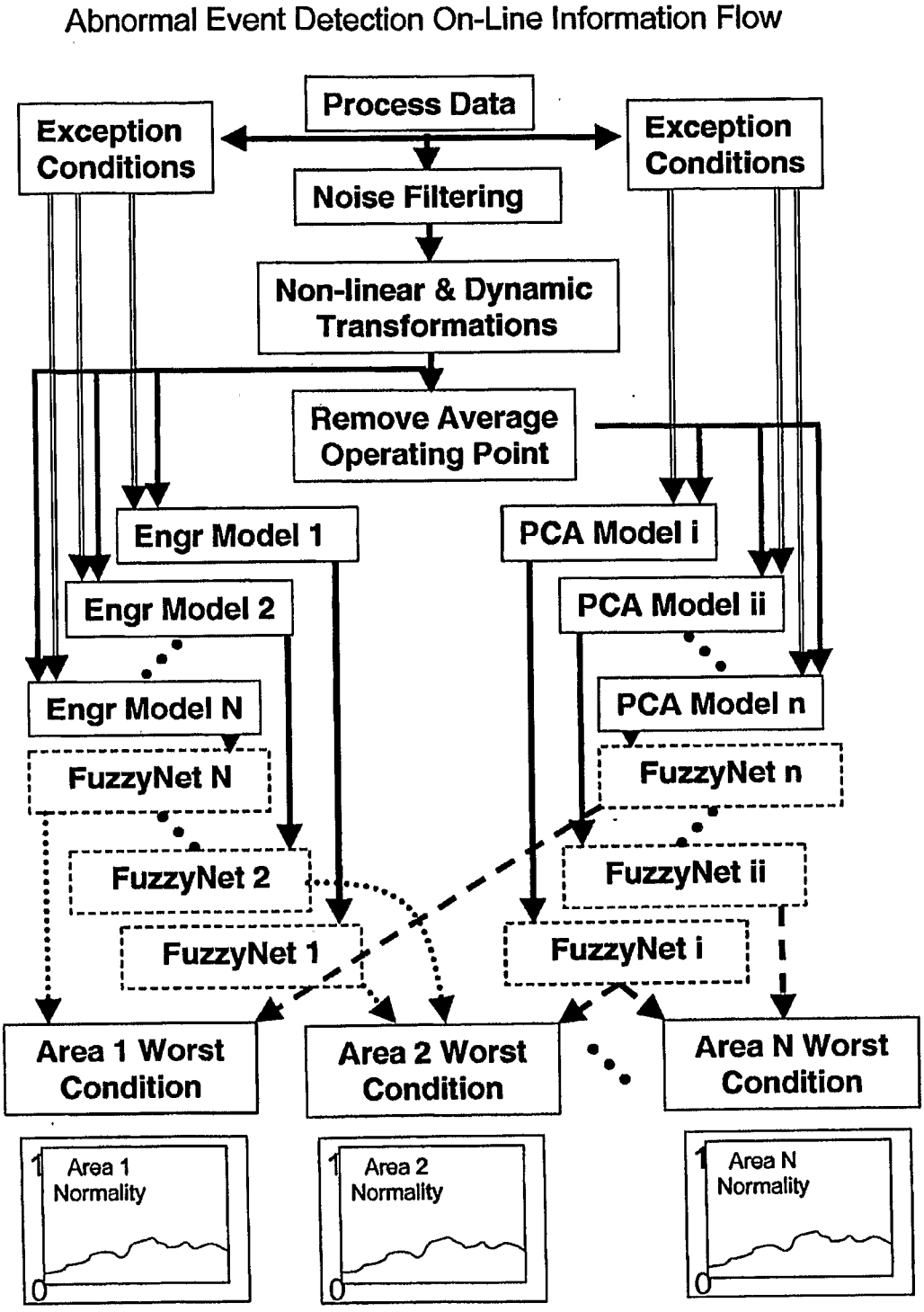

Abnormal Event Detection On-Line Information Flow
Process Data
Exception Conditions
Exception Conditions
Noise Filtering
Non-linear & Dynamic Transformations
Remove Average Operating Point
Engr Model 1
Engr Model 2
Engr Model N
FuzzyNet N
FuzzyNet 2
FuzzyNet 1
PCA Model i
PCA Model ii
PCA Model n
FuzzyNet n
FuzzyNet ii
FuzzyNet i
Area 1 Worst Condition
Area 2 Worst Condition
Area N Worst Condition
1
Area 1 Normality
0
1
Area 2 Normality
0
1
Area N Normality
0

FIG. 1

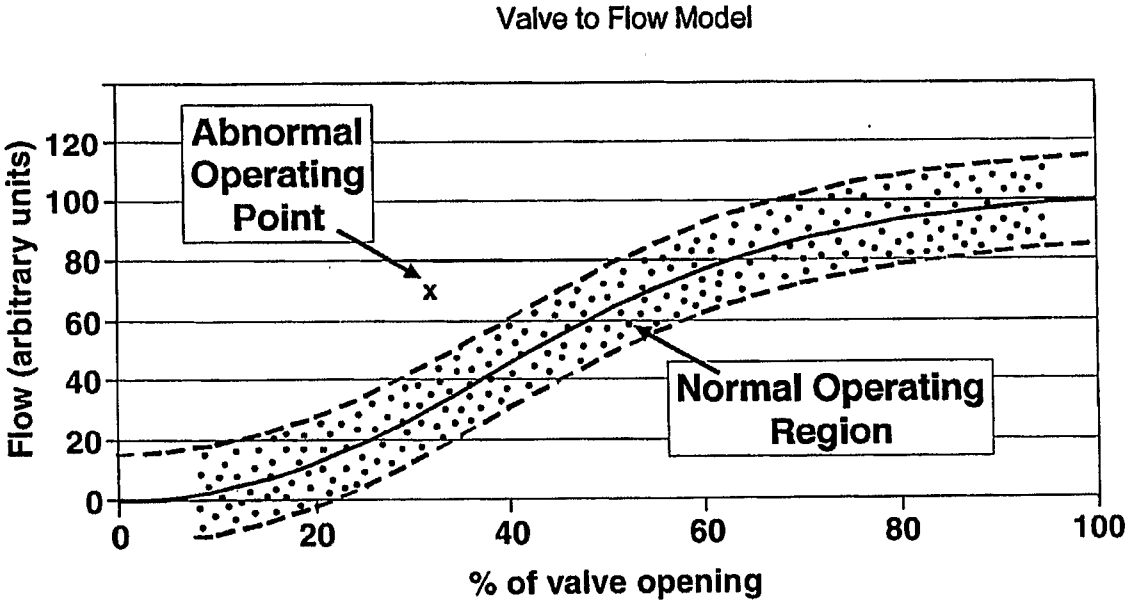

Valve to Flow Model
Abnormal Operating Point
x
Normal Operating Region
Flow (arbitrary units)
120
100
80
60
40
20
0
0
20
40
60
80
100
% of valve opening

FIG. 2

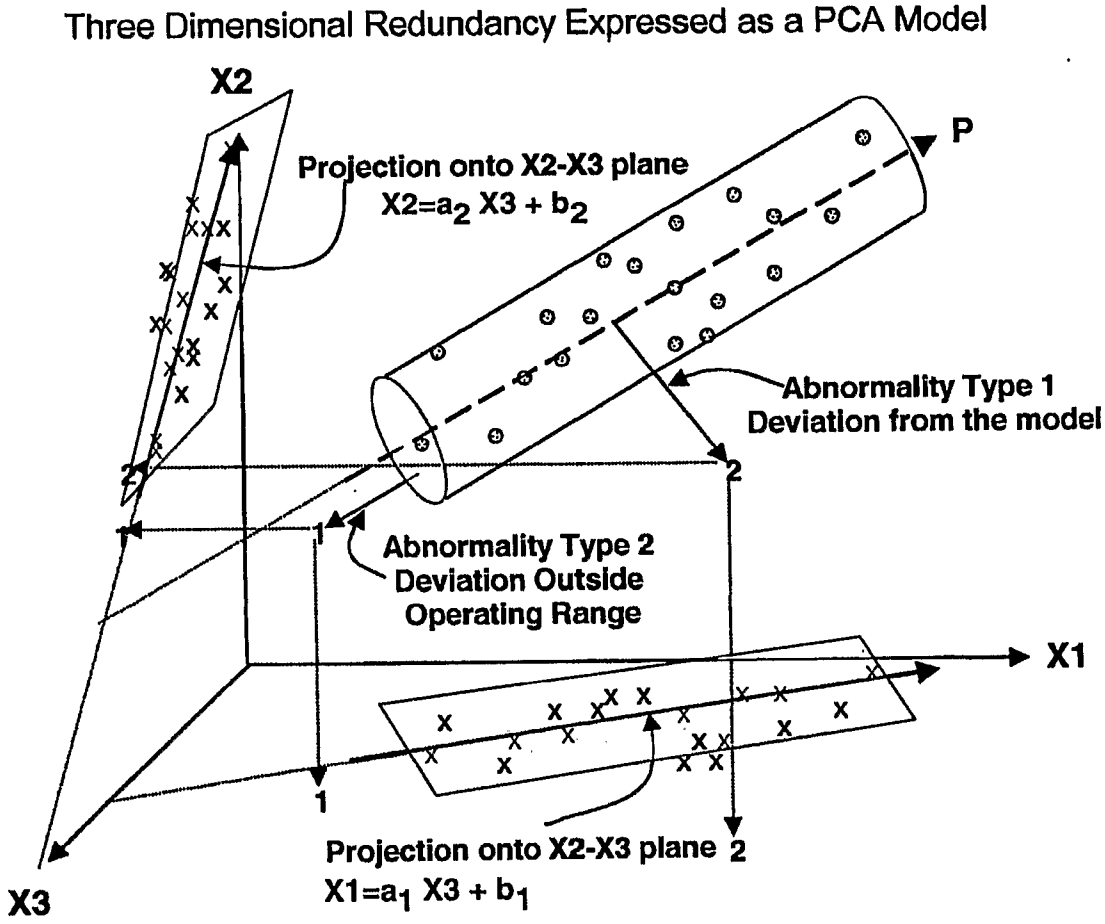

Three Dimensional Redundancy Expressed as a PCA Model
X2
Projection onto X2-X3 plane
X2=a2 X3 + b2
P
Abnormality Type 1
Deviation from the model
Abnormality Type 2
Deviation Outside
Operating Range
X1
X3
Projection onto X2-X3 plane
X1=a1 X3 + b1
1
2

FIG. 3

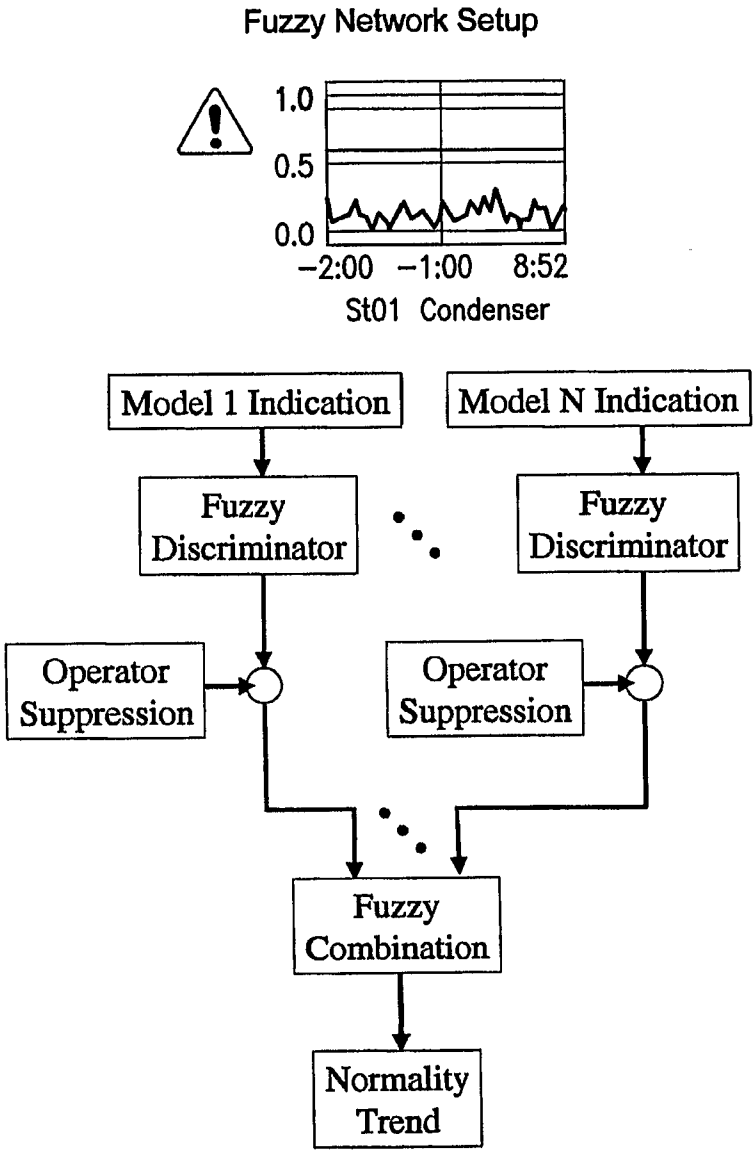

Fuzzy Network Setup
1.0
0.5
0.0
−2:00 −1:00 8:52
St01 Condenser
Model 1 Indication
Model N Indication
Fuzzy Discriminator
Fuzzy Discriminator
Operator Suppression
Operator Suppression
Fuzzy Combination
Normality Trend

FIG. 4

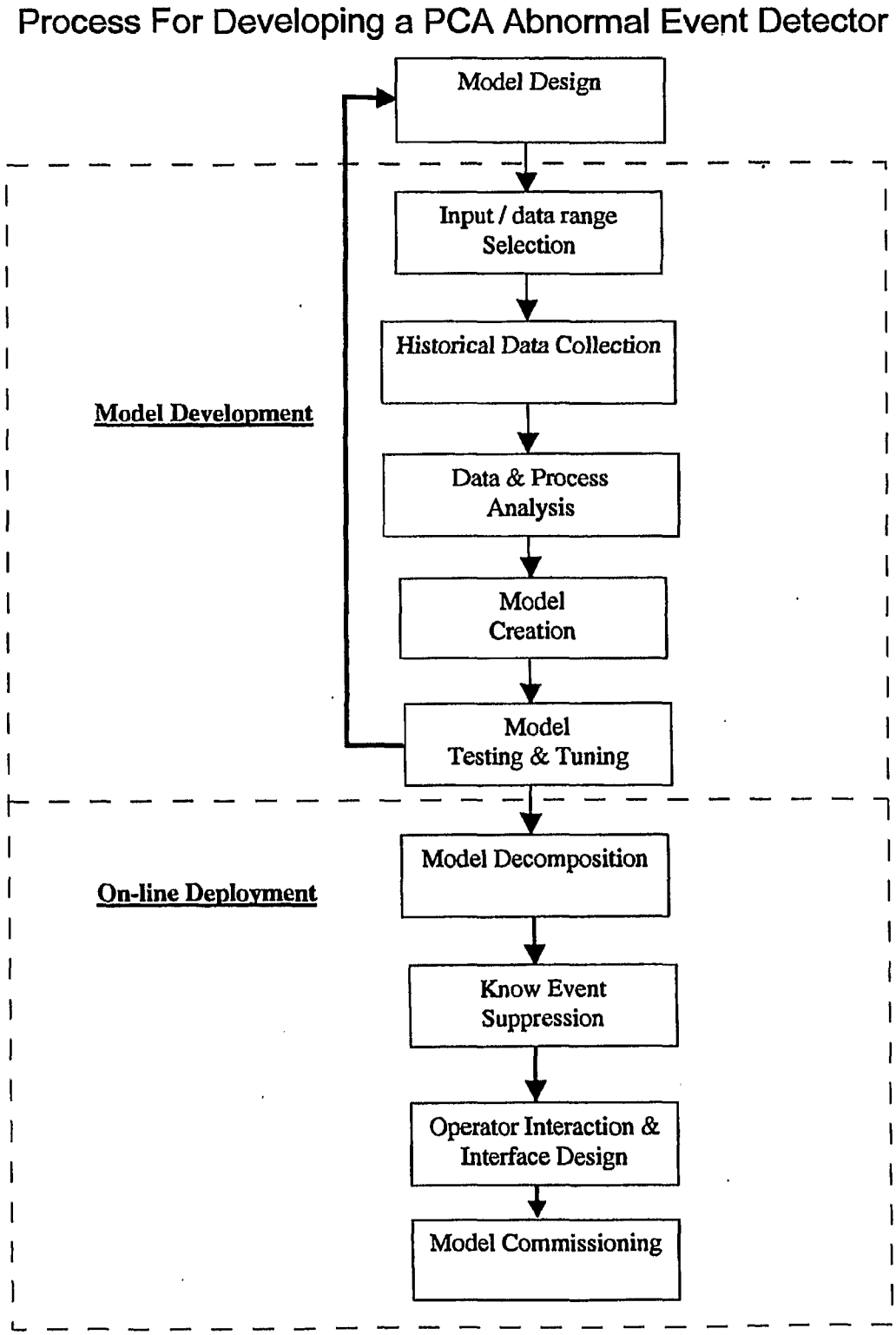

Process For Developing a PCA Abnormal Event Detector
Model Design
Input / data range Selection
Historical Data Collection
Model Development
Data & Process Analysis
Model Creation
Model Testing & Tuning
Model Decomposition
On-line Deployment
Know Event Suppression
Operator Interaction & Interface Design
Model Commissioning

FIG. 5

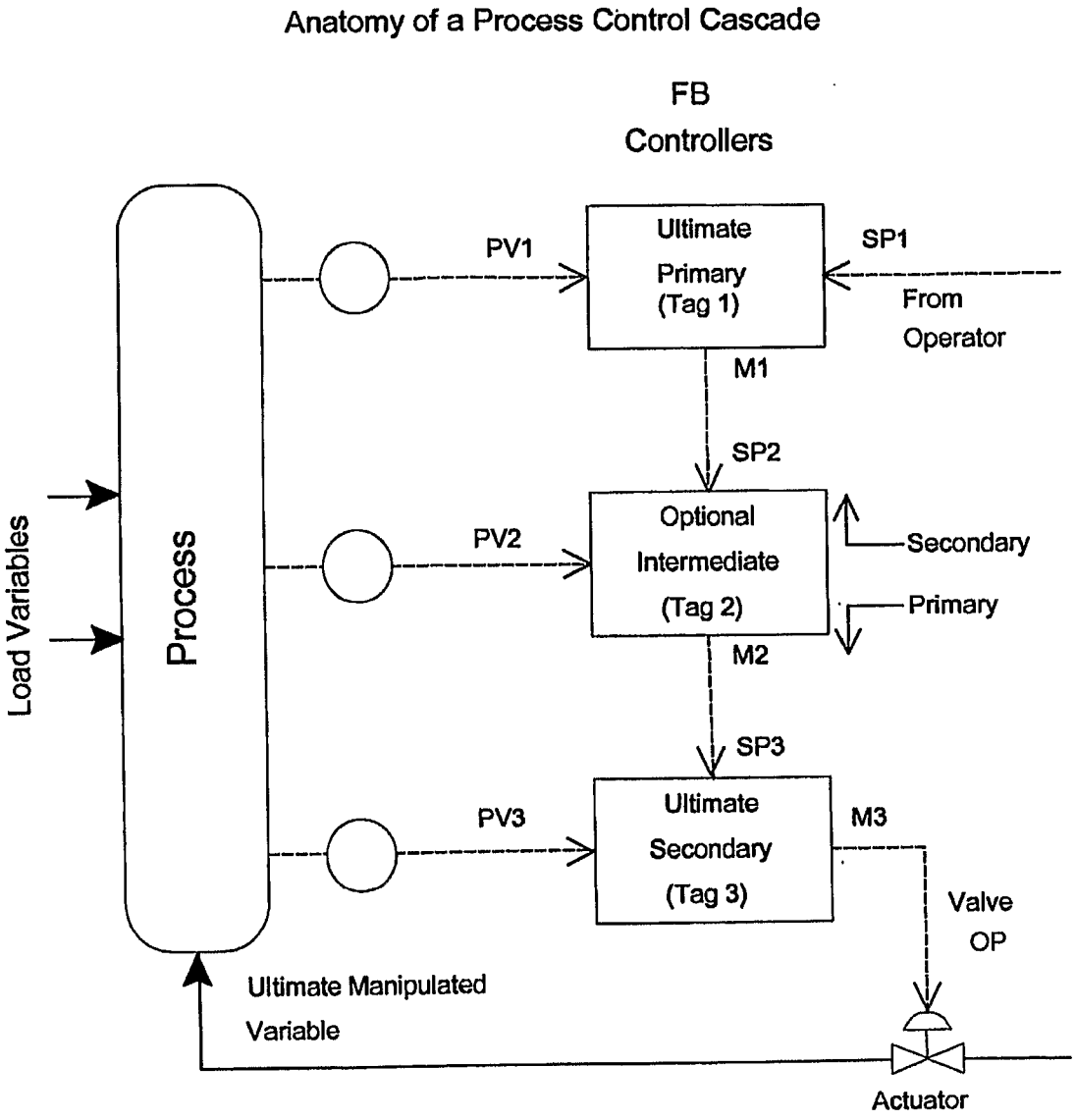

Anatomy of a Process Control Cascade
FB
Controllers
Ultimate
Primary
(Tag 1)
PV1
SP1
From
Operator
M1
SP2
Optional
Intermediate
(Tag 2)
PV2
Secondary
Primary
M2
SP3
Ultimate
Secondary
(Tag 3)
PV3
M3
Valve
OP
Load Variables
Process
Ultimate Manipulated
Variable
Actuator

FIG. 6

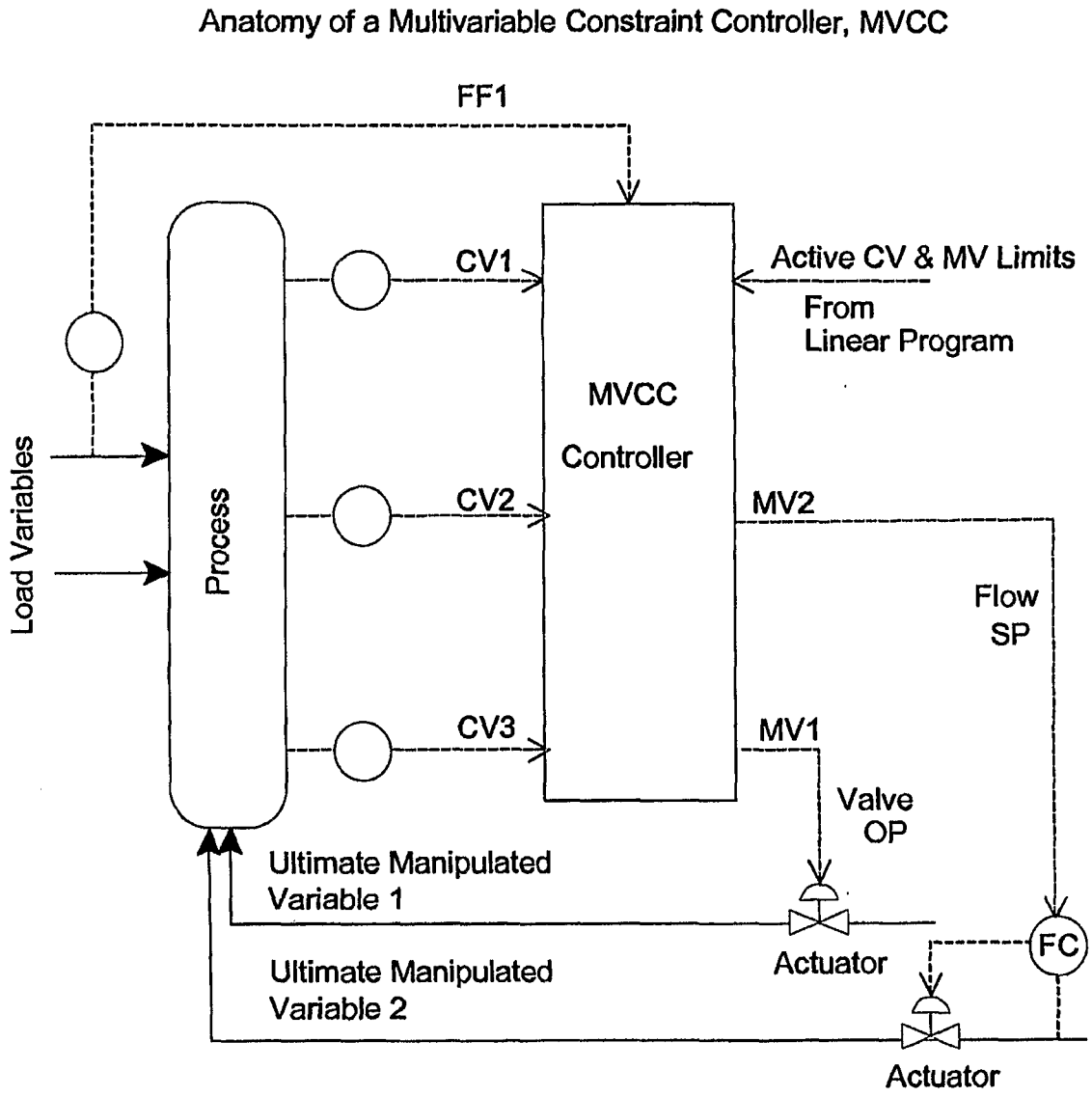

Anatomy of a Multivariable Constraint Controller, MVCC
FF1
CV1
Active CV & MV Limits
From
Linear Program
MVCC
Controller
Load Variables
Process
CV2
MV2
Flow
SP
CV3
MV1
Valve
OP
Ultimate Manipulated
Variable 1
Actuator
FC
Ultimate Manipulated
Variable 2
Actuator

FIG. 7

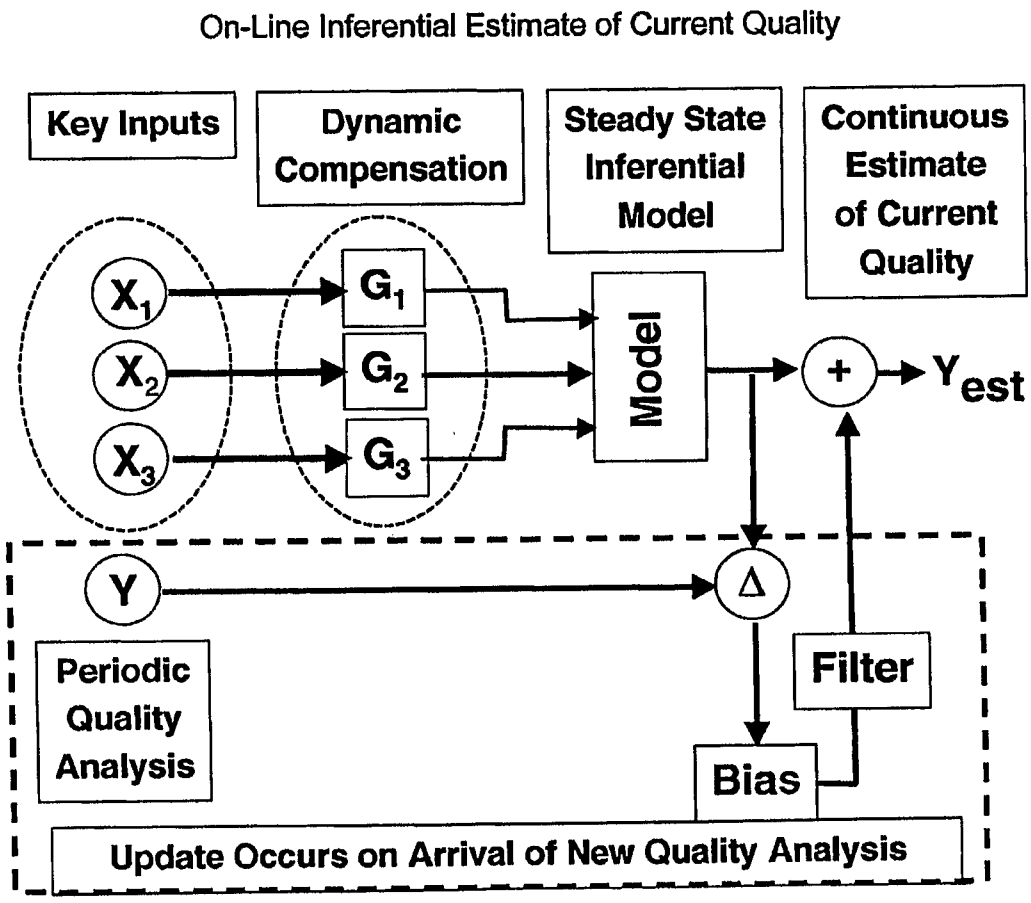

On-Line Inferential Estimate of Current Quality
Key Inputs
Dynamic Compensation
Steady State Inferential Model
Continuous Estimate of Current Quality
X1
X2
X3
G1
G2
G3
Model
+
Yest
Y
Δ
Filter
Bias
Periodic Quality Analysis
Update Occurs on Arrival of New Quality Analysis

FIG. 8

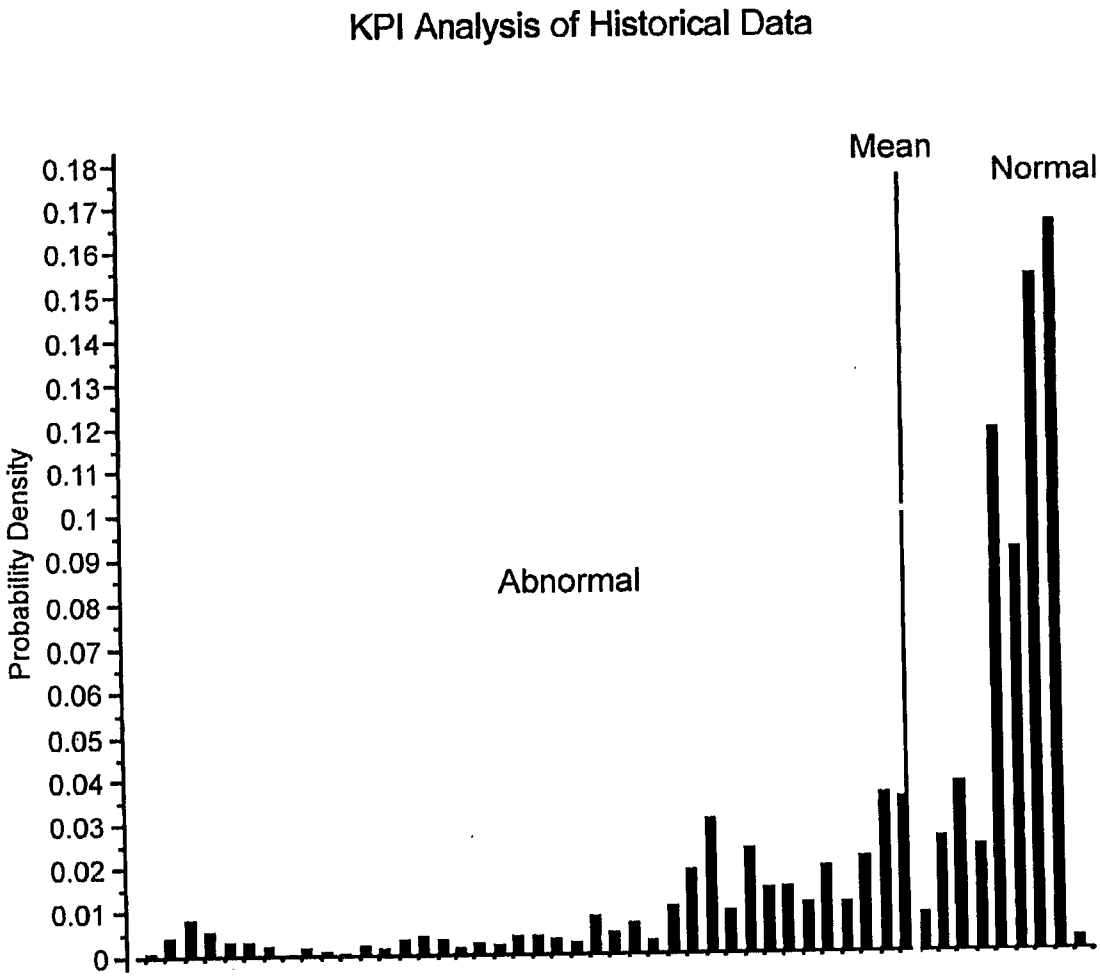

KPI Analysis of Historical Data
Mean
Normal
Abnormal
Probability Density
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0

FIG. 9

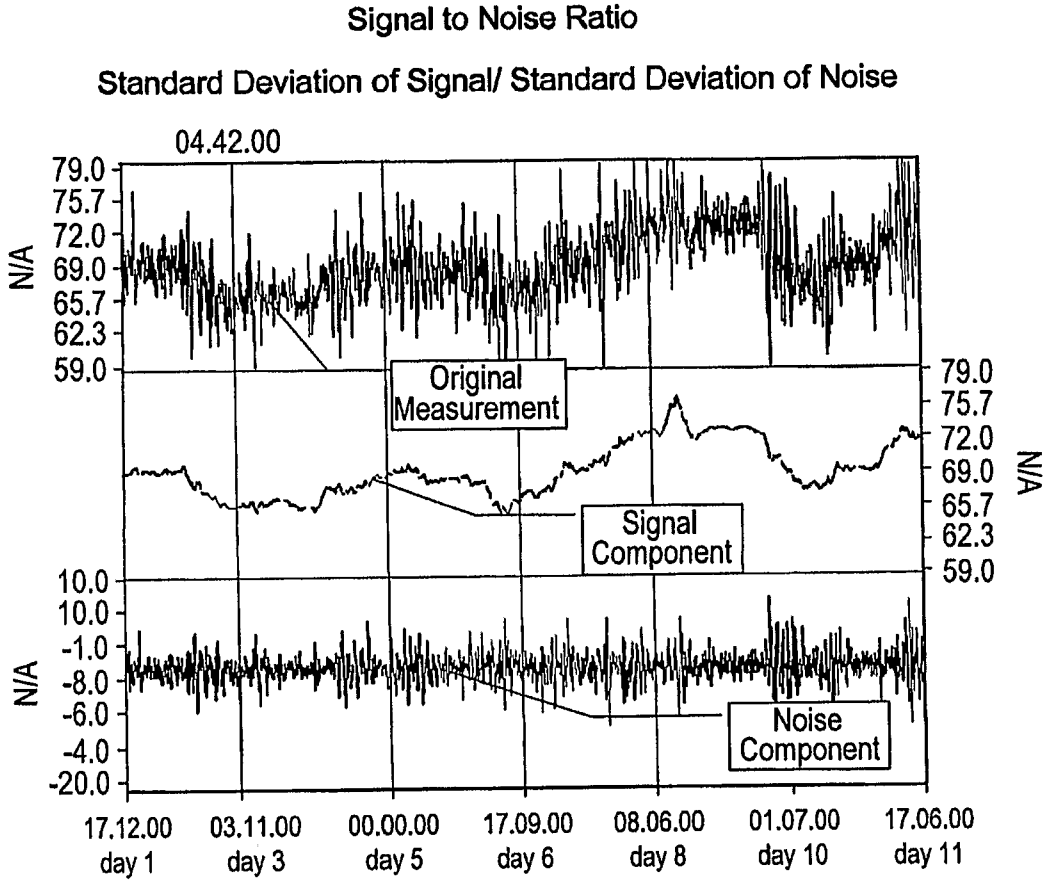

Signal to Noise Ratio
Standard Deviation of Signal/ Standard Deviation of Noise
04.42.00
79.0
75.7
72.0
69.0
65.7
62.3
59.0
N/A
Original Measurement
Signal Component
Noise Component
10.0
10.0
-1.0
-8.0
-6.0
-4.0
-20.0
17.12.00 day 1
03.11.00 day 3
00.00.00 day 5
17.09.00 day 6
08.06.00 day 8
01.07.00 day 10
17.06.00 day 11

FIG. 10

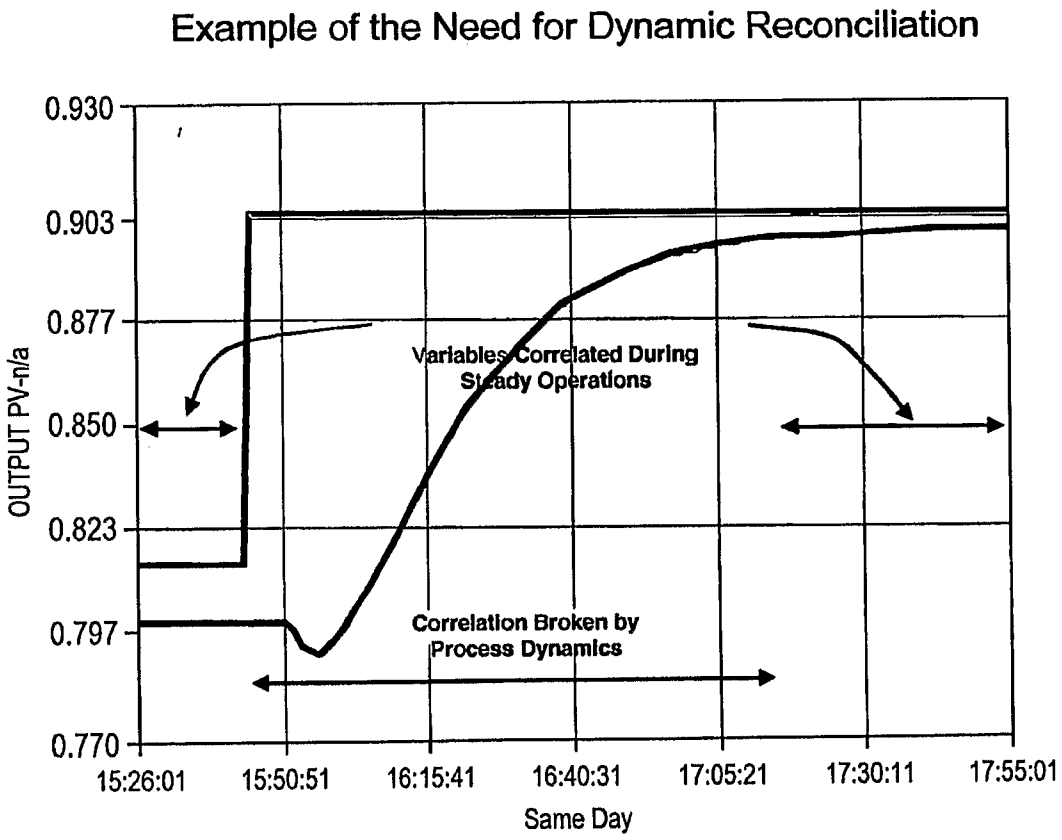
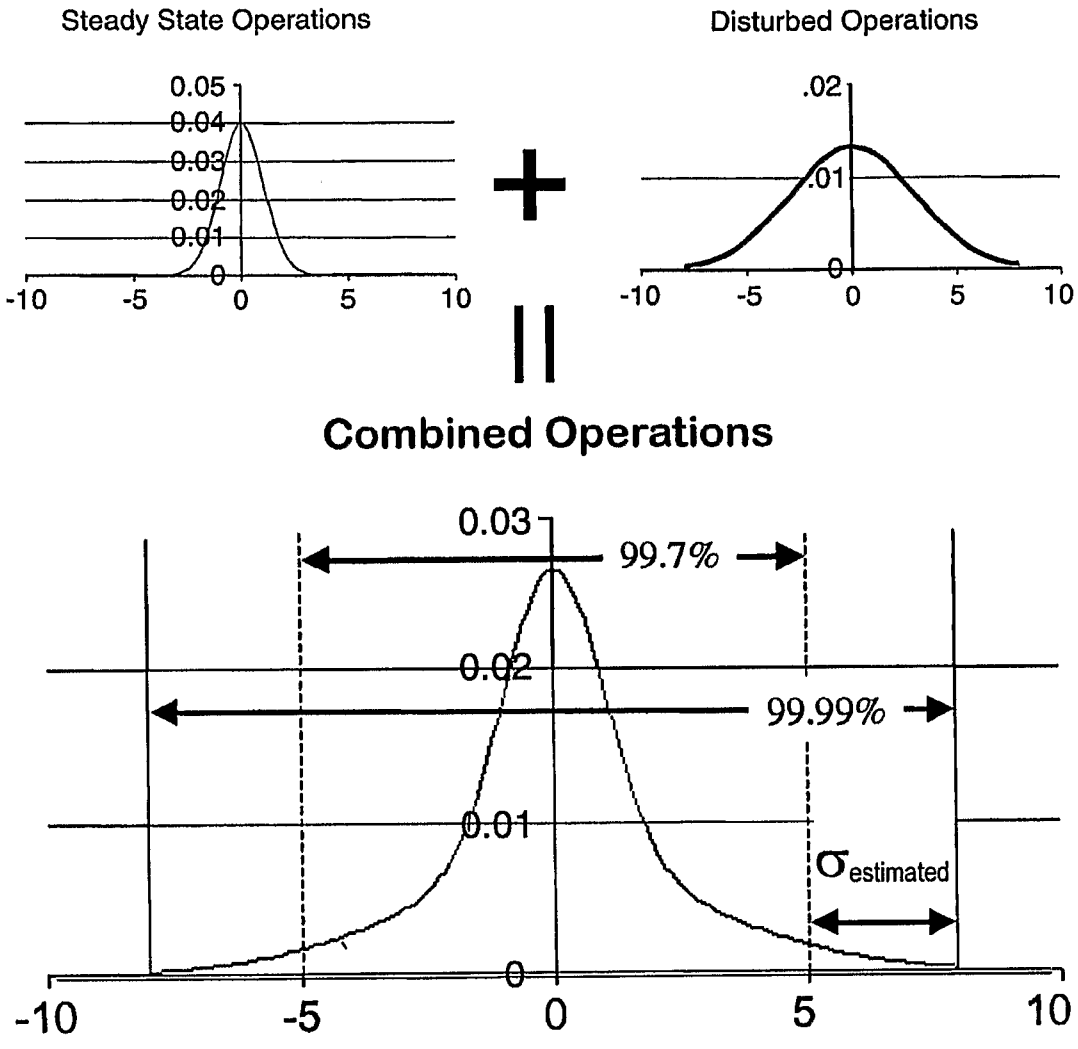

Example of the Need for Dynamic Reconciliation
0.930
0.903
0.877
0.850
0.823
0.797
0.770
OUTPUT PV-n/a
Variables Correlated During Steady Operations
Correlation Broken by Process Dynamics
15:26:01
15:50:51
16:15:41
16:40:31
17:05:21
17:30:11
17:55:01
Same Day

FIG. 11



Probability Distribution of Process Data
Combined Continuous and Disturbed Operations

FIG. 12

An Illustration of the Press Statistic

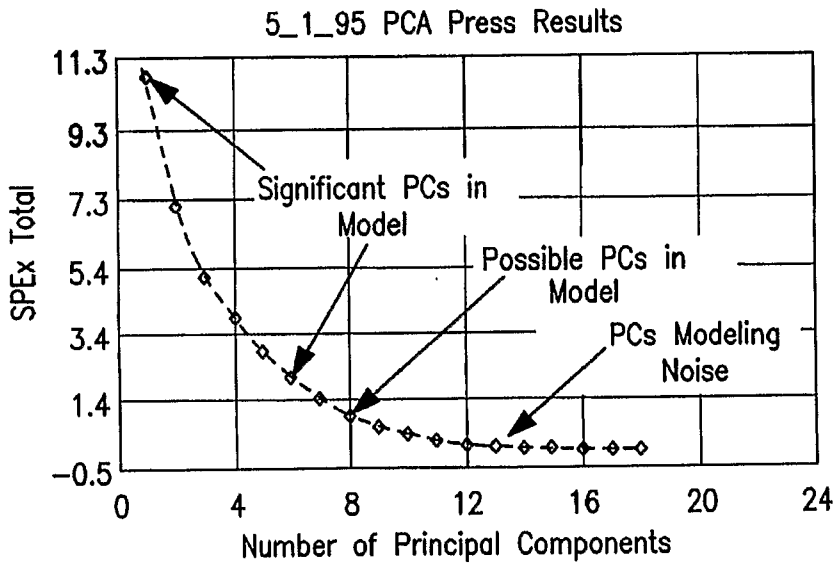


FIG. 13

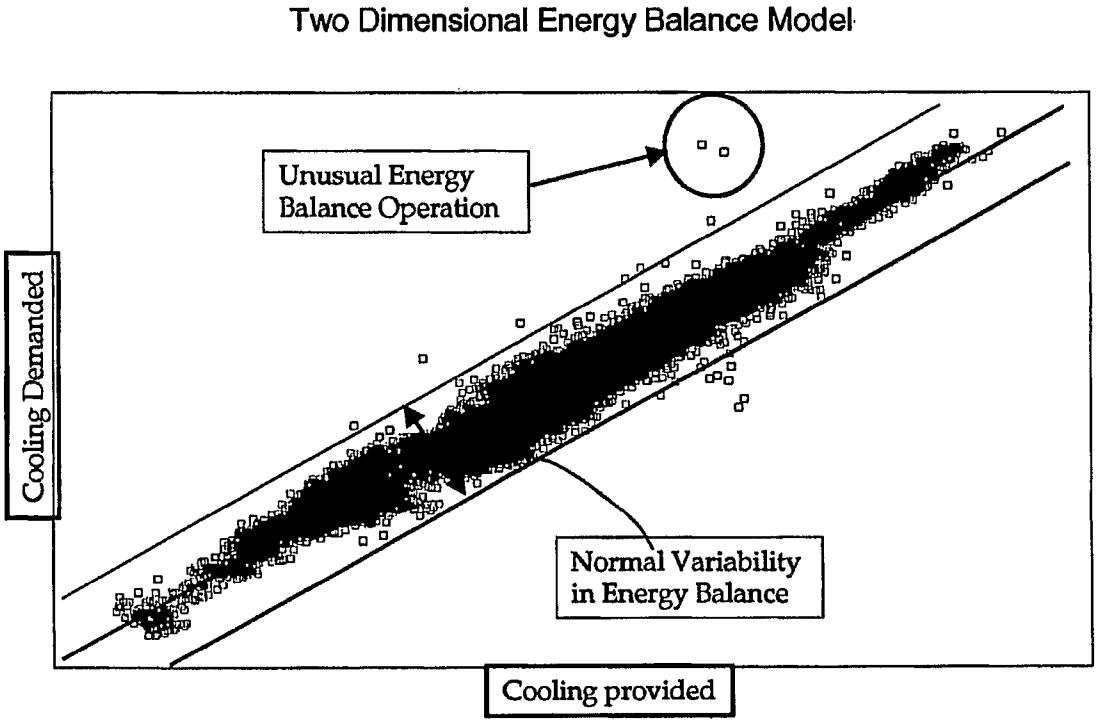

Two Dimensional Energy Balance Model
Unusual Energy Balance Operation
Cooling Demanded
Normal Variability in Energy Balance
Cooling provided

FIG. 14

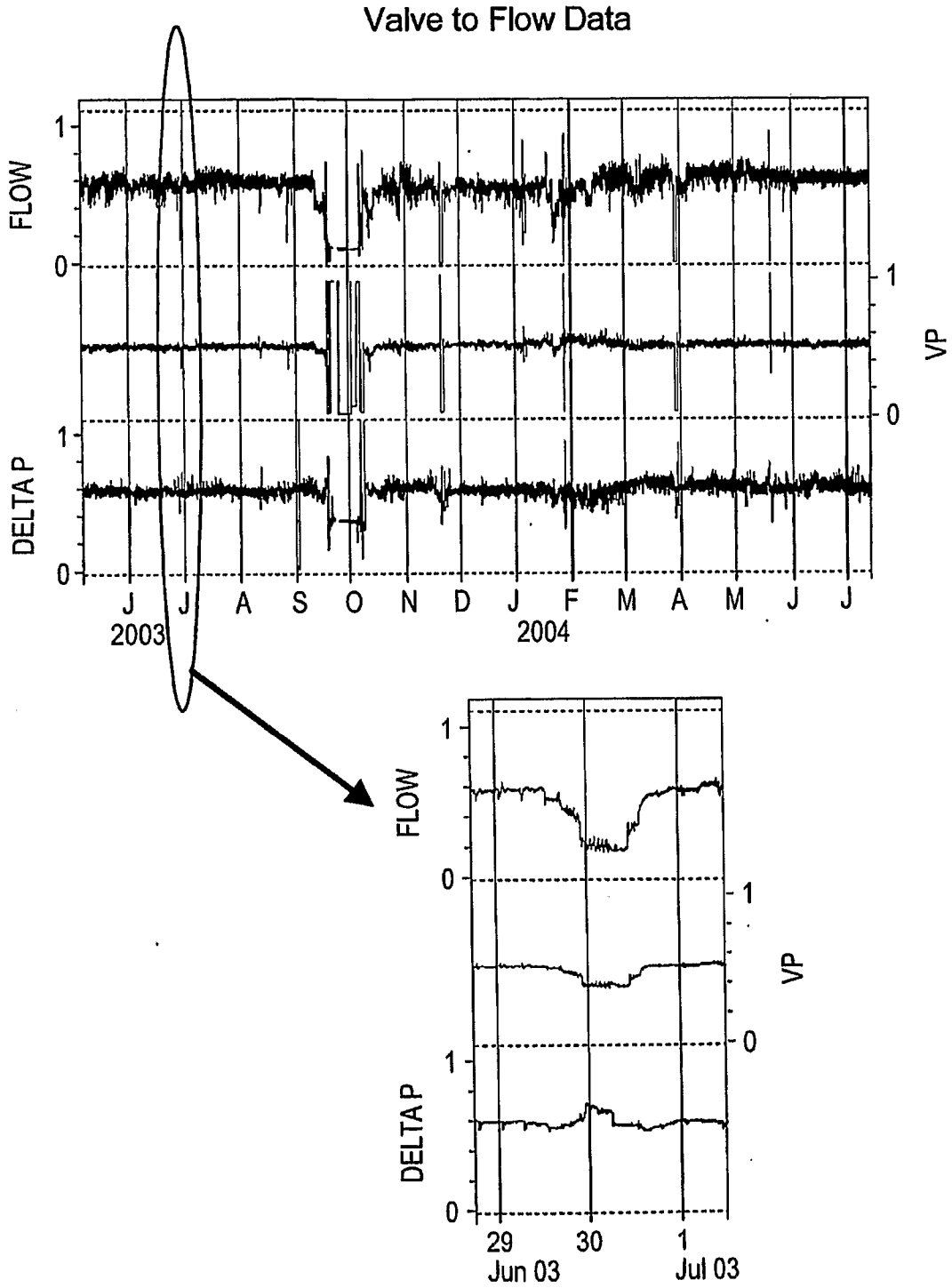

Valve to Flow Data
FLOW
DELTA P
VP
1
0
J
J
A
S
O
N
D
J
F
M
A
M
J
J
2003
2004
29
30
1
Jun 03
Jul 03

FIG. 15

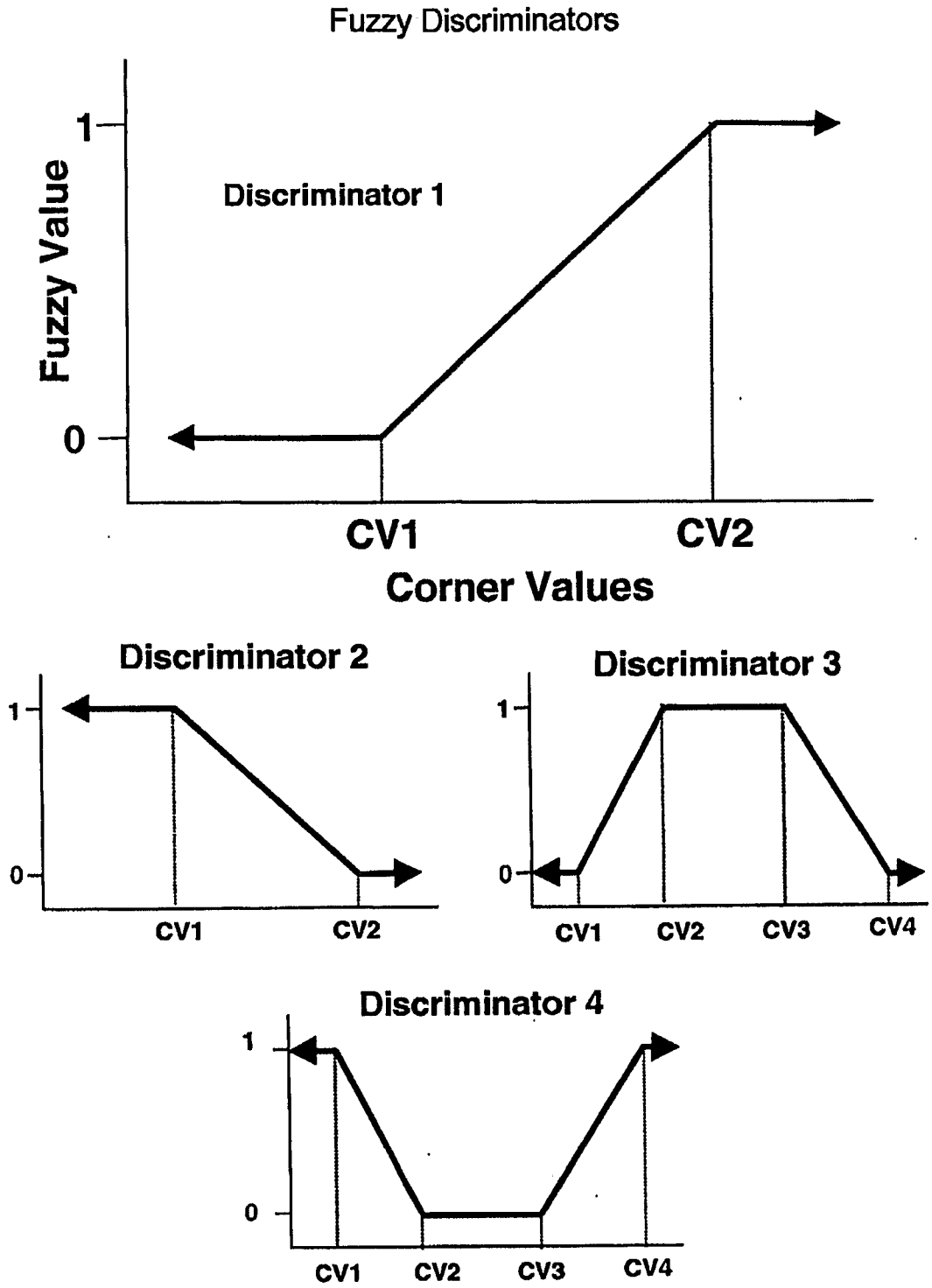

Fuzzy Discriminators
Fuzzy Value
1
0
Discriminator 1
CV1
CV2
Corner Values
Discriminator 2
1
0
CV1
CV2
Discriminator 3
1
0
CV1
CV2
CV3
CV4
Discriminator 4
1
0
CV1
CV2
CV3
CV4

FIG. 16

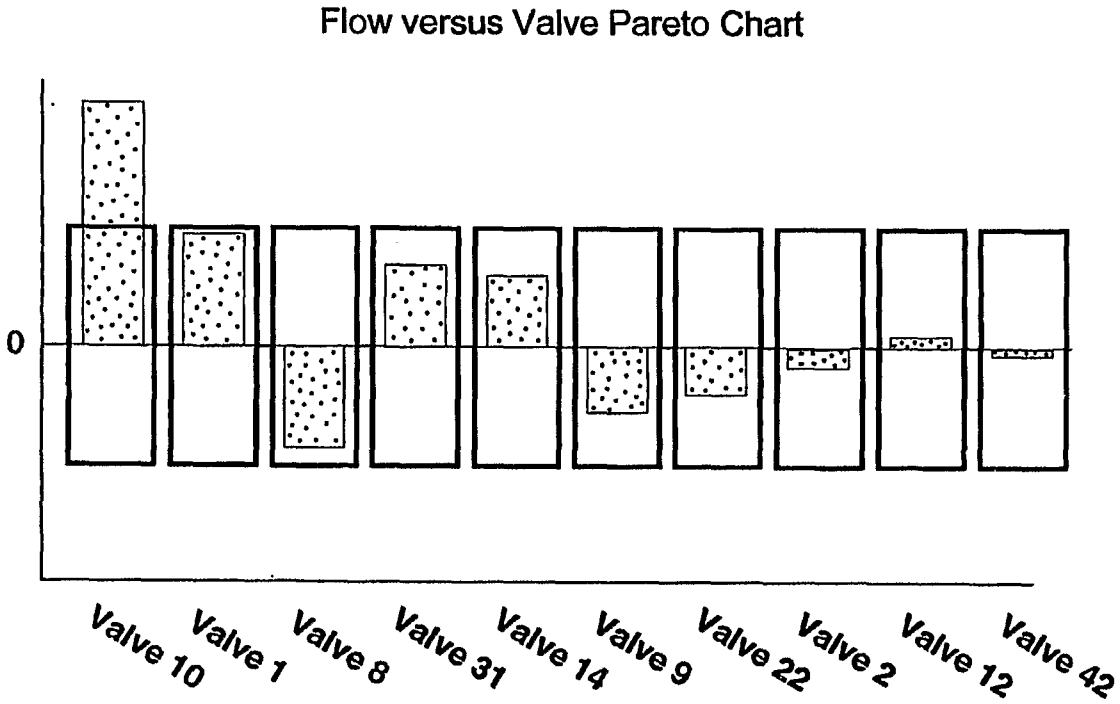

Flow versus Valve Pareto Chart
0
Valve 10
Valve 1
Valve 8
Valve 31
Valve 14
Valve 9
Valve 22
Valve 2
Valve 12
Valve 42

FIG. 17

Operator Suppression Logic

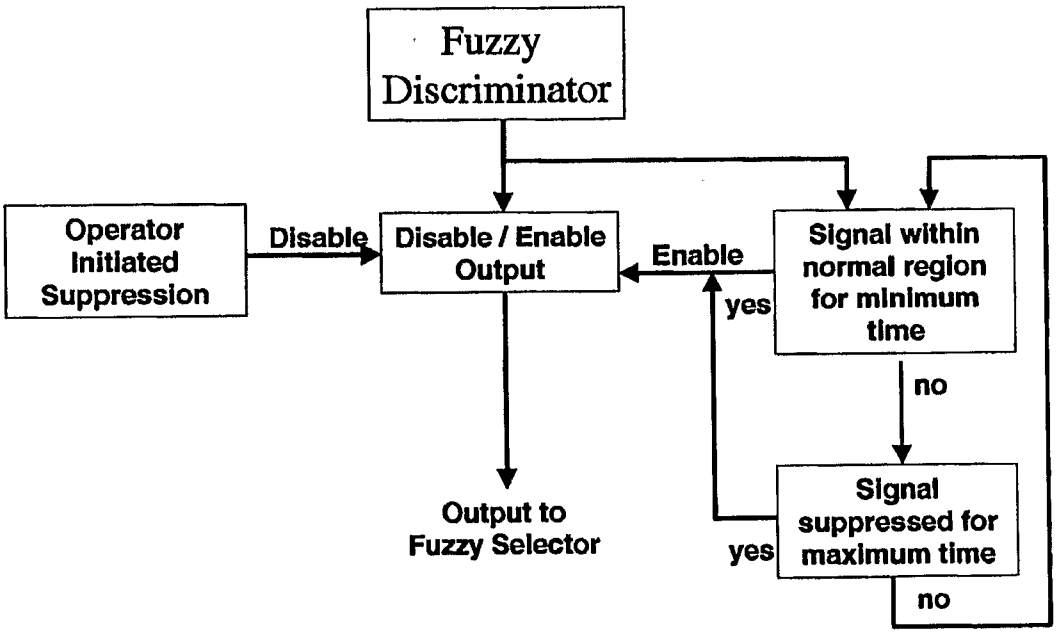


FIG. 18

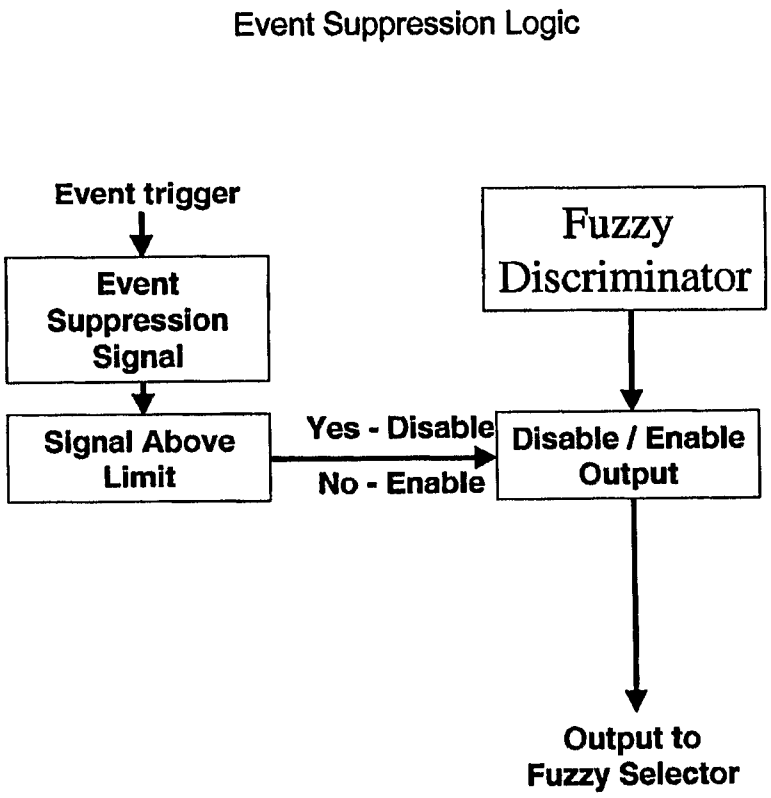

Event Suppression Logic
Event trigger
Event Suppression Signal
Signal Above Limit
Yes - Disable
No - Enable
Fuzzy Discriminator
Disable / Enable Output
Output to Fuzzy Selector

FIG. 19

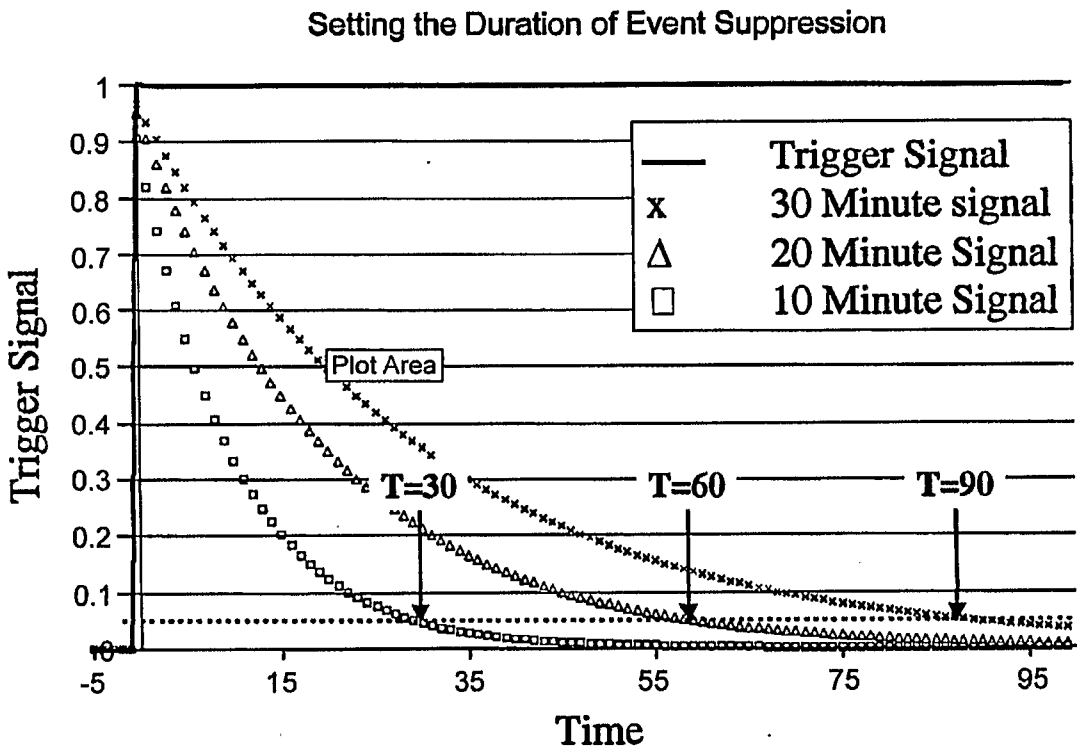

Setting the Duration of Event Suppression
Trigger Signal
30 Minute signal
20 Minute Signal
10 Minute Signal
Plot Area
T=30
T=60
T=90
Trigger Signal
Time
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-5
15
35
55
75
95

FIG. 20

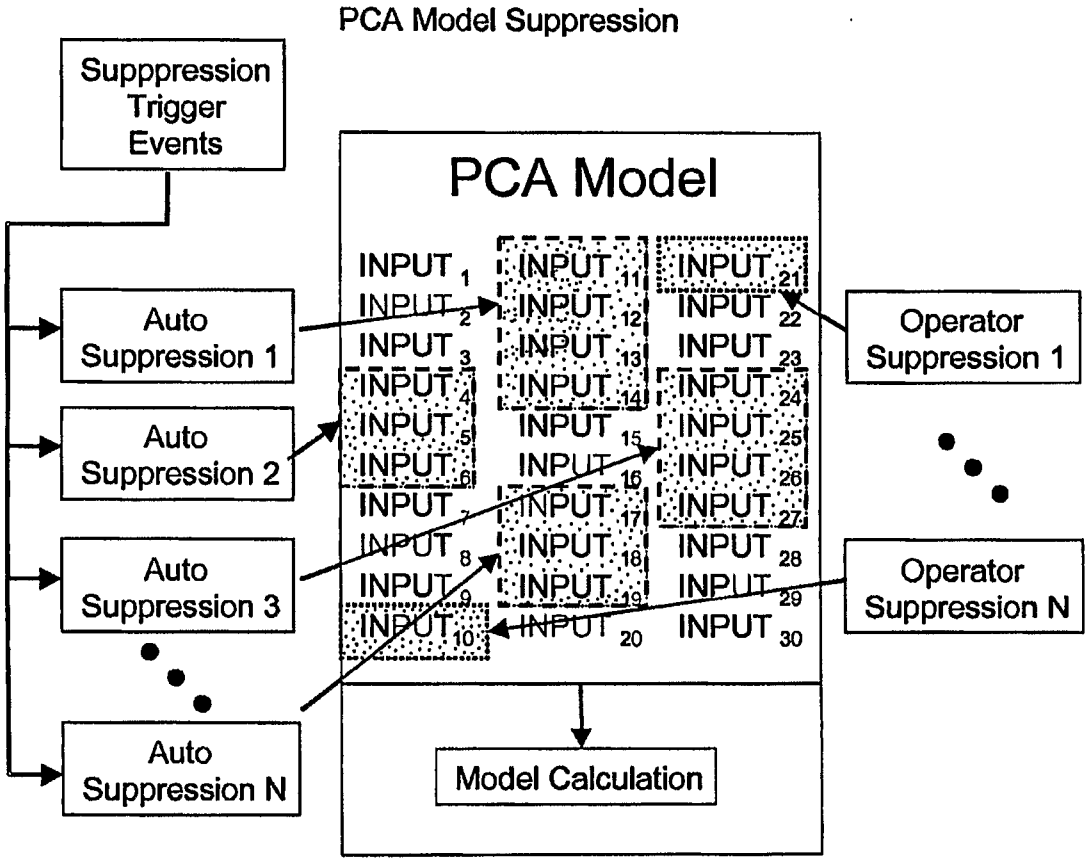

PCA Model Suppression
Supppression Trigger Events
PCA Model
INPUT 1
INPUT 2
INPUT 3
INPUT 4
INPUT 5
INPUT 6
INPUT 7
INPUT 8
INPUT 9
INPUT 10
INPUT 11
INPUT 12
INPUT 13
INPUT 14
INPUT 15
INPUT 16
INPUT 17
INPUT 18
INPUT 19
INPUT 20
INPUT 21
INPUT 22
INPUT 23
INPUT 24
INPUT 25
INPUT 26
INPUT 27
INPUT 28
INPUT 29
INPUT 30
Auto Suppression 1
Auto Suppression 2
Auto Suppression 3
Auto Suppression N
Operator Suppression 1
Operator Suppression N
Model Calculation

FIG. 21

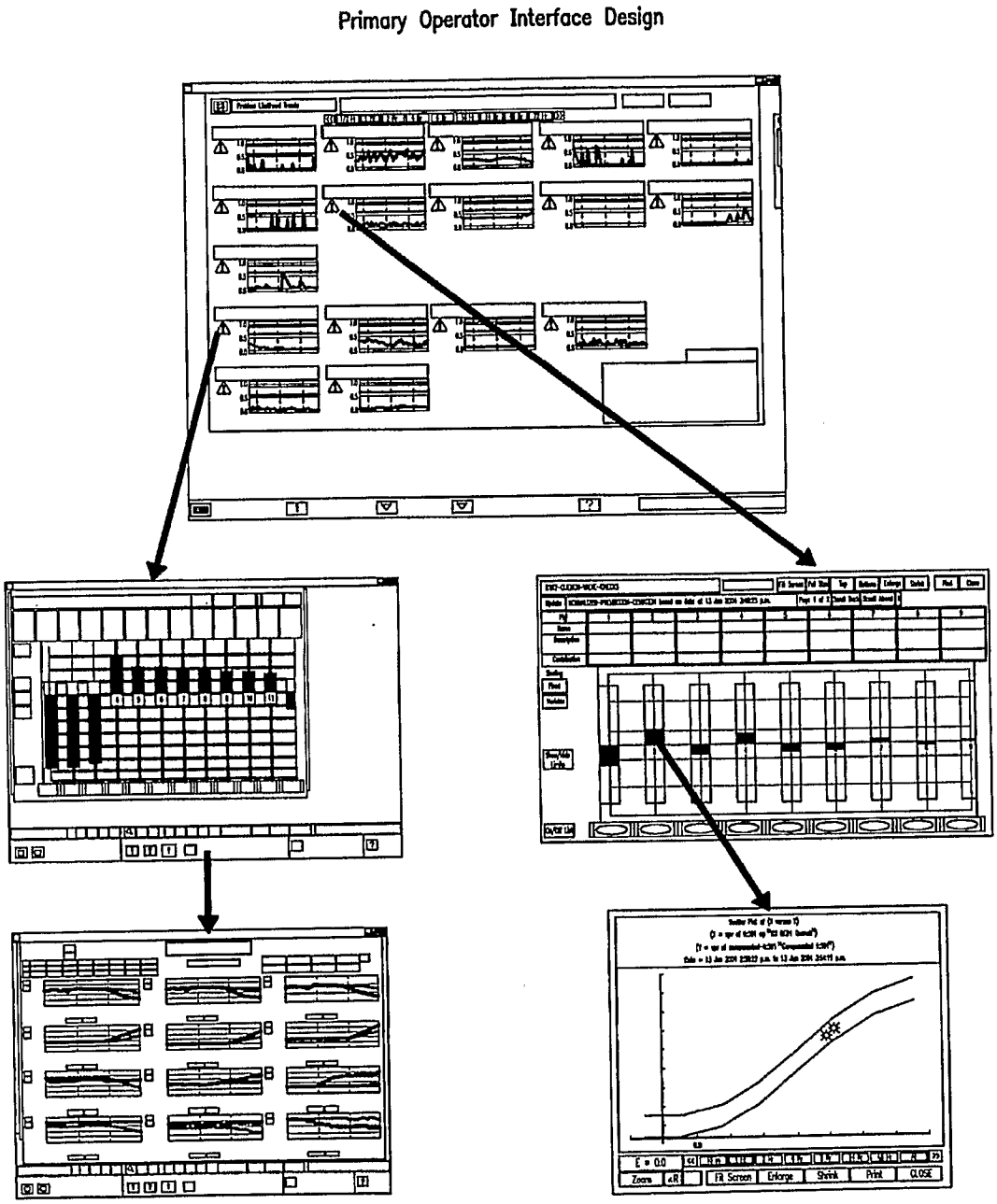


FIG. 22

FIG. 23

DCU Schematic Layout

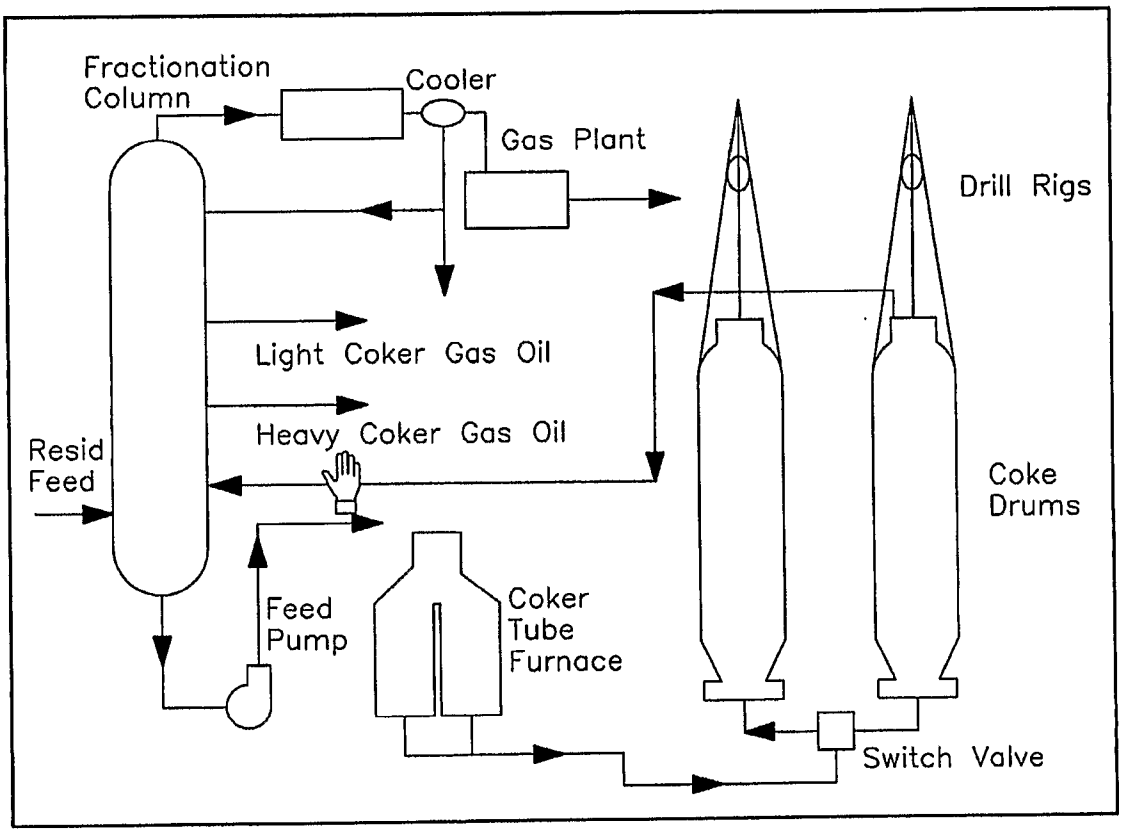


FIG. 24

DCU and Light Ends Processing Units

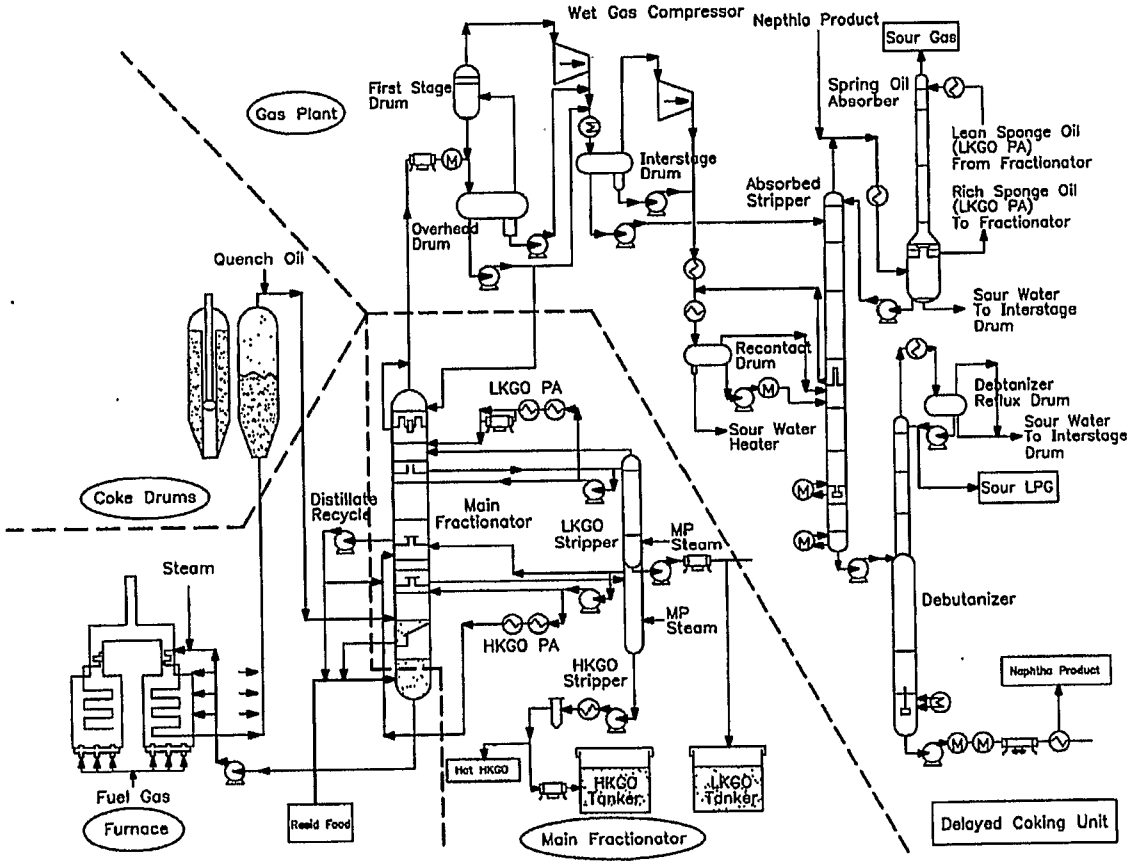


FIG. 25

AED Overview of DCU Process

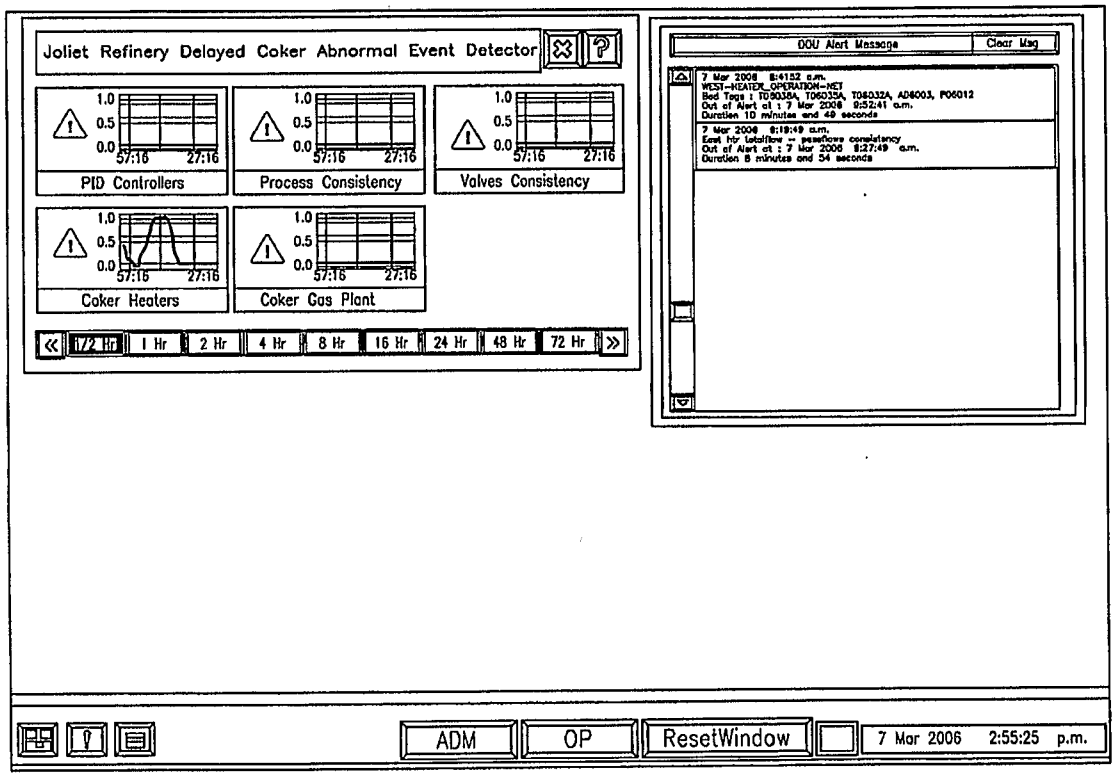


FIG. 26

Fuzzy Logic Based Continuous Abnormality Indicator

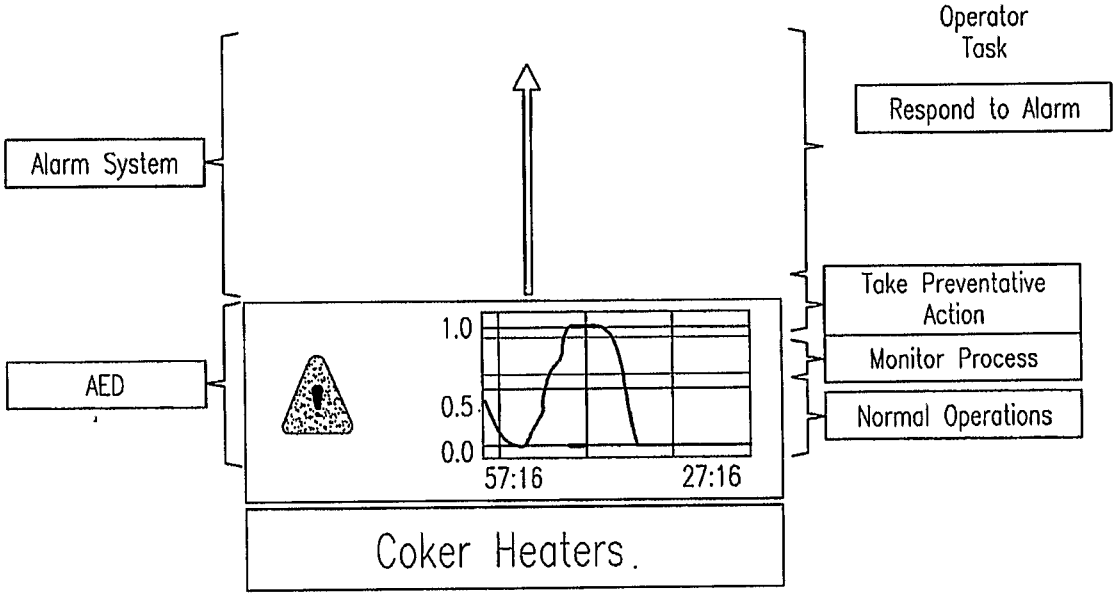


FIG. 27

Fuzzy Logic Network for a Level Controller Monitor

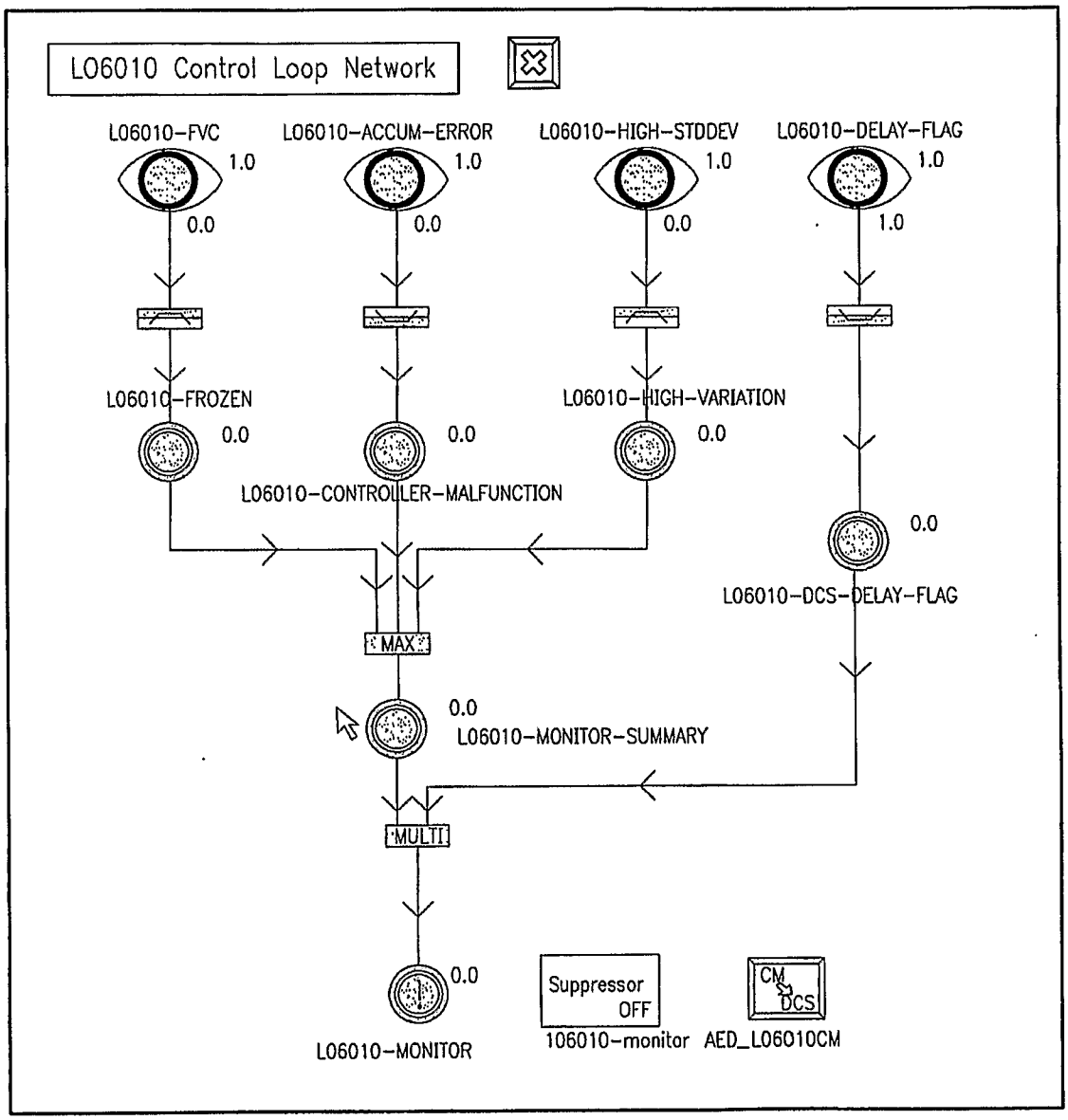
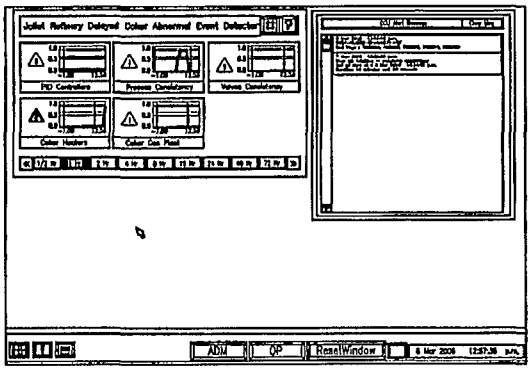
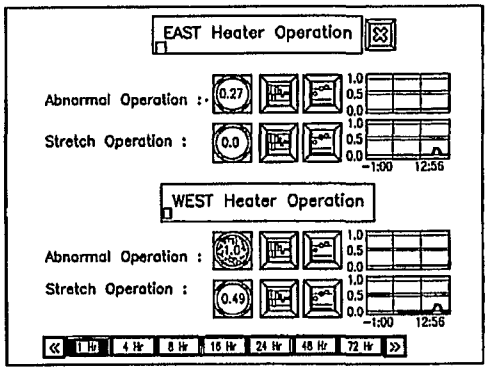


FIG. 28

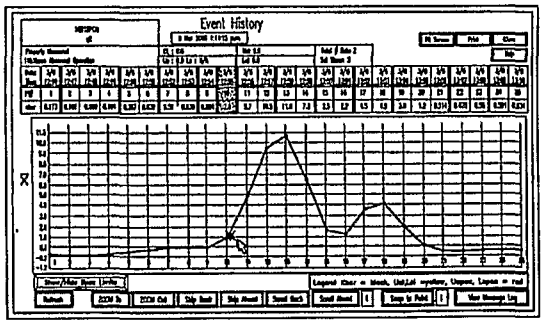
Complete Drill Down of a Furnace problem in AED

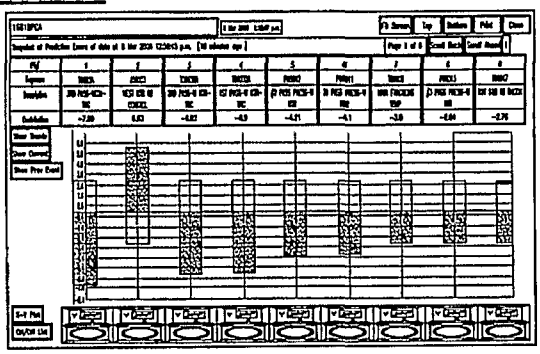
OVERVIEW LEVEL



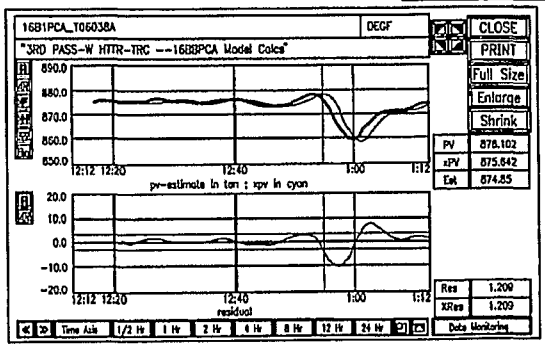


SUMMARY LEVEL





DETAIL LEVEL



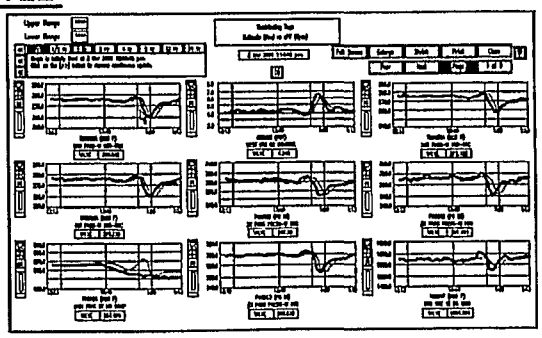


FIG. 29

Overview Display on the Occurrence of a Furnace Problem

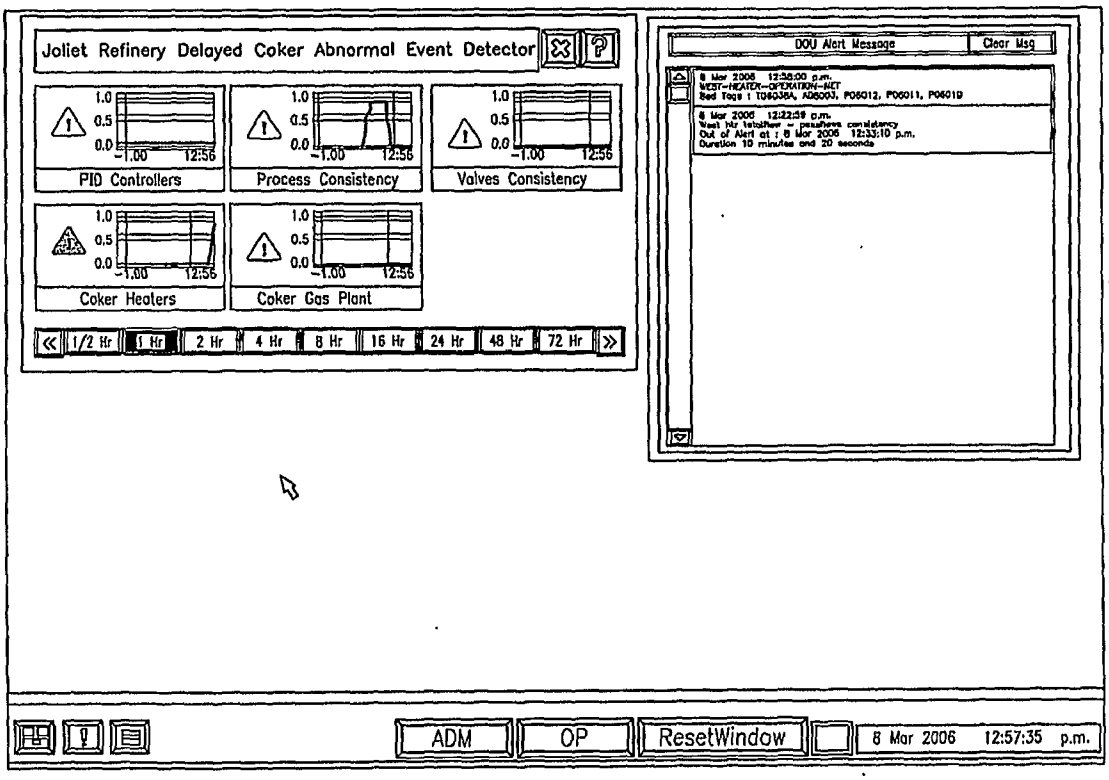


FIG. 30

Indication of Furnace Sub–Area with a Problem

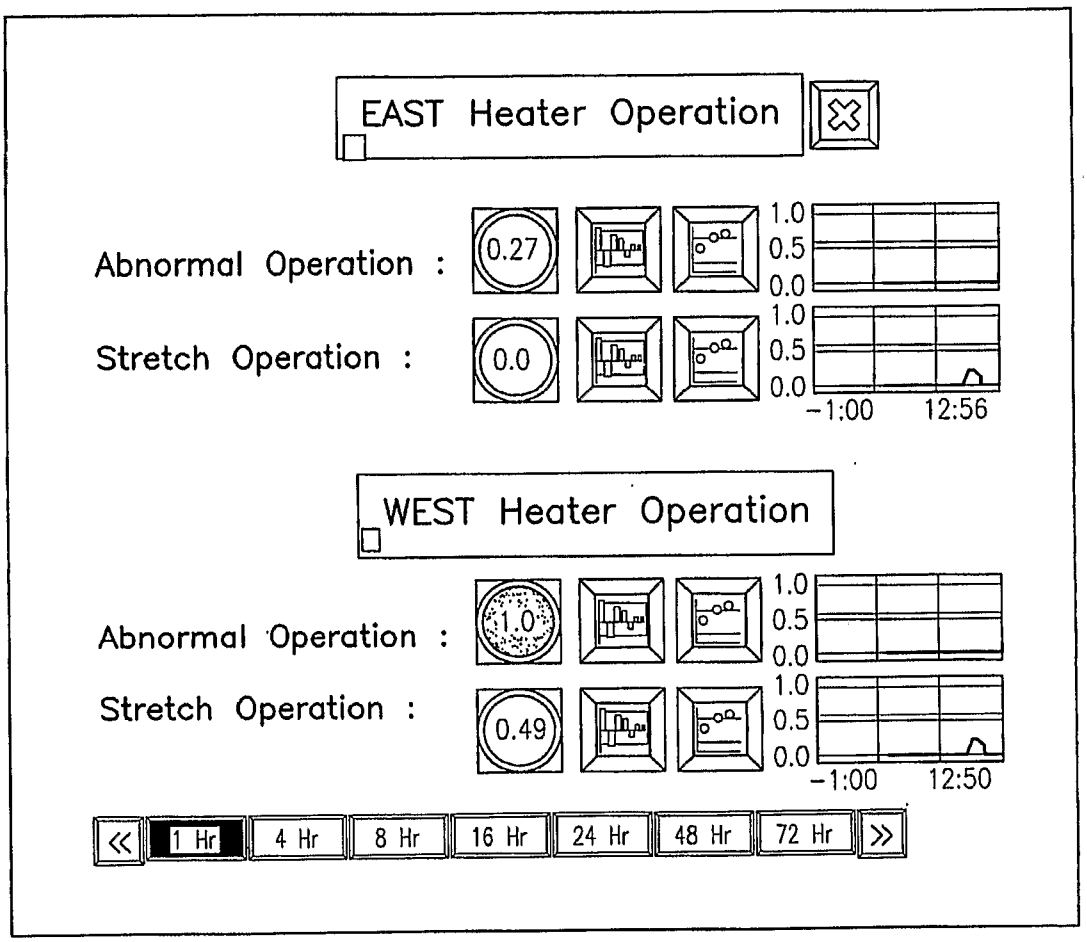


FIG. 31

Bad Actor Pareto–Chart for a Furnace Problem

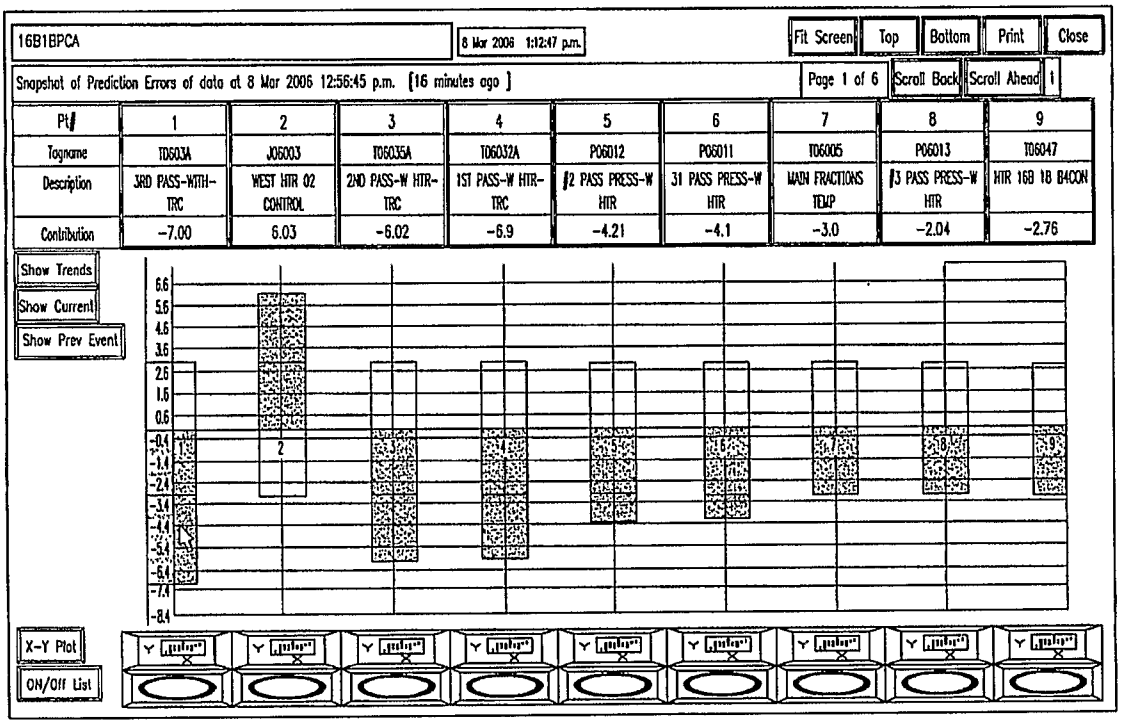


FIG. 32

Multi–Trend Chart of Bad Actors (Predicted vs. Actual)

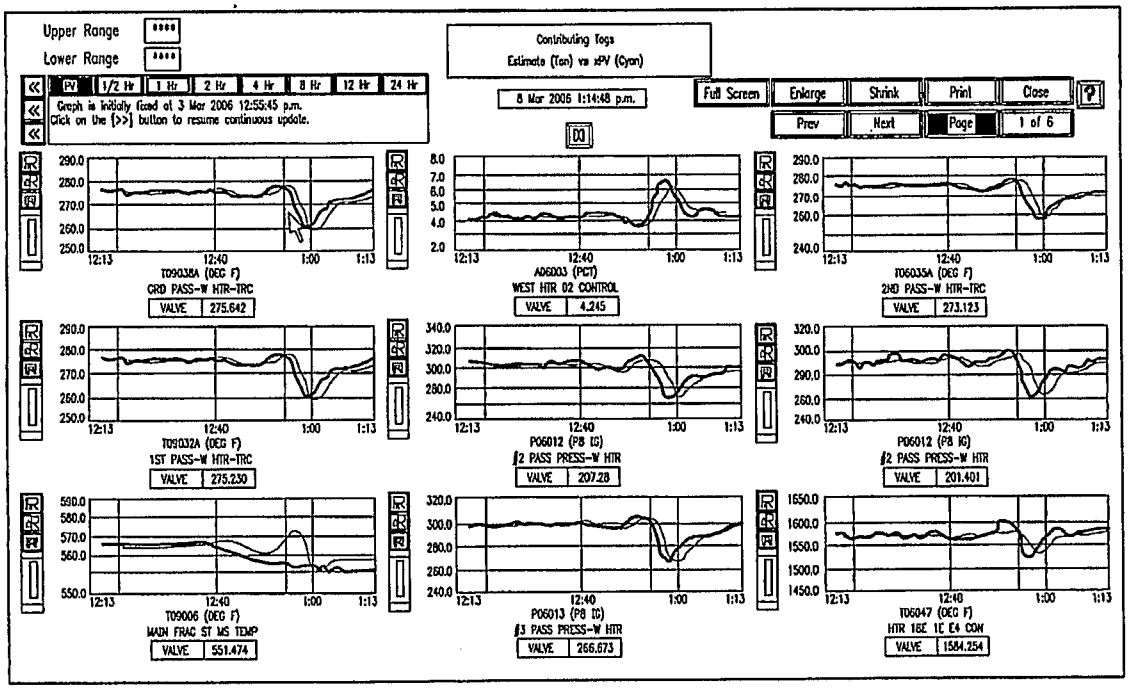


FIG. 33

Detailed Trend of Worst Actor for Furnace Problem

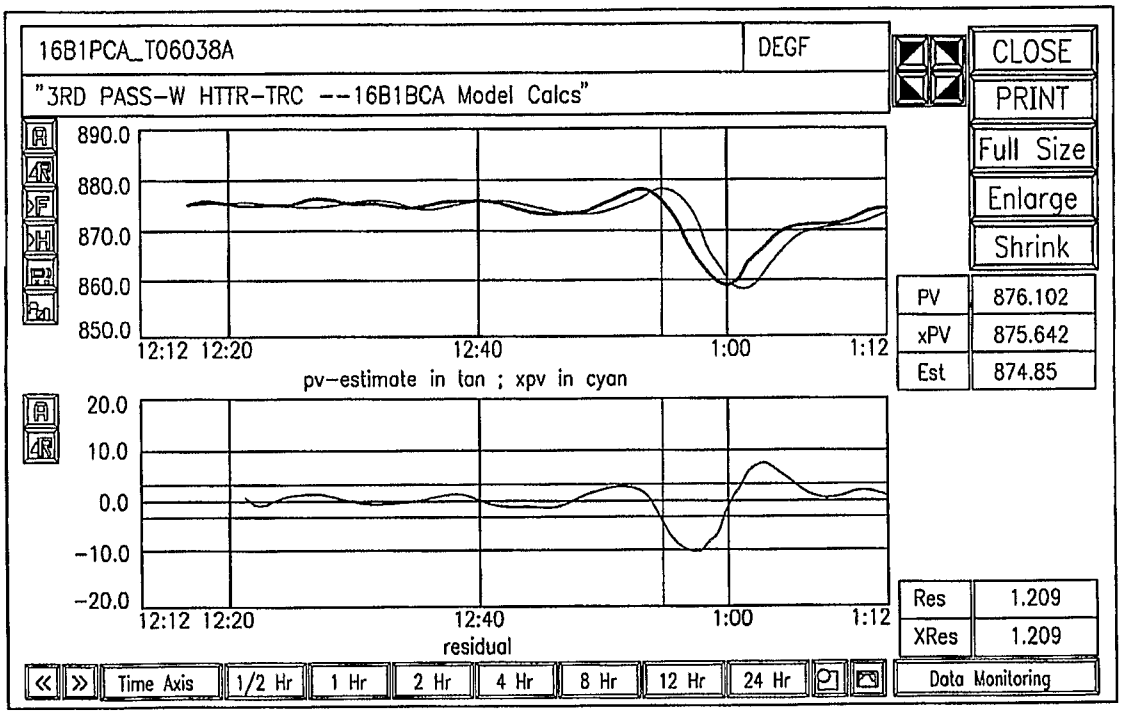


FIG. 34

Historical Trend of Furnace Sub–Area Normality Indicator

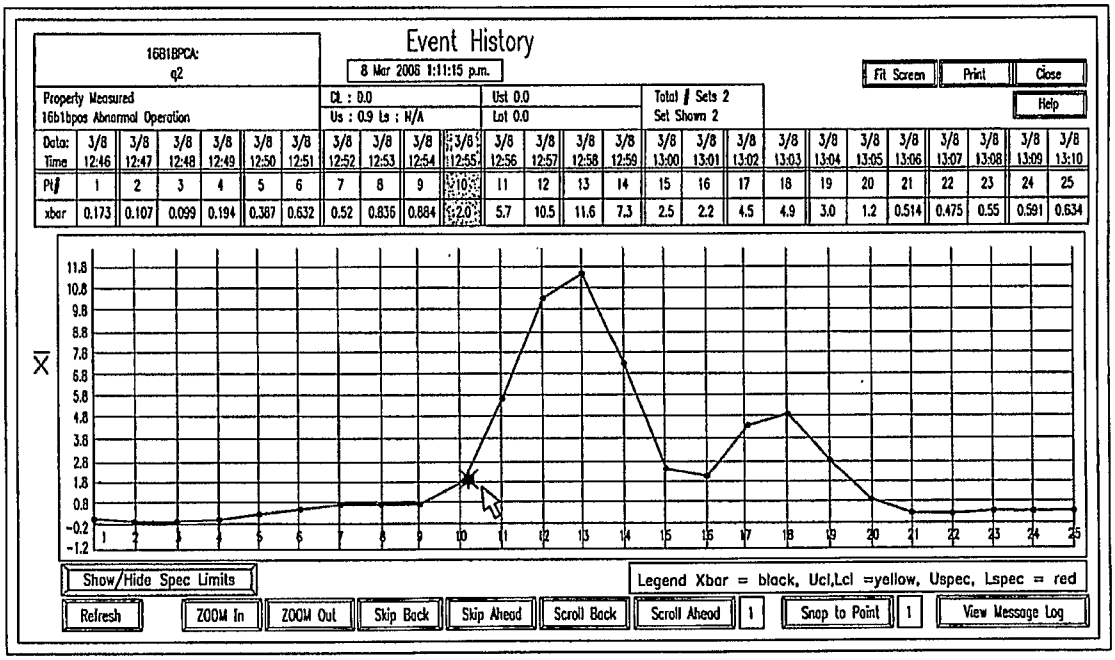


FIG. 35

Valve Flow Pareto Chart (Furnace Feed Valves)

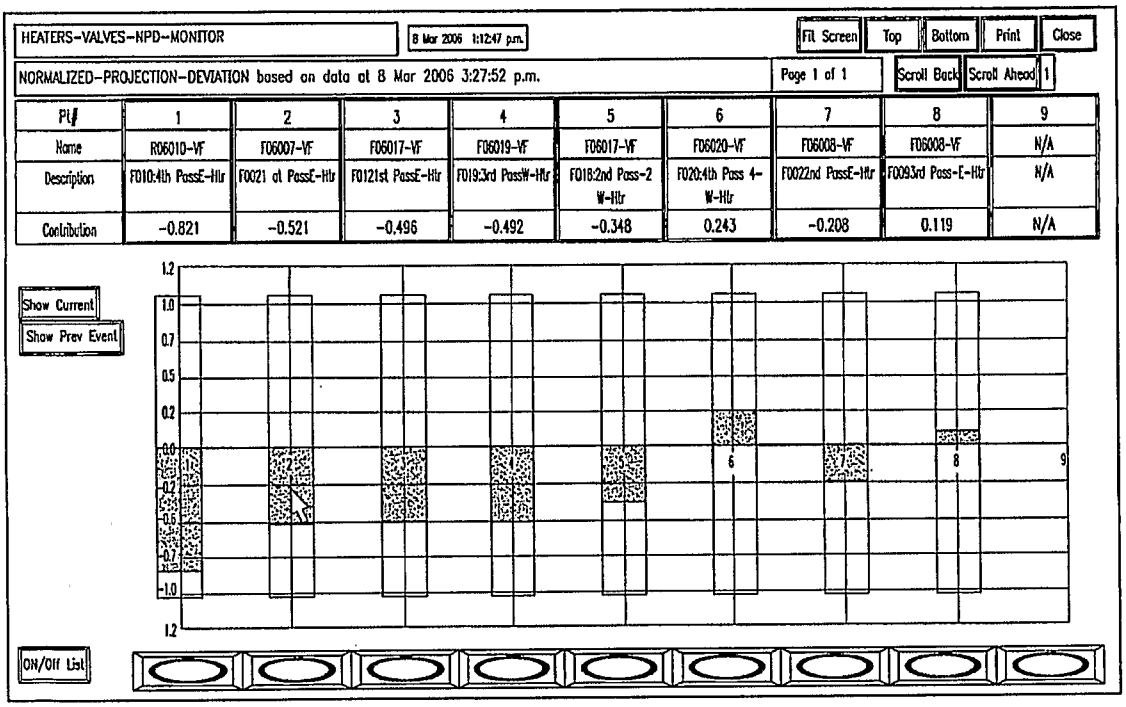


FIG. 36

Valve–Flow model X–Y plot

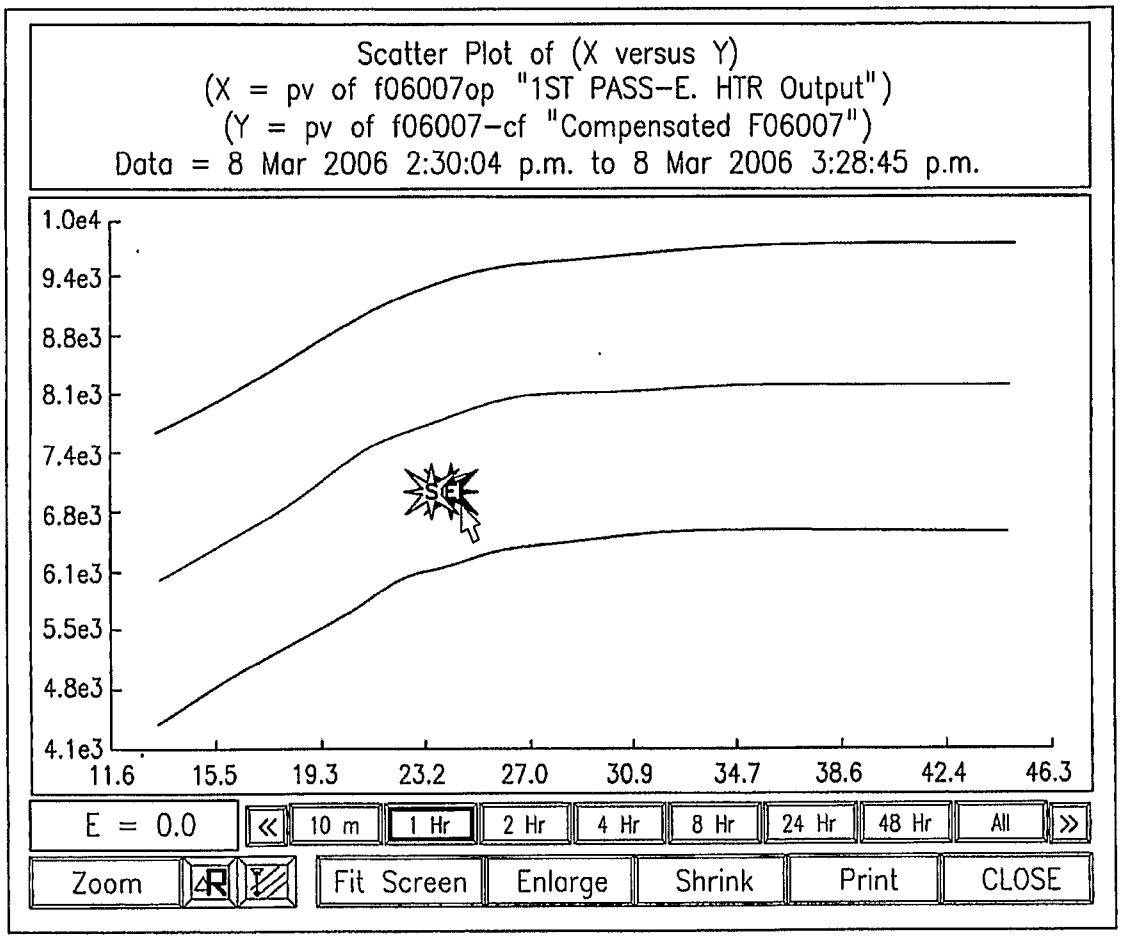


FIG. 37

Valve–Flow Fuzzy Network (Heater Valves)

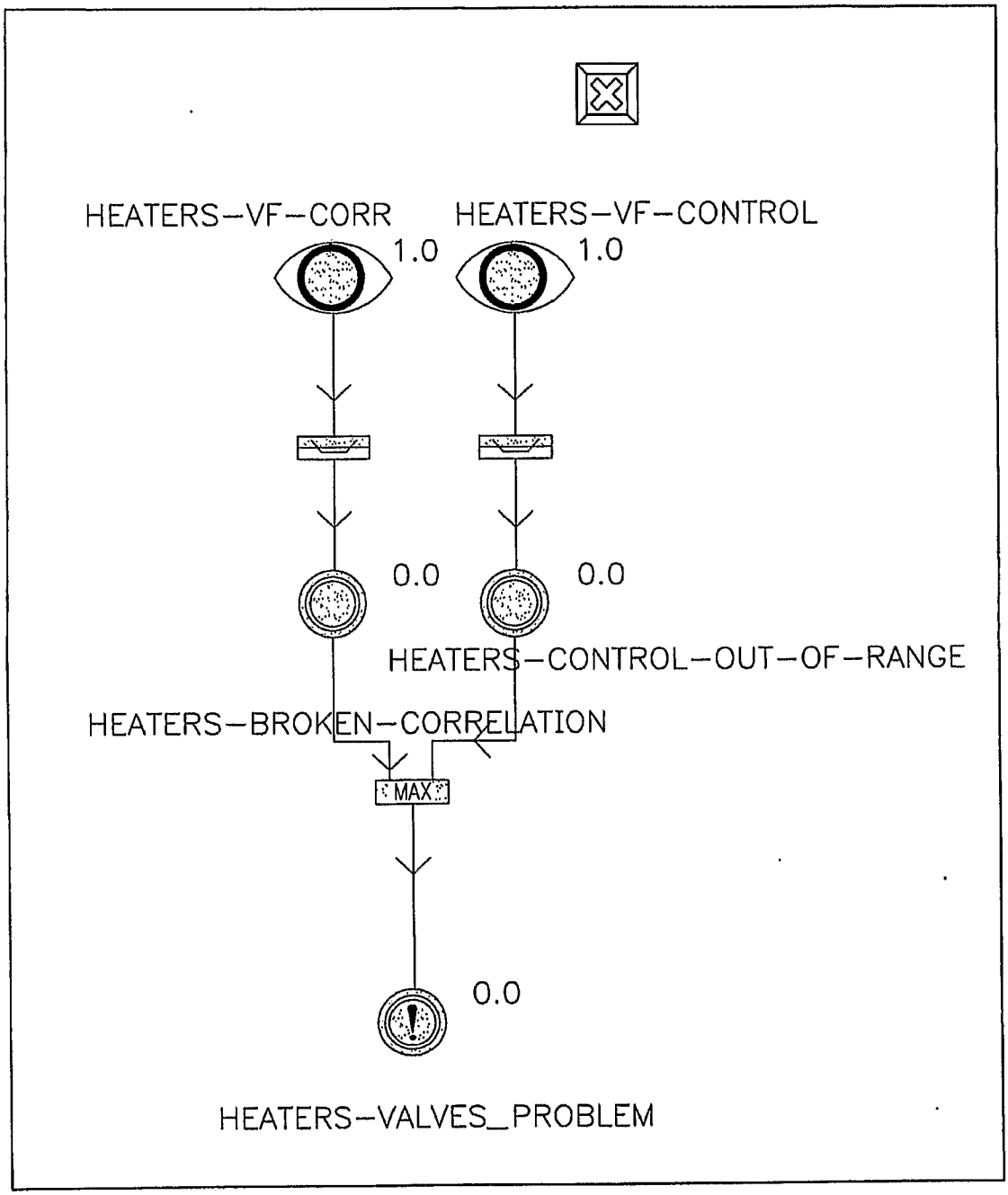


FIG. 38

Example of Valve Out of Controllable Range

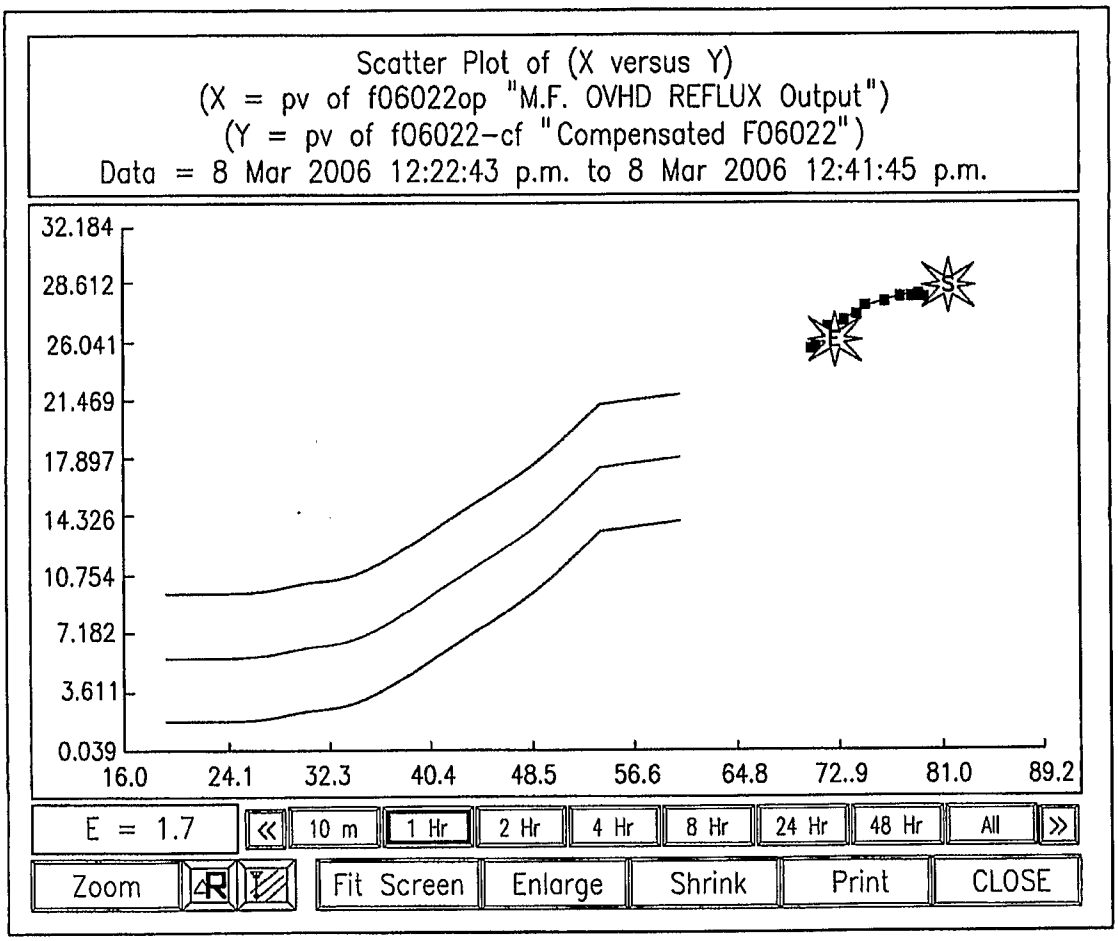


FIG. 39

Building a PCA Model: Distribution of Principal Components

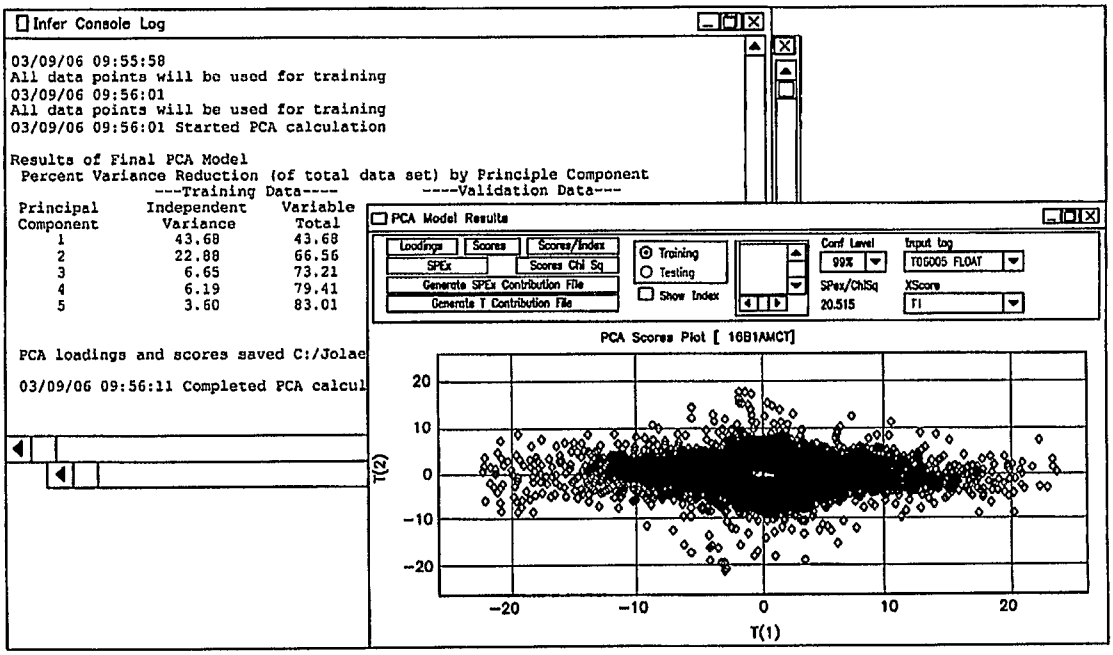


FIG. 40

Alert Suppression Network

