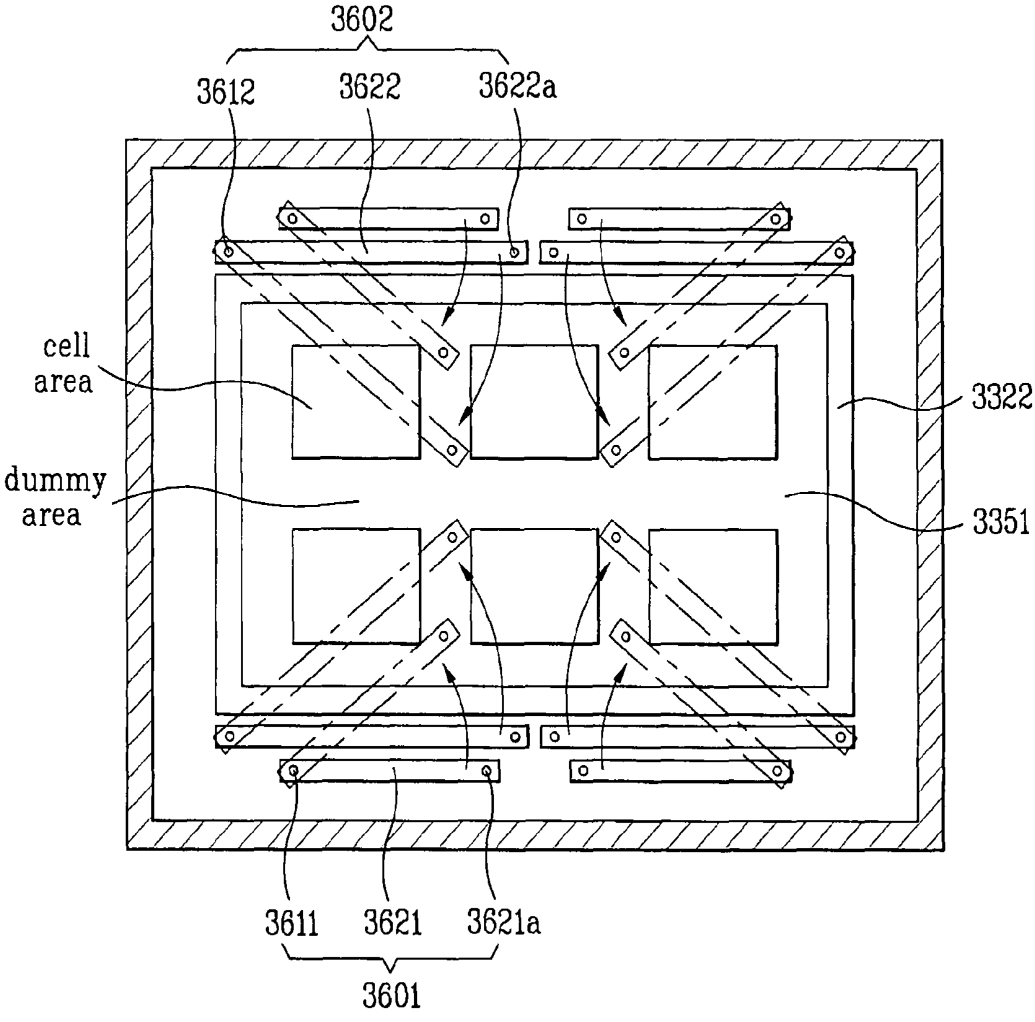

3602
3612
3622
3622a
cell area
dummy area
3322
3351
3611
3621
3621a
3601

FIG. 115

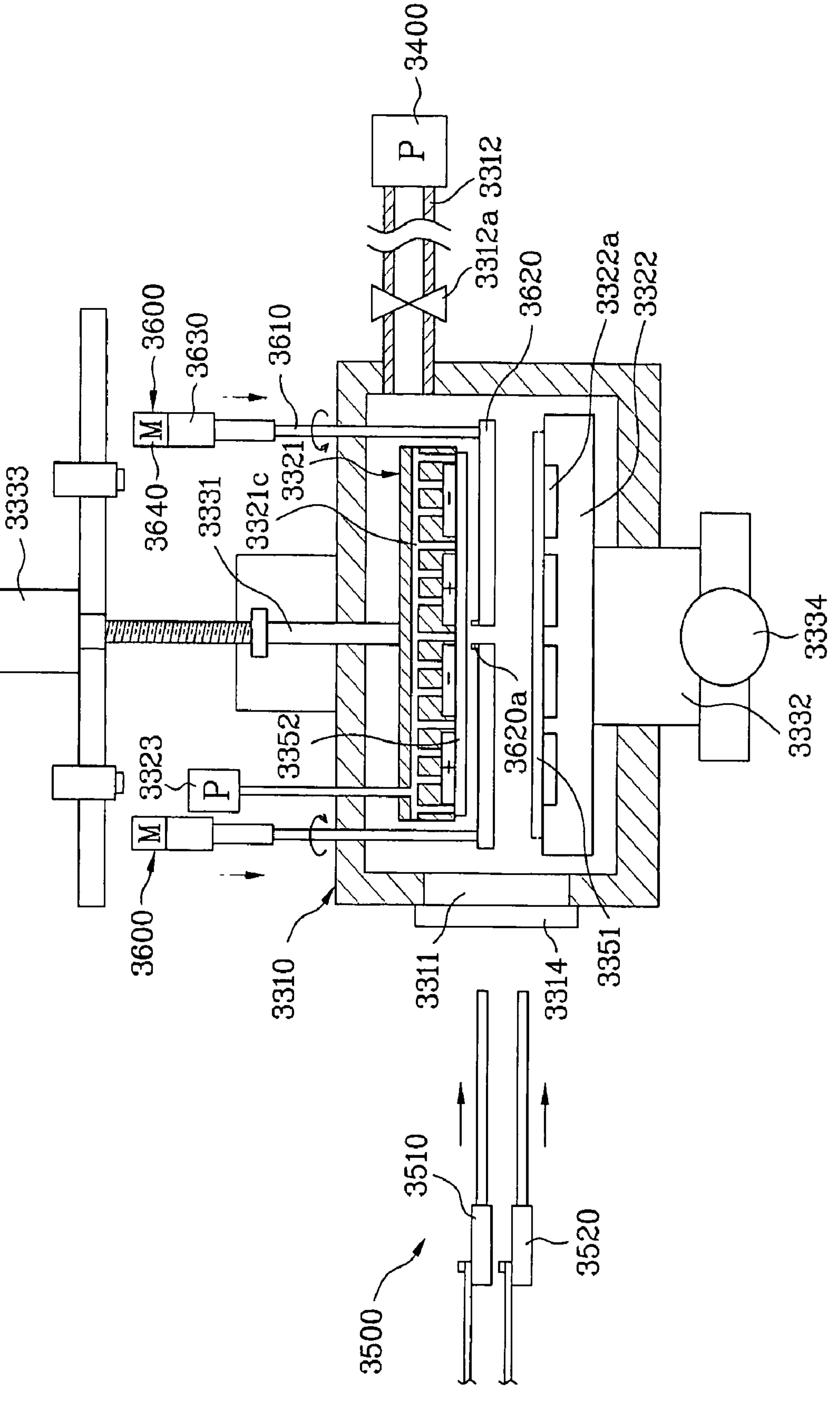

3400
P
3312
3312a
3620
3322a
3322
3600
3630
3610
M
3333
3640
3331
3321c
3321
3352
3323
P
3620a
M
3600
3310
3311
3314
3351
3334
3332
3510
3520
3500

FIG. 116

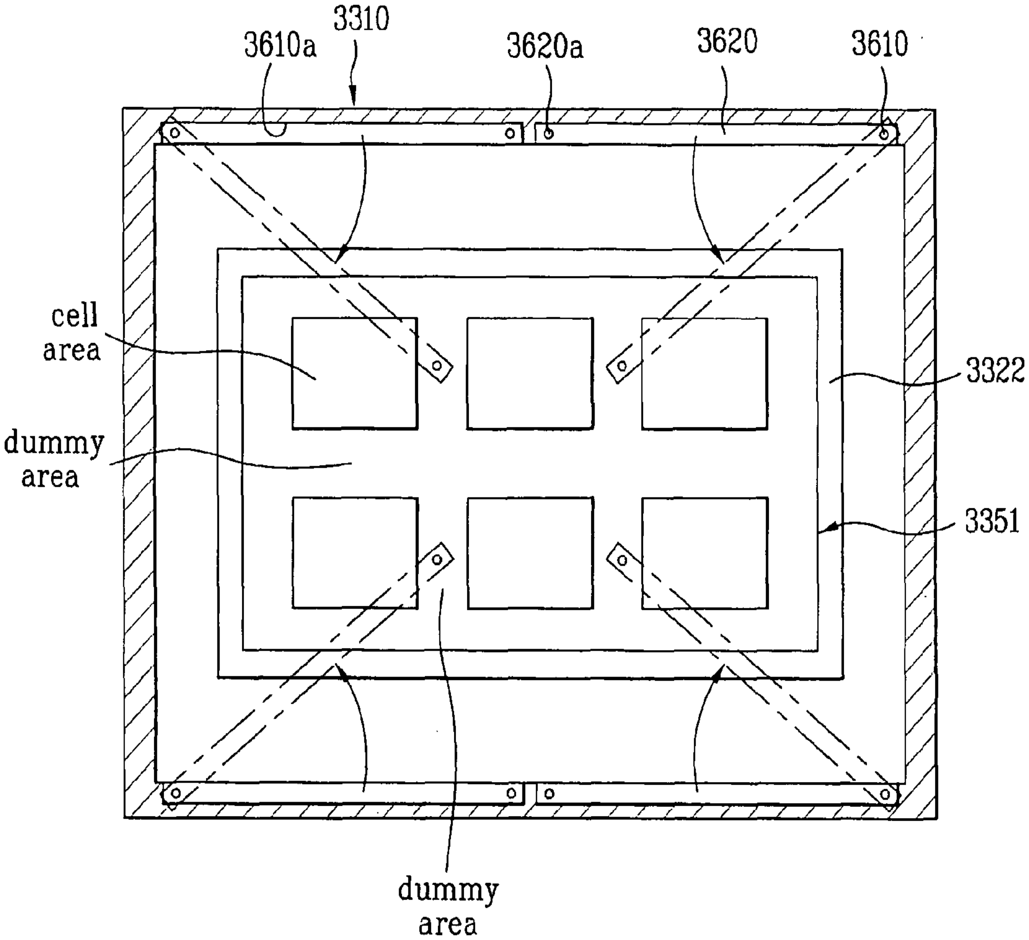

3310
3610a
3620a
3620
3610
cell area
3322
dummy area
3351
dummy area

FIG. 117

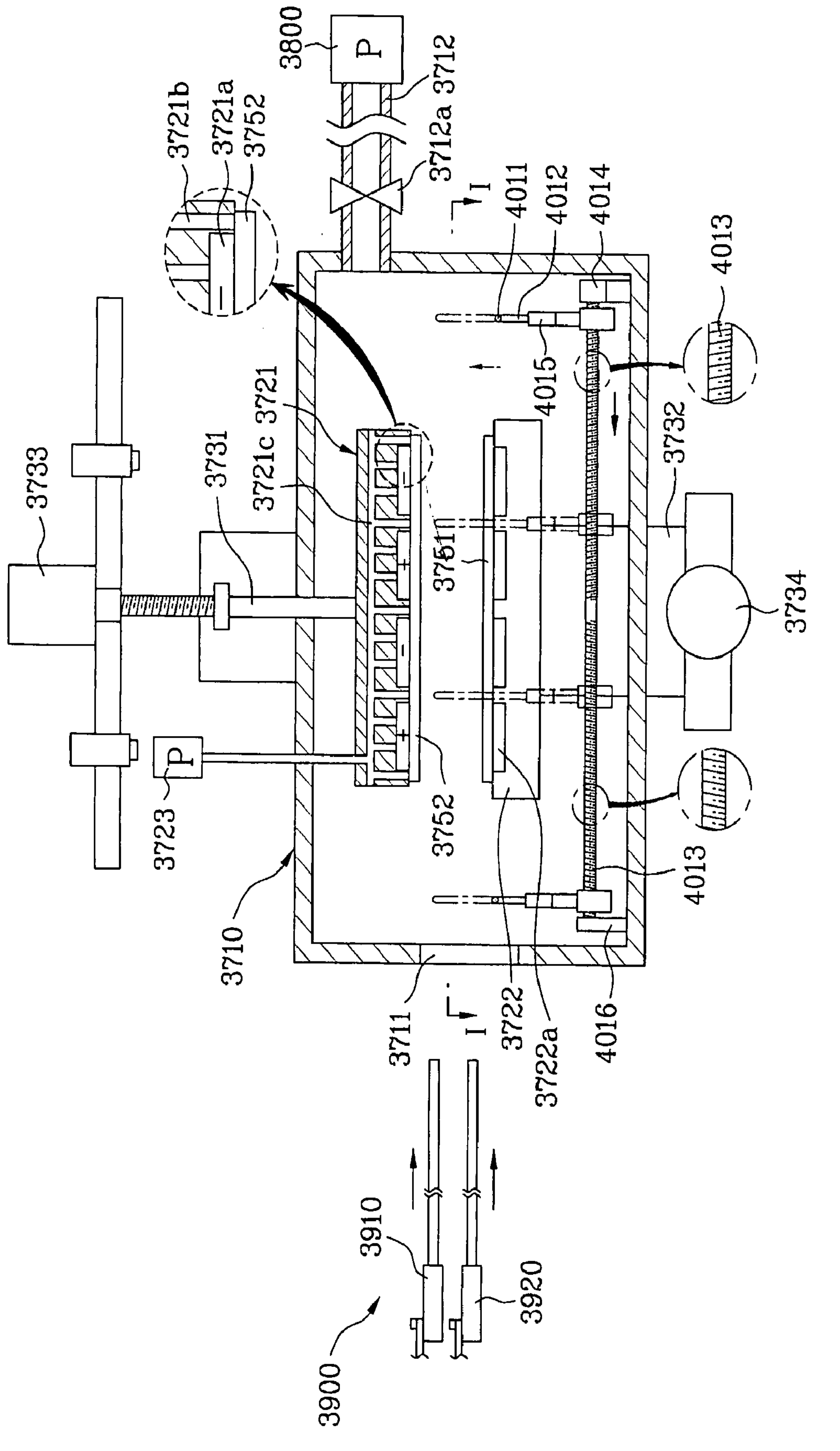

3800
P
3712
3712a
3721b
3721a
3752
4011
4012
4014
4013
4015
3732
3733
3731
3721c
3721
3751
3734
3723
P
3752
3722
3722a
4013
3710
3711
4016
I
3900
3910
3920

FIG. 118

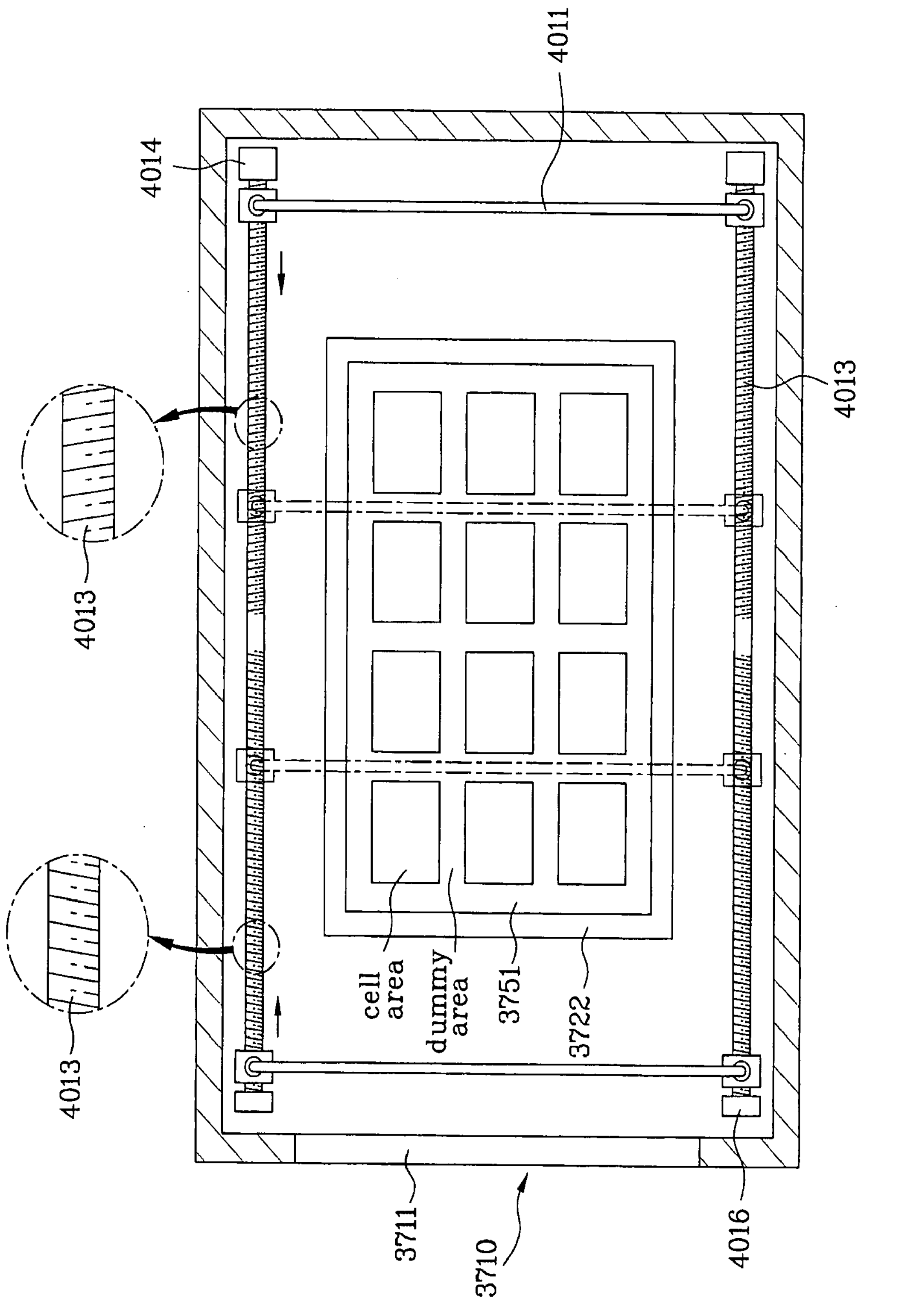

4011
4014
4013
4013
4013
cell area
dummy area
3751
3722
3711
3710
4016

FIG. 119

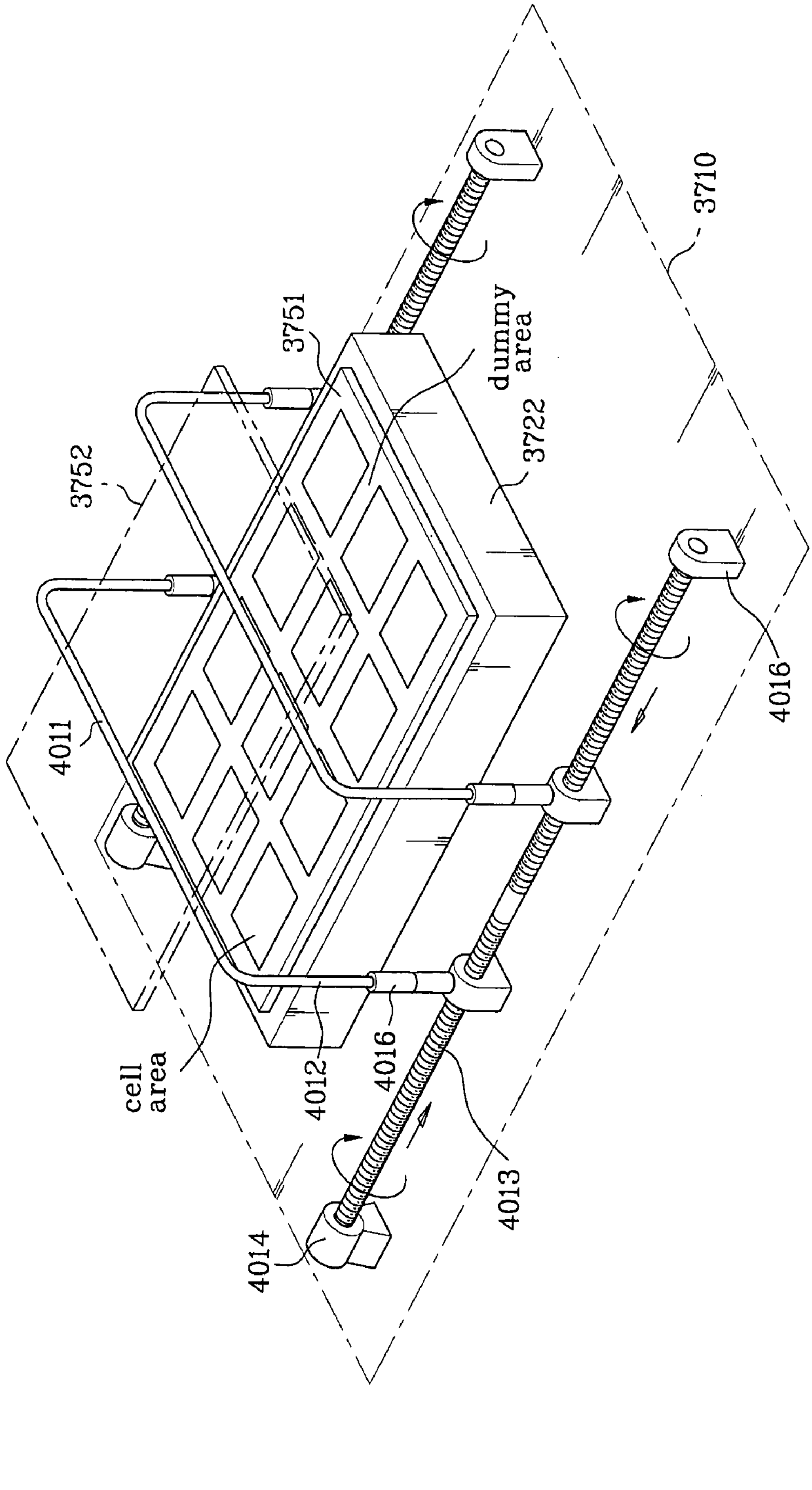

3710
3751
dummy area
3722
3752
4016
4011
cell area
4012
4016
4013
4014

FIG. 120A

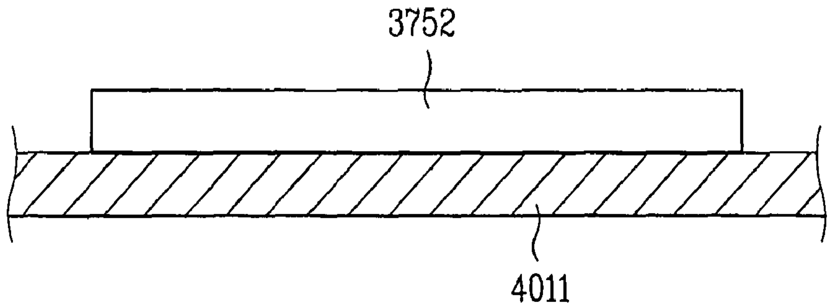


FIG. 120B

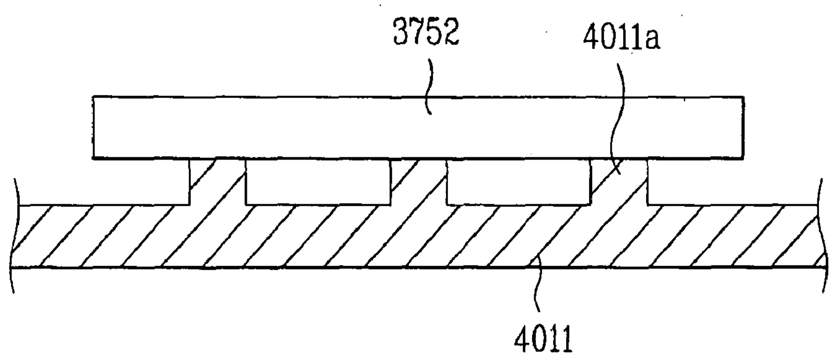


FIG. 120C

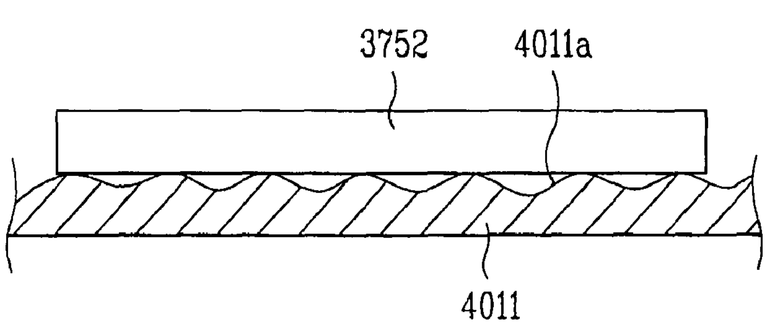


FIG. 121

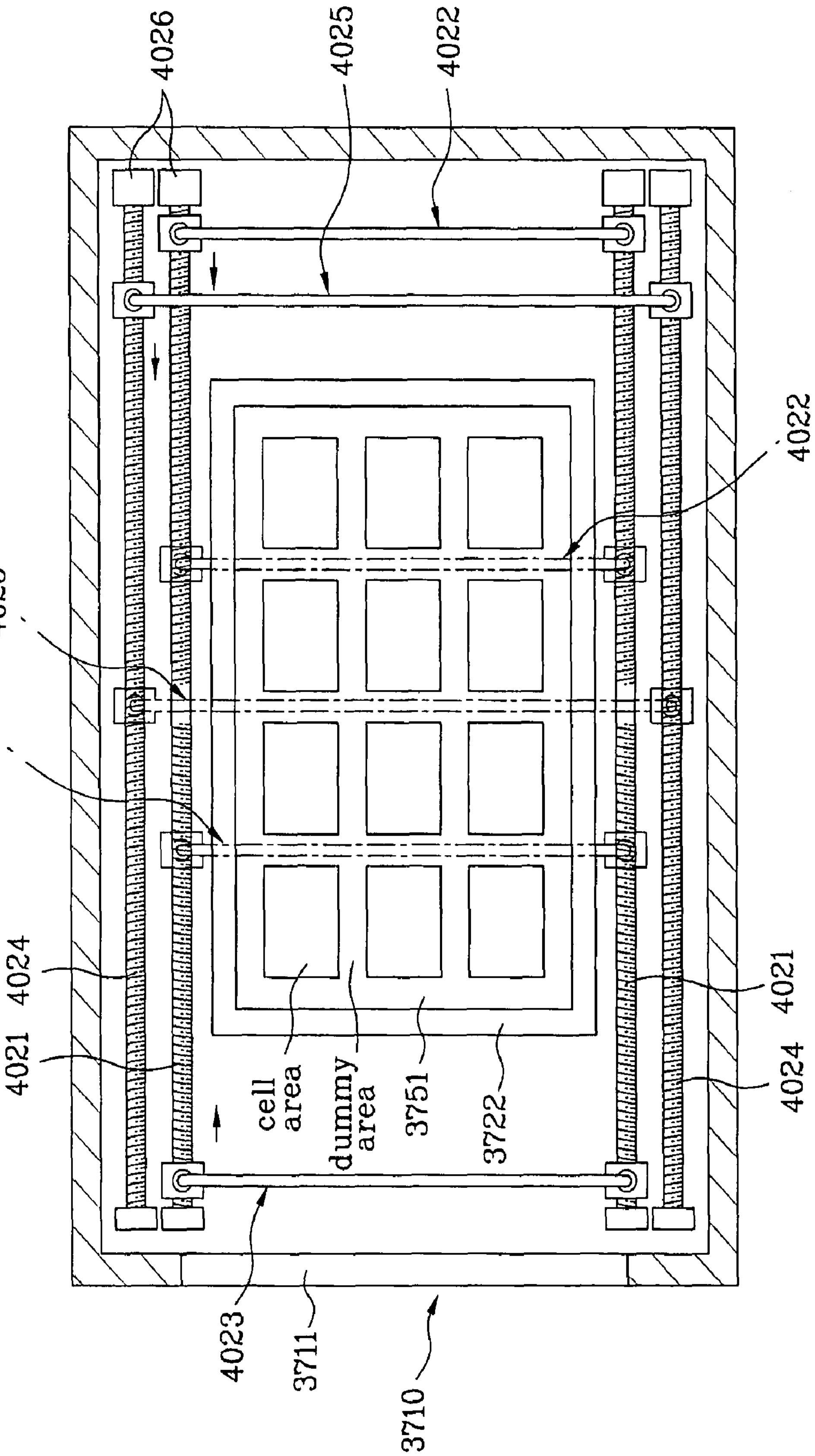

4026
4025
4022
4022
4025
4023
4024
4021
4021
4024
cell area
dummy area
3751
3722
4023
3711
3710

FIG. 122

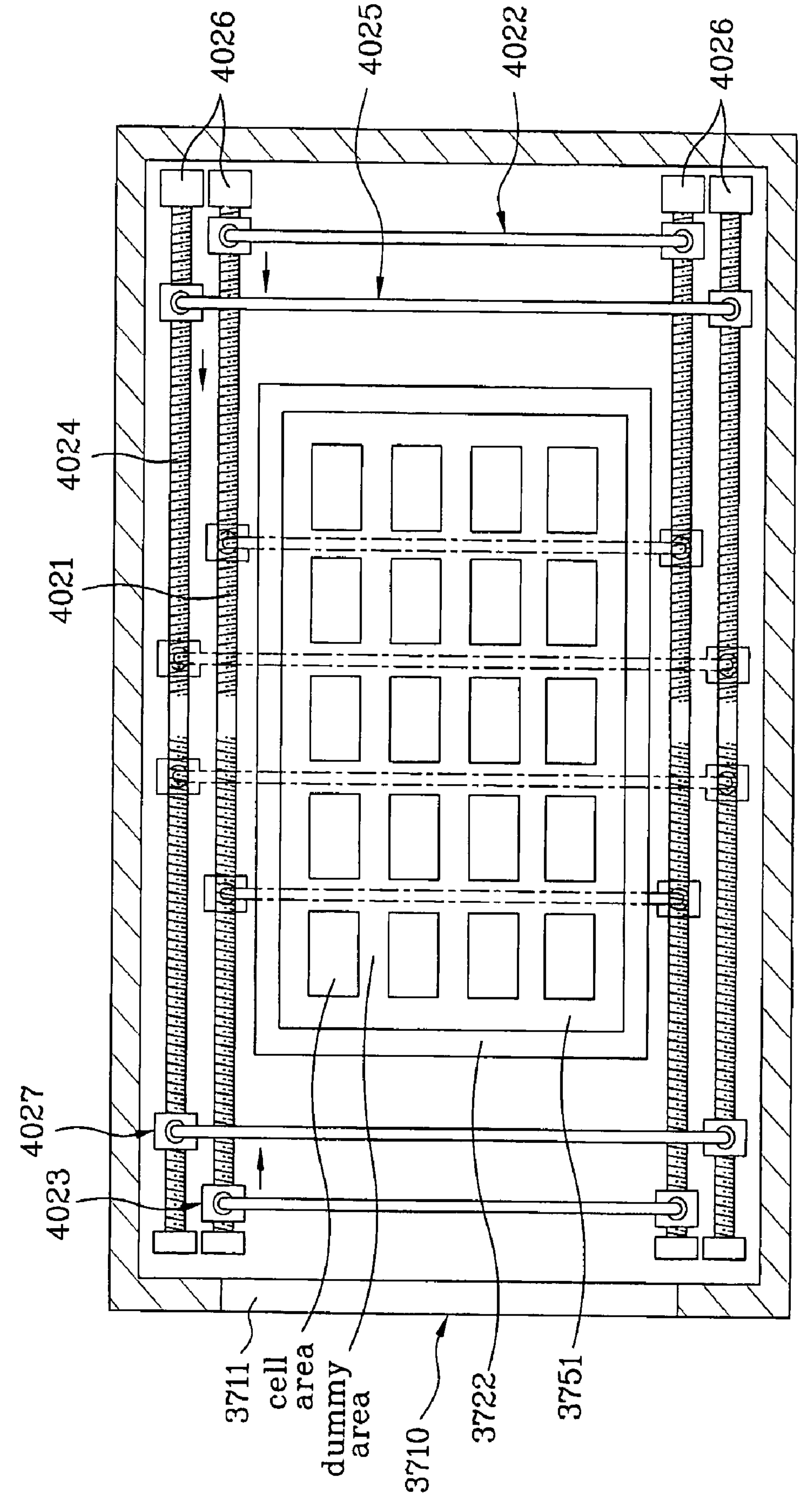

4026
4025
4022
4026
4024
4021
4027
4023
3711
cell area
dummy area
3710
3722
3751

FIG. 123

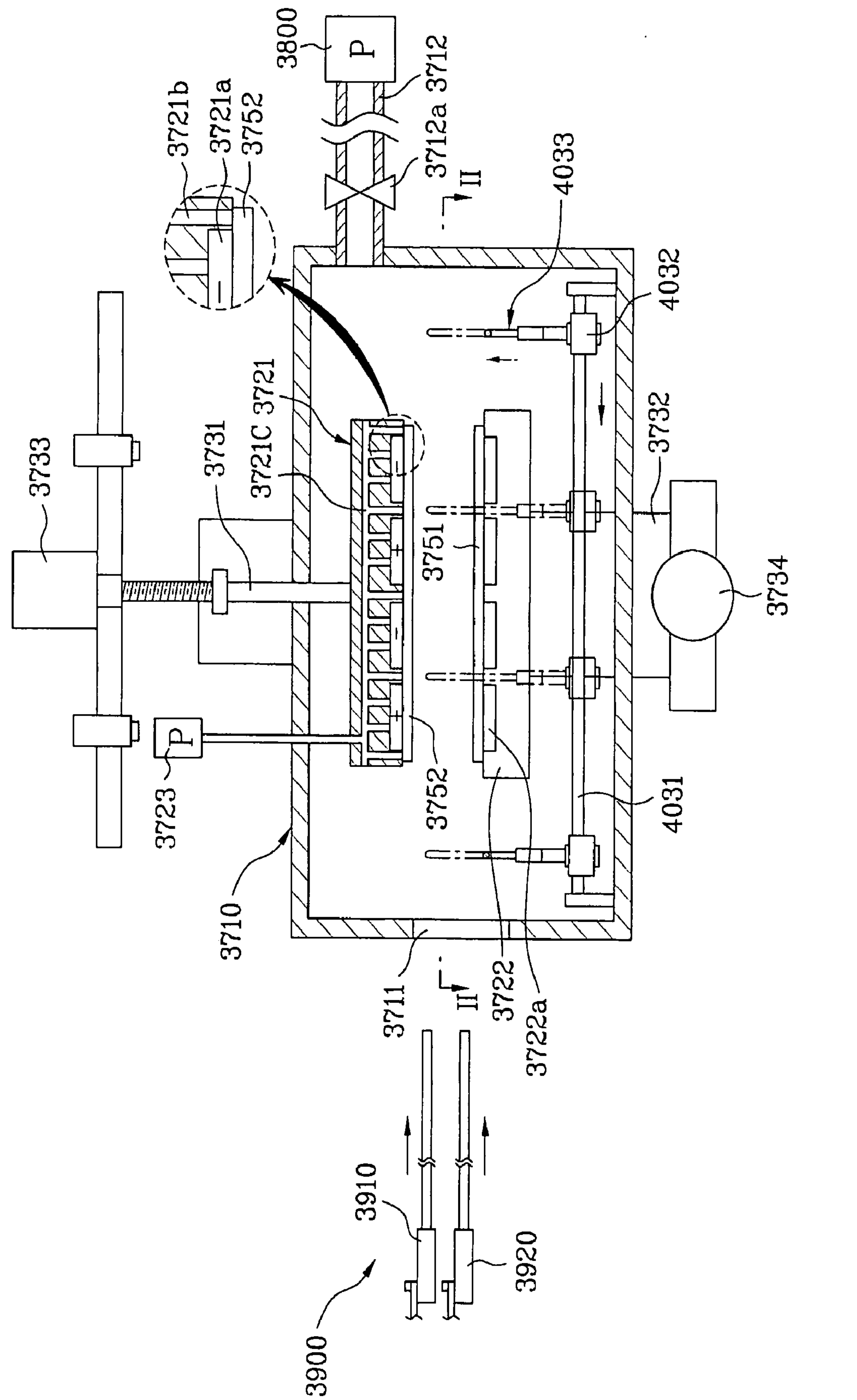

3800
P
3712
3712a
3721b
3721a
3752
II
4033
4032
3733
3731
3721C
3721
3732
3751
3734
P
3723
3752
4031
3710
3711
II
3722
3722a
3910
3920
3900

FIG. 124

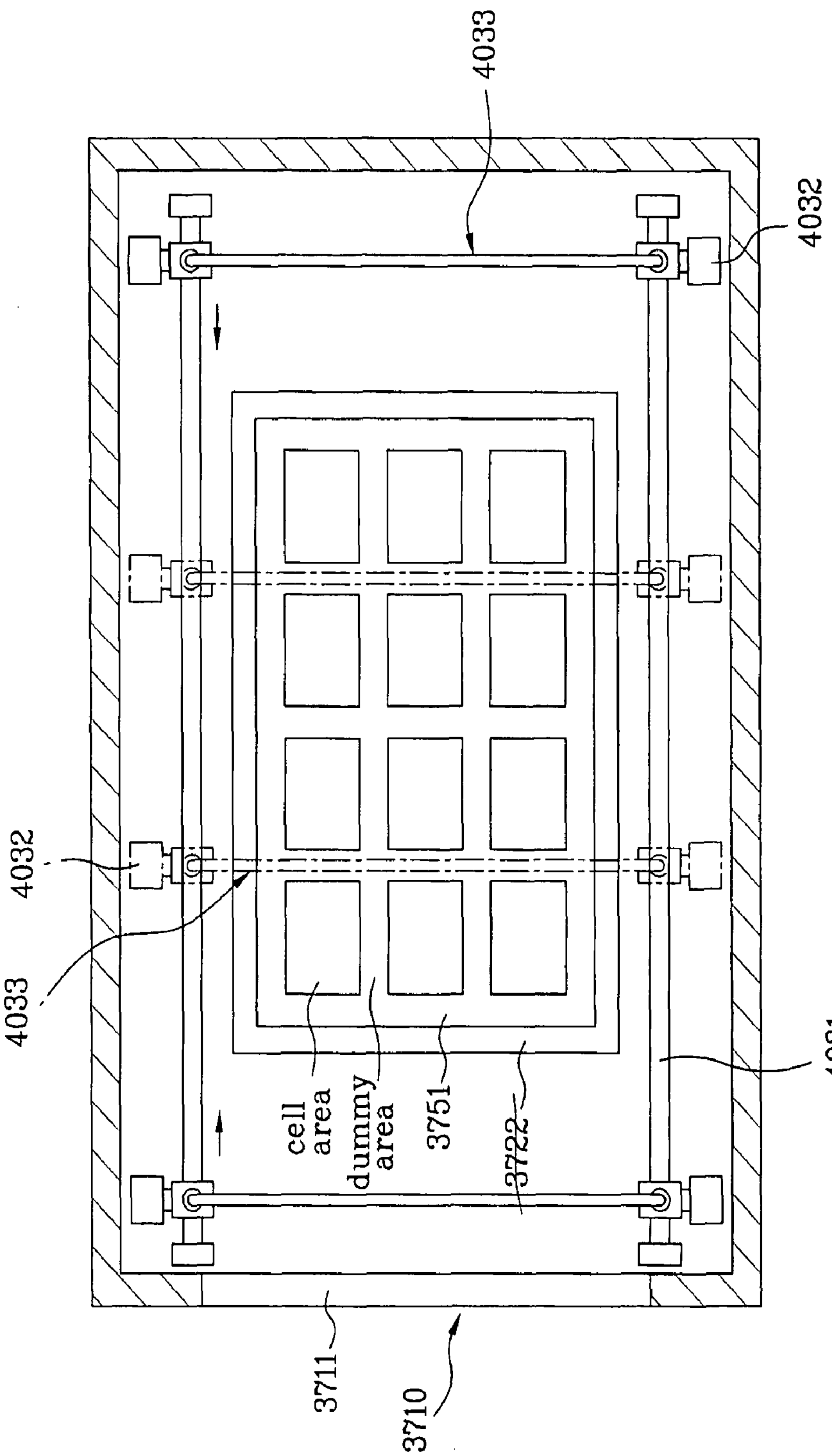

4033
4032
4032
4033
cell area
dummy area
3751
3722
4031
3711
3710

FIG. 125

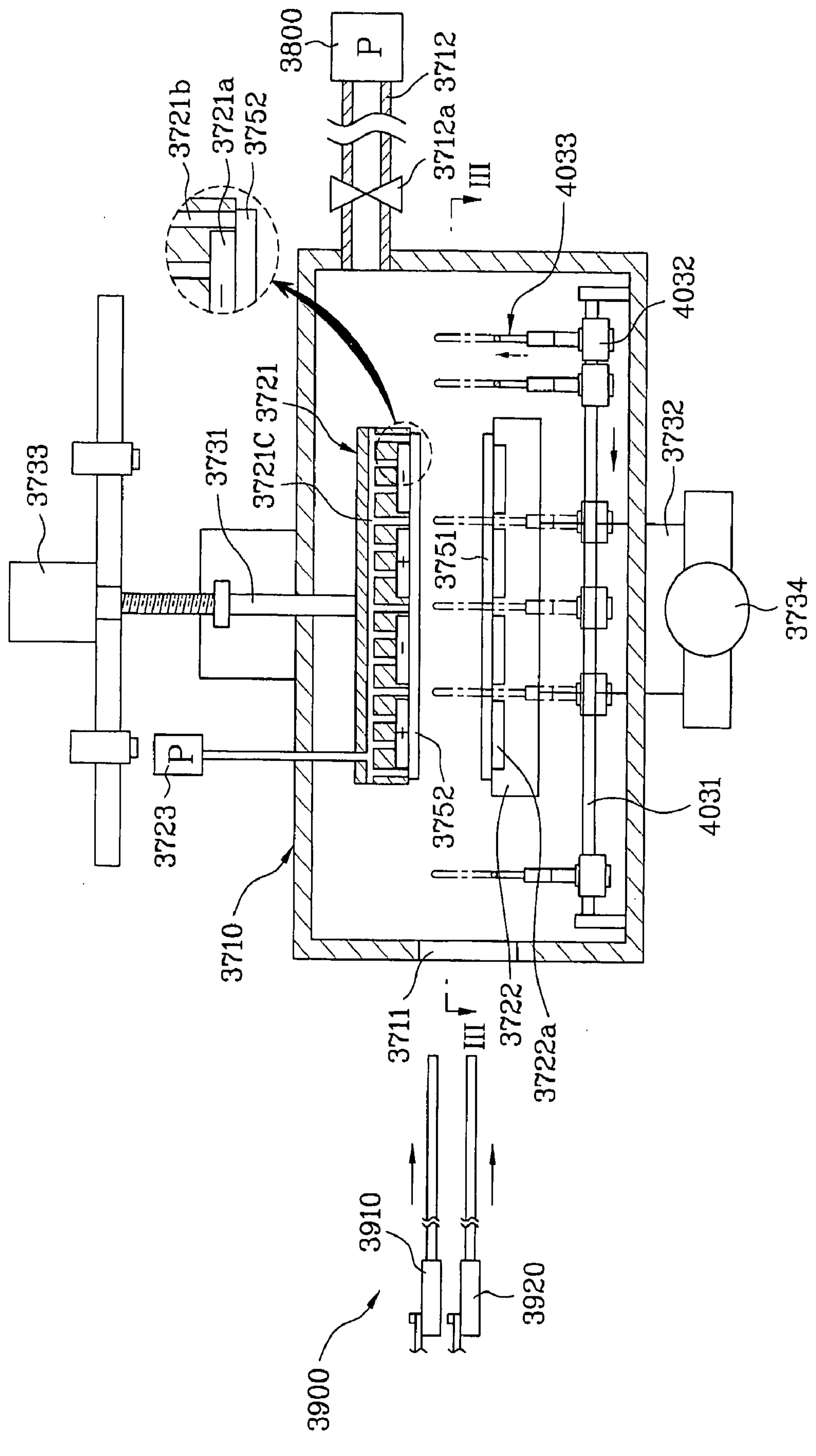

3800
P
3712
3712a
3721b
3721a
3752
III
4033
4032
3733
3731
3721C
3721
3732
3751
3734
P
3723
3752
4031
3710
3711
III
3722
3722a
3910
3920
3900

FIG. 126

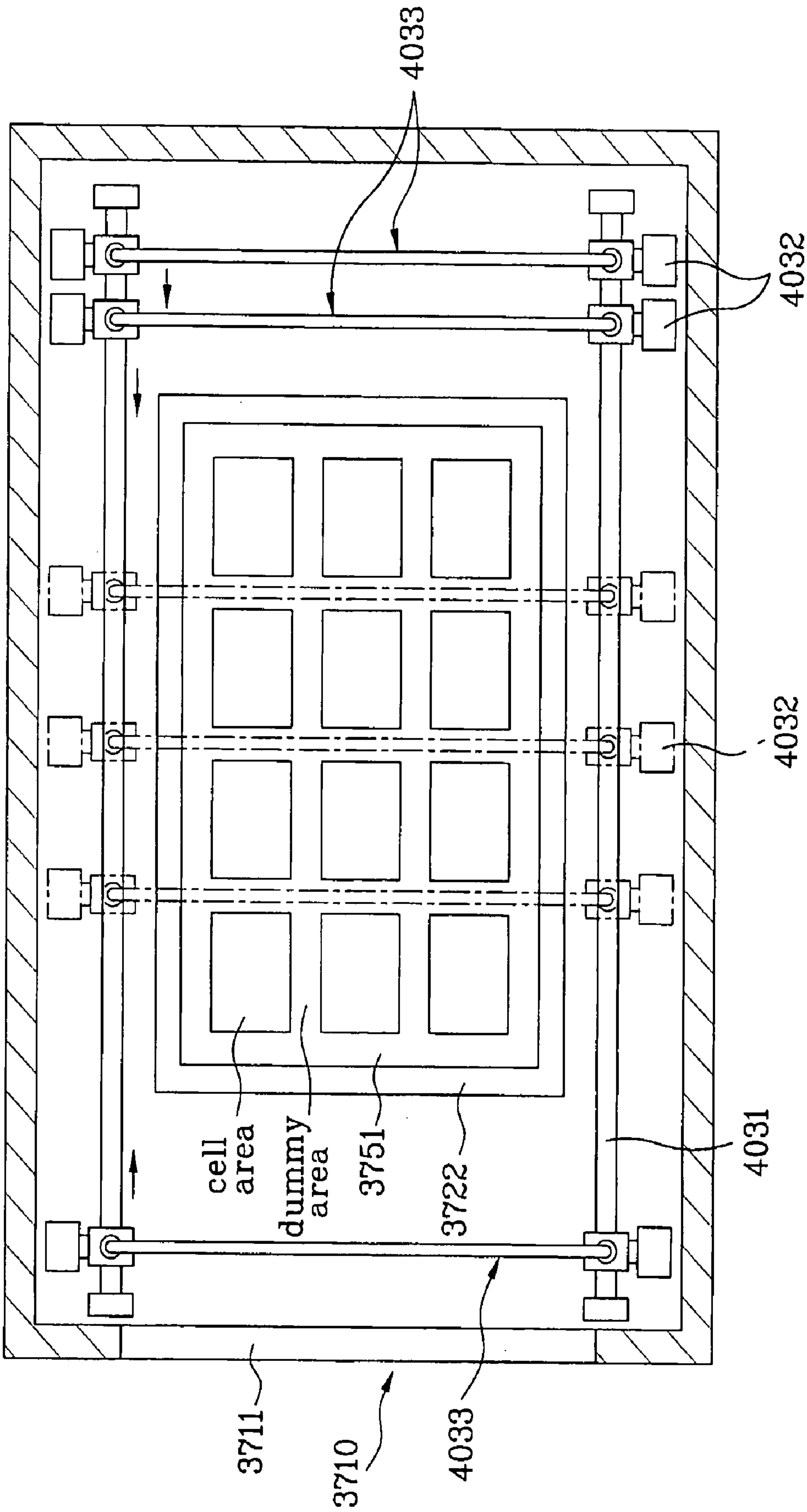

4033
4032
4032
cell area
dummy area
3751
3722
4031
3711
3710
4033

FIG. 127

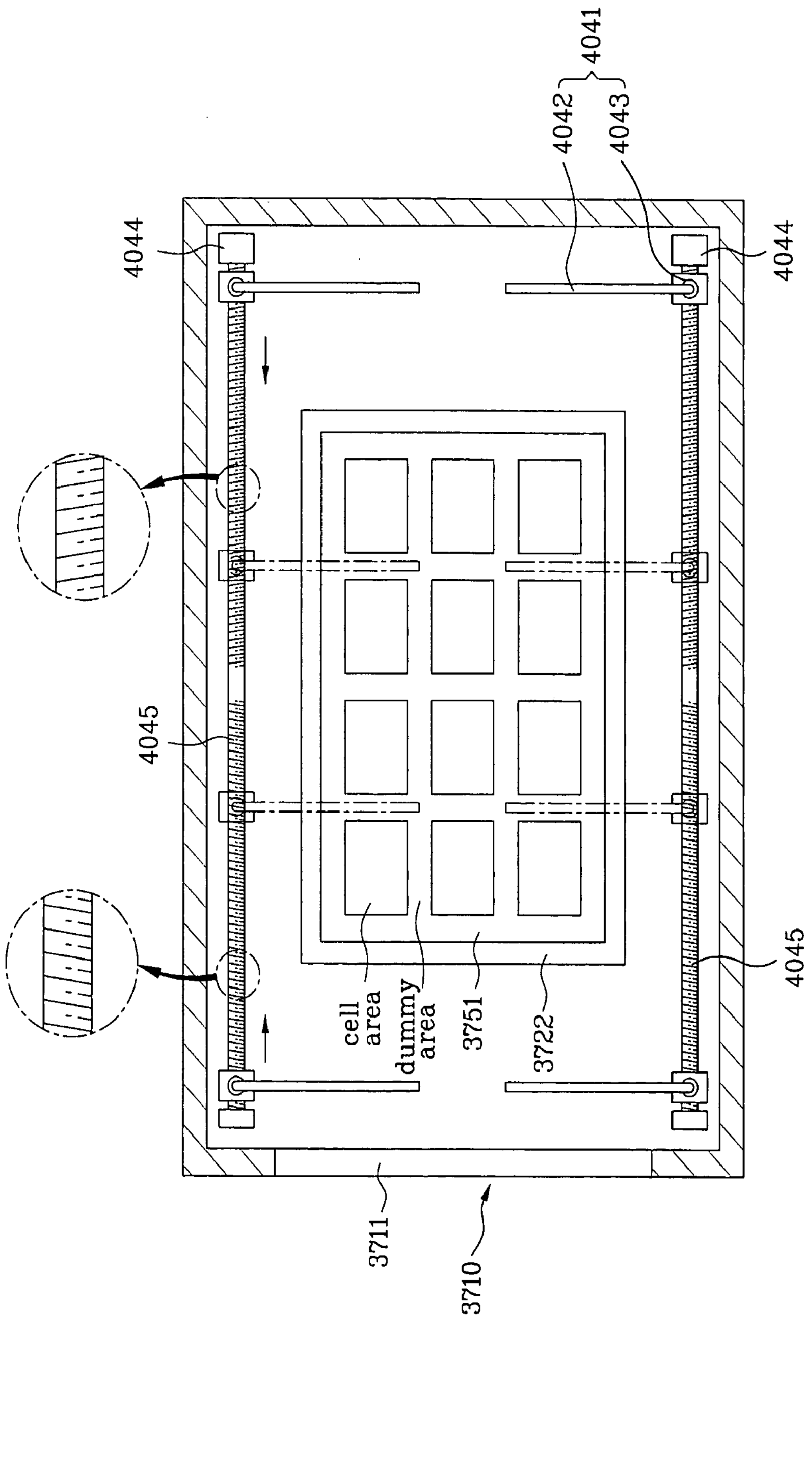

4041
4042
4043
4044
4044
4045
4045
cell area
dummy area
3751
3722
3711
3710

FIG. 128

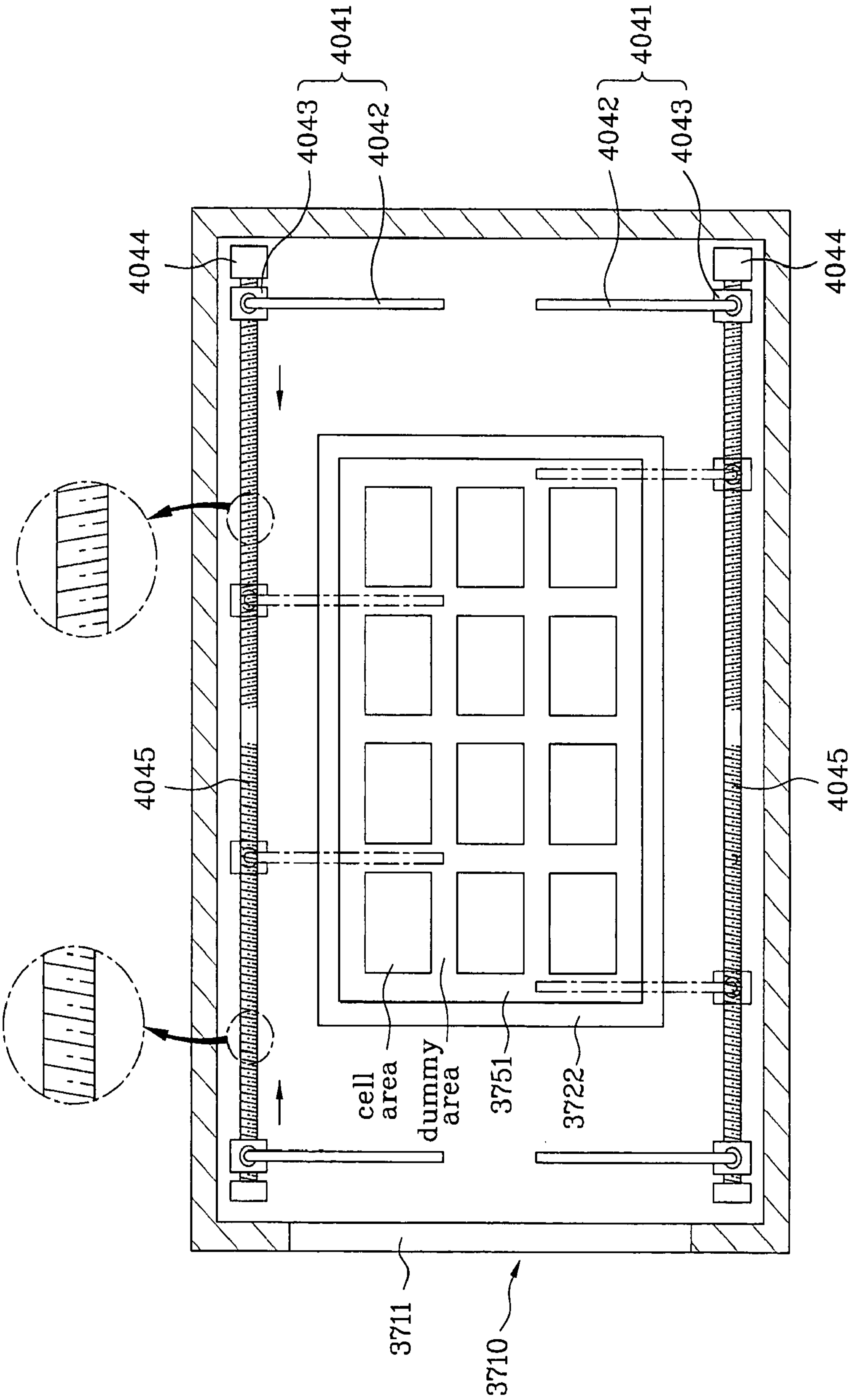

4041
4043
4042
4041
4042
4043
4044
4044
4045
4045
cell area
dummy area
3751
3722
3711
3710

FIG. 129

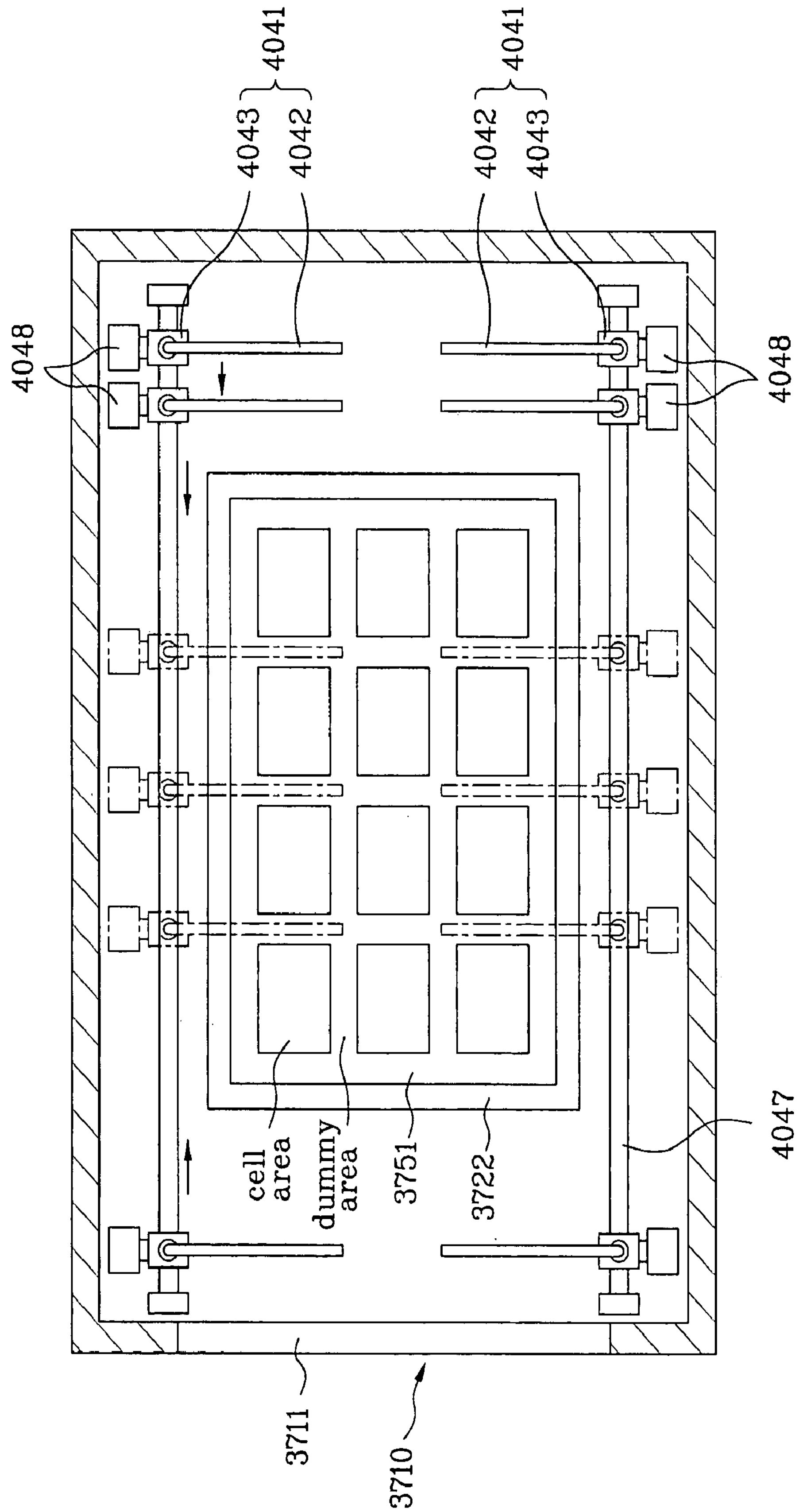

4041
4043
4042
4041
4042
4043
4048
4048
cell area
dummy area
3751
3722
4047
3711
3710

FIG. 130

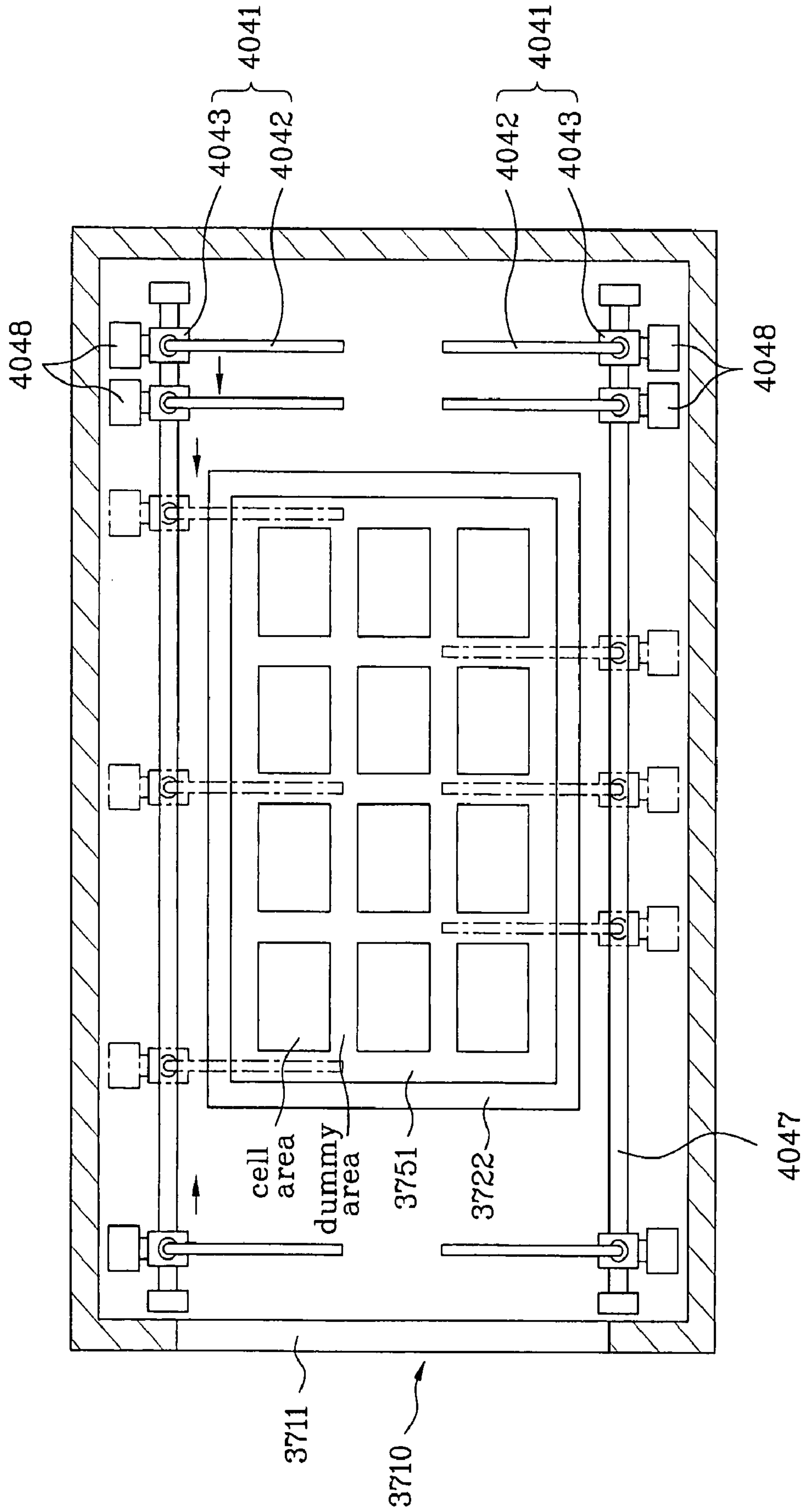

4041
4043
4042
4041
4042
4043
4048
4048
cell area
dummy area
3751
3722
4047
3711
3710

FIG. 131

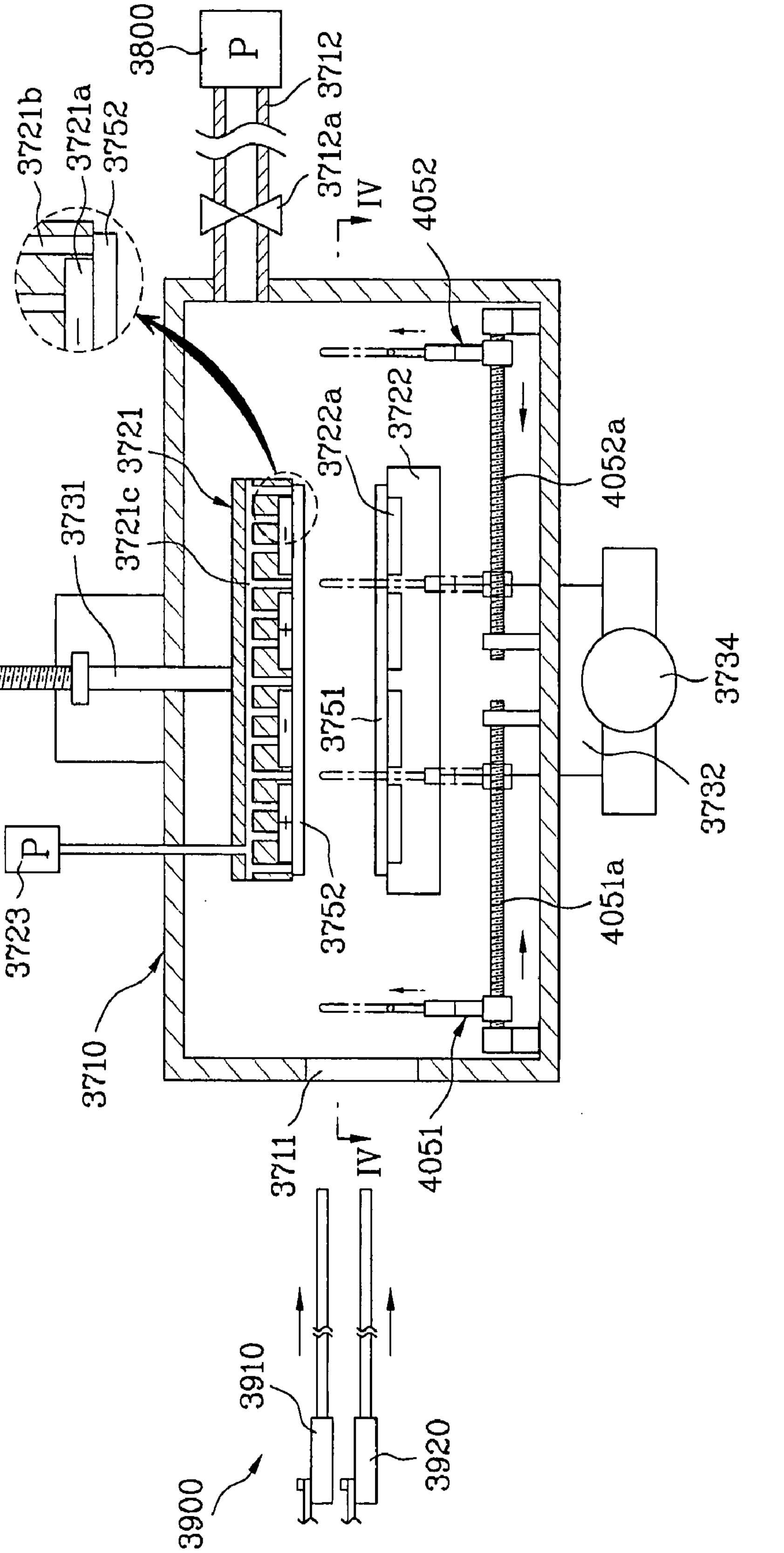

3800
P
3712
3712a
3721b
3721a
3752
IV
4052
3733
3731
3721c 3721
3722a
3722
4052a
3751
3734
3732
P
3723
3752
4051a
3710
3711
IV
4051
3910
3920
3900

FIG. 132

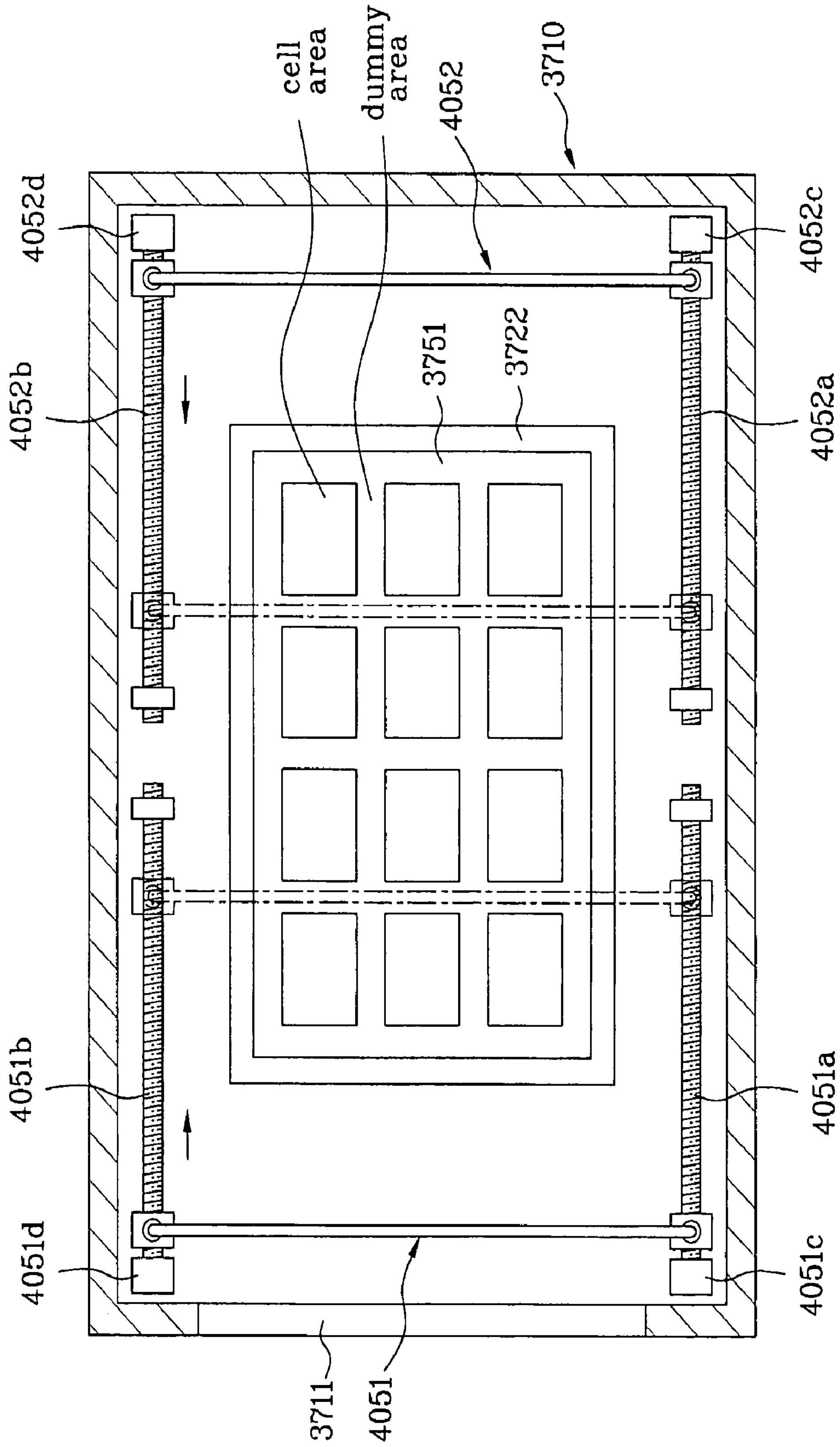

cell area
dummy area
4052
3710
4052d
4052c
4052b
4052a
3751
3722
4051b
4051a
4051d
4051c
3711
4051

FIG. 133

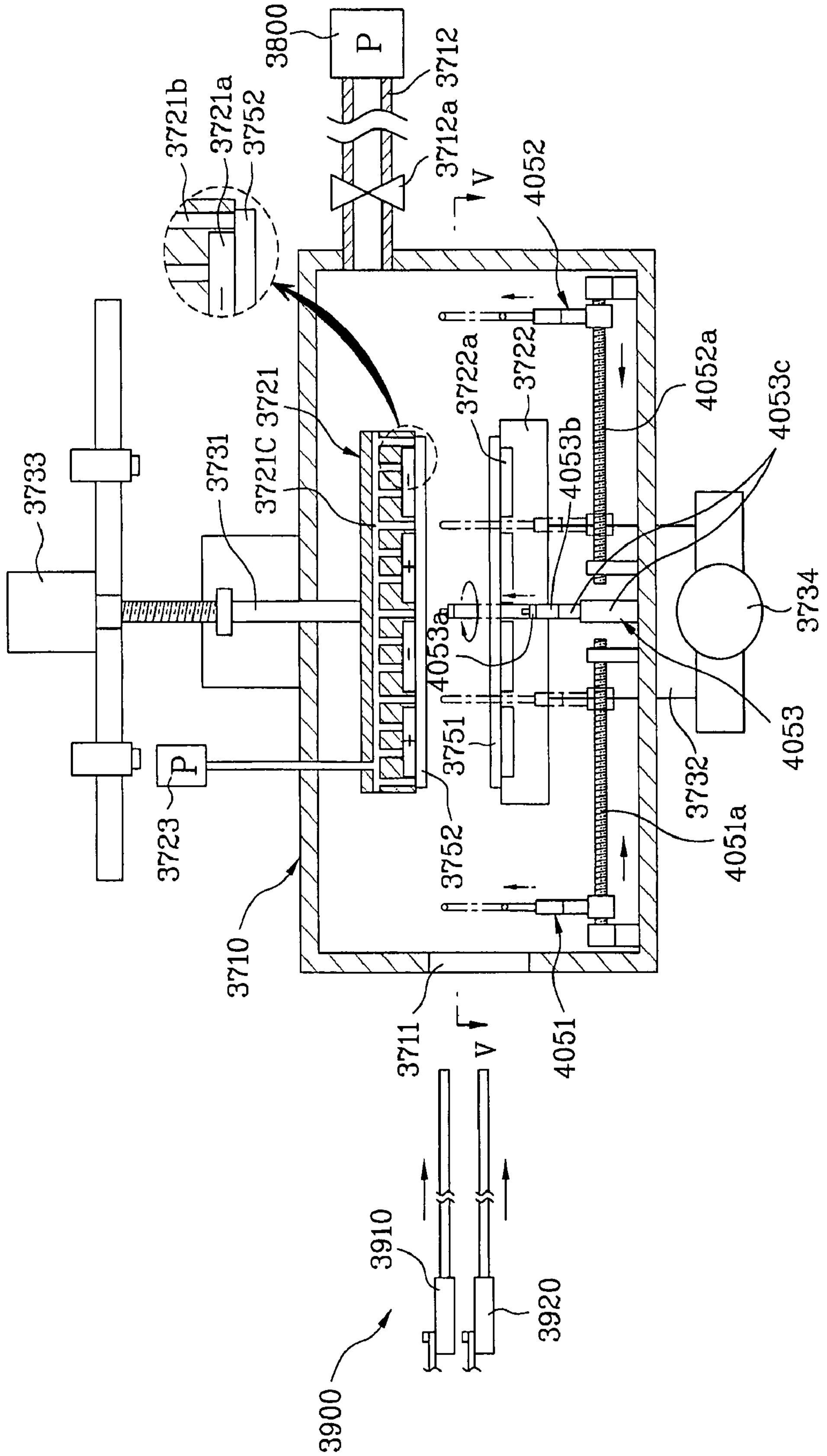

3800
P
3712
3712a
3721b
3721a
3752
V
4052
3733
3731
3721C 3721
3722a
3722
4052a
4053c
4053b
4053a
3734
P
3723
3751
3752
3732
4053
4051a
3710
3711
V
4051
3910
3920
3900

FIG. 134

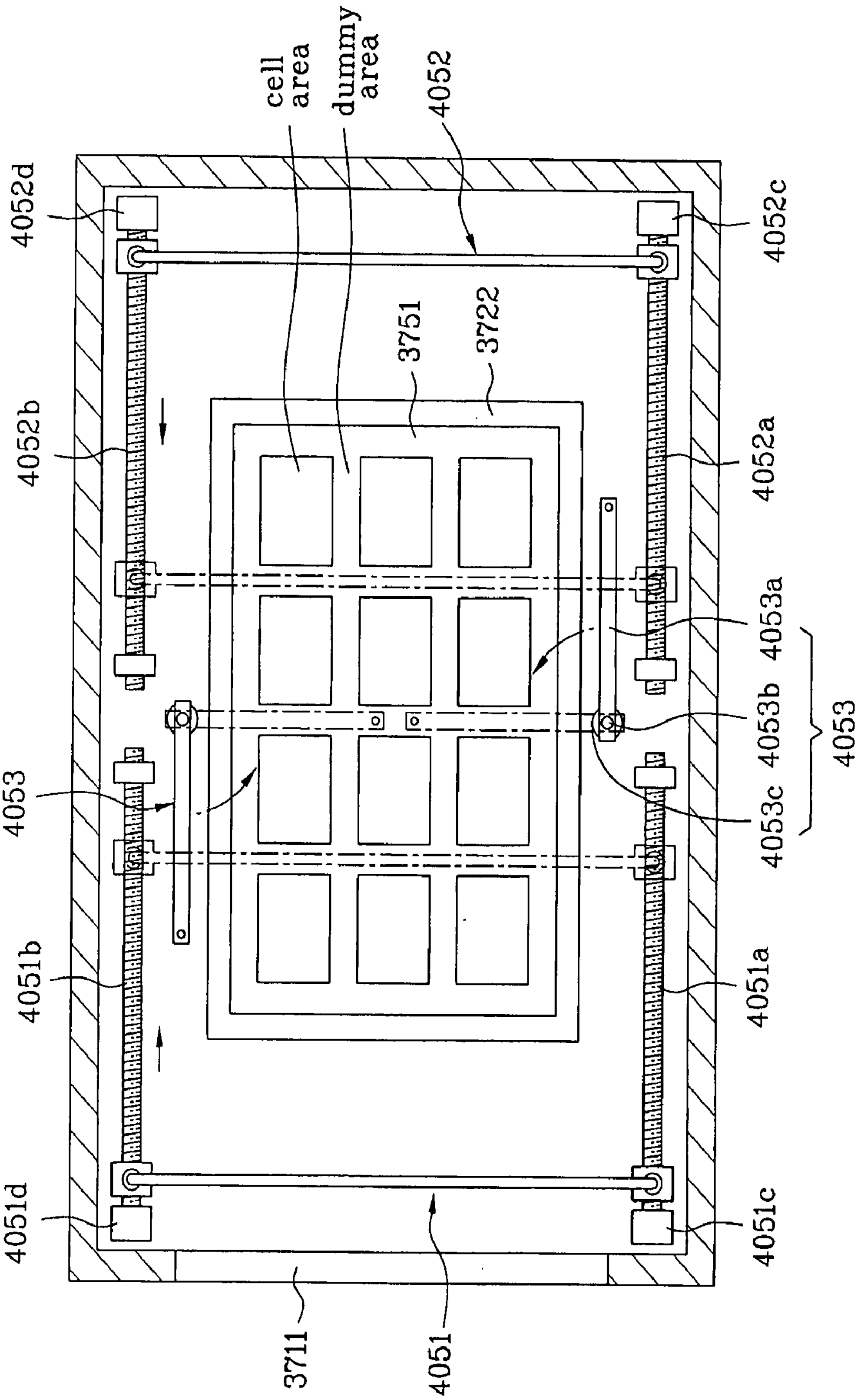

cell area
dummy area
4052
4052d
4052c
3751
3722
4052b
4052a
4053a
4053b
4053
4053c
4053
4051b
4051a
4051d
4051c
3711
4051

FIG. 135

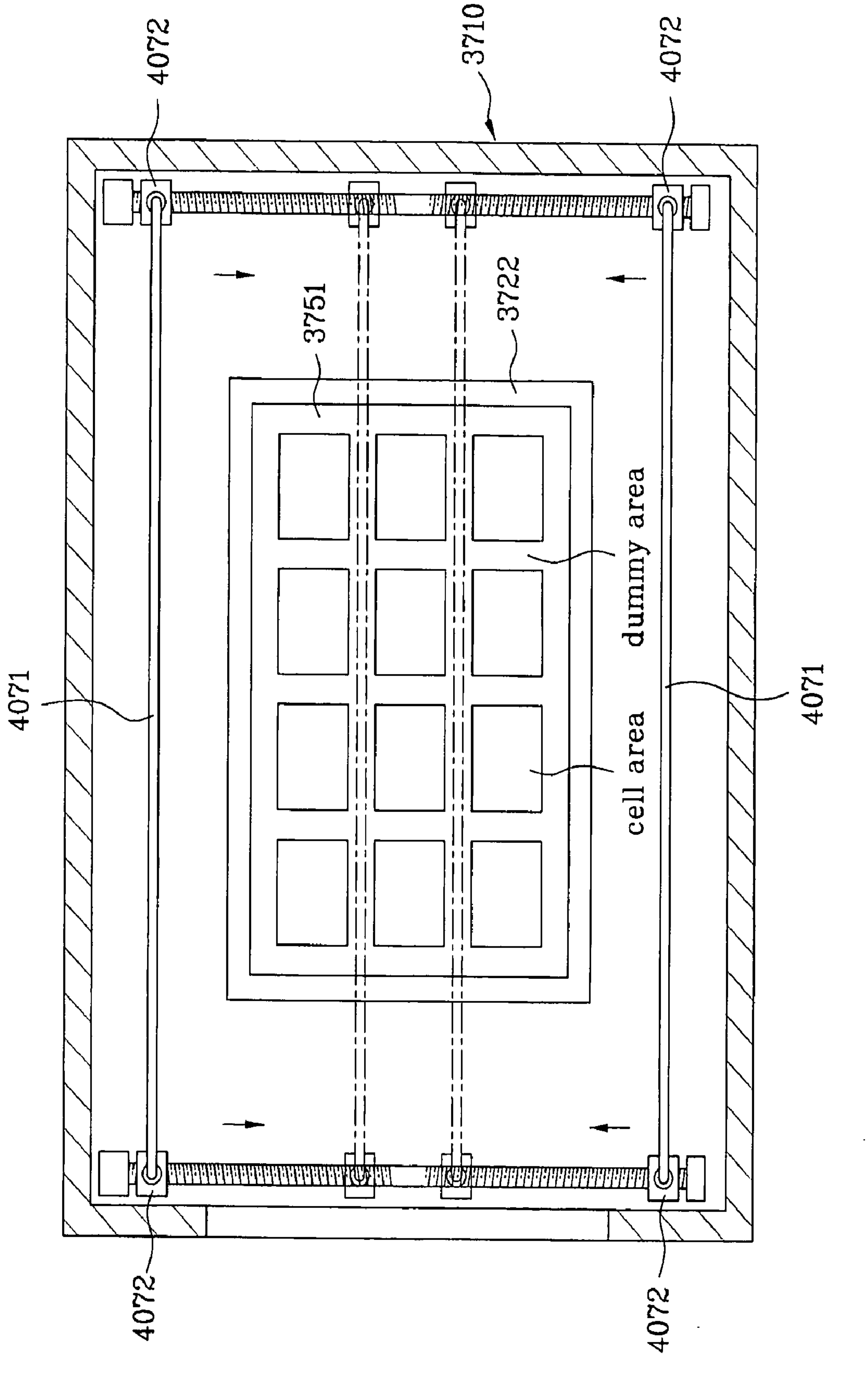

4072
3710
4072
3751
3722
dummy area
cell area
4071
4071
4072
4072

FIG. 136

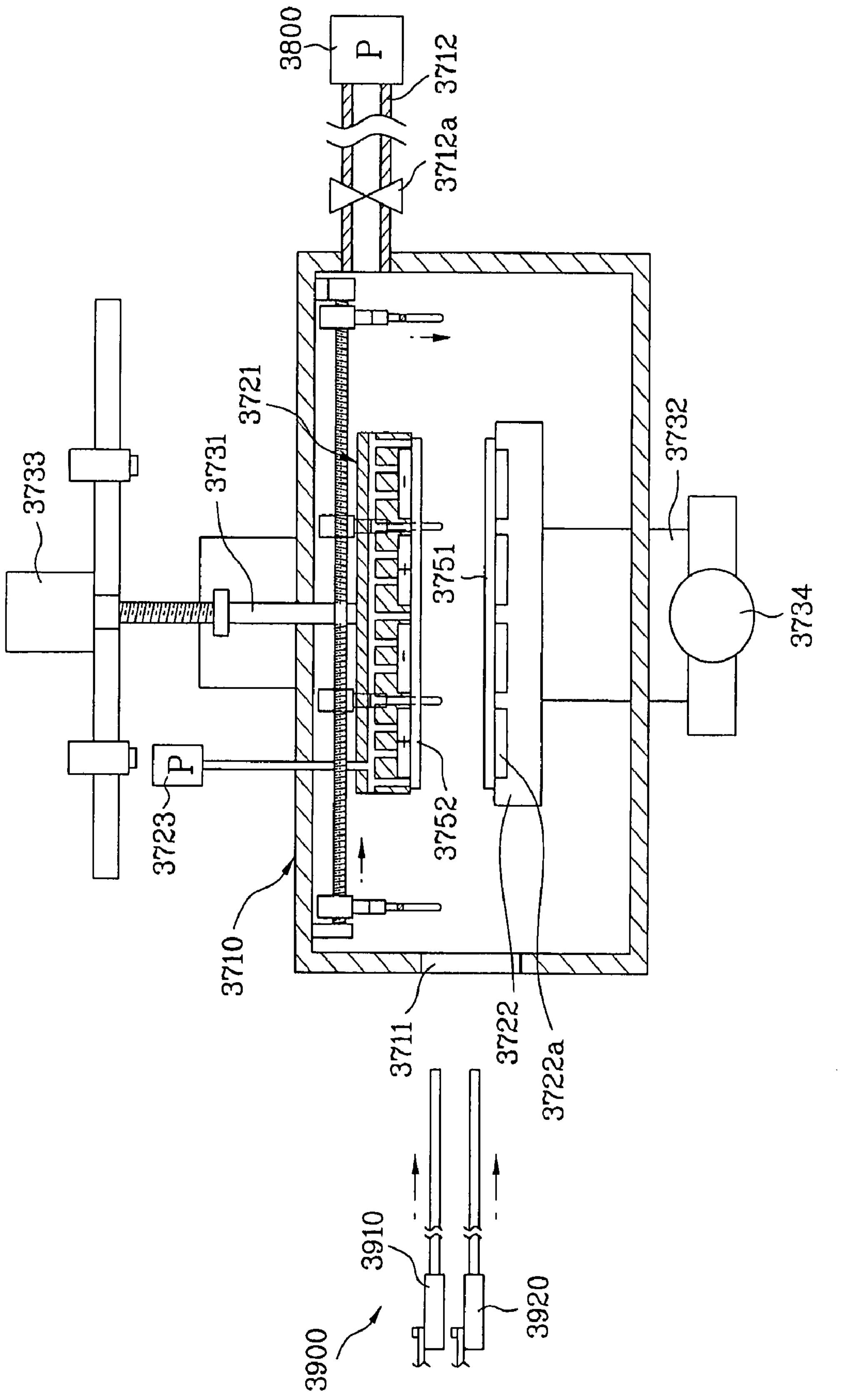

3800
P
3712
3712a
3733
3731
3721
3732
3751
3734
P
3723
3752
3710
3711
3722
3722a
3910
3900
3920

FIG. 137A

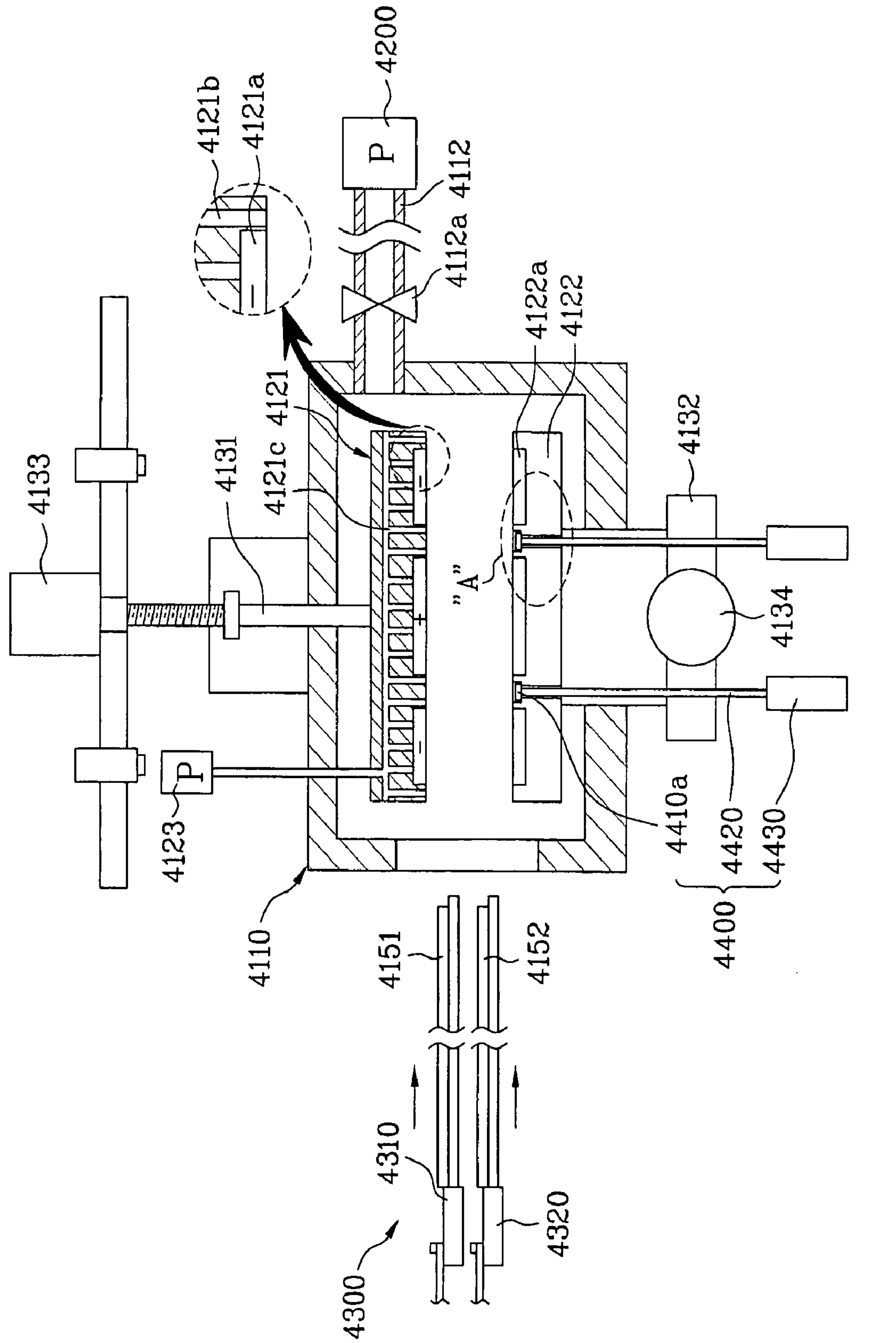

4121b
4121a
4200
P
4112
4112a
4122a
4122
4121c
4121
4131
4133
"A"
4132
4134
4123
P
4110
4410a
4420
4430
4400
4151
4152
4310
4320
4300

FIG. 137B

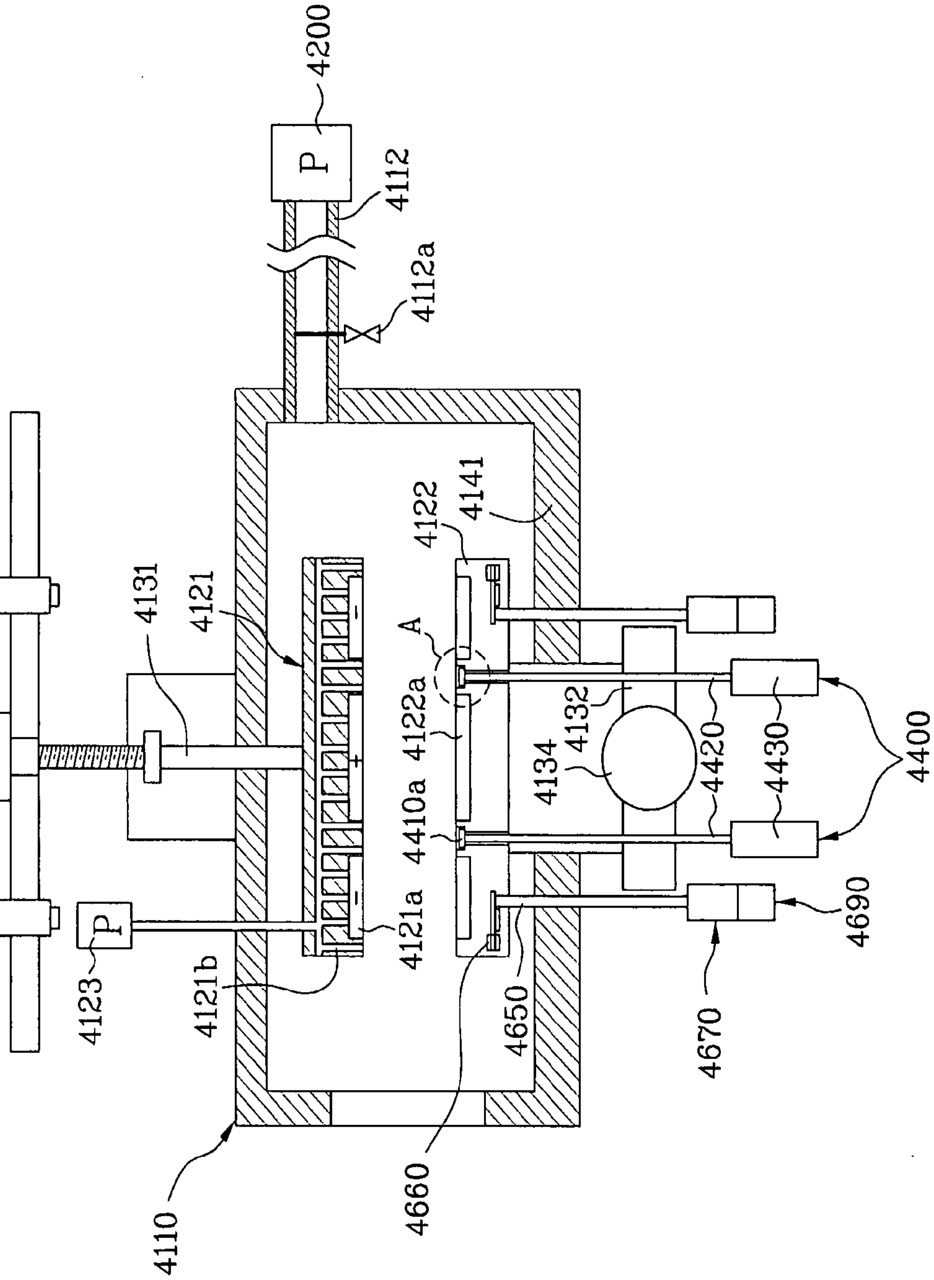

4200
P
4112
4112a
4133
4131
4121
4122
4141
A
4122a
4132
4134
4410a
4420
4430
4400
4121a
4690
P
4123
4121b
4650
4670
4110
4660
+
-

FIG. 137C

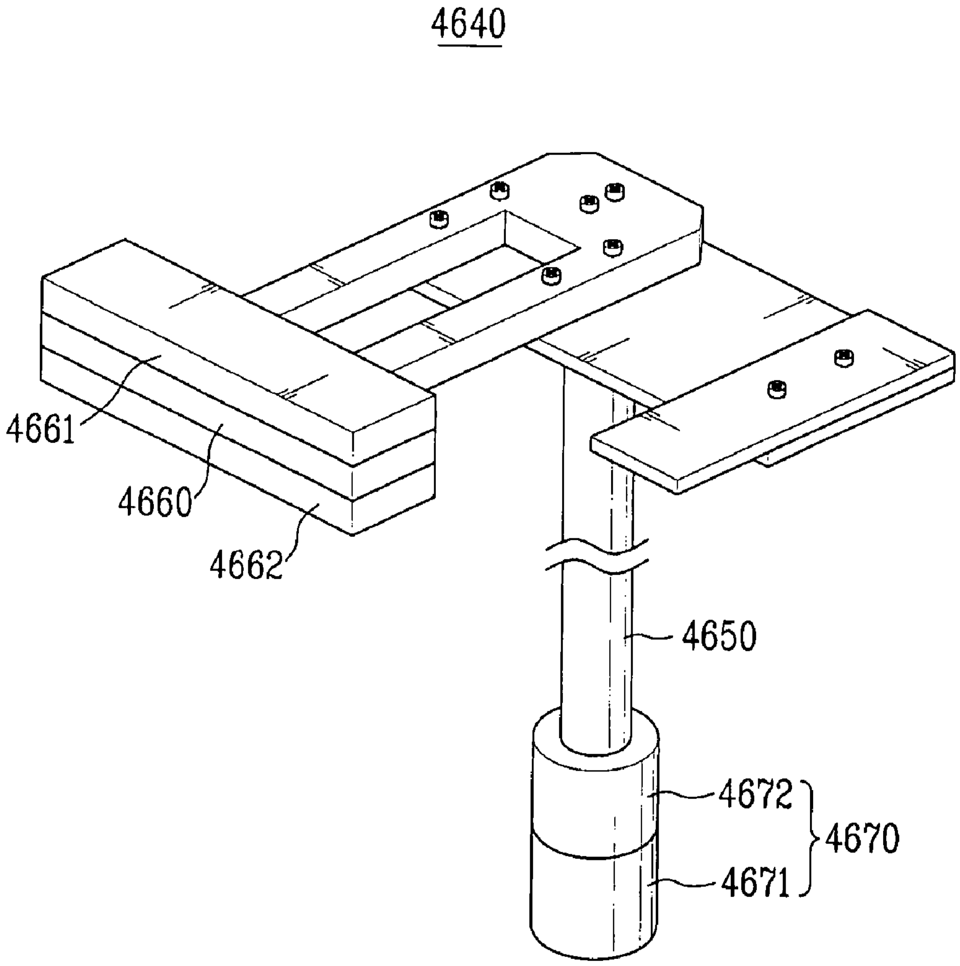


FIG. 137D

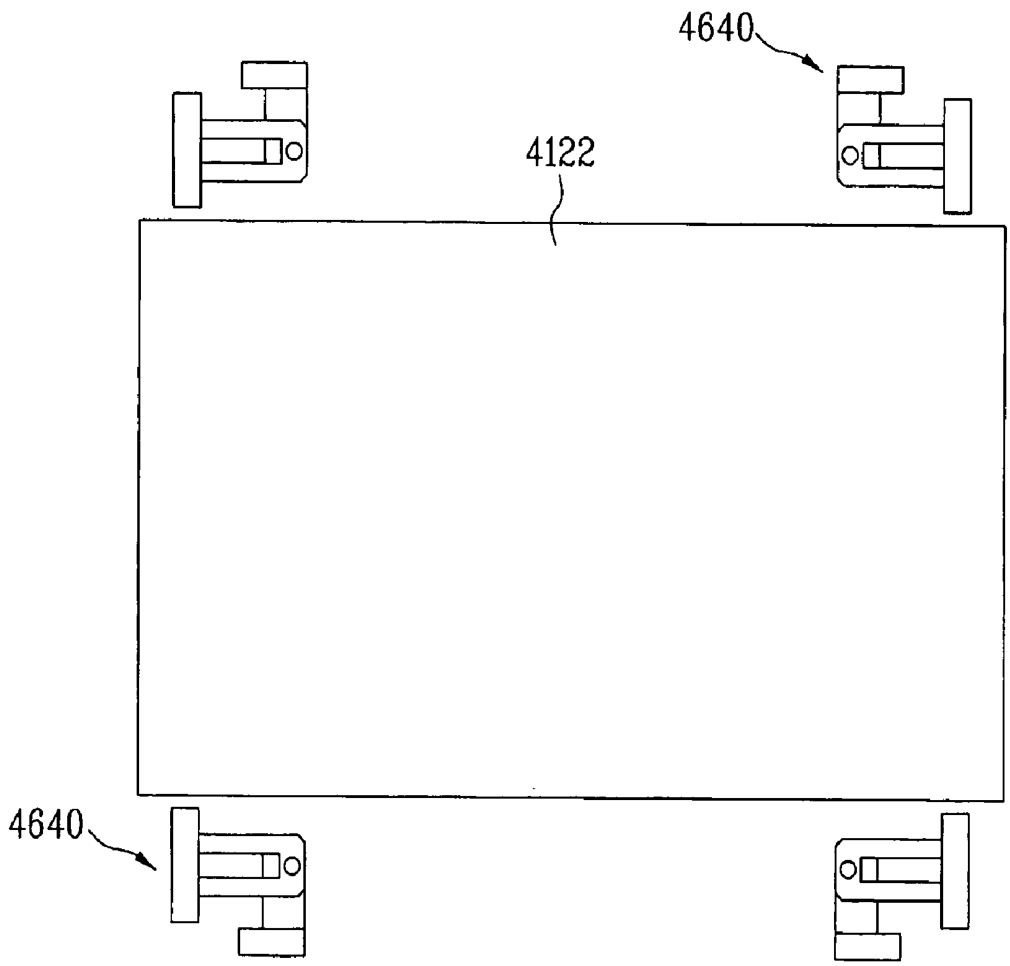


FIG. 138

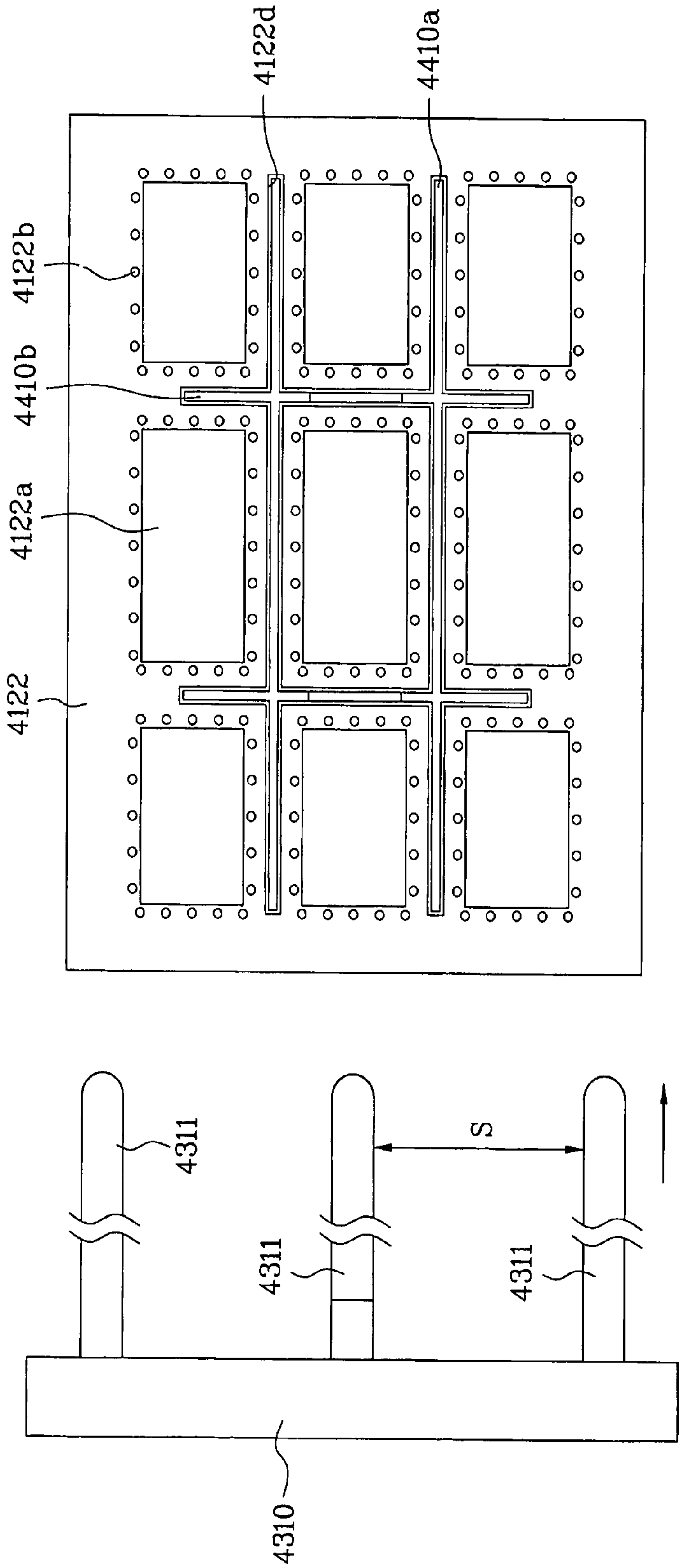


FIG. 139A

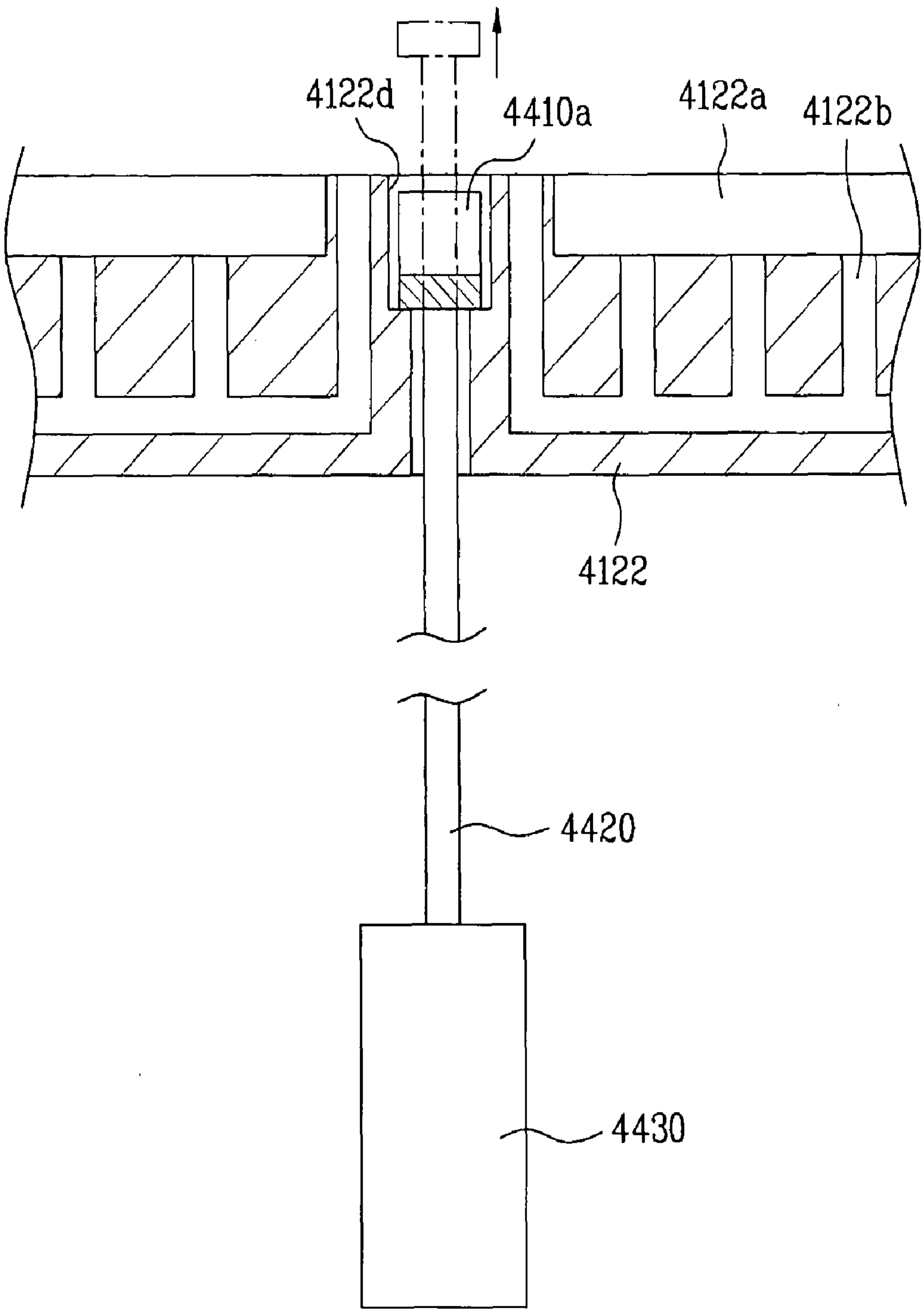


FIG. 139B

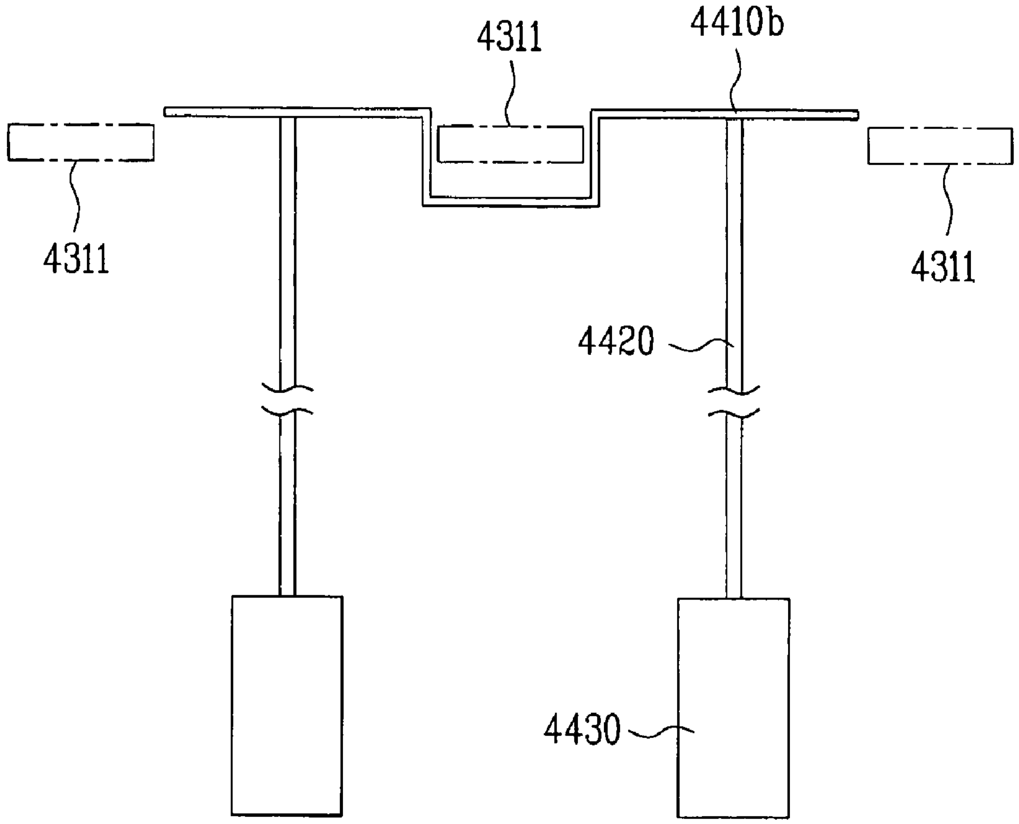


FIG. 140

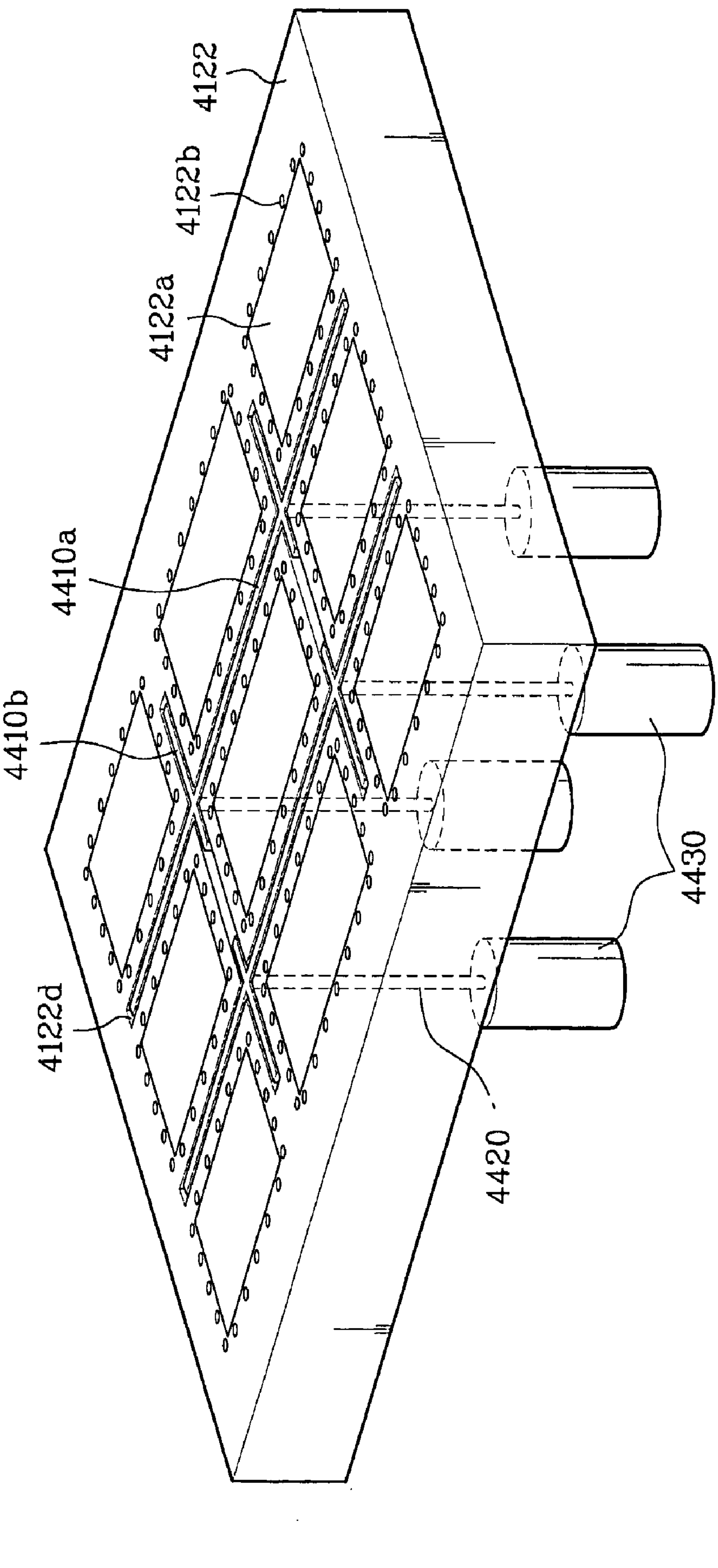


FIG. 141A

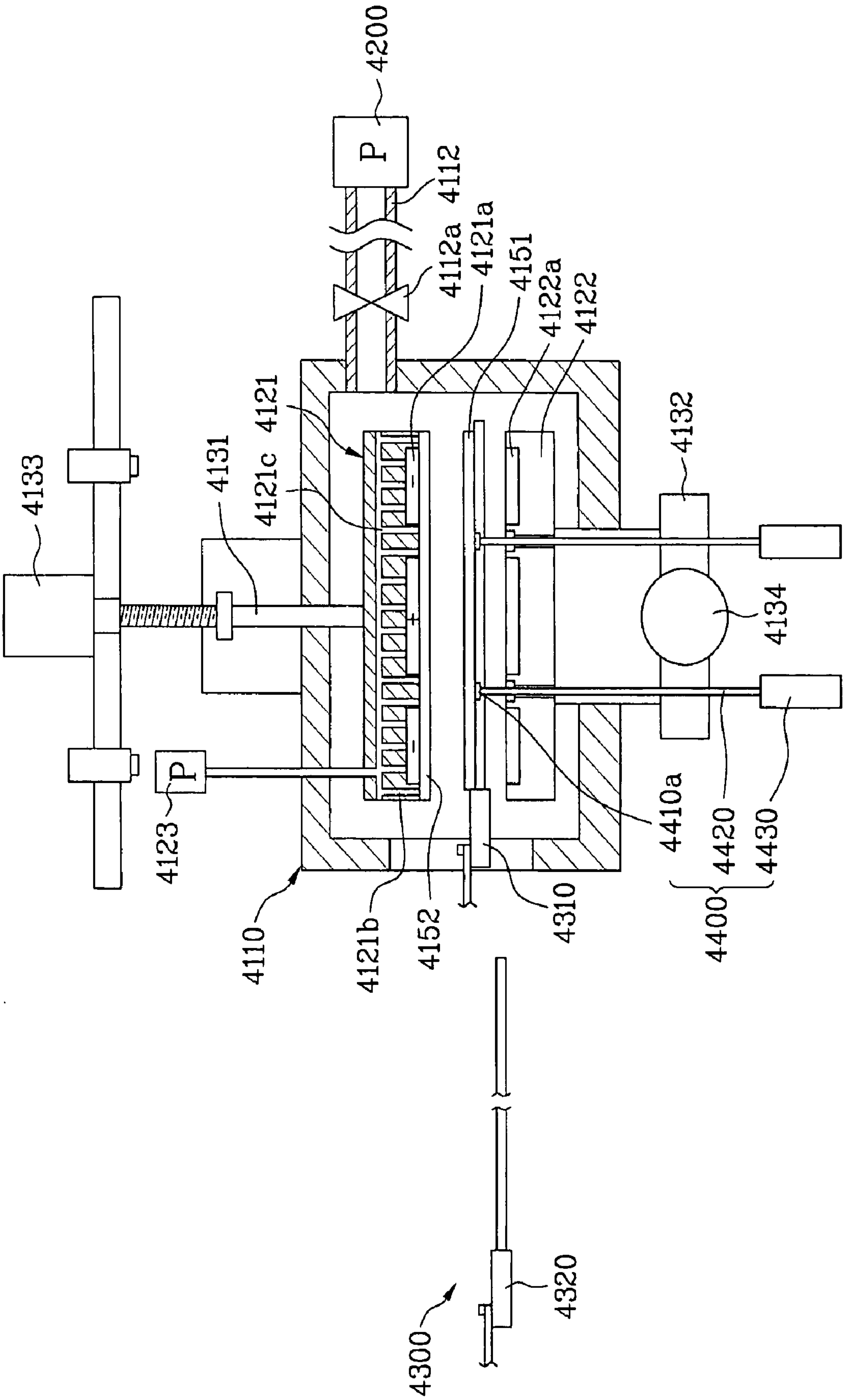
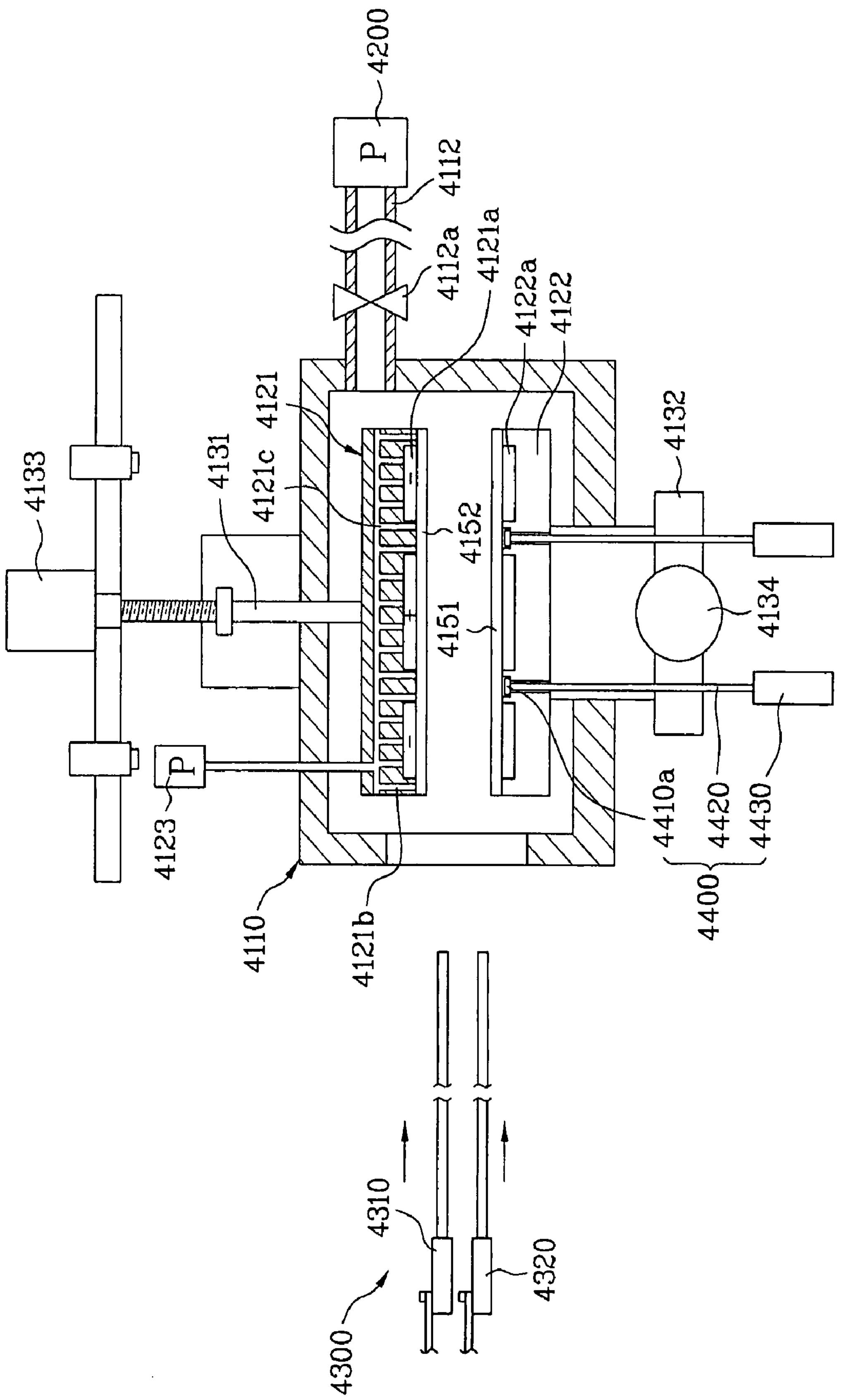

4200
P
4112
4112a
4121a
4151
4122a
4122
4133
4131
4121c
4121
4132
4134
P
4123
4110
4121b
4152
4310
4410a
4420
4430
4400
4320
4300

FIG. 141B


4200
P
4112
4112a
4121a
4122a
4122
4133
4131
4121c
4121
4132
4152
4151
4134
P
4123
4410a
4420
4430
4400
4110
4121b
4310
4320
4300

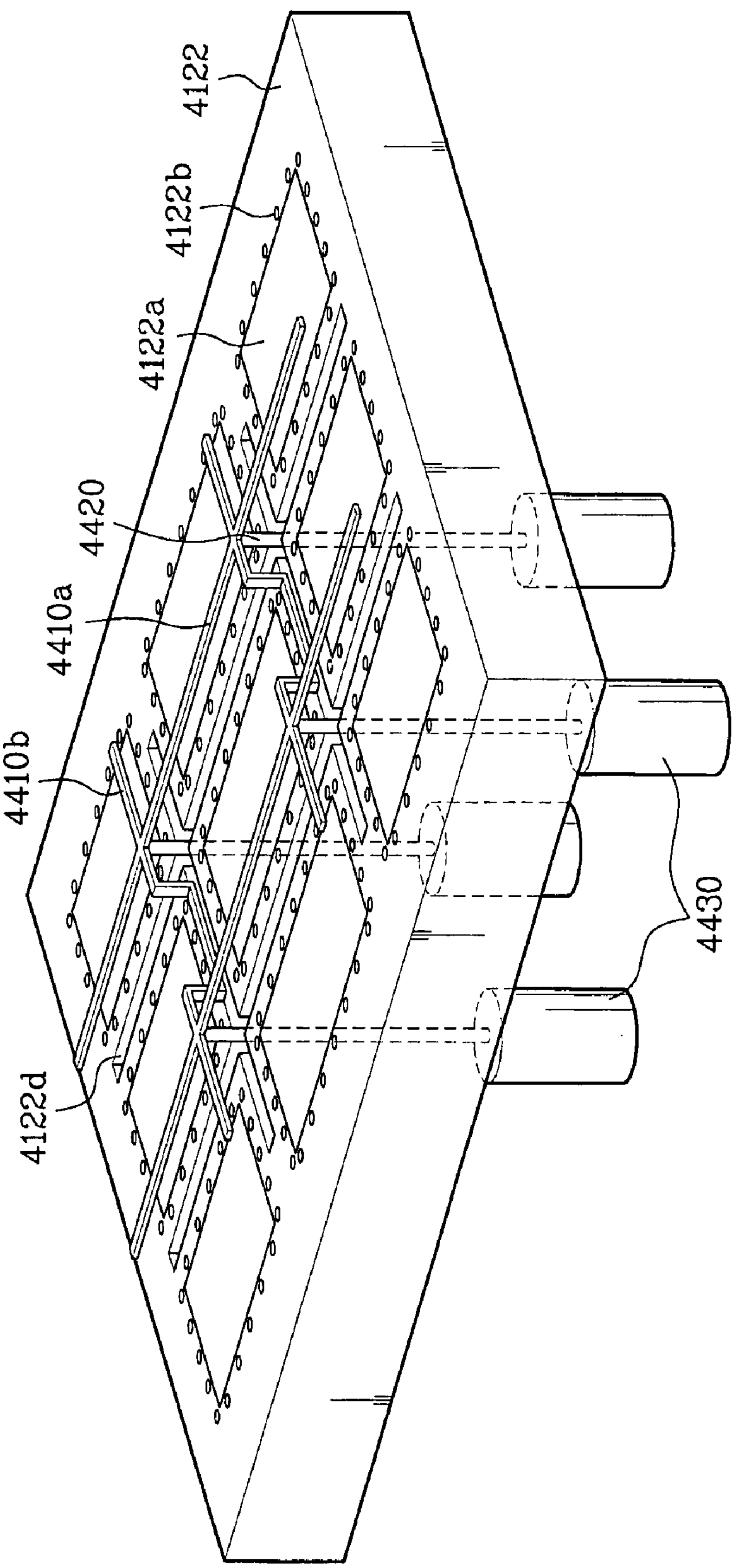


FIG. 142

FIG. 143

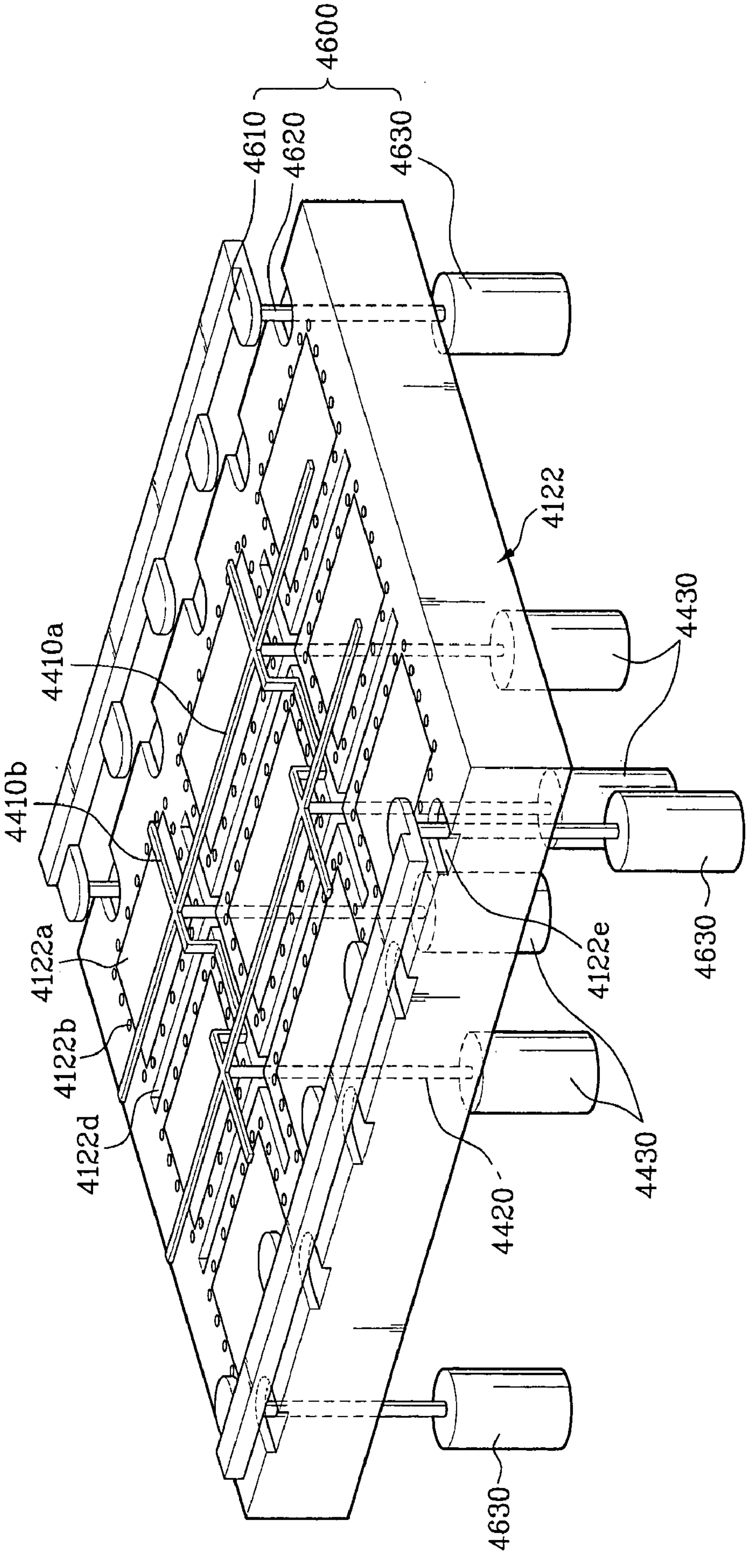

4600
4610
4620
4630
4122
4430
4410a
4410b
4122a
4122b
4122d
4122e
4630
4420
4430
4630

FIG. 144

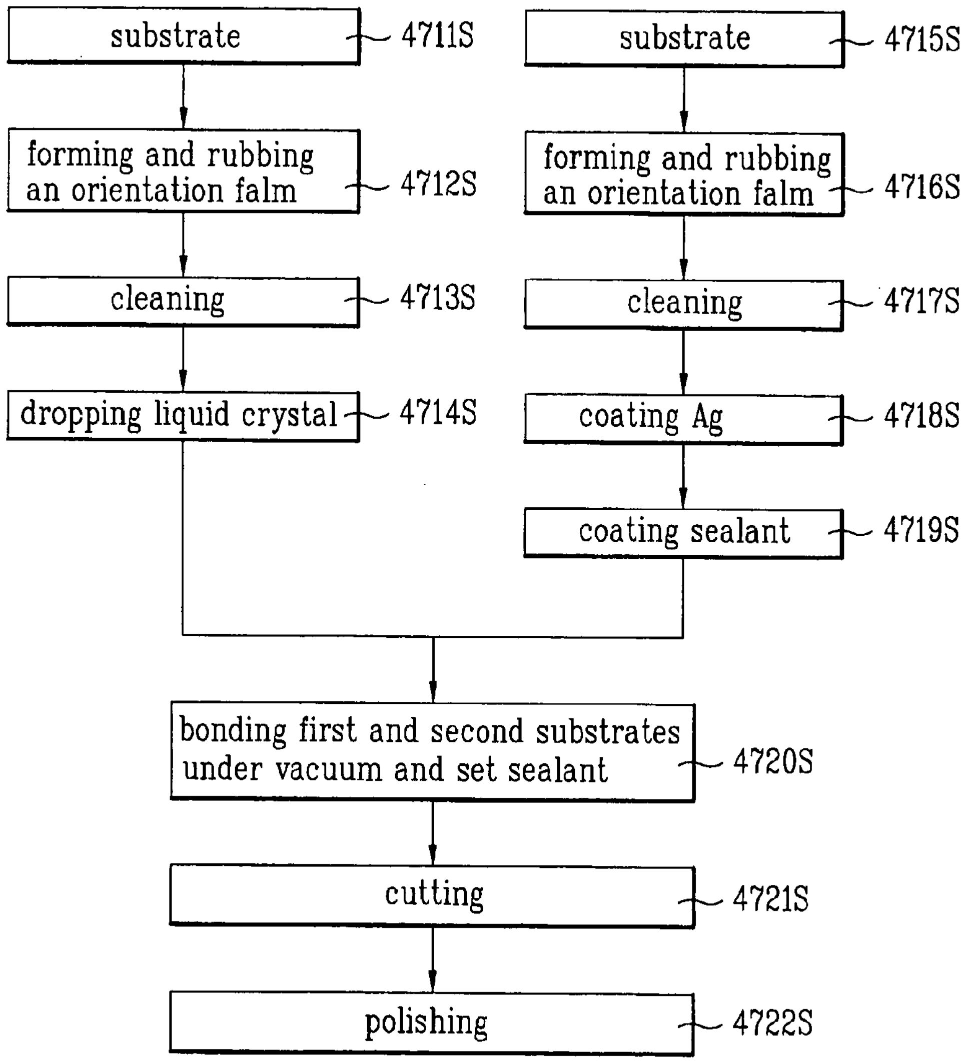

substrate
4711S
forming and rubbing an orientation falm
4712S
cleaning
4713S
dropping liquid crystal
4714S
substrate
4715S
forming and rubbing an orientation falm
4716S
cleaning
4717S
coating Ag
4718S
coating sealant
4719S
bonding first and second substrates under vacuum and set sealant
4720S
cutting
4721S
polishing
4722S

FIG. 145A

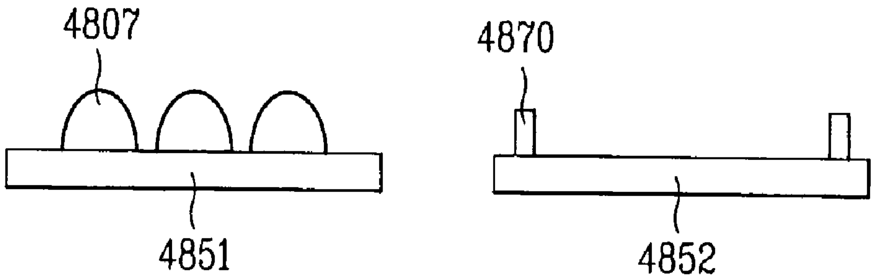


FIG. 145B

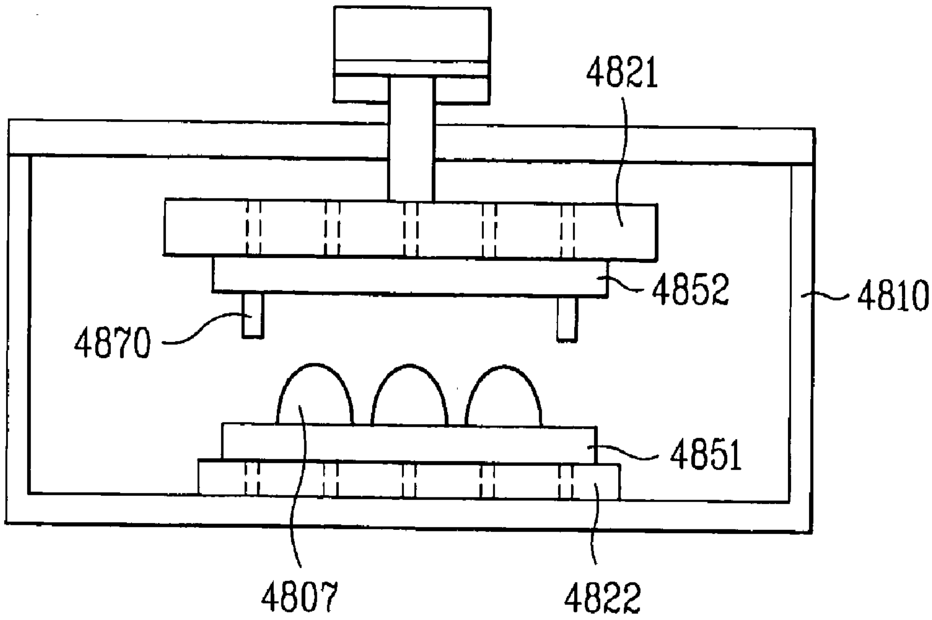


FIG. 145C

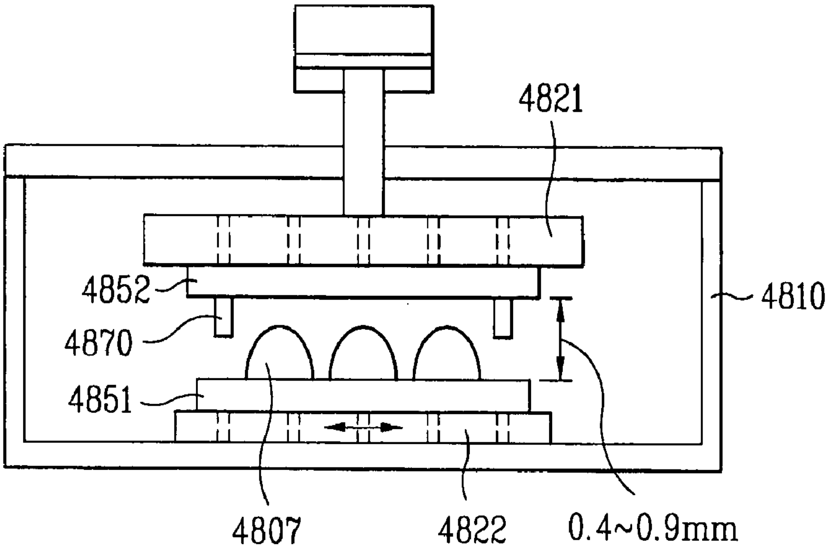


FIG. 145D

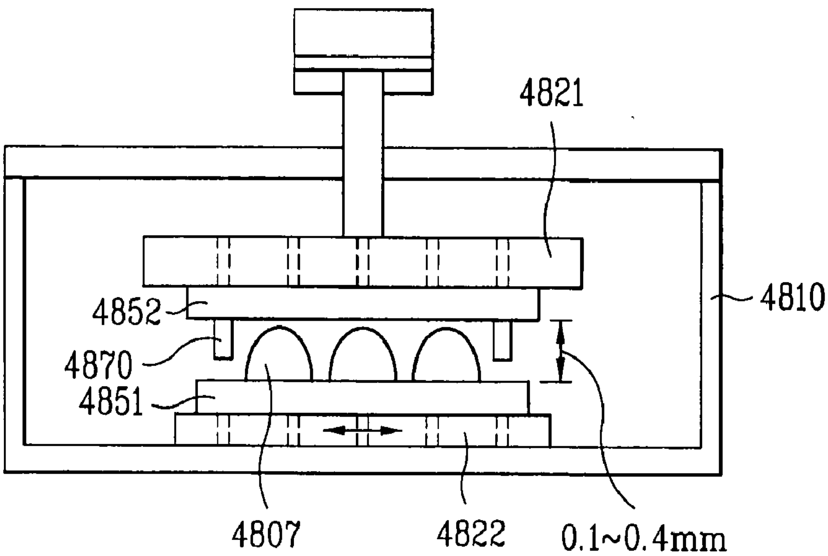


FIG. 145E

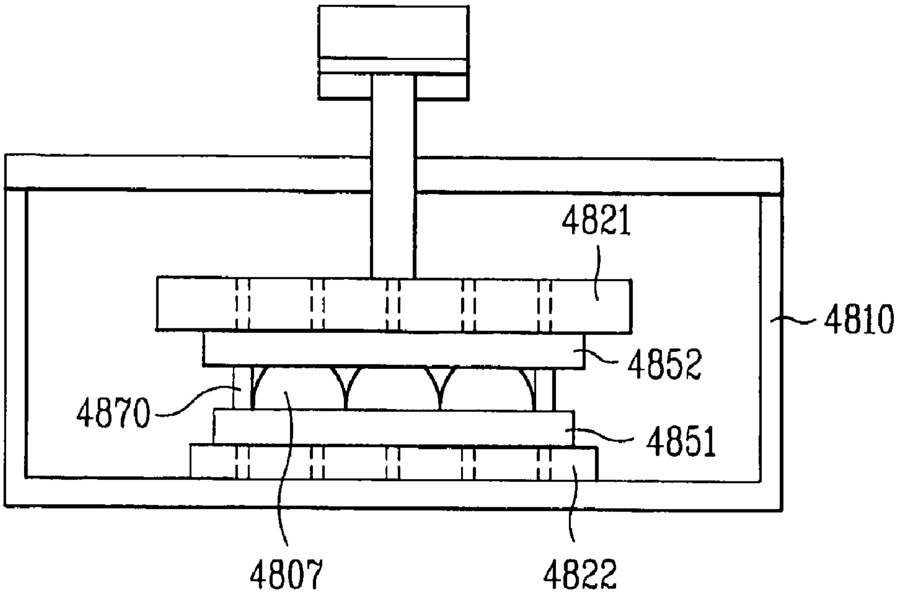


FIG. 145F

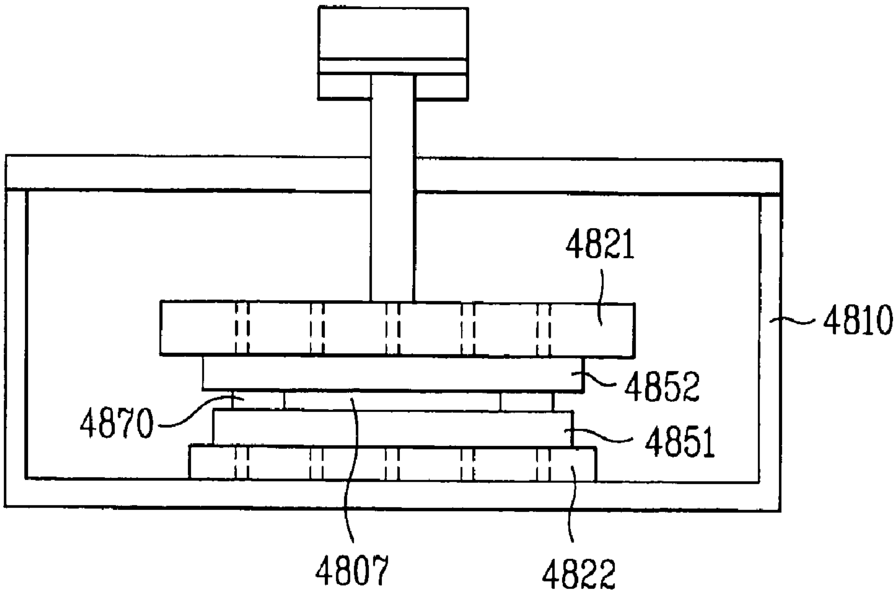


FIG. 145G

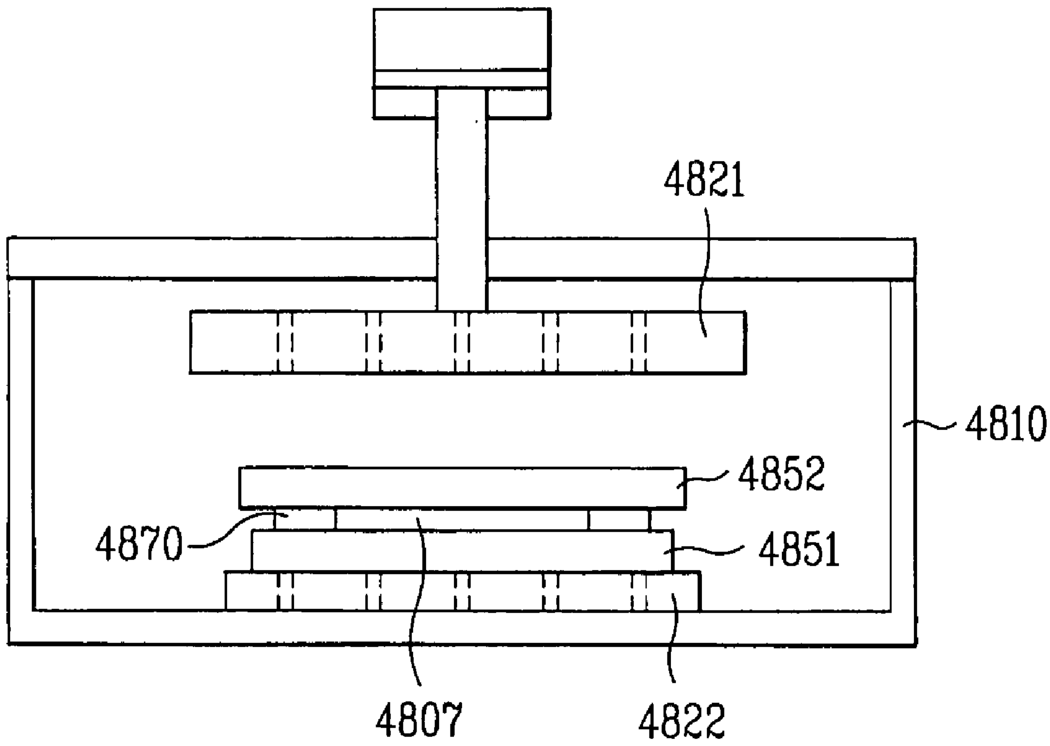


FIG. 146

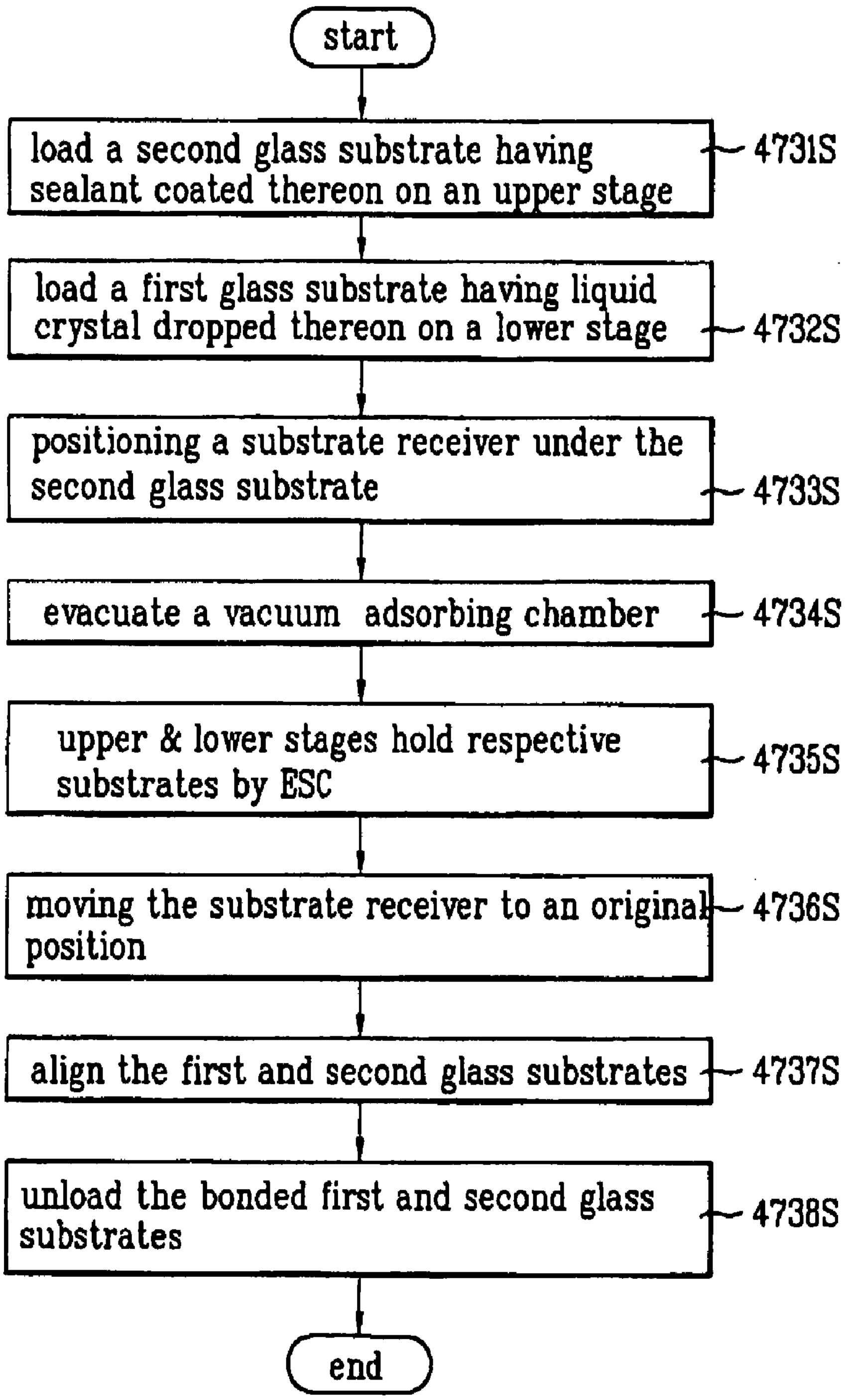

start
load a second glass substrate having sealant coated thereon on an upper stage
4731S
load a first glass substrate having liquid crystal dropped thereon on a lower stage
4732S
positioning a substrate receiver under the second glass substrate
4733S
evacuate a vacuum adsorbing chamber
4734S
upper & lower stages hold respective substrates by ESC
4735S
moving the substrate receiver to an original position
4736S
align the first and second glass substrates
4737S
unload the bonded first and second glass substrates
4738S
end

FIG. 147

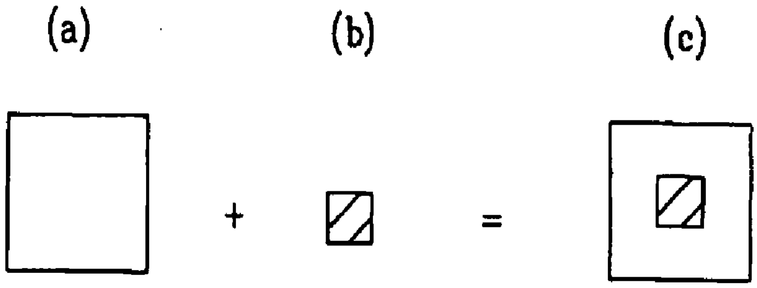


FIG. 148

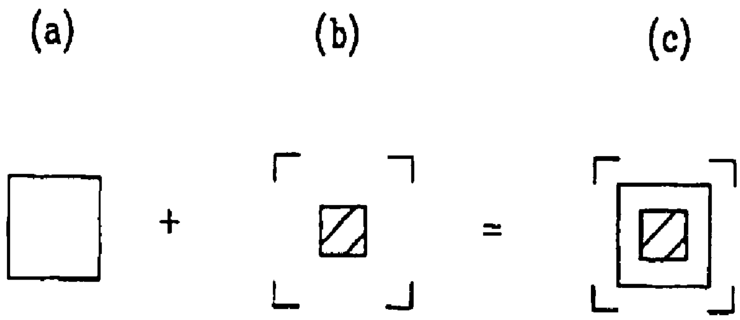


FIG. 149

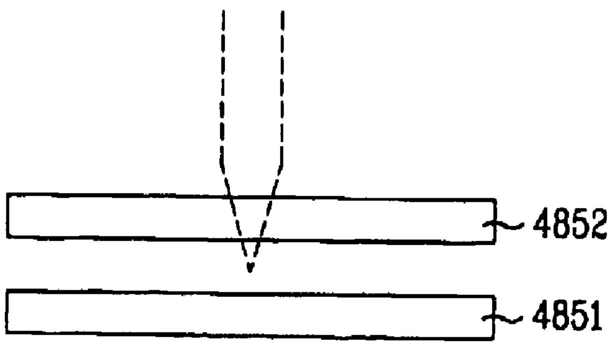


FIG. 150

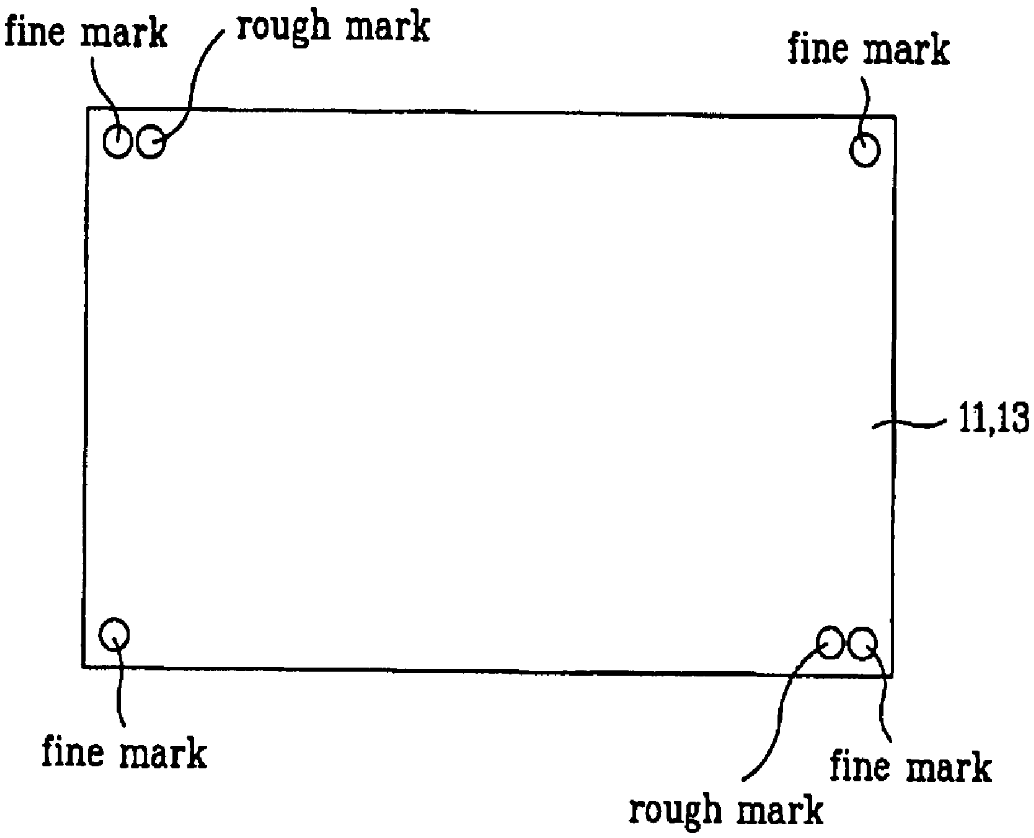

fine mark
rough mark
fine mark
11,13
fine mark
fine mark
rough mark

FIG. 151A

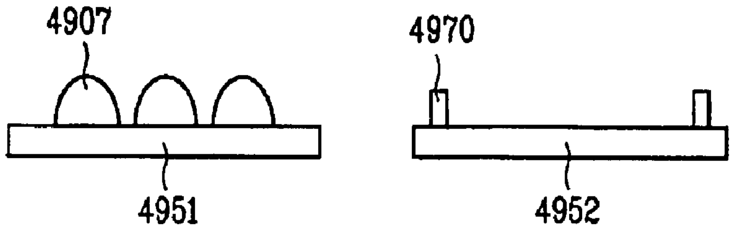


FIG. 151B

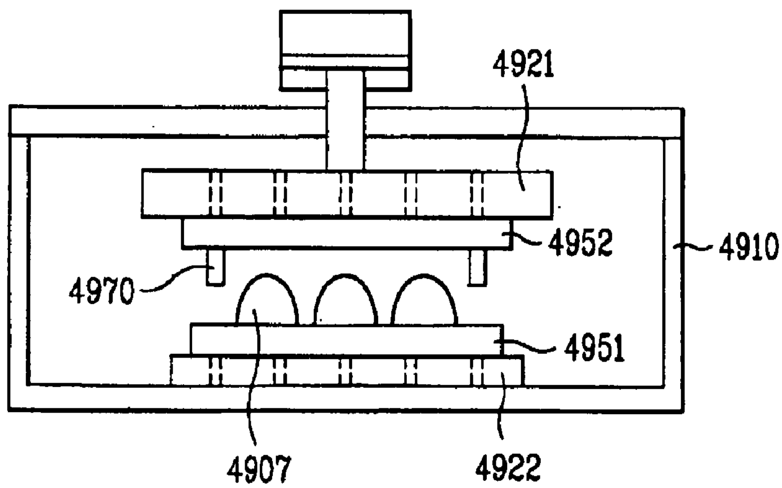


FIG. 151C

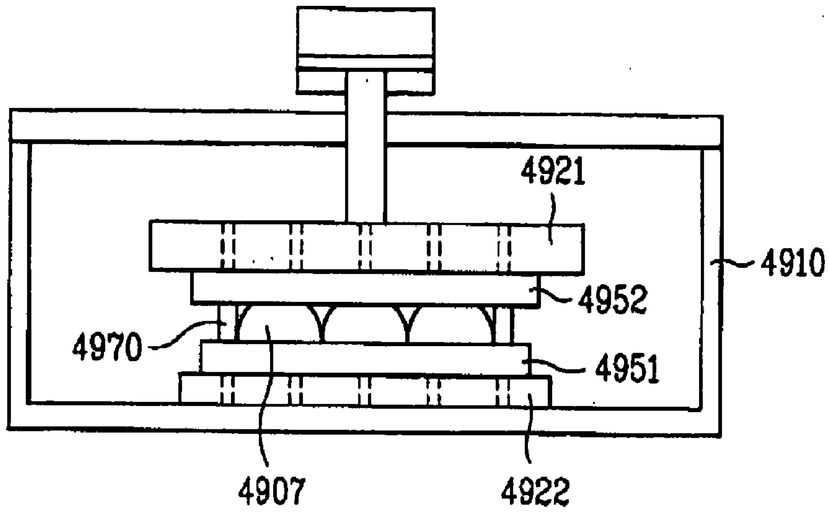


FIG. 151D

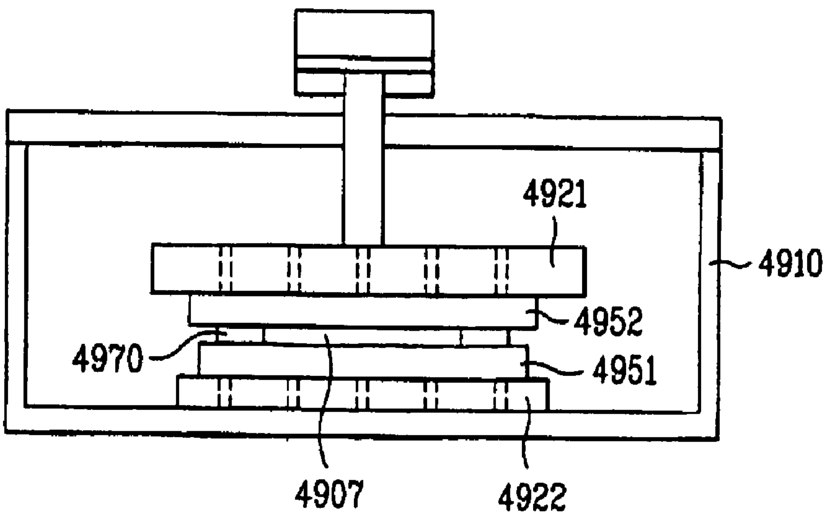


FIG. 151E

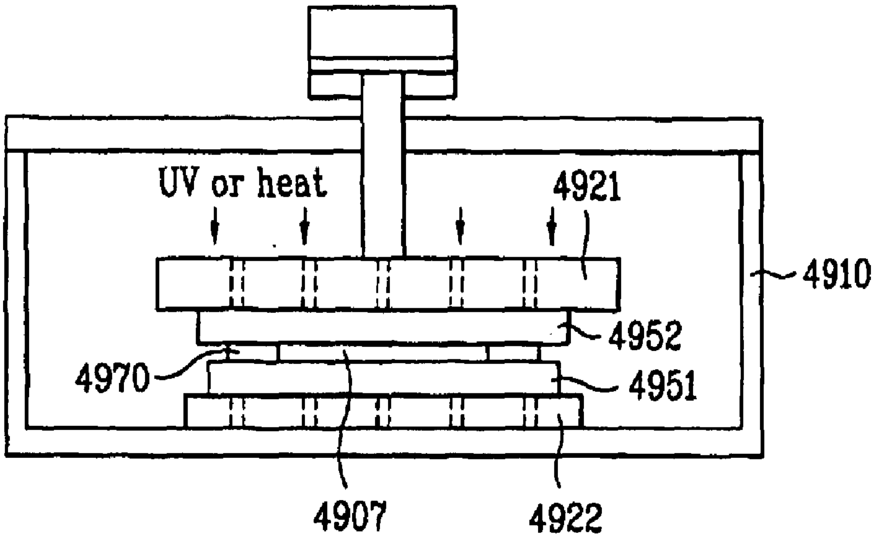


FIG. 151F

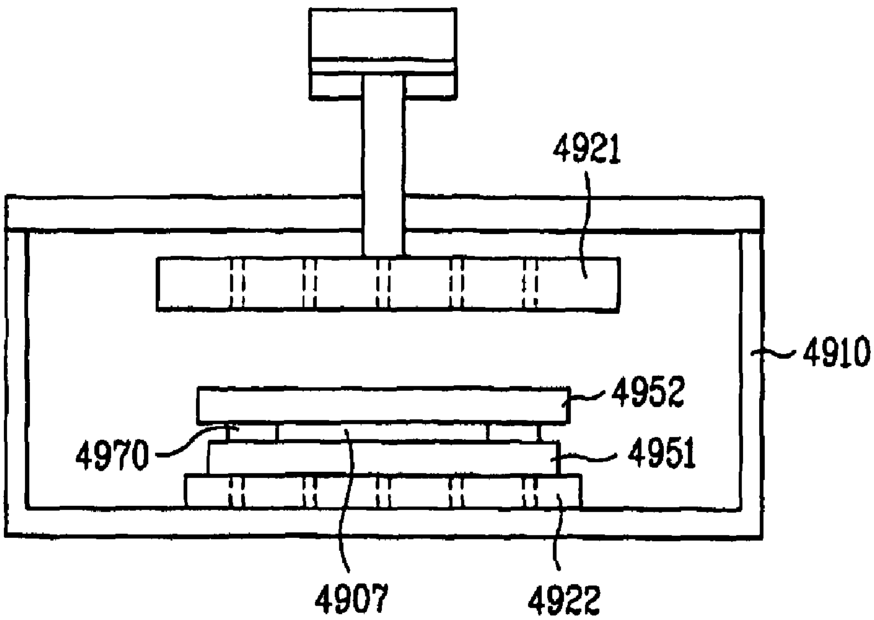


FIG. 152

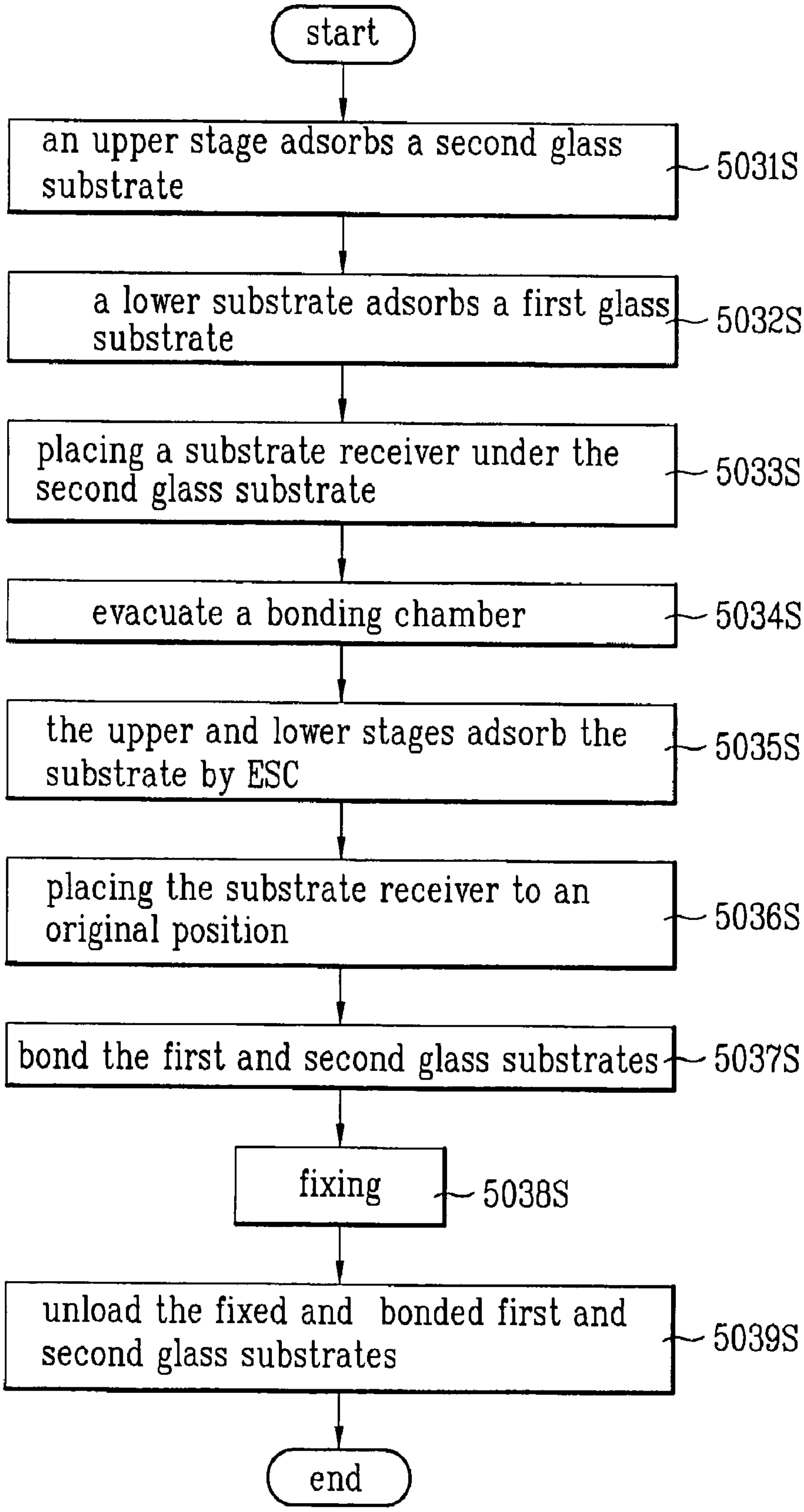

start
an upper stage adsorbs a second glass substrate
5031S
a lower substrate adsorbs a first glass substrate
5032S
placing a substrate receiver under the second glass substrate
5033S
evacuate a bonding chamber
5034S
the upper and lower stages adsorb the substrate by ESC
5035S
placing the substrate receiver to an original position
5036S
bond the first and second glass substrates
5037S
fixing
5038S
unload the fixed and bonded first and second glass substrates
5039S
end

FIG. 153

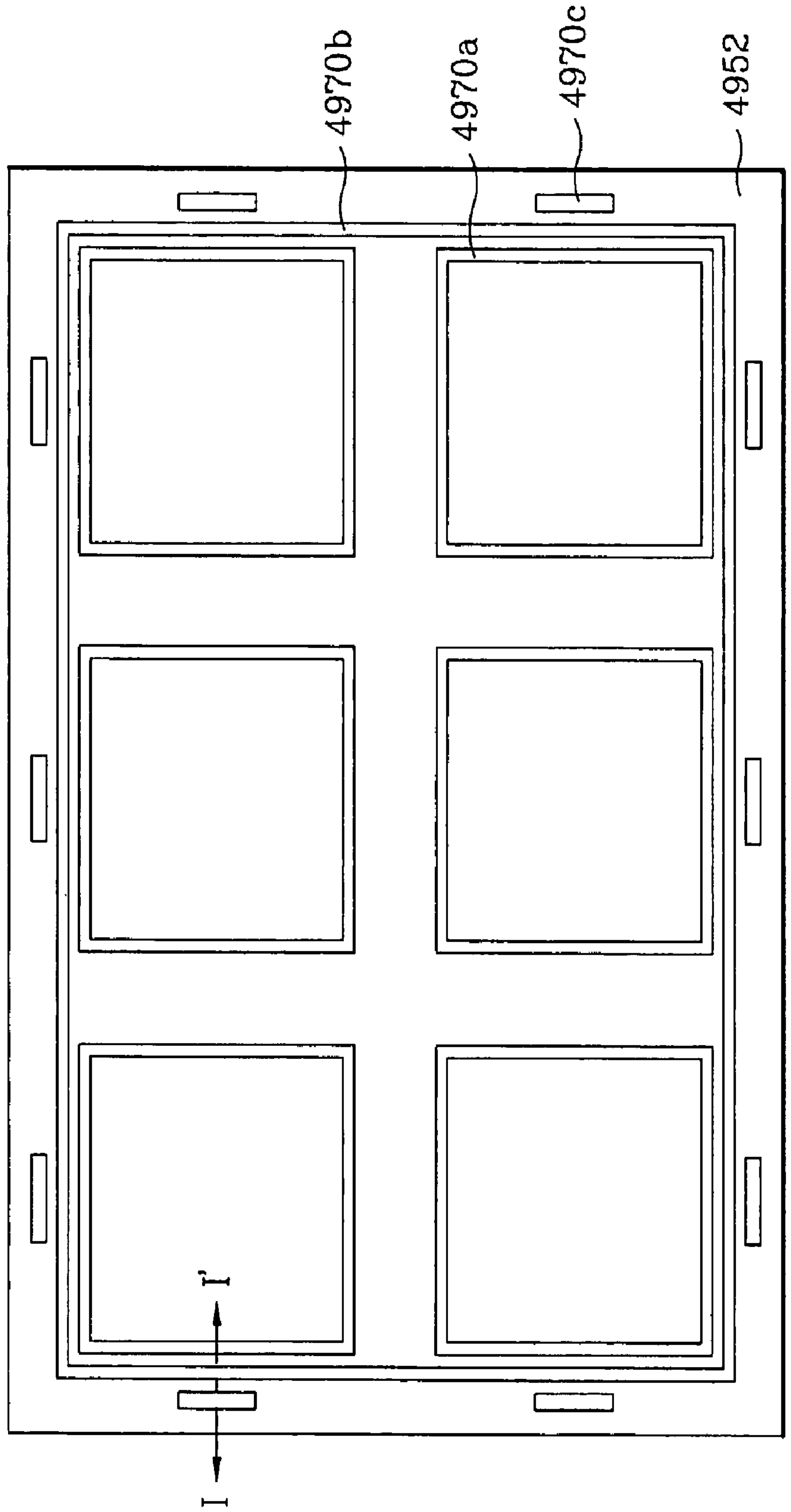


FIG. 154

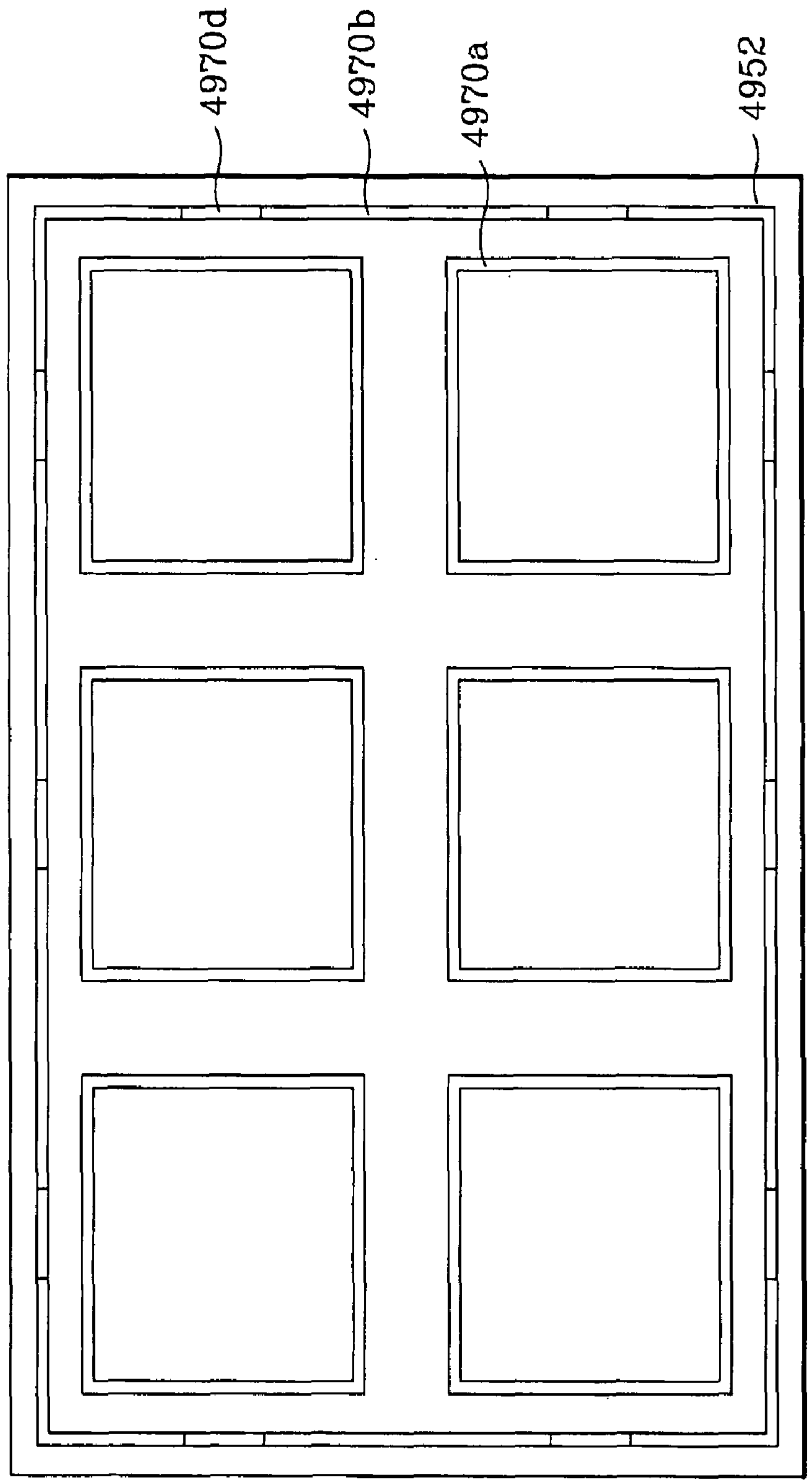


FIG. 155

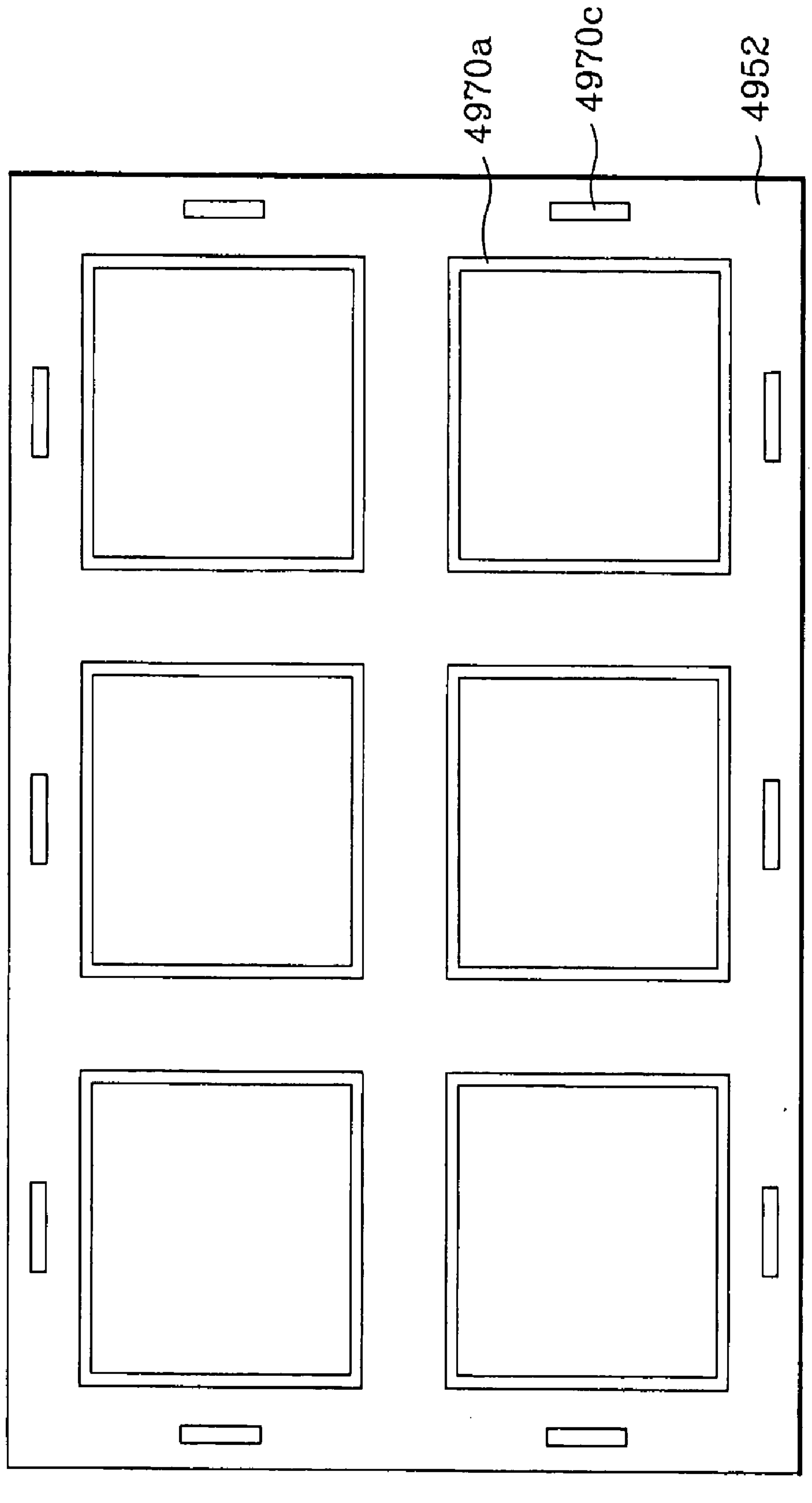


FIG. 156

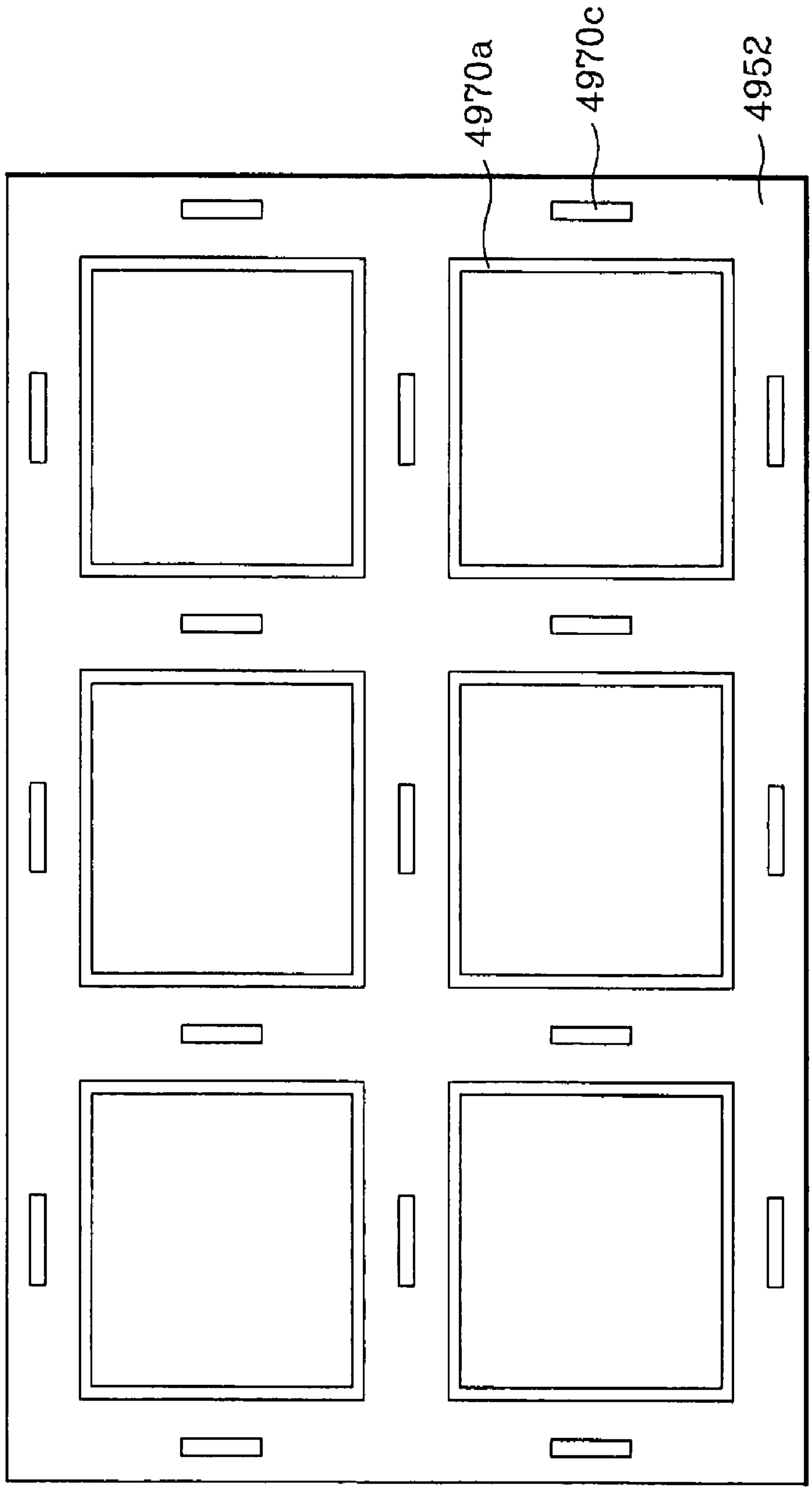


FIG. 157

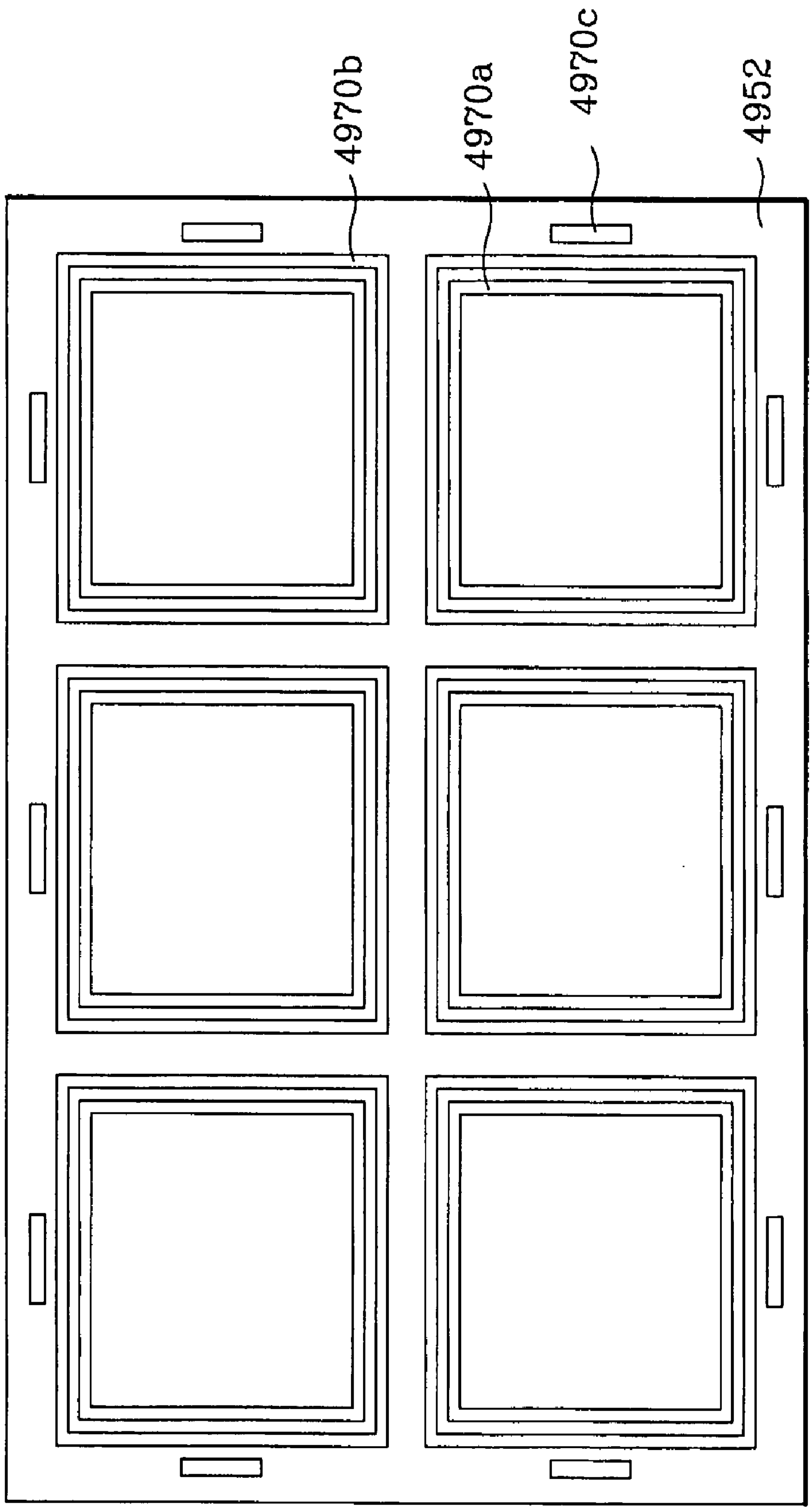


FIG. 158

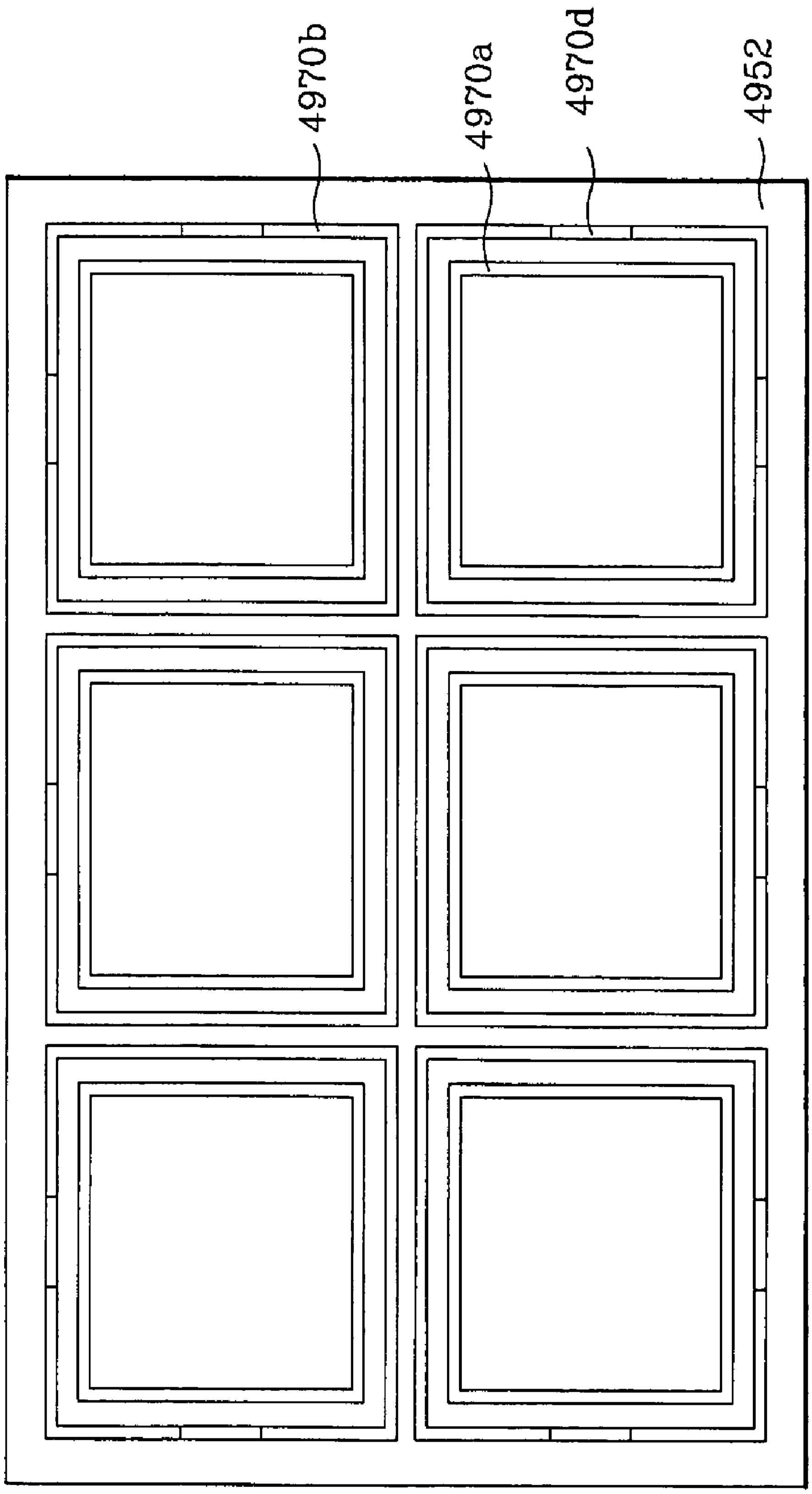


FIG. 159

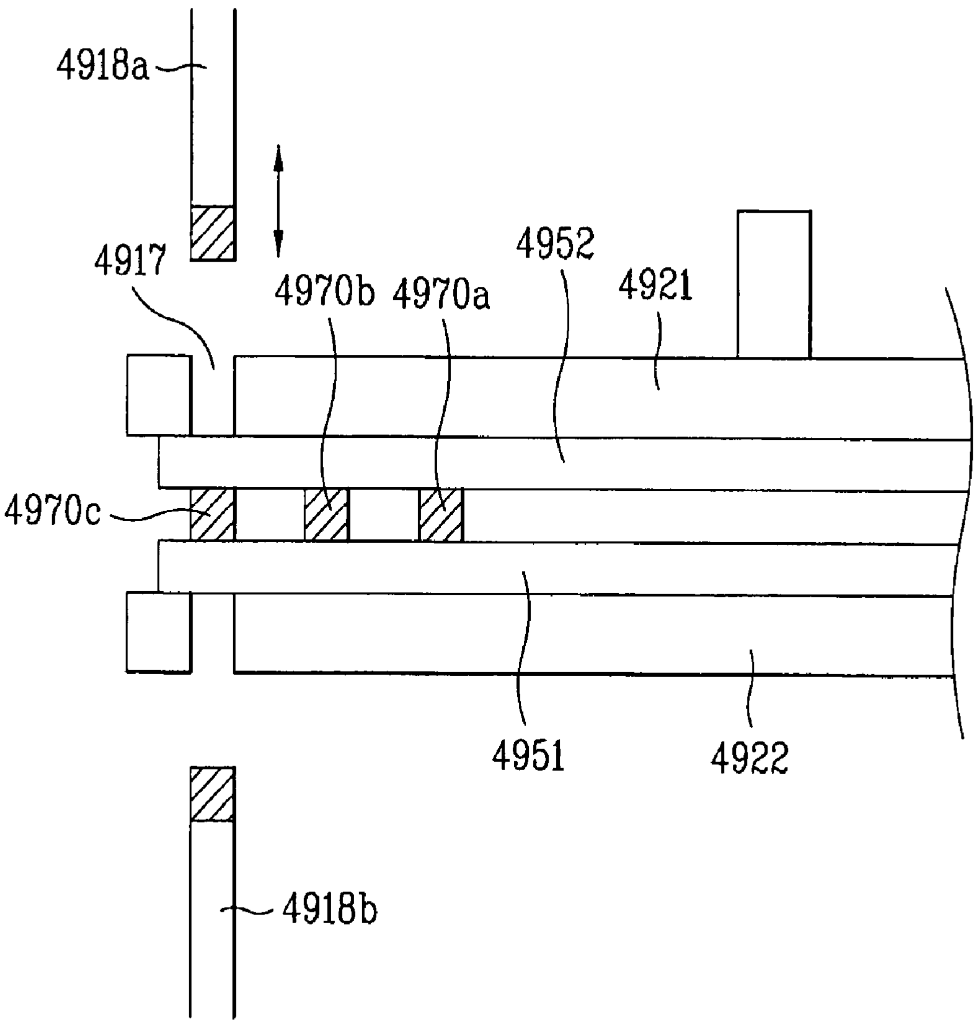


FIG. 160A

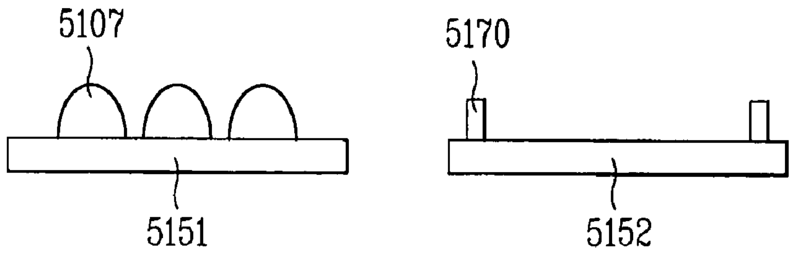


FIG. 160B

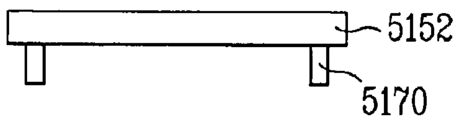


FIG. 160C

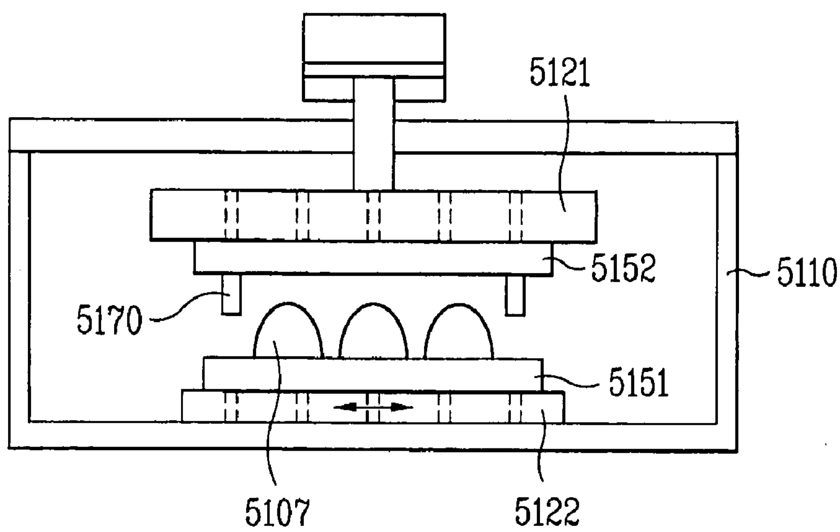


FIG. 160D

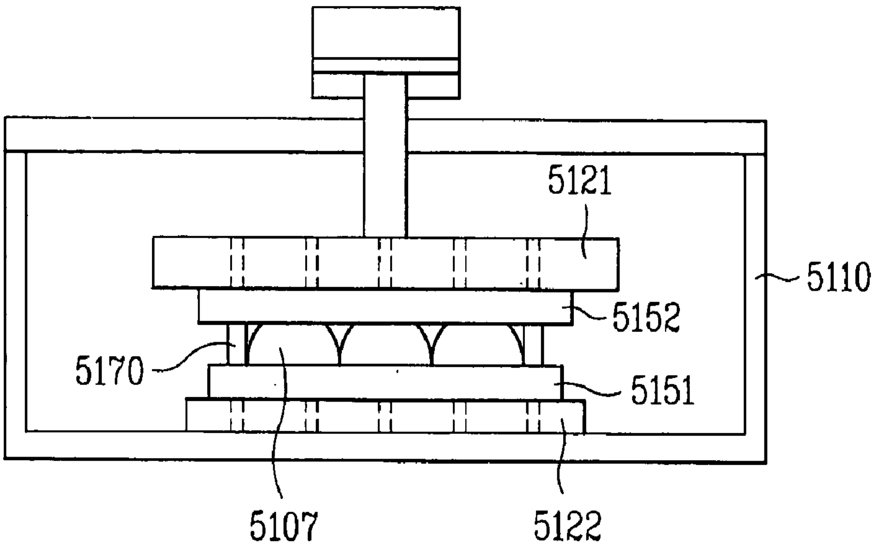


FIG. 160E

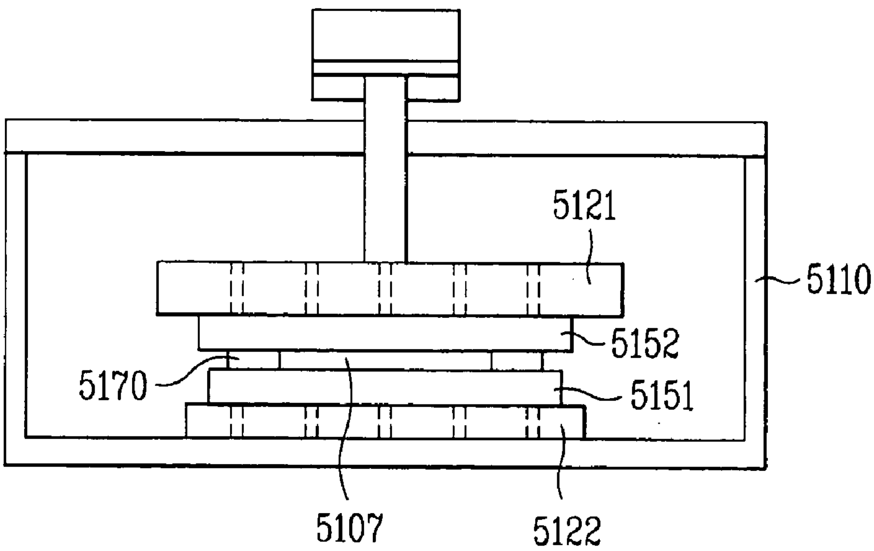


FIG. 160F

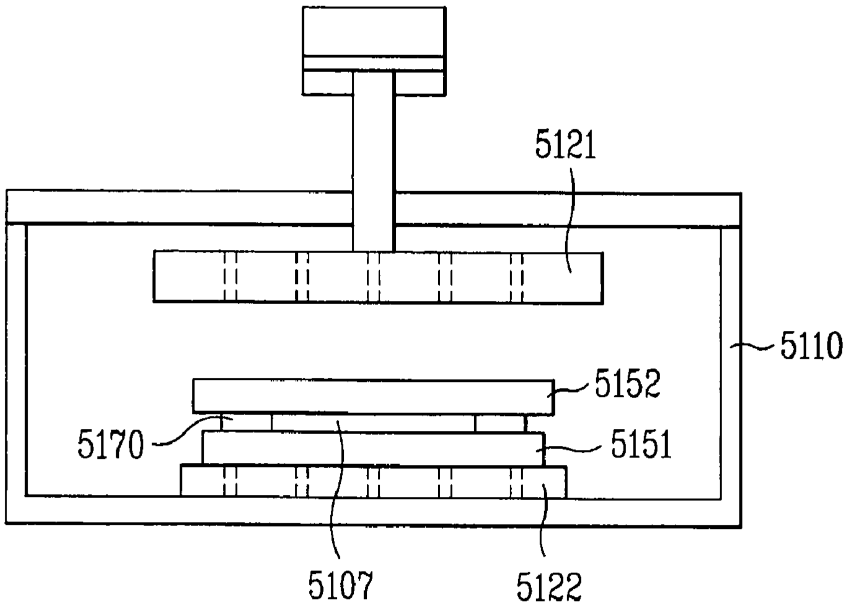


FIG. 160G

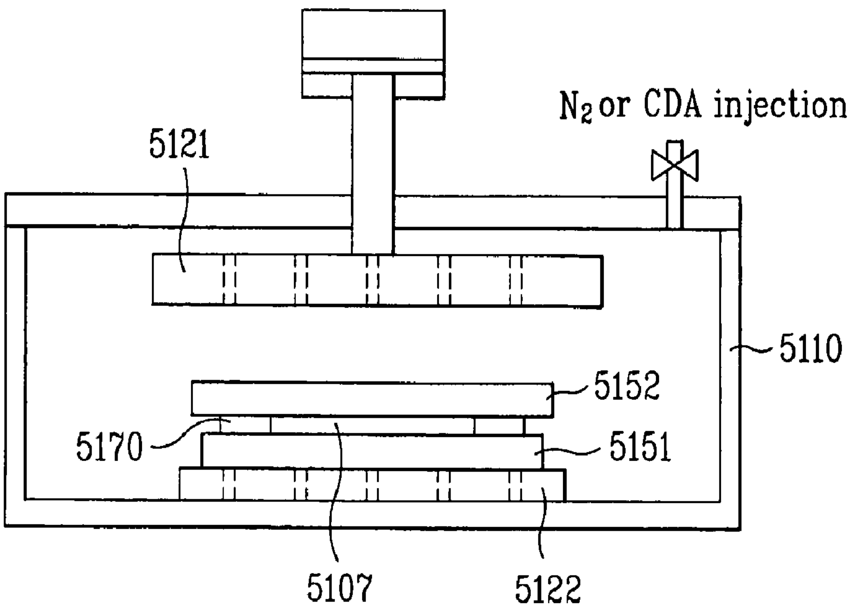


FIG. 161

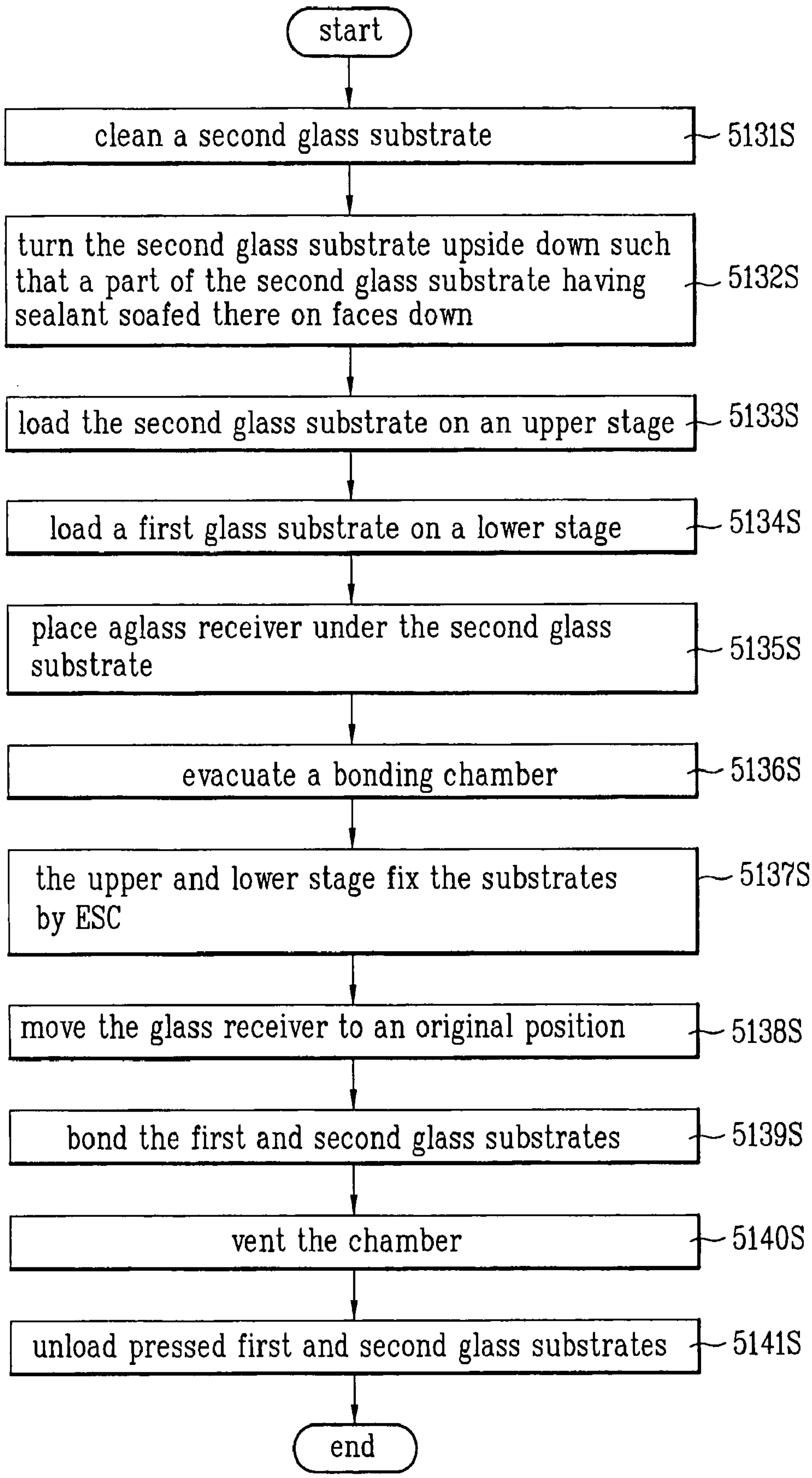

start
clean a second glass substrate
5131S
turn the second glass substrate upside down such that a part of the second glass substrate having sealant soafed there on faces down
5132S
load the second glass substrate on an upper stage
5133S
load a first glass substrate on a lower stage
5134S
place aglass receiver under the second glass substrate
5135S
evacuate a bonding chamber
5136S
the upper and lower stage fix the substrates by ESC
5137S
move the glass receiver to an original position
5138S
bond the first and second glass substrates
5139S
vent the chamber
5140S
unload pressed first and second glass substrates
5141S
end

FIG. 162A

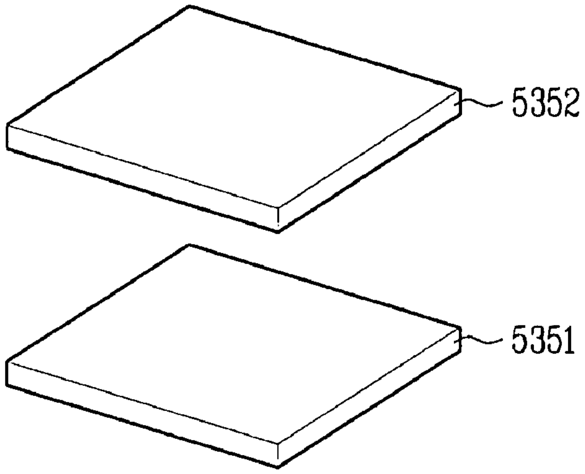


FIG. 162B

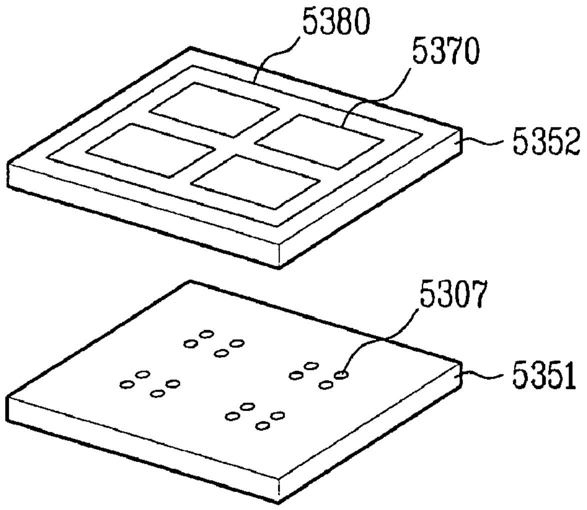


FIG. 162C

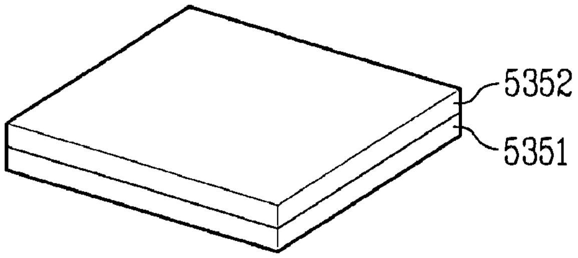


FIG. 162D

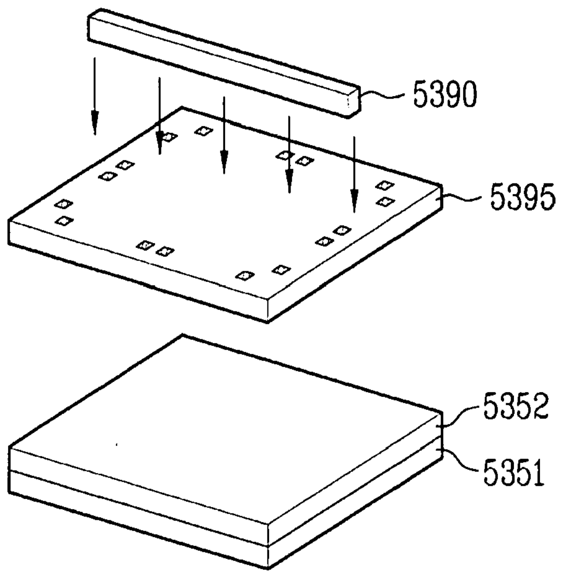


FIG. 162E

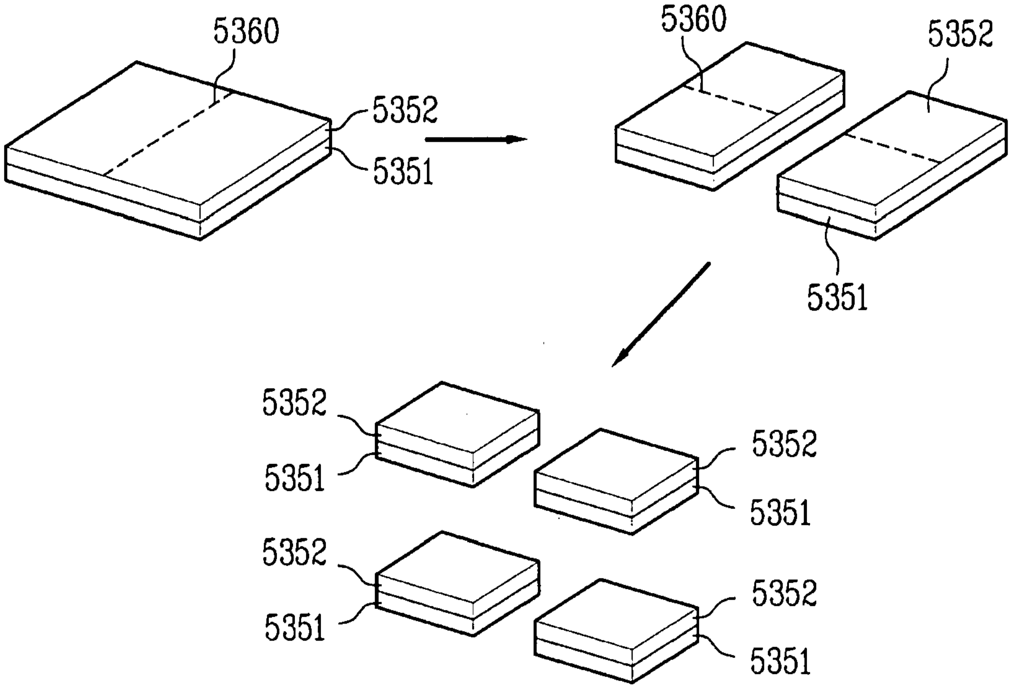


FIG. 163A

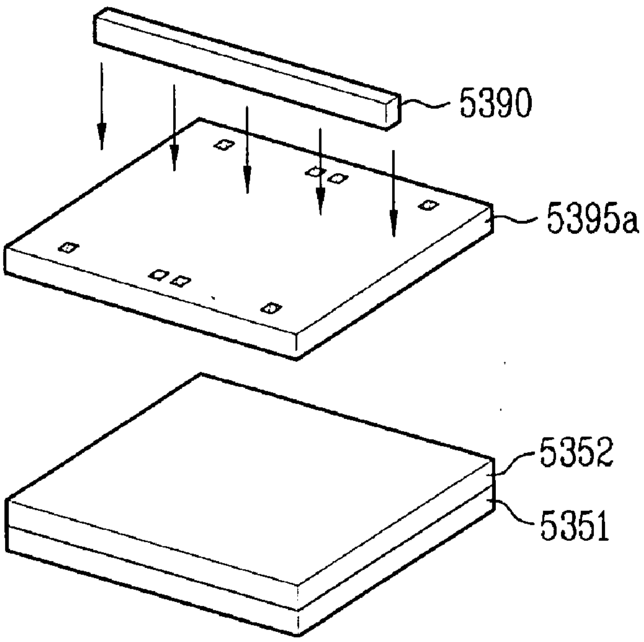


FIG. 163B

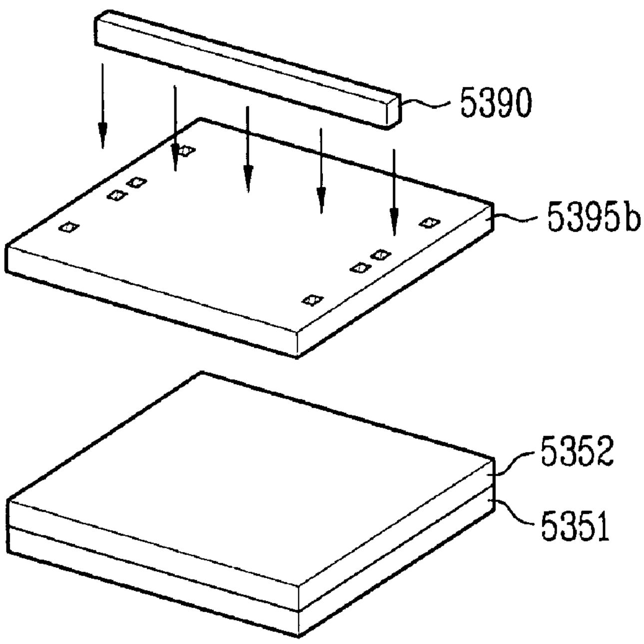


FIG. 163C

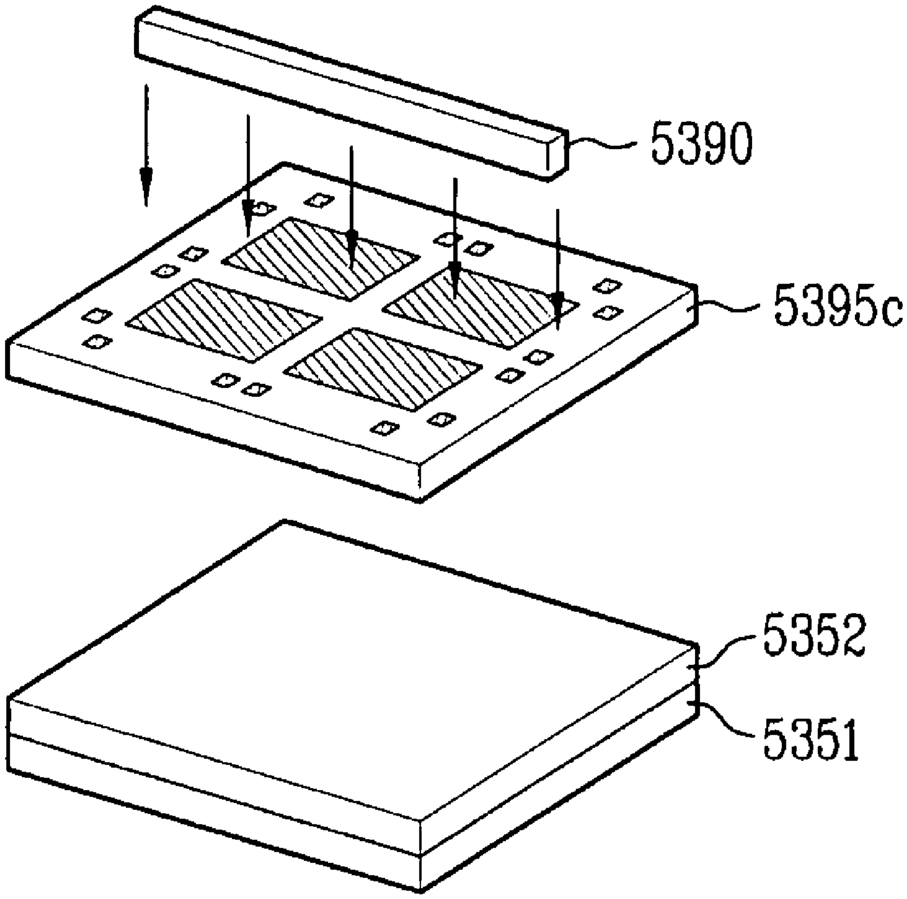


FIG. 164

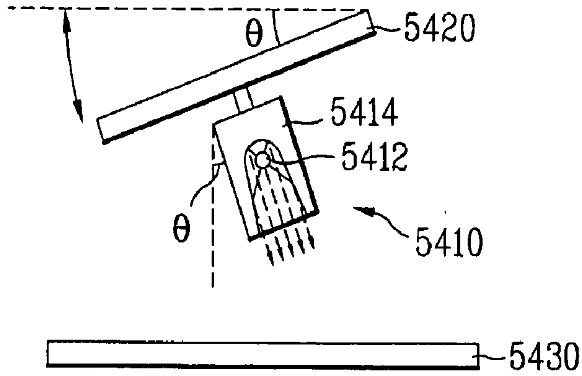


FIG. 165A

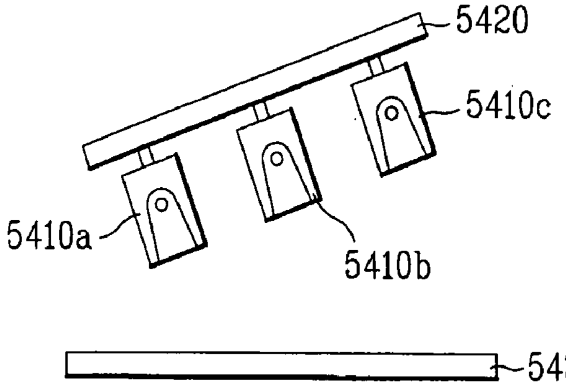


FIG. 165B

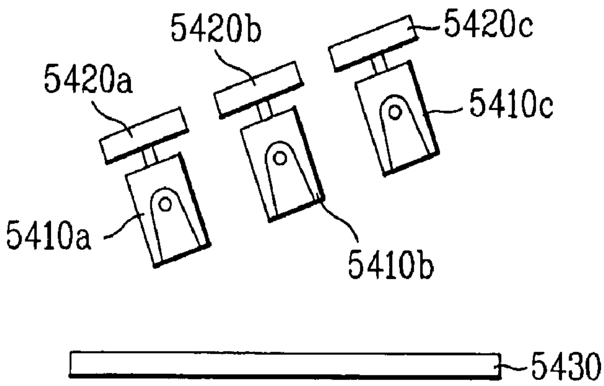


FIG. 166

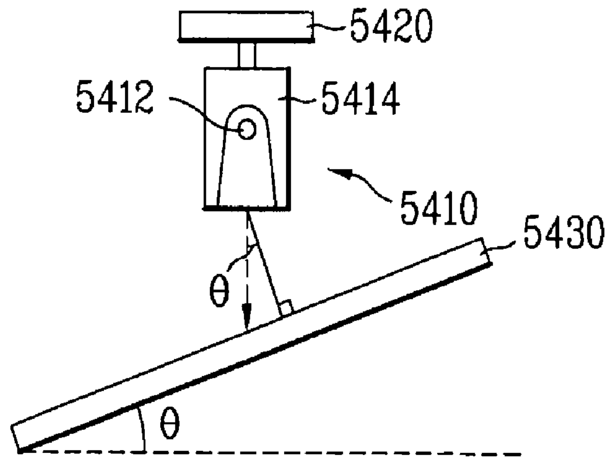


FIG. 167

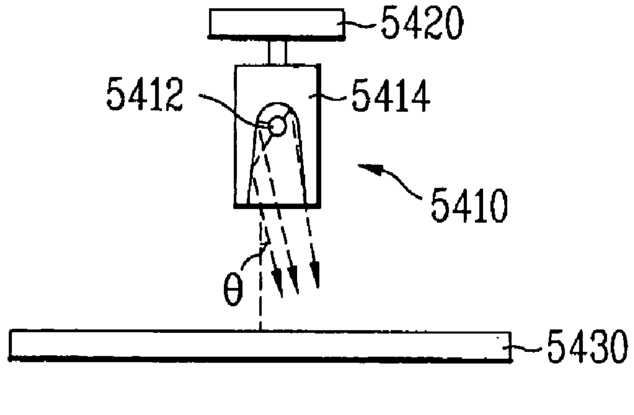


FIG. 168A

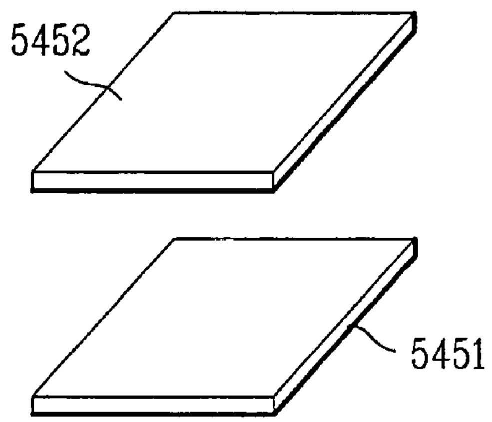


FIG. 168B

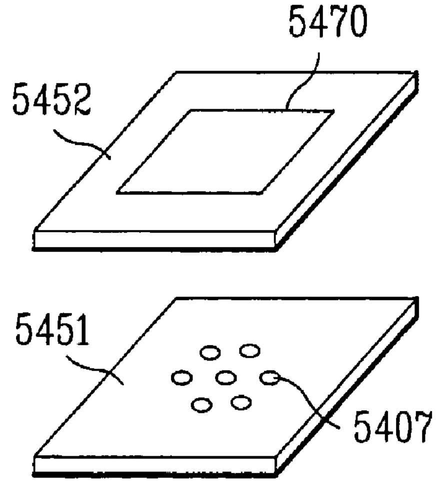


FIG. 168C

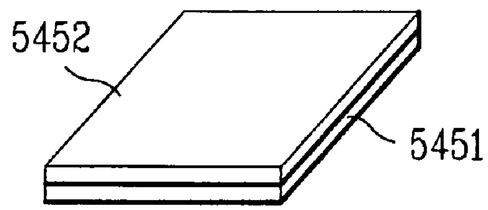


FIG. 168D

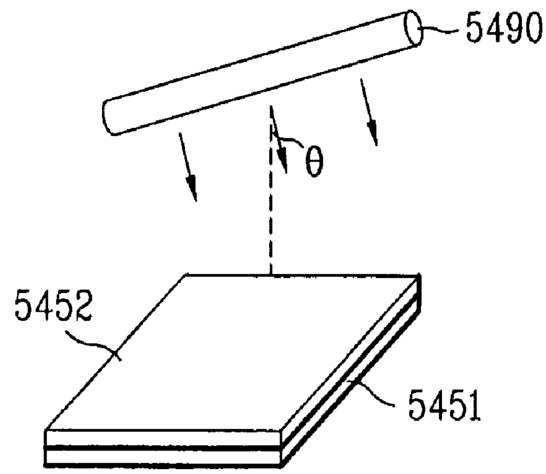


FIG. 169A

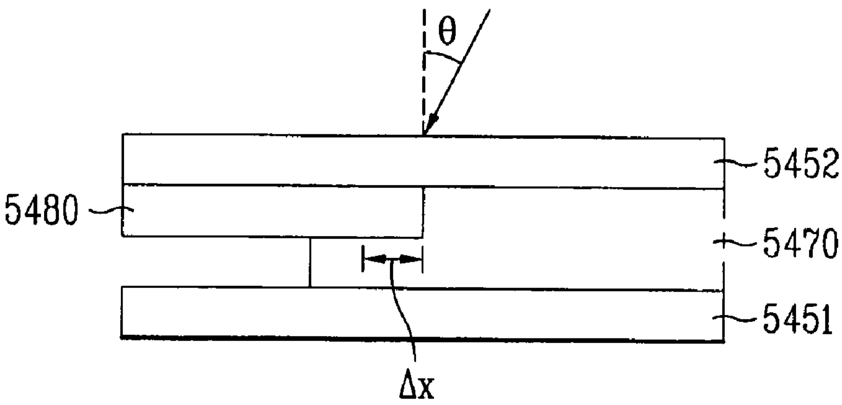


FIG. 169B

hardening rate of sealant (%)

range of sealant Δx (μm)	tilt angle θ (°)				
	0	15	30	45	60
0 ~ 260	56.8	77.8	87.7	98.7	99.1
260 ~ 520	38.4	78.7	81.7	93.7	98.2

FIG. 170A

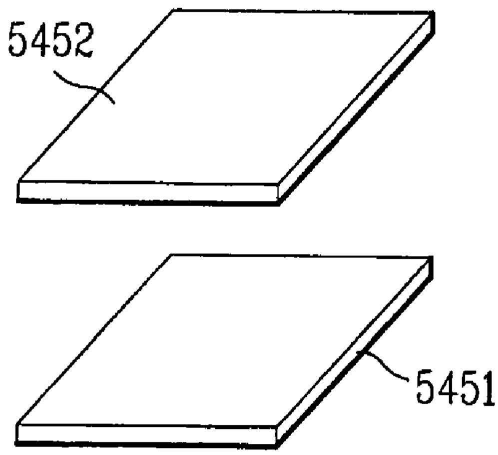


FIG. 170B

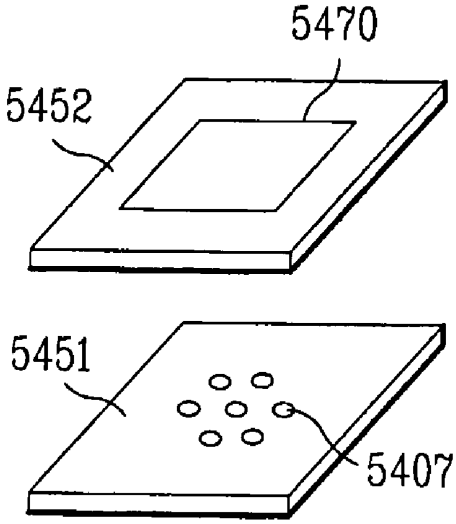


FIG. 170C

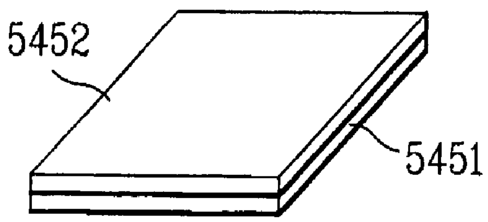


FIG. 170D

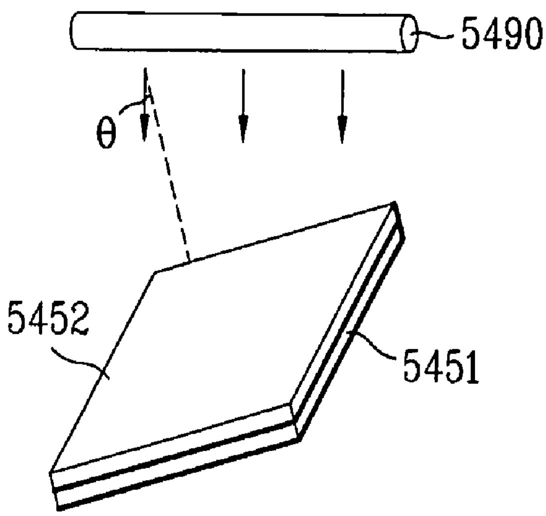


FIG. 171A

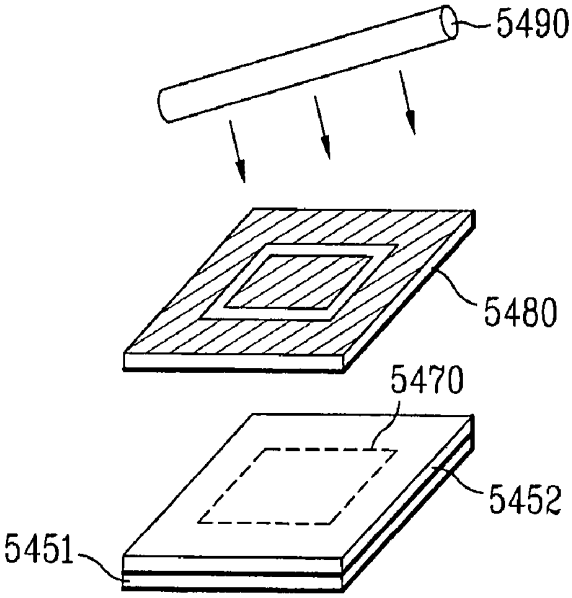


FIG. 171B

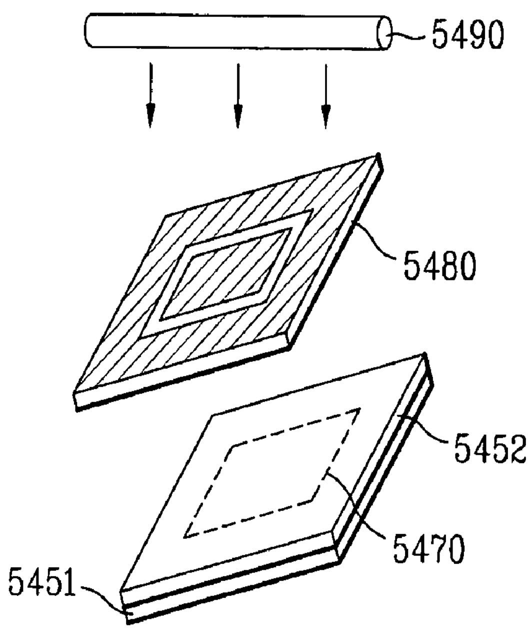


FIG. 171C

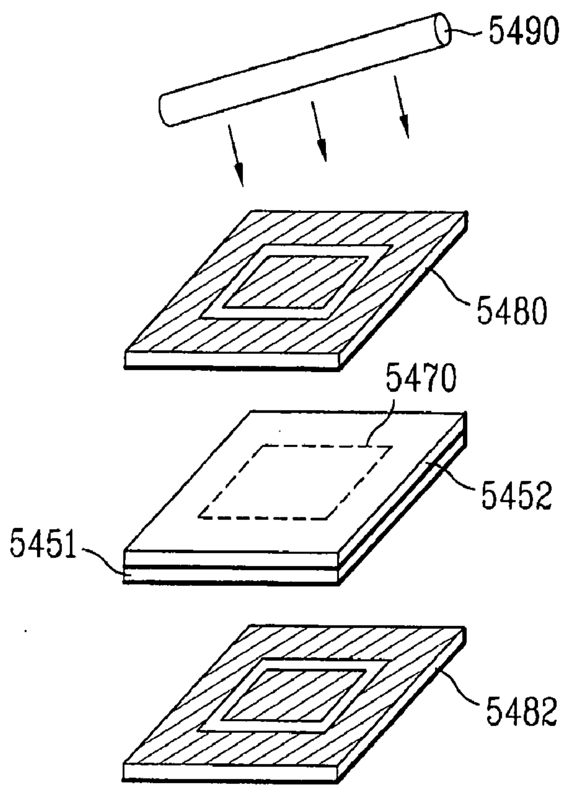


FIG. 171D

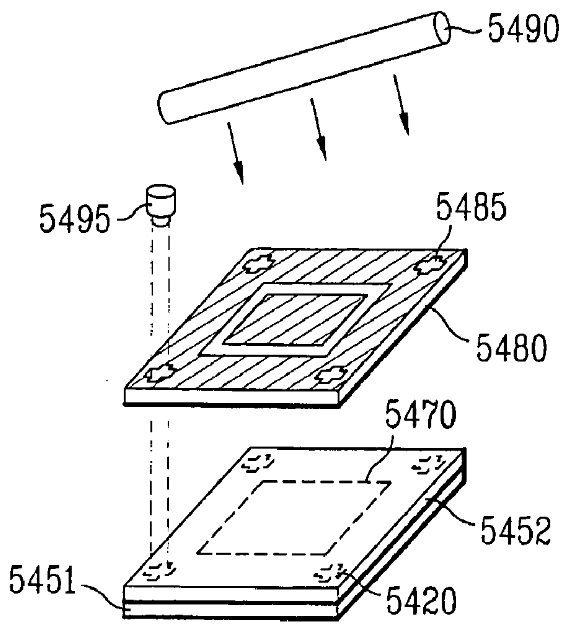


FIG. 172

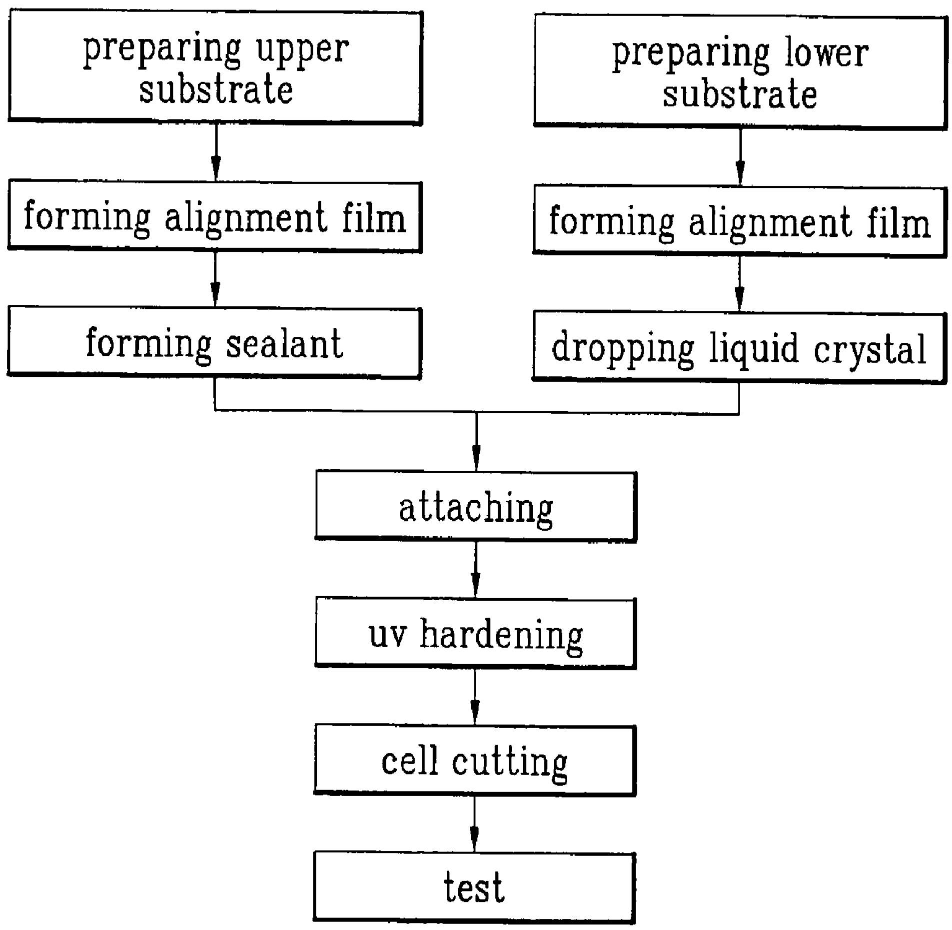

preparing upper substrate
forming alignment film
forming sealant
preparing lower substrate
forming alignment film
dropping liquid crystal
attaching
uv hardening
cell cutting
test

FIG. 173

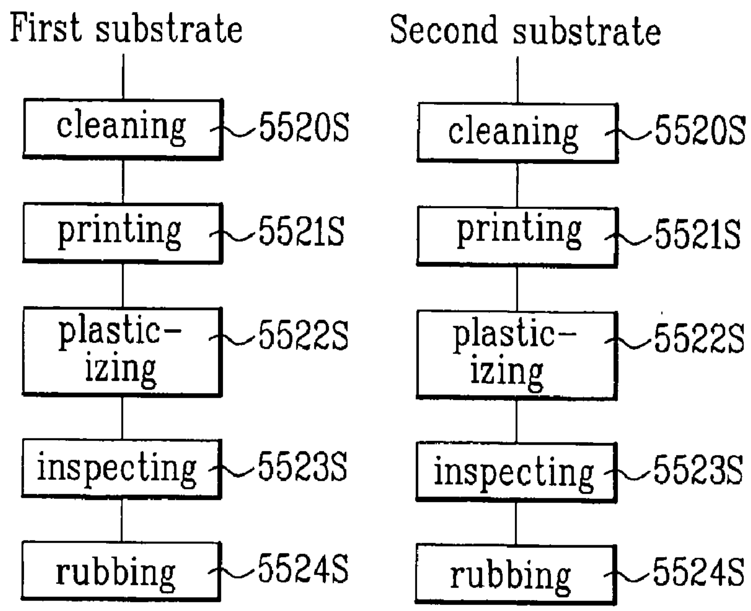


FIG. 174

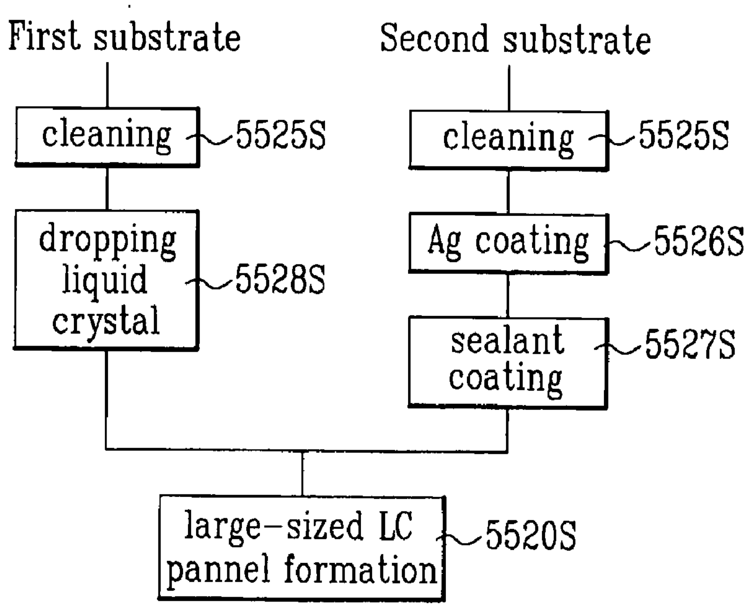


FIG. 175

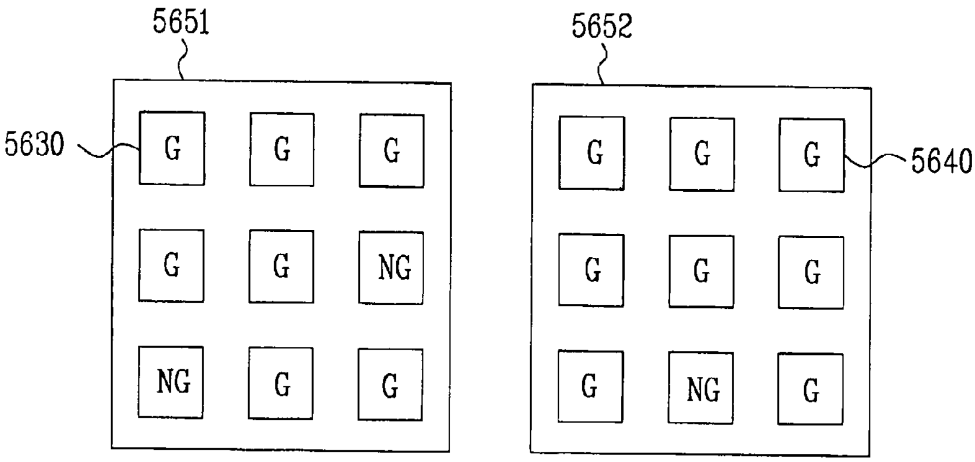


FIG. 176

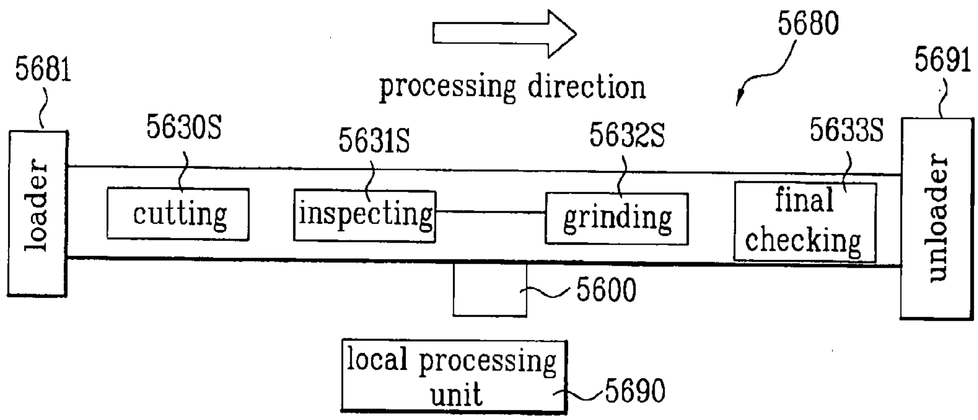


FIG. 177

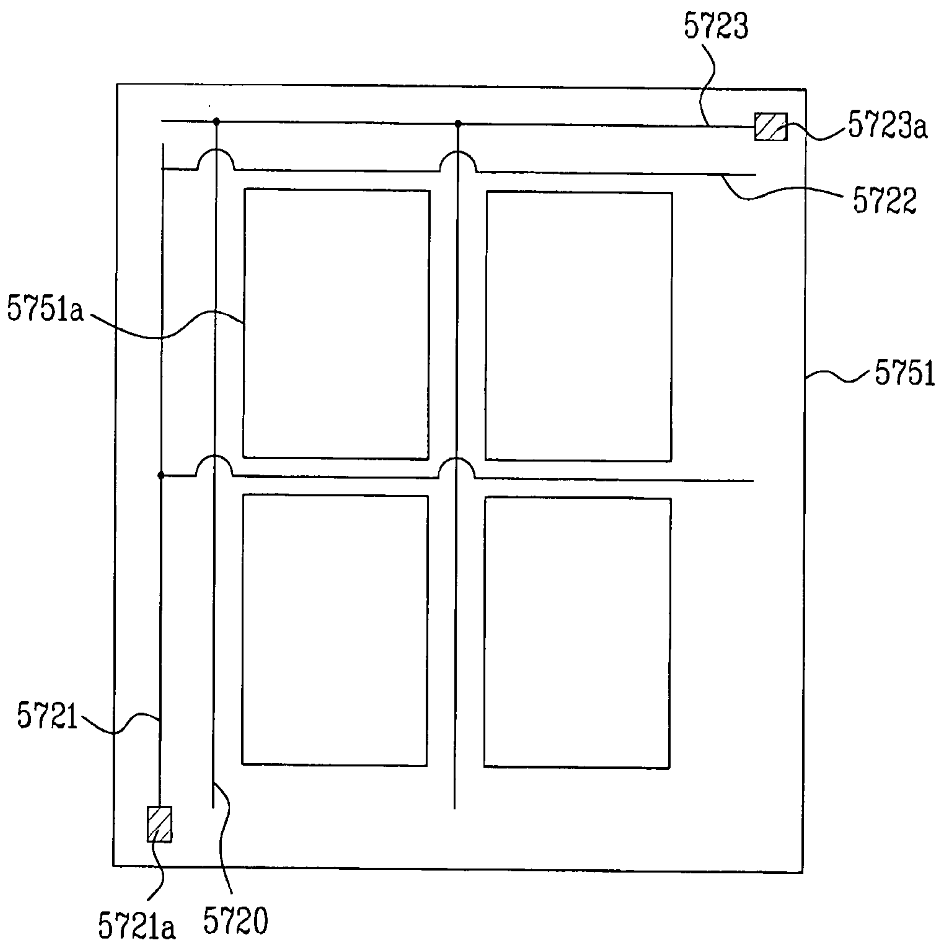


FIG. 178

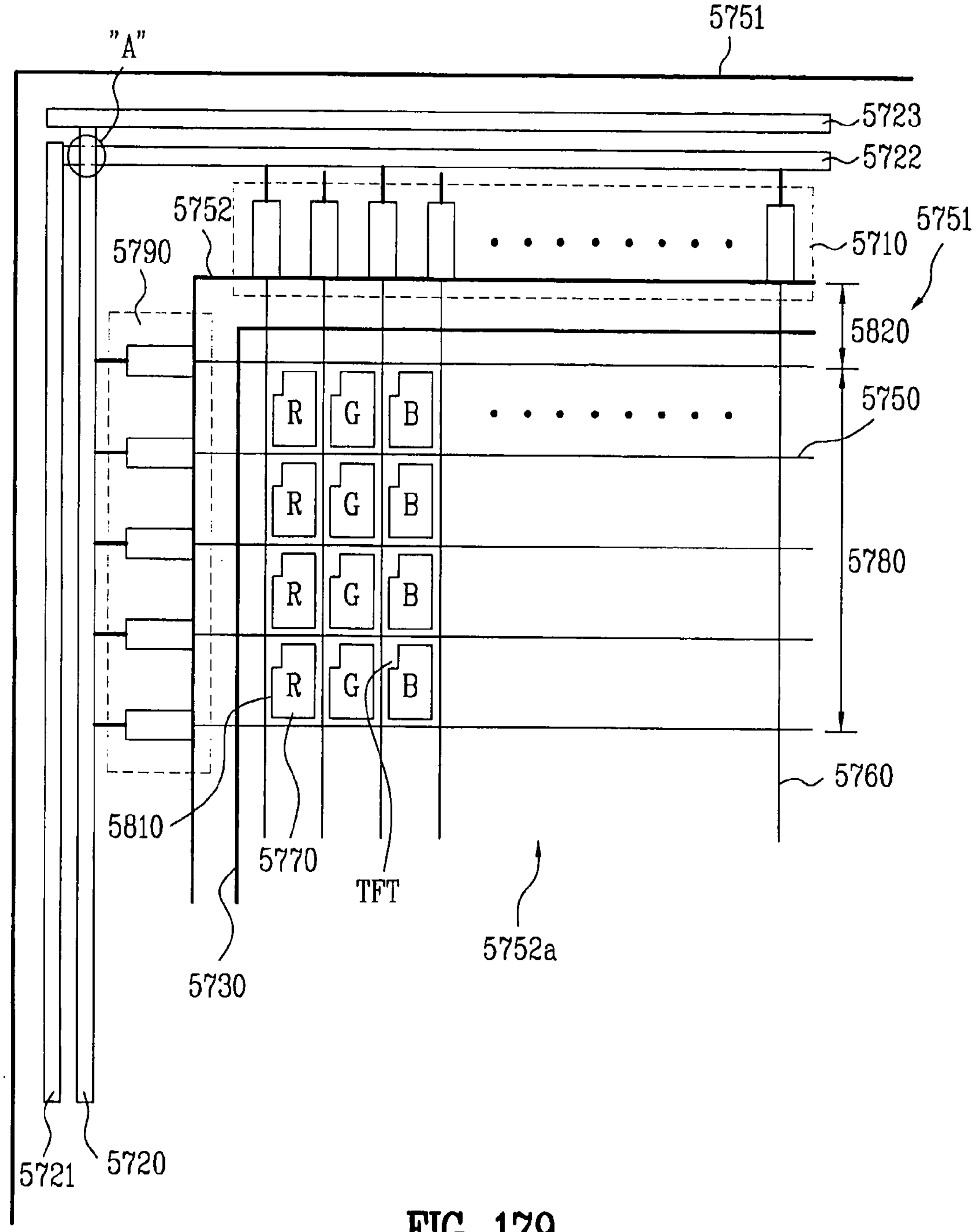


FIG. 179

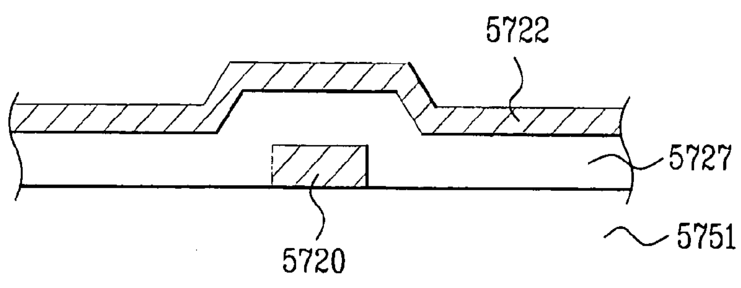


FIG. 180

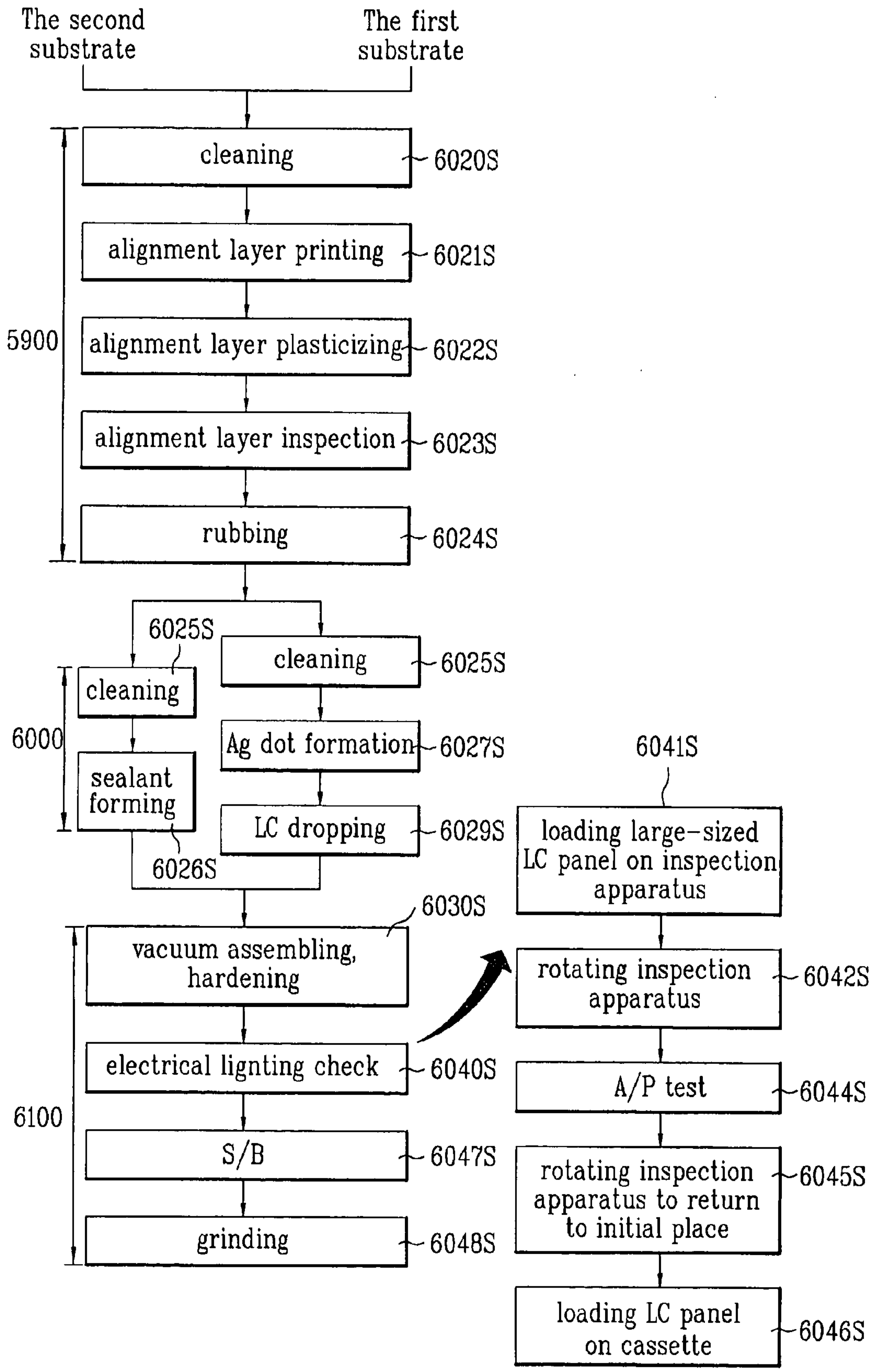

The second substrate
The first substrate
cleaning
6020S
alignment layer printing
6021S
alignment layer plasticizing
6022S
alignment layer inspection
6023S
rubbing
6024S
5900
6025S
cleaning
cleaning
6025S
Ag dot formation
6027S
sealant forming
6026S
LC dropping
6029S
6000
6041S
loading large-sized LC panel on inspection apparatus
6030S
vacuum assembling, hardening
rotating inspection apparatus
6042S
electrical lignting check
6040S
A/P test
6044S
6100
S/B
6047S
rotating inspection apparatus to return to initial place
6045S
grinding
6048S
loading LC panel on cassette
6046S

FIG. 181

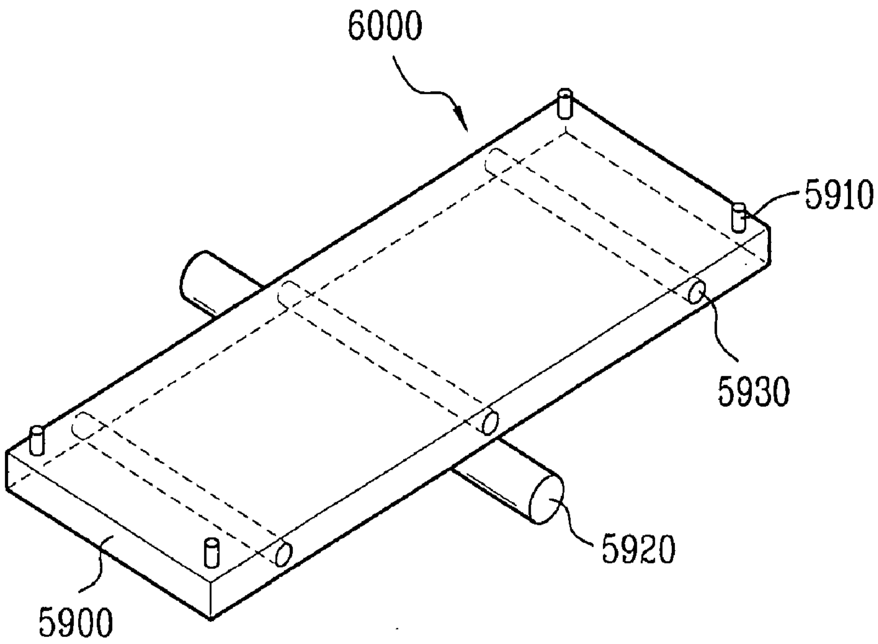


FIG. 182

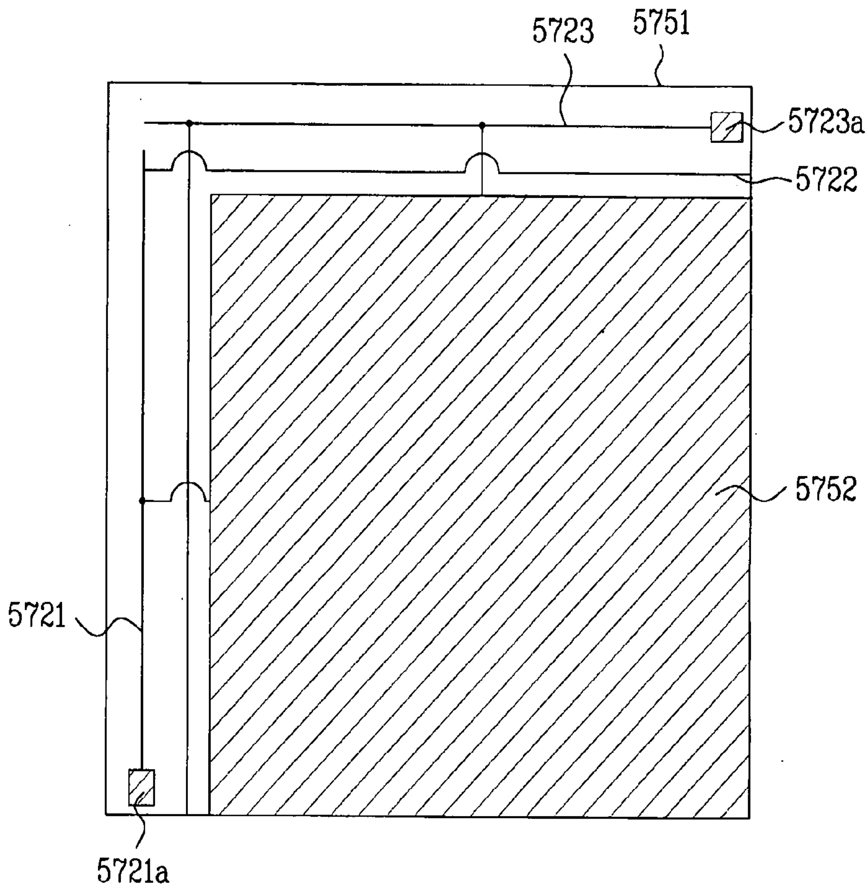


FIG. 183

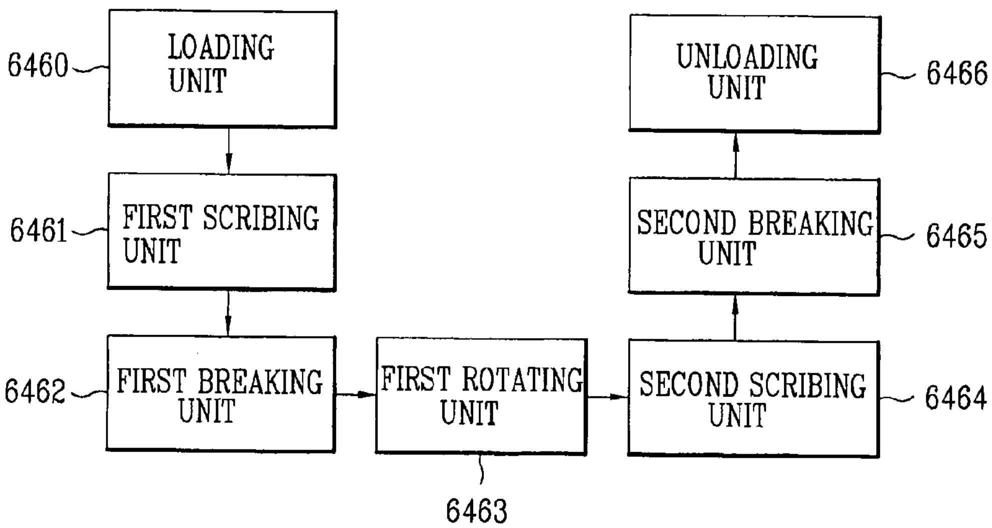

LOADING UNIT
6460
FIRST SCRIBING UNIT
6461
FIRST BREAKING UNIT
6462
FIRST ROTATING UNIT
6463
SECOND SCRIBING UNIT
6464
SECOND BREAKING UNIT
6465
UNLOADING UNIT
6466

FIG. 184A

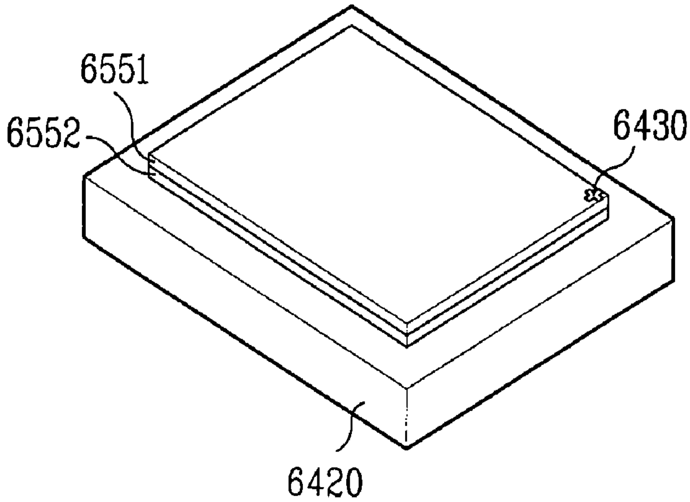


FIG. 184B

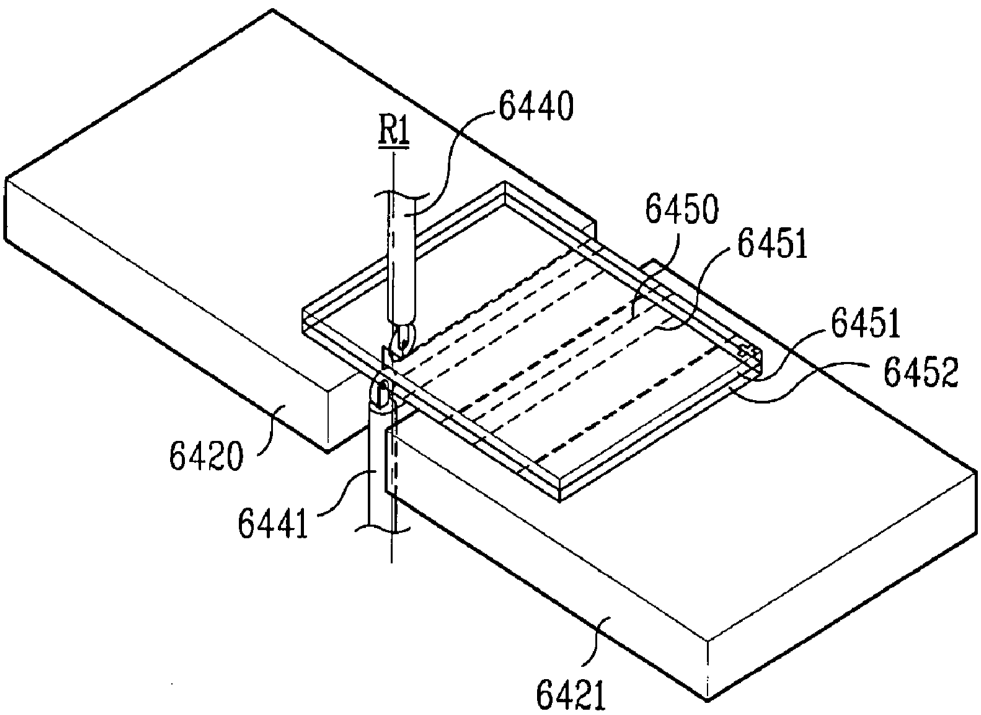


FIG. 184C

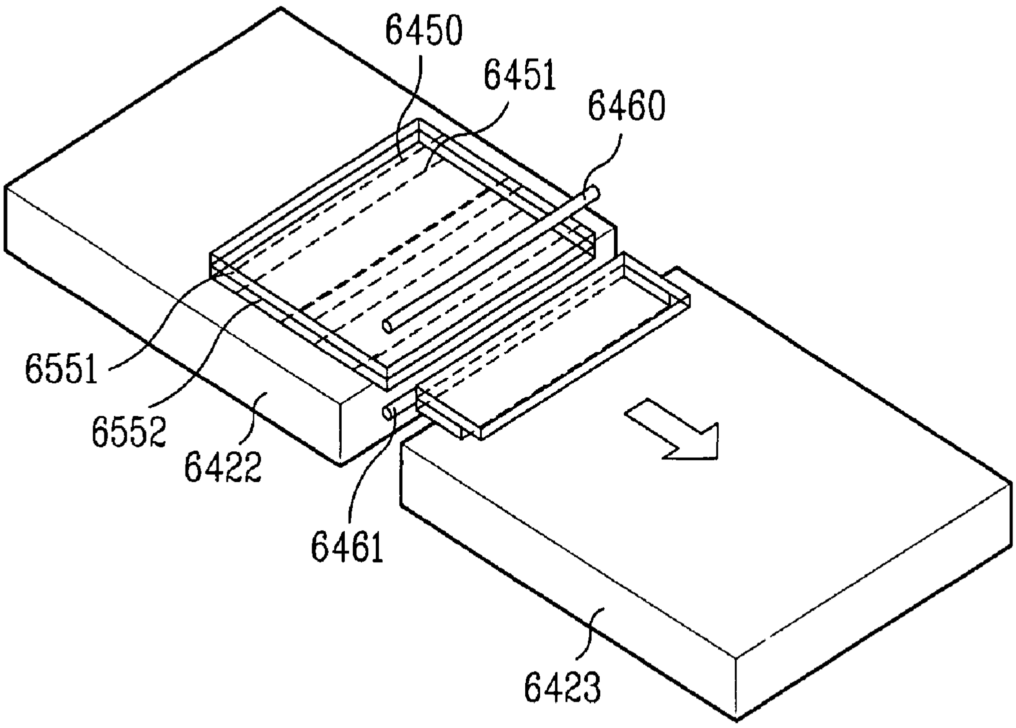


FIG. 184D

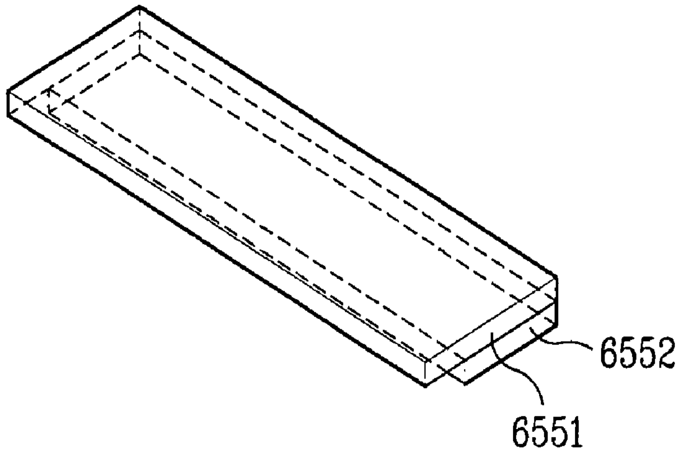


FIG. 184E

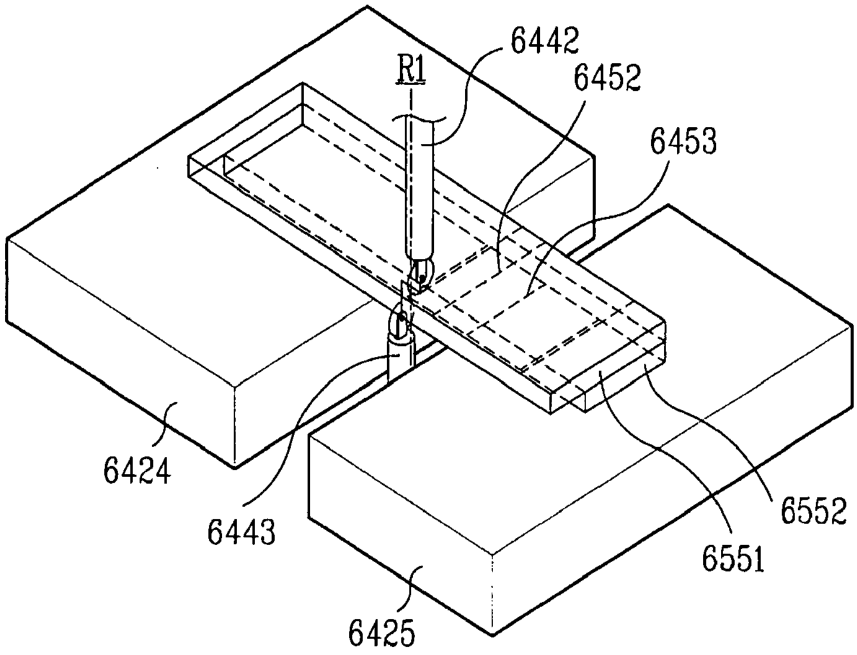


FIG. 184F

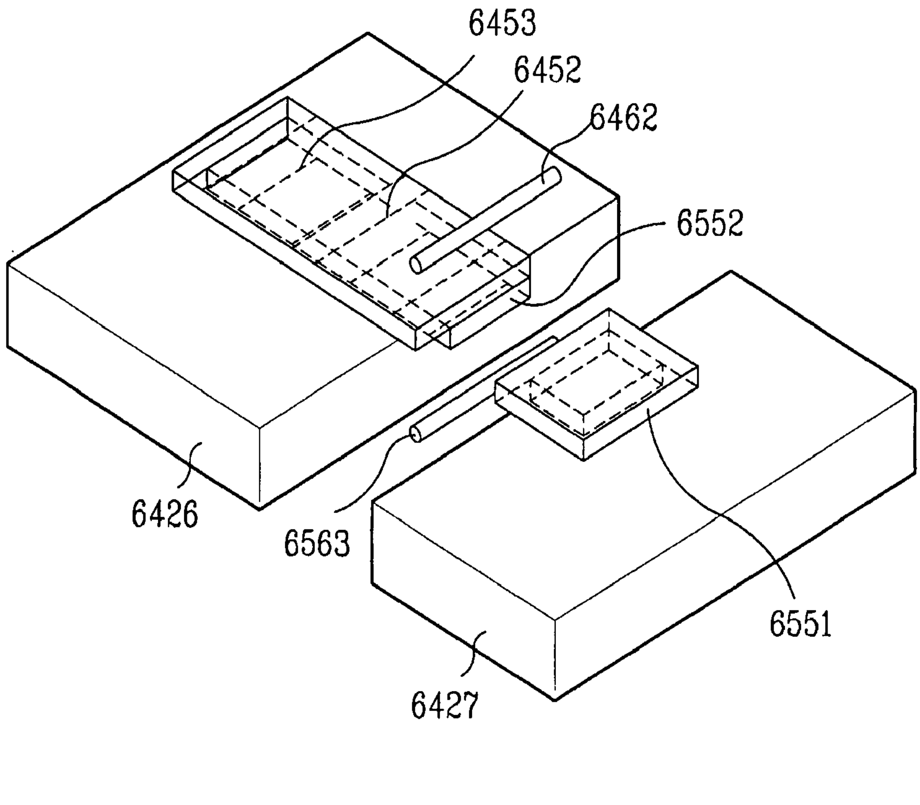


FIG. 184G

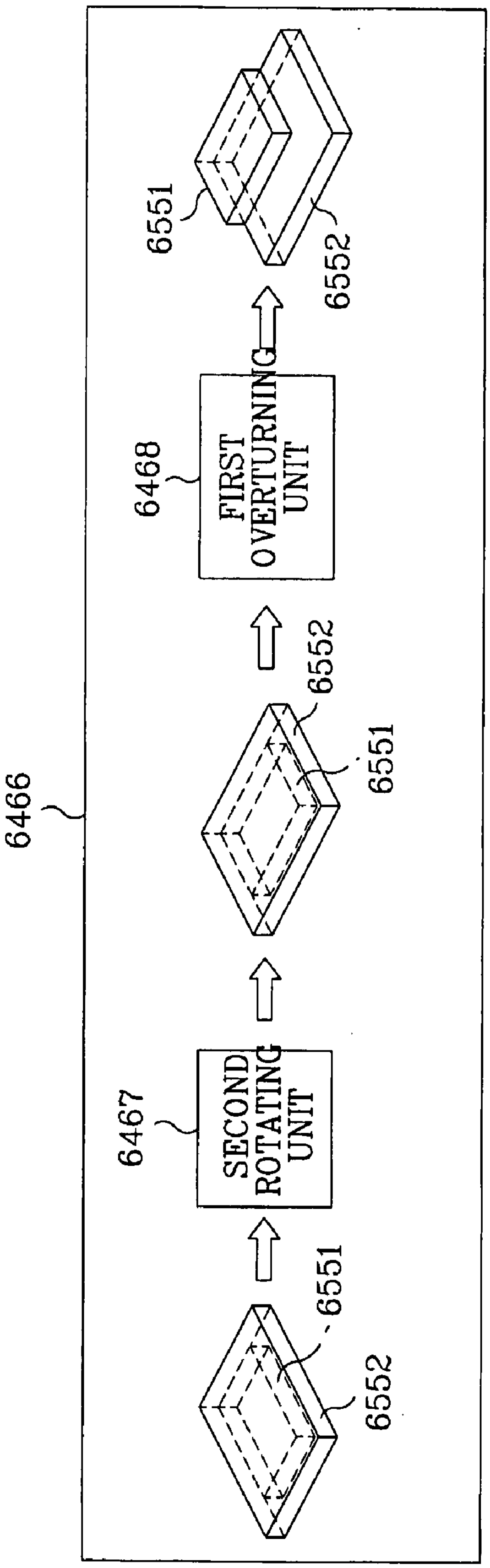

6466
6551
6552
SECOND ROTATING UNIT
6467
6551
6552
FIRST OVERTURNING UNIT
6468
6551
6552

FIG. 185

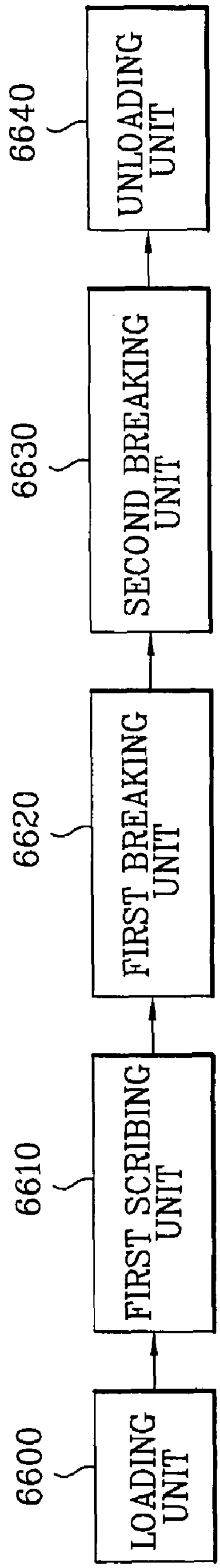

6600
LOADING UNIT
6610
FIRST SCRIBING UNIT
6620
FIRST BREAKING UNIT
6630
SECOND BREAKING UNIT
6640
UNLOADING UNIT

FIG. 186A

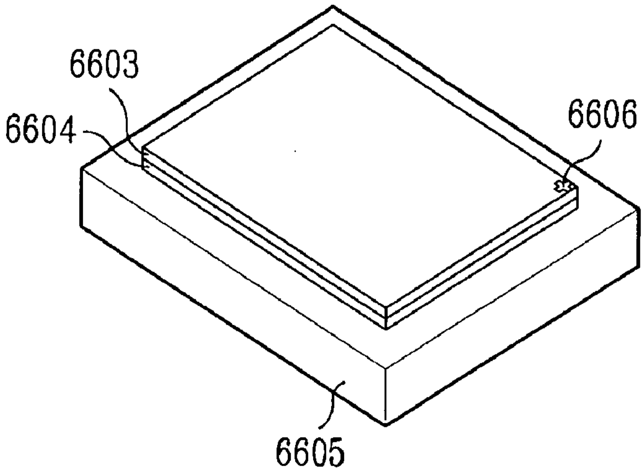


FIG. 186B

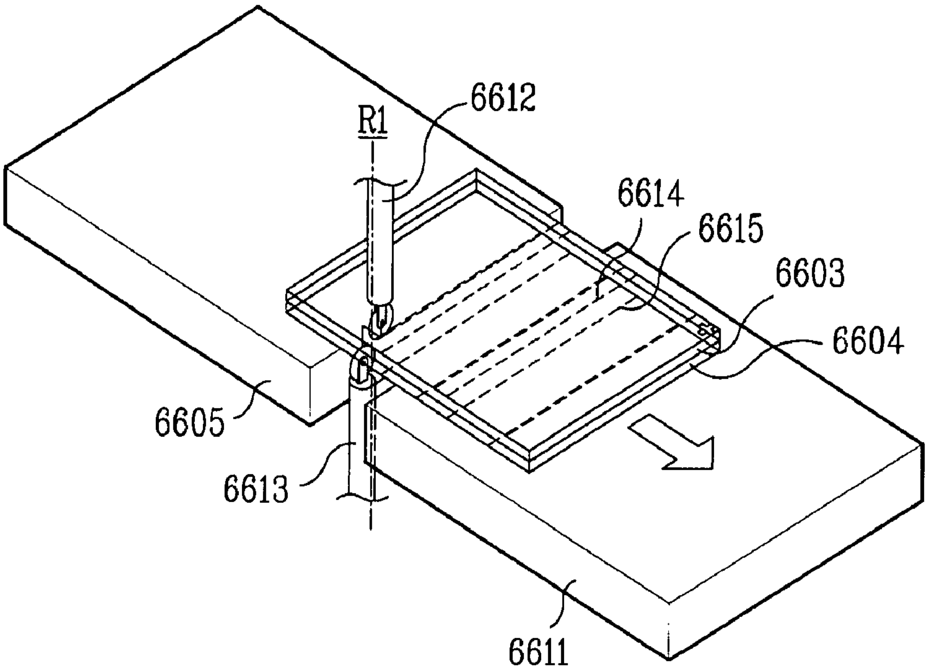


FIG. 186C

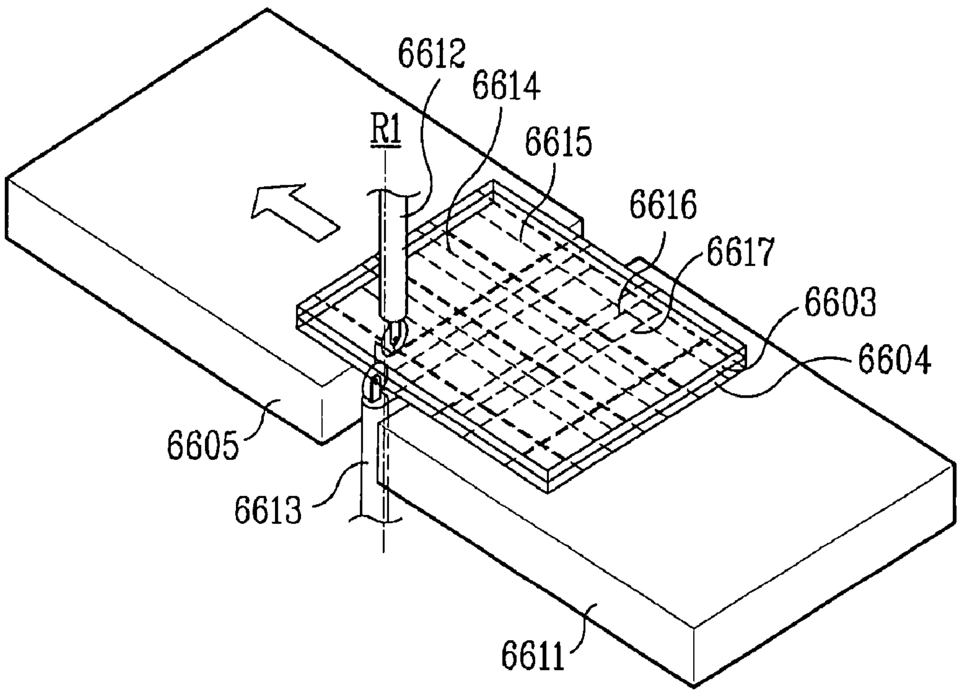


FIG. 186D

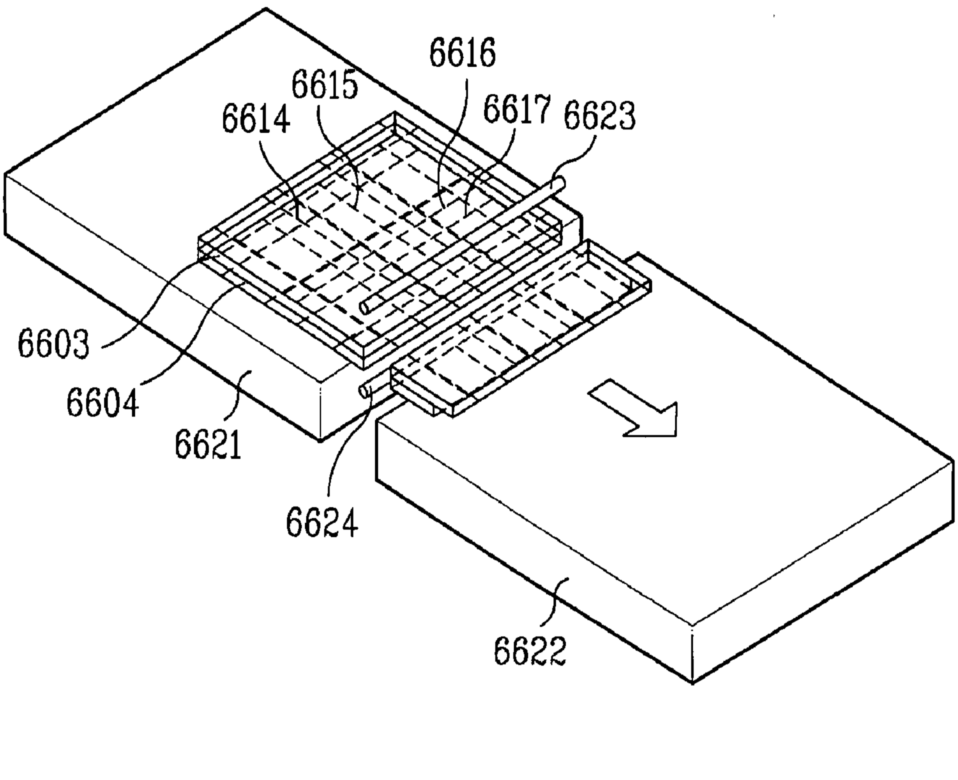


FIG. 186E

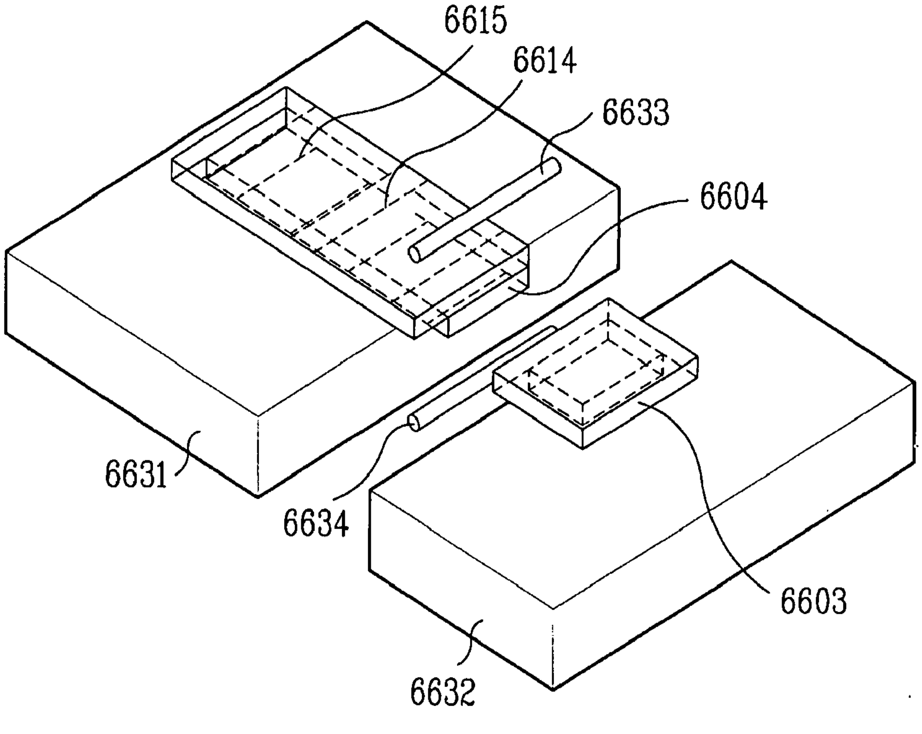


FIG. 186F

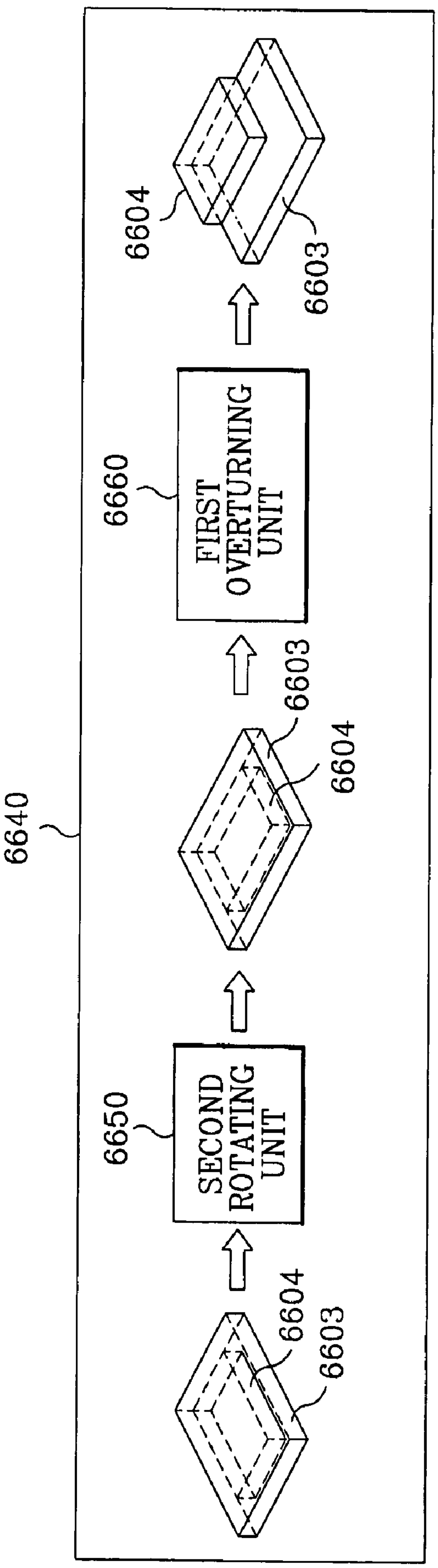

6640
6603
6604
SECOND ROTATING UNIT
6650
6603
6604
FIRST OVERTURNING UNIT
6660
6604
6603

FIG. 187A

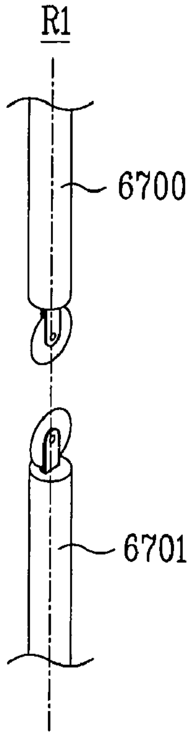


FIG. 187B

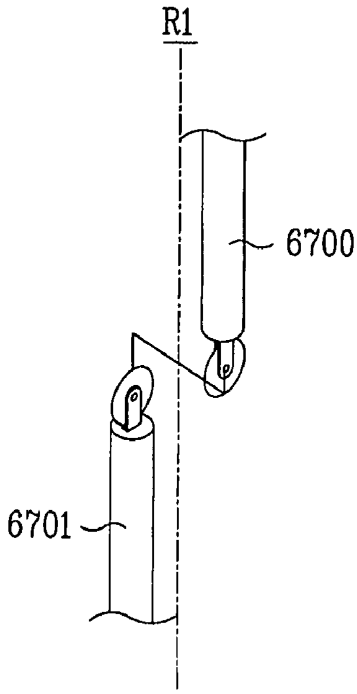


FIG. 187C

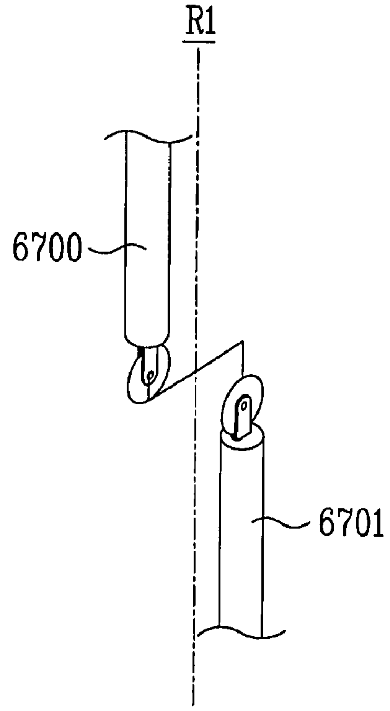


FIG. 188

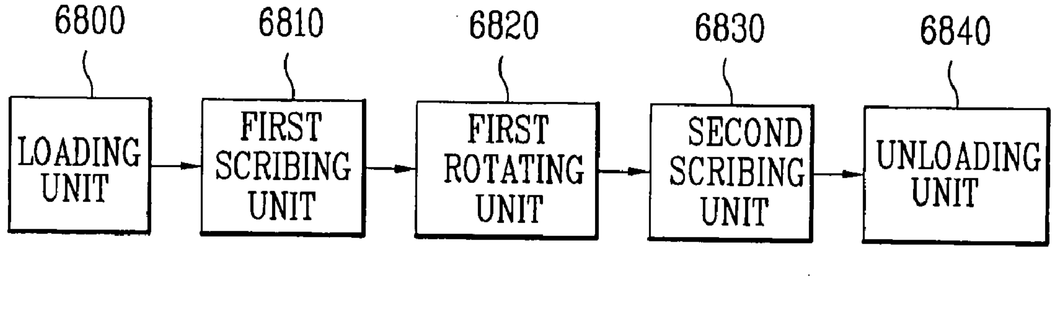


FIG. 189A

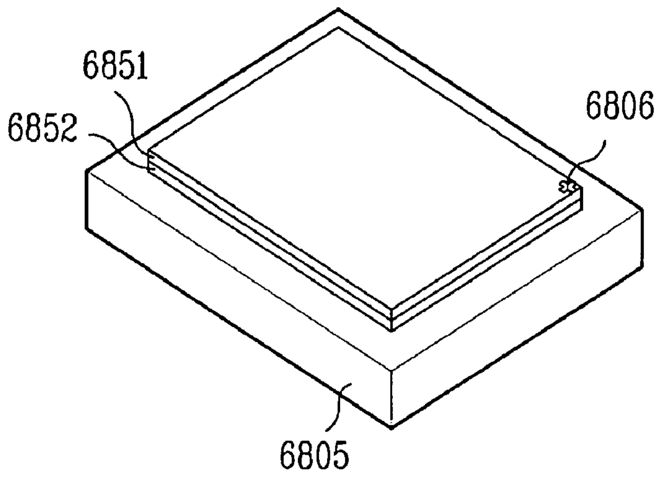


FIG. 189B

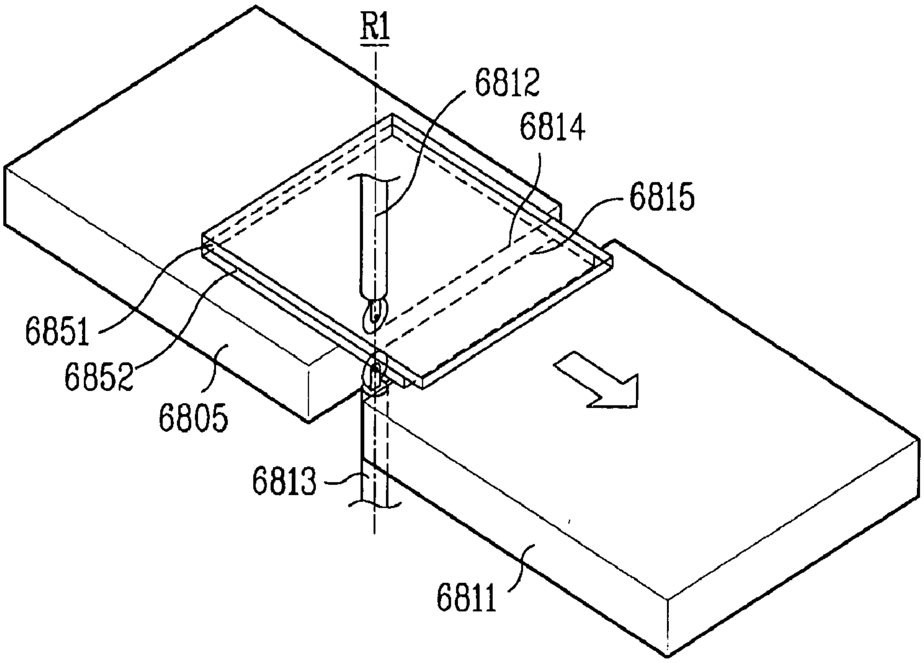


FIG. 189C

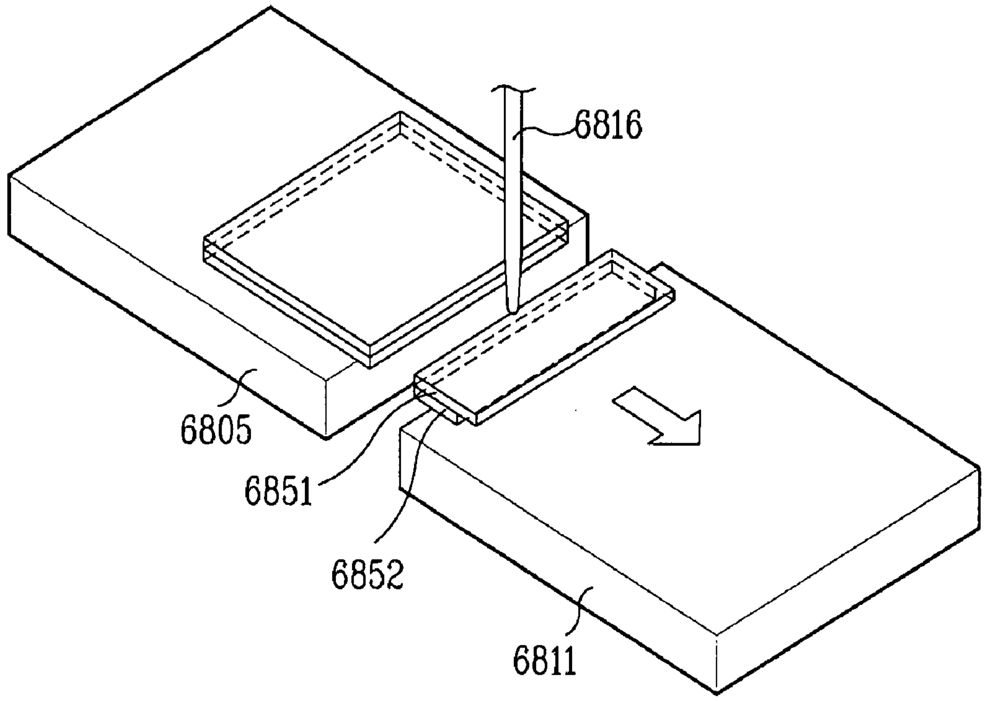


FIG. 189D

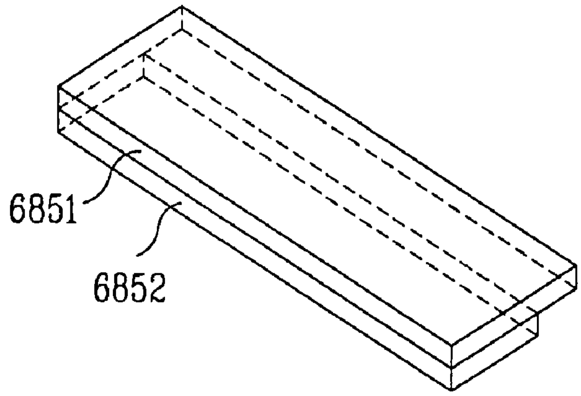


FIG. 189E

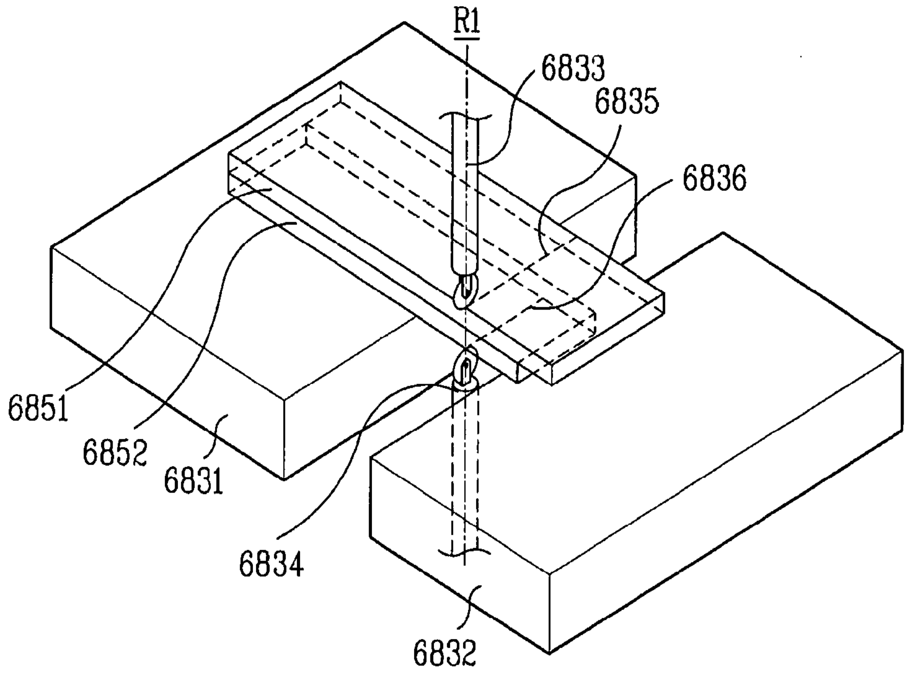


FIG. 189F

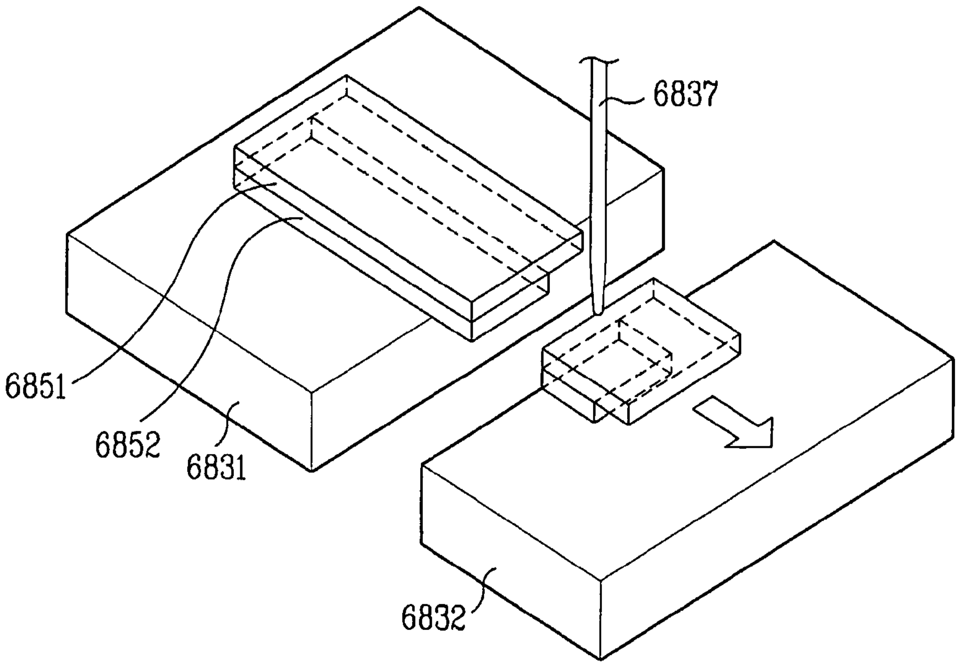
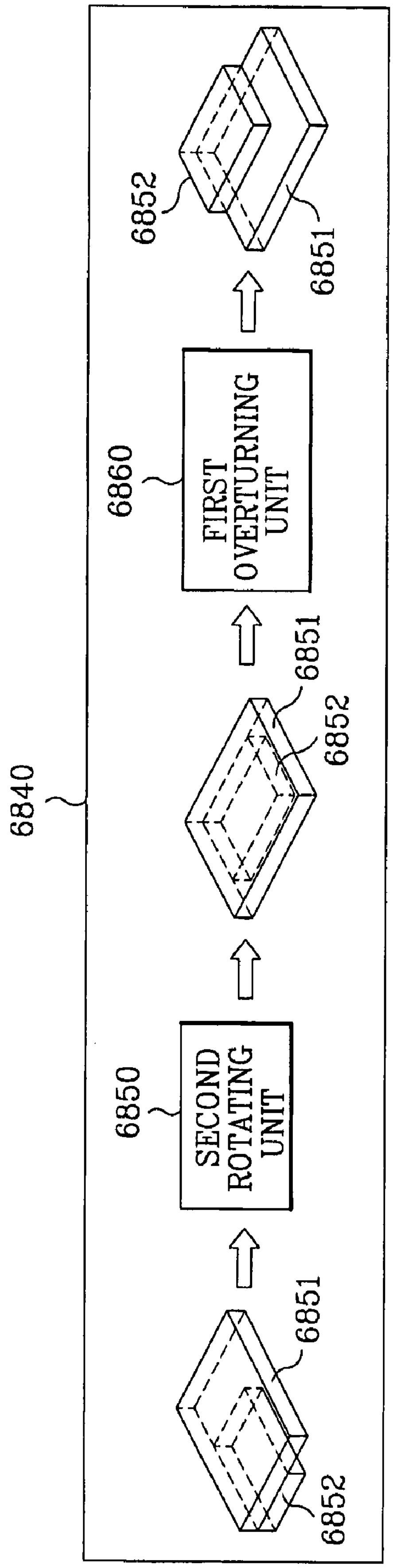


FIG. 189G


6840
6852
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SECOND ROTATING UNIT
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6852
FIRST OVERTURNING UNIT
6860
6852
6851

FIG. 190

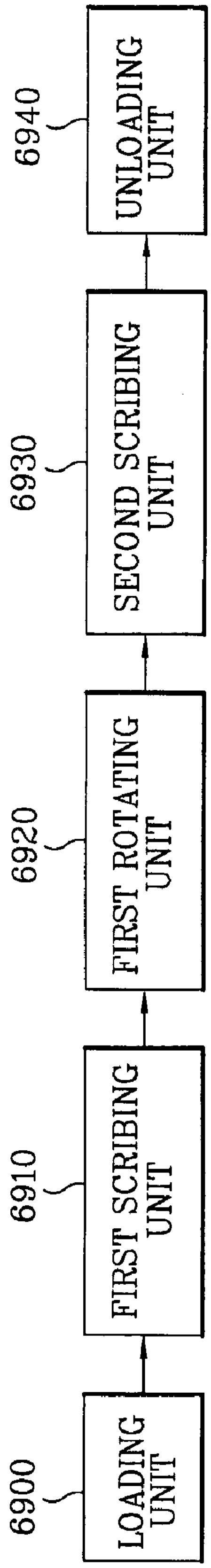

6900
LOADING UNIT
6910
FIRST SCRIBING UNIT
6920
FIRST ROTATING UNIT
6930
SECOND SCRIBING UNIT
6940
UNLOADING UNIT

FIG. 191A

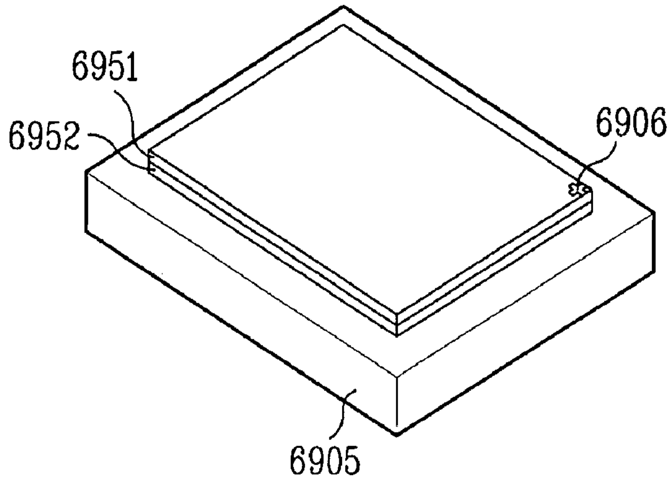


FIG. 191B

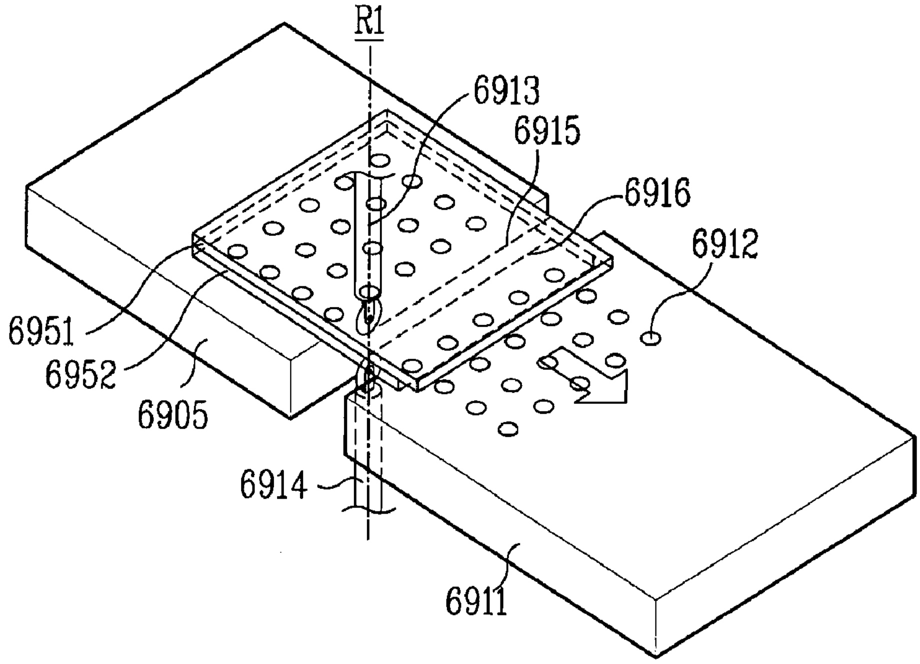


FIG. 191C

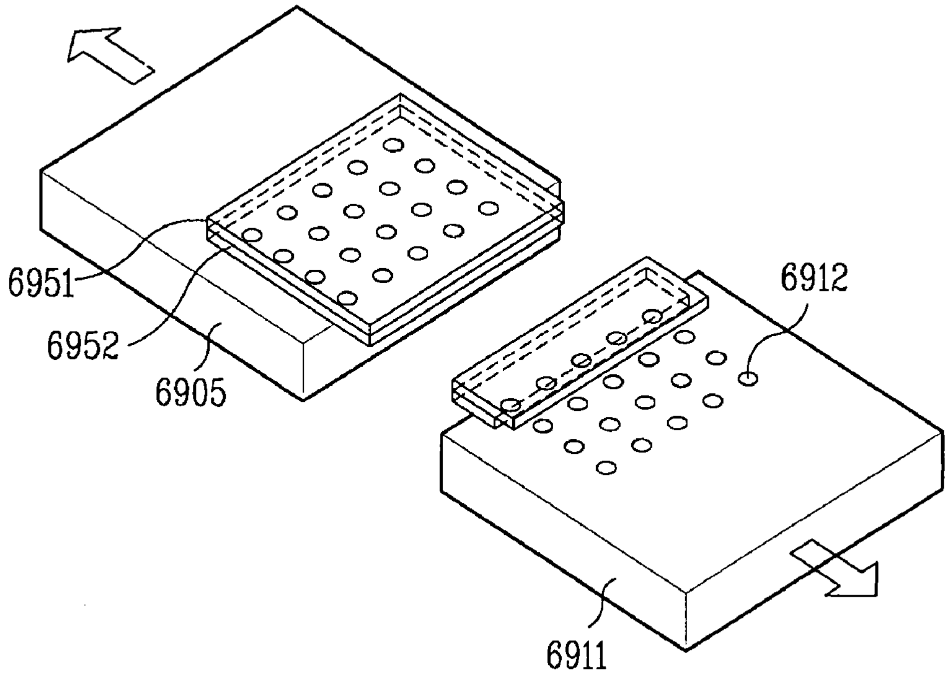


FIG. 191D

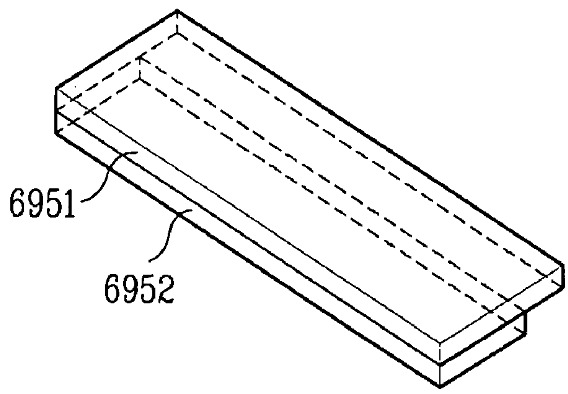


FIG. 191E

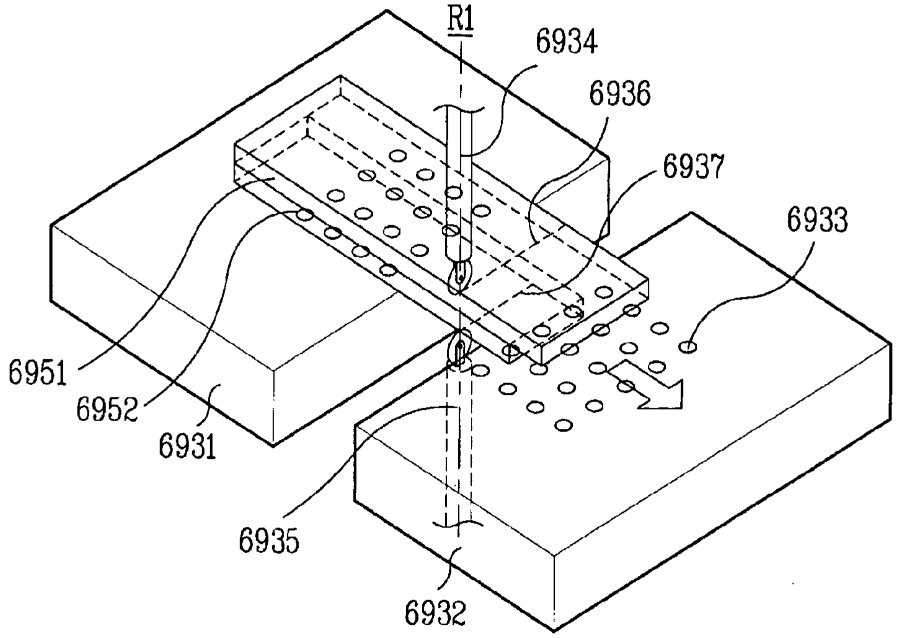


FIG. 191F

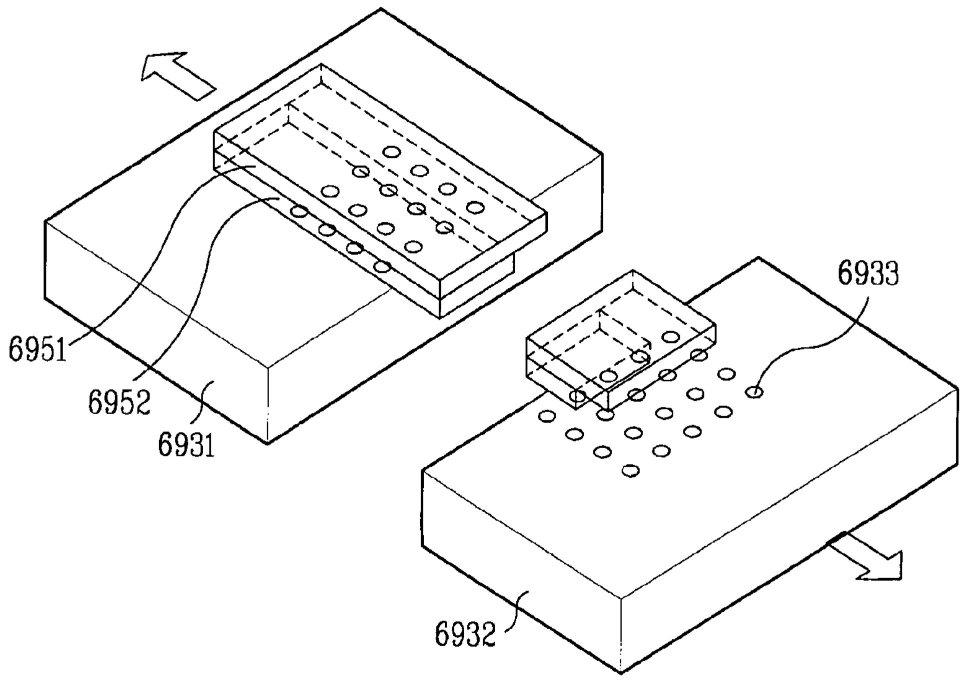
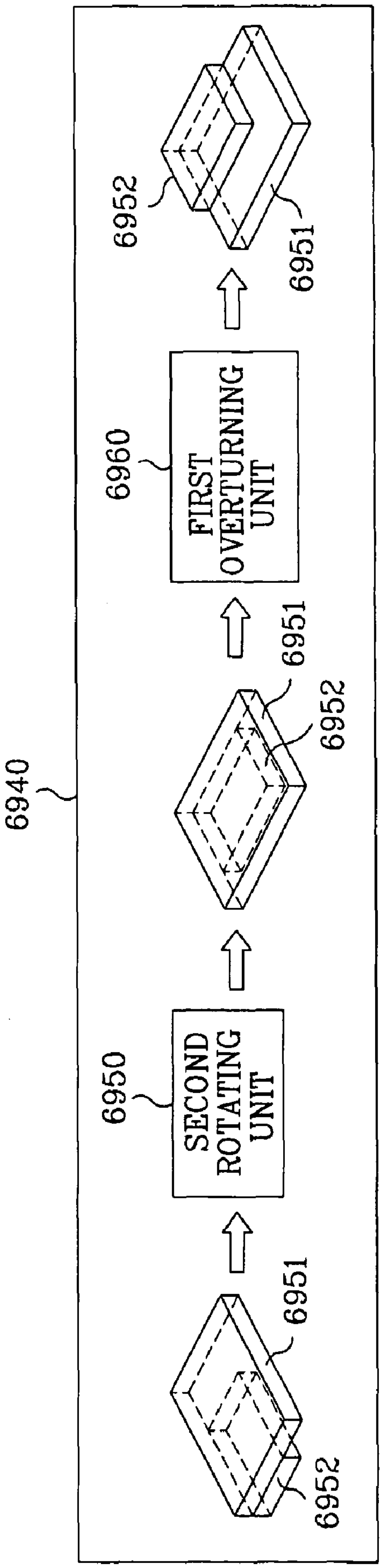


FIG. 191G


6940
6951
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6950
SECOND ROTATING UNIT
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6952
6960
FIRST OVERTURNING UNIT
6952
6951

FIG. 192

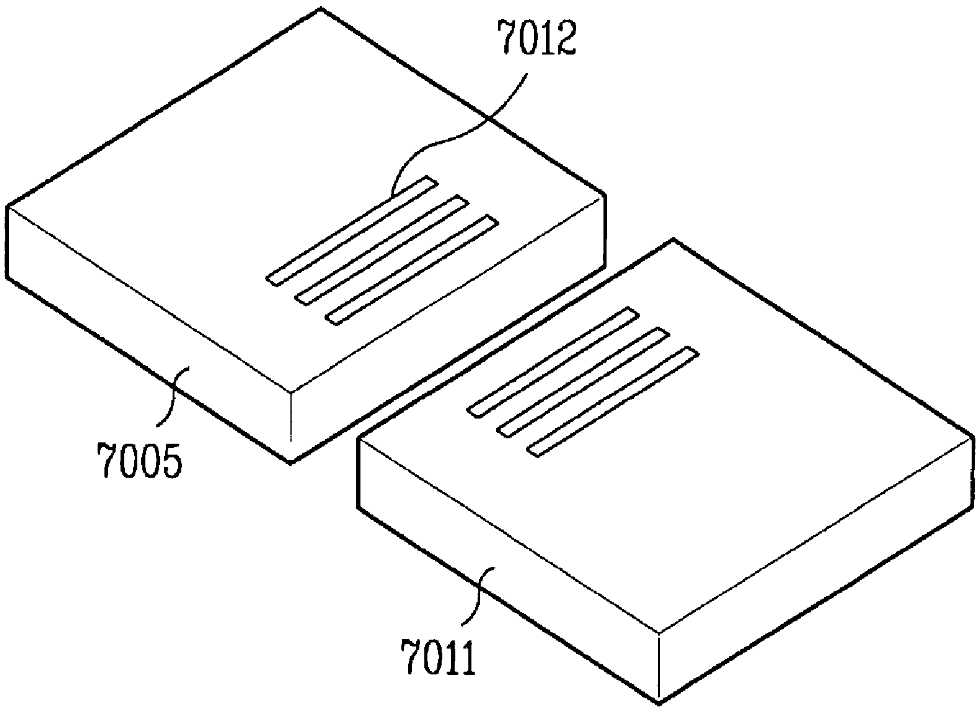


FIG. 193A

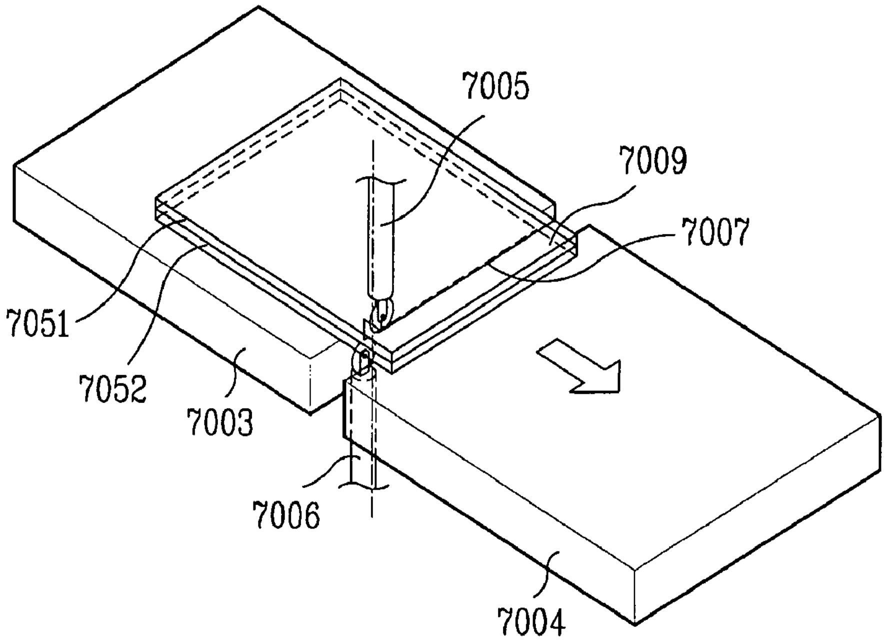


FIG. 193B

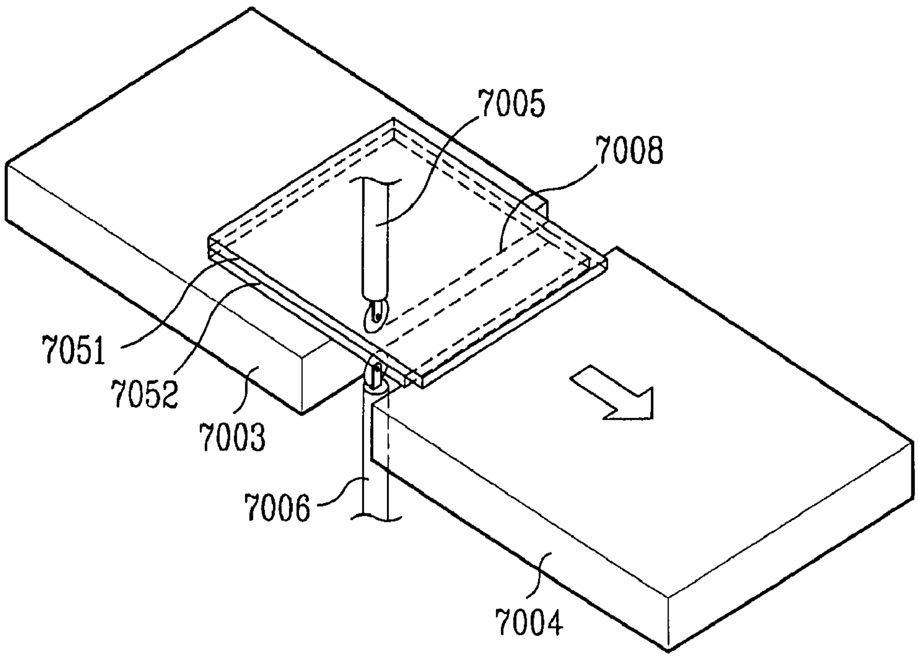


FIG. 194A

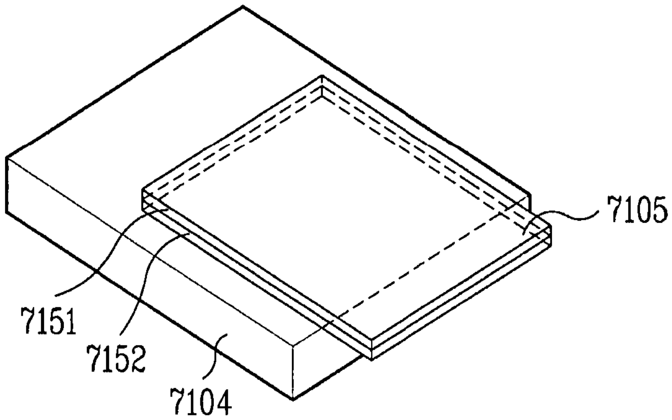


FIG. 194B

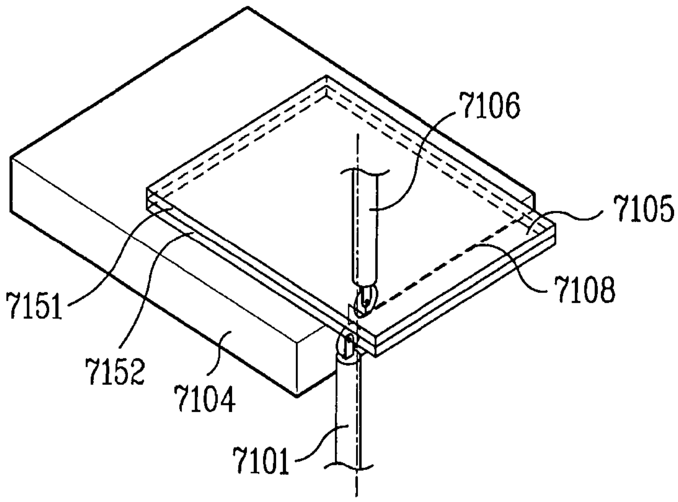


FIG. 194C

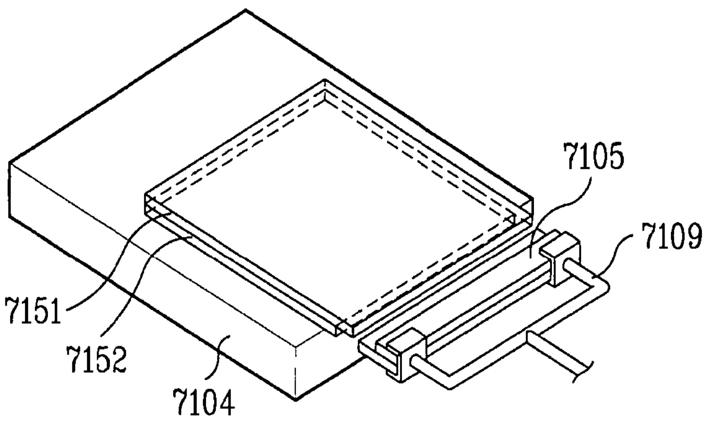


FIG. 194D

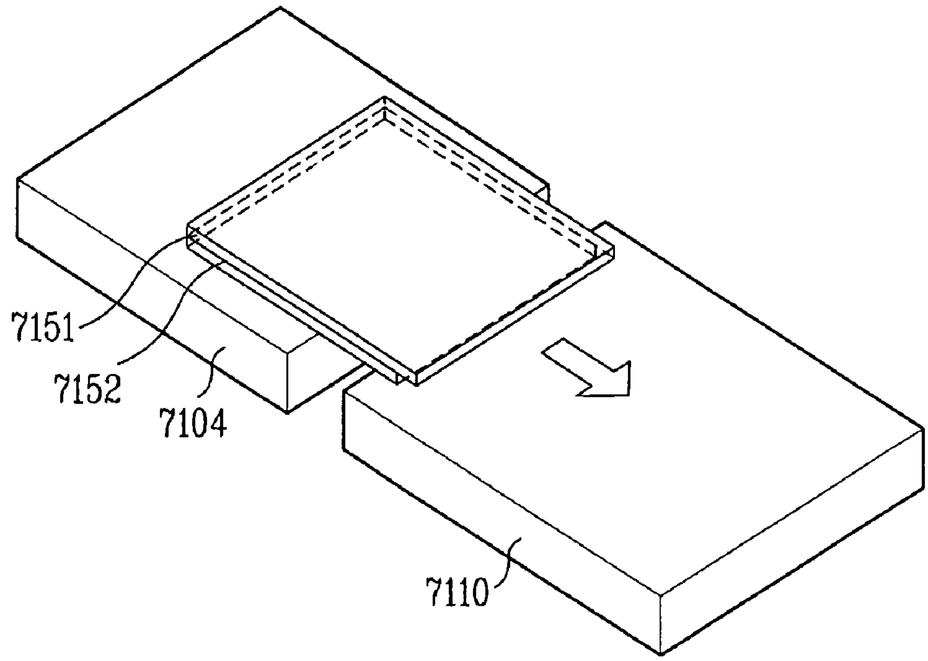


FIG. 194E

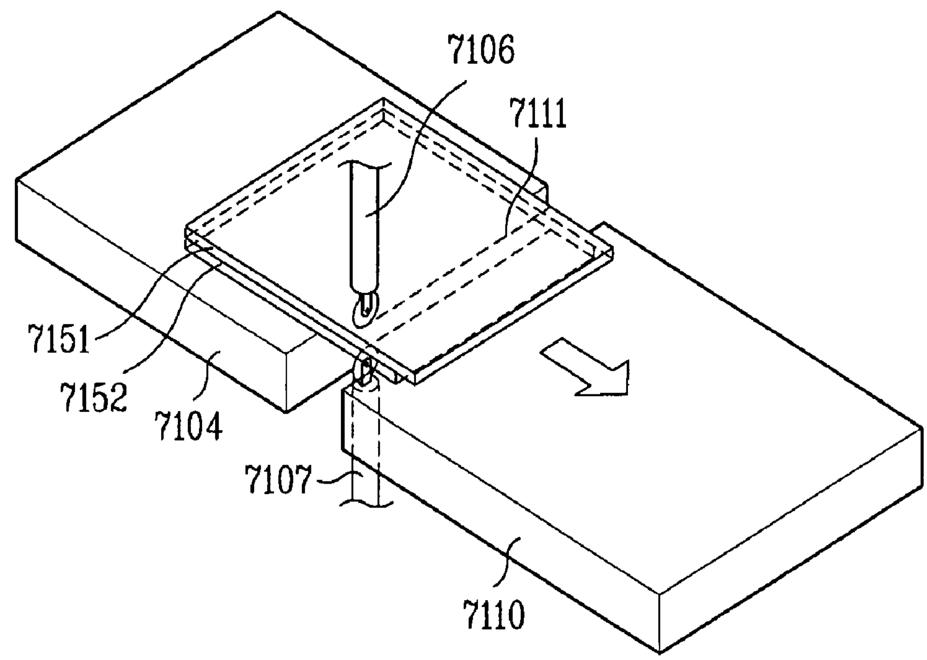


FIG. 194F

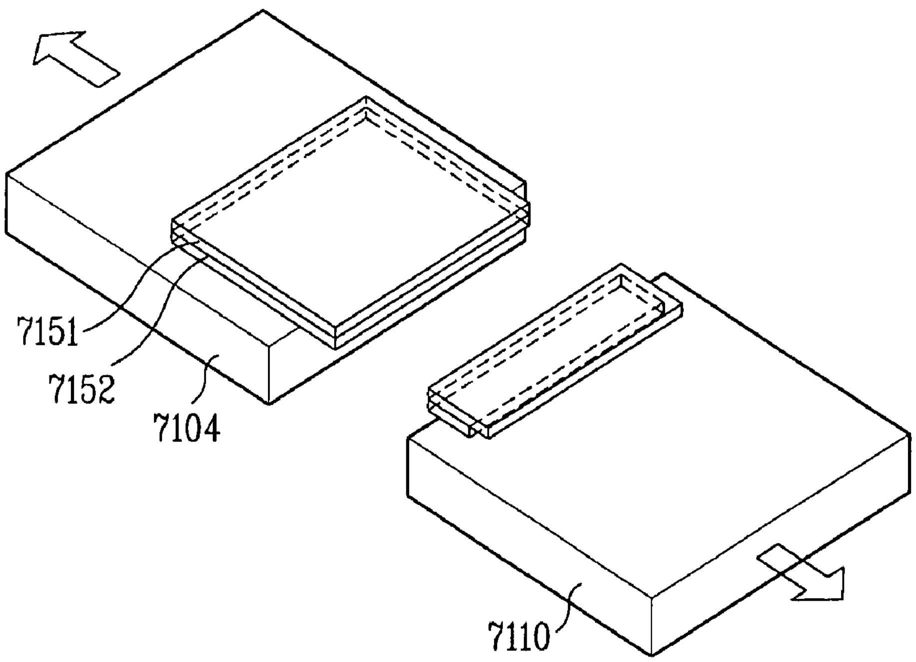


FIG. 195

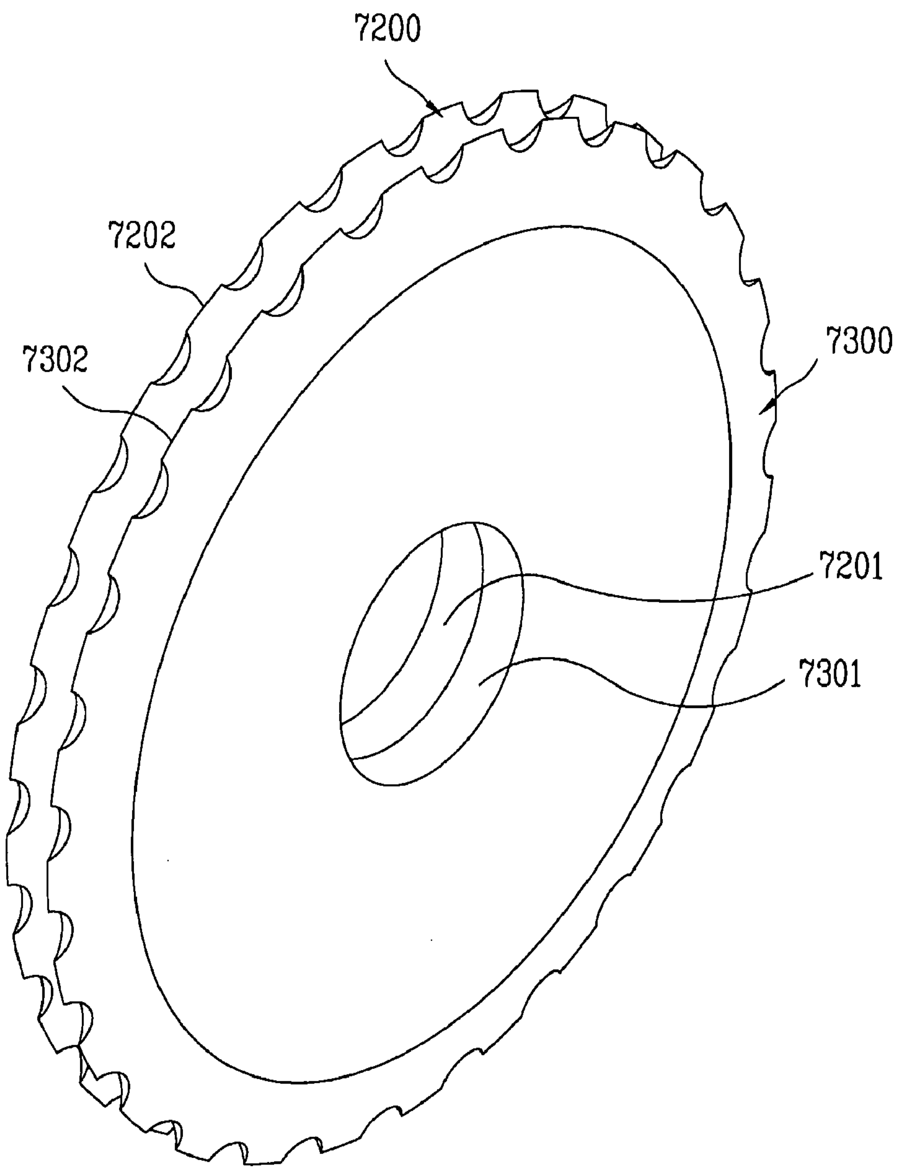


FIG. 196

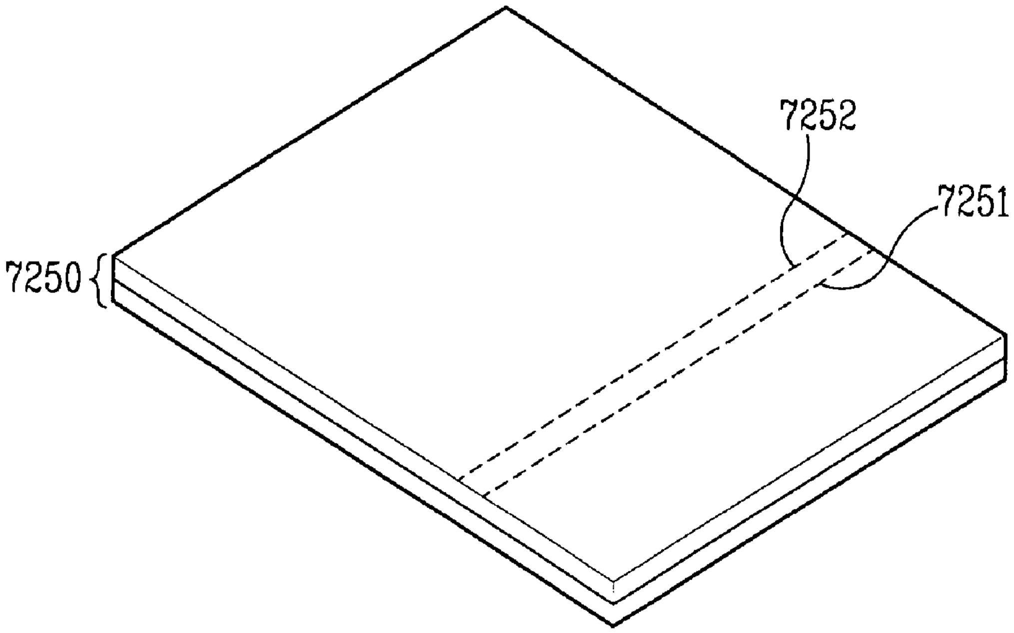


FIG. 197

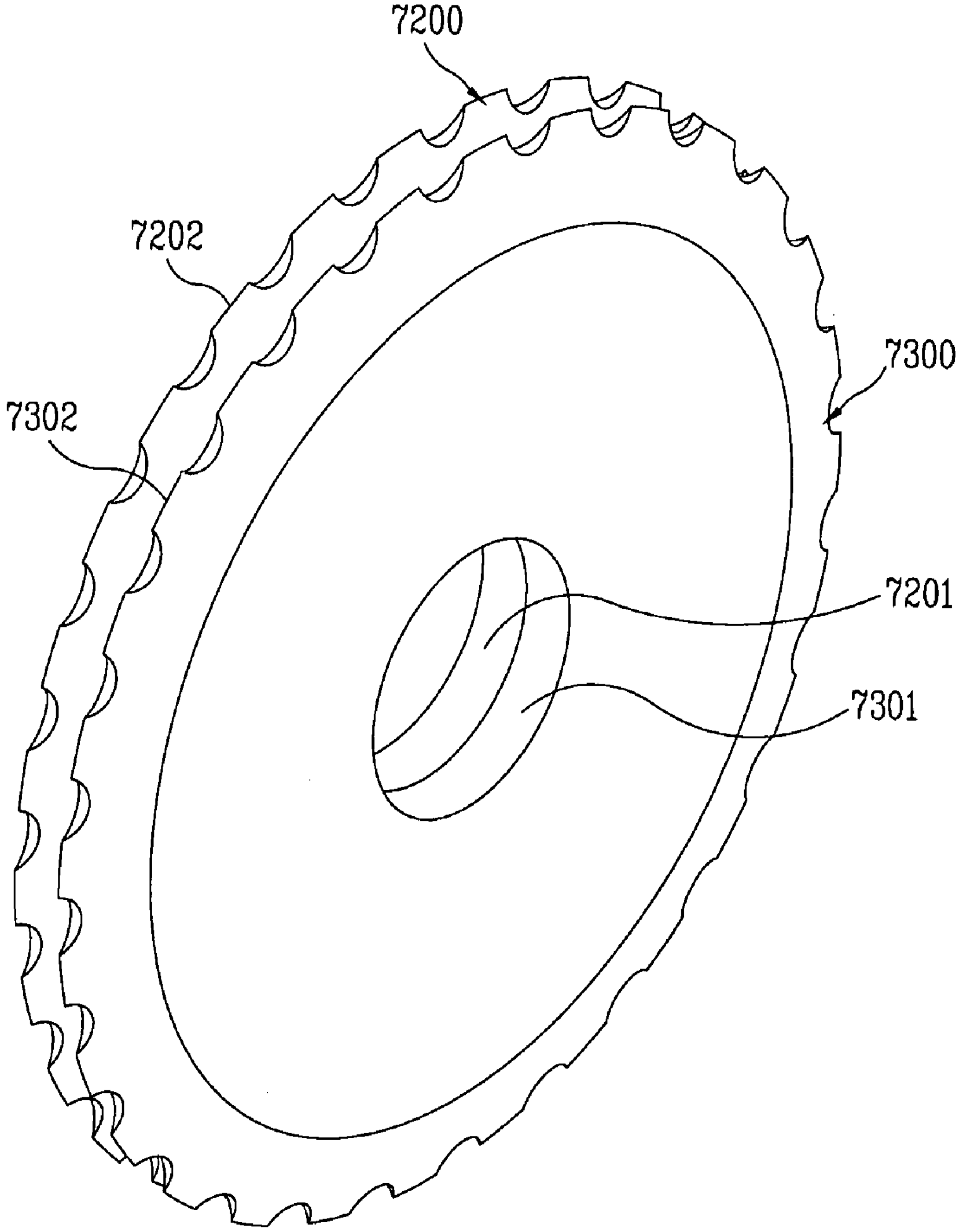


FIG. 198

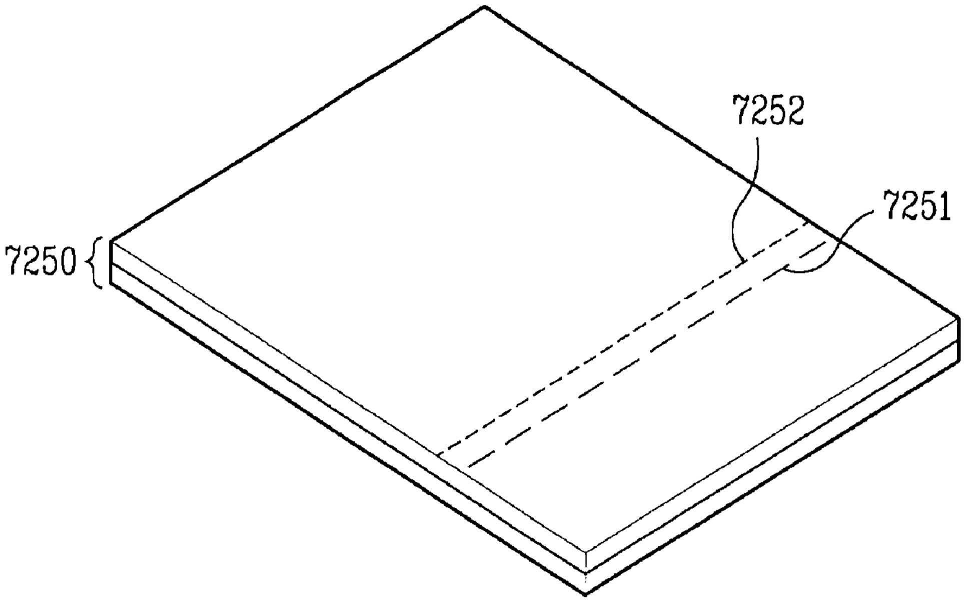


FIG. 199

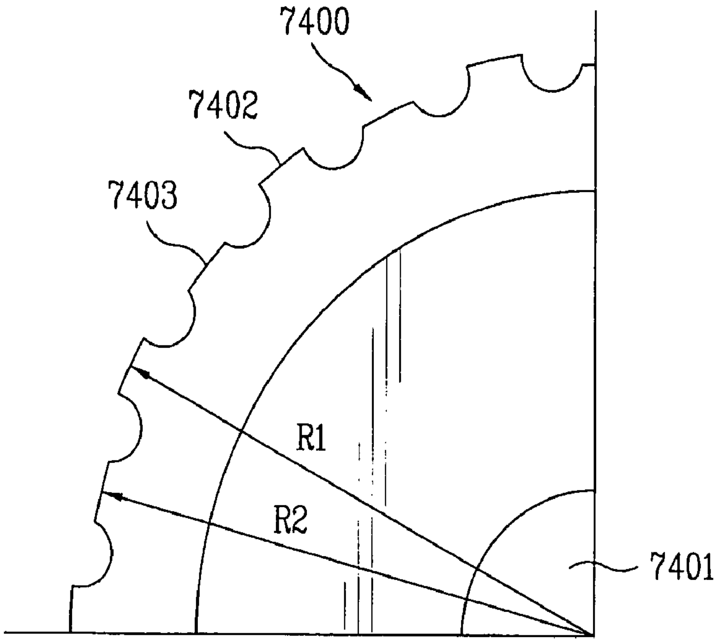


FIG. 200

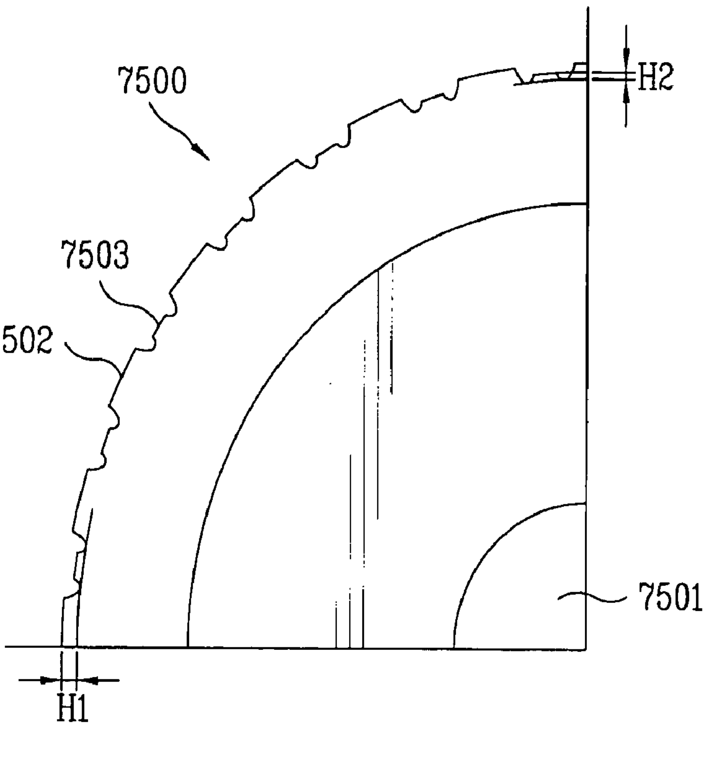


FIG. 201

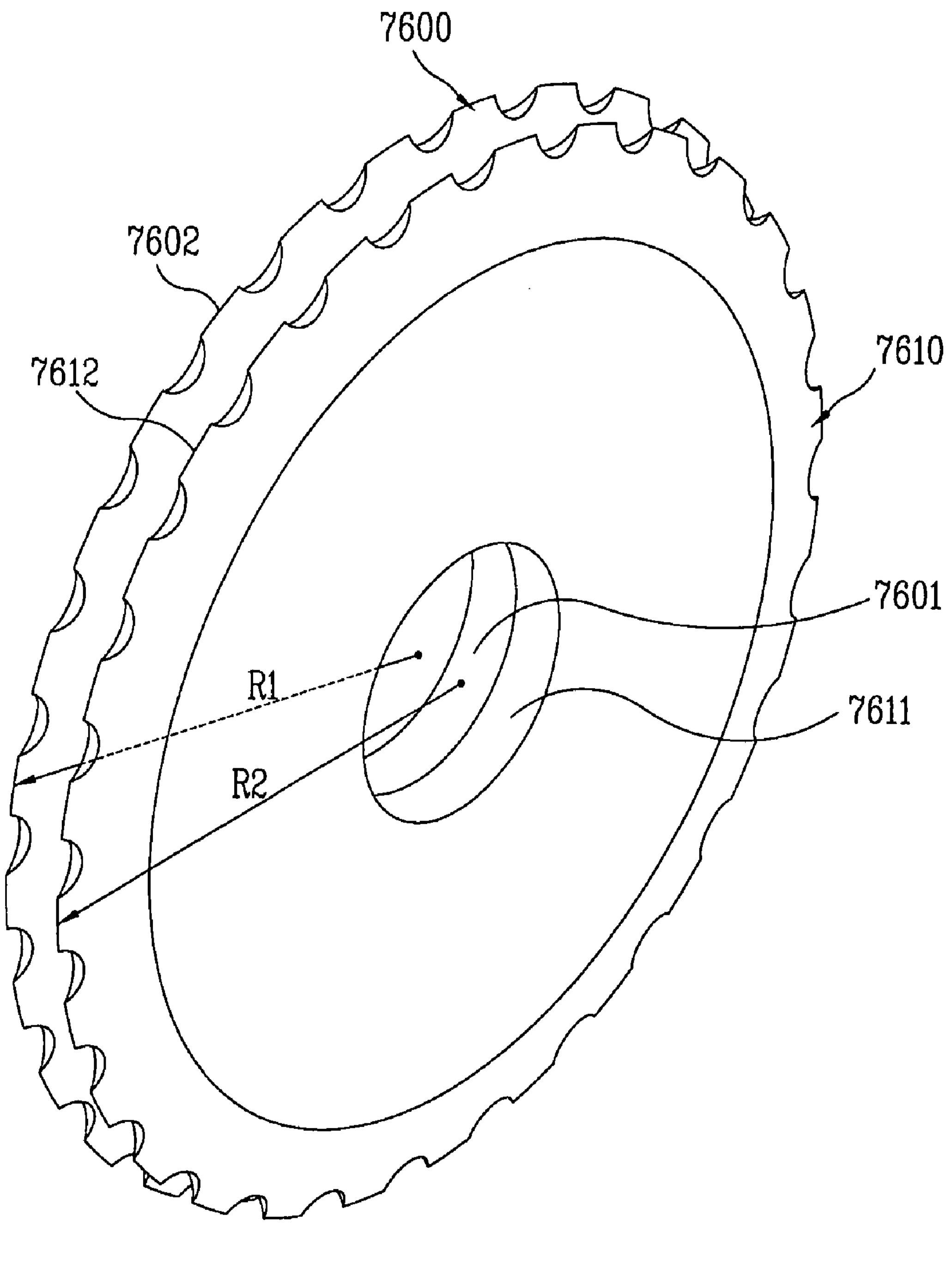
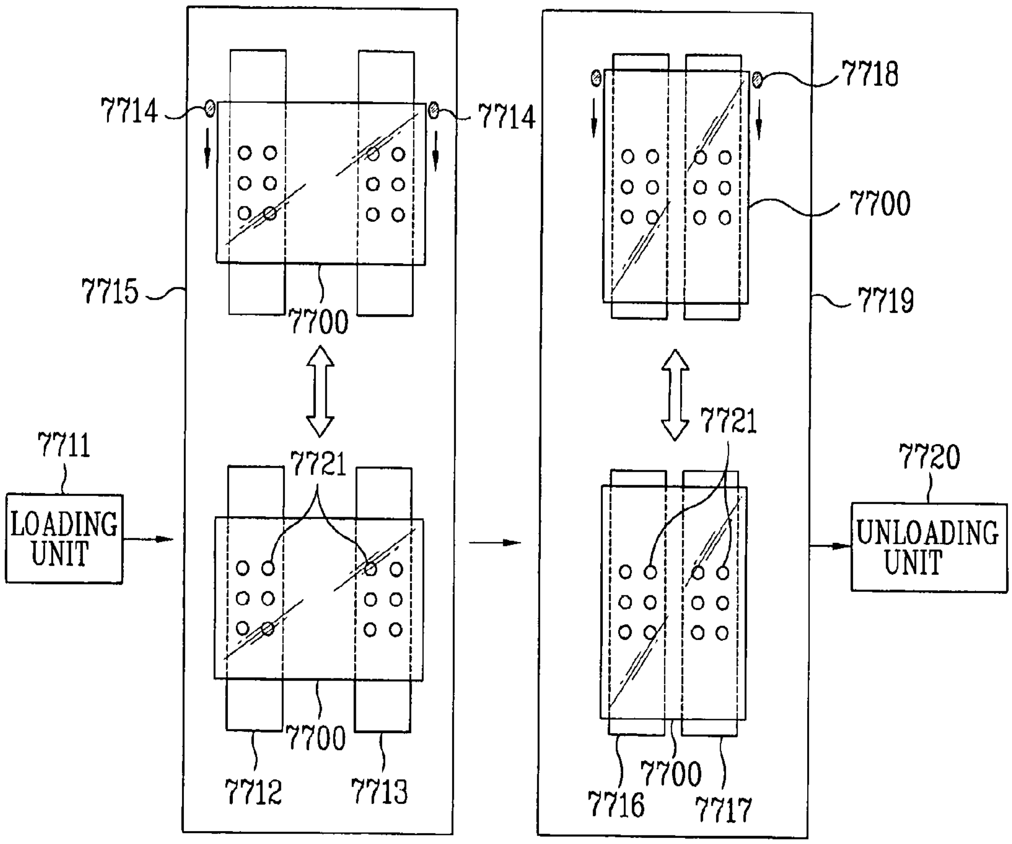


FIG. 202


7714
7714
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7711
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7718
7700
7719
7721
7720
UNLOADING UNIT
7700
7716
7717

FIG. 203A

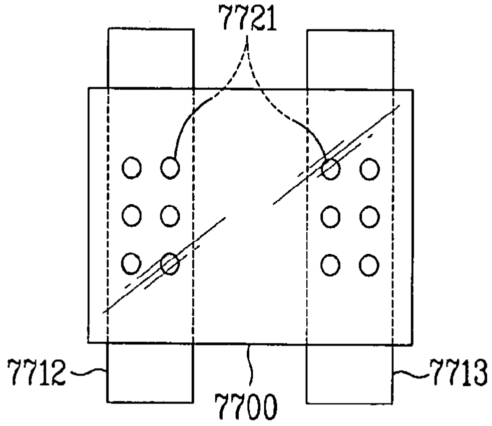


FIG. 203B

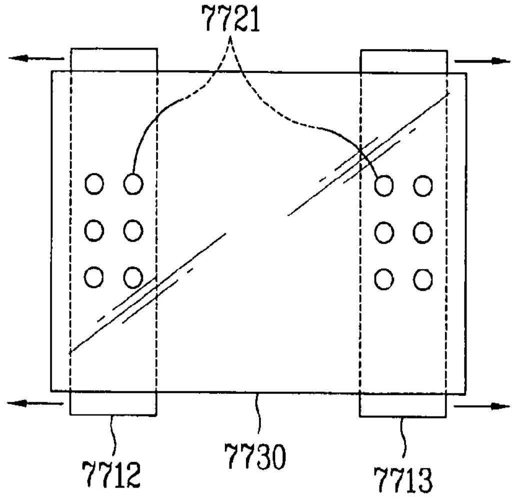


FIG. 203C

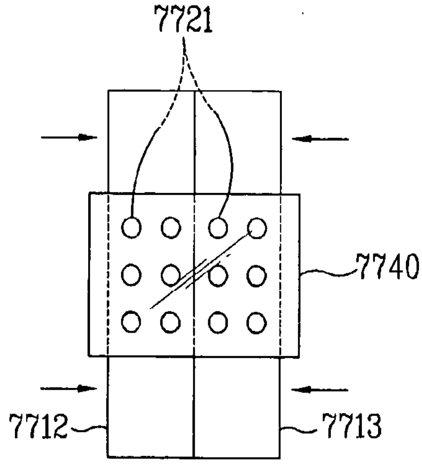
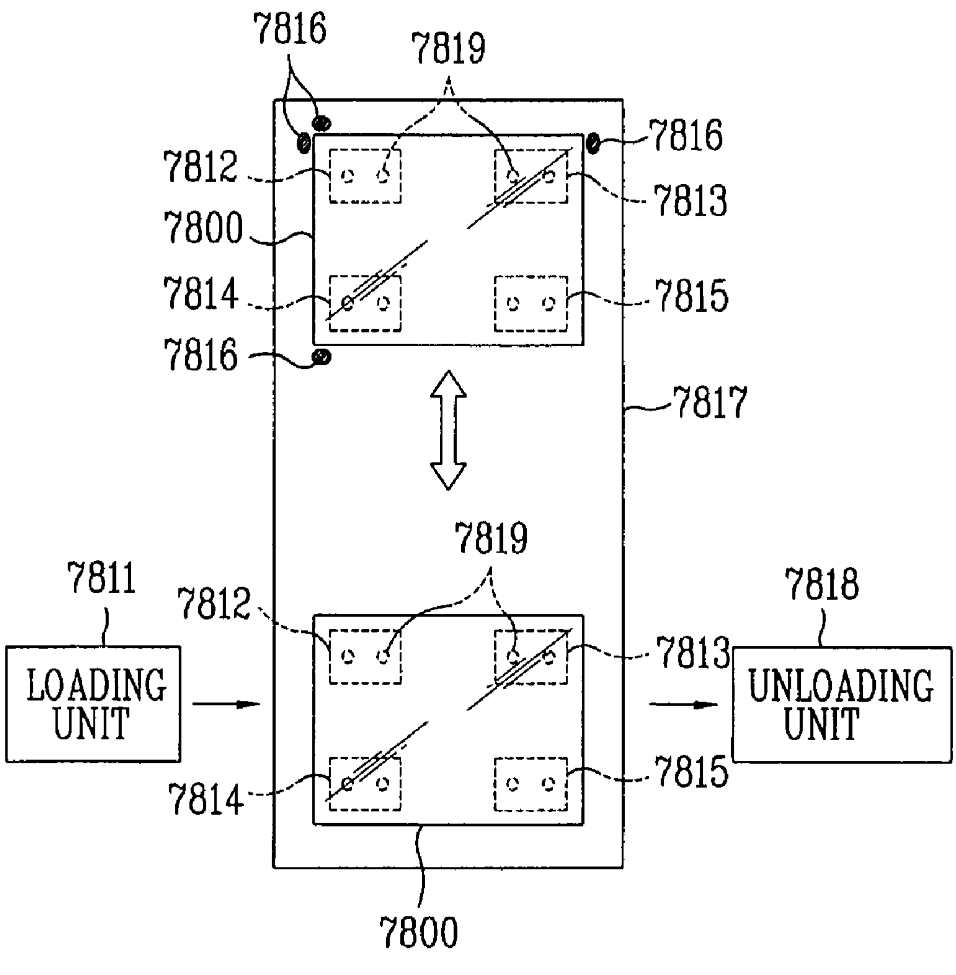


FIG. 204


7816
7819
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7814
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7811
7812
7818
LOADING UNIT
7813
UNLOADING UNIT
7814
7815
7800

FIG. 205A

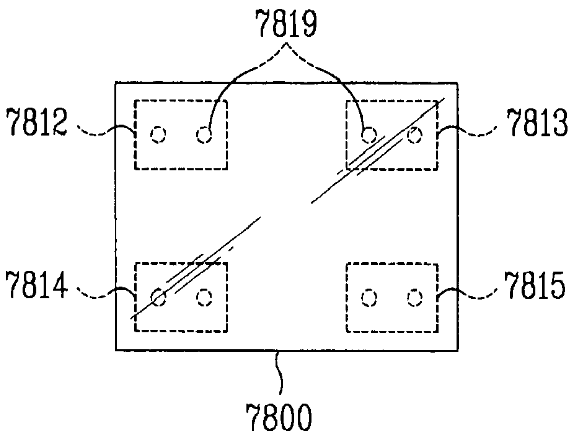


FIG. 205B

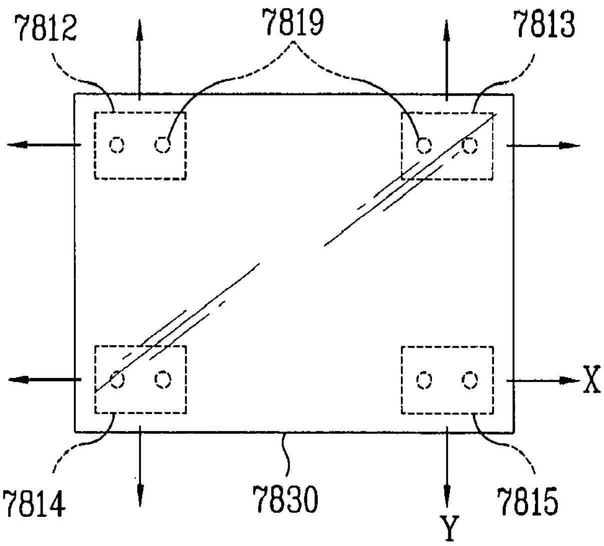


FIG. 205C

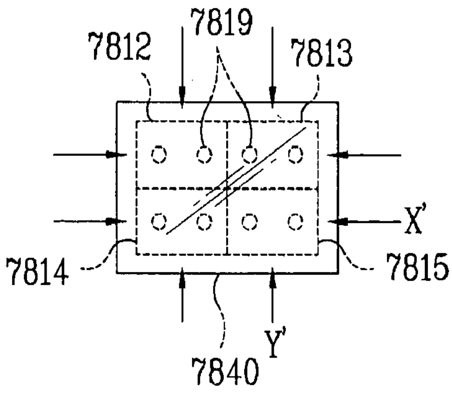


FIG. 206A

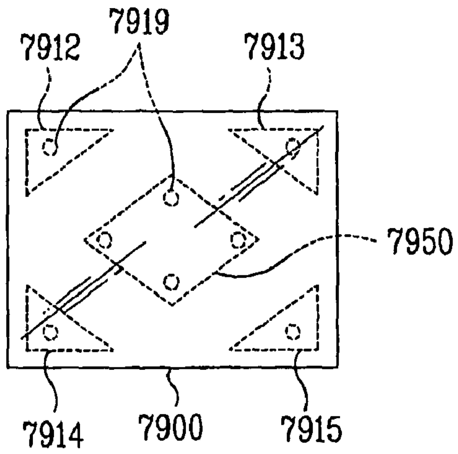


FIG. 206B

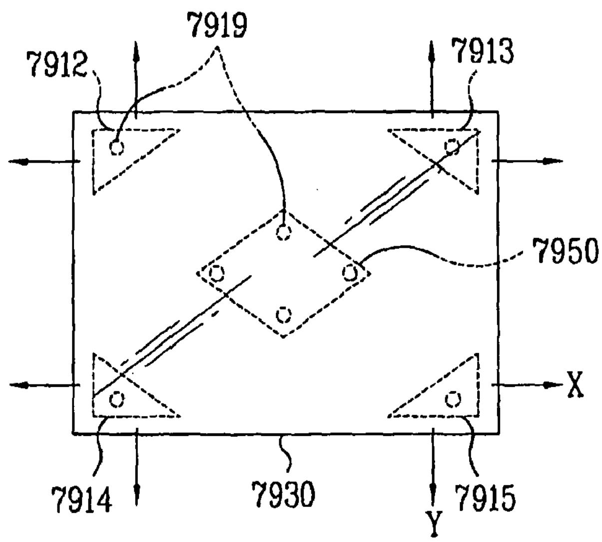


FIG. 206C

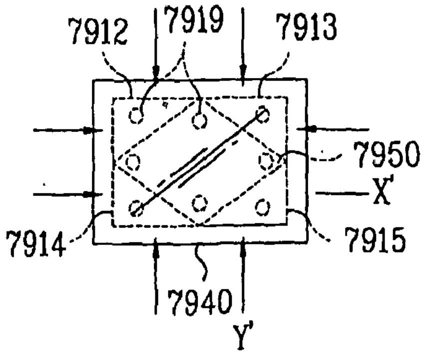


FIG. 207

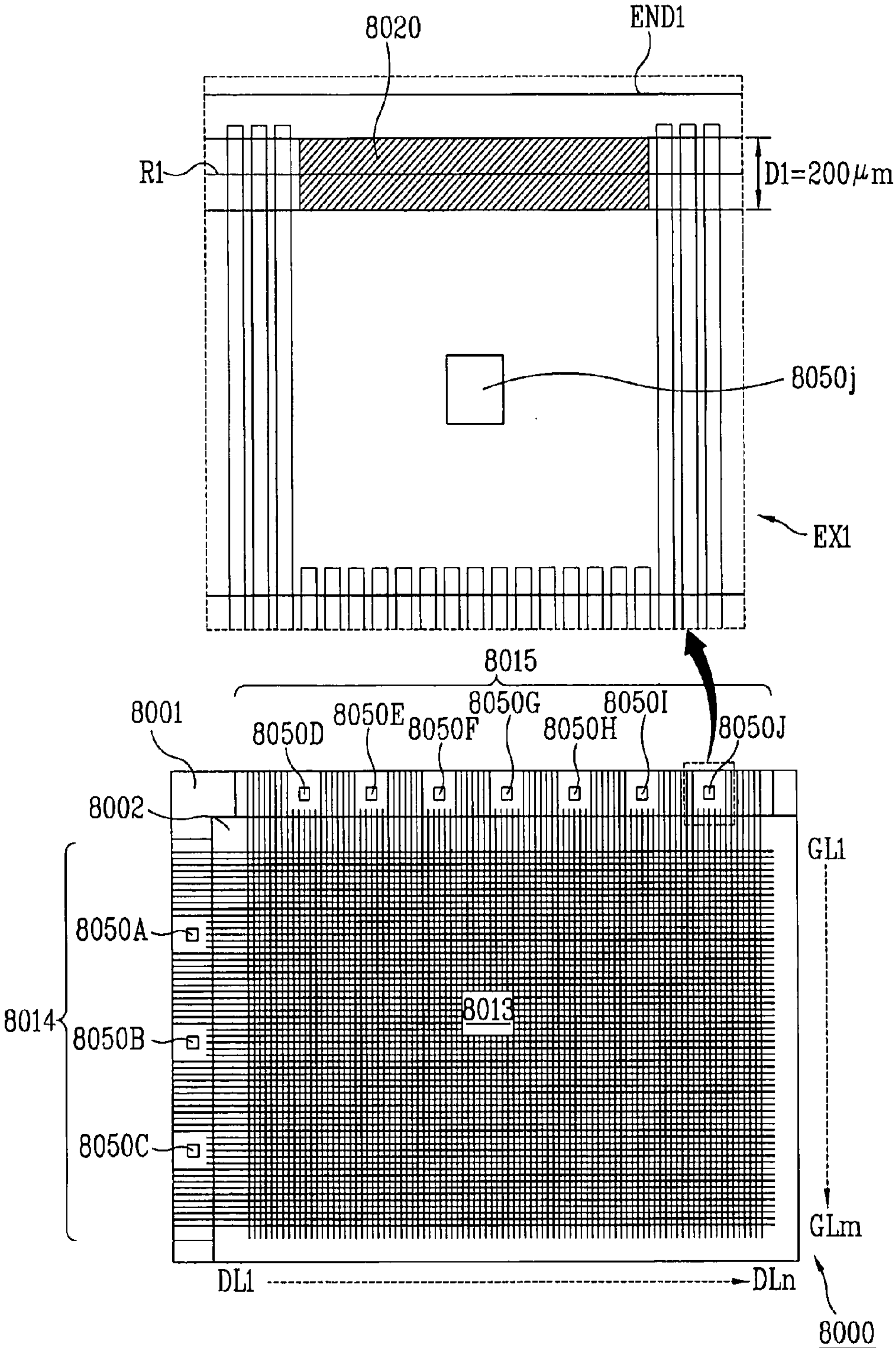
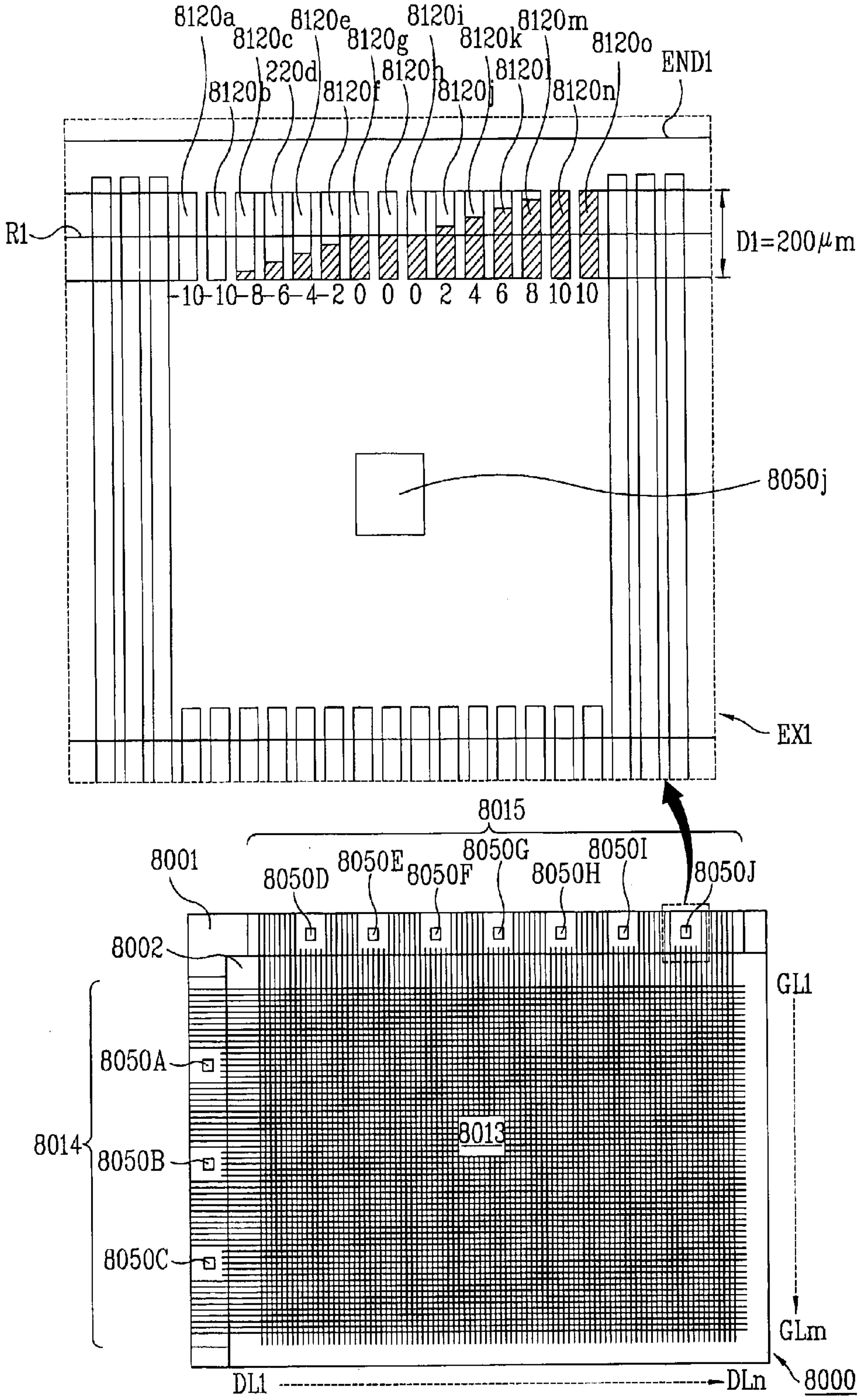

8020
END1
R1
D1=200μm
8050j
EX1
8015
8001
8050D
8050E
8050F
8050G
8050H
8050I
8050J
8002
GL1
8050A
8014
8050B
8013
8050C
GLm
DL1
DLn
8000

FIG. 208



8120a
8120c
8120e
8120g
8120i
8120k
8120m
8120o
END1
8120b
220d
8120f
8120h
8120j
8120l
8120n
R1
D1=200μm
-10 -10 -8 -6 -4 -2 0 0 0 2 4 6 8 10 10
8050j
EX1
8015
8001
8050D
8050E
8050F
8050G
8050H
8050I
8050J
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GL1
8050A
8014
8050B
8013
8050C
GLm
DL1
DLn
8000

FIG. 209

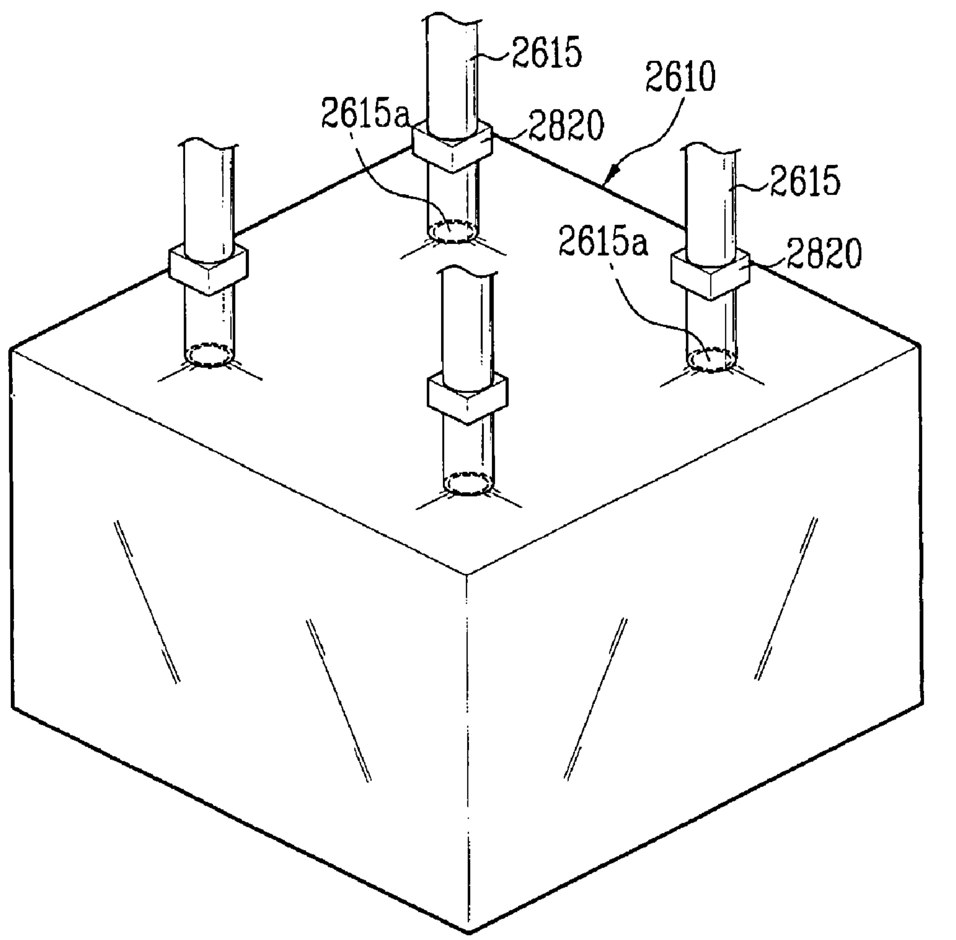


FIG. 210

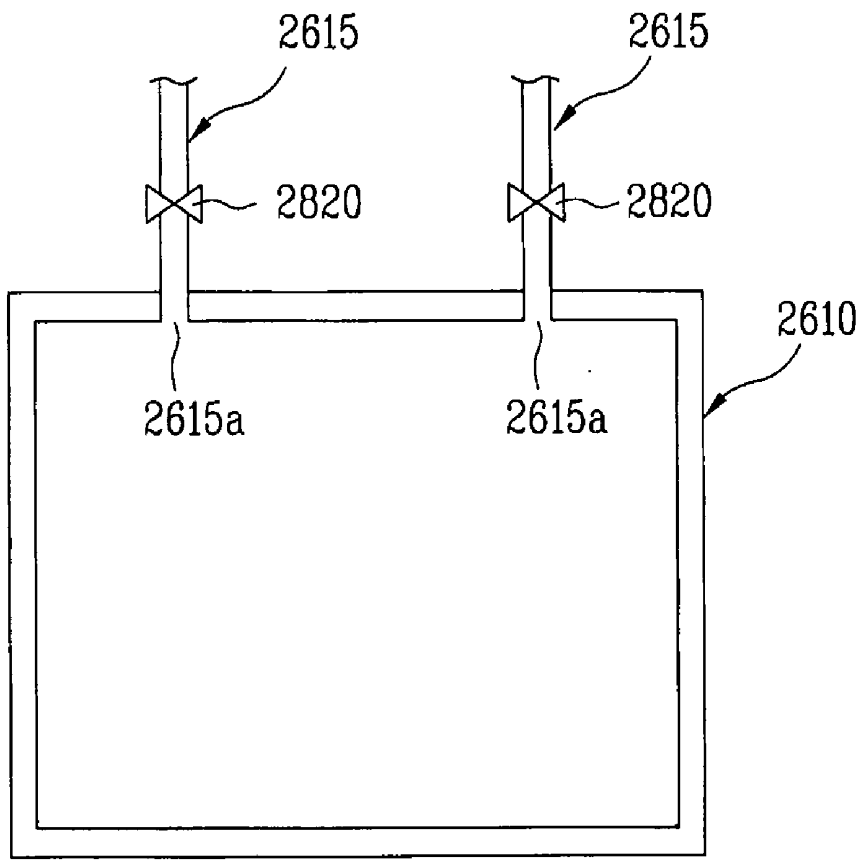


FIG. 211

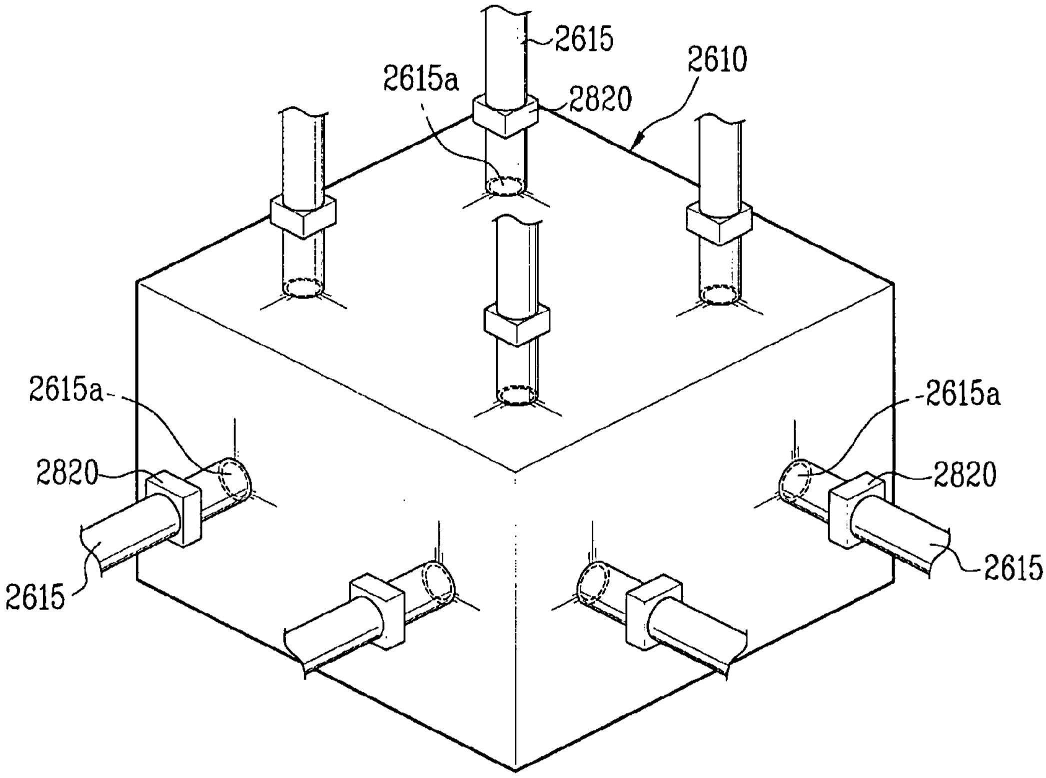
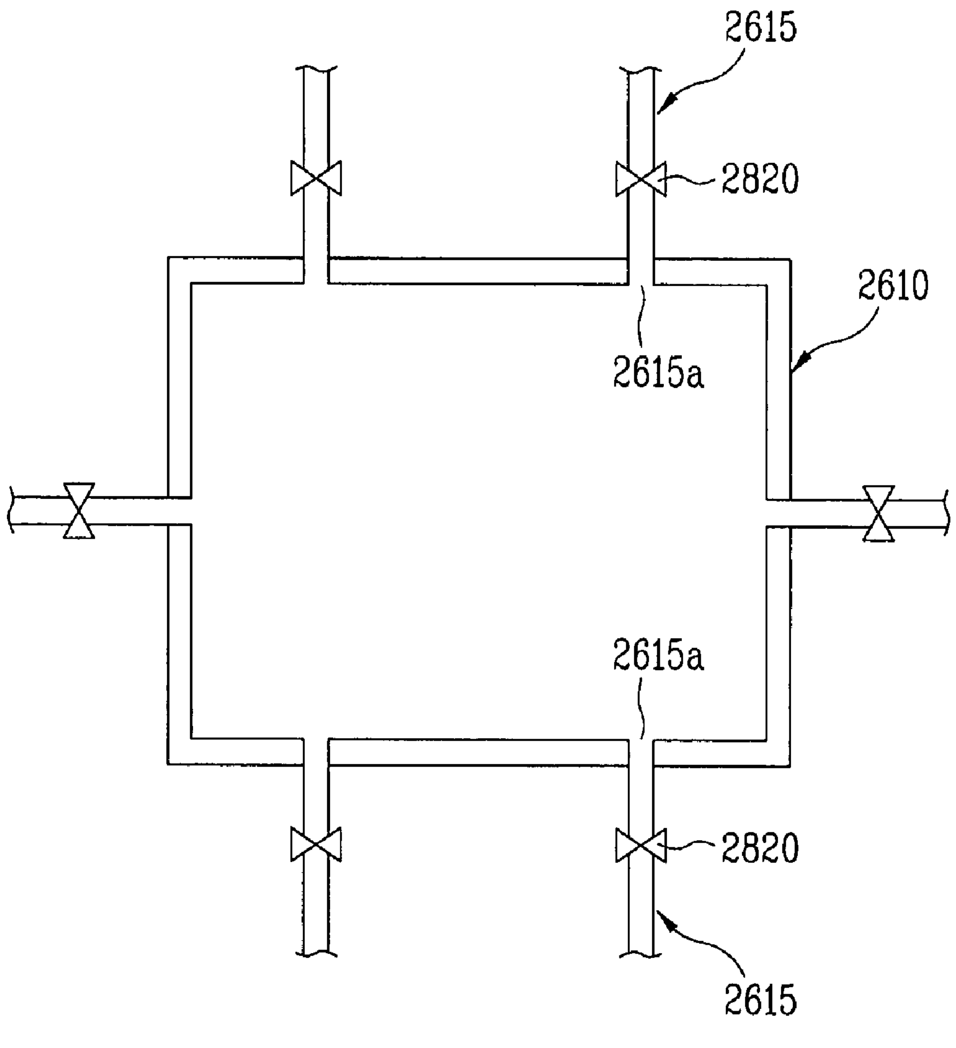


FIG. 212



SYSTEM AND METHOD FOR MANUFACTURING LIQUID CRYSTAL DISPLAY DEVICES

This application is a continuation of U.S. patent application Ser. No. 10/184,096 filed Jun. 28, 2002, now U.S. Pat. No. 7,295,279 all of which is hereby incorporated by reference for all purposes as fully set forth herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to disposing liquid crystal within a liquid crystal display panel.

2. Description of the Related Art

Portable electronic devices such as mobile phones, personal digital assistants (PDA), and notebook computers often require thin, lightweight, and efficient flat panel displays. There are various types of flat panel displays, including liquid crystal displays (LCD), plasma display panels (PDP), field emission displays (FED), and vacuum fluorescent displays (VFD). Of these, LCDs have the advantages of being widely available, easy to use, and possessing superior image quality.

With characteristic advantages of excellent image quality, lightness, slim size, and low power consumption, LCD, one of the panel devices, has been widely used so as to replace CRT (cathode ray tube) as a mobile image display. Besides the mobile usage for a monitor of a notebook computer, LCD is also developed as a monitor for computer, television, or the like so as to receive and display broadcasting signals.

In spite of various technical developments to perform a role as an image display in various fields, an effort to improve image quality of LCD inevitably becomes contrary to the above characteristics and advantages in some aspects. In order to use LCD for various fields as a general image display, the development of LCD depends on the facts that the characteristics of lightness, slim size, and low power consumption are maintained and that image of high quality including definition, brightness, large-scaled area, and the like is realized properly.

Such an LCD is mainly divided into a liquid crystal display panel displaying an image thereon and a driving unit applying a drive signal to the liquid crystal display panel, in which the liquid crystal display panel includes first and second glass substrates bonded to each other so as to have a predetermined space therebetween and a liquid crystal layer injected between the first and second glass substrates.

The LCD device displays information based on the refractive anisotropy of liquid crystal. As shown in FIG. **1**, an LCD **10000** includes a lower substrate **10005**, an upper substrate **10003**, and a liquid crystal layer **10007** that is disposed between the lower substrate **10005** and the upper substrate **10003**. The lower substrate **10005** includes an array of driving devices and a plurality of pixels (not shown). The individual driving devices are usually thin film transistors (TFT) located at each pixel. The upper substrate **10003** includes color filters for producing color. Furthermore, a pixel electrode and a common electrode are respectively formed on the lower substrate **10005** and on the upper substrate **10003**. Alignment layers are formed on the lower substrate **10005** and on the upper substrate **10003**. The alignment layers are used to uniformly align the liquid crystal layer **10007**.

The lower substrate **10005** and the upper substrate **10003** are attached using a sealing material **10009**. In operation, the liquid crystal molecules are initially oriented by the alignment layers, and then reoriented by the driving device according to video information so as to control the light transmitted through the liquid crystal layer to produce an image.

The fabrication of an LCD device requires the forming of driving devices on the lower substrate **10005**, the forming of color filters on the upper substrate **10003**, and disposing liquid crystal in a cell process (described subsequently) between the lower substrate **10005** and the upper substrate **10003**. Those processes as typically performed in the prior art will be described with reference to FIG. **2**.

Initially, in step **S11101**, a plurality of perpendicularly crossing gate lines and data lines are formed on the lower substrate **10005**, thereby defining pixel areas between the gate and data lines. A thin film transistor that is connected to a gate line and to a data line is formed in each pixel area. Also, a pixel electrode that is connected to the thin film transistor is formed in each pixel area. This enables driving of the liquid crystal layer according to signals applied through the thin film transistor.

In step **S11104**, R (Red), G (Green), and B (Blue) color filter layers (for reproducing color) and a common electrode are formed on the upper substrate **10003**. Then, in steps **S11102** and **S11105**, alignment layers are formed on the lower substrate **10005** and on the upper substrate **10003**. The alignment layers are rubbed to induce surface anchoring (thereby establishing a pretilt angle and an alignment direction) for the liquid crystal molecules. Thereafter, in step **S11103**, spacers for maintaining a constant, uniform cell gap is dispersed onto the lower substrate **10005**.

Then, in steps **S11106** and **S11107**, a sealing material is applied to outer portions such that the resulting seal has a liquid crystal injection opening. The opening is used to inject liquid crystal. The upper substrate **10003** and the lower substrate **10005** are then attached together by compressing the sealing material.

While the foregoing has described forming a single panel area, in practice it is economically beneficial to form a plurality of unit panel areas. To this end, the lower substrate **10005** and the upper substrate **10003** are large glass substrates that contain a plurality of unit panel areas, each having a driving device array or a color filter array that is surrounded by sealant having a liquid crystal injection opening. To isolate the individual unit panels, in step **S11108** the assembled glass substrates are cut into individual unit panels. Thereafter, in step **S11109** liquid crystal is injected into the individual unit panels by way of the liquid crystal injection openings, which are then sealed. Finally, in step **S11110** the individual unit panels are tested.

As described above, in the prior art liquid crystal is injected through a liquid crystal injection opening. Injection of the liquid crystal was usually pressure induced. FIG. **3** shows a prior art device for injecting liquid crystal. As shown, a container **10012** that contains liquid crystal, and a plurality of individual unit panels **10001** are placed in a vacuum chamber **10010** such that the individual unit panels **10001** are located above the container **10012**. The vacuum chamber **10010** is connected to a vacuum pump that generates a predetermined vacuum. A liquid crystal display panel moving device (not shown) moves the individual unit panels **10001** into contact with the liquid crystal **10014** such that each injection opening **10016** is in the liquid crystal **10014**.

When the pressure within the chamber **10010** is increased by inflowing nitrogen gas (N_2), the liquid crystal **10014** is injected into the individual unit panels **10001** through the liquid crystal injection openings **10016**. After the liquid crystal **10014** entirely fills the individual unit panels **10001**, the liquid crystal injection opening **10016** of each individual unit panel **10001** is then sealed by a sealing material.

While the prior art technique described above is generally successful, there are problems with pressure injecting liquid crystal **10014**. First, the time required for the liquid crystal **10014** to inject into the individual unit panels **10001** is rather long. Generally, the gap between the driving device array substrate and the color filter substrate is very narrow, on the order of micrometers. Thus, only a very small amount of liquid crystal **10014** is injected per unit time. For example, it takes about 8 hours to inject liquid crystal **10014** into an individual 15-inch unit panel **10001**. Increasing the size of the individual unit panel **10001**, say to a 24-inch unit panel, dramatically increases the already excessive time (to more than twenty hours) that is required to inject the liquid crystal.

Second, the prior art technique requires an excessive amount of liquid crystal **10014**. For example, consider that only a small amount of liquid crystal **10014** in the container **10012** is actually injected into the individual unit panels **10001**. However, since liquid crystal **10014** exposed to air or to certain other gases can be contaminated by chemical reaction, the remaining liquid crystal **10014** in the container **10012** should be discarded. This increases liquid crystal fabrication costs.

Therefore, an improved method and apparatus for applying a liquid crystal between substrates would be beneficial.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a system and method for manufacturing liquid crystal display devices from large mother substrate panels that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An advantage of the present invention is to provide a system for fabricating a liquid crystal display panel using liquid crystal dropping and a method of fabricating a liquid crystal display panel using the same enabling a reduced processing time and improved productivity.

An advantage of the present invention is to provide a method of dispensing liquid crystal onto a liquid crystal panel mother substrate before bonding of a second mother substrate panel thereto.

Another advantage of the present invention is to provide improved dispensing devices for dispensing a precise amount of liquid crystal onto a substrate.

Another advantage of the present invention is to provide a pattern of dispensing or dropping liquid crystal drops onto a substrate.

Another advantage of the present invention is to provide a pattern of applying sealant to a substrate to facilitate filling a cell gap between first and second substrates of a unit LCD panel with liquid crystal without contaminating the liquid crystal with sealant.

Another advantage of the present invention is to provide a spacer between substrates of a large unit panel liquid crystal display device.

Another advantage of the present invention is to provide a method of bonding first and second mother substrates to form a plurality of unit liquid crystal display panels therefrom.

Another advantage of the present invention is to provide a device for bonding first and second mother substrates to form a plurality of unit liquid crystal display panels therefrom.

Another advantage of the present invention is to provide a method of curing sealant for bonding a first mother substrate panel and a second mother substrate panel.

Another advantage of the present invention is to provide a method of inspecting liquid crystal display panels.

Another advantage of the present invention is to provide an apparatus for inspecting liquid crystal display panels.

Another advantage of the present invention is to provide a method for cutting unit liquid crystal display panels from a mother substrate assembly.

Another advantage of the present invention is to provide an apparatus for cutting unit liquid crystal display panels from a mother substrate assembly.

Another advantage of the present invention is to provide a method for grinding edges of unit liquid crystal display panels.

Another advantage of the present invention is to provide an apparatus for grinding edges of unit liquid crystal display panels.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention. These and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, a device for fabricating a liquid crystal display device includes a liquid crystal dispensing device for dispensing liquid crystal onto one of a first and second substrates; a sealant applicator for applying sealant onto one of the first and second substrates; a bonding unit for bonding the first and second substrates to each other with the liquid crystal therebetween; a sealant curing device for curing the sealant after the first and second substrates have been bonded; a cutting device for cutting the bonded first and second substrates into unit liquid crystal panels; and a grinder for grinding edges of the unit liquid crystal panels.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention.

In the drawings:

FIGS. **1-3** a related art liquid crystal display device and a method of manufacturing the same.

FIGS. **4-6** illustrate are flow charts each illustrating the steps of a method for manufacturing a liquid crystal display device in accordance with exemplary embodiments of the present invention;

FIGS. **7**A and **7**B show an exemplary apparatus for manufacturing an LCD device according to the present invention;

FIG. **8** shows another exemplary apparatus for manufacturing an LCD device according to the present invention;

FIG. **9** shows another exemplary apparatus for manufacturing an LCD device according to the present invention;

FIGS. **10**A and **10**B show cross sectional views of main portions an exemplary LCD device illustrating photo-hardening degree states of the sealant according to relative positions of the bonded substrates during a photo-curing process according to the present invention;

FIG. **11** shows another exemplary apparatus for manufacturing an LCD device according to the present invention;

FIG. **12** is a perspective view illustrating an exemplary apparatus and method for deaerating a liquid crystal in accordance with an embodiment of the present invention;

FIG. **13** is a flow chart showing the process steps of a method for manufacturing a liquid crystal display device in accordance with an embodiment of the present invention;

FIG. **14** is a perspective view showing an apparatus for measuring a dispensing amount of liquid crystal drops in FIG. **10**;

FIG. **15** is a view showing an exemplary LCD fabricated using a method for dropping liquid crystal according to the present invention;

FIG. **16** is a flow chart showing an exemplary method for fabricating the LCD according to the liquid crystal dropping method;

FIG. **17** is a view showing the basic concept of the liquid crystal dropping method;

FIG. **18**A illustrates a state in which liquid crystal is not dropped from a liquid crystal dropping apparatus;

FIG. **18**B illustrates a state in which liquid crystal is being dropped from a liquid crystal dropping apparatus;

FIG. **19** illustrates dropping liquid crystal onto a substrate having 4 columns of liquid crystal panel areas using four liquid crystal dispensing devices;

FIG. **20** illustrates dropping liquid crystal onto a substrate having 5 columns of liquid crystal panel areas using four liquid crystal dispensing devices;

FIGS. **21**A and **21**B illustrate dropping liquid crystal onto the liquid crystal panel area disposed on a first substrate according to the principles of the present invention;

FIGS. **22**A and **22**B illustrate dropping liquid crystal onto the liquid crystal panel area disposed on a second substrate according to the principles of the present invention;

FIGS. **23**A and **23**B illustrate dropping liquid crystal onto the liquid crystal panel areas disposed on a third and a fourth substrate according to the principles of the present invention;

FIGS. **24**A and **24**B are views showing a structure of an exemplary liquid crystal dispensing apparatus according to the present invention;

FIG. **25** is an exploded perspective view showing the liquid crystal dispensing apparatus shown of FIGS. **24**A and **24**B;

FIG. **26** is a view showing the liquid crystal dispensing apparatus in which a fluorine resin film is formed on inner side of the liquid crystal container and on the needle according to the present invention;

FIGS. **27**A and **27**B are cross-sectional views respectively showing an exemplary apparatus for dropping liquid crystal according to the present invention in a state in which the liquid crystal is not dispensed and a state in which the liquid crystal is dispensed;

FIG. **27**C is an exploded perspective view showing the apparatus of FIGS. 7A and 7B;

FIG. **28** is a block diagram showing an exemplary structure of a main control unit in the apparatus for dropping the liquid crystal according to the present invention;

FIG. **29** is a block diagram showing an exemplary structure of a dropping amount calculation unit shown in FIG. **28**;

FIG. **30** is a block diagram showing an exemplary method for dropping the liquid crystal according to the present invention;

FIG. **31** is a block diagram showing an exemplary structure of the main control unit performing the compensation of single liquid crystal dropping amount;

FIG. **32** is a block diagram showing an exemplary structure of a compensating amount control unit shown in FIG. **31**;

FIG. **33** is a flow chart showing an exemplary method for compensating the dropping amount of the liquid crystal according to the present invention;

FIG. **34** is illustrates a conventional pneumatic liquid crystal dispensing apparatus;

FIG. **35**A illustrates a first view of a liquid crystal dispensing apparatus according to the present invention;

FIG. **35**B illustrates a second view of a liquid crystal dispensing apparatus according to the present invention;

FIG. **36** is an exploded perspective view of a liquid crystal dispensing apparatus according to the present invention;

FIG. **37** illustrates the liquid crystal apparatus of FIG. **36** dispensing liquid crystal;

FIG. **38**A illustrates a state in which liquid crystal is not dropped from a liquid crystal dropping apparatus;

FIG. **38**B illustrates a state in which liquid crystal is being dropped from a liquid crystal dropping apparatus;

FIG. **39** is an exploded perspective view of FIGS. **38**A and **38**B;

FIG. **40** is an exploded and enlarged view showing a needle;

FIGS. **41**A and **41**B are views showing a structure of an exemplary liquid crystal dispensing apparatus according to the present invention;

FIG. **42** is a view showing a structure of the liquid crystal dispensing apparatus of FIGS. **41**A and **41**B when the liquid crystal is dropping according to the present invention;

FIGS. **43**A and **43**B are views showing a nozzle structure for the exemplary liquid crystal dispensing apparatus of FIGS. **41**A and **41**B according to the present invention;

FIG. **44** is a view showing another exemplary nozzle structure for a liquid crystal dispensing apparatus according to the present invention;

FIG. **45** illustrates an apparatus for dispensing liquid crystal onto a substrate according to the present invention;

FIG. **46** illustrates functional components of an input unit illustrated in the apparatus of FIG. **45**;

FIG. **47** illustrates functional components of a dispensing pattern calculation unit illustrated in the apparatus of FIG. **45**;

FIG. **48** illustrates a flowchart of an exemplary liquid crystal dropping method according to the present invention;

FIG. **49** illustrates a functional components of an apparatus for calculating a compensation amount in dispensing liquid crystal onto a substrate;

FIG. **50** illustrates a compensation amount calculation unit according to the present invention;

FIG. **51** illustrates a dispensing pattern compensation unit according to the present invention;

FIG. **52** illustrates a flowchart of a method of compensating the liquid crystal dropping amount according to the present invention;

FIGS. **53**A to **53**F illustrate exemplary patterns for dropping liquid crystal on a substrate according to the present invention;

FIGS. **53**G-**53**I illustrate exemplary diagrams for explaining a shape of a liquid crystal panel;

FIGS. **53**J-**53**M illustrate exemplary dispensing patterns;

FIGS. **53**N-O illustrate substrates;

FIG. **53**P illustrates a cross-sectional view along a line A-A' of FIG. **53**O;

FIGS. **53**Q-**53**R illustrates a liquid crystal drop;

FIGS. **53**S-**53**V illustrates exemplary dispensing patterns;

FIGS. **54**A to **54**D are perspective views illustrating a method of manufacturing an LCD device according to an embodiment of the present invention;

FIGS. **55**A to **55**D are perspective views illustrating a process of forming a UV sealant in manufacturing an LCD device according to another embodiment of the present invention of the present invention;

FIGS. **56**A and **56**B are perspective views illustrating a process of forming a UV sealant in a method of manufacturing an LCD device according to another embodiment of the present invention of the present invention;

FIG. **57** is a perspective view illustrating an LCD device according to another embodiment of the present invention;

FIGS. **58**A and **58**B are sectional views taken along lines I-I and II-II of FIG. **57**;

FIGS. **59**A to **59**C illustrate perspective views showing a bonding method in accordance with another embodiment of the present invention;

FIG. **60**A illustrates a perspective view of a lower bonding stage in accordance with the same embodiment of the present invention;

FIG. **60**B illustrates an upper substrate placed on the lower bonding stage in FIG. **60**A;

FIGS. **61**A to **61**C illustrate perspective views of a substrate for a liquid crystal display panel in accordance with the same embodiment of the present invention;

FIGS. **62**A to **62**E illustrate perspective views of a method for fabricating a liquid crystal display panel in accordance with the same embodiment of the present invention;

FIG. **63** is a perspective view to illustrate a UV irradiation process in a method for fabricating a liquid crystal display panel in accordance with a different embodiment of the present invention;

FIG. **64** illustrates a partial cross-sectional view of a liquid crystal display panel in accordance with the previous embodiment of the present invention;

FIG. **65**A is a plan view of an LCD device according to the previous embodiment of the present invention;

FIG. **65**B is a sectional view taken along line I-I of FIG. **54**A;

FIGS. **66**A to **66**D are perspective views illustrating a method of manufacturing an LCD device according to one of the embodiments of the present invention;

FIG. **67** is a perspective view illustrating a process of irradiating UV in the method of manufacturing an LCD device according to the present invention;

FIG. **68** illustrates a plane view of an LCD panel in accordance with another embodiment of the present invention;

FIGS. **69**A to **69**C are cross-sectional views taken along line IV-IV of FIG. **68**;

FIG. **70** illustrates a plane view of an LCD panel in accordance with another embodiment of the present invention;

FIG. **71** illustrates a plane view of an LCD panel in accordance with another embodiment of the present invention;

FIGS. **72**A to **72**C are cross-sectional views taken along line VII-VII of FIG. **71**;

FIG. **73** illustrates a plane view of an LCD panel in accordance with another embodiment of the present invention;

FIG. **74** illustrates a plane view of an LCD panel in accordance with another embodiment of the present invention;

FIGS. **75**A to **75**C are cross-sectional views taken along line X-X of FIG. **74**;

FIG. **76** illustrates a plane view of an LCD panel in accordance with another embodiment of the present invention;

FIGS. **77**A and **77**B are plane views of an LCD panel in accordance with another embodiment of the present invention;

FIGS. **78**A to **78**D are perspective views illustrating a method for fabricating an LCD panel in accordance with another embodiment of the present invention;

FIG. **79** is a perspective view illustrating irradiating a UV ray in a method for fabricating an LCD panel in accordance with the present invention;

FIG. **80** illustrates a plane view of an LCD panel in accordance with an embodiment of the present invention;

FIGS. **81**A to **81**D are cross-sectional views taken along line IV-IV of FIG. **80**;

FIGS. **82**A and **82**B illustrate plane views of an LCD panel in accordance with another embodiment of the present invention;

FIG. **83** illustrates a plane view of an LCD panel in accordance with another embodiment of the present invention;

FIGS. **84**A to **84**H are cross-sectional views taken along line VII-VII of FIG. **83**;

FIGS. **85**A and **85**B illustrate plane views of an LCD panel in accordance with another embodiment of the present invention;

FIG. **86** illustrates a plane view of an LCD panel in accordance with another embodiment of the present invention;

FIGS. **87**A to **87**D are cross-sectional views taken along line X-X of FIG. **86**;

FIGS. **88**A and **88**B illustrate plane views of an LCD panel in accordance with another embodiment of the present invention;

FIGS. **89**A to **89**D are plane views of an LCD panel in accordance with another embodiment of the present invention;

FIGS. **90**A to **90**D are perspective views illustrating a method for fabricating an LCD panel in accordance with another embodiment of the present invention;

FIG. **91** is a perspective view illustrating irradiating a UV ray in a method for fabricating an LCD panel in accordance with the present invention;

FIG. **92** shows an exemplary apparatus for manufacturing a liquid crystal display device during a loading process according to the present invention;

FIG. **93** shows the exemplary apparatus for manufacturing a liquid crystal display device during a vacuum process according to the present invention;

FIG. **94** shows the exemplary apparatus for manufacturing a liquid crystal display device during a location alignment process between substrates according to the present invention;

FIG. **95** shows the exemplary apparatus for manufacturing a liquid crystal display device during a bonding process of the substrates according to the present invention;

FIG. **96** shows the exemplary apparatus for manufacturing a liquid crystal display device during a further bonding process according to the present invention;

FIG. **97** shows the exemplary apparatus for manufacturing a liquid crystal display device during an unloading process according to the present invention.

FIGS. **98**A and **98**B illustrate states of operation of a bonding machine of the present invention, in which loading of substrates are finished;

FIGS. **99**A and **99**B illustrate states of operation of a bonding machine of the present invention, in which a low vacuum pump evacuates interior of a bonding chamber to turn the bonding chamber into a vacuum state;

FIGS. **100**A and **100**B illustrate states of operation of a bonding machine of the present invention, in which a high vacuum pump evacuates interior of a bonding chamber to turn the bonding chamber into a vacuum state;

FIGS. **101**A and **101**B illustrate states of operation of a bonding machine of the present invention, in which a pressure is applied to substrates to bond the substrates;

FIGS. **102**A and **102**B illustrate states of operation of a bonding machine of the present invention, in which an interior of a bonding chamber is slowly turned into an atmospheric pressure state;

FIGS. **103**A and **103**B illustrate states of operation of a bonding machine of the present invention, in which an interior of a bonding chamber is turned into an atmospheric pressure state, fully;

FIGS. **104**A-**104**E illustrate sections showing the steps of a method for fabricating an LCD having a liquid crystal dropping method applied thereto in accordance with an embodiment of the present invention, schematically;

FIG. **105** illustrates a flow chart showing the steps of a method for fabricating an LCD in accordance with an embodiment of the present invention.

FIG. **106** illustrates a flowchart showing the method steps for fabricating an LCD in accordance with an embodiment of the present invention;

FIGS. **107**A-**107**F illustrate steps of a method for fabricating an LCD in accordance with an embodiment of the present invention;

FIG. **108** illustrates a flowchart showing the bonding steps of the present invention.

FIG. **109** is a cross-sectional view of an exemplary apparatus to which an exemplary substrate receiving system is applied according to the present invention;

FIG. **110**A is a plane view of the exemplary substrate receiving system along I-I of FIG. **109** according to the present invention;

FIG. **110**B is a plane view of another exemplary substrate receiving system along line I-I of FIG. **109** according to the present invention;

FIG. **111**A is a cross sectional view of an exemplary operational state of a substrate receiving system according to the present invention;

FIG. **111**B is a cross sectional view of another exemplary operational state of the substrate receiving system receiving a substrate in FIG. **109** according to the present invention;

FIG. **112** is a plane view of an exemplary substrate receiving system according to the present invention;

FIG. **113** is a plane view of an apparatus having another exemplary substrate receiving system;

FIG. **114** is a plane view of an apparatus having another exemplary substrate receiving system;

FIG. **115** is a cross sectional view of an exemplary substrate receiving system according to the present invention;

FIG. **116** is a plane view of another exemplary substrate receiving system according to the present invention;

FIG. **117** is a cross sectional view of an exemplary apparatus according to the present invention;

FIG. **118** is a plane view along line I-I of FIG. **117** according to the present invention;

FIG. **119** is a perspective view of an operational state of the exemplary substrate receiving system according to the present invention;

FIGS. **120**A to **120**C are cross sectional views showing a contact state between a substrate and a lift-bar according to the present invention;

FIG. **121** is a plane view showing an internal structure of an exemplary apparatus having a substrate receiving system according to the present invention;

FIG. **122** is a plane view showing an internal structure of another exemplary apparatus according to the present invention;

FIG. **123** is a cross sectional view showing an internal structure of another exemplary apparatus according to the present invention;

FIG. **124** is a plane view along line II-II of FIG. **123**;

FIG. **125** is a cross sectional view showing another exemplary apparatus according to the present invention;

FIG. **126** is a plane view along line III-III of FIG. **125**;

FIGS. **127** to **130** are plane views showing other exemplary apparatus' according to the present invention;

FIG. **131** is a cross sectional view showing another exemplary apparatus according to the present invention;

FIG. **132** is a plane view along line IV-IV of FIG. **131**;

FIG. **133** is a cross sectional view showing another exemplary apparatus according to the present invention;

FIG. **134** is a plane view along line V-V of FIG. **133**;

FIG. **135** is a plane view showing another exemplary apparatus according to the present invention;

FIG. **136** is a cross sectional view showing another exemplary apparatus according to the present invention;

FIG. **137** is a cross sectional view of an exemplary apparatus including a substrate lifting system according to the present invention;

FIG. **138** shows a schematic layout of a lower stage of an exemplary substrate lifting system according to the present invention;

FIG. **139**A is an exploded view of a portion A in FIG. **137**;

FIG. **139**B shows an exemplary substrate lifting system according to the present invention;

FIG. **140** is a perspective view of an exemplary substrate lifting system according to the present invention;

FIG. **141**A shows a cross sectional view of an exemplary substrate lifting system according to the present invention;

FIG. **141**B shows a cross sectional view of the exemplary substrate lifting system according to the present invention where a substrate is loaded onto a lower stage;

FIG. **142** shows a perspective view of the exemplary substrate lifting system shown in FIG. **141** according to the present invention;

FIG. **143** shows a perspective view of an exemplary substrate lifting system according to the present invention;

FIG. **144** illustrates a flow chart showing the steps of a method for fabricating an LCD in accordance with an embodiment of the present invention, schematically;

FIGS. **145**A-**145**G illustrate sections showing the steps of a method for fabricating an LCD in accordance with an embodiment of the present invention, schematically;

FIG. **146** illustrates a flow chart showing the steps of bonding of the present invention;

FIGS. **147**A-**148**C illustrate rough and fine marks for explaining an alignment method in accordance with an embodiment of the present invention;

FIG. **149** illustrates a camera focusing position used in an alignment method in accordance with an embodiment of the present invention;

FIG. **150** illustrates an exemplary layout of rough and fine marks used in an alignment method in accordance with an embodiment of the present invention;

FIGS. **151**A-**151**F illustrate sections showing the steps of a method for fabricating an LCD having a liquid crystal dropping method applied thereto in accordance with an embodiment of the present invention, schematically;

FIG. **152** illustrates the steps of bonding in accordance with an embodiment of the present invention;

FIG. **153** illustrates a layout of seal for explaining fixing in accordance with an embodiment of the present invention;

FIG. **154** illustrates a layout of seals for explaining fixing in accordance with an embodiment of the present invention;

FIG. **155** illustrates a layout of seals for explaining fixing in accordance with an embodiment of the present invention;

FIG. **156** illustrates a layout of seals for explaining fixing in accordance with an embodiment of the present invention;

FIG. **157** illustrates a layout of seals for explaining fixing in accordance with an embodiment of the present invention;

FIG. **158** illustrates a layout of seals for explaining fixing in accordance with an embodiment of the present invention;

FIG. **159** illustrates a section across a line I-I' in FIG. **153** showing upper and lower stages and substrates;

FIGS. **160**A-**160**G illustrate sections showing the steps of a method for fabricating an LCD having a liquid crystal dropping method applied thereto in accordance with an embodiment of the present invention, schematically;

FIG. **161** illustrates the steps of bonding in accordance with an embodiment of the present invention;

FIGS. **162**A to **162**E are expanded perspective views illustrating a method for fabricating an LCD panel according to an embodiment of the present invention;

FIGS. **163**A to **163**C are perspective views to illustrate the process of UV irradiation in a method for fabricating an LCD according to an embodiment of the present invention;

FIG. **164** is a schematic view of a UV irradiating device according to an embodiment of the present invention;

FIGS. **165**A and **165**B are schematic views of another UV irradiating device according to an embodiment of the present invention;

FIG. **166** is a schematic view of a UV irradiating device according to an embodiment of the present invention;

FIG. **167** is a schematic view of a UV irradiating device according to an embodiment of the present invention;

FIGS. **168**A to **168**D are perspective views illustrating a method of manufacturing an LCD device in accordance with the principles of the present invention;

FIG. **169**A is a sectional view illustrating a process of irradiating UV light at a tilt angle of θ upon an attached substrate having a light-shielding layer overlapped on a sealant;

FIG. **169**B is a table illustrating a hardening rate of the sealant according to a change of a tilt angle of θ;

FIGS. **170**A to **170**D are perspective views illustrating a method of manufacturing an LCD device according to an embodiment of the present invention;

FIGS. **171**A to **171**D are perspective views illustrating a process of irradiating UV in the method of manufacturing an LCD device according to an embodiment of the present invention;

FIG. **172** is a layout illustrating a method of manufacturing an LCD according to the present invention;

FIG. **173** is a flow chart showing an alignment forming process according to the present invention;

FIG. **174** is a flow chart of a gap forming process according to the present invention;

FIG. **175** shows an exemplary diagram of substrates having good and NG substrate panel areas;

FIG. **176** shows the layout of a processing line according to the present invention;

FIG. **177** schematically illustrates a first substrate of an LC panel according to an embodiment of the present invention;

FIG. **178** schematically illustrates an LC panel according to an embodiment of the present invention;

FIG. **179** illustrates a magnified cross-sectional view of portion 'A' in FIG. **178**;

FIG. **180** illustrates a flowchart of an LCD fabrication method according to an embodiment of the present invention;

FIG. **181** illustrates an inspection apparatus according to an embodiment of the present invention;

FIG. **182** schematically illustrates a structural layout of an LC panel according to an embodiment of the present invention;

FIG. **183** is a schematic block diagram of a device for cutting a liquid crystal display panel in accordance with an embodiment of the present invention;

FIGS. **184**A to **184**G illustrate sequential processes in each block of FIG. **183**;

FIG. **185** is a schematic block diagram of a device for cutting a liquid crystal display panel in accordance with an embodiment of the present invention;

FIGS. **186**A to **186**F illustrate sequential processes for performing each block of FIG. **185**;

FIGS. **187**A to **187**C illustrate different alignments of an upper wheel and a lower wheel for simultaneously scribing the first and second mother substrates in accordance with the present invention;

FIG. **188** is a schematic block diagram of a device for cutting a liquid crystal display panel in accordance with an embodiment of the present invention;

FIGS. **189**A to **189**G illustrate sequential processes in each block of FIG. **188**;

FIG. **190** is a schematic block diagram of a device for cutting a liquid crystal display panel in accordance with an embodiment of the present invention;

FIGS. **191**A to **191**G illustrate sequential processes for performing each block of FIG. **190**;

FIG. **192** is a schematic view showing a plurality of vacuum suction holes formed at the first through the fourth tables of FIGS. **191**A to **191**G;

FIGS. **193**A and **193**B illustrate first and second scribing processes for cutting a liquid crystal display panel in the present invention;

FIGS. **194**A to **194**F illustrate sequential processes for cutting a liquid crystal display panel in accordance with an embodiment of the present invention;

FIG. **195** illustrates a perspective view of a cutting wheel for a liquid crystal display panel according to an embodiment of the present invention;

FIG. **196** illustrates an exemplary diagram of first and second grooves formed on a surface of a liquid crystal display panel by first and second cutting wheels;

FIG. **197** illustrates a perspective view of first and second cutting wheels having first and second blades are staggered or offset with respect to each other according to an embodiment of the present invention;

FIG. **198** illustrates an exemplary diagram of first and second grooves formed on a surface of a liquid crystal display panel through first and second cutting wheels in FIG. **197**;

FIG. **199** illustrates an enlarged partial view of a liquid crystal display panel cutting wheel according to an embodiment of the present invention;

FIG. **200** illustrates an enlarged partial view of a liquid crystal display panel cutting wheel according to an embodiment of the present invention; and

FIG. **201** illustrates an enlarged view of a liquid crystal display panel cutting wheel in part according to an embodiment of the present invention;

FIG. **202** illustrates a diagram of a grinding table apparatus for a liquid crystal display panel and a grinder apparatus using the same according to an embodiment of the present invention;

FIGS. **203**A to **203**C illustrate exemplary diagrams for grinding tables of a first grinding unit moving in a farther or closer direction reciprocally so as to cope with a size of a liquid crystal display panel in FIG. **202**;

FIG. **204** illustrates a diagram of a grinding table apparatus for a liquid crystal display panel and a grinder apparatus using the same according to another embodiment of the present invention;

FIGS. **205**A to **205**C illustrate exemplary diagrams for grinding tables of a first grinding unit moving in farther or closer directions reciprocally so as to cope with a size of a liquid crystal display panel in FIG. **204**;

FIGS. **206**A to **206**C illustrate exemplary diagrams for grinding tables of a first grinding unit moving in farther or closer directions reciprocally so as to cope with a size of a liquid crystal display panel according to a further embodiment of the present invention;

FIG. **207** is a schematic view illustrating an indicator for detecting a grinding amount of an LCD panel in accordance with an embodiment of the present invention;

FIG. **208** is a schematic view illustrating an indicator for detecting a grinding amount of the LCD panel in accordance with an embodiment of the present invention;

FIG. **209** illustrates multiple vent holes at the top of the bonding chamber in accordance with the present invention;

FIG. **210** illustrates a cross-sectional view of FIG. **209**;

FIG. **211** illustrates multiple vent holes at all sides of the bonding chamber in accordance with the present invention; and

FIG. **212** illustrates a cross-sectional view of FIG. **211**.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Reference will now be made in detail to an embodiment of the present invention, examples of which are illustrated in the accompanying drawings.

FIGS. **4**,**5**, and **6** illustrate flow charts each showing the steps of a method for manufacturing a liquid crystal display in accordance with first, second, and third embodiments of the present invention.

Referring to FIG. **4**, a first substrate and a second substrate are provided. The first substrate (hereafter referred to as a "TFT substrate") includes a plurality of gate lines running in one direction at fixed intervals, a plurality of data lines running in a direction perpendicular to the gate lines at fixed intervals, a plurality of thin film transistors, and pixel electrodes in a matrix pixel region defined by the gate lines and the data lines, formed thereon. The second substrate (hereafter referred to as a "color filter substrate") includes a black matrix layer for shielding a light incident to parts except the pixel region, a color filter layer, and a common electrode.

The TFT substrate and the color filter substrate are alternately provided into a production line having a single line structure for progressing the liquid crystal cell process. Processing equipment can be considered as equipment for the TFT substrate, equipment for the color filter substrate or both. The respective substrates are preferably provided to and processed by the corresponding equipment automatically in accordance with information on the substrates.

An overview of the liquid crystal cell process will now be explained as follows.

An orientation step is carried out for both of the TFT substrate and the color filter substrate. The orientation step is progressed in an order of cleaning (**20**S) before coating the orientation film, printing of the orientation film (**21**S), baking of the orientation film (**22**S), inspecting of the orientation film (**23**S), and rubbing (**24**S).

After the TFT substrate and the color filter substrate that have passed through the orientation step are cleaned (**25**S), a sealing material is coated onto the color filter substrate, without providing an hole structure for liquid crystal injection so that the color filter substrate can later be assembled with the TFT substrate on a periphery of a pixel region with a fixed gap between the TFT substrate and the color filter substrate (**26**S). In contrast, the TFT substrate passes through the sealing material coating step (**26**S) without coating the sealing material and is provided into the next step.

Silver is coated on the TFT substrate in forms of dots for electrical connection with a common electrode on the color filter substrate (**27**S). However, the color filter substrate passes through the silver forming step (**27**S) without the silver forming and is provided into the next step.

Next, a step for applying or dropping the liquid crystal onto the TFT substrate in a region corresponding to an area inside the sealing material coated on the color filter substrate is carried out (**28**S). Here, the color filter substrate passes through the liquid crystal applying or dropping step (**28**S) without having the liquid crystal dropped thereon and is provided into the next step.

Of course, it should be recognized that the present invention is not limited to this arrangement. For example, the forming of the sealing material, and the applying or dropping of the liquid crystal material may carried out on either of the TFT substrate or the color filter substrate. The silver dot forming step may be omitted for the production of an IPS (In-Plane Switching) mode LCD in which both the pixel electrode and the common electrode are formed on a single TFT substrate.

Then, the TFT substrate and the color filter substrate are loaded into a vacuum chamber and assembled into a large panel (i.e., a panel having a plurality of LCD unit panels) such that the applied liquid crystal is spread over the panels uniformly and the sealing material is cured (**29**S).

The large panel, having a TFT substrate and a color filter substrate with liquid crystal therebetween, is cut into individual unit panels (**30**S). Each individual unit panel is ground, and finally inspected (**31**S), thereby completing the manufacturing of an LCD device.

FIGS. **2** and **3** illustrate flow charts showing a method for manufacturing of a liquid crystal display in accordance with a second and third embodiments of the present invention, respectively, where the order of steps from the sealing material forming step (**26**S) to the liquid crystal dropping step (**28**S) in FIG. **4** are varied.

That is, referring to FIG. **5**, after both the TFT substrate and the color filter substrate passed through the cleaning step (**25**S) of the orientation process, silver is formed on the TFT substrate in form of dots for electrical connection with a common electrode on the color filter substrate (**40**S). However, the color filter substrate passes through the silver forming step (**40**S) without the silver coating and is provided into the next step.

Next, a sealing material is formed on the color filter substrate without providing the liquid crystal filling hole so that the color filter substrate may later be assembled with the TFT substrate on a periphery of a pixel region with a fixed gap between the TFT substrate and the color filter substrate (**41**S). Here, the TFT substrate passes through the sealing material forming step (**41**S) without forming the sealing material thereon and is provided into the next step.

Next, a step for dropping the liquid crystal onto the TFT substrate in a region corresponding to an area inside the sealing material formed on the color filter substrate is carried out (**42**S). However, the color filter substrate passes through the dropping step without having the liquid crystal dropped thereon, and is provided into the next step.

Again, it should be recognized that the present invention is not limited to this arrangement. For example, the forming of the sealing material and the dropping of the liquid crystal may be carried out on either of the TFT substrate or the color filter substrate. The silver dot forming step may be omitted for the production of an IPS mode LCD in which the pixel electrode and the common electrode are formed on a single TFT substrate.

The remaining liquid crystal cell process is finished through the vacuum assembling step of the TFT substrate with the color filter substrate, the curing step of the sealing material (**29**S), cutting (**30**S), and final inspection (**31**S).

Referring to FIG. **6**, after both the TFT substrate and the color filter substrate passed through the cleaning step (**25**S) of the orientation process, silver is formed on the TFT substrate in form of dots for electrical connection with a common electrode on the color filter substrate (**50**S). Here, the color filter substrate passes through the silver forming step without the silver forming and is provided into the next step.

Next, a step for applying or dropping the liquid crystal onto the TFT substrate in a region corresponding to an area inside the sealing material formed on the color filter substrate is carried out (**51**S). Here, the color filter substrate passes through the liquid crystal dropping step without having the liquid crystal dropped thereon, and is provided into the next step.

Next, a sealing material is formed on the color filter substrate without providing a liquid crystal filling hole so that the color filter substrate may later be assembled with the TFT substrate on a periphery of a pixel region with a fixed gap between the TFT substrate and the color filter substrate (**52**S). However, the TFT substrate passes through the sealing material forming step (**52**S) without forming the sealing material thereon and is provided into the next step.

Again, it should be recognized that the present invention is not limited to the above arrangement. For example, the forming of the sealing material and the dropping of the liquid crystal may be carried out on either of the TFT substrate or the color filter substrate. The silver dot forming step may be omitted for the production of an IPS mode LCD in which the pixel electrode and the common electrode are formed on a single TFT substrate.

The remaining liquid crystal cell process is finished through the vacuum assembling step of the TFT substrate with the color filter substrate, the curing step of the sealing material (**29**S), cutting (**30**S), and final inspection (**31**S).

Also, it should be recognized that a particular step may be performed on one substrate at the same time that a different step is performed on the other substrate. That is, the production process line receives many thin film transistor substrates and color filter substrates in serial order. Each pair of substrates will pass through each component of the production process line. However, both substrates of each pair need not be disposed in the same component of the production process line at the same time. Thus, one substrate of the pair may be operated on by one component of the production process line at the same time that the other substrate of the pair is being operated on by another component.

As has been explained, the method for manufacturing a liquid crystal display in accordance with the present invention can improve spatial efficiency by adopting a single production line for the liquid crystal cell process, increase the productivity by providing an effective and simple liquid crystal cell process, and can overcome problems caused by a process time difference between the TFT substrate process line and the color filter substrate line. Here, management of respectively providing the TFT substrate and the color filter is simple. Meanwhile, though not shown, the silver dot forming (**50**S) in the third embodiment may be carried out at a step between the liquid crystal dropping (**51**S) and the sealing material forming (**52**S), or after the liquid crystal dropping (**51**S) and the sealing material forming (**52**S).

FIGS. **7**A and **7**B show an exemplary apparatus for manufacturing an LCD device according to the present invention. In FIGS. **7**A and **7**B, the apparatus may include a first reverse unit **110**, at least one bonding unit **120** disposed within a vacuum processing chamber **121**, and a plurality of loading/unloading units **130**. In addition, the apparatus may be provided with a hardening unit **140**.

A liquid crystal material may be applied or deposited (i.e., drop dispensed) onto a first substrate **151**, and a sealant (not shown) may be applied or deposited onto a second substrate **152**. Then, the first reverse unit **110** may reverse (i.e., flip) the second substrate **152** upon which the sealant is dispensed. The first reverse unit **110** may not necessarily reverse each of the first and second substrates **151** and **152**, and may reverse only one of the first and second substrates **151** and **152** upon which the liquid crystal material is not deposited. Moreover, the first and second substrate **151** and **152** may be one of either a TFT array substrate or a color filer (C/F) substrate. Alternatively, the first reverse unit may reverse the substrate having the liquid crystal material deposited thereupon provided that the viscosity of the liquid crystal material is large enough so as to prevent any flow of the liquid crystal material during the reversing process.

The first reverse unit **110** may have various configurations based upon the assumption that only one the first and second substrates **151** and **152** may be reversed. For example, although not shown, the liquid crystal material may be deposited on the first substrate **151**, which may be a C/F substrate, and the sealant may be deposited on the second substrate **152**, which may be a TFT array substrate. Moreover, both the liquid crystal material and the sealant may be deposited on the first substrate **151**, which may be a TFT array substrate, and the second substrate **152**, which may be a C/F substrate, may not have either of the liquid crystal material or the sealant deposited thereon. Furthermore, both the liquid crystal material and the sealant may be deposited on the first substrate **151**, which may be a C/F substrate, and the second substrate **152**, which may be a TFT array substrate, may not have either of the liquid crystal material or the sealant deposited thereon.

The bonding unit **120** may be provided within the vacuum processing chamber **121**, and may include an upper stage **122***a*, a lower stage **122***b*, and a moving means **123** for selectively moving either one or both of the upper and lower stages **122***a* and **122***b*. Accordingly, the upper stage **122***a* may be provided at an upper side of the vacuum processing chamber **121** to hold the second substrate **152** and, the lower stage **122***b* may be provided at a lower side of the vacuum processing chamber **121** to hold the first substrate **151**. The bonding unit **120** may bond the first and second substrates **151** and **152** to produce bonded substrates.

The hardening unit **140** may include a photo-curing (photo-hardening) unit **141**, which may subject the bonded substrates to an emitted light such as UV, for example, and thermal hardening unit **142**, which may heat the bonded substrates. Accordingly, the hardening unit **140** may include the photo-curing unit **141** and the thermal hardening unit **142** as a single processing unit. Alternatively, the hardening unit **140** may include the photo-curing unit **141** and the thermal hardening unit **142** as multiple processing units. If the hardening unit **140** is provided with both the photo-curing unit **141** and the thermal hardening unit **142**, the photo-curing unit **141** receives the bonded substrates and cures the bonded substrates by the emitted light. Then, the thermal hardening unit **142** may receive the photo-cured, bonded substrates, and harden the sealant by processing under high temperature conditions. In addition, the thermal hardening unit **142** may permit the liquid crystal material to flow between the bonded substrates, thereby dispersing the liquid crystal material uniformly between the bonded substrates.

The loading/unloading units **130** may be provided between the first reverse unit **110**, the bonding unit **120**, and the hardening unit **140**. The loading/unloading units **130** may include a first loading/unloading unit **131**, a plurality of second loading/unloading units **132**, a third loading/unloading unit **133**, and a fourth loading/unloading unit **134**. Each of the loading/unloading units **130** may include mechanical devices such as a robot-arm, for example, to obtain relatively high precision and accuracy in moving the substrates. Alternatively, the loading/unloading units **130** may include various types of devices for providing relatively high precision and accuracy and may combine various different types of devices such as conveyors and robot arms.

A processing time of each processing step may vary according to each individual processing modules (i.e., units). For example, a processing time for the plurality of bonding units **120** may be different than a processing time for the hardening unit **140**. Accordingly, buffer units may be provided between any of the reverse, bonding, and hardening units to provisionally store any of the first and second substrates **151** and **152**, as well as the bonded substrates prior to subsequent processing steps. The buffer units may have at least one substrate cassette in which a plurality of bonded substrates may be provisionally stored at multiple levels.

In FIG. 7B, a first buffer unit **161** may be provided at a first side, or sides of the first loading/unloading unit **131** for loading the first and second substrates **151** and **152** to the first reverse unit **110**. A second buffer unit **162** may be provided at a side of the plurality of second loading/unloading units **132** for unloading the bonded substrates from the bonding unit **120** and at a side of the third loading/unloading unit **133** for loading the bonded substrates into the hardening unit **140**. A third buffer unit **163** may be provided at a side of the fourth loading/unloading unit **134** for unloading the bonded substrates from the hardening unit **140**. Each of the first, second, and third buffer units **161**, **162** and **163** may be provided with a pair of substrate cassettes for temporarily storing each of the first and second substrates **151** and **152** in the first buffer unit **161**, the bonded substrates in the second buffer unit **162**, and the bonded substrates in the third buffer unit **163** after being processed in the hardening unit **140**.

In FIG. 7B, a plurality of the bonding units **120** may be disposed to face each other, and the plurality of second loading/unloading units **132** may be provided between the first reverse unit **110** and each of the plurality of bonding units **120**. Accordingly, the plurality of second loading/unloading units **132** may selectively load the first and second substrates **151** and **152** from the first reverse unit **110** into the plurality of bonding units **120**, and simultaneously transfer the bonded substrates to the second buffer unit **162**. In addition, the first reverse unit **110**, the second buffer unit **162**, and the second loading/unloading unit **132** may be arranged along a first line, and the plurality of bonding units **120** may be arranged along a second line that is perpendicular to the first line. The third loading/unloading unit **133** may be provided between the second buffer unit **162** and the photo-curing unit **141**. The third loading/unloading unit **133** may load the bonded substrates into the photo-curing unit **141** from the second buffer unit **162**. In addition, a fourth loading/unloading unit **134** may be provided between the photo-curing unit **141** and the thermal hardening unit **142**. The fourth loading/unloading unit **134** may load the bonded substrate into the thermal hardening unit **142** from the photo-curing unit **141**.

Operation of the exemplary apparatus for manufacturing a LCD device according to the present invention will be described with regard to FIGS. 7A and 7B. During a first transfer process, the first loading/unloading unit **131** may selectively transfer the first and second substrates **151** and **152** to the first reverse unit **110** from the first buffer unit **161**. The first substrate **151** and the second substrate **152** may have undergone a plurality of processing steps prior to being placed into the first buffer unit **161**. For example, the first and second substrates **151** and **152** may have undergone cleaning, liquid crystal material deposition, and sealant forming processes prior to loading the first and second substrates **151** and **152** into the first buffer unit **161**. In addition, the first and second substrates **151** and **152** may have undergone inspection processes prior to, or between the different clean, liquid crystal deposition, and sealant deposition processing. As previously described above, the first and second substrates **151** and **152** may have one of many different combinations of the liquid crystal material and/or sealant deposited thereupon. In addition, the first and second substrates **151** and **152** may alternatively include one of a C/F substrate and a TFT array substrate.

After the first transfer process, a first loading process may include individually loading the first and second substrates **151** and **152** into the first reverse unit **110** from the first buffer unit **161** by the first loading/unloading unit **131**. Alternatively, the first loading process may include simultaneously loading the first and second substrates **151** and **152** into the first reverse unit **110** from the first buffer unit **161** by the first loading/unloading unit **131**.

After the first loading process, a sensing process may include sensing by the first reverse unit **110** as to whether the first substrate **151** or the second substrates **152** has the liquid crystal material. During the sensing process, the first reverse unit **110** may sense each of the first and second substrates **151** and **152** by reading a specific indicia (not shown) that is assigned to each of the first and second substrates **151** and **152**. For example, a distinctive mark or code may be disposed in an inactive region of each of the first and second substrates **151** and **152**. Accordingly, the first reverse unit **110** may include a mark or code reader (not shown) that reads the mark or code of each of the first and second substrates **151** and **152** and senses whether the mark or code indicates that the first and second substrates **151** ad **152** does or does not have the liquid crystal material.

After the sensing process, a reversing process may performed in which the one of the first and second substrates **151** and **152** not having the liquid crystal material may be reversed (flipped).

After the reversing process, a second loading process may include individually loading the first and second substrates **151** and **152** into one of the plurality of bonding units **120** from the first reverse unit **110** by a plurality of the second loading/unloading units **132**. Alternatively, the second loading process may include simultaneously loading the first and second substrates **151** and **152** into the plurality of bonding units **120** from the first reverse unit **110** by the plurality of second loading/unloading units **132**.

During the second loading process, the substrate that includes the liquid crystal material (now referenced as the first substrate **151**), may be loaded onto a lower stage **122***b* of the vacuum processing chamber **121** by a first of the plurality of second loading/unloading units **132**. In addition, the substrate that does not include the liquid crystal material (now referenced as the second substrate **152**), may be loaded onto an upper stage **122***a* of the vacuum processing chamber **121** by the first of the plurality of second loading/unloading units **132**. Alternatively, the second substrate **152** may be loaded onto the upper stage **122***a* by a second of the plurality of second loading/unloading units **132**.

After the second loading process, a bonding process may include a moving means **123** of the bonding unit **120** that may move at least one of the upper and lower stages **122***a* and **122***b* to press and bond the first and second substrates **151** and **152**, thereby forming bonded substrates.

After the bonding process, a third loading process may include individually loading the bonded substrates into the second buffer unit **162** from each of the plurality of bonding units **120** by the plurality of second loading/unloading units **132**. Alternatively, the third loading process may include simultaneously loading the bonded substrates into the second buffer unit **162** from the plurality of bonding units **120** by the plurality of second loading/unloading units **132**.

After the third loading process, a fourth loading process may include individually loading the bonded substrates into the photo-curing unit **141** of the hardening unit **140** from the second buffer unit **162** by the third loading/unloading unit **133**.

After the fourth loading process, a photo-curing process may include exposing the sealant disposed between the bonded substrates to light such as ultraviolet (UV) light, for example, thereby curing the sealant. The photo-curing unit **141** may include a mask such that a TFT array region of the TFT array substrate **151** is shielded from the light.

After the photo-curing process, a fifth loading process may include individually loading the bonded substrates into the thermal hardening unit **142** from the photo-curing unit **141** by the fourth loading/unloading unit **134**. The thermal hardening unit **142** may expose the bonded substrates to elevated temperatures, thereby raising a temperature of the liquid crystal material. Accordingly, the liquid crystal material may flow to evenly disperse between the bonded substrates, and the sealant may harden.

After the fifth loading process, a sixth loading process may include individually loading the bonded substrates into a third buffer unit **163** from the thermal hardening unit **142** by the fourth loading/unloading unit **134**. Then, the bonded substrates may be transferred for further processing.

FIG. **8** shows another exemplary apparatus for manufacturing an LCD device according to the present invention. The exemplary apparatus shown in FIG. **8** may include the features shown in FIGS. **7**A and **7**B, and may include a plurality of supplemental pressing units **170** arranged between the plurality of bonding units **120** and the hardening unit **140**. The supplemental pressing units **170** may additionally apply pressure to the bonded substrates to improve a bonding state between the bonded substrates. In addition, each of the plurality of supplemental pressing units may be arranged at opposing sides of the third loading/unloading unit **133**. The third loading/unloading unit **133** may individually load the bonded substrates into one of the supplemental pressing units **170** from the second buffer unit **162**. In addition, the third loading/unloading unit **133** may also individually load the bonded substrates into the photo-curing unit **141** of the hardening unit **140** from the supplemental pressing units **170**. Accordingly, an additional loading process may include individually loading the bonded substrates into the photo-curing unit **141** from the supplemental pressing units **170** without the need for an additional loading/unloading unit.

In FIG. **8**, the second buffer unit **162** and the supplemental pressing units **170** may not be formed along a single line. Accordingly, the third loading/unloading unit **133** may be provided along another line with the second buffer unit **162** and the photo-curing unit **141**, and the supplemental pressing units **170** may be provided along a line perpendicular to the third loading/unloading unit **133**. Accordingly, the first and second substrates **151** and **152** may first be bonded by the bonding unit **120**, and then additionally pressed by the supplemental pressing unit **170**. Then, the third loading/unloading unit **133** may transfer the bonded substrates additionally pressed by the supplemental pressing units **170** to the second buffer unit **162**.

FIG. **9** shows another exemplary apparatus for manufacturing an LCD device according to the present invention. The exemplary apparatus shown in FIG. **9** may include the features shown in FIGS. **7**A and **7**B, and may include a second reverse unit **180** arranged between the plurality of bonding units **120** and the hardening unit **140**. The second reverse unit **180** may selectively reverse the bonded substrates bonded by the plurality of bonding units **120**.

FIGS. **10**A and **10**B show cross sectional views of main portions an exemplary LCD device illustrating photo-hardening degree states of the sealant according to relative positions of the bonded substrates during a photo-curing process according to the present invention. In FIGS. **10**A and **10**B, black matrix films **152***a* may be formed on the second substrate **152** (C/F substrate) except for regions corresponding to pixel regions of the first substrate **151** (TFT array substrate). The black matrix **152** prevents the light emitted during the photo-curing unit **141** from reaching the sealant. Accordingly, the sealant may not be sufficiently hardened.

The second reverse unit **180** may include a sensing unit that may sense whether the black matrix **152***a* is formed on the C/F substrate **152** or on the TFT array substrate **151**. In cases where the black matrix **152***a* is formed on the C/F substrate **152**, the bonded substrates are reversed by the second reverse unit **180** shown in FIG. **9**. Accordingly, the sealant will be exposed to the light in the photo-curing unit **141**, thereby sufficiently hardening the sealant. The sensing unit may read a specific indicia (not shown) that is assigned to each of the bonded substrates. For example, a distinctive mark or code may be disposed in an inactive region of each of the bonded substrates. The second reverse unit **180** may include a mark or code reader (not shown) that reads the mark or code of each of the bonded substrates, and senses whether the mark or code indicates that the upper bonded substrate is a C/F substrate or a TFT array substrate. Accordingly, during the operation of the apparatus shown in FIG. **9**, a second reverse process may be necessary after the third loading process. During the second reverse process, the bonded substrates that are sensed to have a C/F substrate as the uppermost substrate may be individually loaded into the second reverse unit **180** from the plurality of bonding units **120** by the second loading/unloading units **132**. Then, the second reverse unit **180** reverses an orientation of the bonded substrates such that the TFT array substrate is now the uppermost substrate. The reversed bonded substrate is loaded to the second buffer unit **162** from the second reverse unit **180** by one of the second loading/unloading units **132**, or by the third loading/unloading unit **133**. Alternatively, an additional loading/unloading unit may be incorporated, whereby neither of the second loading/unloading units **132** nor the third loading/unloading unit **133** need to be used.

FIG. **11** shows another exemplary apparatus for manufacturing an LCD device according to the present invention. The exemplary apparatus shown in FIG. **11** may include the features shown in FIGS. **7**A and **7**B, and may include bonding degree sensing units **190** for sensing a degree of bonding between the bonded substrate provided between the photo-curing unit **141** and the thermal hardening unit **142**, and a fifth loading/unloading unit **135** provided between the bonding degree sensing units **190**, the photo-curing unit **141**, and the fourth loading/unloading unit **134**. The fifth loading/unloading unit **135** may load the bonded substrates into the bonding degree sensing units **190** from the photo-curing unit **141**, and may load the bonded substrates into the thermal-hardening unit **142** if the bonding degree of the bonded substrates are determined to be sufficient by the bonding degree sensing units **190**. Alternatively, the fifth loading/unloading unit **135** may be omitted, and the fourth loading/unloading unit **134** may load the bonded substrates between the photo-curing unit **141**, the bonding degree sensing units **190**, and the thermal-hardening unit **142**. Moreover, it may not be necessary to provide the bonding degree sensing unit **190** between the photo-curing unit **141** and the thermal hardening unit **142**.

Alternatively, the bonding degree sensing units **190** may be provided at a processing region after the plurality of bonding units **120** and before the hardening unit **140**, thereby removing bonded substrates with insufficient bond degree and preventing unnecessary processing time of the bonded substrates.

Detail processes involved in manufacturing an LCD will now be described in detail. In addition, various devices for performing functions in the production line will also be described.

FIG. **12** is a perspective view illustrating an exemplary apparatus for deaerating liquid crystal used in manufacturing a liquid crystal display device by the liquid crystal dropping method in accordance with the present invention.

Referring to FIG. **12**, a plurality of liquid crystal syringes **201** (only one syringe is shown in the drawing) filled with a liquid crystal **202** to be deaerated are placed in a chamber **210**. Of course, the chamber **210** need not hold more than one liquid crystal syringe **201**, but it is more efficient to deaerate more than one at a time. The liquid crystal syringes **201** is placed in the chamber **210** for deaerating the liquid crystal **202** using a deaerating apparatus **200**. At this time, the liquid crystal syringes **201** are not yet assembled and set. After deaeration process step is finished, the liquid crystal syringe **201** will be assembled and set to be mounted on the liquid crystal dispenser in the production line. The liquid crystal syringe **201** may include, for example, a container **205** for containing the liquid crystal **202**, an opening and shutting part **207** connected to the container **205** for dispensing the liquid crystal **202**, and a nozzle **209** connected to the opening and shutting part **207** having the liquid crystal **202** dispensed. Of course, other syringe types or liquid crystal dispensers may be used in accordance with the present invention.

There is a first portion (holder) **214** in the chamber **210** to hold the liquid crystal syringe **201**. The first portion **214** may include a first holding part **214***a* for holding the opening and shutting part **207** of the liquid crystal syringe **201**, and a second holding part **214***b* for holding the container **205**. The first holding part **214***a* has a plurality of first holes **215** matched to a diameter of the opening and shutting part **207**, and the second holding part **214***b* has a plurality of second holes **216** matched to a diameter of the container **205**. The first and second holding parts **214***a* and **214***b* hold the liquid crystal syringe **201**. Of course, other configurations for the first portion **214** may be used as long as such configurations serve as a holder to securely hold the liquid crystal syringes **201**.

There is a displacing mechanism **220** to cause displacements of the chamber **210**. That is, the displacing mechanism **220** may vibrate and/or rotate the chamber **210**. The displacing mechanism **220** may be located below the chamber **210** to vibrate and/or rotate the chamber **210**, thereby disturbing or inducing flow in the liquid crystal **202** in the liquid crystal syringe **201** in the chamber **201**. Generally, a circular motion is preferred to circulate the liquid crystal **202** without causing air bubbles.

The deaerating apparatus **200** may also include a vacuum system **30** for evacuating the chamber **210**, a gas supply **240** for restoring the chamber **210** to an atmospheric pressure state, and a body **250** for supporting the chamber **210** and the displacing mechanism **220**. The vacuum system **230** (for example, a vacuum pump) reduces a pressure of the chamber **210** by discharging air from the chamber **210** to the atmosphere. The gas supply **240** inflows gas, preferably an inert gas such as nitrogen gas (N_2), into the chamber **210** to restore the chamber **210** to an atmospheric pressure state again.

The method for deaerating the liquid crystal **202** by using the apparatus **200** in accordance with the present invention can be explained as follows.

At first, a cover **211** is opened to mount the liquid crystal syringe **1** on the first and second holding parts **214***a* and **214***b* in the chamber **210**. Then, the cover **211** is closed to seal the chamber **210**, and the displacing mechanism **220** starts to operate, thereby circulating the liquid crystal **202** in the liquid crystal syringe **201**. At the same time, the vacuum system **230** starts to evacuate air inside of the chamber **210** through a vacuum line (not shown), thereby removing moisture and air in the liquid crystal **202** due to a pressure difference between the chamber **210** and the liquid crystal **202**. The foregoing deaeration process step can remove moisture and air in the liquid crystal **202** effectively and quickly since the deaeration process step is carried out while flowing of the liquid crystal **202**. That is, liquid crystal flow is induced in the up down, left, and right directions or rotational directions.

To finish the deaeration process, the gas supply **240** provides nitrogen gas (N_2) into the chamber **210** through a nitrogen gas line (not shown); thereby restoring the pressure of the chamber **210** to the atmospheric pressure.

After completion of all the foregoing process steps, the liquid crystal syringe **201** is taken out of the chamber **210**, and the liquid crystal dropping process is carried out as described in detail herein. That is, though not shown, after the liquid crystal syringe **201** having been deaerated, it is assembled and set to be mounted on the liquid crystal dispenser of the production line. Then, the liquid crystal **202** is dropped and dispensed onto the pixel region of the TFT substrate or the color filter substrate to manufacture a large LCD panel. Here, a large LCD panel having a plurality of unit panels is formed.

As has been explained, the apparatus and method for deaerating a liquid crystal of the present invention have the following advantages. First, process time loss can be minimized by carrying out deaeration of a liquid crystal in a plurality of syringes placed in the chamber. Also, the deaeration process can remove moisture and air in the liquid crystal effectively and quickly since the deaeration process step is carried out while liquid crystal flow is induced. Further, the effective removal of moisture and air in the liquid crystal can reduce the occurrence of defective LCDs, thereby improving yield.

FIG. **13** illustrates a flow chart showing the process steps of a method for manufacturing a liquid crystal display device in accordance with an embodiment of the present invention, and FIG. **14** illustrates a perspective view for explaining the apparatus for measuring a dispensing amount of the liquid crystal drops in FIG. **6**.

Referring to FIG. **13**, a first substrate and a second substrate are provided. The first substrate (hereafter called as a "TFT substrate") includes a plurality of gate lines running in one direction at fixed intervals, a plurality of data lines running in the other direction perpendicular to the gate lines at fixed intervals, a plurality of thin film transistors and pixel electrodes in a matrix pixel region defined by the gate lines and the data lines, formed thereon. The second substrate (hereafter called as a "color filter substrate") includes a black matrix layer for shielding a light incident to parts except the pixel region, a color filter layer, and a common electrode.

The liquid crystal cell process will be explained in detail as follows.

An orientation step (**301**S) is carried out for both of the TFT substrate and the color filter substrate. The orientation step is in order of cleaning before coating the orientation film, printing the orientation film, baking the orientation film, inspecting the orientation film, and rubbing.

Then, the color filter substrate is cleaned (**302**S). The cleaned color filter substrate is loaded on a stage of a seal dispenser, and a sealing material is formed on a periphery of unit panel areas in the color filter substrate (**303**S). The sealing material may be a photo-hardening resin, or thermo-hardening resin. However, no liquid crystal filling hole is required.

At the same time, the cleaned TFT substrate is loaded on a stage of a silver (Ag) dispenser, and a silver paste material is dispensed onto a common voltage supply line on the TFT substrate in the form of a dot (**305**S). Then, the TFT substrate is transferred to a LC dispenser, and a liquid crystal material is dropped onto an active array region of each unit panel area in the TFT substrate (**306**S). Of course, the present invention is not limited to this configuration. For example, the forming of the sealing material may be either on the TFT substrate or the color filter substrate.

The liquid crystal dropping process will now be described as follows.

After a liquid crystal material is contained into an LC syringe before the LC syringe is assembled and set, air dissolved in the liquid crystal material is removed under a vacuum state (**310**S), and the liquid crystal syringe is assembled and set (**311**S). The LC syringe is then mounted on an apparatus for measuring a dispensing amount of liquid crystal drops (**312**S).

Referring to FIG. **14**, the apparatus for measuring a dispensing amount of liquid crystal drops includes a liquid crystal syringe **350**, a column **355** for supporting the liquid crystal syringe **350**, a container **360** for containing the liquid crystal dispensed from the liquid crystal syringe **350**, a measuring part **370** for measuring a dispensed amount of the liquid crystal drops, and a monitoring part **380** for receiving a data from the measuring part **370** and determining functionality of the liquid crystal syringe.

The proper function of the assembled and set liquid crystal syringe **350** is determined by the apparatus for measuring a dispensing amount of liquid crystal drops (**313**S). Proper function is determined such that, for example, a dispensing amount of the unit liquid crystal drop is displayed on the monitoring part **380** in milligrams, and, if the dispensing amount of the unit liquid crystal drop is out of a preset range of an error (for example, ±1%), assembling, setting, and testing of the liquid crystal syringe is repeated until the amount is within the preset error range.

As a result of the foregoing repeated test, if the amount is within the preset range of error, the assembled and set LC syringe having liquid crystal filled therein and the parts for controlling dispensing of the liquid crystal in the liquid crystal syringe are determined to be good. Once assembled and set the liquid crystal syringe is determined to be good according to the functionality determination of the liquid crystal syringe, the liquid crystal syringe is mounted on the liquid crystal dispenser of the production line (**314**S).

Then, when the substrate is loaded onto a stage of the liquid crystal dispenser, the liquid crystal is dropped onto the substrate using the liquid crystal syringe (**306**S), by making uniform dotting of a preset dispensing amount of the liquid crystal drop onto the TFT substrate with defined pitches inside of a coating area of the sealing material (pixel region).

The functionality determination of the assembled and set liquid crystal syringe may be made again by measuring a dispensing amount of the liquid crystal drop by using a container in the liquid crystal dispensing system before actual dispensing of the liquid crystal on the substrate.

After the TFT substrate and the CF substrate are loaded into a vacuum assembling chamber, the TFT substrate and the CF substrate are assembled into a liquid crystal panel such that the dropped liquid crystal is uniformly spread over unit panel areas in the liquid crystal panel (**307**S). Then, the sealing material is cured (**307**S). The assembled TFT substrate and color filter substrate (which is a large panel) is cut into individual unit panels (**308**S). Each unit panel is ground and inspected (**309**S), thereby completing manufacturing of the LCD unit panel.

As has been explained, the apparatus for measuring a dispensing amount of a liquid crystal drops and the method for manufacturing a liquid crystal display device by using the same of the present invention has numerous advantages. For example, by progressing the liquid crystal cell process step after making sure of appropriateness of assembled and set states of the liquid crystal syringe using an independent apparatus for measuring a dispensed amount of liquid crystal drops before mounting the liquid crystal syringe on the liquid crystal dispenser in the production line, we can prevent the inconvenience and time delay of the manufacturing process causing by ensuring the functionality of the liquid crystal syringe after it is mounted on the liquid crystal dispenser in a state where the liquid crystal syringe is completely assembled and set. Thus, a working environment and a time efficiency can be maximized, thereby increasing a production yield.

To solve the problems of the conventional liquid crystal injection methods, a novel liquid crystal dropping method has been recently introduced. The liquid crystal dropping method forms a liquid crystal layer by directly applying liquid crystal onto a substrate and then spreading the applied liquid crystal by pressing substrates together. According to the liquid crystal dropping method, the liquid crystal is applied to the substrate in a short time period such that the liquid crystal layer can be formed quickly. In addition, liquid crystal consumption can be reduced due to the direct application of the liquid crystal, thereby reducing fabrication costs.

FIG. **15** illustrates the basic liquid crystal dropping method. As shown, liquid crystal is dropped (applied) directly onto a lower substrate **451** before the lower substrate **451** and the upper substrate **452** are assembled. Alternatively, the liquid crystal **407** may be dropped onto the upper substrate **452**. That is, the liquid crystal may be formed either on a TFT (thin film transistor) substrate or on a CF (color filter) substrate. However, the substrate on which the liquid crystal is applied should be the lower substrate during assembly.

A sealing material **409** is applied on an outer part of the upper substrate (substrate **452** in FIG. **15**). The upper substrate **452** and the lower substrate **451** are then mated and pressed together. At this time the liquid crystal drops **407** spread out by the pressure, thereby forming a liquid crystal layer having uniform thickness between the upper substrate **452** and the lower substrate **451**.

FIG. **16** presents a flowchart of a method of fabricating LCDs using the liquid crystal dropping method. As shown, in steps S**501** and S**502** the TFT array is fabricated and processed, and an alignment layer is formed and rubbed. In steps S**504** and S**505** a color filter array is fabricated, and processed, and an alignment layer is formed and rubbed. Then, as shown in step S**503** liquid crystal is dropped (applied) onto one of the substrates. In FIG. **16**, the TFT array substrate is shown as receiving the drops, but the color filter substrate might be preferred in some applications. Additionally, as shown in step S**506**, a sealant is formed on one of the substrates, in FIG. **16** the color filter substrate (the TFT array substrate might be preferred in some applications). It should be noted that the TFT array fabrication process and the color filter fabrication process are generally similar to those used in conventional LCD fabrication processes. By applying liquid crystals by dropping it directly onto a substrate it is possible to fabricate LCDs using large-area glass substrates (1000×1200 mm^2 or more), which is much larger than feasible using conventional fabrication methods.

Thereafter, the upper and lower substrates are disposed facing each other and pressed to attach to each other using the sealing material. This compression causes the dropped liquid crystal to evenly spread out on entire panel. This is performed in step S**507**. By this process, a plurality of unit liquid crystal panel areas having liquid crystal layers are formed by the assembled glass substrates. Then, in step S**508** the glass substrates are processed and cut into a plurality of liquid crystal display unit panels. The resultant individual liquid crystal panels are then inspected, thereby finishing the LCD panel process, reference step S**509**.

The liquid crystal dropping method is much faster than conventional liquid crystal injection methods. Moreover, the liquid crystal dropping method avoids liquid crystal contamination. Finally, the liquid crystal dropping method, once perfected, is simpler than the liquid crystal injection method, thereby enabling improved fabrication efficiency and yield.

In the liquid crystal dropping method, to form a liquid crystal layer having a desired thickness, the dropping position of the liquid crystal and the dropping amount of the liquid crystal should be carefully controlled. FIG. **17** illustrates dropping liquid crystal **407** onto the substrate **451** (beneficially a large glass substrate) using a liquid crystal dispensing device **420**. As shown, the liquid crystal dispensing device **420** is installed above the substrate **451**.

Generally, liquid crystal **407** is dropped onto the substrate **451** as well-defined drops. The substrate **451** preferably moves in the x and y-directions according to a predetermined pattern while the liquid crystal dispensing device **420** discharges liquid crystal at a predetermined rate. Therefore, liquid crystal **407** drops are arranged in a predetermined pattern such that the drops are separated by predetermined spaces. Alternatively, the substrate **451** could be fixed while the liquid crystal dispensing device **420** is moved. However, a liquid crystal drop may be trembled by the movement of the liquid crystal dispensing device **420**. Such trembling could induce errors. Therefore, it is preferable that the liquid crystal dispensing device **420** is fixed and the substrate **451** is moved.

FIG. **18**A illustrates the liquid crystal dispensing device **420** in a state in which liquid crystal is not being dropped. FIG. **18**B illustrates the liquid crystal dispensing device **420** in a state in which liquid crystal is being dropped. As shown in those figures, the liquid crystal dispensing device **420** includes a cylindrically shaped, polyethylene liquid crystal container **424** that is received in a stainless steel case **422**. Generally, polyethylene has superior plasticity, it can be easily formed into a desired shape, and does not react with liquid crystal **407**. However, polyethylene is structurally weak and is thus easily distorted. Indeed, if the case was of polyethylene it could be distorted enough that liquid crystal might not be dropped at the exact position. Therefore, a polyethylene liquid crystal container **424** is placed in a stainless steel case **422**.

A gas supplying tube (not shown) that is connected to an external gas supplying (also not shown) is beneficially connected to an upper part of the liquid crystal container **424**. A gas, such as nitrogen, is input through the gas supplying tube so as to fill the space without liquid crystal. The gas compresses the liquid crystal, thus tending to force liquid crystal from the liquid crystal dispensing device **420**.

The liquid crystal container **424** may be made of a metal such as stainless steel. Then, the liquid crystal container **424** is unlikely to be distorted and an outer case would not be needed. But, a fluorine resin film should be applied on the liquid crystal container **424** to prevent liquid crystal **407** from chemically reacting with the liquid crystal container.

Referring back to FIGS. **18**A and **18**B, an opening is formed on a lower end of the case **422** by a first connecting portion **441**. The first connecting portion **441** mates to a second connecting portion **442**. A needle sheet **443** is positioned between the first connecting portion **441** and the second connecting portion **442**. Beneficially, the first connecting portion **441** and the second connecting portion **442** are threaded members dimensioned to receive the needle sheet **443**, which is then retained in place when the first and second connecting portions are mated. The needle sheet **443** includes a discharge hole through which liquid crystal **407** is discharged into the second connecting portions **442**.

Still referring to FIGS. **18**A and **18**B, a nozzle **446** having a small discharge opening is connected to the second connecting portion **442**. The nozzle **446** is for dropping liquid crystal **407** as small, well-defined drops. The nozzle **446** beneficially includes a supporting portion **447** that mates to the second connecting portion **442**, thus retaining the nozzle **446** in position. A discharging tube from the discharge hole of the needle sheet **443** to the discharge opening of the nozzle **446** is thus formed.

Still referring to FIGS. **18**A and **18**B, a needle **436** is inserted into the liquid crystal container **424**. One end of the needle **436** contacts the needle sheet **443** discharge hole when the needle **436** is inserted as far as possible into the liquid crystal container **424**. That end of the needle **436** is conically shaped and fits into the discharge hole so as to close that hole.

A spring **428** is installed on the other end of the needle **436**. That end of the needle extends into an upper case **426** of the liquid crystal dispensing device **420**. A magnetic bar **432** connected to a gap controlling unit **434** is positioned above the end of the needle **436**. The magnetic bar **432** is made from a ferromagnetic material or from a soft magnetic material. A cylindrical solenoid coil **430** is positioned around the magnetic bar **432**. The solenoid coil **430** selectively receives electric power. That power produces a magnetic force that interacts with the magnetic bar **432** to move the needle **436** against the spring **428**, thus opening the discharge hole of the needle sheet **445**. When the electric power is stopped, the needle **436** is returned to its static position by the elasticity of the spring **428**, thus closing the discharge hole.

Several comments about the liquid crystal dispensing device **420** might be helpful. First, the gap controlling unit **434** controls the distance X between the end of the magnetic bar **432** and the end of the needle **436**. Next, since one end of the needle **436** repeatedly contacts the needle sheet **443**, the needle **436** and the needle sheet **443** are exposed to repeated shock that could damage those parts. Therefore, it is desirable that the end of the needle **436** that contacts the needle sheet

443, and the needle sheet itself, should be formed from materials that resist shock, for example, a hard metal such as stainless steel. Finally, it should be noted that the liquid crystal 407 drop size depends on the time that the discharge hole is open and on the gas pressure. The opening time is determined by the distance (x) between the needle 436 and the magnetic bar 432, the magnetic force produced by the solenoid coil 430, and the tension of the spring 428. The magnetic force can be controlled by the number of windings that form the solenoid coil 430, or by the magnitude of the applied electric power. The distance x can be controlled by the gap controlling unit 434.

As shown in FIG. 17, a liquid crystal dispensing device 420 drops liquid crystal onto a substrate. However, in practice it is beneficial to use a number of liquid crystal dispensing devices 420 to speed up liquid crystal application. While the number of liquid crystal dispensing device 420 can vary according to processing conditions, hereinafter it will be assumed that four liquid crystal dispensing devices 420 are used in an automated application process.

In order to solve the problems of the conventional liquid crystal injection methods such as a liquid crystal dipping method or liquid crystal vacuum injection method, a liquid crystal dropping method is described herein. The liquid crystal dropping method is a method for forming a liquid crystal layer by directly dropping the liquid crystal and spreading the dropped liquid crystal over the entire panel by assembling pressure of the panel, not by injecting the liquid crystal by the pressure difference between the inner and outer sides of the panel. According to the liquid crystal dropping method, the liquid crystal is directly dropped on the substrate for a short period so that the liquid crystal layer in the LCD of larger area can be formed quickly. In addition, the liquid crystal consumption can be minimized due to the direct dropping of the liquid crystal as required amount, thereby reducing the fabrication cost.

In the method for fabricating LCD adopting the liquid crystal dispensing method, to form the liquid crystal layer having the desired thickness, the dropping position of the liquid crystal and the dropping amount of the liquid crystal must be controlled. Since the thickness of the liquid crystal layer is related closely to the cell gap of the liquid crystal display panel, especially, the exact dropping position of the liquid crystal and the dropping amount are very important to prevent the inferiority of the liquid crystal display panel. Therefore, there is need for an apparatus for dropping an exact amount of liquid crystal at a predetermined position.

FIG. 17 illustrates a basic method for dropping the liquid crystal 407 on the substrate (glass substrate of larger area) using the liquid crystal dispensing apparatus 420 according to the present invention. As shown, the liquid crystal dispensing apparatus 420 is installed above the substrate 451. Although not shown in FIG. 17, the liquid crystal is filled into and contained in the liquid crystal dispensing apparatus 420 to be dropped on the substrate.

Generally, the liquid crystal is dropped onto the substrate as a drop shape. The substrate 451 is preferably moving in the x and y-directions according to a predetermined speed and the liquid crystal dispensing apparatus 420 discharges the liquid crystal during a predetermined time interval. Therefore, the liquid crystal 407 dropping on the substrate 451 is arranged toward x and y direction with a predetermined intervals therebetween. At this time, the substrate may be fixed, while the liquid crystal dispensing apparatus 420 may move toward the x and y direction to drop the liquid crystal with a predetermined interval. However, in this case, the liquid crystal of drop shape is trembled by the movement of the liquid crystal dispensing apparatus, so that an error in the dropping position and the dropping amount of the liquid crystal may be occurred. Therefore, it is preferable that the liquid crystal dispensing apparatus 420 be fixed and that substrate 451 be moved.

FIG. 24A is a cross-sectional view showing another exemplary liquid crystal dispensing apparatus when the liquid crystal is not dropped, FIG. 24B is a cross-sectional view showing the apparatus when the liquid crystal is dropped, and FIG. 25 is an exploded perspective view of the apparatus shown in FIGS. 24A and 24B. The liquid crystal dispensing apparatus according to the present invention will now be described with reference to the accompanying Figures.

As shown, the liquid crystal 607 is contained in a liquid crystal container 624 of cylindrical shape. The liquid crystal container 624 is made of a metal such as stainless steel, and a gas supplying tube (not shown) which is connected to a gas supply unit formed on an upper part of the container. Gas such as nitrogen (N_2) is supplied through the gas supply tube from the gas supply unit to fill the area above where the liquid crystal is contained, thereby compressing the liquid crystal 607. As a result, the liquid crystal 607 is dropped (i.e., dispensed) when the needle 636, which forms a valve with needle sheet 643, is in an up position.

The liquid crystal container 624 had been formed using polyethylene in the general liquid crystal dispensing apparatus. Since the polyethylene has superior plasticity, a container of the desired shape can be made easily. However, the polyethylene is weak in strength, and therefore, is distorted easily even by a weak external shock. Therefore, to use a liquid crystal container made of the polyethylene, an additional case should be used having high strength to enclose the liquid crystal container is enclosed. However, the structure of the liquid crystal dispensing apparatus becomes complex, and the fabrication cost is increased.

In addition, with the polyethylene liquid crystal container, if the liquid crystal container is distorted by the external forces (for example, movement of the liquid crystal dispensing apparatus, or the non-uniform pressure applied by the nitrogen) within the case, a liquid crystal discharging path (i.e., the nozzle) is also distorted. Therefore, the liquid crystal can not be dropped at the exact position due to the distorted nozzle.

However, if the liquid crystal container 624 is made of metal as described above, the structure of the liquid crystal dispensing apparatus becomes simple and the fabrication cost is reduced. Also, the dropping of the liquid crystal 607 at inexact position due to non-uniform external forces can be prevented.

A protrusion 638 is formed on a lower end part of the liquid crystal container 624 to be connected to a first connecting portion 641, as shown in FIG. 25. A nut (female threaded portion) is formed on the protrusion 638 and a bolt (male threaded portion) is formed on one side of the first connecting portion 641 so that the protrusion 638 and the first connecting portion 641 are interconnected by the nut and the bolt. Of course, the connection may be formed such that the bolt is formed on the protrusion 638 and the nut is formed on the first connecting portion 638 to connect the protrusion 638 and the first connecting portion 641. The bolt and the nut act as a connection when they are formed on the objects which will be connected, and they do not need to be installed on a certain connecting objects. Therefore, the bolt and the nut which will be described hereinafter are for connecting the components, and it is not important the manner in which they are installed.

A nut is formed on the other side of the first connecting portion 641 and a bolt is formed on one side of a second connecting portion **642**, so that the first connecting portion **641** and the second connecting portion **642** are interconnected. At that time, a needle sheet **643** is located between the first connecting portion **641** and the second connecting portion **642**. The needle sheet **643** is inserted into the nut of the first connecting portion **641**, and then the needle sheet **643** is placed between the first connecting portion **641** and the second connecting portion **642** when the bolt of the second connecting portion **642** is inserted and bolted. A discharging hole **644** is formed on the needle sheet **643**, and the liquid crystal **607** (of FIGS. **24**A and **24**B) contained in the liquid crystal container **624** is discharged through the discharging hole **644** passing by the second connecting portions **642**.

Also, a nozzle **645** is connected to the second connecting portion **642**. The nozzle is for dropping the liquid crystal **607** contained in the liquid crystal container **624** as a small amount. The nozzle **645** comprises a supporting portion **647** including a bolt connected to the nut at one end of the second connecting portion **642** so as to connect the nozzle **645** with the second connecting portion **642** and a discharging opening **646** protruded from the supporting portion **647** so as to drop a small amount of liquid crystal on the substrate as a drop shape. A discharging tube extended from the discharging hole **644** of the needle sheet **643** is formed in the supporting portion **647** and the discharging tube is connected to the discharging opening **646**. Generally, the discharging opening **646** of the nozzle **645** has very small diameter in order to control the fine liquid crystal dropping amount and the discharging opening **646** is protruded from the supporting portion **647**. Here, the nozzle **645** may also include a protection member to protect discharging opening **646** as described in Korean Patent Application Nos. 7151/2002 and 7772/2002 which are hereby incorporated by reference for all purposes as if fully set forth herein.

A needle **636** made of the metal such as the stainless steel is inserted into the liquid crystal container **624**, and one end part of the needle **636** contacts with the needle sheet **643**. Especially, the end of the needle contacted with the needle sheet **643** is conically shaped to be inserted into the discharging hole **644** of the needle sheet **643** so as to close the discharging hole **644**.

Further, a spring **628** is installed on the other end of the needle **636** located in the upper case **626** of the liquid crystal dispensing apparatus **620**, and a magnetic bar **632** above which a gap controlling unit **634** is connected is mounted on an upper part of the needle **636**. The magnetic bar **632** is made of magnetic material such as a ferromagnetic material or a soft magnetic material, and a solenoid coil **630** of cylindrical shape is installed on outer side of the magnetic bar **632** to be surrounded thereof. The solenoid coil **630** is connected to an electric power supplying unit to supply the electric power thereto. Thus, a magnetic force is generated on the magnetic bar **632** as the electric power is applied to the solenoid coil **630**.

The needle **636** and the magnetic bar **632** are separated by a predetermined interval (x). When the electric power is applied to the solenoid coil **630** from the electric power supplying unit **650** to generate the magnetic force on the magnetic bar **632**, the needle **636** is contacted with the magnetic bar **632** by the generated magnetic force. When the electric power supplying is stopped, the needle **636** is returned to the original position by the elasticity of the spring **628** installed on the end of the needle **636**. By the movement of the needle in up-and-down direction, the discharging hole **644** formed on the needle sheet **643** is opened or closed. The end of the needle **636** and the needle sheet **643** repeatedly contact to each other according to the supplying status of the electric power to the solenoid coil **630**. Accordingly, the end of the needle **636** and the needle sheet **643** may be damaged by the repeated shock of the repeated contact. Therefore, it is desirable that the end of the needle **636** and the needle sheet **643** be formed using a material which is strong with respect to shock. For example, a hard metal may be used to prevent the damage caused by the shock. As a result, the needle **636** and needle sheet **643** may be formed of stainless steel.

As shown in FIG. **24**B and referring to FIG. **25**, when the electric power is applied to the solenoid coil **630**, the discharging hole **644** of the needle sheet **643** is opened by the moving of the needle **636** upward, and accordingly, the nitrogen gas supplied into the liquid crystal container **624** compresses on the liquid crystal to drop the liquid crystal **607** through the nozzle **645**. At that time, the dropping amount of the liquid crystal **607** is dependant upon the opening time of the discharging hole **644** and the pressure compressed onto the liquid crystal. The opening time is determined by the distance (x) between the needle **636** and the magnetic bar **632**, the magnetic force of the magnetic bar **632** generated by the solenoid coil, and the tension of the spring **628** installed on the needle **636**. The magnetic force of the magnetic bar **632** can be controlled according to the winding number of the solenoid coil **630** installed around the magnetic bar **632** or the magnitude of the electric power applied to the solenoid coil **630**. And the distance x between the needle **636** and the magnetic bar **632** can be controlled by the gap controlling unit **634** installed on the end part of the magnetic bar **632**.

Although not shown, the solenoid coil **630** may be installed around the needle **636** instead of the magnetic bar **632**. In that case, the needle **636** is magnetized when the electric power is applied to the solenoid coil **630** because the needle is made using a magnetic material, and therefore, the needle **636** moves upward to contact with the magnetic bar **632** because the magnetic bar **632** is fixed and the needle can move in up-and-down direction.

As described above, the liquid crystal container **624** is formed using the metal such as the stainless steel and it is connected to the nozzle through which the liquid crystal is dropped on the substrate using the protrusion formed on the liquid crystal container **624**, according to the present invention. Therefore, the liquid crystal container **624** can be easily fabricated, the fabrication cost can be reduced, and the inexact dropping of liquid crystal can be prevented effectively. However, there may some problems in the metal container as follows. That is, when the liquid crystal contacts with the metal, the metal and the liquid crystal react chemically. By this reaction, the liquid crystal may be contaminated. As a result, the LCD using this contaminated liquid crystal may have inferiority.

In the present invention, a fluorine resin film (e.g., teflon layer) **625** is preferably formed on inner side of the metal container **624** by dipping or spraying method in order to prevent the liquid crystal from being contaminated, as shown in FIG. **26**. Generally, the fluorine resin film **625** has characteristics such as abrasion resistance, heat resistance, and chemical resistance. Thus, the fluorine resin film **625** is able to prevent the liquid crystal from being contaminated effectively.

Since the fluorine resin film **637** is preferably also formed on a surface of the needle **136** made of the metal, the contamination of the liquid crystal due to the chemical reaction between the metal and the liquid crystal can be prevented more effectively.

On the other hand, the fluorine resin film **625** or **637** provides low friction coefficient. The liquid crystal has the viscosity higher than that of general liquid. Therefore, when the needle **636** moves in the liquid crystal, and movement of the needle **636** is delayed by the friction between the liquid crystal and the surface of the needle **636**. Although it is possible that the opening time of the discharging hole can be calculated by adding the delay of the needle movement as a variable, the amount of the liquid crystal contained in the liquid crystal container is reduced and accordingly the delaying time of the needle is also reduced. Therefore, it is difficult to drop exact amount of liquid crystal. However, in case that the fluorine resin film **637** is formed on the needle **636** as in the present invention, the friction between the fluorine resin film **637** and the liquid crystal is decreased by the low friction coefficient. Accordingly, the delay due to the movement of the needle may be trivial. Therefore, the opening time of the discharging hole **646** can be set to be constant and exact amount of the liquid crystal can be dropped.

At that time, although the fluorine resin film **637** may be formed only on the area where the hard metal is not formed (that is, the area except the end part of the conical shape), it is desirable that the fluorine resin film is formed on entire surface of the needle **636**. It is because that the fluorine resin film has the abrasion resistance, and therefore, the fluorine resin film **637** can prevent the needle **636** from being abraded by the shock between the needle **136** and the needle sheet **643**.

As described above, the liquid crystal container is preferably made of a metal such as stainless steel having pressure endurance and distortion resistance. Therefore, the structure of the liquid crystal dispensing apparatus can be simple, fabrication cost can be reduced, and the inferiority of the liquid crystal dropping caused by the distortion of the liquid crystal chamber can be prevented. Also, in accordance with the present invention, the fluorine resin film of chemical resistance is preferably formed on the inner part of the liquid crystal container and on the needle, thereby preventing the contamination of the liquid crystal due to the chemical reaction between the metal and the liquid crystal.

FIG. **27**A is a cross-sectional view showing another exemplary liquid crystal dispensing apparatus when the liquid crystal is not dropped, FIG. **27**B is a cross-sectional view showing the apparatus when the liquid crystal is dropped, and FIG. **27**C is an exploded perspective view showing the apparatus. The liquid crystal dispensing apparatus **720** will be described in more detail with reference to drawings as follows.

As shown in FIGS. **27A-27**C, a cylindrical liquid crystal container **724** is enclosed in a case **722** of the liquid crystal dispensing apparatus **720**. The liquid crystal container **724** containing the liquid crystal **707** may be made of polyethylene. Further, the case **722** is made of a stainless steel to enclose the liquid crystal container **724** therein. Generally, because polyethylene has superior plasticity, it can be easily formed in the desired shape. Since polyethylene does not react with the liquid crystal **707** when the liquid crystal **707** is contained therein, polyethylene can be used for the liquid crystal container **724**. However, polyethylene has a weak strength so that it can be easily distorted by external shocks or other stresses. For example, when polyethylene is used as the liquid crystal container **724**, the container **724** may become distorted so that the liquid crystal **707** cannot be dropped at the exact position. Therefore, the container **724** should be enclosed in the case **722** made of the stainless steel or other material having greater strength. A gas supply tube **753** connected to an exterior gas supply unit **752** may be formed on an upper part of the liquid crystal container **724**. An inert gas, such as nitrogen, is provided through the gas supply tube **753** from the gas supply unit **752** to fill the portion where the liquid crystal is not contained. Thus, the gas pressure compresses the liquid crystal **707** to be dispensed.

On the lower portion of the case **722**, an opening **723** is formed. When the liquid crystal container **724** is enclosed in the case **722**, a protrusion **738** formed on a lower end portion of the liquid crystal container **724** is inserted into the opening **723** so that the liquid crystal container **724** is connected to the case **722**. Further, the protrusion **738** is connected to a first connecting portion **741**. As shown, a nut (i.e., female threaded portion) is formed on the protrusion **738**, and a bolt (i.e., male threaded portion) is formed on one side of the first connecting portion **741** so that the protrusion **738** and the first connecting portion **741** are interconnected by the nut and the bolt. Of course, it should be recognized that in this description and in the following description other connection types or configurations may be used.

A nut is formed on the other side of the first connecting portion **741** and a bolt is formed on one side of a second connection portion **742**, so that the first connecting portion **741** and the second connecting portion **742** are interconnected. A needle sheet **743** is located between the first connecting portion **742** and the second connecting portion **742**. The needle sheet **743** is inserted into the nut of the first connecting portion **741**, and then the needle sheet **743** is combined between the first connecting portion **741** and the second connecting portion **742** when the bolt of the second connecting portion **742** is inserted and bolted. A discharging hole **744** is formed through the needle sheet **743**, and the liquid crystal **707** contained in the liquid crystal container **724** is discharged through the discharging hole **744** passing through the second connecting portions **742**.

A nozzle **745** is connected to the second connecting portion **742**. The nozzle **745** is used to drop the liquid crystal **707** contained in the liquid crystal container **724** as much as a small amount. The nozzle **745** comprises a supporting portion **747** including a bolt connected to the nut at one end of the second connecting portion **742** to connect the nozzle **745** with the second connecting portion **742**, a discharging opening **746** protruded from the supporting portion **747** to drop a small amount of liquid crystal onto the substrate as a drop.

A discharging tube extended from the discharging hole **744** of the needle sheet **743** is formed in the supporting portion **747**, and the discharging tube is connected to the discharging opening **746**. Generally, the discharging opening **746** of the nozzle **745** has very small diameter to finely control the liquid crystal dropping amount, and the discharging opening **746** protrudes from the supporting portion **747**.

A needle **736** is inserted into the liquid crystal container **724**, and one end part of the needle **736** is contacted with the needle sheet **743**. Preferably, the end part of the needle **736** contacted with the needle sheet **743** is conically formed to be inserted into the discharging hole **744** of the needle sheet **743**, thereby closing the discharging hole **744**.

Further, a spring **728** is installed on the other end of the needle **736** located in an upper case **726** of the liquid crystal dispensing apparatus **720** to bias the needle **736** toward the needle sheet **743**. A magnetic bar **732** and a gap controlling unit **734** are preferably connected above the needle **736**. The magnetic bar **732** is made of magnetic material such as a ferromagnetic material or a soft magnetic material, and a solenoid coil **730** of cylindrical shape is installed on outer side of the magnetic bar **732** to be surrounded thereof. The solenoid coil **730** is connected to an electric power supplying unit **750** to supply electric power thereto, thereby generating a magnetic force on the magnetic bar **732** as the electric power is applied to the solenoid coil **730**.

The needle **736** and the magnetic bar **732** are separated by a predetermined interval (x). When the electric power is applied to the solenoid coil **730** from the electric power supplying unit **750** to generate the magnetic force on the magnetic bar **732**, the needle **736** contacts the magnetic bar **732** as a result of the generated magnetic force. When the electric power supplying is stopped, the needle **736** is returned to the original position by the elasticity of the spring **728**. By the movement of the needle **736** in up-and-down directions, the discharging hole **744** formed on the needle sheet **743** is opened or closed. The end of the needle **736** and the needle sheet **743** repeatedly contact each other according to the supplying status of the electric power to the solenoid coil **730**. Thus, the part of the needle **736** and the needle sheet **743** may be damaged by the repeated shock caused by the repeated contact. Therefore, it is desirable that the end part of the needle **736** and the needle sheet **743** are preferably formed by using a material which is strong to shock, for example, a hard metal to prevent the damage caused by the shock. Also, the needle **736** should be formed of a magnetic material in this exemplary configuration to be magnetically attracted to the magnetic bar **732**.

As shown in FIG. **27**B, as the discharging hole **744** of the needle sheet **743** is opened, the gas (nitrogen gas) supplied to the liquid crystal container **724** compresses the liquid crystal, thereby dropping liquid crystal **707** from the nozzle **745**. At that time, the dropping amount of the liquid crystal **707** is dependant upon the opening time of the discharging hole **744** and the gas pressure applied onto the liquid crystal **707**. The opening time is determined by the distance (x) between the needle **736** and the magnetic bar **732**, the magnetic force of the magnetic bar **732** generated by the solenoid coil, and the tension of the spring **728** installed on the needle **736**. The magnetic force of the magnetic bar **732** can be controlled according to the winding number of the solenoid coil **730** installed around the magnetic bar **732** or the magnitude of the electric power applied to the solenoid coil **730**. Here, the distance x between the needle **736** and the magnetic bar **732** can be controlled by the gap controlling unit **734** installed on the end part of the magnetic bar **732**.

The distance x between the needle **736** and the magnetic bar **732** as well as the tension of the spring **728** can be set by the operator. That is, the operator is able to directly set the distance x between the needle **736** and the magnetic bar **732** by operating the gap controlling unit **734**, or the operator is able to set the tension of the spring **728** by operating a spring controlling means (not shown) to change the length of the spring **728**.

In contrast, the amount of the electric power applied to the solenoid coil **730** or the amount of the nitrogen gas (N_2) supplied to the liquid crystal container **724** are controlled by the main control unit **760** through the power supply unit **750** and a flow control valve **754** installed on the gas supplying tube **753** supplying the gas into the liquid crystal container **724**, respectively. That is, the amount of the electric power supply and the flow amount of the gas are not determined by the direct operation of the operator, but by the automated control of the main control unit **760**. The amount of electric power supply and the flow amount of the gas are calculated according to input data.

As shown in FIG. **28**, the main control unit **760** comprises a data input unit **761** for inputting various data such as the size of the liquid crystal unit panel to be fabricated, the number of liquid crystal panel areas included in the substrate, the cell gap of the liquid crystal panel (i.e., a height of a spacer), and information of the liquid crystal; a dropping amount calculation unit **770** for calculating the amount of liquid crystal to be dropped onto the substrate, the number of liquid crystal drops, a single drop amount of liquid crystal, and the dropping positions of the liquid crystal based on the input data and then outputting a signal; a substrate driving unit **763** for driving the substrate based on the dropping positions of the liquid crystal calculated by the dropping amount calculation unit **770**; a power control unit **765** for supplying the electric power to the solenoid coil **730** by controlling the power supplying unit **750** based on the single dropping amount of the liquid crystal calculated by the dropping amount calculation unit **770**; a flow control unit **767** for supplying the gas into the liquid crystal container **724** from the gas supplying unit **752** by controlling the flow control valve **754** based on the single dropping amount of the liquid crystal calculated by the dropping amount calculation unit **770**; and an output unit **769** for outputting the inputted data, the calculated dropping amount and dropping positions, and current status of the liquid crystal dropping.

The input unit **761** inputs data using a general operating device such as a keyboard, a mouse, or a touch panel. The data such as the size of the liquid crystal unit panel to be fabricated, the size of the substrate, and the cell gap of the liquid crystal panel is input by the operator. The output unit **769** notifies the operator of various information. The output unit **769** includes a display device such as a cathode ray tube (CRT) or LCD and an output device such as a printer.

The dropping amount calculation unit **770** calculates the total dropping amount of liquid crystal to be dropped onto the substrate having a plurality of liquid crystal unit panel areas, an amount of each dropping, the dropping positions of each liquid crystal drop and the dropping amount of the liquid crystal to be dropped on a particular liquid crystal unit panel area. As shown in FIG. **29**, the dropping amount calculation unit **770** comprises a total dropping amount calculation unit **771** for calculating the total amount of the liquid crystal to be dropped on the liquid crystal unit panel area and the total amount of the liquid crystal to be dropped on the entire substrate having a plurality of liquid crystal unit panel areas based on the size of the liquid crystal unit panel and the cell gap input through the input unit **761**; a dropping times calculation unit **775** for calculating the number of times the liquid crystal is dropped based on the total dropping amount data calculated by the total dropping amount calculation unit **771**; a single dropping amount calculation unit **773** for calculating the single dropping amount of the liquid crystal dropped on a certain position of the substrate; and a dropping position calculation unit **777** for calculating the dropping positions on the substrate.

The total dropping amount calculation unit **771** calculates the dropping amount (Q) on the liquid crystal unit panel area according to the input size (d) of the unit panel and the cell gap (t) ($Q=d\times t$) and calculates the total dropping amount of liquid crystal to be dropped on the substrate according to the number of the unit panel areas formed on the substrate.

The dropping times calculation unit **775** calculates the number of times the liquid crystal is dropped within the unit panel area based on the input total dropping amount, the size of the unit panel, and characteristics of the liquid crystal and the substrate. Generally, in the dropping method, the liquid crystal to be dropped on the substrate spreads out on the substrate by the pressure generated when the upper and lower substrates are attached. The spreading of the liquid crystal depends on characteristics of the liquid crystal such as the viscosity of the liquid crystal and the structure of the substrate on which the liquid crystal will be dropped, for example, the distribution of the pattern. Therefore, the spreading area of the liquid crystal which is dropped once is determined by these factors. Thus, the number of drops of the liquid crystal that should be dropped is determined by considering the above spreading area. Also, the number of drops on the entire substrate is calculated from the number of drops on the respective unit panels.

Further, the single dropping amount calculation unit **773** calculates the single dropping amount of the liquid crystal based on the inputted total dropping amount. As shown in FIG. **29**, the dropping times calculation unit **775** and the single dropping amount calculation unit **773** are preferably formed separately to calculate the dropping times and the single dropping amount based on the inputted total dropping amount. However, the dropping times calculation unit **775** and the single dropping amount calculation unit **773** are related closely to each other, and the dropping times and the single dropping amount are correlated. In other words, the single dropping amount should be determined according to the dropping times.

The dropping position calculation unit **777** calculates the positions at which the liquid crystal will be dropped by calculating the area where the dropped liquid crystal spreads out based on the dropping amount and the characteristics of the liquid crystal.

The dropping times, the single dropping amount, and the dropping positions calculated as above are input into the substrate driving unit **763**, the power control unit **765**, and the flow control unit **767** of FIG. **28**. The power control unit **765** of FIG. **28** calculates the electric power based on the inputted data (for example, dropping times and the single dropping amount), and then outputs a signal to the power supplying unit **750** to supply corresponding electric power to the solenoid coil **730**. The flow control unit **767** calculates the flow amount of the gas based on the inputted data, and supplies the corresponding nitrogen gas (N_2) by controlling the flow control valve **754** of FIGS. **27**A and **27**B. Further, the substrate driving unit **763** outputs a substrate driving signal based on the calculated dropping position data to operate a substrate driving motor (not shown). Therefore, the substrate is moved to align the liquid crystal dispensing apparatus at the next dropping position on the substrate.

On the other hand, the output unit **769** displays the size of the liquid crystal unit panel, the cell gap, and the characteristic information of the liquid crystal which are input by the operator through the input unit **761**. The output unit **769** also displays the dropping number, the single drop amount, and the dropping positions which are calculated based on the input data, and the present dropping status such as the times, position, and the amount of the liquid crystal at present. Thus, the operator can identify the above information.

As described above, in the liquid crystal dispensing apparatus, the dropping positions, the number of drops, and the single drop amount of the liquid crystal are calculated based on the data input by the operator, and subsequently, the liquid crystal is dropped on the substrate automatically. The liquid crystal dropping method using the above liquid crystal dispensing apparatus will be described as follows.

FIG. **30** is a flow chart showing an exemplary liquid crystal dropping method. As shown, when the operator inputs the size of the liquid crystal unit panel, cell gap, and the characteristic information of the liquid crystal through the input unit **761** by operating the keyboard, the mouse, or the touch panel (S**801**), the total dropping amount calculation unit **771** calculates the total dropping amount of the liquid crystal to be dropped on the substrate (or each unit panel area) (S**802**). Thereafter, the dropping time calculation unit **775**, the single dropping amount calculation unit **773**, and the dropping position calculation unit **777** calculate the dropping times, the dropping position, and the single dropping amount of the liquid crystal based on the calculated total dropping amount, respectively (S**803** and S**805**).

The substrate, disposed beneath the liquid crystal dispensing apparatus **720**, is moved along the x and y directions by a motor. The dropping position calculation unit **777** calculates the next position where the liquid crystal is dropped based on the input total dropping amount, the characteristic information of the liquid crystal, and the substrate information. The dropping position calculation unit then moves the substrate by operating the motor so that the liquid crystal dispensing apparatus **720** is located at the calculated dropping position (S**804**).

As described above, the power control unit **765** and the flow control unit **767** calculate the electric power amount and flow amount of the gas corresponding to the opening time of the discharging hole **744** for the single dropping amount based on the single dropping amount of the liquid crystal in the state that the liquid crystal dispensing apparatus **720** is located at the dropping position (S**806**). Subsequently, electric power is supplied to the solenoid coil **730** and the nitrogen gas (N_2) is supplied to the liquid crystal container **724** by controlling the power supply unit **750** and the flow control valve **754** to start the liquid crystal dropping at the calculated dropping position (S**807** and S**808**).

As described above, the single dropping amount of the liquid crystal is determined by the amount of the electric power applied to the solenoid coil **730** and the amount of nitrogen gas (N_2) supplied to the liquid crystal container **724** to compress the liquid crystal. The liquid crystal dropping amount may be controlled by changing these two elements. Alternatively, the dropping amount may be controlled by fixing one element and changing another element. That is, the calculated amount of liquid crystal may be dropped on the substrate by fixing the flow amount of the nitrogen gas (N_2) supplied to the liquid crystal container **724** and by changing the amount of the electric power applied to the solenoid coil **730**. In addition, the calculated amount of the liquid crystal may be dropped on the substrate by fixing the amount of the electric power applied to the solenoid coil **730** to be the calculated amount and by changing the flow amount of the nitrogen gas (N_2) supplied to the liquid crystal container **724**.

Alternatively, the single drop amount of the liquid crystal dropped on the dropping position of the substrate can be determined by controlling the tension of the spring **728** or by controlling the distance x between the needle **736** and the magnetic bar **732**. However, it is desirable that the tensile force of the spring **728** or the distance x are set in advance because the operator is able to control these two elements by a simple manual operation.

When the liquid crystal is dropped on the substrate, the dropping amount of the liquid crystal is very small amount, for example, in order of magnitude of milligrams. Therefore, it is very difficult to drop such fine amounts exactly, and such fine amounts can be changed easily by various facts. Therefore, in order to drop exact amount of the liquid crystal on the substrate, the dropping amount of the liquid crystal should be compensated. This compensation for the dropping amount of the liquid crystal may be achieved by a compensating control unit included in the main control unit **760** of FIG. **27**A.

As shown in FIG. **31**, an exemplary compensating control unit comprises a dropping amount measuring unit **781** for measuring the amount of dropping liquid crystal and a compensating amount calculation unit **790** for comparing the measured dropping amount with the predetermined dropping amount to calculate compensating amount of the liquid crystal.

Although not shown, a balance for measuring the precise weight of the liquid crystal is installed on the liquid crystal dispensing apparatus (or on an outer part of the liquid crystal dispensing apparatus) to measure the weight of the liquid crystal at regular times or occasionally. Generally, the liquid crystal weighs only a few milligrams. Therefore, it is difficult to weigh a single liquid crystal drop exactly. Therefore, in the present invention, the amount of predetermined dropping times, for example, the liquid crystal amount of 10 drops, 50 drops, or 100 drops are preferably measured. Thus the single dropping amount of the liquid crystal can be determined.

As shown in FIG. **32**, the compensating amount calculation unit **790** comprises a dropping amount setting unit **791** for setting the dropping amount calculated by the single dropping amount calculation unit **773** as a present dropping amount; a comparing unit **792** for comparing the set dropping amount with the dropping amount measured by the dropping amount measuring unit **781** and calculating a difference value between the amounts; a pressure error calculation unit **794** for calculating an error value of the pressure corresponding to the difference value of dropping amount calculated by the comparing unit **792**; and an electric power error calculation unit **796** for calculating an error value of the electric power corresponding to the difference value of the dropping amount calculated in the comparing unit.

The pressure error calculation unit **794** outputs the error value of the pressure into the flow control unit **767**. Then, the flow control unit **767** converts the error value into the supplying amount of the gas to outputs a controlling signal to the flow control valve **754** so as to increase or decrease the flow amount of the gas flowed into the liquid crystal container **724**.

Further, the electric power error calculation unit **796** outputs the calculated error value of the electric power into the power control unit **765**. Then, the power control unit **765** converts the inputted error value into the electric power amount to apply the increased or decreased electric power into the solenoid coil **730** so as to compensate the dropping amount of the liquid crystal.

FIG. **33** is a view showing an exemplary method for compensating the dropping amount of the liquid crystal. As shown, after the liquid crystal dropping of the predetermined number of times is completed, the dropping amount of the liquid crystal is measured using the balance (S**901**). Subsequently, the measured dropping amount is compared to the set dropping amount to determine whether or not there is an error in the dropping amount (S**902** and S**903**).

If there is no error value, it means that the present dropping amount is same as the set dropping amount and the dropping process proceed. If there is an error value, the pressure error calculation unit **794** calculates the pressure of the nitrogen gas (N_2) corresponding to the error value (S**904**). Further, the flow control unit **767** calculates the flow amount of the nitrogen gas (N_2) which will be supplied to the liquid crystal container **724** based on the pressure corresponding to the error value (S**905**). Then, the flow control valve **754** is operated to supply the nitrogen gas (N_2) after increasing or decreasing to the above calculated amount from the originally calculated amount of the gas to the liquid crystal container **724**, thereby compensating the amount of liquid crystal to be dropped on the substrate (S**906** and S**909**).

Alternatively, or in addition, if there is an error in the dropping amount of the liquid crystal, the electric power error calculation unit **796** can calculate the electric power amount corresponding to the error, and applies an increased or decreased amount of electric power as compared to the calculated amount to the solenoid coil **730** by controlling the electric power supply unit **750**. Accordingly, a compensated amount of liquid crystal can be dropped on the substrate (S**907**, S**908**, and S**909**).

The compensating processes described above may be repeated. For example, whenever a predetermined number of liquid crystal drops are completed, the compensating processes can be repeated to always drop the exact amount of the liquid crystal.

During the compensating process of the liquid crystal dropping amount, the dropping amount of the liquid crystal can be compensated by controlling the flow amount of the nitrogen supplied to the liquid crystal container **724** together with the electric power applied to the solenoid coil **730** mutually. However, the dropping amount of the liquid crystal can be compensated by fixing one element and controlling another element. Further, it is desirable that the tension of the spring **728** or the distance (x) are fixed at initially predetermined values.

As described above, the position and the amount of liquid crystal dropping on the substrate are calculated by the inputted size of the unit panel area, the cell gap, and the characteristic information of the liquid crystal. Therefore, an exact amount of liquid crystal can always be dropped on the exact position. Also, if the amount of dropping liquid crystal is different from the set dropping amount, the error can be automatically compensated. Thus, defective liquid crystal panels caused by errors in the dropping amount of the liquid crystal can be prevented.

As described above, the dropping amount of the liquid crystal to be dropped on the substrate is calculated automatically based on the size of the unit panel, the cell gap, and the characteristic information of the liquid crystal. Then, the liquid crystal is dropped as the predetermined amount on the substrate. In addition, if there is an error in the dropping amount of the liquid crystal after measuring the amount of dropping liquid crystal, the error value is compensated, thereby always maintaining an exact amount of the liquid crystal to be dropped on the substrate. Therefore, the dropping position, dropping times, and the dropping amount of the liquid crystal are automatically calculated based on the inputted data, and if there is an error after measuring the dropping amount, the error is compensated automatically.

While the above descriptions have been provided for the liquid crystal dispensing apparatus having a specified structure, or the principles described above can be applied to all liquid crystal dispensing apparatus including the function of automatically calculating the dropping position, the dropping times, and the dropping amount and the function of automatic compensating, as described herein or as appreciated by those of skill in the art.

To drop exact amounts of liquid crystal onto the substrate the amount of liquid crystal dropping must be accurately controlled, a liquid crystal dispensing apparatus may use air pressure to control the dropping amounts. Such a liquid crystal dispensing apparatus is referred to as a pneumatic liquid crystal dispensing apparatus, and is described with reference to FIG. **34**.

As shown in FIG. **34**, the pneumatic liquid crystal dispensing apparatus **1020** includes a cylindrical case **1022** having a center axis that is directed vertically. A movable, long, thin bar shaped piston **1036** is supported along the center axis. An end portion of the piston **1036** is installed so as to enable movement into a nozzle **1045** that is disposed on a lower end of the case **1022**. On a side wall around the nozzle **1045** is an opening that enables liquid crystal in the liquid crystal container **1024** to flow into the nozzle **1045** through a supply tube **1026**. The liquid crystal from the nozzle **1045** is dropped according to the motion of the nozzle **1045**. However, the surface tension of the liquid crystal prevents discharge until a force is supplied.

Two air inducing holes **1042** and **1044** are formed in a side wall of an air room in the case **1022**. A separating wall **1023** divides the interior of the air room into two parts defined by the piston **1036**. The separating wall is installed to move the interior wall between the air inducing holes **1042** and **1044** using the piston **1036**. Therefore, the separating wall is moved downward when compressed air is induced from the air inducing hole **1042** into the air room, and moved upward by compressed air induced from the air inducing hole **1044** into the air room. The piston **1036** is moves up-and-down direction a predetermined amount.

The air inducing holes **1042** and **1044** are connected to a pump controlling portion **240** that removes air from and provides air to the air inducing holes **1042** and **1044**.

When operated, a predetermined amount of liquid crystal is dropped from the pneumatic liquid crystal dispensing apparatus. The dropping amount (volume) can be controlled by controlling the movement of the piston **1036** using a micro gauge **1034** that is fixed on the piston **1036** and which protrudes above the case **1022**.

In the conventional pneumatic liquid crystal dispensing apparatus the liquid crystal drop size is controlled by air pressure. However, it takes a significant amount of time to supply the air room with the air. Additionally, the movement of the separating wall by the air pressure is particularly rapid. Therefore, the liquid crystal drop size is not rapidly controllable. Also, the amount of air provided to the air room through the pump should be calculated exactly. However, it is impossible to provide the air room with the exact amount of air that is required. Moreover, motion of the piston can be changed by frictional forces between the separating wall and the piston even if the exact amount of air is provided. Therefore, it is difficult to accurately move the piston in a controlled fashion.

To solve the problems of the conventional pneumatic liquid crystal dispensing apparatus, a new electronic liquid crystal dispensing apparatus will be described in detail with reference to the accompanying Figures.

FIGS. **35**A and **35**B illustrate a liquid crystal dispensing apparatus **1120** according to the principles of the present invention, while FIG. **36** is an exploded perspective view of the liquid crystal dispensing apparatus **1120**. As shown in FIGS. **35**A, **35**B and **36**, liquid crystal **1107** is contained in a cylindrical liquid crystal container **1124**. The liquid crystal container **1124** is beneficially comprised of polyethylene. In addition, a stainless steel case **1122** houses the liquid crystal container **1124**. Polyethylene has superior plasticity, it can be formed into a desired shape easily, and polyethylene does not react with the liquid crystal **1107**. However, polyethylene can be easily distorted. Such distortion could cause liquid crystal to be dropped improperly. Therefore, the liquid crystal container **1124** is housed in the case **1122**, which, being made from stainless steel, suffers little distortion.

The liquid crystal container **1124** could be made from a metal such as stainless steel. The structure of the liquid crystal dispensing apparatus would be simplified and the fabrication cost could be reduced. But, Teflon should then be applied inside the liquid crystal dispensing apparatus to prevent the liquid crystal from contaminating chemical reactions with the metal.

Although not shown in the Figures, a gas supply tube on an upper part of the liquid crystal container **1124** is connected to a gas supply. The gas, beneficially nitrogen, fills the volume of the liquid crystal container **1124** that is not filled with liquid crystal. Gas pressure assists liquid crystal dropping.

Referring now to FIG. **36**, an opening **1123** is formed at the lower end of the case **1122**, while a protrusion **1138** is formed at the lower end of the liquid crystal container **1124**. The protrusion **1138** is inserted through the opening **1123** to enable coupling of the liquid crystal container **1124** to the case **1122**. The protrusion **1138** is mated to a first connecting portion **1141**. As shown in FIG. **36**, threads are formed on the protrusion **1138**, while receiving threads are formed on one side of the first connecting portion **1141**. This enables the protrusion **1138** and the first connecting portion **1141** to be threaded together.

Additionally, the first connecting portion **1141** and a second connecting portion **1142** are threaded so as to enable matting of the first connecting portion **1141** and the second connecting portion **1142**. A needle sheet **1143** is located between the first connecting portion **1141** and the second connecting portion **1142**. The needle sheet **1143** is inserted into the first connecting portion **1141** and is held in place when the first connecting portion **1141** and the second connecting portion **1142** are mated. The needle sheet **1143** includes a discharging hole **1144** that enables liquid crystal **1107** in the liquid crystal container **1124** to be discharged into the second connecting portion **1142**.

Also, a nozzle **1145** is connected to the second connecting portion **1142**. The nozzle **1145** is for dropping liquid crystal **1107** in small amounts. The nozzle **1145** comprises a supporting portion **1147**, comprised of a bolt that connects to the second connecting portion **1142**, and a nozzle opening **1146** that protrudes from the supporting portion **1147** to form dispensed liquid crystal into a drop.

A discharging tube from the discharging hole **1144** to the nozzle opening **1146** is formed by the foregoing components. Generally, the nozzle opening **1146** of the nozzle **1145** has a very small diameter and protrudes from the supporting portion **1147**.

Referring now to FIGS. **35**A, **35**B and **36**, a needle **1136** is inserted into the liquid crystal container **1124** through a supporting portion **1121**. One end of the needle **1136** contacts the needle sheet **1143**. That end of the needle **1136** is conically shaped and fits into the discharging hole **1144** to enable closing of the discharging hole **1144**.

A spring **1128** is installed on the other end of the needle **1136**, which extends into an upper case **1126**. The spring **1128** is received in a cylindrical spring receiving case **1150**. A spring fixing portion **1137** prevents the spring from sliding down the needle **1136**. As shown in FIG. **36**, the supporting portion **1121** includes a protruding threaded member **1139**. The spring receiving case **1150** includes mating threads that enable mating of the threaded member **1139** to the spring receiving case **1150**, thus fixing the spring receiving case **1150** on the supporting portion **1121**.

The spring receiving case **1150** further includes threads that mate with an elongated threaded bolt **1153** of a tension controlling unit **1152** that controls the tension of the spring **1128**. The bolt **1153** is threaded onto the spring receiving case **1150**. An end portion of the bolt **1153** contacts the spring **1128**. Therefore, the spring is fixed between the spring fixing portion **1137** and the bolt **1153**.

In FIGS. **35**A, **35**B and **36** the reference numeral **1154** represents a fixing plate for preventing the tension controlling unit **1152** from being moved. As shown in FIGS. **35**A and **35**B, the tension controlling unit **1152** can be rotated such that the bolt **1153** adjusts the length of the spring, and thus the spring's tension. When the tension is correct, the fixing plate can lock the spring length to produce a desired tension.

As described above, since the spring **1128** is installed and fixed between the spring fixing portion **1137** and the tension controlling unit **1152**, the tension of the spring **1128** can be set by the length of the tension controlling unit **1152** inserted into the spring receiving case **1150**. For example, when the tension controlling unit **1152** is controlled to make the length of the bolt **1153** inserted into the spring receiving case **1150** short (by make the length of the bolt outside the spring receiving case **1150** long), the length of the spring **1128** is lengthened and the tension is lowered, reference FIG. **35**B. In addition, when the length of the bolt **1153** outside the spring receiving case **1150** becomes short, the tension is increased, reference FIG. **35**A. The tension of the spring **1128** can be controlled to a desired level by controlling the tension controlling unit **1152**.

A magnetic bar **1132** above a gap controlling unit **1134** is disposed above the needle **1136**. The magnetic bar **1132** is made of magnetic material such as a ferromagnetic material or a soft magnetic material. A solenoid coil **1130** is installed around the magnetic bar. The solenoid coil **1130** is connected to an electric power supply that selectively supplies electric power to the solenoid coil **1130**. This selectively produces a magnetic bar on the magnetic bar **1132**.

The magnetic bar **1132** is separated by a predetermined interval (x) from the needle **1136**. When the electric power is applied to the solenoid coil **1130** the resulting magnetic force causes the needle **1136** to contact the magnetic bar **1132**. When the electric power is stopped, the needle **1136** returns to its stable position by the elasticity of the spring **1128**. Vertical movement of the needle causes the discharging hole **1144** to selectively open and close.

The end of the needle **1136** and the needle sheet **1143** may be damaged by the shock of repeated contact. Therefore, it is desirable that the end of the needle **1136** and the needle sheet **1143** be made from a material that resists shock. For example, a hard metal such as stainless steel is suitable.

FIG. **37** illustrates the liquid crystal dispensing apparatus **1120** when the discharging hole **1144** is open. As shown, the electric power applied to the solenoid coil **1130** causes the needle **1136** to move upward. The nitrogen gas in the liquid crystal container **1124** forces liquid crystal through the nozzle **1145**. The drop size depends on the time that discharging hole **1144** is open and on the gas pressure. The opening time is determined by the distance (x) between the needle **1136** and the magnetic bar **1132**, the magnetic force of the magnetic bar **1132** and the solenoid coil **1130**, and the tension of the spring **1128**.

The magnetic force can be controlled by the number of windings of the solenoid coil **1130**, field of the magnetic bar **1132**, or by the applied electric power. The distance x can be controlled by the gap controlling unit **1134**.

The tension of the spring **1128** is controlled by the tension controlling unit **1152**. FIG. **35**A shows the length of the spring **1128** as y_1 (having a high tension) while FIG. **35**B shows the length of the spring y_2 (having a low tension). The position Y can be adjusted by the tension controlling unit **1152**. Consequently, the returning speed of the needle **1136** can be adjusted by the tension controlling unit **1152**, the opening time of the discharging hole **1144** can be adjusted by the tension controlling unit **1152**, and the amount of liquid crystal dropped can be adjusted by the tension controlling unit **1152**. Thus, the liquid crystal drop size can be accurately controlled.

Using the tension controlling unit **1152** to control the size of the liquid crystal drop has advantageous. A controller, such as a microcomputer, as well as its costs and programming, is not required. Furthermore, overall operation is simplified.

FIG. **38**A illustrates the liquid crystal dispensing device **1220** in a state in which liquid crystal is not being dropped. FIG. **38**B illustrates the liquid crystal dispensing device **1220** in a state in which liquid crystal is being dropped. FIG. **39** is an exploded perspective view of the liquid crystal dispensing device **1220**.

Referring now to FIGS. **38**A, **38**B and **39**, as shown, the liquid crystal dispensing device **1220** includes a cylindrically shaped, polyethylene liquid crystal container **1224** that is received in a stainless steel case **1220**. Generally, polyethylene has superior plasticity, it can be easily formed into a desired shape, and does not react with liquid crystal **1207**. However, polyethylene is structurally weak and is thus easily distorted. Indeed, if the case was of polyethylene it could be distorted enough that liquid crystal might not be dropped at the exact position. Therefore, a polyethylene liquid crystal container **1224** is placed in a stainless steel case **1222**.

A gas supplying tube (not shown) that is connected to an external gas supplying (also not shown) is beneficially connected to an upper part of the liquid crystal container **1224**. A gas, such as nitrogen, is input through the gas supplying tube to fill the space without liquid crystal. The gas compresses the liquid crystal, thus tending to force liquid crystal from the liquid crystal dispensing device **1220**.

An opening **1223** (see FIG. **39**) is formed on a lower end portion of the case **1222**. A protrusion **1238**, formed on a lower end of the liquid crystal container **1224**, is inserted through the opening **1223** to enable coupling of the liquid crystal container to the case **1222**. The protrusion **1238** is coupled to a first connecting portion **1241**. As shown in FIG. **39**, the protrusion **1238** and the first connecting portion thread together.

The other end of the first connecting portion **1241** is also threaded to enable mating with a second connecting portion **1242**. A needle sheet **1243** having a discharging hole **1244** is located between the first connecting portion **1241** and the second connecting portion **1242**. Liquid crystal **1207** in the liquid crystal container **1224** is selectively discharged through the discharging hole **1244** to the second connecting portions **1242**.

A nozzle **1245** is connected to the second connecting portion **1242**. The nozzle **1245** includes a discharging opening **1246** for dropping liquid crystal **1207** as small, well-defined drops. The nozzle **1245** further comprises a supporting portion **1247** that threads into the second connecting portion **1242** to connect the nozzle **1245** to the second connecting portion **1242**. A discharging tube that extends from the discharging hole **1244** to the discharging opening **1246** is thus formed. Generally, the discharging opening **1246** of the nozzle **1245** has a very small diameter in order to accurately control the liquid crystal drop.

A needle **1236**, comprised of a first needle portion **1236** and a second needle portion **1237**, is inserted into the liquid crystal container **1224**. The first needle portion **1236** contacts with the needle sheet **1243**. The end of the first needle portion **1236** that contacts the needle sheet **1243** is conically shaped to fit into the discharging hole **1244** so as to close the discharging hole **1244**.

The first needle portion **1236** and the second needle portion **1237** are constructed to be separable. As shown in FIG. **40**, the first needle portion **1236** includes a conical shaped end that contacts the needle sheet **1243** and a threaded protrusion **1236*a*** on the other end. Also as shown in FIG. **40**, one end of the second needle portion **1237** has a threaded recess **1237*a*** that mates with the protrusion **1236*a***. Disposed between the protrusion **1236*a*** and the recess **1237*a*** is a fixing coupler **1239** that prevents the first needle portion **1236** and the second needle portion **1237** from undesirably separating. The fixing coupler **1239** is beneficially a split lock washer.

In operation, the fixing coupler **1239** is inserted onto the protrusion **1236***a*, that protrusion is mated to the recess **1237***a*, and the first and second needle portions are firmly threaded together.

The needle **1236** is designed and constructed to be separated. The needle **1235** is a very important component in the liquid crystal dispensing apparatus **1220**. In practice the first needle portion **1236** and the needle sheet **1243** form a set. If one is damaged, both are replaced. This is important because the up-and-down movement of the needle **1235** to open and close the discharging hole **1244** produces shocks. Moreover, the needle **1235** is much thinner than it is long, which means the needle **1235** is susceptible to distortion and other damage. Such damage may cause undesirable leakage from the discharging hole **1244**, meaning that liquid crystal may be dropped when it should not be dropped.

The principles of the present invention provide for a first needle portion **1236** and a second needle portion **1237** that can be separated. Thus, only the damaged portion needs to be replaced, which reduces replacement costs. This is particularly advantageous when the second needle portion **1237** is damaged since the needle sheet **1243** then does not have to be replaced (since the first needle portion **1236** continues to be used). However, it should be understood that the second needle portion **1237** should be magnetic.

While a specific separable needle **1235** has been described, the principles of the present invention are not limited to that particular needle. For example, the first needle portion **1236** and the second needle portion **1237** can be coupled without the fixing coupler **1239**. Also, a bolt may be formed on the first needle portion **1236** and a nut may be formed on the second needle portion **1237**.

Referring once more to FIGS. **38**A, **38**B and **39**, a spring **1228** is disposed on an end of the second needle portion **1237**, which is located in an upper case **1226**. A magnetic bar **1232** connected to a gap controlling unit **1234** is positioned above the end of the second needle portion **1237**. The magnetic bar **1232** is made from a ferromagnetic material or from a soft magnetic material. A cylindrical solenoid coil **1230** is positioned around the magnetic bar **1232**. The solenoid coil **1230** selectively receives electric power. That power produces a magnetic force that interacts with the magnetic bar **1232** to move the needle **1235** against the spring **1228**, thus opening the discharging hole **1244** of the needle sheet **1243**. This is why the second needle portion **1237** should be magnetic. When the electric power is stopped, the needle **1235** is returned to its static position by the elasticity of the spring **1228**, thus closing the discharge hole.

The end of the first needle portion **1236** and the needle sheet **1243** repeatedly contact each other. Accordingly, the end of the first needle portion **1236** and the needle sheet **1243** may be damaged by repeated shocks from repeated contact. Therefore, it is desirable that the end of the first needle portion **1236** and the needle sheet **1243** be formed using a material which is strong with respect to shock. For example, a hard metal, such as stainless steel may be used to prevent shock damage. As a result, the first needle portion **1236** and the needle sheet **1243** are beneficially comprised of stainless steel.

As shown in FIG. **38**B, when the discharging hole **1244** of the needle sheet **1243** is opened, the gas (nitrogen) supplied to the liquid crystal container **1224** pressurizes the liquid crystal force liquid crystal **1207** through the nozzle. It should be noted that the liquid crystal **1207** drop size depends on the time that the discharge hole is open and on the gas pressure. The opening time is determined by the distance (x) between the second needle portion **1237** and the magnetic bar **1232**, the magnetic force produced by the solenoid coil **1230**, and the tension of the spring **1228**. The magnetic force can be controlled by the number of windings that form the solenoid coil **1230**, or by the magnitude of the applied electric power. The distance x can be controlled by the gap controlling unit **1234**.

Also, although it is not shown in Figures, the solenoid coil **1230** may be installed around the second needle portion **1237**. In that case, since the second needle portion **1237** is made of a magnetic material, the second needle portion **1237** is magnetized when electric power is applied to the solenoid coil **1230**. Thus needle **1235** will rise to contact the magnetic bar **1232**.

As described above, the needle **1235** is comprised of two needle portions that can be separated. Therefore, the needle **1235** can be repaired, which reduces replacement cost if the needle becomes distorted or damaged. This is particularly advantageous if the second needle portion **1237** becomes distorted or damaged since only the second needle portion **1237** must be replaced. This avoids the need to replace the needle sheet **1243**.

As described above, there is provided a liquid crystal dispensing apparatus including a needle which can be separated and coupled, and therefore, the needle can be replaced easily at lower price when the needle is distorted or damaged. The liquid crystal dispensing apparatus of the present invention is not limited to a specified liquid crystal dispensing apparatus, but can be applied to all apparatuses used for dropping liquid crystal.

FIG. **41**A is a cross-sectional view showing an exemplary liquid crystal dispensing apparatus according to the present invention, and FIG. **41**B is an exploded perspective view. The liquid crystal dispensing apparatus **1320** according to the present invention will now be described in detail.

As shown, a cylindrical liquid crystal container **1324** is enclosed in a case **1322** of the liquid crystal dispensing apparatus. The liquid crystal container **1324** containing the liquid crystal **1307** may be made of polyethylene. Further, the case **1322** is made of a stainless steel to enclose the liquid crystal container **1324** therein. Generally, because the polyethylene has superior plasticity, it can be easily formed in the desired shape. Since polyethylene does not reacted with the liquid crystal **1307** when the liquid crystal **1307** is contained therein, the polyethylene can be used for the liquid crystal container **1324**. However, the polyethylene has a weak strength so that it can be easily distorted by external shocks or other stresses. For example, when the polyethylene is used as the liquid crystal container **1324**, the container **1324** may become distorted so that the liquid crystal **1307** cannot be dropped at the exact position. Therefore, the container **1324** should be enclosed in the case **1322** made of the stainless steel or other material having greater strength. Although not shown, a gas supply tube connected to an exterior gas supply unit may be formed on an upper part of the liquid crystal container **1324**. An inert gas, such as nitrogen, is provided through the gas supply tube from the gas supply unit to fill the portion where the liquid crystal is not filled. Thus, the gas pressure compresses the liquid crystal to be dispensed.

On the lower portion of the case **1322**, an opening **1323** is formed. When the liquid crystal container **1324** is enclosed in the case **1322**, a protrusion **1338** formed on a lower end portion of the liquid crystal container **1324** is inserted into the opening **1323** so that the liquid crystal container **1324** is connected to the case **1322**. Further, the protrusion **1338** is connected to a first connecting portion **1341**. As shown, a nut (female threaded portion) is formed on the protrusion **1338**, and a bolt (male threaded portion) is formed on one side of the first connecting portion **1341** so that the protrusion **1338** and the first connecting portion **1341** are interconnected by the nut and the bolt. Of course, it should be recognized that in this description and in the following description that other connection types or configurations may be used.

A nut is formed on the other side of the first connecting portion **1341** and a bolt is formed on one side of a second connecting portion **1342**, so that the first connecting portion **1341** and the second connecting portion **1342** are interconnected. A needle sheet **1343** is located between the first connecting portion **1341** and the second connecting portion **1342**. The needle sheet **1343** is inserted into the nut of the first coupling portion **1341**, and then the needle sheet **1343** is combined between the first connecting portion **1341** and the second connecting portion **1342** when the bolt of the second connecting portion **1342** is inserted and bolted. A discharging hole **1344** is formed on the needle sheet **1343**, and the liquid crystal **1307** contained in the liquid crystal container **1324** is discharged through the discharging hole **1344** passing through the second connecting portions **1342**.

A nozzle **1345** is connected to the second connecting portion **1342**. The nozzle **1345** is used to drop the liquid crystal **1307** contained in the liquid crystal container **1324** as a small amount. The nozzle **1345** comprises a supporting portion **1347** including a bolt connected to the nut at one end of the second connecting portion **1342** to connect the nozzle **1345** with the second connecting portion **1342**, a discharging opening **1346** protruded from the supporting portion **1347** to drop a small amount of liquid crystal on the substrate as a drop, and a protecting wall **1348** formed on an outer portion of the supporting portion **1347** to protect the discharging opening **1346**.

A discharging tube extended from the discharging hole **1344** of the needle sheet **1343** is formed in the supporting portion **1347**, and the discharging tube is connected to the discharging opening **1346**. Generally, the discharging opening **1346** of the nozzle **1345** has very small diameter to finely control the liquid crystal dropping amount, and the discharging opening **1346** protrudes from the supporting portion **1347**. Therefore, the nozzle **1345** may be affected by external forces when the nozzle **1345** is connected to the second connecting portion **1342** or separated from the second connecting portion **1342**. For example, if the discharging opening **1346** is distorted or damaged, when the nozzle **1345** is connected to the second connecting portion **1342**, the diameter and the direction of the discharging opening **1346** is changed. As a result, the liquid crystal drops onto the glass substrate cannot be controlled precisely. In addition, the liquid crystal may be sputtered through damaged portion so that the liquid crystal is dropped unwanted position. Even the liquid crystal may not be able to be dropped at all due to a breakdown of the discharging opening **1346**. Especially, if the liquid crystal drops are sputtered toward the sealing area (the area on which the sealing material is applied and the upper substrate and the lower substrate are attached thereby) by the damage of the discharging opening **1346**, the sealing material is broken around the area where the liquid crystal is sputtered when both substrates are attached, thereby causing a defect on the liquid crystal panel.

The protecting wall **1348** for protecting the discharging opening **1346** prevents the discharging opening **1346** of the nozzle **1345** from being damaged. That is, as shown, the protecting wall **1348** of predetermined height is formed around the discharging opening **1346**, to prevent external forces from damaging the discharging opening **1346**.

A needle **1336** is inserted into the liquid crystal container **1324**, and one end part of the needle **1336** is contacted with the needle sheet **1343**. Especially, the end part of the needle **1336** contacted with the needle sheet **1343** is conically formed to be inserted into the discharging hole **1344** of the needle sheet **1343** to close the discharging hole **1344**.

Further, a spring **1328** is installed on the other end of the needle **1336** located in an upper case **1326** of the liquid crystal dispensing apparatus **1320** to bias the needle **1336** toward the needle sheet **1343**. A magnetic bar **1332** and a gap controlling unit **1334** are connected above the needle **1336**. The magnetic bar **1332** is made of magnetic material such as a ferromagnetic material or a soft magnetic material, and a solenoid coil **1330** of cylindrical shape is installed on outer side of the magnetic bar **1332** to be surrounded thereof. The solenoid coil **1330** is connected to an electric power supplying unit (not shown in figure) to supply electric power thereto, thereby generating a magnetic force on the magnetic bar **1332** as the electric power is applied to the solenoid coil **1330**.

The needle **1336** and the magnetic bar **1332** are separated with a predetermined interval (x). When the electric power is applied to the solenoid coil **1330** from the electric power supplying unit (not shown) to generate the magnetic force on the magnetic bar **1332**, the needle **1336** contacts the magnetic bar **1332** as a result of the generated magnetic force. When the electric power supplying is stopped, the needle **1336** is returned to the original position by the elasticity of the spring **1328**. By the movement of the needle in up-and-down direction, the discharging hole **1344** formed on the needle sheet **1343** is opened or closed. The end of the needle **1336** and the needle sheet **1343** repeatedly contact each other according to the supplying status of the electric power to the solenoid coil **1330**. Thus, the part of the needle **1336** and the needle sheet **1343** may be damaged by the repeated shock caused by the repeated contact. Therefore, it is desirable that the end part of the needle **1336** and the needle sheet **1343** are preferably formed by using a material which is strong to shock, for example, the hard metal to prevent the damage caused by the shock. Also, the needle **1336** should be formed of a magnetic material in this exemplary configuration to be magnetically attracted to the magnetic bar **1332**.

FIG. **42** shows the liquid crystal dispensing apparatus **1320** in which the discharging hole **1344** of the needle sheet **1343** is opened by the moving of the needle **1336** in the upper direction. As the discharging hole **1344** of the needle sheet **1343** is opened, the gas (preferably N_2 gas) supplied to the liquid crystal container **1324** compresses the liquid crystal **1307** to start the dropping of the liquid crystal **1307** through the nozzle **1345**. The dropping amount of the liquid crystal **1307** is dependant upon the opening time of the discharging hole **1344** and the pressure compressed onto the liquid crystal **1307**. The opening time is determined by the distance (x) between the needle **1336** and the magnetic bar **1332**, the magnetic force of the magnetic bar **1332** generated by the solenoid coil, and the elastic force of the spring **1328** installed on the needle **1336**. The magnetic force of the magnetic bar **1332** can be controlled according to the winding number of the solenoid coil **1330** installed around the magnetic bar **1332** or the magnitude of the electric power applied to the solenoid coil **1330**. The distance x between the needle **1336** and the magnetic bar **1332** can be controlled by the gap controlling unit **1334**.

Also, although not shown, the solenoid coil **1330** may be installed around the needle **1336** instead of the magnetic bar **1332**. In that case, the needle **136** is made of the magnetic material, and therefore, the needle **1336** is magnetized when the electric power is applied to the solenoid coil **1330**. Consequently, the needle **1336** moves in the upper direction to contact with the magnetic bar **1332** because the magnetic bar **1332** is fixed and the needle **136** moves in the up-and-down direction.

FIGS. **43**A and **43**B provide enlarged views of portion A in FIG. **42**A. Here, FIG. **43**A is a perspective view, and FIG. **43**B is a cross-sectional view. As shown, the protecting wall **1348** is formed around the discharging opening **1346** of the nozzle **1345** to be the same or higher height than that of the discharging opening **1346**. In an exemplary configuration, the discharge opening **1346** projects a distance of about 0.8 times the distance of the protecting wall **1348**. Therefore, the distortion or damage of the discharging opening **1346** due to the devices such as a tool for connecting when the nozzle **1345** is connected or separated can be prevented.

Also, the size (diameter) of the nozzle **1345** is beneficially increased due to the large protecting wall **1348**. Generally, the size of the nozzle **1345** is very small. Thus, it is very difficult to handle when the nozzle **1345** is connected to or separated from the second connecting portion **1342**. However, if the size of the nozzle **1345** is increased by forming the protecting wall **1348** as in the present invention, the workability of the nozzle **1345** is improved thereby facilitating connection and separation of the nozzle, **1345**.

Though the protecting wall **1348** may be formed using any material that can protect the discharging opening **1346** from the external force. However, the stainless steel or other hard metal with high strength is preferred.

Further, as shown in FIG. **43**B, a material having higher contact angle for the liquid crystal such as a fluorine resin **1350** is applied around the discharging opening **1346** of the nozzle **1345**. The contact angle is an angle made when liquid makes a thermodynamic balance on a surface of solid material. The contact angle is a measure representing a wettability on the surface of the solid material. The nozzle **1345** is made of the metal having the low contact angle. Therefore, the metal has high wettability (that is, high hydrophile property) and high surface energy. Thus, the liquid crystal very easily spreads out. In addition, if the liquid crystal is dropped through the nozzle **1345** made of the metal, the liquid crystal is disposed as drops (a drop shape means that the contact angle is high) at the end part of the discharging opening **1346** on the nozzle **1345**, but instead spreads out on the surface of the nozzle **1345**. As the liquid crystal dropping is repeated, the liquid crystal spreads onto the surface of the nozzle **1345** and lumps.

The phenomenon of the liquid crystal spreading out on the surface of the nozzle **1345** makes the exact liquid crystal dropping impossible. If the amount of liquid crystal discharged through the discharging opening **1346** of the nozzle **1345** is controlled by controlling the opening time of the discharging opening and the gas pressure compressing the liquid crystal, some of the liquid crystal spreads out onto the surface of the nozzle **1345**. Therefore, the actual dropping amount of liquid crystal is smaller than the amount of the liquid crystal discharged through the discharging opening **1346**. Of course, the discharged amount may be controlled considering the amount of the liquid crystal spread out on the surface. However, it is not possible to calculate the amount of the liquid crystal spread out on the surface of the nozzle **1345**.

Also, since the liquid crystal lumped on the nozzle **1345** by the repeated dropping operations may later be added to the amount of the liquid crystal being discharged through the discharging opening **1346**, a larger dropping amount than expected may be dropped on the substrate. That is, the dropping amount of the liquid crystal is irregular or unpredictable due to the low contact angle characteristic of the metal liquid crystal interface.

In contrast, if a fluorine resin film **1350** having higher contact angle is formed on the nozzle **1345**, especially, around the discharging opening **1346** of the nozzle **1345**, the liquid crystal **1307** discharged through the discharging opening **1346** makes a nearly perfect drop shape instead of being spread out on the surface of the nozzle **1345**. Consequently, the liquid crystal can be dropped on the substrate precisely as amount expected.

The fluorine resin film **1350** is a teflon coating film. Three basic forms of teflons, that is, polytetrafluoro ethylene (PTFE), fluorinated ethylene prophylene (FEP), and polyfluoroalkoxy (PEA) can preferably be used. Also, an organic compound can be added to the basic forms. The fluorine resin film **1350** is formed on the surface of the nozzle **1345** by a dipping or spraying method. In FIG. **43**B, the fluorine resin film **1350** is formed only around the discharging opening **1346**, but it may be applied to entire nozzle **1345** including the protecting wall **1348**. The fluorine resin has high contact angle, and also, has various characteristics such as abrasion resistance, heat resistance, and chemical resistance. Therefore, the application of the fluorine resin film **1350** is able to prevent the distortion and damage of the nozzle **1345** by the external forces effectively.

Of course it should be recognized that the dispensing apparatus or nozzle configuration can be varied in accordance with the present invention. For example, a nozzle with a sloped discharge opening as shown in FIG. **44** can be used.

As described above, the protecting wall is installed and the fluorine resin film is formed on the nozzle of the liquid crystal dispensing apparatus, and therefore, following effects can be gained. First, the protecting wall is formed around the discharging opening **1346** of the nozzle **1345**, and therefore the distortion and the damage of the discharging opening **1346** can be prevented when the nozzle is connected or separated. In addition, the inferiority of the liquid crystal dropping caused by the distortion or the damage of the discharging opening can be prevented. Second, the phenomena that the liquid crystal is sputtered to the sealing area by the distortion of the discharging opening and the sealing area is broken by the dropped liquid crystal when the upper substrate and the lower substrate are attached can be prevented by the protecting wall **1348**. Third, the fluorine resin film **1350** is formed around the discharging opening of the nozzle, thereby permitting an exact amount of liquid crystal to be dropped on the substrate. Fourth, the fluorine resin film is formed around the discharging opening and on the entire nozzle to increase the strength of the nozzle, and thereby the nozzle is not affected by the external forces.

FIG. **19** illustrates four liquid crystal dispensing devices **420**_a_~**420**_d_ applying liquid crystal to a substrate. As shown, that substrate **405** has twelve liquid crystal panel areas **401** that are to receive liquid crystal, with the twelve liquid crystal panel areas **401** being evenly arranged in four columns. With four liquid crystal dispensing devices **420**_a_~**420**_d_ applying liquid crystal to four columns of liquid crystal panel areas **401**, rapid application of liquid crystal is possible.

However, as shown in FIG. **20**, a problem occurs when the liquid crystal is to be applied to a substrate having fifteen liquid crystal panel areas arranged in five columns when using four liquid crystal dispensing devices **420**_a_~**420**_d_. Liquid crystal can be applied quickly to four columns, but one of the four liquid crystal dispensing devices **420**_a_~**420**_d_ must apply liquid crystal to the fifth column. However, in that case one of the four liquid crystal dispensing devices **420**_a_~**420**_d_ runs out of liquid crystal faster than the other three. That is, the amount of liquid crystal in the liquid crystal dispensing device **420** that drops liquid crystal onto the fifth column is becomes than in the other liquid crystal dispensing devices **120**.

Having one liquid crystal container **424** run out of liquid crystal faster than the others is a problem. Consider that each liquid crystal dispensing device **420***a*~**420***d* has the same fixed capacity, which enables the liquid crystal dispensing devices to be interchangeable. When all liquid crystal in a liquid crystal container **424** has been applied, the liquid crystal container **424** is removed from the liquid crystal dispensing device (**420***a*~**420***d*) and cleaned. Then, the liquid crystal container **424** is re-filled. It is more efficient to clean and refill all four liquid crystal containers **424** at one time. That way, the liquid crystal dispensing devices **420***a*~**420***d* can operate with the least amount of down time, and adjustments of all of the liquid crystal dispensing device **420***a*~**420***d* can be done together. However, if one liquid crystal dispensing device **420***a*~**420***d* runs out faster than the others, efficiency is lost.

According to the present invention, the above problem is addressed by evenly dispensing liquid crystal from all of the liquid crystal dispensing devices over time. When there are M liquid crystal panel columns and N liquid crystal dispensing devices (M>N), liquid crystal is dropped onto N columns of a first substrate using the N liquid crystal dispensing devices, and then liquid crystal is dropped onto the remaining column(s) (M−N) of the first substrate using at least a first of the liquid crystal dispensing devices. Then, liquid crystal is dropped onto N columns of liquid crystal panel areas of a second substrate using the N liquid crystal dispensing devices, and then liquid crystal is dropped onto the remaining column(s) (M−N) of the second substrate using at least a second of the N liquid crystal dispensing devices.

As described above, liquid crystal is dropped onto the liquid crystal panel columns formed on respective substrates using the N liquid crystal dispensing devices. Then, liquid crystal is dropped onto the remaining liquid crystal panel columns (M−N) of different substrates using different liquid crystal dispensing devices. The result is that the liquid crystal is, over time, dispensing from the N liquid crystal dispensing devices equally.

The present invention will be described with reference to accompanying FIGS. **18**A through **20**B, which illustrate dropping liquid crystal onto substrates having fifteen liquid panel areas, arranged in five columns, using four liquid crystal dispensing devices. As shown in FIG. **21**A, liquid crystal is dropped onto the first to fourth columns of liquid crystal panel areas **401***a*~**401***d* using the four liquid crystal dispensing devices **420***a*~**420***d*. The hatched parts of the FIGs. represent the panel areas on which liquid crystal was dropped. As shown in FIG. **21**A, liquid crystal is not dropped onto the fifth column (panels **401***e*).

Then, as shown in FIG. **21**B, liquid crystal is dropped onto the fifth column (**401***e*) using the fourth liquid crystal dispensing device **420***d*. This completes the application of liquid crystal to the first substrate **451***a*. The result is that liquid crystal is dropped from the first~third liquid crystal dispensing devices **420***a*~**420***c* once, while the fourth device **420***d* is used twice.

Then, as shown in FIG. **22**A, liquid crystal is dropped onto the first~fourth columns **401***a*~**401***d* of a second substrate **451***b* by the four liquid crystal dispensing devices **420***a*~**420***d*. Liquid crystal is not dropped onto the fifth column **401***e*. Then, as shown in FIG. **22**B, liquid crystal is dropped onto the fifth column **401***e* using the third liquid crystal dispensing device **420***c*. Thus, the first, second, and fourth liquid crystal dispensing devices **420***a*, **420***b*, and **420***d* are used once, and the third liquid crystal dispensing device **420***d* is used twice. Therefore, overall, the first and the second liquid crystal dispensing devices **420***a* and **420***b* have been used twice, while the third and fourth liquid crystal dispensing devices **420***c* and **420***d* have been used three times.

Then, as shown in FIG. **23**A, liquid crystal is simultaneously dropped onto the second~fifth columns **401***b*~**401***e* of a third substrate **451***c* using the four liquid crystal dispensing devices **420***a*~**420***d*. Then, liquid crystal is dropped onto the liquid crystal panel area of the first column **101***a* using the second liquid crystal dispensing device **420***b*. Thus, the first, third and fourth liquid crystal dispensing devices **420***a*, **420***c*, and **420***d* are used once, and the second liquid crystal dispensing device **420***b* is used twice. Therefore, overall, the first liquid crystal dispensing devices **420***a* has been used three times, while the second, third and fourth liquid crystal dispensing devices **420***c* and **420***d* have been used four times.

Next, as shown in FIG. **23**B, liquid crystal is simultaneously dropped onto the second~fifth columns **401***b*~**401***e* of a fourth substrate **451***d* using the four liquid crystal dispensing devices **420***a*~**420***d*. In addition, liquid crystal is dropped onto the first column **401***a* using the first liquid crystal dispensing device **420***a*.

Therefore, overall, the all of the liquid crystal dispensing devices **420***a* have been used five times. Consequently, the remaining amount of liquid crystal in each liquid crystal container **424** is the same. Therefore, the cleaning and refilling of the liquid crystal containers can be efficiently performed at one time.

The foregoing has described a particular sequence of using four liquid crystal dispensing devices **420***a*~**420***d* to apply liquid crystal to five columns of liquid crystal panel areas **401***a*~**401***e*. However, it is not necessary to follow the specific sequence described above. For example, liquid crystal could be dropped on the first~fourth columns of every substrate, and then the fifth column could have liquid crystal applied by each of the four liquid crystal dispensing devices **420***a*~**420***d*. Furthermore, there might be six columns and four liquid crystal dispensing devices **420***a*~**420***d*. In that case, liquid crystal could be applied to four columns of a first substrate using the four liquid crystal dispensing devices, and then liquid crystal could be applied to the two remaining columns using the last two of the four liquid crystal dispensing devices. Then, liquid crystal could be applied to four columns of a second substrate using the four liquid crystal dispensing devices, and then liquid crystal could be applied to the two remaining columns using the first two of the four liquid crystal dispensing devices.

As described above, according to the present invention, liquid crystal in N liquid crystal dispensing devices is, over time, evenly dispensed onto substrates having M liquid crystal panel columns, where M>N.

As shown in FIG. **45**, a main control unit **8270**, includes an input unit **8271** inputting various kinds of information; a dropping amount calculation unit **8273** that calculates a dropping amount of liquid crystal to be applied or dropped on an entire substrate based on the input data; a dispensing pattern calculation unit **8275** that calculates a dispensing pattern of the liquid crystal based on the dropping amount of the liquid crystal calculated by the dropping amount calculation unit **8273**; a substrate driving unit **8276** that drives the substrate based on the dispensing pattern calculated by the dispensing pattern calculation unit **8275**; a power control unit **8277** that controls the power supply unit **8260** so as to supply the solenoid coil **8230** with power corresponding to the dropping amount of the liquid crystal to be dropped based on the dispensing pattern calculated by the dispensing pattern calculation unit **8275**; a flow control unit **8278** that controls the flow control valve **8261** so as to supply the liquid crystal container **8224** with a gas in an amount corresponding to the dropping amount of the liquid crystal to be dropped from the gas supply unit **8262** based on the dispensing pattern calculated by the dispensing pattern calculation unit **8275**; and an output unit **8279** that outputs the input data, the calculated dropping amount, the calculated dispensing pattern, the present status of liquid crystal dropping, and the like.

The input unit **8271**, as shown in FIG. **46**, includes a spacer height input unit **8280** that inputs a height of a spacer formed at a substrate, a liquid crystal characteristic information input unit **8282** that inputs information about characteristics of the liquid crystal such as viscosity, and a substrate information input unit **8284** that inputs a size of a liquid crystal display panel to be fabricated and various kinds of information about the substrate.

The amount of liquid crystal to be dispensed or dropped is determined by the height of a column spacer formed on the color filter substrate. However, when the height of the column spacer actually formed on a color filter substrate is different from an optimal or calculated cell gap, the amount of the liquid crystal actually filling the gap between the substrates of the fabricated liquid crystal display panel would be different from an optimal amount of liquid crystal because of the difference between generated the optimal cell gap and the height of the actually formed column spacer. If the dropping amount of the liquid crystal, which is actually dropped is smaller than the optimal dropping amount, for instance, a problem will arise in the level of black in the normally black mode or the level of white in the normally white mode.

Moreover, if the dropping amount of the liquid crystal, which is actually dropped is greater than the optimal dropping amount, a gravity failure is brought about when a liquid crystal display panel is fabricated. The gravity failure is generated because the volume of the liquid crystal layer formed inside the liquid crystal display panel increases with temperature. Thus, the cell gap of the liquid crystal display panel is expanded with the increase in liquid crystal volume. In addition, the larger volume of the liquid crystal moves downward due to gravity. Hence, the cell gap of the liquid crystal display panel becomes non-uniform, thereby degrading quality of the liquid crystal display.

In order to overcome such problems, the main control unit **8270** adjusts the dropping amount of the liquid crystal to be dropped onto the substrate in accordance with the height of the spacer formed on the substrate as well as calculates the dropping amount of the liquid crystal. In other words, the dropping amount of the liquid crystal currently calculated is compared to that calculated based on the height of the spacer, and then liquid crystal amounting to the corresponding difference is added or subtracted to be dropped on the substrate.

The height of the spacer is inputted in a spacer forming process of a TFT or color filter process. Namely, in the spacer forming process, the height of the spacer is measured and the measurement is provided to the dropping amount calculation unit **8273** through the spacer height input unit **8280**. A spacer forming line is separated from a liquid crystal dropping line. Hence, the measured height of the spacer is inputted to the spacer height input unit **8280** through wire or wireless.

The liquid crystal characteristic information input unit **8282** or the substrate information input unit **8284** inputs data through a general operating means such as a keyboard, mouse, touch panel, or the like, in which substrate information such as a size of a liquid crystal display panel to be fabricated, a substrate size, and the number of panels formed on the substrate and liquid crystal characteristic information are inputted by a user. The output unit **8279** informs the user of various information, and includes various outputting devices such as a display including cathode ray tube (CRT) and LCD and a printer.

The dropping amount calculation unit **8273** calculates a total dropping amount of the liquid crystal, which will be dropped onto an entire substrate having a plurality of liquid crystal display panels formed thereon as well as the dropping amount of the liquid crystal, which will be dropped onto each of the liquid crystal display panels of the substrate and provides the dispensing pattern calculation unit **8275** with the calculated dropping amounts.

The dispensing pattern calculation unit **8275**, as shown in FIG. **47**, includes a single dropping amount calculation unit **8286** that calculates a single liquid crystal drop amount of liquid crystal dropped on a specific position on a substrate based on the dropping amount calculated in the dropping amount calculation unit **8273**; a dropping number calculation unit **8287** that calculates the number of liquid crystal drops which will be dropped on the substrate, a drop position calculation unit **8288** that calculates positions of liquid crystal drops on the substrate based on the single liquid crystal drop amount calculated in the single dropping amount calculation unit **8286** and the dropping number calculated in the dropping number calculation unit **8287**; and a dispensing pattern decision unit **8289** that determines the dispensing pattern of the liquid crystal drops in accordance with the calculated dropping position and the type of liquid crystal panel to be formed.

The single dropping amount calculation unit **8286** calculates a single dropping amount of liquid crystal based on the calculated total dropping amount. In other words, the single dropping amount has a close relation to the total dropping amount as well as the dropping number.

The dropping number calculation unit **8287** calculates the number of drops to be dropped onto one liquid crystal panel based on an input of the total dropping amount, an area of the panel, and characteristics of the liquid crystal and the substrate.

In a general dropping dispensing method, the liquid crystal dropped on the substrate spreads over the substrate by the pressure applied thereto when upper and lower substrates are bonded to each other. Such a spread of the liquid crystal depends on liquid crystal characteristics such as viscosity of liquid crystal and structures of the substrate on which the liquid crystal will be dropped such as arrangement or disposition of pattern and the like. Hence, an area over which a single drop of liquid crystal spreads is determined by the above characteristics. The number of drops of liquid crystal is calculated considering such an area. Moreover, the number of drops to be dropped on the entire substrate is calculated in accordance with the number of drops for each unit panel to be formed on the entire substrate.

The dropping position calculation unit **8288** calculates a dropping position of liquid crystal based on the number of drops of liquid crystal dropped on the panel, the amount of liquid crystal in a single drop, pitch between the dropped liquid crystal drops, and a spreading characteristic of the liquid crystal. Specifically, the spreading characteristic of liquid crystal is important in judging whether the liquid crystal will reach the sealant on bonded substrates. Hence, the dropping position calculation unit **8288** considers the spreading characteristic of liquid crystal in calculating the dropping position to prevent the liquid crystal from contacting the sealant before the sealant is hardened. Generally, factors influencing the spreading characteristic of liquid crystal include a shape of panel, the pattern of devices, such as transistors and signal lines, formed on the panel, and rubbing direction (alignment direction) of an alignment layer of the panel. Thus, the dropping position calculation unit **8288** considers such factors so as to calculate the dropping position of liquid crystal.

As a liquid crystal display panel is generally rectangular, the distance to a corner of the panel is greater than a distance to any one side of the panel. As a result, the distance the liquid crystal has to travel to the corner is greater than the distance the liquid crystal has to travel to the sides of the panel. In addition, step differences (e.g., device heights) occur because of device patterns on the substrates. For example, the gate line crossing with data lines on a first substrate (TFT substrate) of a liquid crystal display panel and a color filter layer arranged along a data line direction on a second substrate (color filter layer). These step differences interrupt the spreading of the liquid crystal such the liquid crystal spreading speed in a device pattern direction is greater than in a direction perpendicular to the device pattern direction. The liquid crystal spreading speed of the first substrate on which the data and gate lines cross with each other is not affected greatly. However, the color filter layer on the color filter substrate affects the spreading speed of liquid crystal.

Another factor having influence on the dropping position of liquid crystal is alignment for aligning adjacent liquid crystal molecules in a specific direction by giving an alignment regulating force or a surface fixing force to an alignment layer. The alignment is provided by rubbing the alignment layer in a specific direction using a soft cloth or by photolithography. Minute grooves aligned in a specific (rubbing) direction are formed on the alignment layer by such a rubbing, and the liquid crystal molecules are aligned by the grooves in a specific direction. Because the spreading speed of the liquid crystal in an alignment direction is greater than that in another direction, the dropping position of liquid crystal is calculated by considering such a fact.

As mentioned in the above description, the dropping position of liquid crystal depends on a shape of a panel and pattern and alignment directions of a device formed on a liquid crystal display panel.

FIG. **53**A to **53**C illustrate layouts of LC dropping patterns determined in accordance with the dropping positions of liquid crystal calculated by the above factors. FIG. **53**A illustrates a dropping pattern of liquid crystal of a TN (twisted nematic) mode liquid crystal display panel. FIG. **53**B illustrates a dropping pattern of liquid crystal of an IPS (in plane switching) mode liquid crystal display panel. FIG. **53**C illustrates a dropping pattern of liquid crystal of a VA (vertical alignment) mode liquid crystal display panel.

In case of a TN mode, the alignment directions of alignment layers formed on first and second substrates are perpendicular to each other. As a result when bonding the substrates, the alignment directions of the alignment layers have a minimal influence on the overall spreading rate of the liquid crystal between the substrates. The factors that affect the spreading rate of the liquid crystal are the shape of the panel and the location of devices formed on the panel. Referring to the figures, because of the rectangular shape of the panel, the distance the liquid crystal has to travel to the any corner of the panel is greater than the distance the liquid crystal has to travel to any side of the panel. Therefore, the liquid crystal **8207** should be applied to substantially cover regions near the corners of the rectangular panel **8251***a*. In other words, the liquid crystal as applied need not substantially cover the regions near the side of the panel **8251***a*, as liquid crystal will fill these regions during spreading. In addition, due to the patterns formed on the substrate (including patterns on color filter and TFT substrates), the rate at which the liquid crystal spreads in a gate line direction is slower than the rate at which the liquid crystal spreads in the data line direction. Therefore, the liquid crystal should be applied to more substantially cover the area in the gate line direction versus the area in the data line direction.

An optimal liquid crystal dropping (dispensing) pattern considering the above factors is a dumbbell shape, as shown in FIG. **53**A. For example, such dispensing pattern has a predetermined width in a gate line direction in a central area of the panel **8251***a* and includes rectangular patterns on each side of the central area of the panel **8251***a*.

When liquid crystal is dropped to have the dumbbell shape, the drops of liquid crystal should be dropped at a uniform interval (dispensing or dropping pitch) with respect to each other. This is because the dropped liquid crystal on the substrate spreads a predetermined distance from its dropping point so as to come into contact with adjacent liquid crystal drops before the substrate bonding. If the liquid crystal does not contact the adjacent liquid crystal drops before the substrates are bonded, traces of liquid crystal will remain on the substrate. These traces may cause the failure of a liquid crystal display panel.

The dropping pitch of liquid crystal is not fixed, but can be varied in accordance with the amount of liquid crystal in a single drop and the spreading speed of liquid crystal. The dropping pitch of liquid crystal is about 9 to about 17 mm in a TN or VA mode liquid crystal display panel or about 8 to about 13 mm in an IPS mode liquid crystal display panel. Viscosity of the liquid crystal is about 10 to about 40 cps.

In IPS mode the alignment direction is different from both the gate line direction and the data line direction by an angle θ (see FIG. **53**B). The angle θ as measured from the data line is about 10~20°. In other words, in IPS mode, the spread of liquid crystal depends greatly on the alignment directions on the alignment layers on respective substrates, as well as the shape of liquid crystal display panel and the configuration of the device patterns. Hence, it is preferable that, as shown in FIG. **53**B, a lightning-like dispensing pattern is formed. Namely, a dispensing pattern having a central area and tail areas in a direction opposite to an alignment direction. In this case, the term 'lightning-like' is used for convenience of explanation and is not intended to limit a shape of the dispensing pattern of the present invention. Moreover, the 'tail area' means a portion of the dispensing pattern extending in a direction opposite to the alignment direction (e.g., substantially perpendicular to the alignment direction). Again, the term 'tail area' is used for convenience of explanation and is not intended to limit the specific shape of the dispensing pattern of the present invention.

In a vertical alignment mode the formation of an alignment direction is not necessary. Thus, the liquid crystal can be dispensed to have a generally rectangular shape at a central portion of a substrate **8251***a* or a dumbbell shape as shown in FIG. **53**A. Moreover, an alignment direction may be determined according to distortion of an electric field caused by a protrusion, rib, or frame formed on a first or second substrate **8251** or **8252**, or a slit formed at a common or pixel electrode, or a pattern of an auxiliary electrode formed on the first substrate **8251** or second substrate **8252**. If photo-alignment is utilized instead of rubbing of an alignment layer, the alignment direction is determined by the light irradiating direction.

In the dispensing device according to the present invention, as mentioned in the above description, liquid crystal is automatically dropped on the substrate after a user calculates the dispensing pattern of liquid crystal based on various data.

The present invention considers the factors having influence on the extent that the liquid crystal drops spread. These factors include substrate shape, rubbing direction of an alignment layer, and the patterns formed on the substrate. The above-explained factors affect the dispensing of the liquid crystal.

The substrate shape, rubbing direction, and patterns formed on the substrate should be considered when calculating the dispensing pattern to utilize. When the alignment direction is formed by a method other than rubbing, the factors having influence on the liquid crystal dispensing pattern may vary. For instance, when the alignment direction is formed utilizing a photo-alignment method, the photo-irradiation direction or the polarization direction of irradiated light may be considered as being a factor having influence on the dispensing pattern.

The following explanation is for embodiments according to the present invention, to which the above factors are substantially applied so as to represent dispensing patterns of liquid crystal displays of various modes.

FIG. **53**F generally illustrates a dispensing pattern **8117** of a TN mode liquid crystal display (LCD). In the case of a TN mode LCD, alignment directions of alignment layers formed on the first and second substrates are perpendicular to each other. As a result of this orientation the effect that the alignment direction have when bonding the substrates is minimized. Rather, the factors that significantly affect the spreading rate of the liquid crystal include the shape of the panel and the location of devices formed on the panel.

Device patterns on the substrate form step differences. For example, a color filter layer arranged along the data line creates step differences in the gate line direction. Accordingly, the color filter affects the spreading rate of the liquid crystal such that the spreading rate of liquid crystal is greater in the data line direction than in the gate line direction.

As liquid crystal panels are generally rectangular, the distance from the center to any corner of the panel is greater than the distance to any one side of the panel. Accordingly, rectangular dispensing pattern **117** may be arranged on the panels. The rectangular dispensing pattern still may not be adequate, however, because the spreading rate of the liquid crystal in the data line direction is greater than in the data line direction.

Therefore, as illustrated in FIG. **53**F, the dimensions of the dispensing pattern **8117** in the data line direction may be made smaller than the dimensions of the dispensing pattern **8117** in the gate line direction in order to compensate for the aforementioned anisotropic spreading rate.

In one aspect of the present invention, the dispensing pattern **8117** may be formed such that an interval L**1** between the dispensing pattern **8117** in the data line direction and a side of the liquid crystal panel **8105** is greater than the other interval L**2** between the dispensing pattern in the gate line direction and the side of the liquid crystal panel **8105**. That is, the distance L**1** should be greater than the distance L**2** (L**1**>L**2**).

The dispensing pitch is an interval between adjacent liquid crystal drops **8107** of the dispensing pattern **8117** and influences the spreading rate of the liquid crystal. Generally the liquid crystal drops **8107**, arranged within the dispensing pattern **8117**, spread isotropically and merge into adjacent liquid crystal drops. As a result, the liquid crystal drops **8107** merge together so as to cover the substrate prior to the bonding of the substrates. However, dropping traces occur if the liquid crystal drops arranged on the substrate do not come into contact with adjacent liquid crystal drops prior to the bonding of the substrates. Dropping traces are a significant reason for the degradation of the liquid crystal panels.

An important factor in preventing the degradation of the liquid crystal panel as well as uniformly distributing the liquid crystal drops is the dispensing pitch. The dispensing pitch of liquid crystal drops depends on the viscosity of the liquid crystal drops and more specifically, on the single dropping amount of liquid crystal drops arranged on the substrate.

For example, in the TN mode liquid crystal display of the present invention, the dispensing pitch is preferably set up as about 9-17 mm. As explained in detail above, the spreading rate of the liquid crystal drops is greater in the data line direction than in the gate line direction. Accordingly, the dispensing pitch t**1** in the data line direction should be set up to be greater than t**2** in the gate line direction (t**1**>t**2**).

In addition, the spreading of the liquid crystal drops **8107** arranged on the substrate may be influenced by the application of pressure to the substrates. The liquid crystal drops arranged on the substrate are spread across the substrate by pressure generated from bonding the upper and lower substrates together. Ideally when bonding the substrates pressure may be uniformly applied to the substrates. However, typically the pressure applied to the central area of the substrate is greater than the pressure applied to the circumferential area of the substrate. Therefore, the liquid crystal drops are arranged in a rectangular dispensing pattern, as shown in FIG. **53**F. The liquid crystal reaches the sealant before the liquid crystal drops is hardened because the central portion of the rectangular shape spreads faster in the data line direction (by mutual effect of the speed increasing pattern and pressure).

Although the effect of the pressure differentials may be negligible, such problems should be overcome to remove the degradation of the liquid crystal display. In order to overcome these pressure problems the dispensing pattern of liquid crystal drops as shown in FIG. **53**D is utilized.

Referring to the figure, the dispensing pattern **217** is formed so that a middle portion of the rectangular dispensing pattern is removed in part as shown in the data line direction. In other words, the width of the middle area (width along the data line direction) is smaller that the rest. Forming the dispensing pattern **8217** this way effectively prevents the degradation of liquid crystal display.

As shown in the figure, the dispensing pattern **8217** has a "dumbbell shape." The term "dumbbell shape" is used for convenience of explanation, and is not intended to limit the shape of the dispensing pattern in the present invention. The term "dumbbell-shaped dispensing pattern" means a shape formed by removing a partial middle portion of the dispensing pattern in the data line direction of an initial rectangular dispensing pattern, that is having a narrow width in the data line direction.

In the middle area of the dumbbell-shaped dispensing pattern **8217** is a first dispensing pattern **8217***a*, which has a width narrower in the data line direction than the widths of the second or third dispensing patterns **8217***b* or **8217***c*, respectively. The distance L**3** between the first dispensing pattern **8217***a* and a side of a liquid crystal panel **8205** is greater than distance L**1** of the second or third dispensing pattern **8217***b* or **8217***c* (L**3**>L**1**).

The dispensing pitches t**1**, t**2**, and t**3** of the dumbbell-shaped dispensing pattern **8217** are formed such that dispensing pitch t**1** of the second or third dispensing pattern **8217***b* or **8217***c* in the data line direction is longer than dispensing pitch t**2** in the gate line direction and dispensing pitch t**3** of the first dispensing pattern **8217***a* in the data line direction is longer than that dispensing pitch t**1** of the second or third dispensing pattern **8217***b* or **8217***c*.

The rectangular dispensing pattern having a narrow width in the data line direction (dumbbell-shaped dispensing pattern) is utilized for a TN mode liquid crystal display. Thus, enabling prompt and uniform distribution of liquid crystal drops across the substrate.

As explained in detail above for TN mode liquid crystal displays the alignment directions have minimal influence on the overall spreading of the liquid crystal. Accordingly, the dispensing patterns are formed ignoring the affect of the alignment directions. Similarly, the same techniques can be utilized in the VA mode liquid crystal displays. In general VA mode liquid crystal display have no specific alignment direction. The dispensing pattern of the VA mode liquid crystal display can be formed similar to the dispensing pattern used in the TN mode liquid crystal display. That is, a rectangular or dumbbell-shaped dispensing pattern as shown in FIG. **53**D or FIG. **53**F can be utilized. Therefore, the corresponding explanation of the dispensing pattern of the VA mode liquid crystal display is skipped.

FIG. **53**E generally illustrates a dispensing pattern **8317** of an IPS (in-plane switching) mode liquid crystal display. The alignment direction of an alignment layer in an IPS mode liquid crystal display is formed in one direction. As shown in the figure, the alignment direction is formed at an angle θ measured counter-clockwise from the gate line direction. The dispensing pattern **8317** in an IPS mode liquid crystal display depends on the shape of a liquid crystal panel, pattern shape, and the alignment direction.

The dispensing pattern **8317** of the IPS mode liquid crystal can be divided into parts. A first dispensing pattern **8317***a* in the middle of the dispensing pattern **8317** extends in along the data line direction. Because of the various patterns formed on the substrate the spreading rate of liquid crystal drops in the gate line direction is faster than that the spreading rate in the data line direction. Accordingly, the distance L**1** between the dispensing pattern **8317***a* and a side of a liquid crystal panel is greater than the distance L**2** between the dispensing pattern **8317***a* and the side of the liquid crystal panel (L**1**>L**2**).

The spread speed of liquid crystal drops in the data line direction in the TN or VA mode liquid crystal display shown in FIG. **53**D or FIG. **53**F is faster than that in the gate line direction. Yet, the spread speed of liquid crystal drops in the gate line direction in the IPS mode liquid crystal display is faster. The corresponding reason is explained as follows.

In case of a TN or VA mode liquid crystal display, a color filter layer is arranged along a data line direction and a step difference is formed along a gate line direction. Yet, in an IPS mode liquid crystal display, a color filter layer is arranged along a gate line direction and a step difference is formed along a data line direction. Hence, the dropped liquid crystal drops spread faster along the gate line direction in the IPS mode liquid crystal display. The arrangement of the color filter layer according to the mode is for using effectively a glass plate (i.e. substrate) on which a plurality of liquid crystal panels are formed. In other words, the color filter layer is formed along the gate or data line direction in accordance with the mode of the liquid crystal display in a method of fabricating a liquid crystal display using liquid crystal dropping. It is a matter of course that the arrangement direction of the color filter layer is not limited to a specific direction. More important thing is not whether a direction of a dispensing pattern established in the IPS mode liquid crystal display is an x or y direction but that the dispensing pattern extends in a direction having a slow flow speed of liquid crystal drops (or a direction of step difference of the color filter layer).

Therefore, the first dispensing pattern **8317***a* extends in the data line direction in the IPS mode liquid crystal display, which is just one of examples for an extending direction of the dispensing pattern, Instead, the first dispensing pattern **8317** can extend in any direction having a slow flow speed of liquid crystal drops.

Besides, the second dispensing patterns **8317***b* and **8317***c* extend from both ends of the first dispensing pattern **8317** in directions opposite to each other, respectively. The extending directions of the second dispensing patterns **8317***b* and **8317***c* are vertical to the alignment direction. Each of the spread speeds of liquid crystal drops in these directions is slower than the spread speed in the alignment direction, which is compensated by the second dispensing patterns **8317***b* and **8317***c*.

The factors having influence on the spread speed of liquid crystal drops in the IPS mode liquid crystal display are the shape of the pattern and the alignment direction. Hence, the two factors should be considered so as to establish the dispensing pitches.

Namely, a pitch t**1** in the data line direction, a pitch t**2** in the gate line direction, a pitch t**3** in the alignment direction, and a pitch t**4** in the direction vertical to the alignment direction should be established. Generally, the pitch of the dispensing pattern **8217** of liquid crystal drops of the IPS mode liquid crystal display is about 8-13 mm.

Considering the difference between the spread speeds of liquid crystal drops due to pattern, the pitch t**1** in the gate line direction is formed greater than that t**2** in the data line direction. Considering the spread speed in the alignment direction, the pitch t**3** in the alignment direction should be established to be greater than that t**4** in the direction vertical to the alignment direction.

The above-established dispensing pattern of liquid crystal drops has a shape like a lightning facing the data line direction. In other words, the dispensing pattern includes a middle portion on a liquid crystal panel and tail portions in directions opposite to the alignment direction of the alignment layer. In this case, the term "lightning," is used for convenience of explanation, and does not limit the scope of the shape of the dispensing pattern of the present invention.

The substrates are bonded to each other after the liquid crystal drops have been dropped along the above-established dispensing pattern from a liquid crystal dispenser. Therefore, the dropped liquid crystal drops are distributed uniformly on the entire substrate.

The above dispensing pattern is calculated before the liquid crystal drops are dropped. A nozzle is moved along the calculated dispensing pattern so as to drop the liquid crystal drops. The dispensing pattern of liquid crystal drops may be calculated by the shape of the substrate or the shape of a pattern formed on the substrate. The dispenser, although not shown in the drawing, may be connected to a control system so as to carry out the dropping of the dispensing pattern and liquid crystal drops by the control of the control system.

Various kinds of information about a substrate such as substrate area, number of panels formed on the substrate, dropping amount of liquid crystal drops, shape of substrate or panel, rubbing direction carried out on an alignment layer formed on the substrate, shape of pattern formed on the substrate, and the like are inputted to the control system. The control system calculates a total dropping amount of liquid crystal drops to be dropped on the panel or substrate, a dropping number, a single dropping amount, a dispensing pattern based on the inputted information so as to control a driving means (not shown in the drawing) for driving the liquid crystal dispenser and substrate in order to drop the liquid crystal drops on a predetermined position.

In one aspect of the present invention, the dispensing patterns illustrated in FIGS. **53**D-**53**F may be compensated if the dropping amount in the calculated dispensing pattern is different than a dropping amount in the actual dispensing pattern. By compensating the dispensing pattern, the actual shape of the actual dispensing pattern does not change from the calculated dispensing pattern. Accordingly, compensation dispensing patterns, similar to those discussed with reference to FIGS. **53**A to **53**C, may be provided in the dispensing patterns illustrated in FIGS. **53**D to **53**F.

Additionally, while referring to FIGS. **53**G to **53**S, the position of liquid crystal drops is an important factor that causes fatal failure or degradation of liquid crystal panels. As previously discussed, liquid crystal panels may be fabricated by dropping liquid crystal material on upper or lower substrates and bonding the upper and lower substrates together so as to evenly distribute the liquid crystal material over the substrates. Bonding of the upper and lower substrates may be completed by hardening a sealant after the distribution of the liquid crystal layer. However, as the liquid crystal drops spread between the substrates prior to hardening of the sealant, the liquid crystal contacts the sealant. Deleteriously, the unhardened sealant may break upon contact with the liquid crystal, and thereby degrades the integrity of the liquid crystal panel. If the sealant fails to break, particles in the sealant flow into and contaminate the liquid crystal material, and thereby degrades the integrity of the liquid crystal panel.

Degradation of the liquid crystal panel integrity may also originate from a difference between a calculated dropping position and an actual dropping position or a miscalculated dropping position.

Calculation of liquid crystal dropping positions involves determining the number of liquid crystals dropped on a panel, amount of liquid crystal material in a single liquid crystal drop, a pitch between the liquid crystal drops, and a spreading characteristic of liquid crystal drops. The spreading characteristic of liquid crystal drops may be analyzed to determine whether the liquid crystals will contact the sealant when the substrates are bonded to each other. Accordingly, the liquid crystal dropping positions should be calculated considering the spreading characteristic of liquid crystals in order to prevent the liquid crystals from reaching the sealant before the hardening of the sealant.

If an area on a substrate containing liquid crystal drops is too small, liquid crystal drops may be prevented from contacting the unhardened sealant however an excess amount of time is required to allow the liquid crystal drops to evenly distribute over the entire surface of the substrate. If an area on the substrate containing liquid crystal drops is too large, liquid crystal drops undesirably contact the unhardened sealant. Accordingly, consideration of liquid crystal panel integrity and fabrication time requirements must be made in calculating the positions of liquid crystal drops.

According to the principles of the present invention, the liquid crystal drops are positioned such that they may be distributed (e.g., spread) over about 70% of the entire area of the substrate prior to hardening the sealant and distributed (e.g., spread) over about 30% of the entire area of the substrate upon thermo-hardening of the sealant. The spreading speed of liquid crystal drops may be increased during thermo-hardening of the sealant.

The spreading characteristics of liquid crystal drops relate to the viscosity of liquid crystal material. Accordingly, factors determining the spreading characteristics of liquid crystal drops in liquid crystal displays of various sizes and modes includes substrate geometry (e.g., panel shape, size, etc.), a device pattern formed on the panel, and an alignment direction (e.g., rubbing direction) of an alignment layer on the panel. According to the principles of the present invention, the aforementioned factors may be considered such a pattern of liquid crystal drops may be used to efficiently distribute liquid crystal across the substrate.

FIGS. **53**G-**53**I illustrates the relationship between liquid crystal panel geometry and spreading characteristics of liquid crystal material. As shown in FIG. **53**G, when a circular liquid crystal drop **8107** is dropped on, for example a lower substrate **8251***c* of a square liquid crystal panel, a difference between a first distance "a" from the liquid crystal drop **8107** to a side and a second distance "b" from the liquid crystal drop **8107** to a corner is generated. As shown in FIG. **53**H, assuming the spreading speed of liquid crystal drop is isotropic on the lower substrate **8251***c*, the liquid crystal **8107** reaches the side leaving a distance "b'" between the liquid crystal drop **8107** and the corner. Consequently, no liquid crystal is distributed to the area between the liquid crystal drop **8107** and the corner of the lower substrate **8251***c*.

Referring to FIG. **53**I, a dispensing pattern **8117** including bubble type liquid crystal drops **8107** is shown. The liquid crystal drops **8107** may be dispensed on, for example, a lower substrate **8251***c* of a square liquid crystal panel such that corner portions of the dispensing pattern include a rectangular extension and pitches t**1** and t**2** that are equal to each other in x and y directions. Assuming an isotropic liquid crystal spreading speed, the liquid crystal drops in the dispensing pattern **8117** may be evenly distributed across the lower substrate **8251***c* upon bonding the substrates and prior to hardening the sealant. Accordingly, the liquid crystal drops, spread during a bonding process, are brought to equal distances from the corners and sides of the substrate **8251***c*.

It is, however, noted that the dispensing pattern **8117** need not necessarily be limited to any specific shape but may be modified in accordance with the shape of the substrate. For example, if the substrate is rectangular, the dispensing pattern of liquid crystals dropped on the substrate may also have a rectangular shape having that extends to corner areas such that distances between distributed liquid crystal drops and sides of a substrate and distances between distributed liquid crystal drops and corners of substrate are the same.

As mentioned above, an alignment direction of an alignment layer influences the shape of a particular dispensing pattern. Alignment layers provide an alignment regulating force or surface fixing force to align adjacent liquid crystal molecules in a specific direction. Alignment may be achieved by rubbing the alignment layer with a smooth cloth in a specific direction (e.g., rubbing direction) to produce micro grooves arranged in the rubbing direction.

FIGS. **53**J-**53**M illustrates the relationship between alignment direction of an alignment layer and spreading characteristics of liquid crystal material. As shown in **53**J, when an alignment direction of an alignment layer is provided in the arrow direction, grooves are formed on the alignment layer along the alignment direction. Referring to FIG. **53**K, when, for example, a circular liquid crystal drop **8127** are provided on a lower substrate **8251***c* of a square liquid crystal panel, a spreading speed of the dropped liquid crystals increases in the rubbing direction because the liquid crystals spread through the grooves on the alignment layer. Accordingly, the liquid crystal drop **8127** may be distributed as an oval shape with a long axis parallel to the alignment direction.

Referring to FIG. **53**M, a dispensing pattern **8117** including bubble type liquid crystal drops **8107** is shown. The liquid crystal drops **8127** may be dispensed on, for example, a lower substrate **8251***c* of a square liquid crystal panel. Liquid crystal drops **8127** may be provided in a oval shaped dispensing pattern **8117**. The short axis of the oval shaped dispensing pattern **8117** is parallel with the alignment direction of the alignment layer. The long axis of the oval shaped dispensing pattern **8117** is transverse to the alignment direction of the alignment layer. In one aspect of the present invention, the oval shaped dispensing pattern **8117** has a long-axis-directional pitch t**1** smaller than a short-axis-directional pitch t**2**. Therefore, the liquid crystal drops may be distributed uniformly across the entire substrate **8115** upon bonding the substrates together.

As mentioned above, patterns formed on a substrate influence the distribution shape of a particular dispensing pattern. Patterns generate step differences on the substrate. Step differences interrupt the flow of liquid crystal material within the liquid crystal drops in their distribution to anisotropically affect the spreading speed of liquid crystal drops.

Referring to FIG. **53**N, lower substrate **8251***c* of a liquid crystal panel containing TFTs includes a plurality of red (R), green (G), blue (B) pixels, **8106***a* to **8106***c* arranged in a matrix. Although not shown in the drawing, the pixels **106***a* to **106***c* may be defined by a plurality of gate and data lines arranged horizontally and vertically. A driving device and a pixel electrode (not shown) may be formed in each of the pixels **8106***a* to **8106***c*. Referring to FIG. **53**O, R, G, B color filters **8104***a* to **8104***c* may be formed on an upper substrate **8103**. The R, G, and B color filters **8104***a*, **8104***b*, and **8104***c* correspond to the pixels **8106***a* to **8106***c* formed on the lower substrate **8155**, respectively. Moreover, a black matrix **8108** may be formed between the color filters **8104***a* to **8104***c* of the upper substrate **8252***c*. The black matrix **8108** prevents light from leaking to a non-display area of a liquid crystal display and is arranged adjacent areas between the pixels **8106***a* to **8106***c* so as to prevent light from leaking through the areas.

FIG. **53**P illustrates a cross-sectional view along a cutting line A-A' in FIG. **53**O. Referring to FIG. **53**P, a plurality of black matrixes **8108** may be formed on the upper substrate **8252***c* having a width greater than an interval between the pixels. Color filters **8104***a* to **8104***c* may be formed in the pixel area between the black matrixes **8108**. In this case, color filters **8104***a* to **8104***c* may partially overlap the black matrixes **8108** but not each other. Hence, a predetermined-high step difference may be generated on the black matrixes **8108**. Color filters **8104***a* to **8104***c* may be arranged along a data line so that step differences is generated by color filters **8104***a* to **8104***c*.

Step differences interrupt the spread of liquid crystals. Moreover, step differences provide grooves that are aligned a direction of the data line, thereby spreading of liquid crystal drops may be made smoother. When liquid crystal drops are distributed on a substrate upon pressurizing upper and lower substrates, the step difference induces anisotropic spreading speeds in directions of gate and data lines. As shown in FIG. **53**Q, when a circular-shaped liquid crystal **8137** is dropped on a central area of a substrate **8251***c*, the spreading speeds in directions of the data and gate line are different from each other. For example, the spreading speed in the direction of the data line is faster than the spreading speed in the direction of the gate line because no step difference exists along the data line direction. Accordingly, the circular liquid crystal drop **8137** shown in FIG. **53**Q may be transformed into an oval shaped liquid crystal drop **8137** having long and short axes in the data and gate line directions, respectively, as shown in FIG. **53**R after the substrate have been bonded.

Referring to FIG. **53**S, a dispensing pattern **8147** including bubble type liquid crystal drops **8251***c* is shown. The liquid crystal drops **8137** may be dispensed on, for example, a lower substrate **8251***c* of a square liquid crystal panel. Liquid crystal drops **8137** may be provided in an oval shaped dispensing pattern **8147**. The short axis of the oval shaped dispensing pattern **8147** parallel to a data line direction. The long axis of the oval shaped dispensing pattern **8147** is parallel to the gate line direction. In one aspect of the present invention, the pitches of the oval shaped dispensing pattern **8147** has a gate-line-directional pitch t**2** is greater than a data-line-directional pitch t**1**. Therefore, the liquid crystal drops may be distributed uniformly across the entire substrate **8251***c* upon bonding the substrates together.

Patterns influencing the distribution shape of dispensing patterns may include the lower substrate **8251***c* containing TFT substrate as well as the upper substrate **8103**. For example, any number of gate and data lines may be formed on the lower substrate **8251***c* of a TN (twisted nematic) mode liquid crystal display. In one example, a liquid crystal display having 600×800 pixels may includes include 600 gate lines and 800 data lines. Accordingly, the number of the step differences in a gate line direction outnumbers the number of step differences in a data line direction. Therefore, the step differences interrupt the spread of liquid crystals in the gate line direction so as to slow down the spreading speed of liquid crystals in the gate line direction. However, various insulating layers (e.g., organic or inorganic, etc.) and other device components may be formed on the lower substrate **8251***c* to reduce the effects the step differences present. Accordingly, the step differences' effect lower substrate **8251***c* has less influence on the distribution shape of liquid crystals than that of the color filter layers on the upper substrate **8103**.

The abovementioned factors influence individual liquid crystal drops. Accordingly, substrate shape, alignment direction, and patterns formed on the substrate should be considered so as to calculate the dispensing pattern of liquid crystal drops. Factors related to the alignment direction that influence the distribution shape may include rubbing direction or a photo-irradiation and/or polarization direction of irradiated light may.

The following explanation is for embodiments according to the present invention, to which the above factors are substantially applied so as to represent dispensing patterns of liquid crystal displays of various modes.

FIG. **53**T generally illustrates a dispensing pattern **8157** of a TN mode liquid crystal display (LCD). In the case of a TN mode LCD, alignment directions of alignment layers formed on the first and second substrates are perpendicular to each other. As a result of this orientation the effect that the alignment direction have when bonding the substrates is minimized. Rather, the factors that significantly affect the spreading rate of the liquid crystal include the shape of the panel and the location of devices formed on the panel.

Device patterns on the substrate form step differences. For example, a color filter layer arranged along the data line creates step differences in the gate line direction. Accordingly, the color filter affects the spreading rate of the liquid crystal such that the spreading rate of liquid crystal is greater in the data line direction than in the gate line direction.

As liquid crystal panels are generally rectangular, the distance from the center to any corner of the panel is greater than the distance to any one side of the panel. Accordingly, rectangular dispensing pattern **8157** may be arranged on the panels. The rectangular dispensing pattern still may not be adequate, however, because the spreading rate of the liquid crystal in the data line direction is greater than in the data line direction.

Therefore, as illustrated in FIG. **53**U, the dimensions of the dispensing pattern **8217** in the data line direction may be made smaller than the dimensions of the dispensing pattern **8217** in the gate line direction in order to compensate for the aforementioned anisotropic spreading rate.

In one aspect of the present invention, the dispensing pattern **8217** may be formed such that an interval L**1** between the dispensing pattern **8217***b* in the data line direction and a side of the liquid crystal panel **8251***c* is greater than the other interval L**2** between the dispensing pattern in the gate line direction and the side of the liquid crystal panel **8251***c*. That is, the distance L**1** should be greater than the distance L**2** (L**1**>L**2**).

The dispensing pitch is an interval between adjacent liquid crystal drops **8207** of the dispensing pattern **8217** and influences the spreading rate of the liquid crystal. Generally the liquid crystal drops **8207**, arranged within the dispensing pattern **8217**, spread isotropically and merge into adjacent liquid crystal drops. As a result, the liquid crystal drops **8207** merge together so as to cover the substrate prior to the bonding of the substrates. However, dropping traces occur if the liquid crystal drops arranged on the substrate do not come into contact with adjacent liquid crystal drops prior to the bonding of the substrates. Dropping traces are a significant reason for the degradation of the liquid crystal panels.

An important factor in preventing the degradation of the liquid crystal panel as well as uniformly distributing the liquid crystal drops is the dispensing pitch. The dispensing pitch of liquid crystal drops depends on the viscosity of the liquid crystal drops and more specifically, on the single dropping amount of liquid crystal drops arranged on the substrate.

For example, in the TN mode liquid crystal display of the present invention, the dispensing pitch is preferably set up as about 9-17 mm. As explained in detail above, the spreading rate of the liquid crystal drops is greater in the data line direction than in the gate line direction. Accordingly, the dispensing pitch t**1** in the data line direction should be set up to be greater than t**2** in the gate line direction (t**1**>t**2**).

In addition, the spreading of the liquid crystal drops **8207** arranged on the substrate may be influenced by the application of pressure to the substrates. The liquid crystal drops arranged on the substrate are spread across the substrate by pressure generated from bonding the upper and lower substrates together. Ideally when bonding the substrates pressure may be uniformly applied to the substrates. However, typically the pressure applied to the central area of the substrate is greater than the pressure applied to the circumferential area of the substrate. Therefore, the liquid crystal drops are arranged in a rectangular dispensing pattern, as shown in FIG. **53**U. The liquid crystal reaches the sealant before the liquid crystal drops is hardened because the central portion of the rectangular shape spreads faster in the data line direction (by mutual effect of the speed increasing pattern and pressure).

Although the effect of the pressure differentials may be negligible, such problems should be overcome to remove the degradation of the liquid crystal display. In order to overcome these pressure problems the dispensing pattern of liquid crystal drops as shown in FIG. **53**U is utilized.

Referring to the figure, the dispensing pattern **8217** is formed so that a middle portion of the rectangular dispensing pattern is removed in part as shown in the data line direction. In other words, the width of the middle area (width along the data line direction) is smaller that the rest. Forming the dispensing pattern **8217** this way effectively prevents the degradation of liquid crystal display.

As shown in the figure, the dispensing pattern **8217** has a “dumbbell shape.” The term “dumbbell shape” is used for convenience of explanation, and is not intended to limit the shape of the dispensing pattern in the present invention. The term “dumbbell-shaped dispensing pattern” means a shape formed by removing a partial middle portion of the dispensing pattern in the data line direction of an initial rectangular dispensing pattern, that is having a narrow width in the data line direction.

In the middle area of the dumbbell-shaped dispensing pattern **8217** is a first dispensing pattern **8217***a*, which has a width narrower in the data line direction than the widths of the second or third dispensing patterns **8217***b* or **8217***c*, respectively. The distance L**3** between the first dispensing pattern **8217***a* and a side of a liquid crystal panel **8205** is greater than distance L**1** of the second or third dispensing pattern **8217***b* or **8217***c* (L**3**>L**1**).

The dispensing pitches t**1**, t**2**, and t**3** of the dumbbell-shaped dispensing pattern **8217** are formed such that dispensing pitch t**1** of the second or third dispensing pattern **8217***b* or **8217***c* in the data line direction is longer than dispensing pitch t**2** in the gate line direction and dispensing pitch t**3** of the first dispensing pattern **8217***a* in the data line direction is longer than that dispensing pitch t**1** of the second or third dispensing pattern **8217***b* or **8217***c*.

The rectangular dispensing pattern having a narrow width in the data line direction (dumbbell-shaped dispensing pattern) is utilized for a TN mode liquid crystal display. Thus, enabling prompt and uniform distribution of liquid crystal drops across the substrate.

As explained in detail above for TN mode liquid crystal displays the alignment directions have minimal influence on the overall spreading of the liquid crystal. Accordingly, the dispensing patterns are formed ignoring the affect of the alignment directions. Similarly, the same techniques can be utilized in the VA mode liquid crystal displays. In general VA mode liquid crystal display have no specific alignment direction. The dispensing pattern of the VA mode liquid crystal display can be formed similar to the dispensing pattern used in the TN mode liquid crystal display. That is, a rectangular or dumbbell-shaped dispensing pattern as shown in FIG. **53**T or FIG. **53**U can be utilized. Therefore, the corresponding explanation of the dispensing pattern of the VA mode liquid crystal display is skipped.

FIG. **53**V generally illustrates a dispensing pattern **8317** of an IPS (in-plane switching) mode liquid crystal display. The alignment direction of an alignment layer in an IPS mode liquid crystal display is formed in one direction. As shown in the figure, the alignment direction is formed at an angle θ measured counter-clockwise from the gate line direction. The dispensing pattern **8317** in an IPS mode liquid crystal display depends on the shape of a liquid crystal panel, pattern shape, and the alignment direction.

The dispensing pattern **8317** of the IPS mode liquid crystal can be divided into parts. A first dispensing pattern **8317***a* in the middle of the dispensing pattern **8317** extends in along the data line direction. Because of the various patterns formed on the substrate the spreading rate of liquid crystal drops in the gate line direction is faster than that the spreading rate in the data line direction. Accordingly, the distance L**1** between the dispensing pattern **8317***a* and a side of a liquid crystal panel is greater than the distance L**2** between the dispensing pattern **8317***a* and the side of the liquid crystal panel (L**1**>L**2**).

The spread speed of liquid crystal drops in the data line direction in the TN or VA mode liquid crystal display shown in FIG. **53**T or FIG. **53**U is faster than that in the gate line direction. Yet, the spread speed of liquid crystal drops in the gate line direction in the IPS mode liquid crystal display is faster. The corresponding reason is explained as follows.

In case of a TN or VA mode liquid crystal display, a color filter layer is arranged along a data line direction and a step difference is formed along a gate line direction. Yet, in an IPS mode liquid crystal display, a color filter layer is arranged along a gate line direction and a step difference is formed along a data line direction. Hence, the dropped liquid crystal drops spread faster along the gate line direction in the IPS mode liquid crystal display. The arrangement of the color filter layer according to the mode is for using effectively a glass plate (i.e. substrate) on which a plurality of liquid crystal panels are formed. In other words, the color filter layer is formed along the gate or data line direction in accordance with the mode of the liquid crystal display in a method of fabricating a liquid crystal display using liquid crystal dropping. It is a matter of course that the arrangement direction of the color filter layer is not limited to a specific direction. More important thing is not whether a direction of a dispensing pattern established in the IPS mode liquid crystal display is an x or y direction but that the dispensing pattern extends in a direction having a slow flow speed of liquid crystal drops (or a direction of step difference of the color filter layer).

Therefore, the first dispensing pattern **8317**_a_ extends in the data line direction in the IPS mode liquid crystal display, which is just one of examples for an extending direction of the dispensing pattern, Instead, the first dispensing pattern **8317** can extend in any direction having a slow flow speed of liquid crystal drops.

Besides, the second dispensing patterns **8317**_b_ and **8317**_c_ extend from both ends of the first dispensing pattern **8317** in directions opposite to each other, respectively. The extending directions of the second dispensing patterns **8317**_b_ and **8317**_c_ are vertical to the alignment direction. Each of the spread speeds of liquid crystal drops in these directions is slower than the spread speed in the alignment direction, which is compensated by the second dispensing patterns **8317**_b_ and **8317**_c_.

The factors having influence on the spread speed of liquid crystal drops in the IPS mode liquid crystal display are the shape of the pattern and the alignment direction. Hence, the two factors should be considered so as to establish the dispensing pitches.

Namely, a pitch t**1** in the data line direction, a pitch t**2** in the gate line direction, a pitch t**3** in the alignment direction, and a pitch t**4** in the direction vertical to the alignment direction should be established. Generally, the pitch of the dispensing pattern **8317** of liquid crystal drops of the IPS mode liquid crystal display is about 8-13 mm.

Considering the difference between the spread speeds of liquid crystal drops due to pattern, the pitch t**1** in the gate line direction is formed greater than that t**2** in the data line direction. Considering the spread speed in the alignment direction, the pitch t**3** in the alignment direction should be established to be greater than that t**4** in the direction vertical to the alignment direction.

The above-established dispensing pattern of liquid crystal drops has a shape like a lightning facing the data line direction. In other words, the dispensing pattern includes a middle portion on a liquid crystal panel and tail portions in directions opposite to the alignment direction of the alignment layer. In this case, the term "lightning," is used for convenience of explanation, and does not limit the scope of the shape of the dispensing pattern of the present invention.

The substrates are bonded to each other after the liquid crystal drops have been dropped along the above-established dispensing pattern from a liquid crystal dispenser. Therefore, the dropped liquid crystal drops are distributed uniformly on the entire substrate.

The above dispensing pattern is calculated before the liquid crystal drops are dropped. A nozzle is moved along the calculated dispensing pattern so as to drop the liquid crystal drops. The dispensing pattern of liquid crystal drops may be calculated by the shape of the substrate or the shape of a pattern formed on the substrate. The dispenser, although not shown in the drawing, may be connected to a control system so as to carry out the dropping of the dispensing pattern and liquid crystal drops by the control of the control system.

Various kinds of information about a substrate such as substrate area, number of panels formed on the substrate, dropping amount of liquid crystal drops, shape of substrate or panel, rubbing direction carried out on an alignment layer formed on the substrate, shape of pattern formed on the substrate, and the like are inputted to the control system. The control system calculates a total dropping amount of liquid crystal drops to be dropped on the panel or substrate, a dropping number, a single dropping amount, a dispensing pattern based on the inputted information so as to control a driving means (not shown in the drawing) for driving the liquid crystal dispenser and substrate in order to drop the liquid crystal drops on a predetermined position.

FIG. **48** illustrates a flowchart of an exemplary liquid crystal dropping method according to the present invention. If a user operates a keyboard, mouse, or touch panel so as to input information, such as liquid crystal display panel information, other characteristic information of the liquid crystal display panel, and a height (i.e. cell gap) of a spacer measured in a previous process (S**8321**), through the input unit **8271**, the dropping amount calculation unit **8273** calculates a total dropping amount of liquid crystal that will be dropped onto a substrate (or panel) (S**8322**). Subsequently, the single dropping amount calculation unit **8286** and dropping number calculation unit **8287** calculate a single liquid crystal drop amount and a number of liquid crystal drops to be applied, respectively. The dropping position calculation unit **8288** then calculates a dropping position of liquid crystal based on the single drop amount and dropping number so as to calculate a dispensing pattern of liquid crystal (S**8323**, S**8324**).

A substrate disposed under the dispensing device as described above is moved in x and y directions by a motor. The dispensing pattern calculation unit **8275** calculates a position on which the liquid crystal will be dropped based on the inputted dropping amount, characteristic information of liquid crystal, and substrate information, and then moves the substrate so that the dispensing device is disposed at a determined dropping position by actuating the motor based on the calculated position on which the liquid crystal will be dropped (S**8327**, S**8328**).

When the substrate is moved, the electric power control unit and flow control unit calculate a power and a gas pressure corresponding to an open time of the discharging hole of the dispensing apparatus and the single drop amount of liquid crystal based on the calculated single drop amount of liquid crystal (S**8325**) and then control the power supply unit and flow control valve so as to supply the solenoid coil with the power and the liquid crystal container with nitrogen corresponding to the calculated gas pressure. Thus, dispensing of the liquid crystal is begun at the predetermined position (S**8326**, S**8329**).

The single drop amount is determined by the amount of power applied to the solenoid coil and the supply quantity of nitrogen applied to the liquid crystal container to pressurize the liquid crystal. The dropping amount of liquid crystal can be adjusted by varying the above two factors. Instead, the dropping amount can be controlled by fixing one of the two factors and varying the other as well. In other words, only the amount of power applied to the solenoid coil may be varied, while a flow of nitrogen supplied to the liquid crystal container **8224** is fixed as a setup amount, so as to drop a demanded amount of the liquid crystal on the substrate. On the other hand, the amount of power applied to the solenoid coil may be fixed to be a setup value, while a flow of nitrogen supplied to the liquid crystal container is varied, so as to drop a demanded amount of the liquid crystal on the substrate.

Meanwhile, the single drop amount of liquid crystal dropped on a specific position of a substrate can be varied as described above with respect to the dispensing apparatus.

The amount of liquid crystal dropped onto a substrate is a very minute amount, in the range of several milligrams. It is very difficult to drop the minute amount precisely. Besides, the predetermined amount to be dropped may easily changed by various factors. Hence, it is necessary to compensate the amount of liquid crystal to be dropped so as to drop the exact amount of liquid crystal onto the substrate all the times. Such a compensation is carried out by a compensation control unit included in the main control unit **8270**.

The compensation control unit **8290**, as shown in FIG. **49**, includes a dropping amount measuring unit **8291** that measures the dropping amount liquid crystal, a compensating amount calculation unit **8292** that calculates a compensation amount of liquid crystal by comparing the measured dropping amount to a predetermined dropping amount, and a dispensing pattern compensation unit **8293** that calculates a new dispensing pattern by compensating an initially calculated dispensing pattern by the compensating amount calculated by the compensating amount calculation unit **8292**.

Although not shown in the drawing, a scale for measuring the weight of the liquid crystal periodically or non-periodically is installed at (or outside) the dispensing device. As a minute amount of liquid crystal can weigh only several milligrams (mg), there is limit to accurately measuring these minute amounts. Accordingly, a fixed number of drops (e.g., 10, 50, or 100) can be measured and extrapolated to calculate a total dropping amount.

Referring to FIG. **50**, the compensating amount calculation unit **8292** includes a dropping amount setting unit **8295** that sets the dropping amount calculated by the single dropping amount calculation unit **8286** in FIG. **47** as a current dropping amount; a comparison unit **8296** that compares the set dropping amount to a dropping amount measured by the dropping amount measuring unit **8291** in FIG. **49** to calculate a difference value therebetween; and a dropping amount error calculation unit **8297** that calculates an error value of the dropping amount of liquid crystal corresponding to the amount compared by the comparison unit **8296**.

The dispensing pattern compensation unit **8293**, as shown in FIG. **51**, includes a single dropping amount compensation unit **8293***a* that calculates a single compensating amount based on the dropping amount error calculated by the compensating amount calculation unit **8292** in FIG. **49**; a dropping number compensation unit **8293***b* that calculates a compensated dropping number based on the dropping amount error; a dropping position compensation unit **8293***c* that calculates the dropping position; and a compensated pattern calculation unit **8293***d* that calculates a compensated dispensing pattern of liquid crystal based on the single compensating amount and the compensated dropping number calculated in the single dropping number compensation unit **8293***a*, the dropping amount compensation unit **8293***b*, and the dropping position compensation unit **8293***c*.

The compensated dispensing pattern calculated by the compensated dispensing pattern calculation unit **8293***d* includes the compensated single dropping amount and compensated dropping number. Hence, the power control unit **8297** calculates an electric power corresponding to the compensated dropping amount to output a signal corresponding to the calculated electric power to the power supply unit **8260**, and the power supply unit **8260** supplies the solenoid coil (not shown) with the electric power corresponding to the dropping amount compensated in accordance with the signal. Moreover, the flow control unit **8298** calculates a pressure corresponding to the compensated dropping amount to output a corresponding signal to the flow control valve (not shown), and the flow control valve supplies the dispensing device **8220** with a gas flow corresponding to the dropping amount compensated in accordance with the inputted signal.

FIG. **52** illustrates a flowchart of a method of compensating the liquid crystal dropping amount according to the present invention. Referring to FIG. **52**, after the predetermined number of liquid crystal drops have been carried dispensed, the amount of liquid crystal dropped is measured using a scale (S**8331**). Subsequently, the measured dropping amount is compared to the predetermined measuring amount to determine whether the correct amount of liquid crystal has been dispensed, i.e., whether or not there is an error value of dropped liquid crystal (S**8332**, S**8333**).

If there is no error value, it is judged that the amount of liquid crystal that has been dropped is equal to the predetermined amount. If there is an error value, the error is calculated to compensate the dispensing pattern and the dispensing pattern compensation unit **8293** calculates a new dispensing pattern (S**8334**). After the substrate has been moved to a dropping position determined by the compensated dispensing pattern (S**8335**), a power amount error corresponding to the dropping amount error is calculated to calculate a compensated power amount, and the power control unit **8297** is controlled to supply the solenoid coil with the calculated power amount from the power supply unit **8260** to drop the compensated amount of liquid crystal on the dropping position (S**8336**, S**8337**, S**8341**).

Moreover, the compensated pattern calculation unit **8293***d* calculates a gas pressure error corresponding to the dropping amount error (S**8338**). Thereafter, a flow supply amount corresponding to the gas pressure error is calculated to provide a compensated flow supply amount. A corresponding amount of gas is supplied from the gas supply unit **8262** to the liquid crystal container **8224** to control the flow control valve **8261** to drop the compensated amount of liquid crystal on the compensated dropping position (S**8339**, S**8340**, S**8341**).

The above-described processes for compensating the dropping amount of liquid crystal are repeated. Whenever the liquid crystal droppings of the predetermined number have been applied, the above compensation process is repeated so as to drop the exact amount of liquid crystal on the substrate.

Generally, the compensation of the dropping amount of liquid crystal, as mentioned in the forgoing description, is achieved by compensating the single dropping amount by controlling the power supply unit **8260** and flow control valve. Since the single dropping amount of liquid crystal is very minute, it is very difficult to adjust the single dropping amount precisely. It is a matter of course that both of the single dropping amount and the dropping number should be compensated in order to compensate the dropping amount of liquid crystal exactly, which is more difficult. Therefore, for a simpler compensation of the dropping amount, the dropping amount of liquid crystal can be compensated by compensating the number of drops of liquid crystal only. 'Compensating the number of drops of liquid crystal' means that the dispensing pattern is compensated by calculating a new dropping position for the predetermined dispensing pattern.

When the dispensing pattern is compensated by adjusting the number of liquid crystal drops, the basic dispensing patterns described above are not modified. Because the calculated (or predetermined) dispensing pattern includes all the factors required for the liquid crystal dropping, the calculation of new dispensing pattern is difficult as well. Therefore, when the dropping amount of liquid crystal is adjusted in the present invention, the dropping amount is applied using the previously calculated dispensing pattern. When liquid crystal is initially applied, liquid crystal is not applied to certain areas of the dispensing patterns. As shown in FIG. **53**A, FIG. **53**B, and FIG. **53**C, certain portions of dispensing patterns **8207***a* are reserved for adjusting the amount of liquid crystal applied. For example, the portions of the patterns indicated by the solid lines in FIG. **53**A, FIG. **53**B, and FIG. **53**C are the actual dispensing patterns, while additional dropping patterns **8207***b* as indicated by dotted lines are compensation dispensing patterns. Namely, when the actual amount of liquid crystal dropped is smaller than the predetermined dropping amount (i.e., the liquid crystal amount should actually be increased), liquid crystal may also be dropped in the compensation dispensing pattern to provide for additional liquid crystal on the panel. That is, the amount of liquid crystal actually dropped on the panel is increased to be the predetermined dropping amount. Moreover, when the measured dropping amount exceeds the predetermined dropping amount, no liquid crystal is applied in the compensation dispensing pattern **8207***b*.

In the above description, the liquid crystal **8207** is dropped on the first substrate **8251** as a TFT array substrate, while the Ag dots and sealant are coated on the second substrate (not shown in FIG. **53**) as a color filter array substrate. Yet, in accordance with a mode of liquid crystal display, the liquid crystal **8207** can be dropped on the second substrate (not shown in FIG. **53**) as a color filter array substrate, while the Ag dots and sealant are formed on the first substrate **8251** as a TFT array substrate.

FIGS. **54**A to **54**D are perspective views illustrating a method of manufacturing an LCD device according to the present invention;

Although the drawings illustrate only one unit cell, a plurality of unit cells may be formed depending upon the size of the substrate.

As shown in FIG. **54**A, a lower substrate **1651** and an upper substrate **1652** are prepared for the process. A plurality of gate and data lines (not shown) are formed on the lower substrate **1651**. The gate lines cross the data lines to define a pixel region. A thin film transistor (not shown) having a gate electrode, a gate insulating layer, a semiconductor layer, an ohmic contact layer, source/drain electrodes, and a protection layer is formed at each crossing point of the gate lines and the data lines. A pixel electrode (not shown) connected with the thin film transistor is formed in the pixel region.

An alignment film (not shown) is formed on the pixel electrode to initially align the molecules of liquid crystal. The alignment film may be formed of polyamide or polyimide based compound, polyvinylalcohol (PVA), and polyamic acid by rubbing. Alternatively, the alignment film may be formed of a photosensitive material, such as polyvinvylcinnamate (PVCN), polysilioxanecinnamate (PSCN) or cellulosecinnamate (CelCN) based compound, by using a photo-alignment method.

A light-shielding layer (not shown) is formed on the upper substrate **1652** to shield light leakage from the gate lines, the data lines, and the thin film transistor regions. A color filter layer (not shown) of R, G, and B is formed on the light-shielding layer. A common electrode (not shown) is formed on the color filter layer. Additionally, an overcoat layer (not shown) may be formed between the color filter layer and the common electrode. The alignment film is formed on the common electrode.

Silver (Ag) dots are formed outside the lower substrate **1651** to apply a voltage to the common electrode on the upper substrate **1652** after the lower and upper substrates **1651** and **1652** are attached to each other. Alternatively, the silver dots may be formed on the upper substrate **1652**.

For an in plane switching (IPS) mode LCD, the common electrode is formed on the lower substrate like the pixel electrode, and so that an electric field can be horizontally induced between the common electrode and the pixel electrode. The silver dots are not formed on the substrate.

As shown in FIG. **54**, a liquid crystal **1607** is applied onto the lower substrate **1651** to form a liquid crystal layer in accordance with the liquid crystal application principles described herein.

An auxiliary UV curable sealant **1670***a* is formed in a dummy area at a corner region of the upper substrate **1652**, subsequently, a main UV curable sealant **1670***b* having no injection hole is formed, using a dispensing method.

The auxiliary UV sealant **1670***a* is prevents any problem that may occur due to a sealant concentrated upon the end of a nozzle of a dispensing device. Therefore, it does not matter where the auxiliary UV sealant **1670***a* is formed in the dummy area of the substrate, i.e., any blob of sealant will be formed away from the active region of the liquid crystal display device and away from a region where the liquid crystal panel will be cut away from the mother substrate assembly. Formation of the main UV sealant **1670***b* is preceded by the formation of the auxiliary UV sealant **1670***a*. The auxiliary UV sealant **1670***a* may be formed in a straight line as shown. Alternatively, the auxiliary UV sealant **1670***a* may be formed in a curved line or other shape as long as it is formed in a dummy region.

Monomers or oligomers each having both ends coupled to the acrylic group, mixed with an initiator are used as the UV sealants **1670***a* and **1670***b*. Alternatively, monomers or oligomers each having one end coupled to the acrylic group and the other end coupled to the epoxy group, mixed with an initiator are used as the UV sealants **1670***a* and **1670***b*.

Also, the liquid crystal **1607** may be contaminated if it comes into contact with the main UV sealant **1670***b* before the main UV sealant **1670***b* is hardened. Accordingly, the liquid crystal **1607** may preferably be applied on the central part of the lower substrate **1651**. In this case, the liquid crystal **1607** is gradually spread even after the main UV sealant **1670***b* is hardened. Thus, the liquid crystal **1607** is uniformly distributed on the substrate.

The liquid crystal **1607** may be formed on the upper substrate **1652** while the UV sealants **1670***a* and **1670***b* may be formed on the lower substrate **1651**. Alternatively, the liquid crystal **1607** and the UV sealants **1670***a* and **1670***b* may be formed on one substrate. In this case, there is an imbalance between the processing times of the substrate with the liquid crystal and the sealants and the substrate without the liquid crystal and the sealants in the manufacturing process. For this reason, the total manufacturing process time increases. Also, when the liquid crystal and the sealants are formed on one substrate, the substrate may not be cleaned even if the sealant contaminates the panel before the substrates are attached to each other.

Accordingly, a cleaning process for cleaning the upper substrate **1652** may additionally be provided before the attaching process after the UV sealants **1670***a* and **1670***b* are formed on the upper substrate **1652**.

Meanwhile, spacers may be formed on either of the two substrates **1651** and **1652** to maintain a cell gap. Preferably, the spacers may be formed on the upper substrate **1652**.

Ball spacers or column spacers may be used as the spacers. The ball spacers may be formed in such a manner that they are mixed with a solution having an appropriate concentration and then spread at a high pressure onto the substrate from a spray nozzle. The column spacers may be formed on portions of the substrate corresponding to the gate lines or data lines. Preferably, column spacers may be used for the large sized substrate since the ball spacers may cause an uneven cell gap for the large sized substrate. The column spacers may be formed of a photosensitive organic resin.

As shown in FIG. **54**C, the lower substrate **1651** and the upper substrate **1652** are attached to each other by the following processes which are described herein in detail. First, one of the substrates having the liquid crystal dropped thereon is placed at the lower side. The other substrate is placed at the upper side by turning by 180 degrees so that its portion having layers faces into the substrate at the lower side. Thereafter, the substrate at the upper side is pressed, so that both substrates are attached to each other. Alternatively, the space between the substrates may be maintained under the vacuum state so that both substrates are attached to each other by releasing the vacuum state.

Then, as shown in FIG. **54**D, UV light is irradiated upon the attached substrates through a UV irradiating device **1690**.

Upon irradiating the UV light, monomers or oligomers activated by an initiator constituting the UV sealants are polymerized and hardened, thereby bonding the lower substrate **1651** to the upper substrate **1652**.

If monomers or oligomers each having one end coupled to the acrylic group and the other end coupled to the epoxy group, mixed with an initiator are used as the UV sealants, the epoxy group is not completely polymerized by the application of UV light. Therefore, the sealants may have to be additionally heated at about 120° C. for one hour after the UV irradiation, thereby hardening the sealants completely.

Afterwards, although not shown, the bonded substrates are cut into a unit cells and final test processes are performed.

In the cutting process, a scribing process is performed by forming a cutting line on surfaces of the substrates with a pen or wheel of a material having hardness greater than that of glass, such as diamond, and then the substrates are cut along the cutting line by mechanical impact (breaking process). Alternatively, the scribing process and the breaking process may simultaneously be performed using a pen or wheel of a diamond or other hard material.

The cutting line of the cutting process is formed between the start point of the auxiliary sealant **1670***a*, which may be a blob A of sealant, and a main UV sealant **1670***b* across the initially formed auxiliary UV sealant **1670***a*. Consequently, a substantial portion of the excessively distributed auxiliary UV sealant **1670***a* is removed.

FIGS. **55**A to **55**D are perspective views illustrating a process of irradiating UV light in the method of manufacturing an LCD device according to the another embodiment of the present invention. This embodiment is similar to the previous embodiment except for the UV irradiation process. In this embodiment, a region where the sealants are not formed is covered with a mask before the UV light is irradiated. Since the other elements of the second embodiment are the same as those of the first embodiment, the same reference numerals will be given to the same elements and their detailed description will be omitted.

If the UV light is irradiated upon the entire surface of the attached substrates, the UV light may deteriorate characteristics of devices such as a thin film transistor on the substrate and may change a pre-tilt angle of an alignment film formed for the initial alignment of the liquid crystal.

Therefore, in the second embodiment of the present invention, the UV light is irradiated when the area where no sealant is formed is covered with a mask.

Referring to FIG. **55**A, a region where the auxiliary UV sealant **1670***a* and the main UV sealant **1670***b* are formed is covered with a mask **1680**. The mask **1680** is placed at an upper side of the attached substrates, and the UV light is irradiated.

Also, the mask **1680** may be placed at a lower side of the attached substrates. Also, although the UV light is irradiated upon the upper substrate **1652** of the attached substrates as shown, the UV light may be irradiated upon the lower substrate **1651** by turning the attached substrates.

If the UV light from a UV irradiating device **1690** is reflected and irradiated upon an opposite side, it may deteriorate characteristics of devices, such as the thin film transistor on the substrate and the alignment film, as described above. Therefore, masks are preferably formed at lower and upper sides of the attached substrates.

That is, as shown in FIG. **55**B, masks **1680** and **1682** that cover the region where the sealants **1670***a* and **1670***b* are not formed are placed are at upper and lower sides of the attached substrates. The UV light is then irradiated thereupon.

Meanwhile, since the auxiliary UV sealant **1670***a* does not act as a sealant, it does not require hardening. Also, since the region of the auxiliary UV sealant **1670***a* overlaps the cell cutting line during the later cell cutting process, it is more desirable for the cell cutting process that the auxiliary UV sealant **1670***a* is not hardened.

Referring to FIGS. **55**C and **55**D, the auxiliary UV sealant **1670***a* is not hardened by irradiating the UV light when only the area where the main UV sealant **1670***b* is not formed is covered with the mask, i.e., the auxiliary sealant **1670***a* is also covered by a mask.

In this case, in FIG. **55**C, the UV light is irradiated with the mask **1680** in place at a lower or upper side of the attached substrates. In FIG. **55**D, the UV light is irradiated when the mask **1680** is respectively placed at lower and upper sides of the attached substrates.

FIGS. **56**A and **56**B are perspective views illustrating a process of forming a UV sealant in a method of manufacturing an LCD device according to the third embodiment of the present invention of the present invention.

Another embodiment is identical to the previous embodiment except for the UV irradiation process. In the third embodiment, the UV light is irradiated at a tilt angle. Since the other elements of the this embodiment are identical to those of the previous embodiment, the same reference numerals will be given to the same elements and their detailed description will be omitted.

If a light-shielding layer and a metal line such as gate and data lines are formed on a region where the UV sealant **1670** is formed, the UV light is not irradiated upon the region, thereby failing to harden the sealant. For this reason, adherence between the lower and upper substrates is reduced.

Therefore, in the this embodiment of the present invention, the UV light is irradiated at a tilt angle upon the substrate where the UV sealant is formed, so that the UV sealant is hardened even if the light-shielding layer or the metal line layer is formed between the UV irradiating surface and the sealant.

To irradiate the UV light at a tilt angle, as shown in FIG. **56**A, the attached substrates are horizontally arranged and a UV irradiating device **1690** is arranged at a tilt angle of θ. Alternatively, as shown in FIG. **56**B, the attached substrates may be arranged at a tilt angle and the UV irradiating device **1690** may horizontally be arranged.

Also, the UV light may be irradiated at a tilt angle when the area where the sealant is not formed is covered with the mask as shown in FIGS. **44**A to **44**D.

FIG. **57** is a perspective view illustrating an LCD device according to another embodiment of the present invention, and FIGS. **47**A and **47**B are sectional views taken along lines I-I and II-II of FIG. **57**.

As shown in FIGS. **57** and **58**, an LCD device according to the present invention includes lower and upper substrates **1651** and **1652**, a UV sealant between the lower and upper substrates **1651** and **1652**, having an auxiliary UV sealant **1670***a* in a dummy area and a perimeter of main UV sealant **1670***b* connected to the auxiliary UV sealant **1670***a*, and a liquid crystal layer **1607** between the lower and upper substrates **1651** and **1652**.

At this time, although not shown, a thin film transistor, a pixel electrode, and an alignment film are formed on the lower substrate **1651**. A black matrix layer (not shown), a color filter layer (not shown), a common electrode (not shown) and an alignment film (not shown) are formed on the upper substrate **1652**. Also, spacers are formed between the lower and upper substrates **1651** and **1652** to maintain a cell gap between the substrates.

As aforementioned, the LCD device and the method of manufacturing the same according to the present invention have the following advantages.

Since the sealant concentrated upon the end of the nozzle of the dispensing device is formed in the dummy area on the substrate, the liquid crystal layer is not contaminated by the attaching process of the substrates and the cell cutting process is easily performed.

Furthermore, if the UV light is irradiated upon the substrate when the mask is formed at the lower and/or upper side of the attached substrates, the UV light is irradiated upon only the region where the UV sealant is formed. In this case, the alignment film formed on the substrate is not damaged and the characteristics of the devices, such as the thin film transistor, are not deteriorated.

Finally, if the UV light is irradiated at a tilt angle, the sealant can be hardened even if the light-shielding layer or the metal line is formed on the sealant, thereby avoiding reducing adherence between the lower and upper substrates.

FIGS. **59**A to **59**C illustrate perspective views showing a bonding method in accordance with the present invention.

Referring to FIG. **59**A, a lower substrate **1751** having a liquid crystal **1707** formed thereon is loaded on a lower bonding stage **1710**, and an upper substrate **1752** is loaded on an upper pre-bonding stage **1720** such that the surface of the upper substrate **1752** having the liquid crystal formed thereon faces into the lower substrate **1751**.

Then, referring to FIG. **59**B, the lower substrate **1751** and the upper substrate **1752** are attached under vacuum, and the vacuum is released to apply the atmospheric pressure thereto, thereby completing the attaching process.

Since the attached substrates in the above process have a substantial weight due to the liquid crystal, it will be difficult to move the attached substrates to the later process step by using a vacuum gripping method.

Consequently, as shown in FIG. **60**A, in order to unload the attached substrates from the alignment device, the lower bonding stage **1710** has holes **1712**, and a lifter (not shown) is placed under the lower bonding stage **1710**. The lifter is capable of moving in up and down directions of the lower bonding stage **1710** through the holes **1712**.

Accordingly, upon completion of the attaching process, the lifter moves up through the holes **1712** to lift the attached substrates over the lower bonding stage **1710** leaving a gap between the attached substrates and the lower bonding stage **1710**, through which robot arms move in and lift the attached substrates and transfer the attached substrates to a UV irradiating device.

FIG. **60**B illustrates a plane view of the attached substrates placed on the lower bonding stage **1710** having the holes **1712**. Especially, a main UV sealant **1770** and a dummy UV sealant **1775** are formed on the upper substrate **1752** that is placed on the lower bonding stage **1710**. A part of the dummy sealant **1775** on the upper substrate **1752** is located over the holes **1712** in the lower bonding stage **1710**.

Consequently, bonding of the dummy sealant **1775** over the holes **1712** becomes poor, and results in deformation of the main sealant **1770** pattern at the inside of the dummy sealant **1775** that is not bonded perfectly. This is because air infiltrates through the deformed sealant when the vacuum is released to apply the atmospheric pressure to the attached substrates for bonding the substrates during the attaching process. Therefore, the present invention suggests forming a dual dummy UV sealant outside the main UV sealant to eliminate the foregoing problem.

FIGS. **61**A to **61**C illustrate perspective views of a substrate for a liquid crystal display panel in accordance with the first embodiment of the present invention. As an example, four unit cells are illustrated on the mother substrate in the drawings. However, the number of unit cells may be varied.

Referring to FIGS. **61**A to **61**C, there are a main UV sealant **1870** formed on a substrate **1851** in a closed line without an injection hole, and a first dummy UV sealant **1875** formed at the dummy region in the outside of the main UV sealant **1870** in a closed line without an injection hole. Also, there may be a second dummy UV sealant **1880**, **1880***a*, or **1880***b* at the outside of the first dummy UV sealant **1875**.

As shown in FIG. **61**A, the second dummy UV sealant **1880** covers at least the area of the lift pin holes of the attaching device, which may be formed in discontinued straight lines at the outside of one side of the first dummy UV sealant **1875**.

In general, since the lift pin holes of the attaching device is formed at the longer sides of the substrate for lifting the substrate to prevent bending of the substrate, the second dummy UV sealant **1880** will be formed at the outside of the longer side of the corners at the first dummy UV sealant **1875**.

In the meantime, as shown in FIG. **61**A, the second dummy UV sealant **1880** is formed in discontinued straight lines on one side of the corner of the first dummy UV sealant **1875**. In this embodiment, there may be a possibility that air infiltrates through the other side of the corner where no second dummy UV sealant is formed, thereby deforming the main UV sealant **1870**.

As shown in FIG. **61**B, the second dummy UV sealant **1880***a* is formed in a '⌉' form as an example at the outside of both sides of the corners of the first dummy UV sealant **1875**. The specific shape of the second dummy UV sealant **1880***a* is not required as long as it covers each corner of the outside of the first dummy UV sealant **1875**.

Referring to FIG. **61**C, the dummy UV sealant **1880***b* may also be formed at the outside of the first dummy UV sealant **1875** in a single closed continued line.

The main, first, and second dummy UV sealants **1870**, **1875**, **1880**, **1880***a*, and **1880***b* are formed of one of monomer and oligomer having both ends coupled with an acryl group mixed with an initiator. Alternatively, one of monomer and oligomer has one end coupled with an acryl group and the other end coupled with an epoxy group mixed with an initiator.

The liquid crystal display panel includes a lower substrate, an upper substrate, and a liquid crystal between the two substrates. A sealant may be formed on either one of the substrates.

When the substrate of the LCD shown in one of FIGS. **61**A to **61**C is a lower substrate, the substrate **1851** has a plurality of gate lines, data lines, thin film transistors, and pixel electrodes. When the substrate is an upper substrate, the substrate **1851** has a black matrix, a color filter layer, and a common electrode.

Moreover, a plurality of column spacers may be formed on one of the substrates for maintaining a cell gap. The column spacers may be formed at the region opposite to the region of the gate lines or the data lines. For example, the column spacers may be formed of photosensitive organic resin.

FIGS. **62**A to **62**E illustrate perspective views of a method for fabricating a liquid crystal display panel in accordance with the present invention. As an example, four unit cells are shown in the drawings. However, the number of unit cells may be varied.

Referring to FIG. **62**A, a lower substrate **1951** and an upper substrate **1952** are prepared for further processes. A plurality of gate lines and data lines (both not shown) are formed on the lower substrate **1951** to cross one another defining a plurality of pixel regions, a thin film transistor having a gate electrode, a gate insulating film, a semiconductor layer, an ohmic contact layer, and source/drain electrodes. A protection layer is formed at each crossed points of the gate lines and the data lines. A plurality of pixel electrodes are formed to be connected to the thin film transistors at the pixel regions.

An orientation film is formed on the pixel electrodes for an initial orientation of the liquid crystal. The orientation film may be formed of one of polyamide or polyimide group compound, polyvinylalcohol (PVA), and polyamic acid by rubbing orientation. Alternatively, a photosensitive material, such as polyvinvylcinnamate (PVCN), polysilioxanecinnamate (PSCN), and cellulosecinnamate (CelCN) group compound may be selected for the orientation film by using photo orientation.

A black matrix is formed on the upper substrate **1952** for shielding the light leakage from the gate lines, the data lines, and regions of the thin film transistor regions. A color filter layer of red, green, and blue is formed thereon. A common electrode is formed on the color filter layer. An overcoat layer may be formed between the color filter layer and the common electrode, additionally. The orientation film is formed on the common electrode.

Silver (Ag) dots are formed on the outer periphery of the lower substrate **1951** for applying a voltage to the common electrode on the upper substrate **1952** after the two substrates **1951** and **1952** are attached to each other. The silver dots may be formed on the upper substrate **1952**.

In an in-plane switching (IPS) mode LCD, a lateral field is induced by the common electrode formed on the lower substrate. The pixel electrode is also formed on the lower substrate, and the silver dots are not formed.

Referring to FIG. **62**C, a main UV sealant **1970** is coated on the upper substrate **1952** in a closed line. A first dummy UV sealant **1975** is also formed in a closed line at the dummy region outside of the main UV sealant **1970**.

Although FIG. **62**B illustrates that the second dummy UV sealant **1980** is formed at the outside of each corner of the first dummy UV sealant **1975** in a ']' form, the second dummy UV sealant **1980** may be formed at the outside of one side of the first dummy UV sealant **1975** in a discontinuous straight line. Alternatively, it may also be formed at the outside of the first dummy UV sealant **1975** in a continued closed line. Detailed patterns of the foregoing second dummy UV sealant **1980** are similar to those of FIGS. **61**A to **61**C.

The sealant may be formed by using one of screen printing and dispensing method. When the sealant is coated by the screen printing method, it may damage the orientation film formed on the substrate. This is because the screen comes into contact with the substrate. In addition, it is not economically feasible because a large amount of the sealant may be wasted in the screen printing method when the substrate is large.

The main, first, and second dummy UV sealant **1970**, **1975**, and **1980** are formed of one of monomer and oligomer having both ends coupled with an acryl group mixed with an initiator. Alternatively, one of monomer and oligomer has one end coupled with an acryl group and the other end coupled with an epoxy group mixed with an initiator.

A liquid crystal **1907** is then dropped onto the lower substrate **1951** to form the liquid crystal layer.

The liquid crystal **1907** may be contaminated when the liquid crystal contacts the main sealant **1970** before the main sealant **1970** is hardened. Therefore, the liquid crystal may have to be dropped onto the central part of the lower substrate **1951** to avoid this problem. The liquid crystal **1907** dropped onto the central part spreads slowly even after the main sealant **1970** is hardened, so that the liquid crystal is distributed throughout the entire substrate with the same concentration.

The drawing illustrates that the liquid crystal **1907** is dropped and the sealants **1970**, **1975**, and **1980** are formed on the lower substrate **1951**. However, the liquid crystal **1907** may be formed on the upper substrate **1952**, and the UV sealant **1970**, **1975**, and **1980** may be coated on the lower substrate **1951**.

Moreover, the liquid crystal **1907** and the UV sealant **1970**, **1975**, and **1980** may be formed on the same substrate. However, when the liquid crystal and the sealants are formed on different substrates, a fabrication time may be shortened. When the liquid crystal and the sealants are formed on the same substrate, there occurs an unbalance in processes between the substrate having the liquid crystal and the sealant and the substrate without the liquid crystal and the sealant. As a result, the substrate cannot be cleaned when the sealant is contaminated even before attaching the substrates.

Therefore, after the UV sealants **1970**, **1975**, and **1980** are coated on the upper substrate **1952**, a cleaning process may be added for cleaning the upper substrate **1952** before the attaching process.

Moreover, a plurality of spacers (not shown) may be formed on either of the two substrates **1951** or **1952** for maintaining a cell gap. A plurality of ball spacers mixed with a solution at an appropriate concentration may be sprayed at a high pressure onto the substrate from a spray nozzle. Alternatively, a plurality of column spacers may be formed on the substrate opposite to the regions of the gate lines or data lines. The column spacers may be used for the large sized substrate since the ball spacers may form an uneven cell gap in the large sized substrate. The column spacers may be formed of photosensitive organic resin.

Referring to FIG. **62**C, the lower substrate **1951** and the upper substrate **1952** are attached to each other. The lower substrate **1951** and the upper substrate **1952** may be attached, by placing the lower substrate **1951** with the dropped liquid crystal on the lower part, rotating the upper substrate **1952** by 180 degrees such that the side of the upper substrate having the liquid crystal faces into the upper surface of the lower substrate **1951**, and pressing the upper substrate **1952**, or by evacuating the space between the two substrates **1951** and **1952** into vacuum and releasing the vacuum, thereby attaching the two substrates **1951** and **1952**.

Referring to FIG. **62**D, a UV ray is irradiated to the attached substrates **1951** and **1952** by using a UV irradiating device **1990**. Upon irradiation of the UV ray thereto, one of monomer and oligomer in the UV sealants **1970**, **1975**, and **1980** activated by an initiator is polymerized and hardened, thereby bonding the lower substrate **1951** and the upper substrate **1952**.

When monomer or oligomer each having one end coupled with an acrylic group and the other end coupled with an epoxy group mixed with an initiator is used as the UV sealant **1970**, **1975** and **1980**, the epoxy group is not reactive with the UV ray. Thus, the sealant has to be heated at about 120° C. for one hour in addition to the UV ray irradiation for hardening the sealant.

In the UV irradiation, if the UV ray is irradiated onto the entire surface of the bonded substrates, the UV ray may affect the device characteristics of the thin film transistors, and the like on the substrates. As a result, a pretilt angle of the orientation film for the initial orientation of the liquid crystal may be changed due to the UV irradiation.

Therefore, as shown in FIG. **63**, the UV ray is irradiated with a mask **1995** placed between the bonded substrates **1951** and **1952** and the UV irradiating device **1990** for masking the active region in the main UV sealant **1970**.

Referring back to FIG. **62**E, the bonded substrates are cut into a plurality of unit cells after the UV irradiation. After scribing the surface of the bonded substrates by a scriber, such as a diamond pen having a hardness higher than glass, a material of the substrates (scribing process), a mechanical impact is given along the scribing line (breaking process), thereby obtaining a plurality of unit cells. Alternatively, a cutting apparatus having a toothed wheel may be used to carry out the scribing process and the breaking process at the same time.

When the cutting apparatus is used for cutting and breaking at the same time, an equipment space and a cutting time period may be reduced.

The scribing lines (not shown) for cutting the cells are formed between the main UV sealant **1970** and the first dummy UV sealant **1975**. Therefore, after the cell cutting process, the unit cell has no first and second dummy UV sealants **1975** and **1980**.

A final inspection (not shown) is carried out after the cell cutting process. The final inspection determines whether there are defects before the substrates cut into the unit cells are assembled for a module. The examination is performed by operating pixels with an applied voltage thereto.

FIG. **64** is a partial cross-sectional view of an LCD panel in accordance with the first embodiment of the present invention, illustrating a part of the LCD panel before the cell cutting process.

In FIG. **64**, the LCD panel includes a lower substrate **1951** and an upper substrate **1952**, arranged to be spaced apart from each other.

The lower substrate **1951** has a plurality of gate lines, data lines, thin film transistors, and pixel electrodes. The upper substrate **1952** has a black matrix, a color filter layer, and a common electrode. An IPS mode LCD panel has the common electrode formed on the lower substrate **1951**.

There are a plurality of spacers between the two substrates **1951** and **1952** for maintaining a cell gap. The spacers may be ball spacers spread on the substrate, or column spacers formed on the substrate. The column spacers may be formed on the upper substrate **1952**.

There are a main UV sealant **1970** in a closed line between the two substrates **1951** and **1952**, a first dummy UV sealant **1975** in a closed line at the outside of the main UV sealant **1970**, and a second dummy UV sealant **1980** at the outside of the first dummy UV sealant **1975**.

As explained, the second dummy UV sealant may have different patterns.

There is a liquid crystal layer **1907** within the boundary of the main UV sealant **1970** between the two substrates **1951** and **1952**.

As has been explained, the LCD panel and the method for fabricating the same of the present invention have the following advantage.

A dual dummy UV sealant provided for protecting the main UV sealant prevents deformation of the main UV sealant.

FIG. **65**A is a plan view of an LCD device according to an embodiment of the present invention, and FIG. **65**B is a sectional view taken along line I-I of FIG. **65**A.

As shown in FIGS. **65**A and **65**B, an LCD device according to the first embodiment of the present invention includes a lower substrate **2051**, an upper substrate **2052**, a sealant **2070** that is at least partially curable by ultraviolet (UV) light formed between the lower and upper substrates **2051** and **2052**, and a liquid crystal layer **2007** formed within a volume formed by the UV sealant **2070** between the lower and upper substrates **2051** and **2052**.

The UV sealant **2070** is patterned to form a part **2075** for controlling a liquid crystal flow at four corner regions. The part **2075** is formed to receive excess liquid crystal from an active region of the LCD device, such as a cavity, reservoir or well. Therefore, if the liquid crystal is applied excessively, i.e., overfilled, the excess liquid crystal enters into the part **2075** away from an active region.

Also, even if the liquid crystal expands during a heating process, the excess liquid crystal enters into the part **2075** so that overfilling of the liquid crystal in the active region does not occur. If the expanded liquid crystal shrinks, the liquid crystal filled in the part **2075** moves to the active region.

The size of the part **2075** can appropriately be adjusted and may have various shapes such as a round, triangular, rectangular, polygonal, or any other shape as would be appreciated by one of skill in the art.

Although not shown, a thin film transistor and a pixel electrode are formed on the lower substrate **2051**. The thin film transistor includes a gate electrode, a gate insulating layer, a semiconductor layer, an ohmic contact layer, and source/drain electrodes.

Although not shown, a light-shielding layer, a color filter layer, and a common electrode are formed on the upper substrate **2052**. The light-shielding layer shields light leakage from a region other than the pixel electrode. Additionally, an overcoat layer (not shown) may be formed on the color filter layer. In an In-Plane Switching (IPS) mode LCD device, the common electrode is formed on the lower substrate **2051**.

The part **2075** formed by a pattern of the UV sealant **2070** corresponds to a region where the light-shielding layer is formed. Therefore, picture quality characteristics are not deteriorated even if the liquid crystal **2007** is filled imperfectly in the part **2075**.

Spacers may be formed between the substrates **2051** and **2052** to maintain a cell gap. Ball spacers or column spacers may be used as the spacers. The ball spacers may be formed in such a manner that they are mixed with a solution having an appropriate concentration and then spread at a high pressure onto the substrate from a spray nozzle. The column spacers may be formed on portions of the substrate corresponding to gate lines or data lines. Preferably, the column spacers may be formed of a photosensitive organic resin.

FIGS. **66**A to **66**D are perspective views illustrating a method of manufacturing an LCD device according to the second embodiment of the present invention.

Although the drawings illustrate only one unit cell, a plurality of unit cells may be formed depending upon the size of the substrate.

Referring to FIG. **66**A, a lower substrate **2051** and an upper substrate **2052** are prepared. A plurality of gate and data lines (not shown) are formed on the lower substrate **2051**. The gate lines cross the data lines to define a pixel region. A thin film transistor having a gate electrode, a gate insulating layer, a semiconductor layer, an ohmic contact layer, source/drain electrodes, and a protection layer is formed at each crossing point of the gate lines and the data lines. A pixel electrode connected with the thin film transistor is formed in the pixel region.

An alignment film (not shown) is formed on the pixel electrode to initially align the liquid crystal. The alignment film may be formed of polyamide or polyimide based compound, polyvinylalcohol (PVA), and polyamic acid by rubbing. Alternatively, the alignment film may be formed of a photosensitive material, such as polyvinylcinnamate (PVCN), polysilioxanecinnamate (PSCN) or cellulosecinnamate (CelCN) based compound, by using a photo-alignment method.

A light-shielding layer (not shown) is formed on the upper substrate **2052** to shield light leakage from the gate lines, the data lines, and the thin film transistor regions. A color filter layer (not shown) of R, G, and B is formed on the light-shielding layer. A common electrode (not shown) is formed on the color filter layer. Additionally, an overcoat layer (not shown) may be formed between the color filter layer and the common electrode. The alignment film is formed on the common electrode.

Silver (Ag) dots (not shown) are formed outside the lower substrate **2051** to apply a voltage to the common electrode on the upper substrate **2052** after the lower and upper substrates **2051** and **2052** are bonded to each other. Alternatively, the silver dots may be formed on the upper substrate **2052**.

In an in plane switching (IPS) mode LCD, the common electrode is formed on the lower substrate like the pixel electrode, and, in operation, an electric field is horizontally induced between the common electrode and the pixel electrode. The silver dots are not formed on the substrates.

A sealant **2070** that is at least partially curable by UV light is formed on the upper substrate **2052** to have a part **2075** for controlling a liquid crystal flow at four corner regions.

The part **2075** may have various shapes such as a round, triangular, rectangular, polygonal shape or any other shape as would be appreciated by one of skill in the art with a size may appropriately adjusted according factors such as the level of liquid crystal applied and the size of the substrate.

The UV sealant is formed by a screen printing method or a dispensing method. In the screen printing method, because a screen comes into contact with the substrate, the alignment film formed on the substrate may be damaged. Also, if the substrate has a large area, loss of the sealant increases. In these respects, the dispensing method is preferably used.

Monomers or oligomers each having both ends coupled to the acrylic group, mixed with an initiator are used as the UV sealant **2070**. Alternatively, monomers or oligomers each having one end coupled to the acrylic group and the other end coupled to the epoxy group, mixed with an initiator are used as the UV sealant **2070**.

Also, the liquid crystal **2007** is applied onto the lower substrate **2051** to form a liquid crystal layer. At this time, the amount of the liquid crystal **2007** is determined by considering the size of the substrate and a cell gap. Preferably, the liquid crystal **2007** is substantially applied in an amount greater than the minimum level sufficient to fill the cell gap.

The liquid crystal **2007** may be contaminated if it comes into contact with the UV sealant **2070** before the UV sealant **2070** is hardened. Accordingly, the liquid crystal **2007** may preferably be applied on the central part of the lower substrate **2051**. In this case, the liquid crystal **2007** is gradually spread evenly after the UV sealant **2070** is hardened. If the liquid crystal **2007** is applied excessively, the liquid crystal **2007** enters into the part **2075**. Thus, the liquid crystal **2007** is uniformly distributed in the active region of the substrate, thereby maintaining a uniform cell gap.

Also, if the liquid crystal is applied in an amount (application amount) more than a minimum amount required to fill the cell gap in the active region (minimum amount), it takes a short time to spread the liquid crystal to the corner regions so that the liquid crystal is spread to the active region before the final test process. A principle of the method for applying liquid crystal onto a substrate before attaching a second substrate is described herein.

Meanwhile, although FIG. **66**B illustrates the process of applying the liquid crystal **2007** on the lower substrate **2051** and forming the UV sealant **2070** on the upper substrate **2052**, the liquid crystal **2007** may be formed on the upper substrate **2052** while the UV sealant **2070** may be formed on the lower substrate **2051**.

Alternatively, both the liquid crystal **2007** and the UV sealant **2070** may be formed on one substrate. In this case, an imbalance occurs between the processing times of the substrate with the liquid crystal and the sealant and the substrate without the liquid crystal and the sealant. For this reason, the manufacturing process time increases. Also, when the liquid crystal and the sealant are formed on one substrate, the substrate may not be cleaned even if the sealant is contaminated before the substrates are attached to each other.

Accordingly, a cleaning process for cleaning the upper substrate **2052** may additionally be provided after the UV sealant **2070** is formed on the upper substrate **2052**.

Meanwhile, spacers may be formed on either of the two substrates **2051** and **2052** to maintain a cell gap. Preferably, the spacers may be formed on the upper substrate **2052**.

Ball spacers or column spacers may be used as the spacers. The ball spacers may be formed in such a manner that they are mixed with a solution having an appropriate concentration and then spread at a high pressure onto the substrate from a spray nozzle. The column spacers may be formed on portions of the substrate corresponding to the gate lines or data lines. Preferably, the column spacers may be used for the large sized substrate since the ball spacers may cause an uneven cell gap for the large sized substrate. The column spacers may be formed of a photosensitive organic resin.

Referring to FIG. **66**C, the lower substrate **2051** and the upper substrate **2052** are attached to each other by the following processes. First, one of the substrates having the liquid crystal applied thereon is placed at the lower side. The other substrate is placed at the upper side by turning by 180 degrees so that its portion having certain layers faces into the surface of the lower substrate having certain layers. Thereafter, the substrate at the upper side is pressed, so that both substrates are attached to each other. Alternatively, the space between the substrates may be maintained under the vacuum state so that both substrates are attached to each other by releasing the vacuum state.

Then, as shown in FIG. **66**D, UV light is irradiated upon the attached substrates through a UV irradiating device **2090**. Upon irradiating the UV, monomers or oligomers activated by an initiator constituting the UV sealant **2070** are polymerized and hardened, thereby bonding the lower substrate **2051** to the upper substrate **2052**.

If monomers or oligomers each having one end coupled to the acrylic group and the other end coupled to the epoxy group, mixed with an initiator are used as the UV sealant **2070**, the epoxy group is not completely polymerized. Therefore, the sealant may have to be additionally heated at about 120° C. for one hour after the UV irradiation, thereby hardening the sealant completely.

In the UV irradiation, if the UV light is irradiated upon the entire surface of the attached substrates, the UV light may deteriorate characteristics of devices such as a thin film transistor on the substrate and change a pre-tilt angle of an alignment film formed for the initial alignment of the liquid crystal.

Therefore, as shown in FIG. **67**, the UV light is irradiated in a state that an active region in the UV sealant **2070** is covered with a mask **2095**.

Although not shown, the bonded substrates are cut into a unit cell.

In the cutting process, a cutting line is formed on a surface of the substrates with a pen or cutting wheel of a material that has a hardness greater than that of glass, e.g., diamond, and then the substrate is cut along the cutting line by mechanical impact or breaking process. Thus, a plurality of unit cells can be obtained simultaneously.

Alternatively, the scribing process and the breaking process may simultaneously be performed using a pen or cutting wheel of a material that has a hardness greater than that of glass, thereby obtaining a unit cell. In this case, space occupied by cutting equipment that cuts the glass is reduced over the space occupied by equipment required to scribe and break the glass and the overall cutting process time is also reduced over the combined scribe and break process.

As aforementioned, the LCD and the method of manufacturing the same according to the present invention have the following advantages.

Since the liquid crystal the level of liquid crystal applied to the substrate can be greater than the amount required to cover the active area of the LCD panel and the sealant is formed to have the part for controlling a liquid crystal flow, the liquid crystal is filled appropriately without any imperfections caused by an overfill in the active area. Thus, a uniform cell gap can be maintained.

Furthermore, even if the liquid crystal expands or shrinks, for example, during the heating process, the liquid crystal exits or enters the part for controlling a liquid crystal flow, thereby avoiding any defect in a cell gap that may occur.

Reference will now be made in detail to the illustrated embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

FIG. **687** illustrates a plan view of an LCD panel in accordance with an embodiment of the present invention.

Referring to FIG. **68**, the LCD panel includes a lower substrate **2151**, an upper substrate **2152**, and a UV sealant **2170** between the substrates **2151** and **2152**. Column spacers (not shown) are formed in a pixel region (a line 'A' represents an imaginary line for indicating a pixel region), and a dummy column spacer **2160** is formed inside the UV sealant **2170** in the dummy region to regulate a liquid crystal flow. A liquid crystal layer (not shown) is formed between the lower and upper substrates **2151** and **2152**. The column spacer serves to maintain a cell gap between the lower substrate **2151** and the upper substrate **2152**.

More specifically, the dummy column spacer **2160** has a height the same as the column spacer, and an opened portion **2162** in at least one of the corner-regions. Although the drawing shows that the opened portion **2162** is formed at all four corners, the number of the opened portion **2162** may be varied. Alternatively, the opened portion **2160** may not be formed at all. The dummy column spacer **2162** serves as a liquid crystal flow passage, thereby uniformly filling the liquid crystal throughout the cell, and preventing the liquid crystal from being contaminated by the UV sealant **2170**. That is, as shown in arrows in the drawing, since the liquid crystal flows along the dummy column spacer **2160**, and to the corner-region of the substrate through the opened portion **2162**, the liquid crystal in the corner-regions of the substrates is uniformly spread throughout the substrate. Moreover, the dummy column spacer **2160** without the opened portion **2162** serves as a dam for preventing the liquid crystal from contacting the UV sealant and being contaminated by the UV sealant.

Variations of the embodiments of the present invention will be explained with reference to FIGS. **69**A to **69**C, which are cross-sectional views taken along line IV-IV of FIG. **57** (a region having no opened portion **2162** is formed in the dummy column spacer **2160**) illustrating other embodiments.

Referring to FIG. **69**A, a black matrix **2110**, a color filter layer **2120**, and a common electrode **2130** are formed on the upper substrate **2152** in this order. Gate lines, data lines, thin film transistors, and pixel electrodes (all not shown) are formed on the lower substrate **2151**. A plurality of column spacers **2150** are formed in the pixel region on the upper substrate **2152** each having a height of the cell gap. Since the column spacers **2150** are formed in regions of the gate lines and the data lines, the column spacers **2150** are formed on the common electrode **2130** over the black matrix **2110** on the upper substrate **2152**. A dummy column spacer **2160** is formed in the dummy region on the upper substrate **2152** with a height the same as the column spacer **2150**. The dummy column spacer may be formed in any region except for the pixel region as far as the region is within the dummy region on the inner side of the UV sealant **2170**. Although the drawing shows that the dummy column spacer **2160** is formed on the common electrodes **2130** without an underlying color filter layer **2120**, the dummy column spacer **2160** may be formed on the common electrodes **2130** with the underlying color filter layer **2120**. For example, the column spacer **2150** and the dummy column spacer **2160** may be formed of a photosensitive resin.

In the meantime, an overcoat layer may be additionally formed between the color filter layer **2120** and the common electrode **2130** on the upper substrate **2152**, and alignment layers may be formed on the upper substrate **2152** inclusive of the column spacers **2160** and the lower substrate **2151**, respectively.

FIG. **69**B illustrates a cross-sectional view of an LCD panel in accordance with another variation of the first embodiment of the present invention. In this embodiment, instead of the common electrode **2130**, the overcoat layer **2140** is formed on the upper substrate **2152** in the foregoing LCD panel, shown in FIG. **69**A.

The LCD panel in FIG. **69**B is called an in-plane switching (IPS) mode LCD panel, and has a common electrode formed on the lower substrate **2151**. Therefore, the IPS mode LCD panel is the same as the LCD panel in FIG. **69**A, except for that the column spacer **2150** and the dummy column spacer **2160** are formed on the overcoat layer **2140**.

FIG. **69**C illustrates a cross-sectional view of an LCD panel in accordance with another embodiment of the present invention. In the LCD panel in FIG. **69**B, the overcoat layer **2140** is patterned such that it is formed on the black matrix **2110** and not on the sealant **2170**. The others are similar to the LCD panel in FIG. **69**B.

FIG. **70** illustrates a plan view of an LCD panel in accordance with another embodiment of the present invention.

Referring to FIG. **70**, the LCD panel according to this embodiment includes a dummy column spacer **2160** having an opened portion **2162**. The opened portion **2162** includes a plurality of openings in each corner-region of the substrate.

The opened portion **2162** including a plurality of openings permits a liquid crystal to easily flow to the corners of the substrate, and allows a uniform filling of the liquid crystal. The opened portion **2162** may be formed in at least one of the corner-regions. A plurality of openings may be formed at either a constant interval or an irregular interval. The others are similar to the first embodiment.

FIG. **71** illustrates a plan view of an LCD panel in accordance with a third embodiment of the present invention.

Referring to FIG. **71**, the LCD panel includes a lower substrate **2151**, an upper substrate **2152**, and a UV sealant **2170** between the lower and upper substrates **2151** and **2152**. A plurality of column spacers (not shown) are formed in a pixel region (a line 'A' represents an imaginary line for indicating the pixel region), and a dummy column spacer **2160** is formed on inside the UV sealant **2170** in the dummy region to regulate a liquid crystal flow. The dummy column spacer **2160** is formed at a height the same as the column spacer and has an opened portion **2162** in at least one of the corner-regions. The opened portion **2162** may not be formed at all. Also, a dotted line type dummy column spacer **2180** may be additionally formed at the inner dummy region of the dummy column spacer **2160** for assisting the regulation of the liquid crystal flow. A liquid crystal layer (not shown) is formed between the substrates **2151** and **2152**.

The additional dotted line type dummy column spacer **2180** inside the dummy column spacer **2160** facilitates more smooth regulation of the liquid crystal flow because the liquid crystal flows along spaces of not only the dummy column spacer **2160**, but also the dotted line type dummy column spacer **2180**.

Variations of this embodiment of the present invention will be explained in detail with reference to FIGS. **72**A to **72**C, which are cross-sectional views taken along line VII-VII of FIG. **6** (a region having no opened portion **2162** in the dummy column spacer **2160**).

Referring to FIG. **72**A, a black matrix **2110**, a color filter layer **2120**, and a common electrode **2130** are formed on the upper substrate **2152** in this order. A plurality of gate lines, data lines, thin film transistors, and pixel electrodes (all not shown) are formed on the lower substrate **2151**. Column spacers **2150** are formed in the pixel region on the upper substrate **2152** each having a height of the cell gap. The dummy column spacer **2160** is formed in the dummy region on the upper substrate **2152** with a height the same as the column spacer **2150**. The dotted line type dummy column spacer **2180** is formed in the dummy region inside the dummy column spacer **2160** with a height the same as the column spacer **2150**. Although only one dotted line type dummy column spacer **2170** is shown in FIG. **72**A, there may be a plurality of the dotted line type column spacers **2180**. The dotted line type dummy column spacer **2180** may be formed in any region as far as the region is within the dummy region. For example, the column spacer **2150**, the dummy column spacer **2160**, and the dotted line type dummy column spacer **2180** may be formed of a photosensitive resin.

In the meantime, an overcoat layer may be additionally formed between the color filter layer **2120** and the common electrode **2130** on the upper substrate **2152**, and alignment films (not shown) are formed on the upper substrate **2152** inclusive of the column spacers **2160** and the dotted line type dummy column spacer **2180**, and the lower substrate **2151**, respectively.

FIG. **72**B illustrates a cross-sectional view of an LCD panel in accordance with another variation of the previous embodiment of the present invention, wherein, in the foregoing LCD panel in FIG. **72**A, not the common electrode **2130**, but the overcoat layer **2140**, is formed on the upper substrate **2152**. The LCD panel in FIG. **72**B is an IPS mode LCD panel, and has the common electrode formed on the lower substrate **2151**. Therefore, the IPS mode LCD panel is similar to the LCD panel in FIG. **72**A, except for that the column spacer **2150**, the dummy column spacer **2160**, and the dotted line type dummy column spacer **2180** are formed on the overcoat layer **2140**.

FIG. **72**C illustrates a cross-sectional view of an LCD panel in accordance with another variation of the previous embodiment of the present invention. In this embodiment, the overcoat layer **2140** is patterned such that the sealant **2170** is formed directly on the upper substrate **2152**. Others are similar to the LCD panel in FIG. **72**B.

FIG. **73** illustrates a plane view of an LCD panel in accordance with a another embodiment of the present invention.

Referring to FIG. **73**, the LCD panel according to this embodiment of the present invention includes a dummy column spacer **2160** having an opened portion **2162**. The opened portion **2162** includes a plurality of openings in the corner-region of the substrate.

The opened portion **2162** may be formed in at least one of the corner-regions. A plurality of openings may be formed at either a constant interval or an irregular interval. The others are similar to the third embodiment.

FIG. **74** illustrates a plane view of an LCD panel in accordance with another embodiment of the present invention. In this embodiment, a dotted line type dummy column spacer **2180** is formed outside the dummy column spacer **2160**. Since the others are similar to the third embodiment, detailed descriptions are omitted for simplicity. FIGS. **75**A to **75**C illustrate cross-sectional views taken along line X-X of FIG. **74** for variations.

FIG. **76** illustrates a plan view of an LCD in accordance with another embodiment of the present invention.

Referring to FIG. **76**, the LCD panel includes a dummy column spacer **2160** having an opened portion **2162**. The opened portion **2162** includes a plurality of openings in the corner-regions of the substrate. The opened portion **2162** may be formed in at least one of the corner-regions. A plurality of openings may be formed at either a constant interval or an irregular interval. The others are similar to the fifth embodiment.

FIGS. **77**A and **77**B illustrate plan views of LCDs in accordance with another embodiment of the present invention, wherein a second dummy column spacer **2185** is additionally formed inside or outside a first dummy column spacer **2160**.

The dummy column spacer is duplicated for a better regulation of the liquid crystal flow. The first dummy column spacer **2160** and/or the second dummy column spacer **2185** may have the opened portion **2162** in at least one of the corner-regions. The opened portion **2162** may include a plurality of openings formed at either a constant interval or an irregular interval. The first dummy column spacer **2160** and the second dummy column spacer **2185** may be varied similar to the foregoing dummy column spacer **2160** and the dotted line type dummy column spacer **2180**.

FIGS. **78**A to **78**D are perspective views illustrating a method for fabricating an LCD panel in accordance with another embodiment of the present invention. Although the drawing illustrates only one unit cell, there may be more than one unit cell.

Referring to FIG. **78**A, a lower substrate **2151** and an upper substrate **2152** are prepared for the process. A plurality of gate lines and data lines (both not shown) are formed on the lower substrate **2151** to cross each other defining pixel regions. A thin film transistor having a gate electrode, a gate insulating film, a semiconductor layer, an ohmic contact layer, source/drain electrodes, and a protection film, is formed at every crossed point of the gate lines and the data lines. A pixel electrode is formed at each of the pixel regions connected to the thin film transistor.

An alignment film is formed on the pixel electrode for an initial orientation of the liquid crystal. The alignment film may be formed of one of polyimide, polyamide group compound, polyvinylalcohol (PVA), and polyamic acid by rubbing, or a photosensitive material, such as polyvinvylcinnamate (PVCN), polysilioxanecinnamate (PSCN), or cellulosecinnamate (CelCN) group compound by photo-alignment.

A black matrix is formed on the upper substrate **2152** for shielding a light leakage from the gate lines, the data lines, and the thin film transistors. A color filter layer of red, green, and blue is formed thereon. A common electrode is formed thereon. An overcoat layer may be additionally formed between the color filter layer and the common electrode.

Silver (Ag) dots are formed on the lower substrate **2151**, for applying a voltage to the common electrode on the upper substrate **2152** after the two substrates **2151** and **2152** are bonded with each other. Alternatively, the silver dots may be formed on the upper substrate **2152**.

In an in-plane switching mode LCD panel, a lateral field is induced by the common electrode formed on the lower substrate the same as the pixel electrode. Thus, the silver dots may not be formed on the substrates. As shown in the first to eighth embodiments, the column spacer, the dummy column spacer, the dotted line type dummy column spacer, and the second dummy column spacer are formed on the various locations of the upper substrate **2152**. The column spacer and the dummy column spacer, the column spacer, the dummy column spacer, and the dotted line type dummy column spacer, or the column spacer, the dummy column spacer, and the second dummy column spacer may be formed of photosensitive resin at the same time with the same height (i.e., at the height of a cell gap). The foregoing alignment film is formed on the upper substrate **2152**.

Referring to FIG. **78**B, a UV sealant **2170** is coated on the upper substrate **2152**. The sealant may be coated by using a dispensing method or a screen printing method. However, the screen printing method may damage the alignment film formed on the substrate since the screen directly contacts the substrate. Also, the screen printing method may not be economically feasible due to a large amount of the sealant loss for a large substrate.

For example, monomers or oligomers each having both ends coupled with an acrylic group mixed with an initiator, or monomers or oligomers each having one end coupled with an acrylic group and the other end coupled with an epoxy group mixed with an initiator is used as the UV sealant **2170**.

Then, a liquid crystal **2107** is dispensed onto the lower substrate **2151** to form a liquid crystal layer. A dispensed amount of the liquid crystal is determined with a substrate size and a cell gap. Generally, the liquid crystal is dispensed more than the determined amount.

The liquid crystal is contaminated once the liquid crystal contacts the sealant **2170** before the sealant **2170** is hardened. Therefore, the liquid crystal **2107** is dispensed onto the central part of the lower substrate **2151**. A flow speed of liquid crystal **2151** dispensed onto the central part is appropriately regulated by the dummy column spacer and the dotted line type dummy column spacer, thereby uniformly speeding the liquid crystal **2107** inside of the UV sealant **2170**.

FIG. **78**B illustrates that the liquid crystal **2107** is dispensed on the lower substrate **2151**, and the UV sealant **2170** is coated on the upper substrate **2152**. Alternatively, the liquid crystal **2107** may be dispensed on the upper substrate **2152**, and the UV sealant **2170** may be coated on the lower substrate **2151**.

Moreover, the liquid crystal **2107** and the UV sealant **2170** may be formed on the same substrate. The liquid crystal and the sealant may be formed on different substrates in order to shorten the fabrication time period. When the liquid crystal **2107** and the UV sealant **2170** are formed on the same substrate, there occurs unbalance in the fabricating processes between the substrate with the liquid crystal and the sealant and the substrate without the liquid crystal and the sealant. In addition, the substrate cannot be cleaned when the sealant is contaminated before the substrates are attached to each other since the liquid crystal and the sealant are formed on the same substrate. Therefore, after coating the UV sealant, a substrate cleaning step may be added.

Referring to FIG. **78**C, the lower substrate **2151** and the upper substrate **2152** are attached to each other. The lower substrate **2151** and the upper substrate **2152** may be bonded by the following processes. First, a liquid crystal is dispensed on one of the substrates. The other substrate is turned by 180 degrees so that the side of the substrate at the upper side having the liquid crystal layers faces into the upper surface of the substrate at the lower side. Thereafter, the substrate at the upper side is pressed, or the space between the substrates is evacuated, and releasing the vacuum, thereby attaching the two substrates.

Then, referring to FIG. **78**D, a UV ray is irradiated on the attached substrates by using a UV irradiating device **2190**. Upon irradiating the UV ray, monomers or oligomers are polymerized by the initiator in the UV sealant, thereby bonding the lower substrate **2151** and the upper substrate **2152**.

Monomers or oligomers each having one end coupled to an acrylic group and the other end coupled to an epoxy group mixed with an initiator are used as the UV sealant **2170**. Since the epoxy group is not reactive with the UV irradiation, the sealant may have to be heated at about 120° C. for one hour after the UV irradiation for hardening the sealant.

In the meantime, the irradiation of the UV ray to the entire surface of the attached substrates may affect characteristics of devices, such as thin film transistors formed on the substrate, and alter a pre-tilt angle of the alignment film formed for an initial orientation of the liquid crystal.

Therefore, as shown in FIG. **79**, the UV irradiation is carried out with masking the pixel regions inside the UV sealant **2170** by a mask **2195**. Then, the bonded substrates are cut into unit cells. In the cutting step, after forming a scribing line (scribing process) on the surface of the bonded substrates by a scriber, such as a diamond pen with a hardness higher than the substrate, a mechanical impact is applied thereto along the scribing line by using a breaker (a break process), to obtain a plurality of unit cells at the same time.

Alternatively, a pen or wheel of diamond may be used to carry out the scribing and the breaking in one step, to obtain a unit cell one by one. A cutting device carrying out the scribing/breaking at the same time may be used in considering an occupied space of the cutting device and a required cutting time period.

Then, a final inspection is carried out after the cutting. In the final inspection, presence of defects is verified before the substrates cut into cell units are assembled into a module, by examining a proper operation of the pixels when a voltage applied thereto is turned on/off.

As explained previously, the LCD panel and the method for fabricating the same of the present invention have the following advantages.

The dummy column spacer and the dotted line type dummy column spacer, both having openings in the dummy region, control the liquid crystal flow, thereby maintaining a uniform cell gap and improving a picture quality.

The dummy column spacer and the dotted line type dummy column spacer serve as dams and prevent the liquid crystal from contacting the UV sealant.

FIG. **80** illustrates a plane view of an LCD in accordance with an embodiment of the present invention.

Referring to FIG. **80**, the LCD panel includes a lower substrate **2151**, an upper substrate **2152**, and a UV sealant **2170** between the substrates **2151** and **2152**. Column spacers (not shown) are formed in a pixel region (a line 'A' represents an imaginary line for indicating a pixel region), and a dummy column spacer **2160** is formed inside the UV sealant **2170** in the dummy region to regulate a liquid crystal flow. A liquid crystal layer (not shown) is formed between the lower and upper substrates **2151** and **2152**. The column spacer serves to maintain a cell gap between the lower substrate **2151** and the upper substrate **2152**.

The dummy column spacer **2160** has a height the same as the column spacer. The dummy column spacer **2160** may be formed at various locations to provide a gap with the lower substrate **2151**, thereby regulating a liquid crystal flow through the gap. Also, the dummy column spacer **2160** may serve as a path for the liquid crystal flow, thereby facilitating the liquid crystal flow at the corner regions of the substrates.

That is, as shown in arrows in the drawing, since the liquid crystal flows along the dummy column spacer **2160**, the liquid crystal reaches to the corner regions of the substrates without difficulty. And, since the liquid crystal flows through the gap between the dummy column spacer **2160** and the lower substrate **2151**, the gap regulates the liquid crystal flow according to an amount of the liquid crystal.

The dummy column spacer **2160** formed at the various locations for adjusting a required gap to the lower substrate **2151** will be explained with reference to FIGS. **81**A to **81**C which are cross-sectional views taken along line IV-IV of FIG. **80** illustrating other embodiments.

Referring to FIG. **81**A, a black matrix **2110**, a color filter layer **2120**, and a common electrode **2130** are formed on the upper substrate **2152** in this order. A plurality of gate lines, data lines, thin film transistors, and pixel electrodes (all not shown) are formed on the lower substrate **2151**. A plurality of column spacers **2150** are formed in the pixel region on the upper substrate **2152** each having a height of the cell gap. Since the column spacers **2150** are formed in regions of the gate lines and the data lines, the column spacers **2150** are formed on the common electrode **2130** over the black matrix **2110** on the upper substrate **2152**. A dummy column spacer **2160** is formed in the dummy region on the upper substrate **2152** with a height the same as the column spacer **2150**.

More specifically, since the dummy column spacer **2160** is formed on the common electrode **2130** over the black matrix **2110** in the dummy region, the dummy column spacer **2160** is spaced apart from the lower substrate **2151** as much as the height of the color filter layer **2120**. For example, the column spacer **2150** and the dummy column spacer **2160** may be formed of a photosensitive resin.

In the meantime, an overcoat layer may be additionally formed between the color filter layer **2120** and the common electrode **2130** on the upper substrate **2152**, and alignment layers may be formed on the upper substrate **2152** inclusive of the column spacers **2160** and the lower substrate **2151**, respectively.

FIG. **81**B illustrates a cross-sectional view of an LCD in accordance with another variation of the first embodiment of the present invention. In this embodiment, instead of the common electrode **2130**, the overcoat layer **2140** is formed on the upper substrate **2152** in the foregoing LCD panel, as shown in FIG. **81**A.

The LCD panel in FIG. **81**B is an in-plane switching (IPS) mode LCD panel, and has a common electrode formed on the lower substrate **2151**. The other elements are similar to the structures shown in FIG. **81**A. Also, the dummy column spacer **2160** formed on the overcoat layer **2140** is spaced apart from the lower substrate **2151**.

FIG. **81**C illustrates a cross-sectional view of an LCD panel in accordance with another embodiment of the present invention. In the LCD panel in FIG. **81**C, the overcoat layer **2140** is patterned such that it is formed on the black matrix **2110**, not on the sealant **2170**. The others are similar to the LCD panel in FIG. **81**B.

FIG. **81**D illustrates a cross-sectional view of an LCD panel in accordance with another embodiment of the present invention. In the LCD in FIG. **81**B, the overcoat layer **2140** is patterned such that it is not formed on the black matrix **2110**. At the end, since the dummy column spacer **2160** is formed on the black matrix **2110**, a gap to the lower substrate **2151** becomes greater. Although the overcoat layer **2140** is patterned to be formed only on the color filter layer **2120** in the drawing, it may be formed on the black matrix **2110** without the dummy column spacers **2160**.

FIGS. **82**A and **82**B illustrate plan views of an LCD panel in accordance with another embodiment of the present invention.

Referring to FIG. **82**A, the LCD panel according to the second embodiment of the present invention includes a dummy column spacer **2160** having an opened portion **2162** in each corner region of a substrate. Accordingly, the liquid crystal moves to the corner regions of the substrate more easily through the opened portion **2162**, thereby facilitating a uniform filling of the liquid crystal. The opened portion **2162** may be formed in at least one corner region of the substrates. Other elements, such as the dummy column spacer **2160**, may be formed at different locations so as to be spaced apart from the lower substrate **2151**.

Referring to FIG. **82**B, the opened portion **2162** formed in the corner region of the substrate includes a plurality of openings for maximizing a liquid crystal flow. A plurality of openings may be formed at either a constant interval or an irregular interval.

FIG. **83** illustrates a plane view of an LCD panel in accordance with another embodiment of the present invention.

Referring to FIG. **83**, the LCD panel includes a lower substrate **2151**, an upper substrate **2152**, and a UV sealant **2170** between the substrates **2151** and **2152**. A plurality of column spacers (not shown) are formed in a pixel region (a line 'A' represents an imaginary line for indicating the pixel region), and a dummy column spacer **2160** is formed inside the UV sealant **2170** in the dummy region to regulate a liquid crystal flow. Also, a dotted line type dummy column spacer

2180 may be additionally formed at the inner dummy region of the dummy column spacer 2160 for assisting the regulation of the liquid crystal flow. A liquid crystal layer (not shown) is formed between the substrates 2151 and 2152.

The dummy column spacer 2160 is spaced apart from the lower substrate 2151 to regulate the liquid crystal flow by the gap. When a liquid crystal is excessively dispensed on the substrate, the liquid crystal may pass through the dummy column spacer 2160 and contact the UV sealant 2170. Thus, the liquid crystal may be contaminated by the UV sealant 2170.

To solve the problem, in the third embodiment of the present invention, a dotted line type dummy column spacer 2180 is additionally formed inside the dummy column spacer 2160, thereby regulating the excessively dispensed liquid crystal. The dotted line type dummy column spacer 2180 may be formed on the lower substrate 2151.

The dummy column spacer 2160 and the dotted line type dummy column spacer 2180 formed at various locations will be explained with reference to FIGS. 84A to 84F, which are cross-sectional views taken along line VII-VII of FIG. 83.

Referring to FIG. 84A, a black matrix 2110, a color filter layer 2120, and a common electrode 2130 are formed on the upper substrate 2152 in this order. A plurality of gate lines, data lines, thin film transistors, and pixel electrodes (all not shown) are formed on the lower substrate 2151. Column spacers 2150 are formed in the pixel region on the upper substrate 2152 each having a height of the cell gap. The dummy column spacer 2160 is formed in the dummy region on the upper substrate 2152, in more detail, on the common electrode 2130 over the black matrix 2110, with a height the same as the column spacer 2150. The dotted line type dummy column spacer 2180 is formed in the dummy region inside the dummy column spacer 2160, more specifically, on the common electrode 2130 over the black matrix 2110, with a height the same as the column spacer 2150. Although only one dotted line type dummy column spacer 2180 is shown in FIG. 84A, there may be more than one dotted line type column spacers 2180. Both the dummy column spacer 2160 and the dotted line type dummy column spacer 2180 may be spaced apart from the lower substrate 2151 as much as the height of the color filter layer 2120.

FIG. 84B illustrates a cross-sectional view of an LCD in accordance with another variation of the third embodiment of the present invention, wherein the dotted line type dummy column spacer 2180 is formed on the common electrode 2130 over the color filter layer 2120 instead of being formed on the common electrode 2130 over the black matrix 2110.

At the end, since the dotted line type dummy column spacer 2180 comes into contact with the lower substrate 2151, the liquid crystal can flow between the dotted line type dummy column spacers 2180.

FIGS. 84C and 84D illustrate cross-sectional views each showing an LCD panel in accordance with other variations of the previous embodiment of the present invention, wherein the overcoat layer 2140 is formed on the upper substrate 2152 instead of the common electrode 2130. That is, it is an in-plane switching (IPS) mode LCD panel, with the common electrode formed on the lower substrate.

FIGS. 84E and 84F illustrate cross-sectional views each showing an LCD panel in accordance with other variations of the previous embodiment of the present invention, wherein the overcoat layer 2140 is patterned to be formed on the black matrix 2110 rather than on the sealant 2170.

FIGS. 84G and 84H illustrate cross-sectional views each showing an LCD panel in accordance with other variations of the previous embodiment of the present invention, wherein the overcoat layer 2140 is patterned so that it is not formed on the black matrix 2110. Since the dummy column spacer 2160 and/or the dotted line dummy column spacer 2180 is formed on the black matrix 2110 rather than on the overcoat layer 2140, the gap to the lower substrate 2152 becomes greater.

FIGS. 85A and 85B illustrate plane views of an LCD panel in accordance with another embodiment of the present invention. The fourth embodiment is similar to the third embodiment, except for that an opened portion 2162 is formed in a dummy column spacer 2160 at the corner regions of the substrate. The opened portion 2162 formed in the corner region of the substrate includes more than one opening for maximizing a liquid crystal flow, as shown in FIG. 85B. The openings may be formed at either a constant interval or an irregular interval.

FIG. 86 illustrates a plan view of an LCD panel in accordance with another embodiment of the present invention, wherein a dotted line type dummy column spacer 2180 is formed outside the dummy column spacer 2160.

Locations of the dummy column spacer 2160 and the dotted line type dummy column spacer 2180 are shown in FIGS. 87A, 87B, and 87C. That is, both of the dummy column spacer 2160 and the dotted line type dummy column spacer 2180 are formed on the common electrode 2130 over the black matrix 2110 in the dummy region, as shown in FIG. 87A. Alternatively, they may be formed on the overcoat layer 2140 over the black matrix 2110 in the dummy region, as shown in FIGS. 87B and 87C. They may be formed on the black matrix 2110 in the dummy region, as shown in FIG. 87D.

FIGS. 88A and 88B illustrate plan views of an LCD panel in accordance with another embodiment of the present invention. This embodiment is similar to the previous embodiment of the present invention except for that an opened portion 2162 is formed in the dummy column spacer 2160 in the corner regions of the substrate. More than one opened portion 2162 may be formed in the corner region of the substrate for maximizing a liquid crystal flow. The openings may be formed at either a constant interval or an irregular interval.

FIGS. 89A to 89D illustrate plan views of an LCD panel in accordance with another embodiment of the present invention, wherein a second dummy column spacer 2185 is additionally formed inside or outside a first dummy column spacer 2160.

FIGS. 89A and 89B illustrate an LCD panel each having the second dummy column spacer 2185 formed outside the first dummy column spacer 2160, and FIGS. 89A and 89D illustrate an LCD panel each having the second dummy column spacer 2185 formed inside the first dummy column spacer 2160.

FIGS. 89B and 89C illustrate LCD panels each having the second dummy column spacer 2185 with an opened portion in at least one of the corner regions of the substrate. More than one opened portion may be formed at either a constant interval or an irregular interval. The first dummy column spacer 2160 may also have an opened portion formed in at least one of the corners of the substrate. Thus, the first dummy column spacer 2160 and the second dummy column spacer 2185 may be formed at various locations.

FIGS. 90A to 90D are perspective views illustrating a method for fabricating an LCD panel in accordance with another embodiment of the present invention. Although the drawing illustrates only one unit cell, there may be more than one unit cell.

Referring to FIG. 90A, a lower substrate 2151 and an upper substrate 2152 are prepared to form a dummy region and a pixel region. The dummy region has a portion spaced apart from the lower substrate **2151**.

A plurality of gate lines and data lines (both not shown) are formed on the lower substrate **2151** to cross each other defining pixel regions. A thin film transistor having a gate electrode, a gate insulating film, a semiconductor layer, an ohmic contact layer, source/drain electrodes, and protection film, is formed at every crossed point of the gate lines and the data lines. A pixel electrode is formed at each of the pixel regions connected to the thin film transistor.

An alignment layer is formed on the pixel electrode for an initial orientation of the liquid crystal. The alignment layer may be formed of one of polyimide, polyamide group compound, polyvinylalcohol (PVA), and polyamic acid by rubbing, or a photosensitive material, such as polyvinvylcinnamate (PVCN), polysilioxanecinnamate (PSCN), or cellulosecinnamate (CelCN) group compound by photo-alignment.

A black matrix is formed on the upper substrate **2152** for shielding a light leakage from the gate lines, the data lines, and the thin film transistors. A color filter layer of red, green, and blue, is formed thereon. A common electrode is formed thereon. An overcoat layer may be additionally formed between the color filter layer and the common electrode.

Silver (Ag) dots are formed on the lower substrate **2151**, for applying a voltage to the common electrode on the upper substrate **2152** after the two substrates **2151** and **2152** are bonded with each other. Alternatively, the silver dots may be formed on the upper substrate **2152**.

In an in-plane switching mode LCD panel, a lateral field is induced by the common electrode formed on the lower substrate the same as the pixel electrode. Thus, the silver dots may not be formed on the substrates. As shown in the first to eighth embodiments, the column spacer, the dummy column spacer, the dotted line type dummy column spacer, the second dummy column spacer may be formed on the various locations of the upper substrate **2152**. The column spacer and the dummy column spacer, the column spacer, the dummy column spacer, and the dotted line type dummy column spacer, or the column spacer, the dummy column spacer, and the second dummy column spacer may be formed of photosensitive resin at the same time with the same height (i.e., at the height of a cell gap). The foregoing alignment layer is formed on the upper substrate **2152**.

Referring to FIG. **90**B, a UV sealant is coated on the upper substrate **2152**. The sealant may be coated by using a dispensing method or a screen printing method. However, the screen printing method may damage the alignment layer formed on the substrate since the screen directly contacts the substrate. Also, the screen printing method may not be economically feasible due to a large amount of the sealant loss for a large substrate.

For example, monomers or oligomers each having both ends coupled with an acrylic group mixed with an initiator, or monomers or oligomers each having one end coupled with an acrylic group and the other end coupled with an epoxy group mixed with an initiator is used as the UV sealant **2170**.

Then, a liquid crystal **2107** is dispensed onto the lower substrate **2151** to form a liquid crystal layer. A dispensed amount of the liquid crystal is determined by a substrate size and a cell gap. Generally, the liquid crystal is dispensed more than the determined amount.

The liquid crystal is contaminated once the liquid crystal contacts the sealant **2170** before the sealant **2170** is hardened. Therefore, the liquid crystal **2107** is dispensed onto the central part of the lower substrate **2151**. A flow speed of the liquid crystal **2107** dispensed onto the central part is appropriately regulated by the dummy column spacer and the dotted line type dummy column spacer, thereby uniformly spreading the liquid crystal **2107** inside the UV sealant **2170**.

FIG. **90**B illustrates that the liquid crystal **2107** is dispensed on the lower substrate **2151** and the UV sealant **2170** are coated on the upper substrate **2152**. Alternatively, the liquid crystal **2107** may be dispensed on the upper substrate **2152**, and the UV sealant **300** may be coated on the lower substrate **2151**.

Moreover, the liquid crystal **2107** and the UV sealant **2170** may be formed on the same substrate. The liquid crystal and the sealant may be formed on the different substrates in order to shorten the fabrication time period. When the liquid crystal **2107** and the UV sealant **2170** are formed on the same substrate, there occurs unbalance in the fabricating processes between the substrate with the liquid crystal and the sealant and the substrate without the liquid crystal and the sealant. In addition, the substrate cannot be cleaned when the sealant is contaminated before the substrates are attached to each other since the liquid crystal and the sealant are formed on the same substrate. Therefore, after coating the UV sealant a substrate cleaning step may be added.

Referring to FIG. **90**C, the lower substrate **2151** and the upper substrate **2152** are attached to each other. The lower substrate **2151** and the upper substrate **2152** may be bonded by the following processes. First, a liquid crystal is dispensed on one of the substrates. The other substrate is turned by 180 degrees so that the side of the substrate at the upper side having the liquid crystal faces into the upper surface of the substrate at the lower side. Thereafter, the substrate at the upper side is pressed, or the space between the substrates is evacuated, and releasing the vacuum, thereby attaching the two substrates.

Then, referring to FIG. **90**D, a UV ray is irradiated on the attached substrates by using a UV irradiating device **2190**. Upon irradiating the UV ray, monomers or oligomers are polymerized by the initiator in the UV sealant, thereby bonding the lower substrate **2151** and the upper substrate **2152**.

Monomers or oligomers each having one end coupled to an acrylic group and the other end coupled to an epoxy group mixed with an initiator are used as the UV sealant **2170**. Since the epoxy group is not reactive with the UV irradiation, the sealant may have to be heated at about 120° C. for one hour after the UV irradiation for hardening the sealant.

In the meantime, the irradiation of the UV ray to the entire surface of the attached substrates may affect characteristics of devices, such as thin film transistors formed on the substrate, and alter a pre-tilt angle of the alignment layer formed for an initial orientation of the liquid crystal.

Therefore, as shown in FIG. **91**, the UV irradiation is carried out with masking the pixel regions inside the UV sealant **2170** by a mask **2195**. Then, the bonded substrates are cut into unit cells. In the cutting step, after forming a scribing line (scribing process) on the surface of the bonded substrates by a scriber, such as a diamond pen with a hardness higher than the substrate, a mechanical impact is applied thereto along the scribing line by using a breaker (a break process), to obtain a plurality of unit cells at the same time.

Alternatively, a pen or wheel of diamond may be used to carry out the scribing and the breaking in one step, to obtain a unit cell one by one. A cutting device carrying out the scribing/breaking at the same time may be used in view of an occupied space of the cutting device and a required cutting time period.

Then, a final inspection is carried out after the cutting. In the final inspection, presence of defects is verified before the substrates cut into cell units are assembled into a module, by examining a proper operation of the pixels when a voltage applied thereto is turned on/off.

As explained above, the LCD panel and the method for fabricating the same of the present invention have the following advantages.

The dummy column spacer and the dotted line type dummy column spacer in the dummy region facilitate the liquid crystal flow on the substrate, thereby maintaining a uniform cell gap and improving a picture quality.

Also, the dummy column spacer and the dotted line type dummy column spacer prevent the liquid crystal from contacting the UV sealant.

FIG. **92** shows an exemplary apparatus for manufacturing a liquid crystal display device during a loading process according to the present invention. In FIG. **92**, the apparatus may include a vacuum processing chamber **2210**, an upper stage **2221**, a lower stage **2222**, an upper stage moving axis **2231**, a lower stage rotational axis **2232**, an upper stage driving motor **2233**, a lower stage driving motor **2234**, a vacuum generating system **2300**, and a loader part **2400**.

The vacuum processing chamber **2210** may be connected to the vacuum generating system **2300** by an air outlet **2212** via an air outlet valve **2212***a* for reducing a pressure of an interior of the vacuum processing chamber **2210**. The vacuum processing chamber may include a vent pipe **2213** for increasing the pressure of the interior of the vacuum processing chamber **2210** via introduction of air or gas through a vent pipe valve **2213***a*. Accordingly, the vacuum processing chamber may include a vacuum processing chamber entrance **2211** to allow for introduction and extraction of a first substrate **2251** and a second substrate **2252** by the loader part **2400**.

The upper and lower stages parts **2221** and **2222** may be provided at upper and lower portions of the vacuum processing chamber **2210**, respectively. The upper and lower stages **2221** and **2222** may include an electrostatic chuck (ESC) **2221***a* and **2222***a* provided at a opposing surfaces of the upper and lower stages **2221** and **2222**, respectively. Accordingly, the upper electrostatic chuck **2221***a* electrostatically attaches the substrate **2252** to the upper stage **2221**, and the lower electrostatic chuck **2222***a* electrostatically attaches the substrate **2251** to the lower stage **2222**. In addition, the upper stage **2221** may include a plurality of vacuum holes **2221***b* formed through the upper stage **2221**, thereby attaching the substrate **2252** to the upper stage **2221** by forming a vacuum within the plurality of vacuum holes **2221***b*. The upper and lower electrostatic chucks **2221***a* and **2222***a* may be provided with at least one pair of electrostatic plates having different polarities to apply serial power having different polarities. Alternatively, the upper and lower electrostatic chucks **2221***a* and **2222***a* may be provided with electrostatic plates simultaneously having two identical polarities.

The plurality of the vacuum holes **2221***b* may be formed in a center portion and along a circumference of the upper electrostatic chuck **2221***a*, and may be connected to a single or multiple pipes **2221***c* to transmit a vacuum force generated by a vacuum pump **2223** connected to the upper stage **2221**. Alternatively, even though the upper electrostatic chuck **2221***a* and the plurality of vacuum holes **2221***b* may be formed to have a shape similar to the upper stage **2221**, it may preferable to arrange the upper electrostatic chuck **2221***a* and the plurality of vacuum holes **2221***b* based upon a geometry of the substrate **2252** or upon a geometry of a region upon which liquid crystal material is disposed.

The upper stage moving axis **2231** drives the upper stage **2221**, the lower stage rotational axis **2232** drives the lower stage **2222**, and the upper and lower stage driving motors **2233** and **2234** drive the upper and lower stages **2221** and **2222**, respectively, at inner and outer sides of the vacuum processing chamber **2210**. A driving system **2235** may be provided driving the lower stage **2222** during an alignment process for aligning the first and second substrates **2251** and **2252**.

The vacuum generating system **2300** may transmit a suction force to generate a vacuum state inside the vacuum processing chamber **2210**, and may include a suction pump driven to generate a general vacuum force. In addition, the vacuum generating system **2300** may be interconnected to the air outlet **2212** of the vacuum processing chamber **2210**.

The loader part **2400** may be a mechanical device separate from the vacuum processing chamber **2210**, and may be provided at the outer side of the vacuum processing chamber **2210**. The loader part **2400** may receive one of the first substrate **2251** and the second substrate **2252** upon which at least the liquid crystal material is disposed. In addition, the first substrate **2251** may include both the liquid crystal material and the sealant. Moreover, the first substrate **2251** may include one of a TFT array substrate and a color filter (C/F) substrate, and the second substrate **2252** may include another one of the TFT array substrate and the C/F substrate. Then, the loader part **2400** may selectively load both of the first and second substrates **2251** and **2252** into the vacuum processing chamber **2210**. The loader part **2400** may include a first arm **2410** to carry the first substrate **2251** upon which at least the liquid crystal material is disposed, and a second arm **2420** to carry the second substrate **2252**. During the loading of the first and second substrates **2251** and **2252**, the first arm **2410** may be placed over the second arm **2420**.

An alignment system **2500** may be further included to certify an alignment state of the first and second substrates **2251** and **2252**. The alignment system **2500** may be provided to at least one of the inner and outer sides of the vacuum processing chamber **2210**. Since movement of the lower stage **2222** may be limited, an alignment state between the first and second substrates **2251** and **2252** may be accurately and quickly achieved.

Hereinafter, a bonding process of the first and second substrates **2251** and **2252** using the apparatus for manufacturing a liquid crystal display device according to the present invention will now be explained.

In FIG. **92**, the loader part **2400** receives one of the first substrate **2251** and the second substrate **2252** upon which at least a liquid crystal material is disposed at the first arm **2410**, and an other of the first substrate **2251** and the second substrate **2252** at the second arm **2420**. The second arm **2420** loads the substrate **2252** onto a lower surface of the upper stage **2221**, and the first arm **2410** loads the substrate **2251** upon which at least the liquid crystal material is disposed onto an upper surface of the lower stage **2222**. The substrate **2252** may be loaded onto the lower surface of the upper stage **2222** before the substrate **2251** upon which at least the liquid crystal material is disposed in order to prevent any particles from being deposited upon the substrate **2251**. During the loading process of the substrate **2251**, the particles can fall on the substrate **2251** on which a liquid crystal material is disposed.

The second arm **2420** carries the substrate **2252** under the upper stage, and then a vacuum pump **2223** is enabled to transmit a vacuum force to each of the plurality of vacuum holes **2221***b* at the upper stage **2221**. The first arm **2410** carries the substrate **2251** above the lower stage **2222** to affix the substrate **2252** to the upper stage **2221** from the second arm **2420** and a vacuum pump (not shown) is enabled to transmit a vacuum force to each of the plurality of vacuum holes (not shown) at the lower stage **2222** to affix the substrate **2251** to the lower stage **2222** from the first arm **2410**.

After the loading of the substrates **2251** and **2252** is completed, shielding door **2214** (FIG. **93**) disposed at the vacuum processing chamber entrance **2211** is enabled, thereby sealing the vacuum processing chamber entrance **2211**.

FIG. **93** shows the exemplary apparatus for manufacturing a liquid crystal display device during a vacuum process according to the present invention. In FIG. **93**, the vacuum generating system **2300** is enabled, and the air outlet valve **2212***a* is opened, thereby evacuating the interior of the vacuum processing chamber **2210**. Once the interior of the vacuum processing chamber **2210** is successfully evacuated to a desired pressure, the vacuum generating system **2300** may be disabled, and the air outlet valve **2212***a* may be closed. Accordingly, power may be applied to the upper and lower electrostatic chucks **2221***a* and **2222***a*, thereby affixing the substrates **2251** and **2252** to the upper and lower stages **2221** and **2222** by an electrostatic force.

FIG. **94** shows the exemplary apparatus for manufacturing a liquid crystal display device during a location alignment process between substrates according to the present invention. In FIG. **94**, the upper stage driving motor **2233** moves the upper stage **2221** toward the lower stage **2222**, so that the upper stage **2221** is placed adjacent to the lower stage **2222**. Then, the alignment system **2500** certifies the alignment state of the first and second substrates **2251** and **2252** that are attached to the upper and lower stages **2221** and **2222**, respectively. The alignment system **2500** transmits a control signal to the upper stage moving axis and to the lower stage rotational axis **2232**, thereby aligning the first and second substrates **2251** and **2252**.

FIG. **95** shows the exemplary apparatus for manufacturing a liquid crystal display device during a bonding process of the substrates according to the present invention. In FIG. **95**, the upper stage moving axis **2231** is driven in response to a drive signal received from the alignment system **2500**, and performs a first bonding process to bond the substrates **2251** and **2252**. However, the first bonding process may not necessarily completely bond the substrates **2251** and **2252**. The first bonding process loosely bonds the substrates **2251** and **2252** such that air is not to be introduced between the bonded substrates when the pressure of the vacuum processing chamber is increased to atmospheric pressure.

FIG. **96** shows the exemplary apparatus for manufacturing a liquid crystal display device during a further bonding process according to the present invention. In FIG. **96**, the vent pipe valve **2213***a* is enabled, thereby allowing the pressure of the interior of the vacuum processing chamber **2210** to reach atmospheric pressure. Accordingly, the bonded substrates are further compressed due to the pressure difference between the evacuated interior between the bonded substrates and the atmospheric pressure of the vacuum processing chamber **2210**.

According to this, more complete bonding process is performed, and if the bonding process is completed, the shielding door **2214** of the vacuum processing chamber **2210** is operative, so that the entrance **2211** closed by the shielding door is opened.

FIG. **97** shows the exemplary apparatus for manufacturing a liquid crystal display device during an unloading process according to the present invention. In FIG. **97**, unloading of the bonded substrates is performed by the second arm **2420** of the loader part **2400**.

FIGS. **98**A-**103**B illustrate sections of liquid crystal display (LCD) vacuum bonding machines for performing the liquid crystal dispensing method of the present invention. The figures illustrate the method in an order of a process.

As noted in the aforementioned drawings, the bonding machines of the present invention include a bonding chamber **2610**, a stage part, a stage moving device, and vacuum means.

The bonding chamber **2610** is designed as a one piece unit and has an interior designed to selectively be in a vacuum state or an atmospheric pressure state. The bonding chamber **2610** also includes a bonding chamber entrance **2611** to allow for ingress and egress of a first substrate **2651** and a second substrate **2652**, into or out of the bonding chamber **2610**.

The bonding chamber **2610** may also include at least one air outlet **2612**, **2613**, and **2614** connected to one side thereof for extracting air from the interior of the bonding chamber **2610** by a vacuum means; and a vent pipe **2615** connected to one side thereof for introducing air or any suitable gas into the bonding chamber **2610** for sustaining the bonding chamber **2610** at atmospheric pressure.

The air outlets **2612**, **2613**, and **2614** include electronically controlled valves **2612***a*, **2613***a*, and **2614***a*, respectively, for selective opening and shutting of tube lines.

The bonding chamber entrance **2611** may include a door **2611***a* (not shown) for sealing the bonding chamber entrance **2611**. The door **2611***a* may be a general sliding or rotating type door, or suitable type of device that can close an opening. In one aspect of the present invention, the sliding or rotating type door may include a sealing member for sealing a gap between the door **2611***a* and the bonding chamber entrance **2611**, thereby allowing an appropriate vacuum state the detail of which is not shown in the drawing.

The stage parts may be provided in the upper and lower spaces of the bonding chamber **2610**. They may face each other and include an upper stage **2621** and a lower stage **2622** for securing the substrates **2651** and **2652** introduced into the bonding chamber **2610**.

The upper and lower stages **2621** and **2622**, respectively, may include at least one electrostatic chuck (ESC) **2621***a* provided at opposing surfaces of the upper and lower stages. The upper electrostatic chuck **2621***a* electrostatically holds the second substrate **2652** to the upper stage **2621**, and the lower electrostatic chuck **2622***a* electrostatically holds the first substrate **2652** to the lower stage **2622**. In addition, the upper and lower stages **2621** and **2622** may also include a plurality of vacuum channels **2621***b* formed therethrough. The vacuum channels enable the substrates **2651** and **2652** to be arranged on the upper stage **2621** and the lower stage **2622**, respectively.

Although the present embodiment suggests that at least two electrostatic chucks **2621***a* may be utilized, pairs of electrostatic chucks having DC voltages of opposite polarities may also be formed to electrostatically hold the substrates to their respective stages. Alternatively, single electrostatic chucks having DC voltages of opposite polarities applied thereto may also provide the electrostatic charge to provide required holding power.

In one aspect of the present invention, the plurality of vacuum channels **2621***b* may be formed in a center portion and/or along the circumference of the electrostatic chucks **2621***a* and may be connected to single or multiple tubes **2621***c*. The vacuum channels **2621***b* transmit a vacuum force generated by a vacuum pump **2623** connected to the upper stage **2621**.

The lower stage **2622** may include at least one electrostatic chucks **2622***a* on a top surface of the lower stage to provide electrostatic power for holding the substrate, and at least one vacuum channel (not shown) for holding the substrate by vacuum.

The electrostatic chuck and the vacuum channel may or may not be identical to the vacuum channels of the upper stage **2621**. The arrangement of the electrostatic chuck and the vacuum channels be determined by taking into account the overall fabrication processes of the substrates and/or each liquid crystal coating regions.

The stage moving device includes a moving shaft **2631** for selective up and down movement of the upper stage **2621**, a rotating shaft **2631** for selective left and right rotation of the lower stage **2622**, and driving motors **2633** and **2634** fitted to the interior or exterior of the chamber **2610**, that are coupled to the stages **2621** and **2622** via shafts, respectively.

The stage moving device is not limited to a system in which the upper stage **2621** is movable only in the up and down directions, and the lower stage **2622** is rotatable only in the left and right directions. Rather, the upper stage **2621** may be made to be rotatable in left and right directions, and the lower stage may be made to be movable in up and down directions when the upper stage **2621** is provided with a separate rotating shaft (not shown). In addition, the upper stage and lower stage **2622** are provided with a separate moving shaft (not shown) for rotation of the upper stage and lower stage **2622** and for up and down directional movement of the lower stage **2622**.

The vacuum means is connected to the air outlets **2612-2614** on the bonding chamber **2610** for extracting air from the interior of the bonding chamber **2610**, and includes at least more than two units, and preferably five units.

At least one of the vacuum means is a Turbo Molecular Pump (TMP) **2710** that has a higher air suction capability compared to other vacuum means, and the rest of the vacuum means are dry pumps **2720**. In particular, there may be one TMP **2710** and four dry pumps **2720**.

Of the three air outlets **2612**, **2613**, and **2614** in total connected to the bonding chamber **2610**, one air outlet ("a first air outlet") **2612** is connected to the TMP **2710**, and the remaining two air outlets **2613** ("a second air outlet") and **2614** ("a third air outlet") are connected to two pairs of the dry pumps, respectively.

Moreover, there may be five air outlets so that one of the air outlets is connected to the TMP **2710** and the other four outlets are connected to the other four dry pumps, respectively.

Along with this, the present invention suggests making a system by connecting gas supplying means **2800** that regulates the amount of air or gas supplied to the vent pipe **2615** and is connected to the bonding chamber **2610**.

The gas supplying means **2800** includes a gas charge part **2810**, having air or gas storage therein, to sustain the atmospheric pressure in the bonding chamber **2610**, and a valve **2820** for selective opening and shutting of the vent pipe **2615** as required.

Moreover, the present invention can make a system inclusive of a pump for forced pumping of the air or gas charged in the gas charge part **2810** to the vent tube **2615** by a selective pressure. That is, the system for sustaining the interior of the bonding chamber at the atmospheric pressure is not limited to the valve, only.

However, since the air or gas can infiltrate into the bonding chamber **2610** by itself through a minute gap as the interior of bonding chamber **2610** is at a vacuum, the forced pumping may not be necessarily used. According, the present invention suggests a system with the valve **2820** applied thereto for selectively opening and shutting the vent tube **2615** as much as required instead of the pump.

Moreover, if the vacuum of the bonding chamber becomes greater than the vacuum applied to the stages during evacuation of the bonding chamber **2610**, when the stages **2621** and **2622**, respectively have the first and second glass substrates held respectively thereto, the stages to lose vacuum holding power and the second glass substrate can fall off the upper stage and drop onto the first glass substrate. To prevent this event from occurring, a substrate receiving means **2900** is provided to the bonding chamber for supporting the substrate to the upper stage **2621**. In this instance, the substrate receiving means **2900** supports a central part of the substrate of the non-active region, rather than supporting only the corner parts of the substrate.

It is noted that FIGS. **98**A, **99**A, **100**A, **101**A, **102**A and **103**A show one embodiment and FIGS. **98**B, **99**B, **100**B, **101**B, **102**B and **103**B show another embodiment. In particular, the vent **2800**, the dry pumps **2720** and the TMP **270** are in different locations in FIGS. **98**B, **99**B, **100**B, **101**B, **102**B and **103**B to show that different locations can be used for such elements. For example, FIGS. **98**B, **99**B, **100**B, **101**B, **102**B and **103**B show the vent **2800** at the top of the bonding chamber **2610**, the dry pumps **2720** at the bottom of the bonding chamber **2610**, and the TMP **2710** at the side of the bonding chamber **2610**, whereas FIGS. **98**A, **99**A, **100**A, **101**A, **102**A and **103**A show the vent **2800** at the side of the bonding chamber **2610**, the dry pumps **2720** at the side of the bonding chamber **2610**, and the TMP **2710** at the top of the bonding chamber **2610**. Other permutations of different suitable locations for these elements are contemplated in the present invention.

For example, FIGS. **209** and **210** show multiple vent holes **2615***a* at the top of the bonding chamber while FIGS. **211** and **212** show multiple vent holes **2615***a* at all sides of the bonding chamber. The plurality of vent holes may be formed at the top of the bonding chamber. The plurality of vent holes may be formed at the top, bottom and sides of the bonding chamber. At least two of said vent holes may be formed at the top of the bonding chamber, at least one of the vent holes may be formed at least at one side of the bonding chamber, and at least two of the vent holes may be formed at the bottom of the bonding chamber. The plurality of vent holes may be formed at the top surface and the side surface of the bonding chamber. The plurality of vent holes may be formed at the top surface and the bottom surface of the bonding chamber. The top surface may have at least two vent holes and the side surface may have at least two vent holes.

FIGS. **104A-104**E illustrate sections showing the steps of a method for fabricating an LCD in accordance with an embodiment of the present invention. FIG. **105** illustrates a flow chart showing the steps of a method for fabricating LCDs having the liquid crystal dispensing method applied thereto in accordance with an embodiment of the present invention. Next, the method for fabricating LCDs by using the bonding machines of the foregoing present invention will be explained, with reference to FIGS. **104**A-**104**E, and **98**A-**103**B.

The method for fabricating LCDs includes the steps of loading the two substrates into the vacuum bonding chamber, evacuating the bonding chamber, bonding the two substrates, venting the bonding chamber for uniform application of pressure to the bonded substrates, and unloading the pressed two substrates from the vacuum bonding chamber.

Referring to FIG. **104**A, liquid crystal **3007** is dropped onto a first glass substrate **2651** and sealant **3070** is coated on a second substrate **2652**. Before loading the substrates into the bonding chamber, the second glass substrate **2652** having the sealant **3070** coated thereon may be cleaned by Ultra Sonic Cleaner (USC), thereby enabling the removal particles formed during the previous processes. The USC is possible as the second glass substrate **2652** has no liquid crystal dropped thereon.

One of the first and second substrates is a substrate having the thin film transistor arrays formed thereon, and the other substrate is a substrate having the color filter layers formed thereon. In this invention, the liquid crystal dropping and the sealant coating may be made applied to only one of the first and second substrates. Only positioning of the substrate having the liquid crystal dropped thereon on the lower stage, and the other substrate on the upper stage is required.

Referring to FIG. **98**A, **98**B, **104**B, or **105** schematically illustrating the loading step, the second glass substrate **2652** having the sealant **3070** coated thereon is held to the upper stage **2621** by vacuum. The second glass substrate **2652** with sealant coated thereon is positioned faced down (**2631**S) on the upper stage **2621**. The first glass substrate **2651** having the liquid crystal **3007** dispensed thereon is held to the lower stage **2622** by vacuum (**2632**S). At this time the vacuum bonding chamber **2610** is at an atmospheric pressure state.

The second glass substrate **2652** having the sealant **3070** coated thereon is held by a loader of a robot (not shown) with the face on which the sealant **3070** is coated facing down and brought into the vacuum bonding chamber **2610**. In this state, the upper stage **2621** in the vacuum bonding chamber **2610** is moved down, and the lower stage holding the second glass substrate **2652** may be moved up. In addition, instead of a vacuum holding the upper and lower substrates, the electrostatic chuck may be used for one substrate or both simultaneously.

Next, the loader of the robot is moved out of the vacuum bonding chamber **2610**, and the first glass substrate **2651** having the liquid crystal **3007** dropped thereon is placed over the lower stage **2622** in the vacuum bonding chamber **2610** by the loader of the robot, so that the lower stage **2622** vacuum channels hold the first substrate **2651**. When respective loading of the substrates **2651** and **2652** on the stages **2621** and **2622** are finished, the door in the bonding chamber entrance **2611** is closed in order to seal the interior of the bonding chamber **2610**. It is preferable that the second substrate **2652** having the sealant coated thereon be loaded on the upper stage **2621** first and that the first substrate **2651** having the liquid crystal dropped thereon loaded on the lower stage **2622** second. This is because if the first substrate **2651** is loaded first and the second substrate **2652** is loaded second, foreign matter may fall onto the first substrate **2651** when the second substrate **2652** is loaded.

The evacuation step is progressed in two stages. That is, after the substrates **2651** and **2652** are held to the upper and lower stages **2621** and **2622**, respectively, and the chamber door is closed a first evacuation is started. After bringing the substrate receiver **2900** below the upper stage **2621** and placing down the second substrate **2652** held to the upper stage **2621** on the substrate receiver **2900**, or bringing the upper stage **2621** and the substrate receiver **2900** to be at a certain distance from the upper stage **2621** holds the substrate. Next, a second evacuation of the vacuum bonding chamber is conducted. In this instance, the second evacuation is made faster than the first evacuation, and the first evacuation is made such that the vacuum in the vacuum bonding chamber is not higher than the vacuum channel force of the upper stage.

Without dividing the evacuation into first and second stages, the evacuation of the bonding chamber **2610** may be started at a fixed rate, and the substrate receiver **2900** may be brought below the upper stage during the evacuation. It is required that the substrate receiver **2900** is brought below the upper stage **2621** before the vacuum in the vacuum bonding chamber becomes higher than the vacuum holding force in upper stage **2621**.

That is, dry pumps **2720** in the vacuum means are put into operation for evacuation of the bonding chamber **2610** through the second and third air outlets **2613** and **2614** and are operated at 10-30 Kl/min (preferably, 23 Kl/min). For example, the valves **2613***a* and **2614***a* on the second and third air outlets **2613** and **2614** are opened during the first evacuation.

It should be noted that if the vacuum force in the bonding chamber **2610** becomes higher than the vacuum force that holds the substrate **2651** to the upper stage **2621** (i.e., the interior of the bonding chamber **2610** reaches a higher vacuum force than in the vacuum channels), then the substrate **2652** held to the upper stage **2652** may drop from the upper stage **2621**.

Referring to FIGS. **99**A and **99**B, in order to prevent the substrate **2652** from dropping and/or being broken, a substrate receiving means **2900** temporarily receives the substrate **2652** held to the upper stage **2621** (**2633**S). The substrate receiving means **2900** moves during the slow evacuation before the bonding chamber **2610** reaches to a high vacuum. The substrate receiver **2900** is contacted with the second substrate **2652** by the following method.

For example, after the second substrate **2652** and the substrate receiver **2900** are brought closer together by either moving the upper stage **2621** down or moving the substrate receiver **2900** up or both, the second substrate **2652** is placed down on the substrate receiving means **2900** by releasing the vacuum channel force of the upper stage **2621**.

Thus, the second glass substrate **2652** held to the upper stage may be arranged on the substrate receiver **2900** before evacuating the vacuum bonding chamber, or the upper stage having the second glass substrate held thereto and the substrate receiver may be brought to be at a certain distance so that the second glass substrate **2652** is arranged on the substrate receiver **2900** from the upper stage **2621** during the evacuation of the chamber. Moreover, other means for fastening the substrates may additionally be provided as there may be an occurrence of airflow in the chamber at the initial stage, which can shake the substrates when the evacuation of the vacuum bonding chamber is started.

The step of evacuating the bonding chamber **2610** is not necessarily carried out after the bonding chamber entrance **2611** is closed by the door **2611***a*.

Considering an initial evacuation that is slow, the bonding chamber entrance **2611** may be closed during the evacuation.

Moreover, the movement of the substrate receiving means **2900** to a location for receiving the second substrate **2652** is not necessarily required until the bonding chamber **2610** reaches a high vacuum, but the movement of the substrate receiving means **2900** can made before the evacuation of the bonding chamber. However, for enhancing the fabrication process efficiency, it is preferable that the substrate receiving means **2900** is moved during the evacuation of the bonding chamber **2610**.

Then, referring to FIGS. **100**A and **100**B, when the vacuum of the bonding chamber **2610** reaches a pressure of approximately 50 Pa (preferably below 13 Pa) by the continuous evacuation of the dry pumps **2720**, the substrate **2652** is held to the upper stage **2621** and is supported on the substrate receiving means **2900**. Next, the valve **2612***a* is opened to open the first air extraction tube **2612** and the TMP **2710** is put into operation, for the second evacuation (**2634**S).

In this instance, the TMP **2710** evacuates the bonding chamber **2610** through the first air extraction tube **2612** rapidly at a rate of approx. 0.1-5 Kl/min (preferably, 1.1 Kl/min).

However, the operation of TMP **2710** and the dry pumps **2720** is not limited to performing the rapid evacuation of the chamber at a particular time. For example, it is not limited to the time when the substrate **2652** held to the upper stage **2621** and supported on the substrate receiving means **2900**. That is, a driving control may be utilized to reach the high vacuum by selective regulation of the valves **2612***a*, **2613***a*, and **2614***a*, fitted on the air outlets **2612**, **2613**, and **2614**.

When the vacuum of the bonding chamber **2610** reaches a desired pressure range, the foregoing steps are conducted. For example, when the vacuum of the bonding chamber **2610** reaches a pressure below 0.01 Pa (preferably, 0.67 Pa), the operation of the TMP is stopped. In this instance, the valve **2612***a* fitted to the first air outlet **2612** closes the first air outlet **2612**.

The vacuum within the vacuum bonding chamber **2610** may have a pressure in a range of about 1.0×10^{-3} Pa to 1 Pa for in-plane switching (IPS) mode liquid crystal display devices, and about 1.1×10^{-3} Pa to 10^{2} Pa for twisted nematic (TN) mode liquid crystal display devices.

Evacuation of the vacuum bonding chamber may be carried out in two stages, thereby preventing deformation or shaking of the substrates in the vacuum bonding chamber that may be caused by rapid evacuation of the vacuum bonding chamber.

Once the vacuum bonding chamber **2610** is evacuated to a preset vacuum pressure, the upper and lower stages **2621** and **2622** bias the first and second glass substrates **2651** and **2652**, respectively by electrostatic chuck (**2635**S) and the substrate receiver **2900** is brought to the home position (**2636**S). That is, the second substrate **2652** is temporarily supported on the substrate receiving means **2900** and is held at the upper stage **2621**, and the first substrate **2651** on the lower stage **2622** is held at the lower stage **2622**.

Using electrostatic charge, the first and second substrates may be fixed to their respective stages by applying negative/positive DC voltages to two or more plate electrodes formed at the stages. When the negative/positive voltages are applied to the plate electrodes, a coulomb force is generated between the conductive layer (e.g., transparent electrodes, common electrodes, pixel electrodes, etc.) formed on the substrate and the stage. When the conductive layer formed on the substrate faces the stage, approximately 0.1-1 KV is applied to the plate electrodes. When the substrate contains no conductive layer formed facing the stage, approximately 3-4 KV is applied to the plate electrodes. An elastic sheet may be optionally provided to the upper stage.

Referring to FIGS. **104**C, **104**D, **101**A and **101**B, after the two glass substrates **2651** and **2652** are held by their respective stages **2621** and **2622** by electrostatic charge, the two stages are moved into proximity such that the two glass substrates may be bonded (**2637**S). The first and second glass substrates are pressed by moving either the upper stage **2621** or the lower stage **2622** in a vertical direction, while varying speeds and pressures at different stage locations. Until the time the liquid crystal **3007** on the first glass substrate **2651** and the second glass substrate **2652** come into contact, or until the time the first glass substrate **2651** and the sealant **3070** on the second glass substrate **2652** come into contact, the stages may be moved at a fixed speed or fixed pressure and the pressure may be incrementally increased from the time of contact to a final pressure. After the load cell fitted to a shaft of the movable stages senses contact, the glass substrates are pressed together with increasing pressures. For example, at contact the substrates are pressed at a pressure of about 0.1 ton; at an intermediate stage they are pressed to a pressure of about 0.3 ton; at an end stage they are pressed to a pressure of about 0.4 ton at an end stage; and finally they are pressed to a pressure of about pressure of 0.5 ton at the final stage (see FIG. **104**D).

Although it is illustrated that the upper stage presses down onto the substrate by means of one shaft, a plurality of shafts may independently apply and control pressure using an individual load cell. If the lower stage and the upper stage are not leveled or fail to press down uniformly, any number of predetermined shafts may be pressed at a lower or higher pressure in order to obtain a uniform bonding of the seal.

Referring to FIG. **104**E, after the foregoing process bonds the two substrates and after the electrostatic charge has been turned off to the upper and lower stages, the upper stage **2621** is moved up in order to separate the upper stage **2621** from the bonded two glass substrates **2651** and **2652**.

Next, referring to FIGS. **102**A and **102**B, the vent pipe **2615** is opened to the required degree via the valve **2820** at an initial stage. Then, referring to FIGS. **103**A and **103**B, the vent pipe **2615** is opened fully in order to pressurize the bonding chamber **2610** slowly. The pressure difference in the bonding chamber **2610** during the slow pressurization of the bonding chamber causes a pressure to be applied to the two substrates. Since the chamber is at the atmospheric pressure and the space between the bonded substrates is at a vacuum, thus the two substrates are subjected to a uniform application of pressure.

Although only one vent **2800** is shown, multiple vents, for example, may positioned at any location on the chamber. For example, referring to FIG. **102**B, the vent may be positioned at the top of the chamber.

Then, the bonded substrates are unloaded (**2638**S). That is, after the door **2611***a* in the bonding chamber **2610** is operated to open the bonding chamber entrance **2611**, the bonded first and second glass substrates **2651** and **2652** are unloaded by using the loader on the robot directly, or after the upper stage holds and moves up the first and second stages **2621**.

To shorten the fabrication time period, one of the first and second glass substrates to be bonded in the next bonding process may be loaded onto an empty stage while the fixed first and second glass substrates are unloaded. For example, after the second glass substrate **2652** to be bonded in the next bonding process is brought to the upper stage **2621** via the loader and held to the upper stage by vacuum, the bonded first and second glass substrates on the lower stage **2622** may be unloaded. Alternatively, after the upper stage **2621** lifts the bonded first and second glass substrates, the loader may load the first glass substrate **2651** to be bonded on the lower stage and the bonded first and second glass substrates may be unloaded.

A liquid crystal spreading process may optionally be added before the process of unloading the bonded substrates in which the liquid crystal between the fixed substrates may be spread toward the sealant. Alternatively, a liquid crystal spreading process may be carried out to evenly spread the liquid crystal toward the sealant when the liquid crystal does not adequately spread after the unloading. The liquid crystal spreading process may be carried out for more than 10 minutes under atmospheric pressure or in a vacuum.

As has been explained the LCD bonding machines and the method for fabricating LCDs have the following advantages.

First, the LCD bonding machines of the present invention includes at least two different vacuum pumps, which have different vacuum powers. For example, a TMP and dry pumps that allow a smooth evacuation of the bonding chamber thereby preventing damage to the liquid crystal panel.

Second, the step by step evacuation of the bonding chamber permits operation of other parts required during the steps of evacuation are made at the same time, thereby improving efficiencies in the fabrication process.

Third, the availability of two staged evacuations from a low vacuum pressure to a high vacuum pressure without generating excessive air suction pressures prevents deformation caused by rapid evacuation and defective distribution of the liquid crystal in the substrates.

Fourth, the availability of gradual introduction of air or gas into the bonding chamber for sustaining the atmospheric pressure in the process of turning the bonding chamber into the atmospheric pressure prevents defective bonding of the substrates.

Fifth, the one-piece bonding chamber is favorable for obtaining a high vacuum in the bonding chamber. That is, it minimizes or eliminates leaks that may be present in the two-piece bonding chamber.

Sixth, the dispensing the liquid crystal on the first substrate and coating of the sealant on the second substrate reduces the fabrication time.

Seventh, dispensing liquid crystal onto the first substrate and coating sealant on the second substrate permits a balanced progression of the fabrication processes to the first and second substrates, thereby making effective use of the production line.

Eighth, not dropping liquid crystal on the second substrate permits the sealant minimizes contamination of particles on the second substrate because it can be cleaned by USC just prior to bonding.

Ninth, since the bonding chamber is evacuated after the substrate receiving means supports a central portion of the substrate prevents falling and breakage of the substrate even if the substrate is of large size.

Tenth, sensing the time during which the two substrates come into contact and varying the pressure in bonding the two substrates minimizes damage made by the liquid crystal to the orientation film.

Eleventh, since the upper stage presses the substrate down by means of a plurality of shafts, each of which is capable of applying pressure independently, uniform bonding of the sealant can be achieved by independently applying a lower or higher pressure by predetermined shafts when the lower stage and the upper stage are not level or fail to bond to the sealant uniformly.

Twelfth, simultaneous loading and unloading of the glass substrates shortens the fabrication time.

Thirteenth, inclusion of a liquid crystal spreading process shortens the LCD fabrication time.

FIG. **106** illustrates a flowchart showing method steps for fabricating an LCD in accordance with a preferred embodiment of the present invention, and FIGS. **107A**-**107E** illustrate method steps for fabricating an LCD in accordance with a preferred embodiment of the present invention.

Referring to FIG. **106**, a plurality of panels are designed on a first glass substrate **2651** and a thin film transistor array is formed on each panel (**3211**S), and a first orientation or alignment film is formed on an entire surface of the first glass substrate **2251**. Then, a rubbing process (**3212**S) is performed. Instead of the rubbing process, a UV alignment process may be performed.

It should be noted that in a single glass substrate, multiple panels may be formed or one large panel may be formed. For example, in a 1.0 meter×1.2 meter glass substrate, 15 panels of about 15 inches each may be formed simultaneously. Many other panel sizes may be formed but the number of panels will differ. For example, in the same size glass substrate (1.0 m×1.2 m), 6 panels of 18 inches may be formed. Even a large panel size of 40 inches or more may be formed on the 1.0 m×1.2 m glass substrate.

A plurality of panels are designed on a second glass substrate **2252** corresponding to the panels on the first glass substrate **2252**, to form a color filter array on each panel (**3215**S). The color filter array includes such elements as a black matrix layer, a color filter layer, and a common electrode. A second orientation or alignment film is formed on an entire surface of the second substrate **2252** and the second orientation film undergoes a rubbing process (**3216**S) similar to the first orientation film. A UV alignment process may replace the rubbing process.

The first and second glass substrates **2251** and **2252** thus formed are cleaned, respectively (**3213**S and **3217**S).

Referring to FIG. **107**A, liquid crystal **3107** is dropped or applied on the first glass substrate **3151** which has been cleaned (**3214**S). Silver (Ag) dots are formed on the cleaned second glass substrate **3152** (**3218**S), as well as a sealant **3170** (**3219**S).

The first and second glass substrates **3151** and **3152** are loaded in a vacuum bonding chamber **3110**, and bonded to spread the applied liquid crystal between the first and second substrates uniformly. Then, the sealant is hardened (**3220**S).

The bonded first and second glass substrates **3151** and **3152** are cut into individual panels (**3221**S). Each panel is polished and inspected (**3222**S). The bonding process will be explained in more detail. FIG. **108** illustrates a flowchart showing the bonding steps of the present invention.

The bonding process includes the step of loading the two substrates in the vacuum bonding chamber, bonding the two substrates, and unloading the bonded substrates from the vacuum bonding chamber.

Although a plurality of panels may be formed for a single glass substrate, a single panel may also be formed to maximize the size of the display, as explained earlier.

Before loading the substrates, the second glass substrate **3152** having the sealant **3170** coated thereon maybe cleaned using the ultra sonic cleaner (USC), for example, for removing undesired particles formed during fabrication. Since the second glass substrate **3152** has the sealant and the Ag dots coated thereon and no liquid crystal applied thereon, the second glass substrate **3152** can be cleaned.

Referring to FIG. **107**B, in the loading step, the second glass substrate **3152** having the sealant **3170** coated thereon is held by an upper stage **3121** by a vacuum chuck, for example, in the vacuum bonding chamber **3110** with the coated sealant facing downward (**3231**S). Before the second glass substrate **3152** is loaded in the bonding chamber **3110**, the substrate **3152** is flipped over so that the surface with the sealant **3170** will face downward. The first and second substrates may be held by the lower and upper substrates, respectively, by several suitable mechanisms including a vacuum chuck and electrostatic charge (ESC).

The second glass substrate **3152** has sealant **3170** coated thereon and is held by a loader portion of a robot (not shown) and the sealant **3170** coating faces downward as it is brought in the vacuum bonding chamber **3110**. Next, the upper stage **3121** in the vacuum bonding chamber **3110** is moved vertically downward or the second glass substrate **3152** may be moved vertically upward by the lower stage **3122**, for example. In addition, utilizing the vacuum chuck or electrostatic charge (ESC) the first and second substrates are held by the lower and upper stages. Other suitable mechanisms may be used to hold the substrates by the stages.

The robot loader is then moved out of the vacuum bonding chamber **3110** and the first glass substrate **3151** is arranged over the lower stage **3122** by the robot loader.

Although it has been explained that the liquid crystal **3170** is dispensed on the first glass substrate **3151** having the thin film transistor array, and the sealant is coated on the second glass substrate **3152**, having the color filter array, the sealant may be coated on the first glass substrate **3151** and the liquid crystal may be dispensed on the second substrate **3152**. In the alternative, the sealant may be applied to both substrates, or the liquid crystal dropping and the sealant coating may be made on either of the two glass substrates, as long as the substrate with the liquid crystal material is located at the lower stage and the other substrate is located at the upper stage.

After the first and second substrates are held by a vacuum chuck, for example, to the lower and upper stages, the first and second substrates may be aligned with each other.

Next, a substrate receiver (not shown) for holding the second glass substrate is positioned to contact the surface of the second glass substrate **3152** (**3233**S) that is facing down by placing the substrate receiver under the second glass substrate **3152** and moving either the upper stage down, the substrate receiver up, or both, until the downward facing surface of the second glass substrate **3152** contacts the substrate receiver.

The substrate receiver is positioned below the second glass substrate **3152**, to prevent the second glass substrate held by the upper stage from becoming detached from the upper stage when the bonding chamber **3110** is under vacuum. In particular, when the bonding chamber **3110** is under vacuum, the vacuum force holding the second substrate onto the upper stage by the vacuum chuck loses its strength. Thus, the second substrate can no longer be held by the vacuum chuck of the upper stage. Before the second substrate **3152** is dropped, however, the substrate receiver temporarily supports the second substrate.

Accordingly, the second glass substrate **3152**, held by the upper stage may be arranged on the substrate receiver before or during the formation of vacuum in the bonding chamber. The upper stage, which holds the second glass substrate, and the substrate receiver may be brought within a predetermined distance of each other so that the second glass substrate **3152** may be safely placed on the substrate receiver from the upper stage when the bonding chamber is evacuated. Moreover, suitable mechanisms for further fastening the substrates onto the stages may be provided additionally as air flow in the chamber may shake the substrates when evacuation of the vacuum bonding chamber is initiated.

Referring to FIG. **108**, once all the elements are in place as explained above, the vacuum bonding chamber **3110** is evacuated (**3234**S). The vacuum within the vacuum bonding chamber **3110** may have a pressure in a first range of about 1.0×10^{-3} Pa to 1 Pa or a second range of about 1.1×10^{-3} Pa to 10^2 Pa. The first range may be especially applicable for an in-plane switching (IPS) mode LCD and the second range may be especially useful for a twisted nematic (TN) mode LCD. Another type of LCD called a vertical alignment (VA) mode LCD may also use these ranges.

Evacuation of the vacuum bonding chamber **3110** may be carried out in two stages as follows. After the substrates are held to their respective stages, the bonding chamber door is closed and the bonding chamber **3110** undergoes evacuation for the first time. After positioning the substrate receiver below the upper stage and placing the second substrate on the substrate receiver or after positioning the upper stage and the substrate receiver to within a predetermined distance where the second substrate held by the upper stage can be safely placed on the substrate receiver, the vacuum bonding chamber is further evacuated for a second time. The second evacuation is faster than the first evacuation. The vacuum force created by the first evacuation is not higher than the vacuum force needed to hold the second glass substrate onto the upper stage.

The aforementioned two stage evacuation process may minimize moving or shaking of the substrates when the vacuum bonding chamber is rapidly evacuated.

Alternatively, after the substrates are held to their respective stages and the bonding chamber door is closed, the evacuation may be implemented in a single step at a fixed rate. In addition, the substrate receiver may be arranged below the second substrate **3152** prior to or at initiation of the evacuation. Before the vacuum pressure in the vacuum bonding chamber becomes higher than the vacuum needed to hold the second substrate onto the upper stage, the substrate receiver should be placed below the second glass substrate **3152** to prevent the second glass substrate from falling to the lower stage if a vacuum chuck is used to hold the substrate onto the stages on the bonding chamber.

Once the vacuum bonding chamber **3110** is evacuated to a preset vacuum, the upper and lower stages **3121** and **3122** reattach to the first and second glass substrates **3151** and **3152** respectively using an electrostatic charge (ESC) (**3235**S) and the substrate receiver is removed to its original position (**3236**S).

Using ESC the first and second glass substrates are held to their respective lower and upper stages by applying negative/positive DC voltages to two or more plate electrodes (not shown) formed within the stages. When the negative/positive voltages are applied to the plate electrodes, a force is generated between a conductive layer (e.g., transparent electrodes, common electrodes, pixel electrodes, etc.) formed on the substrates and the stages. When the conductive layer formed on the substrate faces the stage or is adjacent the stage surface, about 0.1-1 KV is applied to the plate electrodes. When the conductive layer does not face the stage or is not adjacent to the stage surface, about 3-4 KV is applied to the plate electrodes. An elastic sheet may be optionally provided to the upper stage.

Referring to FIG. **107**C, after the two glass substrates **3151** and **3152** are loaded on their respective stages, the two substrates are aligned and held into position by ESC for bonding of the two substrates **3151** and **3152** (**3237**S). The first and second glass substrates **3151** and **3152** are pressed together by moving either the upper stage **3121** or the lower stage **3122** or both in a vertical direction, while varying speeds and the pressures at different stage locations. For example, until the time the liquid crystal **3107** on the first glass substrate **3151** and the seal on the second glass substrate **3152** come into contact, the stages are moved at a fix speed or fixed pressure, and the pressure is increased step by step from the time of contact to a final pressure. That is, a load cell fitted to a shaft of the movable stage senses the time of contact. The two glass substrates **3151** and **3152** may, for example, be pressed at a pressure of 0.1 ton at the time of contact, a pressure of 0.3 ton at an intermediate stage, a pressure of 0.4 ton at an ending stage, and a pressure of 0.5 ton at a final stage (see FIG. **107**D).

Although it is illustrated in the figures that the upper stage presses down toward the lower stage by means of one shaft, a plurality of shafts may independently apply and control pressure using an individual load cell. If the lower stage and the upper stage are not leveled or fail to be pressed uniformly, predetermined number of shafts may be selectively pressed using lower or higher pressures to provide uniform bonding of the seal.

Referring to FIG. **107**E, after the two substrates have been bonded, the ESC is turned off and the upper stage **3121** is moved up in order to separate the upper stage **3121** from the bonded substrates. Then, the bonded substrates are unloaded (**3238**S).

As has been explained, the method for fabricating LCDs of the present invention has the following advantages.

First, applying the liquid crystal on the first substrate and coating the seal on the second substrate shorten the fabrication time prior to bonding the two substrates together.

Second, applying the liquid crystal on the first substrate and coating the seal on the second substrate permits a balanced progression of the fabrication processes for the first and second substrates, thereby making efficient use of the production line.

Third, by applying the liquid crystal on the first substrate and not applying liquid crystal on the second substrate, contamination is reduced as the substrate having the sealant coated thereon can be cleaned by USC prior to bonding.

Fourth, positioning the substrate receiver under the substrate and evacuation of the vacuum bonding chamber permits the substrate held by the upper stage from falling and breaking.

Fifth, sensing the time during which the two substrates come into contact and varying the pressure when bonding the two substrates minimizes damage made by the liquid crystal to the orientation film.

Sixth, since the upper stage presses the substrate down by means of a plurality of shafts, each of which is capable of applying pressure independently, uniform bonding of the sealant can be achieved by independently applying lower or higher pressures by predetermined shafts when the lower stage and the upper stage are not level or fail to bond to the sealant uniformly.

Seventh, the two staged evacuation of the vacuum bonding chamber minimizes moving or shaking of the substrates from the air flow in the chamber caused by a sudden pressure change.

FIGS. **109**, **110**A, **110**B, **111**A, and **111**B illustrate an exemplary apparatus for vacuum bonding a liquid crystal display (LCD) device according to an embodiment of the present invention. In FIG. **109**, the apparatus may include a vacuum processing chamber **3310**, upper and lower stages **3321** and **3322**, a stage moving device, a vacuum device **3400**, a loader part **3500**, and a substrate receiving system **3600**.

The vacuum processing chamber **3310** may be formed such that bonding between upper and lower substrates is selectively carried out in one of a vacuum pressure state and an atmospheric pressure state within the vacuum processing chamber **3310**. To switch to the vacuum pressure state from an atmospheric pressure state, an air outlet **3312** transfers a vacuum force to an inner space of the vacuum processing chamber **3310** via an air outlet valve **3312***a*.

The upper and lower stages **3321** and **3322** may be provided at upper and lower spaces within the vacuum processing chamber **3310**, respectively. The upper and lower stages **3321** and **3322** may receive first and second substrates **3351** and **3352** that are loaded into the vacuum processing chamber **3310** via the loading part **3500**. The upper and lower stages **3221** and **3322** may each include an electrostatic chuck **3321***a* and **3322***a* for affixing the second and first substrates **3352** and **3351**, respectively, onto opposing surfaces of the upper and lower stages **3321** and **3322**. The upper stage **3321** may also include a plurality of vacuum holes **3321***b* formed along at least a circumference of the upper stage **3321**, and interconnected via pipelines **3321***c* to transmit a vacuum force generated by a vacuum pump **3323** to affix the second substrate **3352** to a lower surface of the upper stage **3321**. The plurality of vacuum holes **3321***b* may also be formed at a central portion of the upper substrate. Moreover, the lower stage **3322** may also include a plurality of vacuum holes (not shown) formed along at least a circumference of the lower stage **3322**, and interconnected via pipelines (not shown) to transmit a vacuum force generated by a vacuum pump (not shown) to affix the first substrate **3352** to an upper surface of the lower stage **3322**.

The electrostatic chucks **3321***a* and **3322***a* may include at least one pair of electrostatic plates of opposing polarities to which a direct voltage having the different polarities is applied respectively so as to enable the substrate to adhere thereto by an electrostatic force. Alternatively, the electrostatic force generated from the electrostatic chucks **3321***a* and **3322***a* may include at least one pair of electrostatic plates of similar polarities. In addition, the electrostatic chuck **3322***a* may be mounted at a top surface of the lower stage **3322**, and may include at least one vacuum hole (not shown) provided along a circumference of the electrostatic chuck **3322***a*. Moreover, the electrostatic chuck **3322***a* and the at least one vacuum hole formed at the top surface of the lower stage **3322** is not limited to the same construction of the upper stage **3321**. Preferably, the electrostatic chuck **3322***a* and the at least one vacuum hole at the top surface of the lower stage **3322** are arranged so as to consider the overall shape of a target substrate, and the respective liquid crystal dispensing areas.

The stage moving device includes a moving axis **3331** selectively driven to move the upper stage **3321**, a rotational axis **3332** selectively driven to rotate the lower stage **3322**, and driving motors **3333** and **3334** coupled axially with the upper and lower stages **3321** and **3322**, respectively, at one of the exterior and interior of the vacuum processing chamber **3310** to drive the axes, respectively. Accordingly, the stage moving device is not limited to the device moving the upper stage **3321** up and down or the lower stage **3322** right and left. Preferably, the stage moving device enables movement of the upper stage **3321** along a horizontal direction, and movement of the lower stage **3322** along a vertical direction. In addition, a subsidiary rotational axis (not shown) may be incorporated into the upper stage **3321** to enable rotation of the upper stages **3321**, and a subsidiary moving axis (not shown) may be incorporated into the lower stage **3322** to enable the vertical movement.

The loader part **3500** may be arranged at the exterior of the vacuum processing chamber **3310** separately from various elements provided inside the vacuum processing chamber **3310**. The loader part **3500** may include a first arm **3510** to carry the first substrate **3351** upon which at least the liquid crystal material is disposed into the vacuum processing chamber **3310**, and a second arm **3520** to carry the second substrate **3352** into the vacuum processing chamber **3310**. Alternatively, the first substrate **3351** may have both the liquid crystal material and the sealant disposed on a surface thereof, wherein the first substrate may be one of a TFT array substrate and a color filter (C/F) substrate. The first arm **3510** is disposed over the second arm **3520** so that contaminating particles from the second substrate **3352** will not fall upon the first substrate **3351**.

The substrate receiving system **3600** may contact a portion of the second substrate **3352** at dummy areas particularly located between cell areas formed on the second substrate **3352**. Each of the substrate receiving system **3600** may include a rotational axis **3610**, a support **3620**, a support protrusion, and a driving part **3630**. The substrate receiving system **3600** may be provided at an interior bottom portion of the vacuum processing chamber **3310** adjacent to sides of the lower stage **3322**. Accordingly, a total number of the substrate receiving system **3600** may be about 2 to 10.

FIGS. **110**A and **110**B are a plan views of the exemplary substrate receiving system along line I-I of FIG. **109** according to the present invention. In FIG. **110**A, one end of the support **3620** to which the rotational axis **3610** is coupled may be placed at the interior bottom portion of the vacuum processing chamber **3310**, which corresponds to a corner portion of one of a long side and a short side of each of the upper and lower stages **3321** and **3322**. Specifically, the substrate receiving system **3600** may be provided at a vicinity of one corner portion or both corner portions of one side of the lower stage **3322** or at a vicinity of one corner portion or both corner portions of the other side of the lower stage **3322**. In FIG. **110**B, one end of the support **3620** to which the rotational axis **3610** is coupled may be placed at the interior bottom portion of the vacuum processing chamber **3310**, which corresponds to a middle portion of one of a long side and a short side of each of the upper and lower stages **3321** and **3322**. Specifically, the substrate receiving system **3600** may be provided at a vicinity of a central portion of one or the other side of the lower stage **3322**, or may be provided at each corner and central portions simultaneously. When the substrate receiving system **3600** is provided at the vicinity of the central portion of one side or the other side of the lower stage **3322**, it is also possible to provide a plurality of substrate receiving system **3600**.

In FIG. **110**A, the supports **3620** may be constructed of individual bodies each having a first end attached at the rotational axis **3610** corresponding to a corner region of the lower stage **3322**, and a second end having a support protrusion **3620***a* corresponding to a central region of the lower stage **3322**. The supports **3620** may be formed at a first position along a direction parallel to the long side of the upper and lower stages **3321** and **3322**. During extension of the supports **3620**, each of the rotational axis **3610** rotate the supports **3620** from the first position to a second position in which each of the support protrusions **3620***a* are disposed at a region corresponding to one of the dummy areas. Alternatively, the supports **3620** may be formed along a direction parallel to the short side of the upper and lower stages **3321** and **3322**. However, it may be preferable to provide the substrate receiving system **3600** along the direction parallel to the long side of the upper and lower stages **3321** and **3322** in order to provide sufficient margin space.

Each of the support protrusions **3620***a* may be formed at top portions of the supports **3620** to reduce a contact area between the supports **3620** and the second substrate **3352**. The support protrusions **3620***a* are disposed along the supports **3620** such that when the support **3620** is positioned under the upper stage **3321**, the support protrusions **3620** contact the dummy areas of the second substrate **3352**. Each of the support protrusions **3620***a* may have a same protruding height, or each of the support protrusions **3620***a* may have different relative heights. Moreover, each of the support protrusions **3620***a* may have individually adjustable heights and each support **3620** may have a plurality of at least one support protrusion **3620***a*. When at least two support protrusions **3620***a* are formed at a top surface of the support **3620**, an interval between the at least two support protrusions **3620***a* may be selected to prevent a displacement of the second substrate **3352**. In addition, the interval between the at least two support protrusions **3620***a* may be less than a corresponding distance between adjacent cell areas such that the at least two support protrusions **3620***a* contact the second substrate with the dummy area.

Each of the driving parts **3630** of the substrate receiving system **3600** may include a cylinder to provide a vertical movement of the rotational axis **3610** and a rotational motor **3640** that rotates the rotational axis **3610**. The cylinder may operate using a one, or both of hydraulic or pneumatic control. Alternatively, the driving part **3630** may include both the cylinder and the rotational motor **3640**, wherein the cylinder moves the rotational axis **3610** along a vertical plane and the rotational motor **3640** rotates the rotational axis **3610** along a horizontal plane. Moreover, the cylinder may rotate the rotational axis **3610** along the horizontal plane, and the rotational motor **3640** may move the rotational axis **3610** along the vertical plane.

During deployment of the substrate receiving system **3600**, the supports **3620** may be elevated from a home position to a first position along the vertical direction above an upper surface of the lower stage, and thus above an upper surface of the first substrate **3351**, via one of the cylinder and rotational motor **3640**. Once the supports **3620** have been elevated above the upper surface of the first substrate **3351**, the rotational motor **3640** rotates the supports **3620** about the rotational axis **3610** to a second position in which the support protrusions **3620***a* are disposed adjacent to the dummy areas of the second substrate **3352**. Consideration must be given regarding the home position of the supports **3620**. Specifically, the home position of the support **3620** should be determined such that an upper surface of each of the support protrusions **3620***a* should be lower than a top surface of the lower stage **3322** to prevent any possible interference with a lower surface of the first substrate **3351**. Furthermore, consideration should be given to the first and second arms **3510** and **3520** of the loader part **3500** such that the substrate receiving system **3600** does not interfere with loading and unloading of the first and second substrates **3351** and **3352**.

Each of the driving parts **3630** may be disposed at the exterior of the vacuum processing chamber **3310**. Specifically, the rotational axis **3610** may be provided to penetrate the bottom portion of the vacuum processing chamber **3310**, and a sealing system (not shown) may be provided to prevent air from entering into the vacuum processing chamber **3310** during a vacuum pressure state.

A process for using the apparatus to bond substrates according to the present invention will now be explained with reference to FIGS. **109**, **111**A, and **111**B.

In FIG. **109**, a loading process is conducted wherein the loader part **3500** controls the first and second arms **3510** and **3520** to receive the first and second substrates **3351** and **3352**. The first substrate **3351** includes at least the liquid crystal material disposed on a first surface of the first substrate **3351**. As previously explained, the first substrate **3351** may include both the liquid crystal material and the sealant, and the first substrate **3351** may include one of the TFT array substrate and the C/F substrate. Once the first and second arms **3510** and **3520** retrieve the first and second substrates **3351** and **3352**, respectively. The loader part **3500** controls the second arm **3520** to provide the second substrate **3352** onto the lower surface of the upper stage **3321**. Accordingly, the vacuum pump **3323** provides the necessary vacuum force to the upper stage **3321** to transfer the second substrate **3352** from the second arm **3520** to the lower surface of the upper stage **3321**. Thus, the second substrate **3352** provided by the second arm **3520** is affixed to the upper stage **3321** by the vacuum force generated by the vacuum pump **3323**.

During the loading process, if a bonding process of the first and second substrates **3351** and **3352** has been previously performed, then the bonded substrates remain on the lower stage. Accordingly, the second arm **3520** may unload the bonded substrates remaining on the lower stage **3322** after loading the second substrate **3352** onto the upper stage **3321**. Then, the bonded substrates may be removed from the vacuum processing chamber **3310**, and transferred to another processing step by the second arm **3520**, thereby shorten process time of the bonded substrates.

After the second arm **3520** has transferred the bonded substrates, the loader part **3500** controls the first arm **3510** to provide the first substrate **3351** upon which at least the liquid crystal material is disposed onto an upper surface of the lower stage **3322**. Accordingly, the vacuum pump (not shown) associated with the lower stage **3322** provides the necessary vacuum force to the lower stage **3322** to transfer the first substrate **3351** from the first arm **3351** to the upper surface of the lower stage **3322**. Thus, the first substrate **3351** provided by first arm **3510** is affixed to the lower stage **3322** by the vacuum force generated by the vacuum pump (not shown) that is associated with the lower stage **3322**. After loading the first substrate **3351** onto the lower stage **3322**, the first arm **3510** of the loader part **3500** exits the vacuum processing chamber **3310**. Thus, the loading process is finished.

Once both of the first and second substrates **3351** and **3352** have been loaded onto the upper and lower stages **3321** and **3322**, respectively, the shield door **3314** (FIG. **111**A) provided at the entrance **3311** of the vacuum processing chamber **3310** close the entrance **3311**. The shield door **3314** provides for a vacuum tight seal with the vacuum processing chamber **3310**.

Next, a vacuum process is started where the vacuum device **3400** is actuated to generate a vacuum force while the switch valve **3312***a* provided at the air outlet **3312** of the vacuum processing chamber **3310** keeps the air outlet **3312** open. The vacuum force generated by the vacuum device **3400** is transferred to the interior of the vacuum processing chamber **3310**, thereby gradually reducing the pressure at the interior of the vacuum processing chamber **3310**.

During the vacuum process, a substrate receiving process is performed wherein the substrate receiving system **3600** activates the cylinders and rotational motors **3640** to position the supports **3620** beneath the lower surface of the second substrate **3320**, as shown in FIG. **111**A. Specifically, the support protrusions **3620***a* of each of the supports **3620** are positioned adjacent to the dummy areas of the second substrate **3352**. Then, the vacuum pump **3323** is disabled, thereby removing the vacuum force from the upper stage **3321**. Accordingly, the second substrate **3352** falls from the upper stage **3321** by release of the vacuum force, as shown in FIG. **111**B, and the lower surface of the second substrate **3352** contacts each of the support protrusions **3620***a* of each of the supports **3620**. Alternatively, the supports **3620** may be positioned such that the support protrusions **3620***a* abut the lower surface of the second substrate **3352**. Accordingly, when the vacuum force is removed from the upper stage **3321**, the second substrate **3352** does not necessary fall from the upper stage **3321**, thereby preventing any damage to the second substrate **3352** by contact to the support protrusions **3620***a*.

Meanwhile, once the vacuum pressure at the interior of the vacuum processing chamber **3310** has been attained, the air outlet valve **3312***a* is enabled to close the air outlet **3312**, and the vacuum device **3400** is stopped. However, the substrate receiving process may to be executed after the vacuum process is completed, or prior to a start of the vacuum process. Alternatively, the substrate receiving process may be performed prior to the sealing of the vacuum processing chamber **3310** by the shield door **3314**. Moreover, the substrate receiving process may begin once the second substrate **3352** has been transferred onto the upper stage **3321**.

Once the vacuum process has been competed, an electrostatic process may begin wherein the upper and lower stages **3321** and **3322** may apply an electric power to the electrostatic chucks **3321***a* and **3322***a*, respectively, thereby electrostatically affixing the second and first substrates **3352** and **3351** to the upper and lower stages **3321** and **3322**, respectively. Then, the substrate receiving system **3600** may be enabled to return the supports **3620** to the home position.

Once the substrate receiving system **3600** have returned to the home position, an alignment process may be performed to align the first and second substrates **3351** and **3352**. The alignment process may include an alignment system, wherein lateral and rotational adjustments of one or both of the upper and lower stages **3321** and **3322** may be performed. Once the alignment process is completed, a bonding process wherein the upper and lower drive motors **3333** and **3334** may move one or both of the upper and lower stages **3321** and **3322** to bonding the first and second substrates **3351** and **3352** together may be performed.

After completion of the bonding process, the vacuum pressure at the interior of the vacuum processing chamber **3310** may be decreased by a vacuum release valve (not shown) that may be attached to the vacuum processing chamber **3310**. Then, once the pressure at the interior of the vacuum processing chamber **3310** attains ambient atmospheric pressure, the shield door **3314** of the vacuum processing chamber **3310** may be driven to open the entrance **3311**. Finally, the bonded substrates may be unloaded by the second arm **3520** of the loader part **3500**, and the loading process is started again.

FIGS. **112** and **113** are plan views of exemplary substrate receiving systems according to the present invention. In FIG. **112**, a first substrate receiving system **3601** and a second substrate receiving system **3602** may be incorporated into the apparatus according to the present invention. The first substrate receiving system **3601** may include a first rotational axis **3611**, a first support **3621**, and a first support protrusion **3621***a*. The second substrate receiving system **3602** may include a second rotational axis **3612**, a second support **3622**, and a second support protrusion **3622***a*. The first support **3621** of the first substrate receiving system **3601** may be provided near a middle portion or corner portion of the lower stage **3321**, and may be formed to be shorter than the second support **3622** of the second substrate receiving system **3602**. The first substrate receiving system **3601** may be provided closer to the lower stage **3322** than the second substrate receiving system **3602**. Accordingly, the first supports **3621** of adjacent first substrate receiving systems **3601** are arranged along a first line, and the second supports **3622** of adjacent second substrate receiving systems **3602** are arranged along a second line parallel to the first line. Moreover, each of the adjacent first substrate receiving systems **3601** and each of the adjacent second substrate systems **3602** are symmetrically disposed about the lower stage **3621**.

In FIG. **113**, the first supports **3621** at a first side of the lower stage **3322** are arranged along a first line, and the second supports **3622** at the first side of the lower stage **3322** are not arranged along a second line. Specifically, the second supports **3622** at the first side of the lower stage **3322** are offset.

In FIGS. **112** and **113**, the first rotational axis **3611** of the first substrate receiving system **3601** may be formed to be reciprocally offset to the second rotational axis **3612** of the second substrate receiving system **3602**. In addition, the second rotational axis **3612** may be formed to be closer to a short side of the lower stage **3322** than the first rotational axis **3611**, whereby the first and second rotational axes **3611** and **3612** enable a reciprocal crossing operation. Accordingly, the reciprocal offset prevents reciprocal interference by the rotation of the first support **3621** of the first substrate receiving system **3601** and the second support **3622** of the second substrate receiving system **3602**. Moreover, a timing sequence of the first and second substrate receiving systems **3601** and **3602** are different, thereby further preventing the reciprocal interference.

The first and second substrate receiving systems **3601** and **3602** are arranged at each corner of each long side of the lower stage **3322** in a direction of the long side of the lower stage **3322** so as to confront each other. Accordingly, the first and second substrate receiving systems **3601** and **3602** may be formed to cross each other. Furthermore, the first and second substrate receiving systems **3601** and **3602** may support the second substrate so as not to pass the cell areas but to traverse the dummy area in a straight line. The first and second substrate receiving systems **3601** and **3602** may be provided at the long sides of the lower stage **3322**, since the short sides of the lower stage **3322** fail to provide sufficient margin space. Thus, the first and second substrate receiving systems **3601** and **3602** are provided at a vicinity of the long sides of the lower stage **3322**.

During the substrate receiving process, four of the second substrate receiving systems **3602** operate to move to a work position, thereby enabling support of a specific portion of the second substrate **3352**. Specifically, the second rotational axes of the four second substrate receiving systems **3602** move along an upward direction, and then rotate in clockwise and counterclockwise directions to place each of the second supports **3622** beneath the second substrate **3352**. Accordingly, the second support protrusions **3622***a* are positioned beneath the second substrate **3352** within the dummy areas of the second substrate **3352**. However, the substrate receiving process for the substrate receiving system of FIG. **113** must be performed in a slightly different sequence. In FIG. **113**, the second rotational axes **3612** at a first end of the lower stage **3322** must first be rotated in clockwise and counterclockwise directions, and the second rotational axes at a second end of the lower stage **3322** must be rotated next in clockwise and counterclockwise directions. Thus, the second supports **3622** at the first end of the lower stage **3322** do not interfere with the second supports **3622** at the second end of the lower stage **3322**. Likewise, the sequence must be reversed when moving the second substrate receiving system **3602** into the home position.

Then, the first rotational axes **3611** of the four first substrate receiving systems **3601** move upward, and rotate in a similar direction to the second substrate receiving system **3602** to position the second supports **3622** to a work position, thereby enabling support of a specific portion of the second substrate **3352**. Specifically, the first rotational axes **3611** of the four first substrate receiving systems **3601** move along an upward direction, and then rotate in clockwise and counterclockwise directions to place each of the first supports **3621** beneath the second substrate **3352**. Accordingly, the first support protrusions **3621***a* are positioned beneath the second substrate **3352** within the dummy areas of the second substrate **3352**.

During the previously described substrate receiving process, the vacuum force transferred through the vacuum holes **3321***b* of the upper stage **3321** is released. Alternatively, the vacuum pressure at the interior of the vacuum processing chamber **3310** may become higher than the vacuum force transferred through the vacuum holes **3321***b* of the upper stage **3321**. Accordingly, the second substrate **3352** affixed to the upper stage **3321** falls along a gravitational direction to be placed on the first and second support protrusions **3621***a* and **3622***a* of the first and second substrate receiving systems **3601** and **3602**, respectively. Alternatively, the first and second support protrusions **3621***a* and **3622***a* may be placed to contact the lower surface of the second substrate **3352** such that the second substrate **3352** does not fall after the vacuum force applied by the upper stage **3321** is released. Accordingly, any damage to the second substrate **3352** may be prevented.

Once the vacuum process has been competed, an electrostatic process may begin wherein the upper and lower stages **3321** and **3322** may apply an electric power to the electrostatic chucks **3321***a* and **3322***a*, respectively, thereby electrostatically affixing the second and first substrates **3352** and **3351** to the upper and lower stages **3321** and **3322**, respectively. Then, the first and substrate receiving systems **3601** and **3602** may be enabled to return the first and second supports **3621** and **3622** to the home position. Then, the alignment process and bonding process may be carried out.

FIG. **114** is a plan view of an apparatus having another exemplary substrate receiving system. In FIG. **114**, the second substrate receiving system **3602** may be positioned closer to a central portion inside the vacuum processing chamber **3310** (i.e., farther from an inner wall of the vacuum processing chamber **3310**) than the first substrate receiving system **3601**.

As illustrated in FIGS. **112**, **113**, and **114** lengths of the second supports **3622** of the second substrate receiving system **3602** may be about 500~1200 mm, and the first supports **3621** of the first substrate receiving system **3601** may be 100~500 mm. Preferably, the second supports **3622** of the second substrate receiving system **3602** is about 600 mm, and the first supports **3621** of the first substrate receiving system **3601** is about 400 mm. In general, the second supports **3622** of the second substrate receiving system **3602** may be at least longer than one-third of a long side of the second substrate **3352**, and the first supports **3621** of the first substrate receiving system **3601** may be at least longer than one-fifth of the long side of the second substrate **3352**. Accordingly, even if reciprocal operation between the first and second substrate receiving systems **3601** and **3602** are carried out simultaneously, reciprocal interference fails to occur. Thus, a transit time of the first and second substrate receiving systems **3601** and **3602** is reduced and overall processing time is reduced.

The present invention is not limited to the first and second substrate receiving systems **3601** and **3602** being disposed at the interior bottom portion of the vacuum processing chamber **3310**. FIG. **115** is a cross sectional view of another exemplary substrate receiving system according to the present invention, and FIG. **116** is a plan view of another exemplary substrate receiving system according to the present invention.

In FIG. **115**, an exemplary respective substrate receiving system may be provided at an interior top portion of the vacuum processing chamber **3310** as well as an inner wall of the vacuum processing chamber **3310**, as shown in FIG. **116**. Accordingly, if the substrate receiving system **3600** according to the present invention is provided at the interior top portion of the vacuum processing chamber **3310**, an overall construction (i.e., positions of the rotational axes **3610** and supports **3620** at the interior of the vacuum processing chamber **3310**) is similar of exemplary substrate receiving systems of FIGS. **112**, **113**, and **114**. However, locations of the driving parts of the substrate receiving system **3600**, locations of the rotational axes **3610** coupled axially with the driving parts, and the downward movements of the rotational axes **3610** are inverted. Moreover, if the substrate receiving system **3600** is provided at the inner wall of the vacuum processing chamber **3310**, recesses **3310***a* corresponding to the respective supports may be formed at the interior wall of the vacuum processing chamber **3310**. The recesses **3610***a* allow the supports **3620** to be inserted into the interior wall of the vacuum processing chamber **3310**, and the rotational axes **3610** penetrate into the interior wall of the vacuum processing chamber **3310** so a to be coupled axially with the driving part provided at an exterior of the vacuum processing chamber **3310**.

FIGS. **117** to **119** illustrate an exemplary apparatus for a liquid crystal display (LCD) device according to the first embodiment of the present invention. In FIGS. **117** to **119**, the apparatus may include a vacuum processing chamber **3710**, an upper stage **3721**, a lower stage **3722**, a stage moving device, a vacuum device **3800**, a loader part **3900**, and a substrate receiving system.

The vacuum processing chamber **3710** has an interior that may be placed under a vacuum pressure or atmospheric state so that bonding work between substrates may be performed. An air outlet **3712** transfers a vacuum force generated by the vacuum device **3800** the vacuum processing chamber **3710** via a air outlet valve **3712***a*.

The upper and lower stages **3721** and **3722** may be provided at upper and lower spaces inside the vacuum processing chamber **3710**, respectively, so as to oppose each other. The upper and lower stages **3721** and **3722** affix first and second substrates **3751** and **3752**, which are carried into the vacuum processing chamber **3710**, by a vacuum or electrostatic force. The upper and lower stages **3721** and **3722** travel in a vertical direction to bond the first and second substrates **3751** and **3752**. Accordingly, a lower surface of the upper stage **3721** may be provided with at least one electrostatic chuck (ESC) **3721***a* to fix the first and second substrates **3751** and **3752** to the upper and lower stages **3721** and **3722**, respectively, by a plurality of electrostatic plates.

In addition to the electrostatic chuck **3721***a*, at plurality of vacuum holes **3721***b* may be further provided at the lower surface of the upper stage **3721** to apply a vacuum force to the second substrate **3752**, thereby affixing the second substrate **3752** by a vacuum force. The plurality of vacuum holes **3721***b* may be arranged along a circumference of the electrostatic chuck **3721***a*. The plurality of vacuum holes **3721***b* may be connected to each other through at least one or a plurality of pipe lines **3721***c* so as to receive a vacuum force generated by a vacuum pump **3723** that is connected to the upper stage **3721**. In addition, at least one electrostatic chuck **3722***a* may also be provided at a upper surface of the lower stage **3722**, and at least one vacuum hole (not shown) may be provided along a circumference of the electrostatic chuck **3722***a*.

However, the construction of the electrostatic chuck **3722***a* and the plurality of vacuum holes (not shown) at the upper surface of the lower stage **3722** may not be limited to a configuration of the upper stage **3721**. Moreover, the electrostatic chuck **3722***a* and the plurality of vacuum holes (not shown) at the upper surface of the lower stage **3722** may be arranged to consider an overall shape of a target substrate.

The stage moving device includes a upper stage moving axis **3731** connected to the upper stage **3721** to move the upper stage **3721** along a vertical direction, a lower stage rotational axis **3732** connected to the lower stage **3722** to rotate the lower stage **3722** clockwise or counterclockwise, an upper driving motor **3733** axially coupled to the upper stage **3721**, and a lower driving motor **3734** axially coupled to the lower stage **3722** at an exterior or interior of the vacuum processing chamber **3710**. Accordingly, the stage moving device may not be limited to a configuration that moves the upper stage **3721** along the vertical direction and rotates the lower stage **3722** clockwise or counterclockwise. The stage moving device may enable the upper stage **3721** to rotate clockwise or counterclockwise, and move the lower stage **3722** along the vertical direction. In this case, a subsidiary rotational axis (not shown) may be added to the upper stage **3721** to enable its rotation, and a subsidiary moving axis (not shown) may be added to the lower stage **3722** to enable movement in the vertical direction.

The vacuum device **3800** transfers a vacuum force to enable a vacuum state inside the vacuum processing chamber **3710**, and may include a vacuum pump driven to generate a general vacuum force.

The loader part **3900** may be arranged outside of the vacuum processing chamber **3710** separately from various elements provided inside the vacuum processing chamber **3710**. The loader part **3900** may include a first arm **3910** and a second arm **3920**. The first arm **3910** loads the first substrate **3751** upon which liquid crystal material is dropped, into the vacuum processing chamber **3710**. The second arm **3920** loads the second substrate **3752** upon which a sealant is dispensed, into the vacuum processing chamber **3710**. Alternatively, the liquid crystal material may be deposited (e.g., dropped, dispensed, etc.) on the first substrate **3751**, which may be a TFT array substrate, and the sealant may be deposited on the second substrate **3752**, which may be a color filter (C/F) substrate. Moreover, both the liquid crystal material and the sealant may be deposited on the first substrate **3751**, which may be a TFT array substrate, and the second substrate **3752**, which may be a C/F substrate, may not have either of the liquid crystal material or the sealant deposited thereon. Furthermore, both the liquid crystal material and the sealant may be deposited on the first substrate **3751**, which may be a C/F substrate, and the second substrate **3752**, which may be a TFT array substrate, may not have either of the liquid crystal material or the sealant deposited thereon. The first substrate **3751** may include one of a TFT array substrate and a C/F substrate, and the second substrate **3752** may include another one of the TFT substrate and the C/F substrate.

If the liquid crystal material and the sealant may be deposited on one of the first and second substrates, the first arm **3910** loads the target substrate while the second arm **3920** loads the other substrate.

During the loading of the first and second substrates **3751** and **3752**, the first arm **3910** may be placed over the second arm **3920**. Thus, the liquid crystal material is dropped on the first substrate **3751**. In other words, if the second arm **3920** is placed over the first arm **3910**, various particles generated from the motion of the second arm **3920** may be caused to fall onto the liquid crystal material dropped on the first substrate **3751** mounted on the first arm **3910** so as to cause damage thereupon. Thus, the first arm **3910** is placed over the second arm **3920**, thereby avoiding the damage by contamination.

The substrate receiving system may be constructed to receive the second substrate **3752** that is to be affixed to the upper stage **3721** while moving along the loading/unloading direction of the substrate. The substrate receiving system may include a lifting part and a moving part. The lifting part may include a lift-bar **4011** and a support **4012**. The lift bar **4011** may be longitudinally formed along a width direction of the second substrate **3752** to support the lower surface of the second substrate **3752** affixed to the upper stage **3721**. Alternatively, the lift-bar **4011**, as shown in FIG. **120**A, may be constructed to support the second substrate **3752** by an area contact with the second substrate **3752**. Furthermore, the lift-bar **4011** may have at least one protrusion **4011***a* which is in contact with the lower surface of the second substrate **3752** at a upper surface of the lift-bar **4011** so that the protrusion **4011***a* can support the second substrate **3752** by dot contact with the second substrate **3752**. The protrusion **4011***a* may be formed as shown in FIG. **120**B or FIG. **120**C.

The support **4012** has one end connected to one end of the lift-bar **4011** and the other end connected to the moving part to support the lift-bar **4011**. In addition, at least two or more lifting parts may be provided to simultaneously support each part of the second substrate **3752**, thereby preventing the second substrate **3752** from drooping. In particular, the lifting part may be constructed to selectively support a dummy area among respective portions of the second substrate **3752**, thereby preventing damage due to contact with a cell area from occurring and preventing the second substrate **3752** from bowing or curving.

The moving part may include a screw axis **4013** and a driving motor **4014** to move the lifting part along a horizontal direction. Accordingly, as shown in FIGS. **117** to **119**, the screw axis **4013** may be longitudinally provided along the longitudinal side of the lower stage **3722** within the vacuum processing chamber **3710**. The driving motor **4014** may be axially fixed into the screw axis **4013**. Accordingly, the screw direction of the screw axis **4013** may be formed so that both sides around the center are directed in different directions. That is, one side of the screw axis **4013** is provided with a right-hand screw while the other side of the screw axis **4013** may be provided with a left-hand screw. In addition, the lifting parts may be provided at both sides of the screw axis **4013** so as to move to the center of the screw axis **4013** if the driving motor **4014** is driven. In particular, the screw axis **4013** may be provided at both sides of the longitudinal side of the lower stage **3722**. The support **4012** has one end screwed into the screw axis **4013** to move along the screw axis **4013**, and the other end of the support **4012** is fixed to both ends of the lift-bar **4011**. If two supports **4012** support one lift-bar **4011**, drooping of the lift-bar **4011** may be prevented. Thus, in the preferred embodiment of the present invention, one lifting part includes two supports **4012** and one lift-bar **4011**.

Furthermore, the driving motor **4014** may be connected with the screw axes **4013**, or any one of the screw axes **4013**. Accordingly, the screw axis **4013** which is not connected with the driving motor **4014** may not have a screw thread. The lifting part may be arranged to be lower than the upper surface of the upper stage **3722** when it is not driven. Moreover, a driving means **4015** may be further provided, which moves the support **4012** along the vertical direction. Accordingly, either a hydraulic cylinder that can move the support **4012** along the vertical direction using pneumatic pressure or hydraulic pressure, or move the support **4012** using a step motor that can move the support **4012** along the vertical direction using a rotational moving force is used as the driving means **4015**. A shape of the support **4012** may depend on the driving means **4015**. One end **4016** of the screw axis **4013** may be a fixed part that prevents an opposite side of a side fixed to the driving motor **4014** from drooping and moving.

The substrate bonding process using the aforementioned bonding device for an LCD according to the present invention will now be described. The loader part **3900** controls the first and second arms **3910** and **3920** so that the second substrate **3752** to be loaded to the upper stage **3721** and the first substrate **3751** to be loaded to the lower stage **3722** are respectively fed thereto. Accordingly, the loader part **3900** controls the second arm **3920** so that the second substrate **3752** is carried into the upper stage **3721** in the vacuum processing chamber **3710**, through an opened vacuum chamber entrance **3711** of the vacuum processing chamber **3710**.

A vacuum pump **3723** may be connected to the upper stage **3721** to transfer a vacuum force to each of the plurality of vacuum holes **3721***b* formed in the upper stage **3721** so that the second substrate **3752** is affixed to the lower surface of the upper stage **3721** by vacuum absorption. The second arm **3920** may unload the bonded substrates. Thereafter, if the second arm **3920** moves out of the vacuum processing chamber **3710**, the loader part **3900** controls the first arm **3910** so that the first substrate **3751** may be carried into the lower stage **3722** provided at a lower space in the vacuum processing chamber **3710**. Then, a vacuum pump (not shown) connected to the lower stage **3722** may transfer a vacuum force to each of the plurality of vacuum holes (not shown) formed in the lower stage **3722** so that the first substrate **3751** is affixed to the lower stage **3722** by vacuum absorption. Once the first arm **3910** moves out of the vacuum processing chamber **3710**, loading of the first and second substrates **3751** and **3752** is completed.

During the process, loading of the second substrate **3752** on which a sealant is dispensed is carried out earlier than loading of the first substrate **3751**. This prevents any dust and the like that may be present in the process of loading the second substrate **3752** from falling onto the first substrate **3751** upon which the liquid crystal material is dropped. Once loading of the first and second substrates **3751** and **3752** is completed, an vacuum chamber entrance **3711** of the vacuum processing chamber **3710** is closed so that a closed state is maintained inside the vacuum processing chamber **3710**. Afterwards, the vacuum device **3800** is enabled to generate a vacuum pressure within the interior of the vacuum processing chamber **3710**. Accordingly, the air outlet valve **3712***a* provided with the air outlet **3712** of the vacuum processing chamber **3710** opens the air outlet **3712** to transfer the vacuum force into the vacuum processing chamber **3710**, thereby gradually creating a vacuum pressure inside the vacuum processing chamber **3710**.

The driving means **4015** operates to move each support **4012** along an upward direction. At the same time a pair of driving motors **4014** constructing the moving part are driven to rotate a pair of screw axes **4013**. Thus, a pair of lifting parts fixed to both ends of each screw axis **4013** move toward the center of each screw axis **4013** to correspond to a direction of each screw axis **4013**. In other words, a pair of supports **4012** constructing each lifting part move to the center of the screw axis **4013** by a horizontal moving force due to rotation of the screw axis **4013**, thereby moving the lift-bar **4011**. Accordingly, once each lifting part moves by a set distance, each driving motor **4014** is not driven, thereby resulting in that the lifting part stops. The position of each lifting part is controlled by controlling driving time or driving degree of each driving motor **4014**. Preferably, each lifting part stops below the dummy area of the second substrate **3752**.

Once the above process is completed, the operation of the vacuum pump **3723** is disabled, thereby cutting off the vacuum force that affixes the second substrate **3752** to the lower surface of the upper stage **3721**. Thus, the second substrate **3752** affixed at the lower surface of the upper stage **3721** drops, and is then placed on an upper surface of each lift-bar **4011**. Accordingly, the process of placing the second substrate onto each lift-bar **4011** may be carried out to release the vacuum force after the second substrate **3752** is in contact with each lift-bar **4011** by downwardly moving the upper stage **3721** or by upwardly moving lift-bar **4011**. In this case, it may be possible to avoid any damage that may occur due to impact between the second substrate **3752** and each lift-bar **4011** when the second substrate **3752** is dropped.

Afterwards, once the complete vacuum state is achieved in the vacuum processing chamber **3710** by driving the vacuum device **3800** for a certain time period, driving of the vacuum device **3800** stops and at the same time the air outlet valve **3712***a* of the air outlet **3712** operates, so that the air outlet **3712** is maintained in a closed state.

The power is applied to the electrostatic chucks **3721***a* and **3722***a* of the upper and lower stages **3721** and **3722** so that the respective substrates **3751** and **3752** are electrostatically affixed onto the first and second stages **3721** and **3722**, respectively. Once the electrostatically affixation is completed, the substrate receiving system returns the respective lift-bars **4011** and the respective supports **4012** to their original position. Afterwards, the stage moving system selectively move the upper and lower stages **3721** and **3722** along the vertical direction so that the first and second substrates **3751** and **3752** electrostatically affixed onto the first and second stages **3721** and **3722** are bonded to each other.

Meanwhile, the driving of the substrate receiving system may not be limited to the aforementioned construction that drives the substrate receiving system in the process of generating the vacuum pressure inside the vacuum processing chamber **3710**. That is, the substrate receiving system may be driven before the vacuum pressure is attained inside the vacuum processing chamber **3710** after loading of the first and second substrates **3751** and **3752**.

FIGS. **121** and **122** are plan views showing internal structures of exemplary apparatus' having a substrate receiving system according to the present invention. The substrate receiving system according to the second embodiment of the present invention may include two or more pair of screw axes so that three or four lifting parts selectively move, since the number of lifting parts depends on a model or size of the substrate.

In FIG. **121**, if there are three lifting parts, a pair of first screw axis **4021** provided nearest to the lower stage **3722** are formed so that the screw directions at both sides around the center are directed in different directions. That is, one side of the first screw axis **4021** is provided with a right-hand screw while the other side of the first screw axis **4021** is provided with a left-hand screw. In addition, a first lifting part **4022** and a second lifting part **4023** may be provided at both ends of the first screw axis **4021** to correspond to each other. A pair of second screw axis **4024** may be provided more outwardly as compared to the first screw axis **4021** are formed in one screw direction. A third lifting part **4025** may be provided at one end of the second screw axis **4024**. Accordingly, the first and second screw axes **4021** and **4024** may be axially fixed to corresponding driving motors **4026**. Thus, once each driving motor **4026** is driven to rotate the respective screw axes **4021** and **4024**, the first lifting part **4022** and the second lifting part **4023** respectively move to the center of the first screw axis **4021** while the third lifting part **4025** moves to the center of the second screw axis **4024**, thereby resulting in that the lifting parts stop on preset positions.

In the above construction, the first screw axis **4021** may be formed in one direction, and the second screw axis **4024** may be formed so that both sides around the center are directed in different directions. In this case, the first lifting part **4022** and the second lifting part **4023** may be provided at both ends of the second screw axis **4024** while the third lifting part **4025** may be provided at any one end of the first screw axis **4021**.

In FIG. **122**, four lifting parts are required depending on a model of the substrate, and the second screw axis **4024** has a similar shape as a shape of the first screw axis **4021** while the third lifting part **4025** and a fourth lifting part **4027** are provided at both ends of the second screw axis **4024**. Thus, once each driving motor **4026** is driven to rotate the respective screw axes **4021** and **4024**, the first lifting part **4022** and the second lifting part **4023** respectively move to the center of the first screw axis **4021** while the third lifting part **4025** and the fourth lifting part **4027** respectively move to the center of the second screw axis **4024**, thereby resulting in that the lifting parts stop on preset positions.

FIGS. **123** and **124** illustrate an exemplary substrate receiving system according to the third embodiment of the present invention. The substrate receiving system according to the third embodiment of the present invention is constructed such that the moving part selectively controls and moves a plurality of lifting parts.

In FIG. **123**, the moving part may include a moving system **4032** and operates to move the lifting parts **4033** along the horizontal direction. The moving system **4032** may be directly connected with the moving axis **4031** and the lifting parts **4033** and may be driven to move the lifting part along the moving axis **4031**. The lifting parts **4033** may be connected with the moving axis **4031**. In particular, a typical guide rail may be used as the moving axis **4031**, and a linear motor may be used as the moving system **4032**. Accordingly, the moving system **4032** may be connected with a connection portion between the lifting parts **4033** and the moving axis **4031** so that the lifting parts **4033** move along the moving axis **4031**. All of the lifting parts **4033** may be positioned at any one end of the moving axis **4031**. Alternatively, the lifting parts **4033** may be positioned respectively at both ends of the moving axis **4031**.

As described above, if the respective lifting parts **4033** are separately controlled, as shown in FIG. **125** and FIG. **126**, three or more lifting parts **4033** may be provided. Thus, the substrate receiving system can receive the second substrate **3752** in a more stable manner. Although not shown, rack, gear, or chain drive mechanisms may be used as the moving axis **4031** and a motor axially fixed to pinion, gear, or sprocket wheel may be used as the moving system **4032**. Alternatively, a rail may be used as the moving axis **4031** and a cylinder using hydraulic or pneumatic pressure may be used as the moving system **4032**.

Meanwhile, FIGS. **127** to **130** illustrate the substrate receiving system according to the fourth embodiment of the present invention. The substrate receiving system according to the fourth embodiment of the present invention is constructed such that one lift-bar **4042** of the lifting part **4041** may be supported by one support **4043** only. In other words, the lift-bars **4042** may be separated from each other around the center to oppose each other, so that the respective supports **4043** connected to the respective moving axes **4045** are separately controlled. Thus, any operational error due to operational error of the respective moving part may be prevented from occurring.

As shown in FIGS. **127** and **128**, the moving part may be used as the screw axis **4045** and the driving motor **4044** according to the present invention. Moreover, as shown in FIGS. **129** and **130**, the moving part may be used as the moving axis **4047** and the moving system **4048** according to the present invention.

Particularly, as shown in FIGS. **128** and **130**, when viewing an inner part of the vacuum processing chamber **3710** from the plane, the respective lift-bars **4042** may be arranged to cross each other so that the substrate receiving system may receive the second substrate **3752** in a more stable manner.

FIGS. **131** and **132** illustrate the substrate receiving system according to the present invention. In this embodiment of the present invention, two substrate receiving system may be formed to oppose each other at a portion adjacent to the lower stage **3722**. In FIG. **132**, a first substrate receiving system **4051** of the two substrate receiving system may be provided at a portion where the vacuum chamber entrance **3711** is formed in the vacuum processing chamber **3710**, and a second substrate receiving system **4052** may be provided at a portion opposite to the first substrate receiving system **4051**.

In this embodiment of the present invention, screws of screw axes **4051***a*, **4051***b*, **4052***a*, and **4052***b* may be directed along one direction, and the screw axes **4051***a*, **4051***b*, **4052***a*, and **4052***b* may be controlled by driving motors **4051***c*, **4051***d*, **4052***c*, and **4052***d*, thereby enabling more precise movement. Meanwhile, in the construction of this embodiment, there is no element that can receive the dummy area at the middle part of the second substrate **3752**. Therefore, in the sixth embodiment of the present invention, as shown in FIGS. **133** and **134**, a rotational substrate receiving system **4053** may be further provided, which receives the middle part of the second substrate **3752** while moving upwardly or rotating clockwise or counterclockwise between the substrate receiving system **4051** and **4052**. In this case, the rotational substrate receiving system **4053** may include a support **4053***a*, which is in contact with the second substrate **3752**, a connecting axis **4053***b* connected with the support **4053***a*, and a driving means **4053***c* that provides a driving force to move the connecting axis **4053***b* along the vertical direction and rotate the same clockwise or counterclockwise. At least any one of a cylinder using a hydraulic or pneumatic pressure and a motor may be used as the driving means **4053***c*. In other words, when the substrate receiving system **4051** and **4052** move, the rotational substrate receiving system **4053** moves along the vertical direction and rotates clockwise or counterclockwise so that the support **4053***a* is placed below the dummy area at the middle part of the second substrate **3752**.

The substrate receiving system according to the present invention may not be limited to the construction that receives the lower surface of the second substrate **3752** in a width direction while moving along a loading/unloading direction of the substrate. For example, as shown in FIG. **135** according to the seventh embodiment of the present invention, the substrate receiving system may be constructed to receive the lower surface of the second substrate **3752**, particularly the dummy area of the second substrate **3752**, in a length direction while moving in a direction vertical to the loading/unloading direction of the second substrate **3752**. Accordingly, a lift-bar **4071** of the substrate receiving system may be longitudinally formed along a length direction of the second substrate **3752**, and one or two supports **4072** are formed to support one lift-bar **4071**. Moreover, the moving part of the substrate receiving system according to the present invention may not be limited to the construction that is provided at a lower part in the vacuum processing chamber **3710**.

For example, as shown in FIG. **136** according to the eighth embodiment of the present invention, the moving part may be provided at an upper part in the vacuum processing chamber **3710**. That is, each moving part according to the first to seventh embodiments of the present invention may be provided at an upper part in the vacuum processing chamber.

FIGS. **137**A and **137**B illustrate cross sectional views of an two exemplary apparatuses including a substrate lifting system according to the present invention.

In FIGS. **137**A and **137**B, the apparatus may include a vacuum processing chamber **4110**, an upper stage **4121**, a lower stage **4122**, an upper stage moving system **4131** and **4133**, a lower stage moving system **4132** and **4134**, a vacuum device **4200**, a loader part **4300**, and a first substrate lifting system **4400**.

Referring to FIGS. **137**A and **137**B, the vacuum processing chamber **4110** may include a primary air outlet **4112** transferring a vacuum force to decrease a pressure at an interior of the vacuum processing chamber **4110**. The upper and lower stages **4121** and **4122** may be provided at upper and lower spaces at an interior of the vacuum processing chamber **4110**, respectively. In addition, the upper and lower stages **4121** and **4122** receive first and second substrates **4151** and **4152**, which are loaded into an interior of the vacuum processing chamber **4110** by first and second arms **4310** and **4320** of the loader part **4300**. The first and second substrates **4151** and **4152** may be affixed to the lower and upper stages **4122** and **4121**, respectively, by an electrostatic force that is generated by the upper and lower stages **4121** and **4122**. In addition, the first and second substrates **4151** and **4152** may be affixed to the lower and upper stages **4122** and **4121**, respectively, by a vacuum force that is generated the upper and lower stages **4121** and **4122**. The first and second substrates **4151** and **4152** are maintained to be affixed to the upper and lower stages **4121** and **4122** during a bonding process. Accordingly, the upper and lower stages **4121** and **4122** enable a selective movement to perform the bonding process between the first and second substrates **4151** and **4152**.

A lower surface of the upper stage **4121** may be provided an electrostatic chuck **4121***a* having a plurality of electrostatic plates buried therein for affixing the second substrate **4152** to the upper stage **4121**. In addition, the upper stage **4121** may include a plurality of vacuum holes **4121***b* formed along a circumference of the electrostatic chuck **4121***a*. Each of the vacuum holes **4121***b* may be connected to a vacuum pump **4123** by a plurality of pipe lines **4121***c*. The electrostatic chuck **4121***a* may be constructed with at least one pair of the electrostatic plates each having opposite polarities. Alternatively, the electrostatic chuck **4121***a* may be constructed with at least one pair of electrostatic plates each having similar polarities.

An upper surface of the lower stage **4122** may be provided an electrostatic chuck **4122***a* having a plurality of electrostatic plates buried therein for affixing the first substrate **4151** to the lower stage **4122**. In addition, the lower stage **4122** may include a plurality of vacuum holes (**4122***b* in FIGS. **138** and **139**A) formed along a circumference of the electrostatic chuck **4122***a*. Like the upper stage **4121**, each of the plurality of vacuum holes (**4122***b* in FIGS. **138** and **139**A) may be connected to a vacuum pump (not shown) by a plurality of pipe lines **4121***c*. The electrostatic chuck **4122***a* may be constructed with at least one pair of the electrostatic plates each having opposite polarities. Alternatively, the electrostatic chuck **4122***a* may be constructed with at least one pair of electrostatic plates each having similar polarities.

Alternatively, an arrangement of the electrostatic chuck **4122***a* and the plurality of vacuum holes (**4122***b* in FIGS. **138** and **139**A) formed at the upper surface of the lower stage **4122** may not be limited to the arrangement of the electrostatic chuck **4121***a* and the plurality of vacuum holes **4121***b* formed at the lower surface of the upper stage **121**. The electrostatic chuck **4122***a* and the plurality of vacuum holes (**4122***b* in FIGS. **138** and **139**A) arranged at the upper surface of the lower stage **4122** may be changed to accommodate a geometry of a target substrate and corresponding liquid crystal dispensing areas. However, the plurality of vacuum holes (**4122***b* in FIGS. **138** and **139**A) formed at the upper surface of the lower stage **4122** may not be necessary.

FIG. **138** shows a schematic layout of a lower stage of an exemplary substrate lifting system according to the present invention. In FIG. **138**, at least one a first receiving part **4122***d* may be formed at a first portion of the upper surface of the lower stage **4122** that corresponds to a dummy area of a first substrate (not shown) that may be placed on the upper surface of the lower stage **4122**. The location of the first receiving part **4122***d* may be positioned at other portions of the upper surface of the lower stage **4122** to prevent displacement of the first substrate (not shown). For example, the first receiving part **4122***d* may be formed at a portion corresponding to a bottom region of the dummy area located between adjacent cell areas formed on an upper surface of the first substrate. Alternatively, the first receiving part **4122***d* may have a geometry corresponding to a recess or a penetrating hole formed through the lower stage **4122**. In addition, the first receiving part **4122***d* may be constructed as a recessed slot having a penetrating hole formed only at specific portions of the recessed slot.

In FIGS. **137**A and **137**B, the upper stage moving system may include an upper driving motor **4133** axially coupled with the upper stage **4121** by a moving axis **4131**. The lower stage moving system may include a lower driving motor **4134** axially coupled with the lower stage **4122** by a rotational axis **4132**. The upper and lower driving motors **4133** and **4134** may be arranged at an exterior or an interior of the vacuum processing chamber **4110**.

The loader part **4300** may be arranged as a separate system from the vacuum processing chamber **4110**. The loader part **4300** may include a first arm **4310** to convey a first substrate **4151** upon which a liquid crystal material is dropped, and a second arm **4320** to convey a second substrate **4152** upon which a sealant is dispensed. Alternatively, although the liquid crystal material may be deposited (i.e., dropped, dispensed) on the first substrate **4151**, which may be a TFT array substrate, and the sealant may be deposited on the second substrate **4152**, which may be a color filter (C/F) substrate. Moreover, both the liquid crystal material and the sealant may be deposited on the first substrate **4151**, which may be a TFT array substrate, and the second substrate **4152**, which may be a C/F substrate, may not have either of the liquid crystal material or the sealant deposited thereon. Furthermore, both the liquid crystal material and the sealant may be deposited on the first substrate **4151**, which may be a C/F substrate, and the second substrate **4152**, which may be a TFT array substrate, may not have either of the liquid crystal material or the sealant deposited thereon. The first substrate **4151** may include one of a TFT array substrate and a C/F substrate, and the second substrate **4152** may include another one of the TFT substrate and the C/F substrate.

In FIG. **138**, the first substrate lifting system **4400** may be arranged at the interior of the vacuum processing chamber **4110**. Alternatively, first substrate lifting system **4400** may be arranged at both the exterior and interior of the vacuum processing chamber **4110**. The first substrate lifting system **4400** may include first support parts **4410***a* and second support parts **4410***b* supporting the first substrate **4151**, a first elevating axis **4420** connected to the first support part **4410***a* and extending through the first receiving part **4122***d* from the lower stage **4122**, and a first driving part **4430** to drive the first and second support parts **4410***a* and **4410***b* via the first elevating axis **4420**. The first support parts **4410***a* may be arranged along a first direction parallel to a loading direction of the first substrate **4151**, and second support parts **4410***b* arranged along a second direction perpendicular to the loading direction of the first substrate **4151**.

An arrangement of the first substrate lifting system **4400** may be dependent upon a configuration of the lower stage **4122**, which is also dependent upon the configuration of the first substrate **4151**. For example, in FIG. **138**, the lower stage **4122** supports the first substrate **4151** that has a 3×3 matrix array of individual regions. Accordingly, the first support parts **4410***a* are arranged to contact each of the dummy areas of the first substrate **4151** along the loading direction, and the second support parts **4410***b* are arranged to contact each of the dummy areas of the first substrate **4151** along a direction perpendicular to the loading direction, thereby forming a pattern such as a "#".

Alternatively, a first set of the first support parts **4410***a* may be provided to extend along the loading direction to support the first substrate **4151**. For example, a first set of two first support parts **4410***a* may contact the first substrate **4151** along each of the two dummy areas of the first substrate **4151** that extend along the loading direction, thereby forming a pattern of "=". Moreover, a second set of second support parts **4410***b* may be provided to extend along the second direction, which is perpendicular to the loading direction of the first substrate **4151**, to support the first substrate **4151**. For example, a second set of two second support parts **4410***b* may contact the first substrate **4151** along each of the two dummy areas of the first substrate **4451** that extend along the second direction, thereby forming a pattern of "| |".

The arrangement of the first substrate lifting system **4400** may include a single first support part **4410***a* contacting a single dummy region of the first substrate **4151** that extends along the loading direction, and a single second support part **4410***b* contacting a single dummy region of the first substrate **4151** that extends along the second direction, thereby forming a pattern such as "+".

The arrangement of the first substrate lifting system **4400** may include a first set of three first support parts **4410***a* contacting three dummy regions of the first substrate **4451** that extends along the loading direction, thereby forming a pattern of "≡". Alternatively, the arrangement of the first substrate lifting system **4400** may include a second set of second support parts **4410***b* contacting three dummy regions of the first substrate **4151** that extends along the second direction, thereby forming a pattern such as "| | |". Moreover, the arrangement of the first substrate lifting system **4400** may include a combination of the first set of first support parts **4410***a* and the second set of second support parts **4410***b*.

The first substrate **4151** may have a configuration in which a single individual region is provided. Accordingly, the arrangement of the first substrate lifting system **4400** may include a first set of two first support parts **4410***a* contacting dummy regions of an outermost perimeter of the first substrate **4151** that extends along the loading direction, and second set of two second support parts **4410***b* contacting dummy regions of an outermost perimeter of the first substrate **4151** that extends along the second direction, thereby forming a pattern of "□".

The first and second support parts **4410***a* and **4410***b* may include a plurality of protrusions (not shown) that may be formed on upper portions of the first and second support parts **4410***a* and **4410***b* to minimize a contact area between the first substrate **4151** and the first and second support parts **4410***a* and **4410***b*. The plurality of protrusions (or the first and second supports **4410***a* and **4410***b*) may include Teflon™ or PEEK, for example, to prevent damage to surface portions of the first substrate **4151** that contact the plurality of protrusions, and electrically conductive materials to dissipate any static electricity generated on the first substrate **4151**.

In FIG. **138**, a distance between the first support parts **4410***a* that are arranged along the loading direction of the first substrate **4151** is determined to not interfere with a moving path of finger portions of the first arm **4310**. For example, the first arm **4310** is formed to have three finger portions **4311** mutually separated by an interval S. Accordingly, each of the first support parts **4410**_a_ are separated by the interval S, thereby preventing interference with motion of the first arm **4310**.

FIG. **139**B shows an exemplary substrate lifting system according to the present invention. In FIG. **139**B, central portions of the second support parts **4410**_b_ that are provided along the second direction are offset along a downward direction to prevent the interference with the finger portions **4311** of the first arm **4310**. In addition, side portions of the second support parts **4410**_b_ that contact the first elevating axis **4420** are formed having a length so as to not contact outermost finger portions **4311** of the first arm **4310**.

FIG. **140** is a perspective view of an exemplary substrate lifting system according to the present invention. In FIG. **140**, at least two of the first elevating axis **4420** axially coupled with the first substrate lifting system **4400** and the first driving part **4430** may be provided at each of the first and second support parts **4410**_a_ and **4410**_b_. For example, each of the first elevating axis **4420** may be connected to corresponding first driving parts **4430** that are provided at a crossing portion between the first and second support parts **4410**_a_ and **4410**_b_. Alternatively, a single first driving part **4430** may be used to drive the first and second support parts **4410**_a_ and **4410**_b_. Moreover, instead of using the plurality of protrusions (not shown), faces of the first and second support parts **4410**_a_ and **4410**_b_ that contact the surface portions of the first substrate **4151** may be coated with materials such as Teflon™ or PEEK, for example, to prevent damage caused by the contact between the first and second support parts **4410**_a_ and **4410**_b_ and the first substrate **4151**, and electrically conductive materials to dissipate any static electricity generated on the first substrate **4151**. The first and second support parts **4410**_a_ and **4410**_b_ may have various cross sectional geometries including square, round, and polygonal, for example. Furthermore, the first and second support parts **4410**_a_ and **4410**_b_ may be of a solid material or of a hollow material.

In FIG. **137**A, the first driving part **4430** of the first substrate lifting system **4400** may include at least a step motor and a cylinder. The step motor may move the cylinder vertically along the direction of the first elevating axis **4420** using a pneumatic or hydraulic system. The first driving part **4430** may be fixed to a lower space at the interior of the vacuum processing chamber **4110**, the first driving part **4430** may penetrate a bottom of the vacuum processing chamber **4110** to be fixed at a location at the exterior of the vacuum processing chamber **4110**. Thus, interference between the various driving parts may be avoided, and may provide easy installation of each of the driving parts.

A process of loading/unloading substrates using the apparatus according to the present invention is explained schematically with respect to FIGS. **137**A, **137**B, **141**A, and **141**B.

Then, the loader part **4300** controls the second arm **4320** to load the second substrate **4152**, which may include the sealant, onto the lower surface of the upper stage **4121**, and controls the first arm **4310** to load the first substrate **4151**, which has at least the liquid crystal material, onto the upper surface of the lower stage **4122**.

A substrate loading process includes applying a vacuum force to the plurality of vacuum holes **4121**_b_ of the upper stage **4121**. During the substrate loading process, the vacuum pump **4123**, which is connected to the upper stage **4121**, produces the vacuum force to the upper stage **4121**, thereby transferring the second substrate **4152** from the second arm **4320** and affixing the second substrate **4152** to the lower surface of the upper stage **4121**. The loader part **4300** controls the first arm **4310** so that the first substrate **4151** upon which the liquid crystal material is dropped is loaded onto the upper surface of the lower stage **4122**.

In FIG. **141**A, after the substrate loading process, a substrate elevating process includes enabling the first substrate system **4400** to move the first elevating axes **4420** along an upward direction. The first and second support parts **4410**_a_ and **4410**_b_ that are connected to the first elevating axes **4420** begin to travel in the upward direction from the first receiving part **4122**_d_ formed at the upper surface of the lower stage **4122**, as shown in FIG. **142**. Accordingly, the first and second support parts **4410**_a_ and **4410**_b_ contact a bottom surface of the first substrate **4151** positioned on the first arm **4310**. The first elevating axes **4420** together with the first and second support parts **4410**_a_ and **4410**_b_ continue to travel in the upward direction until the first substrate **4151** is removed from the first arm **4310**. Then, the first elevating axes **4420** stops the upward direction travel after elevation of a predetermined height.

When the first substrate **4151** contacts the upper surfaces of the first and second support parts **4410**_a_ and **4410**_b_, a weight of the first substrate **4151** may be distributed and internal stress of the first substrate **4151** may be alleviated. Thus, the first substrate **4151** is fully supported and any displacement or droop of the first substrate **4151** is avoided. Accordingly, the contacts between the first substrate **4151** and the upper surfaces of the first and second support parts **4410**_a_ and **4410**_b_ may include one of face contacts, line contacts, and point contacts. Alternatively, the contacts between the first substrate **4151** and the upper surfaces of the first and second support parts **4410**_a_ and **4410**_b_ may include a combination of face contacts, line contacts, and point contacts.

The first and second support parts **4410**_a_ and **4410**_b_ may be coated with a material such Teflon™ or PEEK, for example, to prevent damage to the bottom surface of the first substrate **4151** and an electrically conducting material to discharge any static electricity generated on the first substrate **4151**.

In FIG. **141**B, after the substrate elevating process, an extraction process includes extracting the first arm **4310** out of the vacuum processing chamber **4110** by control of the loader part **4300**, and a withdrawal process includes enabling the first driving parts **4430** to withdrawal the first elevating axes **4420** in a downward direction to be placed into the first receiving part **4122**_d_ of the lower stage **4122**. Accordingly, the bottom surface of the first substrate **4151** contact the upper surface of the lower stage **4122**.

After the extraction process and the withdrawal process, a substrate transfer process includes enabling the vacuum pump (not shown) that is connected to the lower stage **4122** to transfer a vacuum force to the plurality of vacuum holes (**4122**_b_ in FIG. **142**). Accordingly, the bottom surface of the first substrate **4151** is affixed to the upper surface of the lower stage **4122** by the vacuum force generated by the vacuum pump **4123**. Alternatively, the substrate transfer process may include applying a potential to the electrostatic plates of the electrostatic chuck **4122**_a_ of the lower stage **4122**, thereby affixing the bottom surface of the first substrate **4151** to the upper surface of the lower stage **4122**.

After the substrate transfer process, a vacuum processing chamber process includes enabling the vacuum device **4200** to reduce a pressure of the interior of the vacuum processing chamber **4110**. Then, once a desired vacuum pressure is attained, a bonding process of the first and second substrates **4151** and **4152** is performed by enabling the upper drive motor **4133** to move the upper stage **4121** in the downward direction, or by enabling the lower drive motor **4134** to move the lower stage **4122** in the upward direction. Alternatively, both the upper and lower drive motors **4133** and **4134** may be enabled, thereby moving the upper and lower stages **4121** and **4122** in the downward and upward direction, respectively.

Alternatively, an alignment process may be performed prior to the bonding process. The alignment process may include a certification procedure that the upper and lower substrates **4151** and **4152** are aligned with each other, and may include optical and computer systems. If the first and second substrate **4151** and **4152** are not certified as being aligned, adjustment systems may be enabled to move the upper stage **4121** along an X-Y plane, and rotate the rotational axis **4132** of the lower stage **4122**. Alternatively, both the upper and lower stages **4121** and **4122** may be moved along an X-Y plane in addition to the rotation of the lower stage **4122**.

Once the first and second substrates **4151** and **4152** have been bonded, a detachment process and an unloading process may be performed, wherein one of the first arm **4310** and the second arm **4320**, may unload the bonded first and second substrates **4151** and **4152** now residing upon the upper surface of the lower stage **4122**.

The detaching process includes removing the vacuum force from the plurality of vacuum holes (**4122***b* in FIG. **142**), or removing the potential from the electrostatic plates of the electrostatic chuck **4122***a*. The lower stage unloading process may include driving the first substrate lifting system **4400** using the driving parts **4430** to move the first elevating axes **4420** and the first and second support parts **4410***a* and **4410***b* in the upward direction. Accordingly, the bonded substrates are removed from the upper surface of the lower stage **4122**, and the driving parts **4430** continue to move the first elevating axes **4420** and the first and second support parts **4410***a* and **4410***b* until the bonded substrates are elevated above the upper surface of the lower stage **4122** by a predetermined amount. As previously described, the driving parts **4430** may be replaced by a single driving part (not shown).

Once the detaching and lower stage unloading processes have been completed, a bonded substrate unloading process includes the loader part **4300** controlling one of the first arm **4310** and the second arm **4320** to place the second substrate **4152** into the interior of the vacuum processing chamber **4110**. Then, a loading position of the second arm **4320** is arranged under the bonded substrates that have been previously moved along the upward direction by the first substrate lifting system **4400**. Accordingly, the first driving parts **4430** of the first substrate lifting system **4400** are driven to move the first elevation axes **4420** and the first and second support parts **4410***a* and **4410***b* along a downward direction. Thus, the bonded substrates that were placed on the first and second support parts **4410***a* and **4410***b* are now placed on the second arm **4320**, and the first and second support parts **4410***a* and **4410***b* continue to move along the downward direction to be received into the first receiving part **4122***d* of the lower stage **4122**.

Once the bonded substrates unloading process has been completed, a bonded substrates extraction process includes the second arm **4320** being withdrawn from the interior of the vacuum processing chamber **4110** by control of the loader part **4300**. After completion of the bonded substrates unloading process, the loading process of the first substrate **4151** by the first arm **4310** and first substrate lifting system **4400** may begin, as described above.

FIG. **143** shows a perspective view of an exemplary substrate lifting system according to the present invention. In FIG. **143**, at least one a second receiving part **4122***e* may be formed at opposing edge portions along an upper circumference of the lower stage **4122** in a direction perpendicular to the loading/unloading direction of the first substrate **4151**. The second receiving parts **4122***e* may be formed of a concave recess or a penetrating form. In addition, a second substrate lifting system **4600** may be received by the second receiving parts **4122***e* to support circumferential edge portions of the first substrate **4151** during the substrate loading process or support circumferential edge portions of the bonded substrates during the bonded substrates unloading process. Accordingly, the displacement or droop of the first substrate or bonded substrate is further prevented.

The second substrate lifting system **4600** may be received inside the second receiving part **4122***e* while being positioned initially at both sides of the lower stage **4122**. In addition, the second substrate lifting system may include at least second support part **4610** that supports a corresponding bottom edge portion of the first substrate **4151**, a second elevating axis **4620** built into one body of the second support part **4610** to move the second support part **4610** along the vertical direction, and a second driving part **4630** connected to the second elevating axis **4620** to move the second elevating axis **4620** along the vertical direction. Accordingly, the second receiving part **4122***e* may be formed to have a predetermined length along a portion corresponding to the dummy area of the first substrate **4151** when placed along the corresponding circumferential upper edge portions of the lower stage **4122**. Furthermore, the second support part **4610** may be formed to have a length corresponding to a shape of the second receiving part **4122***e* to support a circumference of the first substrate **4151**. Specifically, the second support part **4610** may be formed having a bent shape along a first face to provide support to the bottom of the first substrate **4151** and a second face supporting a side of the first substrate **4151**. In addition, a previously described above, a face contacting the first substrate **4151** may be coated with a coating material to prevent the substrate damage caused by the contact between the second support part **4610** and the first substrate **4151**. The coating material may be the same as the first and second support parts **4410***a* and **4410***b*, Teflon□ or PEEK□, for example, and an electrically conductive material to discharge any static electricity generated on the first substrate **4151**.

The second elevating axis **4620** and second driving part **4630** may be formed to have the first elevating axis **4420** and the first driving part **4430**. Moreover, the second support part **4610** may include a single body formed to engage an entire circumference of the lower stage **4122**. The plurality of the second support parts **4610** may be provided and separated from each by a predetermined interval, wherein the interval is sufficient to prevent the first substrate from exceeding a minimum displacement or droop limit. Accordingly, ends of the second support parts **4610** may include a single body with at least one second elevating axis **4620** and second driving part **4630** being are provided at the ends of the second support parts **4610**, thereby enabling a smooth operation of the respective second support parts **4610**.

An operational sequence of the second substrate lifting system **4600** will now be explained with respect to the first substrate lifting system **4400**. The second driving part **4630** of the second substrate lifting system **4600** operates simultaneously in connection with the operation of the first driving part **4430** of the first substrate lifting system **4400**, thereby moving the second elevating axis **4620** and second support part **4610** along the vertical direction. The simultaneous operation of the second driving part **4630** and the first driving part **4430** enables support of the circumferential portions of the first substrate **4151**, as well as the bonded substrates when the first substrate **4151** and the bonded substrates are loaded and unloaded, respectively.

An exemplary method of loading the first substrate **4151** by the simultaneous operation of the first and second substrate lifting systems **4400** and **4600** are described as follows. First, the first lifting system **4400** is enabled to carry out the loading process of the first substrate **4151**, much like the above described process. Sequentially, the upward movement of the first substrate lifting system **4400** is performed, the first substrate **4151** to be loaded onto the upper surface of the lower stage **4122** is placed on the first substrate lifting system **4400**, and the first substrate lifting system **4400** moves downward to place the first substrate **4151** on the upper surface of the lower stage **4122**.

Second, the first and second substrate lifting system **4400** and **4600** are simultaneously moved in the upward direction, the first substrate **4151** to be loaded onto the upper surface of the lower stage **4122** is placed on the first and second substrate lifting systems **4400** and **4600**, and the downward movements of the first and second substrate lifting systems **4400** and **4600** are simultaneously moved in the downward direction to place the first substrate **4151** on the upper surface of the lower stage **4122**. The process of loading the first substrate **4151** may be performed while the central and circumferential portions of the first substrate **4151** are simultaneously supported, thereby preventing the displacement or droop of the first substrate **4151**.

Third, the second substrate lifting system **4600** is moved along the upward direction, the first substrate **4151** to be loaded onto the upper surface of the lower stage **4122** is placed on the second substrate lifting system **4600**, the first substrate lifting system **4400** continues moving along the upward direction to support the first substrate **4151** on the second substrate lifting system **4600**, and the downward direction movement of the first and second substrate lifting system **4400** and **4600** are preformed to place the first substrate **4151** on the upper surface of the lower stage **4122**. Accordingly, after supporting the first substrate **4151** by the second substrate lifting system **4600** and before the unloading process of the first arm **4310**, the first substrate lifting system **4400** moves along the upward direction to support the first substrate **4151** together with the second lifting system **4600**. In addition, after the first substrate **4151** is unloaded by the first arm **4310** and supported by the second substrate lifting system **4600**, the first substrate support system **4400** moves along the upward direction to support the first substrate **4151** together with the second substrate lifting system **4600**. The process prevents interference between the first and second support parts **4410***a* and **4410***b* and the first arm **4310** during the loading process of the first substrate **4151**, as well as avoiding the bending portions of the first support parts **4410***a* and **4410***b*.

Fourth, movement along the upward direction of the first substrate lifting system **4400** is performed, the first substrate **4151** to be loaded onto the upper surface of the lower stage **4122** is placed on the first and second substrate lifting systems **4400** and **4600** moves along the upward direction to support the first substrate **4151** together with the first substrate lifting system **4400**, the first and second substrate lifting system **4400** and **4600** are simultaneously moved along the downward direction to place the first substrate **4151** onto the upper surface of the lower stage **4122**.

The above process of loading the first substrate **4151** using the first and second substrate lifting system **4400** and **4600** according to the present invention may not be limited to the above-mentioned description, but can be achieved various methods as well. Accordingly, the substrate lifting system of the apparatus according to the present invention has the following advantages and effects.

Referring now to FIG. **137**B, the apparatus may further include an auxiliary process means **4640** for securing bonded first and second substrates when the vacuum within the vacuum chamber **4110** is released or for holding the second substrate **4152** to the upper stage **4121** when a vacuum within the vacuum chamber is higher than a vacuum formed within the upper stage.

Referring now to FIG. **137**C, the auxiliary process means **4640** may include a rotational axis **4650**, a support portion **4660**, and a driving part **4670**. The rotational axis **4650** may be placed at a position allowing the support portion **4660** to be raised and rotated within the vacuum chamber **4110** and to be selectively rotated by the driving part **4670** such that the support portion **4660** at a peripheral portion of the lower stage **4122**.

The support portion **4660** may be arranged at one end of the rotational axis **610** within the vacuum chamber such that the support portion contacts predetermined portions of the second substrate **4152**, first and second arms **4310** and **4320**, and the bonded substrates. Accordingly, first and second contact portions **4661** and **4662**, respectively, of the support portion **4660** may contact first and second substrates **4151** and **4152**, respectively. First and second contact portions may be provided as material that will not scratch the first and second substrates, e.g., Teflon™ or PEEK. Alternatively, the first and second contact portions may be replaced by coating corresponding contact faces of the support portion with a material that will not scratch the substrates.

As illustrated in FIG. **137**C, the support portion **4660** may have a cubic shape, a columnar shape, a polyhedral shape, etc. In one aspect of the present invention, the support portion **4660** may have a rectangular parallelepiped shape, thereby providing a wide contact area contacting the first and second substrates.

The driving part **4670** includes a rotational motor **4671** installed externally or within the vacuum chamber **4110**. The rotational motor **4671**, or any other suitable assembly, may be used to rotate the support portion **4660** about the rotational axis **4650**. An elevating cylinder **4672**, or any other suitable assembly, may be used to selectively and hydraulically elevate the support portion **4660**.

The range within which the support portion **4660** may be elevated may include any elevation required to secure the bonded substrates during the release of the vacuum within the vacuum chamber **4110**, any elevation required to hold the second substrate **4152** to the upper stage **4121** when a vacuum within the vacuum chamber is higher than a vacuum formed within the upper stage, and any elevation required to support the ends of the finger portions of the first and second arms.

In one aspect of the present invention, the driving part **4670** illustrated in FIG. **137**C may be arranged outside a lower side of the vacuum chamber **4110** such that the rotational axis **4650** may be arranged within the vacuum chamber **4110** via a hole provided within a wall of the vacuum chamber and sealed by a coupling portion **4671**.

As illustrated in FIG. **137**D, the auxiliary process means **4640** may be arranged at positions adjacent the corners and/or side portions (e.g., central, etc.) of the lower stage **4122**.

FIG. **144** schematically illustrates a flow chart showing the steps of a method for fabricating an LCD in accordance with an embodiment of the present invention while FIGS. **145**A-**145**G schematically illustrate steps of a method for fabricating an LCD in accordance with an embodiment of the present invention.

Referring to FIG. **144**, a plurality of panels may be designed on a first glass substrate **11** and a thin film transistor array is formed on each panel (**4711**S), and a first orientation or alignment film is formed on an entire surface of the first glass substrate **4851**. Then a rubbing process (**4712**S) is performed. Instead of the rubbing process, a UV alignment process may be performed.

A plurality of panels are designed on a second glass substrate **4852** corresponding to the panels on the first glass substrate **4851**, to form a color filter array on each panel (**4715**S). The color filter array includes such elements as a black matrix layer, a color filter layer, and a common electrode. A second orientation or alignment film is formed on an entire surface of the second substrate **4852** and the second orientation film undergoes a rubbing process (**4716**S) similar to the first orientation film.

The first and second glass substrates **4851** and **4852** thus formed are cleaned, respectively (**4713**S and **4717**S).

Referring to FIG. **145**A, liquid crystal **4807** is dispensed or applied to the first glass substrate **4851** which has been cleaned (**4714**S). Silver (Ag) dots are formed on the cleaned second glass substrate **4852** (**4718**S), and a sealant **4870** is coated thereon (**4719**S).

The first and second glass substrates **4851** and **4852** are loaded in a vacuum bonding chamber **4810**, and bonded to spread the applied liquid crystal between the first and second substrates uniformly, and then, the sealant is hardened (**4720**S).

The bonded first and second glass substrates **4851** and **4852** are cut into a plurality of individual panels (**4721**S). Although a plurality of individual panels may be cut from any glass substrate, a single panel may also be formed to maximize the size of the display. Subsequently, each panel is then polished and inspected (**4722**S).

The bonding process will be explained in more detail. FIG. **146** illustrates a flowchart showing the bonding steps of the present invention.

The bonding process may include the steps of loading the two substrates into the vacuum bonding chamber, bonding the two substrates together, and unloading the bonded substrates from the vacuum bonding chamber.

Before loading the substrates, the second glass substrate **4852** having the sealant **4870** coated thereon may be cleaned using, for example, an ultra sonic cleaner (USC) to remove undesirable contaminant particles formed during fabrication. Since the second glass substrate **4852** is coated by the sealant and the Ag dots, and no liquid crystal has been dispensed thereon, the second glass substrate **4852** may be cleaned.

Referring to FIG. **145**B, in the loading step, the second glass substrate **4852** having the sealant **4870** coated thereon and facing in a downward direction, is held to an upper stage **4821** by, for example, a vacuum or electrostatic chuck provided in the vacuum bonding chamber **4810** (**4731**S). Before the second glass substrate **4852** is loaded in the bonding chamber **4810**, the second glass substrate **4852** may be flipped over so that the surface with the sealant **4870** will face in a downward direction, as will be explained in greater detail below.

In flipping over the second glass substrate **4852**, having the sealant **4870** coated thereon, a loader of a robot (not shown) may hold the substrate such that the sealant **4870** is facing in a downward direction as it is brought in the vacuum bonding chamber **4810**. Next, the upper stage **4821** in the vacuum bonding chamber **4810** may be moved vertically downward to contact and hold the second glass substrate **4852**, and then may be moved vertically upward. In one aspect of the present invention, the second glass substrate **4852** may be held to the upper stage **4821** using a vacuum chuck, electrostatic charge (ESC), or any other suitable holding technique.

The loader of the robot is then moved out of the vacuum bonding chamber **4810** and the first glass substrate **4851** is arranged over the lower stage **4822** by the loader of the robot.

Although it has been explained that the liquid crystal **4807** is dispensed on the first glass substrate **4851** having the thin film transistor array and the sealant is coated on the second glass substrate **4852**, the sealant may alternatively be coated on the first glass substrate **4851** while the liquid crystal may alternatively be dispensed on the second substrate. Moreover, the sealant may be applied to both substrates. Further, the liquid crystal may be dispensed, or the sealant coated, on either of the two glass substrates as long as the substrate with the liquid crystal material dispensed thereon is located on the lower stage and the other substrate is located on the upper stage.

After the first and second substrates are held by vacuum to the lower and upper stage, the first and second substrates may be aligned.

Next, a substrate receiver (not shown) is contacted with a bottom surface of the second glass substrate **4852** (**4733**S) by positioning the substrate receiver under the second glass substrate **4852** and moving the upper stage down, or the substrate receiver up, or both, until the second glass substrate **4852** contacts the substrate receiver.

The substrate receiver is positioned below the second glass substrate **4852**, to prevent the second glass substrate held to the upper stage from becoming detached from the upper stage due to a reduction in a vacuum force present within the upper stage when the vacuum pressure in the bonding chamber becomes higher than the vacuum force within the upper and lower stages.

Accordingly, the second glass substrate **4852**, held to the upper stage may be arranged on the substrate receiver before or during the creation of a vacuum in the vacuum bonding chamber. Alternatively, the upper stage holding the second glass substrate and the substrate receiver may be brought within a predetermined distance of each other so that the second glass substrate **4852** may be safely arranged on the substrate receiver from the upper stage when the chamber is evacuated. Moreover, means for fastening the substrates may be provided additionally as air flow in the chamber, capable of shaking the substrates, may occur when evacuation of the vacuum bonding chamber is initiated.

The vacuum within the vacuum bonding chamber **4810** may have a pressure in a first range of about 1.0×10^{-3} Pa to 1 Pa or a second range of about 1.1×10^{-3} Pa to 10^2 Pa. The first range may be especially applicable for an in-plane switching (IPS) mode LCD and the second range may be especially useful for a twisted nematic (TN) mode LCD. Another type of LCD called a vertical alignment (VA) mode LCD may also use these ranges.

Evacuation of the vacuum bonding chamber **4810** may be carried out in two stages. After the substrates are held to their respective stages, a chamber door is closed and the vacuum chamber is evacuated a first time. After positioning the substrate receiver under the upper stage and placing the substrate on the substrate receiver or after positioning the upper stage and the substrate receiver to within the predetermined distance when the upper stage holds the substrate, the vacuum bonding chamber is evacuated a second time. The second evacuation is faster than the first evacuation and the vacuum pressure created by the first evacuation is not greater than the vacuum pressure created within the upper stage.

The aforementioned two stage evacuation process may prevent deformation or shaking of the substrates when the vacuum bonding chamber is rapidly evacuated.

Alternatively, after the substrates are held to their respective stages and the chamber door is closed, the evacuation may be implemented in a single step at a fixed rate. In addition, the substrate receiver may be positioned below the second substrate **4852** held to the upper stage **4821** during the evacuation. Before the vacuum pressure in the vacuum bonding chamber becomes higher than the vacuum holding force of the upper stage it is required that the substrate receiver be in contact with the second glass substrate **4852**.

Once the vacuum bonding chamber **4810** is evacuated to a final vacuum pressure, the first and second glass substrates **4851** and **4852**, respectively, are electrostatically secured to their respective stages using an electrostatic chuck (ESC) (**4735**S) and the substrate receiver may be brought to its original position (**4736**S). Accordingly, the loading process is completed.

Using ESC the first and second glass substrates may be held to their respective stages by applying negative/positive DC voltages to two or more plate electrodes (not shown) formed within the stages. When the negative/positive voltages are applied to the plate electrodes, a coulombic force is generated between a conductive layer (e.g., transparent electrodes, common electrodes, pixel electrodes, etc.) formed on the substrate and the stage. When conductive layer formed on the substrate faces the stage, about 0.1-1 KV may be applied to the plate electrodes. When the substrate contains no conductive layer, about 3-4 KV may be applied to the plate electrodes. An elastic sheet may be optionally be provided to the upper stage.

After the upper stage **4821** is moved down to bring the second glass substrate **4852** closer to the first glass substrate **4851**, the first and second glass substrate **4851** and **4852** are aligned (**4737**S) in an alignment method, as will be explained in greater detail below.

FIGS. **147**A-**147**C illustrate an exemplary rough mark alignment method in accordance with an embodiment of the present invention, FIGS. **148**A-**148**C illustrate a fine mark alignment method in accordance with an embodiment of the present invention, and FIGS. **149**A-**149**C illustrate a camera focusing position used in an alignment method in accordance with an embodiment of the present invention.

Referring to FIGS. **147**A-**147**B and **148**A-**148**B, the first glass substrate **4851** and the second glass substrate **4852** include rough alignment marks measuring approximately 3 μm in size (FIGS. **147**A-**147**C) and fine alignment marks measuring approximately 0.3 μm in size (FIGS. **148**A-**148**C). The first glass substrate **4851** includes a least one rough alignment mark as shown in FIG. **147**A and at least one fine alignment mark as shown in FIG. **148**A. The second glass substrate **4852** includes at least one rough alignment mark as shown in FIG. **147**B and at least one fine alignment mark as shown in FIG. **148**B.

In one aspect of the present invention, different cameras may be used to align the rough marks and the fine marks. Alternatively, a single camera may be used to align both the rough marks and the fine marks.

Referring to FIGS. **149**A-**149**C, the cameras used to align the rough and fine marks may be focused on a central part between the first glass substrate **4851** and the second glass substrate **4852**.

Referring to FIG. **145**C, the upper stage **4821** is moved down a first time such that the second glass substrate **4852** does not touch the liquid crystal dispensed on the first glass substrate and a gap between the first glass substrate **4851** and the second glass substrate **4852** is in a range of 0.4 mm-0.9 mm, for example 0.6 mm. Subsequently, the first glass substrate **4851** is roughly aligned with the second glass substrate **4852** such that the rough marks on the second glass substrate **4852** may be located within the rough marks on the first glass substrate **4851**. In performing the rough alignment an area of approximately 3.0 mm may be searched in order to determine the positions of the rough and fine alignment marks.

Referring to FIG. **145**D, the upper stage **4821** is moved down a second time such that a gap between the first glass substrate **4851** and the second glass substrate **4852** is in a range of 0.1 mm-0.4 mm, for example, 0.2 mm. Subsequently, the first glass substrate **4851** is finely aligned with the second glass substrate **4852** such that the fine mark on the second glass substrate **4852** is accurately located within the fine mark on the first glass substrate **4851**. In performing the fine alignment an area of approximately 0.2 mm may be searched in order to determine the positions of the rough and fine alignment marks. Further, an alignment tolerance of approximately 0.1 μm may be achieved as a result of aligning the first and second substrates. During the step of finely aligning the first and second glass substrates, the liquid crystal **4807** dispensed on the first glass substrate **4851** may contact the second glass substrate **4852**.

Since the upper stage **4821** is movable in vertical, e.g., up and down, directions and the lower stage is movable in horizontal, e.g., X, and Y, directions, the lower stage **4822** may be moved horizontally to align the two substrates.

During alignment of the rough and fine marks, the cameras may be provided above or below the upper or lower surfaces of the first or second substrates. In one aspect of the present invention, the cameras used to locate the alignment marks may be positioned outside the vacuum bonding chamber. Accordingly, the cameras may be used to view rough and fine alignment marks on the first and second substrates through one or more windows provided in top and bottom walls of the vacuum chamber, as required.

In another aspect of the present invention, the windows, through which the alignment marks are viewed by the cameras, may be provided within recessed cavities formed in the top and bottom walls of the vacuum chamber. Accordingly, in the present aspect of the invention, a single camera may be used to view alignment marks formed on the upper and lower substrates by moving the cameras up and down within their respective cavities. Alternately, a single, stationary camera may be used to view alignment marks on a single substrate. Accordingly, movement of the cameras is not required.

In a first exemplary aligning process, a central part between the alignment marks on the second glass substrate **4852** and the alignment marks on the first glass substrate **4851** may be focused on using the cameras. In a second example, a focal point of the cameras may be adjusted to focus on alignment marks formed on the on the second glass substrate **4852** and then to focus on alignment marks formed on the first glass substrate **4851**, thereby improving an alignment accuracy over that of the aforementioned first example.

FIG. **150** illustrates an exemplary layout of rough and fine marks used in an alignment method in accordance with an embodiment of the present invention.

Referring to FIG. **150**, at least four rough and fine marks may be formed on the first and second glass substrates **4851** and **4852**. Alignment marks on one substrate correspond in location to alignment marks formed on another substrate. To improve alignment accuracy, the number of alignment marks may be increased as the size of the glass substrate increases. The rough marks and the fine marks may be formed in regions between panels which are to be cut, or in a periphery region of the substrate outside of where the plurality of panels are formed.

FIGS. **147**C and **148**C illustrate the alignment of rough marks and fine marks, when the first glass substrate **4851** are aligned with the second glass substrate **4852** by employing different cameras in alignment of the rough marks and the fine marks, the alignment can be made more faster and accurately.

Referring to FIGS. **145**E and **145**F, after the two substrates are aligned, the upper stage **4821** is moved down and a pressure is applied to the first and second glass substrates **4851** and **4852**, thereby bonding the two substrates together (**4738**S). The first and second glass substrates **4851** and **4852** are bonded together by moving either the upper stage **4821** or the lower stage **4822** in a vertical direction, while varying speeds and the pressures of the upper and lower stages. Until the time when the liquid crystal **4807** on the first glass substrate **4851** comes into initial contact with the second glass substrate **4852** or when the seal on the second glass substrate **4852** come into initial contact with the first glass substrate **4851**, the stages are moved at a fixed speed or fixed pressure. After the time of initial contact, the pressure is increased gradually from the fixed pressure to a final pressure. Accordingly the time of initial contact is sensed by a load cell fitted to a shaft of the upper or lower stages. The two glass substrates **4851** and **4852** may, for example, be pressed at a first pressure of 0.1 ton at the initial time of contact, a second pressure of 0.3 ton at a first intermediate stage, a third pressure of 0.4 ton at a second intermediate stage, and a fourth pressure of 0.5 ton at a final stage (see FIG. **145**F).

Although it is illustrated that the upper stage presses down onto the substrates by means of one shaft, a plurality of shafts may independently apply and control pressure using individual load cells fitted thereto. If the lower stage and the upper stage are not level or fail to be pressed uniformly, a predetermined number of shafts may be selectively activated to apply lower or higher pressures to the substrates, thereby providing uniform bonding of the sealant.

Referring to FIG. **145**G, after reaching the final stage, applying the fourth pressure, and bonding the two substrates, the ESC is turned off and the upper stage **4821** is raised upward and separates from the bonded glass substrates **4851** and **4852**.

Next, the bonded substrates are unloaded (**4738**S). Accordingly, after the upper stage is raised to a final raised position, the bonded glass substrates may be unloaded using the loader of the robot. Alternatively, the bonded glass substrates may be held by the upper stage during its ascent to its final raised position wherein the loader of the robot unloads the first and second glass substrates **4851** and **4852** from the upper stage **4821**. The bonded substrates may be held to the upper stage by a vacuum or an electrostatic charge.

In order to shorten the fabrication time period, an unbonded first glass substrate **4851** or second glass substrate **4852** may be loaded onto a stage while the bonded substrates are unloaded from a stage. Accordingly, an unbonded second glass substrate **4852** may be brought to the upper stage **4821** by means of the loader of the robot and held to the upper stage by a vacuum or an electrostatic charge while the bonded first and second glass substrates may be unloaded from the lower stage **4822**. Alternatively, an unbonded first glass substrate **4851** may be brought to the lower stage **4822** by means of the loader robot while the bonded first and second glass substrates held by the upper stage **4821** may be unloaded.

A liquid crystal spreading process may be provided before or after the bonded substrates are unloaded. Accordingly, the liquid crystal spreading process spreads the liquid crystal in the gap between the bonded substrates toward the sealant in the event the liquid crystal does not spread sufficiently toward the sealant before unloading. The liquid crystal spreading process may be carried out for at least 10 minutes under the atmospheric or a vacuum pressure.

As has been explained, the method for fabricating LCDs of the present invention has the following advantages.

First, applying the liquid crystal on the first substrate and coating the seal on the second substrate shorten a fabrication time prior to bonding the two substrates together.

Second, applying the liquid crystal on the first substrate and coating the seal on the second substrate permits a balanced progression of the fabrication processes to the first and second substrates, thereby making efficient use of a production line.

Third, dispensing liquid crystal on the first substrate and coating the sealant and the Ag dots on the second substrate prevents the sealant from becoming contaminated with particles as the substrate coated by the sealant may be cleaned by a USC just prior to bonding.

Fourth, positioning the substrate receiver under the substrate and evacuation of the vacuum bonding chamber permits the substrate held to the upper stage from falling and thereby breaking.

Fifth, adjustment of the gap between the first and second glass substrates and the use of cameras during the alignment of rough and fine marks permit fast and accurate alignment of the first and second substrates.

Sixth, sensing the time when the two substrates initially contact each other and varying the pressure applied in bonding the two substrates together minimizes damage to the orientation film caused by the liquid crystal.

Sixth, since the upper stage presses the substrate down by means of a plurality of shafts, each of which capable of applying pressure independently, uniform bonding of the sealant can be achieved by independently applying a lower or higher pressures by predetermined shafts when the lower stage and the upper stage are not level or fail to bond to the sealant uniformly.

Eighth, the simultaneous loading and unloading of unbonded and bonded substrates shortens a fabrication time of the LCD.

Ninth, the two staged evacuation of the vacuum bonding chamber prevents deformation of the substrate and air flow in the chamber caused by sudden pressure changes.

Tenth, the liquid crystal spreading process shortens a fabrication time period of the LCD.

FIGS. **151**A-**151**F schematically illustrate steps of a method for fabricating an LCD in accordance with an embodiment of the present invention.

Referring to FIG. **151**A, liquid crystal **4907** may be applied to a first glass substrate **4951**, and a seal **4970** may be formed on a second glass substrate **4952**. A plurality of corresponding areas designated for panels may be provided in first and second glass substrates **4951** and **4952**, and thin film transistor arrays may be formed on each of the panels within the first glass substrate **4951** while color filter arrays, black matrix layers, a color filter layers, common electrodes, etc., may be formed on each of the panels of the second glass substrate **4952**. Liquid crystal material **4907** may be applied onto the first glass substrate **4951** and a seal **4970** may be coated onto the second glass substrate **4952**. Alternatively, the seal **4970** may be coated on the first glass substrate **4951** and the liquid crystal material **4907** may be dropped on the second glass substrate **4952** or both the liquid crystal material **4907** and the seal **4970** may be dropped and coated on either of the two glass substrates. In any case, however, when placed into the vacuum bonding chamber to be bonded with another substrate, the glass substrate having the liquid crystal dropped thereon must be placed on a lower stage, as will be discussed in greater detail below.

Referring now to FIG. **152**, a bonding process in accordance with an embodiment of the present invention may be explained.

Generally, the bonding process includes steps of loading the two substrates into a vacuum bonding chamber, bonding the two substrates, setting the seal of the bonded substrates to fix the bonded substrates together, and unloading the bonded two substrates from the vacuum bonding chamber.

Before loading the first and second substrates **4951** and **4952** into the vacuum bonding chamber, a seal is formed on the second glass substrate **4952**. Subsequently, particles formed during various fabrication processes are removed from the second glass substrate in a USC (Ultra Sonic Cleaner). Since no liquid crystal applied onto the second glass substrate **4952**, coated by the seal, the second glass substrate **4952** can be cleaned.

Referring generally to FIG. **151**B, the second glass substrate **4952** is held to an upper stage **4921** in the vacuum bonding chamber **4910**, wherein the seal **4970** faces down (**5031**S), and the first glass substrate **4951** is held to a lower stage **4922** in the vacuum bonding chamber **4910** (**5032**S), wherein the liquid crystal material **4907** faces up. The vacuum bonding chamber **4910** is hereby in a standby state.

More specifically, the second glass substrate **4952** with the seal **4970** facing down is held by a loader of a robot (not shown), and is brought into the vacuum bonding chamber **4910**. The upper stage **4921** in the vacuum bonding chamber **4910** is moved down to meet and hold the second glass substrate **4952**, and is then moved back up. The second glass substrate **4952** may be held to the upper stage **4921** with the use of a vacuum force or with an electrostatic force.

Then, the loader is moved out of the vacuum bonding chamber **4910** and places the first glass substrate **4951** over the lower stage **4922** in the vacuum bonding chamber **4910**.

Next, the second glass substrate **4952** is placed on a substrate receiver (not shown) by placing the substrate receiver under the second glass substrate **4952** and moving the upper stage down, or the substrate receiver up, or both, until the second glass substrate **4952** contacts the substrate receiver (**5033**S). After the second glass substrate **4952** and the substrate receiver are brought into contact, the second glass substrate **4952** is held to the upper stage.

The substrate receiver contacts an under side of the second glass substrate **4952**, to prevent the second glass substrate held to the upper stage from becoming detached from the upper stage due to a reduction in a vacuum force present within the upper stage when a vacuum in the bonding chamber becomes higher than the vacuum force within the upper and lower stages.

Accordingly, the second glass substrate **4952**, held to the upper stage, may be placed on the substrate receiver before or during the creation of a vacuum in the vacuum bonding chamber. Alternatively, the upper stage holding the second glass substrate and the substrate receiver may be brought to within a predetermined distance of each other so that the second glass substrate **4952** may be safely placed on the substrate receiver from the upper stage when the chamber is evacuated. Moreover, means for securing the substrates may be provided additionally as air flow in the chamber, capable of shaking the substrates, may occur when evacuation of the vacuum bonding chamber is initiated (**5034**S).

The vacuum within the vacuum bonding chamber **4910** may have a pressure in a range of about 1.0×10^{-3} Pa to about 1 Pa for IPS mode LCDs, and about 1.1×10^{-3} Pa to about 10^2 Pa for TN mode LCDs.

Evacuation of the vacuum bonding chamber **4910** may be carried out in two stages. After the substrates are held to their respective stages, a chamber door is closed and the vacuum chamber is evacuated a first time. After positioning the substrate receiver under the upper stage and placing the substrate on the substrate receiver or after positioning the upper stage and the substrate receiver to within the predetermined distance when the upper stage biases the substrate, the vacuum bonding chamber is evacuated for a second time. The second evacuation is faster than the first evacuation. The vacuum force created by the first evacuation is not higher than the vacuum force within the upper stage.

The aforementioned two stage evacuation process may prevent deformation or shaking of the substrates in the vacuum bonding chamber that conventionally occurs when the vacuum boning chamber is rapidly evacuated.

Alternatively, evacuation of the bonding chamber may be carried out in a single stage. Accordingly, after the substrates are held to their respective stages and the chamber door is closed, the evacuation may be started and the substrate receiver may be brought to the underside of the upper stage during the evacuation. The substrate receiver must be brought to the underside of the upper stage before the vacuum force within the vacuum bonding chamber becomes higher than the vacuum force within the upper stage.

Once the vacuum bonding chamber **4910** is evacuated to a preset vacuum, the upper and lower stages **4921** and **4922** bias and fix the first and second glass substrates **4951** and **4952** respectively using an ESC (Electro Static Charge) (**5035**S) and the substrate receiver is brought to its original position (**5036**S) out from under the upper plate.

Using ESC the first and second glass substrates may be held to their respective stages by applying negative/positive DC voltages to two or more plate electrodes (not shown) formed within the stages. When the negative/positive voltages are applied to the plate electrodes, a coulombic force is generated between a conductive layer (e.g., transparent electrodes, common electrodes, pixel electrodes, etc.) formed on the substrate and the stage. When conductive layer formed on the substrate faces the stage, about 0.1-1 KV is applied to the plate electrodes. When the substrate contains no conductive layer, about 3-4 KV is applied to the plate electrodes. An elastic sheet may be optionally be provided to the upper stage.

Referring to FIGS. **151**C and **151**D, after the two glass substrates **4951** and **4952** are aligned and held to their respective stages by ESC, the two stages are moved into proximity such that the two glass substrates may be bonded together (**5037**S). The first and second glass substrates **4951** and **4952** are pressed together by moving either the upper stage **4921** or the lower stage **4922** in a vertical direction, while varying speeds and pressures at different stage locations. Until the time the liquid crystal **4907** on the first glass substrate **4951** and the second glass substrate **4952** come into contact, or until the time the first glass substrate **4951** and the seal on the second glass substrate **4952** come into contact, the stages are moved at a fix speed or fixed pressure, and the pressure is boosted up step by step from the time of contact to a final pressure. That is, the time of contact may be sensed by a load cell fitted to a shaft of the movable stage. The two glass substrates **4951** and **4952** may, for example, be pressed at a pressure of 0.1 ton at the time of contact, a pressure of 0.3 ton at an intermediate time period, a pressure of 0.4 ton at a full contact stage, and a pressure of 0.5 ton at a final stage (see FIG. **151**D).

Though it is illustrated that the upper stage presses down onto the substrate by means of one shaft, a plurality of shafts may independently apply and control pressure using an individual load cell. If the lower stage and the upper stage are not leveled or fail to be pressed uniformly, predetermined shafts may be selectively pressed using lower or higher pressures to provide uniform bonding of the seal.

Referring to FIG. **151**E, after the two substrates are bonded, a UV ray may be directed, and/or heat may be applied, to the seal in order to cure or harden and fix the first and second glass substrates **4951** and **4952** together (**5038**S). Because the substrates are large (e.g., 1.0 m×1.2 m), and the two substrates are bonded after the liquid crystal is applied, misalignment of the two substrates may occur during subsequent processes or during transfer after the bonding step. Therefore, the fixing is made for prevention of the misalignment of the bonded two substrates and maintaining a bonded state during the next process or transfer after the bonding.

The method of fixing the two substrates to each other will be explained in more detail.

Fixing the two substrates occurs within the bonding chamber under a vacuum or atmospheric pressure. Though it is preferable that the fixing is carried out after the bonding, the fixing may be carried out before the bonding is finished. For simplification of the process, though it is preferable that material of the fixing seal is the same as that of the main seal, material of fixing seal may be different from the main seal to improve efficiency in the fixing process. The fixing seal may, for example, be a photosetting resin, a thermosetting resin, a UV-thermosetting resin, a pressure setting resin, or any other material with a high adhesive force. Fixing conditions used with the photosetting resin may, for example, a UV ray having a power of 50-500 mW (e.g., 200 mW) directed for about 5-40 seconds (e.g., about 14 seconds). Fixing conditions used with the thermosetting resin may be dependent on a material of the fixing seal and may, for example, include a setting temperature in a range of about 50-200° C. applied to the seal for more than about 10 seconds. Accordingly, the bonded substrate may be fixed by any one of light, heat, light and heat, and pressure. The fixing seal may or may not be coated on the same substrate as the main seal.

FIG. **153** illustrates a seal layout pattern in accordance with a first embodiment of the present invention, and FIG. **159** illustrates a section across a line I-I' in FIG. **153** showing upper and lower stages and substrates.

Referring to FIG. **153**, a method for fixing bonded substrates in accordance with a first embodiment of the present invention includes coating any of the aforementioned resins, forming a plurality of main seals **4970***a* on a periphery of each panel for bonding and sealing the liquid crystal between the two substrates, forming a dummy seal **4970***b* to surround a plurality of panels for protecting the main seals **4970***a* on an inner side thereof during bonding and pressing, and forming a plurality of fixing seals **4970***c* on an outer periphery of the dummy seal **4970***b* (an outer periphery of the substrate) at fixed intervals for fixing the two substrates preliminarily, which are removed during cutting, on the second glass substrate **4952** in the foregoing seal **4970** coating.

The bonded two substrates may then be fixed by forming the fixing seals **4970***c*, bonding the two substrates, directing a light (UV) to, and/or heating, the fixing seals **4970***c* thereby setting the fixing seals **4970***c*. When the fixing seals **4970***c* are formed from a the light (UV) setting resin, light (UV) may be directed to the fixing seals **4970***c* to fix the substrates. When the fixing seals **4970***c* are formed of a thermosetting resin, heat may be applied to the fixing seals **4970***c* for setting the fixing seals **4970***c*.

Referring to FIG. **159**, the upper stage **4921** and/or the lower stage **4922** includes a plurality of holes **4917** for directing the light (UV) or applying heat. Before the aligned substrates are bonded, it may be assumed that the fixing seals **4970***c* and the holes **4917** are aligned. Accordingly, upon directing a light (UV) or applying heat to the fixing seals **4970***c* from an upper stage side or a lower stage side through the holes **4917**, the fixing seals **4970***c* are set, and the two substrates are fixed together. The light (UV) having a power of about 50-500 mW (e.g., 200 mW) is emitted from a light (UV) emitting pin (**4918***a* or **4918***b*) for about 5-40 seconds (e.g., about 14 seconds) that moves down from an upper side of the bonding chamber or moves up from a lower side of the bonding chamber. When setting the fixing seals **4970***c* using heat, a heating device **4918***a* or **4918***b* may be moved down from the upper side of the bonding chamber or moved up from the lower side of the bonding chamber to come into contact with a part of the first or second substrates **4951** or **4952** the fixing seals **4970***c* formed thereon through the holes **4917**, and heats the fixing seals **4970***c*. The fixing seals **4970***c* may be heated at a temperature of about 50-200° C. for about 10 seconds to selectively setting the fixing seals **4970***c*. Optionally, light (UV) direction and the heat application may be carried out simultaneously.

In one aspect of the invention, the main seals **4970***a*, the dummy seal **4970***b*, and the fixing seals **4970***c* may all be formed on the second glass substrate. In another aspect of the present invention, the dummy seal **4970***b* and/or the fixing seals **4970***c* may be formed on the first glass substrate **4951** and/or the fixing seals **4970***c* may be formed of a material different from the main seals **4970***a*. In another aspect of the present invention, either the main seals **4970***a* may be formed on the first substrate **4951** while the dummy seal **4970***b* and/or the fixing seals **4970***c* may be formed on the second glass substrate, or the main seals **4970***a* may be formed on the second substrate **4952** and the dummy seal **4970***b* and/or the fixing seals **4970***c* may be formed on the first glass substrate **4951**. In another aspect of the present invention, the main seals **4970***a*, the dummy seal **4970***b*, and the fixing seals **4970***c* may all be formed on the first glass substrate **4951**.

FIG. **154** illustrates a seal layout pattern in accordance with a second embodiment of the present invention.

Referring to FIG. **154**, a method for fixing bonded substrates in accordance with a second embodiment of the present invention includes coating a resin selected from aforementioned materials (e.g., photosetting resin, a thermosetting resin, a UV-thermosetting resin, and a pressure setting resin), forming a plurality of main seals **4970***a* on a periphery of the second substrate for surrounding all the panels for bonding the two substrates and for sealing the liquid crystal between the two substrates, forming a dummy seal **4970***b* to surround a plurality of panels for protecting the main seals **4970***a* on an inner side thereof during bonding, and directing light (UV), and/or applying heat, to parts of the dummy seal **4970***b* for fixing the two substrates.

In accordance with the present embodiment, the dummy seal **4970***b* may be coated in the same region where the fixing seals are intended. Subsequently, light (UV) is directed, and/or heat is applied, to fix portions of the dummy seal **4970***b* corresponding to fixing seal locations. The conditions of light (UV) direction and/or heat application are the same as in the first embodiment. Reference numeral **4970***d* denotes the regions in the dummy seal **4970***b* where the light (UV) is directed and/or the heat is applied. Accordingly, the dummy seal **4970***b* may be used to form fixing seals equivalent to those found in the first embodiment.

FIG. **155** illustrates a seal layout pattern in accordance with a third embodiment of the present invention.

Referring to FIG. **155**, a method for fixing bonded substrates in accordance with a third preferred embodiment of the present invention includes omitting formation of the dummy seal. Accordingly, the two substrates may be fixed together by forming only the main seals **4970***a* and the fixing seals **4970***c* in a periphery of the substrate and directing a light (UV), applying heat, and/or pressure, to the fixing seals **4970***c* as similarly described in the first embodiment of the present invention. Further, the fixing seals **4970***c* may have a closed form, as with the dummy seal in the previous embodiments.

FIG. **156** illustrates a seal layout pattern in accordance with a fourth embodiment of the present invention.

Referring to FIG. **156**, a method for fixing bonded substrates in accordance with a fourth embodiment of the present invention fixes the two bonded substrates by forming the fixing seals **4970***c* in a periphery region of the substrate and also at fixed intervals in cutting regions between panels. Light (UV) may be directed and/or heat or pressure may be applied to the fixing seals **4970***c* as with the third embodiment of the present invention. Other conditions are the same with the first embodiment.

FIG. **157** illustrates a seal layout pattern in accordance with a fifth embodiment of the present invention.

Referring to FIG. **157**, a method for fixing bonded substrates in accordance with a fifth embodiment of the present invention fixes the two bonded substrates by forming a plurality of dummy seals that surround each of panels (main seals), forming the fixing seals **4970***c* in a periphery of the substrate, and directing a light (UV) and/or applying heat or pressure to the fixing seals **4970***c* as previously described with reference to the first embodiment of the present invention. Other conditions are the same with the first embodiment.

FIG. **158** illustrates a seal layout pattern in accordance with a sixth embodiment of the present invention.

Referring to FIG. **158**, a method for fixing bonded substrates in accordance with a sixth embodiment of the present invention fixes the two bonded substrates by selectively directing light (UV) and/or applying heat to portions of a plurality of dummy seals **4970***b* formed on each panel. Light and/or heat may be selectively directed/applied to the dummy seals **4970***b* in accordance with the fifth embodiment of the present invention. Other conditions are the same with the first embodiment.

In each of the foregoing embodiments, the main seals **4970***a*, the dummy seals **4970***b*, and the fixing seals **4970***c* may or may not be formed on the same substrate, and the main seals or the dummy seals may be formed on the substrate having the liquid crystal applied thereto.

Though not shown in the FIGS, a method for fixing bonded substrates in accordance with a seventh embodiment of the present invention fixes the two bonded substrates, not by forming separate dummy seals or fixing seals, but by selectively directing light (UV) and/or applying heat to portions of the main seals, wherein the main seals may be formed of a light (UV) setting resin, a thermosetting resin, or a light (UV) and thermosetting resin.

Also, though not shown in the FIGS, a method for fixing bonded substrates in accordance with an eighth embodiment of the present invention fixes the two bonded substrates by applying an adhesive, having a setting property better than that of the seals, to parts the fixing seals **4970***c* in the first, third, fourth, or fifth embodiment, and bonding the first and second glass substrates using the adhesive.

Once fixing of the two bonded substrates are finished, misalignment of the bonded first and second glass substrates may be prevented during transfer of the substrates for subsequent fabrication processes.

Referring to FIG. **151**F, when fixing of the two bonded substrates is finished, the ESC is turned off and the upper stage **4921** is moved up. Accordingly, the upper stage **4921** is separated from the fixed two glass substrates **4951** and **4952**. Next, the substrates are unloaded in an unloading step (**5038**S) using the loader. Alternatively, the ESC may be left on only in the upper stage and the fixed first and second glass substrates **4951** and **4952** are lifted by the upper stage. Next, the loader unloads the first and second glass substrates **4951** and **4952** from the upper stage **4921**.

In order to shorten the fabrication time for the LCD, one of the first and second glass substrates to be bonded in a next bonding process may be loaded onto an empty stage while the fixed first and second glass substrates are unloaded. For example, after the second glass substrate **4952** to be bonded in a next bonding process is brought to the upper stage **4921** via the loader and held to the upper stage, the fixed first and second glass substrates on the lower stage **4922** may be unloaded. Alternatively, after the upper stage **4921** lifts the fixed first and second glass substrates **4951** and **4952**, the loader may load a first glass substrate **4951** to be bonded in a next bonding process onto the lower stage, and the fixed first and second glass substrates may be unloaded.

A liquid crystal spreading process may optionally be added before the process of unloading the bonded substrates where the liquid crystal between the fixed substrates may be spread, for example, toward the seal. Alternatively, a liquid crystal spreading process may be carried out to evenly spread the liquid crystal toward the seal when the liquid crystal does not adequately spread after the unloading. The liquid crystal spreading process may be carried out for more than 10 min. under atmospheric pressure or in a vacuum.

As has been explained, the method for fabricating an LCD according to the present invention has the following advantages.

First, applying the liquid crystal on the first substrate and coating the seal on the second substrate shorten a fabrication time prior to bonding the two substrates together.

Second, applying the liquid crystal on the first substrate and coating the seal on the second substrate permits a balanced progression of the fabrication processes to the first and second substrates, thereby making efficient use of a production line.

Third, applying the liquid crystal on the first substrate and coating the seal and Ag dots on the second substrate minimizes contamination of the seal from particles because the substrate having the seal coated thereon may be cleaned just prior to bonding.

Fourth, positioning the substrate receiver under the substrate and evacuation of the vacuum bonding chamber permits the substrate affixed to the upper stage from falling down and breaking.

Fifth, sensing the time during which the two substrates come into contact and the varying the pressure in bonding the two substrates minimizes damage made by the liquid crystal to the orientation film.

Sixth, since the upper stage presses the substrate down by means of a plurality of shafts, each of which capable of applying pressure independently, uniform bonding of the seal can be achieved by independently applying a lower or higher pressures by predetermined shafts when the lower stage and the upper stage are not level or fail to bond to the seal uniformly.

Seventh, the two staged evacuation of the vacuum bonding chamber prevents deformation of the substrate and air flow in the chamber caused by a sudden vacuum.

Eighth, misalignment of the fixed substrates is minimized during progression to the next bonding processes or transfer of fixed substrates.

Ninth, simultaneous loading and unloading of glass substrates shortens fabrication times.

Tenth, inclusion of a liquid crystal spreading process shortens the LCD fabrication time.

FIGS. **160**A-**160**G schematically illustrate the steps of a method for fabricating an LCD in accordance with an embodiment of the present invention.

Referring to FIG. **160**A, liquid crystal **5107** may be applied to a first glass substrate **5151**, and seal **5170** may be coated on a second substrate **5152**. A plurality of corresponding areas designated for panels may be provided in first and second glass substrates **5151** and **5152**, and thin film transistor arrays may be formed on each of the panels within the first glass substrate **5151** while color filter arrays, black matrix layers, a color filter layers, common electrodes, etc., may be formed on each of the panels of the second glass substrate **5152**. Liquid crystal material **5107** may be applied onto the first glass substrate **5151** and a seal **5170** may be coated onto the second glass substrate **5152**. Alternatively, the seal **5170** may be coated on the first glass substrate **5151** and the liquid crystal material **5107** may be dropped on the second glass substrate **5152** or both the liquid crystal material **5152** and the seal **5170** may be dropped and coated on either of the two glass substrates. In any case, however, when placed into the vacuum bonding chamber to be bonded with another substrate, the glass substrate having the liquid crystal dropped thereon must be placed on a lower stage, as will be discussed in greater detail below.

With reference to FIG. **161**, the bonding process will be explained in more detail.

FIG. **161** illustrates a flow chart showing the steps of bonding of the present invention. Generally, the bonding process includes a step of loading the two substrates into a vacuum bonding chamber, bonding the two substrates, venting the vacuum bonding chamber to apply a pressure to the bonded substrates, and unloading the bonded substrates from the vacuum bonding chamber.

Before loading the first and second substrates **5151** and **5152** into the vacuum bonding chamber, a seal is formed on the second glass substrate **5152**. Subsequently, particles formed during various fabrication processes are removed from the second glass substrate in a USC (Ultra Sonic Cleaner). Since no liquid crystal applied onto the second glass substrate **5152**, coated by the seal, the second glass substrate **5152** can be cleaned.

Referring to FIG. **160**B, since both a part of the first glass substrate **5151** having the liquid crystal dropped thereon and a part of the second glass substrate **5152** having the seal **5170** coated thereon face upward, it is required that one of the two substrates is turned upside down, for bonding the two substrates **5151** and **5152**. However, the first glass substrate **5151** cannot be turned upside down, the second glass substrate **5152** having the seal coated thereon is turned upside down such that the part of the second glass substrate the seal **5170** coated thereon faces down (**5232**S).

The second glass substrate **5152** is turned upside down by loading the second substrate onto a table of a turner then pre-aligning and securing the second substrate. Next, the table is turned upside down, and the turned substrate is carried to the vacuum bonding chamber.

Referring generally to FIG. **160**C, in the loading step, the second glass substrate **5152** is held to an upper stage **5121** in the vacuum bonding chamber **5110**, wherein the seal **5170** faces down (**5233**S), and the first glass substrate **5151** is held to a lower stage **5122** in the vacuum bonding chamber **5110** (**5234**S), wherein the liquid crystal material **5107** faces up. The vacuum bonding chamber **5110** is hereby in a standby state.

More specifically, the second glass substrate **5152** with the seal **5170** facing down is held by a loader of a robot (not shown), and is brought into the vacuum bonding chamber **5110**. The upper stage **5121** in the vacuum bonding chamber **5110** is moved down to meet and hold the second glass substrate **5152**, and is then moved back up. The second glass substrate **5152** may be held to the upper stage **5121** with the use of a vacuum force or with an electrostatic force.

Then, the loader is moved out of the vacuum bonding chamber **5110** and places the first glass substrate **5151** over the lower stage **5122** in the vacuum bonding chamber **5110**.

Next, the second glass substrate **5152** is placed on a substrate receiver (not shown) by placing the substrate receiver under the second glass substrate **5152** and moving the upper stage down, or the substrate receiver up, or both, until the second glass substrate **5152** contacts the substrate receiver (**5235**S). After the second glass substrate **5152** and the substrate receiver are brought into contact the second glass substrate **5152** is held to the upper stage.

The substrate receiver contacts an under side of the second glass substrate **5152**, to prevent the second glass substrate held to the upper stage from becoming detached from the upper stage due to a reduction in a vacuum force present within the upper stage when a vacuum in the bonding chamber becomes higher than the vacuum force within the upper and lower stages.

Accordingly, the second glass substrate **5152**, held to the upper stage, may be placed on the substrate receiver before or during the creation of a vacuum in the vacuum bonding chamber. Alternatively, the upper stage holding the second glass substrate and the substrate receiver may be brought to within a predetermined distance of each other so that the second glass substrate **5152** may be safely placed on the substrate receiver from the upper stage when the chamber is evacuated. Moreover, means for securing the substrates may be provided additionally as air flow in the chamber, capable of shaking the substrates, may occur when evacuation of the vacuum bonding chamber is initiated.

The vacuum bonding chamber **5110** is evacuated (**5236**S). The vacuum within the vacuum bonding chamber **5110** may have a pressure in a range of about 1.0×10^{-3} Pa to about 1 Pa for IPS mode LCDs, and about 1.1×10^{-3} Pa to about 10^{2} Pa for TN mode LCDs.

Evacuation of the vacuum bonding chamber **5110** may be carried out in two stages. After the substrates are held to their respective stages, a chamber door is closed and the vacuum chamber is evacuated a first time. After positioning the substrate receiver under the upper stage and placing the substrate on the substrate receiver or after positioning the upper stage and the substrate receiver to within the predetermined distance when the upper stage biases the substrate, the vacuum bonding chamber is evacuated for a second time. The second evacuation is faster than the first evacuation. The vacuum force created by the first evacuation is not higher than the vacuum force within the upper stage.

The aforementioned two stage evacuation process may prevent deformation or shaking of the substrates in the vacuum bonding chamber that conventionally occurs when the vacuum bonding chamber is rapidly evacuated.

Alternatively, evacuation of the bonding chamber may be carried out in a single stage. Accordingly, after the substrates are held to their respective stages and the chamber door is closed, the evacuation may be started and the substrate receiver may be brought to the underside of the upper stage during the evacuation. The substrate receiver must be brought to the underside of the upper stage before the vacuum force within the vacuum bonding chamber becomes higher than the vacuum force within the upper stage.

Once the vacuum bonding chamber **5110** is evacuated to a preset vacuum, the upper and lower stages **5121** and **5122** bias and fix the first and second glass substrates **5151** and **5152** respectively using an ESC (Electro Static Charge) (**5237**S) and the substrate receiver is brought to its original position (**5238**S) out from under the upper plate.

Using ESC the first and second glass substrates may be held to their respective stages by applying negative/positive DC voltages to two or more plate electrodes (not shown) formed within the stages. When the negative/positive voltages are applied to the plate electrodes, a coulombic force is generated between a conductive layer (e.g., transparent electrodes, common electrodes, pixel electrodes, etc.) formed on the substrate and the stage. When conductive layer formed on the substrate faces the stage, about 0.1-1 KV is applied to the plate electrodes. When the substrate contains no conductive layer, about 3-4 KV is applied to the plate electrodes. An elastic sheet may be optionally be provided to the upper stage.

Referring to FIGS. **160**D and **160**E, after the two glass substrates **5151** and **5152** are aligned and held to their respective stages by ESC, the two stages are moved into proximity such that the two glass substrates may be bonded together (a first pressure application **5239**S). The first and second glass substrates **5151** and **5152** are pressed together by moving either the upper stage **5121** or the lower stage **5122** in a vertical direction, while varying speeds and pressures at different stage locations. Until the time the liquid crystal **5107** on the first glass substrate **5151** and the second glass substrate **5152** come into contact, or until the time the first glass substrate **5151** and the seal on the second glass substrate **5152** come into contact, the stages are moved at a fix speed or fixed pressure, and the pressure is boosted up step by step from the time of contact to a final pressure. That is, the time of contact may be sensed by a load cell fitted to a shaft of the movable stage. The two glass substrates **5151** and **5152** may, for example, be pressed at a pressure of 0.1 ton at the time of contact, a pressure of 0.3 ton at an intermediate time period, a pressure of 0.4 ton at a full contact stage, and a pressure of 0.5 ton at a final stage (see FIG. **160**E).

Though it is illustrated that the upper stage presses down onto the substrate by means of one shaft, a plurality of shafts may independently apply and control pressure using an individual load cell. If the lower stage and the upper stage are not leveled or fail to be pressed uniformly, predetermined shafts may be selectively pressed using lower or higher pressures to provide uniform bonding of the seal.

Referring to FIG. **160**F, after the two substrates have been bonded, the ESC is turned off and the upper stage **5121** is moved up to separate the upper stage **5121** from the bonded two glass substrates **5151** and **5152**.

Referring to FIG. **160**G, a gas, such as N^2, or clean dry air is subsequently introduced into the bonding chamber **5110**, to vent the vacuum bonding chamber (**5240**S). Venting the vacuum bonding chamber **5110** returns the pressure within the chamber from a vacuum state to an atmospheric state providing uniform pressure application to the bonded substrates.

Thus upon venting the vacuum chamber, a vacuum is created in the space between the first and the second glass substrates newly bonded by the seal **5170** and atmospheric pressure within the chamber provided after venting presses the space between the first and second glass substrates **5151** and **5152** in the vacuum state is pressed uniformly. Accordingly, an even gap is maintained. It should be noted, however, that the bonded substrates **5151** and **5152** are pressed not only by the ambient pressure of the venting gas within the chamber after venting is complete, but also by the venting gas as it is introduced during the venting process.

Uniform application of a pressure to every part of the substrate is required for formation of a seal having a fixed height between the two substrates and uniform distribution of the liquid crystal to thereby prevent breakage of the seal or imperfect filling of the liquid crystal. To ensure uniform pressure application to the substrate while the chamber is vented, the direction a gas is being vented may be monitored and controlled.

A plurality of gas injection tubes may be provided within top, bottom, and side portions of the chamber. The plurality of gas injection tubes within the top, bottom, and side portions of the chamber are capable of injecting gas into the chamber. In one aspect of the invention, the gas may be injected into the chamber from the top. Further, the venting direction of the gas may be determined based on the size of the substrate and the position of the stages within the chamber. In one aspect of the present invention, depending on the size of the substrates being bonded and the size of the chamber, the number of gas injection tubes within any portion of the chamber may be at least 2 (e.g., 8)

As mentioned above, the two substrates **5151** and **5152** are pressed, not only by the atmospheric pressure, but also by a pressure caused by injection of the venting gas. Though the pressure applied to the two substrates are atmospheric 10^5 Pa, a pressure ranging 0.4-3.0 Kg/cm2 is appropriate, and a pressure at 1.0 Kg/cm^2 is preferable.

Since a rapid venting of the chamber may cause shaking of the substrate, that causes misalignment of the bonded substrates, fastening means for preventing the substrates from shaking, may also be provided. Alternately, shaking may be prevented by venting the chamber in a series of progressive steps. Further, a slow valve may also be provided to slow venting of the gas into the chamber.

Venting of the chamber may be started and finished in a single venting step. Alternatively, venting of the chamber may be started slowly at a first rate, to prevent the substrate from shaking, and after a preset time is reached, the venting of the chamber may be carried out at a second rate, higher than the first rate, to quickly reach atmospheric pressure.

Because the bonded substrates on the stage may be shaken or misaligned while the chamber is venting, the amount of time required to inject the gas into the chamber may be monitored and controlled. For purposes of discussion, the venting time is initiated when the space between the two substrates exists in a vacuum, as alignment is complete, and the pressure within the chamber is progressed for the first time. A venting method will now be explained in greater detail.

Generally, in one aspect of the present invention, venting may be started at the same time the upper stage begins its ascent to its final raised position. Venting may be alternatively be started after the substrates have been bonded but prior to any movement of any of the stages. In another aspect of the present invention, the upper stage may be moved either before or after the venting of the chamber is finished.

In one aspect of the present invention, the chamber may be pressurized by a venting process. Accordingly venting of the chamber may be started after the upper stage is moved up to its final raised position. Alternatively, the upper stage may be raised to a predetermined distance to prevent any lifting of the substrates upon initiation of the venting. In another aspect of the present invention, the fabrication time for the LCD may be reduced by starting the venting process before the upper stage is moved up to its final raised position but after the upper stage begins its ascent.

In another aspect of the invention, the chamber may be pressurized by a venting process wherein gas (e.g., N_2, etc.) or clean dry air is also blown through vacuum channels formed in the upper stage. The additional gas or clean dry air may be blown because the upper stage may not be easily separated from the bonded substrates leading to the possibility that the substrates may be shaken and/or fall below the upper stage.

Accordingly, in the present aspect, the venting may be started, then gas or clean dry air may be blown through the upper stage, and then the upper stage may be raised to is final position. Alternately, after the venting begins the gas or the clean dry air may be blown simultaneously with the raising of the upper stage. Alternately still, the venting may begin simultaneously with the blowing of the gas or clean dry air through the upper stage, followed by the raising of the upper stage. In another alternative, the venting, blowing, and raising of the upper stage may occur simultaneously. The gas or clean dry air may alternately be blown through the upper stage, followed by the raising of the upper stage, and followed still by the venting of the chamber via the gas injection tubes. Lastly, the gas or clean dry air may alternately be blown through the upper stage, followed by the venting of the chamber, and then followed by the raising of the upper stage.

After venting is finished and the upper stage is completely raised, the bonded substrates are unloaded (**5241**S). That is, upon completion of the venting, the upper stage **5121** is moved up to its final raised position and the bonded first and second glass substrates **5151** and **5152** are unloaded using the loader. Alternatively, the bonded first and second glass substrates **5151** and **5152** may be held to the upper stage **5152** and moved up where the loader then unloads the first and second glass substrates **5151** and **5152** from the raised upper stage **5121**.

In order to shorten the fabrication time for the LCD, one of the first and second glass substrates to be bonded in a next bonding process may be loaded onto an empty stage while the fixed first and second glass substrates are unloaded. For example, after the second glass substrate **5152** to be bonded in a next bonding process is brought to the upper stage **5152** via the loader and held to the upper stage, the fixed first and second glass substrates on the lower stage **5122** may be unloaded. Alternatively, after the upper stage **5152** lifts the fixed first and second glass substrates **5151** and **5152**, the loader may load a first glass substrate **5151** to be bonded in a next bonding process onto the lower stage, and the fixed first and second glass substrates may be unloaded.

A liquid crystal spreading process may optionally be added before the process of unloading the bonded substrates where the liquid crystal between the fixed substrates may be spread, for example, toward the seal. Alternatively, a liquid crystal spreading process may be carried out to evenly spread the liquid toward the seal when the liquid crystal does not adequately spread after the unloading. The liquid crystal spreading process may be carried out for more than 10 min. under atmospheric pressure or in a vacuum.

As has been explained, the method for fabricating an LCD according to the present invention has the following advantages.

First, applying the liquid crystal on the first substrate and coating the seal on the second substrate shorten a fabrication time prior to bonding the two substrates together.

Second, applying the liquid crystal on the first substrate and coating the seal on the second substrate permits a balanced progression of the fabrication processes to the first and second substrates, thereby making efficient use of a production line.

Third, applying the liquid crystal on the first substrate and coating the seal and Ag dots on the second substrate minimizes contamination of the seal from particles because the substrate having the seal coated thereon may be cleaned just prior to bonding.

Fourth, positioning the substrate receiver under the substrate and evacuation of the vacuum bonding chamber permits the substrate affixed to the upper stage from falling down and breaking.

Fifth, sensing the time during which the two substrates come into contact and the varying the pressure in bonding the two substrates minimizes damage made by the liquid crystal to the orientation film.

Sixth, since the upper stage presses the substrate down by means of a plurality of shafts, each of which capable of applying pressure independently, uniform bonding of the seal can be achieved by independently applying a lower or higher pressures by predetermined shafts when the lower stage and the upper stage are not level or fail to bond to the seal uniformly.

Seventh, the two staged evacuation of the vacuum bonding chamber prevents deformation of the substrate and air flow in the chamber caused by a sudden vacuum.

Eighth, the application of pressure to the bonded substrates, bonded in a vacuum, by venting the bonding chamber to atmospheric pressure permits a uniform application of pressure to the bonded substrates.

Ninth, performing venting in two steps minimizes damage to the substrates.

Tenth, simultaneous loading and unloading of glass substrates shortens fabrication times.

Eleventh, inclusion of a liquid crystal spreading process shortens the LCD fabrication time.

Twelfth, the simultaneous venting and separation of the upper stage from the substrates reduces a venting time period.

FIGS. **162**A to **162**E are expanded perspective views illustrating a method for fabricating an LCD panel according to a first embodiment of the present invention. Although the drawings illustrate only four unit cells, the number of the unit cells may be varied depending upon the size of the substrate.

Referring to FIG. **162**A, a lower substrate **5351** and an upper substrate **5352** are prepared for the process. A plurality of gate lines and data lines (both not shown) are formed on the lower substrate **5351** to cross each other defining pixel regions, a thin film transistor having a gate electrode, a gate insulating film, a semiconductor layer, an ohmic contact layer, source/drain electrodes, and protection film, is formed at every crossing point of the gate lines and the data lines. A pixel electrode is further formed at each of the pixel regions connected to the thin film transistor.

An orientation film is formed on the pixel electrodes for an initial orientation of the liquid crystal. The orientation film may be formed of polyimide, polyamide group compound, polyvinylalcohol (PVA), polyamic acid by rubbing, or a photosensitive material, such as polyvinvylcinnamate (PVCN) and polysilioxanecinnamate (PSCN). Alternatively, cellulosecinnamate (CelCN) group compound may be selected by using photo-alignment method.

A light shielding film is formed on the upper substrate **5352** for shielding a light leakage from the gate lines, the data lines, and the thin film transistor regions. A color filter layer of red, green, and blue is formed thereon. A common electrode is formed thereon in this order. Additionally, an overcoat layer may be formed between the color filter layer and the common electrode. The orientation film is formed on the common electrode.

Silver (Ag) dots are formed at the outside of the lower substrate **5351**, for applying a voltage to the common electrode on the upper substrate **5352** after the lower and upper substrates **5351** and **5352** are bonded with each other. Alternatively, the silver dots may be formed on the upper substrate **5352**.

In an in plane switching (IPS) mode LCD, a lateral field is induced by the common electrode formed on the lower substrate the same as the pixel electrode. The silver dots are not formed on the substrates.

Referring to FIG. **162**B, a main UV sealant **5370** is coated on the upper substrate **5352** in a closed pattern, and a dummy UV sealant **5380** is formed at the outside of the main UV sealant **5370** in a closed pattern. The sealant may be coated by using a dispensing method or a screen printing method. However, the screen printing method may damage the orientation film formed on the substrate since the screen comes into contact with the substrate. Also, the screen printing method may not be economically feasible due to a large amount of the sealant loss in a large substrate.

Then, the liquid crystal droplets **5307** are placed onto the lower substrate **5321** to form a liquid crystal layer. The liquid crystal may be contaminated when the liquid crystal meets the main sealant **5370** before the main sealant **5370** is hardened. Therefore, the liquid crystal droplets may have to be dropped onto the central part of the lower substrate **5351**. The liquid crystal droplets **5307** dropped at the central part spread slowly even after the main sealant **5370** is hardened, so that it is distributed evenly throughout the entire substrate with the same concentration.

FIG. **162**B illustrates that both the liquid crystal droplets **5307** and the sealants **5370** and **5380** are coated on the lower substrate **5351**. However, as an alternative in practicing the present invention, the liquid crystal droplets **5307** may be formed on the upper substrate **5352**, while the UV sealants **5370** and **5380** may be coated on the lower substrate **5351**.

Moreover, the liquid crystal droplets **5307** and the UV sealants **5370** and **5380** may be formed on the same substrate. However, the liquid crystal and the sealant may have to be formed on different substrates in order to shorten the fabrication time period. When the liquid crystal droplets **5307** and the UV sealants **5370** and **5380** are formed on the same substrate, there occurs an unbalance in the fabricating process between the substrate with the liquid crystal and the sealant and the substrate without the liquid crystal. For example, the substrate may not be cleaned when the sealant is contaminated before the substrates are attached to each other since the liquid crystal and the sealant are formed on the same substrate.

Spacers may be formed on either of the two substrates **5351** or **5352** for maintaining a cell gap. The spacers may be sprayed at a high pressure onto the substrate from a spray nozzle mixed with ball spacers and a solution having an appropriate concentration. Alternatively, column spacers may be formed on portions of the substrate of the gate lines or data lines. The column spacers may be used for the large sized substrate since the ball spacers may cause an uneven cell gap for the large sized substrate. The column spacers may be formed of a photosensitive organic resin.

Referring to FIG. **162**C, the lower substrate **5351** and the upper substrate **5352** are attached to each other. The lower substrate **5351** and the upper substrate **5352** may be bonded by the following processes. First, one of the substrates having the liquid crystal dropped thereon is placed at the lower side. The other substrate is turned by 180 degrees so that the side of the substrate at the upper side having layers faces into the upper surface of the substrate at the lower side. Thereafter, the substrate at the upper side is pressed, or the space between the substrates is evacuated, and releasing the vacuum, thereby attaching the two substrates.

Then, referring to FIG. **162**D, a mask **5395** is placed between the attached substrates **5351** and **5352** and a UV irradiating device **5390** for masking the overlapping region between the dummy UV sealant **5380** and the scribing line. A UV ray is then irradiated thereon. Upon irradiating the UV ray, monomers or oligomers are polymerized and hardened, thereby bonding the lower substrate **5351** and the upper substrate **5352**.

The region masked by the mask **5395** is shaded from the UV ray, so that the dummy UV sealant at this region is not hardened. Thus, the dummy UV sealant remains an initial coating condition, i.e., fluidic condition, so that the cell cutting process after the bonding process becomes easy.

Monomers or oligomers each having one end coupled to the acrylic group and the other end coupled to the epoxy group mixed with an initiator are used as the UV sealants **5370** and **5380**. Since the epoxy group is not reactive with the UV irradiation, the sealant may have to be heated at about 120° C. for one hour after the UV irradiation for hardening the sealant. However, even if the dummy sealant is eventually hardened by the thermal process, the hardening ratio drops below 50%, such that the dummy sealant gives no influence to the cell cutting process.

FIG. **162**E illustrates that the bonded substrates are cut into the individual cells. In the cutting process, a cutting device of diamond such as a pen or a toothed wheel is used to cut the unit cells one by one along the scribe lines **5360** by the simultaneous scribing and breaking processes. The use of the cutting device that can carry out the simultaneous scribing and breaking processes may reduce both the space occupied by the device and the cutting time period.

A final inspection (not shown) is carried out after the cutting process. In the final inspection, presence of defects is determined before the substrates cut into the unit cells are assembled, by examining an operation condition of the pixels when a voltage applied thereto is turned on/off.

FIGS. **163**A to **163**C illustrate expanded perspective views each showing the UV irradiation process in the fabricating method of an LCD in accordance with a second embodiment of the present invention. All the fabricating process is similar to the first embodiment except for the UV irradiation process.

In the simultaneous scribing and breaking processes, when the substrates are cut in up and down directions starting from the scribe line at the end of the right or left side, the dummy UV sealant on the right or left side may be removed. Therefore, the removed dummy UV sealant gives no influence to the following cell cutting process.

Accordingly, the same result may be obtained in with masking the cell cutting process even if the UV ray is irradiated after upper and lower side regions of the dummy UV sealant overlapped the cell cutting lines, or only left and right side regions of the dummy UV sealant overlapped the scribing lines.

FIG. **163**A illustrates the UV irradiation process, with masking only upper and lower side regions of the dummy UV sealant overlapping the cell cutting lines by using a mask **5395***a*. FIG. **163**B illustrates the UV irradiation process, with masking only left and right side regions of the dummy UV sealant overlapping the cell cutting lines by using the mask **5395***a*. FIG. **163**A is applicable to an embodiment where upper and lower end portions are cut first, while FIG. **163**B is applicable to an embodiment where left and right end portions are cut first.

FIG. **163**C illustrates a perspective view showing the UV irradiation process in the method for fabricating an LCD in accordance with a second embodiment of the present invention.

In the UV irradiation, if UV is irradiated to the entire surface of the attached substrates, the UV ray may deteriorate device characteristics of the thin film transistors on the substrates, and change a pre-tilt angle of the orientation film formed for the initial orientation of the liquid crystal.

Therefore, in FIG. **163**C, the second embodiment of the present invention suggests irradiating the UV after a mask **5395***c* is placed between the attached substrates **5351** and **5352** and the UV irradiating device **5390**, for masking the regions where the dummy UV sealant **5380** and the scribing lines are crossed, and the active regions inside the main UV sealant **5370**.

As has been explained, the method for fabricating a liquid crystal display panel of the present invention has the following advantages.

The UV irradiation with masking the crossed regions of the dummy UV sealant and the scribing lines makes cell cutting by the simultaneous scribing and breaking processes easier since the dummy UV sealant on the scribing lines is not hardened.

The UV irradiation with masking the active regions in the main UV sealant prevents the UV irradiation from deteriorating characteristics of the thin film transistors, orientation films, and the like, formed on the substrates.

FIG. **164** is a schematic view of a UV irradiating device according to the first embodiment of the present invention.

As shown in FIG. **164**, the UV irradiating device according to the first embodiment of the present invention includes a UV light source **5410**, a support **5420**, and a substrate stage **5430** on which a substrate to be irradiated with a UV light will be placed. The UV light source **5410** includes a UV lamp **5412** and a reflecting plate **5414** on which the UV lamp **5412** is disposed. The support **5420** supports the UV light source **5410** and is moveable to tilt with respect to a horizontal plane.

At this time, a high pressure mercury UV lamp, metal halide UV lamp, or metal UV lamp may be used as the UV lamp **5412**.

The reflecting plate **5414** shields the UV lamp **5412**, and an inner reflecting surface on which the UV lamp **5412** is placed such that the irradiated UV is reflected in a constant straight line as shown. Therefore, an irradiating angle of the UV light source depends on the tilt angle of the UV light source **5410**.

The support **5420** is driven to tilt with respect to a horizontal plane around a driving axis. The tilt angle θ_1 of the support **5420** is within the range of 0° to 90°.

Therefore, if the tilt angle θ_1 of the support **5420** is changed, the UV light source from the UV light source **5410** is irradiated at an angle of θ_2 with respect to a vertical plane where $\theta_1=\theta_2$ according to geometric principles.

Although the support **5420** is shown at an angle of θ_1 with respect to the horizontal plane, the support **5420** may be driven upwardly at an angle of $-\theta_1$. Alternatively, the driving axis of the support **5420** may be changed from right of the support **5420** to left of the support **5420** or may be formed at the center of the support **5420**, or at any other location along the support **5420**.

The substrate stage **5430** is horizontal to receive an attached substrate to which a sealant has been applied. Also, for mass production, the substrate stage **5430** may be formed to move by means of a conveyer belt.

Meanwhile, if the substrate is large, it may be difficult for one UV light source **5410** to uniformly irradiate UV the whole substrate. Accordingly, a UV irradiating device provided with a plurality of UV light sources may be required.

FIGS. **165**A and **165**B are schematic views of a UV irradiating device provided with a plurality of UV light sources. As shown in FIG. **165**A, a plurality of UV light sources **5410***b*, and **5410***c* may be supported by one support **5420**. As shown in FIG. **165**B, the UV light sources **5410***a*, **5410***b*, and **5410***c* may respectively be supported by respective supports **5420***a*, **5420***b*, and **5420***c*.

In case of FIG. **165**A, the distance between each respective light source **5410***a*, **5410***b*, and **5410***c* of the UV irradiating device and the substrate may differ. Thus, the intensity of irradiation from the respective UV light sources onto the substrate surface, and thus onto the sealant to be cured, may differ. In case of FIG. **165**B, the distance between each respective UV light source **5410***a*, **5410***b*, and **5410***c* and the substrate will be substantially the same, and, thus, the irradiating characteristics of the UV light from the respective UV light sources **5410***a*, **5410***b*, and **5410***c* will be substantially the same.

FIG. **166** is a schematic view of a UV irradiating device according to the second embodiment of the present invention.

As shown in FIG. **166**, the UV irradiating device according to the second embodiment of the present invention includes a UV light source **5410**, a support **5420**, and a substrate stage **5430**. The UV light source **5410** includes a UV lamp **5412** and a reflecting plate **5414** on which the UV lamp **5412** is disposed. The support **5420** supports the UV light source **5410** and is horizontal in a fixed state. A substrate to be irradiated with UV light will be placed on the substrate stage **5430**. The substrate stage **5430** is moveable to tilt with respect to a horizontal plane.

In other words, in the UV irradiating device according to the second embodiment of the present invention, the substrate stage **5430** is moveable at a tilt angle instead of the support **5420** so that a UV light is irradiated upon the substrate stage **5430** at a tilt angle.

A high pressure mercury UV lamp, metal halide UV lamp, or metal UV lamp may be used as the UV lamp **5412**. The reflecting plate **5414** shields the UV lamp **5412**, and an inner reflecting surface on which the UV lamp **5412** is placed is formed such that the irradiated UV is reflected in a constant straight line or collimated.

The support **5420** is horizontally placed in a fixed state. Accordingly, the UV light source is vertically irradiated from the UV light source part **5410**.

The substrate stage **5430** is driven to tilt with respect to a horizontal plane around a driving axis. The tilt angle θ of the substrate stage **5430** is within the range of 0° to 90°.

Therefore, if the tilt angle θ of the substrate stage **5430** is changed, the UV light source from the UV light source part **5410** is irradiated at a tilt angle of θ with respect to a vertical plane of the substrate stage **5430**.

Although the substrate stage **5430** is shown at an angle of θ with respect to the horizontal plane, the substrate stage **5430** may be driven downwardly at an angle of −θ. Alternatively, the driving axis of the substrate stage **5430** may be changed from right of the substrate stage **5430** to left of the substrate stage **5430** or may be formed at the center of the substrate stage **5430** or at any other location along the substrate stage **5430**.

A plurality of UV light sources can be used for a large substrate so that a large area of the substrate may be irradiated simultaneously.

FIG. **167** is a schematic view of a UV irradiating device according to an embodiment of the present invention.

As shown in FIG. **167**, the UV irradiating device according to the third embodiment of the present invention includes a UV light source **5410**, a support **5420**, and a substrate stage **5430**. The UV light source **5410** includes a UV lamp **5412** and a reflecting plate **5414** on which the UV lamp **5412** is disposed. Also, the reflecting plate **5414** is formed such that a UV light source is irradiated at a tilt angle θ with respect to a vertical plane. The support **5420** supports the UV light source **5410**. A substrate to be irradiated with a UV light source will be placed on the substrate stage **5430**.

In other words, in the UV irradiating device according to the third embodiment of the present invention, the support **5420** and the substrate stage **5430** are fixed in horizontal plane (or two parallel planes), and an inner reflecting surface of the reflecting plate **5414** is formed so that UV reflected on the reflecting plate **5414** is irradiated onto the substrate at a tilt angle.

A high pressure mercury UV lamp, metal halide UV lamp, or metal UV lamp may be used as the UV lamp **5412**. The substrate stage **5430** may be moveable in the horizontal plane or moveable to be tilted with respect to the horizontal plane.

Since the inner reflecting surface of the reflecting plate **5414** is formed such that the irradiated UV is reflected at a tilt angle, the UV light from the UV light source **5410** is irradiated at a tilt angle of θ against a vertical plane of the substrate stage **5430** (e.g., at an angle of 90°-θ with respect to a horizontal plane if the substrate stage **5430** is in the horizontal plane). At this time, the tilt angle of θ can be adjusted by varying a shape of the inner reflecting surface of the reflecting plate **5414**.

FIGS. **168**A to **168**D are perspective views illustrating an embodiment of a method of manufacturing an LCD device in accordance with the principles of the present invention.

Although the drawings illustrate only one unit cell, a plurality of unit cells may be formed depending upon the size of the substrate.

Referring to FIG. **168**B, a lower substrate **5451** and an upper substrate **5452** are prepared. A plurality of gate and data lines (not shown) are formed on the lower substrate **5451**. The gate lines cross the data lines to define a pixel region. A thin film transistor (not shown) having a gate electrode, a gate insulating layer, a semiconductor layer, an ohmic contact layer, source/drain electrodes, and a protection layer is formed at a crossing point of the gate lines and the data lines. A pixel electrode (not shown) connected with the thin film transistor is formed in the pixel region.

An alignment film (not shown) is formed on the pixel electrode for initial alignment of the liquid crystal. The alignment film may be formed of polyamide or polyimide based compound, polyvinylalcohol (PVA), and polyamic acid by rubbing. Alternatively, the alignment film may be formed of a photosensitive material, such as polyvinvylcinnamate (PVCN), polysilioxanecinnamate (PSCN) or cellulosecinnamate (CelCN) based compound, by using photo-alignment method.

A light-shielding layer (not shown) is formed on the upper substrate **5452** to shield light leakage from the gate lines, the data lines, and the thin film transistor regions. A color filter layer (not shown) of R, G, and B is formed on the light-shielding layer. A common electrode (not shown) is formed on the color filter layer. Additionally, an overcoat layer (not shown) may be formed between the color filter layer and the common electrode. The alignment film is formed on the common electrode.

Silver (Ag) dots (not shown) are formed outside the lower substrate **5451** to apply a voltage to the common electrode on the upper substrate **5452** after the lower and upper substrates **5451** and **5452** are bonded to each other. Alternatively, the silver dots may be formed on the upper substrate **5452**.

In an in plane switching (IPS) mode LCD, the common electrode is formed on the lower substrate like the pixel electrode so that an electric field can be horizontally induced between the common electrode and the pixel electrode. In such case, the silver dots are not formed on the substrates.

Referring to FIG. **168**B, a UV sealant **5470** is formed on one of the lower and upper substrates **5451** and **5452**, and a liquid crystal **5407** is applied on one of the lower and upper substrates **5451** and **5452**. In more detail, the liquid crystal **5407** is applied on the lower substrate **5451** to form a liquid crystal layer, and the UV sealant **5470** is formed on the upper substrate **5452**. However, the liquid crystal **5407** may be formed on the upper substrate **5452**, or the UV sealant **5470** may be formed on the lower substrate **5451**.

Alternatively, both the liquid crystal **5407** and the UV sealant **5470** may be formed on one substrate. However, in this case, there is an imbalance between the processing times of the substrate with the liquid crystal and the sealant and the substrate without the liquid crystal and the sealant. For this reason, the manufacturing process time increases. Also, in the case that the liquid crystal and the sealant are formed on one substrate, the substrate may not be cleaned even if the sealant is contaminated before the substrates are bonded to each other.

Accordingly, a cleaning process for cleaning the upper substrate **5452** may additionally be provided before the bonding process after the UV sealant **5470** is formed on the upper substrate **5452**.

At this time, monomers or oligomers each having both ends coupled to the acrylic group, mixed with an initiator are used as the UV sealant **5470**. Alternatively, monomers or oligomers each having one end coupled to the acrylic group and the other end coupled to the epoxy group, mixed with an initiator are used as the UV sealant **5470**. Such a UV sealant **5470** is formed in a closed pattern by using a dispensing method or a screen printing method.

The liquid crystal **5407** may be contaminated if it comes into contact with the sealant **5470** before the sealant **5470** is hardened. Accordingly, the liquid crystal **5407** may preferably be applied on the central part of the lower substrate **5451**. In this case, the liquid crystal **5407** is gradually spread even after the sealant **5470** is hardened. Thus, the liquid crystal **5407** is uniformly distributed on the surface of the substrate.

Meanwhile, spacers may be formed on either of the two substrates **5451** and **5452** to maintain a cell gap. Preferably, the spacers may be formed on the upper substrate **5452**.

Ball spacers or column spacers may be used as the spacers. The ball spacers may be formed in such a manner that they are mixed with a solution having an appropriate concentration and then spread at a high pressure onto the substrate from a spray nozzle. The column spacers may be formed on portions of the substrate corresponding to the gate lines or data lines. Preferably, the column spacers may be used for the large sized substrate since the ball spacers may cause an uneven cell gap for the large sized substrate. The column spacers may be formed of a photosensitive organic resin.

Referring to FIG. **168**C, the lower substrate **5451** and the upper substrate **5452** are attached to each other by the following processes. First, one of the substrates having the liquid crystal applied thereon is placed at the lower side. The other substrate is turned by 180 degrees, e.g. flipped so that layers on the upper substrate face the substrate layers on the lower side, and so that the upper substrate is above the lower substrate. Thereafter, the substrate at the upper side is pressed, so that both substrates are attached to each other. Alternatively, the space between the substrates may be maintained under the vacuum state so that both substrates are attached to each other by releasing the vacuum state.

Then, referring to FIG. **168**D, the attached substrate is horizontally arranged and a UV light source **5490** is irradiated at a tilt angle of θ with respect to a plane vertical to the substrate. Various light irradiating devices as described in the first and third embodiments may be used to irradiate the UV light source **5490** at a tilt angle.

Although the UV light source **5490** has been formed above the attached substrate in the drawing, it may be formed below the attached substrate. The upper substrate surface or the lower substrate surface of the attached substrate may be used as a UV irradiating surface of the UV light source.

Upon irradiating the UV, monomers or oligomers activated by an initiator constituting the UV sealant are polymerized and hardened, thereby bonding the lower substrate **5451** to the upper substrate **5452**. If the UV is irradiated at a tilt angle with respect to the substrate, the sealant is hardened even if a light-shielding layer or a metal line layer overlaps the UV sealant. Thus, adherence between the substrates is not comprised.

If monomers or oligomers each having one end coupled to the acrylic group and the other end coupled to the epoxy group, mixed with an initiator are used as the UV sealant **5470**, the epoxy group is not completely polymerized. Therefore, the sealant may have to be additionally heated at about 120° C. for one hour after the UV irradiation, thereby hardening the sealant completely.

Meanwhile, FIG. **169**A is a sectional view illustrating a process of irradiating UV upon an attached substrate having a light-shielding layer **5480** overlapping a sealant **5470** at a tilt angle of θ with respect to a plane vertical to the substrate, and FIG. **169**B is a table illustrating a hardening rate of the sealant **5470** according to a change of a tilt angle of θ.

As will be aware of it from FIG. **169**B, when the tilt angle of θ is within the range of 30° to 60°, the hardening rate of the sealant **5470** is 80% or greater. To compensate for angular shadows that may prevent some sections of the sealant **5470** from hardening completely or to a maximum possible extend, the UV light may be applied over a range of angles from 0°-90° or 0-180° or any suitable range, either discretely or continuously.

Although not shown, the process of cutting a substrate into a unit cell after the UV irradiation and the final test process are performed.

In the cutting process, a cutting line is formed on a surface of the substrates with a pen or wheel of a material having hardness higher than that of glass, e.g., diamond (scribing process), and then the substrate is cut along the cutting line by mechanical impact (breaking process). Alternatively, the scribing process and the breaking process may simultaneously be performed using a pen or wheel of a the high hardness material having a toothed shape.

The final test process is to check whether there are any defects before a unit cell is assembled into a liquid crystal module. In the final test process, the liquid crystal module is tested to determine whether each pixel is driven properly when a voltage is applied or no voltage is applied.

FIGS. **170**A to **170**D are perspective views illustrating a method of manufacturing an LCD device according to principles of the present invention.

As shown in FIG. **170**A, a lower substrate **5451** and an upper substrate **5452** are prepared. As shown in FIG. **170**B, a UV sealant **5470** is formed on the upper substrate **5452**, and a liquid crystal is applied on the lower substrate **5451**. As shown in FIG. **170**C, the lower substrate **5451** and the upper substrate **5452** are attached to each other. As shown in FIG. **160**D, the attached substrates are located tilt and a UV light source **5490** is vertically irradiated upon the attached substrates.

The present embodiment is similar to the previous embodiment of the method except for the UV irradiation process. That is, according to the present embodiment unlike the previous embodiment, the attached substrates are placed at a tilt angle and the UV is vertically irradiated.

To tilt the attached substrate, a light irradiating device according to the second embodiment can be used.

Since the other elements of the present embodiment are identical to those of the previous embodiment, the same reference numerals will be given to the same elements and their detailed description will be omitted.

FIGS. **171**A to **171**D are perspective views illustrating another embodiment of the method of irradiating UV in manufacturing an LCD device according to the present invention.

In the UV irradiation, if UV is irradiated upon the entire surface of the attached substrate, the UV may deteriorate characteristics of devices such as a thin film transistor on the substrate or may change a pre-tilt angle of an alignment film formed for the initial alignment of the liquid crystal.

Therefore, in the present embodiment of the present invention shown in FIGS. **161**A to **161**D, UV light is irradiated at a tilt angle and areas where the sealant is not formed are covered with a mask.

Referring to FIG. **171**A, the attached substrates are placed in a horizontal direction, and a mask **5480** that covers the area where the sealant **5470** is not formed is placed in parallel with the attached substrates. The UV light source **5490** is then irradiated at a tilt angle.

At this time, it is preferable that the distance between the surface of the attached substrates and the mask **5480** is within the range of 1 mm to 5 mm.

Referring to FIG. **171**B, the attached substrates are tilted, and the mask **5480** that covers the area where the sealant **5470** is not formed is placed in parallel with the attached substrates. The UV light source **5490** is vertically irradiated.

Referring to FIG. **171**C, masks **5480** and **5482** that cover the area that lacks the sealant **5470** are formed at upper and lower sides of the attached substrates. In FIG. **171**C, the attached substrates and the masks **5480** and **5482** are placed in a horizontal direction while the UV light source **5490** is irradiated at a tilt angle. The attached substrates and the masks **5480** and **5482** may be tilted while the UV light source **5490** may vertically be irradiated.

Once the masks **5480** and **5482** are formed at upper and lower sides of the attached substrates, the irradiated UV light is reflected so that the UV light is prevented from being irradiated upon the area lacking the sealant.

Referring to FIG. **171**D, alignment marks **5420** and **5485** are formed in the attached substrates and the mask **5480** to accurately cover the area lacking the sealant **5470**. The position of the attached substrates and the mask **5480** is adjusted by a camera **5495** checking the alignment marks **5420** and **5485**.

The alignment mark **5420** of the attached substrates may be formed on either the upper substrate **5452** or the lower substrate **5451** of the attached substrates.

Referring to FIG. **171**D, although the attached substrates and the mask **5480** are placed horizontally while the UV light source **5490** is irradiated at a tilt angle, the attached substrates and the mask **5480** may be tilted while the UV light source **5490** may vertically be irradiated. The masks with alignment marks may respectively be formed at upper and lower sides of the attached substrates.

FIG. **172** is a flowchart illustrating a method of manufacturing an LCD according to the present invention.

As shown in FIG. **172**, an upper substrate is prepared and an alignment film is formed thereon. A sealant is then formed on the alignment film, thereby completing the upper substrate. Also, a lower substrate is prepared and an alignment film is formed thereon. A liquid crystal is then applied on the alignment film, thereby completing the lower substrate. At this time, the process of manufacturing the upper substrate and the process of manufacturing the lower substrate are simultaneously performed. The liquid crystal and the sealant may selectively be formed on the substrate.

Afterwards, the completed upper and lower substrates are attached to each other. The UV light is then irradiated to harden the sealant, thereby bonding the substrates. The substrates are cut into unit cells, and the final test process is performed, thereby completing one liquid crystal cell.

As aforementioned, the method of manufacturing an LCD according to the present invention has the following advantages.

The UV light is irradiated at a tilt angle upon the substrates where the UV sealant is formed. The sealant can thus be hardened even if the light shielding layer or the metal line layer is formed between the UV-irradiating surface and the sealant.

In addition, since the UV light is irradiated upon the substrate at a tilt angle in a state that the region where the sealant is not formed is covered with the mask, it is possible to prevent the thin film transistor or the alignment film formed on the substrate from being damaged.

Furthermore, since the substrate stage on which the attached substrates are placed is movably formed, yield is improved.

FIG. **173** is a flow chart showing an alignment process according to the present invention, FIG. **174** is a flow chart of a gap process according to the present invention, FIG. **173** shows an exemplary diagram of substrates having good and no-good (NG) substrate panel areas according to the present invention, and FIG. **176** shows a process layout of a process line according to the present invention. An array process and a color filter process (not shown) are performed to provide a first substrate and a second substrate, each having a plurality of substrate panel areas. Some of the substrate panel areas are good; some are no-good (NG). The good and NG substrate panel areas can be identified by electrical testing and visual testing. The first substrate and the second substrate include a TFT unit substrate and a CF unit substrate. After the array process and the color filter process are finished, the first substrate and the second substrate are loaded in first and second cassettes and transported to another production line that assembles the first and second substrates together.

A process for fabricating unit liquid crystal areas is described as follows. The overall process involves three separate production lines, each having loaders and un-loaders. Those productions lines include an alignment process line, a gap process line, and a test process line.

The alignment process line carries out a cleaning process, an alignment layer printing process, an alignment layer curing process, a rubbing process, and a testing process. The gap process line carries out a cleaning process, a liquid crystal dropping process, a sealing material dropping process, a vacuum assembling process, and a sealing material curing process. The test process line carries out a scribe/break process, a grinding process, and a liquid crystal panel testing process.

FIG. **173** shows the operation of the alignment process line. A cleaning process **5520S** is performed to remove particles. Then, an alignment layer forming process **5521** prints an alignment layer. In the alignment layer forming process **5521S** a solution of an alignment material is dropped between a Doctor roll and an Anilox roll that rotates in a dispenser. This alignment material is maintained as a liquid film on the face of the Anilox roll. Alignment material is removed from the Anilox roll to a print roll having a print rubber plate. With the substrate fixed on a coating machine stage, the alignment material on the printing roll is printed onto the substrate.

Still referring to FIG. **173**, the plasticizing process **5522S** cures the alignment layer. In a process **5522S**, a solvent in the alignment material printed on the substrate is driven off, and/or the alignment material is polymerized.

Still referring to FIG. **173**, the inspection process **5523S** inspects the alignment layer, and a rubbing process **5524S** rubs the alignment layer to produce an alignment surface. Then, the rubbing process **5523S** is carried. Finally, the test process **5524S** tests the alignment layer to locate NG unit substrate areas based on defective alignment layers. For example, NG unit substrate areas can be found from a visual inspection. That information is stored in a computer or other type of processing unit. It should be noted that the alignment process is performed on both the first and second substrates.

After completion of the alignment process, the first substrate and second substrate are un-loader onto third and fourth cassette. Then, the third cassette and the fourth cassette are loaded by a loader of the second processing line that produces gap. The second line is divided into a first gap process line for processing the first substrate, a second gap process line for processing the second substrate, and an assembling line for assembling the first substrate and second substrate. That is, the two separate lines are used for processing the first substrate (say having TFT unit substrate areas) and the second substrate (say with CF unit substrate areas). The assembling line is a continuous line.

A gap process is carried out as follows.

As shown in FIG. **174**, the selected substrates are cleaned (**5525S**). The first substrate is passed by a liquid crystal dispensing apparatus, and the second substrate is passed by an Ag dispensing apparatus and a seal dispensing apparatus.

Ag dots are formed, step **5526S**, on the second substrate for enabling electrical connection between the common electrode of a plurality of the unit CF substrate areas and the pixel electrodes on a plurality of the unit TFT substrate areas. A sealing material is coated, in step **5527S**, on peripheral portions of each unit CF substrate areas. As a sealing material, a photosensitive resin or a thermally curable resin may be used. After the first substrate and the second substrate are assembled, the sealing material is cured by photo or thermal treatment.

Meanwhile, in the liquid crystal dispensing process, liquid crystal is dropped, step **5528S**, onto each substrate panel area of the TFT substrate. Those substrate panel areas correspond to substrate panel areas on the CF substrate.

The liquid crystal dropping process **5528**S is carried out as follows. First, dissolved air in a liquid crystal contained in a liquid crystal container is removed by a vacuum. The liquid crystal container is assembled into a liquid crystal syringe on a head of a liquid crystal dispensing apparatus. Liquid crystal is then dropped to form liquid crystal dots having a uniform pitch on each unit TFT substrate areas.

Referring to step **5530**S, the first substrate and the second substrate processed by the above processes are loaded into a vacuum chamber and assembled into a composite liquid crystal panel. Here, the liquid crystal is uniformly spread out over the substrate panel areas to form unit liquid crystal panel areas. Thereafter, the seal material is cured to form a composite liquid crystal panel having a plurality of unit liquid crystal panel areas formed from two substrate panel areas.

The assembling process **5530**S is performed as follows.

First, the first substrate is mounted on a table in a vacuum vessel that enables movement in a horizontal direction, beneficially using a first suction device. Then, the second substrate is affixed by vacuum suction to second suction devices such that the second substrate is over the first substrate. The vacuum chamber is then closed and a vacuum is formed. The second suction device then descends so as to leave a predetermined interval between the first and second substrates. The first substrate is then moved horizontally so as to align with the second substrate.

Subsequently, the second suction device descends such that the second substrate is mated to the first substrate via the sealant. The first and second substrates are then pressurized together such that the unit liquid crystal panel areas are filled with the liquid crystals (which spread across the unit liquid crystal panel areas). Thus, a composite liquid crystal panel having a plurality of unit liquid crystal panel areas is fabricated. Thereafter, the composite liquid crystal panel is removed from the vacuum chamber and irradiated by UV light to cure the sealing material. Testing of the composite liquid crystal panel is then beneficially performed. Information regarding NG unit substrate areas is gathered and stored for subsequent use.

The composite liquid crystal panel has a plurality of unit liquid crystal panel areas the corresponding to the TFT and CF substrate panel areas FIG. **175** shows nine TFT substrate panel areas **5630** and nine CF substrate panel areas **5640** that are formed on first and second substrates **5651** and **5652**, respectively. The first and second substrates **5651** and **5652** may include NG (no good) TFT or CF substrate panel areas produced by the array and color filter forming processes.

Information about the NG substrate panel areas is stored in a central processing unit that handles all information regarding the process lines. Such information is transmitted to a local processing unit of a test process line that will be subsequently later.

Meanwhile, after completing the gap process the composite liquid crystal panel is loaded into the third line. The third line is a continuous production line that cuts the liquid crystal panel into a plurality of individual liquid crystal panels, a grinding process for grinding the cutting faces of the individual liquid crystal panels, and a test process for checking the appearance of the individual liquid crystal panels and for identifying electric failures.

FIG. **176** illustrates the processing layout of a test line **5680** according to the present invention. As shown, a cassette (not shown) holding a plurality of composite liquid crystal panels is arranged on a loader **5681**. The composite liquid crystal panels are then cut into individual liquid crystal panels.

The cutting process **5630**S produces a plurality of individual liquid crystal panels by forming grooves having a predetermined depth in the composite liquid crystal panels using a cutting wheel that is pressed at a predetermined pressure into the composite liquid crystal panel. That panel is then cut by propagating a crack downward using an external impact.

Subsequently, an inspection step **5631**S is performed. That step checks the state of cut portions of the individual liquid crystal panels to determine whether a burr remains along the cut line of the individual liquid crystal panels.

The cut individual liquid crystal panels then pass by a buffer station **5600** on their way to a grinding process, reference step **5632**S, that grinds the cut faces of the unit liquid crystal panels (**5632**S). However, before the grinding process **5632**S, according to the embodiment of the present invention, a local processing unit **5690** receives information regarding NG unit substrate areas. That information, which is beneficially received from a central processing unit, enables the buffer station **5600** to determine whether a particular individual liquid crystal panel that passes the buffer station **5600** is known to be defective (NG) because it was made from at least one NG substrate panel area.

The unit liquid crystal panels that are not known to be defective (because they were made from good substrate panel areas) pass to the grinding process. However, NG individual liquid crystal panels are removed and stored in a buffer cassette. Units in the buffer cassette are subsequently discarded.

Therefore, the present invention enables a reduction of grinding and subsequent testing by removing known NG individual liquid crystal panel. This enables a reduction in worker fatigue and wasted time in processing defective units.

After grinding, a final checking step **5633**S checks the appearance and electrical integrity of the individual liquid crystal panels is performed. The individual liquid crystal panels are then unloaded onto cassettes provided in an unloader **5691**. This completes the fabrication process.

The checking step beneficially includes checking the appearance and A/P (Auto/Probe) testing to determine problems, such as cross-striped stains, black stains, color filter protrusions, oblique stains, rubbing stripes, pin holes, disconnection or electric shorts of gate and data lines. The stained-failure can be checked automatically by a human observer eyes or by using CCD (charge coupled device).

Thereafter, a module process (not shown) attaches a driver IC, a backlight, and the like is carried out. Accordingly, the process line in a liquid crystal display and fabrication method thereof has the following advantages or effects. The buffer cassette enables storing and handle of NG individual liquid crystal panels based on information regarding NG substrate panel areas, thereby reduce abrasion and testing steps on known defective units, which enables a reduction in worker fatigue and wasted time.

FIG. **177** schematically illustrates a first substrate of an LC panel according to an embodiment of the present invention, FIG. **178** schematically illustrates an unit LC panel area according to an embodiment of the present invention, FIG. **179** illustrates a magnified cross-sectional view of portion 'A' of FIG. **178**, FIG. **180** illustrates a flowchart of an LCD fabrication method according to an embodiment of the present invention, FIG. **181** illustrates an inspection apparatus according to an embodiment of the present invention, and FIG. **182** schematically illustrates a structural layout of a composite LC panel according to an embodiment of the present invention.

Refer to FIG. **177** and FIG. **178** for illustrations of first and second substrates **5751** and **5752**, respectively a TFT array substrate and a color filter array substrate. The first substrate **5751** includes a plurality of first substrate panel areas **5751***a*, while the second substrate **5752** includes a matching set of second substrate panel areas. Completed first and second substrates **5751** and **5752** are loaded on cassettes that enter an LC (liquid crystal) fabrication line.

The first substrate panel areas **5751***a* each include a plurality of gate lines **5750** that are arranged in one direction with a predetermined interval, and a plurality of data lines **5760** are arranged in a perpendicular direction and with a predetermined interval. Matrix type pixel areas **5770** are defined by the gate and data lines **5750** and **5760**. A plurality of thin film transistors TFT and pixel electrodes are formed in the pixel areas **5770**. An image display area **5780** is constructed from a plurality of the pixel areas **5770**. Moreover, while not shown in the drawings, a gate electrode of each of the thin film transistors TFT is connected to a corresponding gate line **5750**, while a source electrode is connected to a corresponding data line **5760**. A drain electrode of each of the thin film transistors is connected to the pixel electrode in the pixel area **5770**. Moreover, a plurality of the gate and data lines **5750** and **5760** are connected to gate and data pads **5790** and **5710** that are disposed along the circumference of the TFT unit substrate area **5751***a*.

Additionally, first and second metal lines **5721** and **5723** are formed in the column and row directions near edges of the first substrate **5751**. External terminals **5721***a* and **5723***a* are formed at ends of the first and second metal lines **5721** and **5723**. The first and second metal lines **5721** and **5723** are conductive lines that will be used for testing the composite liquid crystal panel during A/P testing. The first and second metal lines **5721** and **5723** are eventually discarded.

A column shorting bar **5720** and a row shorting bar **5722** for each substrate panel area electrically shorts the ends of the gate and data lines **5750** and **5760** by connecting to the pads **5790** and **5710**, respectively. The row shorting bars **5722** are electrically connected to the first metal line **5721**, while the column shorting bars **5720** are electrically connected to the second metal line **5723**. As a result, all of the gate lines **5750** of all of the first substrate panel areas **5751***a* are tied together, and all of the data lines **5760** of all of the first substrate panel areas **5751***a* are tied together. It should be noted that static electricity produced at any gate or data pad **5790** and **5710** is discharged into all of the first substrate panel areas **5751***a* by the shorting bars.

Referring specifically to FIG. **178**, a plurality of second substrate areas **5752***a* are formed on the second substrate **5752**. The second substrate areas **5752***a* each include a black matrix layer **5810** that prevents light from passing through the second substrate area **5752***a*, except in the pixel areas **5770**. They also include a color filter layer for three primary colors, a common electrode along an entire face of the second substrate, and a column type spacer (advantageous for a large LCD). The column type spacer is formed to correspond to the gate and data lines on the first substrate **5751**.

A black circumference part **5820** is installed so as to block unnecessary light from the external surroundings of a display part **5780**. The first and second substrates **5751** and **5752** having the first and second substrate areas **5751***a* and **5752***a* are assembled to each other using a sealant **5730** made of a photo-hardened or thermo-hardened resin.

FIG. **179** illustrates a magnified cross-sectional view of the portion 'A' of FIG. **178**. As shown, an insulating layer **5727** is inserted between the column and row shorting bars **5720** and **5722** on the first substrate **5751** so as to isolate the column and row shorting bars **5720** and **5722** from each other.

The above-constructed first and second substrates **5751** and **5752** are fabricated into an individual LC panels using the processing flowchart of FIG. **180**. As shown, the first and second substrates are transferred, by a loader, into an LC cell processing station. The LC cell processing station performs three main steps, the steps **5900**, **6000**, and **6100**.

The first step **5900** is an alignment process for imparting uniform directivity to the liquid crystals. The alignment process is carried out by substrate cleaning **6020**S, followed by alignment layer printing **6021**S, then alignment layer plasticizing **6022**S, followed by alignment layer inspecting **6023**S, and finally alignment layer rubbing **6024**S.

Several comments about the step **5900** may be helpful. After the cleaning process **6020**S remove particles the substrate is ready for printing. An alignment layer liquid is dropped between Doctor and Anilox rolls that rotate in a dispenser. The alignment layer liquid is maintained as a liquid film on the face of the Anilox roll and is transferred to a print roll having a print rubber plate. A film of the alignment layer liquid is then coated on the first and second substrates by transcription.

Subsequently, a baking process plasticizes the alignment layer, reference step **6022**S. Baking then evaporates a solvent in the alignment layer liquid. The alignment layer is then inspected (step **6023**S) and rubbed (step **6024**).

The second step **6000** is then performed. The substrate with the alignment layer is then cleaned (step **6025**S). If the substrate is a CF substrate, a sealant is coated around the second substrate panel areas, step **6026**S. Notably, the sealant has no injection hole.

If the substrate is a TFT substrate, the substrate is also cleaned, step **6025**S, Then, Ag dots are formed to enable electrical connections to the common electrode of the CF substrate, step **6027**S. Liquid crystals are then applied to the first substrate panel areas at locations that correspond to being inside the sealant on the color filter substrate. Beneficially, the liquid crystal is applied by dropping droplets, step **6029**S.

Liquid crystal dropping is performed by removing bubbles from liquid crystals using vacuum, loading an LC dropping device on an LC dispensing equipment, loading the first substrate on the LC dispensing equipment, and dropping liquid crystals on the first substrate using the LC dropping device.

While the foregoing has discussed forming a seal on the CF substrate and dropping liquid crystal on the TFT substrate, in practice, seals could be formed on TFT substrates and liquid crystal could be dropped on the CF substrate.

After step **6000**, the third step **6100** is performed. The first and second substrates are assembled to each other in a vacuum assembling equipment such that the first and second substrate panel areas are opposed. Then UV-rays are irradiated onto the sealant to harden the sealant, thus forming a composite LC panel.

While not shown in the figures, the assembling process is performed as follows. First, the first substrate is mounted on a table in a vacuum vessel that enables movement in a horizontal direction, beneficially, using a first suction device. Then, the second substrate is affixed by vacuum suction to second suction devices such that the second substrate is over the first. The vacuum chamber is then closed and a vacuum is formed. The second suction device then descends so as to leave a predetermined interval between the first and second substrates. The first substrate is then moved horizontally to align with the second substrate.

Subsequently, the second suction device descends such that the second substrate is assembled to the first substrate via the sealant. The first and second substrates are then pressed together such that the liquid crystal unit panel areas are filled with the liquid crystals (which spread across the first substrate liquid crystal unit panel areas). Thus, a large LC panel having a plurality of liquid crystal unit panel areas is fabricated.

Thereafter, the panel is taken out of the vacuum chamber, and is irradiated by UV light so as to cure the sealing material.

An electrical lighting inspection is then performed, reference step **6040**S. The electrical lighting inspection is carried out as follows. Referring now to FIGS. **180** and **181**, the large LC panel is loaded on an inspection equipment **6200** by a robot arm, reference step **6041**S. The inspection equipment **6200**, as shown in FIG. **181**, includes a stage **6300**, at least three protrusions **6310** arranged so as to have a minimum contact area between the stage **6300** and the composite LC panel put on by the robot arm, a rotational member **6320** that tilts, and light sources **6330** within the stage **6300**. The light sources **6330** radiate light uniformly from inside the stage. A first polarizer **6327** is arranged over the light source **6330**. A fixing part (not shown in the drawing) fixes the 1 composite LC panel to the stage **6300** when the stage rotates.

The inspection equipment **6200** further includes at least two voltage terminals **6328** for applying a voltage to external connection terminals **5721***a* and **5723***a*, reference FIG. **177**, which enable the application of electric power to the gate and data pads **5790** and **5710**, reference FIG. **178**.

Referring now to FIG. **181**, the inspection equipment **6200** rotates at predetermined angles by way of the rotational member **6320** after the composite LC panel is loaded on the inspection equipment **6200** by the robot arm, reference steps **6041**S and **6042**S. The composite LC panel receives external power via the external connection terminals **6328**.

Next, a user performs A/P testing using a second polarizer **6329** having a predetermined size that is coupled with the inspection equipment such that the first and second polarizers sandwich the composite LC panel, reference step **6044**S.

FIG. **182** illustrates the layout of the composite LC panel according to an embodiment of the present invention. As shown, an external voltage is applied via external connection terminals **6328** to the terminal **5721***a*, connected to the first metal line **5723**, and to the external connection terminal **5723***a*, connected to the second metal line **5723**. Also, a predetermined DC voltage is applied to the common electrode of the second substrate **5752**. This enables the A/P (auto probe) testing, reference step **6044**S of FIG. **180**.

The inspection equipment **6200** with a composite LC panel sandwiched between the first and second polarizers, together with the light from the light sources **6330** and the applied electrical power simulate an operating LC display module that produces a solid image. Electrical defects, such as open or shorted gate and data lines, will be visually apparent since areas will be blank (or have other distortions). Furthermore, image stains such as cross-striped areas, black regions, color filter protrusions, oblique stains, rubbing stripes, pin holes, open or shorted gate and data lines, and the like will be visible to human observers or to CCD (charge coupled device).

After completion of A/P test, the inspection equipment **6200** is rotated to return to its initial position, reference step **6045**S. The large LC panel is then loaded into a cassette using the robot arm, reference step **6046**S.

Beneficially, A/P test is performed in the processing assembly line, thereby preventing unnecessary delays and inconvenience.

Subsequently, a S/B (scribe/break) process is carried out, reference step **6047**S. The S/B process includes a scribe step of forming cutting line on glass surfaces using a diamond-based pen, and a break step of cutting the glass by applying a force. The S/B process divides the large LC panel into a plurality of unit LC panels called cell units.

Then, a grinding process, step **6048**S is performed to grind faces of the unit LC panels, thereby completing the third step **6100**.

Thereafter, a module process that attaches a driver IC, a backlight, and the like is carried out.

Accordingly, the method of fabricating a liquid crystal display according to the present invention has the following advantages.

First, the electrode structure enables performing electrical and visual inspection of composite LC panels before the individual LC panels are completed. This enables a single inspection that reduces inspection time and worker fatigue. Furthermore, the present invention performs A/P testing in an early fabrication stage, thereby enabling feedback of defect information, which improves mass production.

FIG. **183** is a schematic block diagram of a cutter for cutting a liquid crystal display panel in accordance with a first embodiment of the present invention.

As shown in FIG. **183**, a cutter for cutting a liquid crystal display panel in accordance with the first embodiment of the present invention includes a loading unit **6460** for loading and aligning first and second mother substrates that are attached to each other, a first scribing unit **6461** for forming a plurality of first scribing lines with a first upper wheel and a first lower wheel on the surface of the first and second mother substrates. A first breaking unit **6462** is to break the first and second mother substrates by pressing with first and second breaking bars along the first scribing lines formed on the surface of the first and second mother substrates. A first rotating unit **6463** is to rotate the first and second mother substrates by 90°. A second scribing unit **6464** is to form a plurality of second scribing lines with a second upper wheel and a second lower wheel on the surface of the first and second mother substrates. A second breaking unit **6465** is to break the first and second mother substrates by pressing with a third and a fourth breaking bars along the second scribing lines formed on the surface of the first and second mother substrates and to transmit a crack on the first and second mother substrate. Further, an unloading unit **6466** is to rotate the first and second mother substrate by 90° to be in the direction the same as the initial loading direction, sequentially unloading a plurality of unit liquid crystal panels cut along the first and second scribing lines, and conveying to the equipment for the further processes.

FIGS. **184**A to **184**G illustrate sequential processes for performing each block of FIG. **183**.

As shown in FIG. **184**A, the loading unit **6460** loads a first mother substrate **6551** and a second mother substrate **6552** that are attached to each other. A plurality of thin film transistor array substrates are formed in the first mother substrate, and a plurality of color filter substrates are formed in the second mother substrate **6552**. The first and second mother substrates **6551** and **6552** are aligned through an alignment mark **6430**.

The first mother substrate **6551** including the thin film transistor array substrates is stacked on the second mother substrate **6552** including the color filter substrates. When the first and second mother substrates **6551** and **6552** are loaded as such a state, an impact to a gate pad unit or a data pad unit formed on the thin film transistor array substrate may be minimized by the following breaking process.

In FIG. **184**B, the first scribing unit **6461** sequentially forms a plurality of first scribing lines **6450** and **6451** on the surface of the first and second mother substrates **6551** and **6552**, with a first upper wheel **6440** and a first lower wheel **6441**, in the space between the first and second tables **6420** and **6421**. The first and second mother substrates **6551** and **6552** move to one direction so that the first and second mother substrates **6551** and **6552** are placed between the first table **6420** and the second table **6421** that are isolated by a space therebetween.

One side of the thin film transistor array substrates formed at the first mother substrate **6551** is protruded to be longer than the corresponding side of the color filter substrates formed at the second mother substrate **6552**. This is because the data pad unit formed at the gate pad unit is formed at one of the left and right sides, and the data pad unit is formed at one of the upper and lower sides of the thin film transistor array substrate.

Accordingly, at the region where one side of the thin film transistor array substrates is protruded to be longer than the corresponding side of the color filter substrates, the first upper wheel **6440** is isolated for a certain distance to one side of a reference line R**1**, so as to form a first scribing line **6450** on the surface of the first mother substrate **6551**. The first lower wheel **6441** is isolated for a certain distance in the opposite direction corresponding to the first upper wheel **6440** from the reference line R**1**, so as to form the first scribing line **6451** on the surface of the second mother substrate **6552**.

At the region where no gate pad unit or data pad unit of the thin film transistor array substrates is formed (that is, the region where the thin film transistor array substrates are not protruded to be longer than the color filter substrates), the first upper wheel **6440** and the first lower wheel **6441** are aligned to the straight line, thereby forming the first scribing lines **6450** and **6451** on the surface of the first and second mother substrates **6551** and **6552**.

As shown in FIG. **184**C, the first breaking unit **6462** breaks the first and second mother substrates **6551** and **6552** by pressing with first and second breaking bars **6460** and **6461**, along the first scribing lines **6450** and **6451** formed on the surface of the first and second mother substrates **6551** and **6552**, in the space between the third and fourth tables **6422** and **6423** to transmit a crack on the first and second mother substrates **6551** and **6552**. The first and second mother substrates **6551** and **6552** move to be placed between the third and fourth tables **6422** and **6423**, thereby cutting the first and second mother substrates **6551** and **6552**.

When the first mother substrate **6551** is pressed by the first breaking bar **6460**, the second breaking bar **6461** supports the second mother substrate **6552**. When the second mother substrate **6552** is pressed by the second breaking bar **6461**, the first breaking bar **6460** supports the first mother substrate **6551**.

FIG. **184**D illustrates the first rotating unit **6463** rotating the cut first and second mother substrates **6551** and **6552** by 90°.

As shown in FIG. **184**E, the second scribing unit **6464** sequentially forms the second scribing lines **6452** and **6453** on the surface of the first and second mother substrates **6551** and **6552**, with the second upper wheel **6442** and the second lower wheel **6443** located at the space between the fifth and sixth tables **6424** and **6425**, while the first and second mother substrates **6551** and **6552** move to be placed between the fifth and sixth tables **6424** and **6425** that are isolated by the space therebetween.

As mentioned above, one side of the thin film transistor array substrates formed at the first mother substrate **6551** is protruded to be longer than the corresponding side of the color filter substrates formed at the second mother substrate **6552**. Thus, at the protruded region, like the first upper wheel **6440** and the first lower wheel **6441**, the second upper wheel **6442** and the second lower wheel **6443** are isolated from each other by a certain distance in the opposite direction along the reference line R**1**, so as to form the second scribing lines **6452** and **6453** on the surface of the first and second mother substrates **6551** and **6552**.

Meanwhile, at the region where the thin film transistor array substrates are not protruded to be longer than the color filter substrates, like the first upper wheel **6440** and the first lower wheel **6441**, the second upper wheel **6442** and the second lower wheel **143** are aligned to each other, so as to form the second scribing lines **6452** and **6453** on the surface of the first and second mother substrates **6551** and **6552**.

In FIG. **184**F, the second breaking unit **6465** presses the first and second mother substrates **6551** and **6552** with third and fourth breaking bars **6462** and **6463** along the second scribing lines **6452** and **6453**, formed on the surface of the first and second mother substrates **6551** and **6552** at the space between the seventh and eighth tables **6426** and **6427**, to transmit a crack on the first and second mother substrates **6551** and **6552**. The first and second mother substrates **6551** and **6552** move to be placed between the seventh and eighth tables **6426** and **6427**, thereby cutting the first and second mother substrates **6551** and **6552**.

When the first mother substrate **6551** is pressed by the third breaking bar **6462**, the fourth breaking bar **6463** supports the second mother substrate **6552**. When the second mother substrate **6552** is pressed by the fourth breaking bar **6463**, the third breaking bar **6462** supports the first mother substrate **6551**.

The unloading unit **6466** sequentially unloads the unit panels cut along the first and second scribing lines **6450** to **6453** and conveys to the equipment for the following processes, as shown in FIG. **184**G.

Meanwhile, the unit panels conveyed to the unloading unit **6466** is rotated by 90° compared to the direction of the loading unit **6460**, as shown in FIG. **184**G. A second rotating unit **6467** is installed in the unloading unit **6466** so as to rotate the unit panels by 90° and unloads the unit panels for facilitating the following processes.

In addition, in the following process, when a unit panel requires a state that the color filter substrate is stacked on the thin film transistor array substrate, as shown in FIG. **184**G, the first overturning unit **6468** may be installed in the unloading unit **6466** to overturn the unloaded unit panels and convey to the equipment in the following processes.

As aforementioned, referring to the cutter for cutting a liquid crystal display panel and the method for cutting using the same, there requires only two simultaneous scribings of the first and second mother substrates and two simultaneous breakings of the first and second mother substrates. Also, the formed liquid crystal display panels are individually cut into the unit panels by rotating the first and second mother substrates once only.

FIG. **185** is a schematic block diagram of a cutter for cutting a liquid crystal display panel in accordance another embodiment of the present invention.

As shown in FIG. **185**, the cutter in accordance the second embodiment of the present invention includes a loading unit for loading and aligning first and second mother substrates that are attached to face into each other. A first scribing unit **6610** is to sequentially form a plurality of first scribing lines with a first upper wheel and a first lower wheel on the surface of the first and second mother substrates with moving the first and second mother substrates in one direction, rotating the first and second mother substrates by 90°. A plurality of second scribing lines are sequentially formed with the first upper wheel and the first lower wheel on the surface of the first and second mother substrates with moving the first and second mother substrates to the original position. A first breaking unit **6620** is to sequentially press the first and second mother substrates with first and second breaking bars along the second scribing lines formed on the surface of the first and second mother substrates with moving the first and second mother substrates in one direction to cut the first and second mother substrates. A second breaking unit **6630** is to rotate the first and second mother substrates by 90°. The first and second mother substrates are sequentially pressed with third and fourth breaking bars along the first scribing lines with moving the first and second mother substrates as much as a predetermined distance in one direction. An unloading unit **6640** is to sequentially unload the unit panels cut along the first and second scribing lines and convey to the equipment for the following processes.

FIGS. **186**A to **186**F illustrate sequential processes for performing each block of FIG. **185**.

Initially, the loading unit **6600** loads first and second substrates **6603** and **6604** that thin film transistor array substrates and color filter substrates are formed and attached to face into each other, on a first table **6605**. The first and second substrates **6603** and **6604** are aligned by an alignment mark **6606**, as shown in FIG. **186**A.

The first mother substrate **6603** including the thin film transistor array substrates is stacked on the second mother substrate **6604** with the color filter substrates. When the first and second mother substrates **6603** and **6604** are loaded to be such a state, an impact to a gate pad unit or a data pad unit formed on the thin film transistor array substrate may be minimized in the following breaking processes.

In FIG. **186**B, the first scribing unit **6610** sequentially forms the first scribing lines **6614** and **6615** on the surface of the first and second mother substrates **6603** and **6604** with the first upper wheel **6612** and the first lower wheel **6613** in the space between the first and second tables **6605** and **6611**. In this process, the first and second mother substrates **6603** and **6604** move to one direction as far as a predetermined distance so that the first and second mother substrates **6603** and **6604** may be placed between the first table **6605** and the second table **6611** that are isolated with the space therebetween.

As shown in FIG. **186**C, the first scribing unit **6610** rotates the first and second mother substrates **6603** and **6604** having the first scribing lines **6614** and **6615** by 90°, and sequentially forms a plurality of second scribing lines **6616** and **6617** on the surface of the first and second mother substrates **6603** and **6604** with the first upper wheel **6612** and the first lower wheel **6613** located at the space between the first and second tables **6605** and **6611**. In this process, the first and second mother substrates **6603** and **6604** move back to the original position, so as to be placed between the first and second tables **6605** and **6611**.

One side of the thin film transistor array substrates formed at the first mother substrate **6603** is protruded to be longer than the corresponding side of the color filter substrates formed at the second mother substrate **6604**.

This is because the data pad unit is formed at one of the left and right sides and the data pad unit is formed at one of the upper and lower sides of the thin film transistor array substrate.

Accordingly, at the region where one side of the thin film transistor array substrates is protruded to be longer than the corresponding side of the color filter substrates, the first upper wheel **6612** is isolated for a certain distance to one side of a reference line R1 for forming first and second scribing lines **6614** and **6616** on the surface of the first mother substrate **6603**. The first lower wheel **6613** is isolated for a certain distance to the opposite direction corresponding to the first upper wheel **6612** from the reference line R1 for forming the first and second scribing lines **6615** and **6617** on the surface of the second mother substrate **6604**.

Meanwhile, at the region where no gate pad unit or data pad unit of the thin film transistor array substrates is formed (that is, the region where the thin film transistor array substrates are not protruded to be longer than the color filter substrates), the first upper wheel **6612** and the first lower wheel **6613** are aligned to the straight line. Thus, the first and second scribing lines **6614** to **6617** are formed on the surface of the first and second mother substrates **6603** and **6604**.

The first breaking unit **6620** in FIG. **186**D presses the first and second mother substrates **6603** and **6604** with first and second breaking bars **6623** and **6624** along the second scribing lines **6616** and **6617** formed on the surface of the first and second mother substrates **6603** and **6604** at the space between the third and fourth tables **6621** and **6622**. Thus, a crack is transmitted on the first and second mother substrates **6603** and **6604**. In this process, the first and second mother substrates **6603** and **6604** move to be placed between the third and fourth tables **6621** and **6622**, thereby cutting the first and second mother substrates **6603** and **6604**.

When the first mother substrate **6603** is pressed by the first breaking bar **6623**, the second breaking bar **6624** supports the second mother substrate **6604**. When the second mother substrate **6604** is pressed by the second breaking bar **6624**, the first breaking bar **6623** supports the first mother substrate **6603**.

As shown in FIG. **186**E, the second breaking unit **6630** rotates the cut first and second mother substrates **6603** and **6604** by 90°, and presses the first and second mother substrates **6603** and **6604** with third and fourth breaking bars **6633** and **6634** along the first scribing lines **6614** and **6615** formed on the surface of the first and second mother substrates **6603** and **6604** at the space between the fifth and sixth tables **6631** and **6632**. Thus, a crack moves along the scribing lines in the first and second mother substrates **6603** and **6604** with moving the first and second mother substrates **6603** and **6604** to be placed between the fifth and sixth tables **6631** and **6632**. The unit panels are then cut out from the first and second mother substrates **6603** and **6604**.

When the third breaking bar **6633** presses the first mother substrate **6603**, the fourth breaking bar **6634** supports the second mother substrate **6604**. When the fourth breaking bar **6634** presses the second mother substrate **6604**, the third breaking bar **6633** supports the first mother substrate **6603**.

As shown in FIG. **186**F, the unloading unit **6640** sequentially unloads the unit panels cut along the first and second scribing lines **6614** to **6617** and conveys to the equipment in the following processes.

Meanwhile, the unit panels conveyed to the unloading unit **6640** is rotated by 90° compared to the direction of the loading unit **6600**, as shown in FIG. **186**F. A second rotating unit **6650** is installed in the unloading unit **6640** so as to rotate the unit panels by 90° and unload the unit panels for more convenient processes.

In addition, in the following process, when a unit panel requires a state that the color filter substrate is stacked on the thin film transistor array substrate, as shown in FIG. **186**F, the first overturning unit **6660** may be installed in the unloading unit **6640** to overturn the unloaded unit panels and convey to the equipment in the following processes.

As aforementioned, referring to the device for cutting a liquid crystal display panel and the method for cutting using the same in accordance with the second embodiment of the present invention, there requires only one time of simultaneous scribing of the first and second mother substrates and two simultaneous breakings of the first and second mother substrates. Also, the liquid crystal display panel is cut into the unit panels by rotating the first and second mother substrates twice.

FIGS. **187**A to **187**C illustrate different alignments of an upper wheel and a lower wheel for simultaneously scribing the first and second mother substrates in accordance with the present invention.

The scribing wheel may have to be replaced due to the abrasion. Thus, the wheel should be easily replaceable in order to improve productivity.

As shown in FIG. **187**A, when an upper wheel **6700** and a lower wheel **6701** are aligned to the reference line R**1**, they are not easily replaceable and much time is required for a replacement.

Conversely, when the upper wheel **6700** and the lower wheel **6701** are positioned to be symmetrical in the horizontal direction from the reference line R**1**, as shown in FIG. **187**B, their replacement would be convenient and quick.

FIG. **187**C illustrates another embodiment of the upper wheel **6700** and the lower wheel **6701** to be symmetrical in the forward-backward direction from the reference line R**1**.

In both of the embodiments of the present invention as described above, the scribing and breaking processes are sequentially performed on the first and the second mother substrates with moving the first and second mother substrates. Alternatively, sequential scribing and breaking processes may be performed on the first and second mother substrates with moving the wheel and the breaking bar.

As described above, the device for cutting a liquid crystal display panel and the method for cutting using the same in accordance with the present invention have many advantages as follows.

That is, referring to the first embodiment, the liquid crystal display panels is cut into the unit panels by two simultaneous scribings of the first and second mother substrates, two simultaneous breakings of the first and second mother substrates, and one time of rotation of the first and second mother substrates.

Therefore, the time required for the scribing is minimized compared to that of the conventional art. Also, since the overturning unit is not necessary to overturn the first and second mother substrates, the time required for the scribing and overturning is reduced and productivity is improved. In addition, the problem of wasting an installation expense and an installation space of the equipment is prevented.

With respect to the second embodiment, the liquid crystal display panel is cut to the unit panels by one time of simultaneous scribing of the first and second mother substrates, two simultaneous breakings of the first and second mother substrates, and two rotations of the first and second mother substrates.

Therefore, the scribing equipment is reduced by one as compared to the first embodiment of the present invention, so that the installation expense and installation space of the equipment may be reduced more.

In addition, since the upper wheel and the lower wheel for the scribing of the present invention are positioned to be symmetrical in the horizontal direction and forward-backward direction from the reference line, they may be easily and conveniently replaced. Thus, the time for replacement may be reduced and the productivity may be improved.

FIG. **188** is a schematic block diagram of a device for cutting a liquid crystal display panel in accordance with a first embodiment of the present invention.

As shown in FIG. **188**, the device for cutting a liquid crystal display panel includes a loading unit **6800** for loading and aligning first and second mother substrates including a plurality of unit liquid crystal display panels thereon. A first scribing unit **6810** is to form a first scribing line on the surface of the first and second mother substrates with a first upper wheel and a first lower wheel, and to press at least a portion of the first scribing line with a first roll in order to sequentially cut the first and second mother substrates. A first rotating unit **6820** is to rotate the cut first and second mother substrates by 90°. A second scribing unit **6830** is to form a second scribing line on the surface of the rotated first and second mother substrates with a second upper wheel and a second lower wheel and to press at least a portion of the second scribing line in order to sequentially cut the first and second mother substrates. An unloading unit **6840** is to unload the unit liquid crystal display panels cut by the first and second scribing units **6810** and **6430** and to convey to the equipment for the following processes.

FIGS. **189**A to **189**G illustrate sequential processes for performing each block of FIG. **188**.

Initially referring to FIG. **189**A, a loading unit **6800** loads a first mother substrate **6851** and a second mother substrate **6852** that are attached to each other placed on a first table **6805**. The first mother substrate includes a plurality of thin film transistor array substrates formed thereon, and the second mother substrate includes a plurality of color filter substrates formed thereon. The first and second mother substrates **6851** and **6852** are aligned through an alignment mark **6806**.

When the first and second mother substrates **6851** and **6852** are loaded on the first table **6805**, the first mother substrate **6851** is stacked to be on the second mother substrate **6852**. An impact to the thin film transistor array substrate or the color filter substrate in a cutting process of the first and second mother substrates **6851** and **6852** may be mitigated by this location.

As shown in FIG. **189**B, the first scribing unit **6810** sequentially forms first scribing lines **6814** and **6815** at the surface of the first and second mother substrates **6851** and **6852** through the first upper wheel **6812** and the first lower wheel **6813** located at the space between the first and second tables **6805** and **6811**. In this process, the first and second mother substrates **6851** and **6852** move to be placed between the first table **6805** and the second table **6811**.

One side of the thin film transistor array substrates formed at the first mother substrate **6851** is protruded to be longer than the corresponding side of the color filter substrates formed at the second mother substrate **6852**.

This is because the gate pad unit is formed at one of the horizontal sides and the data pad unit is formed at one of the vertical sides of the thin film transistor array substrate.

Accordingly, at the protruded region of the thin film transistor array substrates longer than the corresponding side of the color filter substrates, the first scribing line **6814** is formed at the surface of the first mother substrate **6851** distanced from a reference line (R**1**) by using the first upper wheel **6812**. The first scribing line **6815** is formed at the surface of the second mother substrate **6852** distanced from the reference line (R**1**) in the opposite direction corresponding to the first upper wheel **6812** by using the first lower wheel **6813**.

Meanwhile, at the region where a gate pad unit or the data pad unit of the thin film transistor array substrates are not formed, the first upper wheel **6812** and the first lower wheel **6813** are aligned to form the first scribing lines **6814** and **6815** at the surfaces of the first and second mother substrates **6851** and **6852**.

The first scribing unit **6810** presses a portion of the first scribing lines **6814** and **6815** with the first roll **6816** to sequentially cut the first and second mother substrates **6851** and **6852**, as shown in FIG. **189**C.

The first roll **6816** presses a portion or several portions of the first scribing line **6814** formed by the first upper wheel **6812**. Thus, a crack is transmitted along the first scribing lines **6814** and **6815** on the first and second mother substrates **6851** and **6852**.

The first upper wheel **6812** forms the first scribing line **6814** at the surface of the first mother substrate **6851** and is moved to the original position. The first roll **6816** works with the first wheel **6812** in motion, so that it may be applied along the first scribing line **6814**.

The first roll **6816** may be applied only to the first scribing line **6815** formed at the surface of the second mother substrate **6852**. Alternatively, it may be applied both to the first scribing lines **6814** and **6815** formed at the surfaces of the first and second mother substrates **6851** and **6852**.

The first roll **6816** may be made of urethane so that it may be less slippery on a glass substrate when the first roll **6816** is applied. The first roll **6816** directly contacts the first mother substrate **6851** having the thin film transistor array substrate formed thereon. Also, a urethane material has an excellent characteristic in static electricity and generates less amount of particles upon contacting with the substrate.

As shown in FIG. **189**D, the first rotating unit **6820** rotates the first and second mother substrates **6851** and **6852** by 90°.

In FIG. **189**E, the second scribing unit **6830** sequentially forms second scribing lines **6835** and **6836** at the surfaces of the first and second mother substrates **6851** and **6852** with a second upper wheel **6833** and a second lower wheel **6834** located at the space between the third and fourth tables **6831** and **6832**. In this process, the rotated first and second mother substrates **6851** and **6852** move to be positioned between third and fourth tables **6831** and **6832**.

In the same manner with the first upper wheel **6812** and the first lower wheel **6813**, as described above with reference to FIG. **189**B, the second upper wheel **6833** and the second lower wheel **6834** form the second scribing lines **6835** and **6836** at the surfaces of the first and second mother substrates **6851** and **6852**. They are isolated with each other for a certain distance in the opposite direction from the reference line **R1** at the region where one side of the thin film transistor array substrates is protruded to be longer than the corresponding side of the color filter substrates.

Meanwhile, at the region where the thin film transistor array substrates are not protruded to be longer than the color filter substrates, the second upper wheel **6833** and the second lower wheel **6834** are aligned to form the second scribing lines **6835** and **6836** at the surfaces of the first and second mother substrates **6851** and **6852**.

As shown in FIG. **189**F, the second scribing unit **6830** presses a portion of the second scribing lines **6835** and **6836** with a second roll **6837** to sequentially cut out the first and second mother substrates **6851** and **6852**.

In the same manner with the second roll **6837** and the first roll **6816** as described above with reference to FIG. **189**C, one portion or several portions of the second scribing line **6835** formed by the second upper wheel **6833** is simultaneously pressed, so that a crack is transmitted along the second scribing lines **6833** and **6836** on the first and second mother substrates **6851** and **6852**.

In this respect, after the second upper wheels **6833** forms second scribing line **6835** at the surface of the first mother substrate **6851**, the second roll **6837** is moved to the original position while it presses along the second scribing line **6835** by working with the second upper wheel **6833**. Thus, the second scribing line **6835** is more effectively pressed.

The second roll **6837** may be made of urethane since it has a little frictional force with a glass substrate and thus has an excellent characteristic in static electricity. Moreover, it generates a little amount of particles upon contacting with the glass substrate.

As shown in FIG. **189**G, the unloading unit **6840** conveys the unit liquid crystal display panels sequentially cut along the first and second scribing lines **6814**, **6815**, **6835**, and **6836** to the equipment for the following processes.

The sequentially cut unit panels is rotated by 90° compared to the direction of the loading unit **6800**. Thus, as shown in FIG. **189**G, the unit panels are rotated by 90° by inserting the second rotating unit **6850** into the unloading unit **6840** and unloaded to the equipment for the following processes. Thus, the present invention facilitates the following processes.

In addition, when the color filter substrate should be stacked on the thin film transistor array substrate in the following processes, as shown in FIG. **189**G, after the unloaded unit panels are overturned by inserting the first overturning unit **6860** into the unloading unit **6840**, they are conveyed to the equipment for the following processes.

As mentioned above, according to the device for cutting a liquid crystal display panel and the method for cutting using the same of the present invention, the first and second mother substrates are cut into the unit panels in such a manner that at least one portion of the first and second scribing lines is pressed with the first and second rolls while the first and second scribing lines are formed through one rotation process, and two simultaneous scribing processes of the first and second mother substrates.

Meanwhile, the thin film transistor array substrate and the color filter substrate attached to each other are fabricated to be separated apart on the first and second mother substrates. A dummy seal pattern may be formed at the exterior of the first and second mother substrates where unit panels are not formed, so as to prevent a distortion of the attached first and second mother substrates depending on the model of the liquid crystal display device.

However, when the first and second mother substrates having a dummy seal pattern is cut by using the first embodiment of the present invention, the first and second mother substrates may not be easily separated from each other.

FIG. **190** is a schematic block diagram of a device for cutting a liquid crystal display panel to effectively cut and separate first and second mother substrates having a dummy seal pattern in accordance with a second embodiment of the present invention.

As shown in FIG. **190**, the device of a liquid crystal display panel in accordance with the second embodiment of the present invention includes a loading unit **6900** for loading and aligning first and second mother substrates where a plurality of unit liquid crystal display panels are formed thereon. The first and second mother substrates are placed on the first table. A first scribing unit **6910** is to load and hold the first and second mother substrates by vacuum suction so that it is placed on both the first table and the second table that are spaced apart by a certain distance. A first scribing line is formed at the surface of the first and second mother substrates with the first upper wheel and the first lower wheel. The first and second mother substrates are sequentially cut by moving the first and second tables in the direction so that they become distant from each other. A first rotating unit **6920** is to rotate the cut first and second mother substrates by 90°. A second scribing unit **6930** is to load and hold the rotated first and second mother substrates by vacuum suction to be bridged between the third and fourth tables that are spaced apart by a certain distance. The second scribing line is formed at the surface of the first and second mother substrates with the second upper wheel and the second lower wheels. The first and second mother substrates are sequentially cut by moving the third and fourth tables in a direction that they become distant from each other. An unloading unit **6940** is to unload the unit liquid crystal display panel cut and separated by the first and second scribing units **6910** and **6930** and to convey to the equipment for the following processes.

FIGS. **191**A to **191**G illustrate sequential processes for performing each block of FIG. **190**.

Initially referring to FIG. **191**A, the loading unit **6900** loads the first mother substrate **6951** and the second mother substrate **6952** that are attached to each other. The first mother substrate includes a plurality of thin film transistor array substrates formed thereon and the second mother substrate includes a plurality of color filter substrates formed thereon. They are placed on a first table **6905** and aligned through an alignment mark **6906**.

If the first and second mother substrates **6951** and **6952** are stacked on the second mother substrate **6952**, an impact caused in the cutting process to the thin film transistor array substrate or the color filter substrate may be mitigated.

As shown in FIG. **191**B, the first scribing unit **6910** loads the first and second mother substrates **6951** and **6952**, so as to be bridged between the first table **6905** and the second table **6911** that are spaced apart from each other. The first scribing unit **6910** also holds the substrates **6951** and **6952** through a plurality of vacuum suction holes **6912**, and sequentially forms the first scribing lines **6915** and **6916** at the surfaces of the first and second substrates **6951** and **6952** through the first upper wheel **6913** and the first lower wheel **6914** located at the space between the first and the second tables **6905** and **6911**.

One side of the thin film transistor array substrates formed at the first mother substrate **6951** is protruded to be longer than to the corresponding side of the color filter substrates formed on the second mother substrate **6952**.

This is because the gate pad unit is formed at one of the horizontal sides and the data pad unit is formed at one of the vertical sides of the thin film transistor array substrate.

Accordingly, at the protruded region of the thin film transistor array substrates, the first scribing line **6915** is formed at the surface of the first mother substrate **6951** distanced from one side of a reference line (R**1**) by using the first upper wheel **6913**. The first scribing line **6915** is formed at the surface of the second mother substrate **6952** distanced from the reference line (R**1**) in the opposite direction corresponding to the first upper wheel **6913** by using the first lower wheel **6914**.

Meanwhile, at the region where a gate pad unit or the data pad unit of the thin film transistor array substrates are not formed, the first upper wheel **6913** and the first lower wheel **6914** are aligned to each other, so as to form the first scribing lines **6915** and **6916** at the surfaces of the first and second mother substrates **6951** and **6952**.

In FIG. **191**C, the first scribing unit **6910** moves the first and second tables **6905** and **6911** on which the first and second mother substrates **6951** and **6952** are held by the a plurality of vacuum suction holes **6912** in a direction that they become distant from each other. Thereafter, the first and the second mother substrates **6951** and **6952** are cut and separated along the first scribing lines **6915** and **6916**.

The vacuum suction holes **6912** may be formed to be separated at constant intervals at the surfaces of the first and second tables **6905** and **6911**. The first and second mother substrates **6951** and **6952** are held onto the first and second tables **6905** and **6911** by sucking air and released from the first and second tables **6905** and **6911** by injecting air when the first and second mother substrates are conveyed to the next process.

Meanwhile, as shown in FIG. **192**, the vacuum suction holes **6912** may be formed as the vacuum suction unit **7012** having a certain area at the surface of the first and second tables **7005** and **7011**, thereby effectively holding the first and second mother substrates **6951** and **6952**. If a suction pressure is too high, a black dot stain may occur at the first and the second mother substrates **6951** and **6952**. This problem may be prevented by using the vacuum suction unit **7012**.

The first rotating unit **6920** rotates the cut first and second mother substrates **6951** and **6952** by 90°, as shown in FIG. **191**A.

The second scribing unit **6930**, in FIG. **191**E, loads the rotated first and second mother substrates **6951** and **6952**, so as to be bridged between the third and fourth tables **6931** and **6932** that are spaced apart by a certain distance. The first and second mother substrates **6951** and **6952** are held by the vacuum suction holes **6933**. The second scribing lines **6936** and **6937** are sequentially formed at the surface of the first and second mother substrates **6951** and **6952** through the second upper wheel **6934** and the second lower wheel **6935** located at the space between the third and fourth tables **6931** and **6932**.

In the same manner with the first upper wheel **6913** and the first lower wheel **6914** as described above with reference to FIG. **191**B, the second upper wheel **6934** and the second lower wheel **6935** form the second scribing lines **6936** and **6937** at the surfaces of the first and second mother substrates **6951** and **6952**, so as to be isolated to each other by a certain distance in the opposite direction from the reference line R**1**, at the region where one side of the thin film transistor array substrates is protruded to be longer than the corresponding side of the color filter substrates.

Meanwhile, at the region where the thin film transistor array substrates are not protruded to be longer than the color filter substrates, the second upper wheel **6934** and the second lower wheel **6935** are aligned to each other, so as to form the second scribing lines **6936** and **6937** at the surface of the first and second mother substrates **6951** and **6952**.

As shown in FIG. **191**F, the second scribing unit **6930** moves the third and fourth tables **6931** and **6932** on which the first and second mother substrates **6951** and **6952** are held by the vacuum suction holes **6933** in a direction that they become distance from each other. The first and second mother substrates **6951** and **6952** are cut and separated from each other along the second scribing lines **6936** and **6937**.

The vacuum suction holes **6933** formed at the surface of the third and fourth tables **6931** and **6932** are the same as the vacuum suction holes **6912** formed at the surface of the aforementioned first and second tables **6905** and **6911**. The vacuum suction holes **6933** may have a different shape, such as the vacuum suction holes **7012** having a rectangular shape, as illustrated in FIG. **192**.

In FIG. **191**G, the unloading unit **6940** conveys the unit liquid crystal display panels that are sequentially cut along the first and second scribing lines **6915**, **6916**, **6936**, and **6937** to the equipment for the following processes.

The sequentially cut unit panels are rotated by 90° compared to the direction of the loading unit **6900**. Thus, as shown in FIG. **191**G, the unit panels are rotated by 90° by inserting the second rotating unit **6950** into the unloading unit **6940** and unloaded to the equipment for the following processes for facilitating the following processes.

If the color filter substrate should be stacked on the thin film transistor array substrate for the following processes, as shown in FIG. **191**G, after the unloaded unit panels are overturned by inserting the first overturning unit **6960** into the unloading unit **6940**, they may be conveyed to the equipment for the following processes.

As mentioned above, according to the cutter for cutting a liquid crystal display panel and the method for cutting using the same of the present invention, the first and second mother substrates are cut into the unit liquid crystal display panels in such a manner that the first and second tables or the third and fourth tables, on which the loaded and held first and the second mother substrates, are moved in the direction that they become distant from each other, while the first and second scribing lines are formed through one rotation process, and two simultaneous scribing processes of the first and second mother substrates.

The first and second scribing processes respectively include cutting and removing a dummy region where the unit panels are not formed from the first and second mother substrates and cutting the region where the unit panels from the first and second mother substrates, which are alternately performed.

That is, as shown in FIG. **193**A, after the first and second mother substrates **7051** and **7052** are moved to be bridged between the first and second tables **7003** and **7004** that are spaced apart by a certain distance, the first scribing line **7007** is formed with the first upper wheel **7005** and the first lower wheel **7006**. And then, similar to the first embodiment of the present invention, at least one portion of the first scribing line **7007** is pressed with the roll. Alternatively, similar to the second embodiment of the present invention, the first and second tables **7003** and **7004** on which the held first and second mother substrates **7051** and **7052** are moved in a direction that they become distant from each other. Then, the dummy region **7009** at one side where the unit liquid crystal display panels are not formed is cut out from the first and second mother substrates **7051** and **7052**.

As shown in FIG. **193**B, the first and second mother substrates **7051** and **7052** without the dummy region **7009** as being removed in the first cutting process are moved in one direction, so as to be bridged between the first and second tables **7003** and **7004**. And then, the second scribing line **7008** is formed with the first upper wheel **7005** and the first lower wheel **7006**, and at least one portion of the first scribing line **7008** is pressed with the roll, similar to the first embodiment of the present invention. Alternatively, the first and second tables **7003** and **7004** holding the first and second mother substrates **7051** and **7052** are moved in the opposite direction so that the unit panels are cut out from the first and second mother substrates **7051** and **7052**.

Thereafter, the first cutting process is performed to cut out the dummy region **7009** where no unit panel is formed from the first and second mother substrates **7051** and **7052**. The second cutting process is performed to cut out the unit panels from the first and second mother substrates **7051** and **7052**. The first and second cutting processes may be repeatedly performed.

In this respect, however, when the cutting processes are performed on the model having the dummy seal pattern to prevent distortion of the first and second mother substrates **7051** and **7052** at the exterior where no unit panel is formed, the dummy region **7009** and the unit panels may not be completely separated in the first or second cutting process.

In addition, in the second cutting process in the second embodiment of the present invention, a unit panel is large enough to cut out the first and second mother substrates **7051** and **7052** held on the first and second tables **7003** and **7004**. However, in the first cutting process, since the dummy region **7009** is very narrow, it is difficult to hold the first and second mother substrates **7051** and **7052** by the first and second tables **7003** and **7004**.

FIGS. **194**A to **194**F illustrate sequential processes for cutting a liquid crystal display panel in accordance with a third embodiment of the present invention.

First, as shown in FIG. **194**A, first and second mother substrates including a plurality of unit panels formed thereon are loaded on a first table **7104**. And then, the first and second mother substrates **7151** and **7152** are moved in one direction, so that a dummy region **7105** where no unit panel is formed is protruded from one side of the first table **7104**.

Next, as shown in FIG. **194**B, a first scribing line **7108** is formed at the surface of the first and second mother substrates protruded from the first table **7104** by using first upper wheel **7106** and first lower wheel **7107**.

And then, as shown in FIG. **194**C, the dummy region **7105** with no unit panel formed is removed from the first and second mother substrates **7151** and **7152** along the first scribing line **7108** by using a robot grip **7109**.

In order to facilitate the removal of the dummy region **405** from the first and second mother substrates **7151** and **7152** with the robot grip **7109**, at least one portion of the first scribing line **7108** is pressed with a roll, similar to the first embodiment of the present invention, after the first scribing line **7108** is formed with the first upper wheel **7106** and the first lower wheel **7107**. Thus, a crack can be transmitted along the first scribing line **7108**.

Since the liquid crystal display panel differs in size according to the model of a liquid crystal display device, the robot grip **7109** may have to be able to control the heights by using a sub motor.

When the first mother substrate **7151** with the thin film transistor array substrates formed thereon is stacked on the second mother substrate **7103** with the color filter substrates formed thereon, the robot grip **7109** is positioned to be lower than the first and second mother substrates **7151** and **7152**, so as to hold the dummy region **7105**, since the thin film transistor substrate is protruded to be longer than the color filter substrate. Conversely, the robot grip **7109** is positioned to be higher than the first and second mother substrates **7151** and **7152**, so as to hold the dummy region **7105**, so that an impact applied to the unit panel may be prevented in advance.

As shown in FIG. **194**D, the first and second mother substrates **7151** and **7152** without the dummy region **7105** are moved in one direction to be bridged between the first table **7104** and the second table **7110** that are spaced apart a certain distance.

As shown in FIG. **194**E, a second scribing line **7111** is formed at the surface of the first and second mother substrates **7151** and **7152** by using the first upper wheel **7106** and the first lower wheel **7107** located at the space between the first and second tables **7104** and **7110**.

Next, as shown in FIG. **194**F, the first and second tables **7104** and **7110** are moved in a direction that they become distant from each other. The unit panels are cut and separated from the first and second mother substrates **7151** and **7152** along the second scribing line **7111**.

In order to easily cut and separate the unit panels from the first and second mother substrates **7151** and **7152** after moving the first and second tables **7104** and **7110** in the opposite direction, the second scribing line **7111** is formed through the first upper wheel **7106** and the first lower wheel **7107**. Then, at least one portion of the second scribing line **7111** is pressed with a roll so that a crack can be transmitted along the second scribing line **7111**.

As so far described, the device of a liquid crystal display panel and the method for cutting using the same in accordance with the present invention have the following advantages over the conventional art.

For example, referring back to the first embodiment of the present invention, the liquid crystal display panels may be cut into the unit liquid crystal display panels by forming the first and second scribing lines by one rotation process and two simultaneous scribing processes of the first and second mother substrates, and pressing a portion of or along the first and second scribing lines with the first and second rolls.

Thus, the time required for scribing may be minimized compared to that of the conventional art. Also, since an overturning unit for overturning the first and second mother substrates and a breaking unit for a crack transmission are not necessary, the time required for scribing, breaking, and overturning is reduced, thereby improving productivity. In addition, an installation expense and an installation space of equipment are effectively used.

Referring to the second embodiment of the present invention, the liquid crystal display panel may be cut into the unit liquid crystal display panels by forming the first and second scribing lines through one rotation process and two simultaneous scribing processes of the first and second mother substrates and moving the first and second table or the third and fourth tables, on which the first and second mother substrates in the opposite direction.

Thus, the unit panels may be more effectively cut out from the mother substrates. Especially, when the dummy seal pattern is formed to prevent distortion of the first and second mother substrates, the unit panels may be effectively cut out from the mother substrates.

Similarly, referring to the third embodiment of the present invention, in case that the dummy seal pattern is formed at the exterior where no unit panel is formed to prevent distortion of the first and second mother substrates, cutting of the unit panels may be effectively performed.

In addition, the dummy region having a small width may be held and processed without difficulty in the third embodiment of the present invention.

FIG. **195** illustrates a perspective view of a cutting wheel for a liquid crystal display panel according to a first embodiment of the present invention.

Referring to FIG. **195**, a cutting wheel for a liquid crystal display panel according to the present invention has a circular shape and includes a first cutting wheel **7200** and a second cutting wheel **7300**.

Penetrating holes **7201** and **7301** are formed at centers of the first and second cutting wheels **7200** and **7300** to receive a support spindle (not shown). And, unevenly-shaped, or serrated first and second blades **7202** and **7302** are formed along edges of the first and second cutting wheels **7200** and **7300**, respectively. Protrusions of first and second blades **7202** and **7302** may also be evenly or unevenly spaced.

The first and second cutting blades **7202** and **7302** according to the first embodiment of the present invention are preferably made of diamond, which has a hardness greater than that of generally used tungsten carbide, which will extend the endurance of the cutting blades. Moreover, the first and second cutting wheels **7200** and **7300** can be formed individually to be bonded to a support spindle (not shown) through the penetrating holes **7201** and **7301**, or the cutting wheels **7200** and **7300** can be built in one body, i.e., unitary.

When grooves are formed on a liquid crystal display panel using the first and second cutting wheels **7200** and **7300** according to the first embodiment of the present invention, the rotating first and second blades **7202** and **7302** along edges of the first and second cutting wheels **7200** and **7300** come into close contact with the liquid crystal display panel of glass at a uniform pressure so as to form grooves having a predetermined depth.

FIG. **196** illustrates an exemplary diagram of first and second grooves formed on a surface of a liquid crystal display panel using the first and second cutting wheels **7200** and **7300** according to the first embodiment of the present invention.

Referring to FIG. **196**, first groove **7251** is formed on a surface of a liquid crystal display panel **7250** by first blades **7202** of the first cutting wheel **7200**, and second groove **7252** is formed on the surface of the liquid crystal display panel **7250** by second blades **7302** of the second cutting wheel **7300**. In this case, the first and second grooves **7251** and **7252** are shown as a pair of parallel dotted lines. In practice, the first and second grooves **7251** and **7252** are about 300 μm apart.

In the first embodiment of the present invention, the first and second blades **7202** and **7302** are formed along the edges of the first and second cutting wheels **7200** and **7300**. The grooves are formed using a pair of the cutting wheels **7200** and **7300**. Hence, the cutting of the liquid crystal display panel can be carried out at a pressure lower than the case of using a single cutting wheel.

Specifically, even if the first blades **7202** are partially broken or particles stick to the first blades **7202**, the second blades **7302** are able to form a normal groove on the surface of liquid crystal display panel.

Namely, when the first blade **7202** of the first cutting wheel **7200** are deteriorated, a groove can be formed on the liquid crystal display panel using the second blade **7302** of the second cutting wheel **7300** instead of replacing the first cutting wheel **7200**, as in the related art.

Therefore, the cutting wheel for the liquid crystal display panel according to the first embodiment of the present invention has an extended endurance longer than that of the cutting wheel having the blade according to the related art.

FIG. **197** illustrates a perspective view of first and second cutting wheels **7200** and **7300**, of which first and second blades **7202** and **7302** are staggered or offset with respect to each other, respectively, according to a second embodiment of the present invention. The offset of the first and second blades **7202** and **7302** may be at a predetermined angle.

Referring to FIG. **197**, first and second blades **7202** and **7302** are arranged so that the blades of the respective wheels **7200** and **7300** are staggered or offset with respect to each other. First and second groves **7251** and **7252**, as shown in FIG. **198**, also alternate with respect to each other on the surface of a liquid crystal display panel **7250**. Cracks can be propagated well from the first and second grooves **7251** and **7252**. Likewise, even when the first blades **7202** of the first cutting wheel **7200** are partially broken or particles stick between protrusions of the first blade **7202**, a groove can be formed on the liquid crystal display panel using the second blade **7302** of the second cutting wheel **7300** so as to extend the endurance of the cutting wheel.

FIG. **199** illustrates an enlarged partial view of a liquid crystal display panel cutting wheel according to the present invention.

Referring to FIG. **199**, a circular cutting wheel **7400** includes a penetrating hole **7401** at a center to receive a support spindle (not shown), evenly-spaced first blades **7402** are formed by grinding front and rear faces of the cutting wheel **7400** along edges so that protrusions of the first blades **7402** protrude from the center of the cutting wheel **7400** at a first radius R1, and evenly-spaced second blades **7403** alternating with the first blades **7402** respectively so that protrusions of the second blades **7403** protrude from the center of the cutting wheel **7400** by a second radius R2. The first and second blades **7402** and **7403** may be unevenly spaced and/or unevenly shaped.

The first and second blades **7402** and **7403** in FIG. **199** are preferably formed of diamond, which has a hardness greater than that of generally-used tungsten carbide.

Operation of the cutting wheel **7400** for a liquid crystal display panel according to the present invention is explained in detail as follows.

First, the first blades **7402** protruding from the center of the cutting wheel **7400** by the first radius R**1** are made to adhere closely to a liquid crystal display panel at a predetermined pressure and are rotated thereon, to form a groove having a predetermined uniform depth. In this case, even though made of diamond, the first blades **7402** are abraded after grooves totaling 6000 m in length have been formed on liquid crystal display panels such that a normal groove cannot be formed on the surface of the liquid crystal display panels.

However, when the first blades **7402** shown in FIG. **199** have been abraded, the second blades **7403** protruding from the center of the cutting wheel **7400** by the second radius R**2** are capable of forming the normal groove on the surface of the liquid crystal display panels.

Namely, when the first blades **7402** are abraded so that the first radius R**1** becomes less than the second radius R**2** of the second blades **7403**, the normal groove can be formed on the liquid crystal display panel using the second blades **7403** instead of replacing the cutting wheel **7400**.

Therefore, the cutting wheel according to the third embodiment of the present invention has an extended endurance compared to that of the cutting wheel according to the related art, thereby extending the life of the cutting wheel.

FIG. **200** illustrates an enlarged partial view of a liquid crystal display panel cutting wheel according to a fourth embodiment of the present invention.

Referring to FIG. **200**, a circular cutting wheel **7500** includes a penetrating hole **7501** at a center to receive a support spindle (not shown), evenly-spaced first blades **7502** formed by grinding front and rear faces of the cutting wheel along edges so as to have a first height H**1** from a perceived edge of the cutting wheel **7500**, and evenly-spaced second blades **7503** formed between the first blades **7502** so as a second height H**2**. The first and second blades **7502** and **7503** may be unevenly shaped and may be unevenly spaced with respect to one another.

When the first blades **7502** having the first height H**1** have been abraded so as not to form a normal groove on a surface of the liquid crystal display panel, the second blades **7503** having the second height H**2** are capable of forming the normal groove on the surface of the liquid crystal display panel.

Namely, when the first blades **7502** are abraded so that the first height H**1** becomes lower than the second height H**2** of the second blades **7503**, the normal groove can be formed on the liquid crystal display panel using the second blades **7503** instead of replacing the cutting wheel **7500**.

Therefore, the cutting wheel according to the present invention has an extended endurance compared to that of the cutting wheel according to the related art, thereby extending the life of the cutting wheel.

FIG. **201** illustrates a perspective view of a liquid crystal display panel cutting wheel according to the present invention.

Referring to FIG. **201**, a first circular cutting wheel **7600** includes a penetrating hole **7601** at a center to receive a support spindle (not shown) and evenly-spaced first blades **7602** formed by grinding front and rear faces of the first cutting wheel **7600** along an edge to protrude from the center of the first cutting wheel **7600** by a first radius R**1** and spaced apart from each other by a predetermined interval. A second circular cutting wheel **7610** includes a penetrating hole **7611** at a center to receive the support spindle and evenly-spaced second blades **7612** formed by grinding front and rear faces of the second cutting wheel **7610** along an edge to protrude from the center of the second cutting wheel **7610** by a second radius R**2** and spaced apart from each other by a predetermined interval. The first and second blades **7602** and **7612** may be unevenly shaped and may be unevenly spaced with respect to each other. The second blades **7612** of the second wheel **7610** may be offset from the first blades **7602** of the first wheel **7600**, for example, by a predetermined angle.

The first and second cutting wheels **7600** and **7610** are manufactured individually so as to be bonded to the support spindle through the penetrating holes **7601** and **7611** or can built in one body, i.e., be unitary.

Like the cutting wheels **7400** and **7500** for the liquid crystal display panels according to the previous embodiments of the present invention, when the first blades **7602** protruding from the center of the first cutting wheel **7600** by the first radius R**1** have been abraded so as not to form a normal groove on a surface of the liquid crystal display panel, the second blades **7612** are capable of forming the normal groove on the surface of the liquid crystal display panel.

Namely, when the first blades **7602** of the first cutting wheel **7600** are abraded so that the first radius R**1** becomes less than the second radius R**2**, the normal groove can be formed on the liquid crystal display panel using the second blades **7612** of the second cutting wheel **7610** instead of replacing the first cutting wheel **7600**.

Therefore, as is the same case of the third or fourth embodiment of the present invention, the cutting wheel for the liquid crystal display panel according to another embodiment of the present invention has an extended endurance compared to that of the cutting wheel according to the related art, thereby extending the life of the cutting wheel.

Accordingly, the cutting wheel for the liquid crystal display panel according to the first or second embodiment of the present invention includes a pair of the same-sized cutting wheels and the blades along the edges respectively, which can be operated under an improved pressure condition compared to the conventional devices. Specifically, the cutting wheel for the liquid crystal display panel according to the first or second embodiment of the present invention is capable of forming a groove on the surface of the liquid crystal display panel continuously even if the blades of one of the cutting wheels are broken in part or particles are attached between the blades, thereby extending the life of the cutting wheel to improve a productivity as well as reduce a cost of purchasing the cutting wheel.

Moreover, the cutting wheel for the liquid crystal display panel according to the present invention has differentiated protruding heights of the blades formed along the edges of the circular cutting wheel, thereby extending the endurance of the cutting wheel compared to that of the related art. Therefore, the present invention extends the replacement time of the cutting wheel to improve productivity as well as reduce a cost of purchasing replacement cutting wheels.

FIG. **202** illustrates a diagram of a grinding table apparatus for a liquid crystal display panel and a grinder apparatus using the same according to an embodiment of the present invention.

Referring to FIG. **202**, a grinder apparatus for a liquid crystal display panel according to the present invention includes a loading unit **7711** loading a unit liquid crystal display panel **7700**, a first grinding unit **7715** having a pair of grinding tables **7712** and **7713** moving in a farther or closer direction to cope with a size of the unit liquid crystal display panel **7700** to receive the unit liquid crystal display panel **7700** loaded on the loading unit **7711** by suction for adherence and grinding short edge sides of the unit liquid crystal display panel **7700** through a first grind wheel **7714**, a second grinding unit **7719** having another pair of grinding tables **7716** and **7717** moving in a farther or closer direction to receive and to hold the unit liquid crystal display panel **7700**, of which short edge sides have been ground, by suction for adherence and grinding long edge sides of the unit liquid crystal display panel **7700** through a second grind wheel **7718**, and an unloading unit **7720** for receiving the unit liquid crystal display panel **7700** of which long edge sides have been ground by the second grinding unit **7719**.

In one embodiment, a plurality of suction holes **7721** are formed at surfaces of the grinding tables **7712**, **7713**, **7716**, and **7717** to make the unit liquid crystal display panel **7700** adhere thereto by suction so as to support the liquid crystal display panel **7700** stably. And, the grinder apparatus may further include a rotating unit enabling grinding of long sides of the unit liquid crystal display panel **7700** by rotating the unit liquid crystal display panel, of which short sides have been ground, at 90°.

FIGS. **203**A to **203**C illustrate exemplary diagrams for grinding tables **7712** and **7713** of a first grinding unit **7715** that is capable of moving in a farther or closer in an x or y direction reciprocally so as to adapt with a size of a liquid crystal display panel **7700** in FIG. **202**.

Referring to FIG. **203**A, a pair of the grinding tables **7712** and **7713** are spaced apart from each other by a predetermined distance so as to make short sides of the liquid crystal display panel **7700** protrude from the corresponding edges of the tables **7712** and **7713**. Thus, the grinding tables **7712** and **7713** support the liquid crystal display panel **7700** so that short edge sides of the unit liquid crystal display panel **7700** can be ground.

Referring to FIG. **203**B, when a size of a unit liquid crystal display panel **7730** is greater than that of the liquid crystal display panel **7700** in FIG. **203**A, the pair of the grinding tables **7712** and **7713** are displaced by a predetermined distance to move the grinding tables **7712** and **7713** farther from each other, i.e. in opposition directions, so as to make edges of a first side, e.g., a short side, of the unit liquid crystal display panel **7730** protrude sufficiently over the edges of the grinding tables for grinding. Thus, the tables **7712** and **7713** support the unit liquid crystal display panel **7730** so that short side edges of the unit liquid crystal display panel **7730** can be ground.

Referring to FIG. **203**C, when a size of a unit liquid crystal display panel **7740** is smaller than that of the liquid crystal display panel **7700** in FIG. **203**A, the pair of the grinding tables **7712** and **7713** are displaced by a predetermined distance to move the grinding tables **7712** and **7713** closer to each other, i.e. an inward direction, so as to make edges of a first side, e.g., a short side, of the unit liquid crystal display panel **7740** protrude sufficiently over the edges of the grinding table for grinding. Thus, the tables **7712** and **7713** support the unit liquid crystal display panel **7740** so that first side edges of the unit liquid crystal display panel **7740** can be ground.

The grinding tables **7712** and **7713** installed at the first grinding unit **7715** are preferably prepared to move to adhere closely to each other to cope with a minimum-sized model as well as move to be spaced apart with a maximum interval in a farther direction to cope with a maximum-sized model. Such relative movement can be achieved by keeping one of the grinding tables **7712** and **7713** fixed relative to the other while moving the other grinding table appropriately.

The other grinding tables **7716** and **7717** installed at the second grinding unit **7719** are preferably prepared to be displaced in order to cope with the various sizes of the unit liquid crystal display panels **7700**, **7730**, and **7740** like the grinding tables **7712** and **7713** installed at the first grinding unit **7715**.

Similarly, such relative movement can be achieved by keeping one of the grinding tables **7716** and **7717** fixed relative to the other while moving the other table appropriately.

Moreover, suction holes **7721** may be formed at surfaces of the grinding tables **7712**, **7713**, **7716**, and **7717** of the first and second grinding units **7715** and **7719**, respectively, so as to support each of the variously-sized unit liquid crystal display panels **7700**, **7730**, and **7740** stably by making them adhere thereto by suction.

Therefore, the grinding table apparatus for the liquid crystal display panel and the grinder apparatus using the same are able to adapt with various sizes of the unit liquid crystal display panels without replacing the grinding table with a corresponding one.

FIG. **204** illustrates a diagram of a grinding table apparatus for a liquid crystal display panel and a grinder apparatus using the same according to another embodiment of the present invention.

Referring to FIG. **204**, a grinder apparatus according to the present invention includes a loading unit **7811** for loading a liquid crystal display panel **7800** thereon, a first grinding unit **7817** having four grinding tables **7812** to **7815** capable of moving in farther or closer directions to adapt with a size of the unit liquid crystal display panel **7800** to receive the unit liquid crystal display panel **7800** loaded on the loading unit **7811** by suction for adherence and for grinding edges of the unit liquid crystal display panel **7800** through a first grind wheel **7816** and an unloading unit **7818** for receiving the unit liquid crystal display panel **7800** of which edges have been ground.

A plurality of suction holes **7819** may be formed at surfaces of the grinding tables **7812** to **7815** to make the unit liquid crystal display panel **7800** adhere thereto by suction to support the liquid crystal display panel **7800** stably.

FIGS. **205**A to **205**C illustrate exemplary diagrams for the grinding tables **7812** to **7815** of the first grinding unit **7817** moving farther or closer reciprocally to adapt with the size of the liquid crystal display panel **7800** in FIG. **204**.

Referring to FIG. **205**A, the grinding tables **7812** to **7815** are spaced apart from each other by predetermined distances to make edges of the liquid crystal display panel **7800** protrude from the corresponding edges of the tables sufficiently for grinding. Thus, the grinding tables **7812** to **7815** support the liquid crystal display panel **7800** so that the edges of the unit liquid crystal display panel **7800** can be ground.

Referring to FIG. **205**B, when a size of a unit liquid crystal display panel **7830** is greater than that of the liquid crystal display panel **7800** in FIG. **205**A, the grinding tables **7812** to **7815** are displaced by predetermined distances in directions to move the grinding tables **7812** to **7815** farther from each other to make edges of the unit liquid crystal display panel **7830** protrude somewhat over edges of the grinding tables. Thus, the tables **7812** to **7815** support the unit liquid crystal display panel **7830** so that the edges of the unit liquid crystal display panel **7830** of which size is greater than that of the unit liquid crystal display panel **7800** in FIG. **205**A can be ground.

Referring to FIG. **205**C, when a size of a unit liquid crystal display panel **7840** is smaller than that of the liquid crystal display panel **7800** in FIG. **205**A, the grinding tables **7812** to **7815** are displaced by predetermined distances in directions to move the grinding tables **7812** to **7815** closer to each other to make edges of the unit liquid crystal display panel **7840** protrude somewhat over edges of the grinding tables. Thus, the grinding tables **7812** to **7815** support the unit liquid crystal display panel **7840** so that the edges of the unit liquid crystal display panel **240** of which size is smaller than that of the one **7800** in FIG. **205**A can be ground.

The grinding tables **7812** to **7815** are preferably prepared so as to be close to each other to cope with a minimum-sized model, as well as to move to be spaced apart with a maximum interval to adapt to a maximum-sized model.

Moreover, suction holes **7819** are preferably formed at surfaces of the grinding tables **7812** to support each of the variously-sized unit liquid crystal display panels **7800**, **7830**, and **7840** stably by making the panels adhere to the tables by suction.

Therefore, the grinding table apparatus for the liquid crystal display panel and the grinder apparatus using the same enable to cope with various sizes of the unit liquid crystal display panels without replacing the grinding table by the corresponding one, thereby allowing grinding of all the edges of the liquid crystal display panel simultaneously. Compared to the foregoing embodiment of the present invention having the first and second grinding units to grind the long and short sides of the liquid crystal display panel respectively and the rotating unit to turn the unit liquid crystal display panel at 90°, this embodiment of the present invention enables the grinding process to be carried out conveniently and rapidly.

FIGS. **206**A to **206**C illustrate exemplary diagrams for grinding tables of a first grinding unit moving in farther or closer directions reciprocally to adapt with a size of a liquid crystal display panel according to a further embodiment of the present invention.

Referring to FIGS. **206**A to **206**C, four movable grinding tables **7912** to **7915** are displaced in farther or closer directions by predetermined distances to adapt for grinding edges of variously-sized unit liquid crystal display panels **7900**, **7930**, and **7940**, respectively.

Besides, the grinder apparatus according to this embodiment of the present invention further includes a support table **7950** at a center of the four movable grinding tables **7912** to **7915**. The support table **7950** maybe fixed at the center of the moveable grinding tables **7912** to **7915**.

The support table **7950** supports each of the unit liquid crystal display panels **7900**, **7930**, and **7940** at the center when the grinding tables **7912** to **7915** are displaced father away from each other, thereby preventing bending, drooping or warping of the corresponding unit liquid crystal display panel **7900**, **7930**, or **7940**.

Preferably, a plurality of suction holes **7919** are formed at surfaces of the grinding tables **7912** to **7915** and support table **7950** so as to support each of the variously-sized liquid crystal display panels **7900**, **7930**, and **7940** stably.

Accordingly, the grinding table for the liquid crystal display panel and the grinder apparatus using the same moves at least two of its grinding tables in a farther or closer direction to cope with various sizes of unit liquid crystal display panels, thereby enabling grinding of the edges of the corresponding liquid crystal display panel.

And, the present invention eliminates the need to replace the grinding tables, thereby reduces process time and improves productivity.

Moreover, the present invention does not require a plurality of grinding tables to cope with the various sizes of the unit liquid crystal display panels. Thus investment costs are reduced and excessive space for storing the grinding tables is not required, which makes the grinding table apparatus and grinder apparatus according to the present invention advantageous in a practical use of space.

FIG. **207** is a schematic view illustrating an indicator having a pattern for detecting a grinding amount of an LCD panel in accordance with the present invention.

As shown in FIG. **207**, a unit LCD panel **8000** includes a picture display unit **8013** having liquid crystal cells arranged in a matrix form, a gate pad unit **8013** for connecting a plurality of gate lines GL**1** to GLm of the picture display unit **8014** to a gate driver integrated circuit (not shown), to which a gate signal is applied, and a data pad unit **8015** for connecting a plurality of data lines DL**1** to DLn of the picture display unit **8013** to a data driver integrated circuit (not shown), to which the picture information is applied. At this time, the gate pad unit **8014** and the data pad unit **8015** are formed at the marginal portion of the thin film transistor array substrate **8001** protruding to be longer than the color filter substrate **8002**.

At the region where the data lines DL**1** to DLn and the gate lines GL**1** to GLm vertically cross one another, a thin film transistor is formed for switching the liquid crystal cell. A pixel electrode is formed to be connected to the thin film transistor for driving the liquid crystal cell. A passivation film is formed at the entire surface to protect the data lines DL**1** to DLn, the gate lines GL**1** to GLm, the thin film transistors and the electrodes.

Also, a shorting line (not shown) for electrically shorting out the conductive films is formed at the marginal portion of the thin film transistor array substrate **8001**, to eliminate static electricity which may be generated in forming conductive films, such as a data line, a gate line, and an electrode, on the thin film transistor array substrate **8001**.

At the color filter substrate **8002** of the picture display unit **8013**, a plurality of color filters are coated and separated by cell regions with a black matrix. A common transparent electrode corresponding to the pixel electrode is formed at the thin film transistor array substrate **8001**.

A cell gap is formed between the thin film transistor array substrate **8001** and the color filter substrate **8002** so that the two substrates are spaced apart and face into each other. The thin film transistor array substrate **8001** and the color filter substrate **8002** are attached by a sealant (not shown) formed at the exterior of the picture display unit **8013**. A liquid crystal layer (not shown) is formed at the space between the thin film transistor array substrate **8001** and the color filter substrate **8002**.

On the other hand, a predetermined number of tap marks **8050***a* to **8050***j* are formed and separated from one another for aligning the data lines DL**1** to DLn, the gate lines GL**1** to GLm to contact a plurality of pins of the gate driver integrated circuit and the data driver integrated circuit. For example, as shown in FIG. **207**, three tap marks **8050***a* to **8050***c* are formed and separated from one another at the gate pad unit **8014** and seven tap marks **8050***d* to **8050***j* are formed to be separated from one another at the data pad unit **8015**.

The above unit LCD panel **8000** must be ground to have a sloped edge from the end of the unit LCD panel **8000** to the grinding line R**1**, as shown in the expansion region EX**1** of FIG. **207**. However, the actual ground line of the unit LCD panel **8000** has an error margin D**1** from the grinding line R**1**. Thus, when the error is beyond the error margin D**1**, it is determined that the grinding is defective.

Conventionally, an operator must take out the ground unit liquid crystal display panel **8000** from the production line for a predetermined period. The selected liquid crystal display panel is measured with an additional apparatus to determine whether the actual ground line of the unit LCD panel **8000** is beyond the error margin D**1** using a high magnifying power camera or a projector positioned at the measuring apparatus.

However, in the embodiment of the present invention, as shown in FIG. **207**, a pattern **8020** for judging grinding amount is formed at a region corresponding to an error margin D**1**. A grinding line R**1** is formed in the middle of the error margin D**1**. At this time, the error margin D**1** is set to be about ±100 μm from the grinding line R**1**. It is desirable that when the pattern for judging the grinding amount **8020** is formed at the gate pad unit **8014**, the pattern and the gate lines GL**1** to GLm are formed at the same time. When the pattern for judging the grinding amount **8020** is formed at the data pad unit **8015**, the pattern and the data lines DL**1** to DLn are formed at the same time.

Therefore, whether the actual ground line of the unit liquid crystal display panel **8000** is beyond the error margin D**1** is determined by naked eyes.

Namely, if the observed pattern for deciding a grinding amount **8020** of the completed unit LCD panel **8000** is not ground at all, it should be more ground. If the observed pattern is completely ground so that no portion of the pattern remains, grinding is too excessive.

With the pattern for deciding a grinding amount of the LCD panel and a method for detecting grinding failure using the same in accordance with the first embodiment of the present invention, an additional measuring instrument is not required and the grinding failure is determined for all of the unit LCD panels **8000** unlike the conventional LCD and the method thereof.

FIG. **208** is a schematic view showing an indicator having a pattern for detecting a grinding amount of the LCD panel in accordance with the present invention.

The unit LCD panel **8000** in FIG. **208** includes a picture display unit **8013** having liquid crystal cells arranged in a matrix form, a gate pad unit **8014** for connecting a plurality of gate lines GL**1** to GLm of the picture display unit **8013** to a gate driver integrated circuit (not shown), to which a gate signal is applied, and a data pad unit **8015** for connecting a plurality of data lines DL**1** to DLn of the picture display unit **8013** to a data driver integrated circuit (not shown), to which picture information is applied. The gate pad unit **8014** and the data pad unit **8015** are formed at the marginal portion of the thin film transistor array substrate **8001** having vertical and horizontal side edges from the color filter substrate **8002**.

At the region where the data lines DL**1** to DLn and the gate lines GL**1** to GLm vertically cross one another, a thin film transistor is formed for switching the liquid crystal cell. A pixel electrode is formed to be connected to the thin film transistor for driving the liquid crystal cell. A passivation film is formed at the entire surface to protect the data lines DL**1** to DLn, the gate lines GL**1** to GLm, the thin film transistors, and the electrodes.

Also, a shorting line (not shown) for electrically shorting out the conductive films is formed at the marginal portion of the thin film transistor array substrate **8001** to remove static electricity which may be generated in forming conductive films, such as a data line, a gate line, and an electrode on the thin film transistor array substrate **8001**.

At the color filter substrate **8002** of the picture display unit **8013**, a plurality of color filters formed to be separated by cell regions with a black matrix and a common transparent electrode corresponding to the pixel electrode are formed at the thin film transistor array substrate **8001**.

A cell gap is formed between the thin film transistor array substrate **8001** and the color filter substrate **8002** so that the two substrates are spaced apart and face into each other. The thin film transistor array substrate **8001** and the color filter substrate **8002** are attached to each other by a sealant (not shown) formed at an exterior of the picture display unit **8013**. A liquid crystal layer (not shown) is formed at the space between the thin film transistor array substrate **8001** and the color filter substrate **8002**.

A plurality of tap marks **8050***a* to **8050***j* are formed separated from one another for aligning the data lines DL1 to DLn, the gate lines GL**1** to GLm to contact a plurality of pins of the gate driver integrated circuit and the data driver integrated circuit. For example, as shown in FIG. **208**, three tap marks **8050***a* to **8050***c* may be formed and separated apart at the gate pad unit **8014** and seven tap marks **8050***d* to **8050***j* are formed separated regularly at the data pad unit **8015**.

The above unit LCD panel **8000** must be ground to have a sloped edge from the end END**1** of the unit LCD panel **8000** to the grinding line R**1**, as shown in the expansion region EX**1** of FIG. **207**. The actual ground line of the unit LCD panel **8000** may have an error margin D**1** from the grinding line R**1**. When the actual ground line is outside the error margin D**1**, it is determined that the grinding is defective.

In another embodiment of the present invention, a plurality of patterns **8120***a* to **8120***o* for detecting a grinding amount are formed to be apart at the region of the error margin D1 including the grinding line R1 in the middle of the error margin region.

The patterns **8120***a* to **8120***i* for detecting a grinding amount are examined by naked eyes by dividing the distance, such as about ±100 μm from the grinding line R1 in the middle of the error margin region D**1**, into a constant scale. Thus, the patterns may have a width of about 200 μm.

For instance, as shown in FIG. **208**, when three patterns **8120***g* to **8120***i* for detecting a grinding amount are formed at the central portion, the first region is in the direction to the end END**1** of the unit LCD panel **8000** and the second region is in the direction to the tap mark **8050***j*. The first and second regions are divided by the grinding line R**1**.

The first region having the patterns **8120***b* to **8120***f* for detecting a grinding amount is formed to be closer to the tap mark **8050***j*. The pattern **8120***a*, which is the same as the pattern **8120***b*, is formed at the furthermost from the central patterns **8120***g* to **8120***i*.

The second region having the patterns **8120***j* to **8120***n* for detecting a grinding amount is formed to be closer to the end END**1** of the unit LCD panel **8000** at a constant distance level. Similarly, the pattern **8120***o*, which is the same as the pattern **8120***n*, is formed at the furthermost from the central patterns **8120***g* to **8120***i*.

The patterns **8120***a* and **8120***o* formed at the furthermost outside are formed for a reliable decision on grinding failure while the three patterns **8120***g* to **8120***i* formed at the central portion are to determine whether the actual ground line and the grinding line R**1** of the unit LCD panel **8000** are identical with each other.

The actual ground amount of the unit LCD panel **8000** may be detected by a plurality of displaying marks. For example, numerical symbols such as (−10, −8, −6, −4, −2, −0, 2, 4, 6, 8, 10) may be used at a constant scale at the marginal portion of the region where the tap mark **8050***j* is formed corresponding to the patterns **8120***a* to **8120***o*. If the error margin D**1** is about ±100 μm from the grinding line R**1**, the scale of the number (−10, −8, −6, −4, −2, −0, 2, 4, 6, 8, 10) is about 10 μm.

In accordance with this embodiment of the present invention, it can be determined whether the actual ground line of the unit LCD panel **8000** is beyond the error margin D1 through the examination with naked eyes.

For example, when the patterns **8120***a* and **8120***b* at the side marginal portion are not observed and the patterns **8120***a* to **8120***o* of the completed unit LCD panel **8000** are observed, it is determined to be defective because grinding is excessive.

Conversely, when the patterns **8120**a and **8120**o at the other side marginal portion are not ground at all, it is determined to be defective because more grinding is needed.

The actual ground line and the grinding line R**1** of the unit LCD panel **8000** may be checked by the examination with naked eyes. Moreover, the actual ground amount of the unit LCD panel **8000** may be detected within an error margin of about 20 μm by checking the numbers (−10, −8, −6, −4, −2, −0, 2, 4, 6, 8, 10) corresponding to the patterns **8120**a to **8120**o with a high magnifying power camera.

The error margin of about 20 μm may be reduced when the divided region is formed to have more patterns **8120**a to **8120**o, thereby forming more minute scales.

Therefore, when the error margin D**1** is initially set to be about ±100 μm from the grinding line R**1** and then changed to about ±80 μm, an operation can still be performed by checking the numbers (−10, −8, −6, −4, −2, −0, 2, 4, 6, 8, 10) corresponding to the patterns **8120**a to **8120**o with a high magnifying power camera according to the second embodiment of the present invention.

Therefore, according to the present invention, productivity is improved because the operator does not have to take out the unit LCD panel from the production line for examining the grinding amount of the cut unit LCD panel to measure the grinding amount. Also, since a measuring apparatus is not required, installing cost and maintaining and repairing costs are reduced.

Moreover, since the grinding failure for all unit LCD panels can be determined by a simple examination with naked eyes, reliability of the examination is improved unlike the conventional method requiring to take out the unit LCD panel for a period of time.

Conventionally, when a grinding failure occurs, the fabrication process must be stopped to examine the entire panel including both the sampled and unsampled panels. Therefore, some completed unit panels may have to be disposed due to the grinding failures. Accordingly, there is a significant waste of raw materials and time. However, the present invention prevents the above problems by inspecting the entire unit on the manufacturing line.

By using the pattern for deciding a grinding amount of the LCD panel and the method for detecting a grinding failure using the same, the detecting process is performed without any difficulty when the error margin becomes narrow, because the actual ground amount of the unit LCD panel is detected with the numbers corresponding to the pattern for judging the grinding amount.

It will be apparent to those skilled in the art that various modifications and variation can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A method of forming a liquid crystal display device, comprising:

providing a first substrate and a second substrate, wherein at least one of the first and second substrates supports a plurality of structures creating a pattern extending along a first direction;

providing a sealant material on one of the first and second substrates;

dispensing a plurality of liquid crystal drops on one of the first and second substrates, wherein a first distance between adjacent ones of the liquid crystal drops along the first direction is different than a second distance between adjacent ones of the liquid crystal drops along a second direction; and

bonding the first and second substrates to each other via the sealant material,

wherein a dispensed pattern of the plurality of liquid crystal drops is a dumbbell shape or a lightning shape.

2. The method according to claim **1**, wherein the second direction is perpendicular to the first direction.

3. The method according to claim **1**, wherein the plurality of structures include gate lines crossing a plurality of data lines.

4. The method according to claim **1**, wherein the plurality of structures include color filters.

5. The method according to claim **1**, wherein the plurality of structures include structures capable of inducing an alignment direction.

6. The method according to claim **1**, wherein the plurality of structures include grooves in an alignment layer.

7. The method according to claim **1**, wherein the plurality of structures include structures capable of distorting an electric field.

8. The method according to claim **1**, wherein the plurality of structures include protrusions.

9. The method according to claim **1**, wherein the plurality of structures include slits formed in an electrode.

10. The method according to claim **1**, wherein the first distance is greater than the second distance.

11. The method according to claim **1**, wherein a distance between adjacent ones of the liquid crystal drops is about 8 to about 17 mm.

12. The method according to claim **1**, further comprising:

providing the sealant material on the first substrate; and

dispensing the plurality of liquid crystal drops on the second substrate.

13. A method of forming a liquid crystal display device, comprising

providing a first substrate and a second substrate;

providing a sealant material on one of the first and second substrates;

dispensing a plurality of liquid crystal drops on one of the first and second substrates; and

bonding the first and second substrates to each other via the sealant material, wherein the bonding includes spreading the plurality of liquid crystal drops over the first and second substrates at a first rate along a first direction and at a second rate along a second direction, wherein the first rate is different from the second rate,

wherein a dispensed pattern of the plurality of liquid crystal drops is a dumbbell shape or a lightning shape.

14. The method according to claim **13**, further including forming a plurality of structures on at least one of the first and second substrates creating a pattern extending along the first direction.

15. The method according to claim **14**, wherein the plurality of structures include alignment grooves within an alignment layer on at least one of the first and second substrates.

16. The method according to claim **14**, wherein the plurality of structures include a color filter layer on one of the first and second substrates.

17. The method according to claim **14**, wherein the plurality of structures include gate and data lines on one of the first and second substrates.

18. The method according to claim **14**, wherein the plurality of structures include slits in an electrode.

19. The method according to claim **14**, wherein the plurality of structures include protrusions on one of the first and second substrates.

20. The method according to claim **13**, wherein the dispensing provides a plurality of liquid crystal drops such that a first distance between adjacent ones of the liquid crystal drops along the first direction is different than a second distance between adjacent ones of the liquid crystal drops along the second direction.

21. The method according to claim **20**, wherein the first distance is greater than the second distance.

22. The method according to claim **13**, wherein a distance between adjacent ones of the liquid crystal drops is about 8 to about 17 mm.

23. The method according to claim **13**, wherein the first rate is greater than the second rate.

24. The method according to claim **13**, further comprising:

providing the sealant material on the first substrate; and

dispensing the plurality of liquid crystal drops on the second substrate.

* * * * *

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专利名称(译)	用于制造液晶显示装置的系统和方法		
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申请(专利权)人(译)	LG.PHILIPS LCD CO. , LTD.		
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摘要(译)

公开了一种使用液晶滴落制造液晶显示器的系统和使用该系统制造液晶显示器的方法。本发明包括在第一基板上滴下液晶的液晶形成线，在第二基板上形成密封剂的密封剂形成线，以及将两个基板彼此粘合并使密封剂硬化的粘合和硬化线，印刷密封剂将基板彼此粘合，并使密封剂硬化，以及将粘合的基板切割成面板单元并研磨和检查单元面板的检查工艺线。并且，GAP工艺线包括And，本发明包括使用分配器在第一基板上滴下LC，在第二基板上形成主UV硬化密封剂，在真空状态下将第一和第二基板彼此接合的工艺，对主要的UV硬化密封剂进行UV硬化，将粘合的基材切割成单元单元，研磨切割的基材，最后检查研磨的基材。