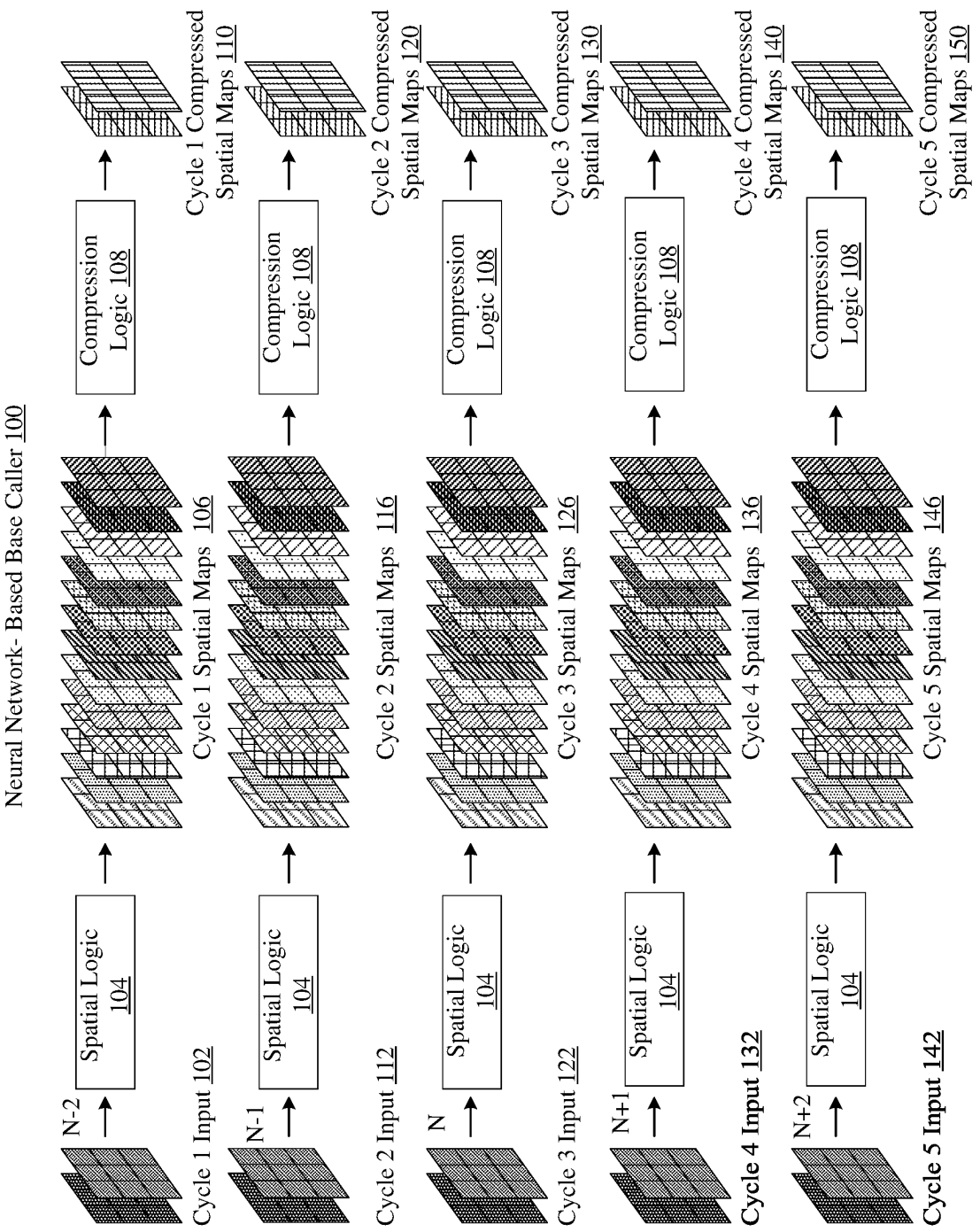
Neural Network- Based Base Caller 100
N-2
Spatial Logic 104
Cycle 1 Input 102
Cycle 1 Spatial Maps 106
Compression Logic 108
Cycle 1 Compressed Spatial Maps 110
N-1
Spatial Logic 104
Cycle 2 Input 112
Cycle 2 Spatial Maps 116
Compression Logic 108
Cycle 2 Compressed Spatial Maps 120
N
Spatial Logic 104
Cycle 3 Input 122
Cycle 3 Spatial Maps 126
Compression Logic 108
Cycle 3 Compressed Spatial Maps 130
N+1
Spatial Logic 104
Cycle 4 Input 132
Cycle 4 Spatial Maps 136
Compression Logic 108
Cycle 4 Compressed Spatial Maps 140
N+2
Spatial Logic 104
Cycle 5 Input 142
Cycle 5 Spatial Maps 146
Compression Logic 108
Cycle 5 Compressed Spatial Maps 150

Figure 1A

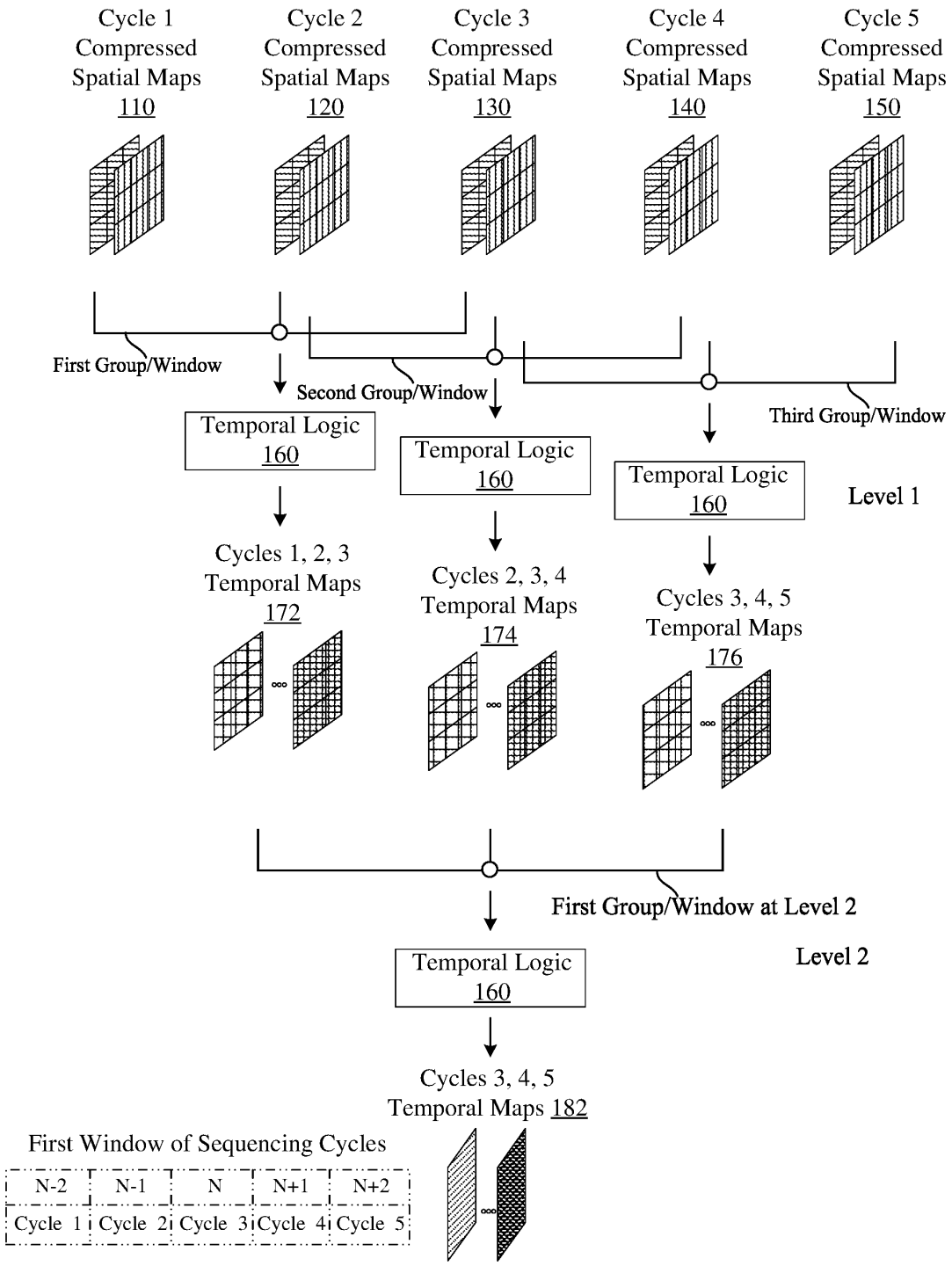
Cycle 1 Compressed Spatial Maps 110
Cycle 2 Compressed Spatial Maps 120
Cycle 3 Compressed Spatial Maps 130
Cycle 4 Compressed Spatial Maps 140
Cycle 5 Compressed Spatial Maps 150
First Group/Window
Second Group/Window
Third Group/Window
Temporal Logic 160
Temporal Logic 160
Temporal Logic 160
Level 1
Cycles 1, 2, 3 Temporal Maps 172
Cycles 2, 3, 4 Temporal Maps 174
Cycles 3, 4, 5 Temporal Maps 176
First Group/Window at Level 2
Level 2
Temporal Logic 160
Cycles 3, 4, 5 Temporal Maps 182
First Window of Sequencing Cycles
N-2
N-1
N
N+1
N+2
Cycle 1
Cycle 2
Cycle 3
Cycle 4
Cycle 5

Figure 1B

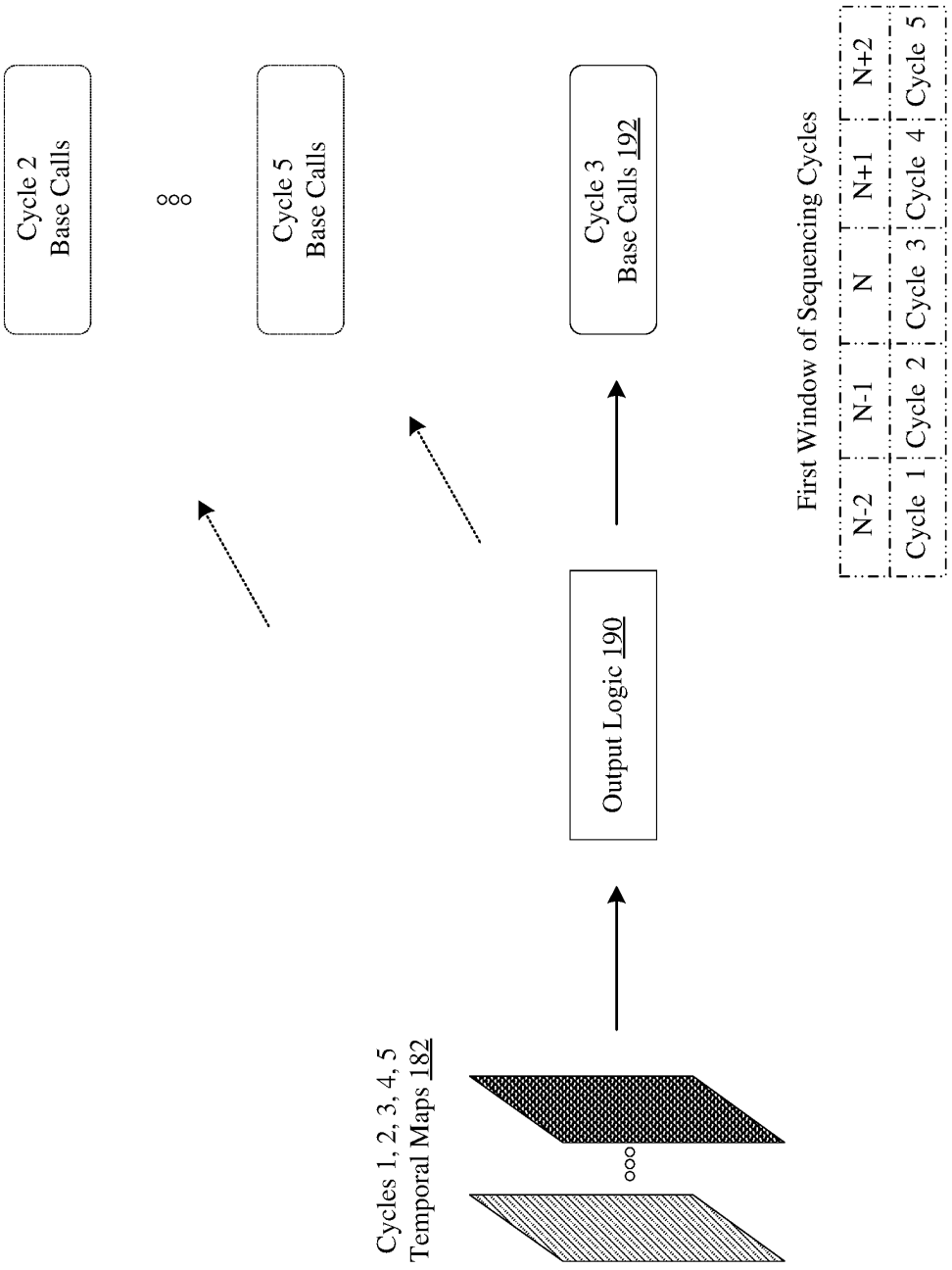
Cycles 1, 2, 3, 4, 5
Temporal Maps 182
Output Logic 190
Cycle 3
Base Calls 192
Cycle 2
Base Calls
Cycle 5
Base Calls
First Window of Sequencing Cycles
N-2
N-1
N
N+1
N+2
Cycle 1
Cycle 2
Cycle 3
Cycle 4
Cycle 5

Figure 1C

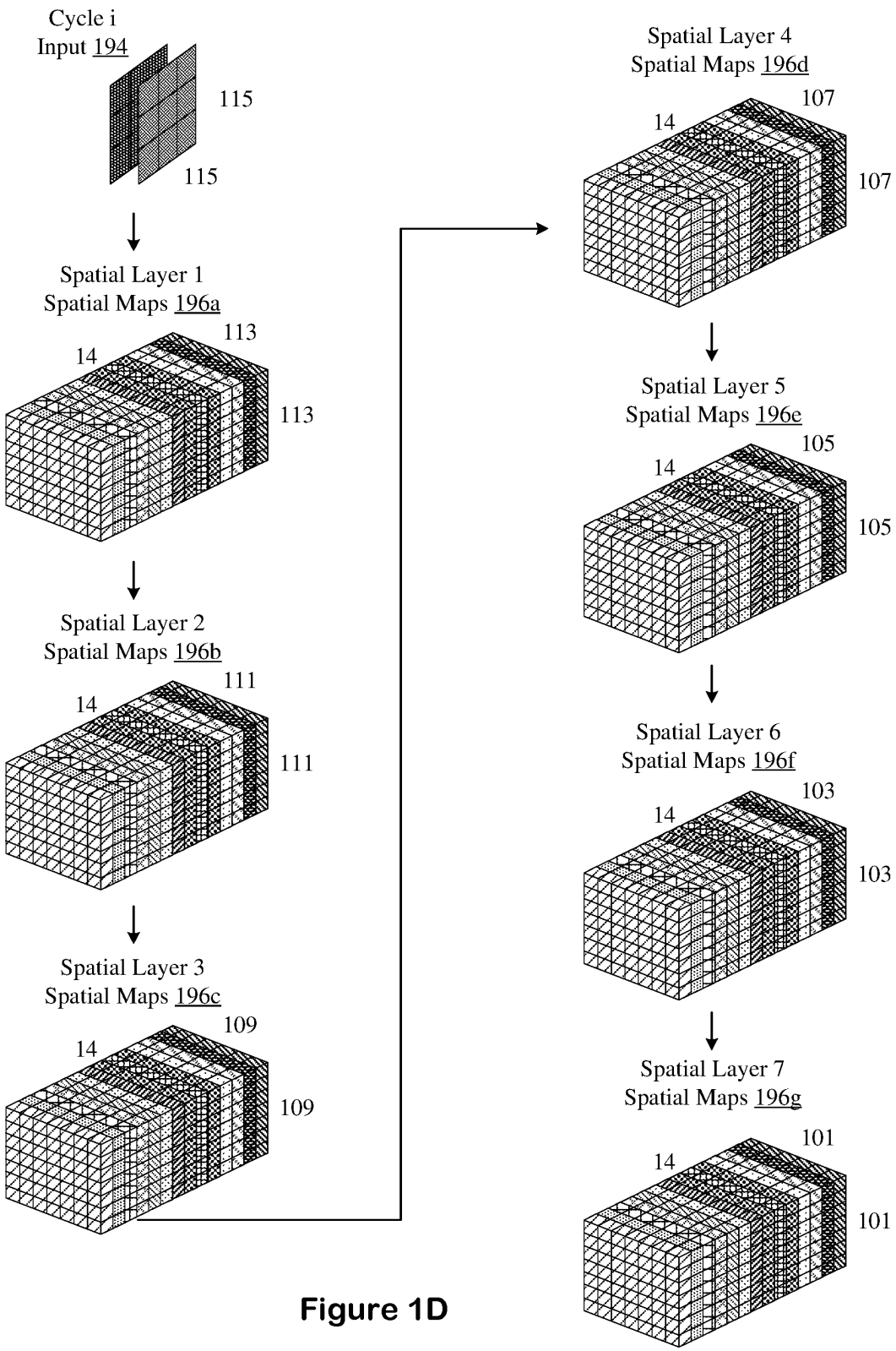
Cycle i
Input 194
115
115
Spatial Layer 1
Spatial Maps 196a
14
113
113
Spatial Layer 2
Spatial Maps 196b
14
111
111
Spatial Layer 3
Spatial Maps 196c
14
109
109
Spatial Layer 4
Spatial Maps 196d
14
107
107
Spatial Layer 5
Spatial Maps 196e
14
105
105
Spatial Layer 6
Spatial Maps 196f
14
103
103
Spatial Layer 7
Spatial Maps 196g
14
101
101

Figure 1D

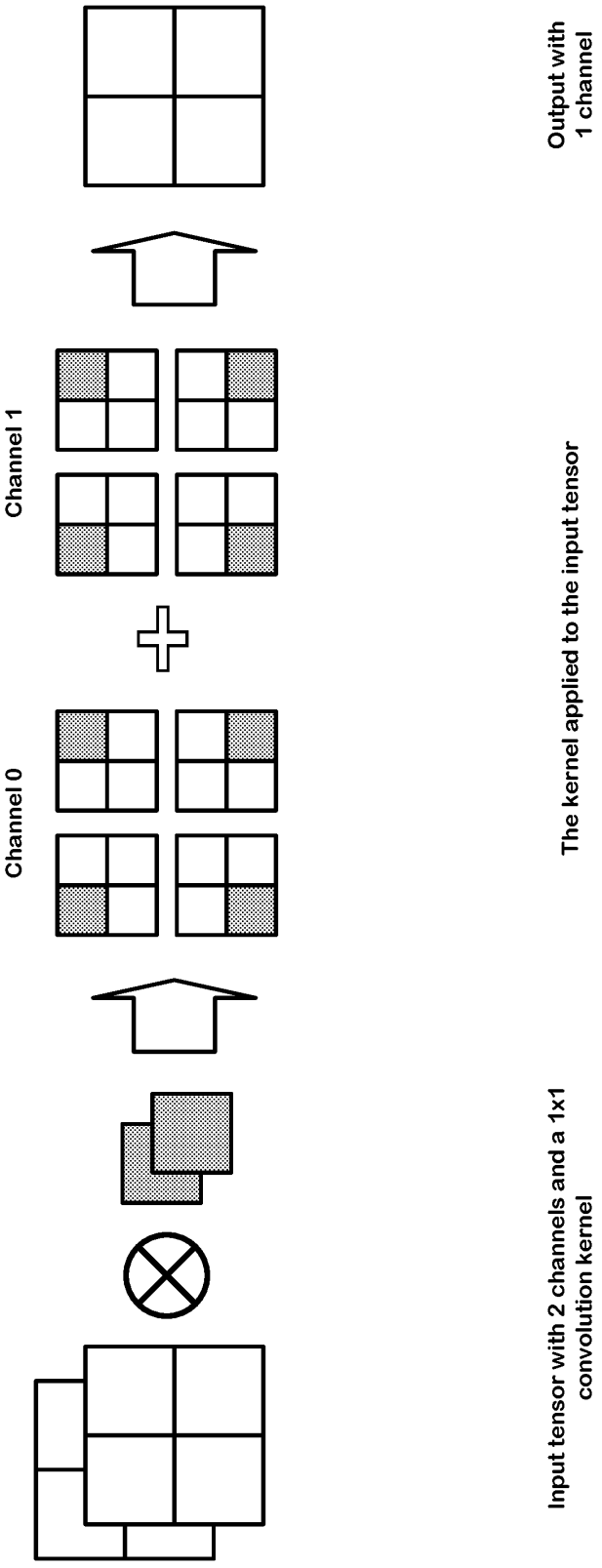
Output with
1 channel
Channel 1
Channel 0
The kernel applied to the input tensor
Input tensor with 2 channels and a 1x1
convolution kernel

Figure 1E

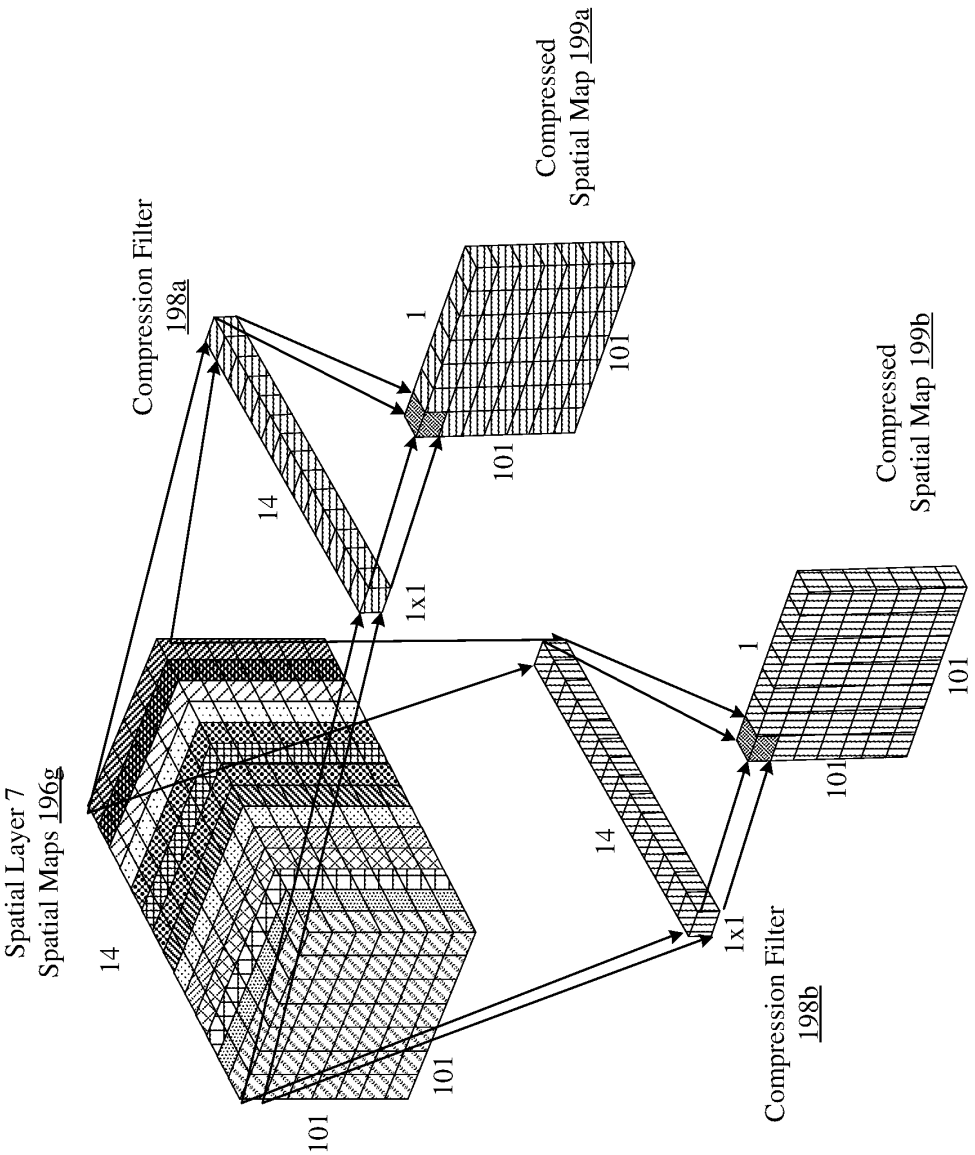
Spatial Layer 7
Spatial Maps 196g
14
101
101
101
Compression Filter
198a
1x1
14
1
101
101
Compressed
Spatial Map 199a
Compression Filter
198b
1x1
14
1
101
101
Compressed
Spatial Map 199b

Figure 1F

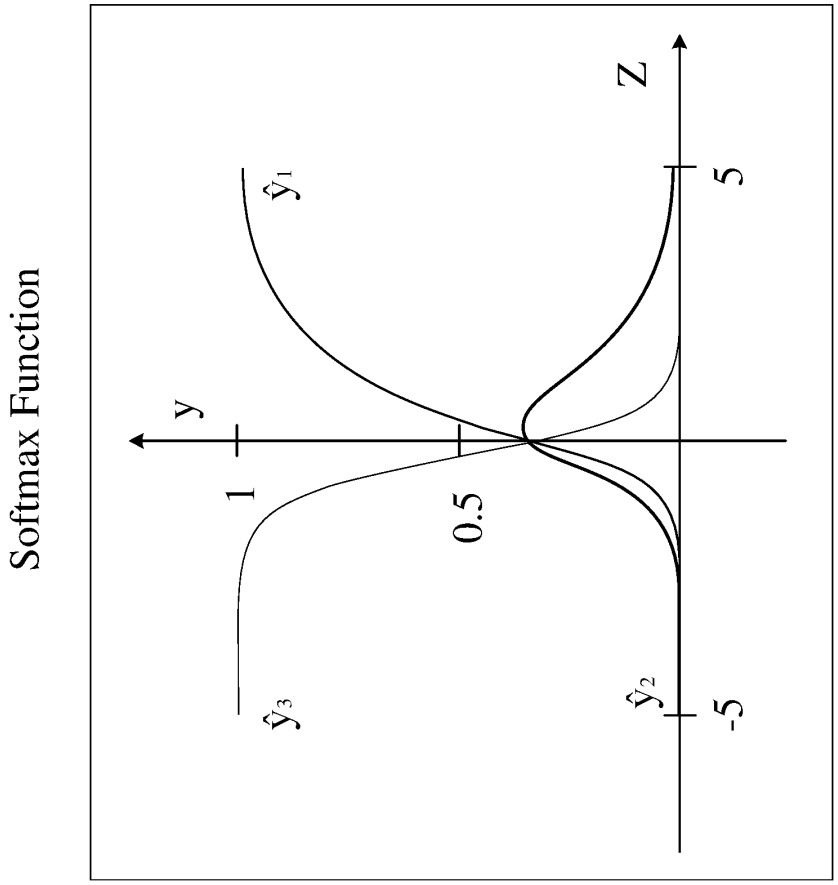

Figure 1G

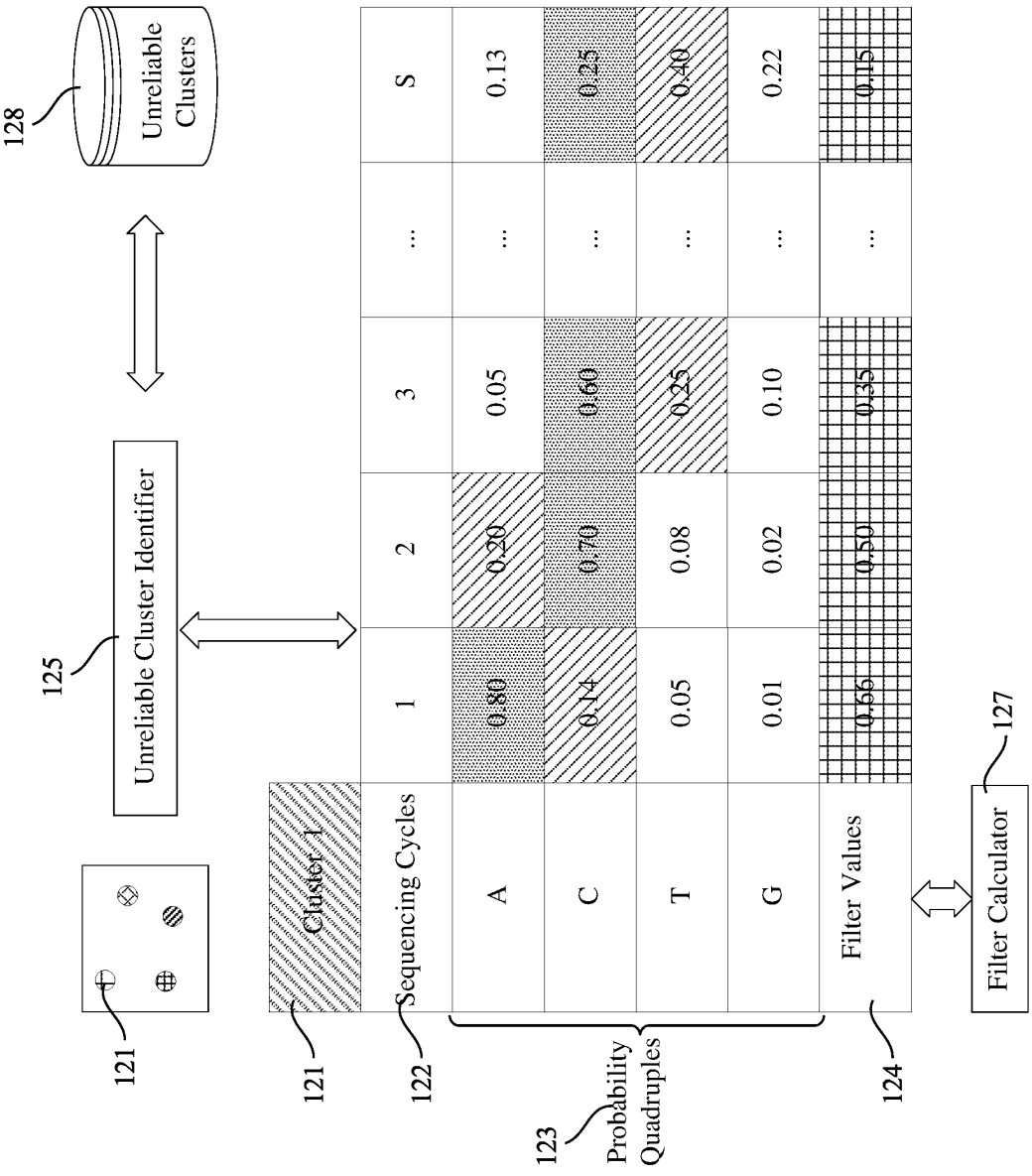
128
Unreliable Clusters
125
Unreliable Cluster Identifier
121
121
Cluster 1
122
Sequencing Cycles
1
2
3
...
S
A
0.80
0.20
0.05
...
0.13
C
0.14
0.70
0.60
...
0.25
T
0.05
0.08
0.25
...
0.40
G
0.01
0.02
0.10
...
0.22
123
Probability Quadruples
Filter Values
0.55
0.50
0.35
...
0.15
124
127
Filter Calculator

Figure 1H

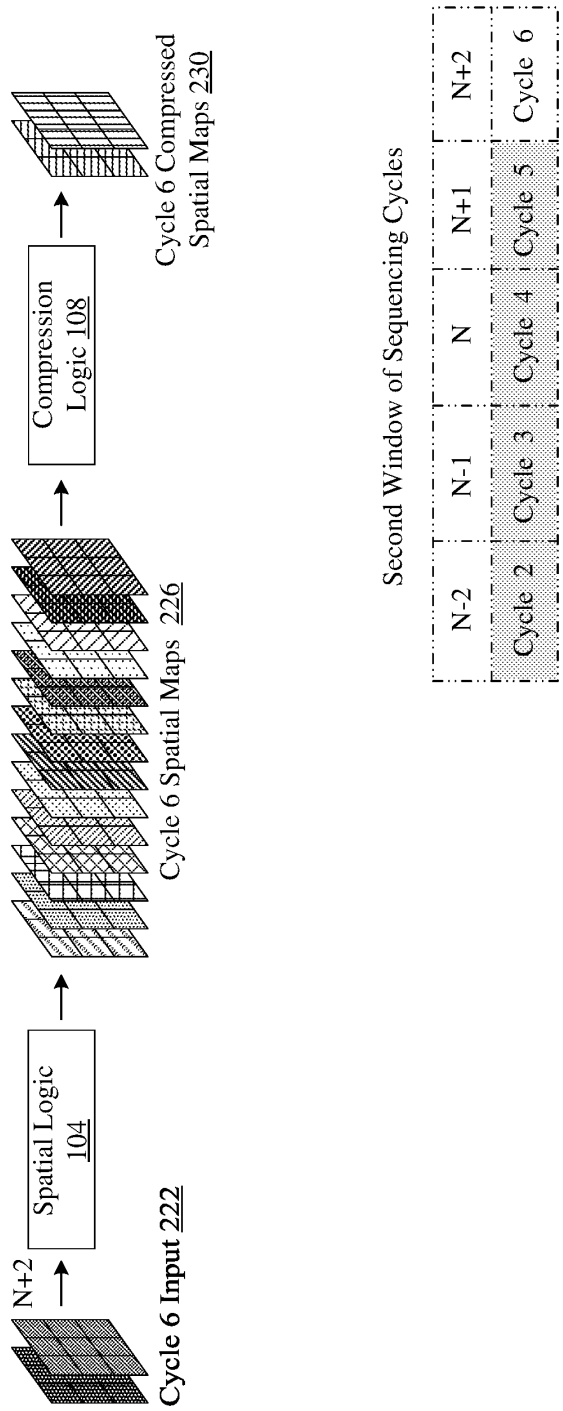
Cycle 6 Input 222
N+2
Spatial Logic 104
Cycle 6 Spatial Maps 226
Compression Logic 108
Cycle 6 Compressed Spatial Maps 230
Second Window of Sequencing Cycles
N-2
N-1
N
N+1
N+2
Cycle 2
Cycle 3
Cycle 4
Cycle 5
Cycle 6

Figure 2A

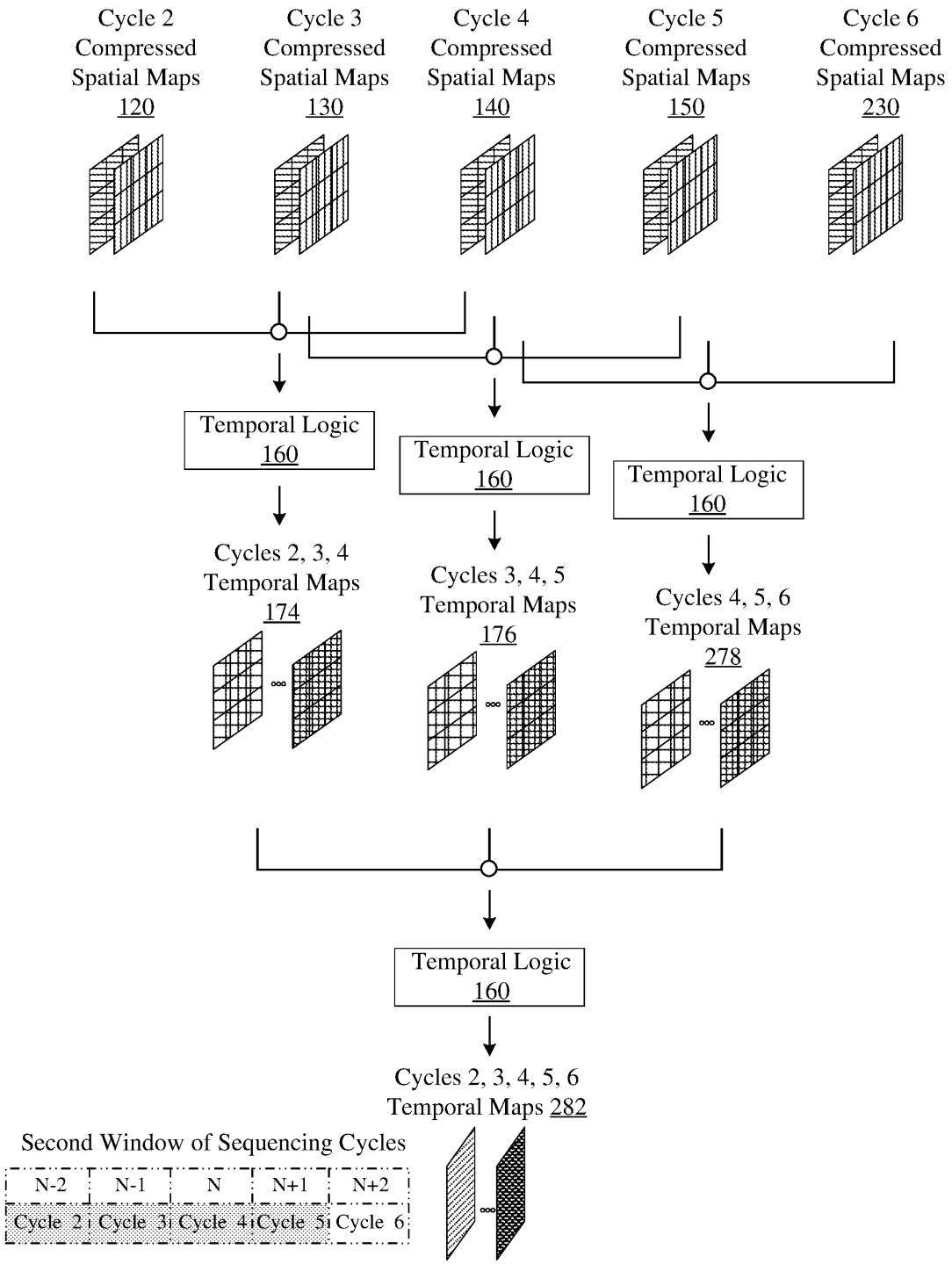
Cycle 2 Compressed Spatial Maps 120
Cycle 3 Compressed Spatial Maps 130
Cycle 4 Compressed Spatial Maps 140
Cycle 5 Compressed Spatial Maps 150
Cycle 6 Compressed Spatial Maps 230
Temporal Logic 160
Temporal Logic 160
Temporal Logic 160
Cycles 2, 3, 4 Temporal Maps 174
Cycles 3, 4, 5 Temporal Maps 176
Cycles 4, 5, 6 Temporal Maps 278
Temporal Logic 160
Cycles 2, 3, 4, 5, 6 Temporal Maps 282
Second Window of Sequencing Cycles
N-2
N-1
N
N+1
N+2
Cycle 2
Cycle 3
Cycle 4
Cycle 5
Cycle 6

Figure 2B

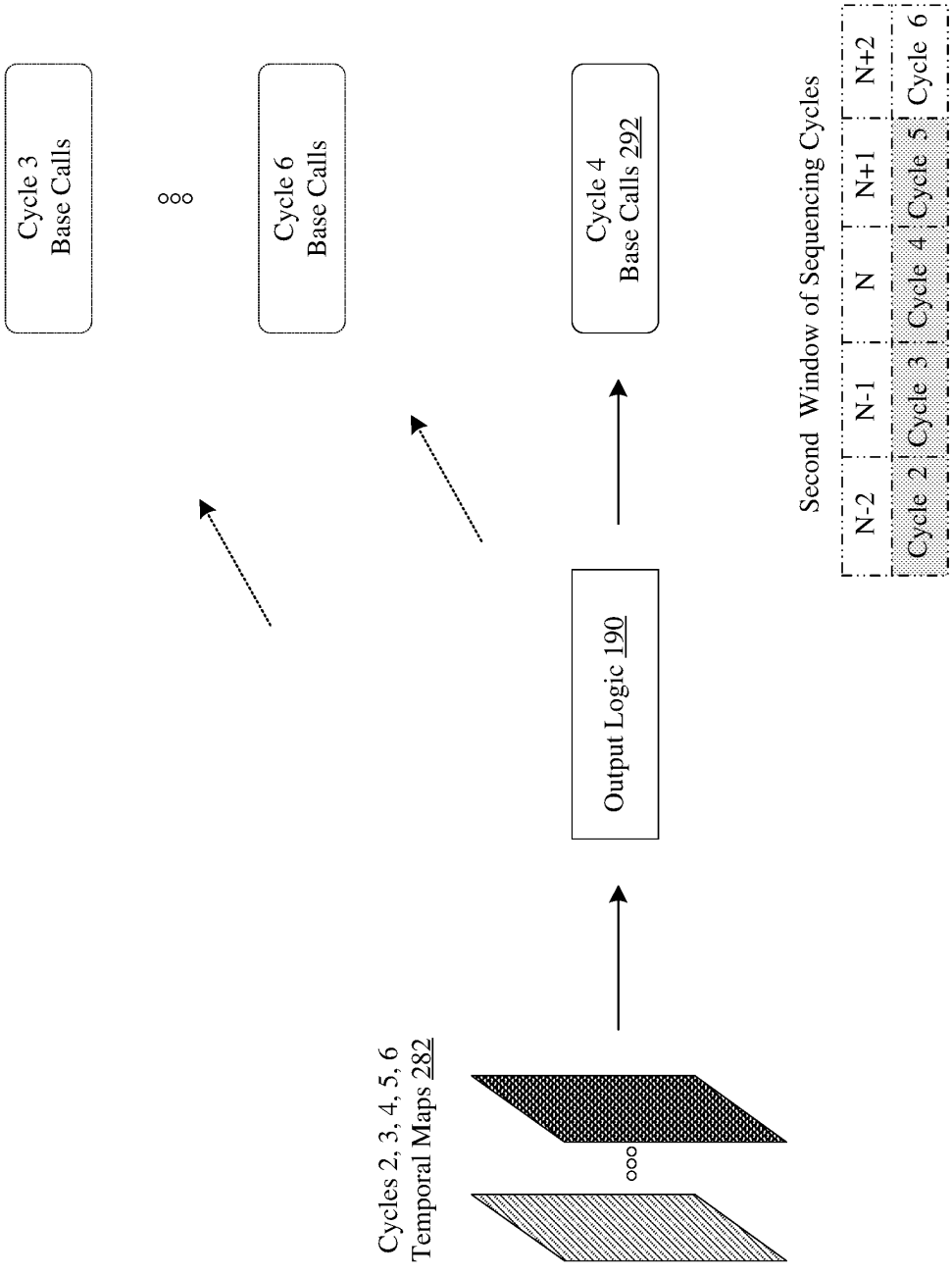
Cycle 3 Base Calls
Cycle 6 Base Calls
Cycle 4 Base Calls 292
Output Logic 190
Cycles 2, 3, 4, 5, 6 Temporal Maps 282
Second Window of Sequencing Cycles
N-2
N-1
N
N+1
N+2
Cycle 2
Cycle 3
Cycle 4
Cycle 5
Cycle 6

Figure 2C

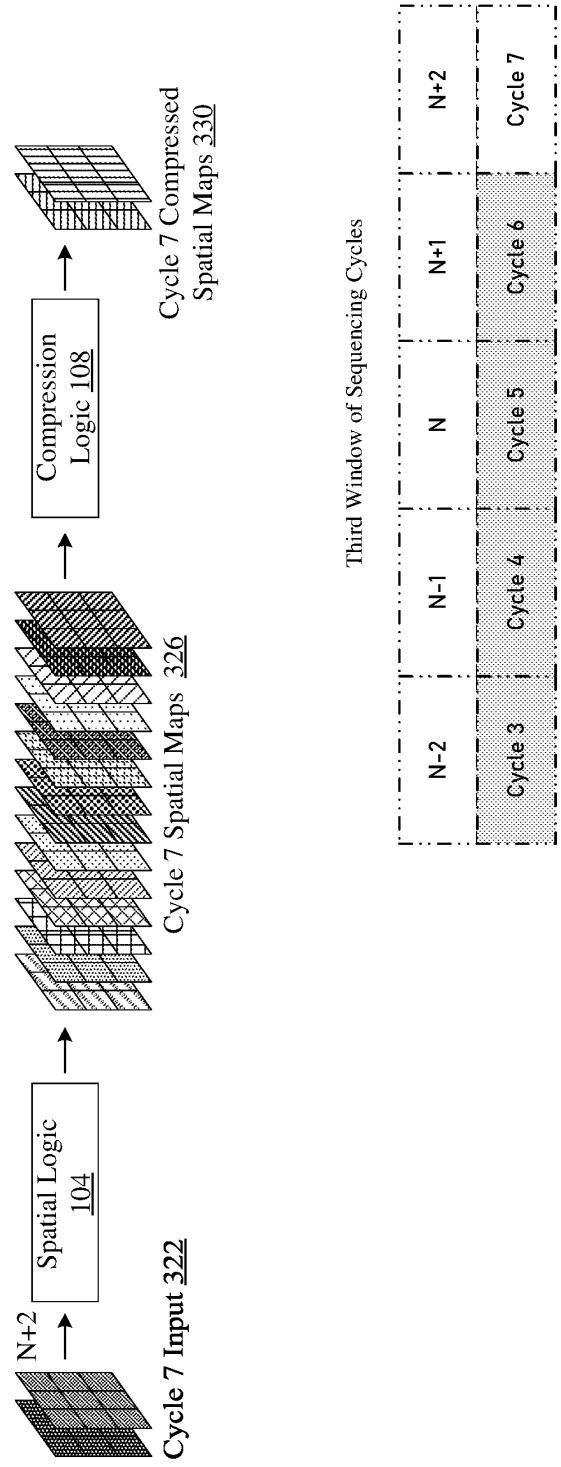
N+2
Cycle 7 Input 322
Spatial Logic 104
Cycle 7 Spatial Maps 326
Compression Logic 108
Cycle 7 Compressed Spatial Maps 330
Third Window of Sequencing Cycles
N-2
N-1
N
N+1
N+2
Cycle 3
Cycle 4
Cycle 5
Cycle 6
Cycle 7

Figure 3A

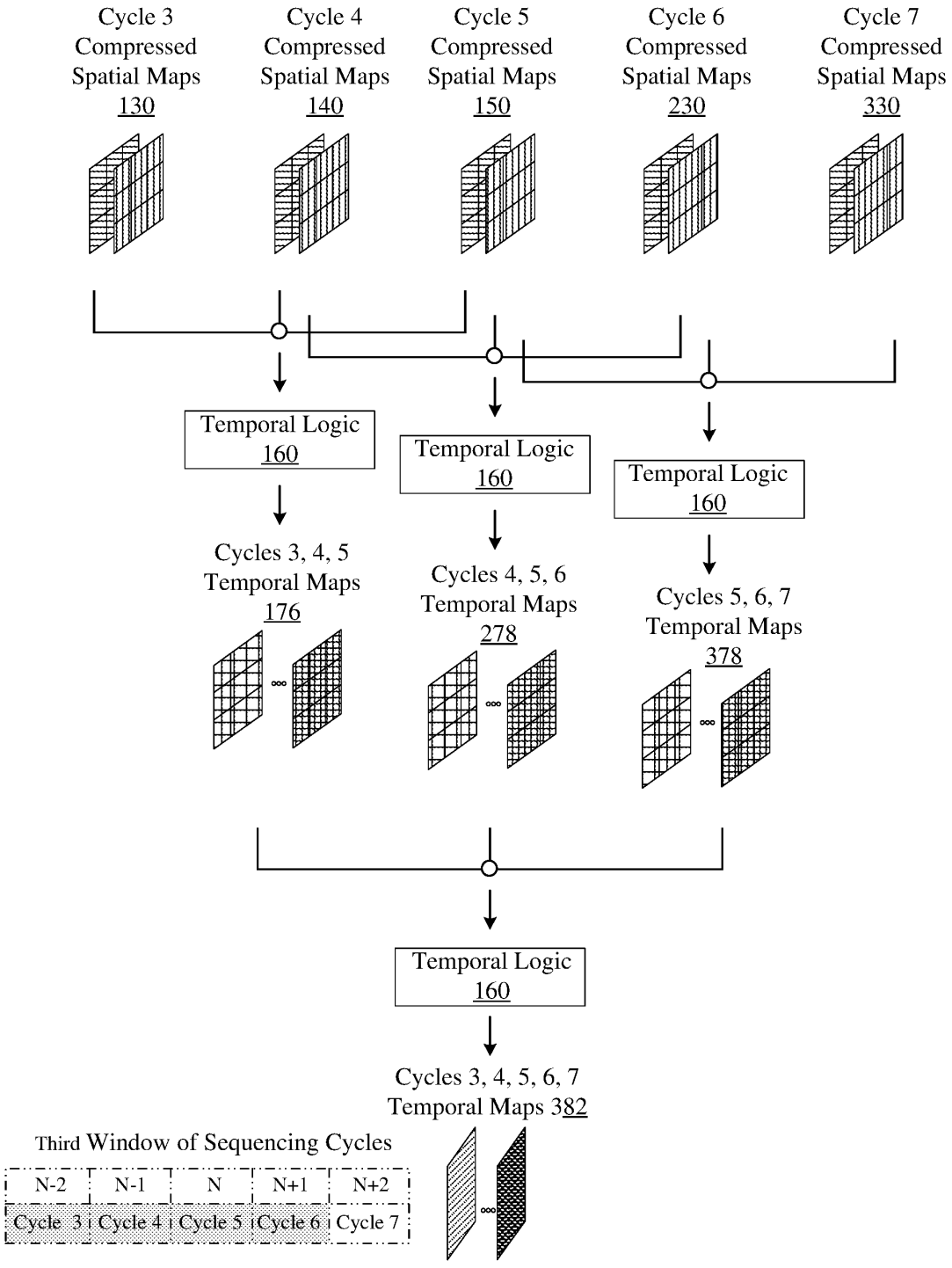
Cycle 3 Compressed Spatial Maps 130
Cycle 4 Compressed Spatial Maps 140
Cycle 5 Compressed Spatial Maps 150
Cycle 6 Compressed Spatial Maps 230
Cycle 7 Compressed Spatial Maps 330
Temporal Logic 160
Temporal Logic 160
Temporal Logic 160
Cycles 3, 4, 5 Temporal Maps 176
Cycles 4, 5, 6 Temporal Maps 278
Cycles 5, 6, 7 Temporal Maps 378
Temporal Logic 160
Cycles 3, 4, 5, 6, 7 Temporal Maps 382
Third Window of Sequencing Cycles
N-2
N-1
N
N+1
N+2
Cycle 3
Cycle 4
Cycle 5
Cycle 6
Cycle 7

Figure 3B

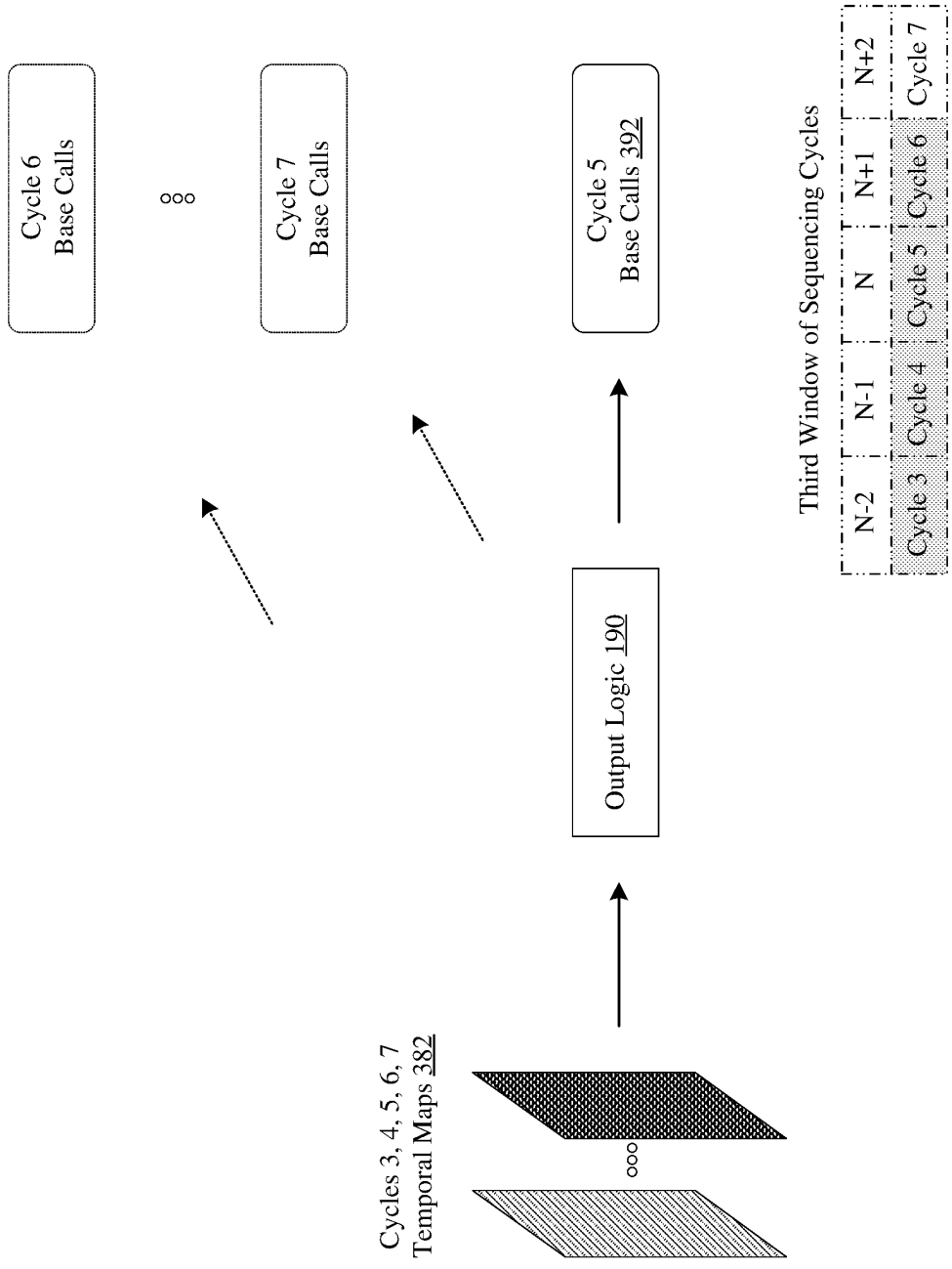
Cycle 6
Base Calls
Cycle 7
Base Calls
Cycle 5
Base Calls 392
Output Logic 190
Cycles 3, 4, 5, 6, 7
Temporal Maps 382
Third Window of Sequencing Cycles
N-2
N-1
N
N+1
N+2
Cycle 3
Cycle 4
Cycle 5
Cycle 6
Cycle 7

Figure 3C

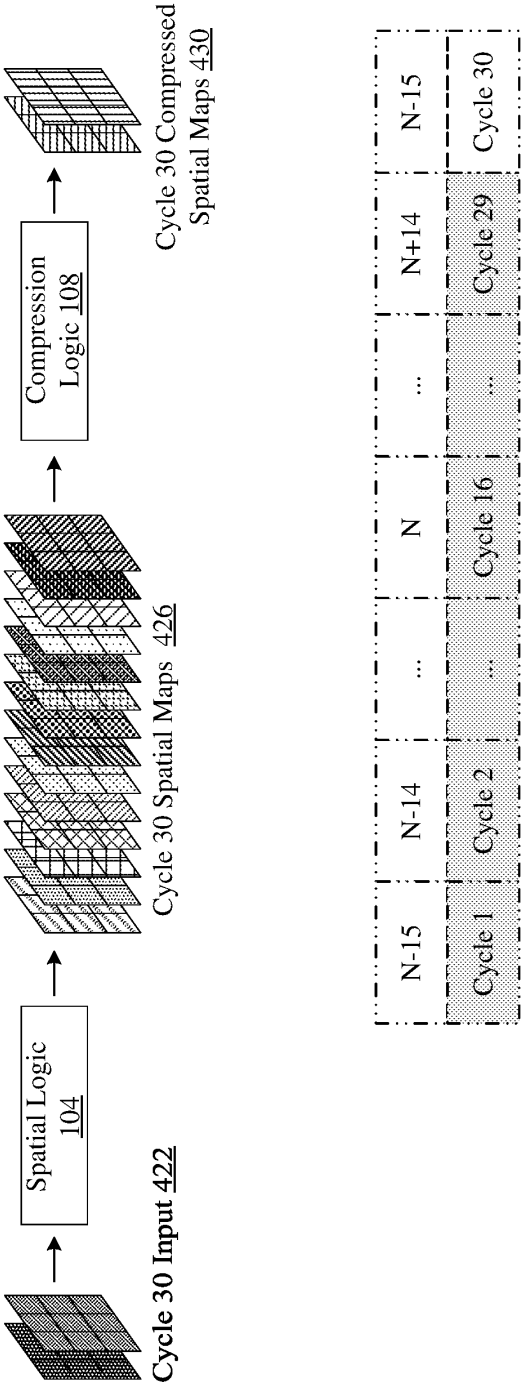
Cycle 30 Input 422
Spatial Logic 104
Cycle 30 Spatial Maps 426
Compression Logic 108
Cycle 30 Compressed Spatial Maps 430
N-15
N-14
...
N
...
N+14
N-15
Cycle 1
Cycle 2
...
Cycle 16
...
Cycle 29
Cycle 30

Figure 4A

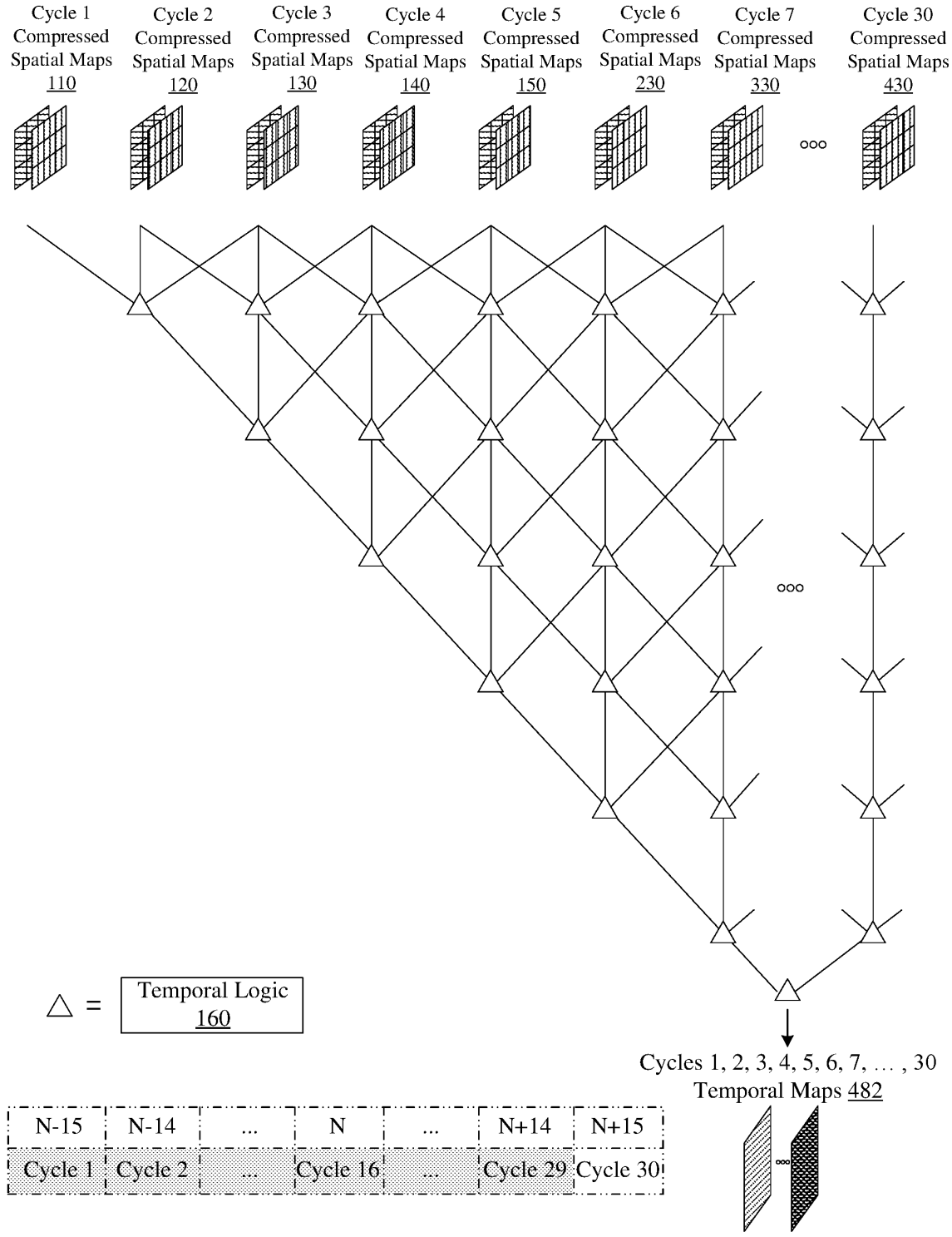
Cycle 1 Compressed Spatial Maps 110
Cycle 2 Compressed Spatial Maps 120
Cycle 3 Compressed Spatial Maps 130
Cycle 4 Compressed Spatial Maps 140
Cycle 5 Compressed Spatial Maps 150
Cycle 6 Compressed Spatial Maps 230
Cycle 7 Compressed Spatial Maps 330
Cycle 30 Compressed Spatial Maps 430
△ = Temporal Logic 160
Cycles 1, 2, 3, 4, 5, 6, 7, … , 30 Temporal Maps 482
N-15
N-14
...
N
...
N+14
N+15
Cycle 1
Cycle 2
...
Cycle 16
...
Cycle 29
Cycle 30

Figure 4B

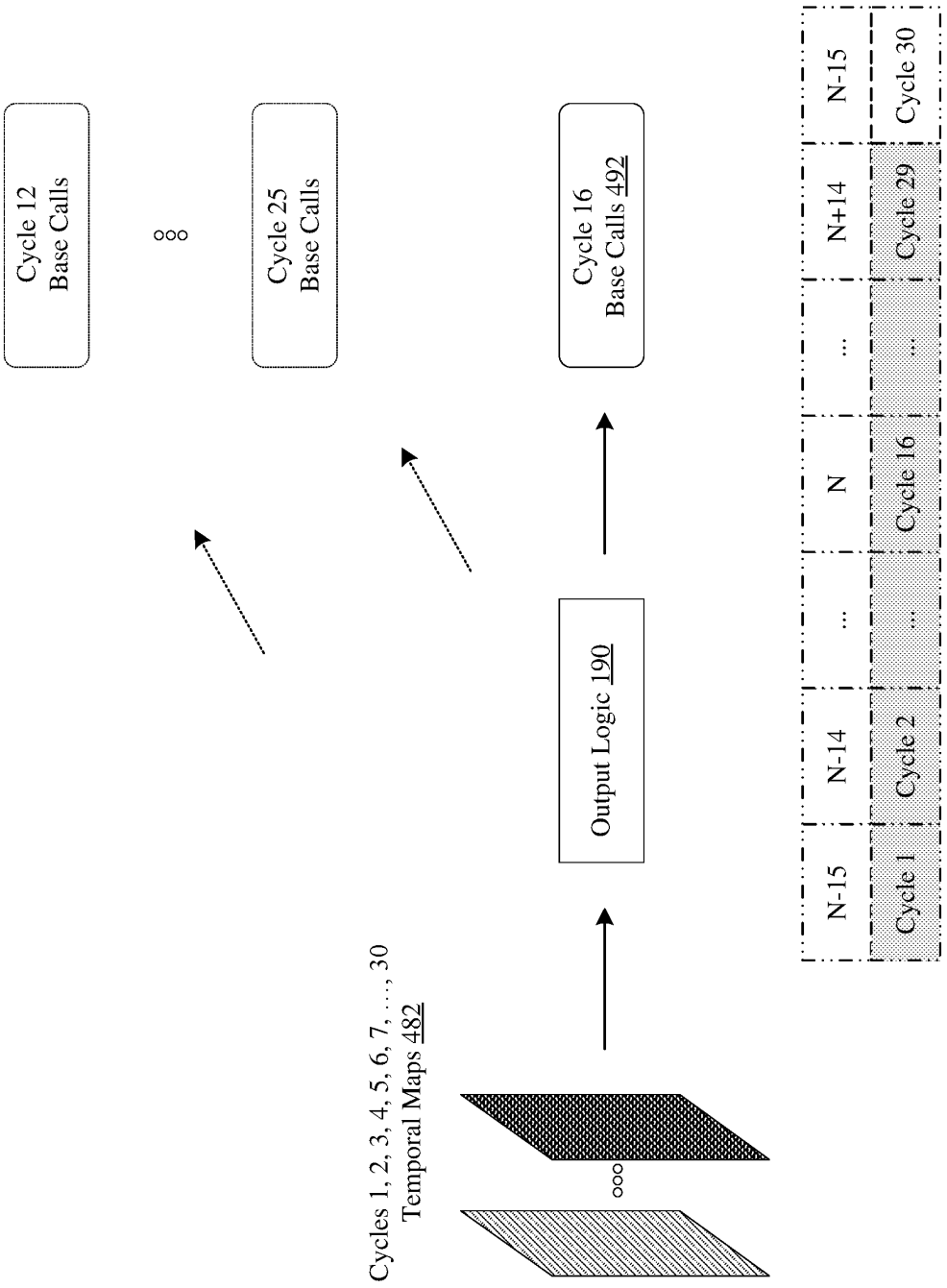
Cycle 12
Base Calls
Cycle 25
Base Calls
Cycle 16
Base Calls 492
Output Logic 190
Cycles 1, 2, 3, 4, 5, 6, 7, ..., 30
Temporal Maps 482
N-15
N-14
...
N
...
N+14
N-15
Cycle 1
Cycle 2
...
Cycle 16
...
Cycle 29
Cycle 30

Figure 4C

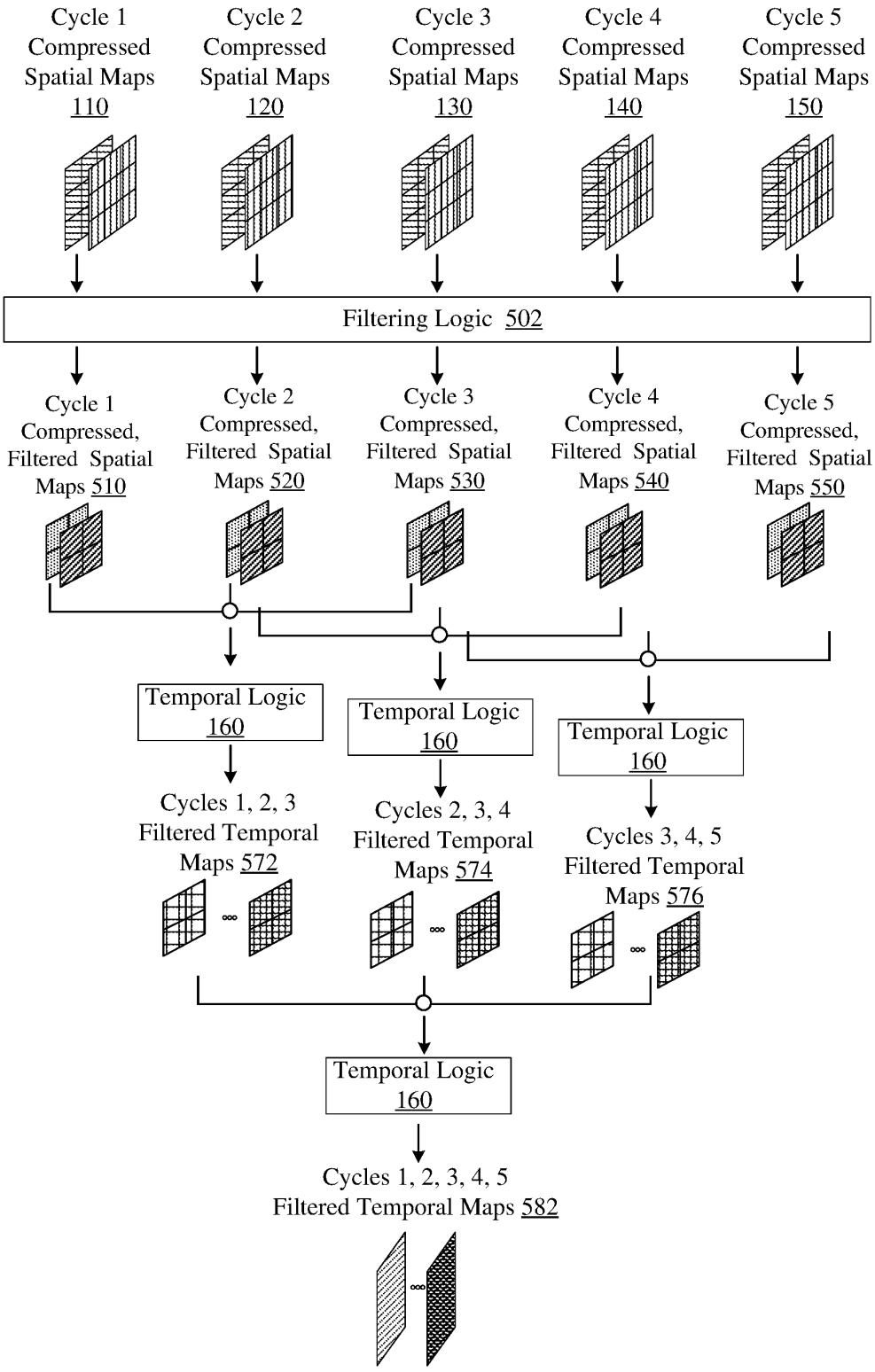
Cycle 1 Compressed Spatial Maps 110
Cycle 2 Compressed Spatial Maps 120
Cycle 3 Compressed Spatial Maps 130
Cycle 4 Compressed Spatial Maps 140
Cycle 5 Compressed Spatial Maps 150
Filtering Logic 502
Cycle 1 Compressed, Filtered Spatial Maps 510
Cycle 2 Compressed, Filtered Spatial Maps 520
Cycle 3 Compressed, Filtered Spatial Maps 530
Cycle 4 Compressed, Filtered Spatial Maps 540
Cycle 5 Compressed, Filtered Spatial Maps 550
Temporal Logic 160
Temporal Logic 160
Temporal Logic 160
Cycles 1, 2, 3 Filtered Temporal Maps 572
Cycles 2, 3, 4 Filtered Temporal Maps 574
Cycles 3, 4, 5 Filtered Temporal Maps 576
Temporal Logic 160
Cycles 1, 2, 3, 4, 5 Filtered Temporal Maps 582

Figure 5A

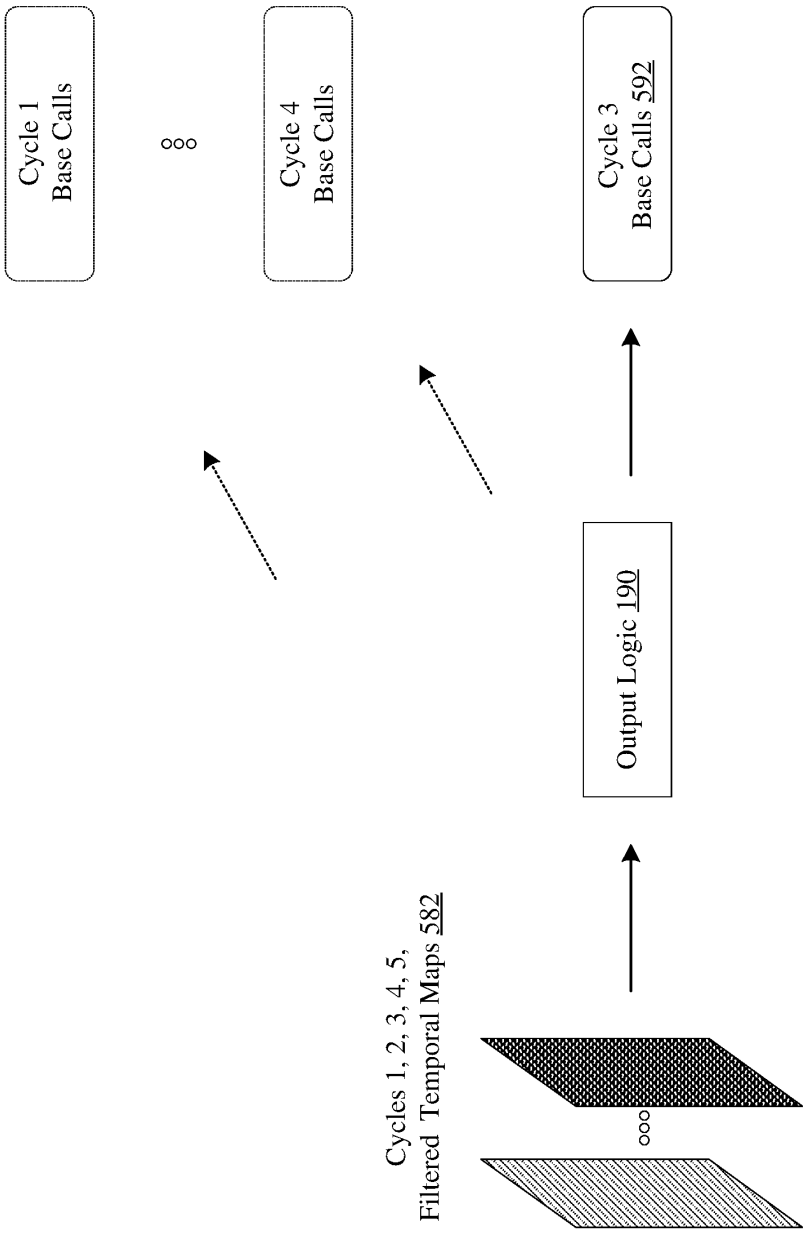
Cycle 1
Base Calls
Cycle 4
Base Calls
Cycle 3
Base Calls 592
Output Logic 190
Cycles 1, 2, 3, 4, 5,
Filtered Temporal Maps 582

Figure 5B

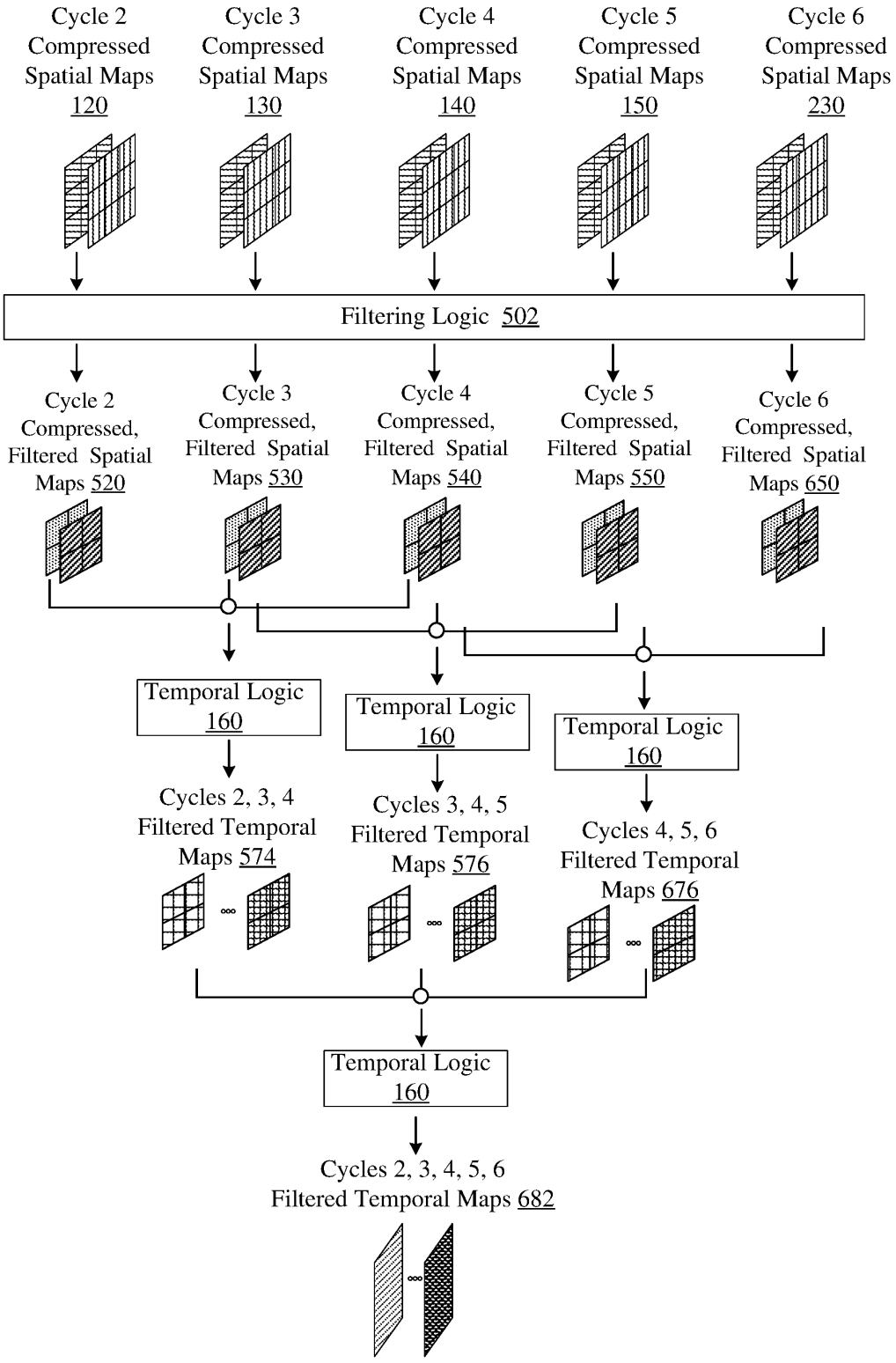
Cycle 2 Compressed Spatial Maps 120
Cycle 3 Compressed Spatial Maps 130
Cycle 4 Compressed Spatial Maps 140
Cycle 5 Compressed Spatial Maps 150
Cycle 6 Compressed Spatial Maps 230
Filtering Logic 502
Cycle 2 Compressed, Filtered Spatial Maps 520
Cycle 3 Compressed, Filtered Spatial Maps 530
Cycle 4 Compressed, Filtered Spatial Maps 540
Cycle 5 Compressed, Filtered Spatial Maps 550
Cycle 6 Compressed, Filtered Spatial Maps 650
Temporal Logic 160
Temporal Logic 160
Temporal Logic 160
Cycles 2, 3, 4 Filtered Temporal Maps 574
Cycles 3, 4, 5 Filtered Temporal Maps 576
Cycles 4, 5, 6 Filtered Temporal Maps 676
Temporal Logic 160
Cycles 2, 3, 4, 5, 6 Filtered Temporal Maps 682

Figure 6A

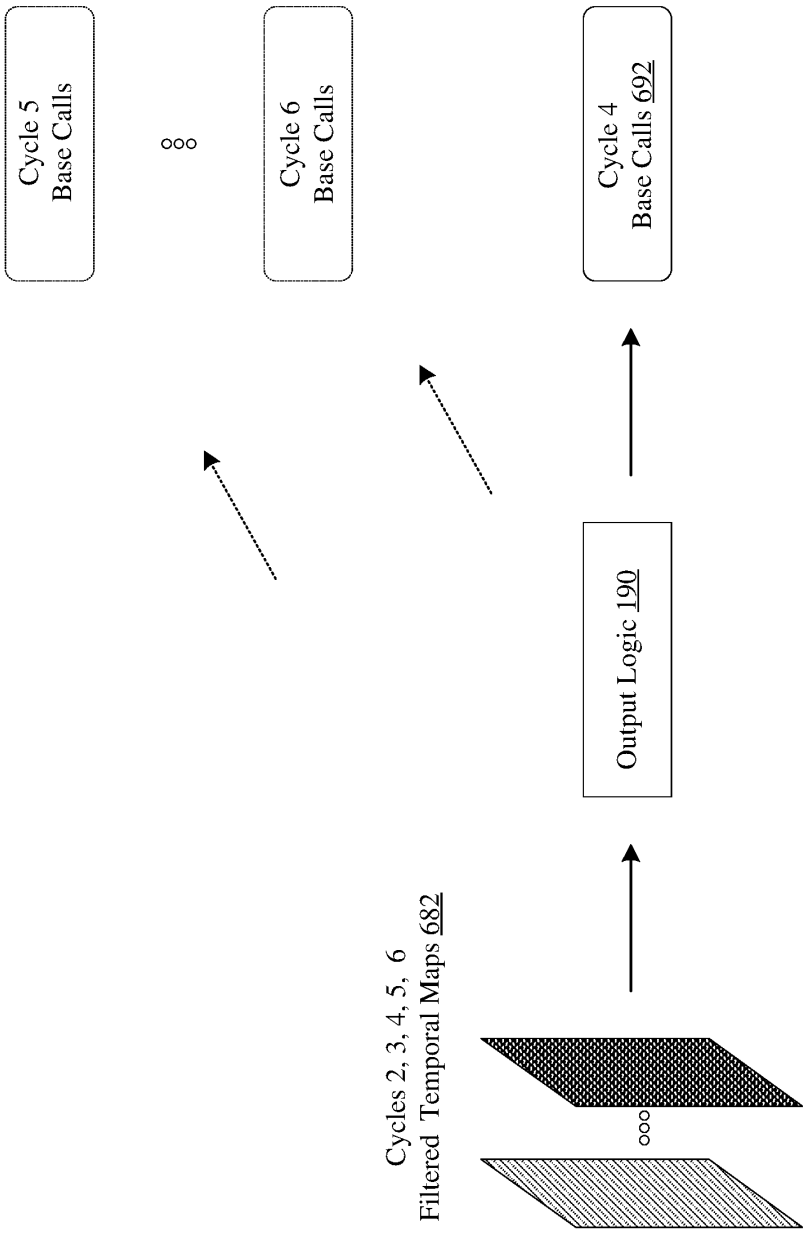
Cycle 5
Base Calls
Cycle 6
Base Calls
Cycle 4
Base Calls 692
Output Logic 190
Cycles 2, 3, 4, 5, 6
Filtered Temporal Maps 682

Figure 6B

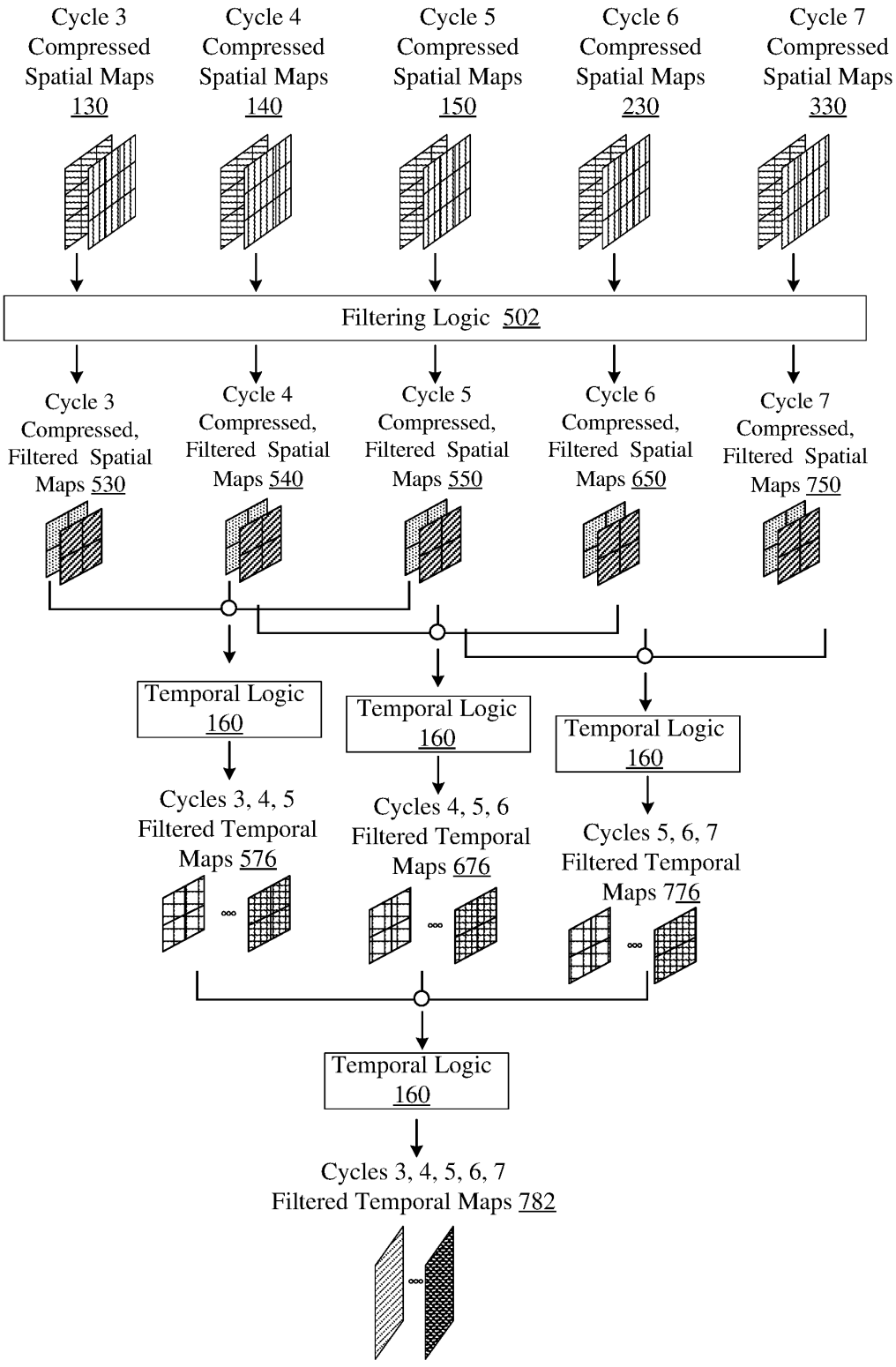
Cycle 3 Compressed Spatial Maps 130
Cycle 4 Compressed Spatial Maps 140
Cycle 5 Compressed Spatial Maps 150
Cycle 6 Compressed Spatial Maps 230
Cycle 7 Compressed Spatial Maps 330
Filtering Logic 502
Cycle 3 Compressed, Filtered Spatial Maps 530
Cycle 4 Compressed, Filtered Spatial Maps 540
Cycle 5 Compressed, Filtered Spatial Maps 550
Cycle 6 Compressed, Filtered Spatial Maps 650
Cycle 7 Compressed, Filtered Spatial Maps 750
Temporal Logic 160
Temporal Logic 160
Temporal Logic 160
Cycles 3, 4, 5 Filtered Temporal Maps 576
Cycles 4, 5, 6 Filtered Temporal Maps 676
Cycles 5, 6, 7 Filtered Temporal Maps 776
Temporal Logic 160
Cycles 3, 4, 5, 6, 7 Filtered Temporal Maps 782

Figure 7A

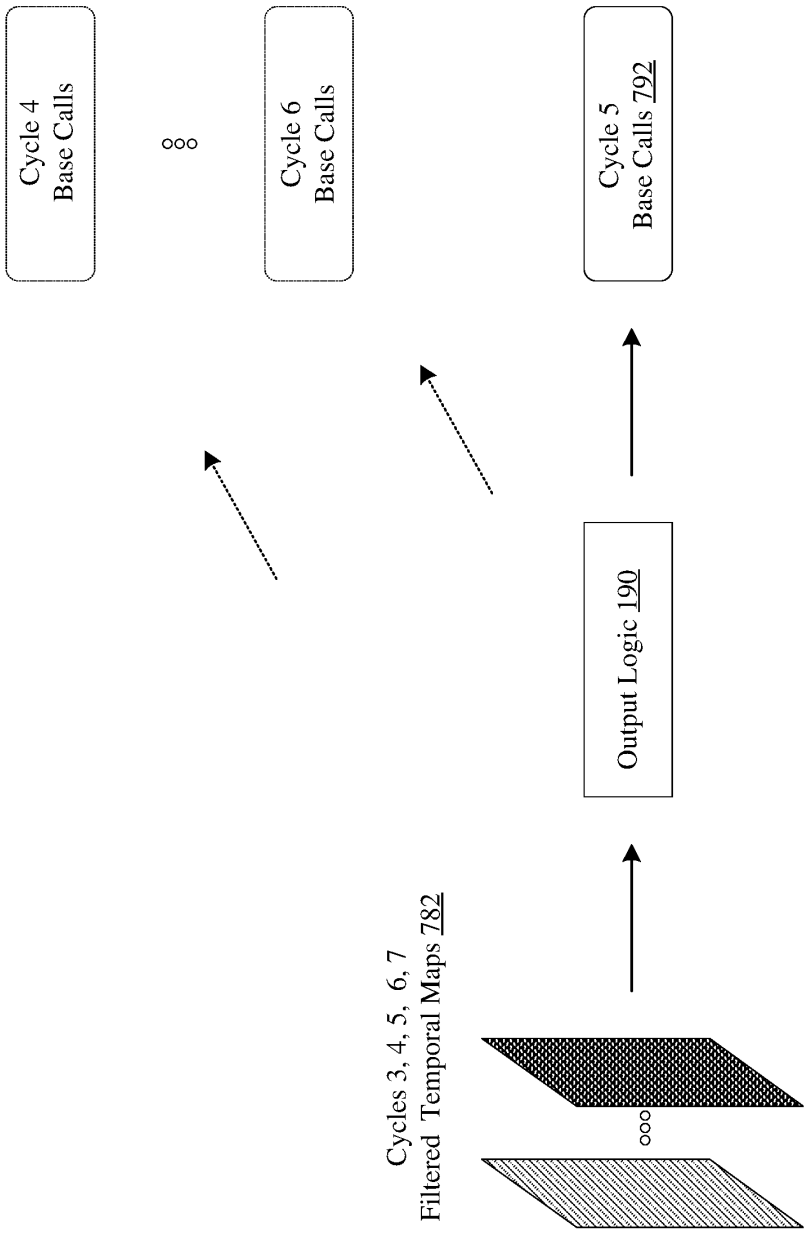
Cycle 4
Base Calls
Cycle 6
Base Calls
Cycle 5
Base Calls 792
Output Logic 190
Cycles 3, 4, 5, 6, 7
Filtered Temporal Maps 782

Figure 7B

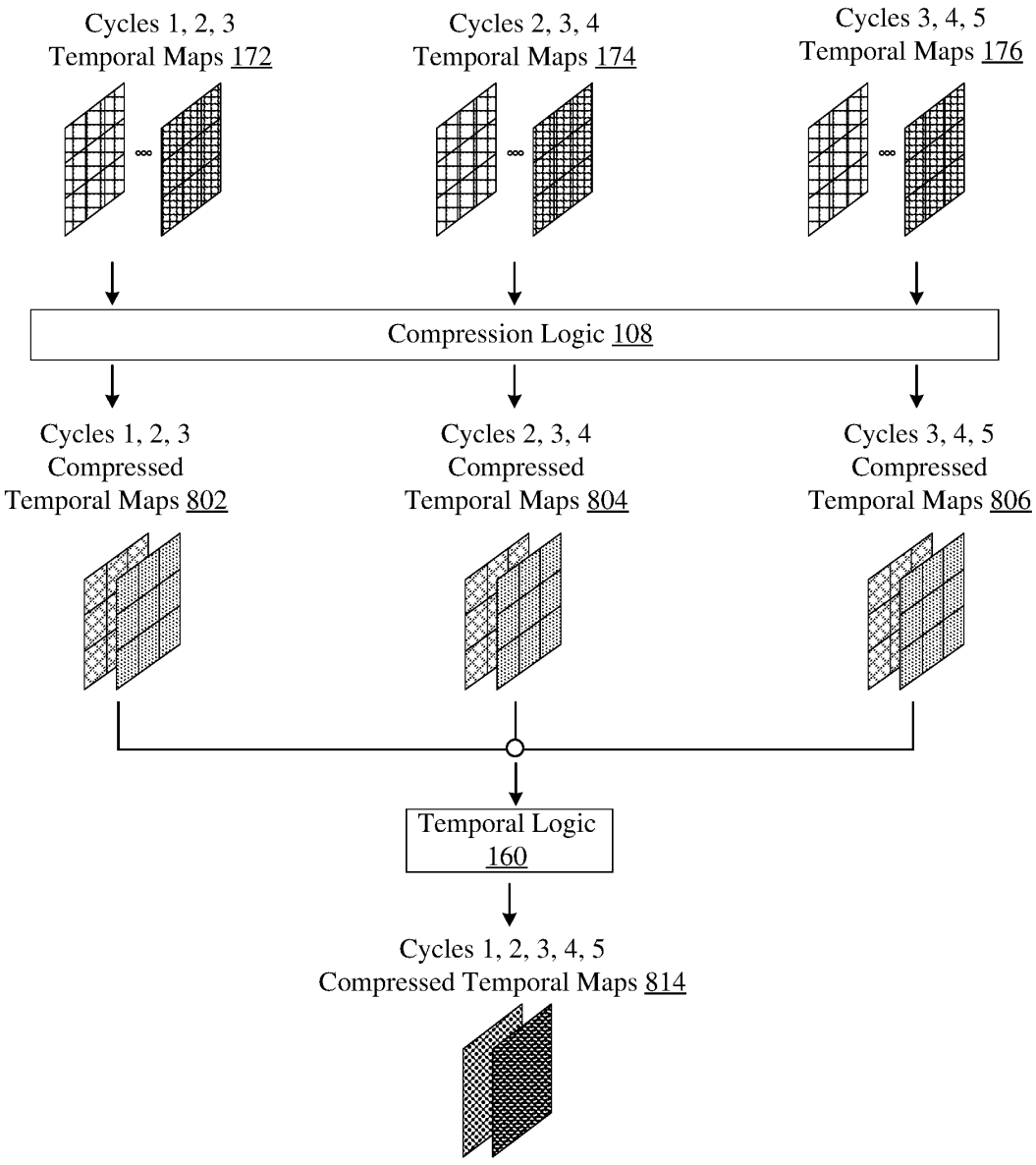
Cycles 1, 2, 3
Temporal Maps 172
Cycles 2, 3, 4
Temporal Maps 174
Cycles 3, 4, 5
Temporal Maps 176
Compression Logic 108
Cycles 1, 2, 3
Compressed
Temporal Maps 802
Cycles 2, 3, 4
Compressed
Temporal Maps 804
Cycles 3, 4, 5
Compressed
Temporal Maps 806
Temporal Logic
160
Cycles 1, 2, 3, 4, 5
Compressed Temporal Maps 814

Figure 8A

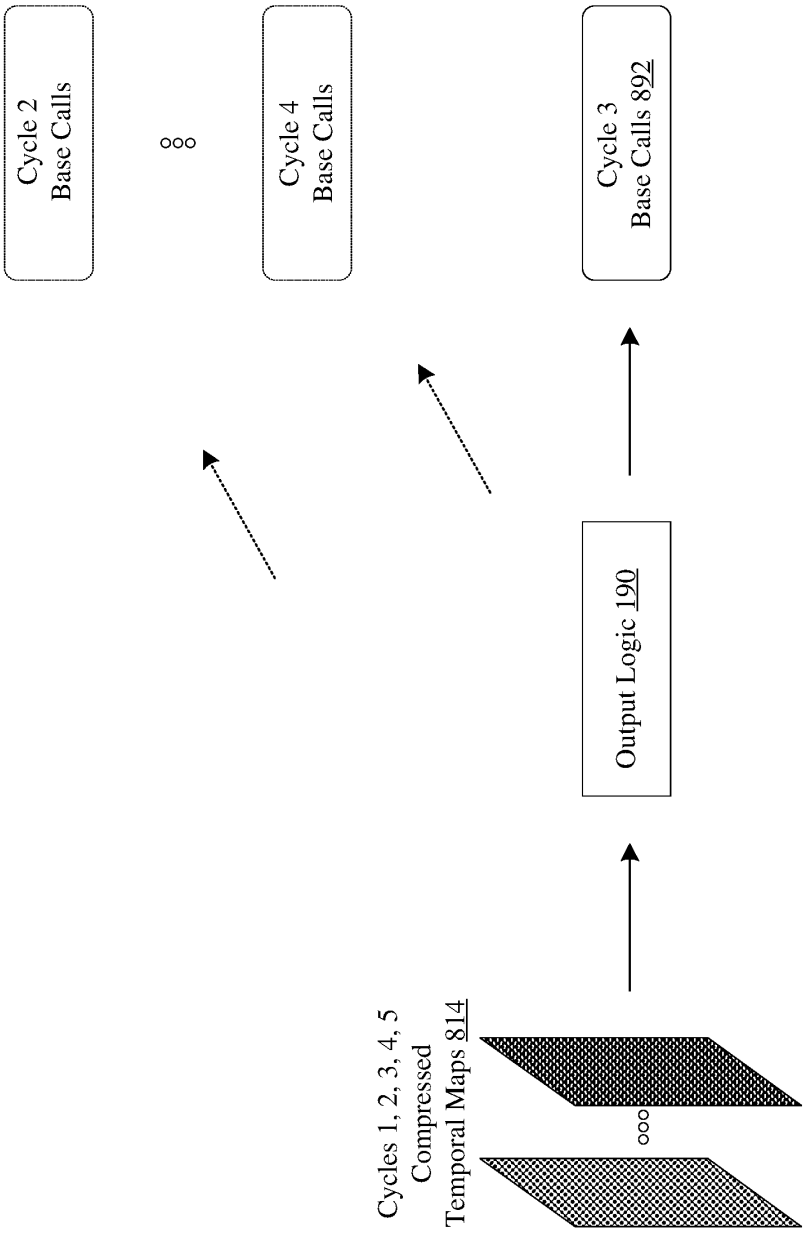
Cycles 1, 2, 3, 4, 5 Compressed Temporal Maps 814
Output Logic 190
Cycle 3 Base Calls 892
Cycle 4 Base Calls
Cycle 2 Base Calls

Figure 8B

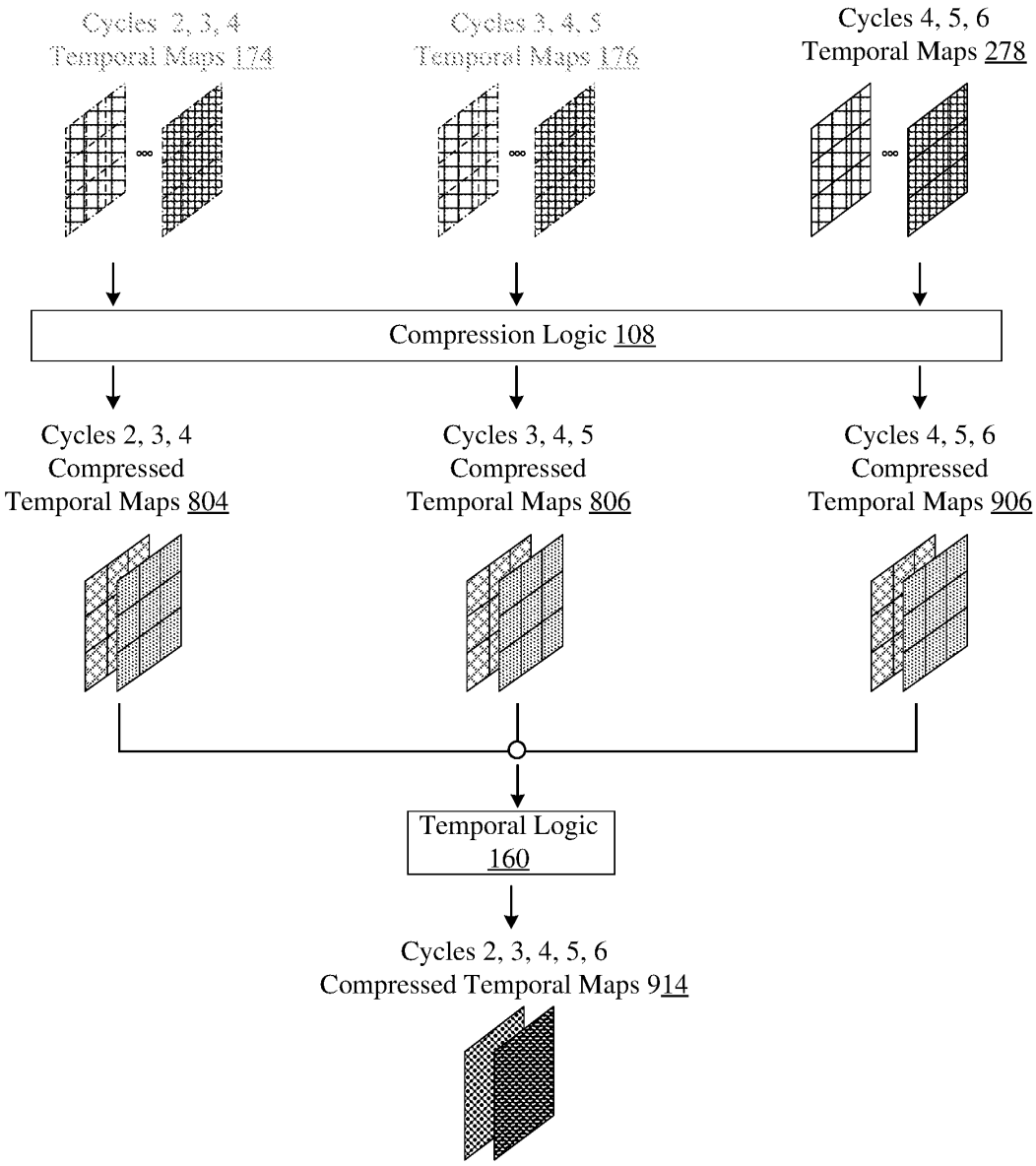
Cycles 2, 3, 4
Temporal Maps 174
Cycles 3, 4, 5
Temporal Maps 176
Cycles 4, 5, 6
Temporal Maps 278
Compression Logic 108
Cycles 2, 3, 4
Compressed
Temporal Maps 804
Cycles 3, 4, 5
Compressed
Temporal Maps 806
Cycles 4, 5, 6
Compressed
Temporal Maps 906
Temporal Logic
160
Cycles 2, 3, 4, 5, 6
Compressed Temporal Maps 914

Figure 9A

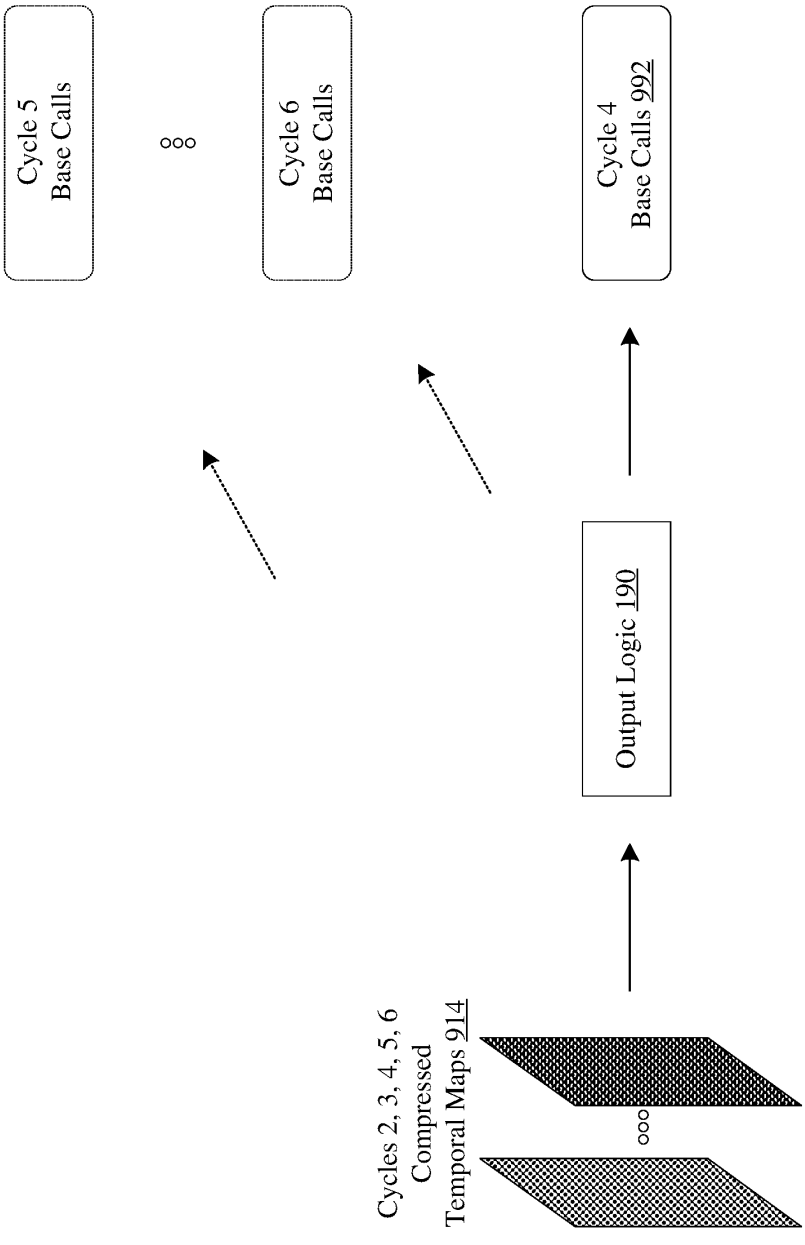
Cycles 2, 3, 4, 5, 6
Compressed
Temporal Maps 914
Output Logic 190
Cycle 4
Base Calls 992
Cycle 6
Base Calls
Cycle 5
Base Calls

Figure 9B

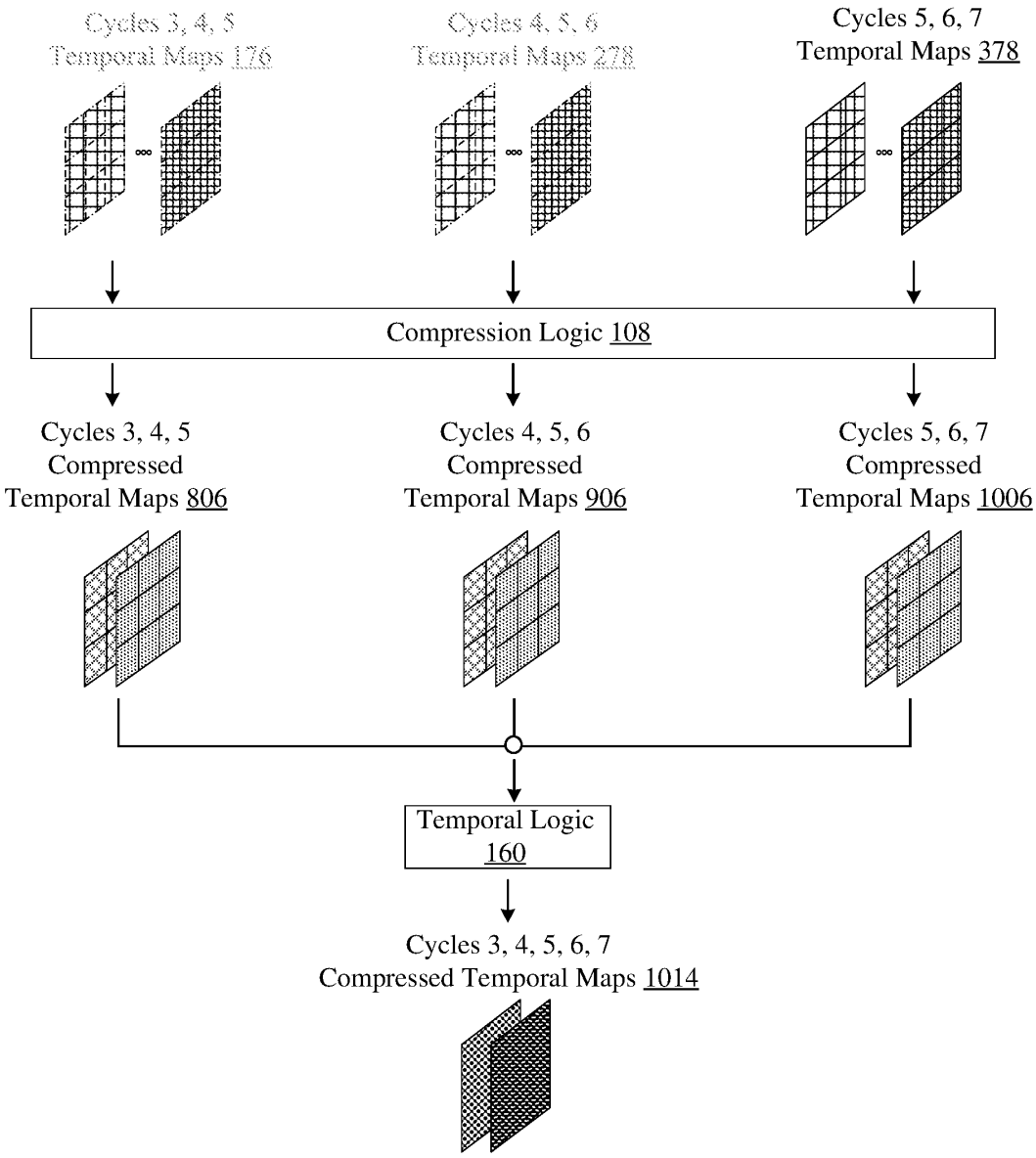
Cycles 3, 4, 5
Temporal Maps 176
Cycles 4, 5, 6
Temporal Maps 278
Cycles 5, 6, 7
Temporal Maps 378
Compression Logic 108
Cycles 3, 4, 5
Compressed
Temporal Maps 806
Cycles 4, 5, 6
Compressed
Temporal Maps 906
Cycles 5, 6, 7
Compressed
Temporal Maps 1006
Temporal Logic
160
Cycles 3, 4, 5, 6, 7
Compressed Temporal Maps 1014

Figure 10A

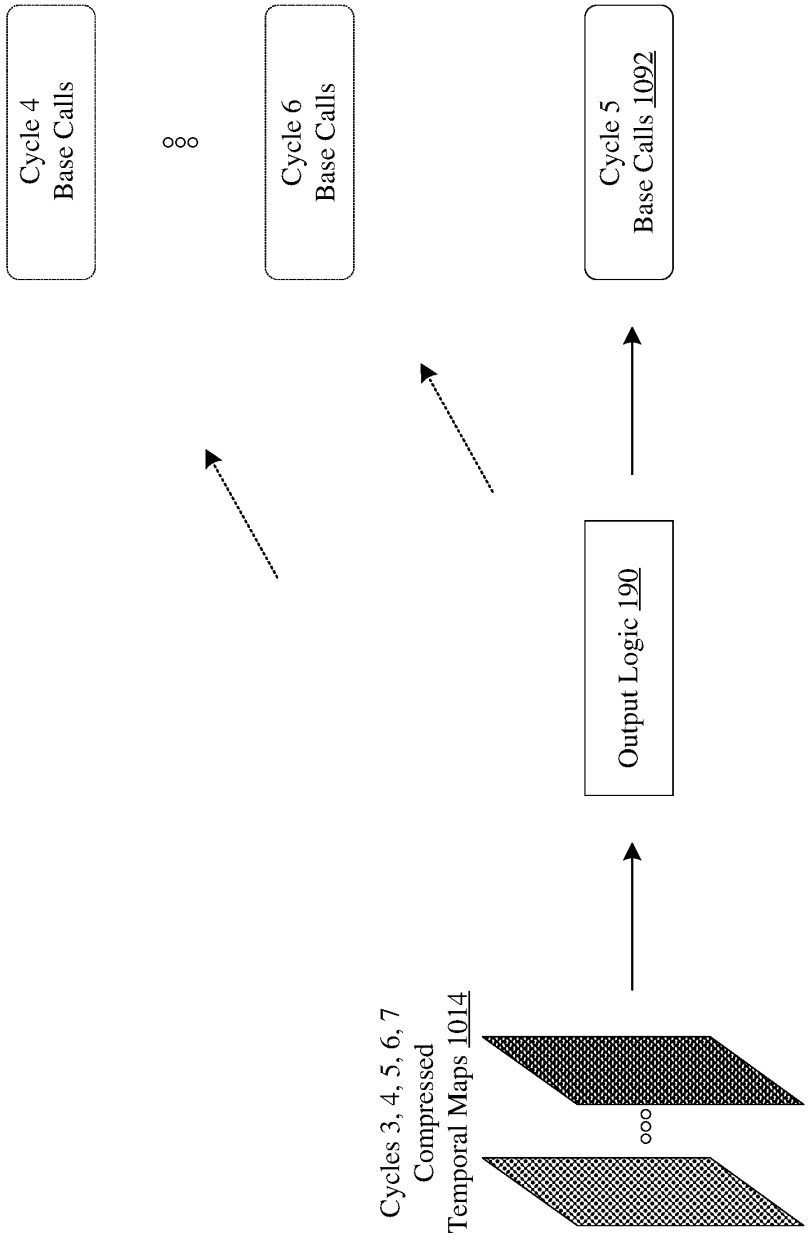
Cycles 3, 4, 5, 6, 7 Compressed Temporal Maps 1014
Output Logic 190
Cycle 5 Base Calls 1092
Cycle 4 Base Calls
Cycle 6 Base Calls

Figure 10B

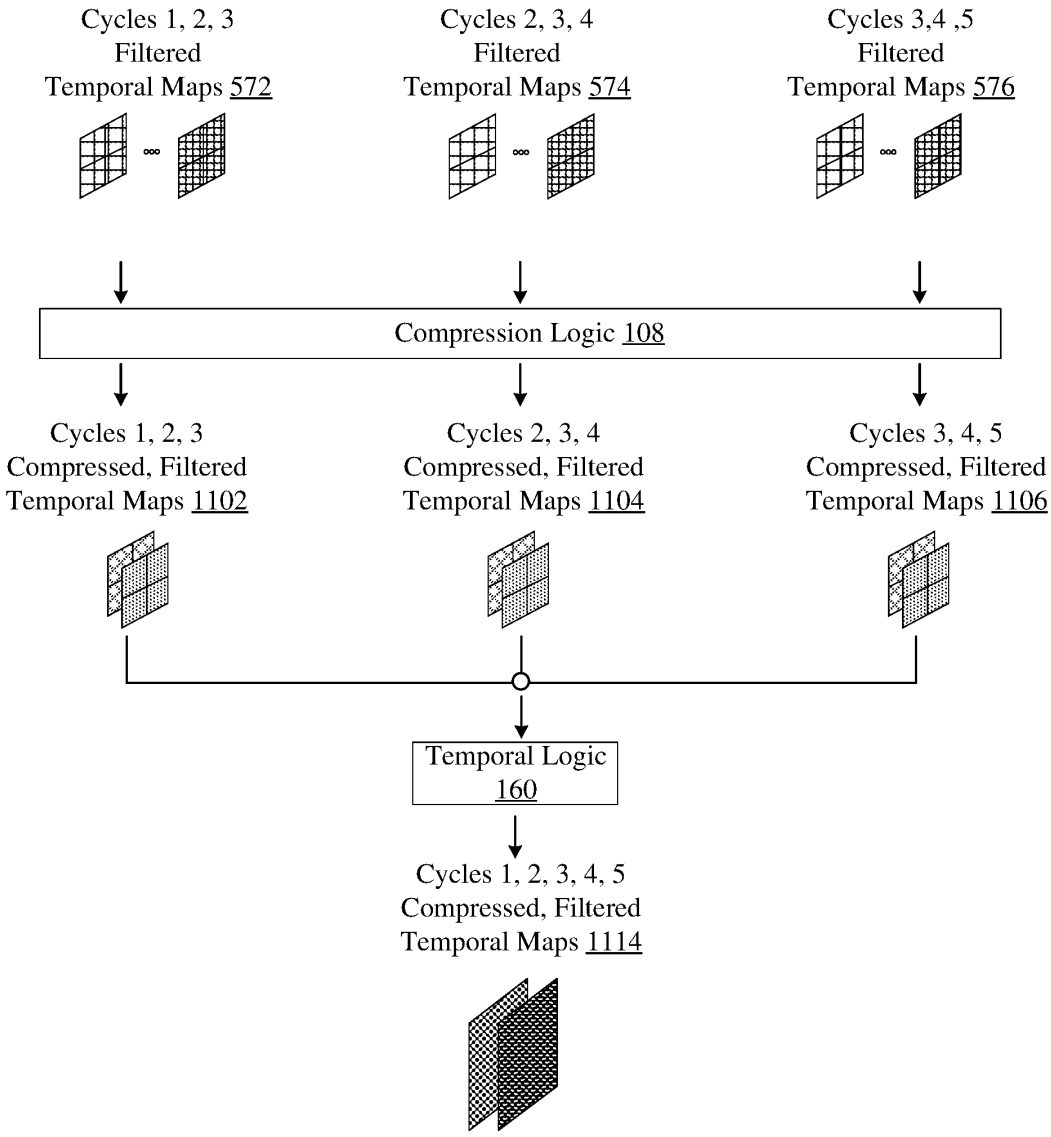
Cycles 1, 2, 3
Filtered
Temporal Maps 572
Cycles 2, 3, 4
Filtered
Temporal Maps 574
Cycles 3,4 ,5
Filtered
Temporal Maps 576
Compression Logic 108
Cycles 1, 2, 3
Compressed, Filtered
Temporal Maps 1102
Cycles 2, 3, 4
Compressed, Filtered
Temporal Maps 1104
Cycles 3, 4, 5
Compressed, Filtered
Temporal Maps 1106
Temporal Logic
160
Cycles 1, 2, 3, 4, 5
Compressed, Filtered
Temporal Maps 1114

Figure 11A

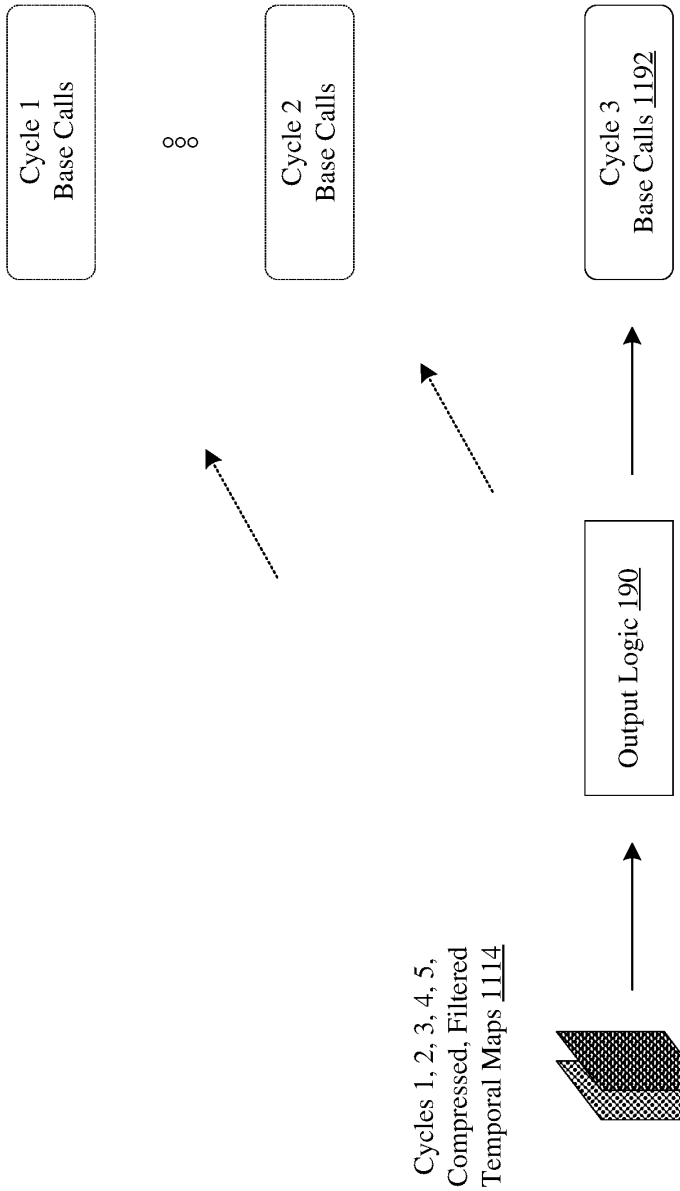
Cycle 1
Base Calls
Cycle 2
Base Calls
Cycle 3
Base Calls 1192
Output Logic 190
Cycles 1, 2, 3, 4, 5,
Compressed, Filtered
Temporal Maps 1114

Figure 11B

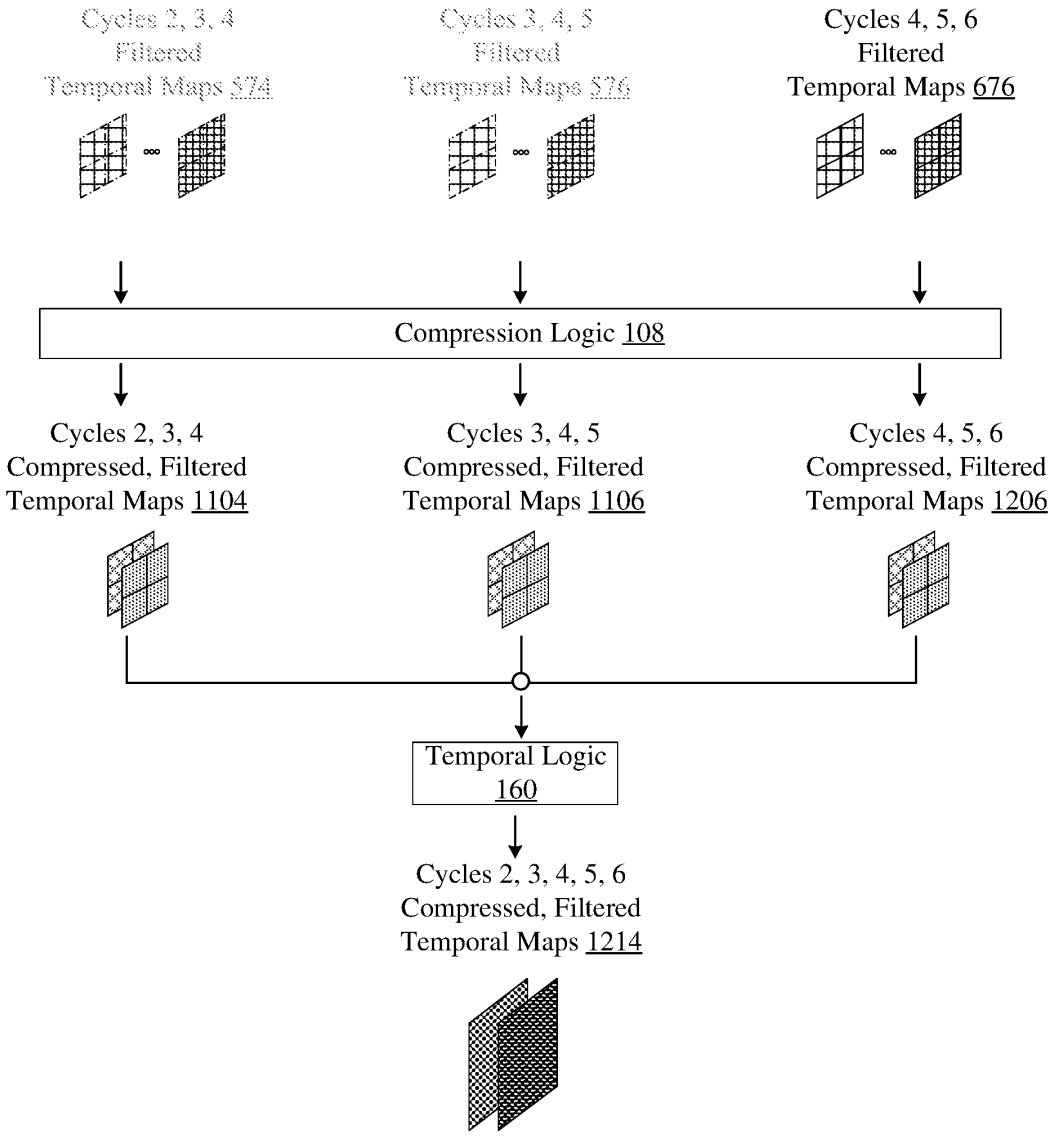
Cycles 2, 3, 4
Filtered
Temporal Maps 574
Cycles 3, 4, 5
Filtered
Temporal Maps 576
Cycles 4, 5, 6
Filtered
Temporal Maps 676
Compression Logic 108
Cycles 2, 3, 4
Compressed, Filtered
Temporal Maps 1104
Cycles 3, 4, 5
Compressed, Filtered
Temporal Maps 1106
Cycles 4, 5, 6
Compressed, Filtered
Temporal Maps 1206
Temporal Logic
160
Cycles 2, 3, 4, 5, 6
Compressed, Filtered
Temporal Maps 1214

Figure 12A

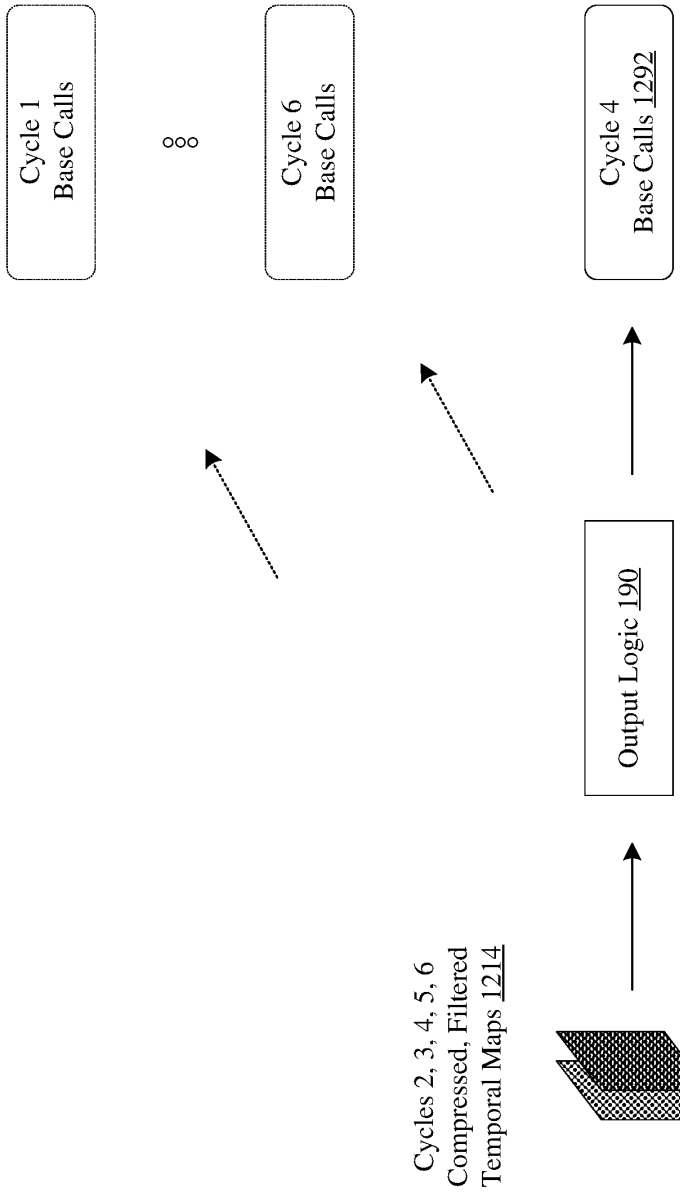
Cycle 1
Base Calls
Cycle 6
Base Calls
Cycle 4
Base Calls 1292
Output Logic 190
Cycles 2, 3, 4, 5, 6
Compressed, Filtered
Temporal Maps 1214

Figure 12B

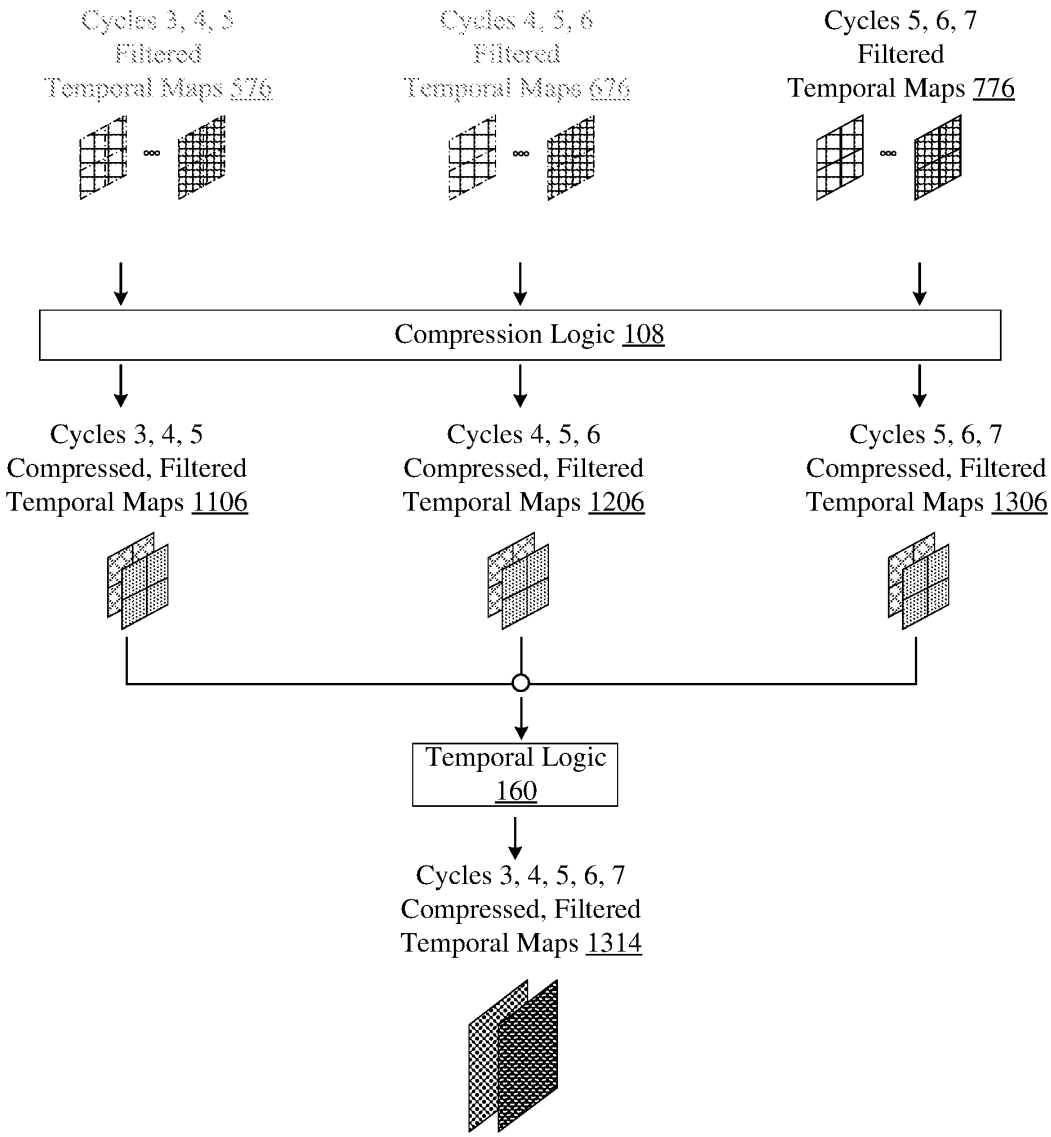
Cycles 3, 4, 5
Filtered
Temporal Maps 576
Cycles 4, 5, 6
Filtered
Temporal Maps 676
Cycles 5, 6, 7
Filtered
Temporal Maps 776
Compression Logic 108
Cycles 3, 4, 5
Compressed, Filtered
Temporal Maps 1106
Cycles 4, 5, 6
Compressed, Filtered
Temporal Maps 1206
Cycles 5, 6, 7
Compressed, Filtered
Temporal Maps 1306
Temporal Logic
160
Cycles 3, 4, 5, 6, 7
Compressed, Filtered
Temporal Maps 1314

Figure 13A

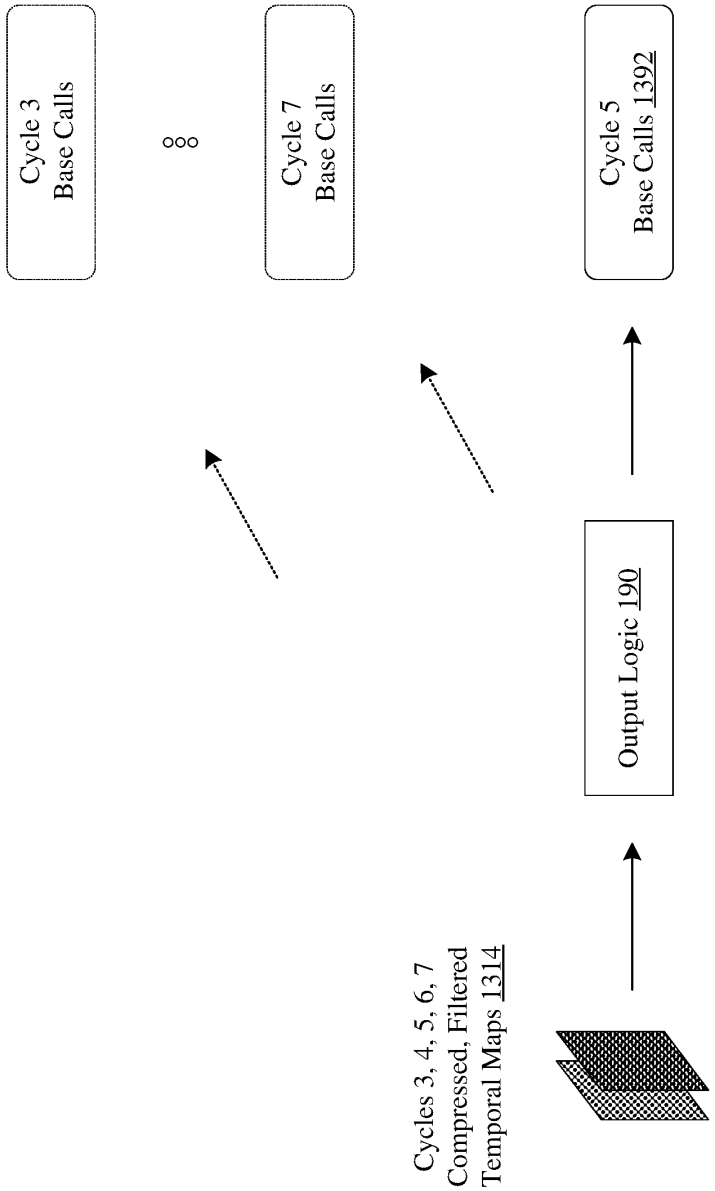
Cycle 3
Base Calls
Cycle 7
Base Calls
Cycle 5
Base Calls 1392
Output Logic 190
Cycles 3, 4, 5, 6, 7
Compressed, Filtered
Temporal Maps 1314

Figure 13B

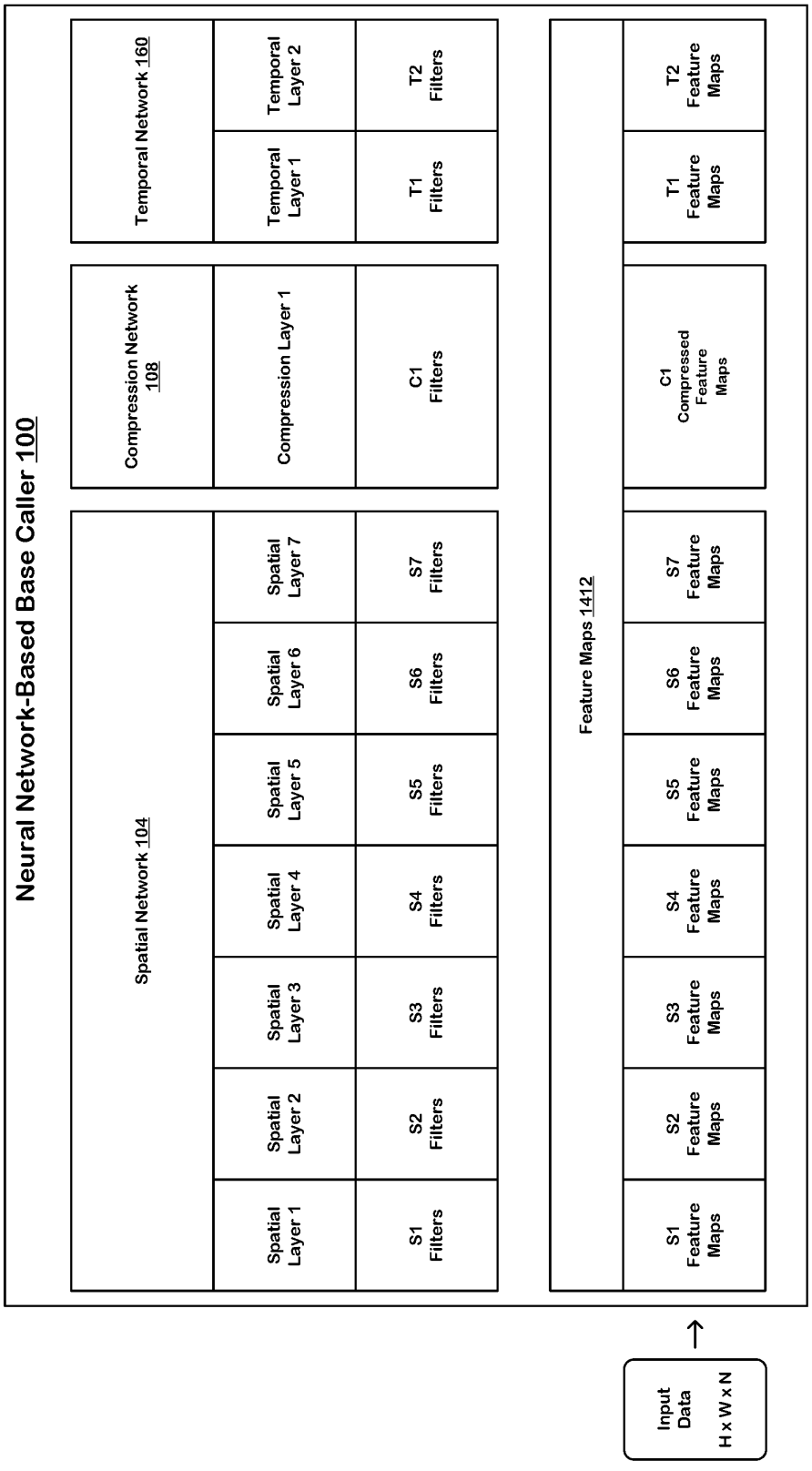
Neural Network-Based Base Caller 100
Spatial Network 104
Spatial Layer 1
Spatial Layer 2
Spatial Layer 3
Spatial Layer 4
Spatial Layer 5
Spatial Layer 6
Spatial Layer 7
S1 Filters
S2 Filters
S3 Filters
S4 Filters
S5 Filters
S6 Filters
S7 Filters
Compression Network 108
Compression Layer 1
C1 Filters
Temporal Network 160
Temporal Layer 1
Temporal Layer 2
T1 Filters
T2 Filters
Feature Maps 1412
S1 Feature Maps
S2 Feature Maps
S3 Feature Maps
S4 Feature Maps
S5 Feature Maps
S6 Feature Maps
S7 Feature Maps
C1 Compressed Feature Maps
T1 Feature Maps
T2 Feature Maps
Input Data
H x W x N
H = 64, 78, 115, 230
W = 64, 78, 115, 230
N = 1, 2, 3, 4
S1 = 7, 14, 21, 64, 128, 254
S2 = 7, 14, 21, 64, 128, 254
S3 = 7, 14, 21, 64, 128, 254
S4 = 7, 14, 21, 64, 128, 254
S5 = 7, 14, 21, 64, 128, 254
S6 = 7, 14, 21, 64, 128, 254
S7 = 7, 14, 21, 64, 128, 254
C1 = 1, 2, 3, 4, or more
T1 = 7, 14, 21, 64, 128, 254
T2 = 7, 14, 21, 64, 128, 254

Figure 14

Neural Network-Based Base Caller 100
Spatial Network 104
Spatial Layer 1
Spatial Layer 2
Spatial Layer 3
Spatial Layer 4
Spatial Layer 5
Spatial Layer 6
Spatial Layer 7
S1 Filters
S2 Filters
S3 Filters
S4 Filters
S5 Filters
S6 Filters
S7 Filters
Compression Network 108
Compression Layer 1
C1 Filters
Filtering Logic 502
Temporal Network 160
Temporal Layer 1
Temporal Layer 2
T1 Filters
T2 Filters
Feature Maps 1512
S1 Feature Maps
S2 Feature Maps
S3 Feature Maps
S4 Feature Maps
S5 Feature Maps
S6 Feature Maps
S7 Feature Maps
C1 Compressed Feature Maps
P1 x P2 x C1
F1 Compressed, Filtered Feature Maps
P3 x P4 x C1
T1 Filtered Feature Maps
T2 Filtered Feature Maps
Input Data
HxWxN
H = 64, 78, 115, 230
W = 64, 78, 115, 230
N = 1, 2, 3, 4
S1 = 7, 14, 21, 64, 128, 254
S2 = 7, 14, 21, 64, 128, 254
S3 = 7, 14, 21, 64, 128, 254
S4 = 7, 14, 21, 64, 128, 254
S5 = 7, 14, 21, 64, 128, 254
S6 = 7, 14, 21, 64, 128, 254
S7 = 7, 14, 21, 64, 128, 254
C1 = 1, 2, 3, 4, or more
P3 = 25% of P1
P2 = 25% of P4
T1 = 7, 14, 21, 64, 128, 254
T2 = 7, 14, 21, 64, 128, 254

Figure 15

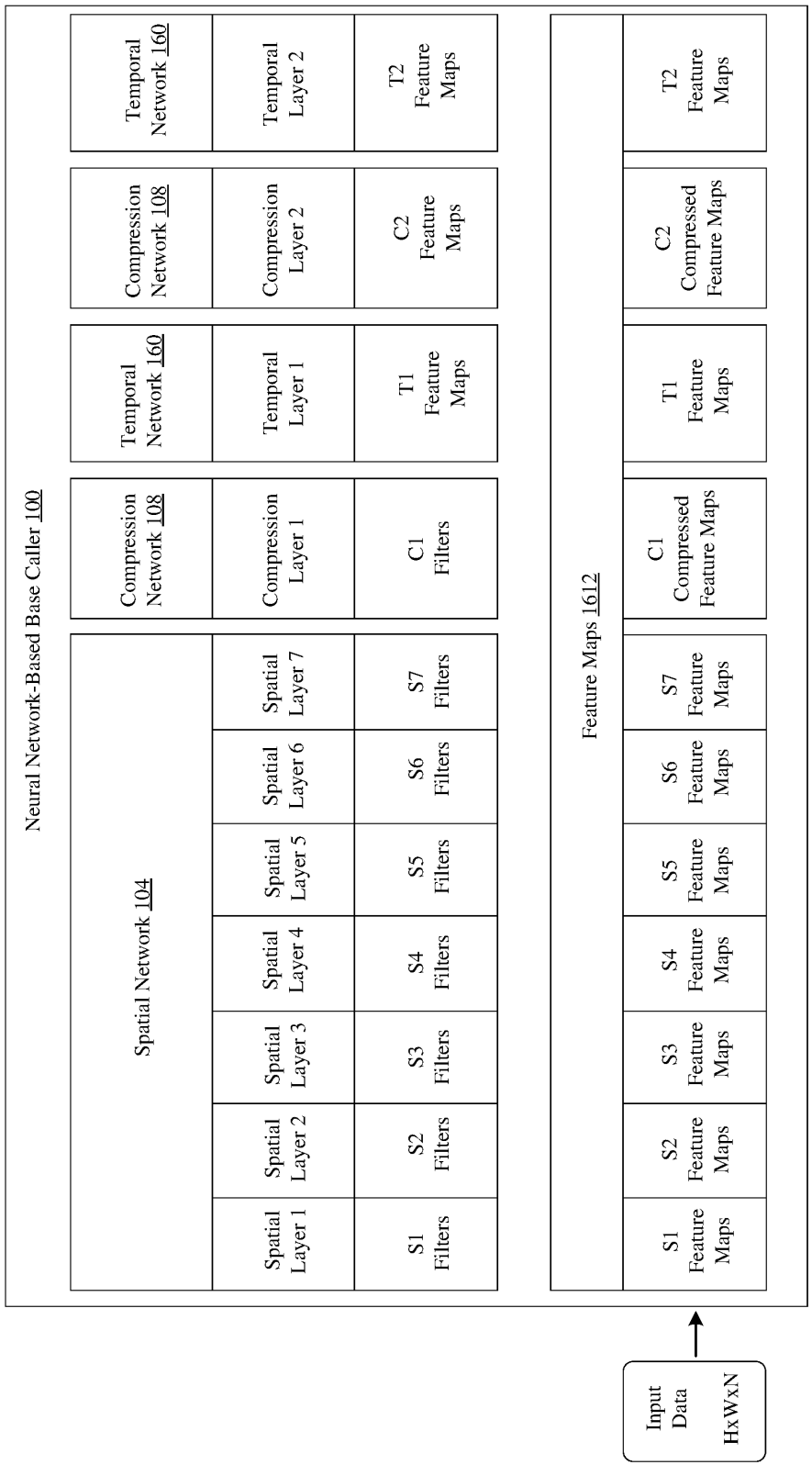
Neural Network-Based Base Caller 100
Spatial Network 104
Spatial Layer 1
Spatial Layer 2
Spatial Layer 3
Spatial Layer 4
Spatial Layer 5
Spatial Layer 6
Spatial Layer 7
S1 Filters
S2 Filters
S3 Filters
S4 Filters
S5 Filters
S6 Filters
S7 Filters
Compression Network 108
Compression Layer 1
C1 Filters
Temporal Network 160
Temporal Layer 1
T1 Feature Maps
Compression Network 108
Compression Layer 2
C2 Feature Maps
Temporal Network 160
Temporal Layer 2
T2 Feature Maps
Feature Maps 1612
S1 Feature Maps
S2 Feature Maps
S3 Feature Maps
S4 Feature Maps
S5 Feature Maps
S6 Feature Maps
S7 Feature Maps
C1 Compressed Feature Maps
T1 Feature Maps
C2 Compressed Feature Maps
T2 Feature Maps
Input Data
HxWxN
H = 64, 78, 115, 230
W = 64, 78, 115, 230
N = 1, 2, 3, 4
S1 = 7, 14, 21, 64, 128, 254
S2 = 7, 14, 21, 64, 128, 254
S3 = 7, 14, 21, 64, 128, 254
S4 = 7, 14, 21, 64, 128, 254
S5 = 7, 14, 21, 64, 128, 254
S6 = 7, 14, 21, 64, 128, 254
S7 = 7, 14, 21, 64, 128, 254
C1 = 1, 2, 3, 4, or more
C2 = 1, 2, 3, 4, or more
T1 = 7, 14, 21, 64, 128, 254
T2 = 1, 2, 3, 4

Figure 16

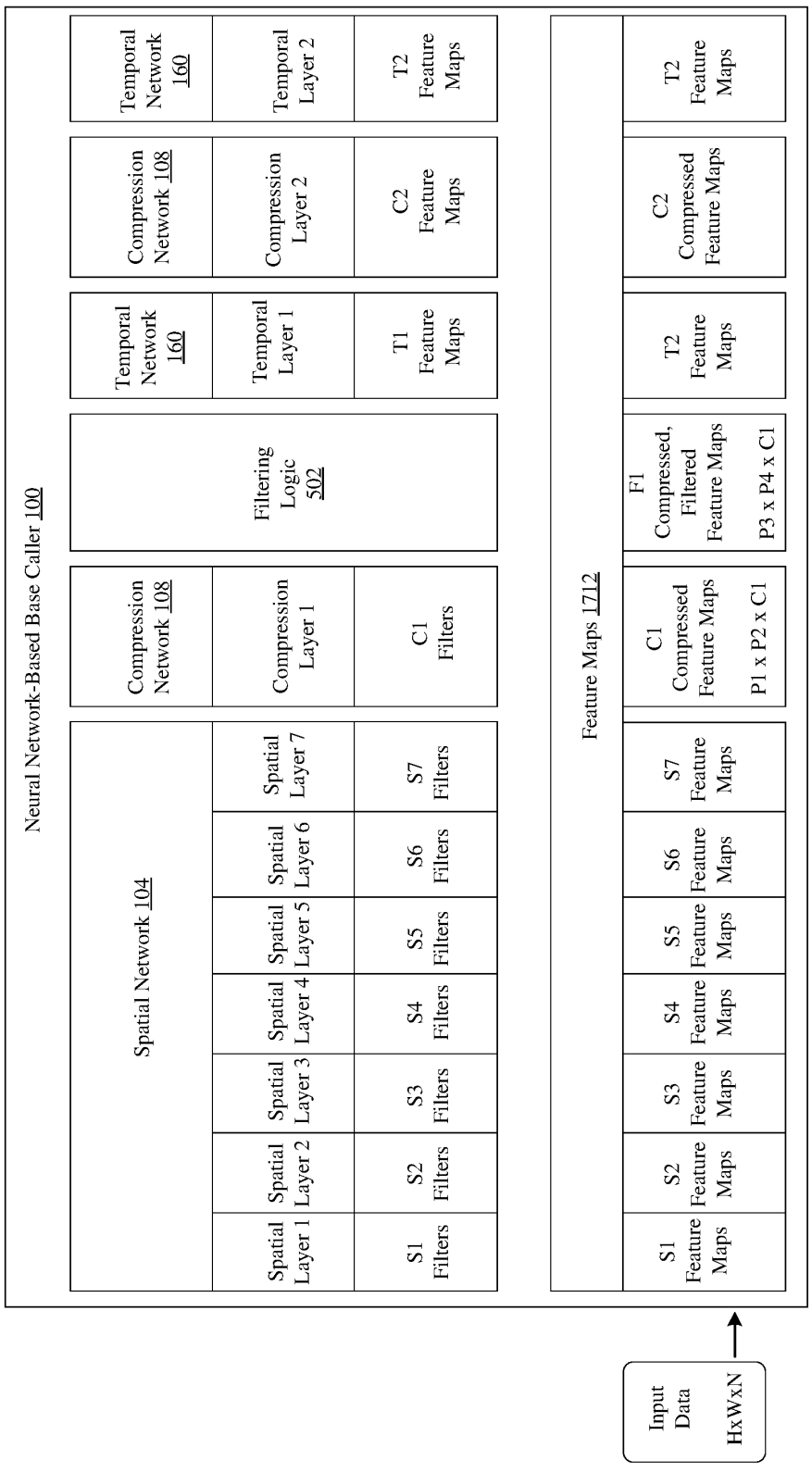
Neural Network-Based Base Caller 100
Spatial Network 104
Spatial Layer 1
Spatial Layer 2
Spatial Layer 3
Spatial Layer 4
Spatial Layer 5
Spatial Layer 6
Spatial Layer 7
S1 Filters
S2 Filters
S3 Filters
S4 Filters
S5 Filters
S6 Filters
S7 Filters
Compression Network 108
Compression Layer 1
C1 Filters
Filtering Logic 502
Temporal Network 160
Temporal Layer 1
T1 Feature Maps
Compression Network 108
Compression Layer 2
C2 Feature Maps
Temporal Network 160
Temporal Layer 2
T2 Feature Maps
Feature Maps 1712
S1 Feature Maps
S2 Feature Maps
S3 Feature Maps
S4 Feature Maps
S5 Feature Maps
S6 Feature Maps
S7 Feature Maps
C1 Compressed Feature Maps
P1 x P2 x C1
F1 Compressed, Filtered Feature Maps
P3 x P4 x C1
T2 Feature Maps
C2 Compressed Feature Maps
T2 Feature Maps
Input Data
HxWxN
H = 64, 78, 115, 230
W = 64, 78, 115, 230
N = 1, 2, 3, 4
S1 = 7, 14, 21, 64, 128, 254
S2 = 7, 14, 21, 64, 128, 254
S3 = 7, 14, 21, 64, 128, 254
S4 = 7, 14, 21, 64, 128, 254
S5 = 7, 14, 21, 64, 128, 254
S6 = 7, 14, 21, 64, 128, 254
S7 = 7, 14, 21, 64, 128, 254
C1 = 1, 2, 3, 4, or more
C2 = 1, 2, 3, 4, or more
P3 = 25% of P1
P2 = 25% of P4
T1 = 7, 14, 21, 64, 128, 254
T2 = 1, 2, 3, 4

Figure 17

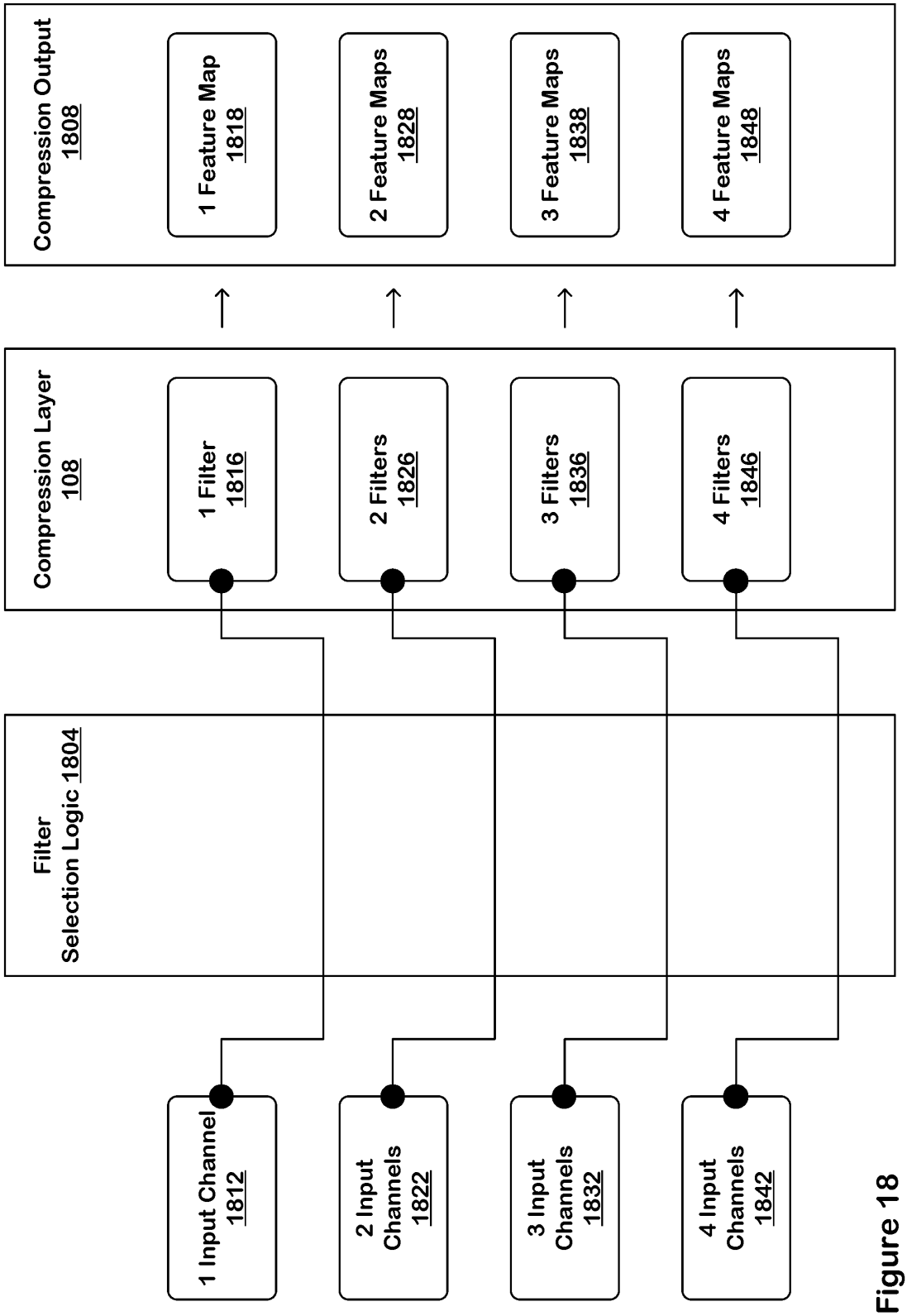
Compression Output 1808
1 Feature Map 1818
2 Feature Maps 1828
3 Feature Maps 1838
4 Feature Maps 1848
Compression Layer 108
1 Filter 1816
2 Filters 1826
3 Filters 1836
4 Filters 1846
Filter Selection Logic 1804
1 Input Channel 1812
2 Input Channels 1822
3 Input Channels 1832
4 Input Channels 1842

Figure 18

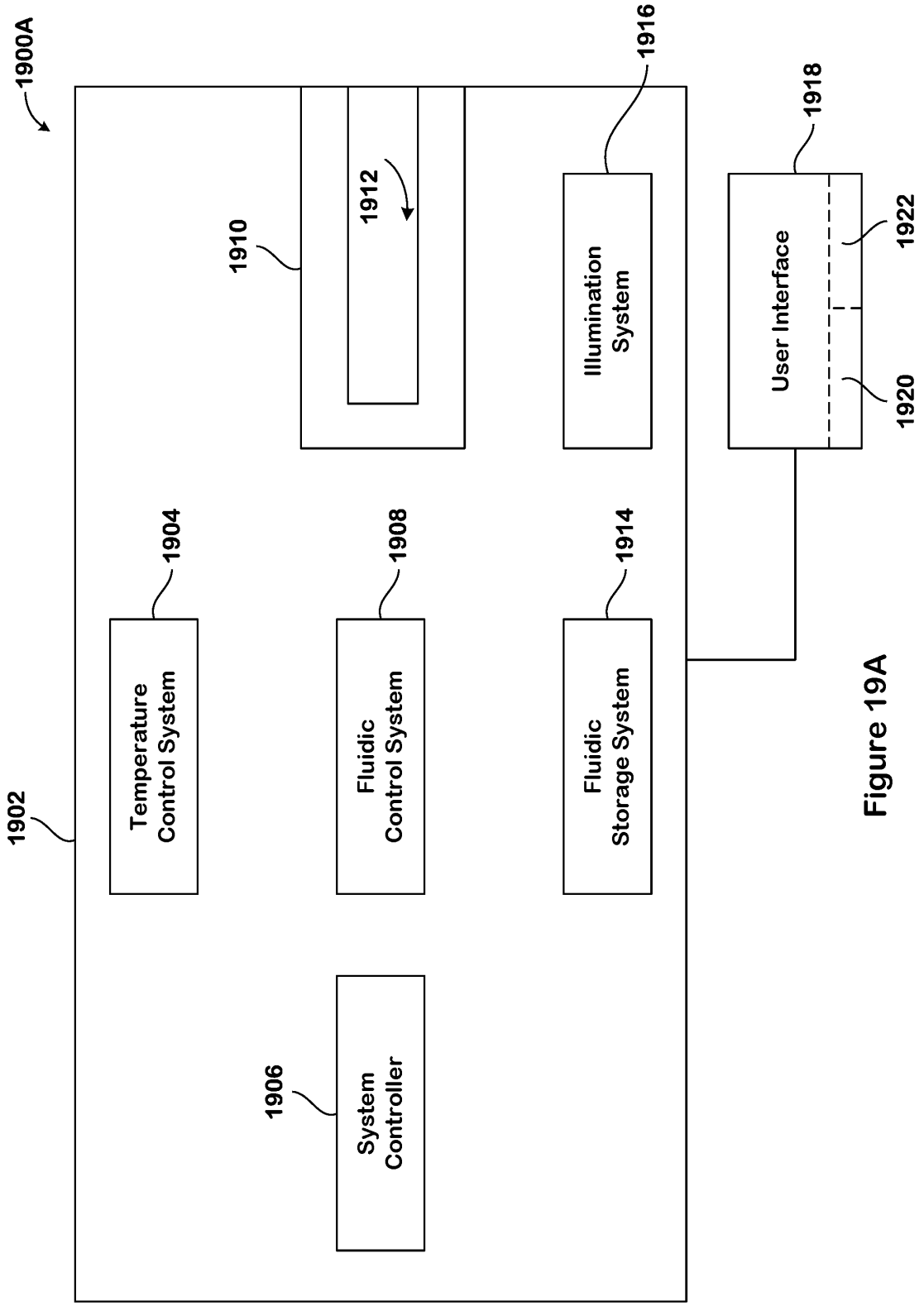
1900A
1902
1904
Temperature Control System
1906
System Controller
1908
Fluidic Control System
1910
1912
1914
Fluidic Storage System
1916
Illumination System
1918
User Interface
1920
1922

Figure 19A

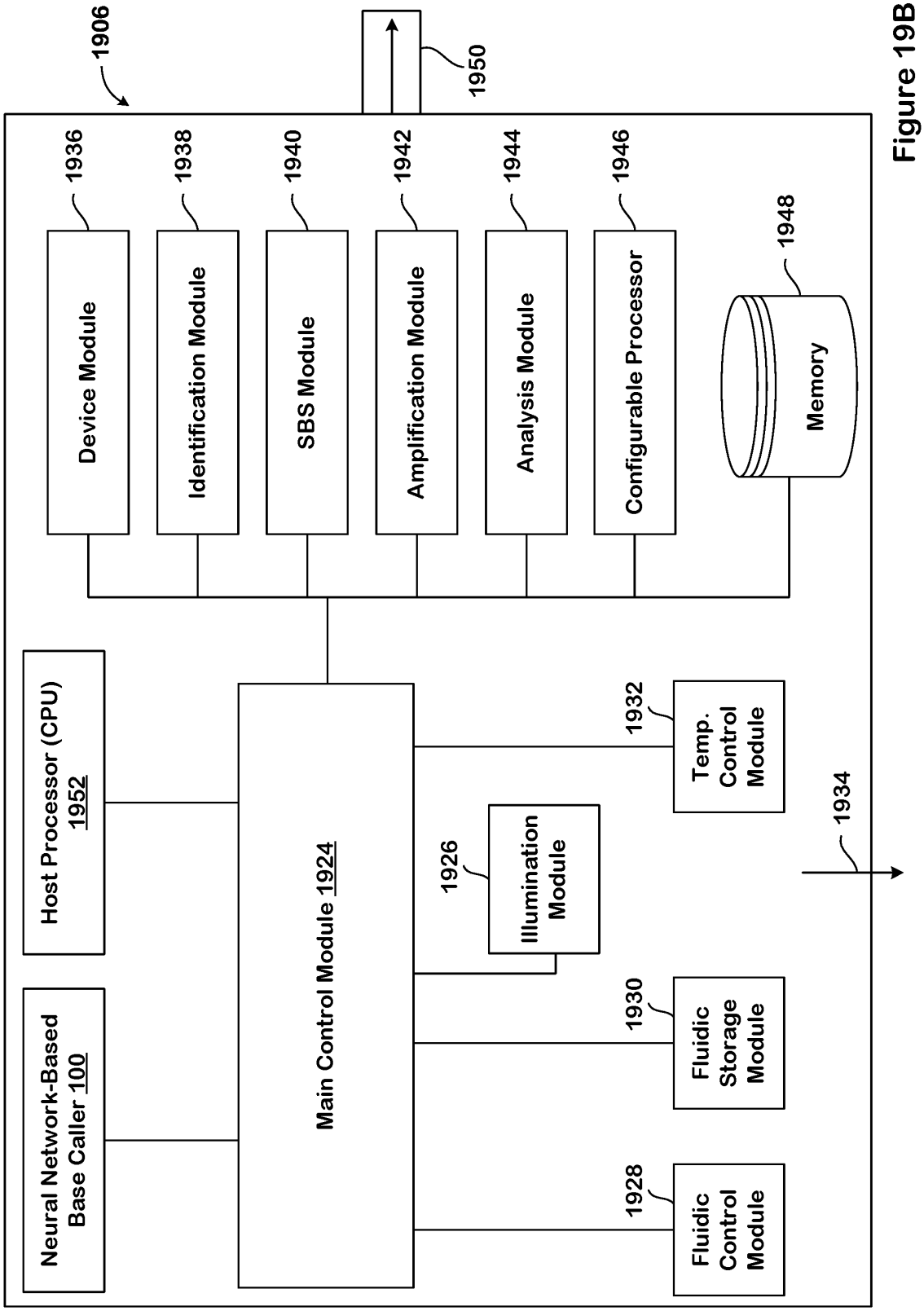
1906
1950
1936
1938
1940
1942
1944
1946
1948
Device Module
Identification Module
SBS Module
Amplification Module
Analysis Module
Configurable Processor
Memory
Host Processor (CPU) 1952
Main Control Module 1924
Neural Network-Based Base Caller 100
1932
Temp. Control Module
1926
Illumination Module
1930
Fluidic Storage Module
1928
Fluidic Control Module
1934

Figure 19B

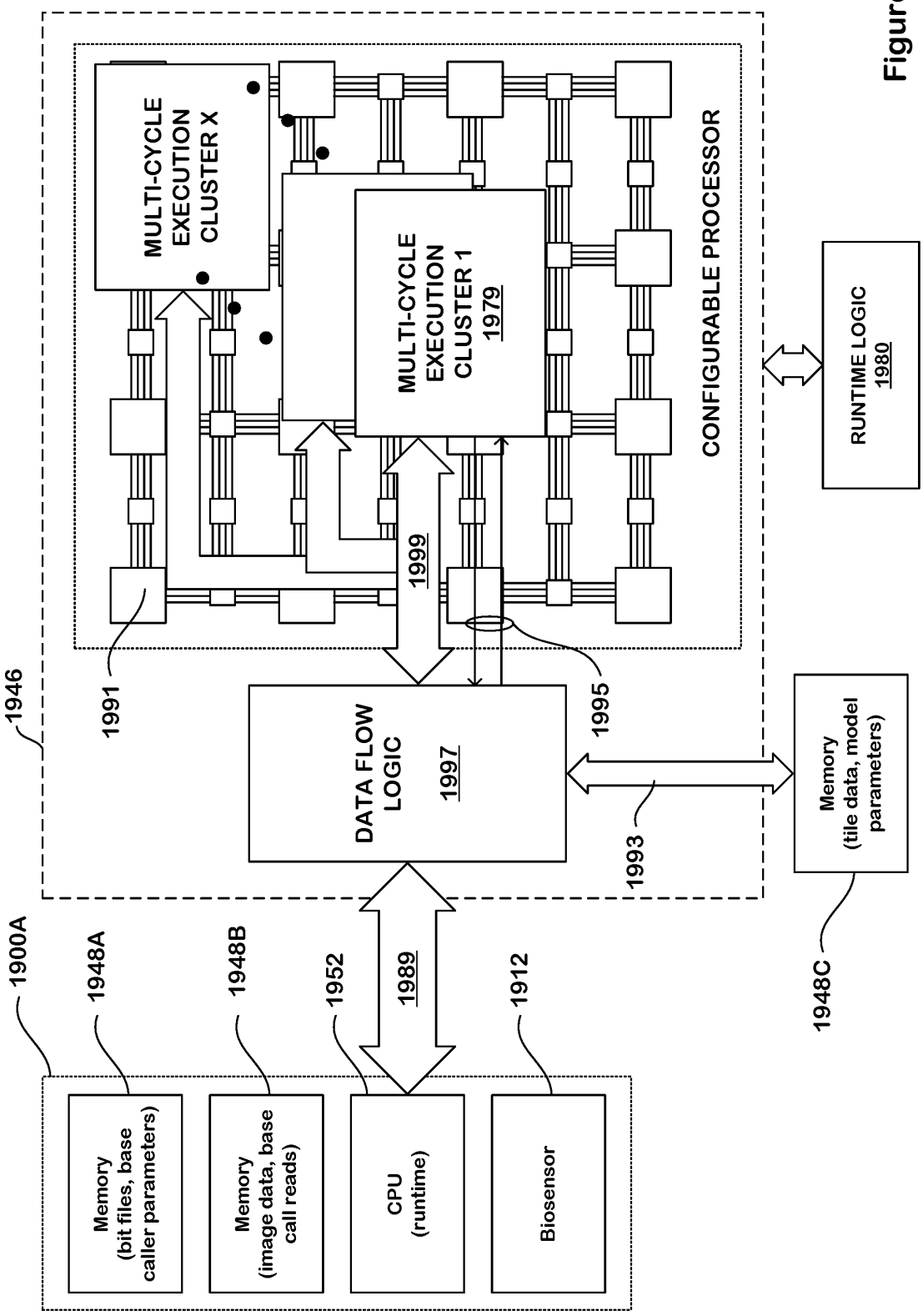
1900A
1948A
1948B
1952
1989
1912
1946
1991
1999
1995
1993
1948C
Memory (bit files, base caller parameters)
Memory (image data, base call reads)
CPU (runtime)
Biosensor
MULTI-CYCLE EXECUTION CLUSTER X
MULTI-CYCLE EXECUTION CLUSTER 1 1979
CONFIGURABLE PROCESSOR
DATA FLOW LOGIC 1997
RUNTIME LOGIC 1980
Memory (tile data, model parameters)

Figure 19C

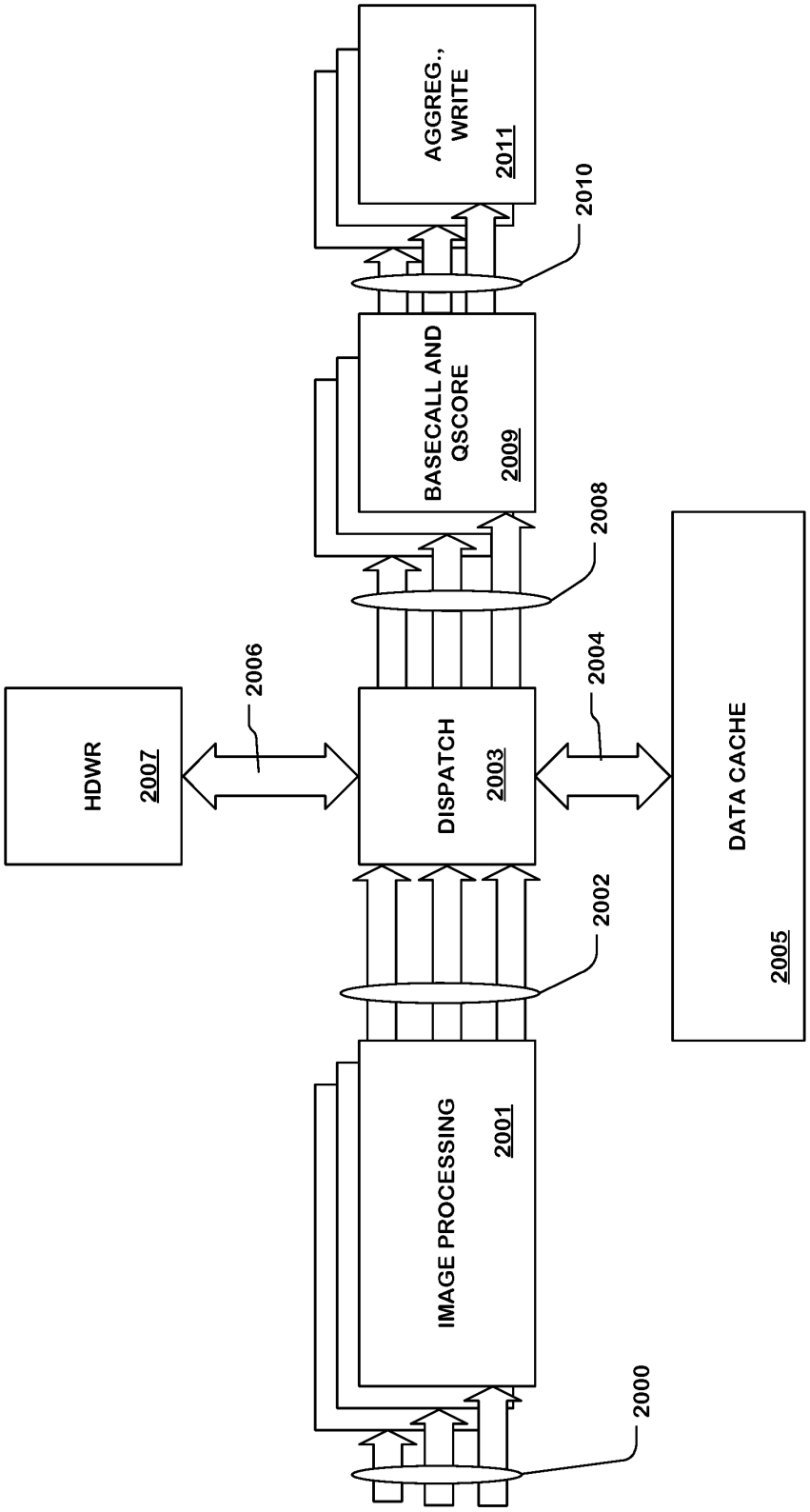
AGGREG., WRITE
2011
2010
BASECALL AND QSCORE
2009
2008
HDWR
2007
2006
DISPATCH
2003
2004
DATA CACHE
2005
2002
IMAGE PROCESSING
2001
2000

Figure 20A

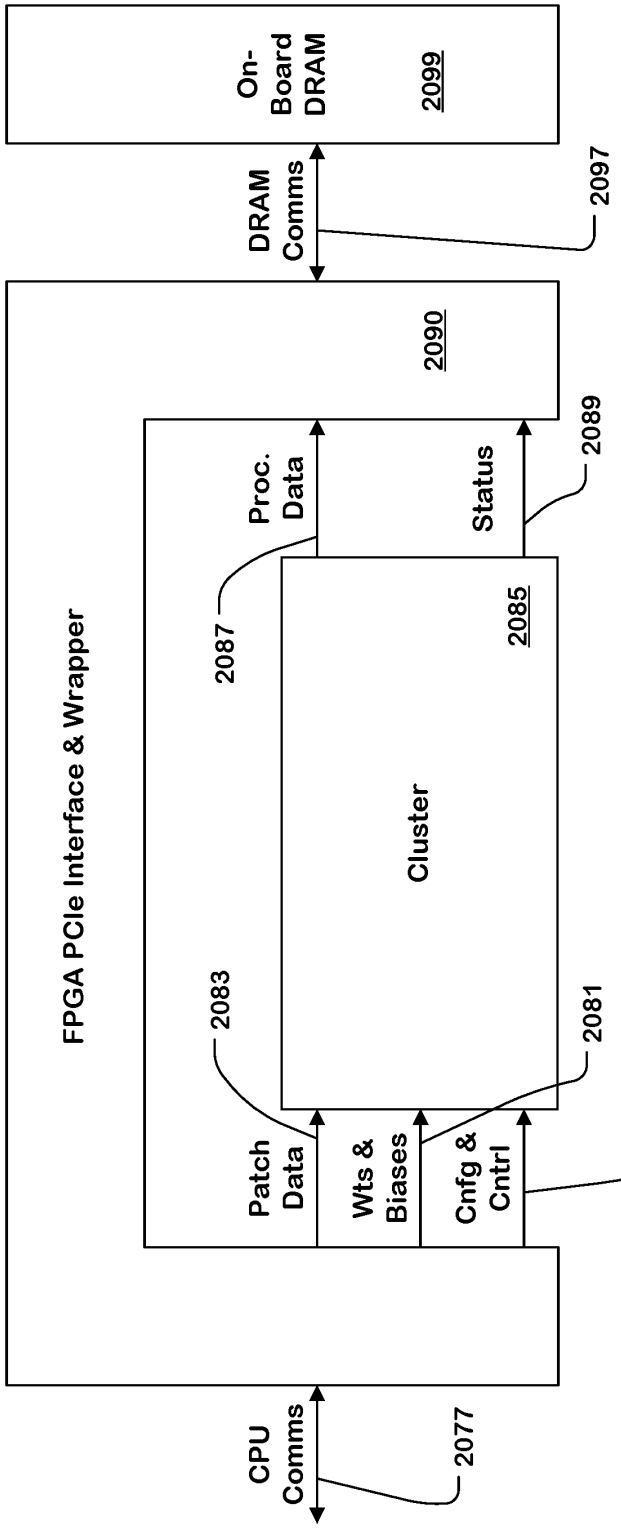
On-Board DRAM
2099
DRAM Comms
2097
FPGA PCIe Interface & Wrapper
2090
Proc. Data
Status
2089
2087
2085
Cluster
2083
2081
Patch Data
Wts & Biases
Cnfg & Cntrl
2079
CPU Comms
2077

Figure 20B

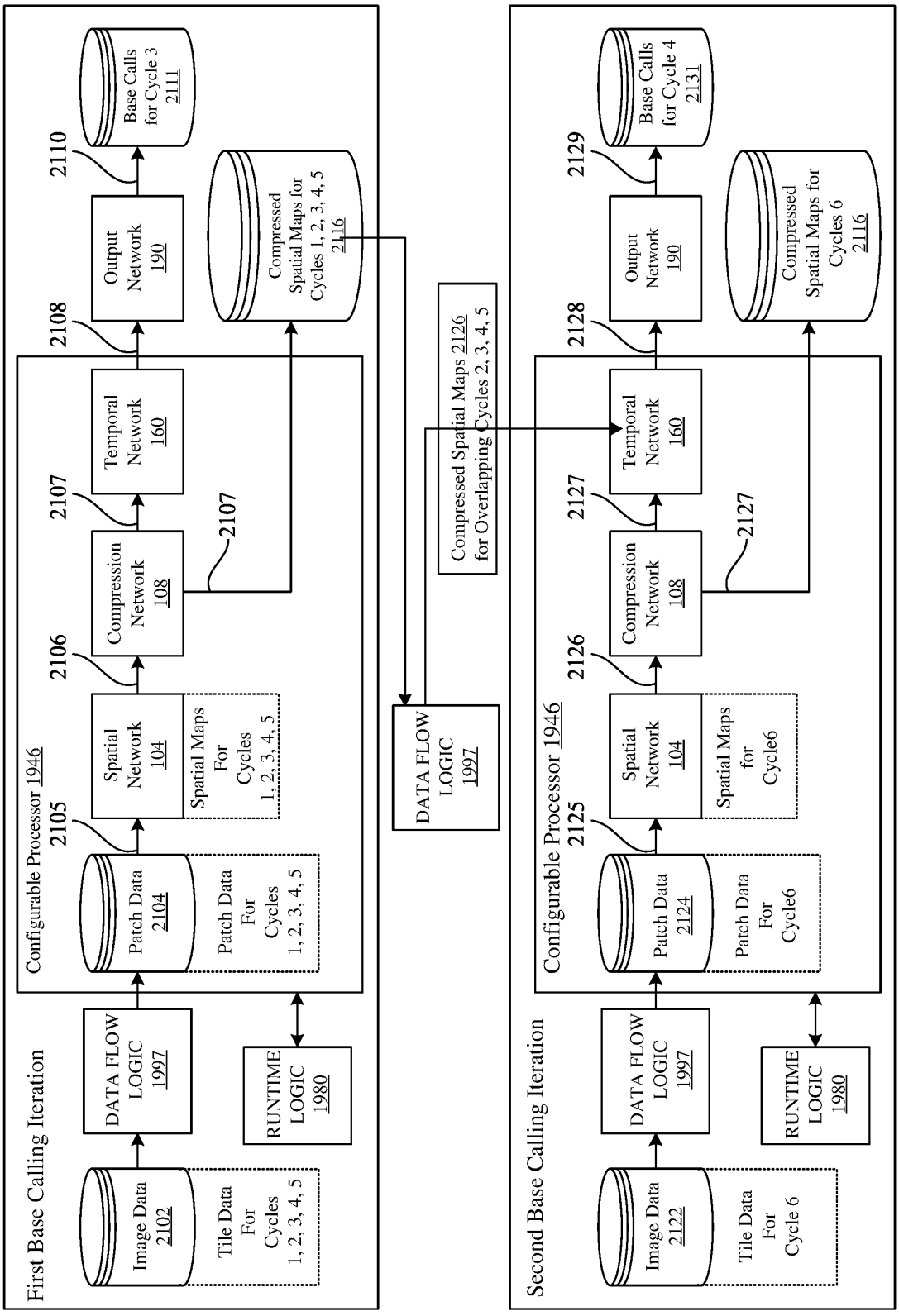
First Base Calling Iteration
Image Data 2102
Tile Data For Cycles 1, 2, 3, 4, 5
DATA FLOW LOGIC 1997
RUNTIME LOGIC 1980
Configurable Processor 1946
2105
Patch Data 2104
Patch Data For Cycles 1, 2, 3, 4, 5
2106
Spatial Network 104
Spatial Maps For Cycles 1, 2, 3, 4, 5
2107
Compression Network 108
2107
2107
Temporal Network 160
2108
Output Network 190
2110
Base Calls for Cycle 3 2111
Compressed Spatial Maps for Cycles 1, 2, 3, 4, 5 2116
DATA FLOW LOGIC 1997
Compressed Spatial Maps 2126 for Overlapping Cycles 2, 3, 4, 5
Second Base Calling Iteration
Image Data 2122
Tile Data For Cycle 6
DATA FLOW LOGIC 1997
RUNTIME LOGIC 1980
Configurable Processor 1946
2125
Patch Data 2124
Patch Data For Cycle6
2126
Spatial Network 104
Spatial Maps for Cycle6
2127
Compression Network 108
2127
2127
Temporal Network 160
2128
Output Network 190
2129
Base Calls for Cycle 4 2131
Compressed Spatial Maps for Cycles 6 2116

Figure 21

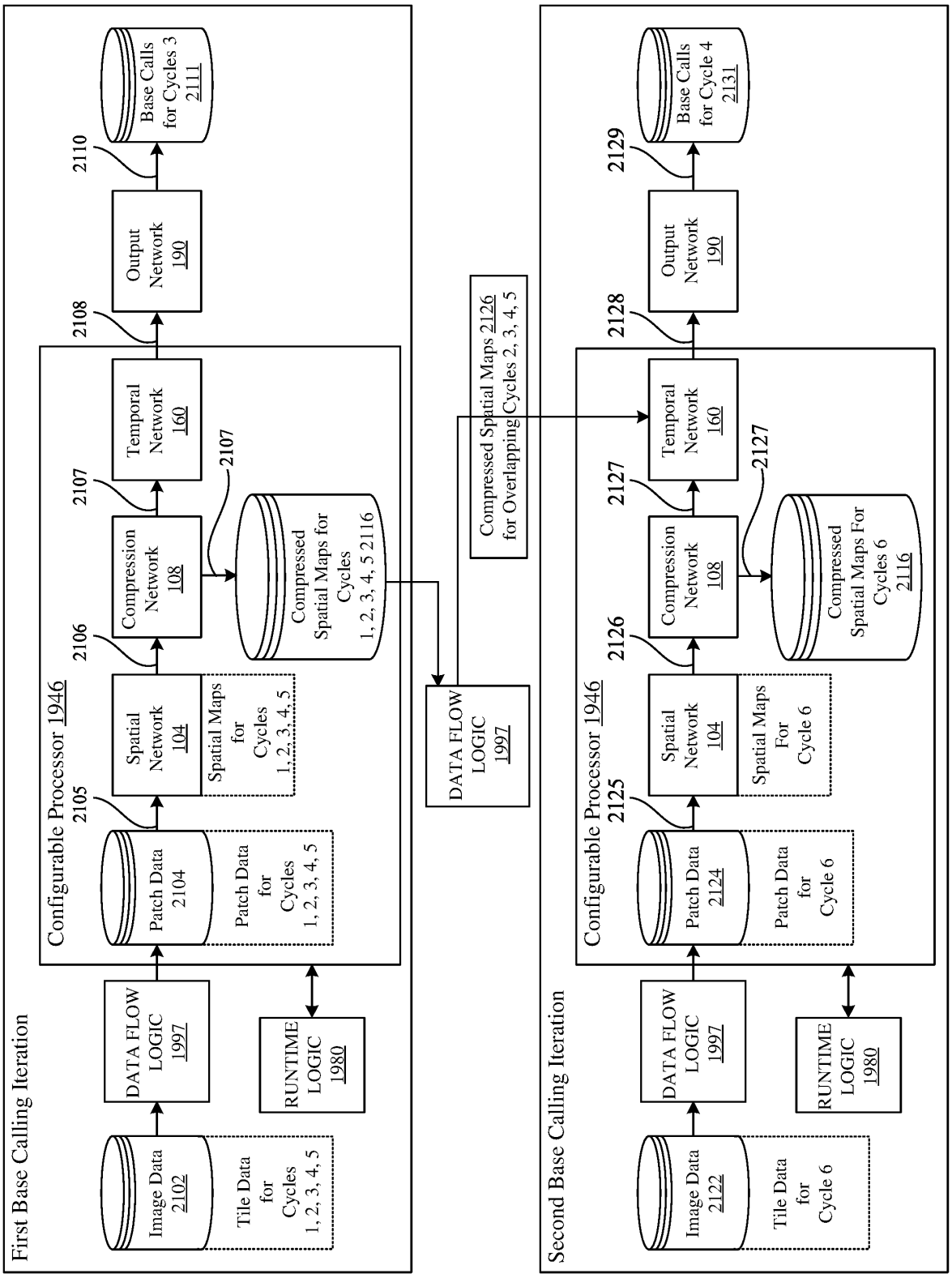
First Base Calling Iteration
Image Data 2102
Tile Data for Cycles 1, 2, 3, 4, 5
DATA FLOW LOGIC 1997
RUNTIME LOGIC 1980
Configurable Processor 1946
2105
Patch Data 2104
Patch Data for Cycles 1, 2, 3, 4, 5
2106
Spatial Network 104
Spatial Maps for Cycles 1, 2, 3, 4, 5
2107
Compression Network 108
Compressed Spatial Maps for Cycles 1, 2, 3, 4, 5 2116
2108
Temporal Network 160
2110
Output Network 190
Base Calls for Cycles 3 2111
DATA FLOW LOGIC 1997
Compressed Spatial Maps 2126 for Overlapping Cycles 2, 3, 4, 5
Second Base Calling Iteration
Image Data 2122
Tile Data for Cycle 6
DATA FLOW LOGIC 1997
RUNTIME LOGIC 1980
Configurable Processor 1946
2125
Patch Data 2124
Patch Data for Cycle 6
2126
Spatial Network 104
Spatial Maps For Cycle 6
2127
Compression Network 108
Compressed Spatial Maps For Cycles 6 2116
2128
Temporal Network 160
2129
Output Network 190
Base Calls for Cycle 4 2131

Figure 22

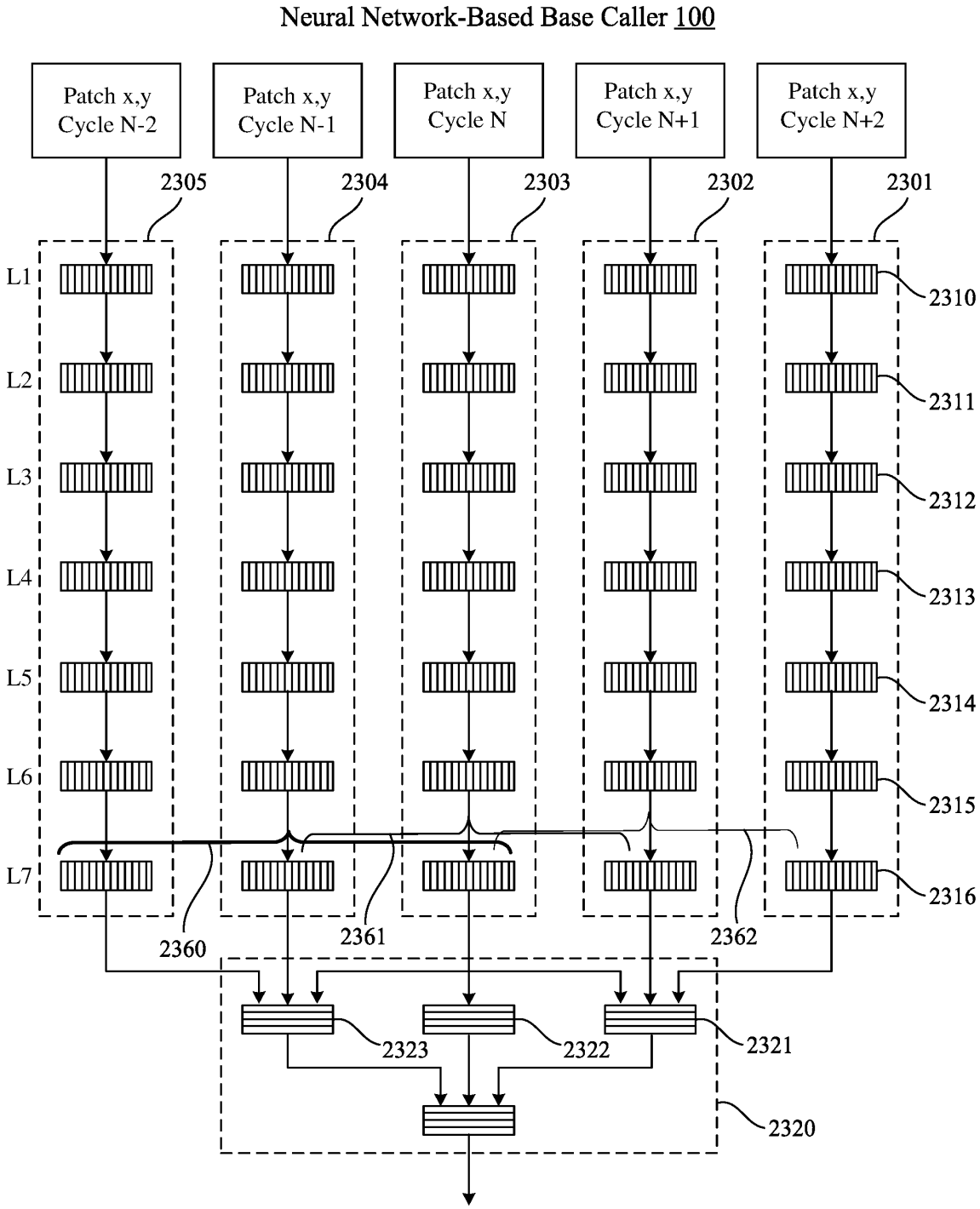
Neural Network-Based Base Caller 100
Patch x,y Cycle N-2
Patch x,y Cycle N-1
Patch x,y Cycle N
Patch x,y Cycle N+1
Patch x,y Cycle N+2
2305
2304
2303
2302
2301
L1
L2
L3
L4
L5
L6
L7
2310
2311
2312
2313
2314
2315
2316
2360
2361
2362
2323
2322
2321
2320

Figure 23

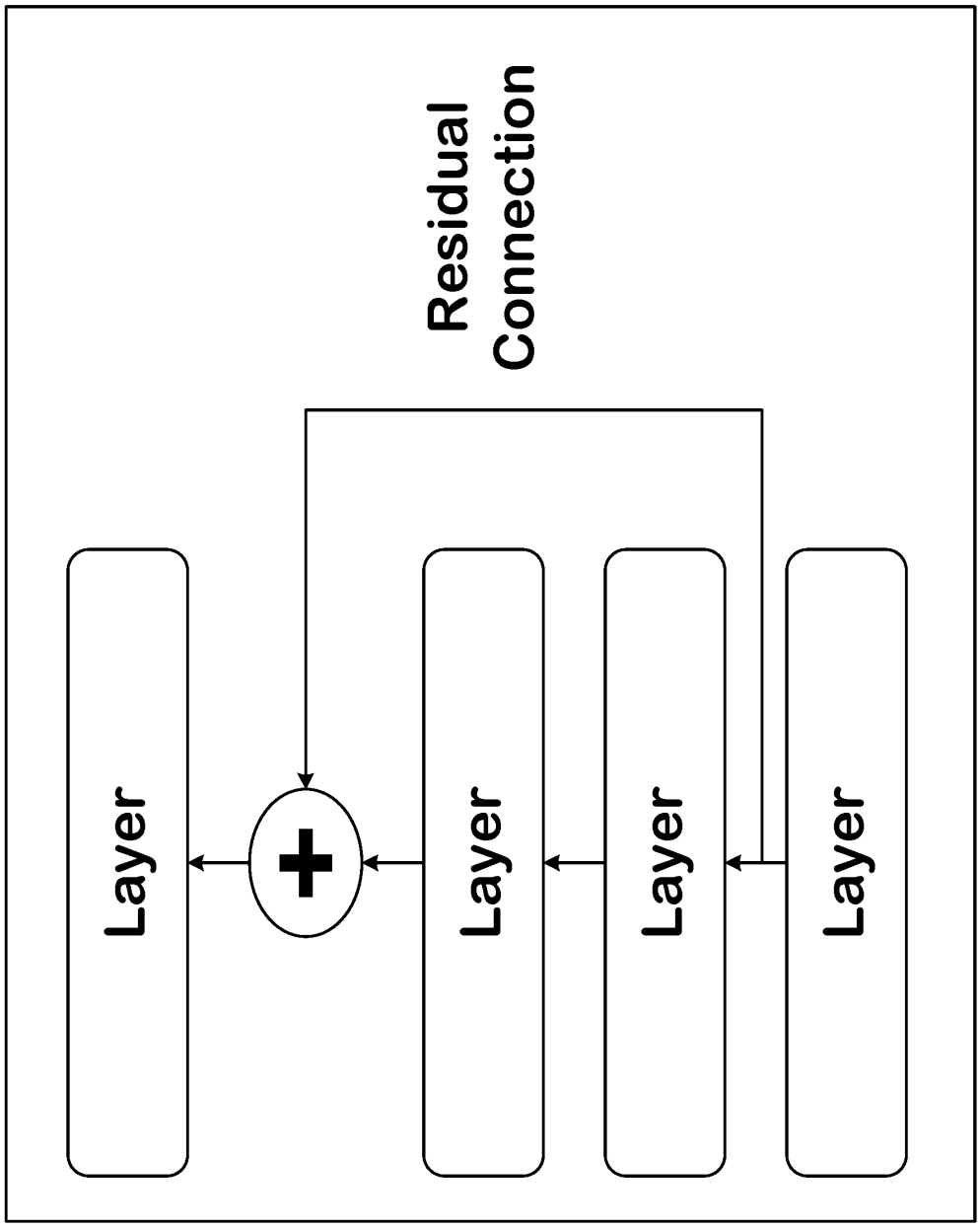

Figure 24A

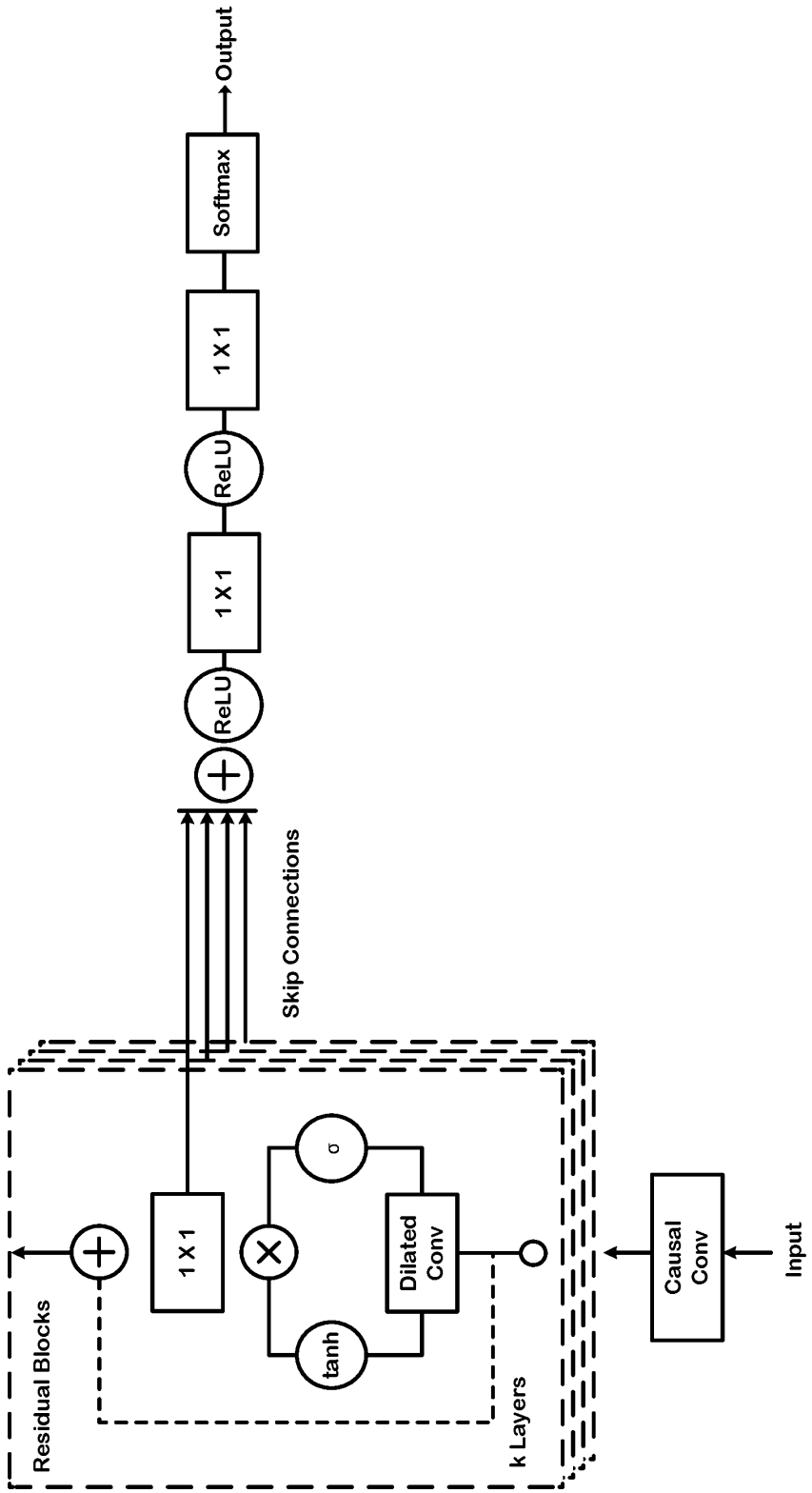
Output
Softmax
1 X 1
ReLU
1 X 1
ReLU
Skip Connections
Residual Blocks
1 X 1
σ
tanh
Dilated Conv
Causal Conv
Input
k Layers

Figure 24B

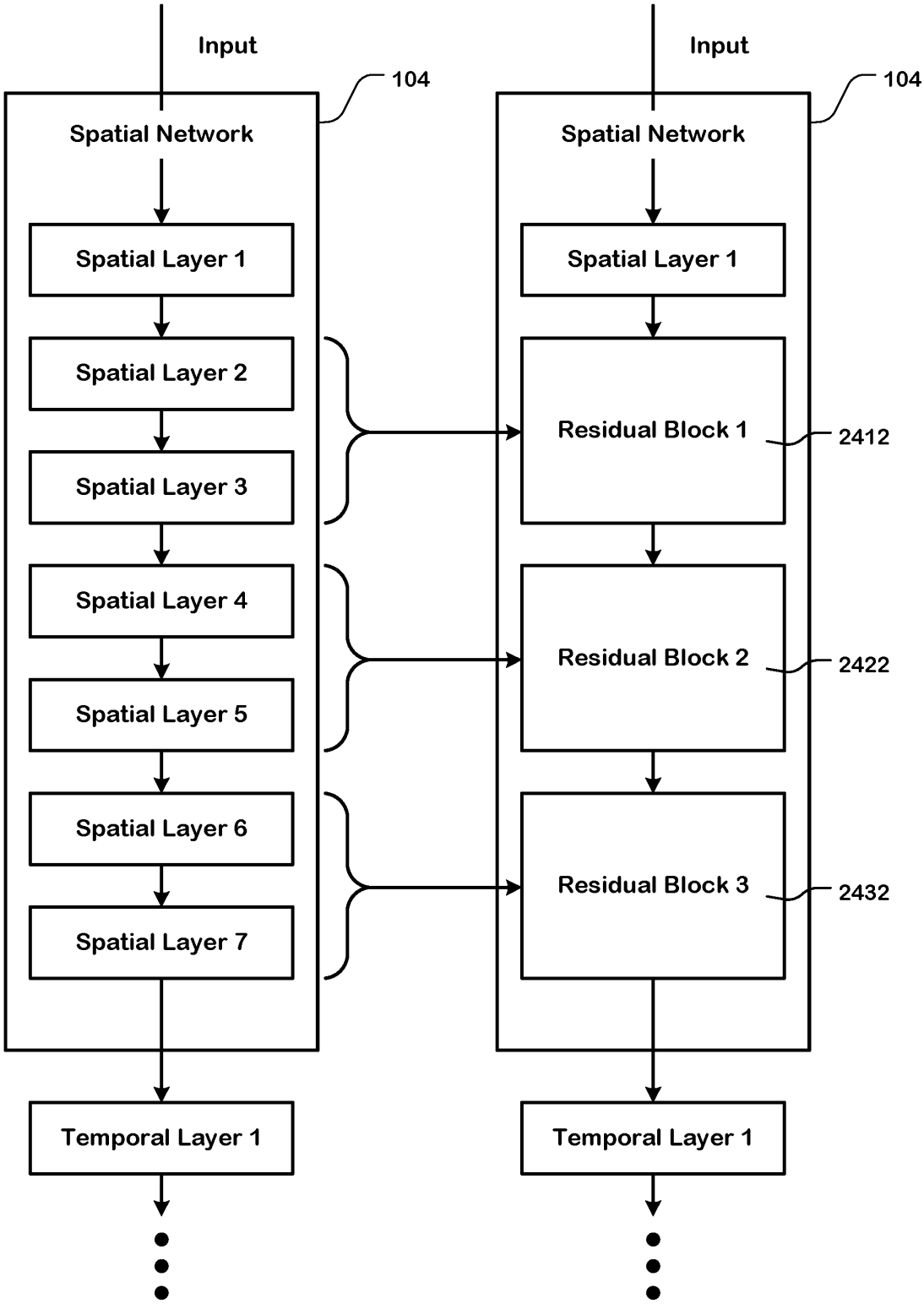
Input
104
Spatial Network
Spatial Layer 1
Spatial Layer 2
Spatial Layer 3
Spatial Layer 4
Spatial Layer 5
Spatial Layer 6
Spatial Layer 7
Temporal Layer 1
Input
104
Spatial Network
Spatial Layer 1
Residual Block 1
2412
Residual Block 2
2422
Residual Block 3
2432
Temporal Layer 1

Figure 24C

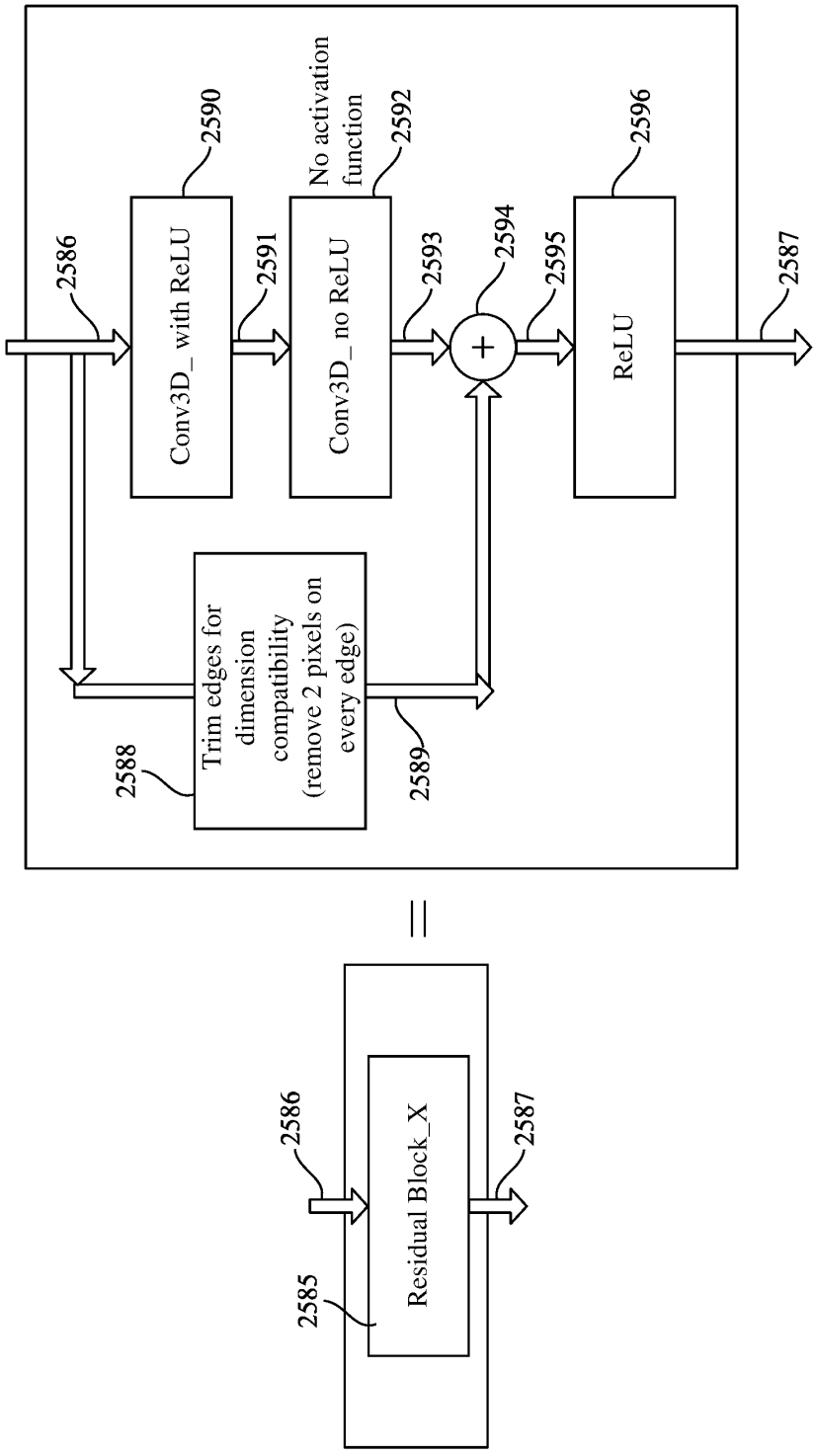
2586
Conv3D_ with ReLU
2590
2591
No activation function
Conv3D_ no ReLU
2592
2593
2594
2595
ReLU
2596
2587
Trim edges for dimension compatibility (remove 2 pixels on every edge)
2588
2589
=
2586
Residual Block_X
2587
2585

Figure 25A

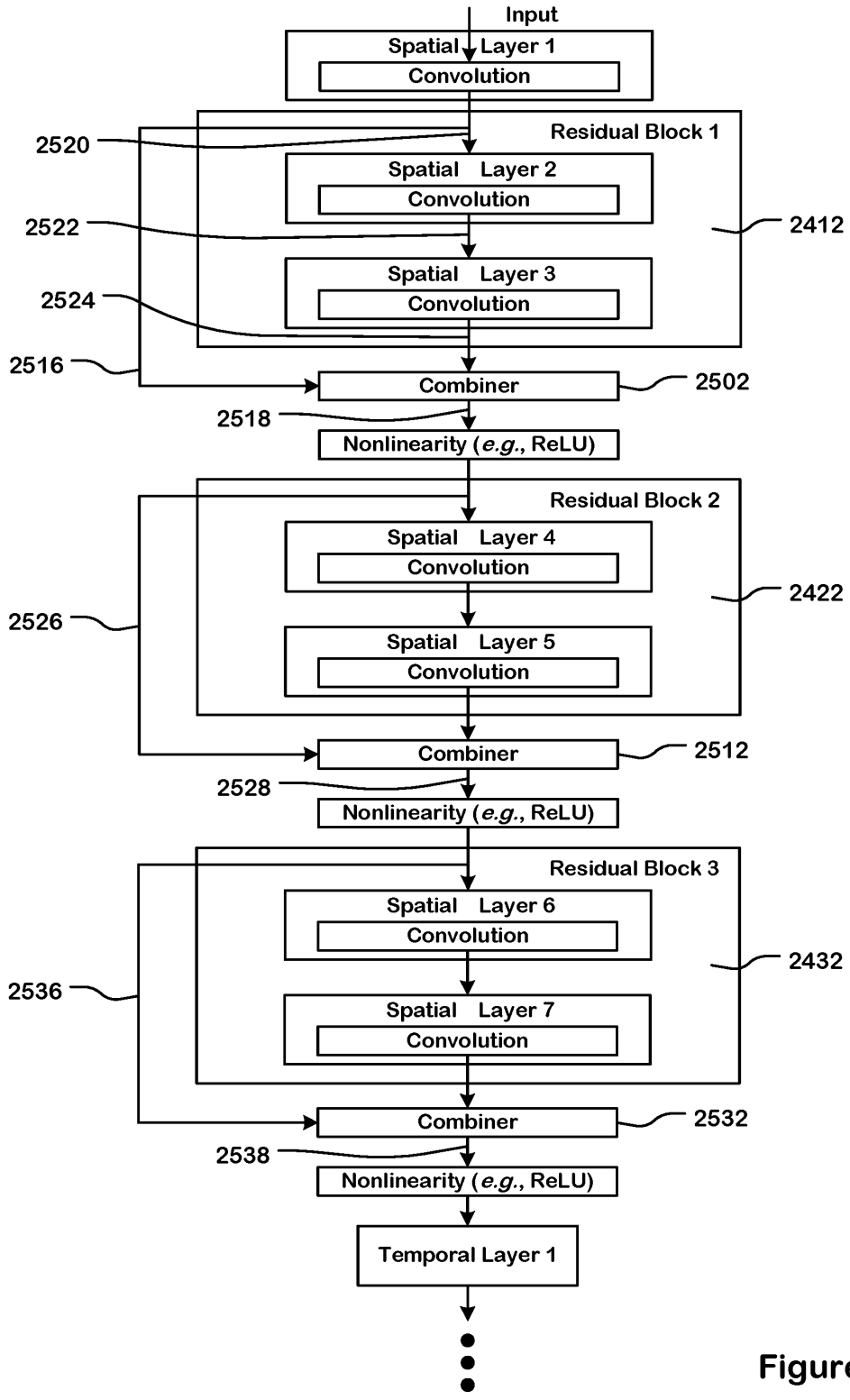
104
Input
Spatial Layer 1
Convolution
Residual Block 1
2520
Spatial Layer 2
Convolution
2522
2412
Spatial Layer 3
Convolution
2524
2516
Combiner
2502
2518
Nonlinearity (e.g., ReLU)
Residual Block 2
Spatial Layer 4
Convolution
2422
2526
Spatial Layer 5
Convolution
Combiner
2512
2528
Nonlinearity (e.g., ReLU)
Residual Block 3
Spatial Layer 6
Convolution
2432
2536
Spatial Layer 7
Convolution
Combiner
2532
2538
Nonlinearity (e.g., ReLU)
Temporal Layer 1

Figure 25B

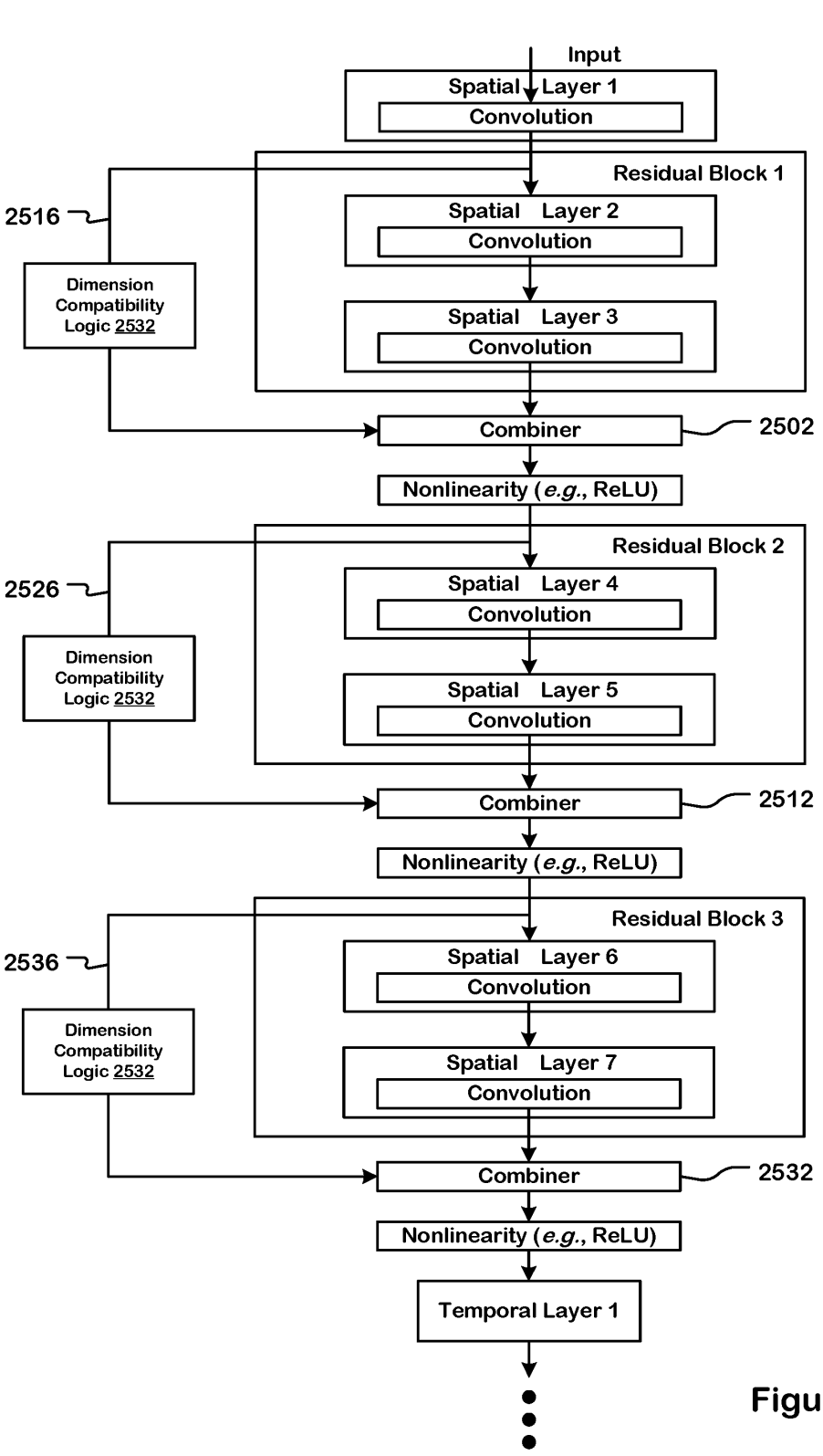
104
Input
Spatial Layer 1
Convolution
Residual Block 1
2516
Spatial Layer 2
Convolution
Dimension Compatibility Logic 2532
Spatial Layer 3
Convolution
Combiner
2502
Nonlinearity (e.g., ReLU)
Residual Block 2
2526
Spatial Layer 4
Convolution
Dimension Compatibility Logic 2532
Spatial Layer 5
Convolution
Combiner
2512
Nonlinearity (e.g., ReLU)
Residual Block 3
2536
Spatial Layer 6
Convolution
Dimension Compatibility Logic 2532
Spatial Layer 7
Convolution
Combiner
2532
Nonlinearity (e.g., ReLU)
Temporal Layer 1

Figure 25C

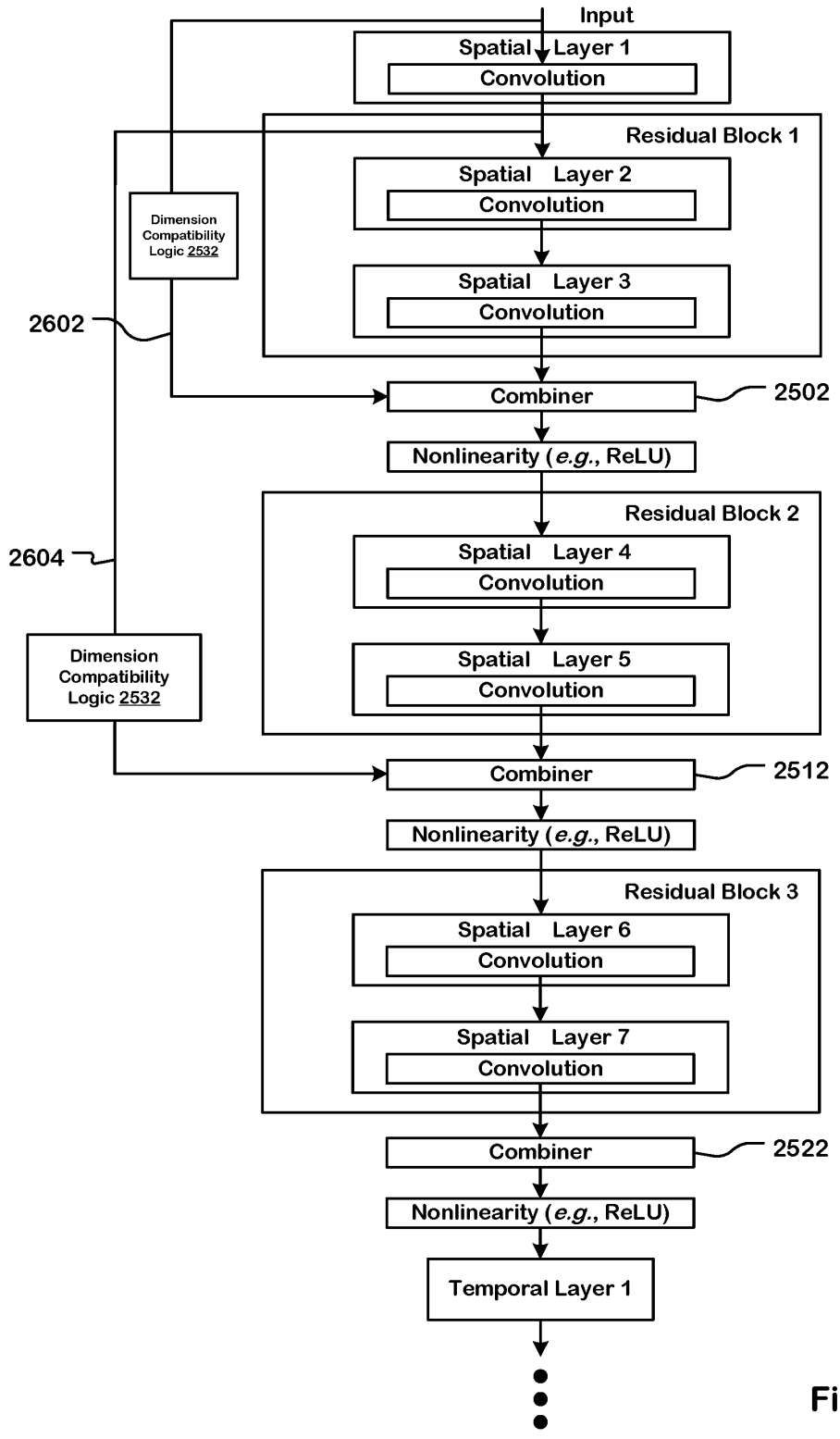
104
Input
Spatial Layer 1
Convolution
Residual Block 1
Spatial Layer 2
Convolution
Spatial Layer 3
Convolution
Dimension Compatibility Logic 2532
2602
Combiner
2502
Nonlinearity (e.g., ReLU)
Residual Block 2
Spatial Layer 4
Convolution
Spatial Layer 5
Convolution
2604
Dimension Compatibility Logic 2532
Combiner
2512
Nonlinearity (e.g., ReLU)
Residual Block 3
Spatial Layer 6
Convolution
Spatial Layer 7
Convolution
Combiner
2522
Nonlinearity (e.g., ReLU)
Temporal Layer 1

Figure 26

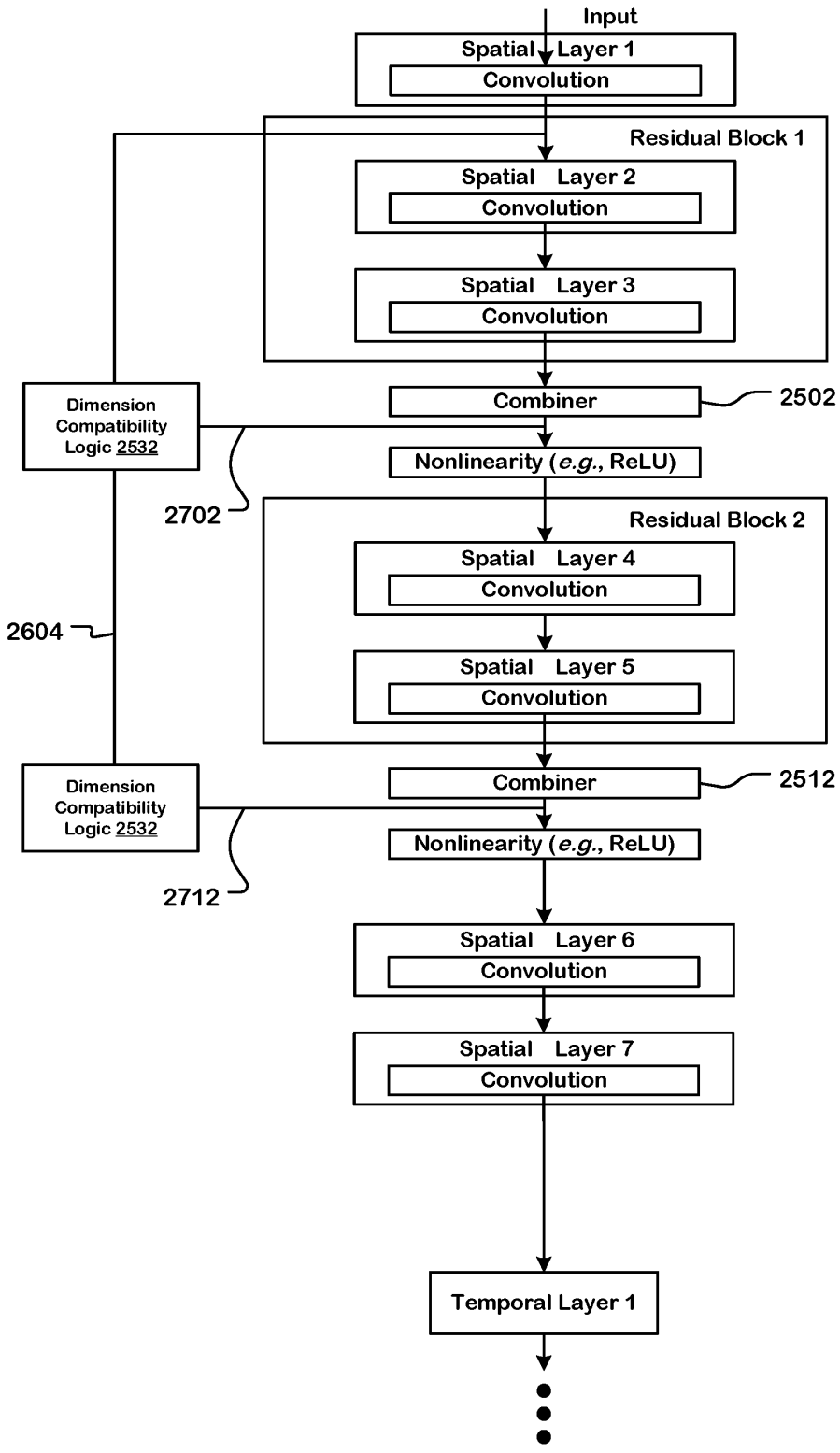
Input
104
Spatial Layer 1
Convolution
Residual Block 1
Spatial Layer 2
Convolution
Spatial Layer 3
Convolution
Combiner
2502
Dimension Compatibility Logic 2532
Nonlinearity (e.g., ReLU)
2702
Residual Block 2
Spatial Layer 4
Convolution
2604
Spatial Layer 5
Convolution
Combiner
2512
Dimension Compatibility Logic 2532
Nonlinearity (e.g., ReLU)
2712
Spatial Layer 6
Convolution
Spatial Layer 7
Convolution
Temporal Layer 1

Figure 27

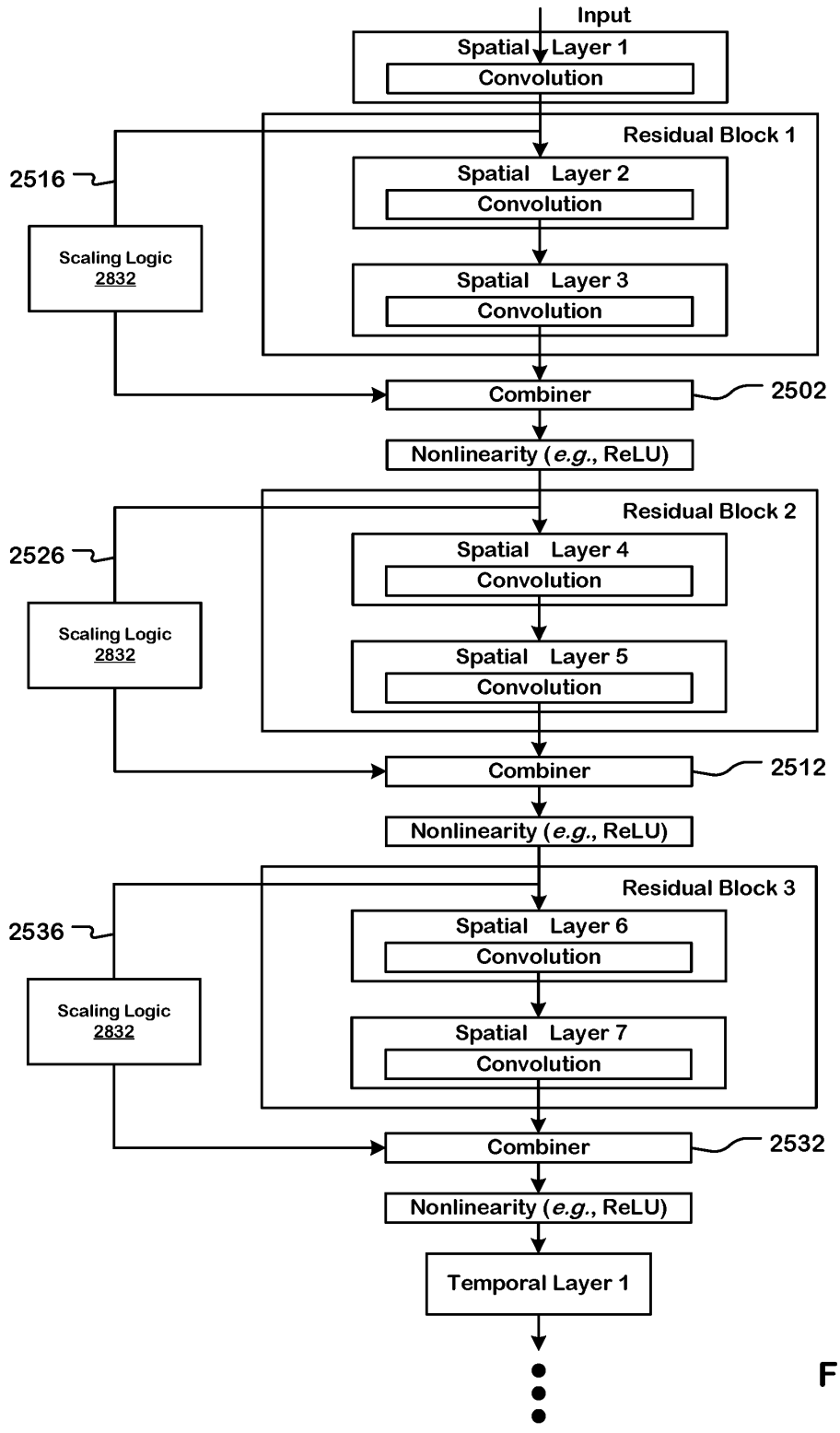
104
Input
Spatial Layer 1
Convolution
Residual Block 1
2516
Spatial Layer 2
Convolution
Scaling Logic
2832
Spatial Layer 3
Convolution
Combiner
2502
Nonlinearity (e.g., ReLU)
Residual Block 2
2526
Spatial Layer 4
Convolution
Scaling Logic
2832
Spatial Layer 5
Convolution
Combiner
2512
Nonlinearity (e.g., ReLU)
Residual Block 3
2536
Spatial Layer 6
Convolution
Scaling Logic
2832
Spatial Layer 7
Convolution
Combiner
2532
Nonlinearity (e.g., ReLU)
Temporal Layer 1

Figure 28

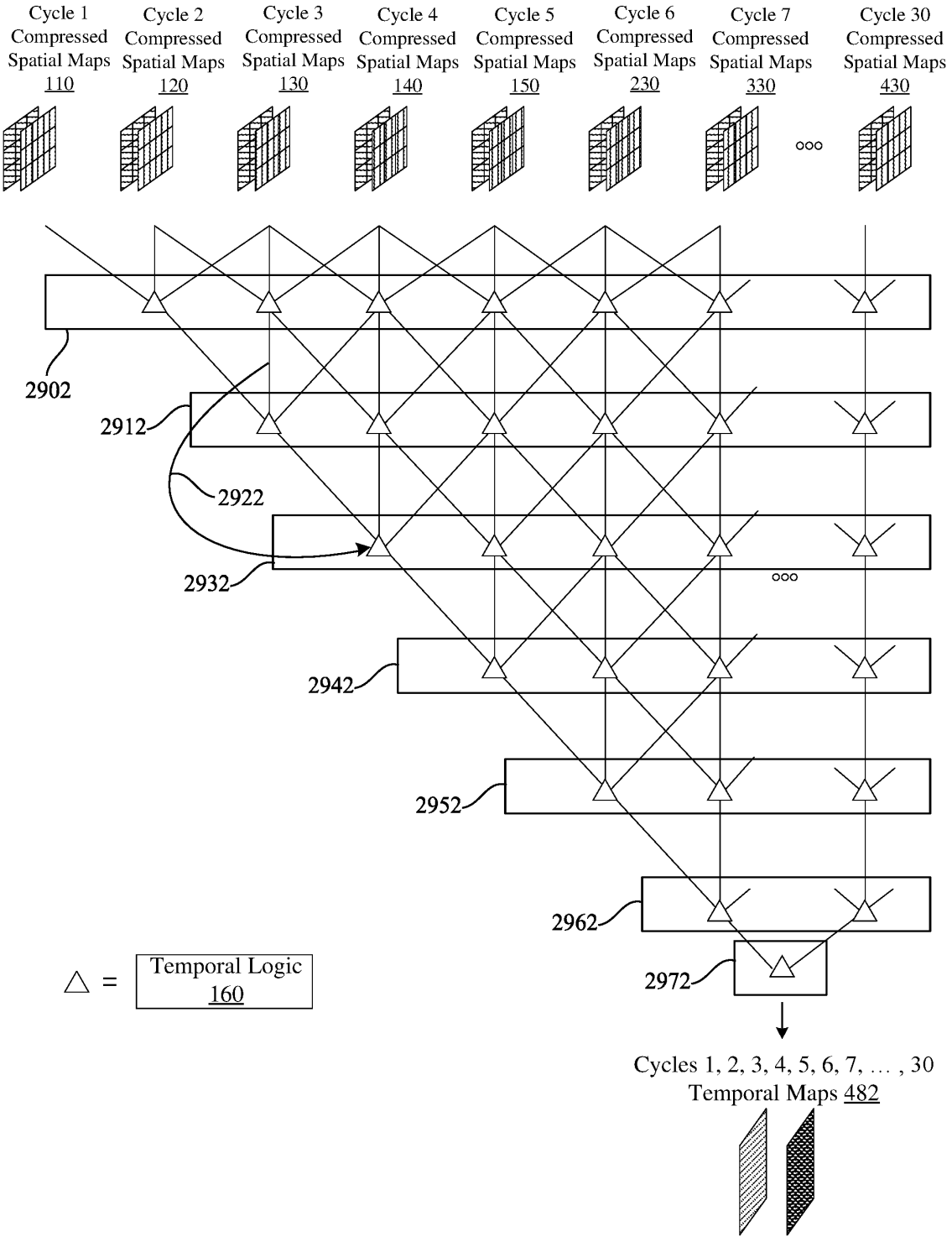
Cycle 1 Compressed Spatial Maps 110
Cycle 2 Compressed Spatial Maps 120
Cycle 3 Compressed Spatial Maps 130
Cycle 4 Compressed Spatial Maps 140
Cycle 5 Compressed Spatial Maps 150
Cycle 6 Compressed Spatial Maps 230
Cycle 7 Compressed Spatial Maps 330
Cycle 30 Compressed Spatial Maps 430
2902
2912
2922
2932
2942
2952
2962
2972
△ = Temporal Logic 160
Cycles 1, 2, 3, 4, 5, 6, 7, … , 30 Temporal Maps 482

Figure 29

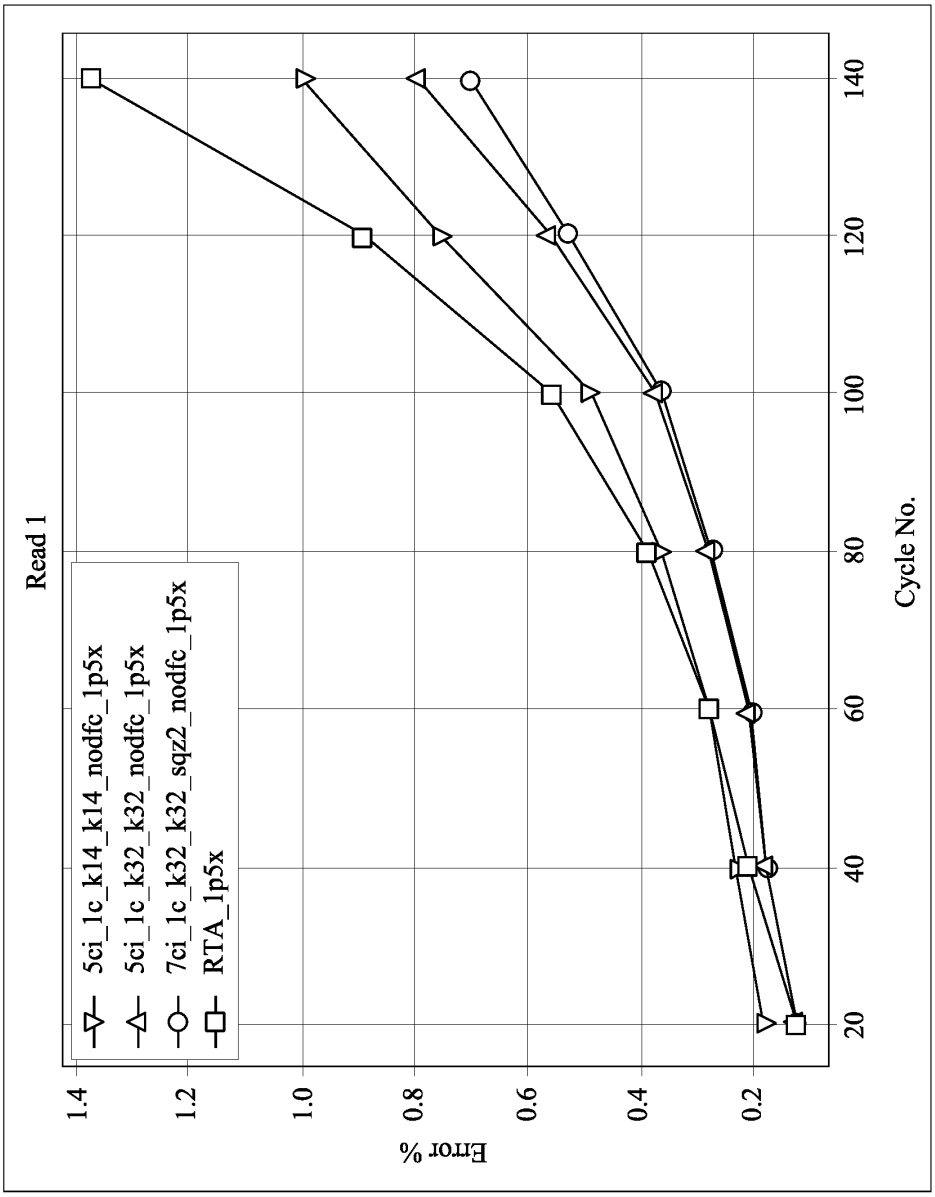
Read 1
5ci_1c_k14_k14_nodfc_1p5x
5ci_1c_k32_k32_nodfc_1p5x
7ci_1c_k32_k32_sqz2_nodfc_1p5x
RTA_1p5x
Error %
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Cycle No.
20
40
60
80
100
120
140

Figure 30

	RAM usage (GB)	DRAM usage (GB)
without Compression Logic 108	90.81344604	0.752478838
with Compression Logic 108	44.95265579	0.826221764

Figure 31

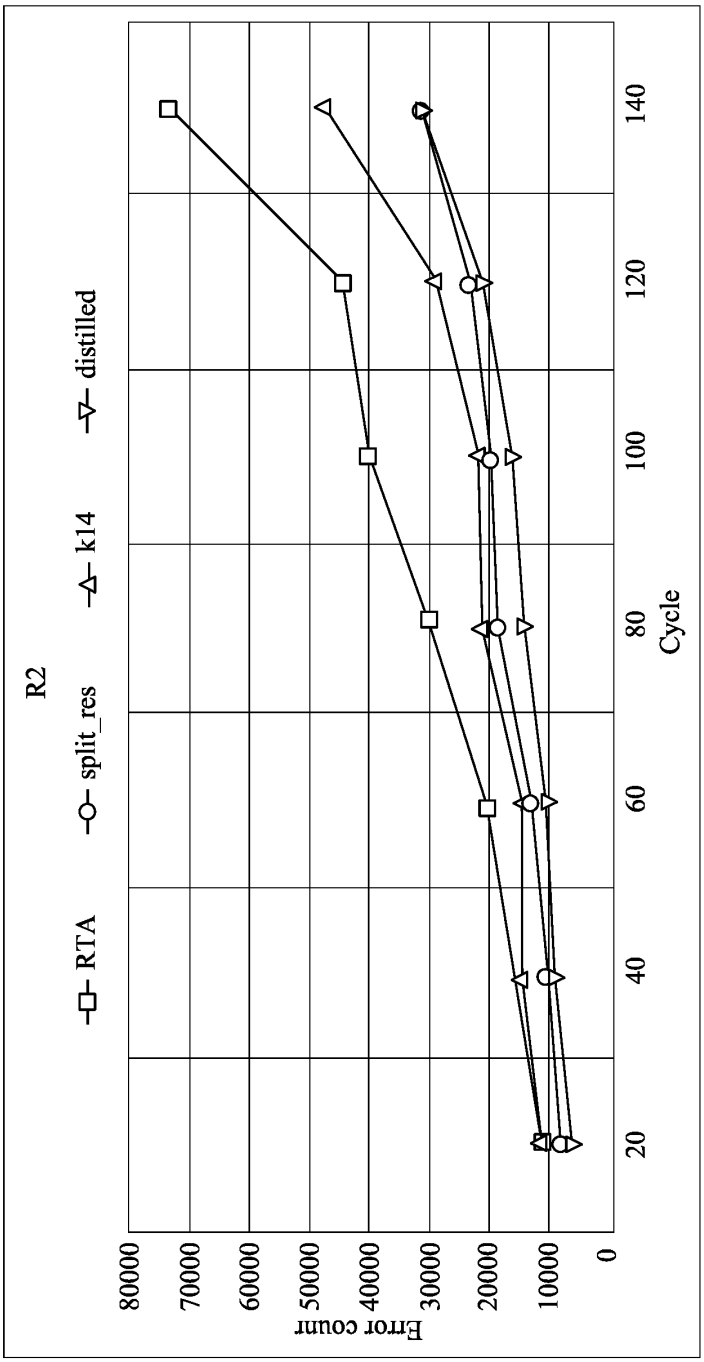
R2
RTA
split_res
k14
distilled
Error count
80000
70000
60000
50000
40000
30000
20000
10000
0
20
40
60
80
100
120
140
Cycle

Figure 32

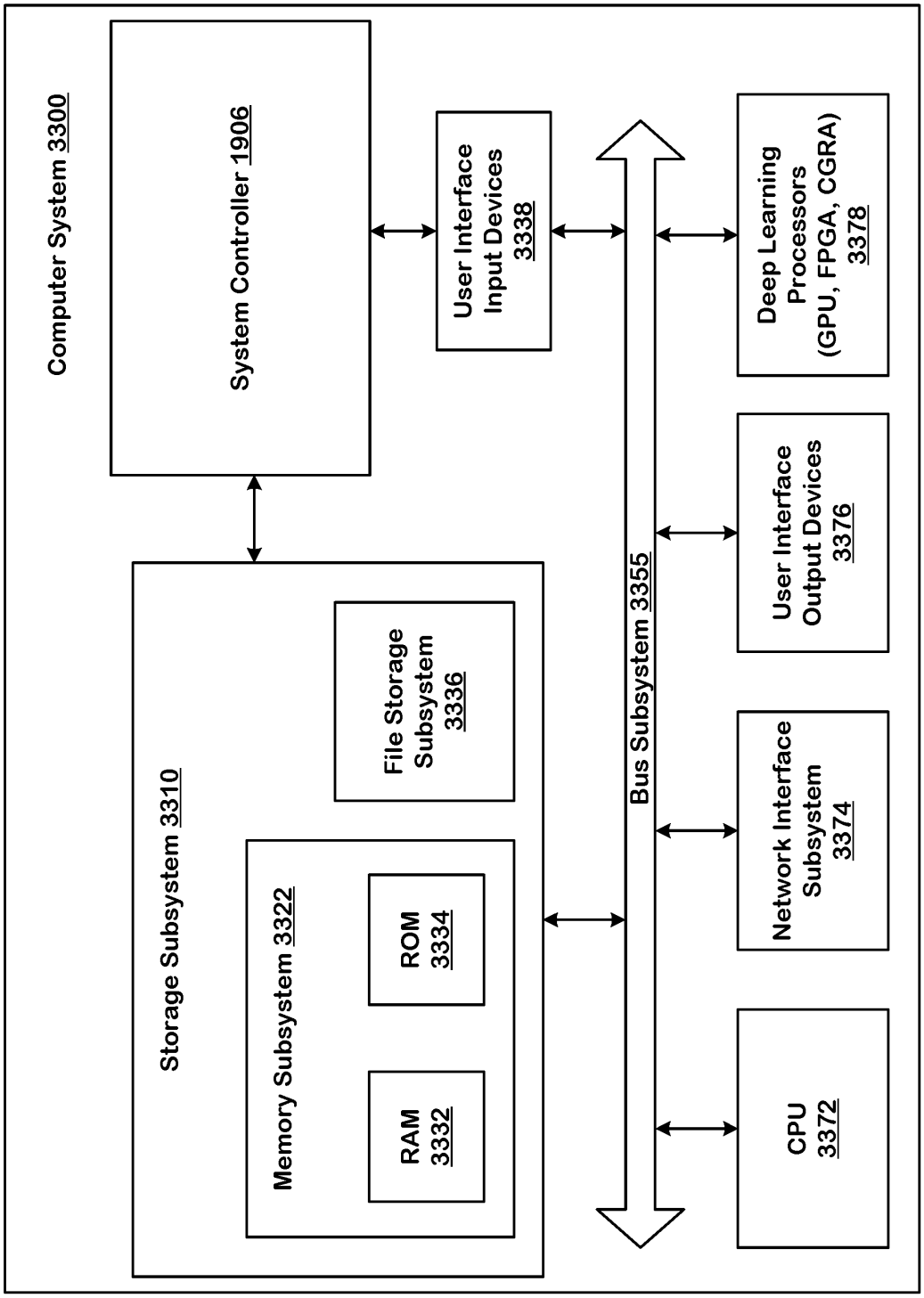
Computer System 3300
System Controller 1906
User Interface Input Devices 3338
Deep Learning Processors (GPU, FPGA, CGRA) 3378
Storage Subsystem 3310
File Storage Subsystem 3336
Memory Subsystem 3322
ROM 3334
RAM 3332
Bus Subsystem 3355
User Interface Output Devices 3376
Network Interface Subsystem 3374
CPU 3372

Figure 33