FIG. 1

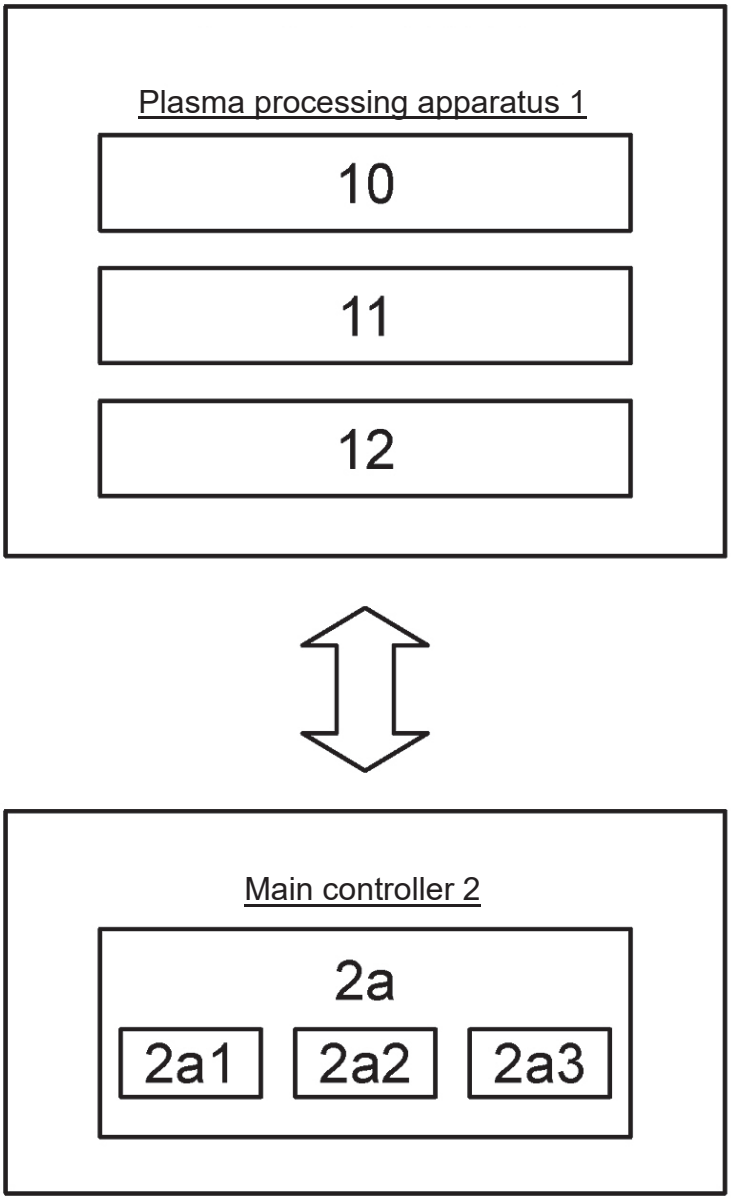
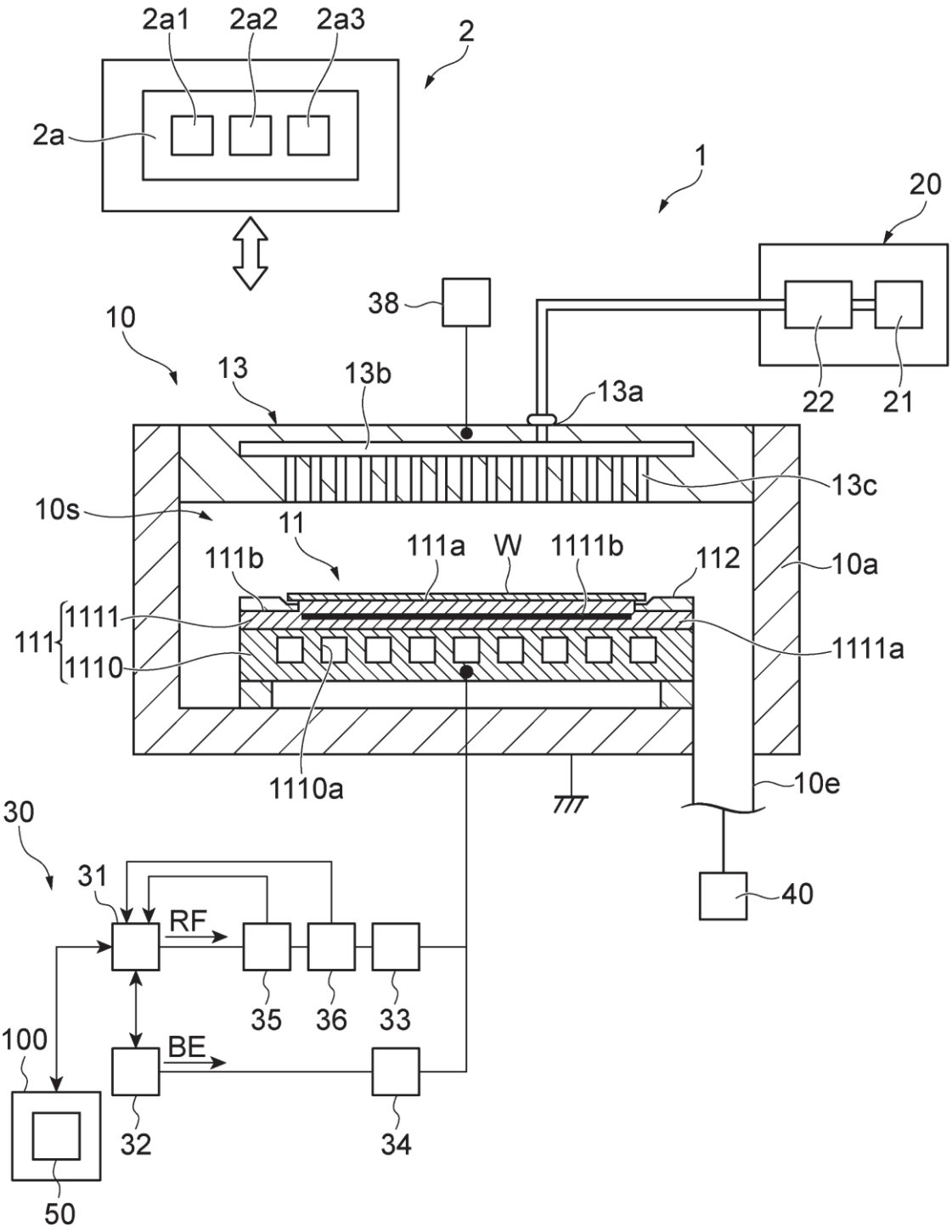

Plasma processing apparatus 1
10
11
12
Main controller 2
2a
2a1
2a2
2a3

FIG. 2


2a1
2a2
2a3
2
2a
1
20
38
10
13
13b
13a
22
21
13c
10s
11
111b
111a
W
1111b
112
10a
111
1111
1110
1111a
1110a
10e
30
31
RF
40
35
36
33
100
BE
32
34
50

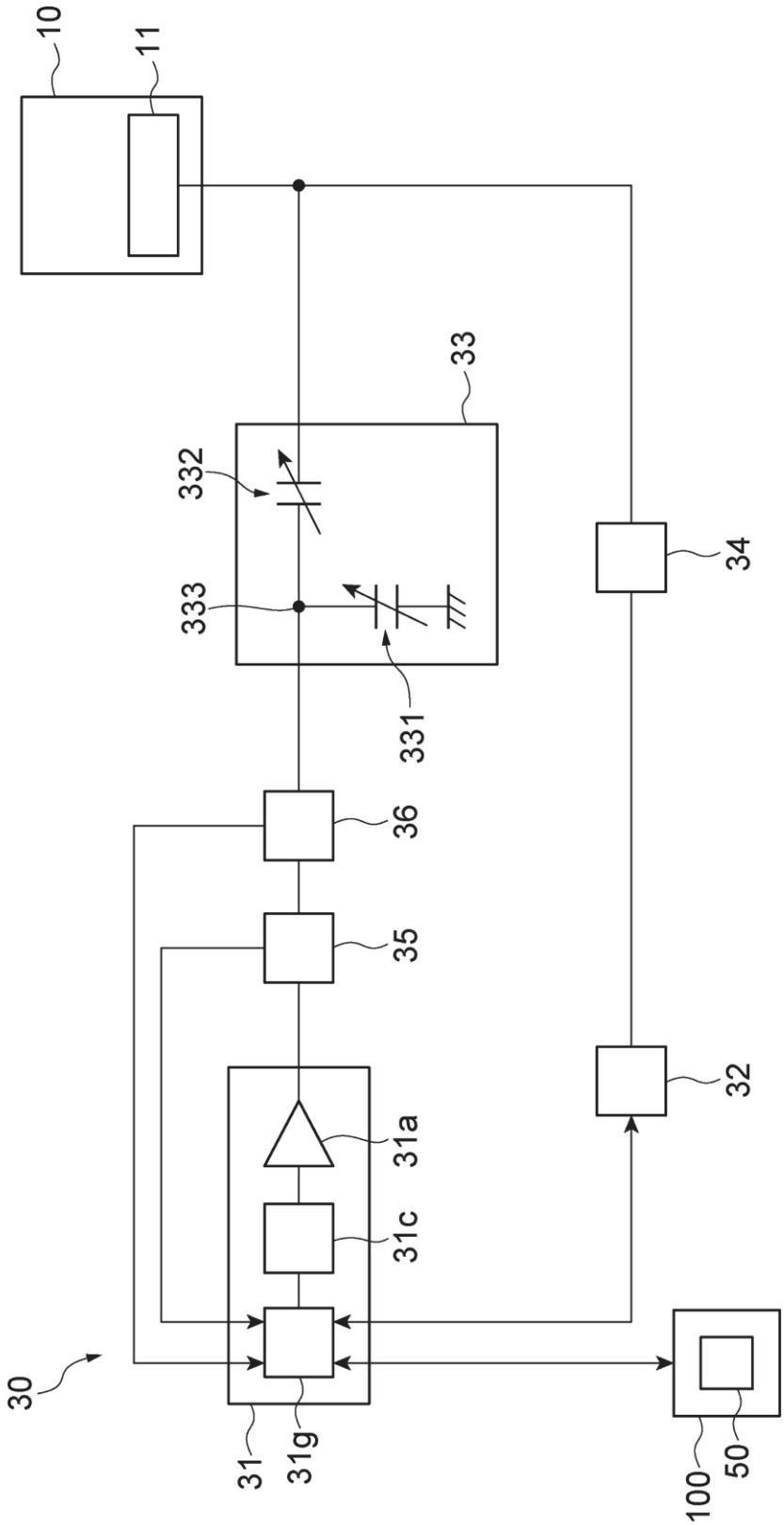
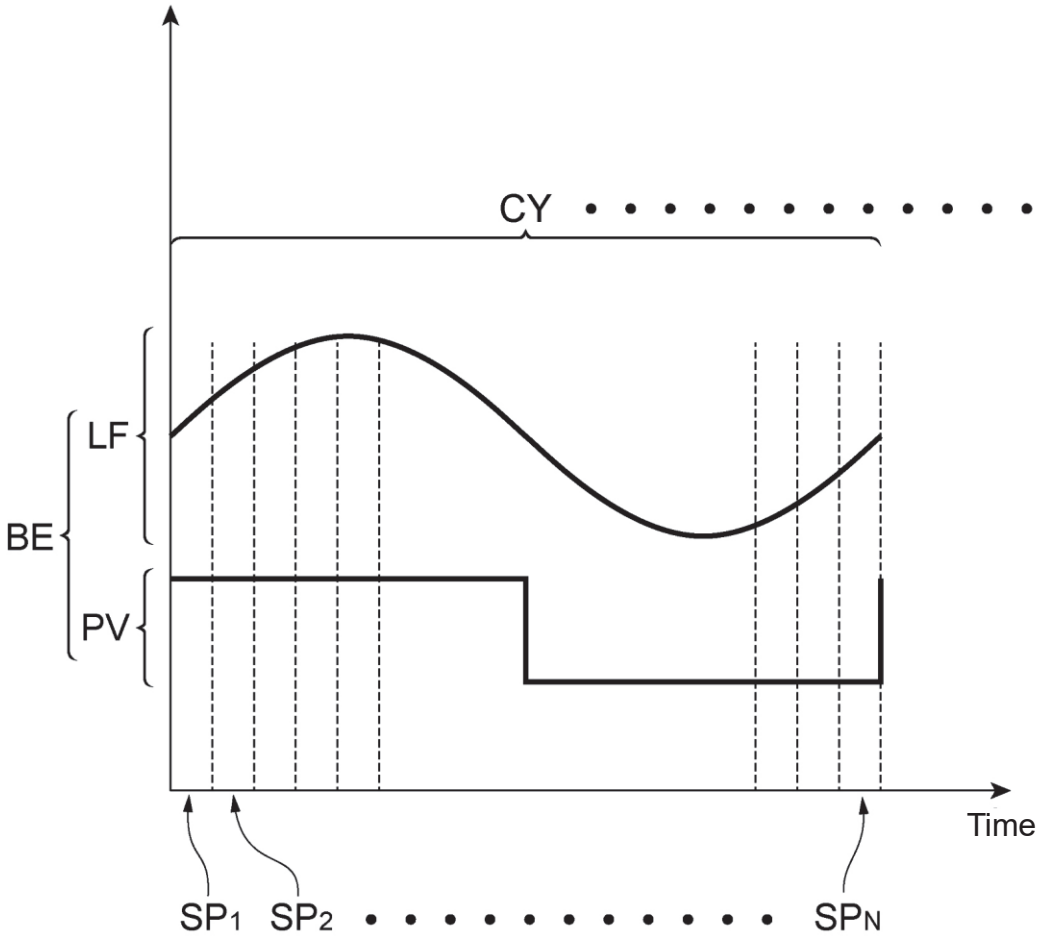


FIG. 3

FIG. 4



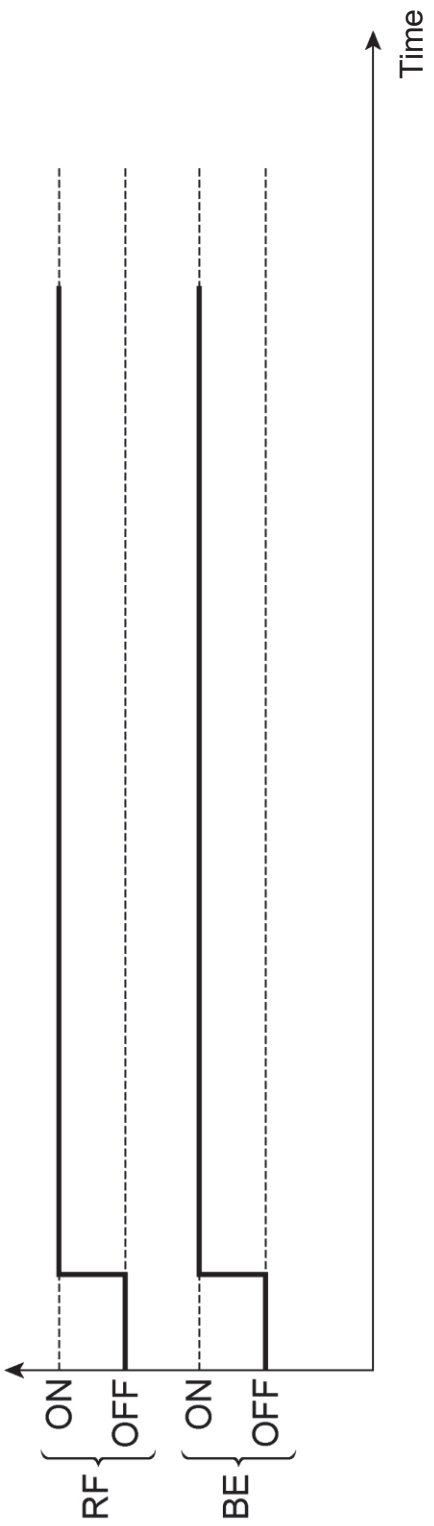


FIG. 5A

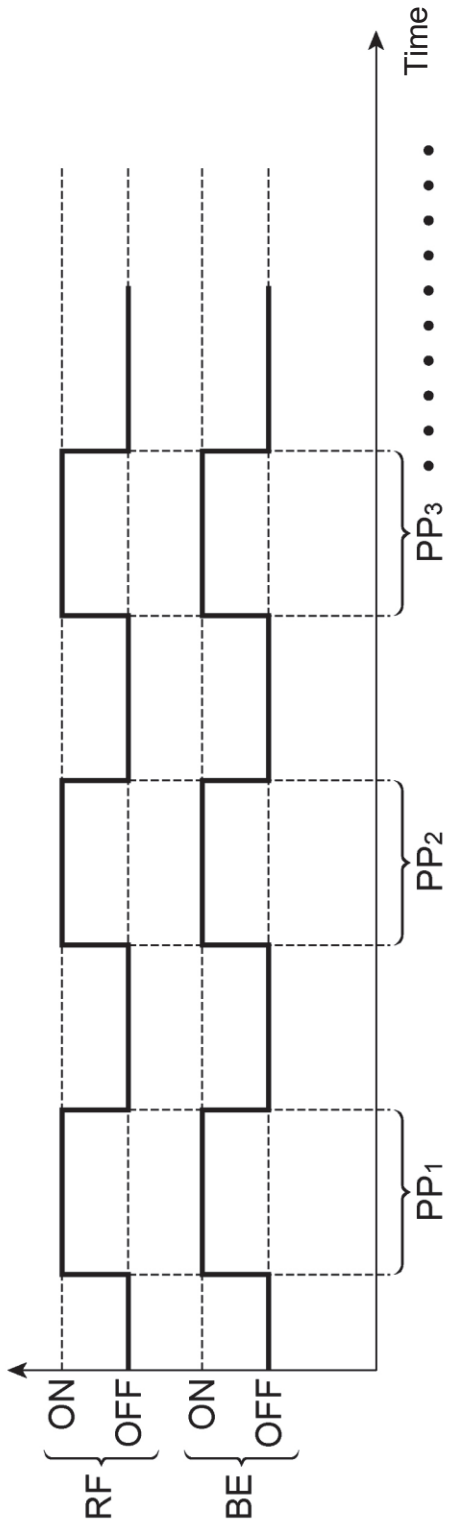


FIG. 5B

FIG. 6

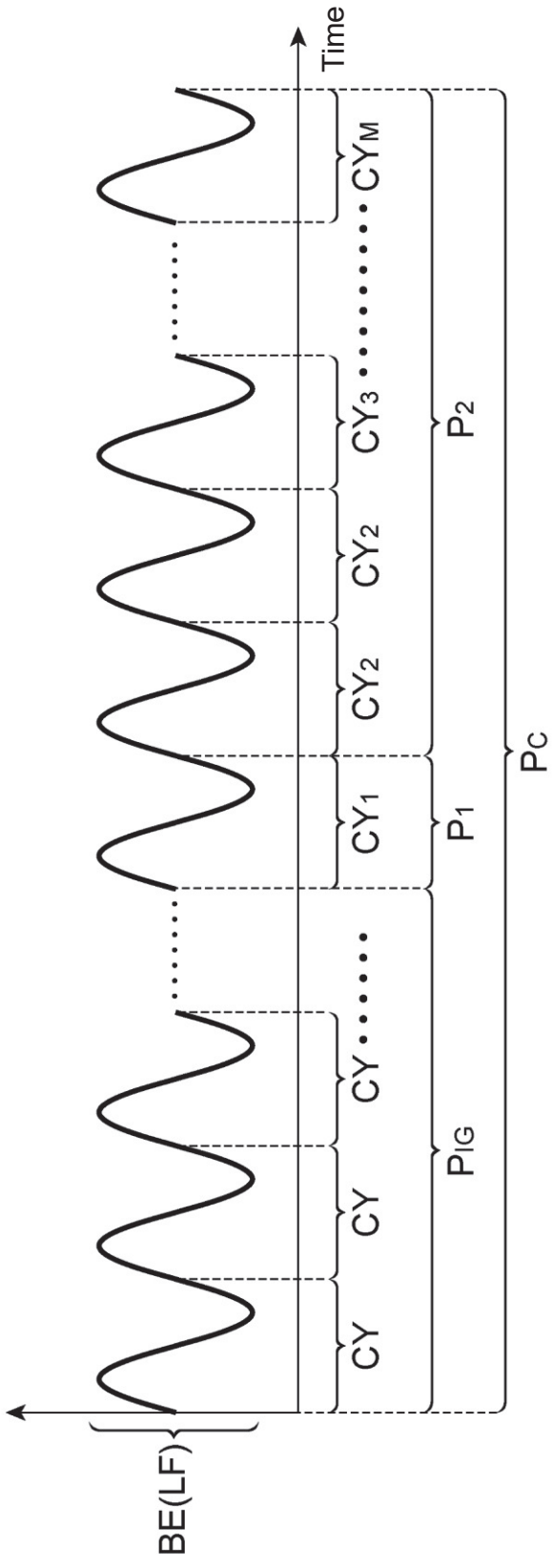


FIG. 7A

Process ID	Process condition dataset
1	$b_{11}, b_{21}, b_{31}, b_{41}, \cdots\cdots, b_{Y1}$
2	$b_{12}, b_{22}, b_{32}, b_{42}, \cdots\cdots, b_{Y2}$
. . . . .	. . . . .
X	$b_{1X}, b_{2X}, b_{3X}, b_{4X}, \cdots\cdots, b_{YX}$

FIG. 7B

Process ID	Frequency group
1	$f_{11}, f_{21}, f_{31}, f_{41}, \cdots\cdots, f_{N1}$
2	$f_{12}, f_{22}, f_{32}, f_{42}, \cdots\cdots, f_{N2}$
. . . . .	. . . . .
X	$f_{1X}, f_{2X}, f_{3X}, f_{4X}, \cdots\cdots, f_{NX}$

FIG. 8

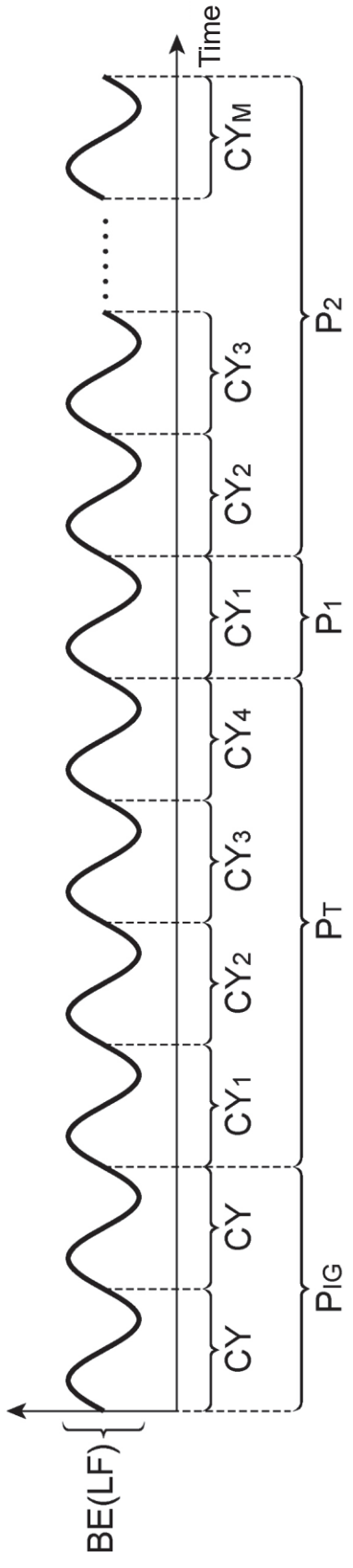


FIG. 9A

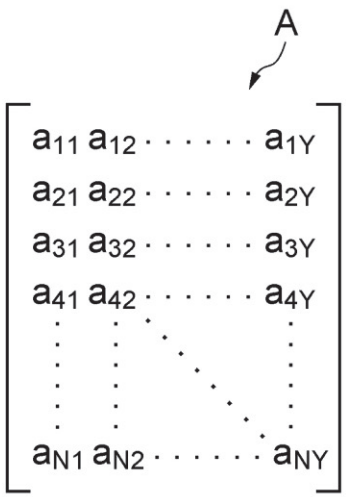

A
a11 a12 · · · · · · a1Y
a21 a22 · · · · · · a2Y
a31 a32 · · · · · · a3Y
a41 a42 · · · · · · a4Y
aN1 aN2 · · · · · · aNY

FIG. 9B

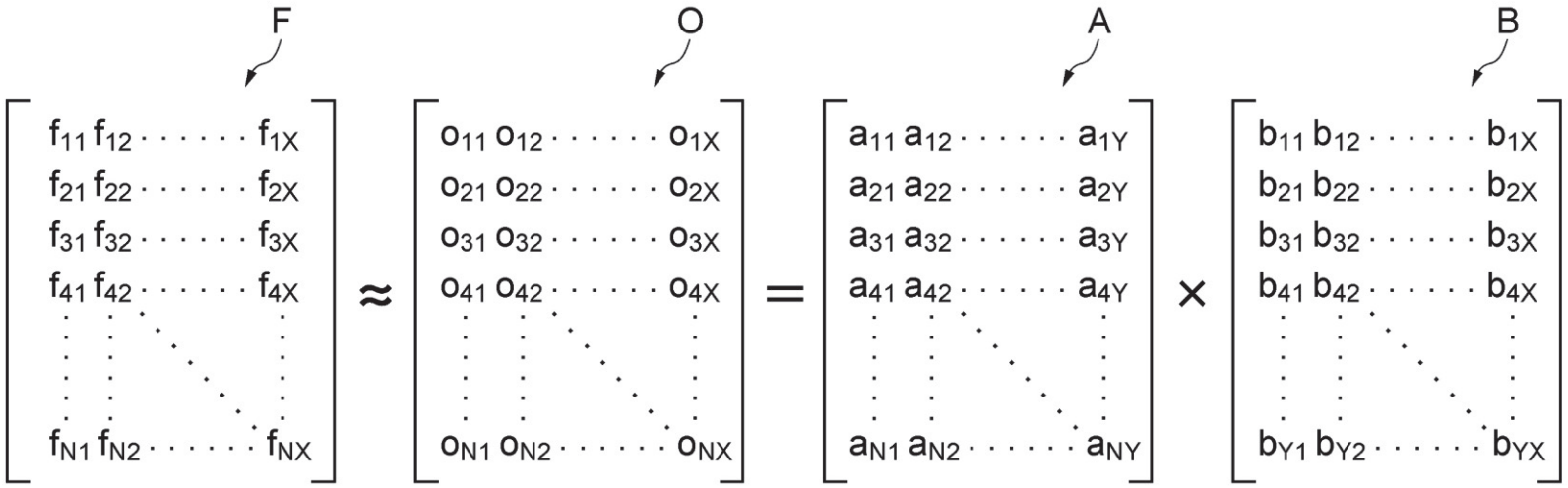

F
O
A
B
f11 f12 · · · · · · f1X
f21 f22 · · · · · · f2X
f31 f32 · · · · · · f3X
f41 f42 · · · · · · f4X
fN1 fN2 · · · · · · fNX
≈
o11 o12 · · · · · · o1X
o21 o22 · · · · · · o2X
o31 o32 · · · · · · o3X
o41 o42 · · · · · · o4X
oN1 oN2 · · · · · · oNX
=
a11 a12 · · · · · · a1Y
a21 a22 · · · · · · a2Y
a31 a32 · · · · · · a3Y
a41 a42 · · · · · · a4Y
aN1 aN2 · · · · · · aNY
×
b11 b12 · · · · · · b1X
b21 b22 · · · · · · b2X
b31 b32 · · · · · · b3X
b41 b42 · · · · · · b4X
bY1 bY2 · · · · · · bYX

FIG. 10

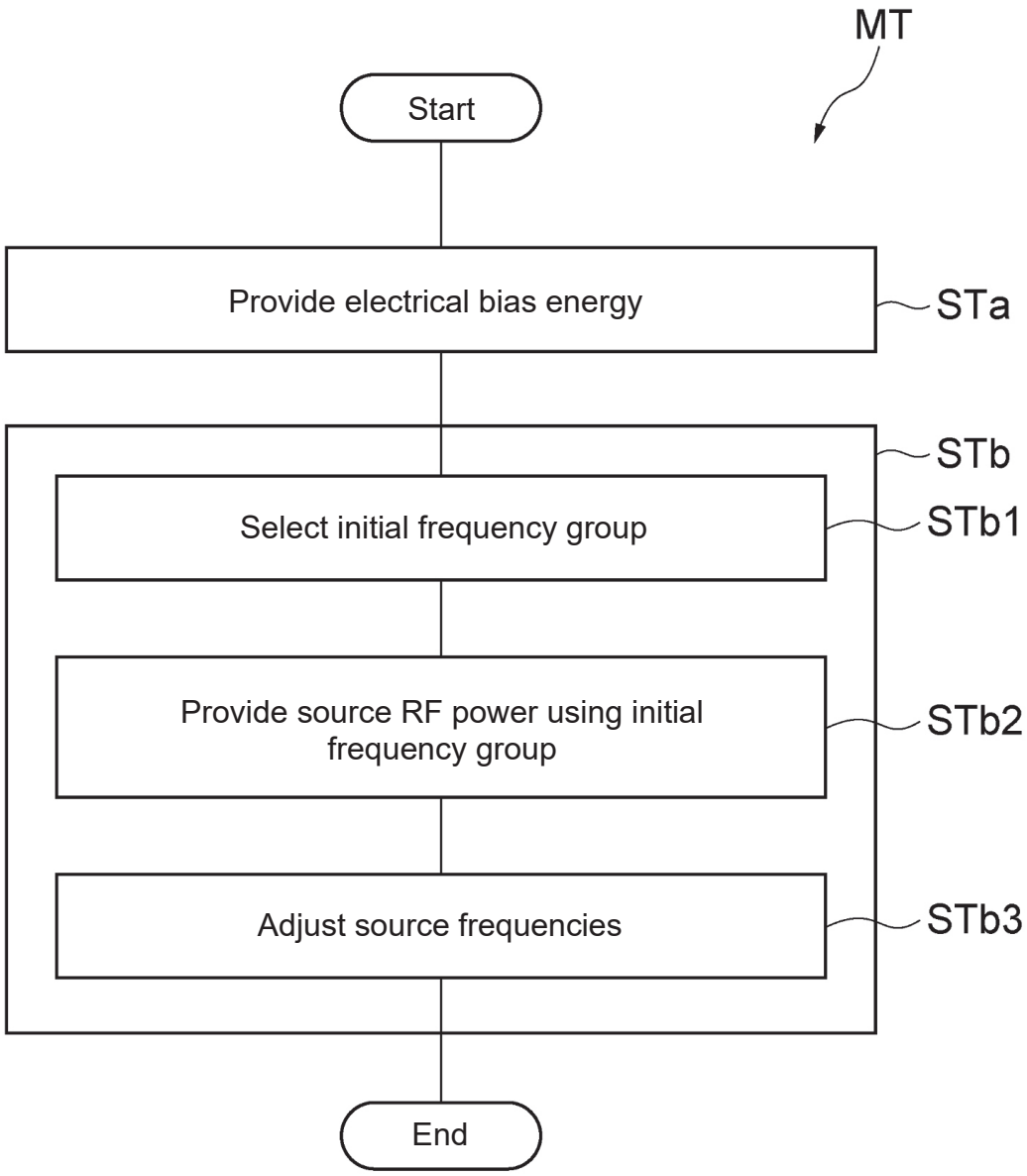

MT
Start
Provide electrical bias energy
STa
STb
Select initial frequency group
STb1
Provide source RF power using initial frequency group
STb2
Adjust source frequencies
STb3
End

FIG. 11

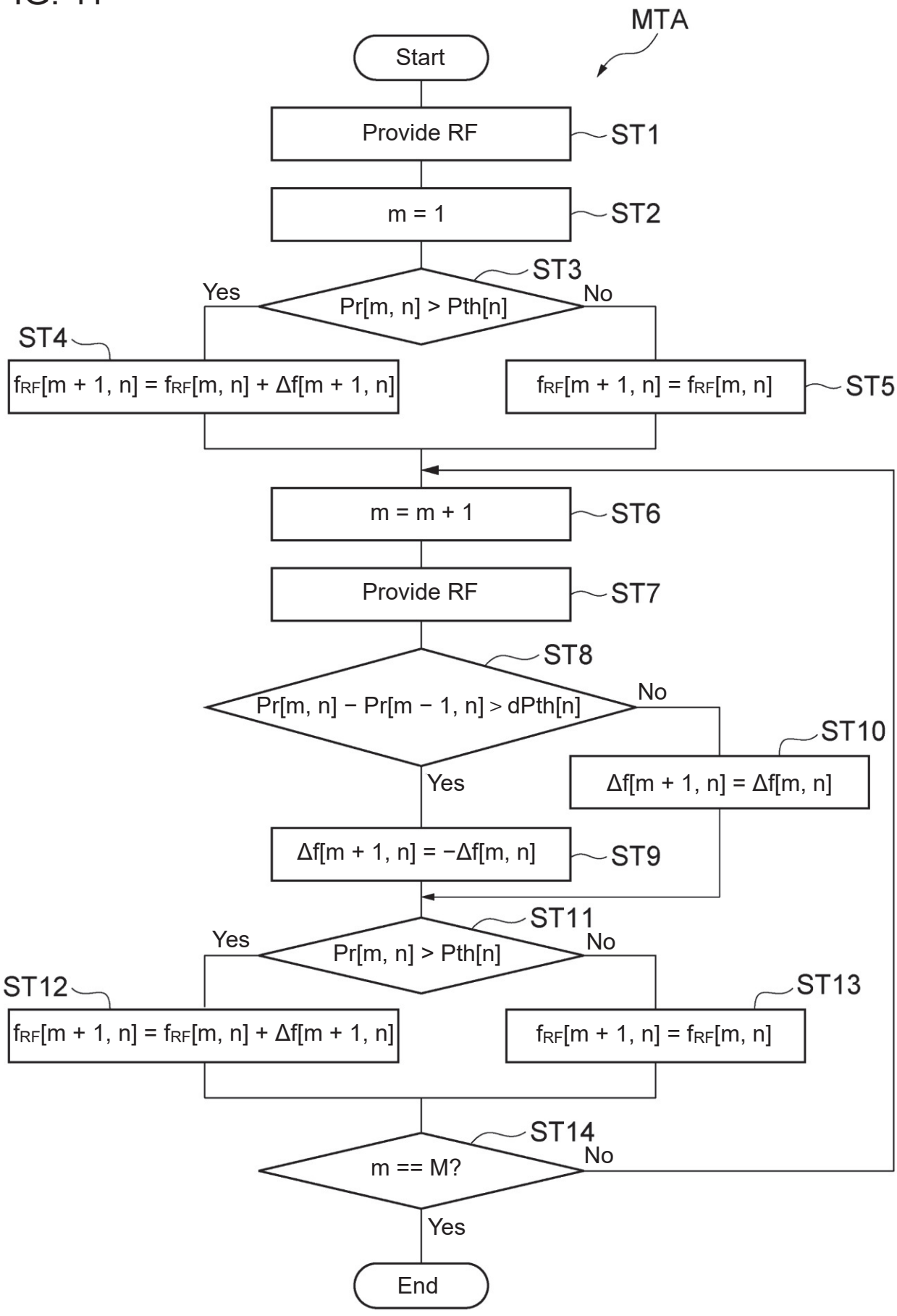

MTA
Start
Provide RF
ST1
m = 1
ST2
ST3
Yes
Pr[m, n] > Pth[n]
No
ST4
fRF[m + 1, n] = fRF[m, n] + Δf[m + 1, n]
fRF[m + 1, n] = fRF[m, n]
ST5
m = m + 1
ST6
Provide RF
ST7
ST8
Pr[m, n] − Pr[m − 1, n] > dPth[n]
No
ST10
Δf[m + 1, n] = Δf[m, n]
Yes
Δf[m + 1, n] = −Δf[m, n]
ST9
ST11
Yes
Pr[m, n] > Pth[n]
No
ST12
fRF[m + 1, n] = fRF[m, n] + Δf[m + 1, n]
ST13
fRF[m + 1, n] = fRF[m, n]
ST14
m == M?
No
Yes
End

FIG. 12

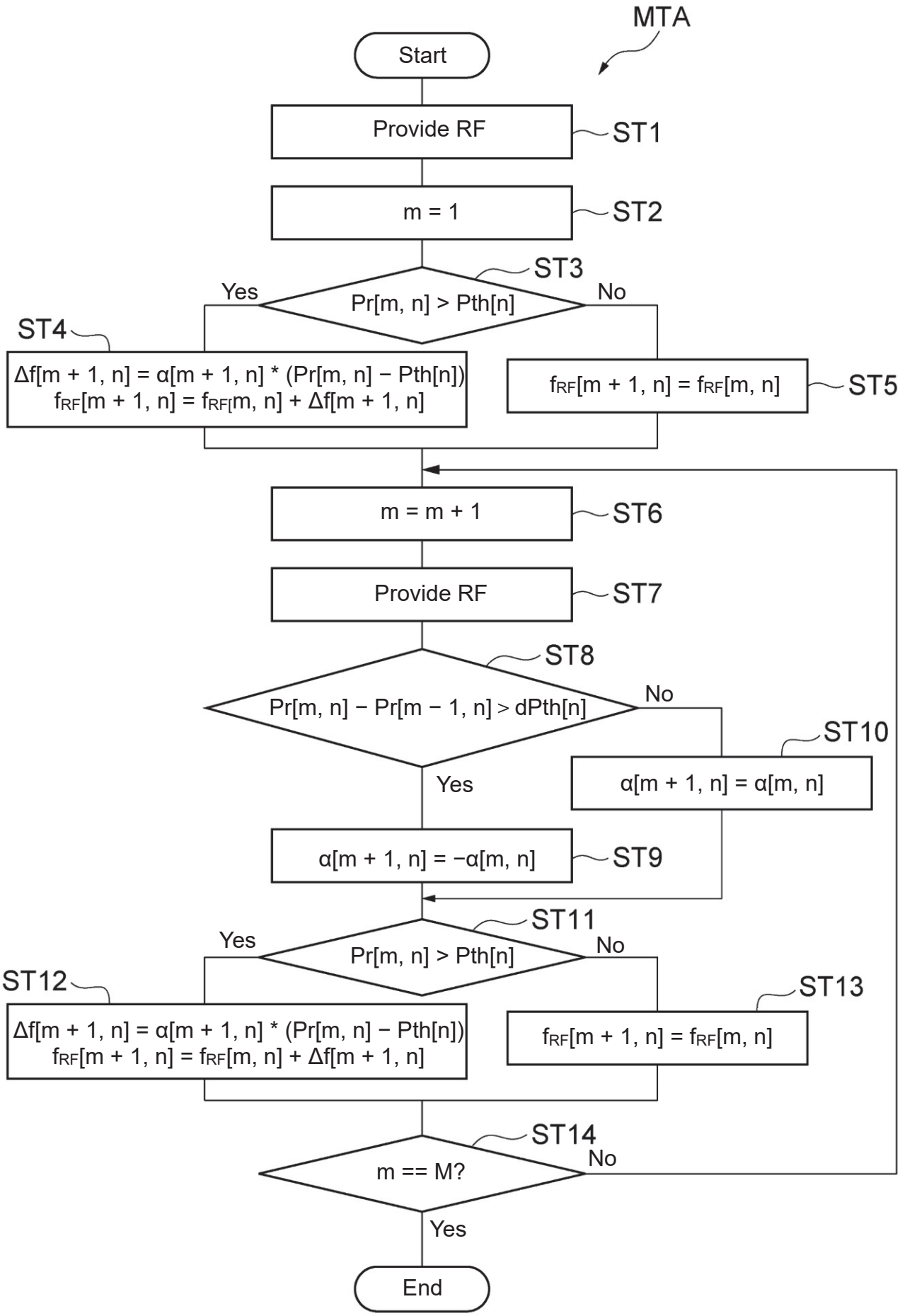

MTA
Start
Provide RF
ST1
m = 1
ST2
ST3
Yes
Pr[m, n] > Pth[n]
No
ST4
Δf[m + 1, n] = α[m + 1, n] * (Pr[m, n] − Pth[n])
fRF[m + 1, n] = fRF[m, n] + Δf[m + 1, n]
fRF[m + 1, n] = fRF[m, n]
ST5
m = m + 1
ST6
Provide RF
ST7
ST8
Pr[m, n] − Pr[m − 1, n] > dPth[n]
No
Yes
ST10
α[m + 1, n] = α[m, n]
α[m + 1, n] = −α[m, n]
ST9
ST11
Yes
Pr[m, n] > Pth[n]
No
ST12
Δf[m + 1, n] = α[m + 1, n] * (Pr[m, n] − Pth[n])
fRF[m + 1, n] = fRF[m, n] + Δf[m + 1, n]
ST13
fRF[m + 1, n] = fRF[m, n]
ST14
m == M?
No
Yes
End

FIG. 13

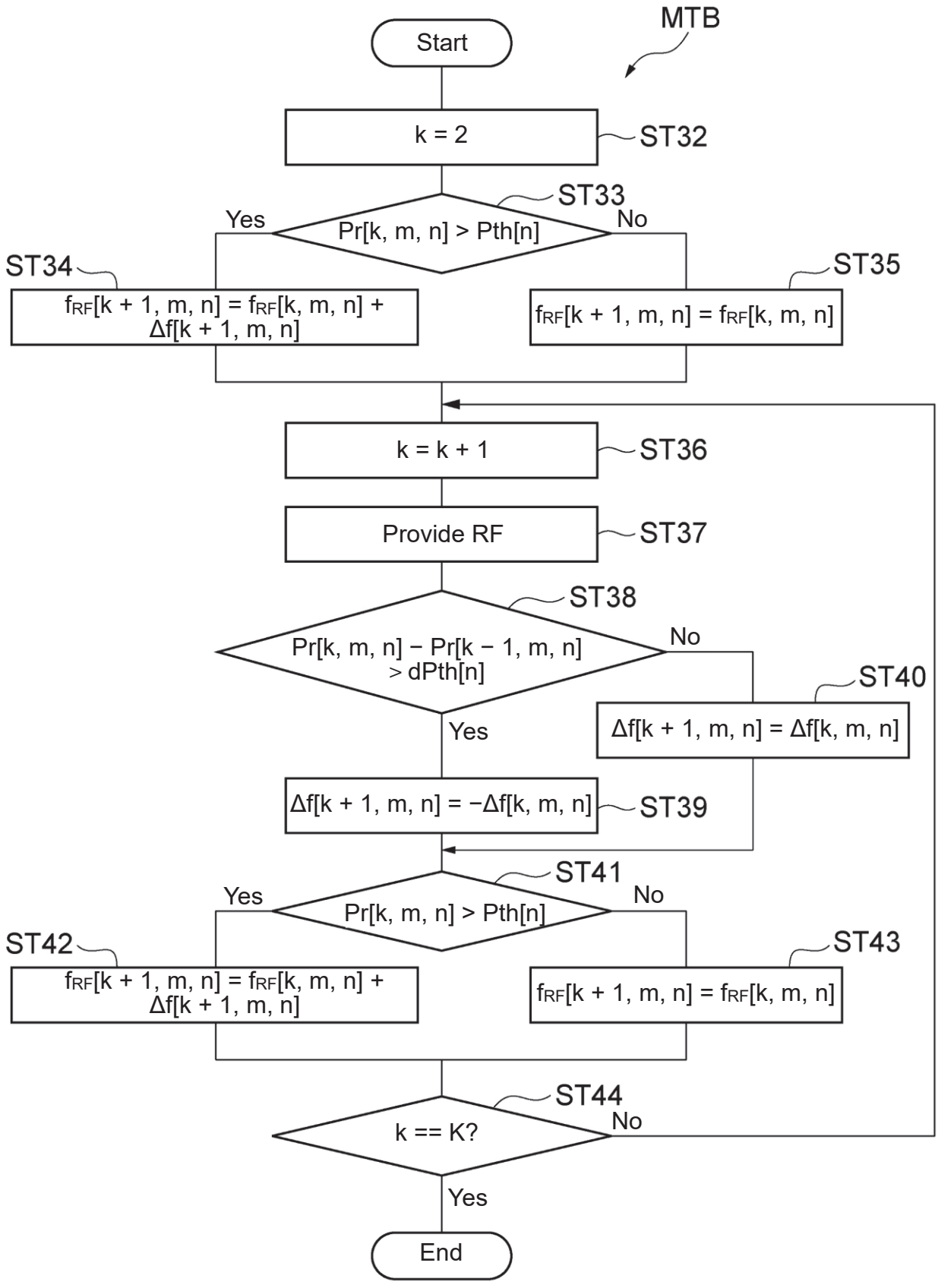
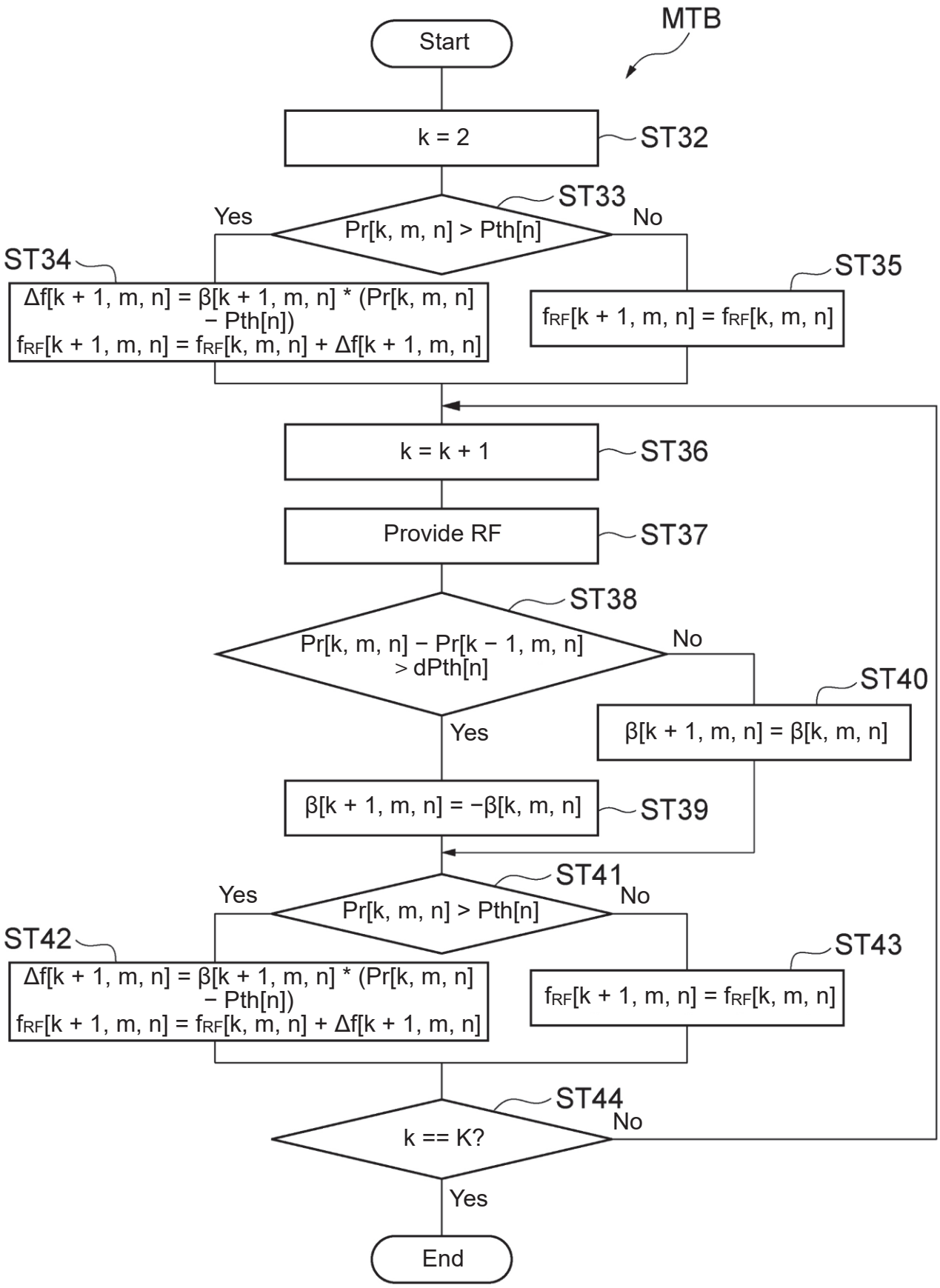

MTB
Start
k = 2
ST32
ST33
Yes
Pr[k, m, n] > Pth[n]
No
ST34
$f_{RF}[k + 1, m, n] = f_{RF}[k, m, n] + \Delta f[k + 1, m, n]$
ST35
$f_{RF}[k + 1, m, n] = f_{RF}[k, m, n]$
k = k + 1
ST36
Provide RF
ST37
ST38
Pr[k, m, n] − Pr[k − 1, m, n] > dPth[n]
No
ST40
$\Delta f[k + 1, m, n] = \Delta f[k, m, n]$
Yes
$\Delta f[k + 1, m, n] = -\Delta f[k, m, n]$
ST39
ST41
Yes
Pr[k, m, n] > Pth[n]
No
ST42
$f_{RF}[k + 1, m, n] = f_{RF}[k, m, n] + \Delta f[k + 1, m, n]$
ST43
$f_{RF}[k + 1, m, n] = f_{RF}[k, m, n]$
ST44
k == K?
No
Yes
End

FIG. 14


MTB
Start
k = 2
ST32
ST33
Yes
Pr[k, m, n] > Pth[n]
No
ST34
Δf[k + 1, m, n] = β[k + 1, m, n] * (Pr[k, m, n] − Pth[n])
fRF[k + 1, m, n] = fRF[k, m, n] + Δf[k + 1, m, n]
ST35
fRF[k + 1, m, n] = fRF[k, m, n]
k = k + 1
ST36
Provide RF
ST37
ST38
Pr[k, m, n] − Pr[k − 1, m, n] > dPth[n]
No
ST40
β[k + 1, m, n] = β[k, m, n]
Yes
β[k + 1, m, n] = −β[k, m, n]
ST39
ST41
Yes
Pr[k, m, n] > Pth[n]
No
ST42
Δf[k + 1, m, n] = β[k + 1, m, n] * (Pr[k, m, n] − Pth[n])
fRF[k + 1, m, n] = fRF[k, m, n] + Δf[k + 1, m, n]
ST43
fRF[k + 1, m, n] = fRF[k, m, n]
ST44
k == K?
No
Yes
End