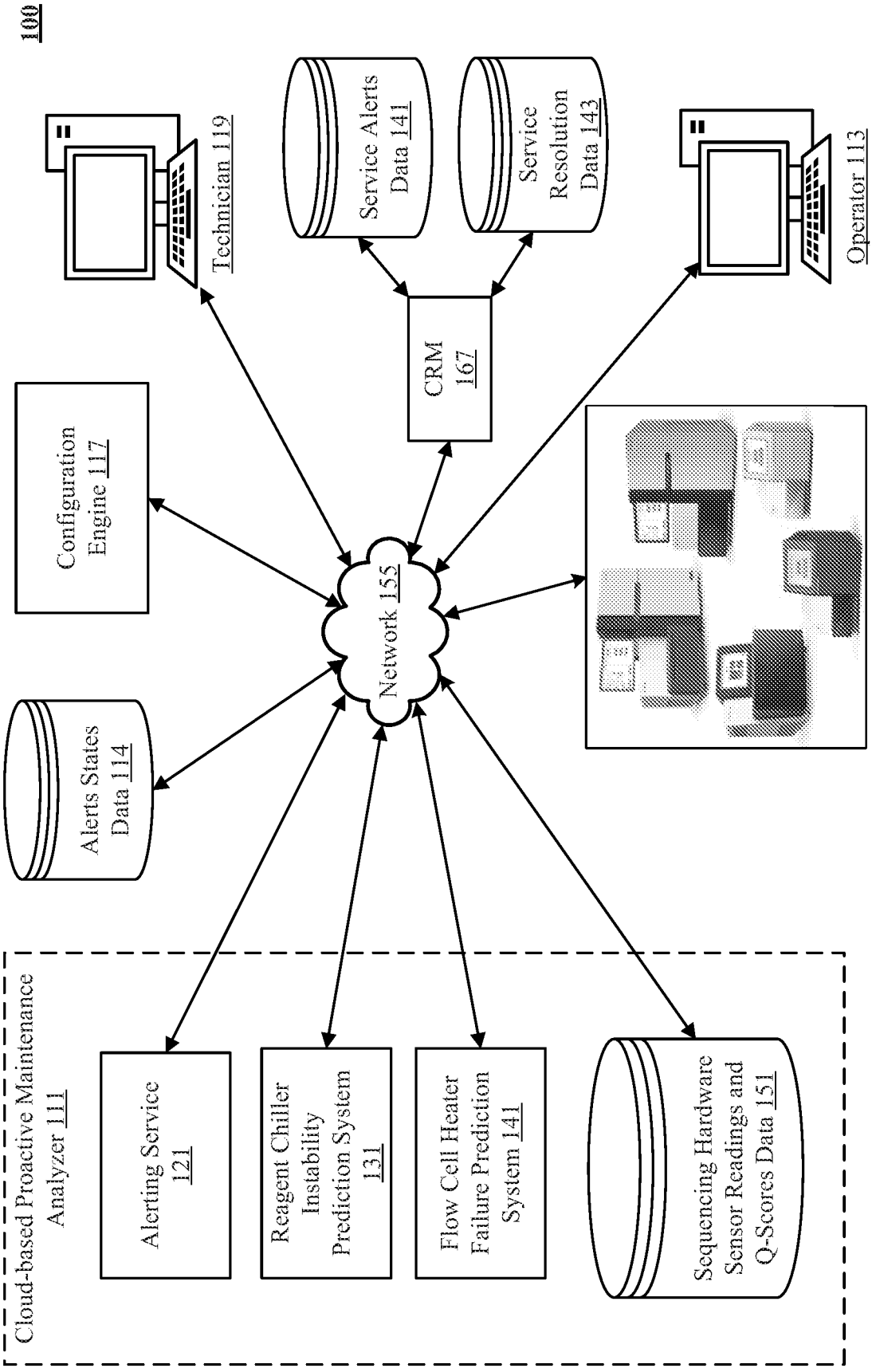

100
Technician 119
Service Alerts Data 141
Service Resolution Data 143
Operator 113
Configuration Engine 117
CRM 167
Network 155
Sequencing Systems 185
Alerts States Data 114
Cloud-based Proactive Maintenance Analyzer 111
Alerting Service 121
Reagent Chiller Instability Prediction System 131
Flow Cell Heater Failure Prediction System 141
Sequencing Hardware Sensor Readings and Q-Scores Data 151

FIG. 1

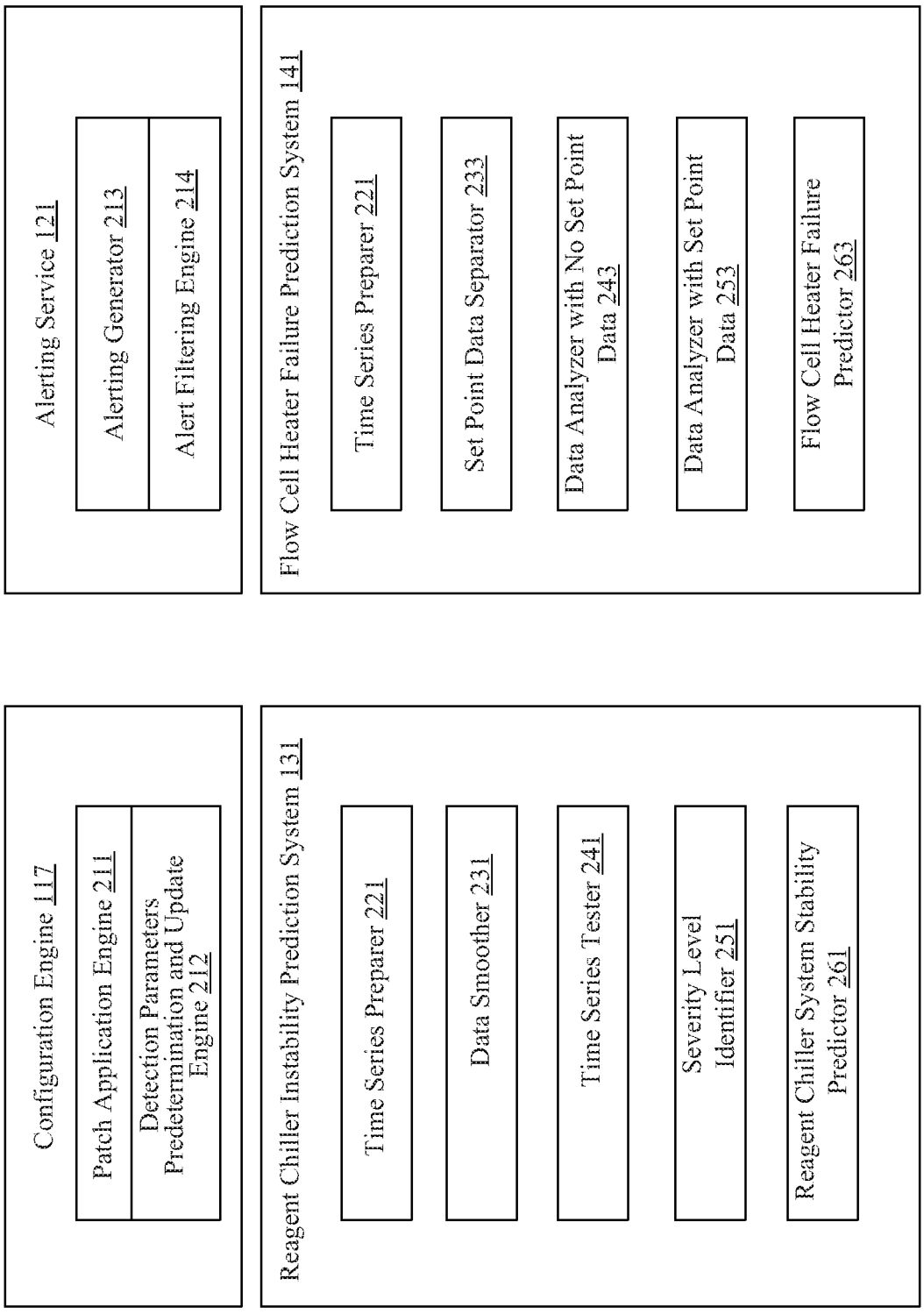

Alerting Service 121
Alerting Generator 213
Alert Filtering Engine 214
Flow Cell Heater Failure Prediction System 141
Time Series Preparer 221
Set Point Data Separator 233
Data Analyzer with No Set Point Data 243
Data Analyzer with Set Point Data 253
Flow Cell Heater Failure Predictor 263
Configuration Engine 117
Patch Application Engine 211
Detection Parameters Predetermination and Update Engine 212
Reagent Chiller Instability Prediction System 131
Time Series Preparer 221
Data Smoother 231
Time Series Tester 241
Severity Level Identifier 251
Reagent Chiller System Stability Predictor 261

FIG. 2

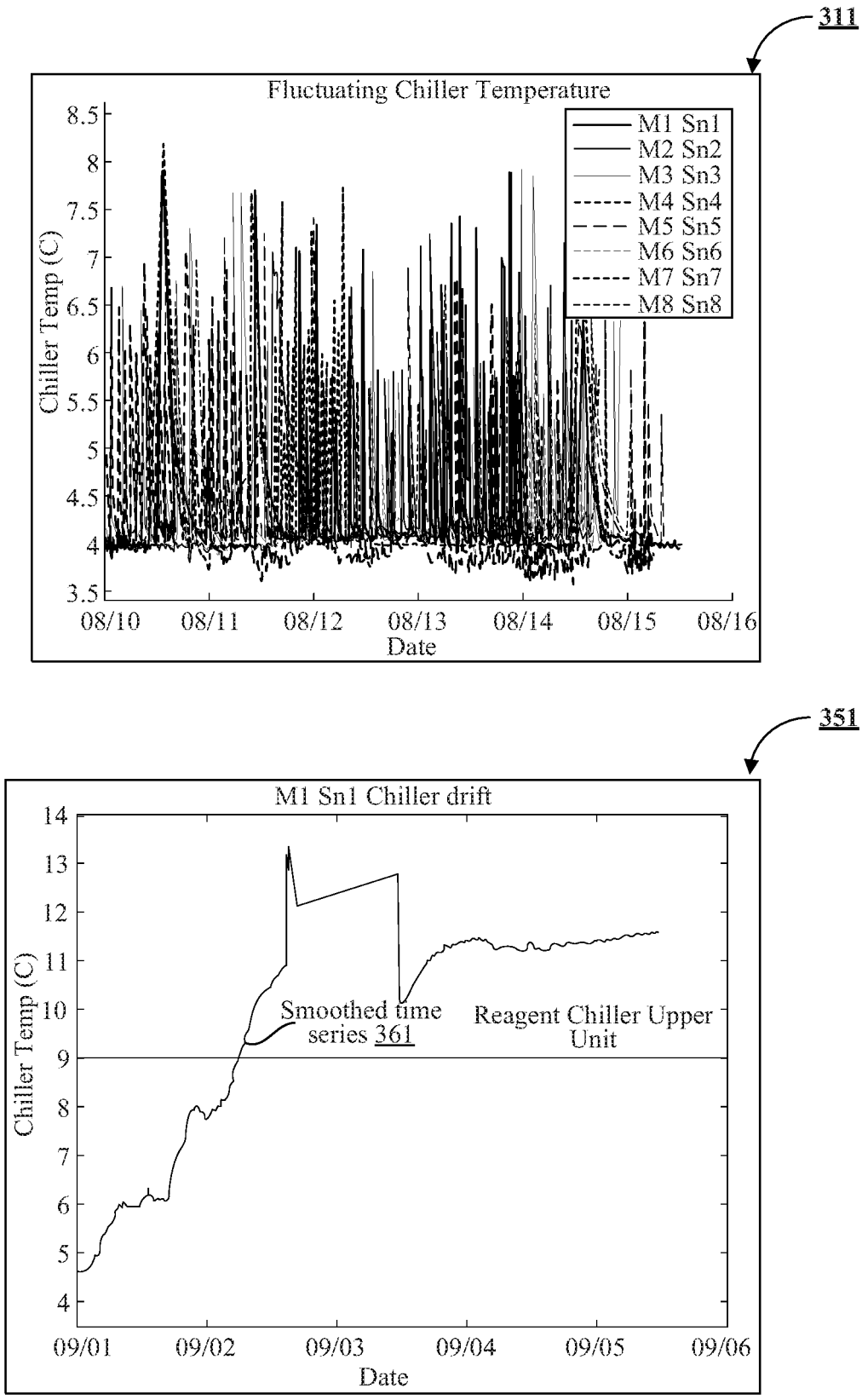

311
Fluctuating Chiller Temperature
M1 Sn1
M2 Sn2
M3 Sn3
M4 Sn4
M5 Sn5
M6 Sn6
M7 Sn7
M8 Sn8
Chiller Temp (C)
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
08/10
08/11
08/12
08/13
08/14
08/15
08/16
Date
351
M1 Sn1 Chiller drift
Chiller Temp (C)
14
13
12
11
10
9
8
7
6
5
4
Smoothed time series 361
Reagent Chiller Upper Unit
09/01
09/02
09/03
09/04
09/05
09/06
Date

FIG. 3

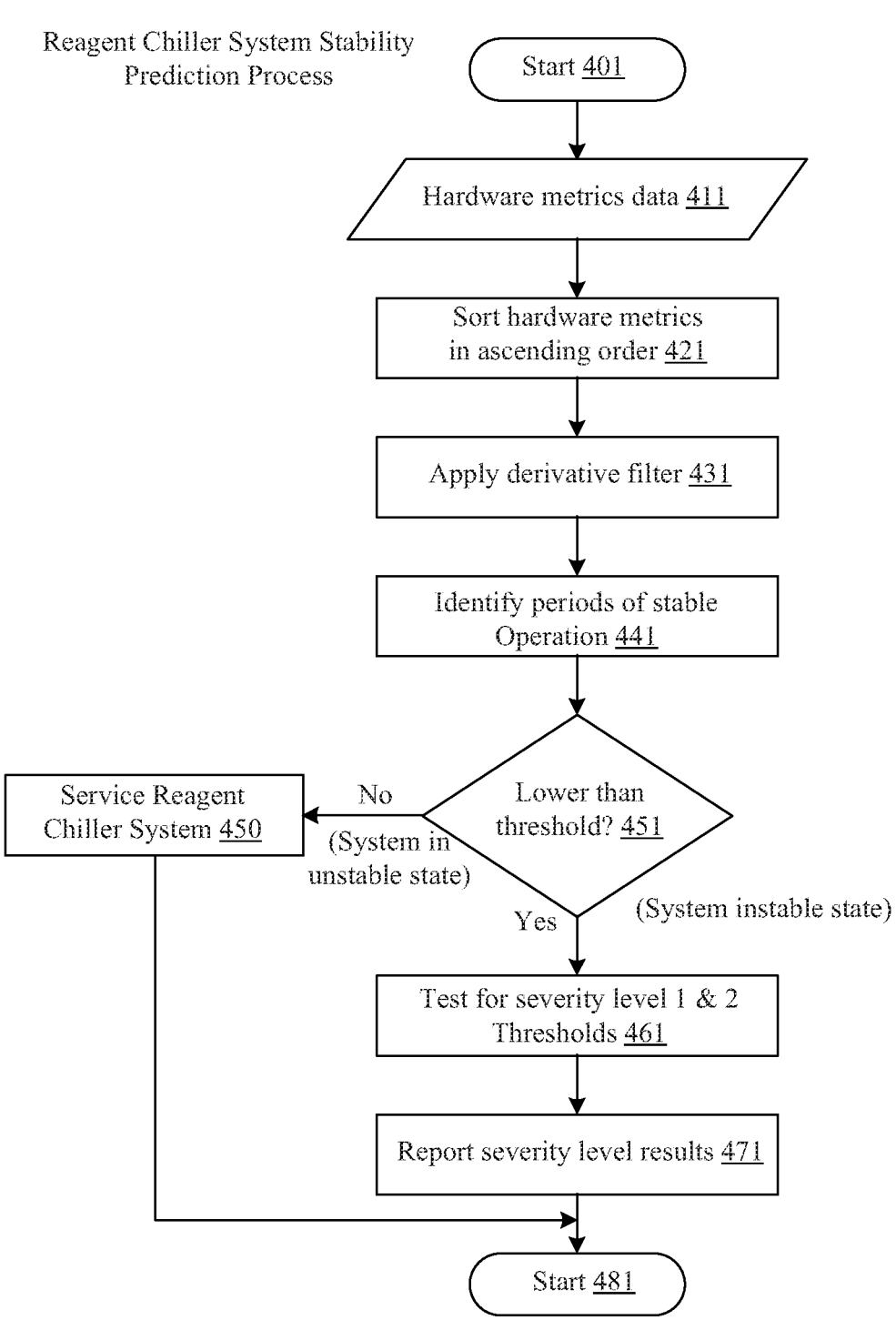

400
Reagent Chiller System Stability Prediction Process
Start 401
Hardware metrics data 411
Sort hardware metrics in ascending order 421
Apply derivative filter 431
Identify periods of stable Operation 441
Lower than threshold? 451
No
(System in unstable state)
Service Reagent Chiller System 450
Yes
(System instable state)
Test for severity level 1 & 2 Thresholds 461
Report severity level results 471
Start 481

FIG. 4

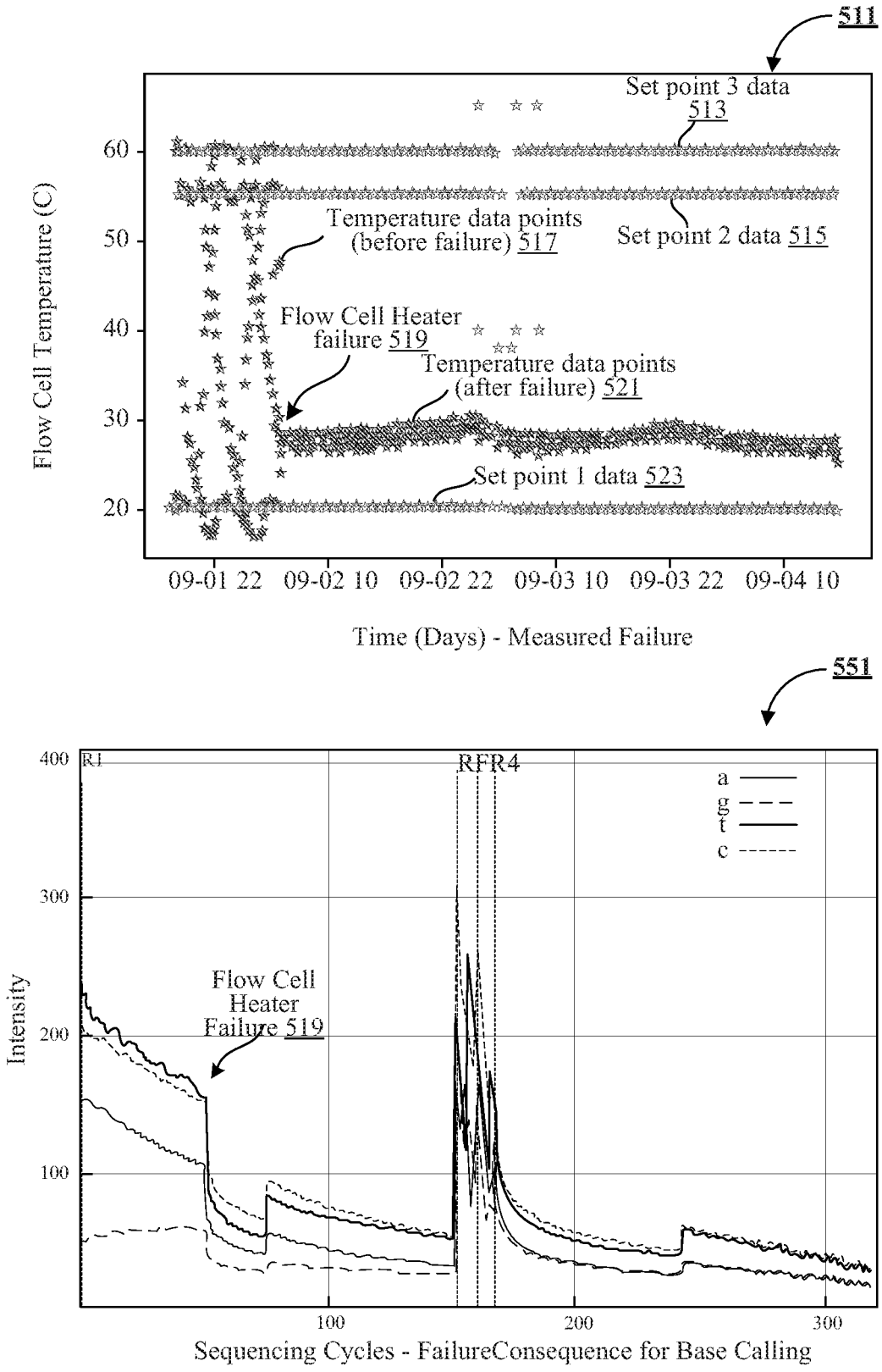

511
Set point 3 data 513
Temperature data points (before failure) 517
Set point 2 data 515
Flow Cell Heater failure 519
Temperature data points (after failure) 521
Set point 1 data 523
Flow Cell Temperature (C)
60
50
40
30
20
09-01 22
09-02 10
09-02 22
09-03 10
09-03 22
09-04 10
Time (Days) - Measured Failure
551
RFR4
a
g
t
c
Flow Cell Heater Failure 519
Intensity
400
300
200
100
100
200
300
Sequencing Cycles - FailureConsequence for Base Calling

FIG. 5

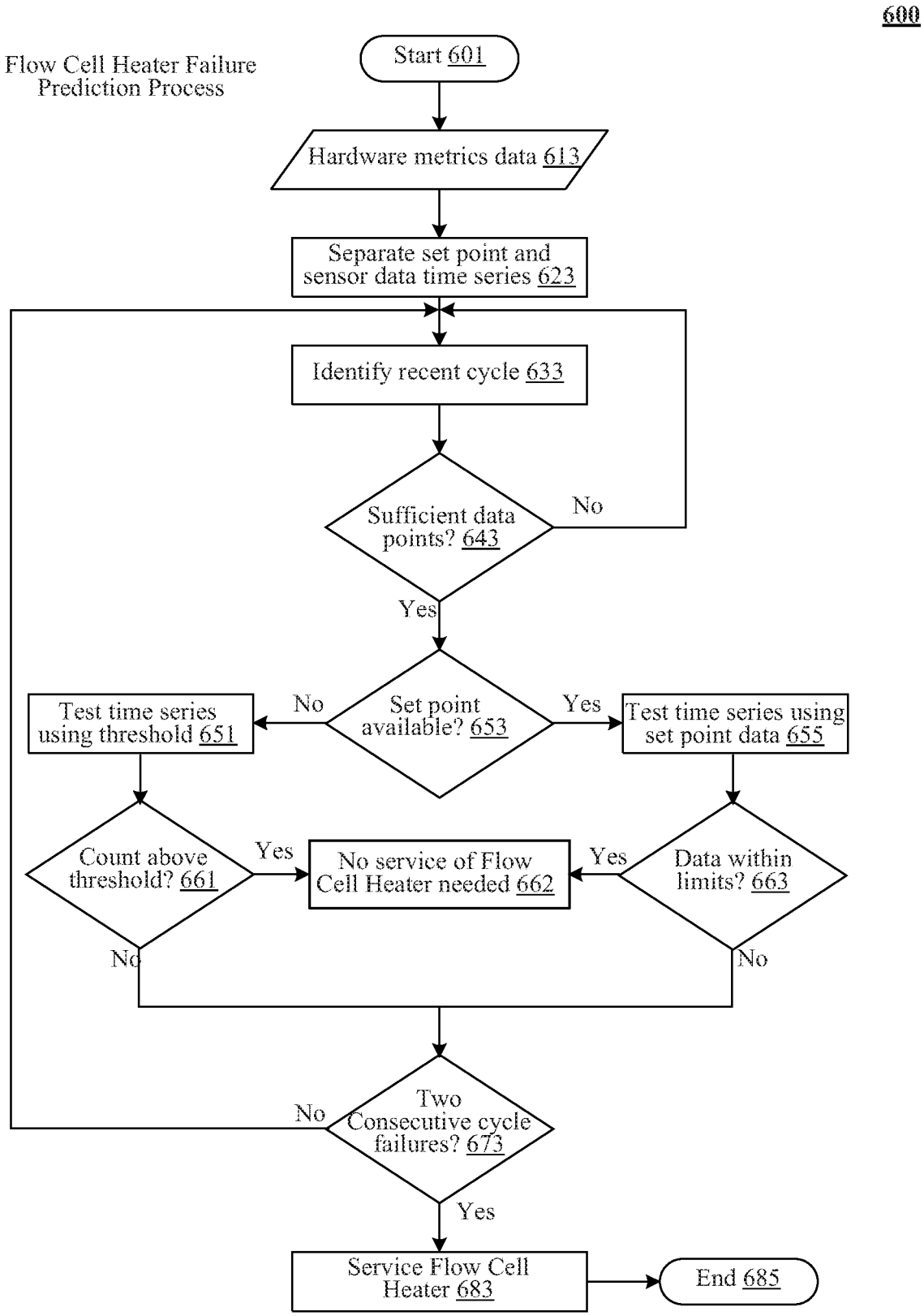

600
Flow Cell Heater Failure Prediction Process
Start 601
Hardware metrics data 613
Separate set point and sensor data time series 623
Identify recent cycle 633
Sufficient data points? 643
No
Yes
Set point available? 653
No
Yes
Test time series using threshold 651
Test time series using set point data 655
Count above threshold? 661
Yes
No service of Flow Cell Heater needed 662
Yes
Data within limits? 663
No
No
Two Consecutive cycle failures? 673
No
Yes
Service Flow Cell Heater 683
End 685

FIG. 6

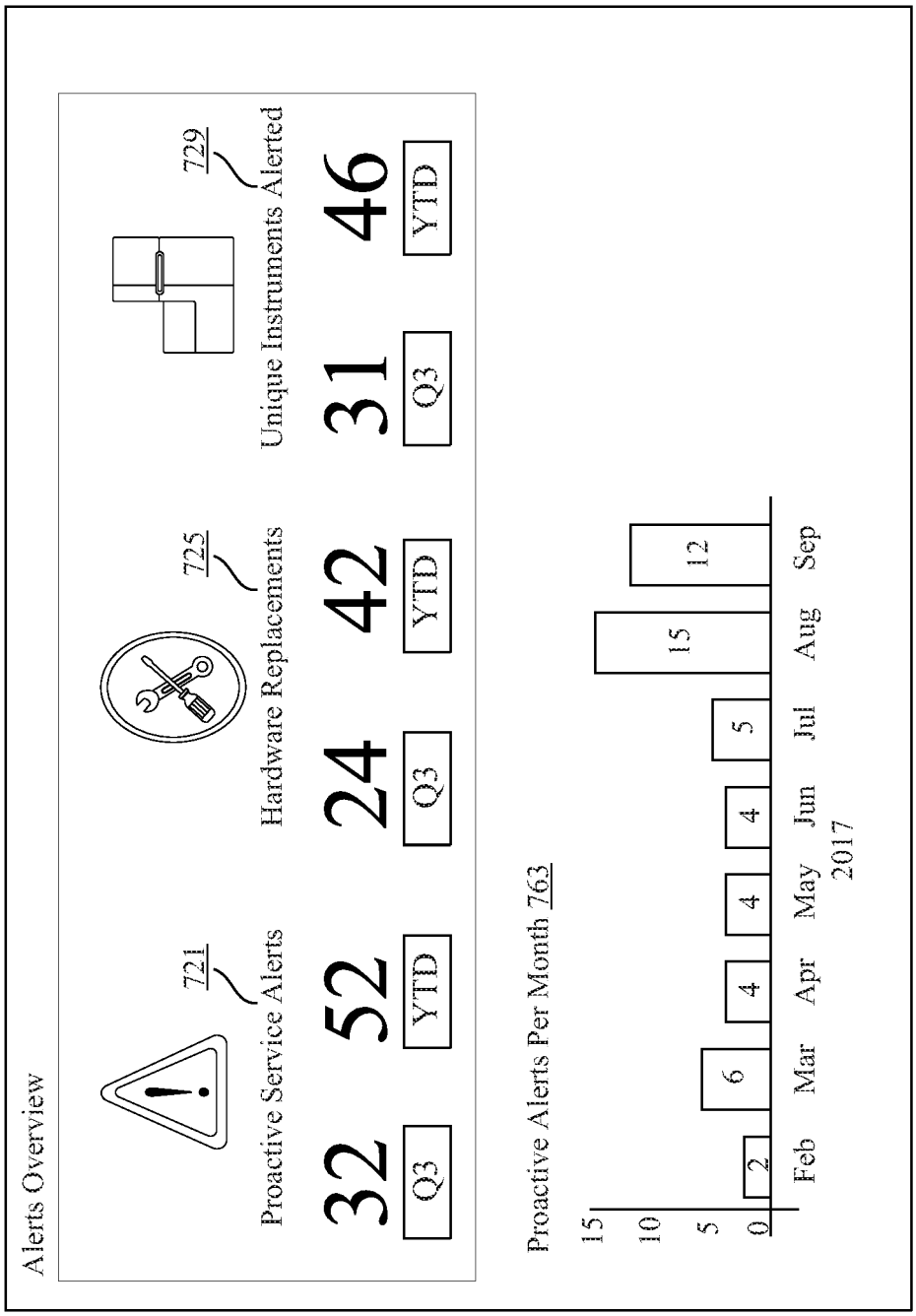

Alerts Overview
721
Proactive Service Alerts
32
Q3
52
YTD
725
Hardware Replacements
24
Q3
42
YTD
729
Unique Instruments Alerted
31
Q3
46
YTD
Proactive Alerts Per Month 763
15
10
5
0
2
6
4
4
4
5
15
12
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
2017

FIG. 7

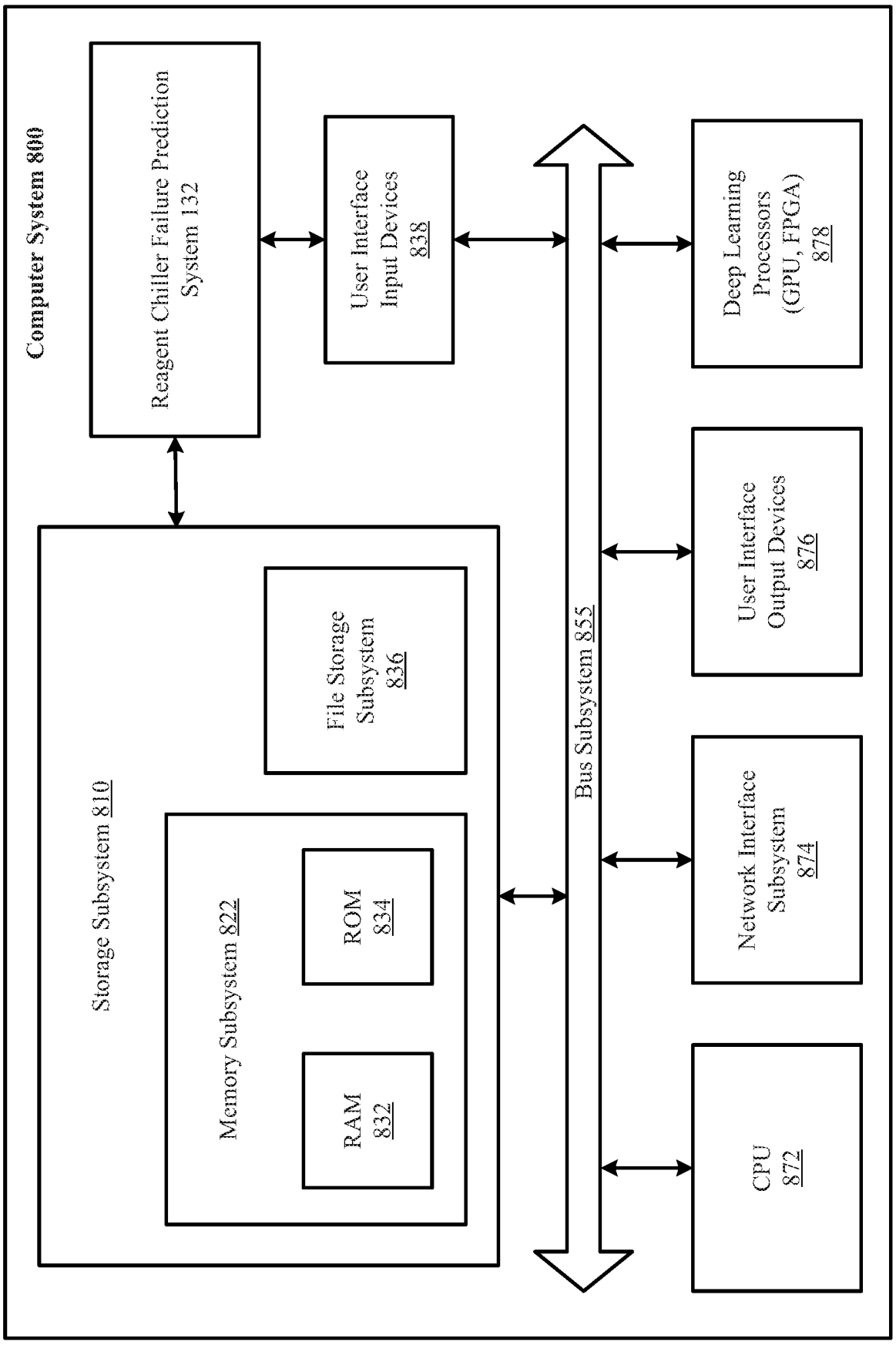

Computer System 800
Reagent Chiller Failure Prediction System 132
User Interface Input Devices 838
Deep Learning Processors (GPU, FPGA) 878
Storage Subsystem 810
File Storage Subsystem 836
Memory Subsystem 822
ROM 834
RAM 832
Bus Subsystem 855
User Interface Output Devices 876
Network Interface Subsystem 874
CPU 872

FIG. 8