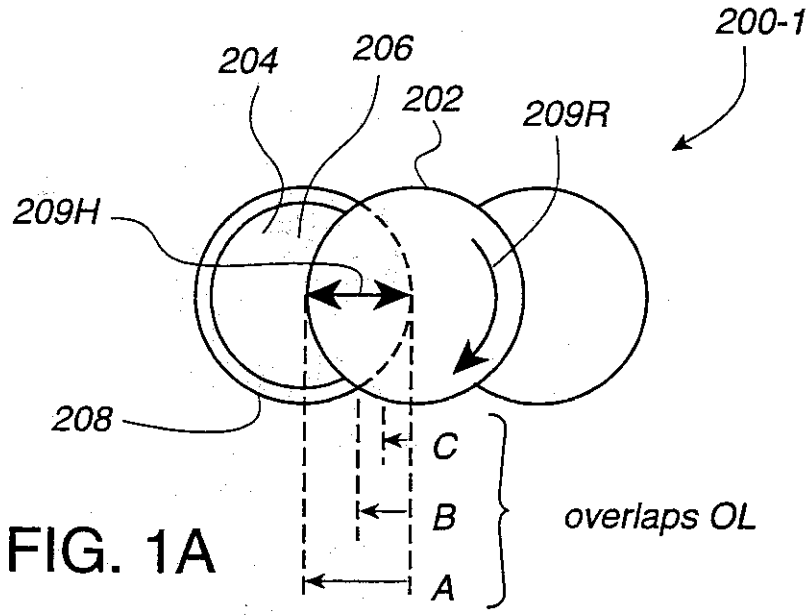

200-1
204
206
202
209R
209H
208
C
B
A
overlaps OL

FIG. 1A

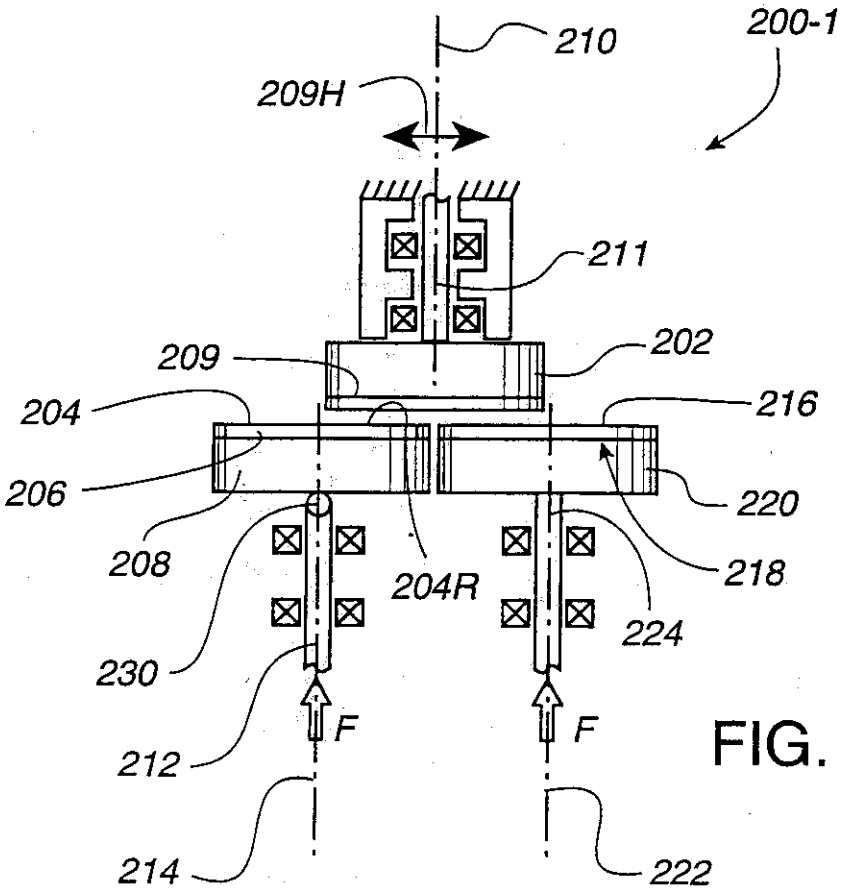

210
200-1
209H
211
209
202
204
216
206
220
208
204R
218
224
230
F
F
212
214
222

FIG. 1B

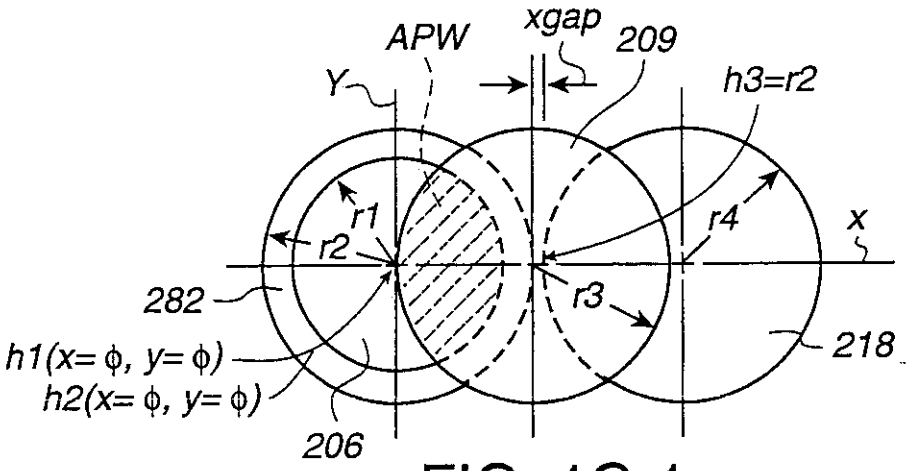


FIG. 1C-1

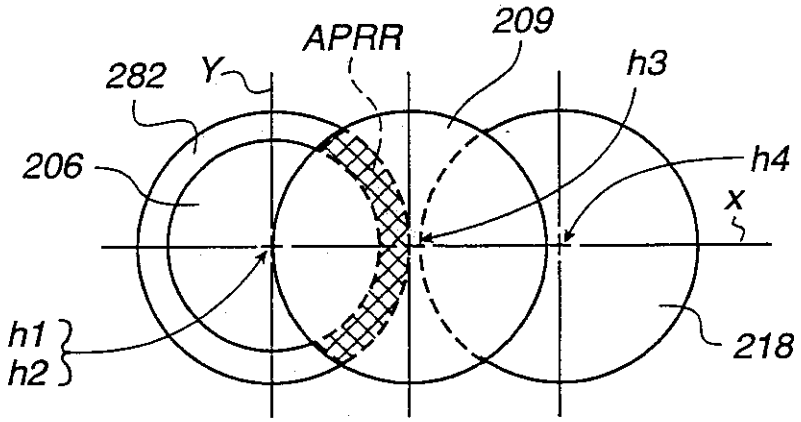


FIG. 1C-2

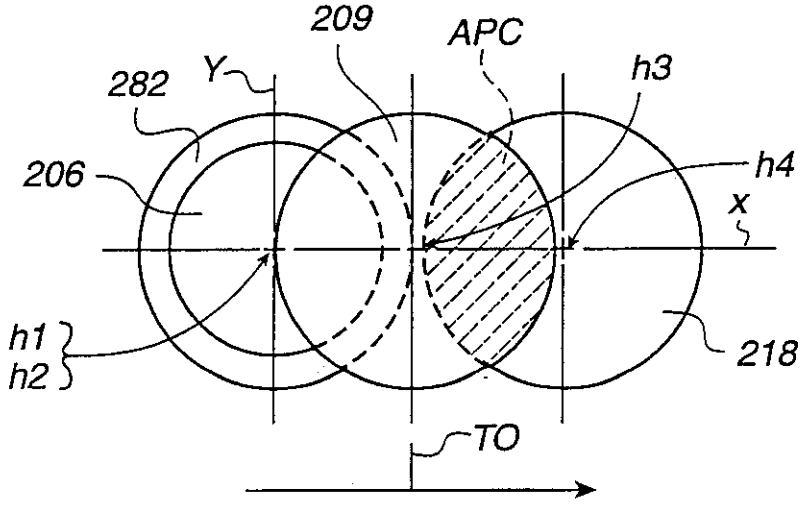


FIG. 1C-3

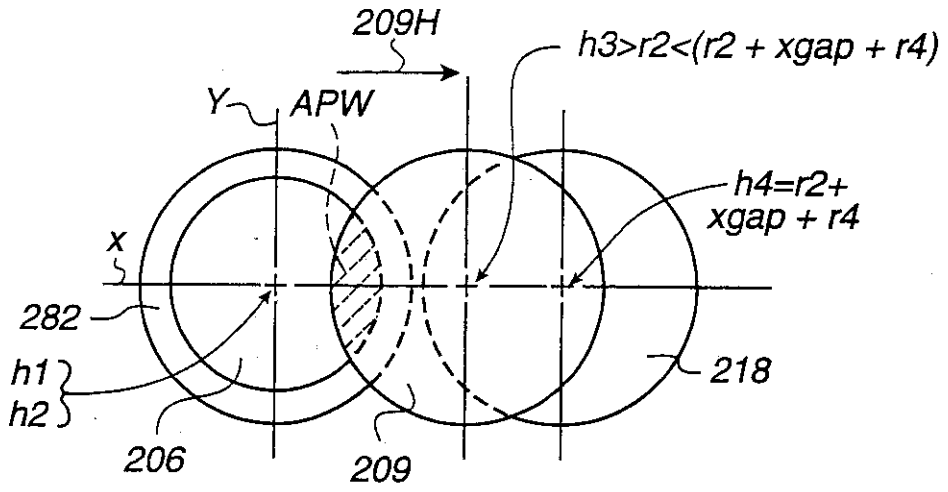


FIG. 1D-1

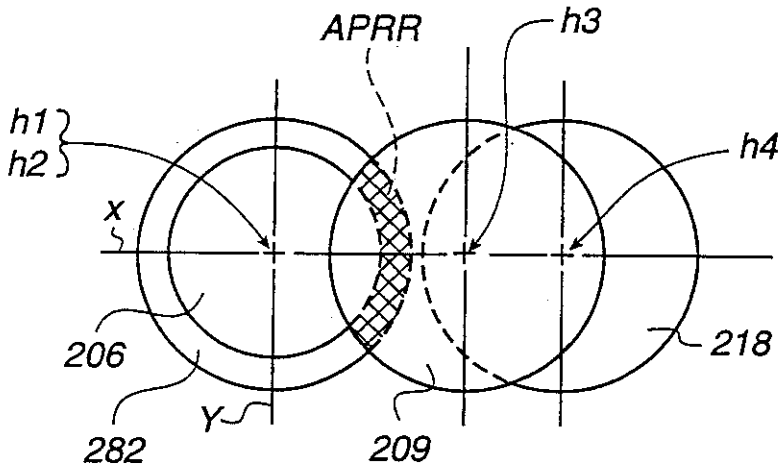


FIG. 1D-2

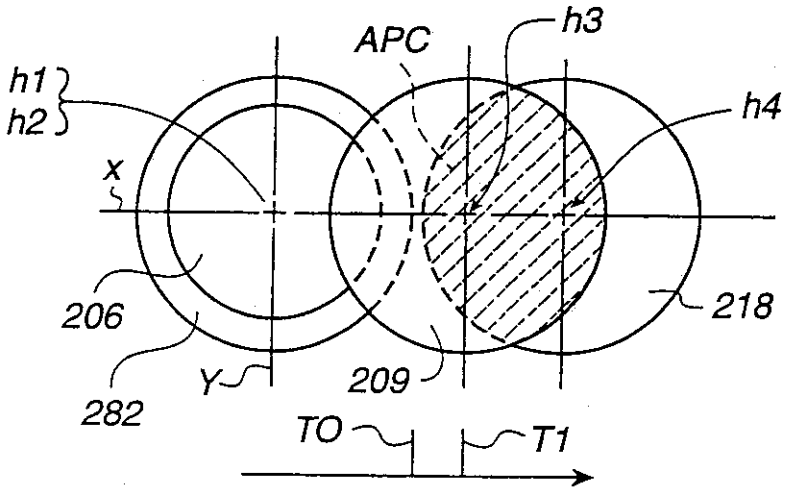


FIG. 1D-3

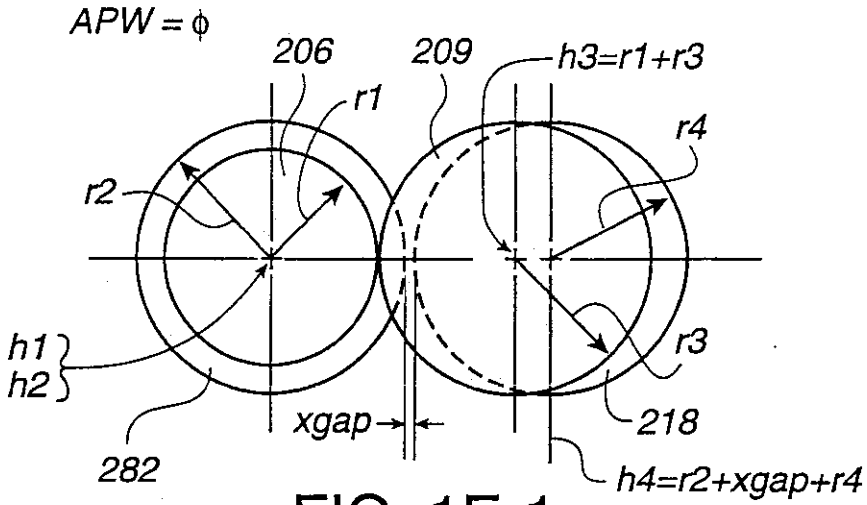


FIG. 1E-1

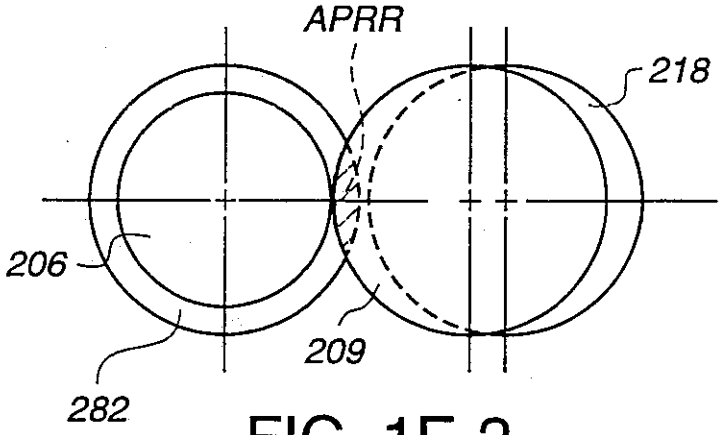


FIG. 1E-2

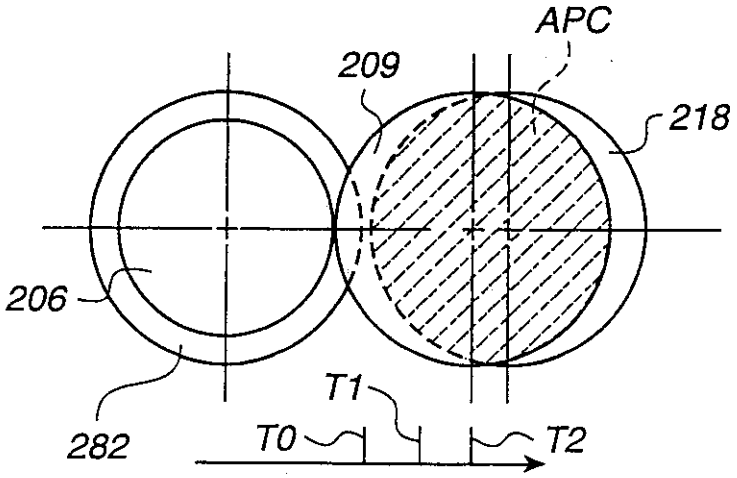


FIG. 1E-3

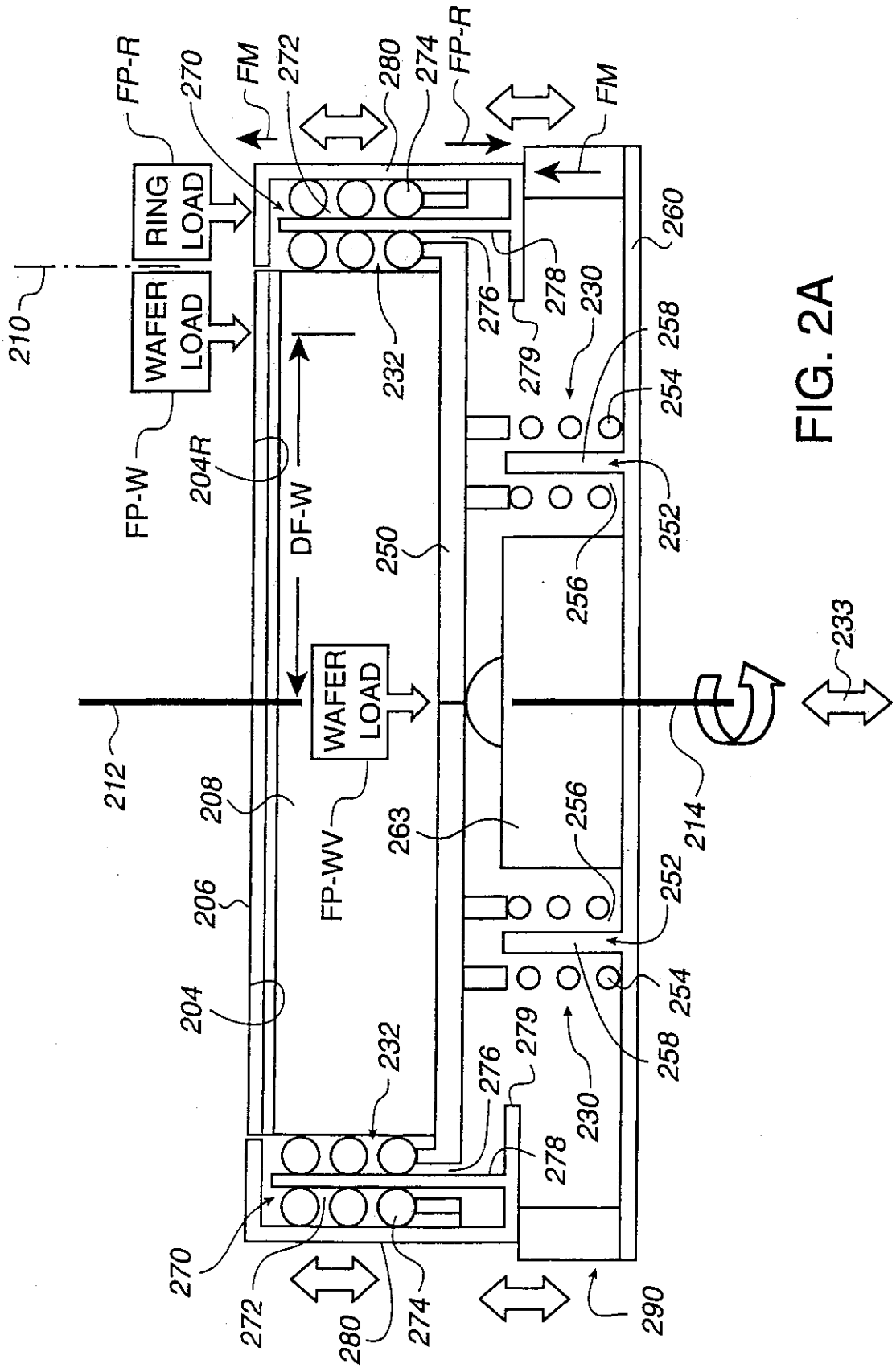

FP-R
270
FM
272
280
274
FP-R
FM
RING LOAD
WAFER LOAD
210
FP-W
204R
DF-W
232
276
278
279
230
258
254
260
250
252
256
WAFER LOAD
212
208
206
204
FP-WV
263
214
233
290

FIG. 2A

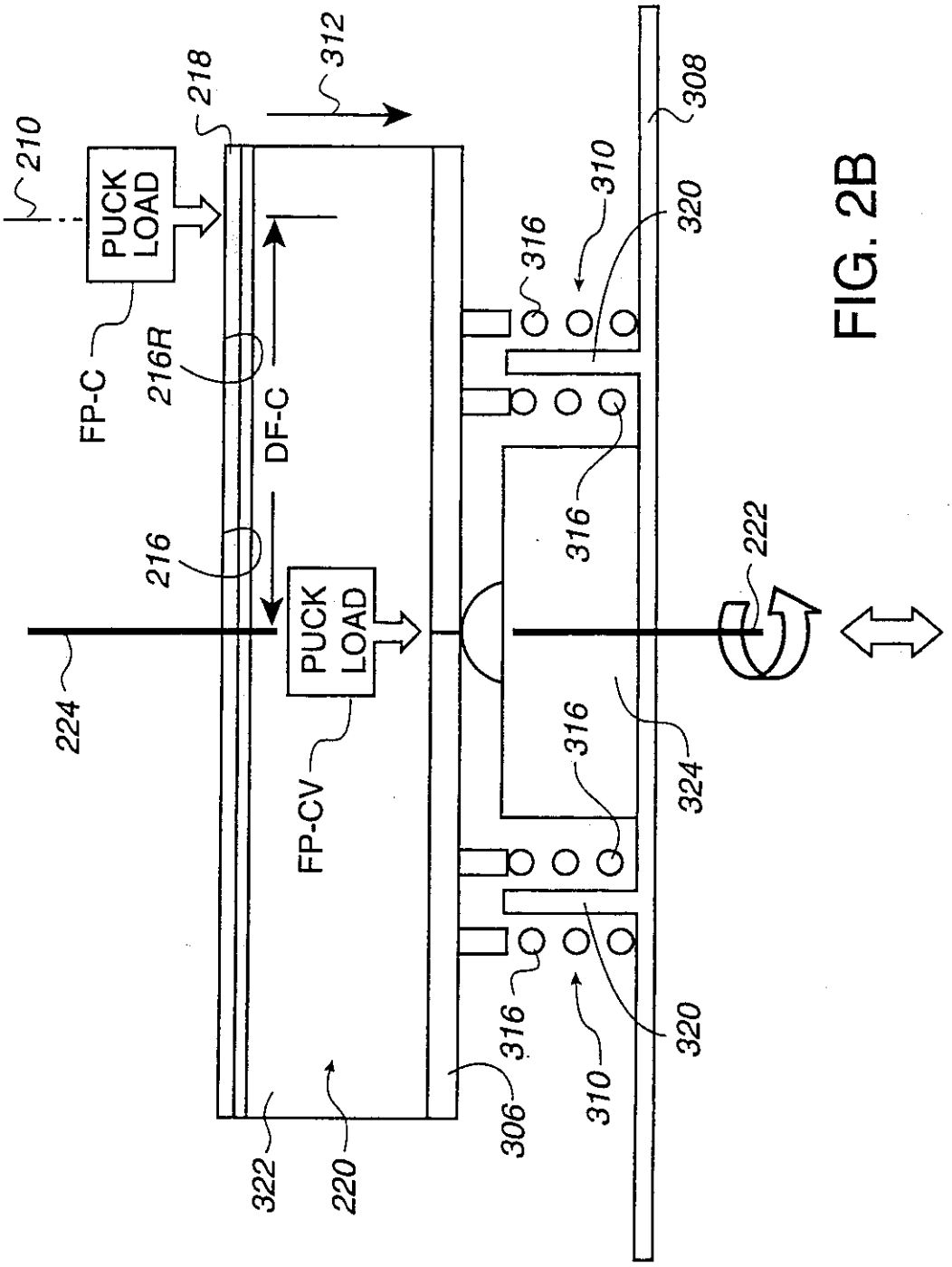

210
PUCK LOAD
218
312
308
310
320
316
FP-C
216R
DF-C
216
PUCK LOAD
222
224
316
316
FP-CV
324
316
320
310
306
322
220

FIG. 2B

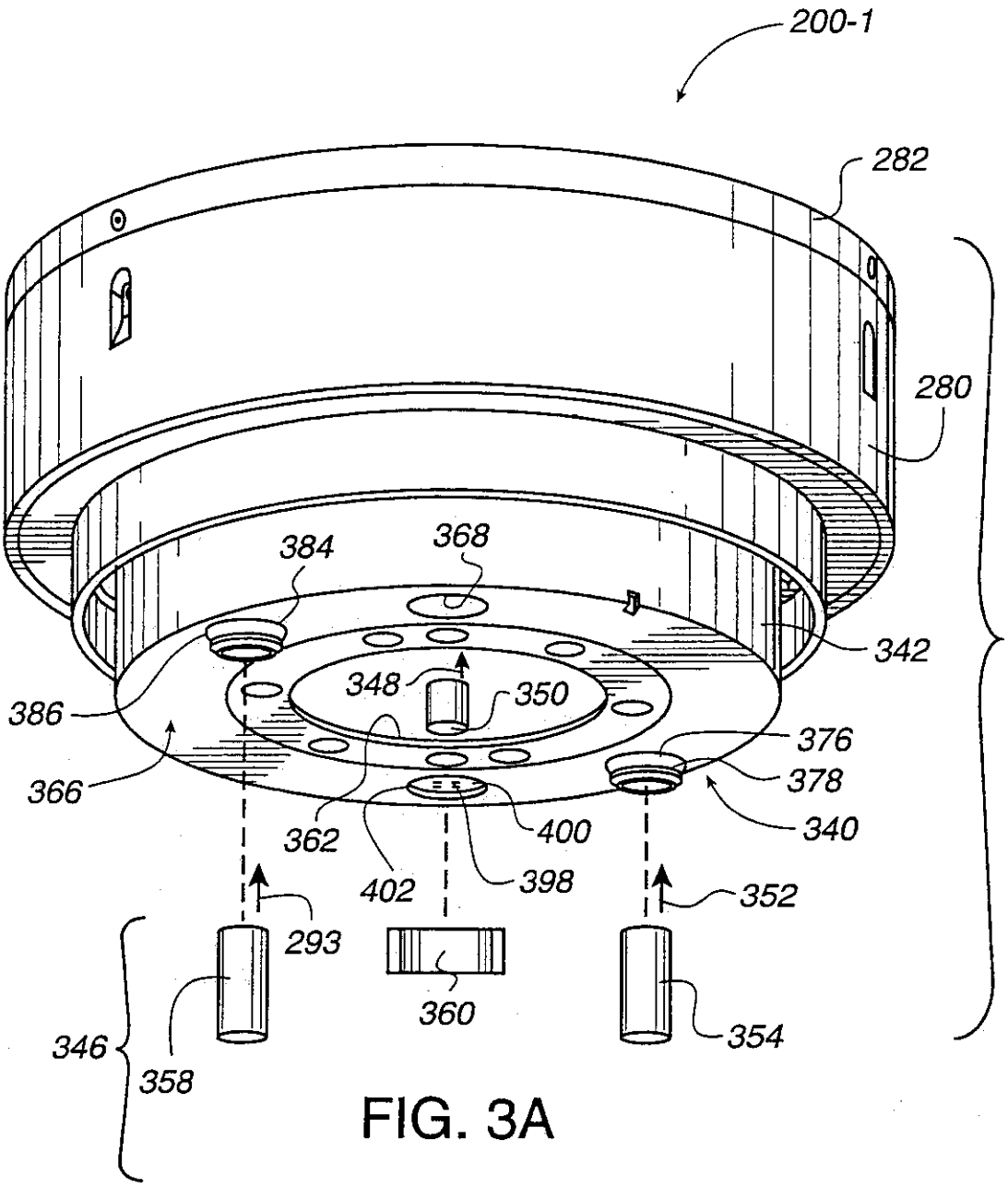

200-1
282
280
384
368
342
348
350
386
376
378
366
340
362
400
402
398
352
293
360
354
346
358

FIG. 3A

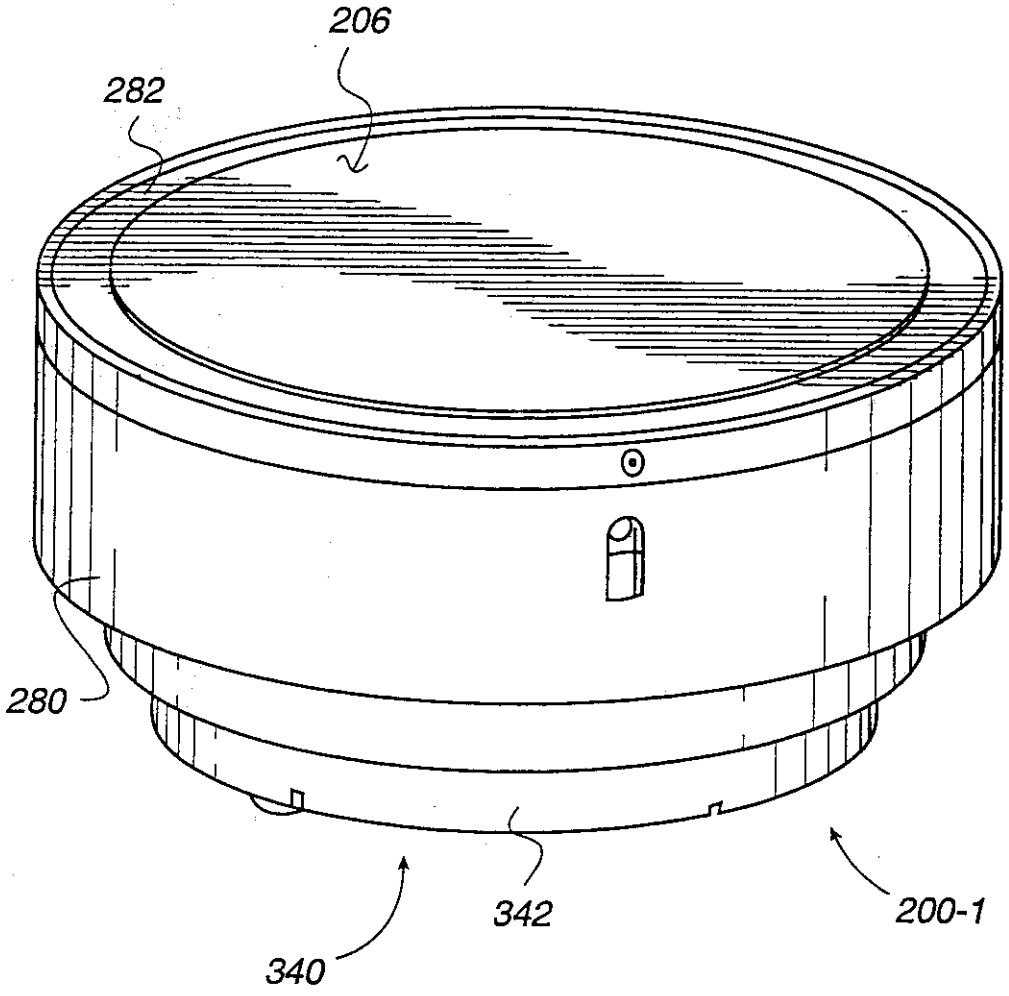


FIG. 3B

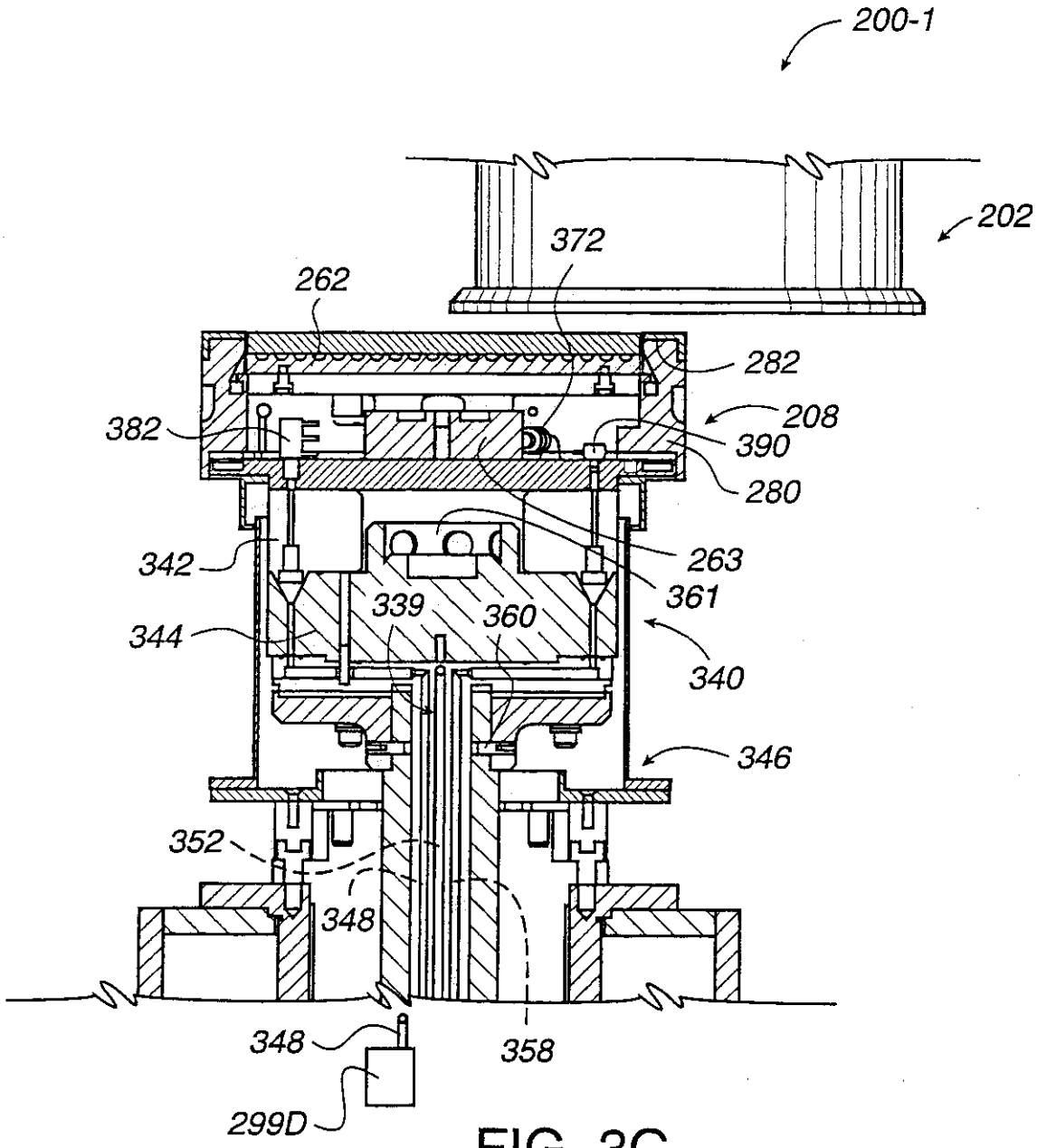

200-1
202
372
262
282
208
382
390
280
263
342
361
339
360
344
340
346
352
348
348
358
299D

FIG. 3C

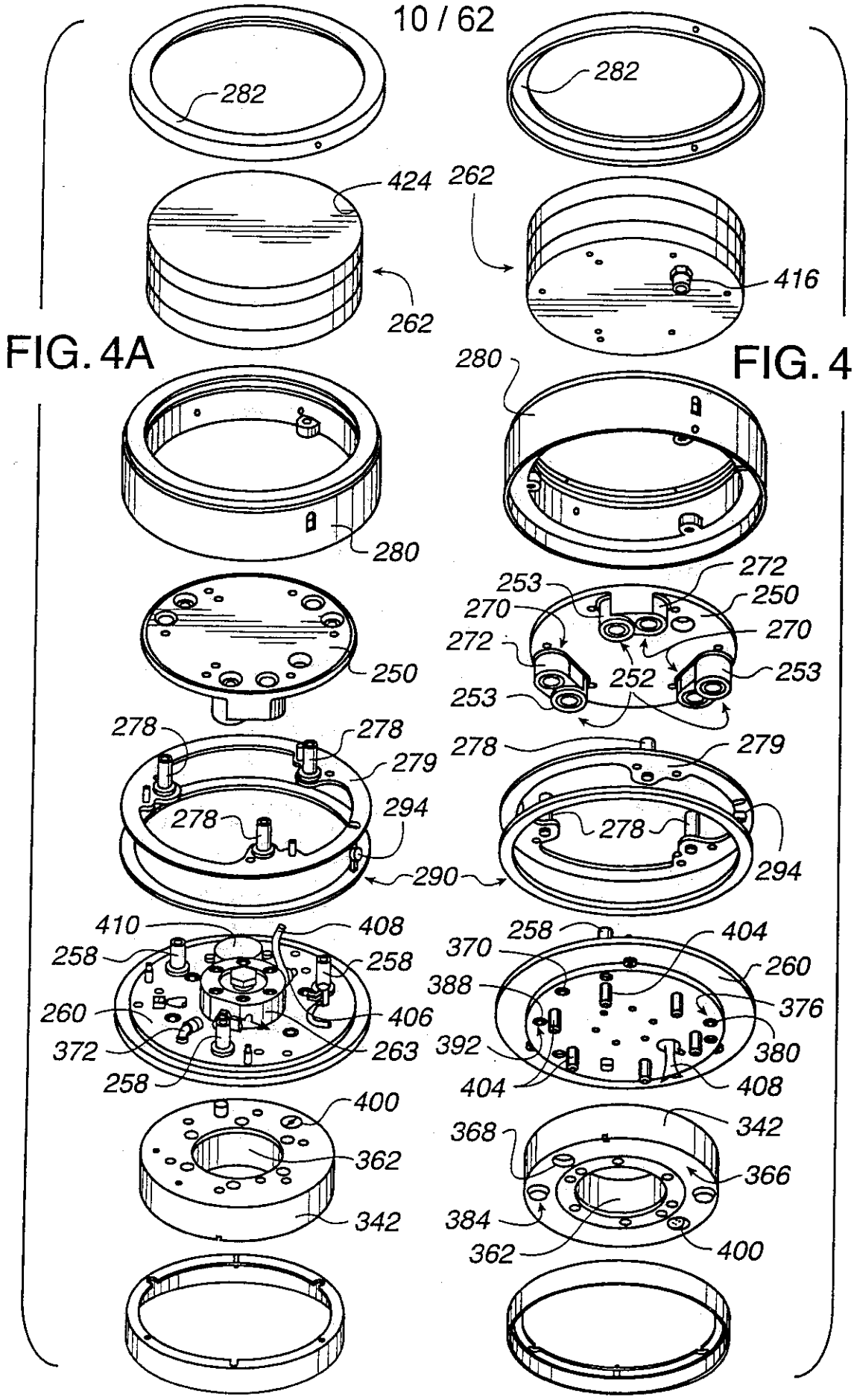

282
424
262
280
250
278
279
294
290
410
408
258
260
406
372
263
400
362
342
282
262
416
280
253
270
272
252
278
279
294
258
404
370
260
388
376
392
380
408
368
342
366
384
362
400

FIG. 4A

FIG. 4B

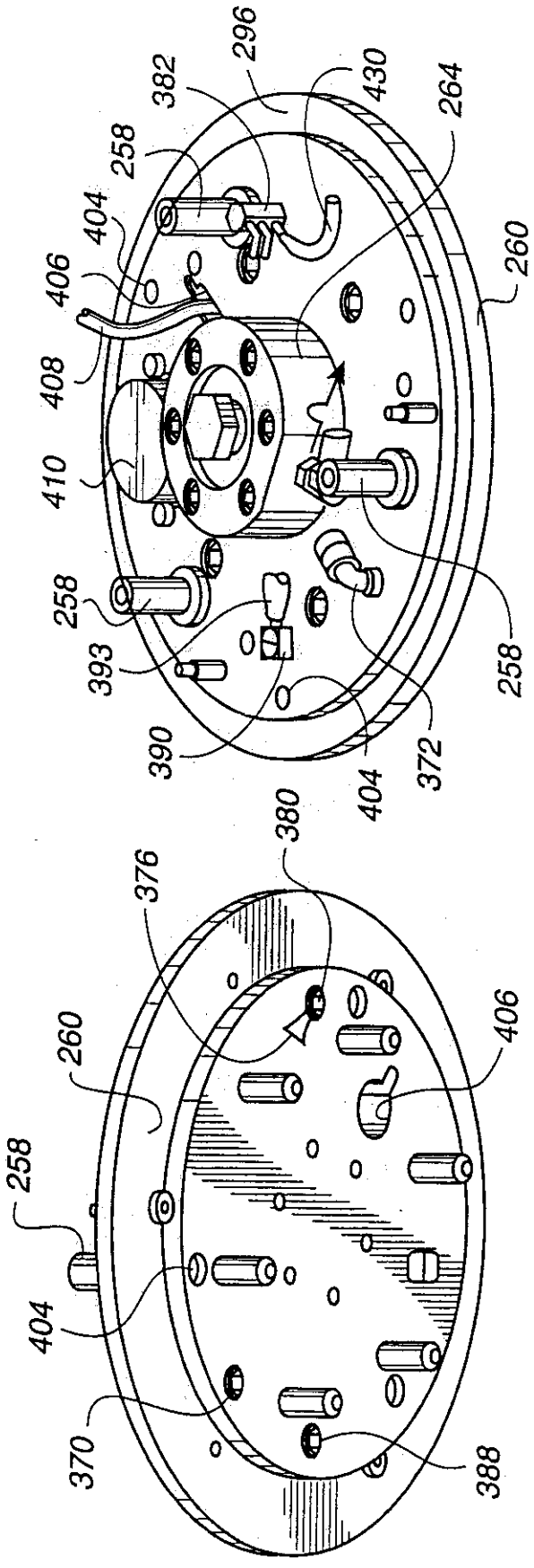


FIG. 5B-1

FIG. 5A-1

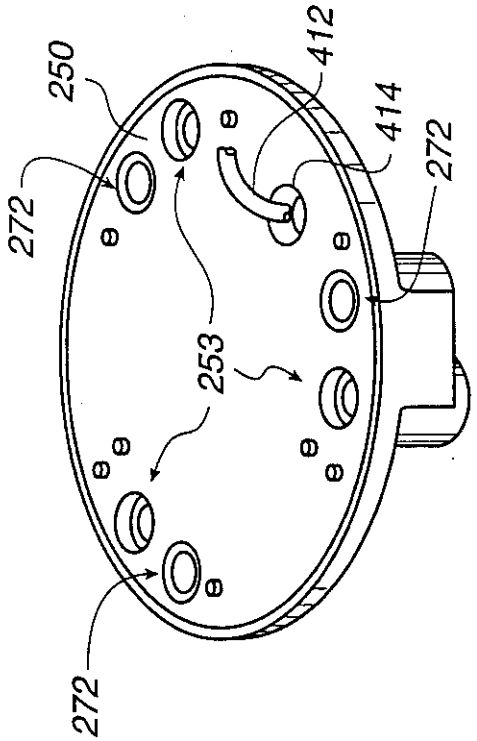


FIG. 5B-2

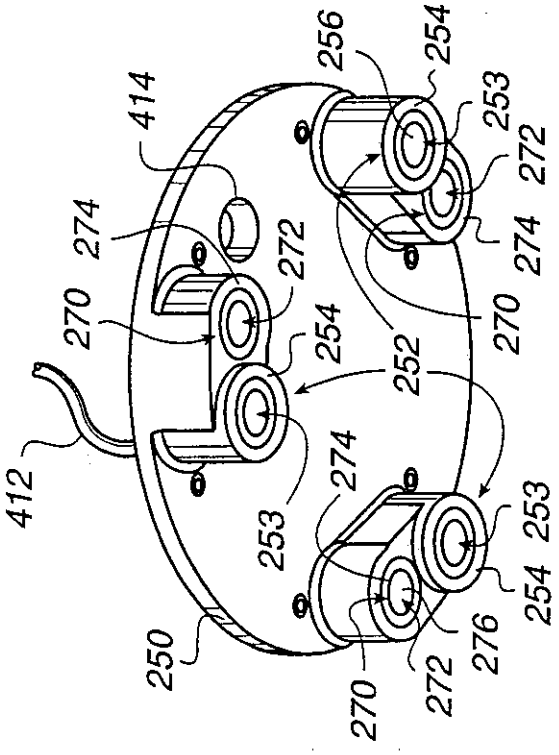


FIG. 5A-2

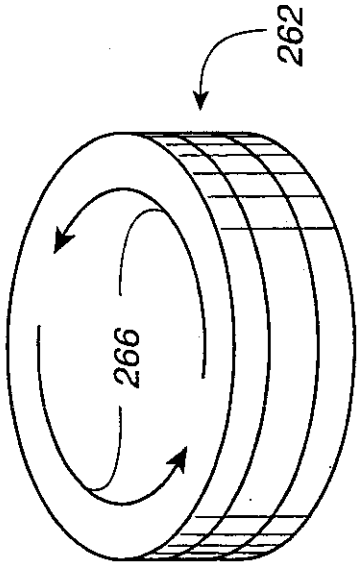


FIG. 5B-3

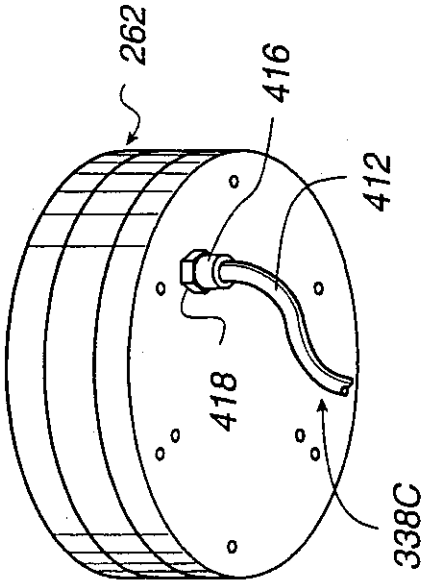


FIG. 5A-3

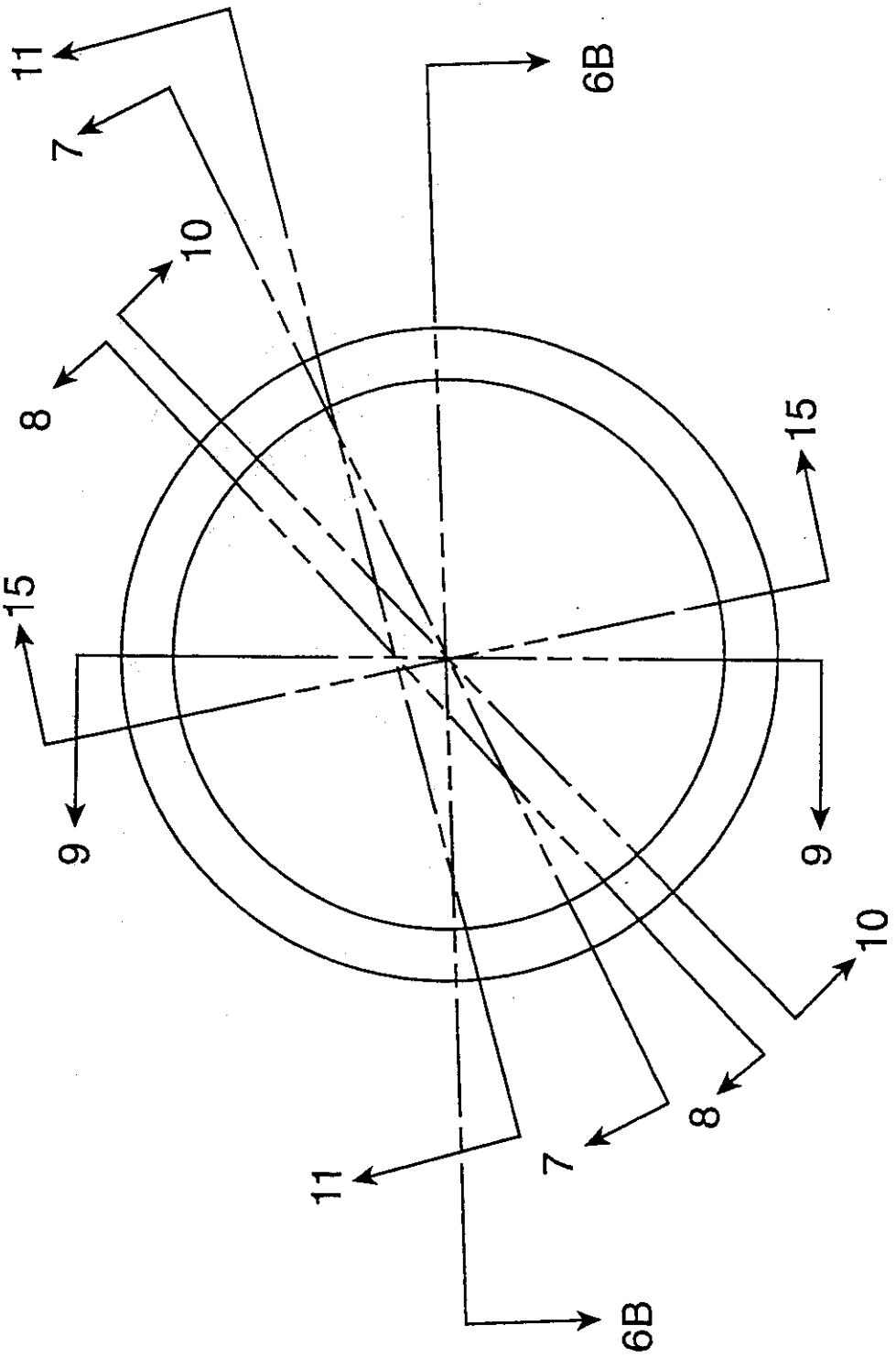


FIG. 6A

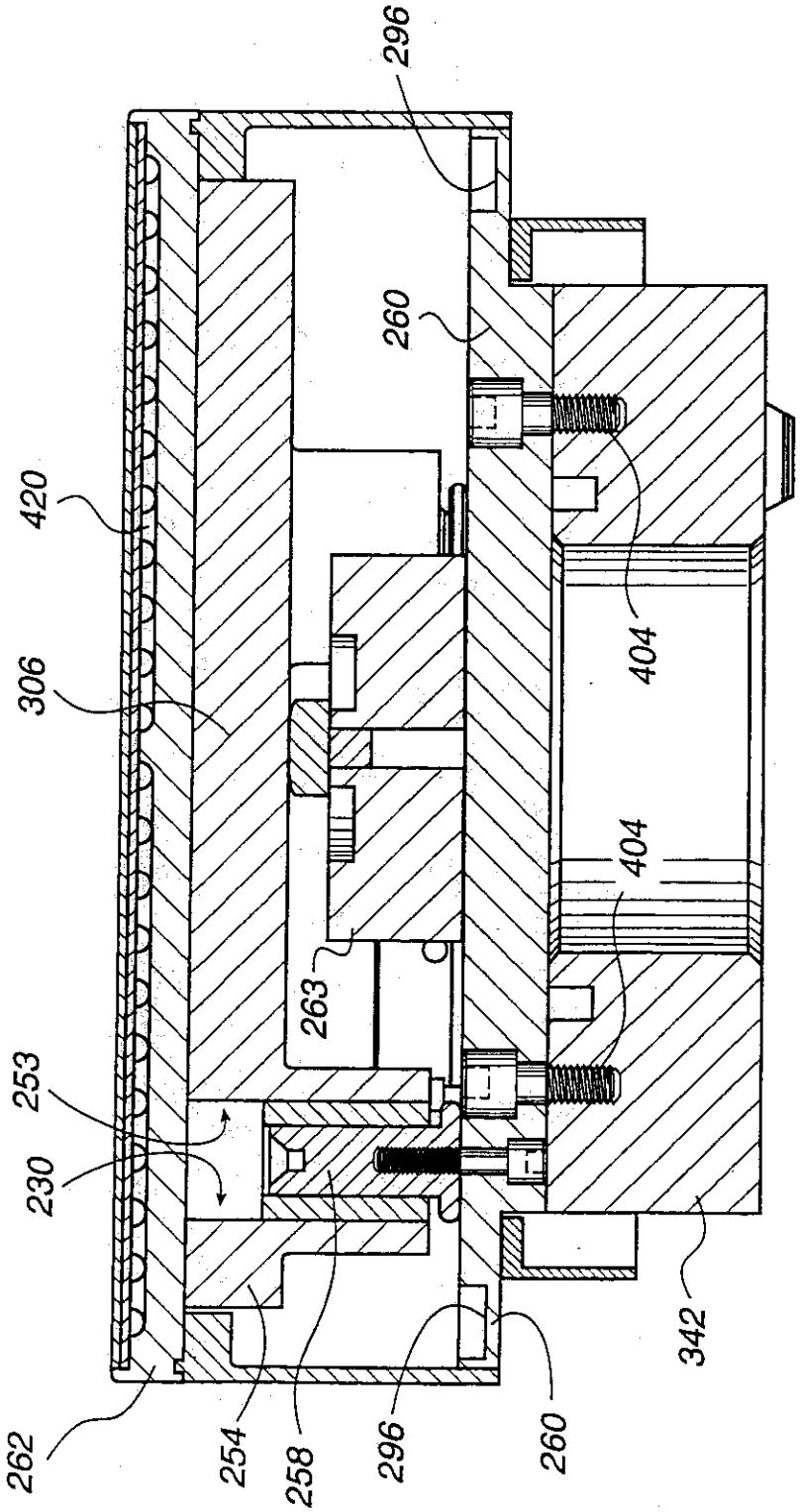


FIG. 6B

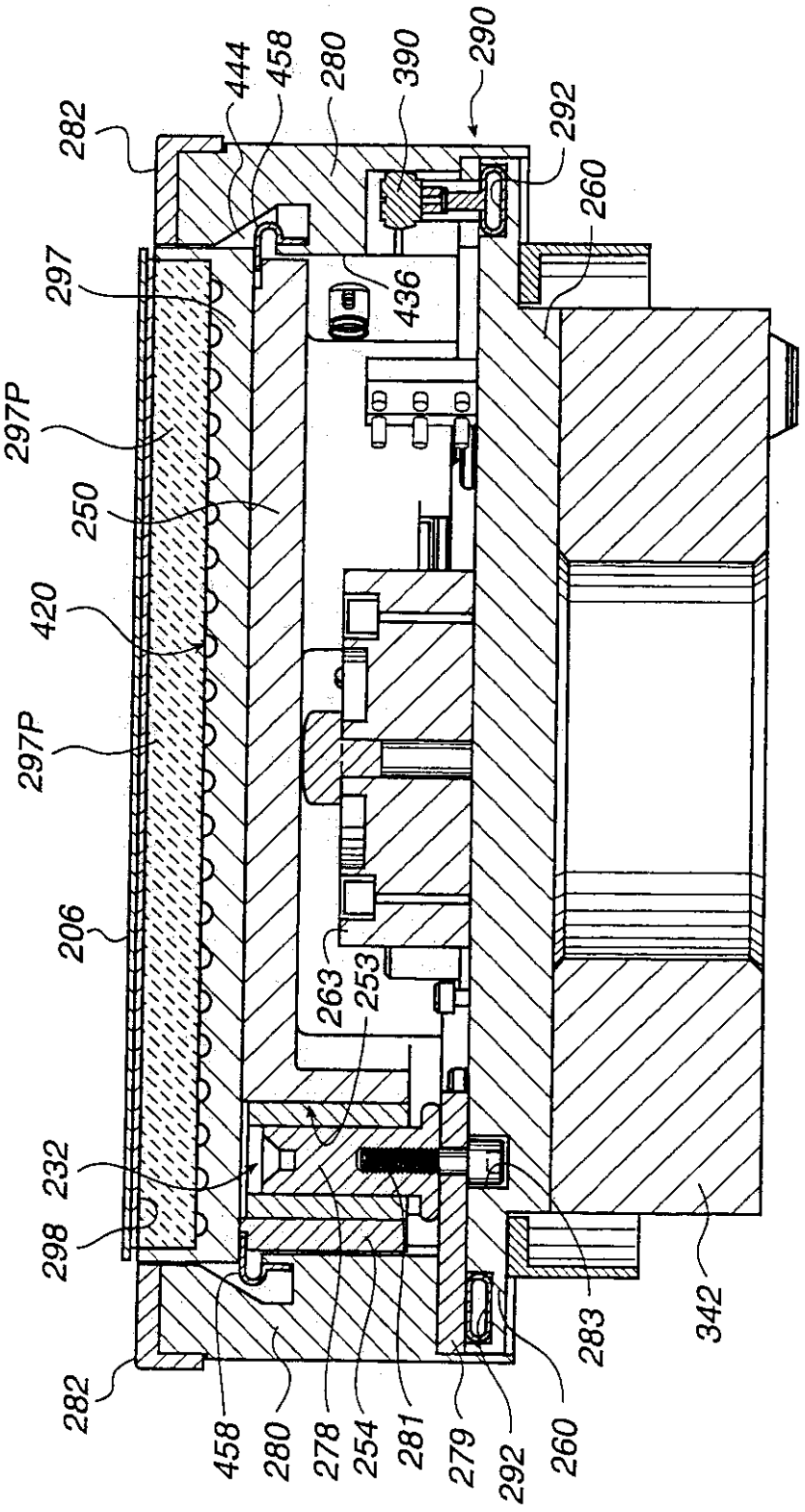

282
444
458
280
390
290
292
260
297
436
297P
250
420
297P
206
263
253
232
298
282
458
280
278
254
281
279
292
260
283
342

FIG. 7

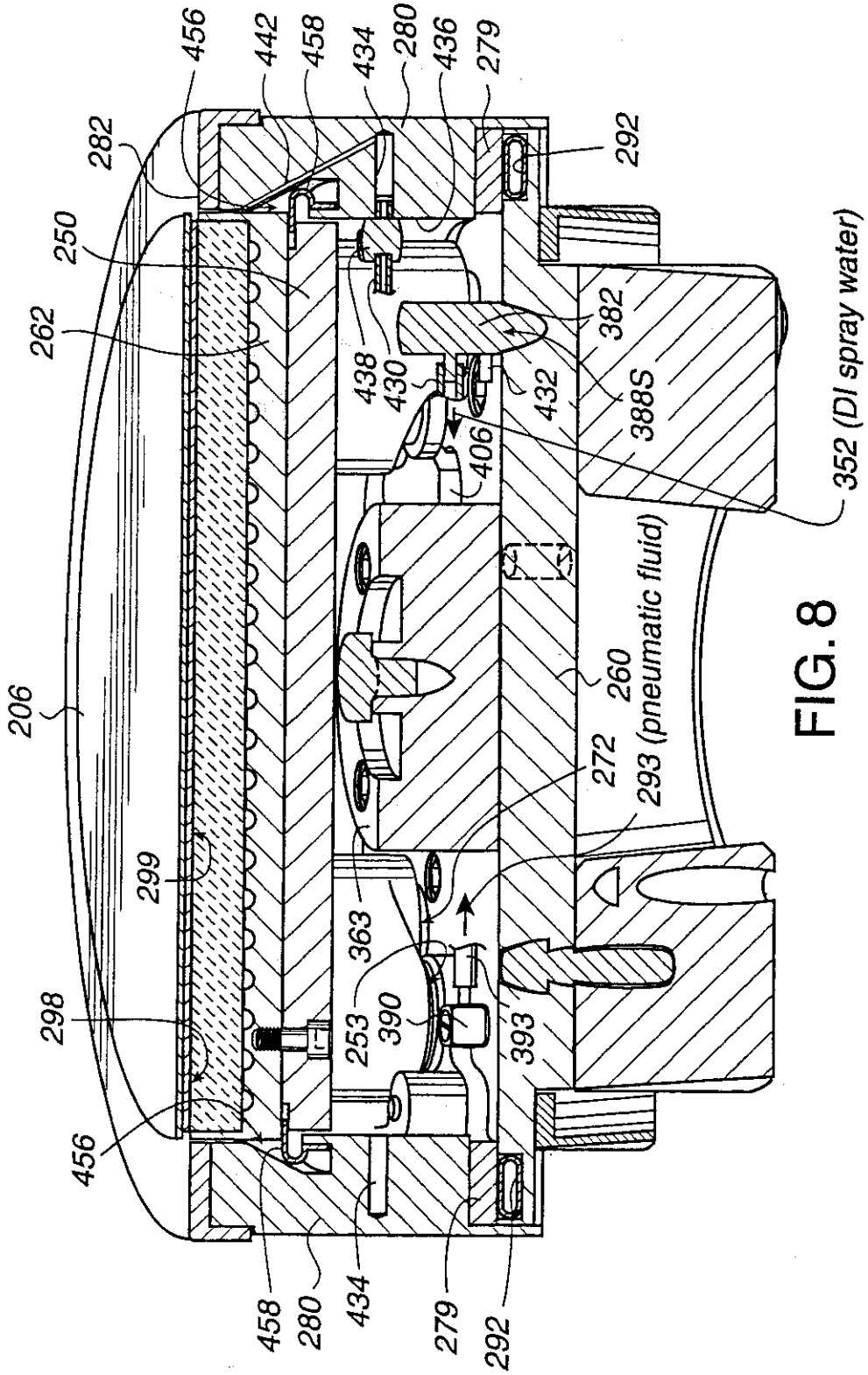

456
442
458
434
280
436
279
282
292
250
262
382
438
430
432
388S
406
352 (DI spray water)
206
260
293 (pneumatic fluid)
272
299
363
298
253
390
393
456
458
280
434
279
292

FIG. 8

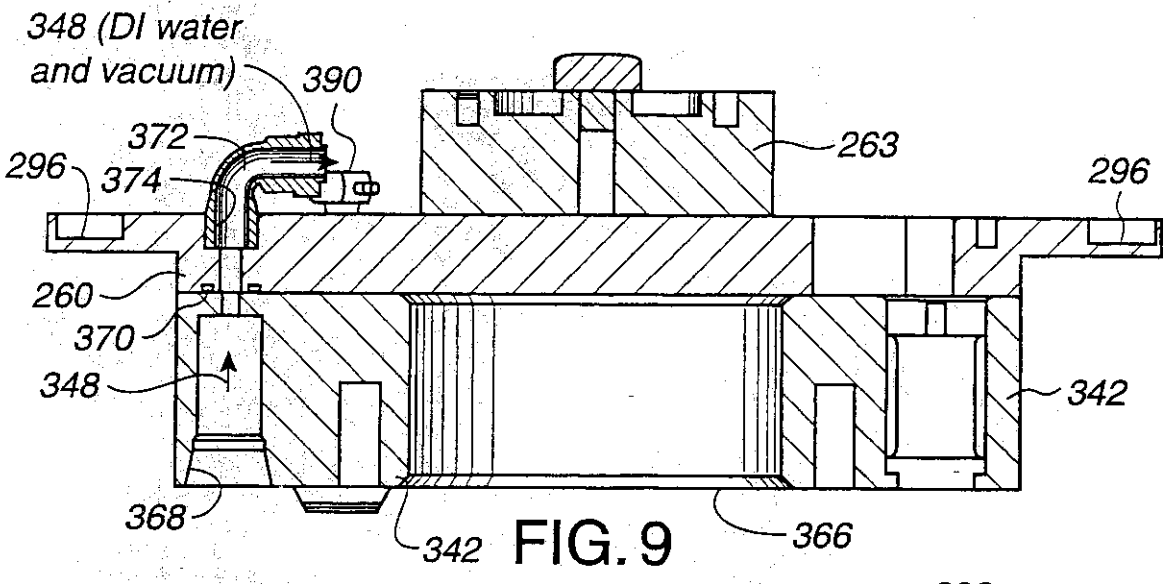


FIG. 9

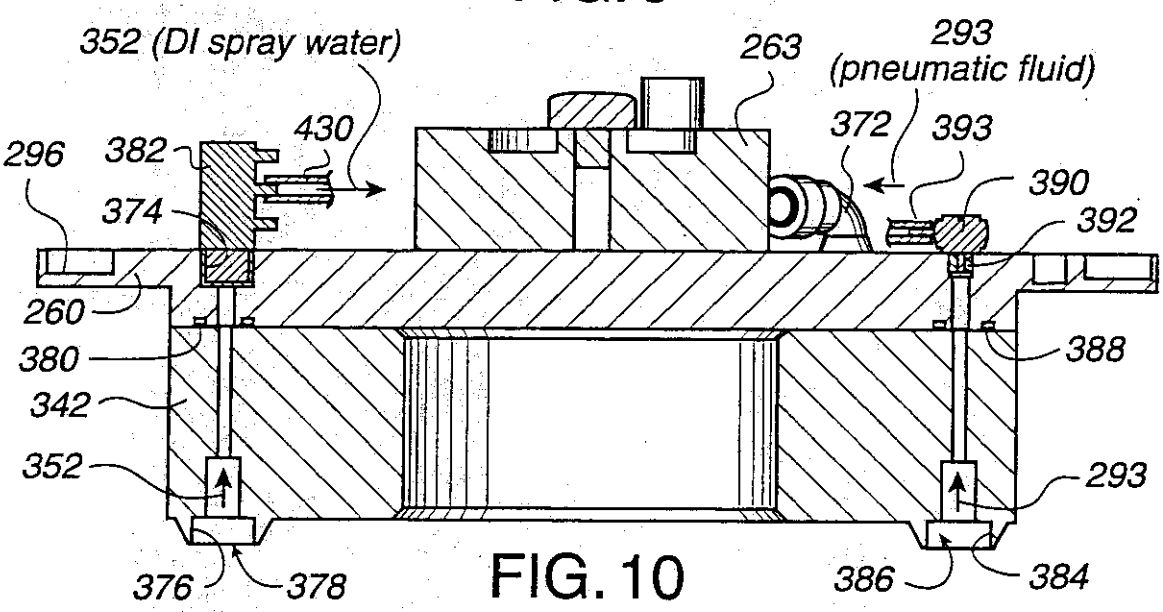


FIG. 10

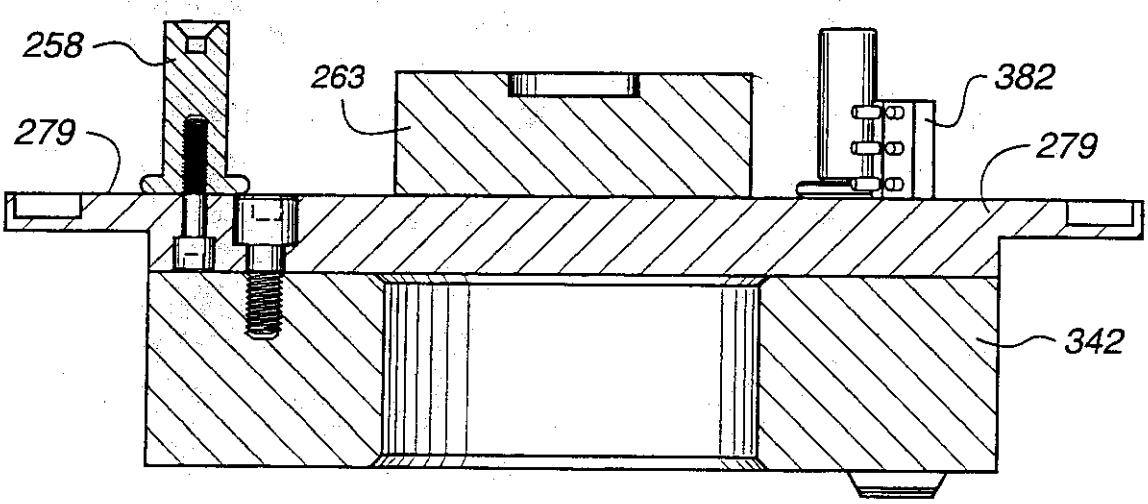


FIG. 11

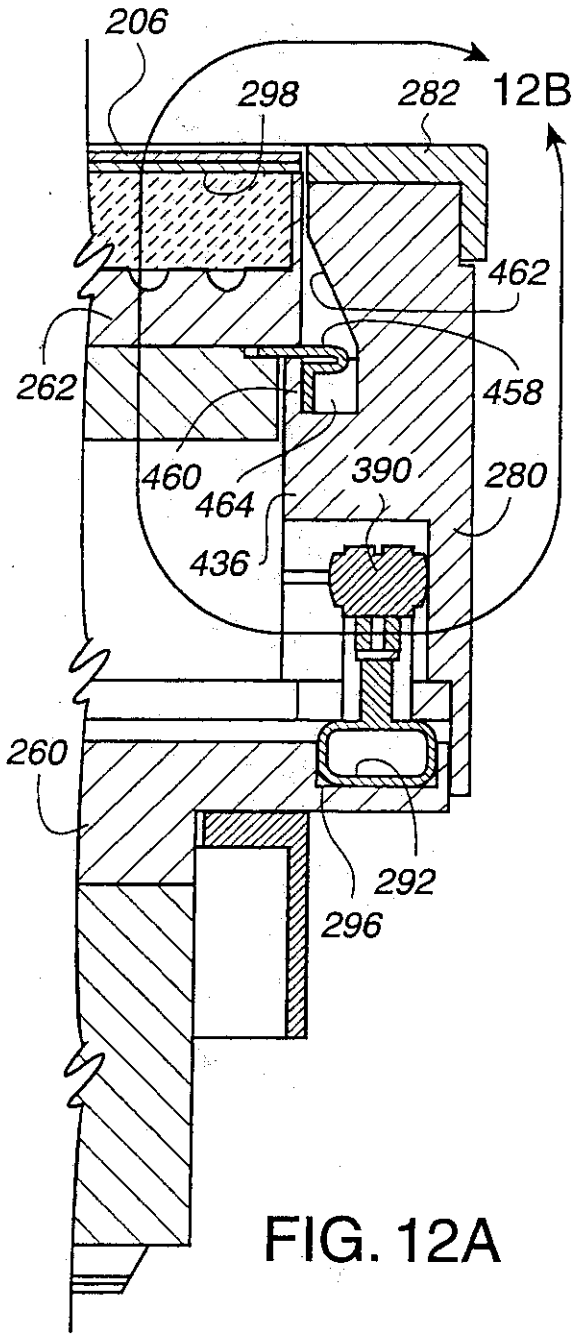


FIG. 12A

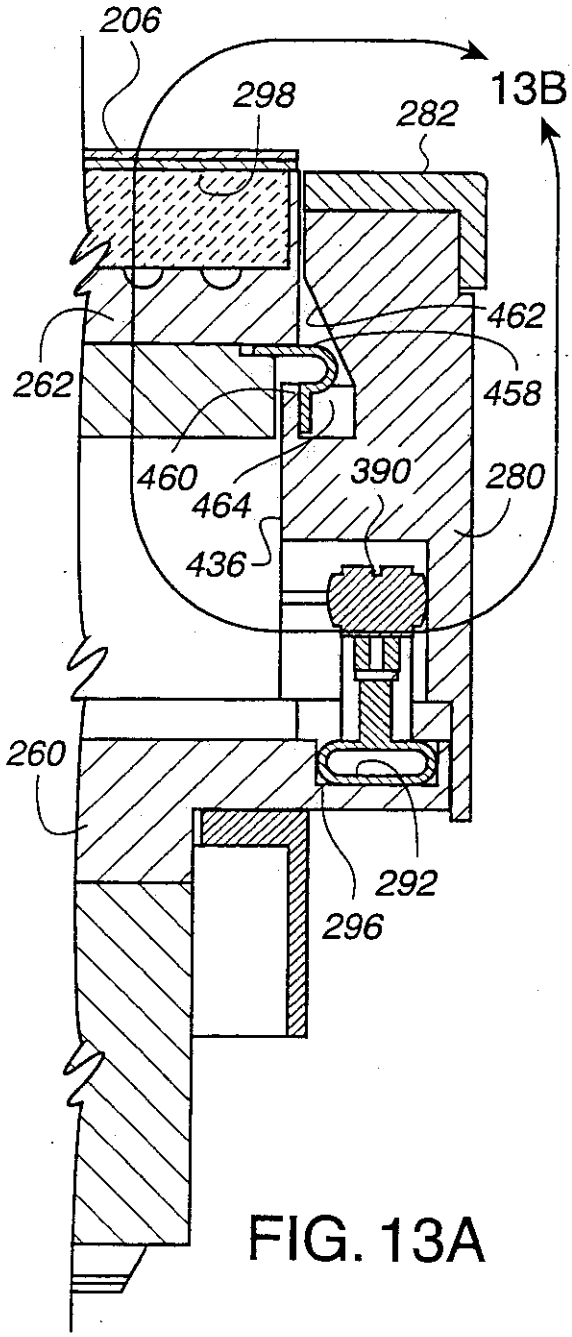


FIG. 13A

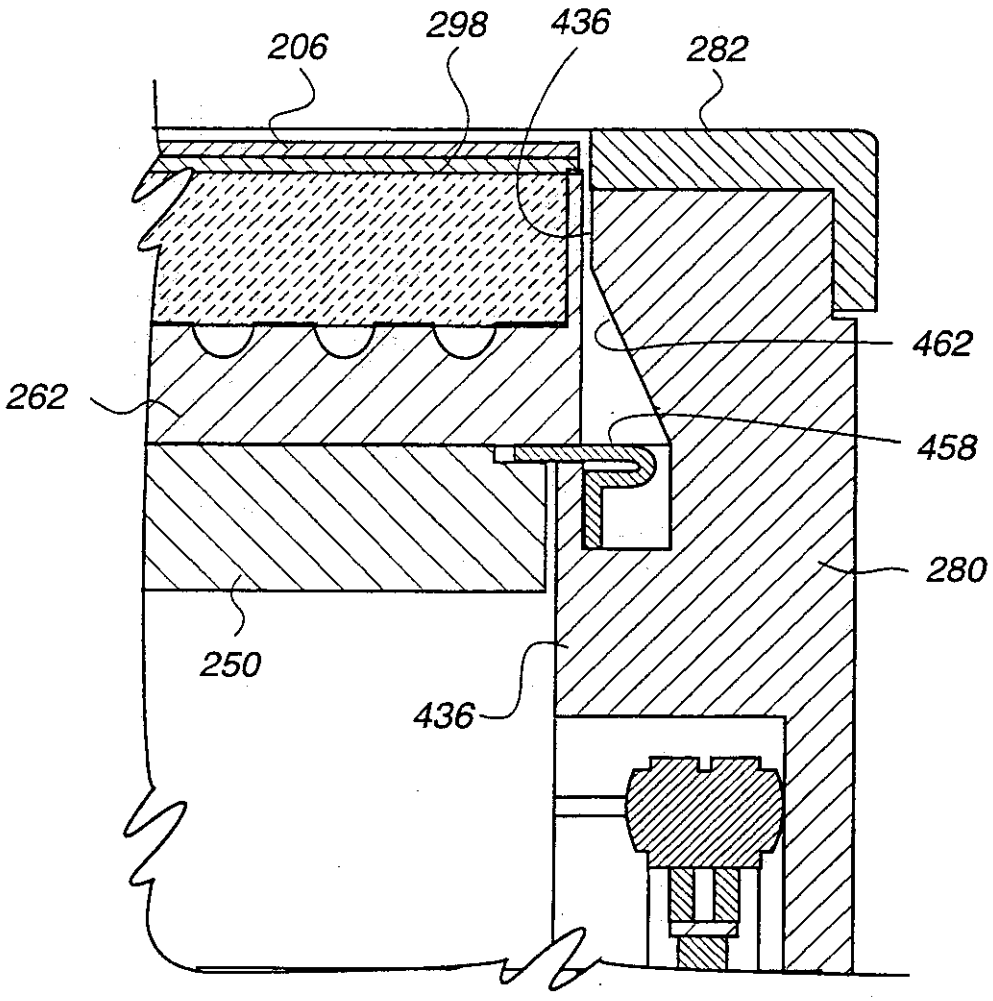


FIG. 12B

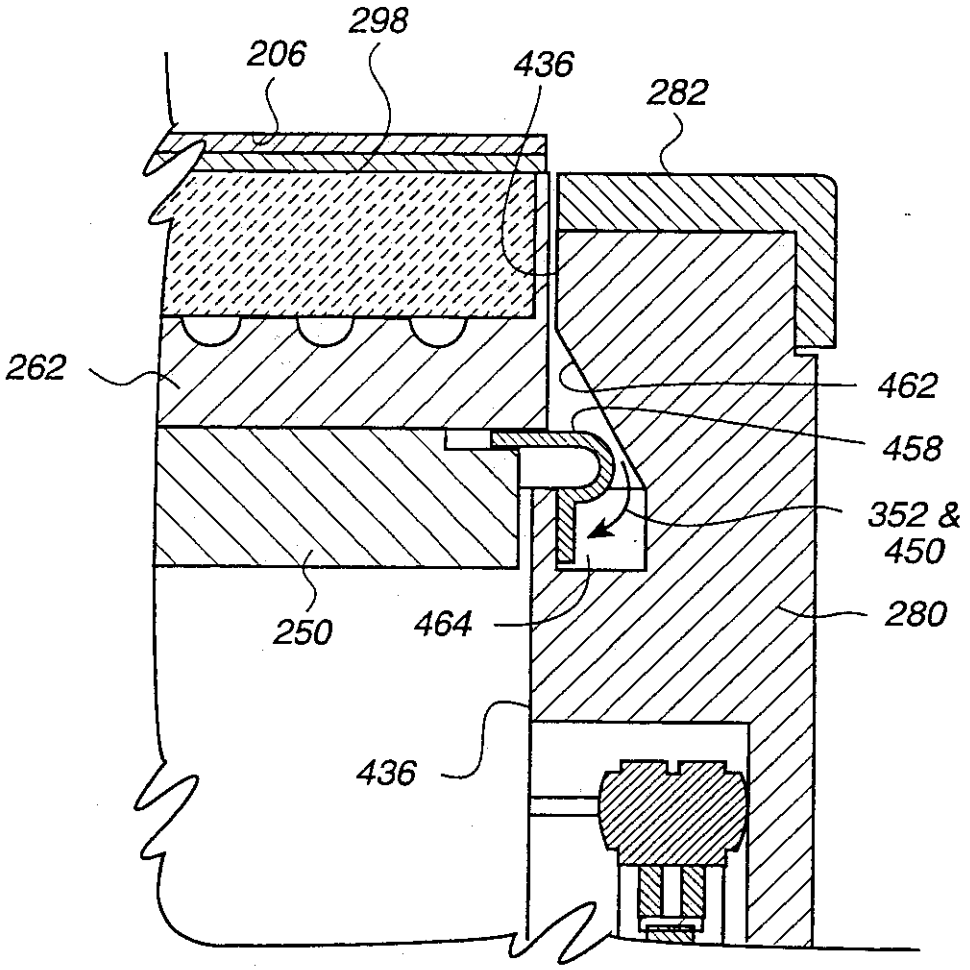


FIG. 13B

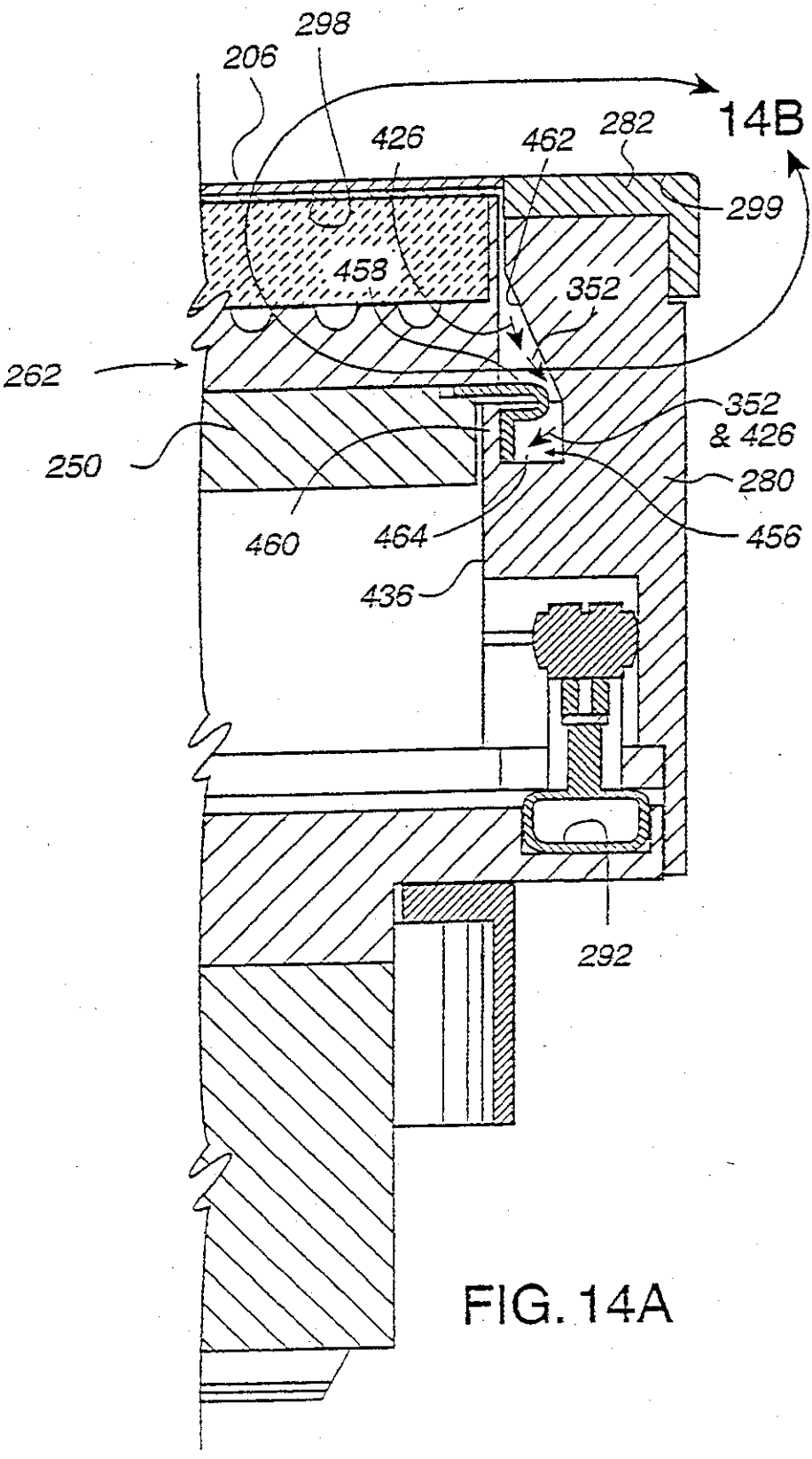

298
206
14B
426
462
282
299
458
352
262
352
& 426
250
280
460
464
456
436
292

FIG. 14A

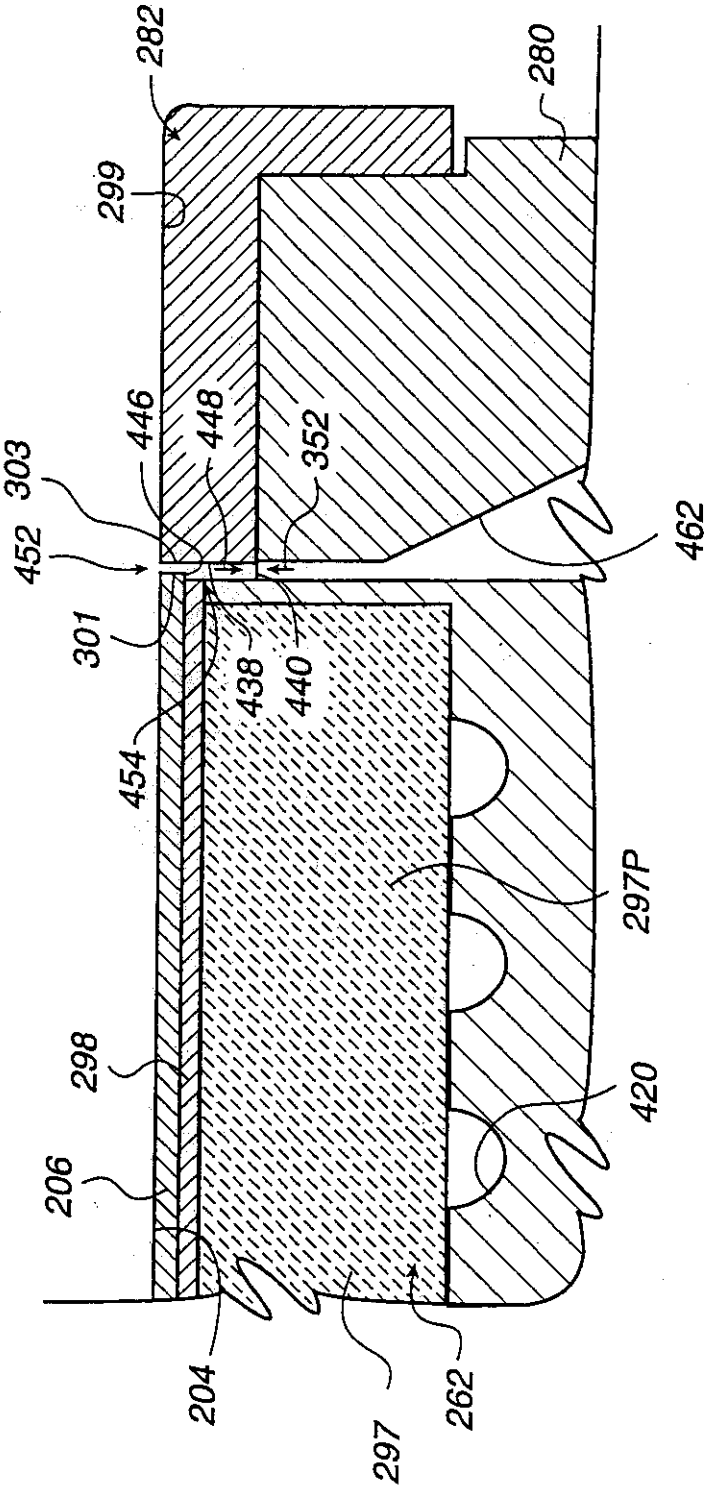

282
280
299
446
448
352
303
452
462
301
438
440
454
297P
298
420
206
204
262
297

FIG. 14B

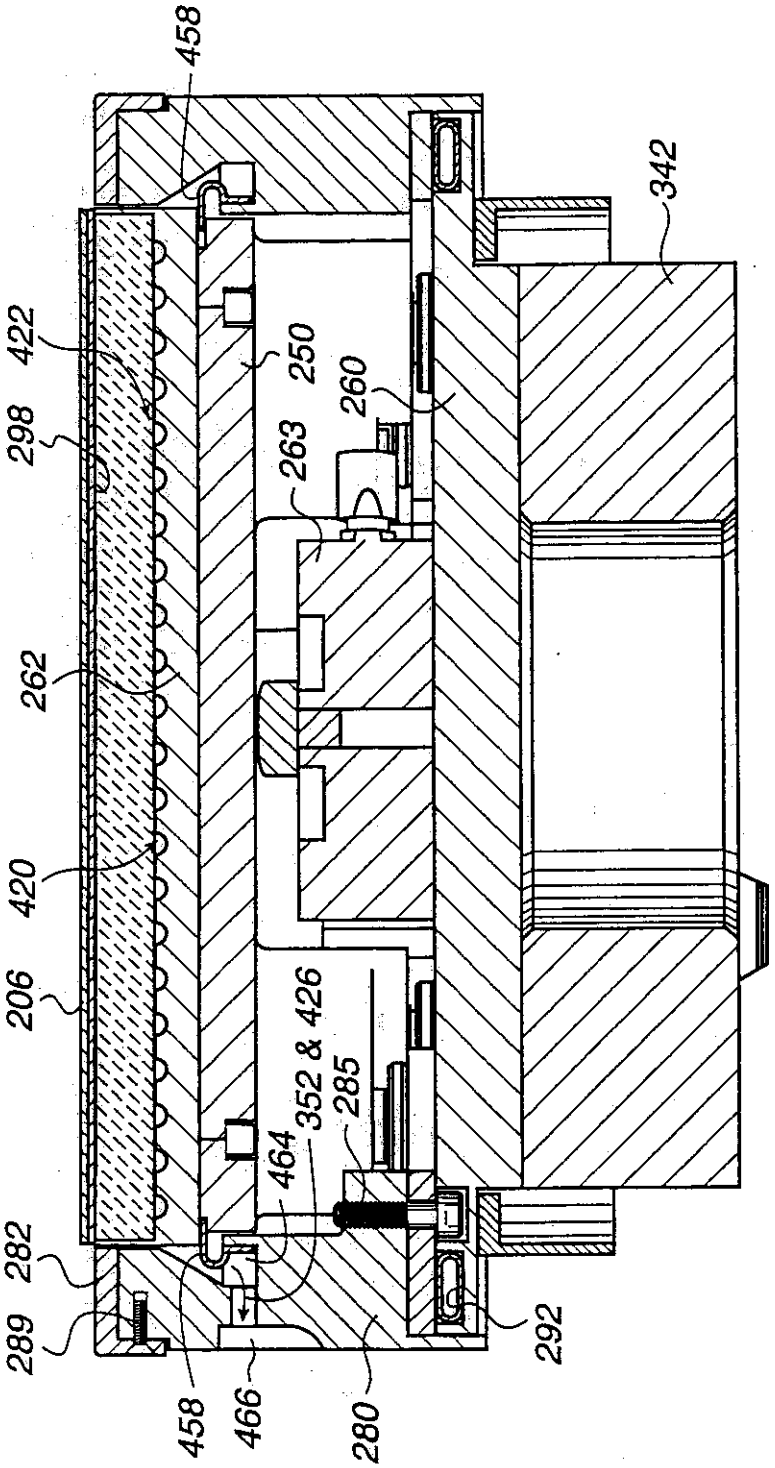
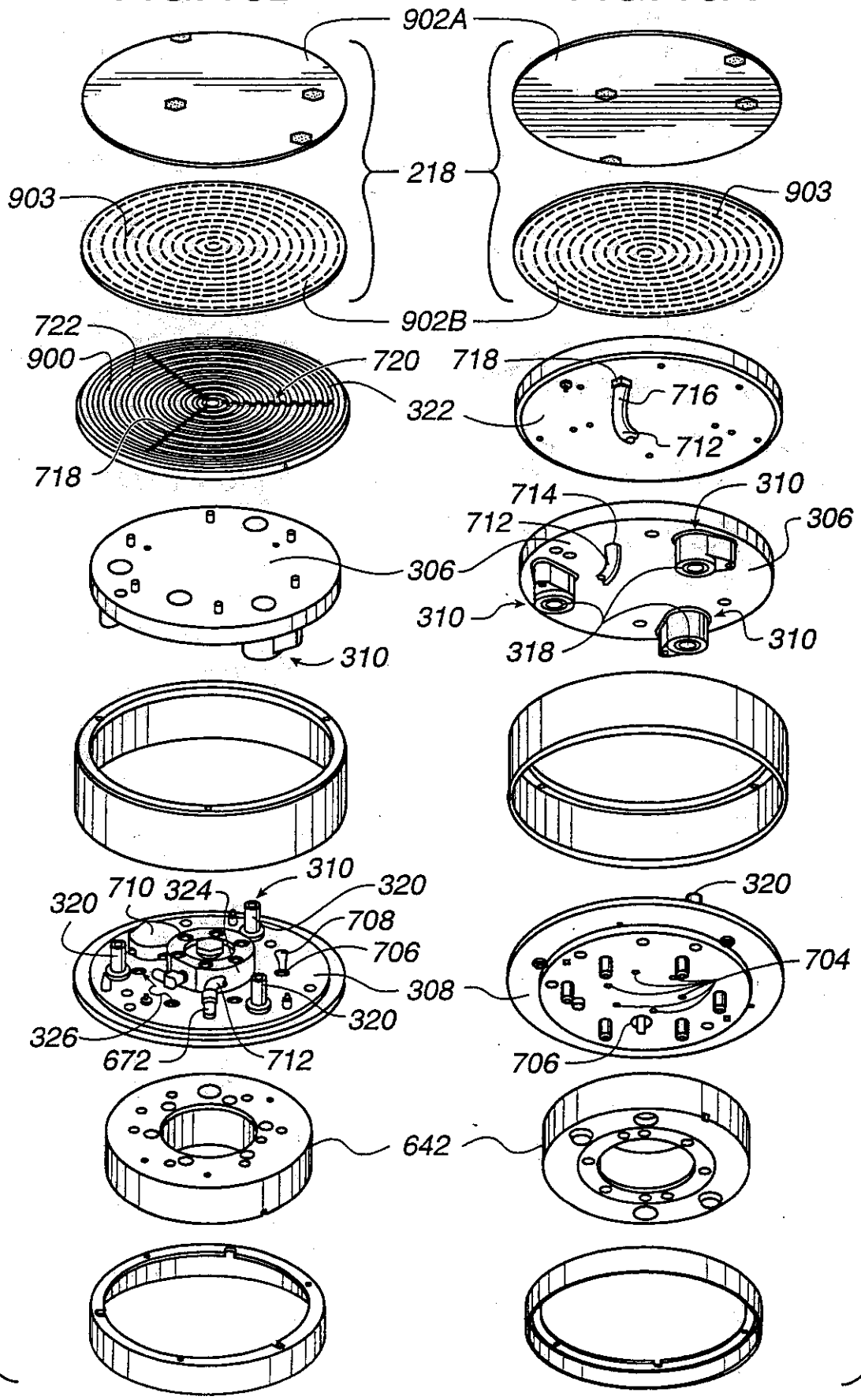

458
342
422
250
260
298
263
262
420
206
352 & 426
285
464
282
289
458
466
280
292

FIG. 15

FIG. 16B

FIG. 16A



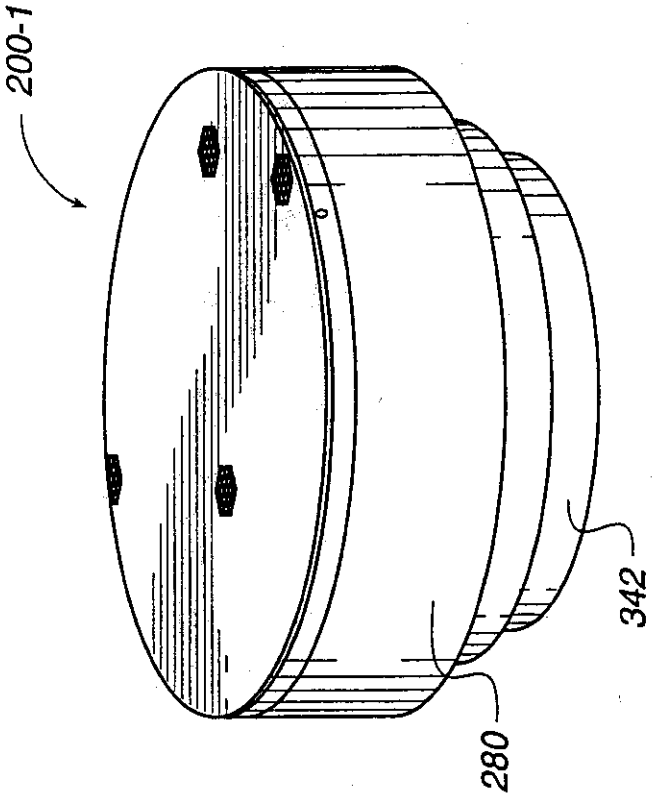


FIG. 17B

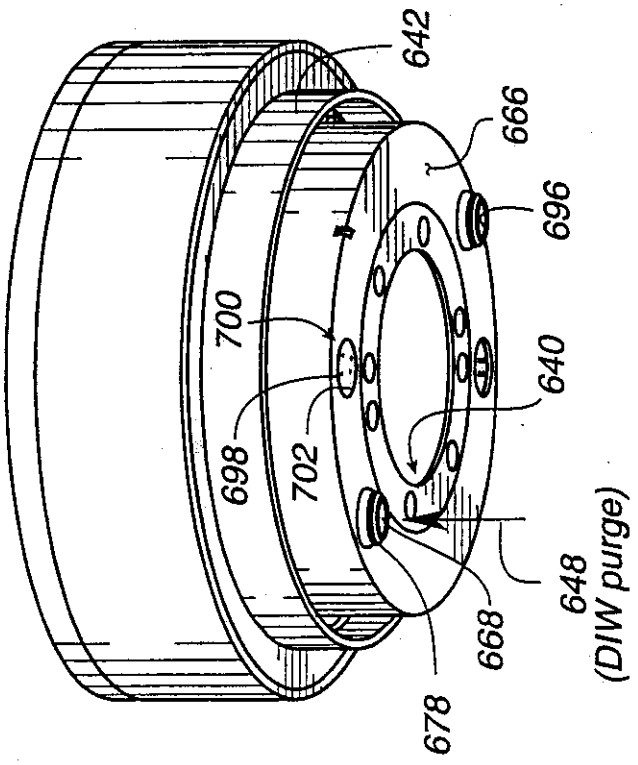


FIG. 17A

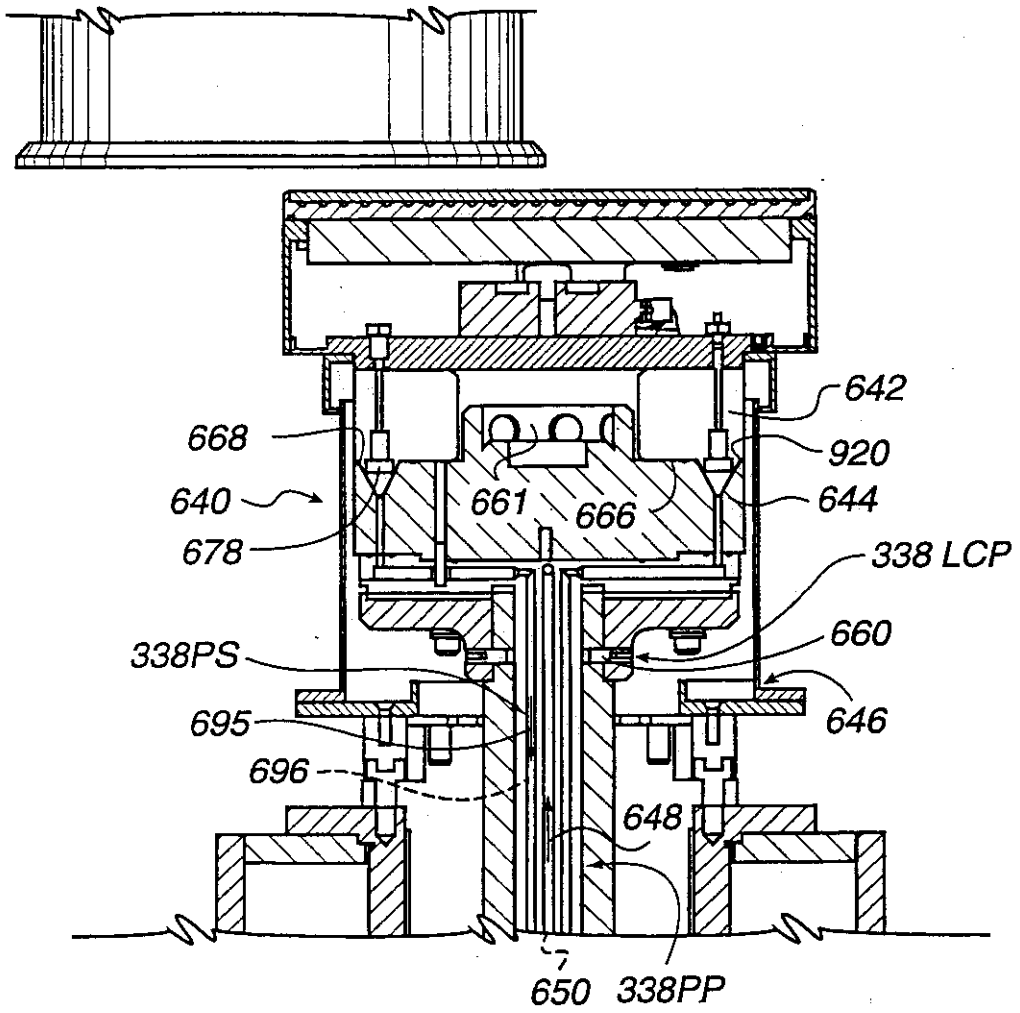

642
668
920
640
661
666
644
678
338 LCP
660
338PS
646
695
696
648
650
338PP

FIG. 17C

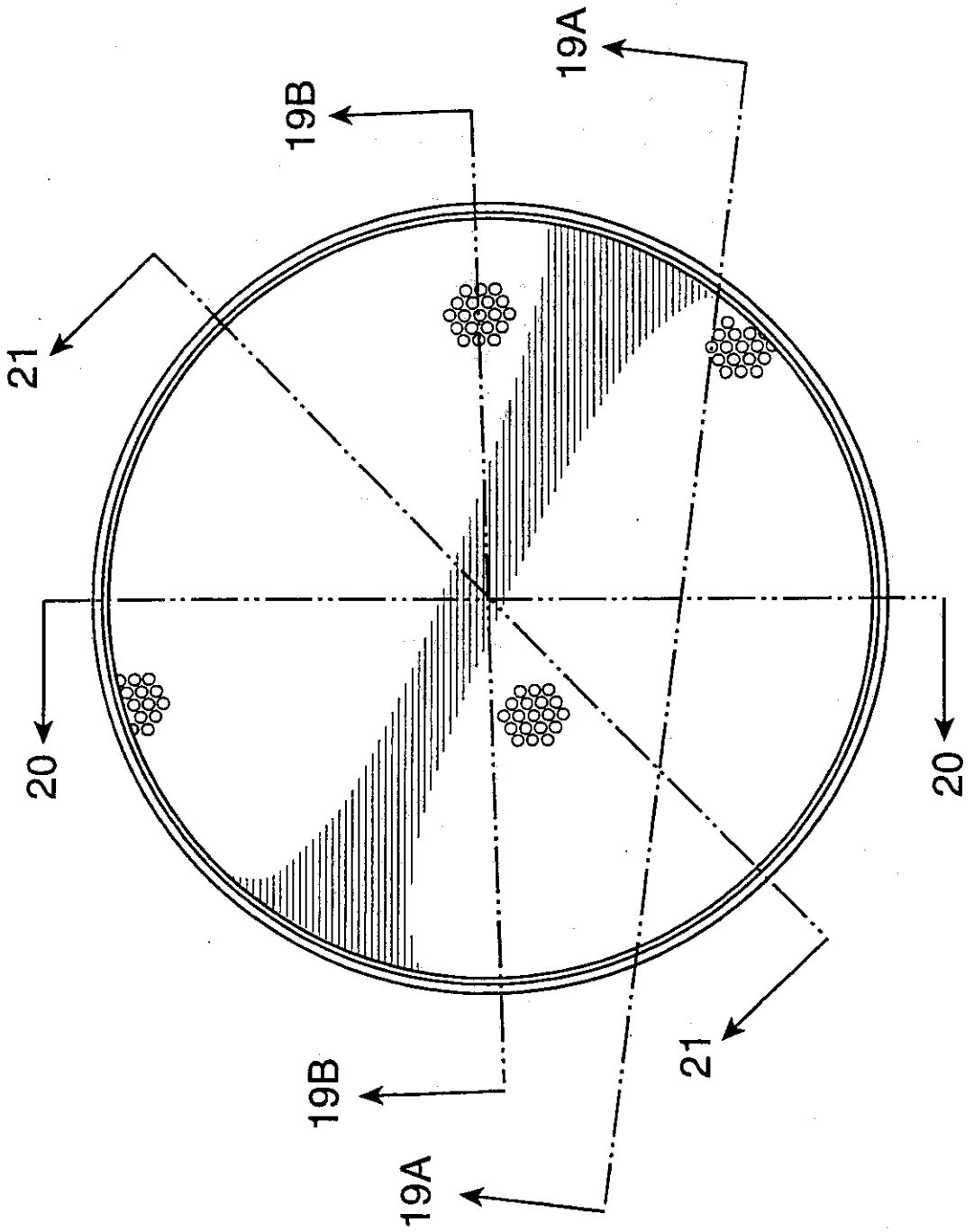


FIG. 18

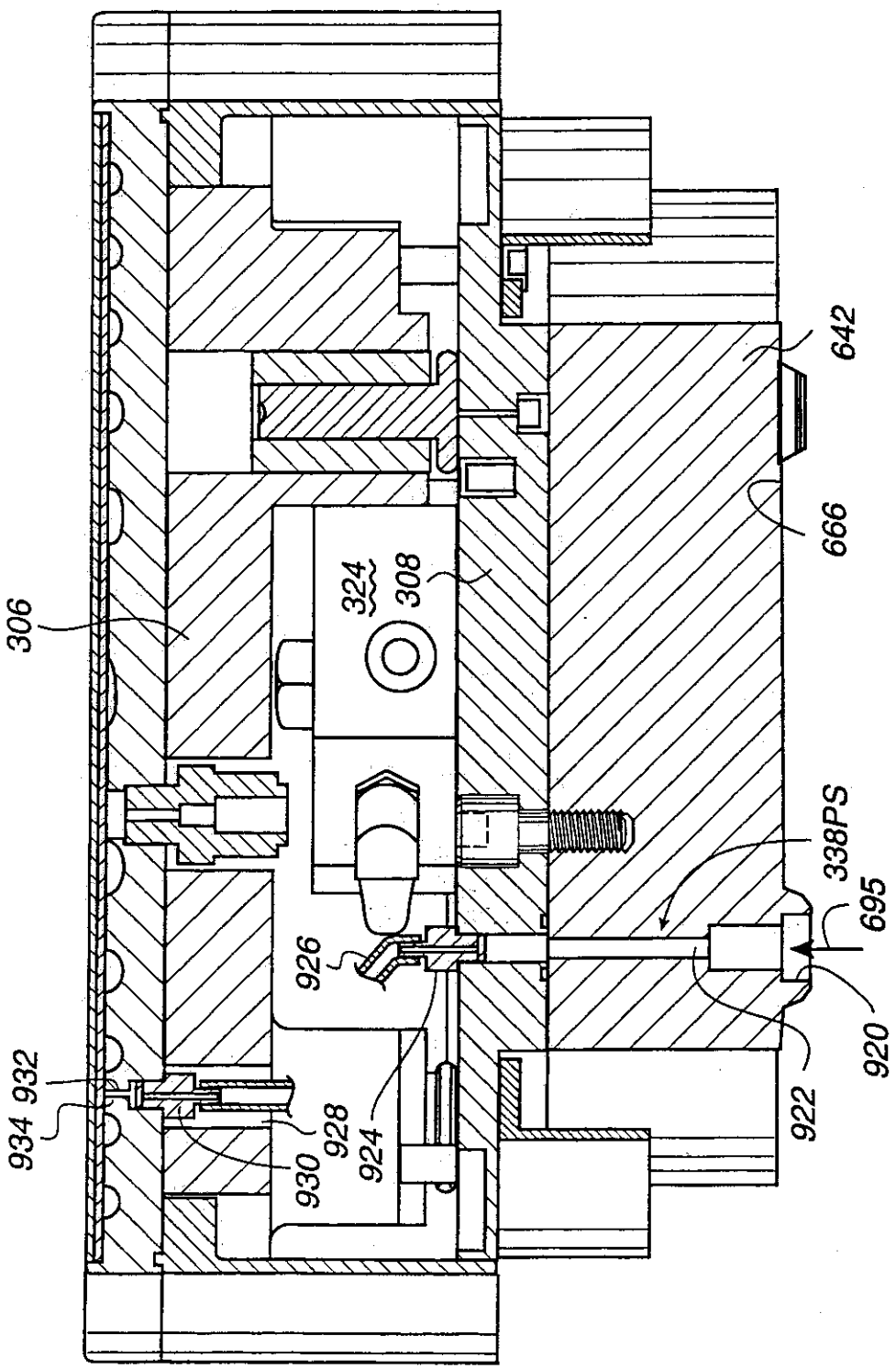


FIG. 19A

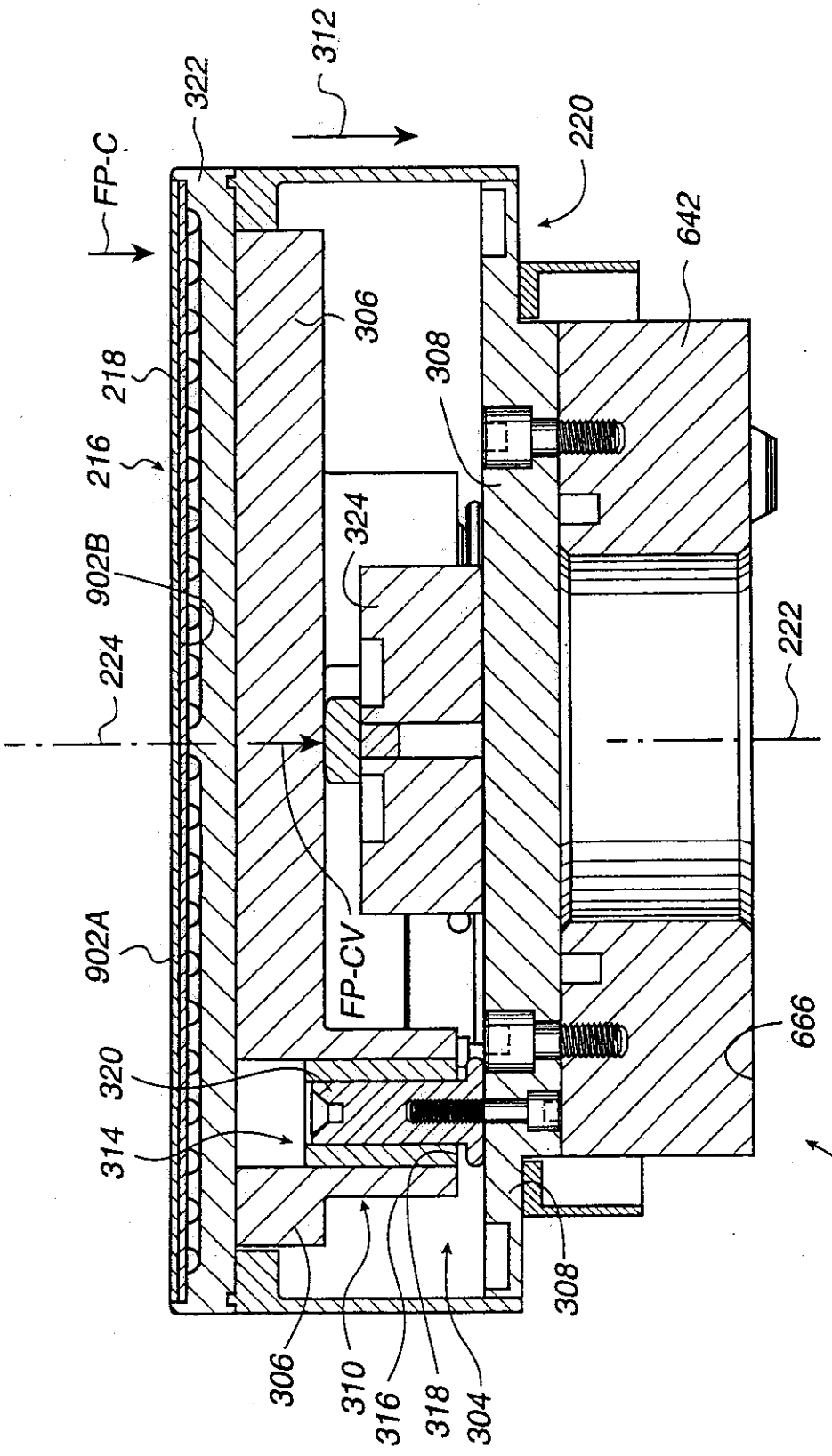

312
322
220
FP-C
642
306
308
218
216
324
902B
224
222
902A
FP-CV
320
666
314
200-1
306
310
316
318
304
308

FIG. 19B

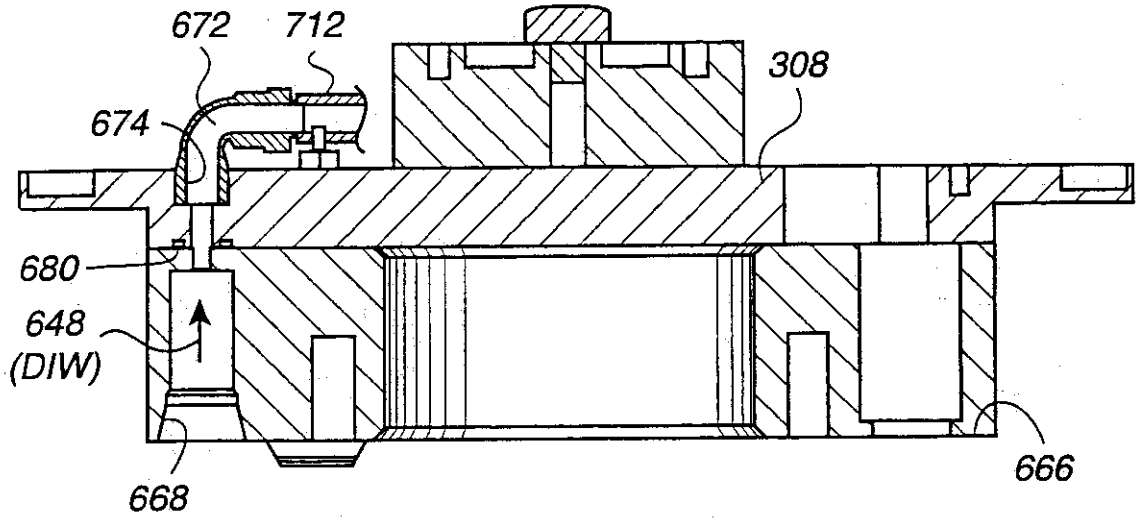

672
712
308
674
680
648
(DIW)
668
666

FIG. 20

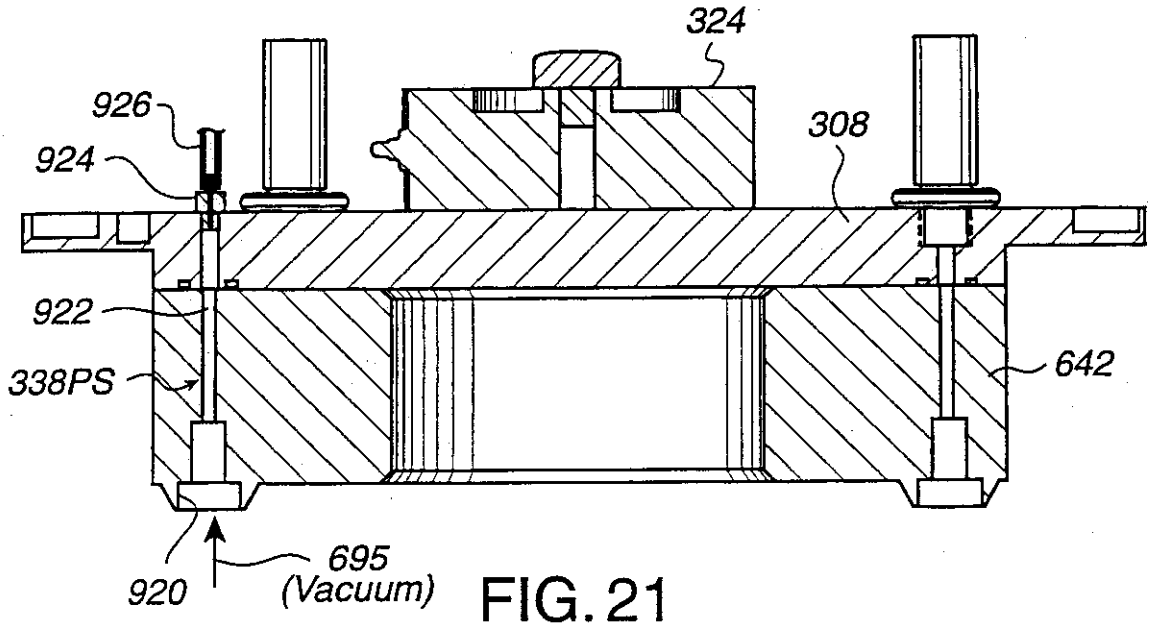

324
926
924
308
922
338PS
642
920
695
(Vacuum)

FIG. 21

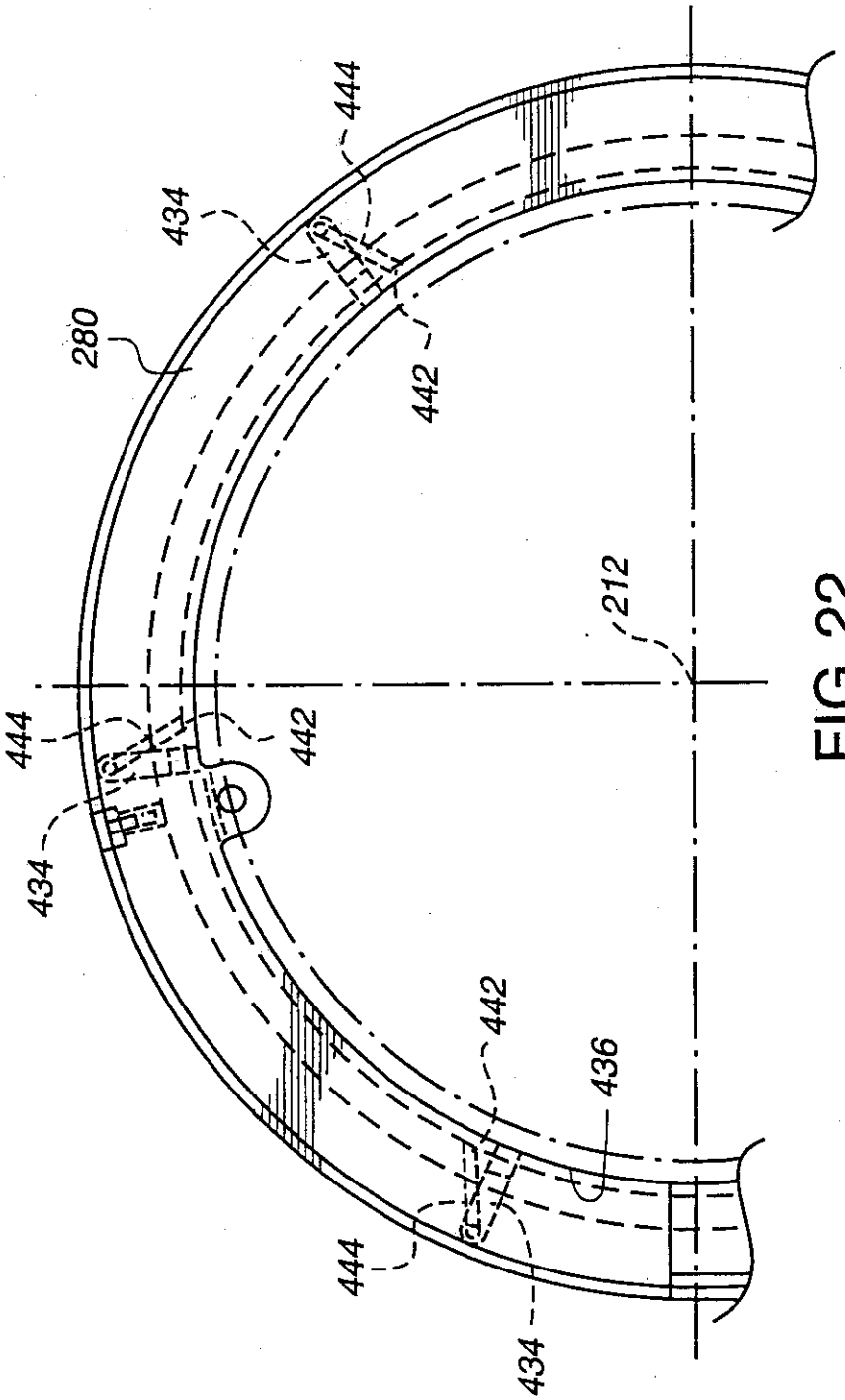


FIG. 22

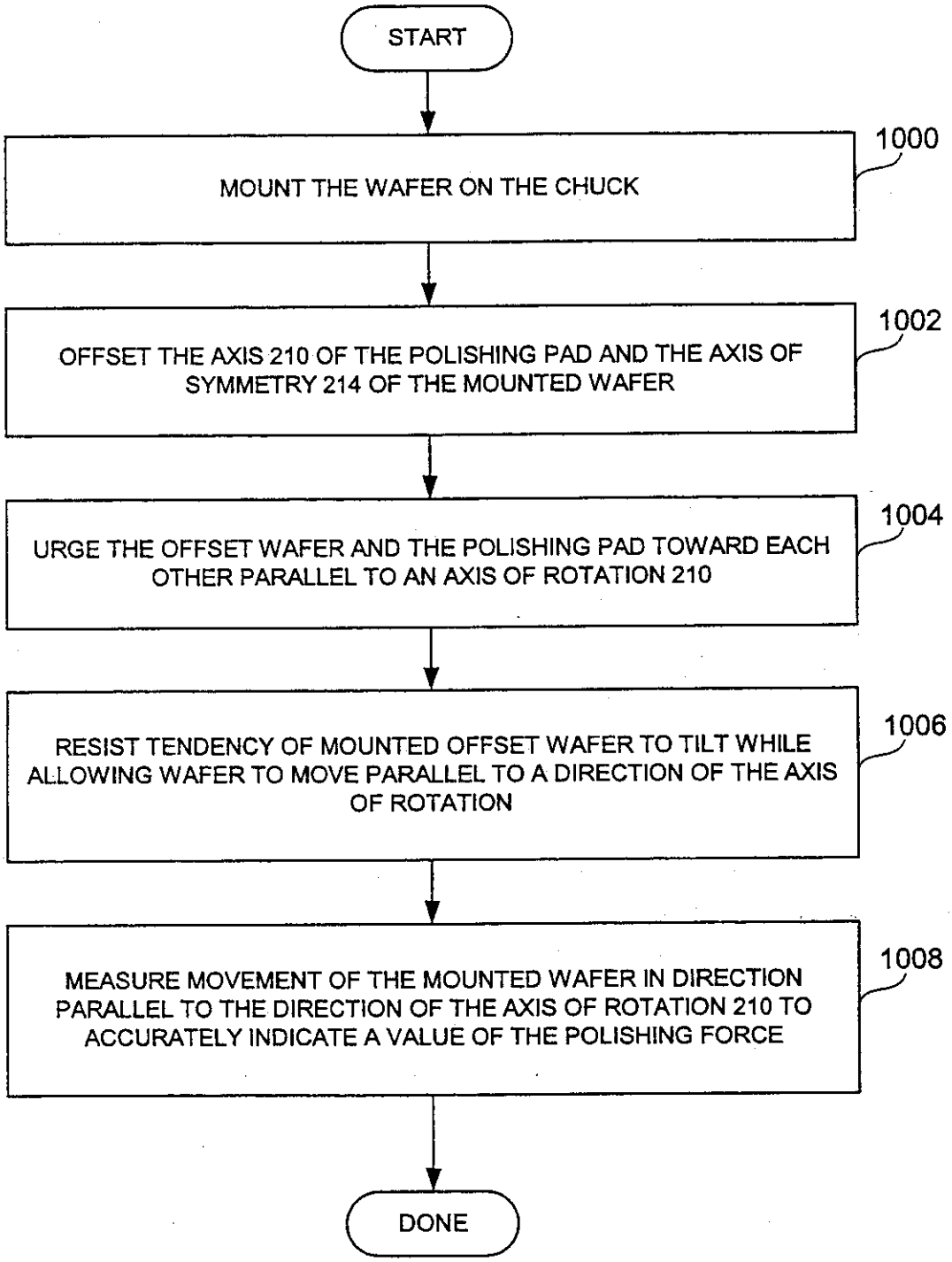

START
MOUNT THE WAFER ON THE CHUCK
1000
OFFSET THE AXIS 210 OF THE POLISHING PAD AND THE AXIS OF SYMMETRY 214 OF THE MOUNTED WAFER
1002
URGE THE OFFSET WAFER AND THE POLISHING PAD TOWARD EACH OTHER PARALLEL TO AN AXIS OF ROTATION 210
1004
RESIST TENDENCY OF MOUNTED OFFSET WAFER TO TILT WHILE ALLOWING WAFER TO MOVE PARALLEL TO A DIRECTION OF THE AXIS OF ROTATION
1006
MEASURE MOVEMENT OF THE MOUNTED WAFER IN DIRECTION PARALLEL TO THE DIRECTION OF THE AXIS OF ROTATION 210 TO ACCURATELY INDICATE A VALUE OF THE POLISHING FORCE
1008
DONE

FIG. 23

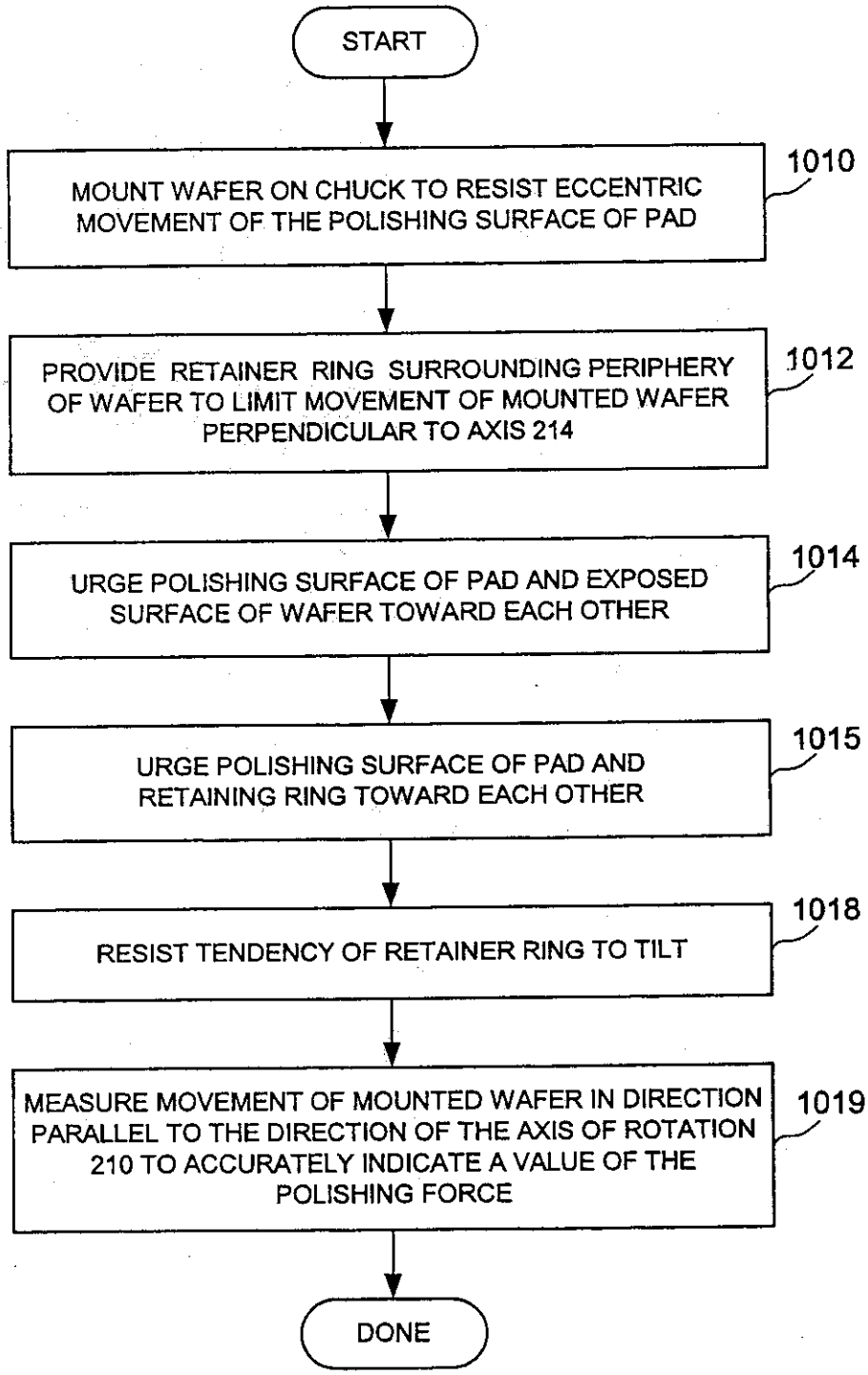

START
MOUNT WAFER ON CHUCK TO RESIST ECCENTRIC MOVEMENT OF THE POLISHING SURFACE OF PAD
1010
PROVIDE RETAINER RING SURROUNDING PERIPHERY OF WAFER TO LIMIT MOVEMENT OF MOUNTED WAFER PERPENDICULAR TO AXIS 214
1012
URGE POLISHING SURFACE OF PAD AND EXPOSED SURFACE OF WAFER TOWARD EACH OTHER
1014
URGE POLISHING SURFACE OF PAD AND RETAINING RING TOWARD EACH OTHER
1015
RESIST TENDENCY OF RETAINER RING TO TILT
1018
MEASURE MOVEMENT OF MOUNTED WAFER IN DIRECTION PARALLEL TO THE DIRECTION OF THE AXIS OF ROTATION 210 TO ACCURATELY INDICATE A VALUE OF THE POLISHING FORCE
1019
DONE

FIG. 24

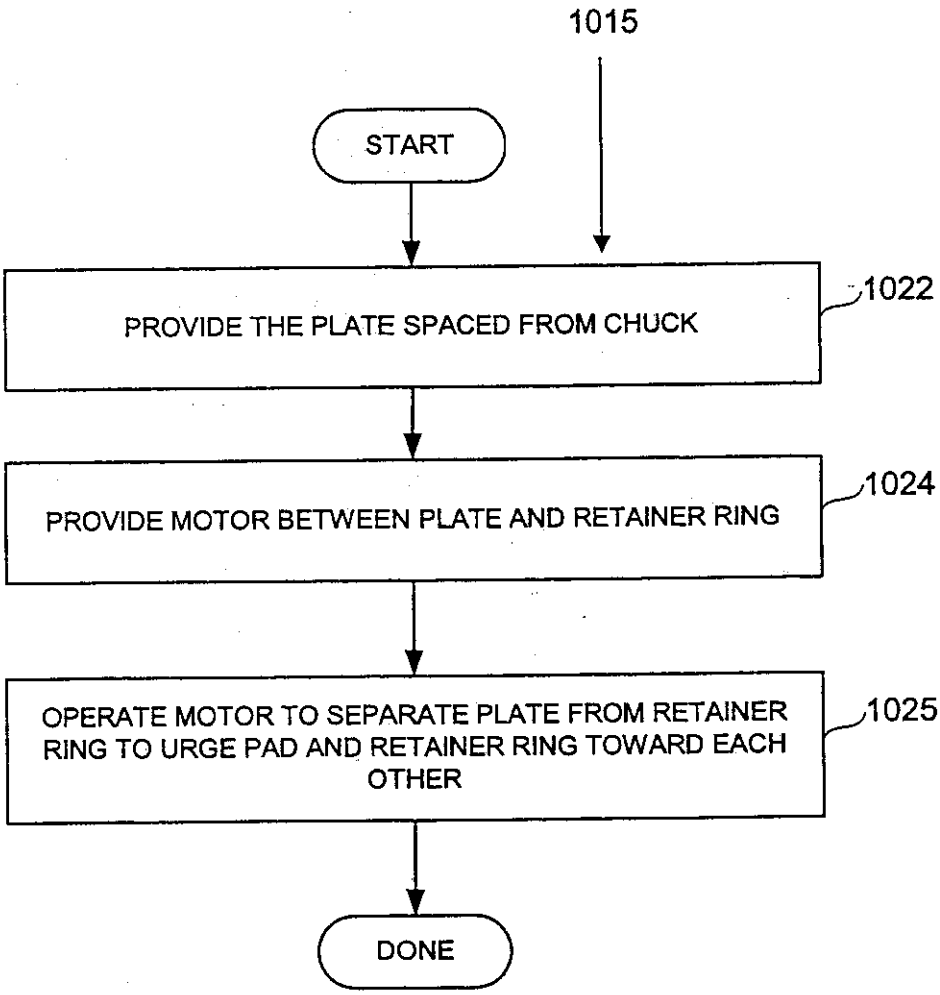

1015
START
PROVIDE THE PLATE SPACED FROM CHUCK
1022
PROVIDE MOTOR BETWEEN PLATE AND RETAINER RING
1024
OPERATE MOTOR TO SEPARATE PLATE FROM RETAINER RING TO URGE PAD AND RETAINER RING TOWARD EACH OTHER
1025
DONE

FIG. 25

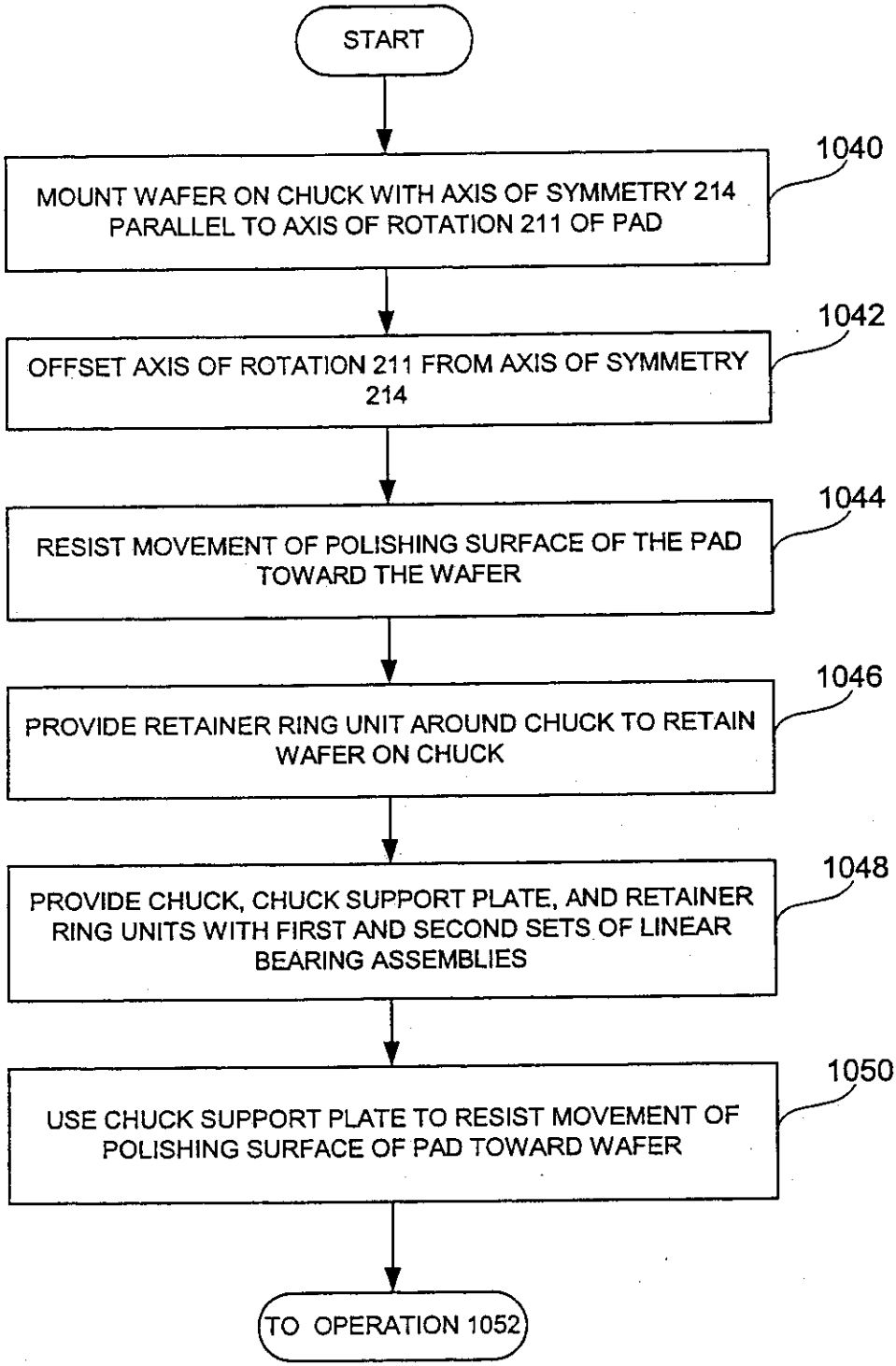

START
MOUNT WAFER ON CHUCK WITH AXIS OF SYMMETRY 214 PARALLEL TO AXIS OF ROTATION 211 OF PAD
1040
OFFSET AXIS OF ROTATION 211 FROM AXIS OF SYMMETRY 214
1042
RESIST MOVEMENT OF POLISHING SURFACE OF THE PAD TOWARD THE WAFER
1044
PROVIDE RETAINER RING UNIT AROUND CHUCK TO RETAIN WAFER ON CHUCK
1046
PROVIDE CHUCK, CHUCK SUPPORT PLATE, AND RETAINER RING UNITS WITH FIRST AND SECOND SETS OF LINEAR BEARING ASSEMBLIES
1048
USE CHUCK SUPPORT PLATE TO RESIST MOVEMENT OF POLISHING SURFACE OF PAD TOWARD WAFER
1050
TO OPERATION 1052

FIG. 26

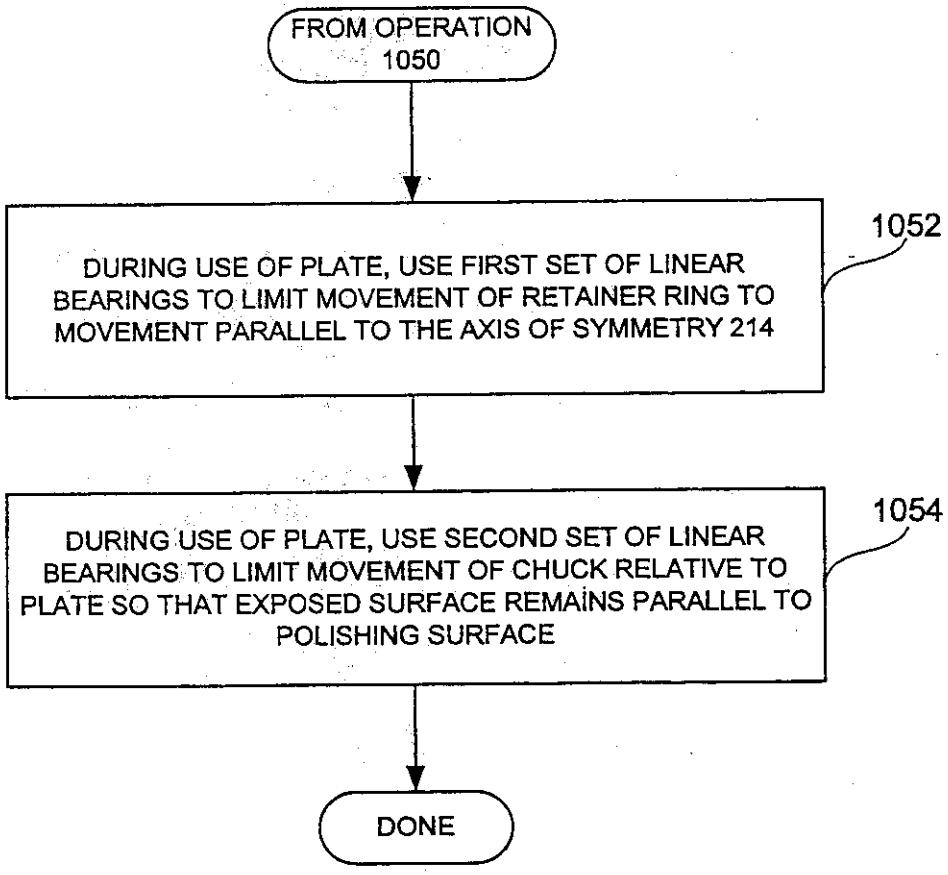

FROM OPERATION 1050
DURING USE OF PLATE, USE FIRST SET OF LINEAR BEARINGS TO LIMIT MOVEMENT OF RETAINER RING TO MOVEMENT PARALLEL TO THE AXIS OF SYMMETRY 214
1052
DURING USE OF PLATE, USE SECOND SET OF LINEAR BEARINGS TO LIMIT MOVEMENT OF CHUCK RELATIVE TO PLATE SO THAT EXPOSED SURFACE REMAINS PARALLEL TO POLISHING SURFACE
1054
DONE

FIG. 27

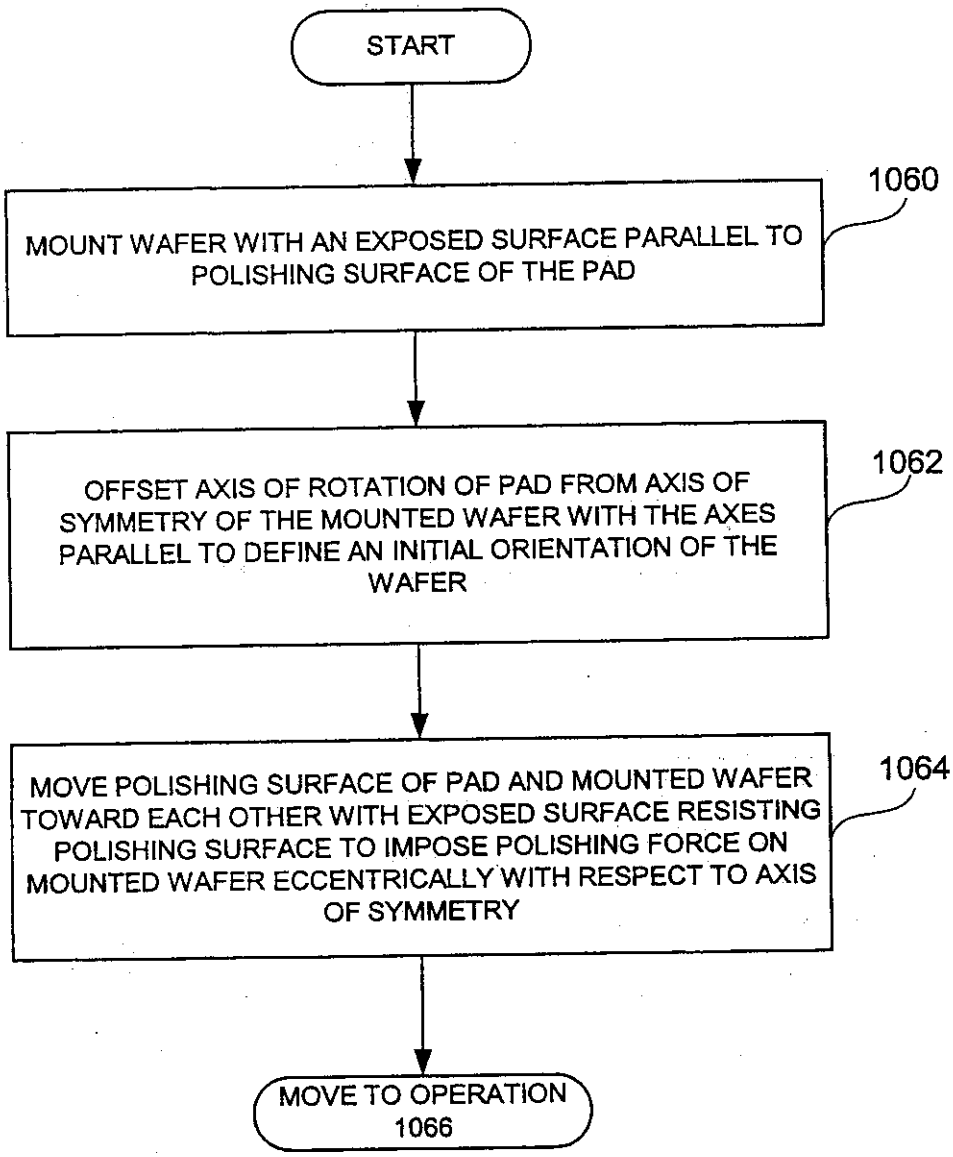

START
MOUNT WAFER WITH AN EXPOSED SURFACE PARALLEL TO POLISHING SURFACE OF THE PAD
1060
OFFSET AXIS OF ROTATION OF PAD FROM AXIS OF SYMMETRY OF THE MOUNTED WAFER WITH THE AXES PARALLEL TO DEFINE AN INITIAL ORIENTATION OF THE WAFER
1062
MOVE POLISHING SURFACE OF PAD AND MOUNTED WAFER TOWARD EACH OTHER WITH EXPOSED SURFACE RESISTING POLISHING SURFACE TO IMPOSE POLISHING FORCE ON MOUNTED WAFER ECCENTRICALLY WITH RESPECT TO AXIS OF SYMMETRY
1064
MOVE TO OPERATION 1066

FIG. 28

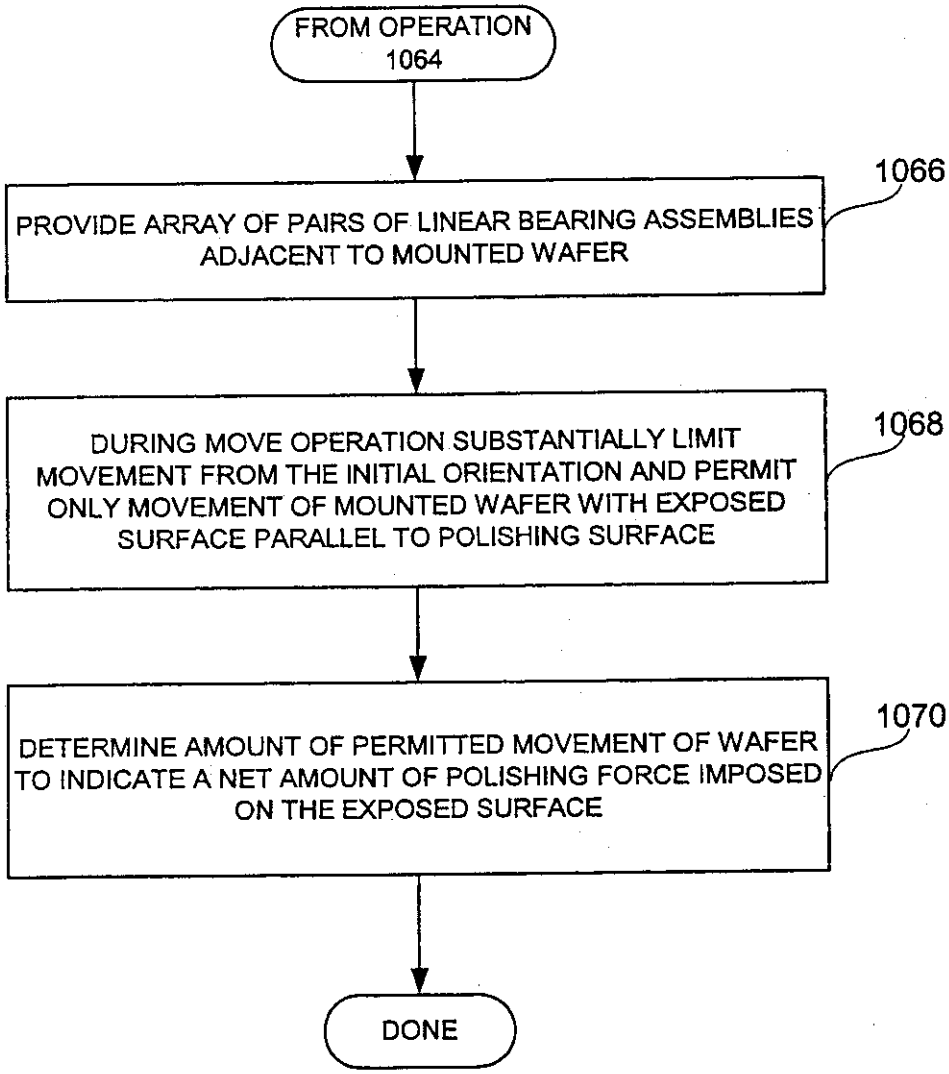

FROM OPERATION 1064
PROVIDE ARRAY OF PAIRS OF LINEAR BEARING ASSEMBLIES ADJACENT TO MOUNTED WAFER
1066
DURING MOVE OPERATION SUBSTANTIALLY LIMIT MOVEMENT FROM THE INITIAL ORIENTATION AND PERMIT ONLY MOVEMENT OF MOUNTED WAFER WITH EXPOSED SURFACE PARALLEL TO POLISHING SURFACE
1068
DETERMINE AMOUNT OF PERMITTED MOVEMENT OF WAFER TO INDICATE A NET AMOUNT OF POLISHING FORCE IMPOSED ON THE EXPOSED SURFACE
1070
DONE

FIG. 29

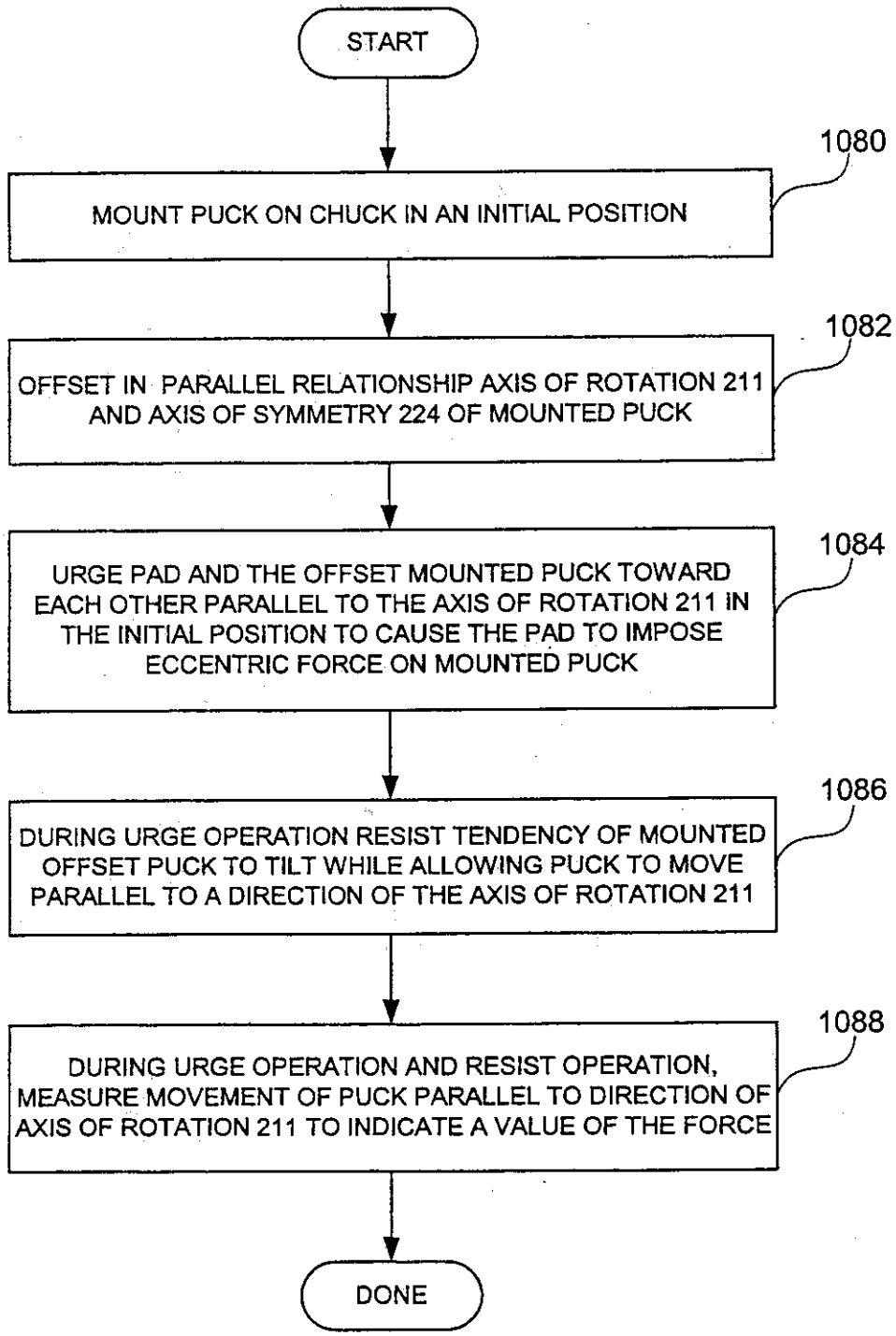

START
1080
MOUNT PUCK ON CHUCK IN AN INITIAL POSITION
1082
OFFSET IN PARALLEL RELATIONSHIP AXIS OF ROTATION 211 AND AXIS OF SYMMETRY 224 OF MOUNTED PUCK
1084
URGE PAD AND THE OFFSET MOUNTED PUCK TOWARD EACH OTHER PARALLEL TO THE AXIS OF ROTATION 211 IN THE INITIAL POSITION TO CAUSE THE PAD TO IMPOSE ECCENTRIC FORCE ON MOUNTED PUCK
1086
DURING URGE OPERATION RESIST TENDENCY OF MOUNTED OFFSET PUCK TO TILT WHILE ALLOWING PUCK TO MOVE PARALLEL TO A DIRECTION OF THE AXIS OF ROTATION 211
1088
DURING URGE OPERATION AND RESIST OPERATION, MEASURE MOVEMENT OF PUCK PARALLEL TO DIRECTION OF AXIS OF ROTATION 211 TO INDICATE A VALUE OF THE FORCE
DONE

FIG. 30

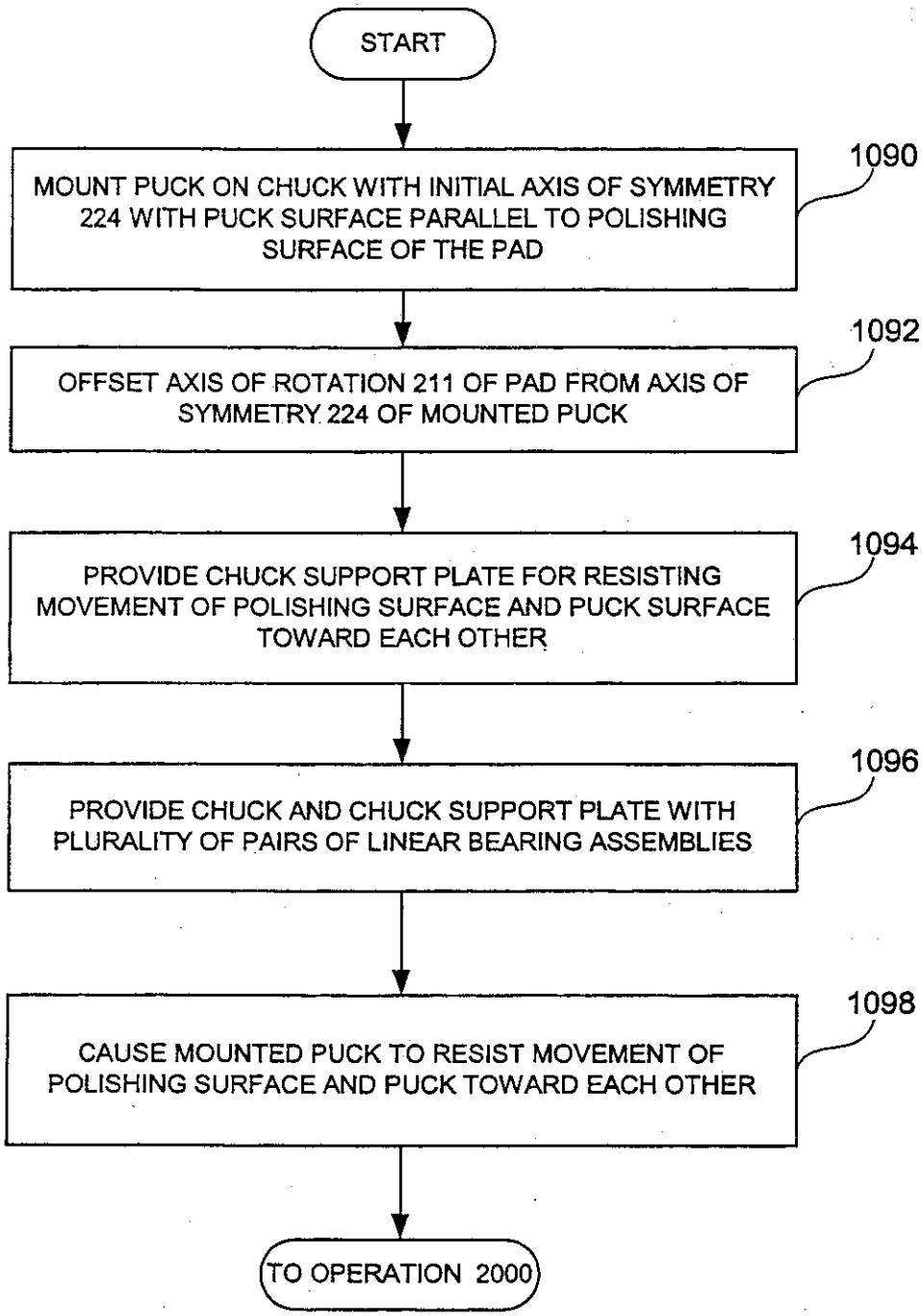

START
MOUNT PUCK ON CHUCK WITH INITIAL AXIS OF SYMMETRY 224 WITH PUCK SURFACE PARALLEL TO POLISHING SURFACE OF THE PAD
1090
OFFSET AXIS OF ROTATION 211 OF PAD FROM AXIS OF SYMMETRY 224 OF MOUNTED PUCK
1092
PROVIDE CHUCK SUPPORT PLATE FOR RESISTING MOVEMENT OF POLISHING SURFACE AND PUCK SURFACE TOWARD EACH OTHER
1094
PROVIDE CHUCK AND CHUCK SUPPORT PLATE WITH PLURALITY OF PAIRS OF LINEAR BEARING ASSEMBLIES
1096
CAUSE MOUNTED PUCK TO RESIST MOVEMENT OF POLISHING SURFACE AND PUCK TOWARD EACH OTHER
1098
TO OPERATION 2000

FIG. 31

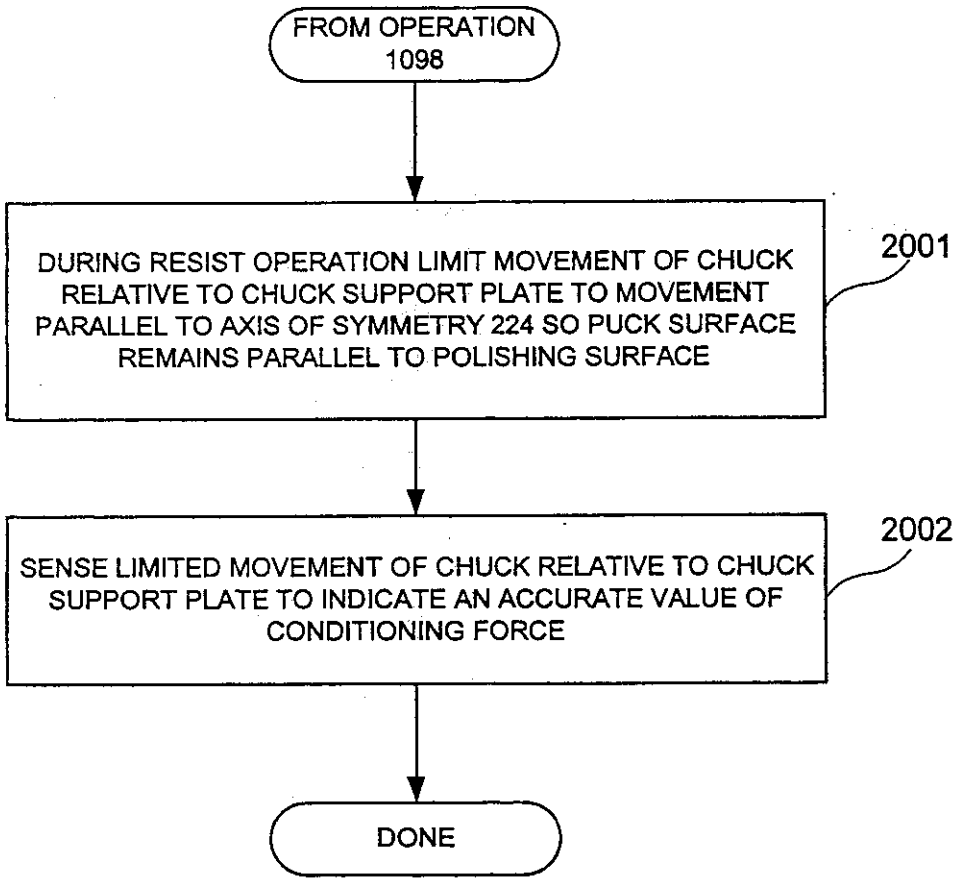

FROM OPERATION 1098
DURING RESIST OPERATION LIMIT MOVEMENT OF CHUCK RELATIVE TO CHUCK SUPPORT PLATE TO MOVEMENT PARALLEL TO AXIS OF SYMMETRY 224 SO PUCK SURFACE REMAINS PARALLEL TO POLISHING SURFACE
2001
SENSE LIMITED MOVEMENT OF CHUCK RELATIVE TO CHUCK SUPPORT PLATE TO INDICATE AN ACCURATE VALUE OF CONDITIONING FORCE
2002
DONE

FIG. 32

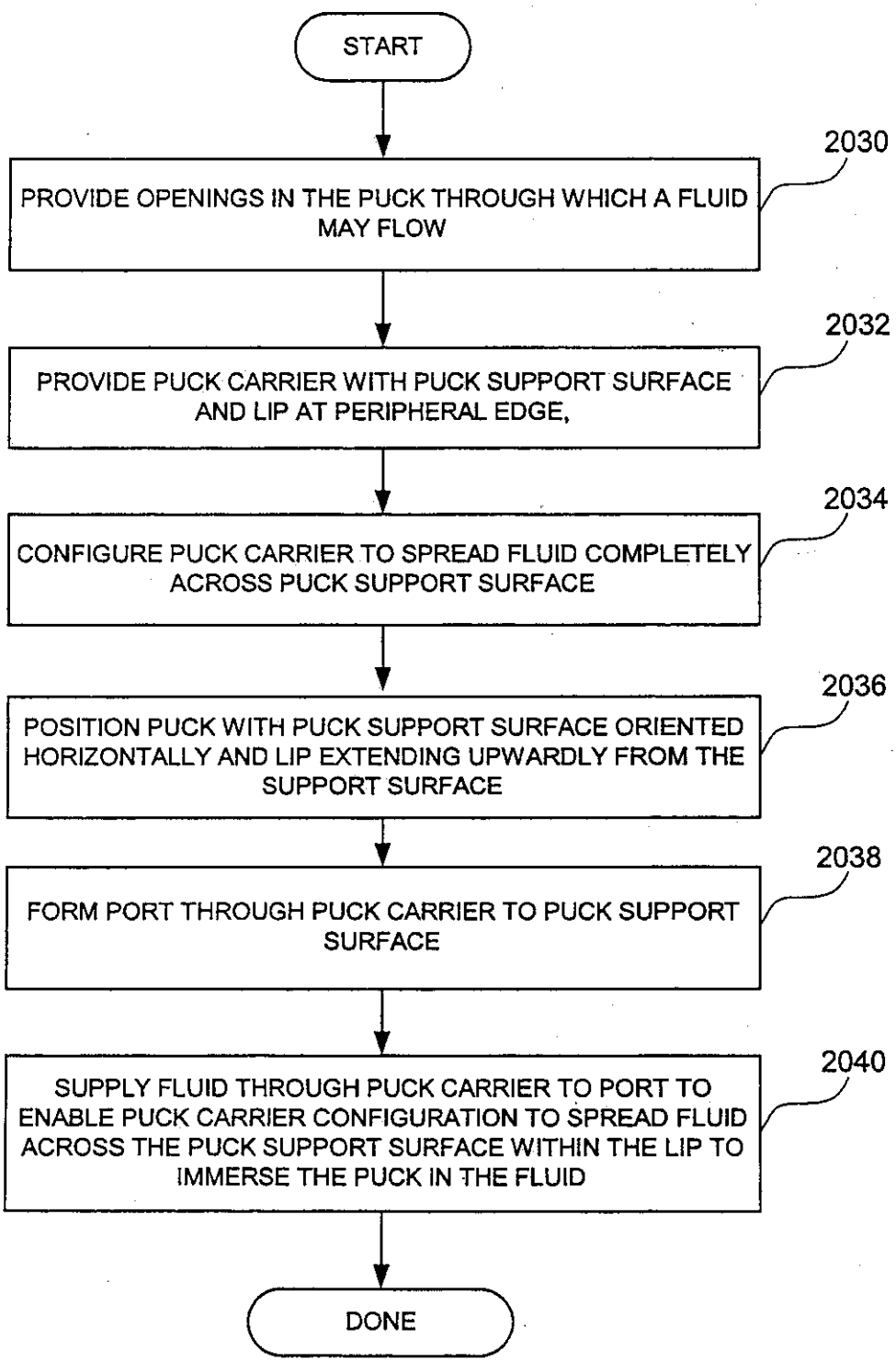

START
2030
PROVIDE OPENINGS IN THE PUCK THROUGH WHICH A FLUID MAY FLOW
2032
PROVIDE PUCK CARRIER WITH PUCK SUPPORT SURFACE AND LIP AT PERIPHERAL EDGE,
2034
CONFIGURE PUCK CARRIER TO SPREAD FLUID COMPLETELY ACROSS PUCK SUPPORT SURFACE
2036
POSITION PUCK WITH PUCK SUPPORT SURFACE ORIENTED HORIZONTALLY AND LIP EXTENDING UPWARDLY FROM THE SUPPORT SURFACE
2038
FORM PORT THROUGH PUCK CARRIER TO PUCK SUPPORT SURFACE
2040
SUPPLY FLUID THROUGH PUCK CARRIER TO PORT TO ENABLE PUCK CARRIER CONFIGURATION TO SPREAD FLUID ACROSS THE PUCK SUPPORT SURFACE WITHIN THE LIP TO IMMERSE THE PUCK IN THE FLUID
DONE

FIG. 33

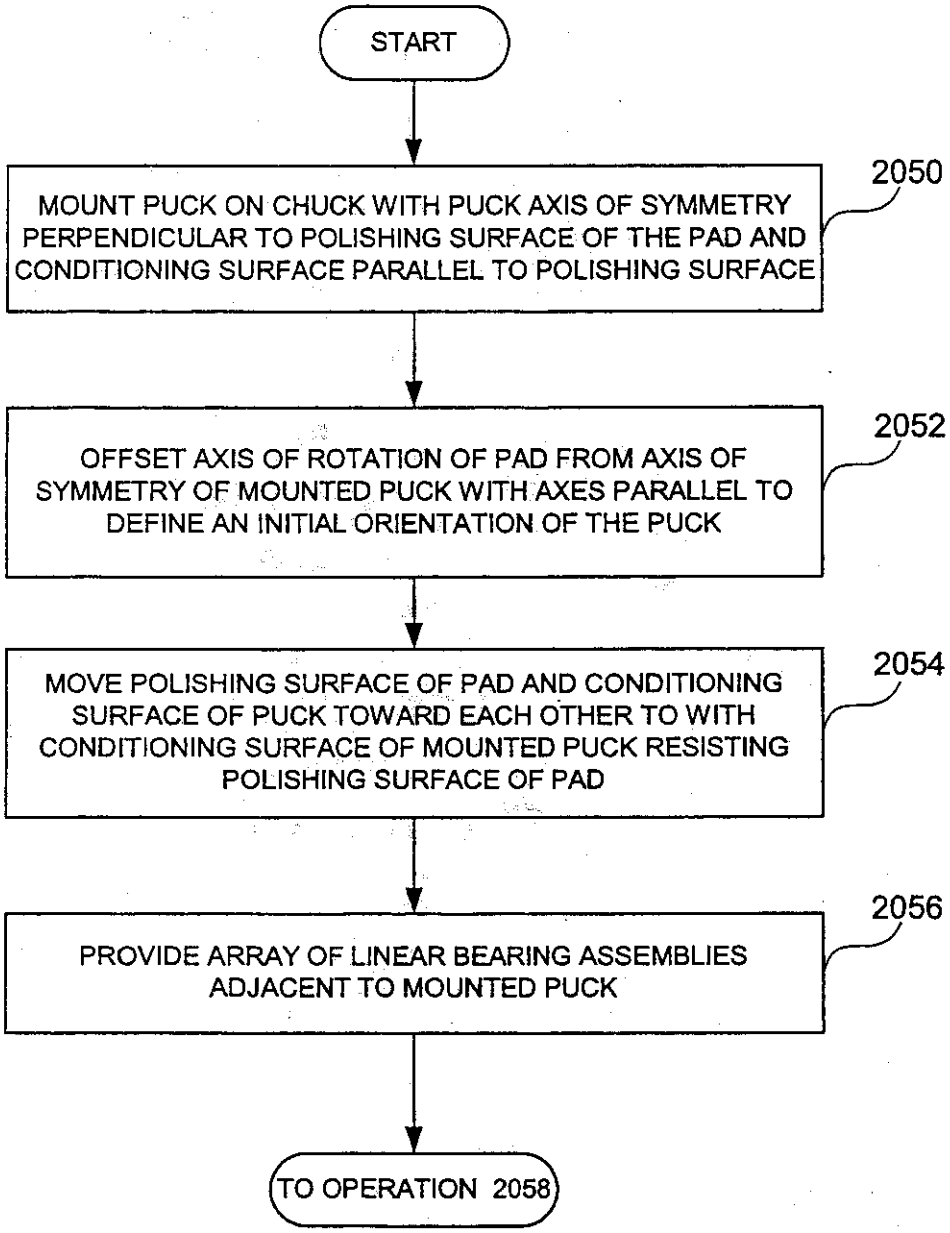

START
MOUNT PUCK ON CHUCK WITH PUCK AXIS OF SYMMETRY PERPENDICULAR TO POLISHING SURFACE OF THE PAD AND CONDITIONING SURFACE PARALLEL TO POLISHING SURFACE
2050
OFFSET AXIS OF ROTATION OF PAD FROM AXIS OF SYMMETRY OF MOUNTED PUCK WITH AXES PARALLEL TO DEFINE AN INITIAL ORIENTATION OF THE PUCK
2052
MOVE POLISHING SURFACE OF PAD AND CONDITIONING SURFACE OF PUCK TOWARD EACH OTHER TO WITH CONDITIONING SURFACE OF MOUNTED PUCK RESISTING POLISHING SURFACE OF PAD
2054
PROVIDE ARRAY OF LINEAR BEARING ASSEMBLIES ADJACENT TO MOUNTED PUCK
2056
TO OPERATION 2058

FIG. 34

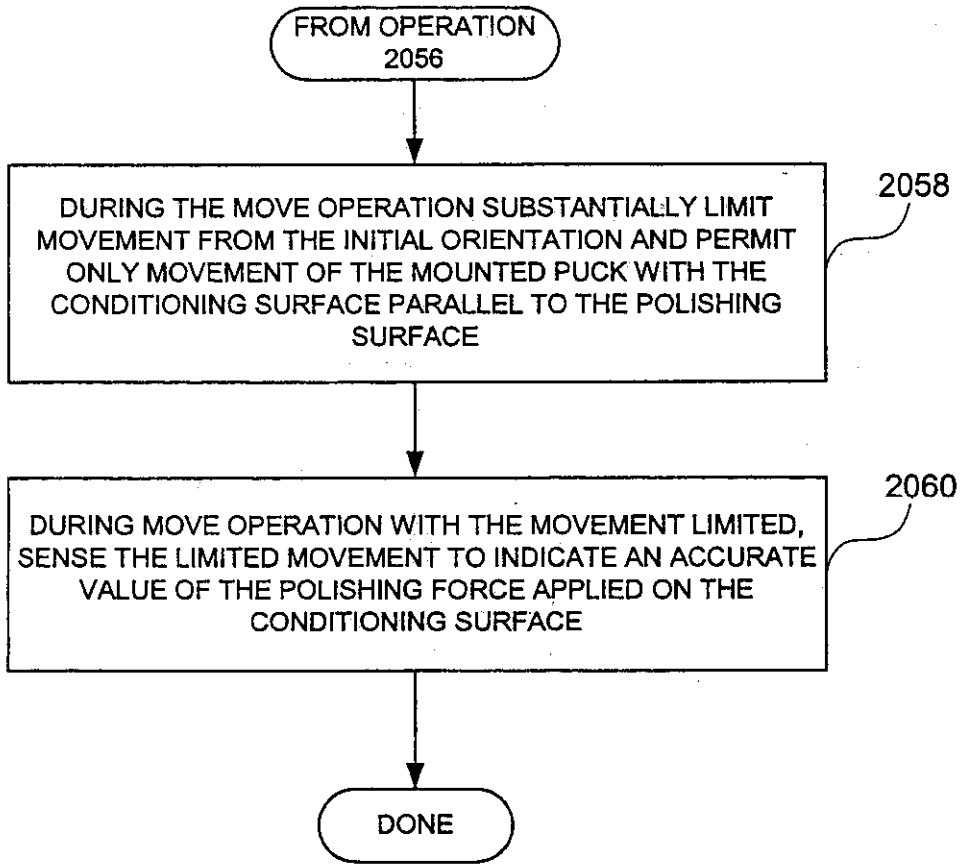

FROM OPERATION 2056
DURING THE MOVE OPERATION SUBSTANTIALLY LIMIT MOVEMENT FROM THE INITIAL ORIENTATION AND PERMIT ONLY MOVEMENT OF THE MOUNTED PUCK WITH THE CONDITIONING SURFACE PARALLEL TO THE POLISHING SURFACE
2058
DURING MOVE OPERATION WITH THE MOVEMENT LIMITED, SENSE THE LIMITED MOVEMENT TO INDICATE AN ACCURATE VALUE OF THE POLISHING FORCE APPLIED ON THE CONDITIONING SURFACE
2060
DONE

FIG. 35

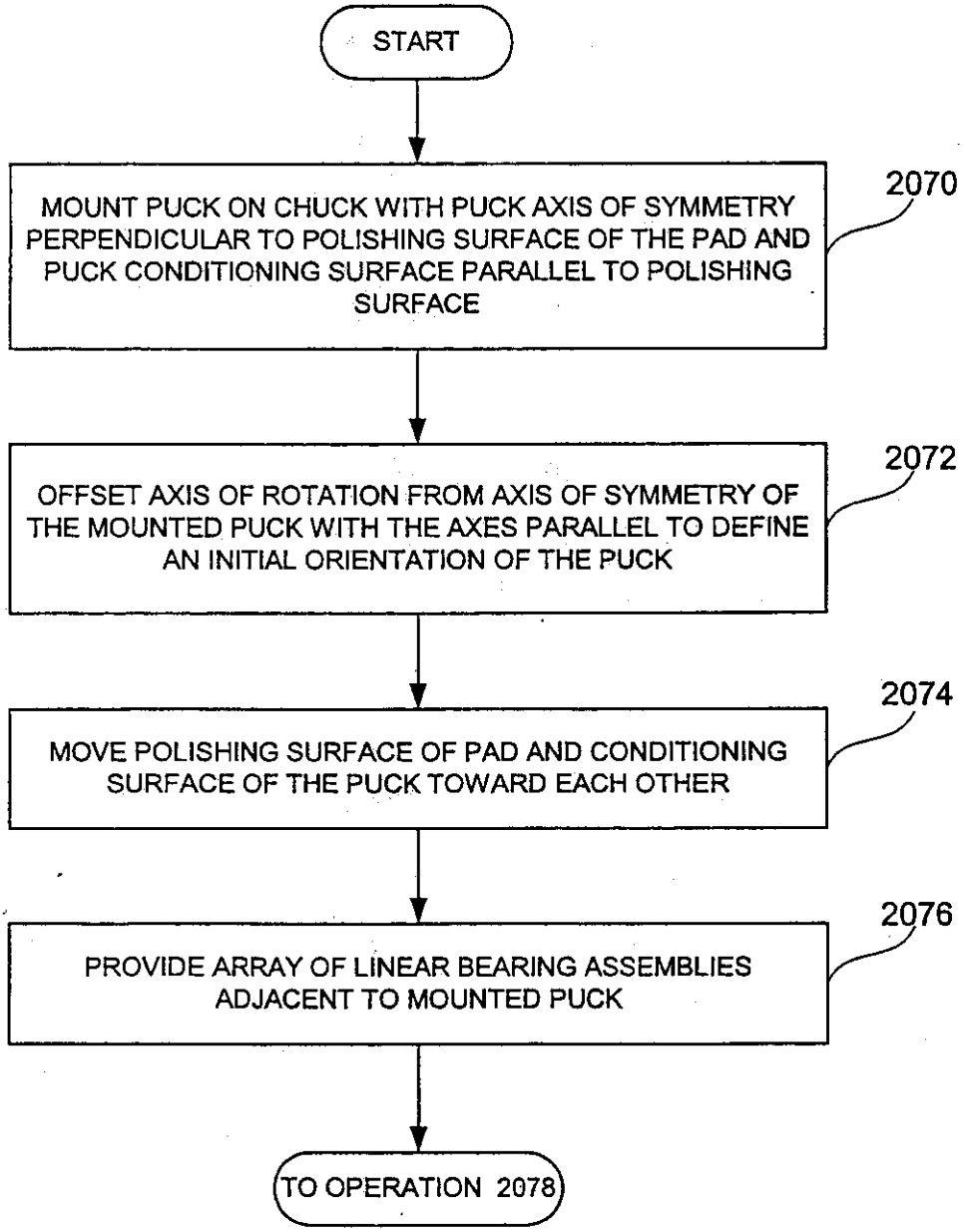

START
MOUNT PUCK ON CHUCK WITH PUCK AXIS OF SYMMETRY PERPENDICULAR TO POLISHING SURFACE OF THE PAD AND PUCK CONDITIONING SURFACE PARALLEL TO POLISHING SURFACE
2070
OFFSET AXIS OF ROTATION FROM AXIS OF SYMMETRY OF THE MOUNTED PUCK WITH THE AXES PARALLEL TO DEFINE AN INITIAL ORIENTATION OF THE PUCK
2072
MOVE POLISHING SURFACE OF PAD AND CONDITIONING SURFACE OF THE PUCK TOWARD EACH OTHER
2074
PROVIDE ARRAY OF LINEAR BEARING ASSEMBLIES ADJACENT TO MOUNTED PUCK
2076
TO OPERATION 2078

FIG. 36

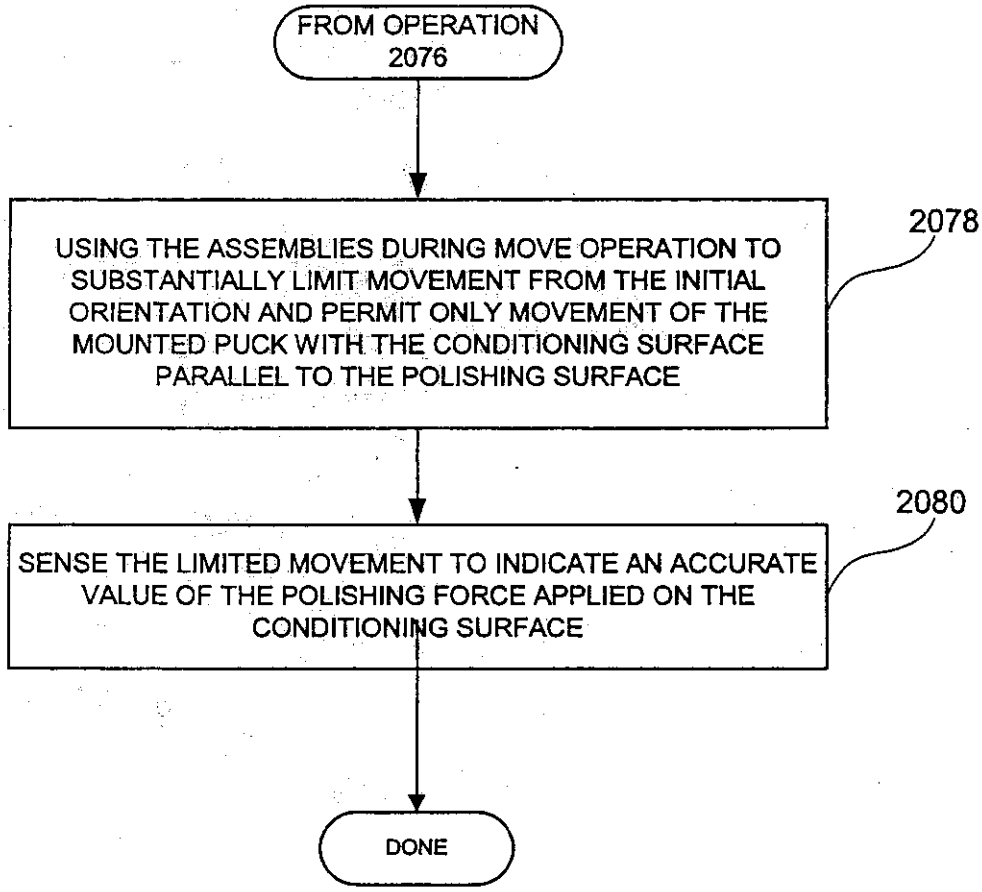

FROM OPERATION 2076
USING THE ASSEMBLIES DURING MOVE OPERATION TO SUBSTANTIALLY LIMIT MOVEMENT FROM THE INITIAL ORIENTATION AND PERMIT ONLY MOVEMENT OF THE MOUNTED PUCK WITH THE CONDITIONING SURFACE PARALLEL TO THE POLISHING SURFACE
2078
SENSE THE LIMITED MOVEMENT TO INDICATE AN ACCURATE VALUE OF THE POLISHING FORCE APPLIED ON THE CONDITIONING SURFACE
2080
DONE

FIG. 37

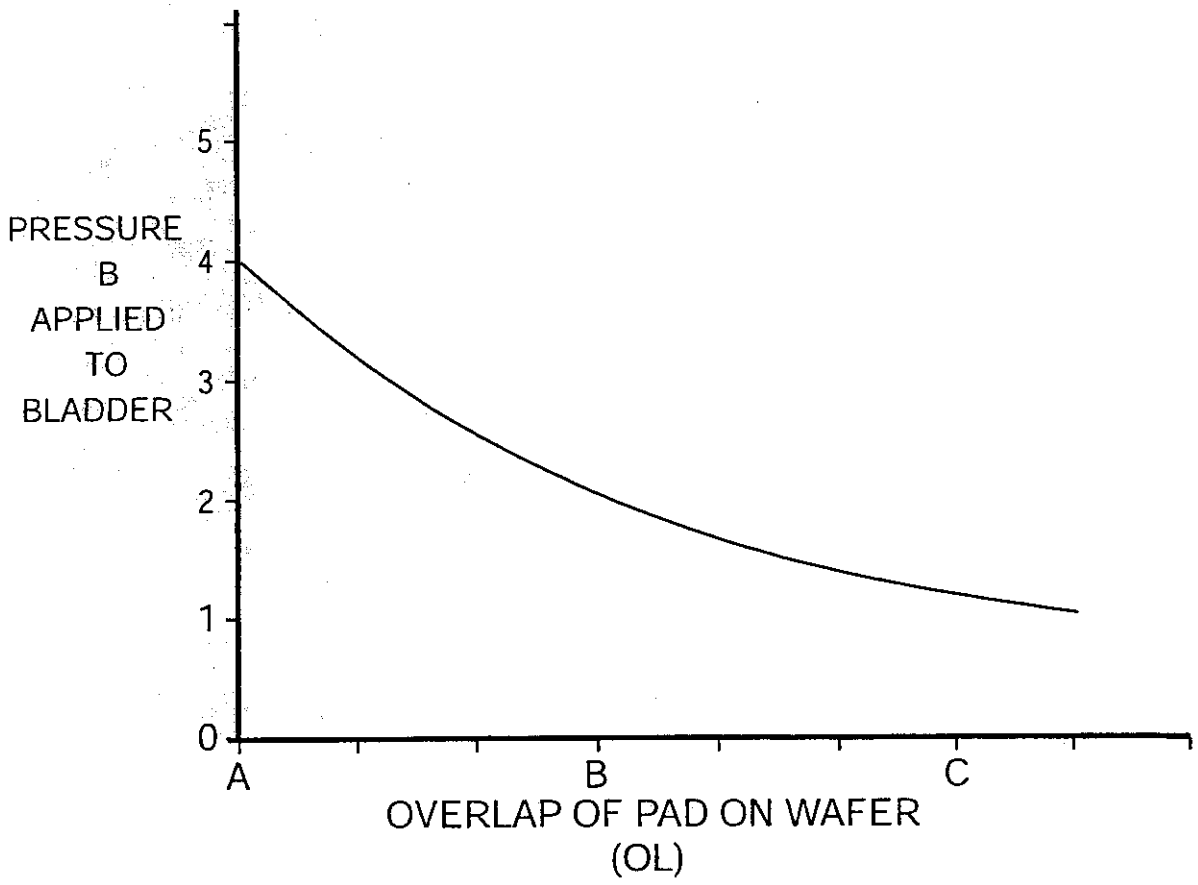

PRESSURE
B
APPLIED
TO
BLADDER
5
4
3
2
1
0
A
B
C
OVERLAP OF PAD ON WAFER
(OL)

FIG. 38

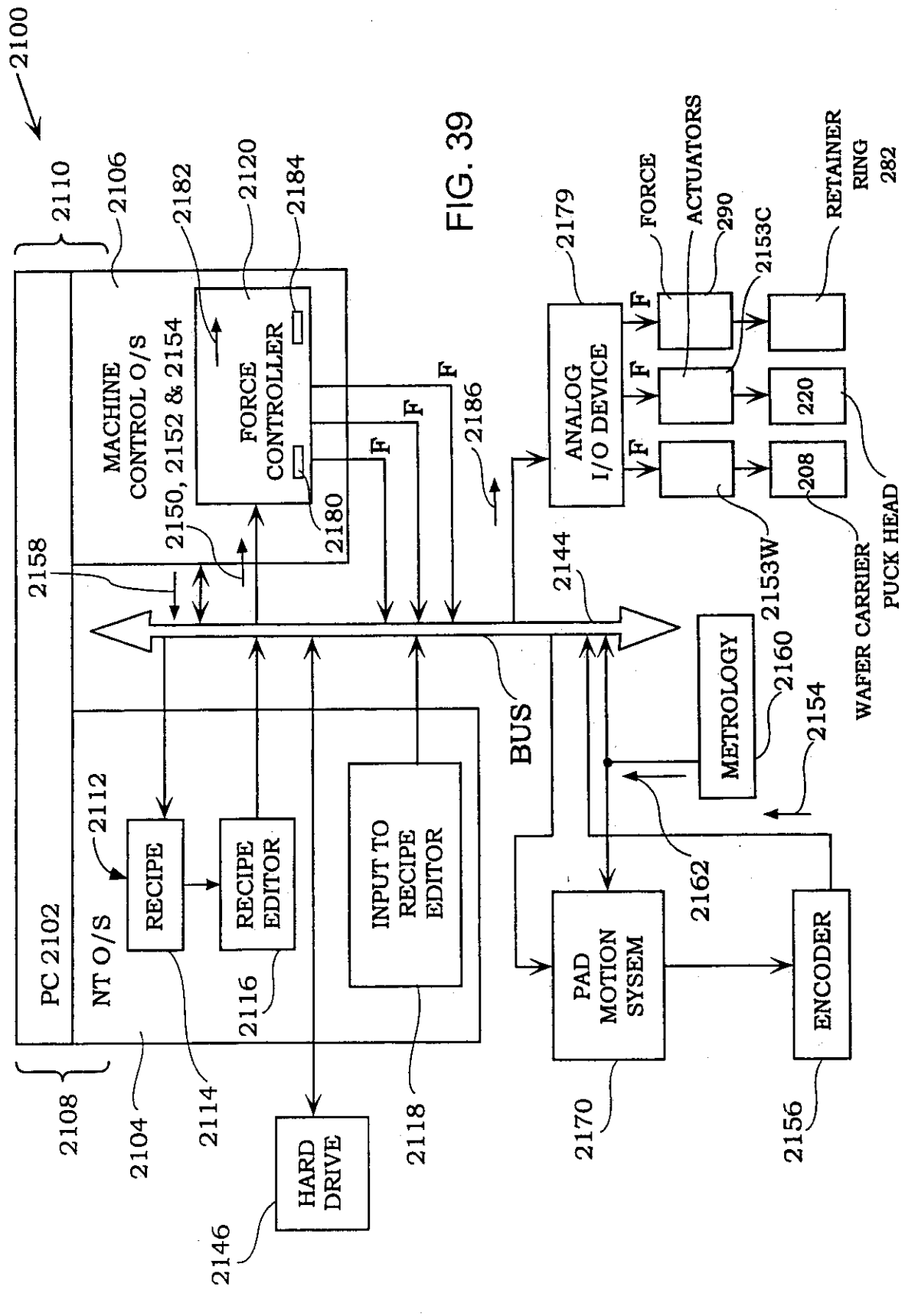

2100
2110
2106
2182
2120
2184
MACHINE CONTROL O/S
2150, 2152 & 2154
FORCE CONTROLLER
2180
2158
F
F
F
2186
2179
ANALOG I/O DEVICE
FORCE
ACTUATORS
290
2153C
RETAINER RING
282
220
208
WAFER CARRIER
PUCK HEAD
2153W
2144
BUS
METROLOGY
2160
2154
2162
PC 2102
NT O/S
2112
RECIPE
RECIPE EDITOR
INPUT TO RECIPE EDITOR
2116
2118
PAD MOTION SYSEM
ENCODER
2170
2156
2108
2104
2114
HARD DRIVE
2146

FIG. 39

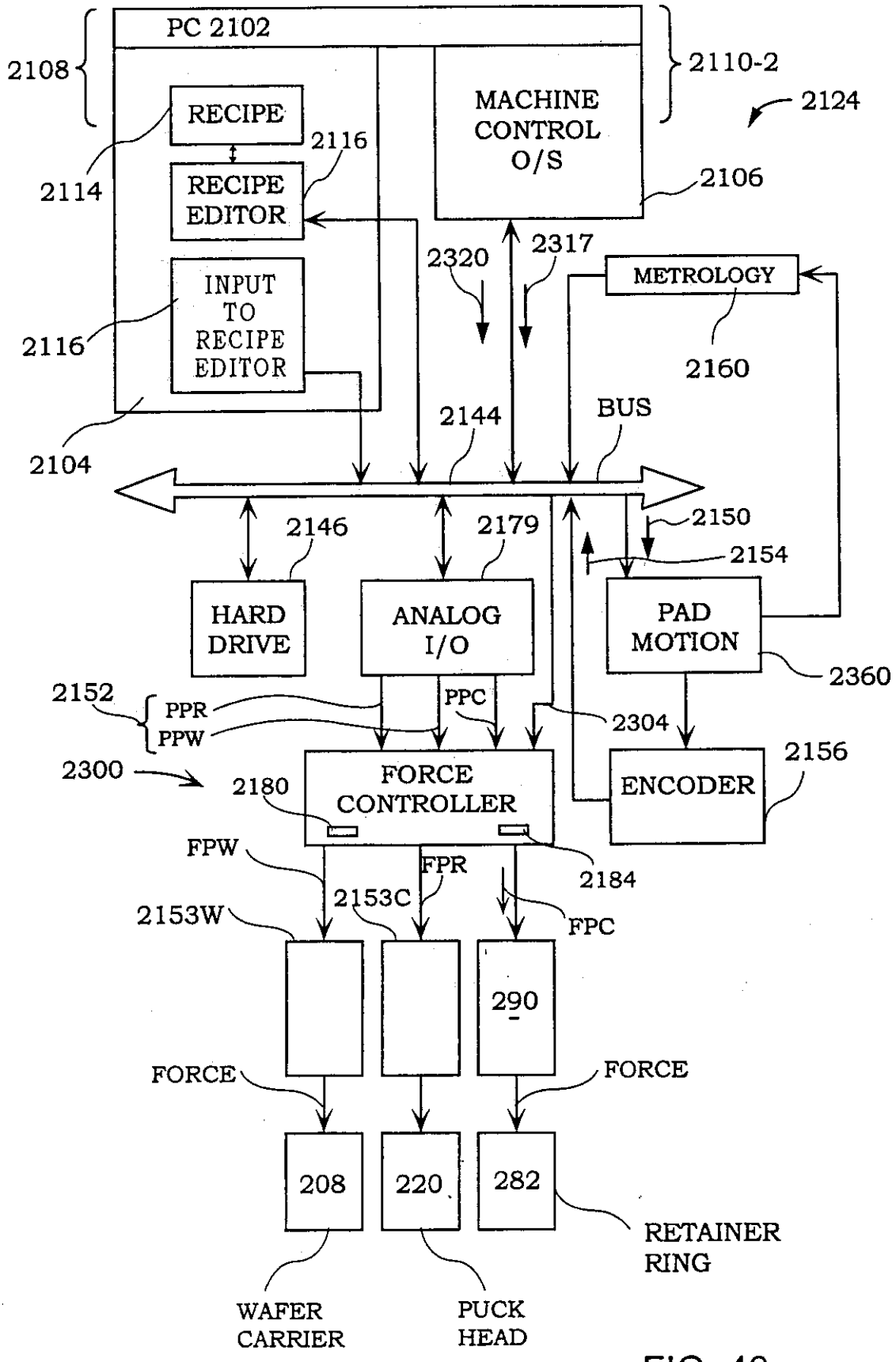

PC 2102
2108
2110-2
RECIPE
2114
2116
RECIPE EDITOR
MACHINE CONTROL O/S
2124
2106
2320
2317
INPUT TO RECIPE EDITOR
2116
METROLOGY
2160
2104
2144
BUS
2146
2179
2150
2154
HARD DRIVE
ANALOG I/O
PAD MOTION
2360
2152
PPR
PPW
PPC
2304
2300
2180
FORCE CONTROLLER
ENCODER
2156
FPW
FPR
2184
2153C
2153W
FPC
290
FORCE
FORCE
208
220
282
RETAINER RING
WAFER CARRIER
PUCK HEAD

FIG. 40

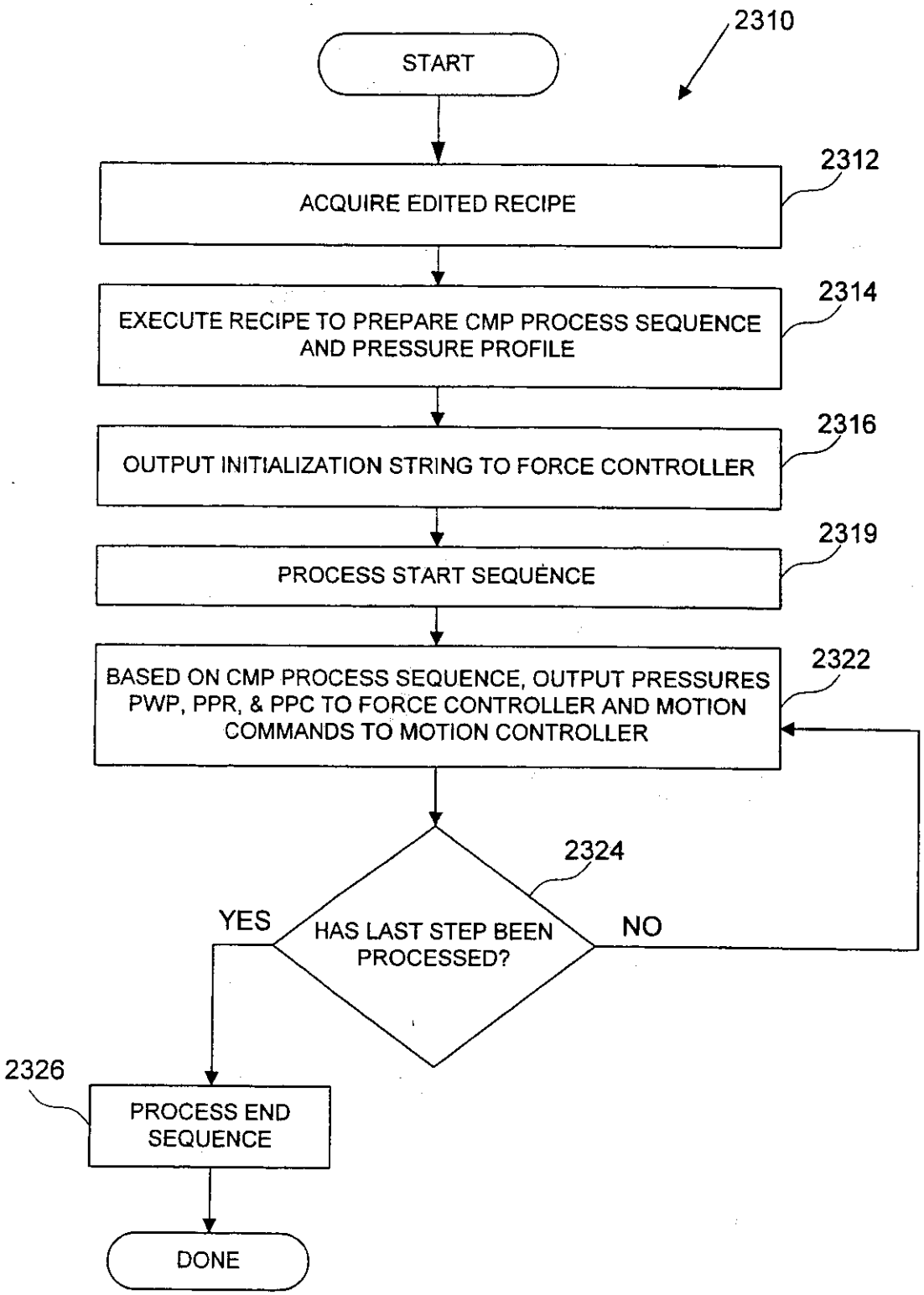

2310
START
2312
ACQUIRE EDITED RECIPE
2314
EXECUTE RECIPE TO PREPARE CMP PROCESS SEQUENCE AND PRESSURE PROFILE
2316
OUTPUT INITIALIZATION STRING TO FORCE CONTROLLER
2319
PROCESS START SEQUENCE
2322
BASED ON CMP PROCESS SEQUENCE, OUTPUT PRESSURES PWP, PPR, & PPC TO FORCE CONTROLLER AND MOTION COMMANDS TO MOTION CONTROLLER
2324
HAS LAST STEP BEEN PROCESSED?
YES
NO
2326
PROCESS END SEQUENCE
DONE

FIG. 41

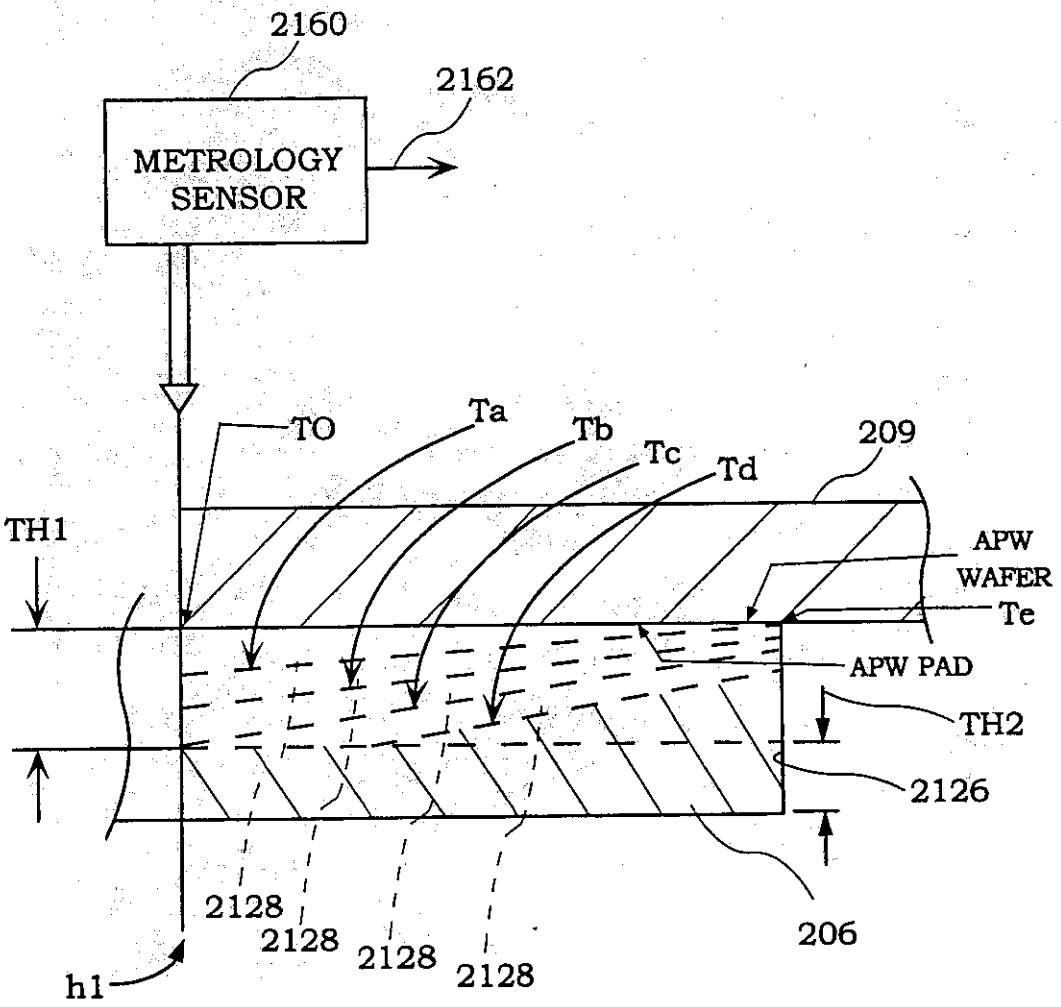

2160
2162
METROLOGY SENSOR
TO
Ta
Tb
Tc
Td
209
TH1
APW WAFER
Te
APW PAD
TH2
2126
2128
2128
2128
2128
206
h1

FIG. 42A

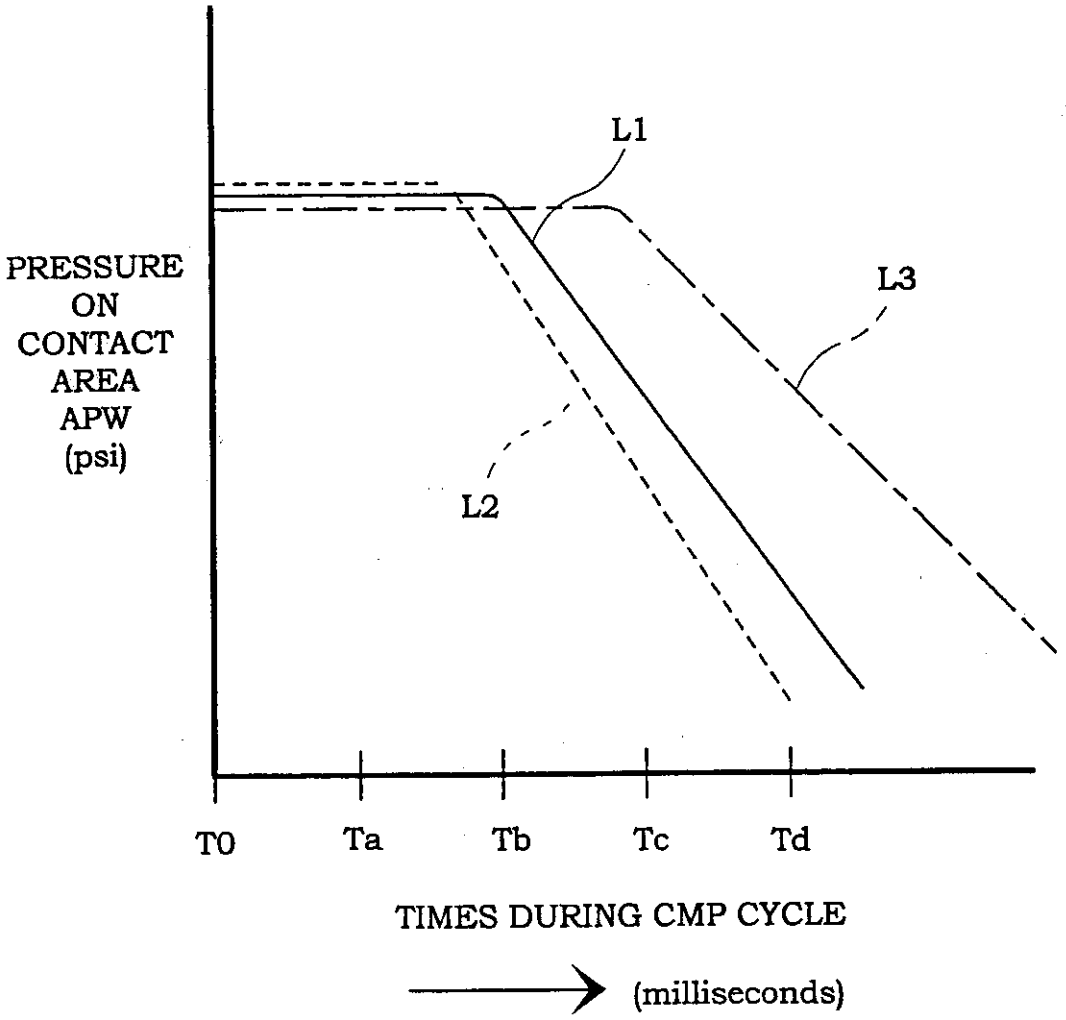

PRESSURE
ON
CONTACT
AREA
APW
(psi)
L1
L2
L3
T0
Ta
Tb
Tc
Td
TIMES DURING CMP CYCLE
(milliseconds)

FIG. 42B

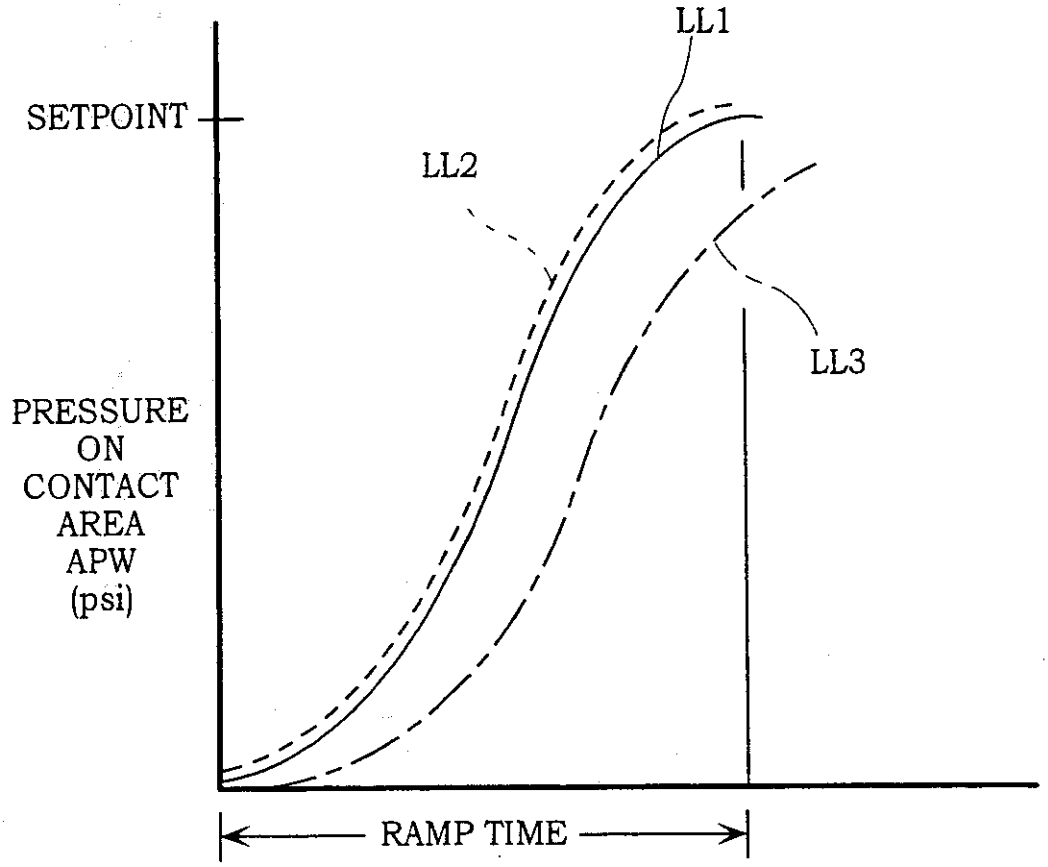

LL1
SETPOINT
LL2
LL3
PRESSURE
ON
CONTACT
AREA
APW
(psi)
RAMP TIME
TIMES DURING RAMP TO DESIRED PRESSURE
(milliseconds)

FIG. 42C

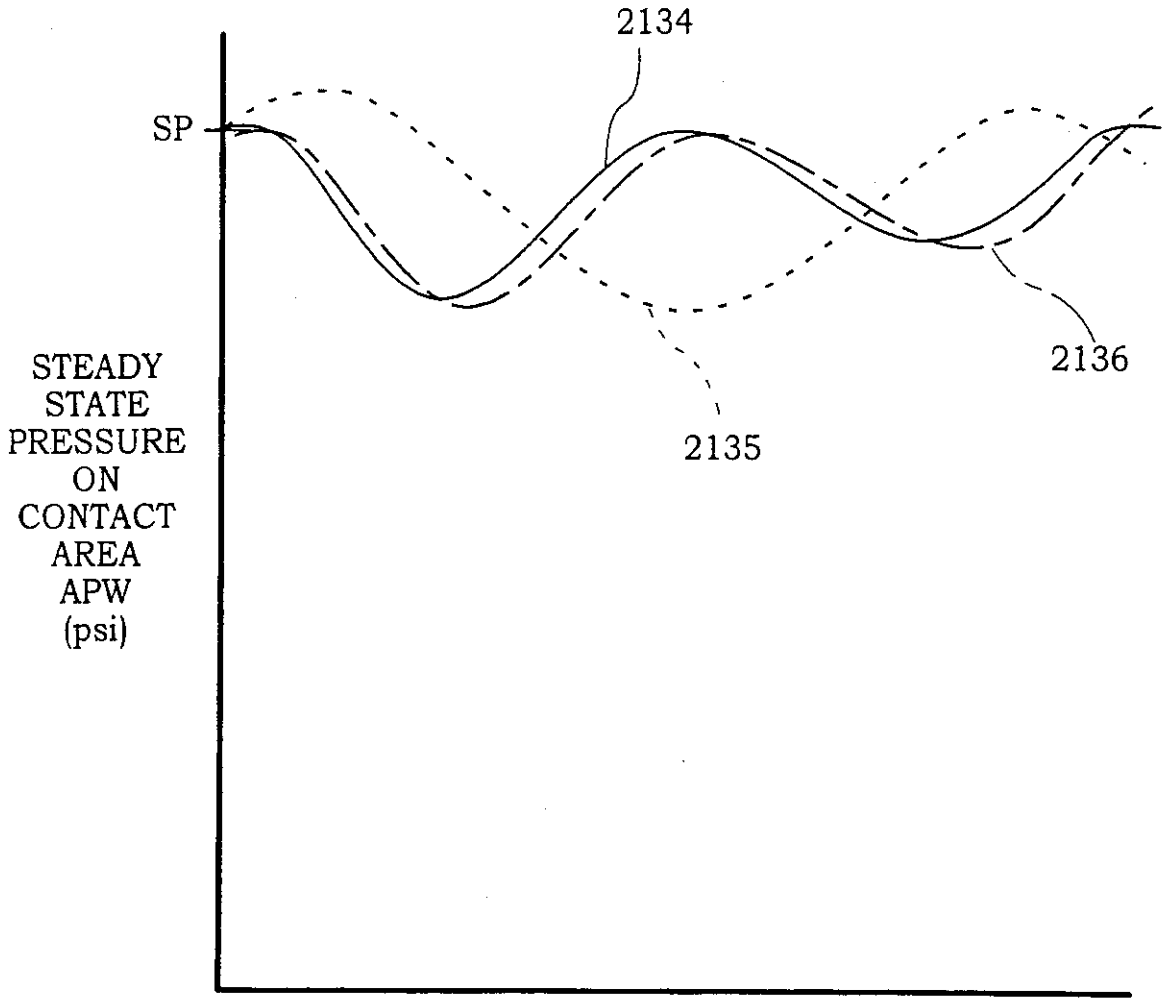

2134
SP
STEADY STATE PRESSURE ON CONTACT AREA APW (psi)
2136
2135
TIMES DURING CMP PRESSURE
(milliseconds)

FIG. 42D

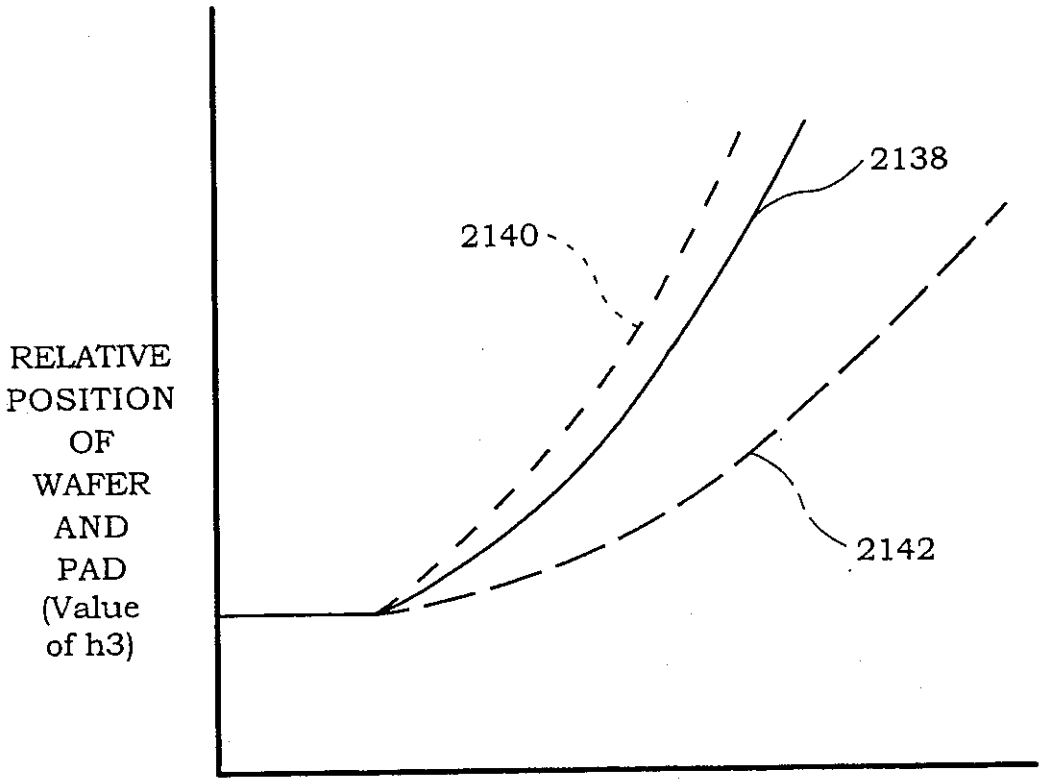

2138
2140
2142
RELATIVE POSITION OF WAFER AND PAD (Value of h3)
TIMES DURING STEP OF CMP CYCLE
(milliseconds)

FIG. 42E

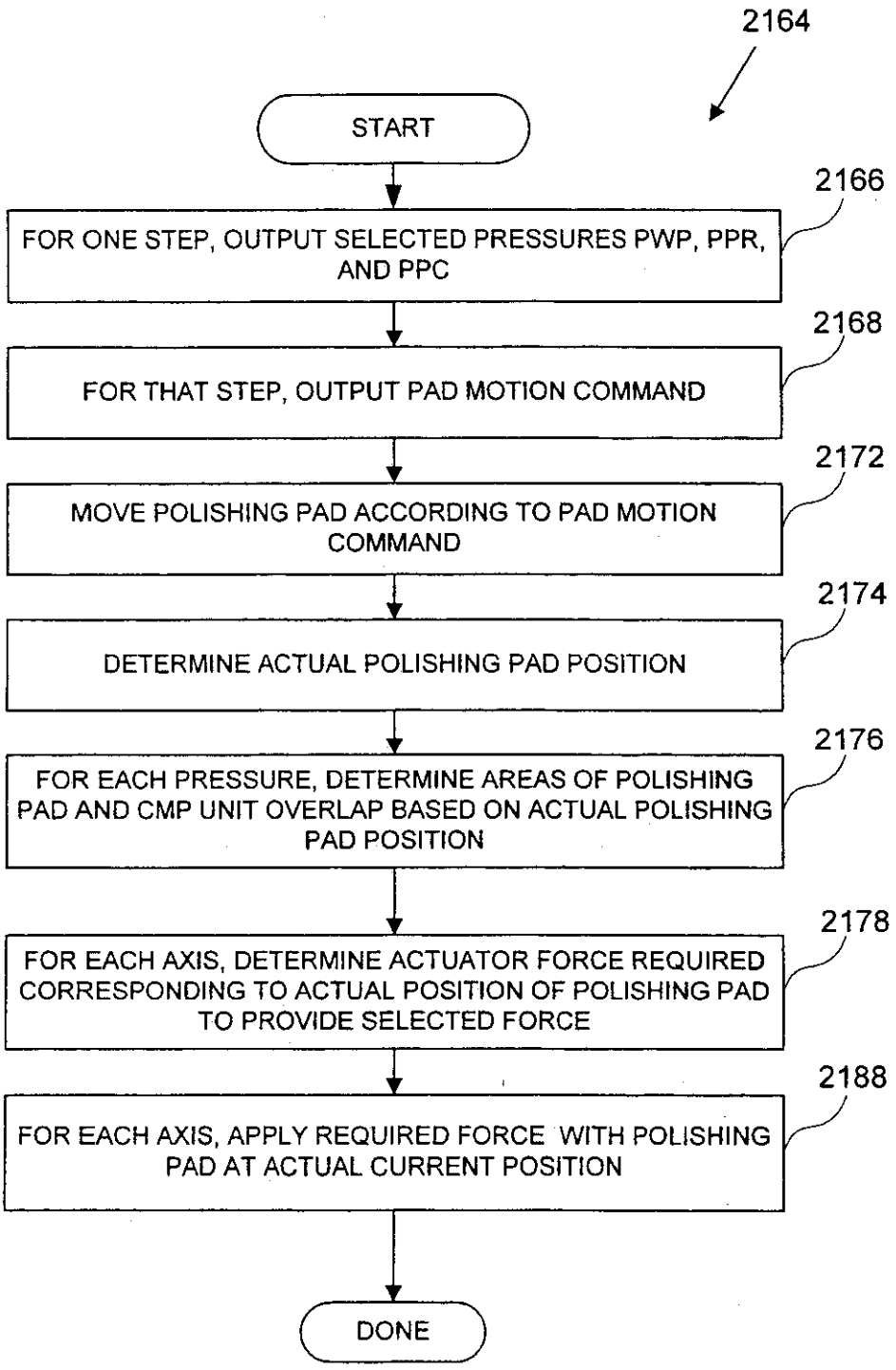

2164
START
2166
FOR ONE STEP, OUTPUT SELECTED PRESSURES PWP, PPR, AND PPC
2168
FOR THAT STEP, OUTPUT PAD MOTION COMMAND
2172
MOVE POLISHING PAD ACCORDING TO PAD MOTION COMMAND
2174
DETERMINE ACTUAL POLISHING PAD POSITION
2176
FOR EACH PRESSURE, DETERMINE AREAS OF POLISHING PAD AND CMP UNIT OVERLAP BASED ON ACTUAL POLISHING PAD POSITION
2178
FOR EACH AXIS, DETERMINE ACTUATOR FORCE REQUIRED CORRESPONDING TO ACTUAL POSITION OF POLISHING PAD TO PROVIDE SELECTED FORCE
2188
FOR EACH AXIS, APPLY REQUIRED FORCE WITH POLISHING PAD AT ACTUAL CURRENT POSITION
DONE

FIG. 43

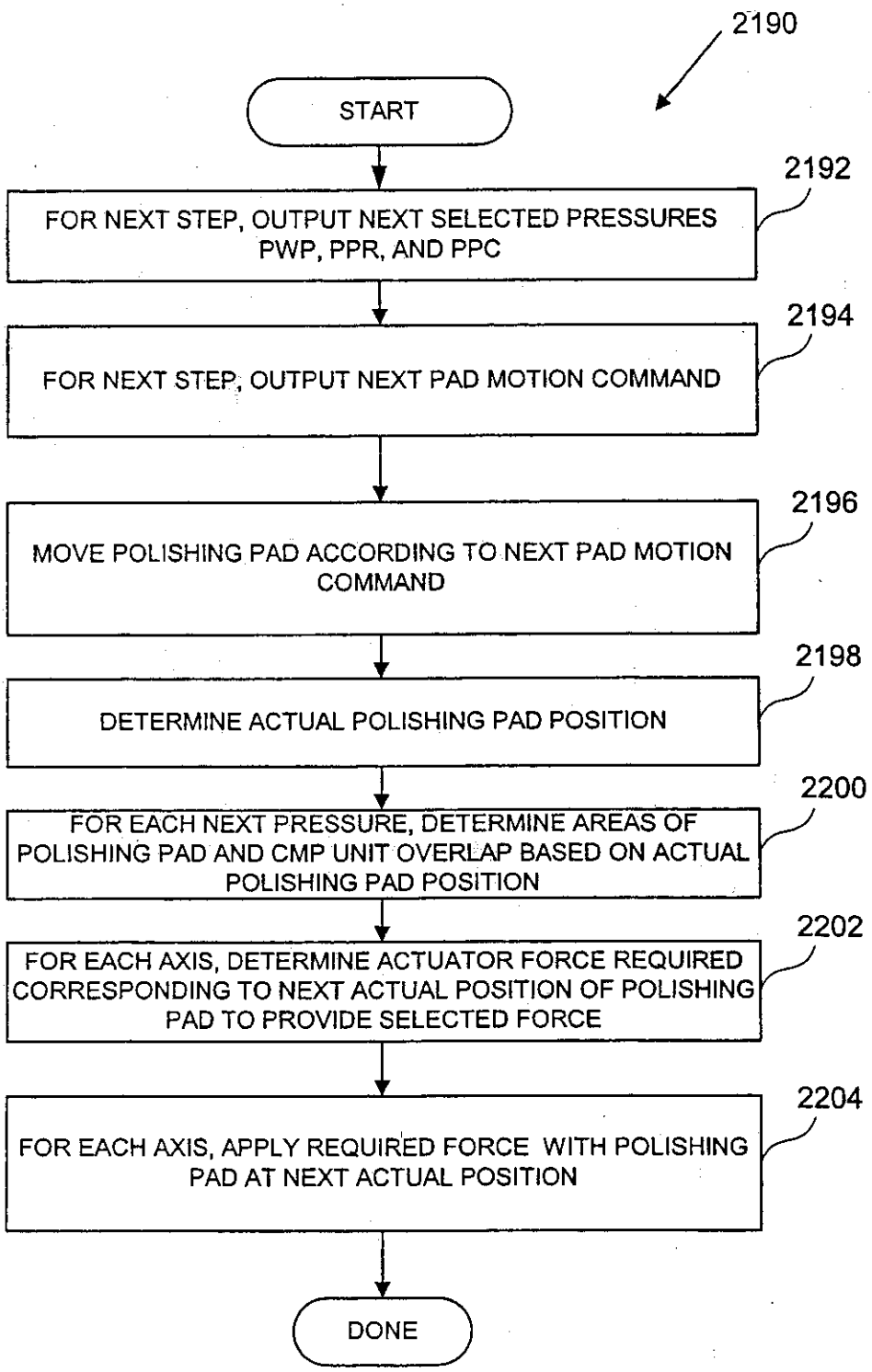

2190
START
2192
FOR NEXT STEP, OUTPUT NEXT SELECTED PRESSURES PWP, PPR, AND PPC
2194
FOR NEXT STEP, OUTPUT NEXT PAD MOTION COMMAND
2196
MOVE POLISHING PAD ACCORDING TO NEXT PAD MOTION COMMAND
2198
DETERMINE ACTUAL POLISHING PAD POSITION
2200
FOR EACH NEXT PRESSURE, DETERMINE AREAS OF POLISHING PAD AND CMP UNIT OVERLAP BASED ON ACTUAL POLISHING PAD POSITION
2202
FOR EACH AXIS, DETERMINE ACTUATOR FORCE REQUIRED CORRESPONDING TO NEXT ACTUAL POSITION OF POLISHING PAD TO PROVIDE SELECTED FORCE
2204
FOR EACH AXIS, APPLY REQUIRED FORCE WITH POLISHING PAD AT NEXT ACTUAL POSITION
DONE

FIG. 44

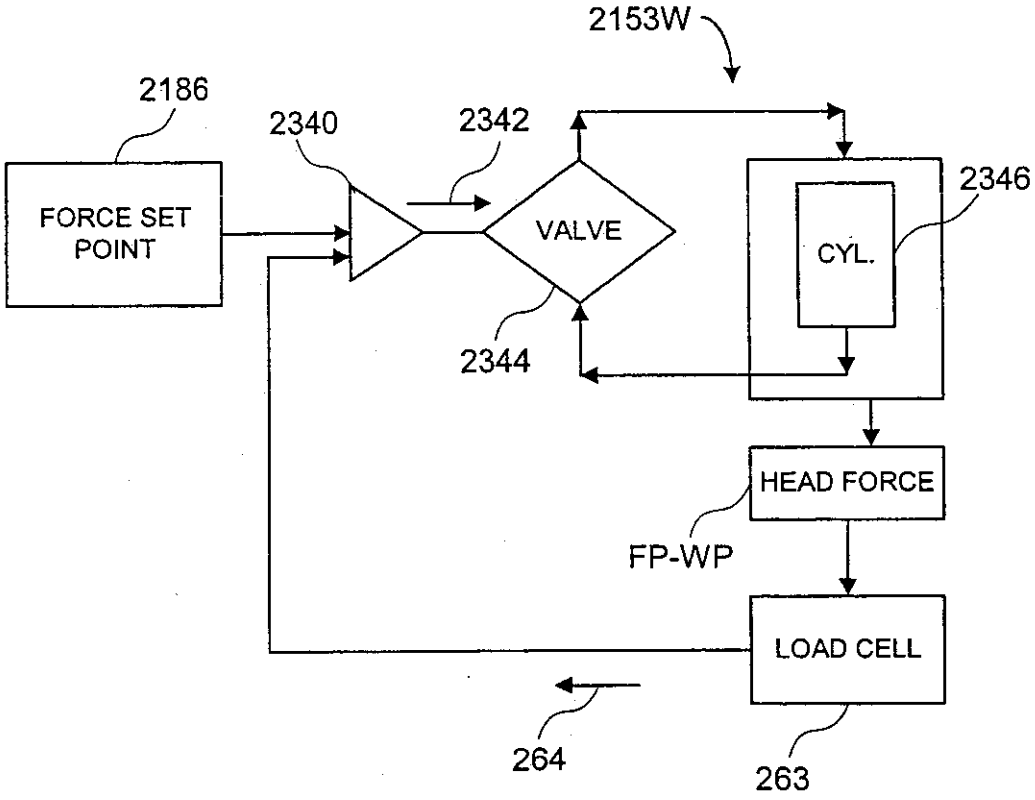

2153W
2186
2340
2342
2346
FORCE SET POINT
VALVE
CYL.
2344
HEAD FORCE
FP-WP
LOAD CELL
264
263

FIG. 45

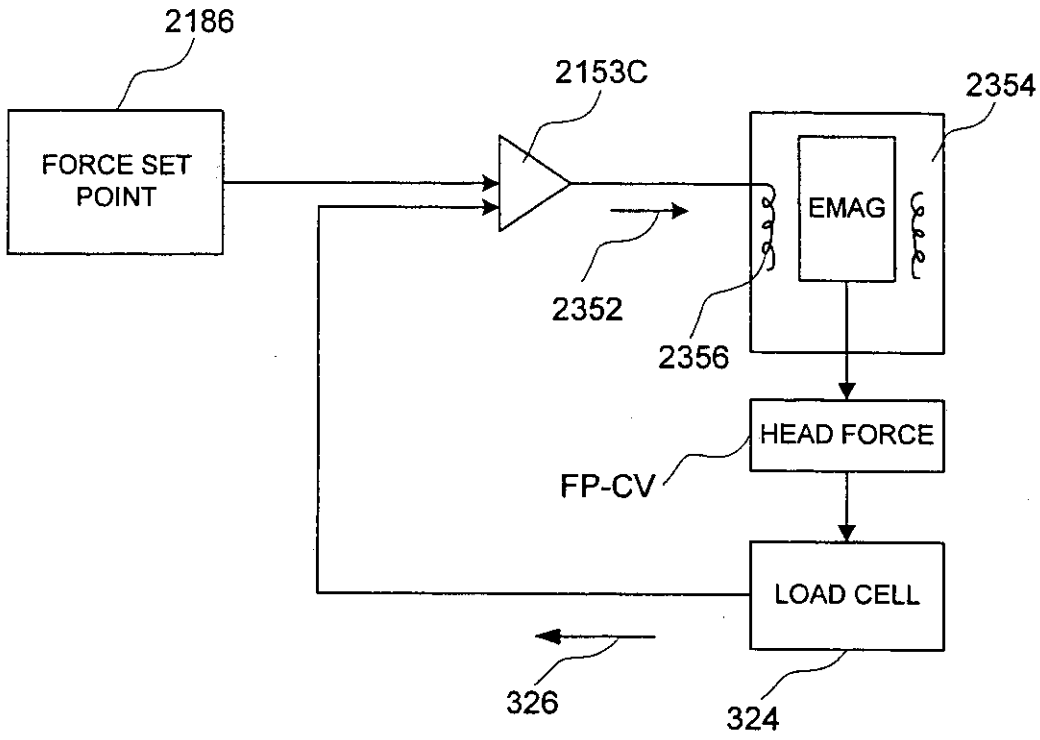

2186
FORCE SET POINT
2153C
2354
EMAG
2352
2356
HEAD FORCE
FP-CV
LOAD CELL
326
324

FIG. 46

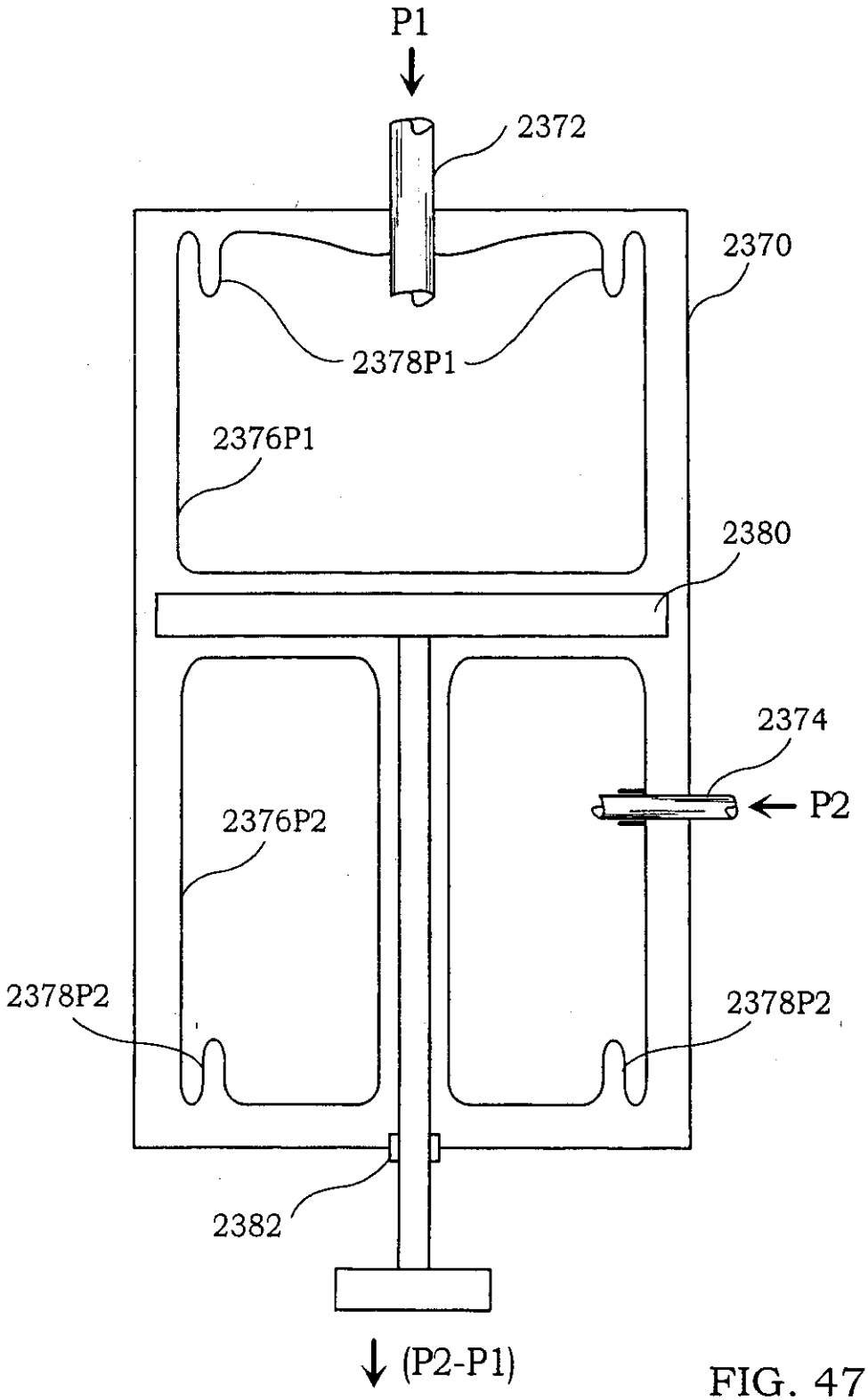

P1
2372
2370
2378P1
2376P1
2380
2374
P2
2376P2
2378P2
2378P2
2382
(P2-P1)

FIG. 47

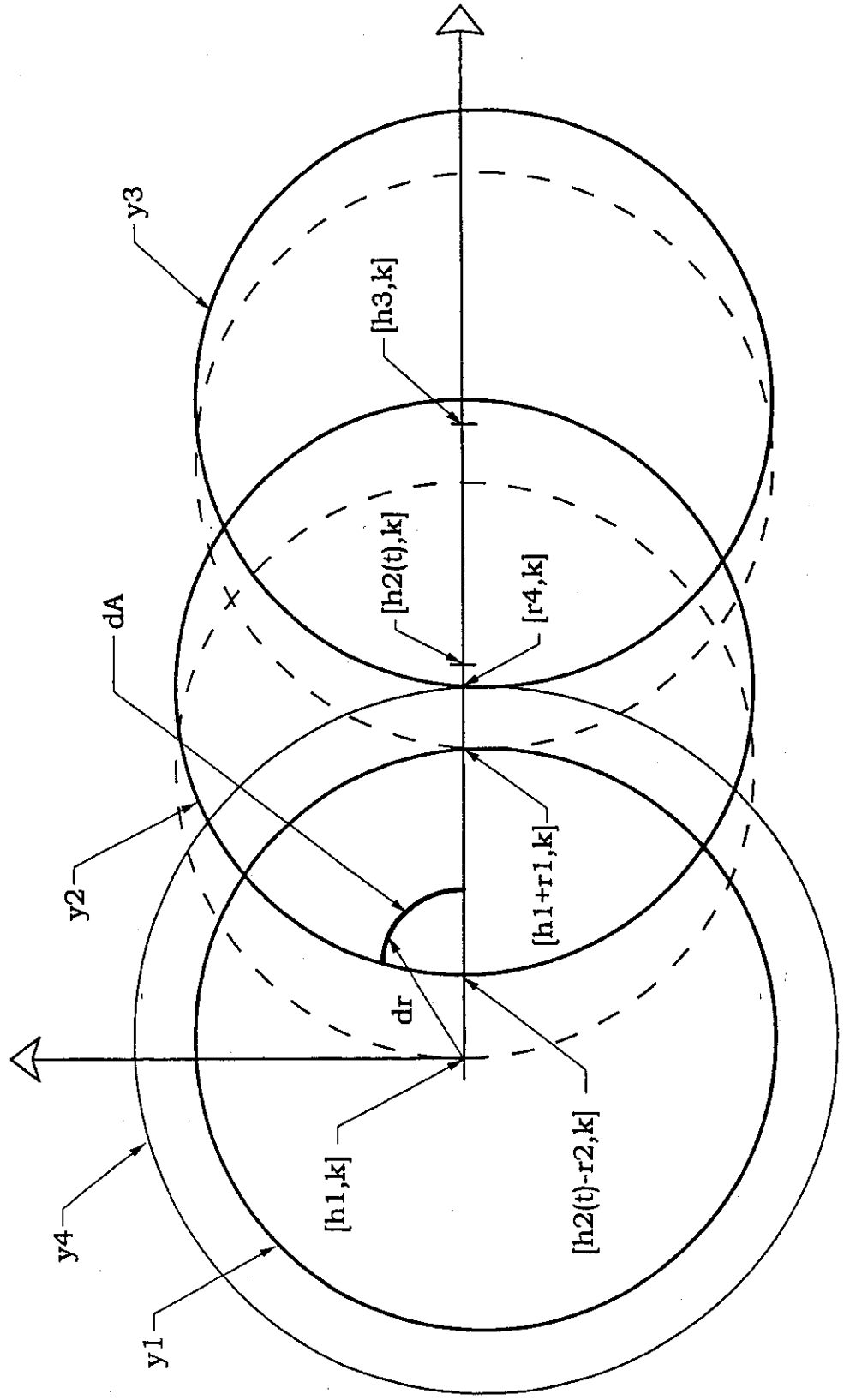


FIG. 48