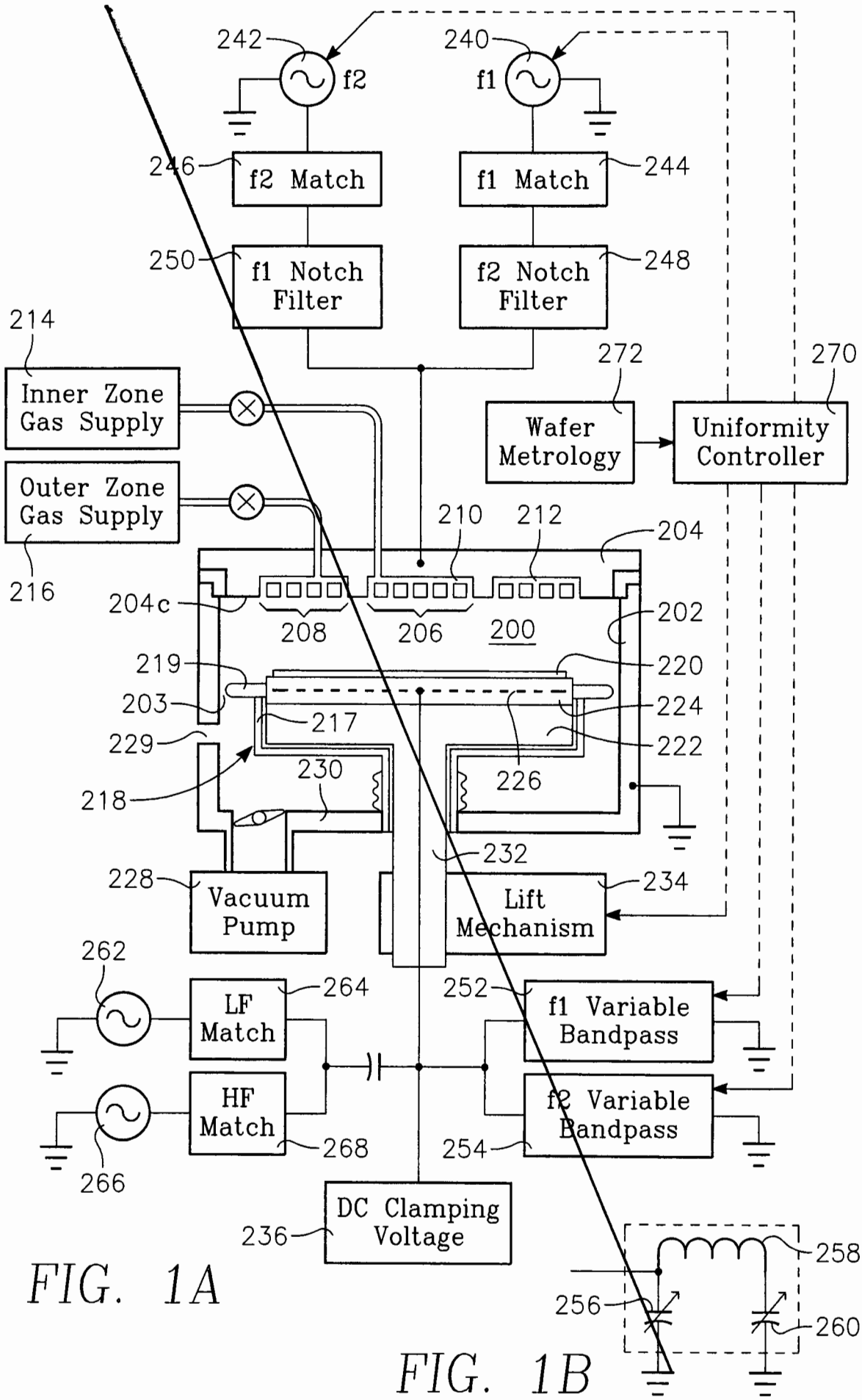

242
f2
240
f1
246
f2 Match
f1 Match
244
250
f1 Notch Filter
f2 Notch Filter
248
214
Inner Zone Gas Supply
272
Wafer Metrology
Uniformity Controller
270
Outer Zone Gas Supply
216
210
212
204
204c
208
206
200
202
219
220
203
224
217
229
222
218
230
226
232
228
Vacuum Pump
Lift Mechanism
234
262
LF Match
264
252
f1 Variable Bandpass
HF Match
268
f2 Variable Bandpass
254
266
DC Clamping Voltage
236
258
256
260

FIG. 1A

FIG. 1B

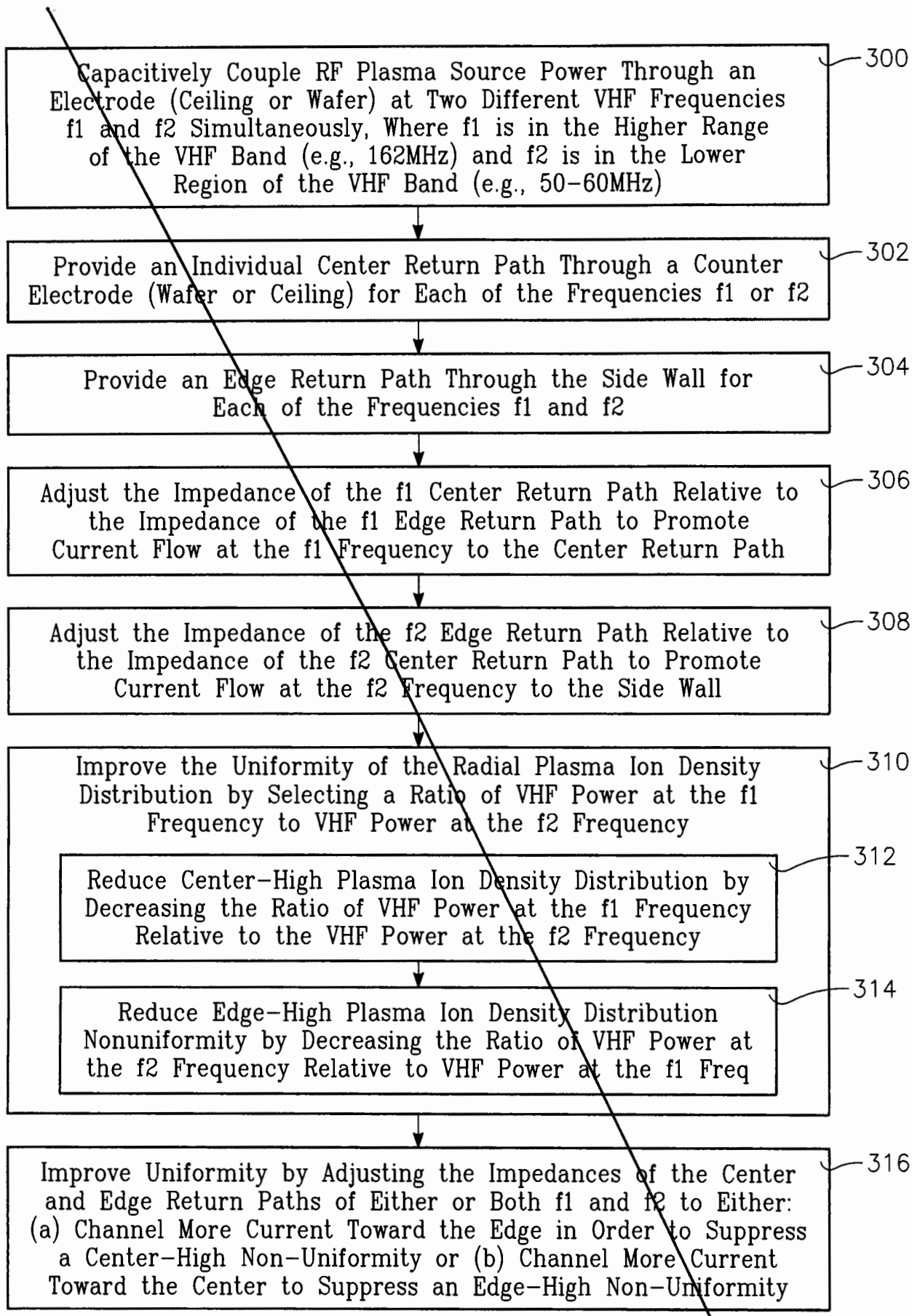

Capacitively Couple RF Plasma Source Power Through an Electrode (Ceiling or Wafer) at Two Different VHF Frequencies f1 and f2 Simultaneously, Where f1 is in the Higher Range of the VHF Band (e.g., 162MHz) and f2 is in the Lower Region of the VHF Band (e.g., 50-60MHz)
300
Provide an Individual Center Return Path Through a Counter Electrode (Wafer or Ceiling) for Each of the Frequencies f1 or f2
302
Provide an Edge Return Path Through the Side Wall for Each of the Frequencies f1 and f2
304
Adjust the Impedance of the f1 Center Return Path Relative to the Impedance of the f1 Edge Return Path to Promote Current Flow at the f1 Frequency to the Center Return Path
306
Adjust the Impedance of the f2 Edge Return Path Relative to the Impedance of the f2 Center Return Path to Promote Current Flow at the f2 Frequency to the Side Wall
308
Improve the Uniformity of the Radial Plasma Ion Density Distribution by Selecting a Ratio of VHF Power at the f1 Frequency to VHF Power at the f2 Frequency
310
Reduce Center-High Plasma Ion Density Distribution by Decreasing the Ratio of VHF Power at the f1 Frequency Relative to the VHF Power at the f2 Frequency
312
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Decreasing the Ratio of VHF Power at the f2 Frequency Relative to VHF Power at the f1 Freq
314
Improve Uniformity by Adjusting the Impedances of the Center and Edge Return Paths of Either or Both f1 and f2 to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
316

FIG. 7

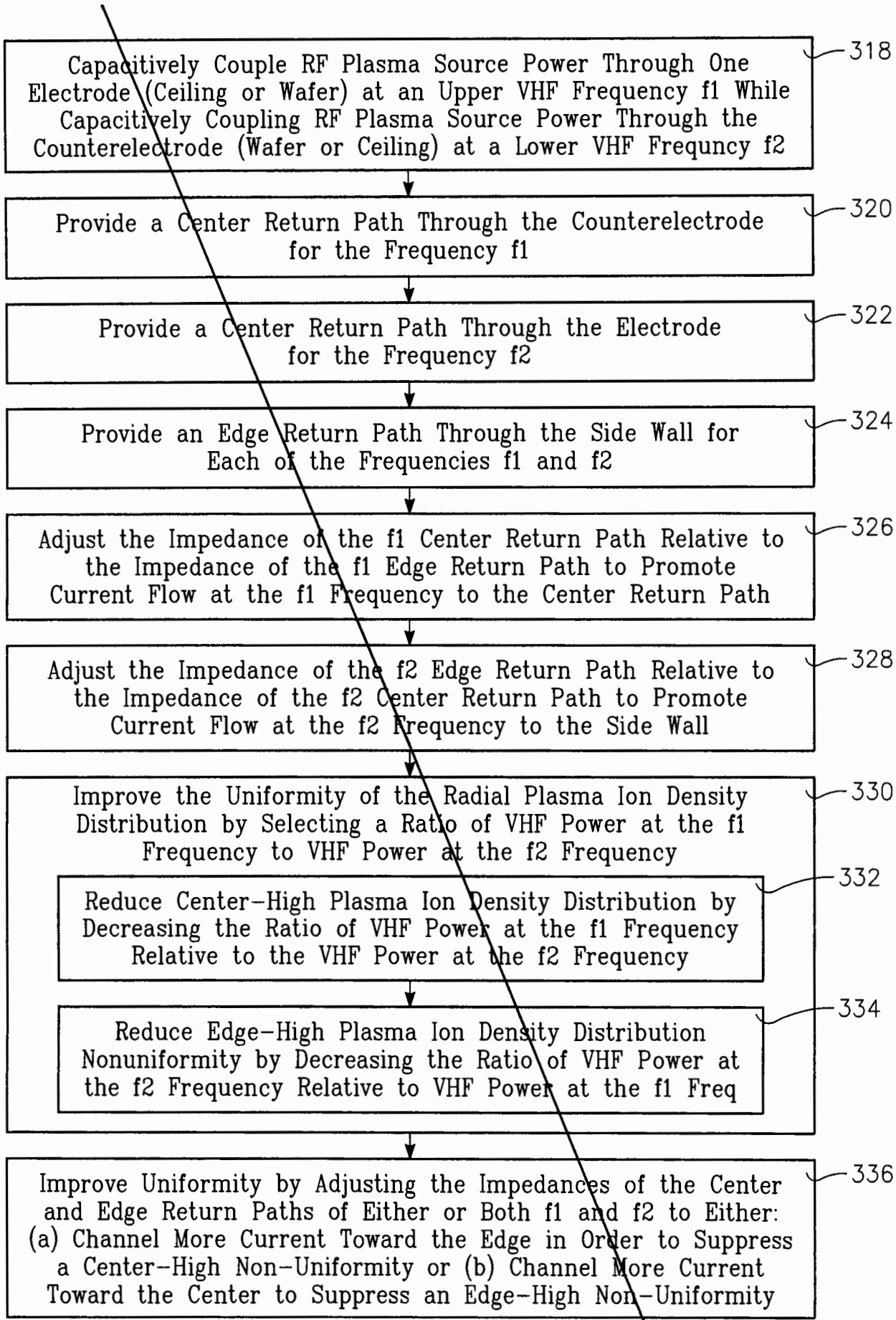

Capacitively Couple RF Plasma Source Power Through One Electrode (Ceiling or Wafer) at an Upper VHF Frequency f1 While Capacitively Coupling RF Plasma Source Power Through the Counterelectrode (Wafer or Ceiling) at a Lower VHF Frequncy f2
318
Provide a Center Return Path Through the Counterelectrode for the Frequency f1
320
Provide a Center Return Path Through the Electrode for the Frequency f2
322
Provide an Edge Return Path Through the Side Wall for Each of the Frequencies f1 and f2
324
Adjust the Impedance of the f1 Center Return Path Relative to the Impedance of the f1 Edge Return Path to Promote Current Flow at the f1 Frequency to the Center Return Path
326
Adjust the Impedance of the f2 Edge Return Path Relative to the Impedance of the f2 Center Return Path to Promote Current Flow at the f2 Frequency to the Side Wall
328
Improve the Uniformity of the Radial Plasma Ion Density Distribution by Selecting a Ratio of VHF Power at the f1 Frequency to VHF Power at the f2 Frequency
330
Reduce Center-High Plasma Ion Density Distribution by Decreasing the Ratio of VHF Power at the f1 Frequency Relative to the VHF Power at the f2 Frequency
332
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Decreasing the Ratio of VHF Power at the f2 Frequency Relative to VHF Power at the f1 Freq
334
Improve Uniformity by Adjusting the Impedances of the Center and Edge Return Paths of Either or Both f1 and f2 to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
336

FIG. 8

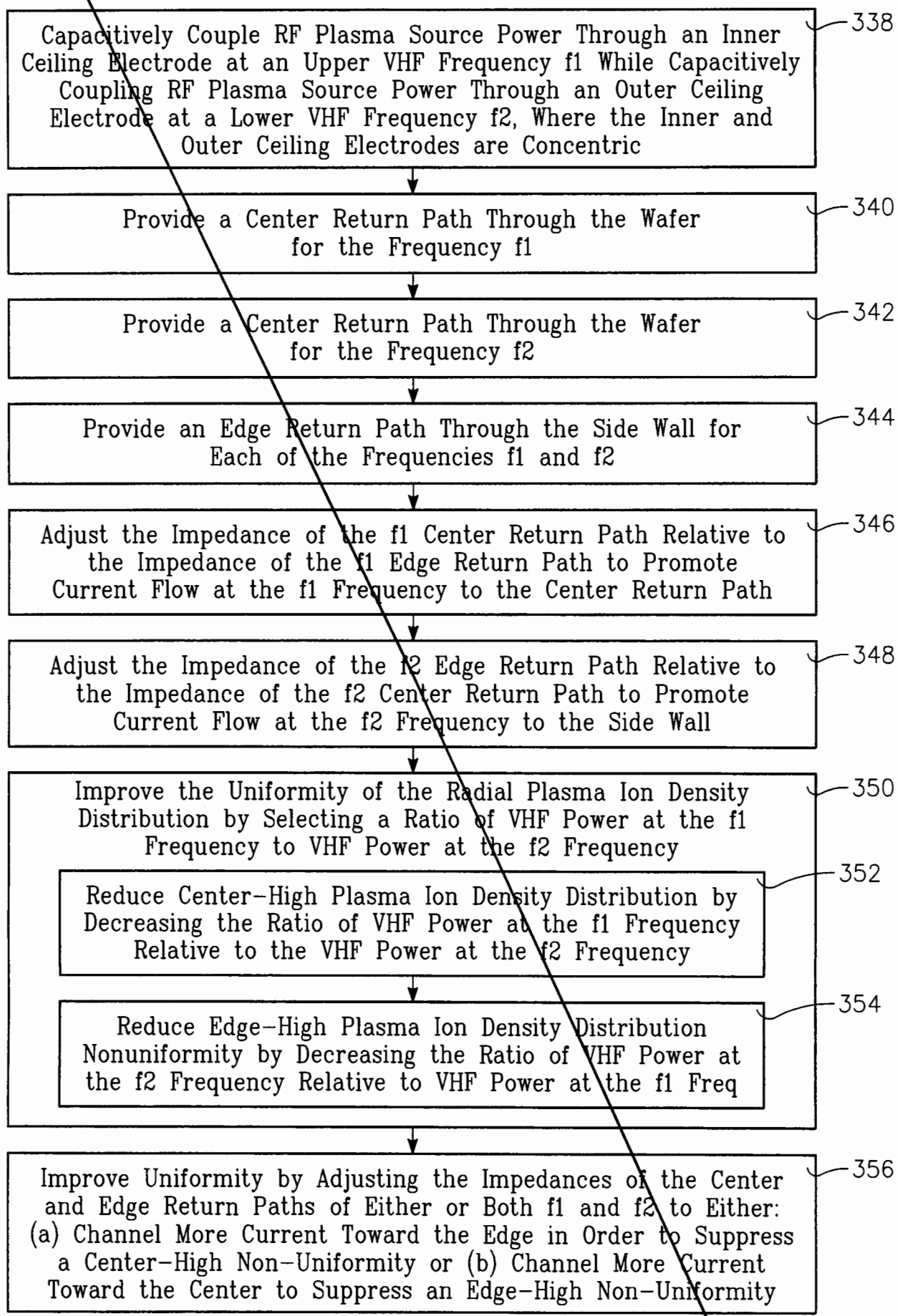

Capacitively Couple RF Plasma Source Power Through an Inner Ceiling Electrode at an Upper VHF Frequency f1 While Capacitively Coupling RF Plasma Source Power Through an Outer Ceiling Electrode at a Lower VHF Frequency f2, Where the Inner and Outer Ceiling Electrodes are Concentric
338
Provide a Center Return Path Through the Wafer for the Frequency f1
340
Provide a Center Return Path Through the Wafer for the Frequency f2
342
Provide an Edge Return Path Through the Side Wall for Each of the Frequencies f1 and f2
344
Adjust the Impedance of the f1 Center Return Path Relative to the Impedance of the f1 Edge Return Path to Promote Current Flow at the f1 Frequency to the Center Return Path
346
Adjust the Impedance of the f2 Edge Return Path Relative to the Impedance of the f2 Center Return Path to Promote Current Flow at the f2 Frequency to the Side Wall
348
Improve the Uniformity of the Radial Plasma Ion Density Distribution by Selecting a Ratio of VHF Power at the f1 Frequency to VHF Power at the f2 Frequency
350
Reduce Center-High Plasma Ion Density Distribution by Decreasing the Ratio of VHF Power at the f1 Frequency Relative to the VHF Power at the f2 Frequency
352
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Decreasing the Ratio of VHF Power at the f2 Frequency Relative to VHF Power at the f1 Freq
354
Improve Uniformity by Adjusting the Impedances of the Center and Edge Return Paths of Either or Both f1 and f2 to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
356

FIG. 9

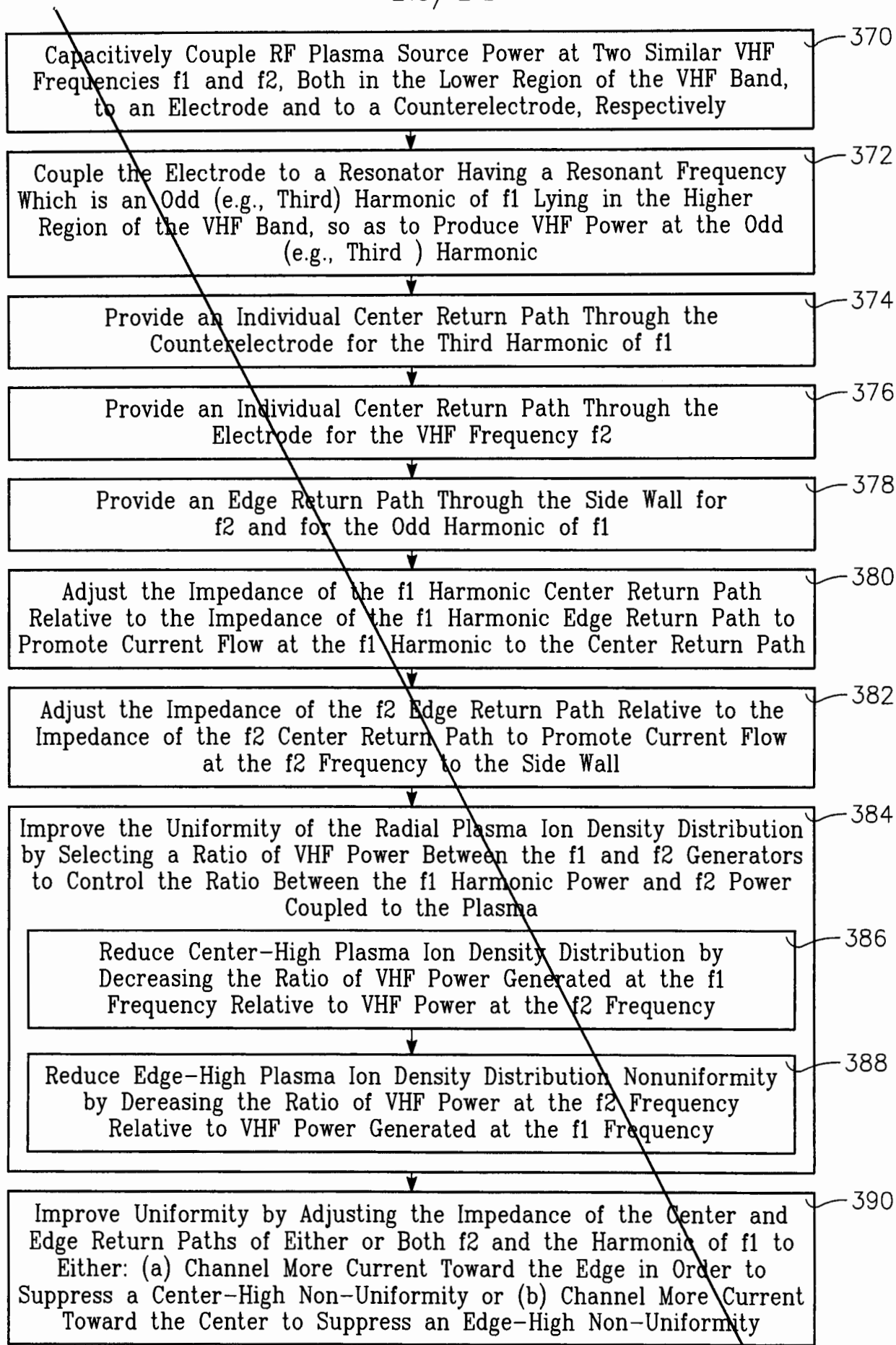

Capacitively Couple RF Plasma Source Power at Two Similar VHF Frequencies f1 and f2, Both in the Lower Region of the VHF Band, to an Electrode and to a Counterelectrode, Respectively
370
Couple the Electrode to a Resonator Having a Resonant Frequency Which is an Odd (e.g., Third) Harmonic of f1 Lying in the Higher Region of the VHF Band, so as to Produce VHF Power at the Odd (e.g., Third) Harmonic
372
Provide an Individual Center Return Path Through the Counterelectrode for the Third Harmonic of f1
374
Provide an Individual Center Return Path Through the Electrode for the VHF Frequency f2
376
Provide an Edge Return Path Through the Side Wall for f2 and for the Odd Harmonic of f1
378
Adjust the Impedance of the f1 Harmonic Center Return Path Relative to the Impedance of the f1 Harmonic Edge Return Path to Promote Current Flow at the f1 Harmonic to the Center Return Path
380
Adjust the Impedance of the f2 Edge Return Path Relative to the Impedance of the f2 Center Return Path to Promote Current Flow at the f2 Frequency to the Side Wall
382
Improve the Uniformity of the Radial Plasma Ion Density Distribution by Selecting a Ratio of VHF Power Between the f1 and f2 Generators to Control the Ratio Between the f1 Harmonic Power and f2 Power Coupled to the Plasma
384
Reduce Center-High Plasma Ion Density Distribution by Decreasing the Ratio of VHF Power Generated at the f1 Frequency Relative to VHF Power at the f2 Frequency
386
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Dereasing the Ratio of VHF Power at the f2 Frequency Relative to VHF Power Generated at the f1 Frequency
388
Improve Uniformity by Adjusting the Impedance of the Center and Edge Return Paths of Either or Both f2 and the Harmonic of f1 to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
390

FIG. 11

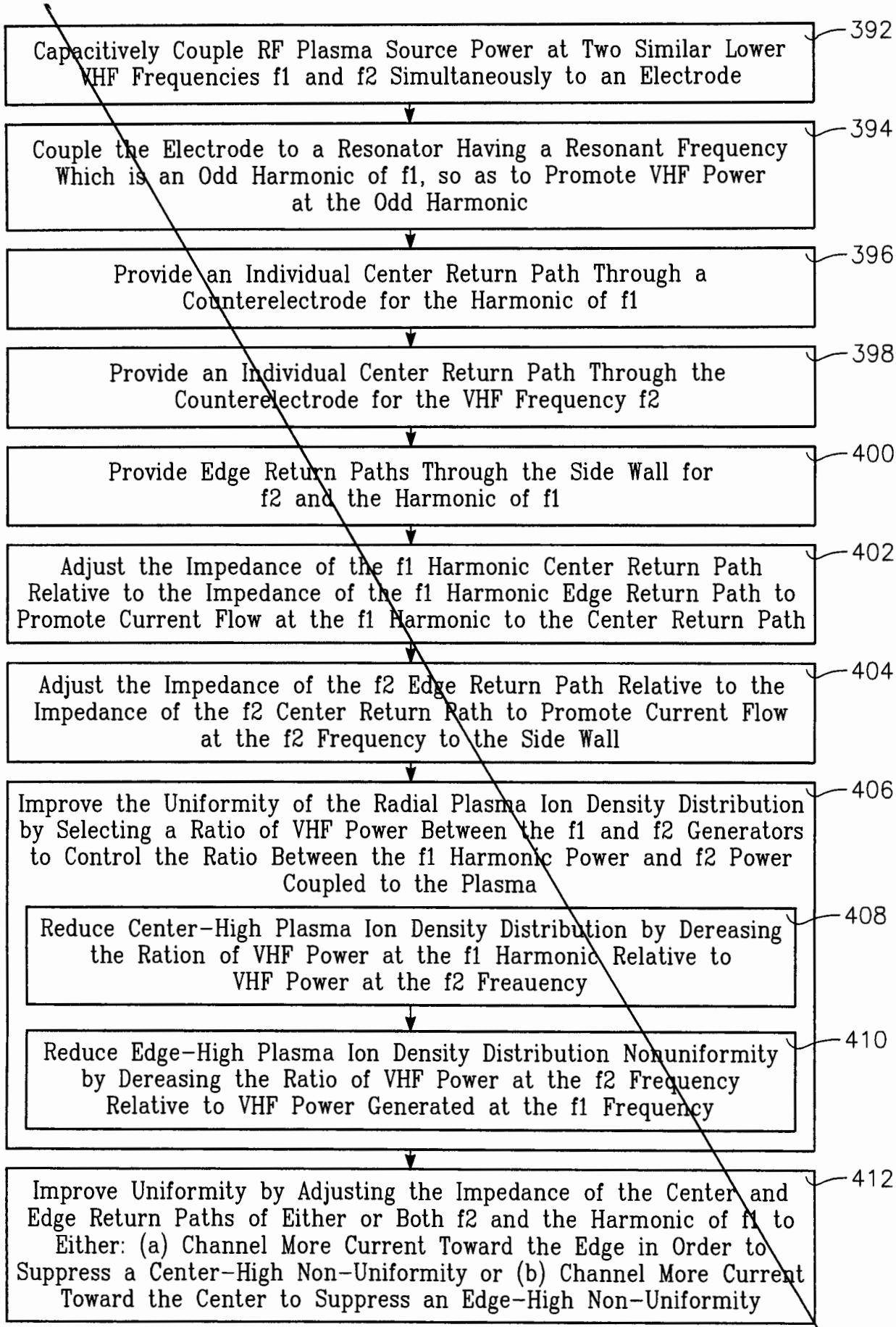

Capacitively Couple RF Plasma Source Power at Two Similar Lower VHF Frequencies f1 and f2 Simultaneously to an Electrode
392
Couple the Electrode to a Resonator Having a Resonant Frequency Which is an Odd Harmonic of f1, so as to Promote VHF Power at the Odd Harmonic
394
Provide an Individual Center Return Path Through a Counterelectrode for the Harmonic of f1
396
Provide an Individual Center Return Path Through the Counterelectrode for the VHF Frequency f2
398
Provide Edge Return Paths Through the Side Wall for f2 and the Harmonic of f1
400
Adjust the Impedance of the f1 Harmonic Center Return Path Relative to the Impedance of the f1 Harmonic Edge Return Path to Promote Current Flow at the f1 Harmonic to the Center Return Path
402
Adjust the Impedance of the f2 Edge Return Path Relative to the Impedance of the f2 Center Return Path to Promote Current Flow at the f2 Frequency to the Side Wall
404
Improve the Uniformity of the Radial Plasma Ion Density Distribution by Selecting a Ratio of VHF Power Between the f1 and f2 Generators to Control the Ratio Between the f1 Harmonic Power and f2 Power Coupled to the Plasma
406
Reduce Center-High Plasma Ion Density Distribution by Dereasing the Ration of VHF Power at the f1 Harmonic Relative to VHF Power at the f2 Freauency
408
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Dereasing the Ratio of VHF Power at the f2 Frequency Relative to VHF Power Generated at the f1 Frequency
410
Improve Uniformity by Adjusting the Impedance of the Center and Edge Return Paths of Either or Both f2 and the Harmonic of f1 to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
412

FIG. 12

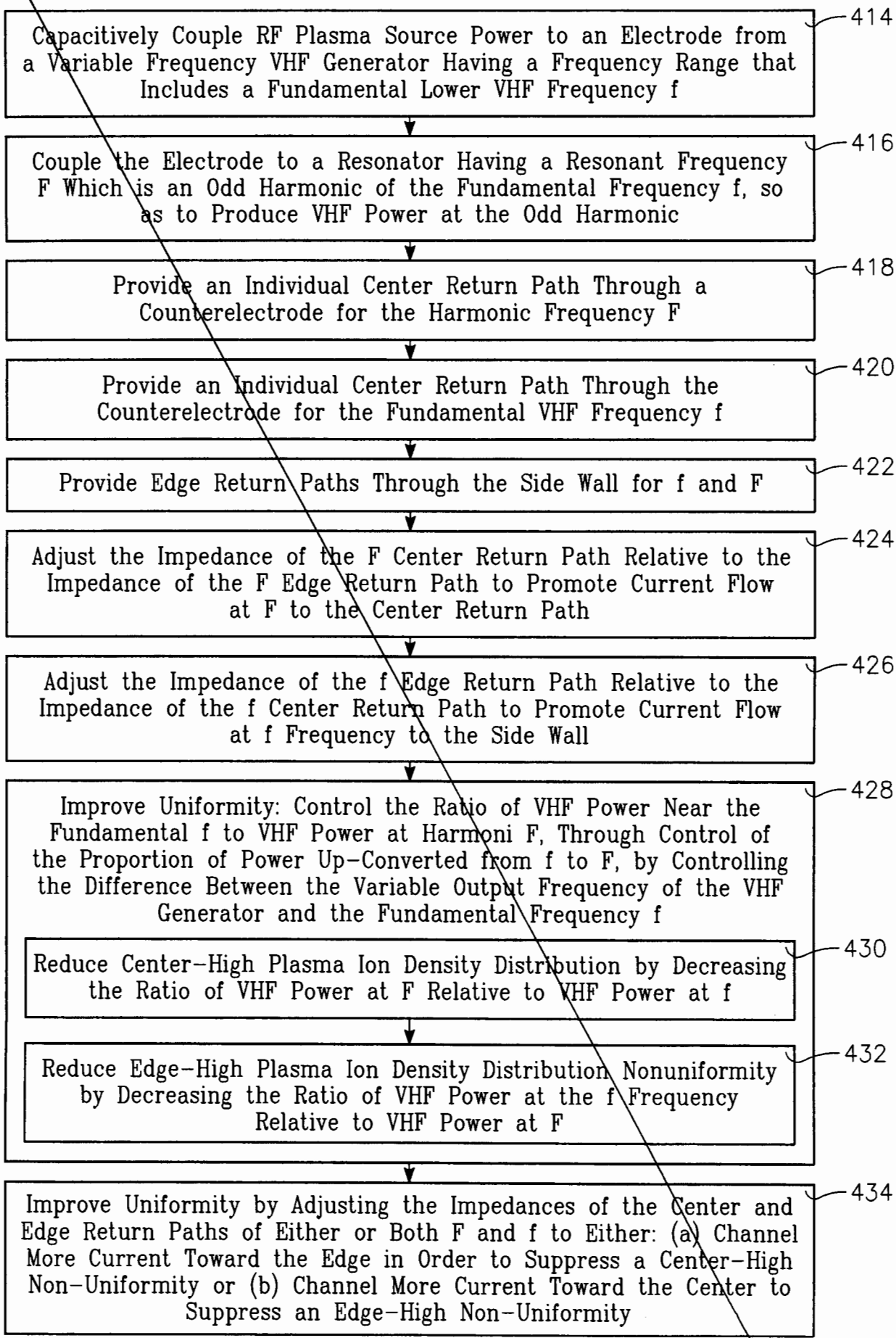

Capacitively Couple RF Plasma Source Power to an Electrode from a Variable Frequency VHF Generator Having a Frequency Range that Includes a Fundamental Lower VHF Frequency f
414
Couple the Electrode to a Resonator Having a Resonant Frequency F Which is an Odd Harmonic of the Fundamental Frequency f, so as to Produce VHF Power at the Odd Harmonic
416
Provide an Individual Center Return Path Through a Counterelectrode for the Harmonic Frequency F
418
Provide an Individual Center Return Path Through the Counterelectrode for the Fundamental VHF Frequency f
420
Provide Edge Return Paths Through the Side Wall for f and F
422
Adjust the Impedance of the F Center Return Path Relative to the Impedance of the F Edge Return Path to Promote Current Flow at F to the Center Return Path
424
Adjust the Impedance of the f Edge Return Path Relative to the Impedance of the f Center Return Path to Promote Current Flow at f Frequency to the Side Wall
426
Improve Uniformity: Control the Ratio of VHF Power Near the Fundamental f to VHF Power at Harmoni F, Through Control of the Proportion of Power Up-Converted from f to F, by Controlling the Difference Between the Variable Output Frequency of the VHF Generator and the Fundamental Frequency f
428
Reduce Center-High Plasma Ion Density Distribution by Decreasing the Ratio of VHF Power at F Relative to VHF Power at f
430
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Decreasing the Ratio of VHF Power at the f Frequency Relative to VHF Power at F
432
Improve Uniformity by Adjusting the Impedances of the Center and Edge Return Paths of Either or Both F and f to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
434

FIG. 13

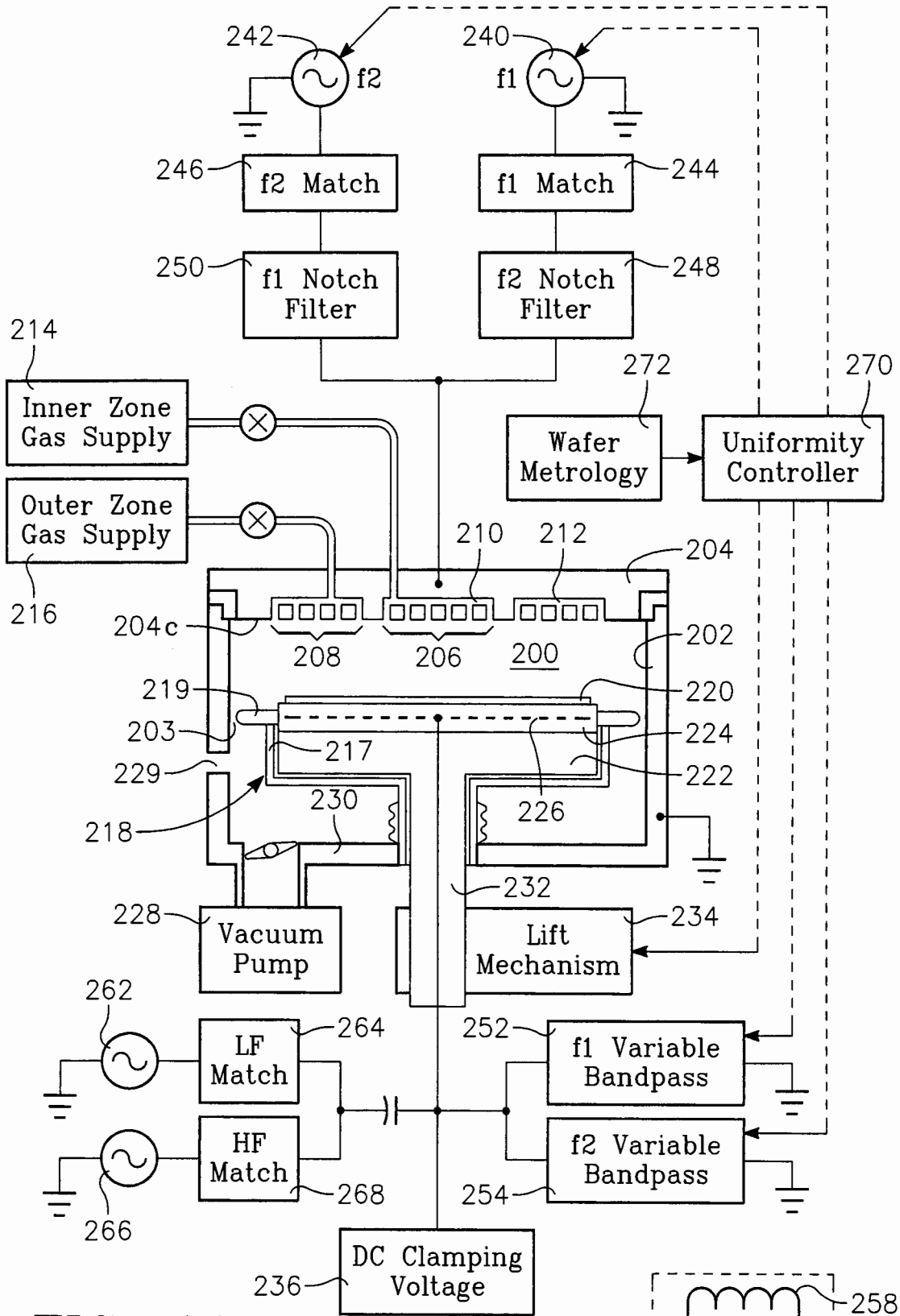

242
f2
240
f1
246
f2 Match
f1 Match
244
250
f1 Notch Filter
f2 Notch Filter
248
214
Inner Zone Gas Supply
Outer Zone Gas Supply
216
272
Wafer Metrology
270
Uniformity Controller
210
212
204
204c
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203
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224
229
222
218
230
226
232
228
Vacuum Pump
Lift Mechanism
234
262
LF Match
264
252
f1 Variable Bandpass
HF Match
268
f2 Variable Bandpass
254
266
DC Clamping Voltage
236

FIG. 1A

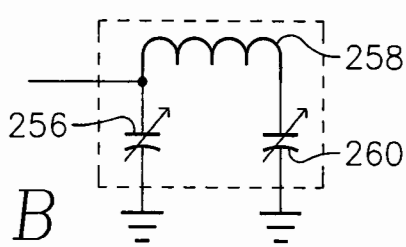

258
256
260

FIG. 1B

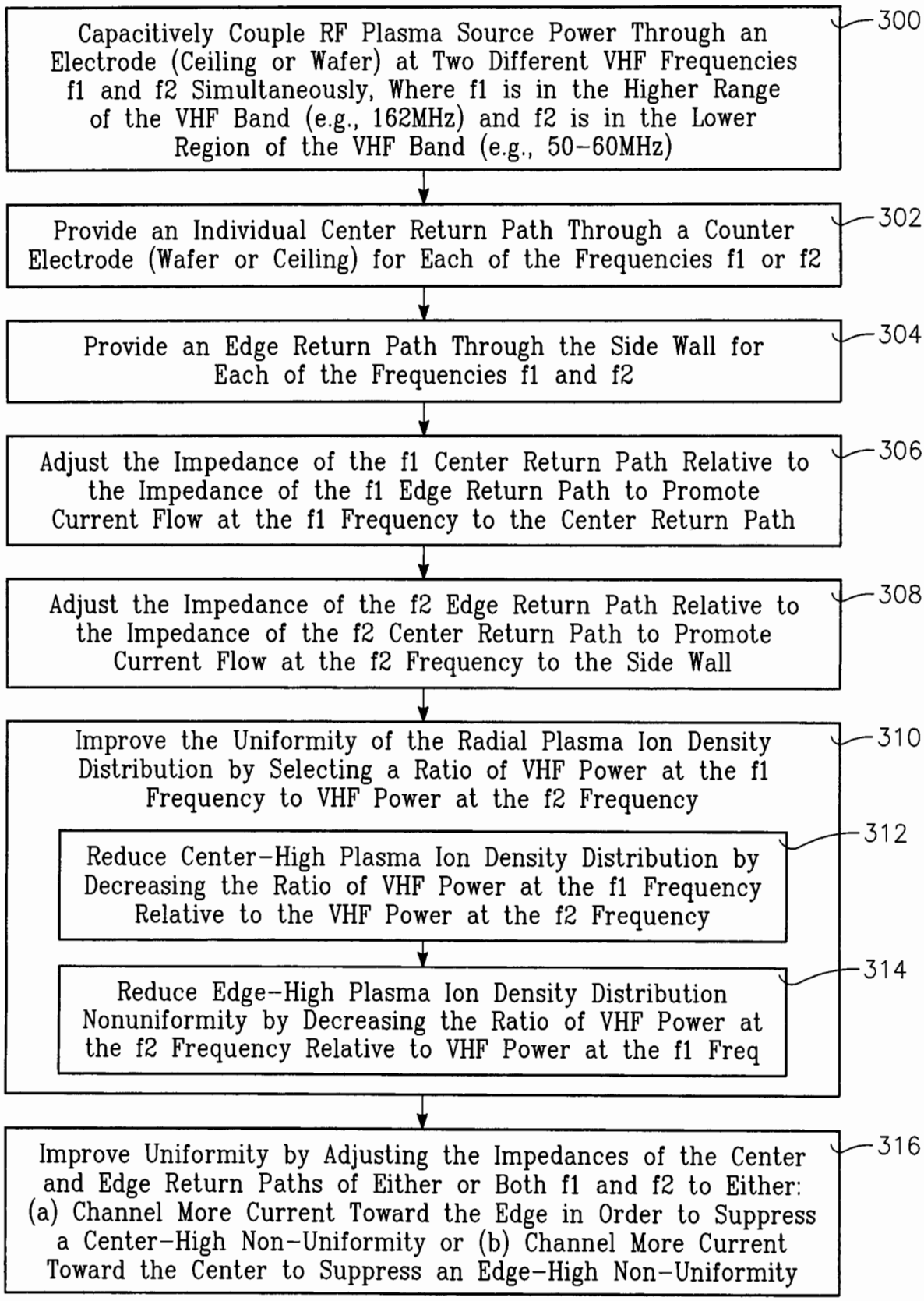

Capacitively Couple RF Plasma Source Power Through an Electrode (Ceiling or Wafer) at Two Different VHF Frequencies f1 and f2 Simultaneously, Where f1 is in the Higher Range of the VHF Band (e.g., 162MHz) and f2 is in the Lower Region of the VHF Band (e.g., 50–60MHz)
300
Provide an Individual Center Return Path Through a Counter Electrode (Wafer or Ceiling) for Each of the Frequencies f1 or f2
302
Provide an Edge Return Path Through the Side Wall for Each of the Frequencies f1 and f2
304
Adjust the Impedance of the f1 Center Return Path Relative to the Impedance of the f1 Edge Return Path to Promote Current Flow at the f1 Frequency to the Center Return Path
306
Adjust the Impedance of the f2 Edge Return Path Relative to the Impedance of the f2 Center Return Path to Promote Current Flow at the f2 Frequency to the Side Wall
308
Improve the Uniformity of the Radial Plasma Ion Density Distribution by Selecting a Ratio of VHF Power at the f1 Frequency to VHF Power at the f2 Frequency
310
Reduce Center–High Plasma Ion Density Distribution by Decreasing the Ratio of VHF Power at the f1 Frequency Relative to the VHF Power at the f2 Frequency
312
Reduce Edge–High Plasma Ion Density Distribution Nonuniformity by Decreasing the Ratio of VHF Power at the f2 Frequency Relative to VHF Power at the f1 Freq
314
Improve Uniformity by Adjusting the Impedances of the Center and Edge Return Paths of Either or Both f1 and f2 to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center–High Non–Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge–High Non–Uniformity
316

FIG. 7

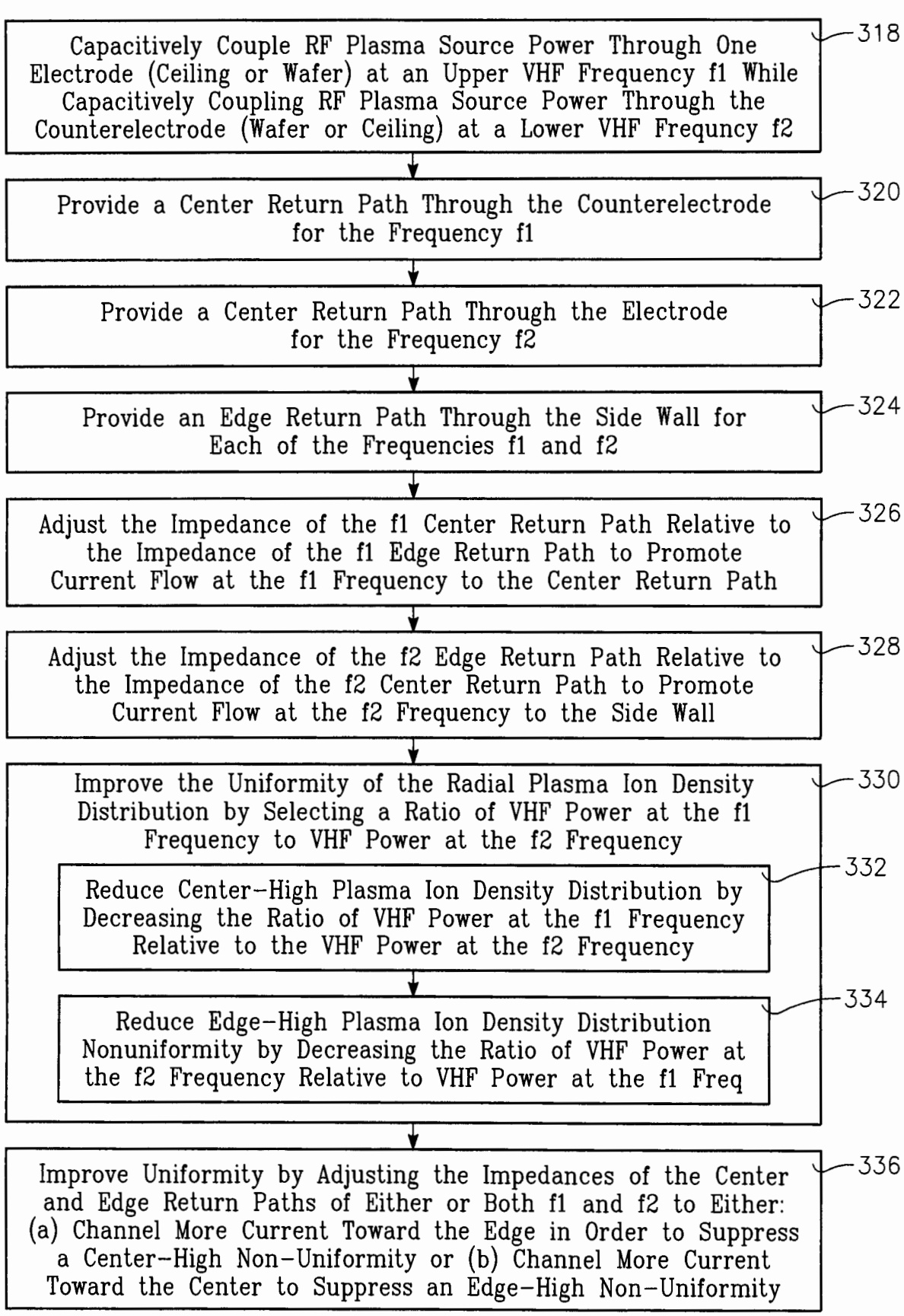

Capacitively Couple RF Plasma Source Power Through One Electrode (Ceiling or Wafer) at an Upper VHF Frequency f1 While Capacitively Coupling RF Plasma Source Power Through the Counterelectrode (Wafer or Ceiling) at a Lower VHF Frequncy f2
318
Provide a Center Return Path Through the Counterelectrode for the Frequency f1
320
Provide a Center Return Path Through the Electrode for the Frequency f2
322
Provide an Edge Return Path Through the Side Wall for Each of the Frequencies f1 and f2
324
Adjust the Impedance of the f1 Center Return Path Relative to the Impedance of the f1 Edge Return Path to Promote Current Flow at the f1 Frequency to the Center Return Path
326
Adjust the Impedance of the f2 Edge Return Path Relative to the Impedance of the f2 Center Return Path to Promote Current Flow at the f2 Frequency to the Side Wall
328
Improve the Uniformity of the Radial Plasma Ion Density Distribution by Selecting a Ratio of VHF Power at the f1 Frequency to VHF Power at the f2 Frequency
330
Reduce Center-High Plasma Ion Density Distribution by Decreasing the Ratio of VHF Power at the f1 Frequency Relative to the VHF Power at the f2 Frequency
332
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Decreasing the Ratio of VHF Power at the f2 Frequency Relative to VHF Power at the f1 Freq
334
Improve Uniformity by Adjusting the Impedances of the Center and Edge Return Paths of Either or Both f1 and f2 to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
336

FIG. 8

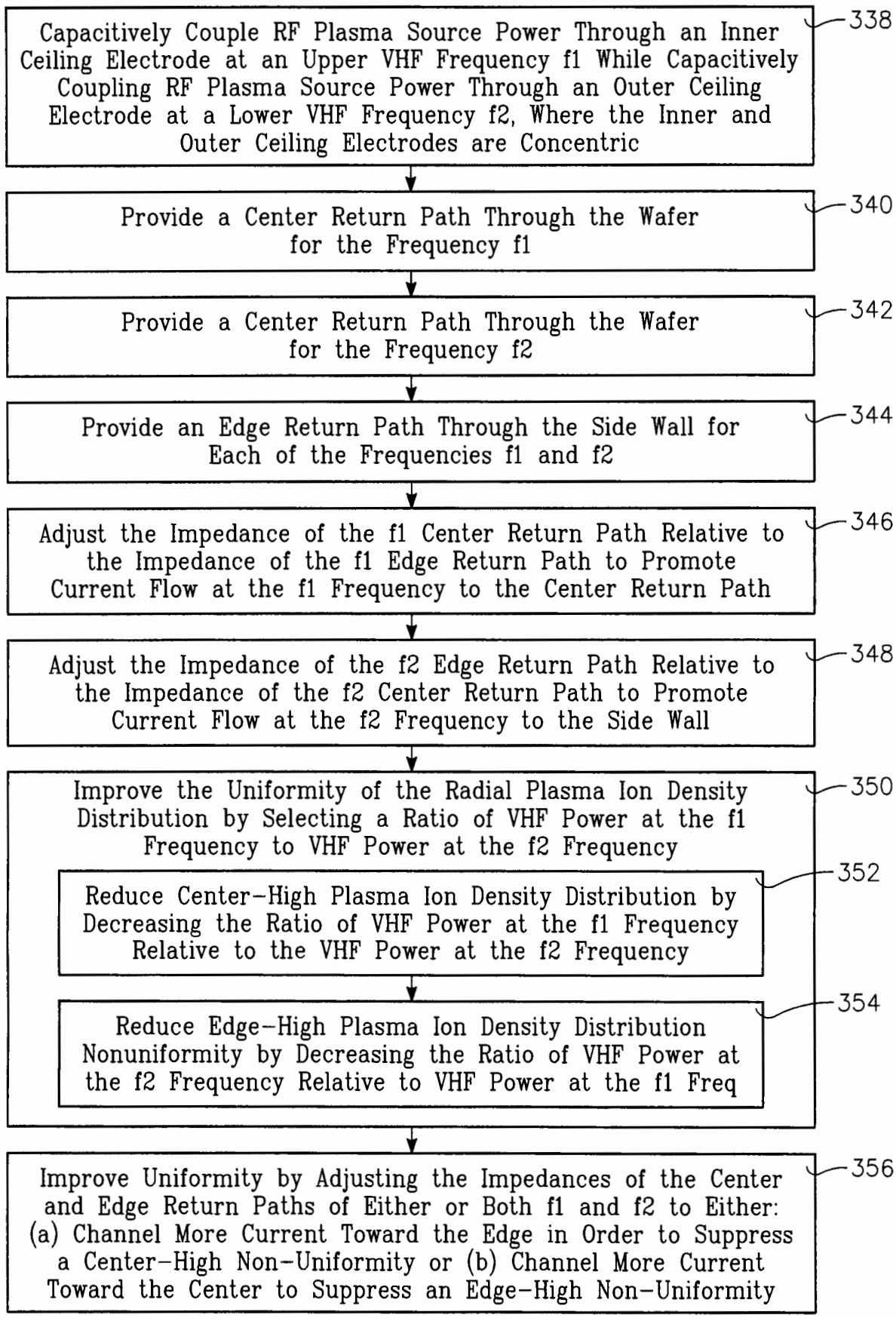

Capacitively Couple RF Plasma Source Power Through an Inner Ceiling Electrode at an Upper VHF Frequency f1 While Capacitively Coupling RF Plasma Source Power Through an Outer Ceiling Electrode at a Lower VHF Frequency f2, Where the Inner and Outer Ceiling Electrodes are Concentric
338
Provide a Center Return Path Through the Wafer for the Frequency f1
340
Provide a Center Return Path Through the Wafer for the Frequency f2
342
Provide an Edge Return Path Through the Side Wall for Each of the Frequencies f1 and f2
344
Adjust the Impedance of the f1 Center Return Path Relative to the Impedance of the f1 Edge Return Path to Promote Current Flow at the f1 Frequency to the Center Return Path
346
Adjust the Impedance of the f2 Edge Return Path Relative to the Impedance of the f2 Center Return Path to Promote Current Flow at the f2 Frequency to the Side Wall
348
Improve the Uniformity of the Radial Plasma Ion Density Distribution by Selecting a Ratio of VHF Power at the f1 Frequency to VHF Power at the f2 Frequency
350
Reduce Center-High Plasma Ion Density Distribution by Decreasing the Ratio of VHF Power at the f1 Frequency Relative to the VHF Power at the f2 Frequency
352
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Decreasing the Ratio of VHF Power at the f2 Frequency Relative to VHF Power at the f1 Freq
354
Improve Uniformity by Adjusting the Impedances of the Center and Edge Return Paths of Either or Both f1 and f2 to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
356

FIG. 9

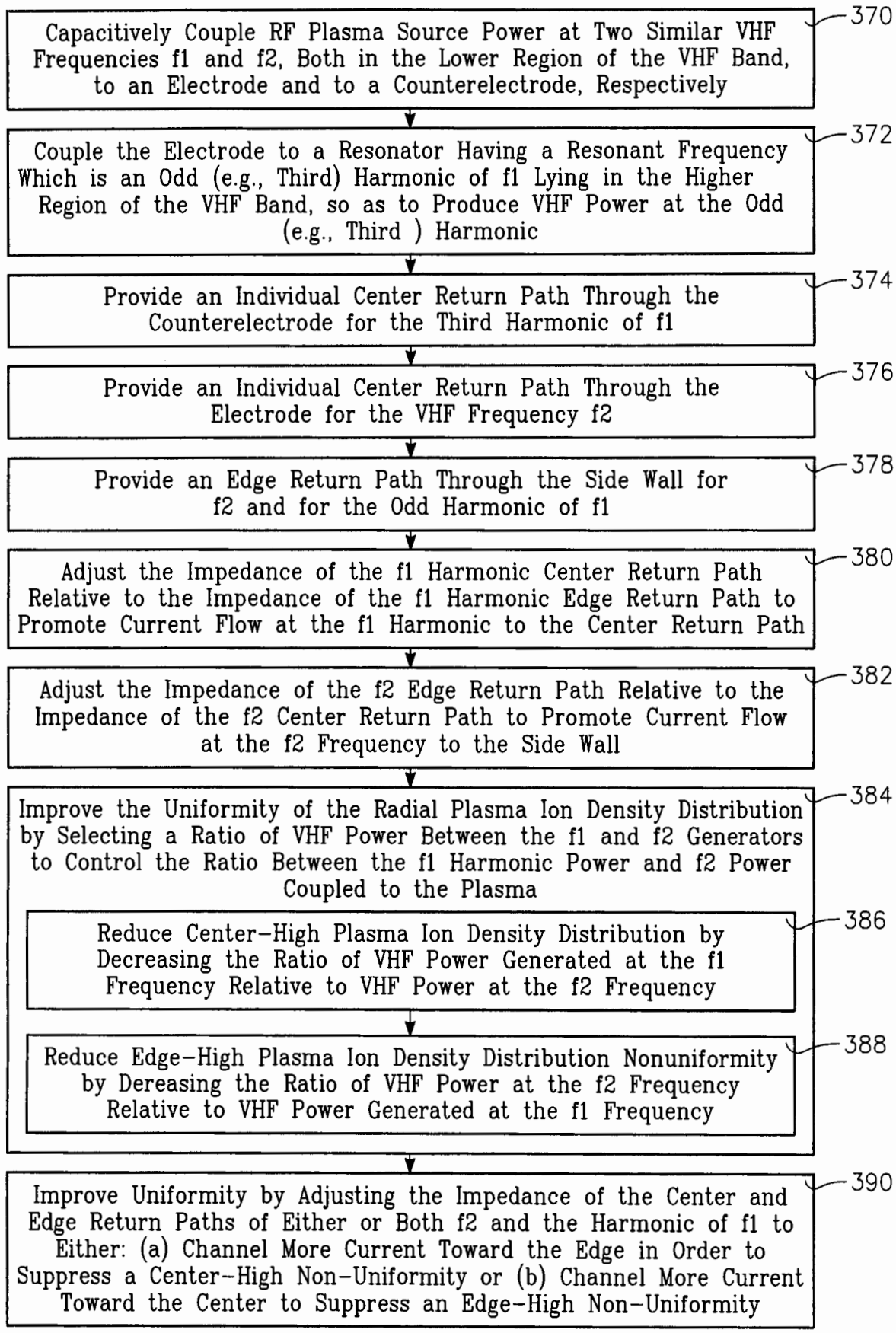

Capacitively Couple RF Plasma Source Power at Two Similar VHF Frequencies f1 and f2, Both in the Lower Region of the VHF Band, to an Electrode and to a Counterelectrode, Respectively
370
Couple the Electrode to a Resonator Having a Resonant Frequency Which is an Odd (e.g., Third) Harmonic of f1 Lying in the Higher Region of the VHF Band, so as to Produce VHF Power at the Odd (e.g., Third) Harmonic
372
Provide an Individual Center Return Path Through the Counterelectrode for the Third Harmonic of f1
374
Provide an Individual Center Return Path Through the Electrode for the VHF Frequency f2
376
Provide an Edge Return Path Through the Side Wall for f2 and for the Odd Harmonic of f1
378
Adjust the Impedance of the f1 Harmonic Center Return Path Relative to the Impedance of the f1 Harmonic Edge Return Path to Promote Current Flow at the f1 Harmonic to the Center Return Path
380
Adjust the Impedance of the f2 Edge Return Path Relative to the Impedance of the f2 Center Return Path to Promote Current Flow at the f2 Frequency to the Side Wall
382
Improve the Uniformity of the Radial Plasma Ion Density Distribution by Selecting a Ratio of VHF Power Between the f1 and f2 Generators to Control the Ratio Between the f1 Harmonic Power and f2 Power Coupled to the Plasma
384
Reduce Center-High Plasma Ion Density Distribution by Decreasing the Ratio of VHF Power Generated at the f1 Frequency Relative to VHF Power at the f2 Frequency
386
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Dereasing the Ratio of VHF Power at the f2 Frequency Relative to VHF Power Generated at the f1 Frequency
388
Improve Uniformity by Adjusting the Impedance of the Center and Edge Return Paths of Either or Both f2 and the Harmonic of f1 to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
390

FIG. 11

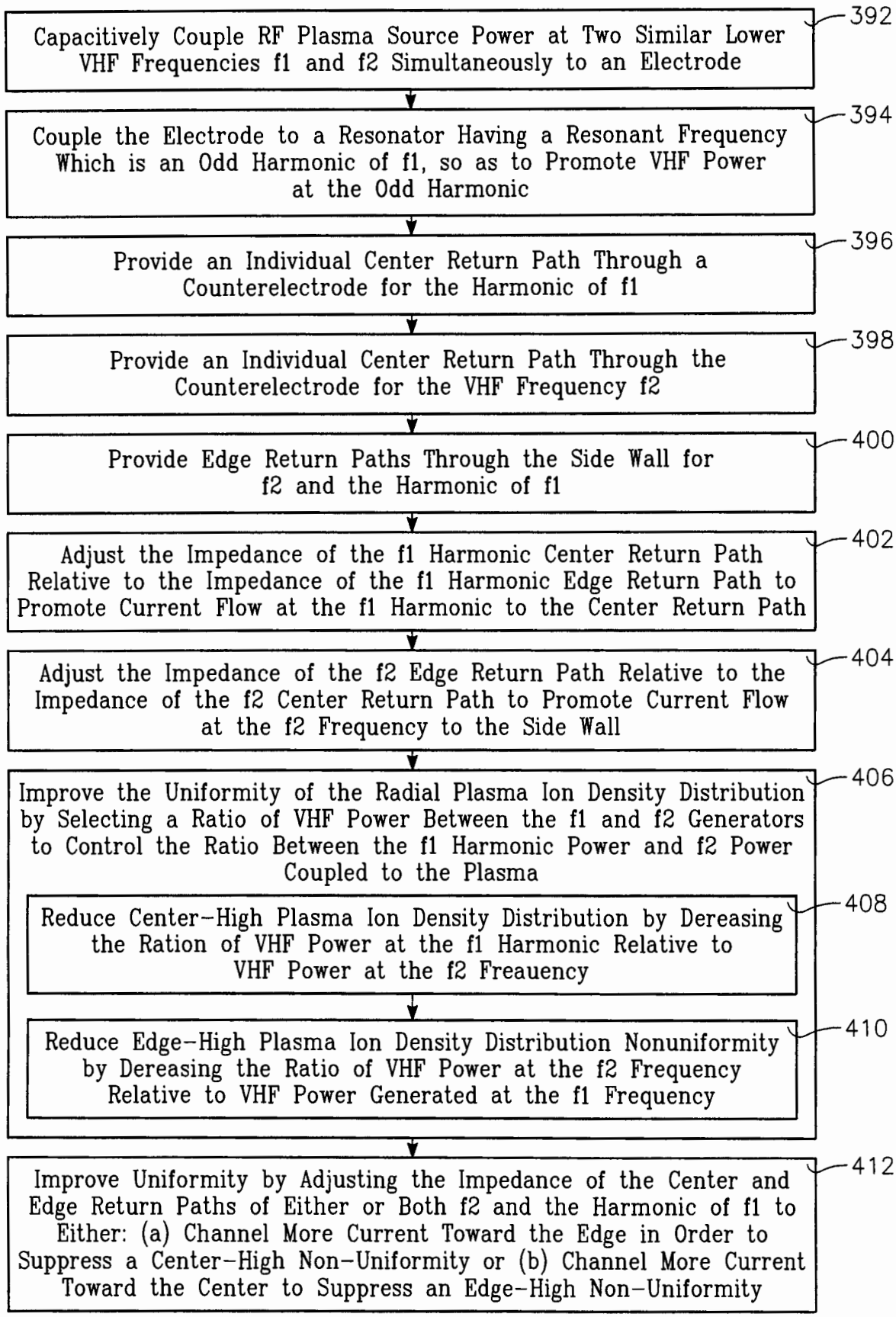

Capacitively Couple RF Plasma Source Power at Two Similar Lower VHF Frequencies f1 and f2 Simultaneously to an Electrode
392
Couple the Electrode to a Resonator Having a Resonant Frequency Which is an Odd Harmonic of f1, so as to Promote VHF Power at the Odd Harmonic
394
Provide an Individual Center Return Path Through a Counterelectrode for the Harmonic of f1
396
Provide an Individual Center Return Path Through the Counterelectrode for the VHF Frequency f2
398
Provide Edge Return Paths Through the Side Wall for f2 and the Harmonic of f1
400
Adjust the Impedance of the f1 Harmonic Center Return Path Relative to the Impedance of the f1 Harmonic Edge Return Path to Promote Current Flow at the f1 Harmonic to the Center Return Path
402
Adjust the Impedance of the f2 Edge Return Path Relative to the Impedance of the f2 Center Return Path to Promote Current Flow at the f2 Frequency to the Side Wall
404
Improve the Uniformity of the Radial Plasma Ion Density Distribution by Selecting a Ratio of VHF Power Between the f1 and f2 Generators to Control the Ratio Between the f1 Harmonic Power and f2 Power Coupled to the Plasma
406
Reduce Center-High Plasma Ion Density Distribution by Dereasing the Ration of VHF Power at the f1 Harmonic Relative to VHF Power at the f2 Freauency
408
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Dereasing the Ratio of VHF Power at the f2 Frequency Relative to VHF Power Generated at the f1 Frequency
410
Improve Uniformity by Adjusting the Impedance of the Center and Edge Return Paths of Either or Both f2 and the Harmonic of f1 to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
412

FIG. 12

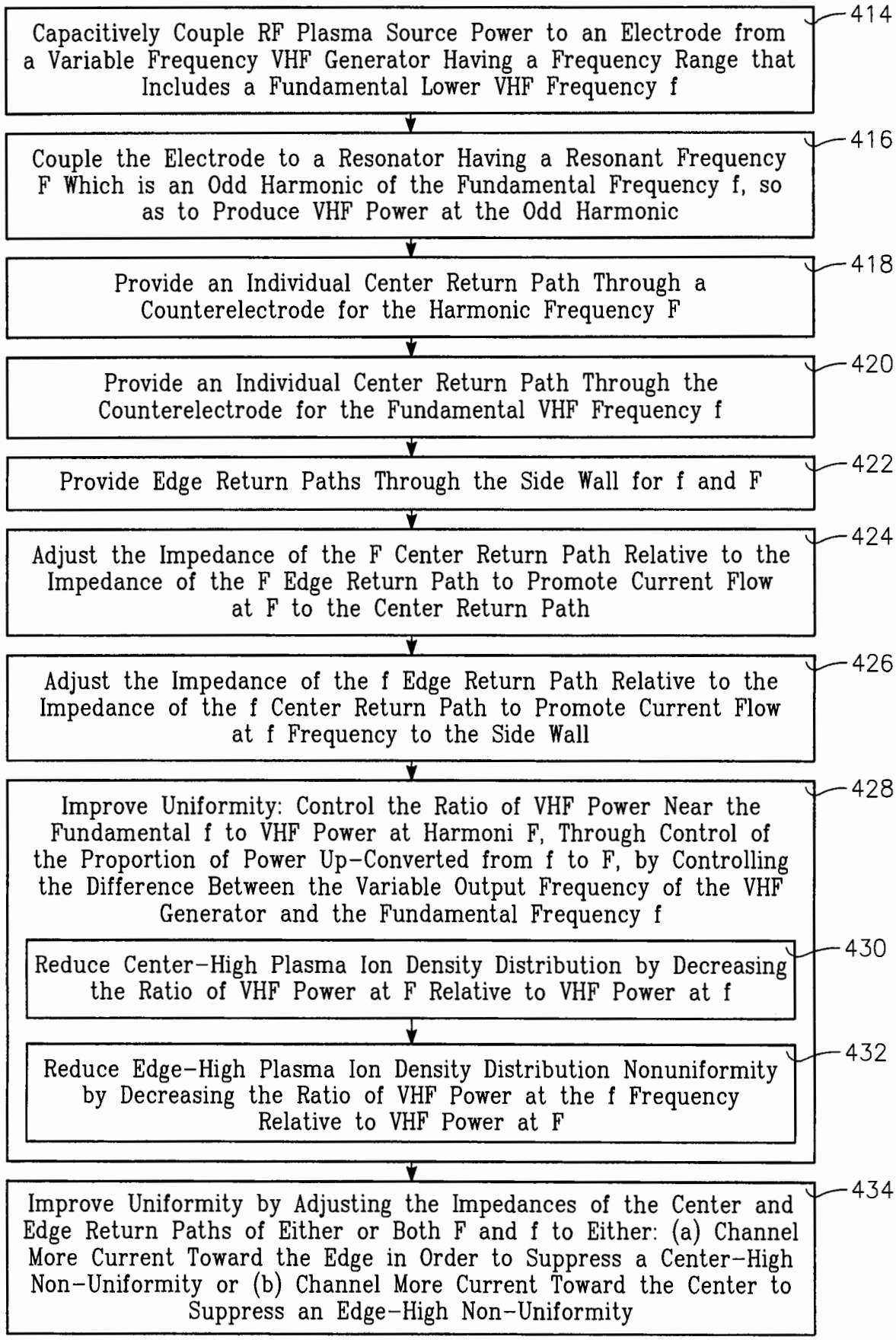

Capacitively Couple RF Plasma Source Power to an Electrode from a Variable Frequency VHF Generator Having a Frequency Range that Includes a Fundamental Lower VHF Frequency f
414
Couple the Electrode to a Resonator Having a Resonant Frequency F Which is an Odd Harmonic of the Fundamental Frequency f, so as to Produce VHF Power at the Odd Harmonic
416
Provide an Individual Center Return Path Through a Counterelectrode for the Harmonic Frequency F
418
Provide an Individual Center Return Path Through the Counterelectrode for the Fundamental VHF Frequency f
420
Provide Edge Return Paths Through the Side Wall for f and F
422
Adjust the Impedance of the F Center Return Path Relative to the Impedance of the F Edge Return Path to Promote Current Flow at F to the Center Return Path
424
Adjust the Impedance of the f Edge Return Path Relative to the Impedance of the f Center Return Path to Promote Current Flow at f Frequency to the Side Wall
426
Improve Uniformity: Control the Ratio of VHF Power Near the Fundamental f to VHF Power at Harmoni F, Through Control of the Proportion of Power Up-Converted from f to F, by Controlling the Difference Between the Variable Output Frequency of the VHF Generator and the Fundamental Frequency f
428
Reduce Center-High Plasma Ion Density Distribution by Decreasing the Ratio of VHF Power at F Relative to VHF Power at f
430
Reduce Edge-High Plasma Ion Density Distribution Nonuniformity by Decreasing the Ratio of VHF Power at the f Frequency Relative to VHF Power at F
432
Improve Uniformity by Adjusting the Impedances of the Center and Edge Return Paths of Either or Both F and f to Either: (a) Channel More Current Toward the Edge in Order to Suppress a Center-High Non-Uniformity or (b) Channel More Current Toward the Center to Suppress an Edge-High Non-Uniformity
434

FIG. 13