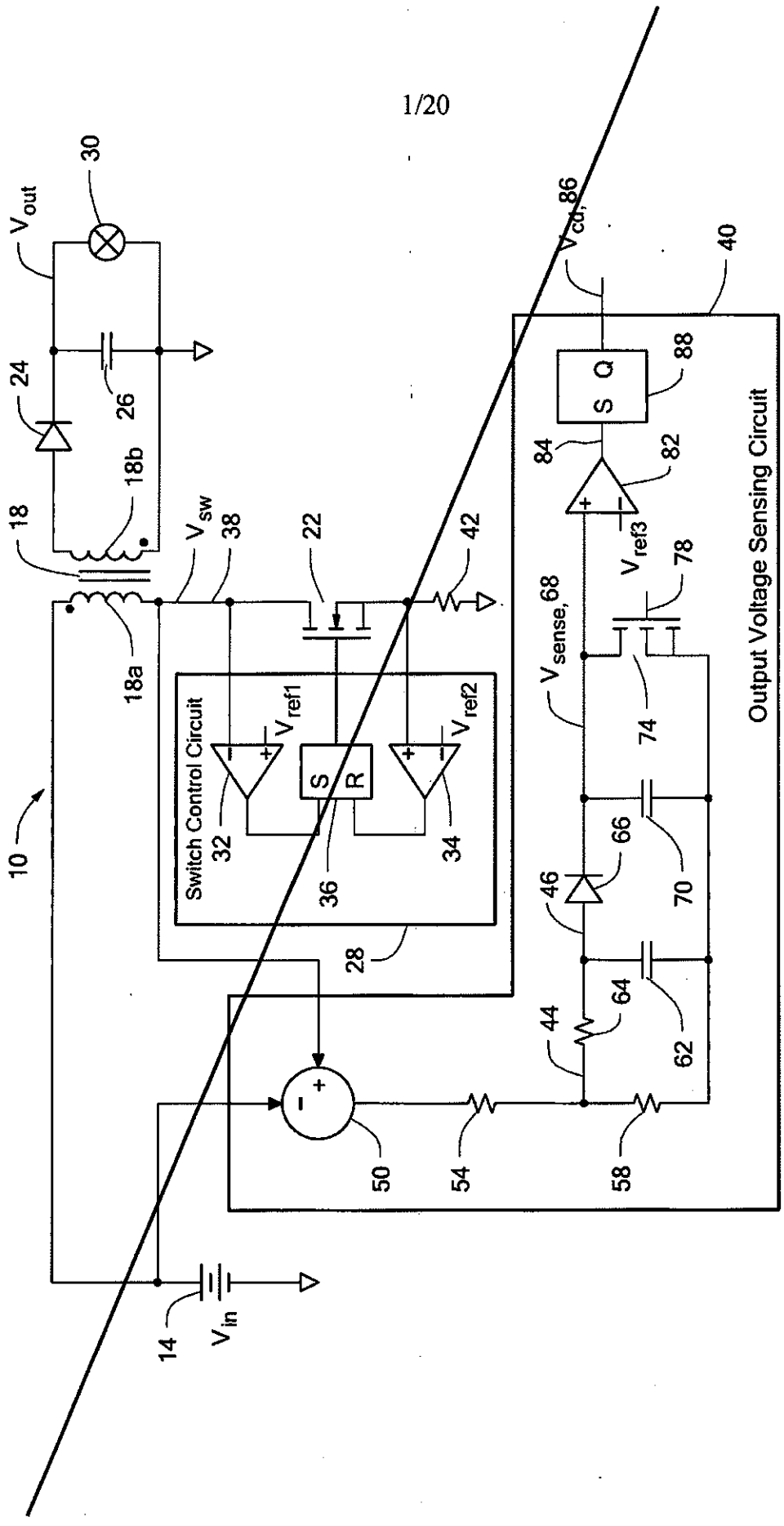

V_{out}
30
24
26
18b
18
V_{sw}
38
22
42
18a
10
Switch Control Circuit
V_{ref1}
V_{ref2}
32
36
34
28
V_{cc}
86
40
88
S Q
84
82
V_{ref3}
78
V_{sense}
68
74
66
70
46
64
62
44
50
54
58
14
V_{in}
Output Voltage Sensing Circuit

FIG. 1

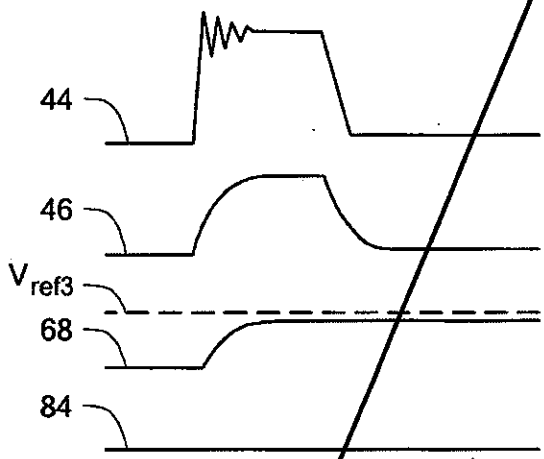


FIG. 1A

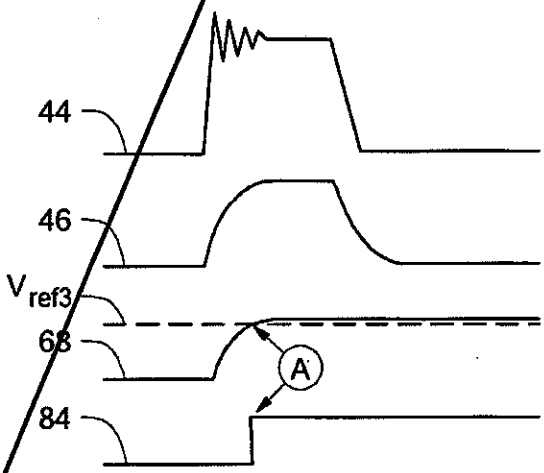


FIG. 1B

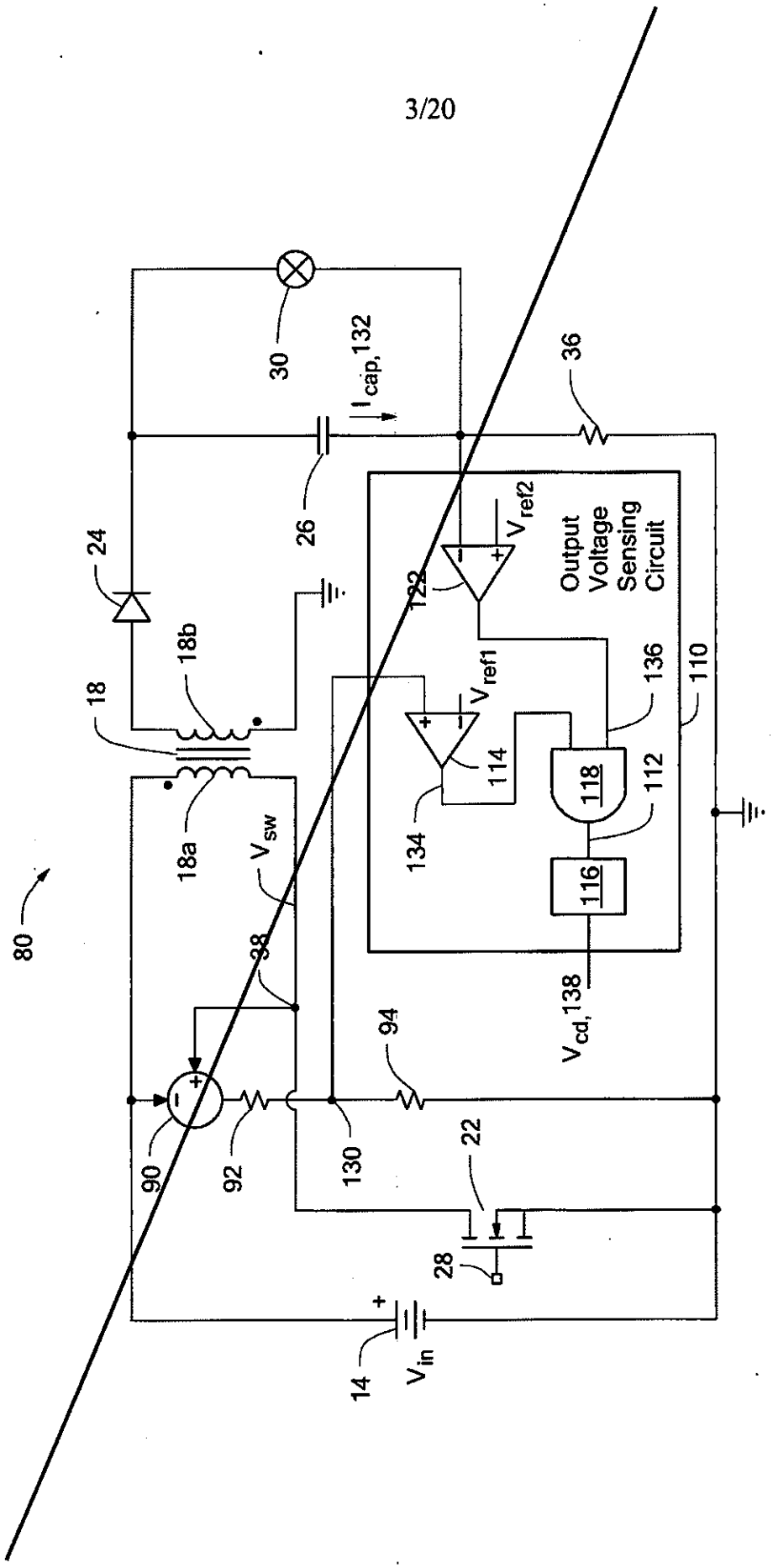

80
14
V_{in}
28
22
90
92
130
94
38
V_{sw}
18a
18
18b
24
26
30
I_{cap}, 132
36
122
V_{ref2}
Output Voltage Sensing Circuit
110
136
V_{ref1}
114
134
118
112
116
V_{cd}, 138

FIG. 2

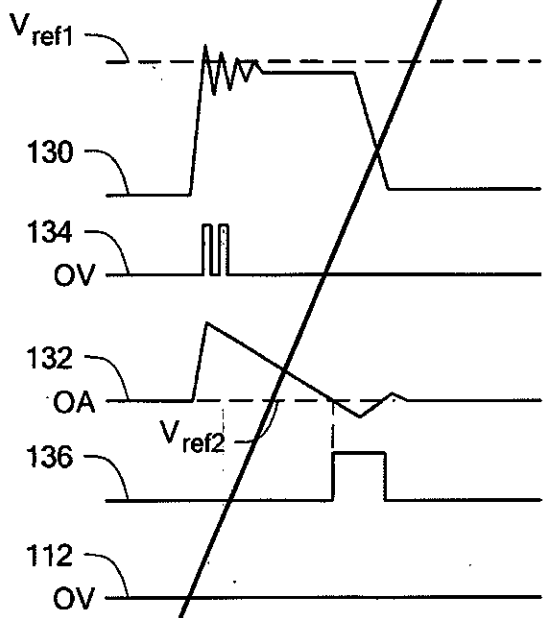

V_{ref1}
130
134
OV
132
OA
V_{ref2}
136
112
OV

FIG. 2A

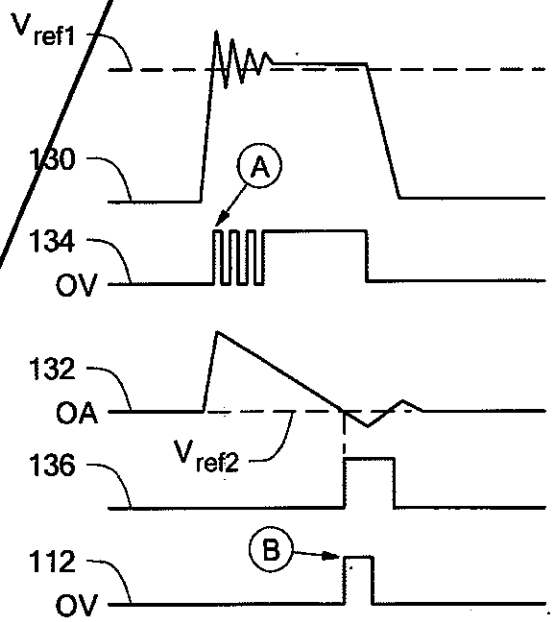

V_{ref1}
130
A
134
OV
132
OA
V_{ref2}
136
B
112
OV

FIG. 2B

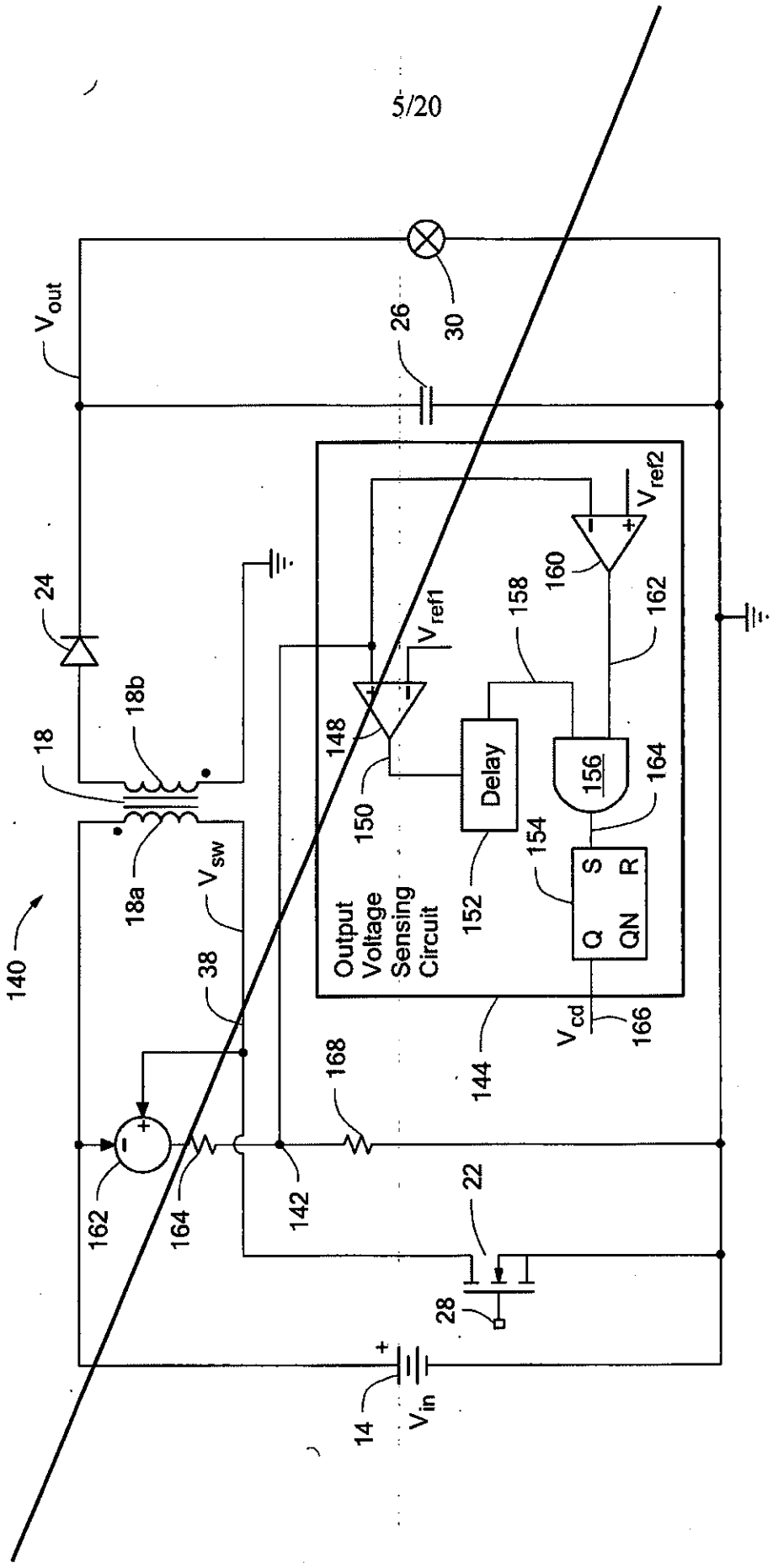

V_{out}
26
30
24
18
18b
18a
V_{sw}
140
38
Output Voltage Sensing Circuit
V_{ref1}
V_{ref2}
148
150
152
154
156
158
160
162
164
Delay
S
R
Q
QN
V_{cd}
166
144
168
142
22
28
14
V_{in}

FIG. 3

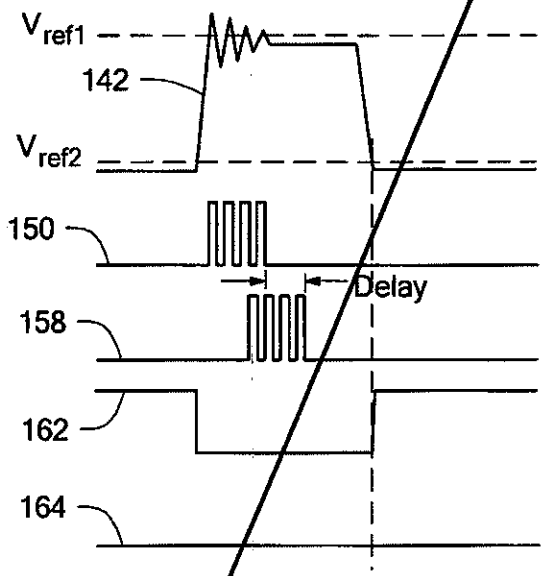

Vref1
142
Vref2
150
Delay
158
162
164

FIG. 3A

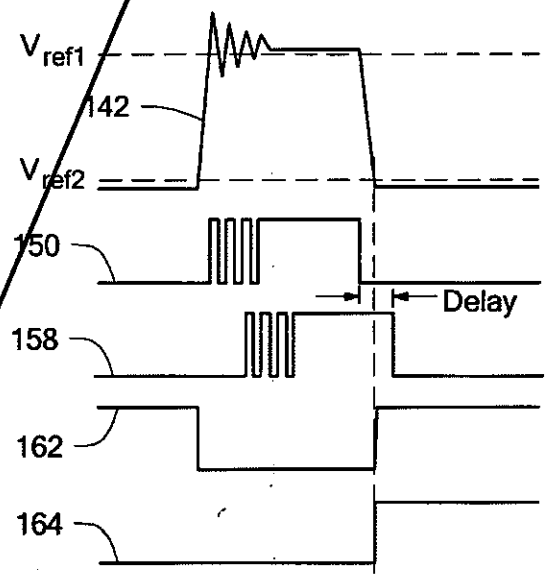

Vref1
142
Vref2
150
Delay
158
162
164

FIG. 3B

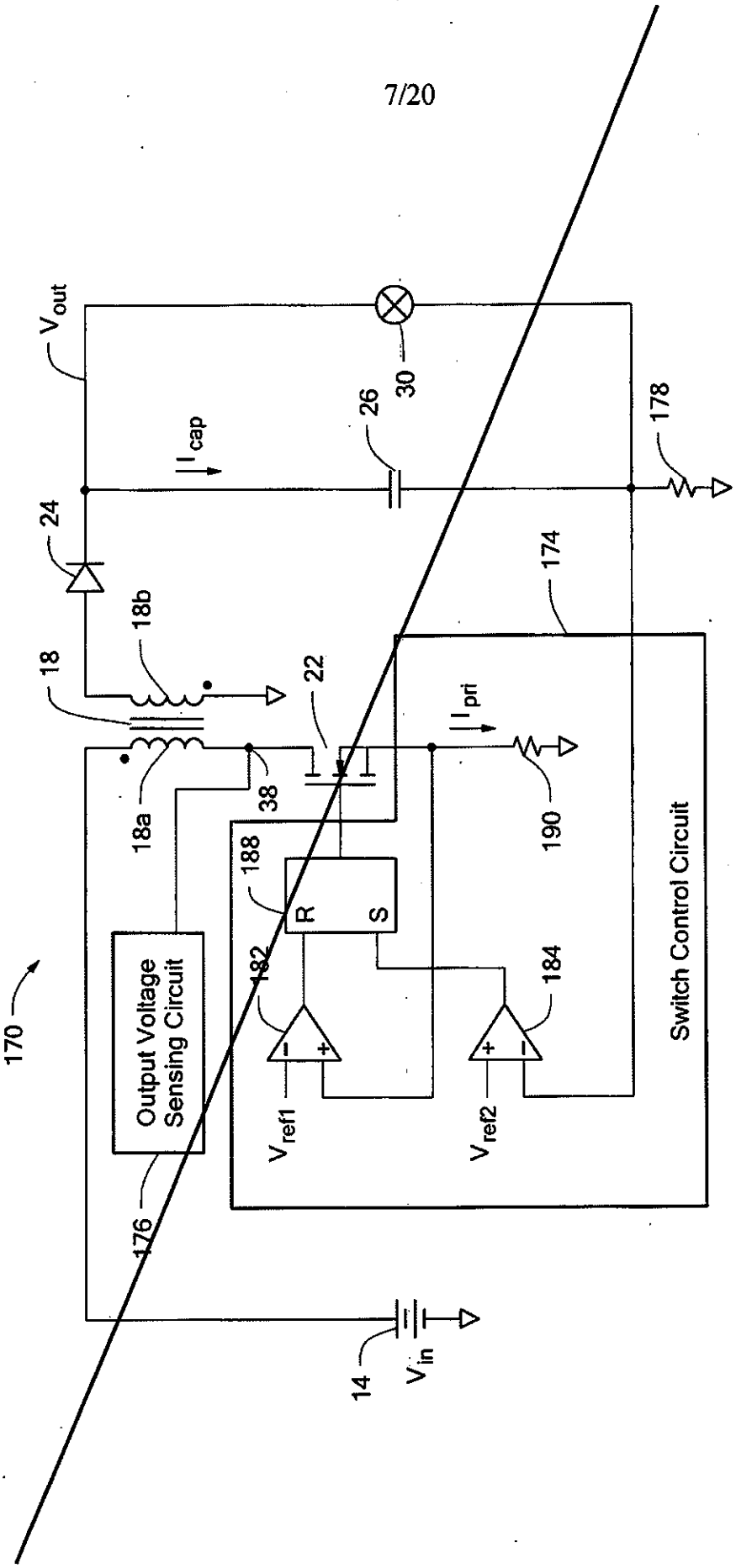

V_{out}
30
26
178
I_{cap}
24
174
18b
18
22
I_{pri}
18a
38
190
188
R
S
182
184
170
Output Voltage Sensing Circuit
Switch Control Circuit
V_{ref1}
V_{ref2}
176
14
V_{in}

FIG. 4

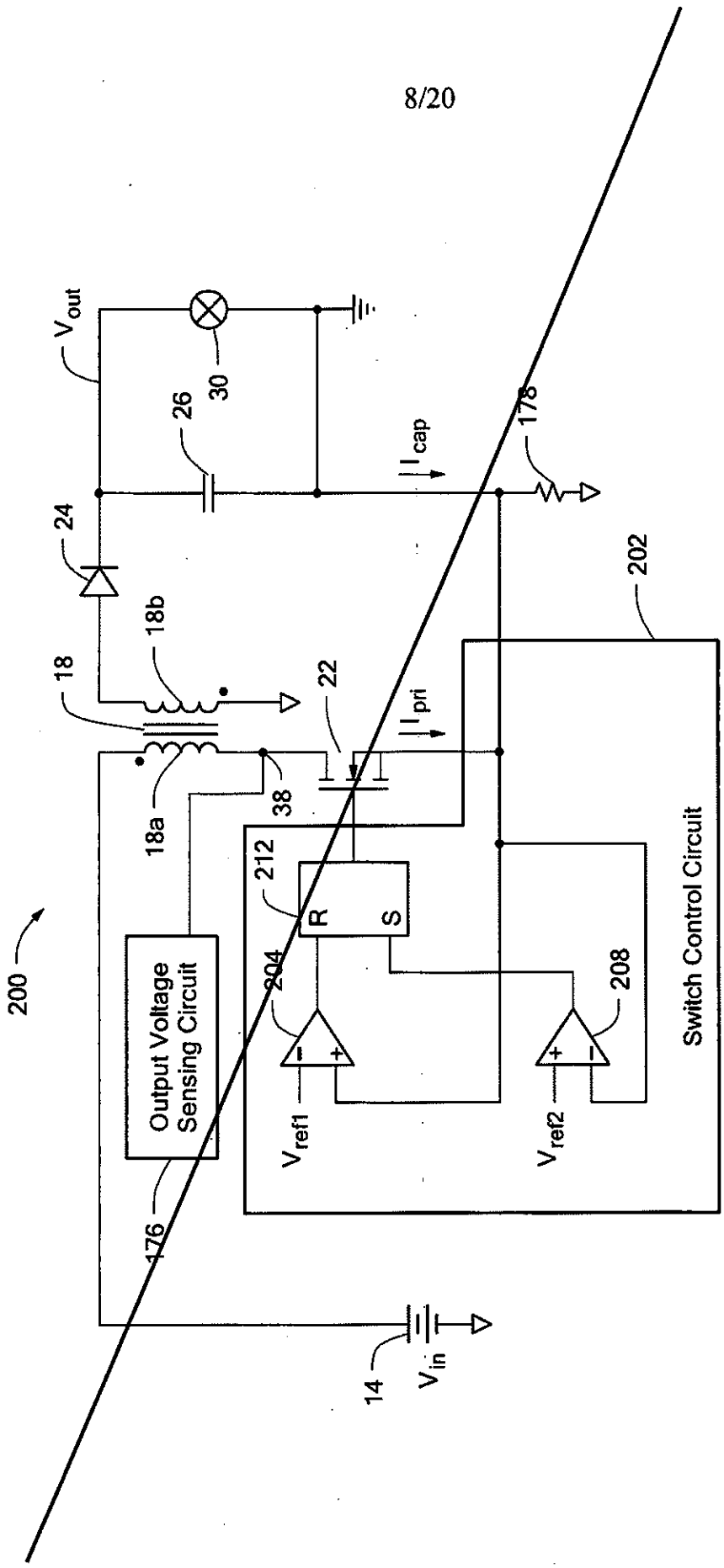

200
V_{out}
30
26
I_{cap}
178
24
18b
18
22
I_{pri}
202
18a
38
212
R
S
204
208
Output Voltage Sensing Circuit
Switch Control Circuit
V_{ref1}
V_{ref2}
176
14
V_{in}

FIG. 5

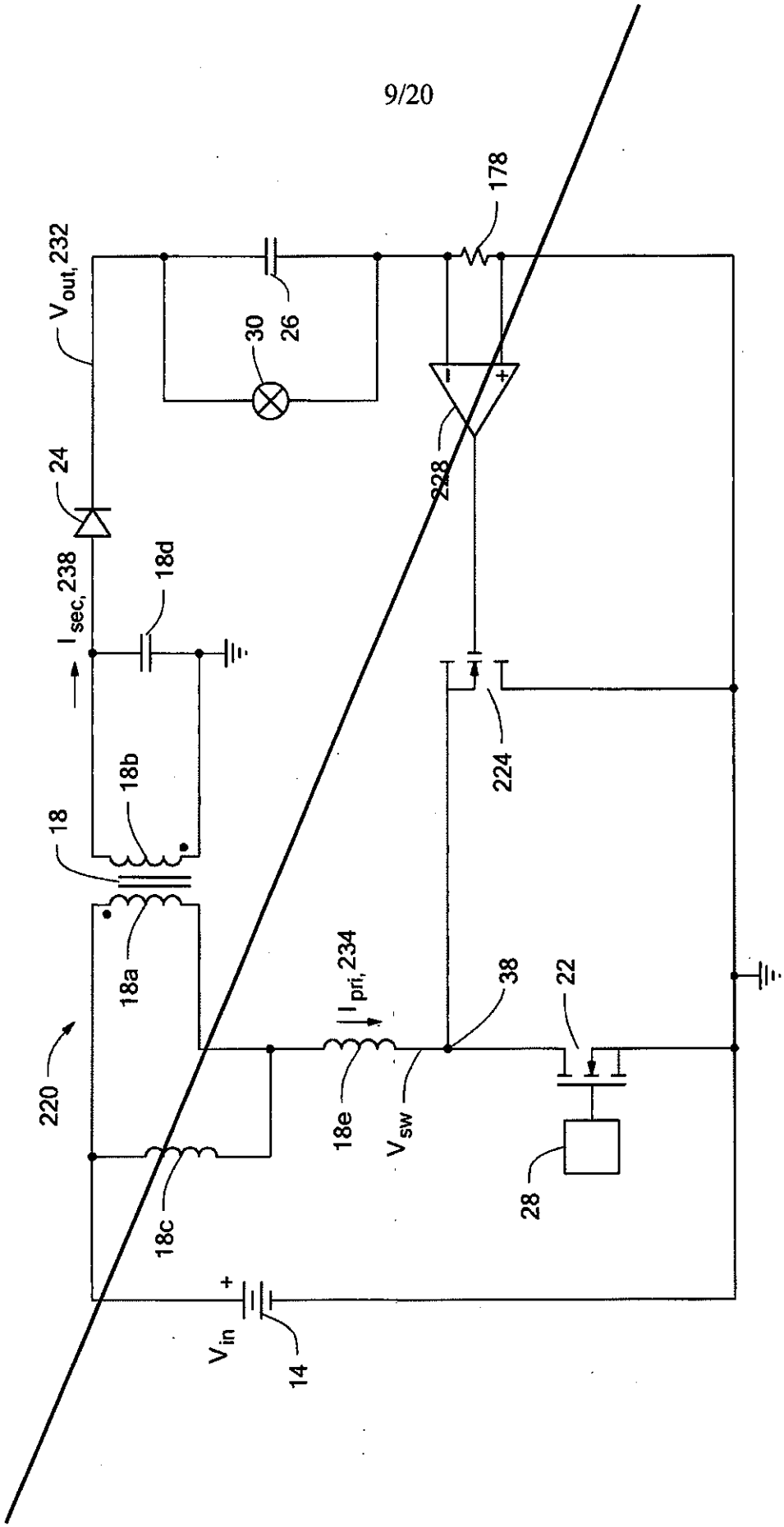

178
V_{out}, 232
30
26
24
228
I_{sec}, 238
18d
224
18b
18
18a
I_{pri}, 234
38
22
220
18e
V_{sw}
28
18c
V_{in}
14

FIG. 6

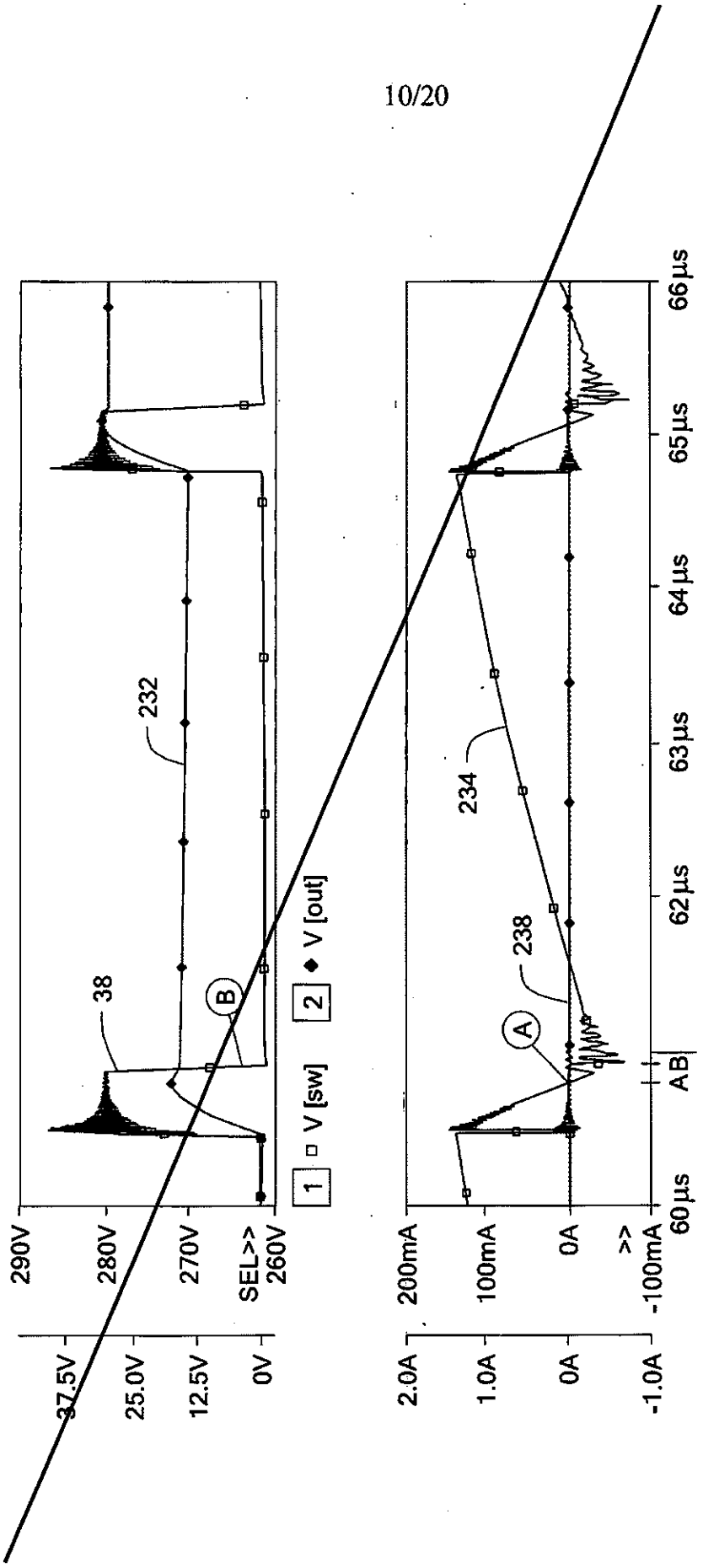

290V
280V
270V
SEL>>
260V
37.5V
25.0V
12.5V
0V
38
232
B
1 □ V [sw]
2 ◆ V [out]
200mA
100mA
0A
>>
-100mA
2.0A
1.0A
0A
-1.0A
234
238
A
60 µs
AB
61 µs
62 µs
63 µs
64 µs
65 µs
66 µs
Time
1 □ I pri
2 ◆ I sec

FIG. 6A

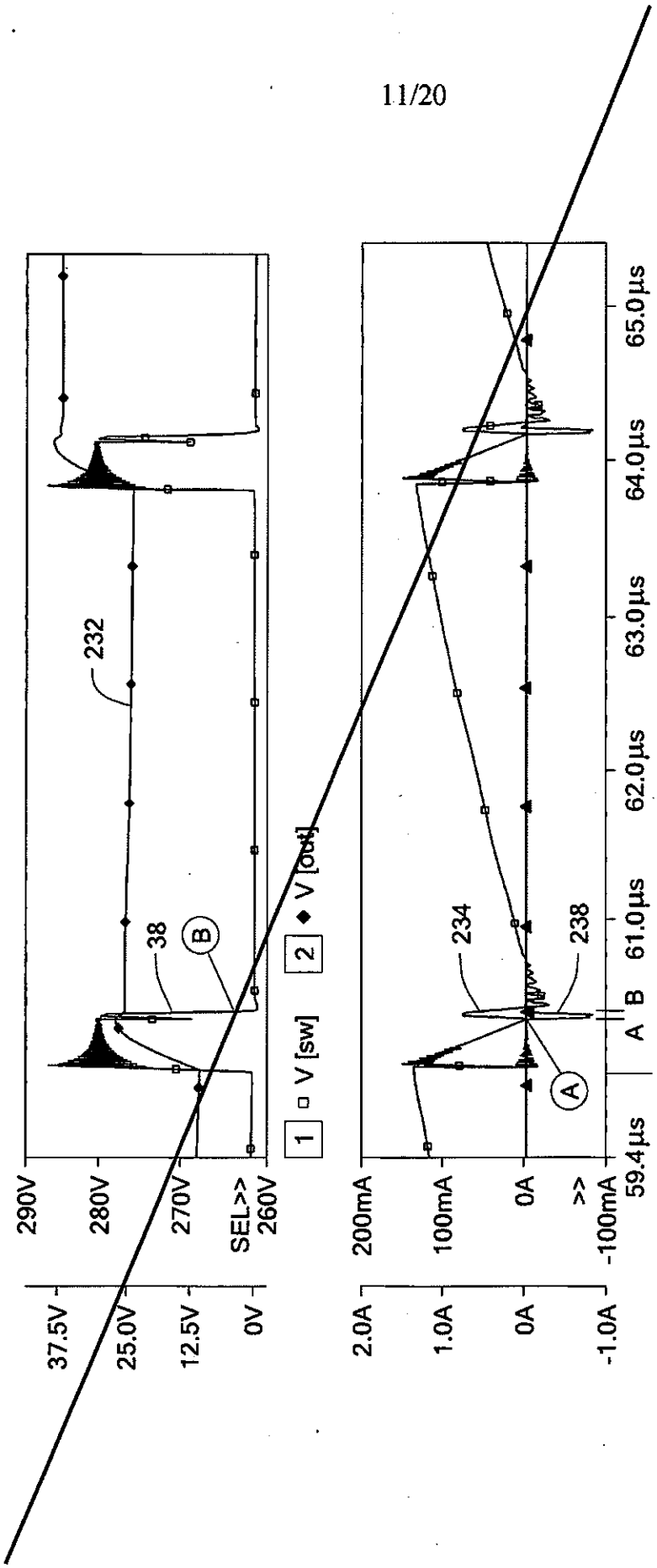

290V
280V
270V
SEL>>
260V
37.5V
25.0V
12.5V
0V
232
38
B
1 □ V [sw]
2 ◆ V [out]
200mA
100mA
0A
>>
-100mA
2.0A
1.0A
0A
-1.0A
234
238
A
A B
59.4µs
60.0µs
61.0µs
62.0µs
63.0µs
64.0µs
65.0µs
Time
1 □ I pri
2 ▲ I sec

FIG. 6B

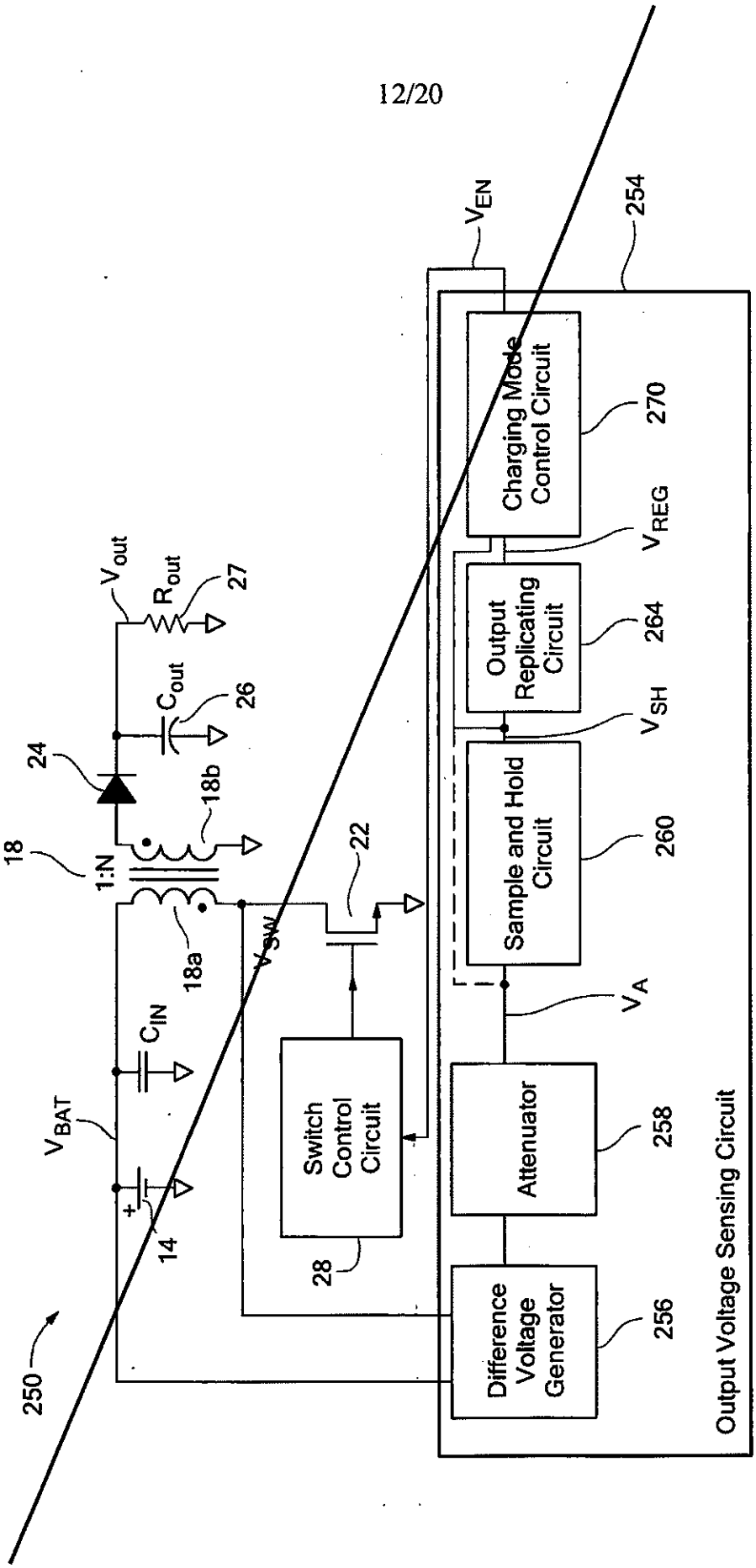

250
18
1:N
18a
18b
24
V_{out}
R_{out}
27
C_{out}
26
C_{IN}
V_{BAT}
14
V_{SW}
22
Switch Control Circuit
28
V_{EN}
254
Charging Mode Control Circuit
270
V_{REG}
Output Replicating Circuit
264
V_{SH}
Sample and Hold Circuit
260
V_A
Attenuator
258
Difference Voltage Generator
256
Output Voltage Sensing Circuit

FIG. 7

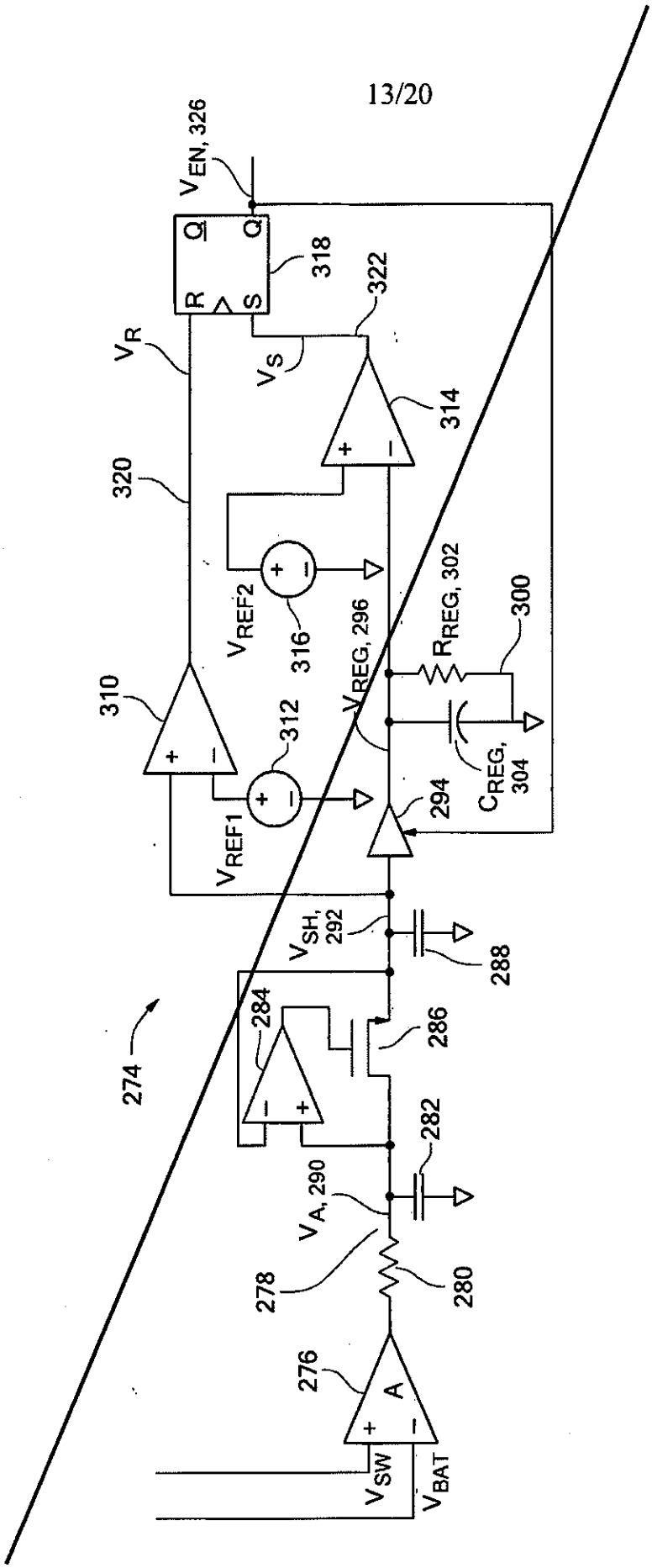

V_{EN}, 326
Q
Q
R
S
318
322
V_R
V_S
314
320
V_{REF2}
316
V_{REG}, 296
R_{REG}, 302
300
310
312
V_{REF1}
294
C_{REG}, 304
V_{SH}, 292
288
284
286
274
282
V_A, 290
278
280
276
A
V_{SW}
V_{BAT}

FIG. 8

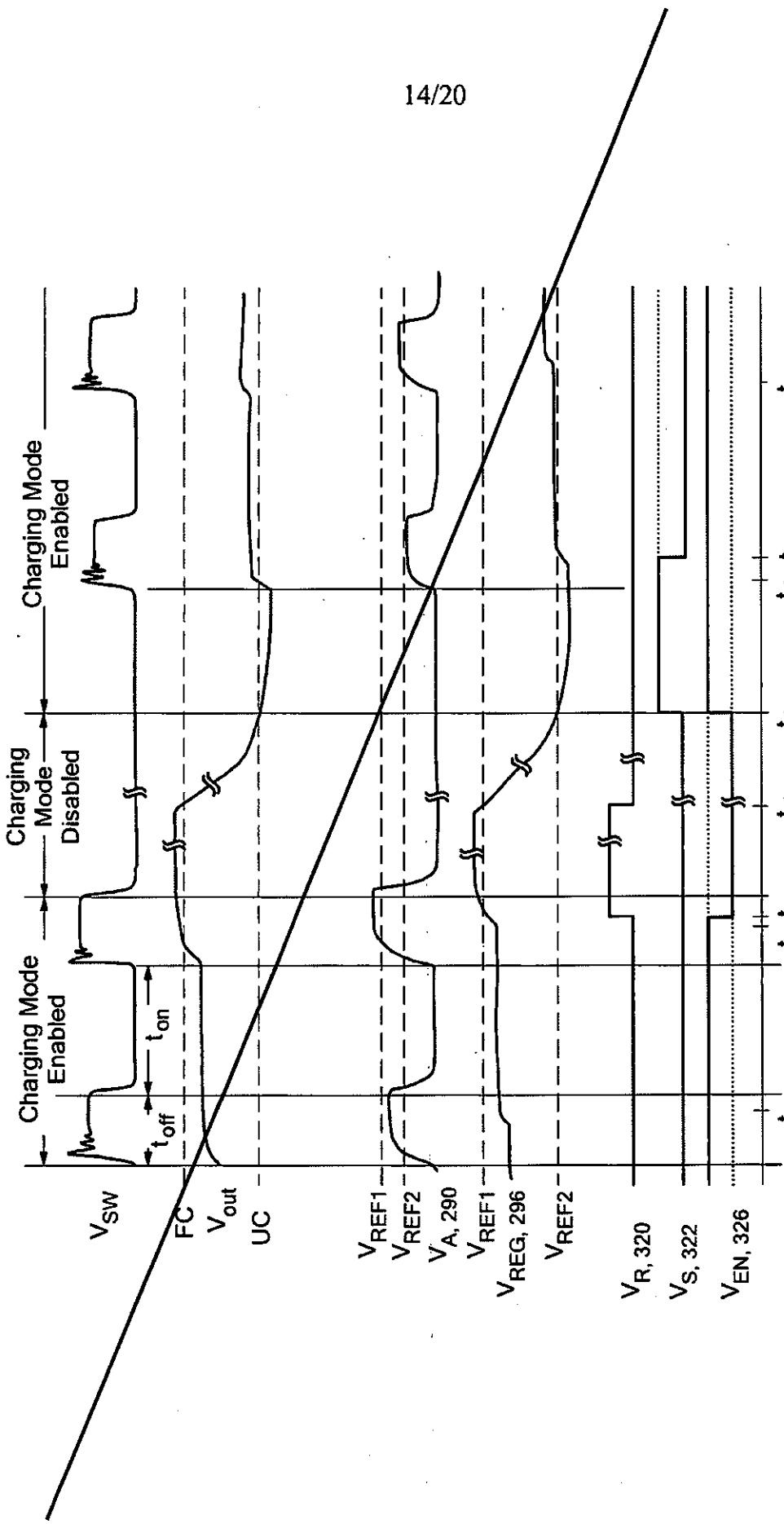

Charging Mode Enabled
Charging Mode Disabled
Charging Mode Enabled
t_{on}
t_{off}
V_{SW}
FC
V_{out}
UC
V_{REF1}
V_{REF2}
$V_{A,\ 290}$
V_{REF1}
$V_{REG,\ 296}$
V_{REF2}
$V_{R,\ 320}$
$V_{S,\ 322}$
$V_{EN,\ 326}$
t_1
t_2 t_3
t_4
t_5
t_6 t_7
t_8

FIG. 9

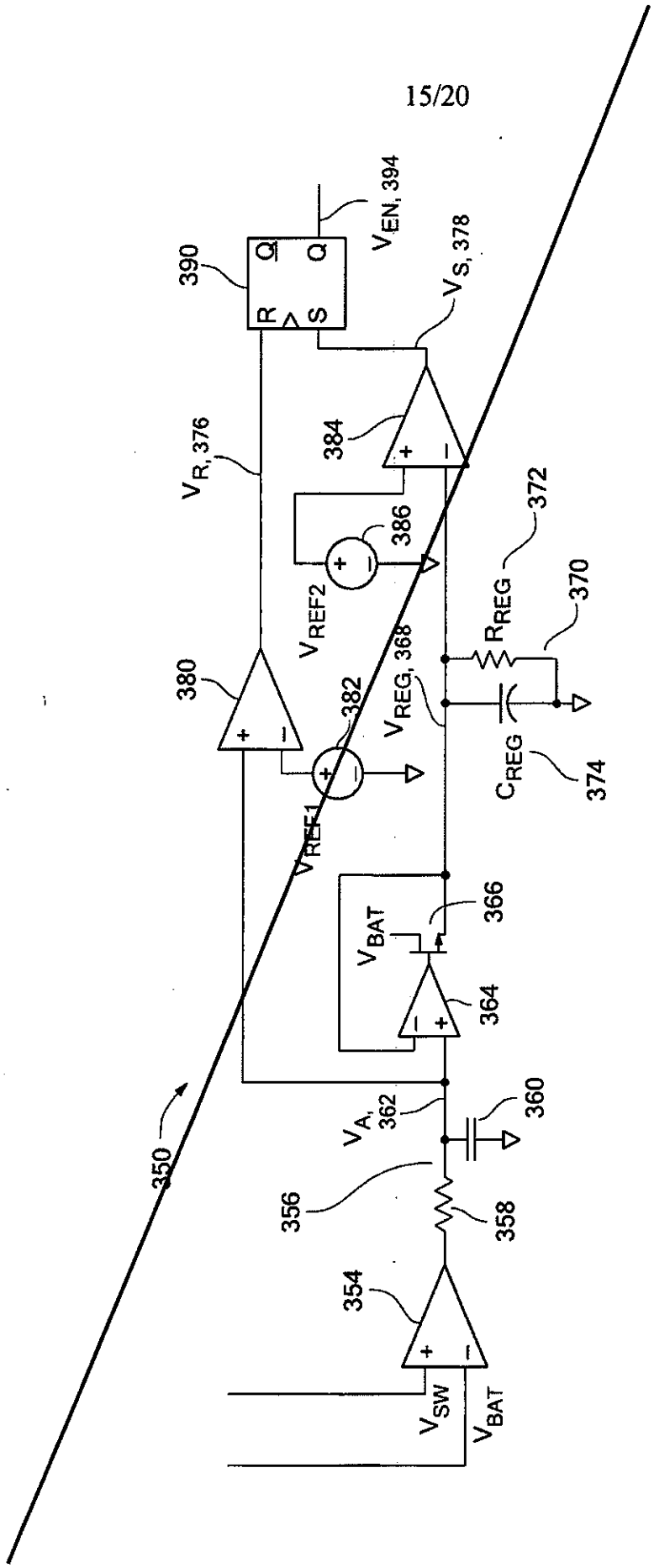

350
390
R
S
Q
Q
$V_{EN,\ 394}$
$V_{S,\ 378}$
$V_{R,\ 376}$
384
386
V_{REF2}
372
R_{REG}
370
380
382
$V_{REG,\ 368}$
V_{REF1}
C_{REG}
374
V_{BAT}
366
364
$V_{A,}$
362
360
356
358
354
V_{SW}
V_{BAT}

FIG. 10

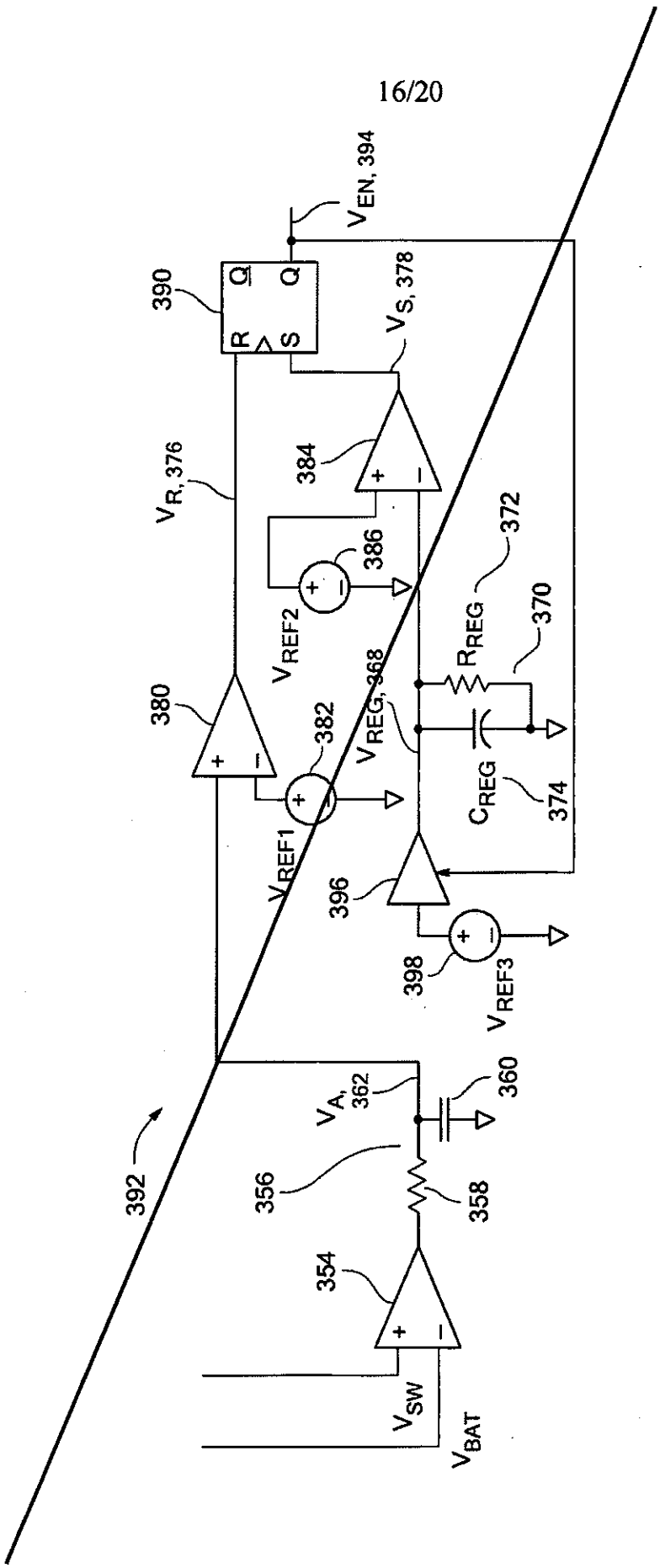

$V_{EN, 394}$
390
Q
$\overline{Q}$
R
S
$V_{S, 378}$
384
$V_{R, 376}$
386
V_{REF2}
372
R_{REG}
370
380
382
$V_{REG, 368}$
C_{REG}
374
V_{REF1}
396
398
V_{REF3}
392
$V_{A, 362}$
360
356
358
354
V_{SW}
V_{BAT}

FIG. 10A

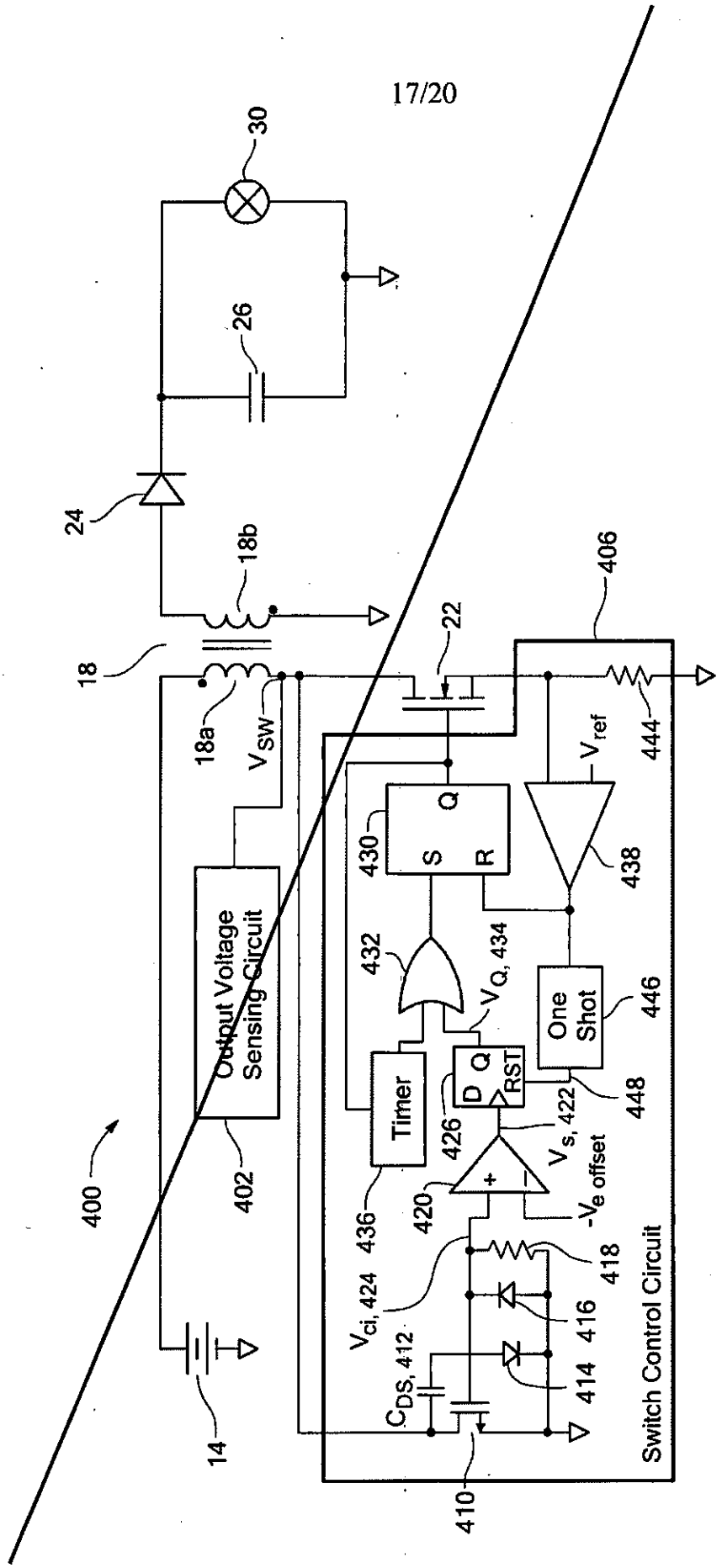

30
26
24
18b
406
22
18
18a
V_{SW}
V_{ref}
444
430
Q
S
R
438
432
$V_{Q,\ 434}$
One Shot
446
Timer
D Q
RST
426
448
$V_{s,\ 422}$
$-V_{e\ offset}$
420
436
$V_{ci,\ 424}$
418
416
414
$C_{DS,\ 412}$
410
Output Voltage Sensing Circuit
402
400
14
Switch Control Circuit

FIG. 11

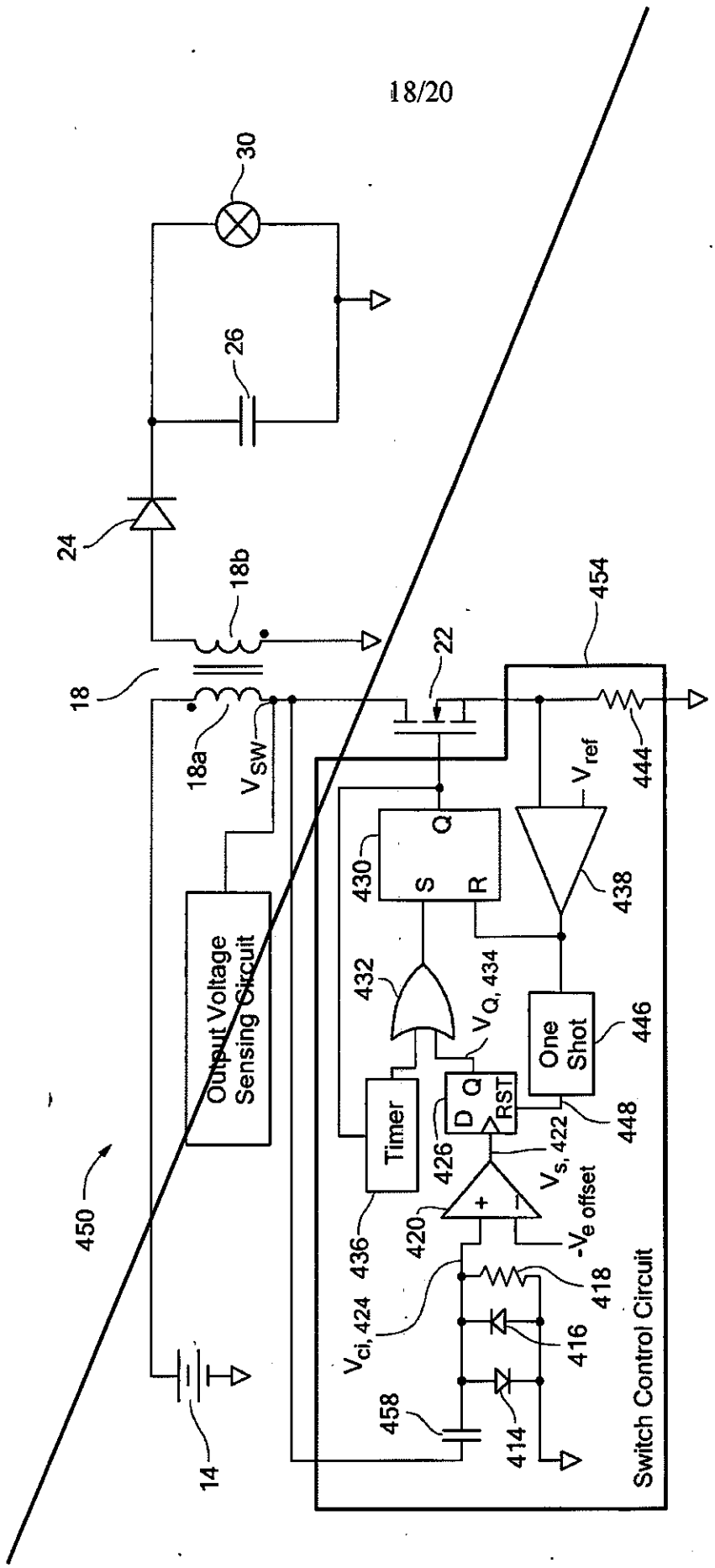

30
26
24
18b
18
18a
V_{SW}
22
454
444
V_{ref}
438
Q
S
R
430
432
$V_{Q,434}$
One Shot
446
448
Timer
D Q
RST
426
$V_{s,422}$
$-V_{e\ offset}$
420
436
$V_{ci,424}$
418
416
414
458
14
450
Output Voltage Sensing Circuit
Switch Control Circuit

FIG. 11A

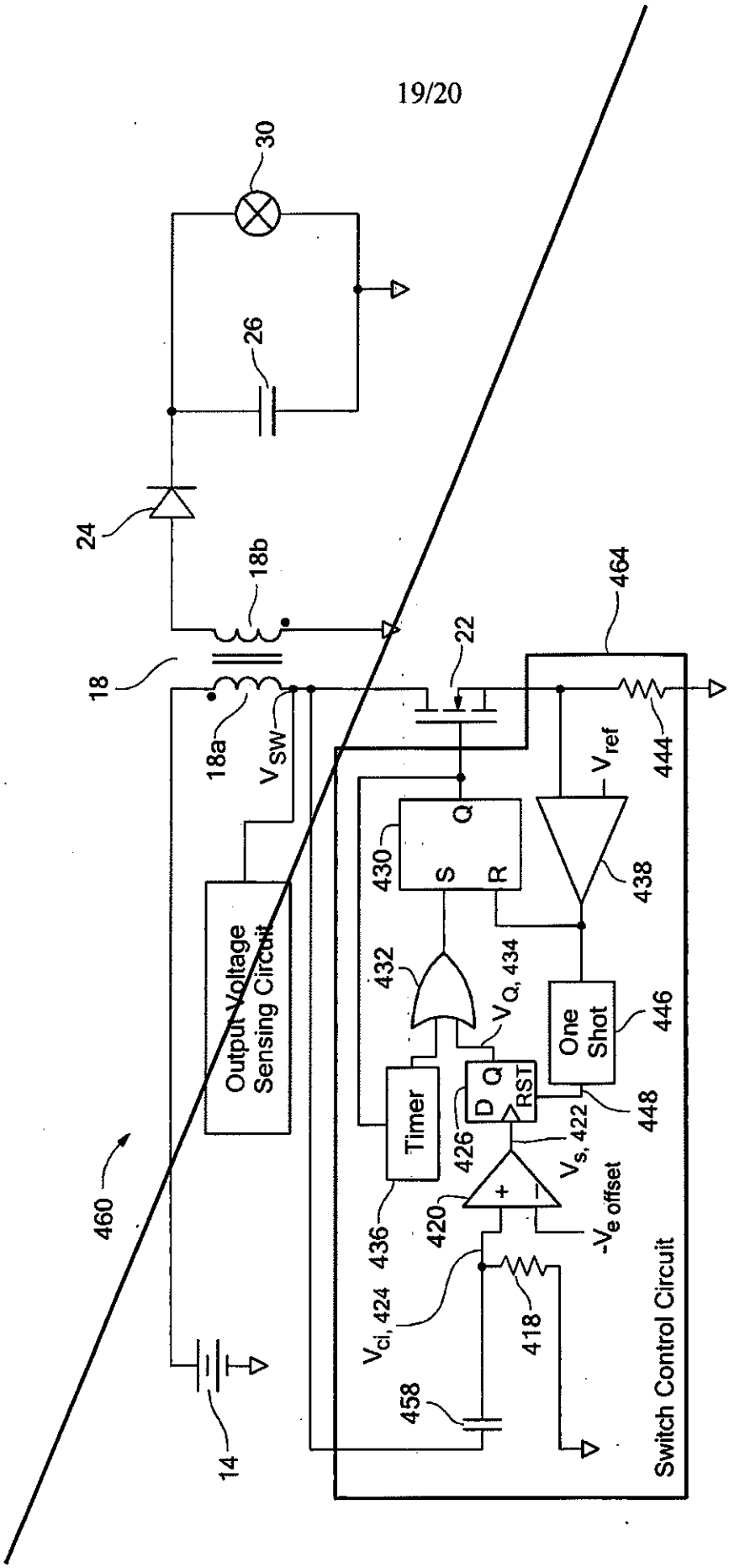

30
26
24
18b
18
18a
V_{SW}
22
464
444
V_{ref}
438
430
S
R
Q
432
$V_{Q,434}$
One Shot
446
448
D
Q
RST
426
$V_{s,422}$
$-V_{e\ offset}$
Timer
436
420
$V_{ci,424}$
418
458
14
460
Output Voltage Sensing Circuit
Switch Control Circuit

FIG. 11B

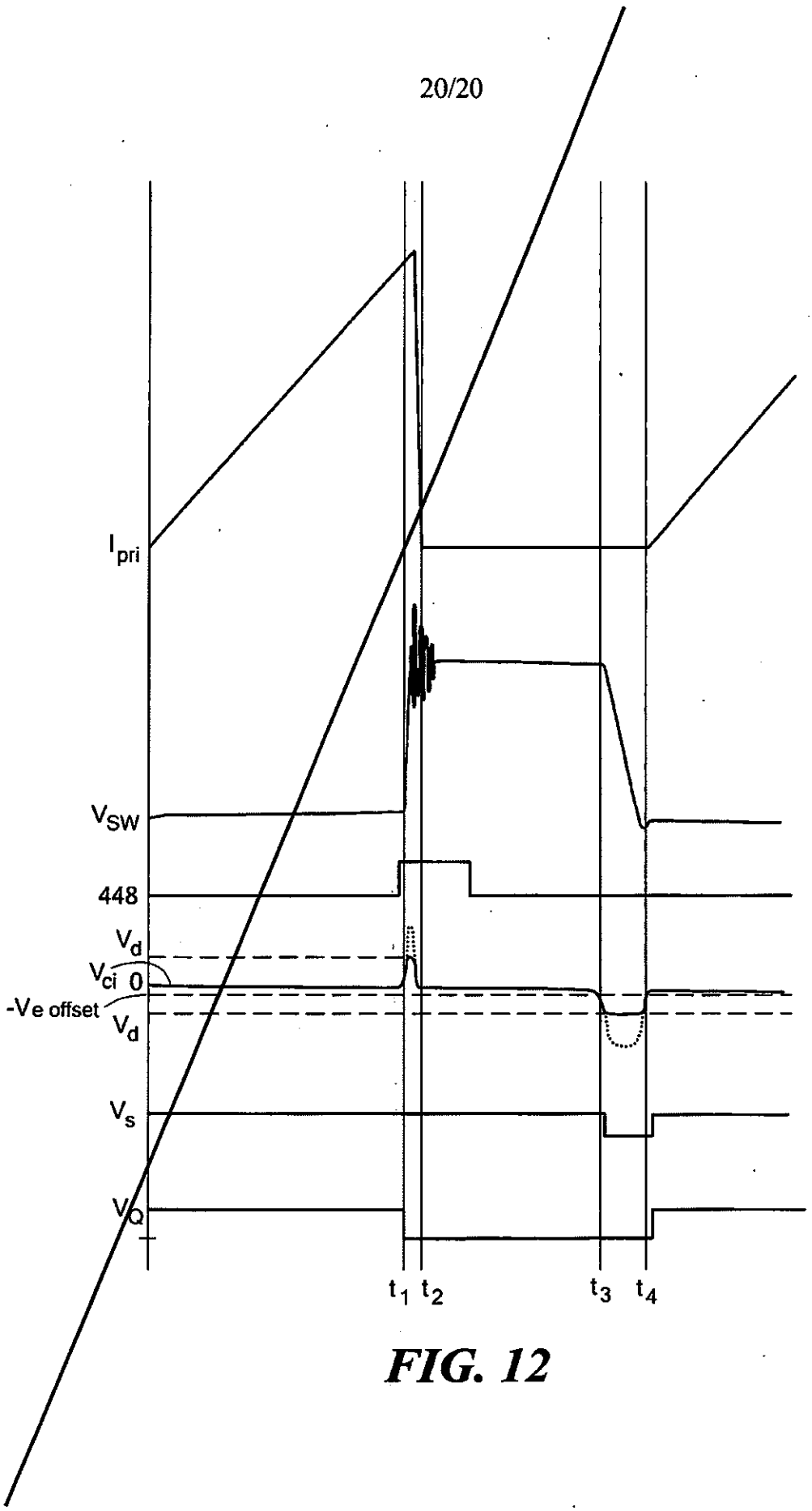


FIG. 12

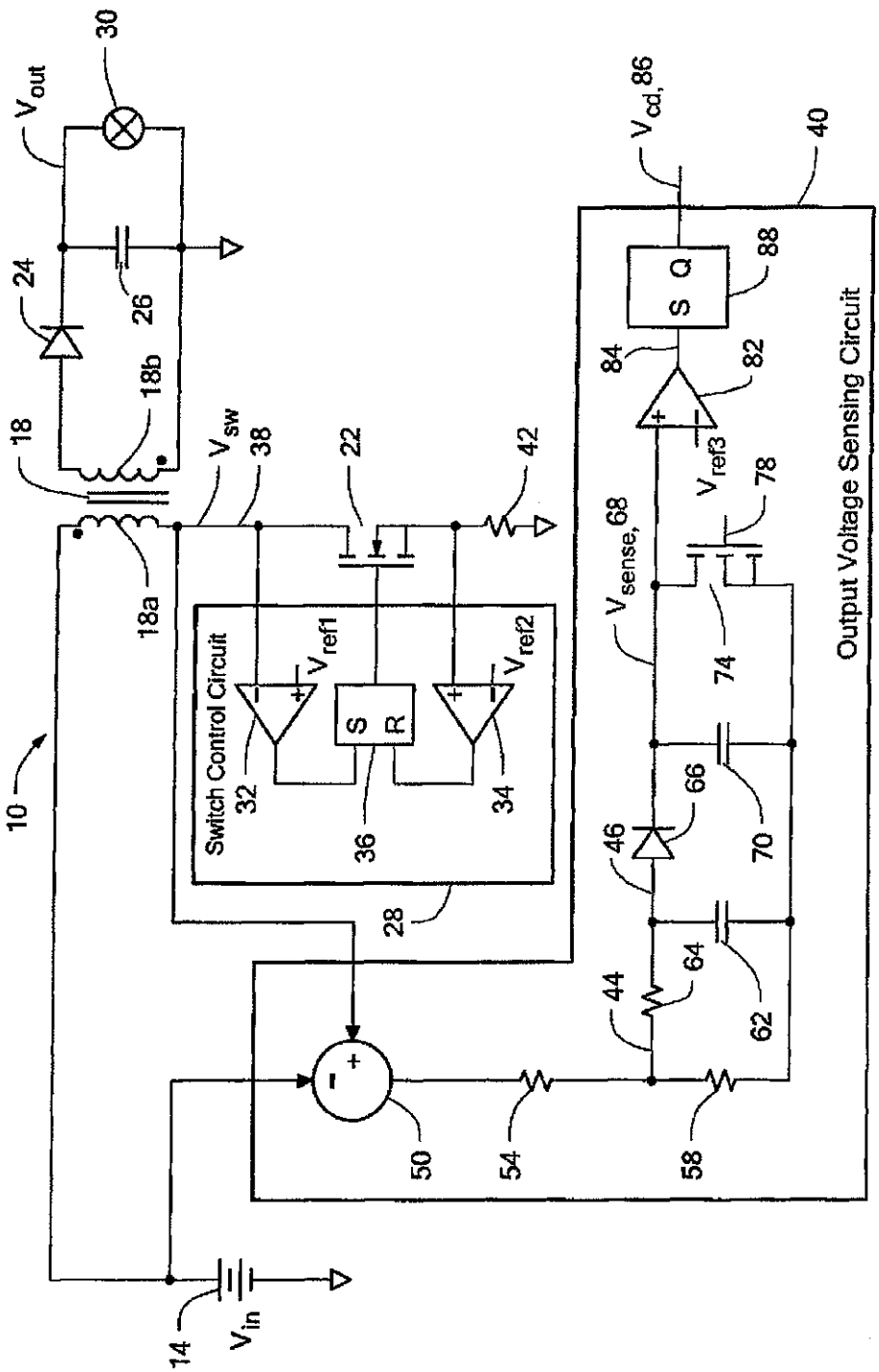

10
14
V_{in}
18
18a
18b
22
24
26
28
30
V_{out}
32
34
36
38
V_{sw}
40
42
44
46
50
54
58
62
64
66
68
V_{sense}
70
74
78
82
84
86
V_{cd}
88
V_{ref1}
V_{ref2}
V_{ref3}
Switch Control Circuit
Output Voltage Sensing Circuit
S
R
Q

FIG. 1

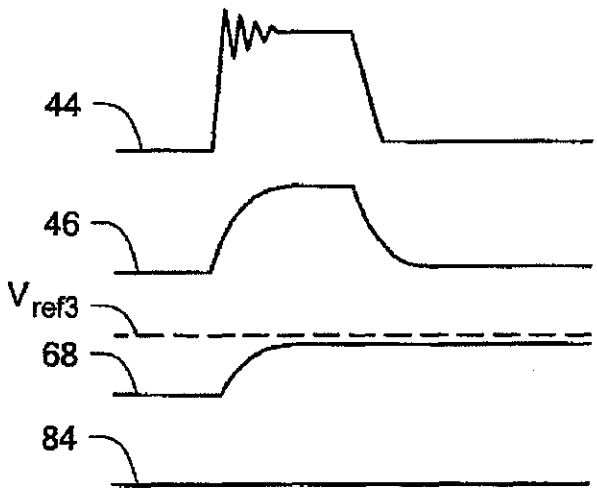


FIG. 1A

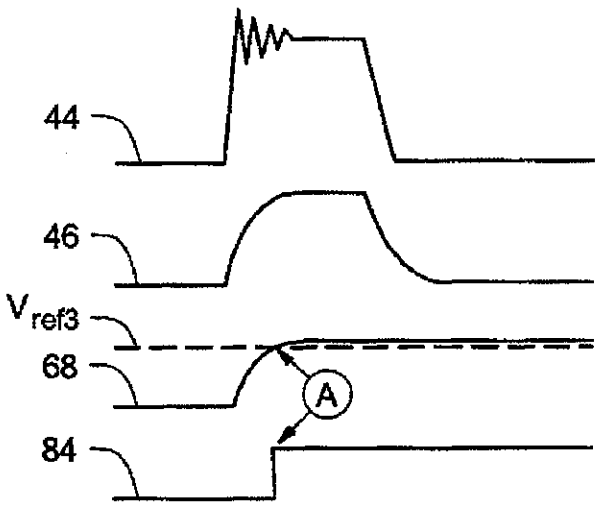


FIG. 1B

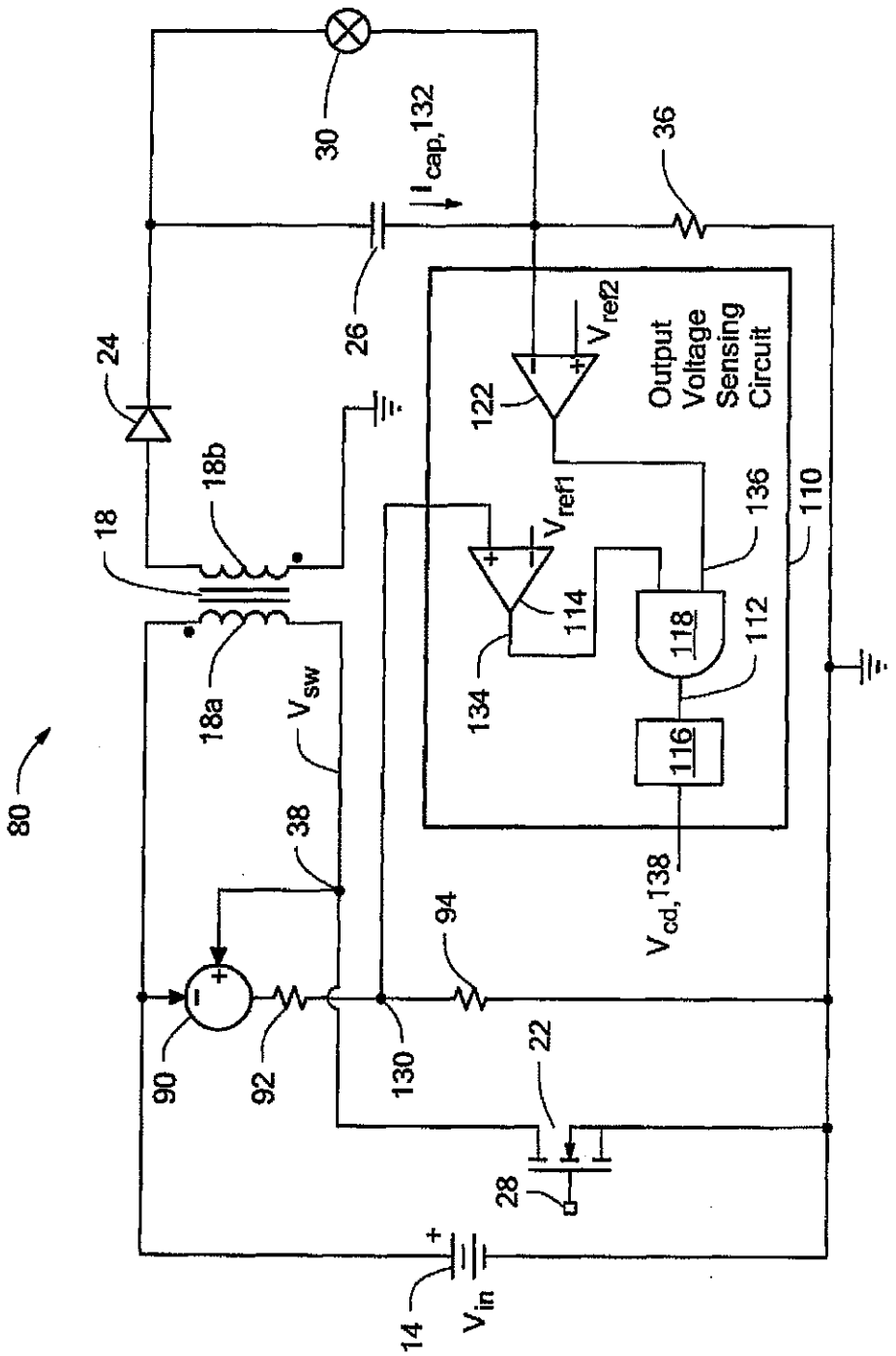

80
14
V_{in}
28
22
130
90
92
94
38
V_{sw}
18a
18
18b
24
30
I_{cap}, 132
26
36
V_{ref2}
122
V_{ref1}
114
134
Output Voltage Sensing Circuit
110
136
118
112
116
V_{cd}, 138

FIG. 2

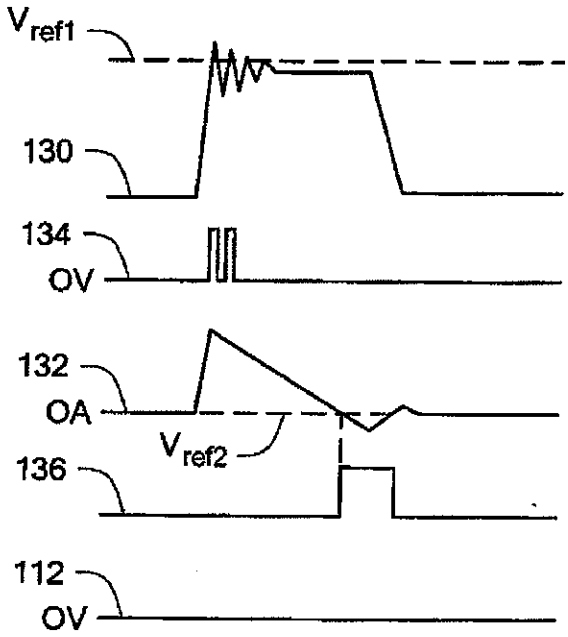

V_{ref1}
130
134
OV
132
OA
V_{ref2}
136
112
OV

FIG. 2A

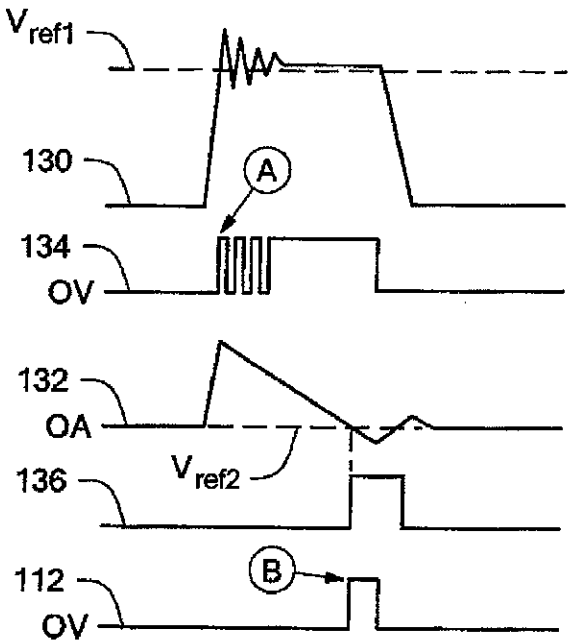

V_{ref1}
130
A
134
OV
132
OA
V_{ref2}
136
B
112
OV

FIG. 2B

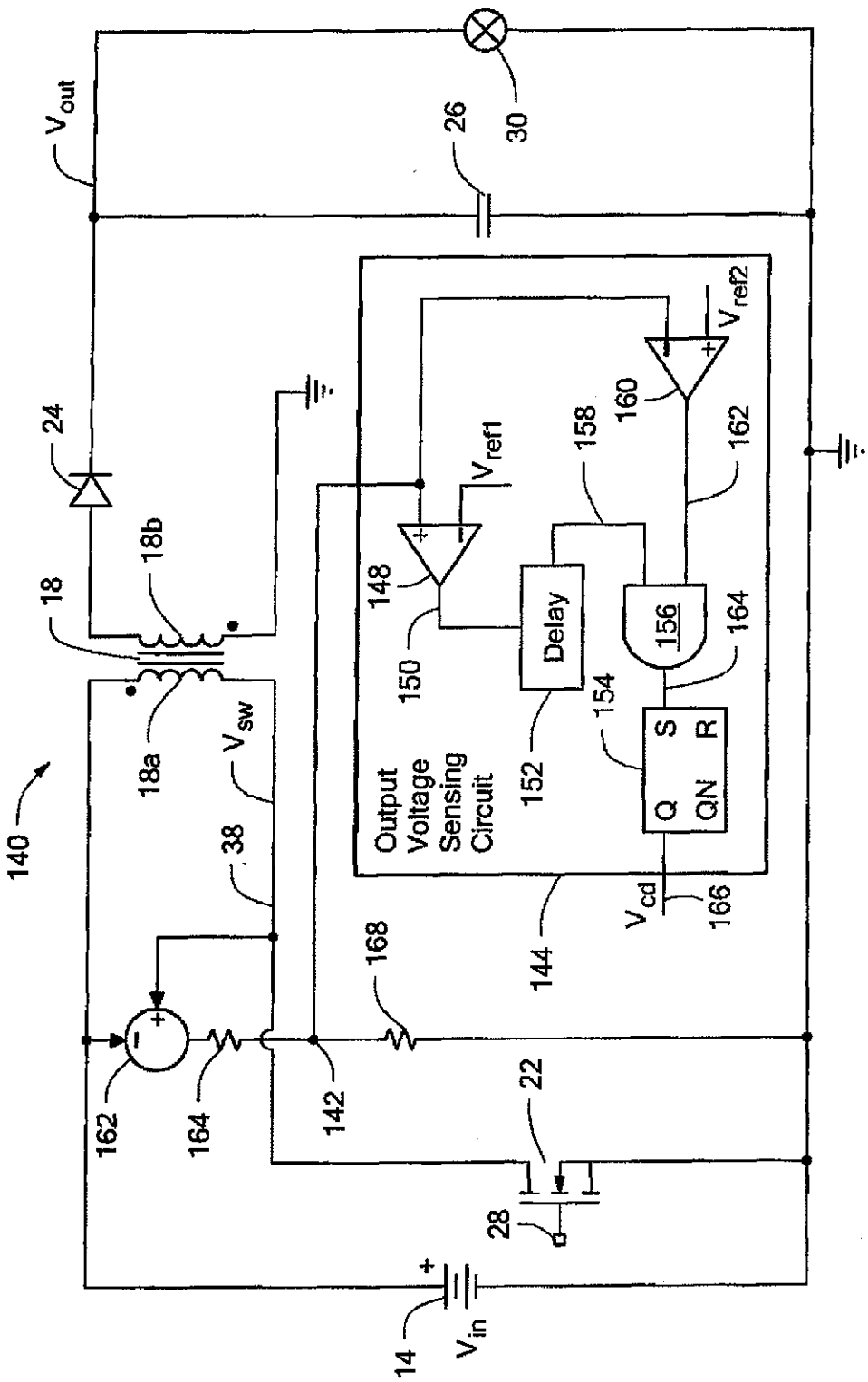

V_{out}
26
30
24
18
18b
18a
V_{sw}
38
140
V_{ref1}
V_{ref2}
148
150
158
160
162
Delay
156
164
154
152
S
R
Q
QN
Output Voltage Sensing Circuit
V_{cd}
166
144
168
142
162
164
22
28
14
V_{in}

FIG. 3

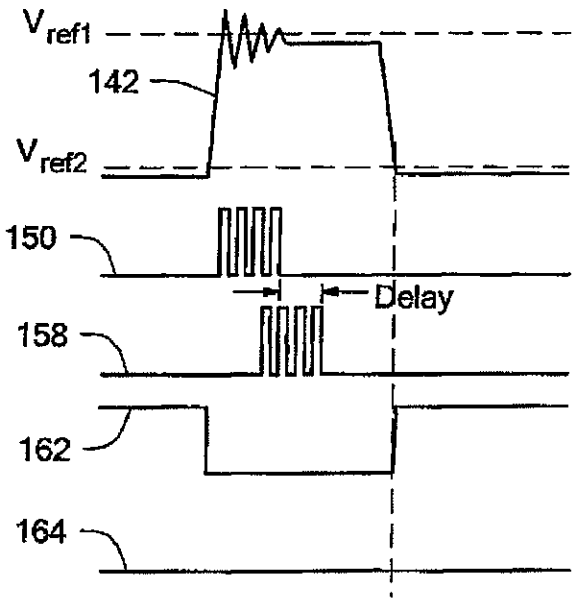

V_{ref1}
142
V_{ref2}
150
Delay
158
162
164

FIG. 3A

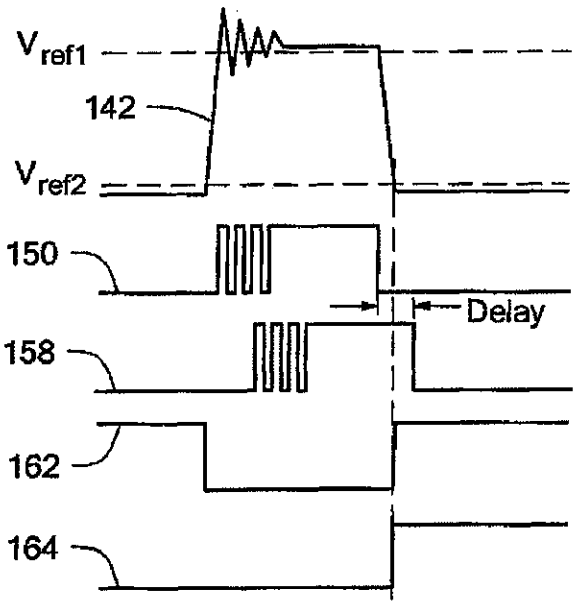

V_{ref1}
142
V_{ref2}
150
Delay
158
162
164

FIG. 3B

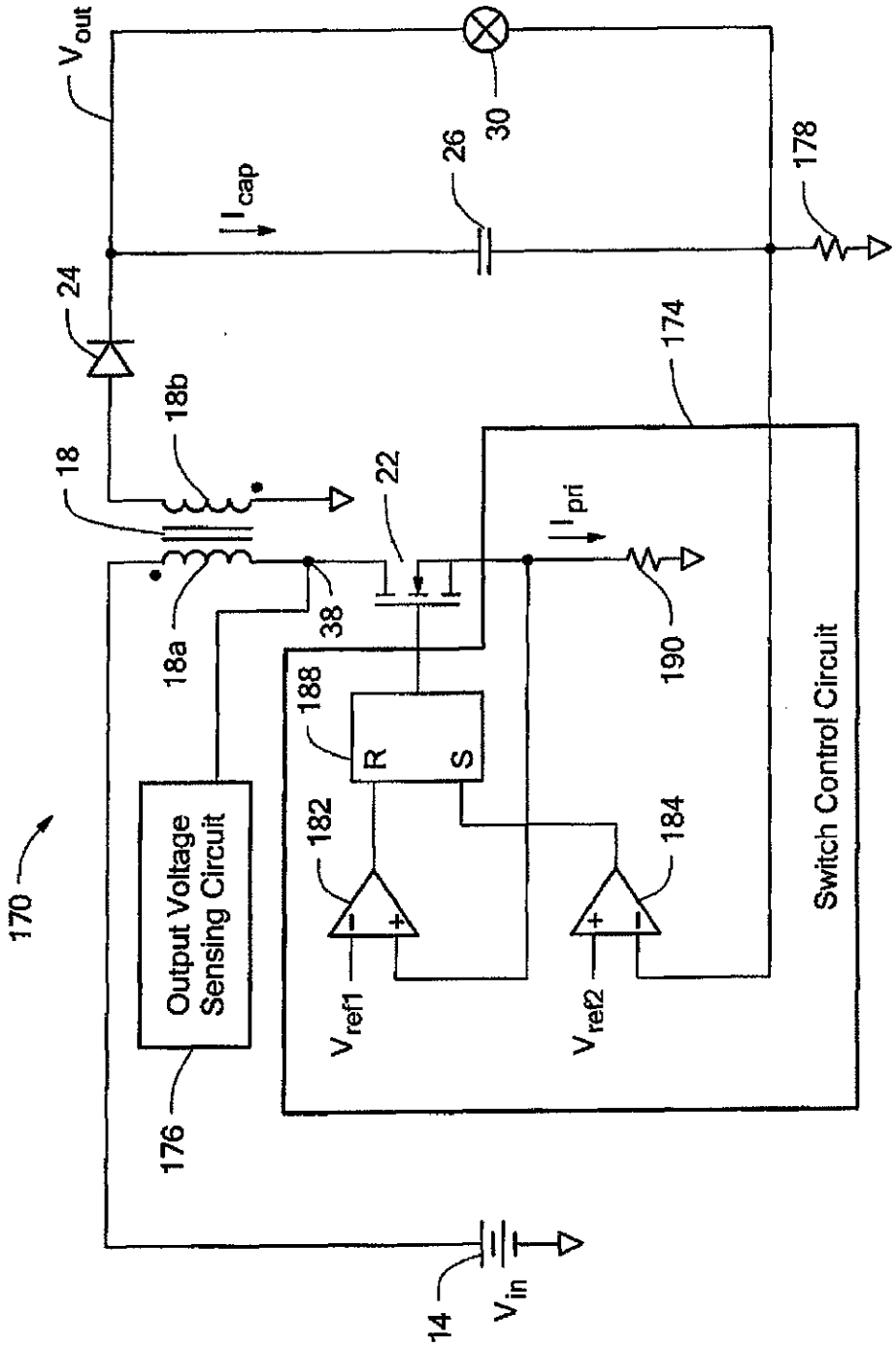

V_{out}
30
26
178
I_{cap}
24
174
18b
18
22
I_{pri}
18a
38
190
188
R
S
182
184
Output Voltage Sensing Circuit
Switch Control Circuit
170
176
V_{ref1}
V_{ref2}
14
V_{in}

FIG. 4

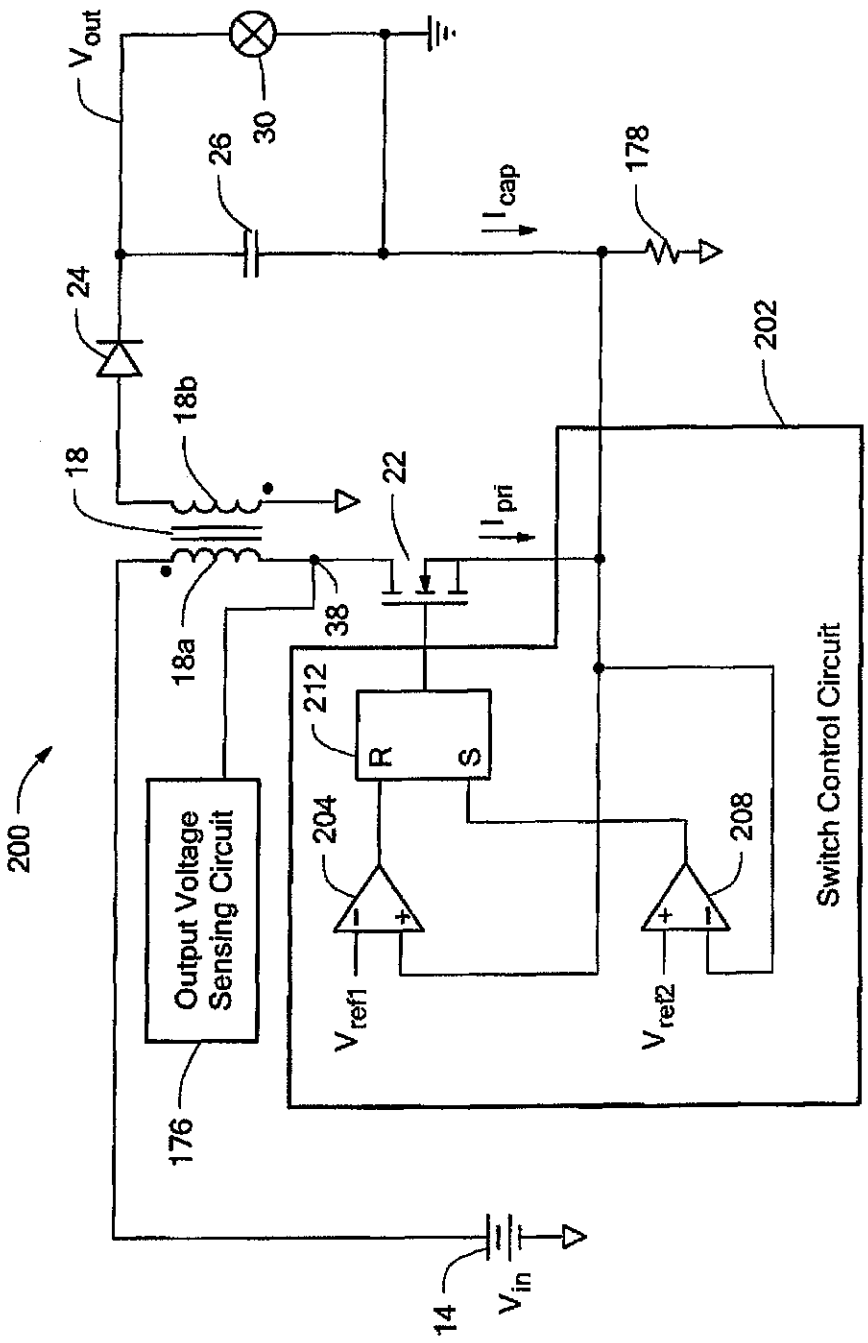

V_{out}
30
26
I_{cap}
178
24
202
18b
18
22
I_{pri}
18a
38
212
R
S
200
Output Voltage Sensing Circuit
204
208
Switch Control Circuit
V_{ref1}
V_{ref2}
176
14
V_{in}

FIG. 5

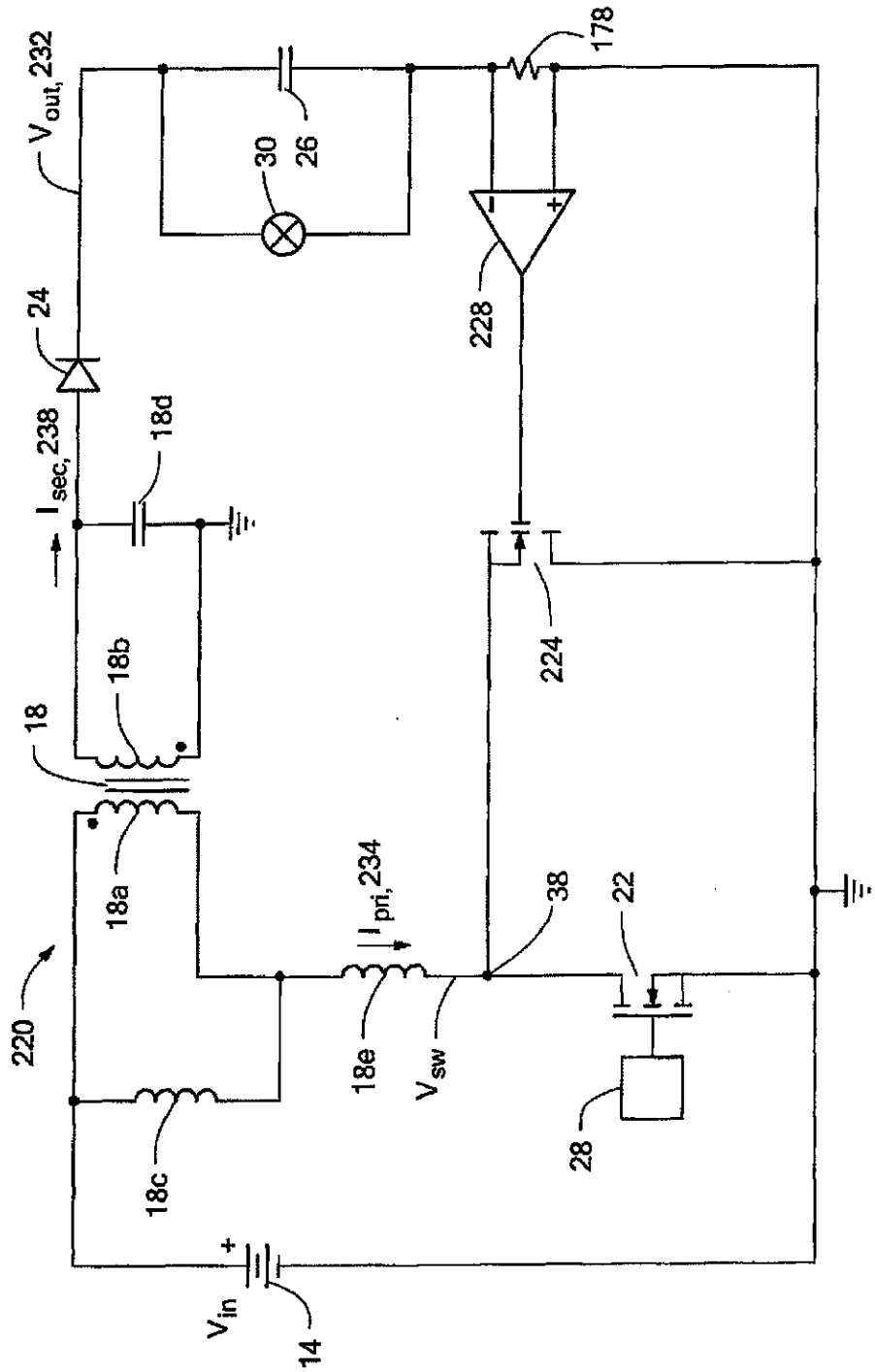

V_{out}, 232
178
30
26
24
228
I_{sec}, 238
18d
18b
18
224
18a
I_{pri}, 234
38
22
220
18e
V_{sw}
28
18c
V_{in}
14

FIG. 6

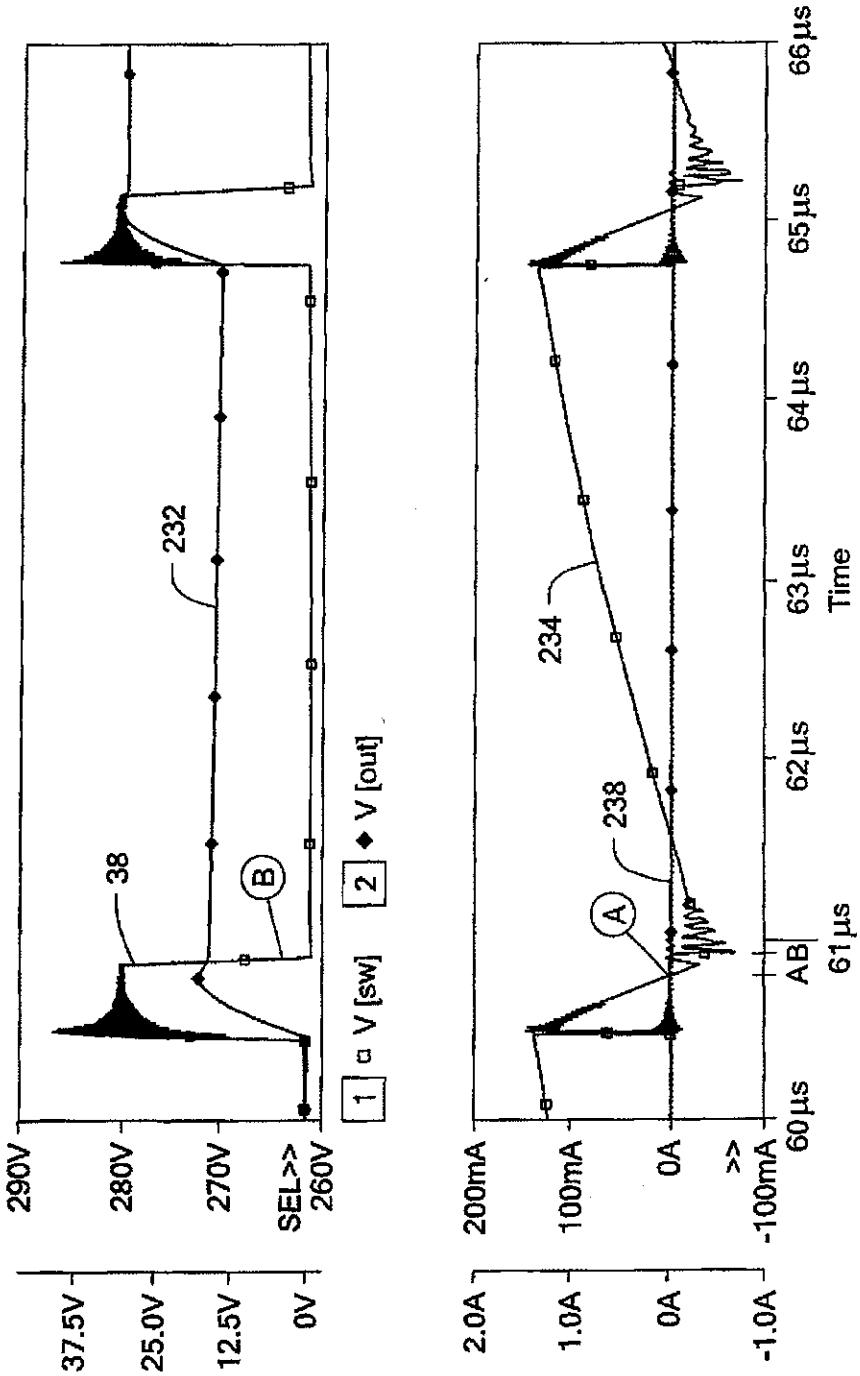

290V
280V
270V
SEL>>
260V
37.5V
25.0V
12.5V
0V
38
232
B
1 V [sw]
2 V [out]
200mA
100mA
0A
>>
-100mA
2.0A
1.0A
0A
-1.0A
234
238
A
60µs
AB
61µs
62µs
63µs
64µs
65µs
66µs
Time
1 I pri
2 I sec

FIG. 6A

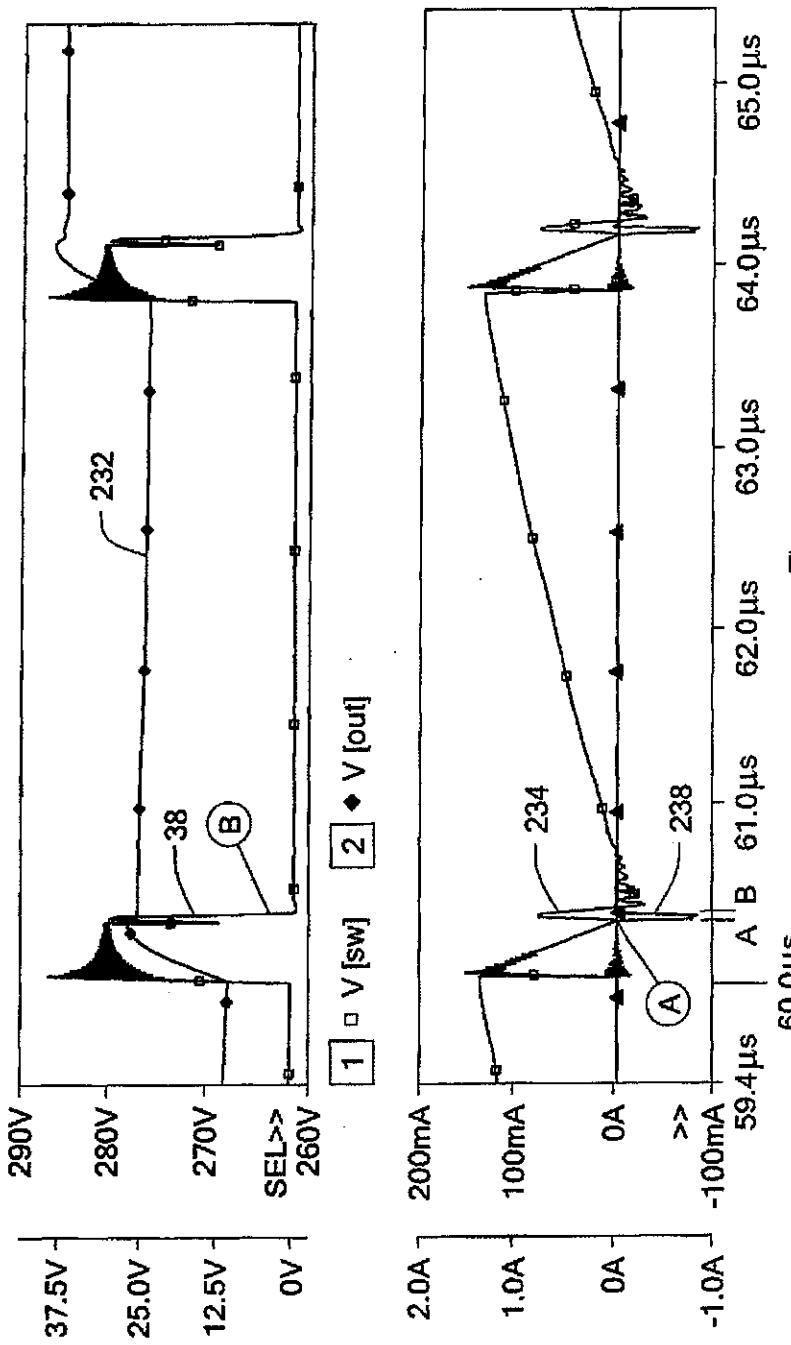

290V
280V
270V
SEL>>
260V
37.5V
25.0V
12.5V
0V
232
38
B
1 □ V [sw]
2 ◆ V [out]
200mA
100mA
0A
>>
-100mA
2.0A
1.0A
0A
-1.0A
234
238
A
59.4µs
60.0µs
A B
61.0µs
62.0µs
63.0µs
64.0µs
65.0µs
Time
1 □ I pri
2 ▲ I sec

FIG. 6B

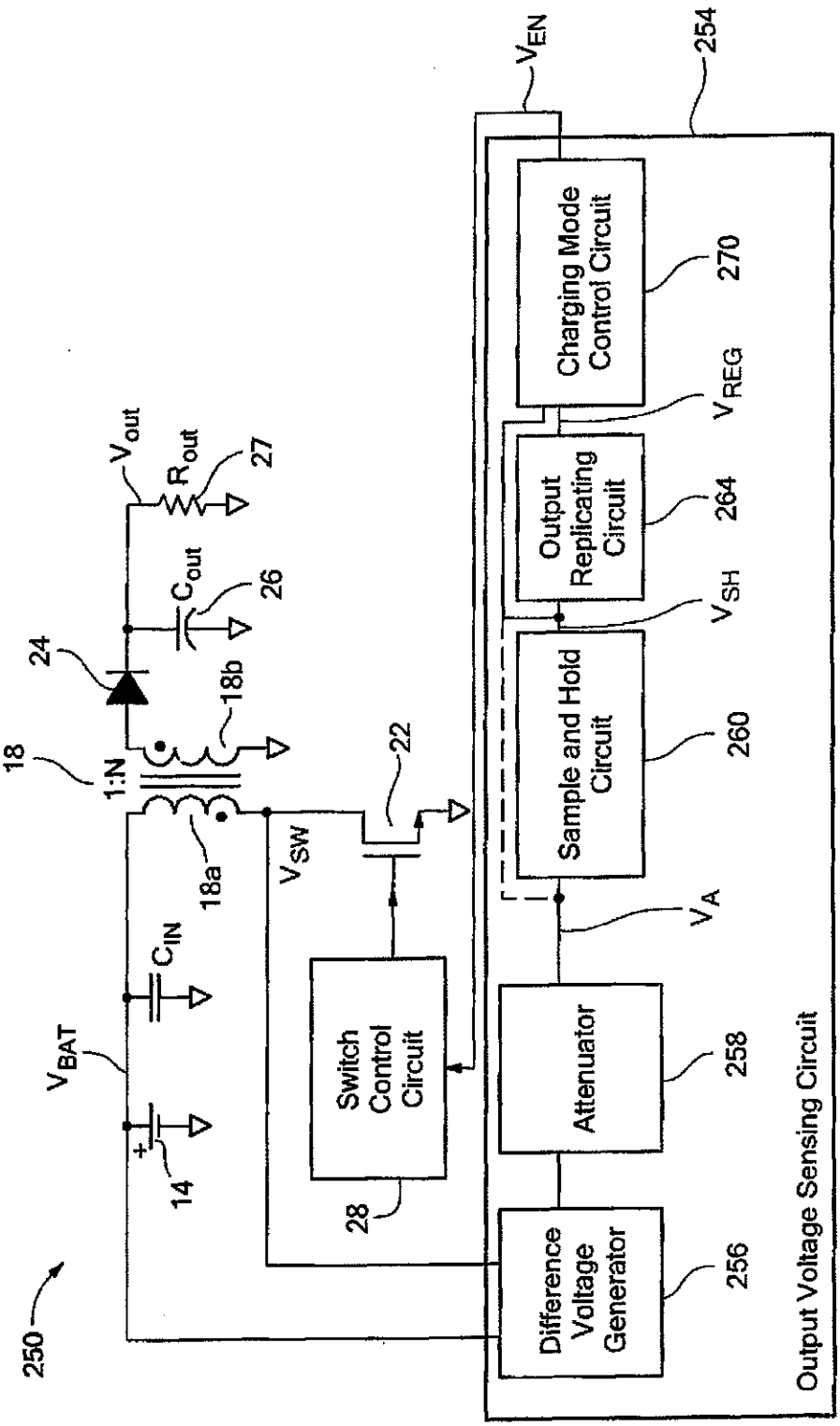

250
V_{BAT}
14
C_{IN}
18
1:N
18a
18b
24
V_{out}
R_{out}
27
C_{out}
26
V_{SW}
22
Switch Control Circuit
28
V_{EN}
254
Charging Mode Control Circuit
270
V_{REG}
Output Replicating Circuit
264
V_{SH}
Sample and Hold Circuit
260
V_A
Attenuator
258
Difference Voltage Generator
256
Output Voltage Sensing Circuit

FIG. 7

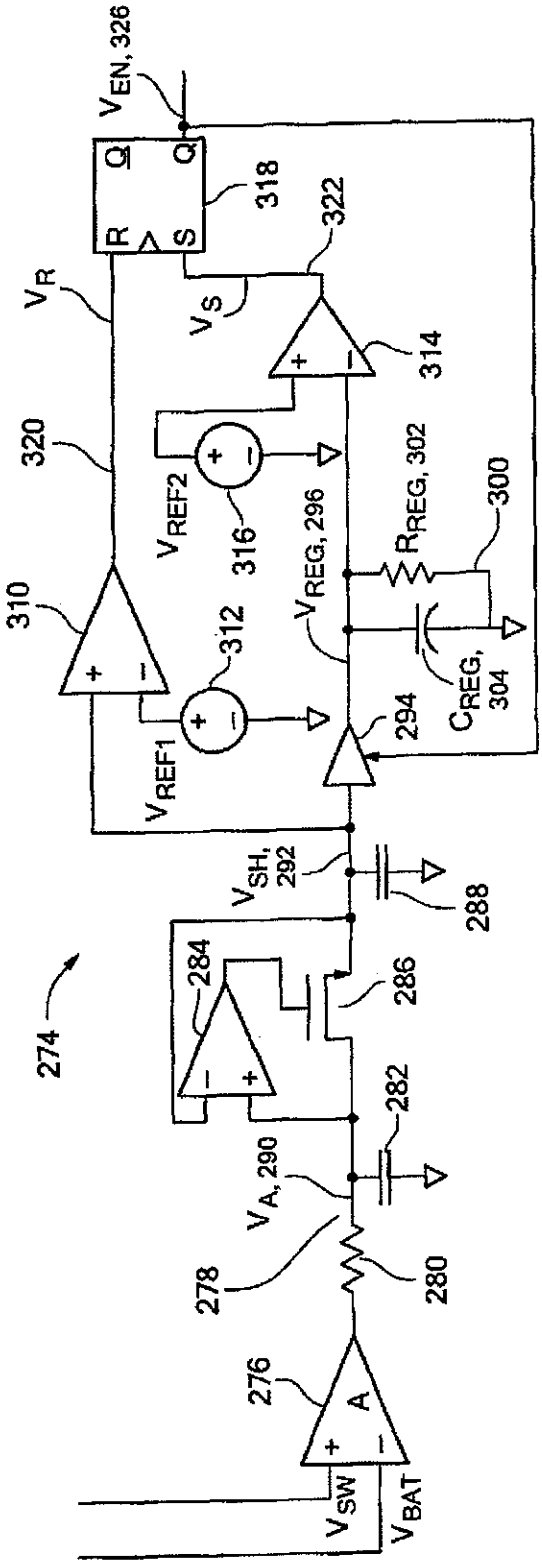

$V_{EN, 326}$
Q
$\overline{Q}$
R
S
318
322
V_R
V_S
314
320
V_{REF2}
316
$V_{REG, 296}$
$R_{REG, 302}$
300
310
312
V_{REF1}
294
$C_{REG, 304}$
$V_{SH, 292}$
288
274
284
286
282
$V_{A, 290}$
278
280
276
A
V_{SW}
V_{BAT}

FIG. 8

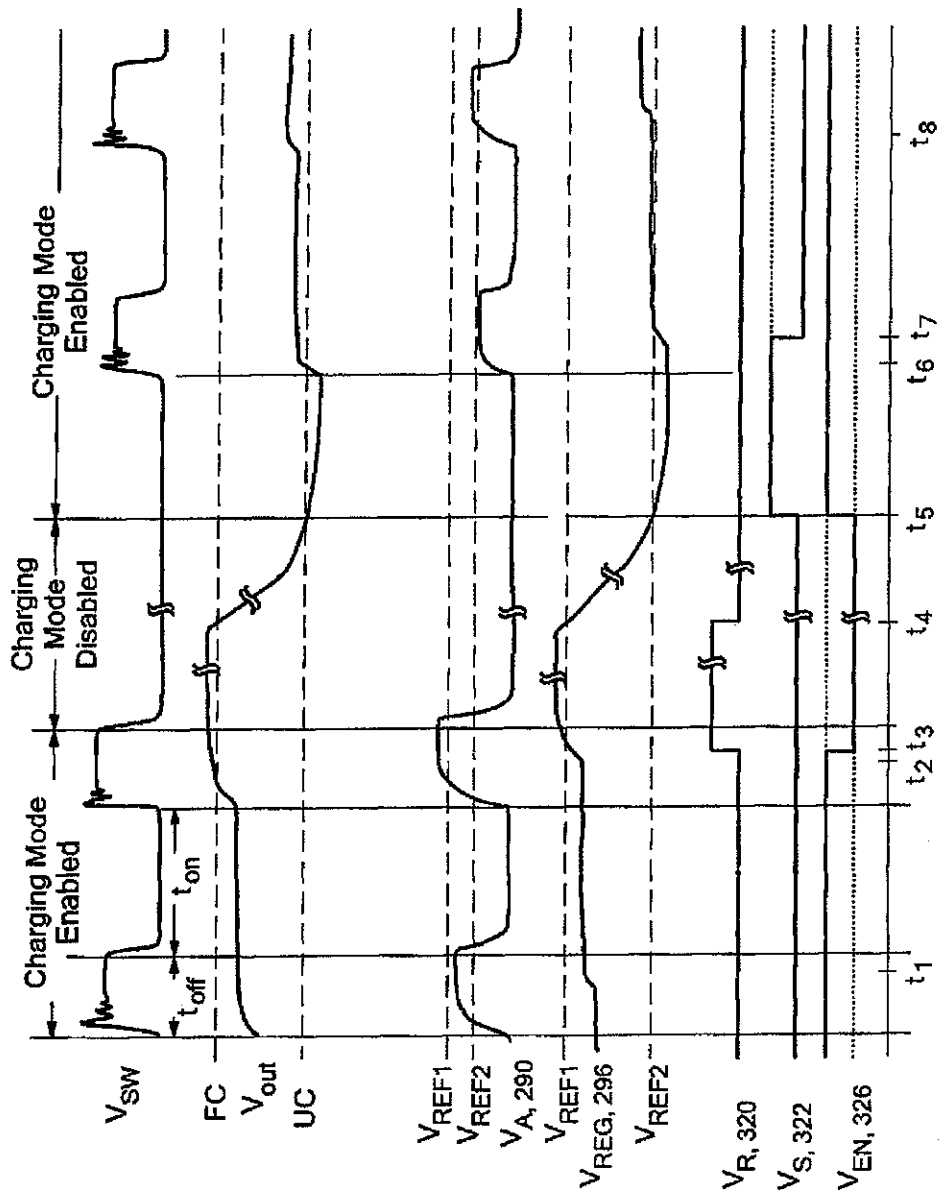

Charging Mode Enabled
Charging Mode Disabled
Charging Mode Enabled
t_{on}
t_{off}
V_{SW}
FC
V_{out}
UC
V_{REF1}
V_{REF2}
$V_{A,\ 290}$
V_{REF1}
$V_{REG,\ 296}$
V_{REF2}
$V_{R,\ 320}$
$V_{S,\ 322}$
$V_{EN,\ 326}$
t_1
t_2 t_3
t_4
t_5
t_6 t_7
t_8

FIG. 9

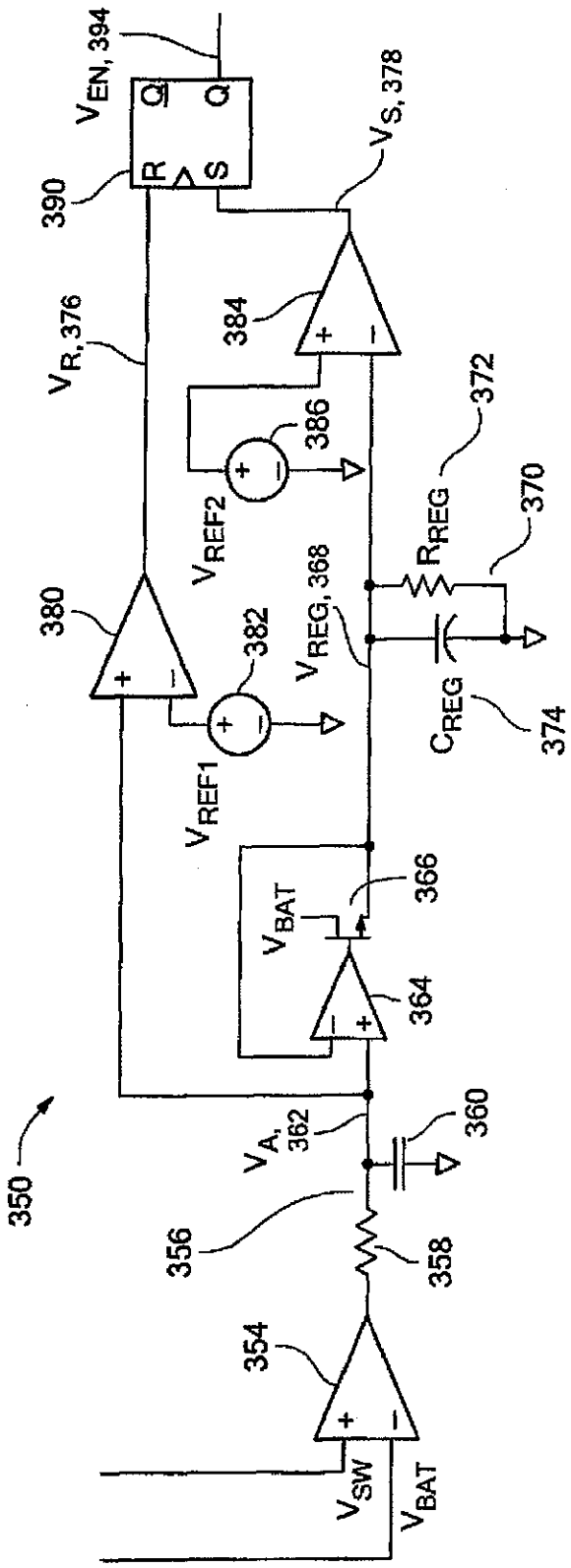

V_{EN}, 394
Q
Q
R
S
390
V_{S}, 378
V_{R}, 376
384
386
V_{REF2}
372
R_{REG}
370
380
382
V_{REG}, 368
V_{REF1}
C_{REG}
374
V_{BAT}
366
364
350
V_{A}, 362
360
356
358
354
V_{SW}
V_{BAT}

FIG. 10

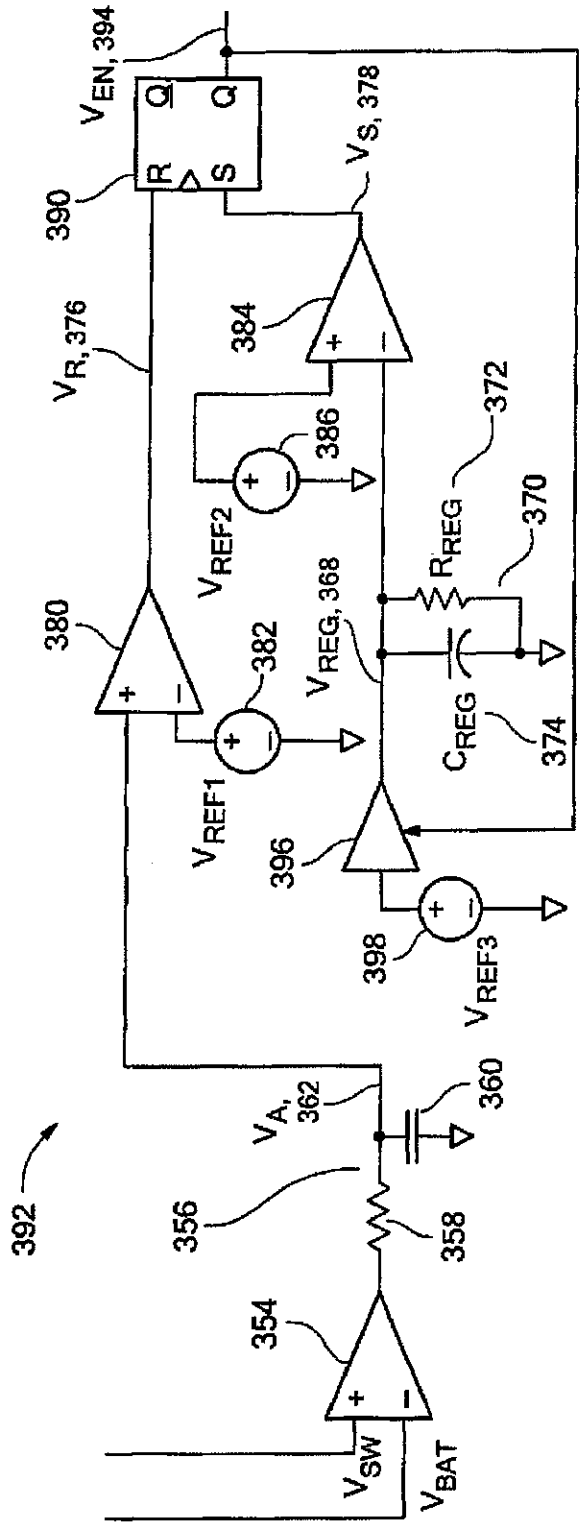

392
V_{EN}, 394
Q
Q
R
S
390
V_{S}, 378
V_{R}, 376
384
386
V_{REF2}
372
R_{REG}
370
380
382
V_{REG}, 368
C_{REG}
374
V_{REF1}
396
398
V_{REF3}
V_{A}, 362
360
356
358
354
V_{SW}
V_{BAT}

FIG. 10A

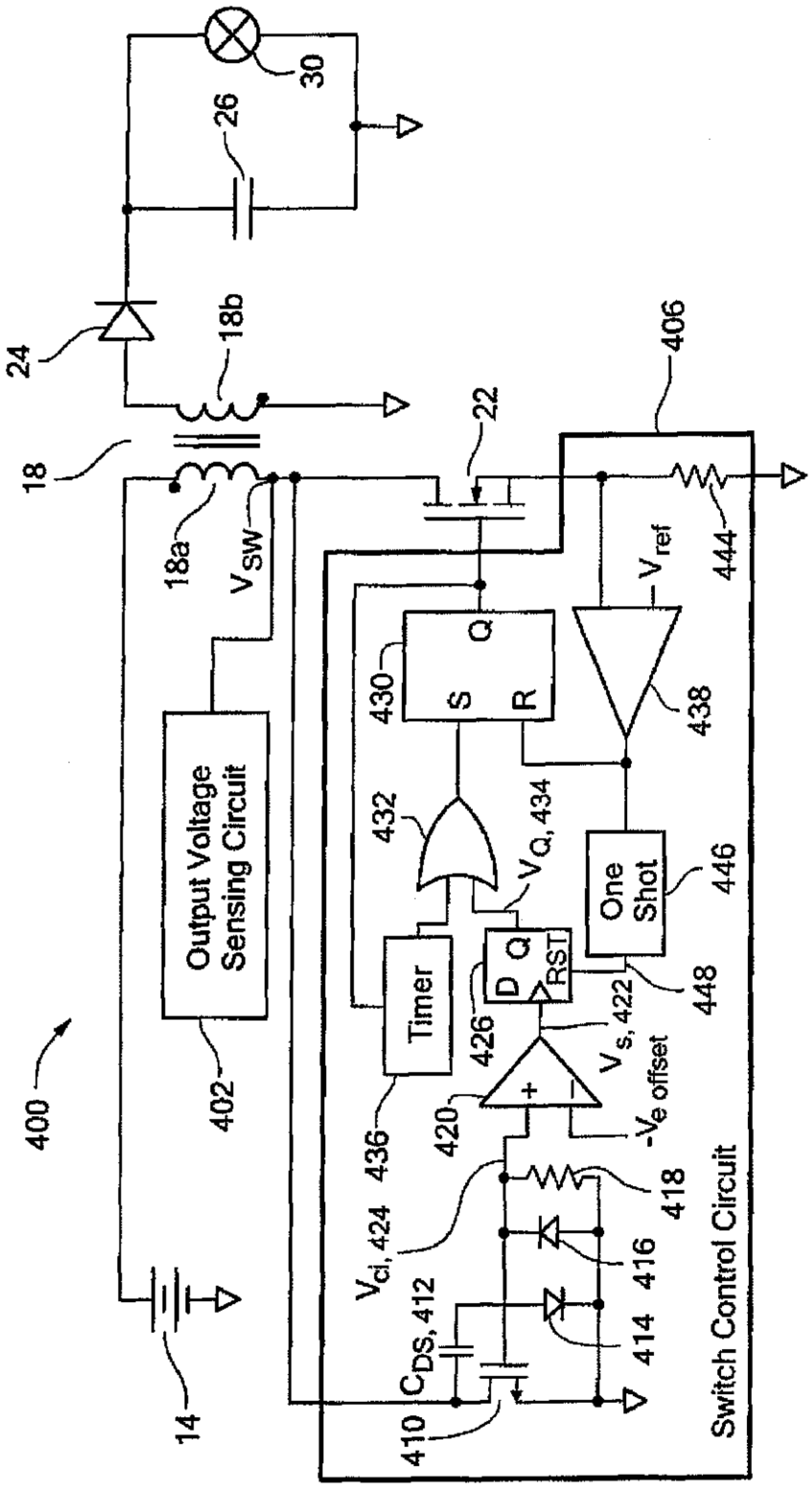

400
402
Output Voltage Sensing Circuit
Timer
Switch Control Circuit
One Shot
S
R
Q
D
RST
+
-
14
18
18a
18b
22
24
26
30
406
444
438
430
432
426
436
420
418
416
414
410
446
448
V_{SW}
V_{ref}
$V_{Q,434}$
$V_{s,422}$
$-V_{e\ offset}$
$V_{cl,424}$
$C_{DS,412}$

FIG. 11

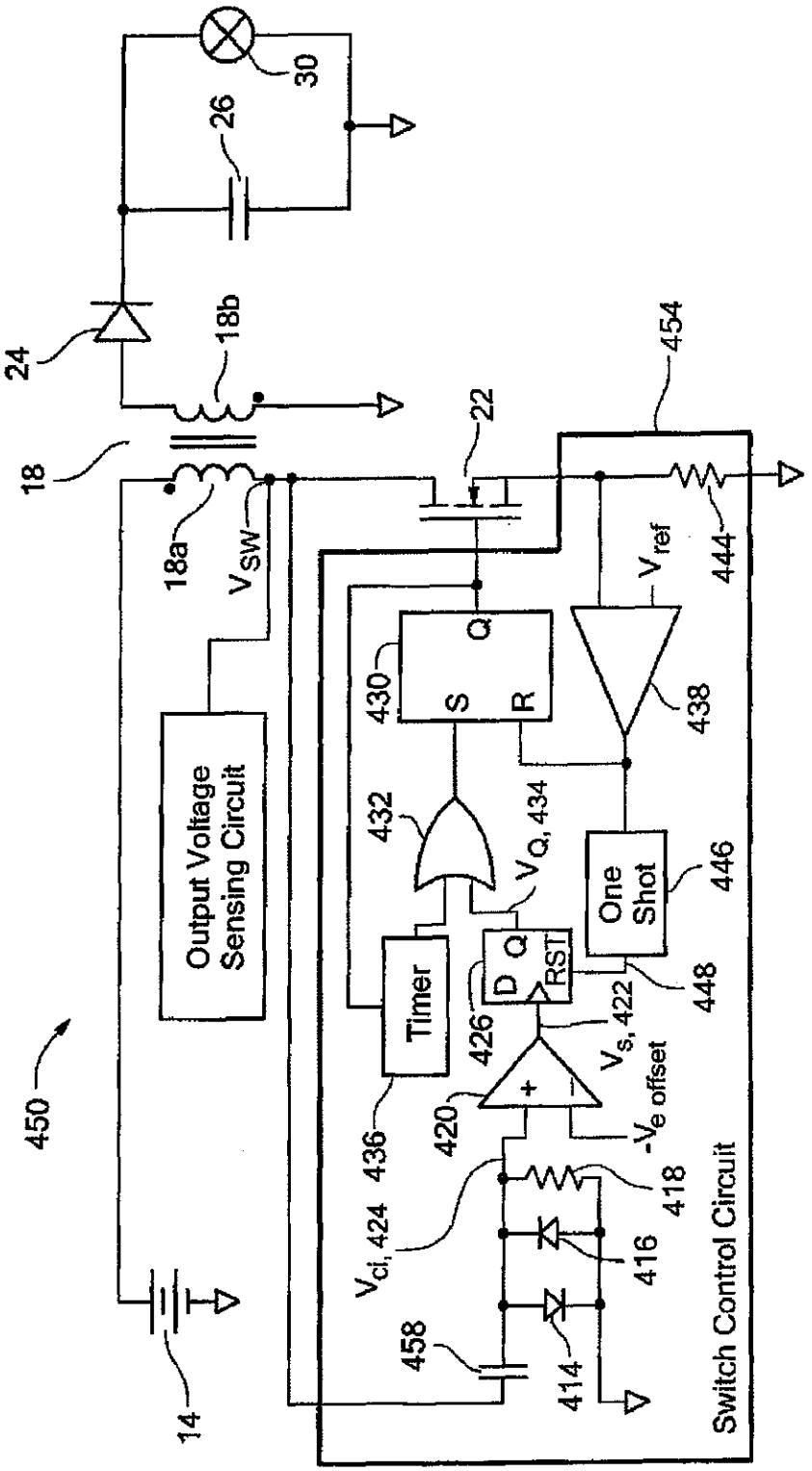

30
26
24
18b
18
18a
V_{SW}
22
454
444
V_{ref}
Output Voltage Sensing Circuit
430
Q
S
R
438
432
$V_{Q,434}$
One Shot
446
Timer
D Q
RST
448
426
$V_{s,422}$
$-V_{e\ offset}$
420
436
$V_{ci,424}$
418
416
458
414
14
450
Switch Control Circuit

FIG. 11A

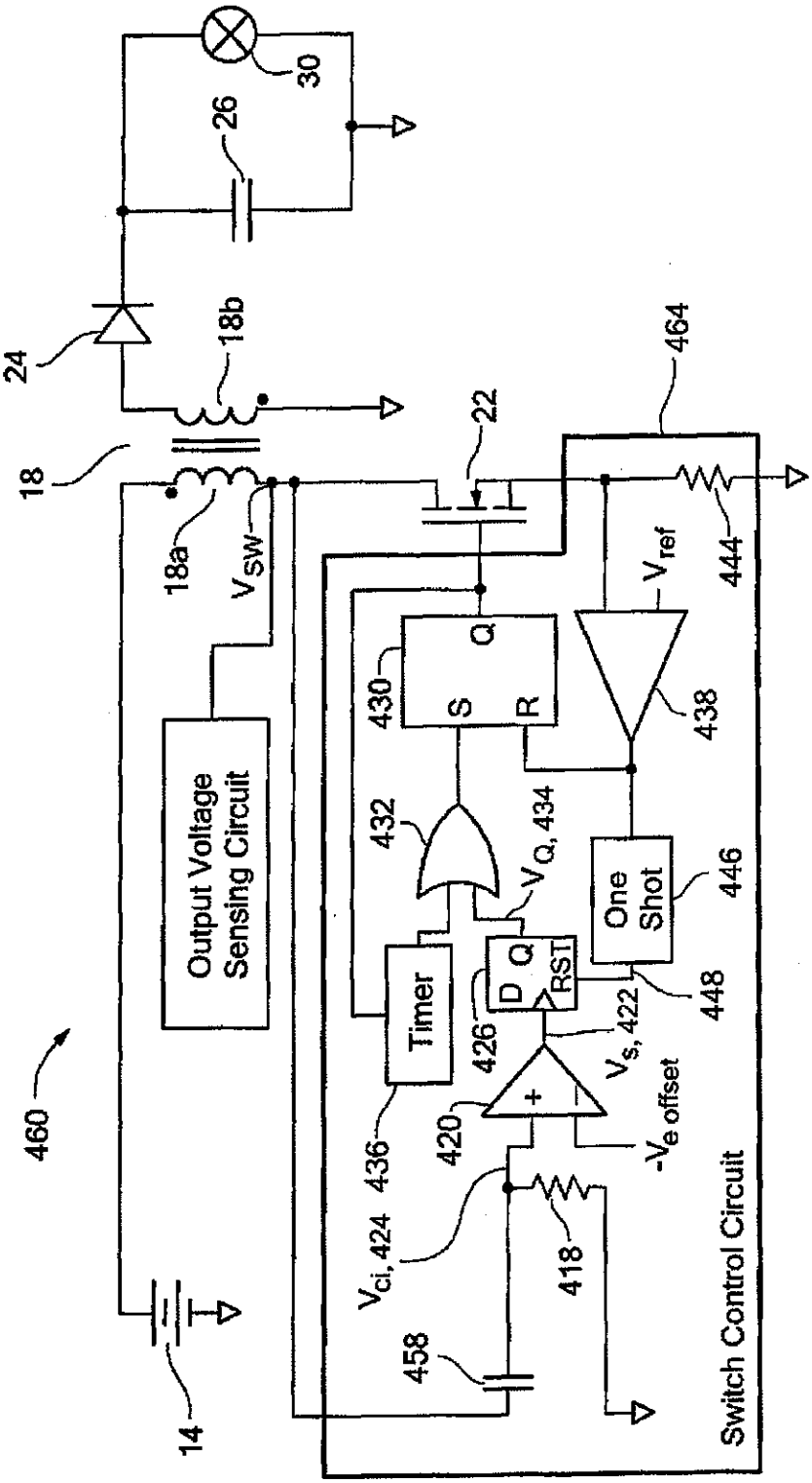

30
26
24
18b
464
18
22
18a
V_{SW}
V_{ref}
444
Output Voltage Sensing Circuit
430
Q
S
R
438
432
$V_{Q,434}$
One Shot
446
Timer
D
Q
RST
448
426
$V_{s,422}$
460
436
420
$-V_{e\ offset}$
$V_{ci,424}$
418
458
14
Switch Control Circuit

FIG. 11B

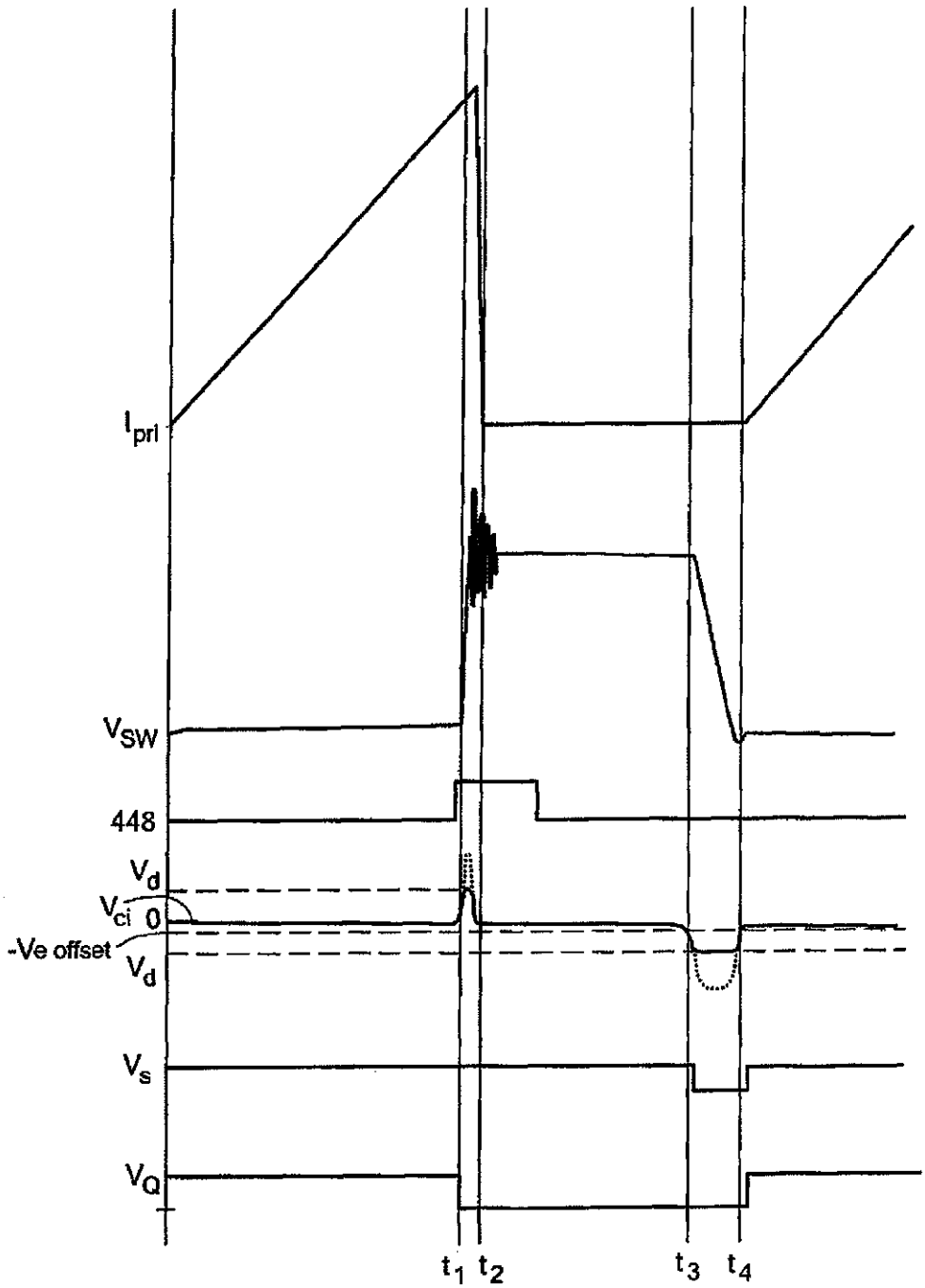


FIG. 12