Abnormal Event Detection On-Line Information Flow

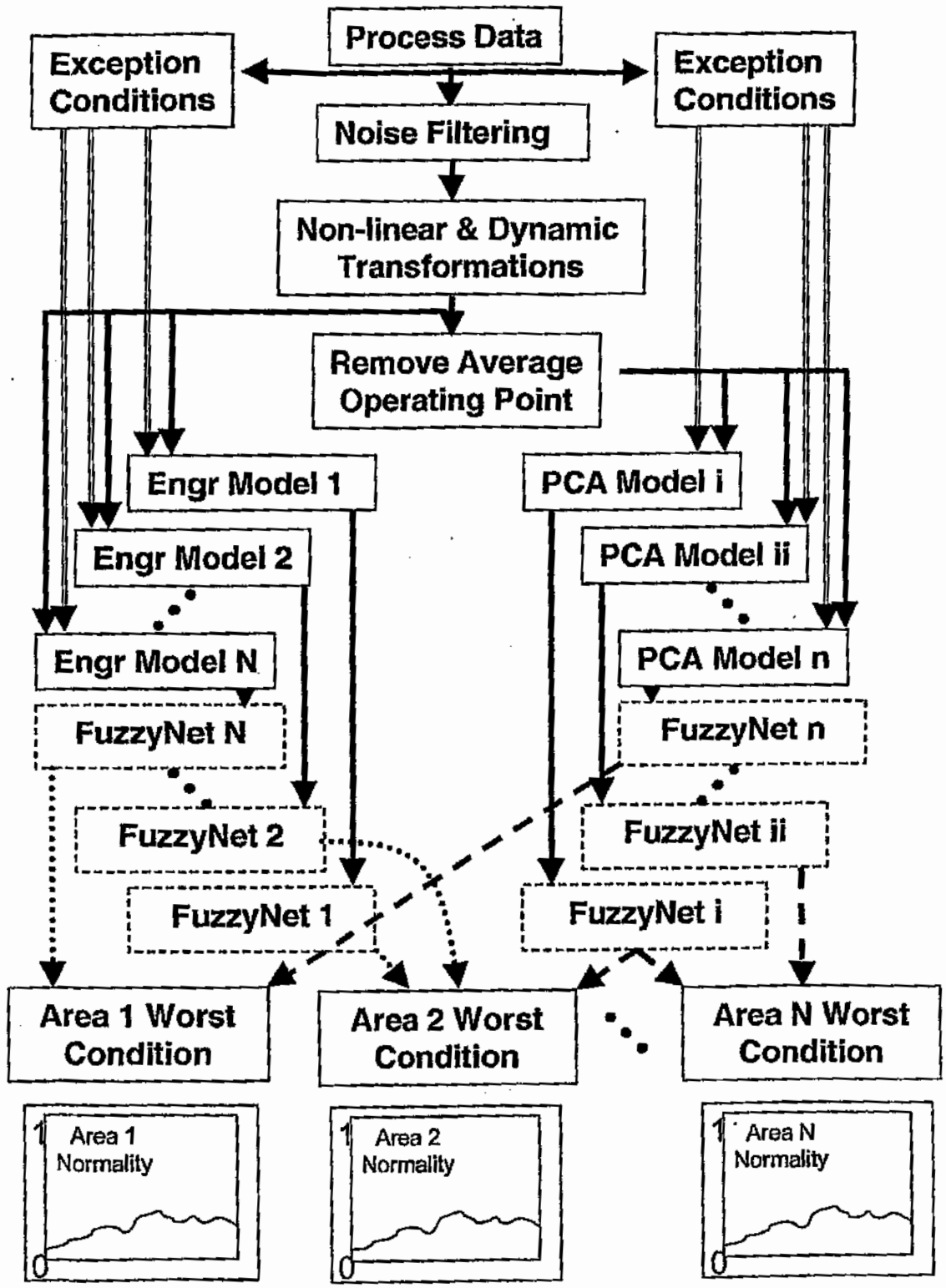


FIG. 1

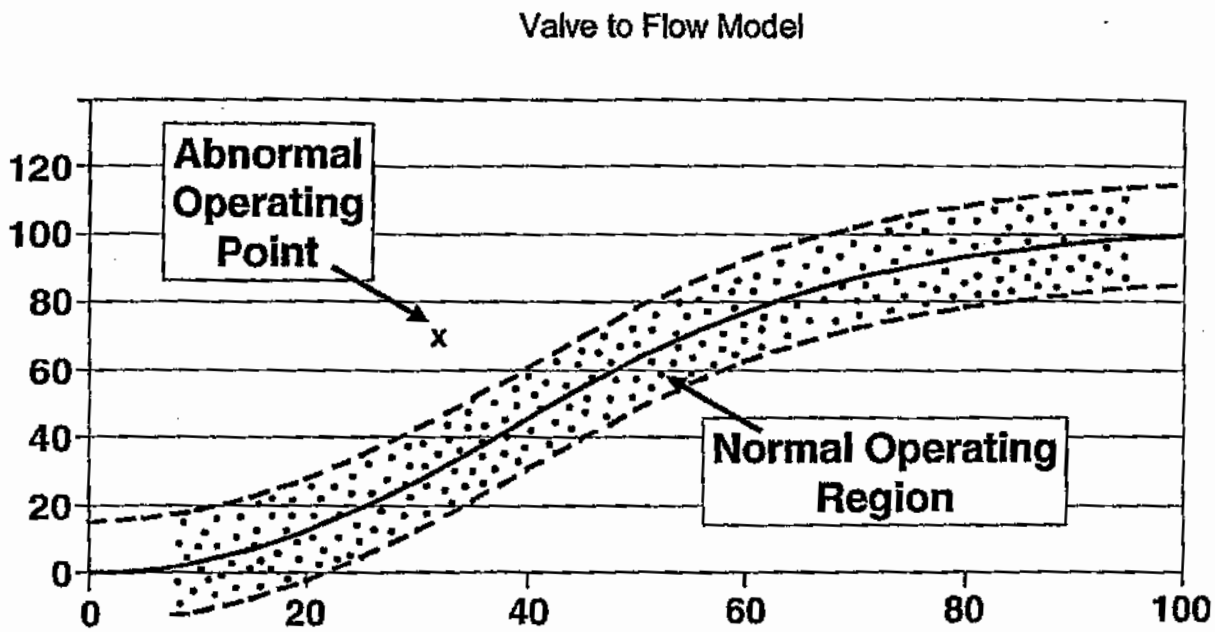

Valve to Flow Model
Abnormal Operating Point
x
Normal Operating Region
120
100
80
60
40
20
0
0
20
40
60
80
100

FIG. 2

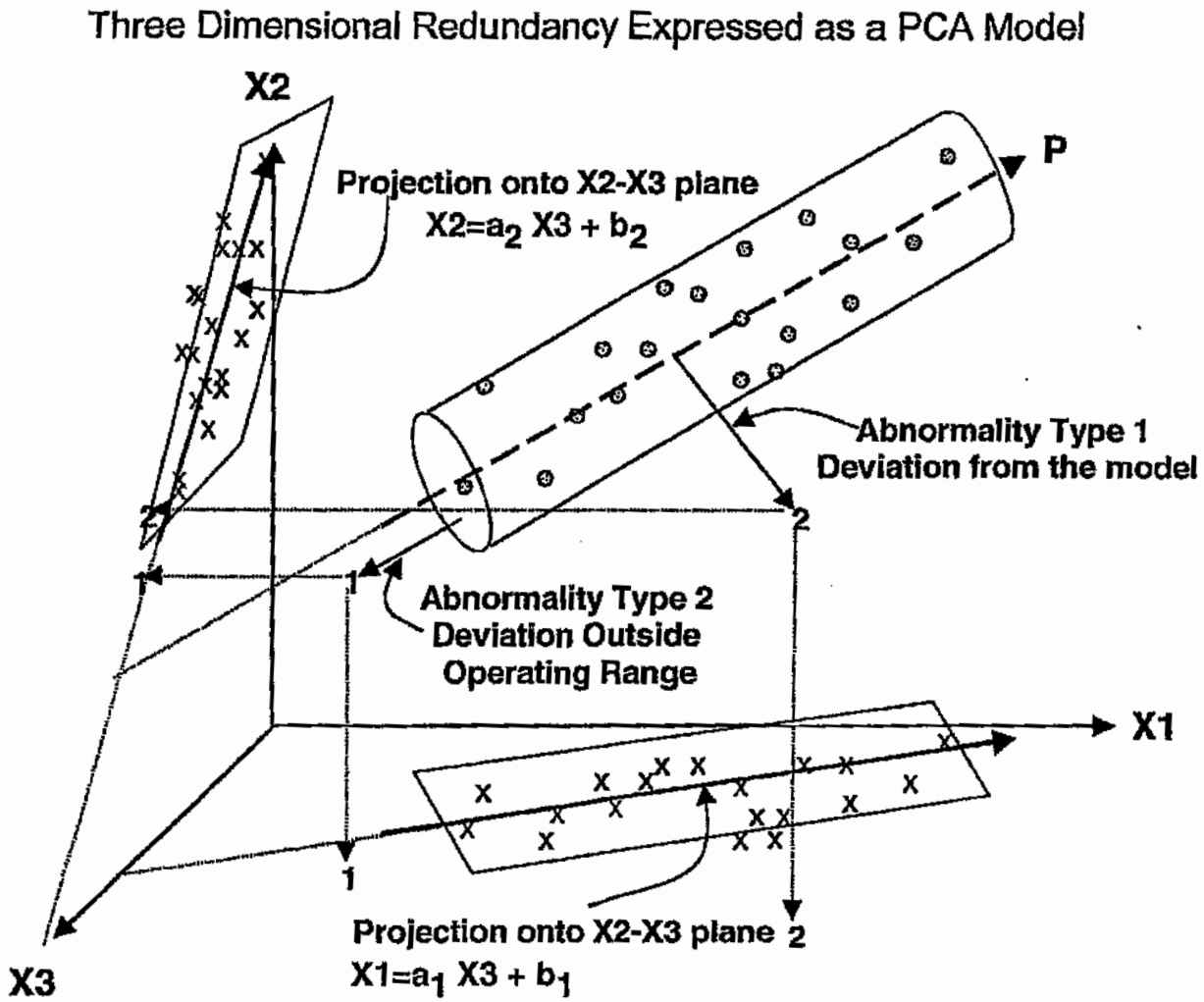

Three Dimensional Redundancy Expressed as a PCA Model
X2
Projection onto X2-X3 plane
X2=a2 X3 + b2
P
Abnormality Type 1
Deviation from the model
Abnormality Type 2
Deviation Outside
Operating Range
X1
X3
Projection onto X2-X3 plane
X1=a1 X3 + b1

FIG. 3

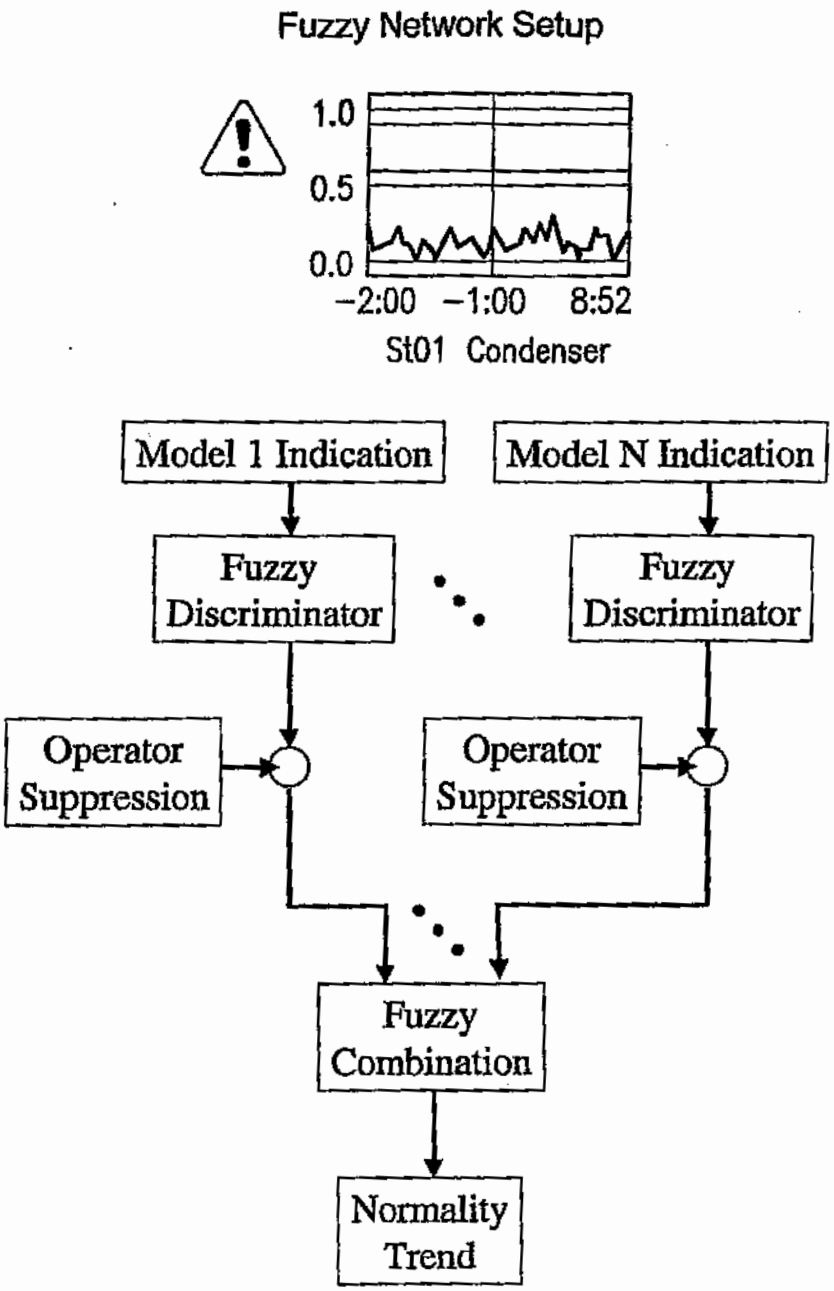

Fuzzy Network Setup
1.0
0.5
0.0
−2:00 −1:00 8:52
St01 Condenser
Model 1 Indication
Model N Indication
Fuzzy Discriminator
Fuzzy Discriminator
Operator Suppression
Operator Suppression
Fuzzy Combination
Normality Trend

FIG. 4

Process For Developing a PCA Abnormal Event Detector

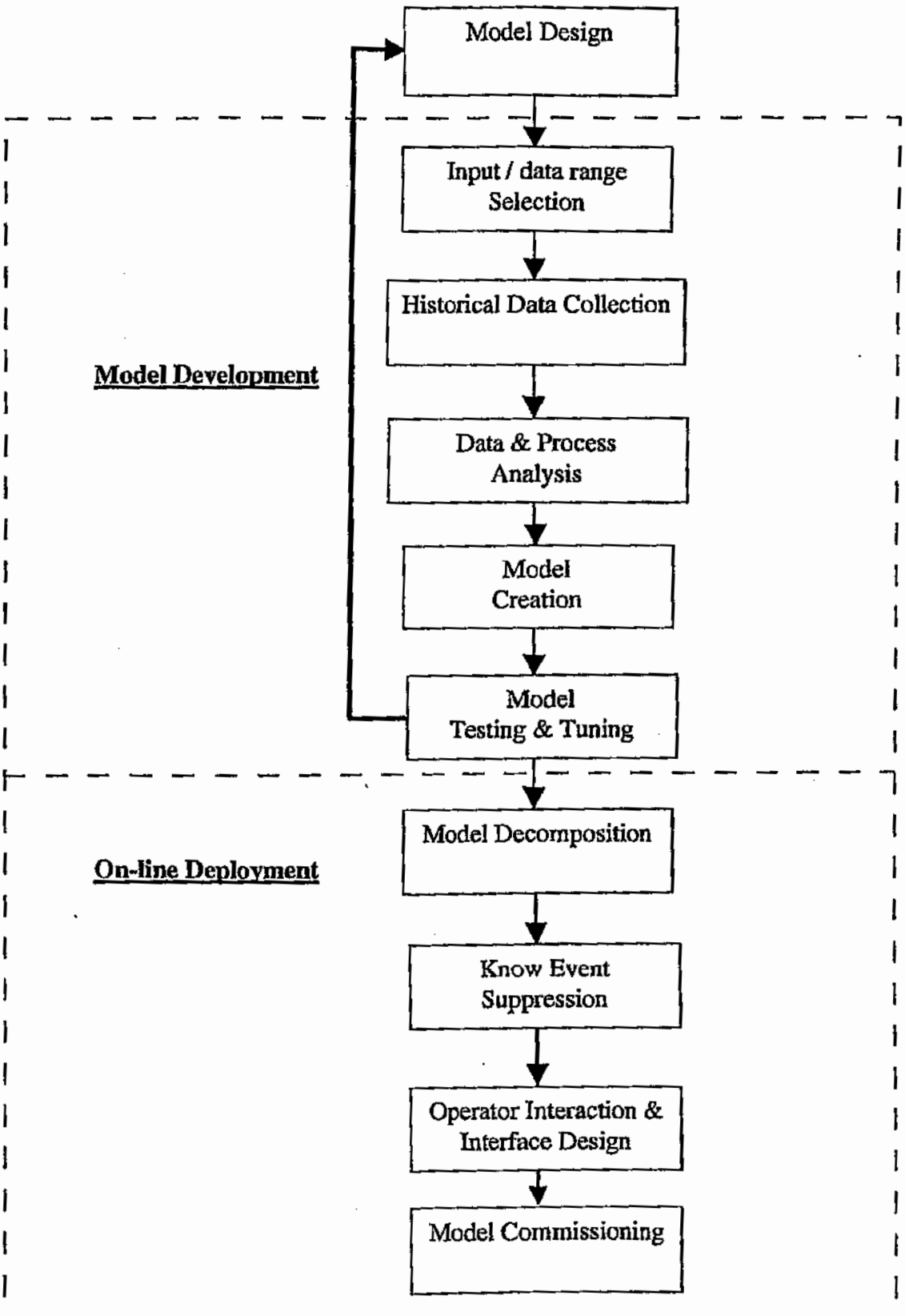


FIG. 5

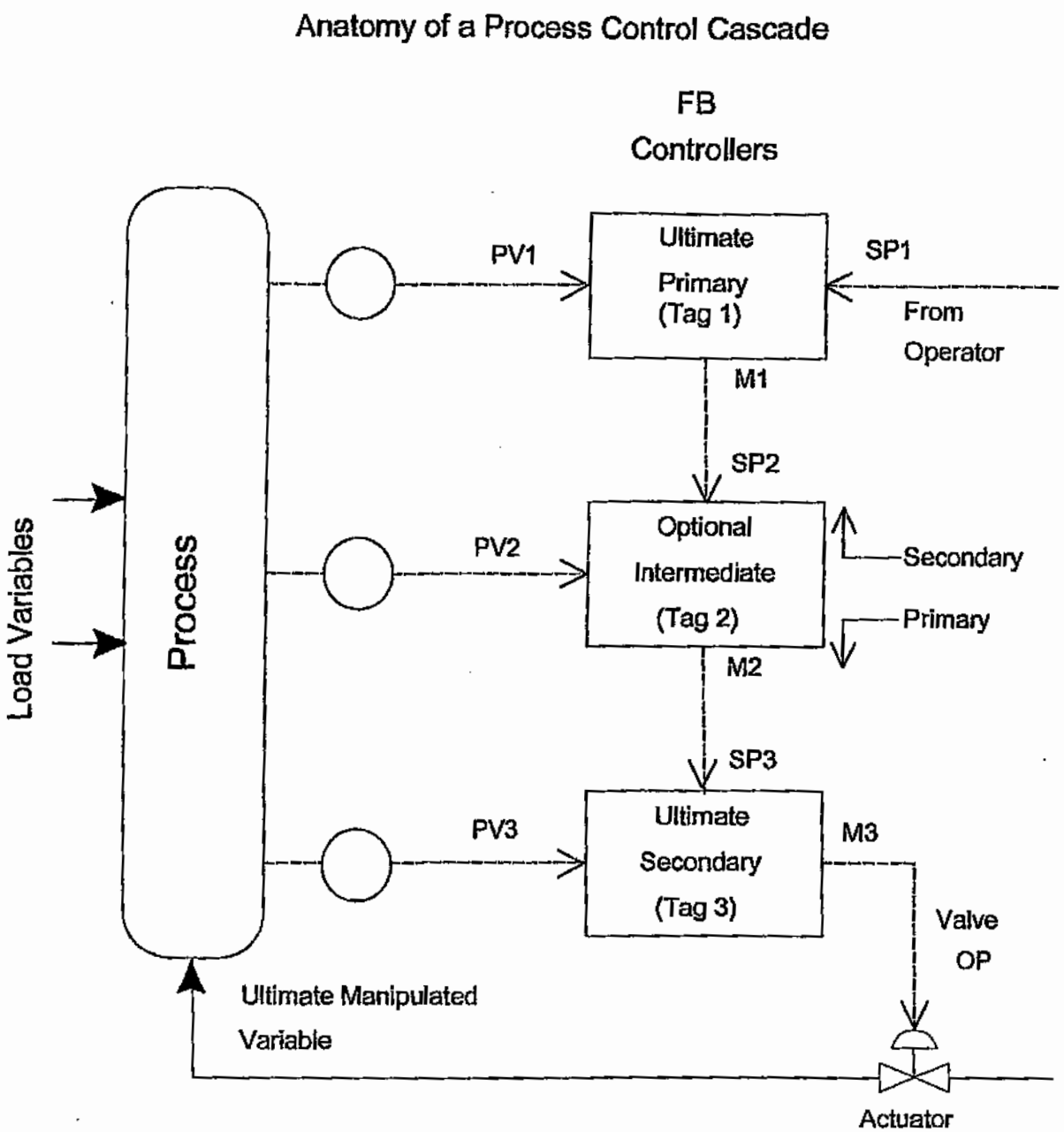

Anatomy of a Process Control Cascade
FB
Controllers
Load Variables
Process
PV1
Ultimate
Primary
(Tag 1)
SP1
From
Operator
M1
SP2
PV2
Optional
Intermediate
(Tag 2)
Secondary
Primary
M2
SP3
PV3
Ultimate
Secondary
(Tag 3)
M3
Valve
OP
Ultimate Manipulated
Variable
Actuator

FIG. 6

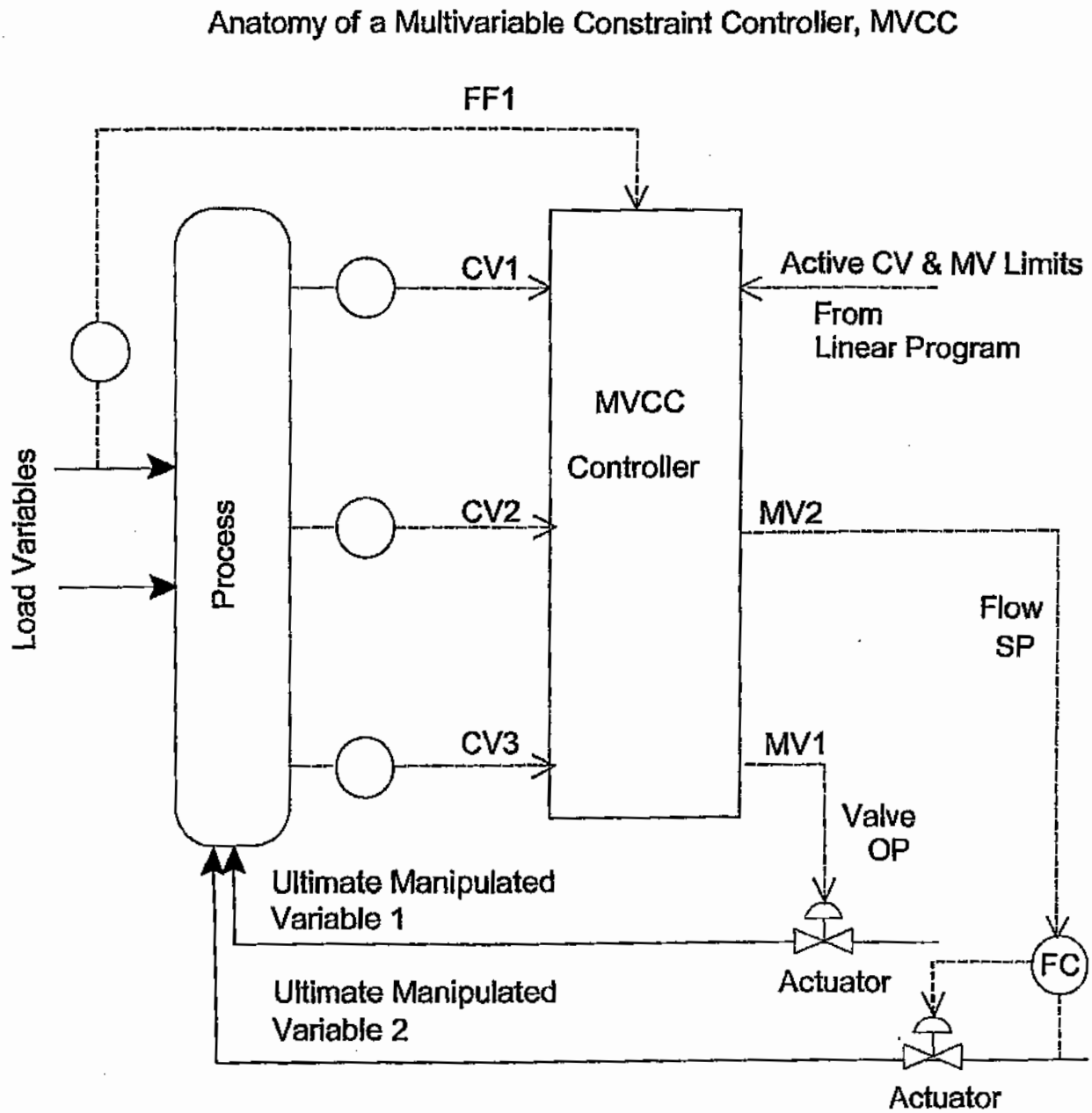

Anatomy of a Multivariable Constraint Controller, MVCC
FF1
CV1
Active CV & MV Limits
From
Linear Program
MVCC
Controller
Load Variables
Process
CV2
MV2
Flow
SP
CV3
MV1
Valve
OP
Ultimate Manipulated
Variable 1
Actuator
FC
Ultimate Manipulated
Variable 2
Actuator

FIG. 7

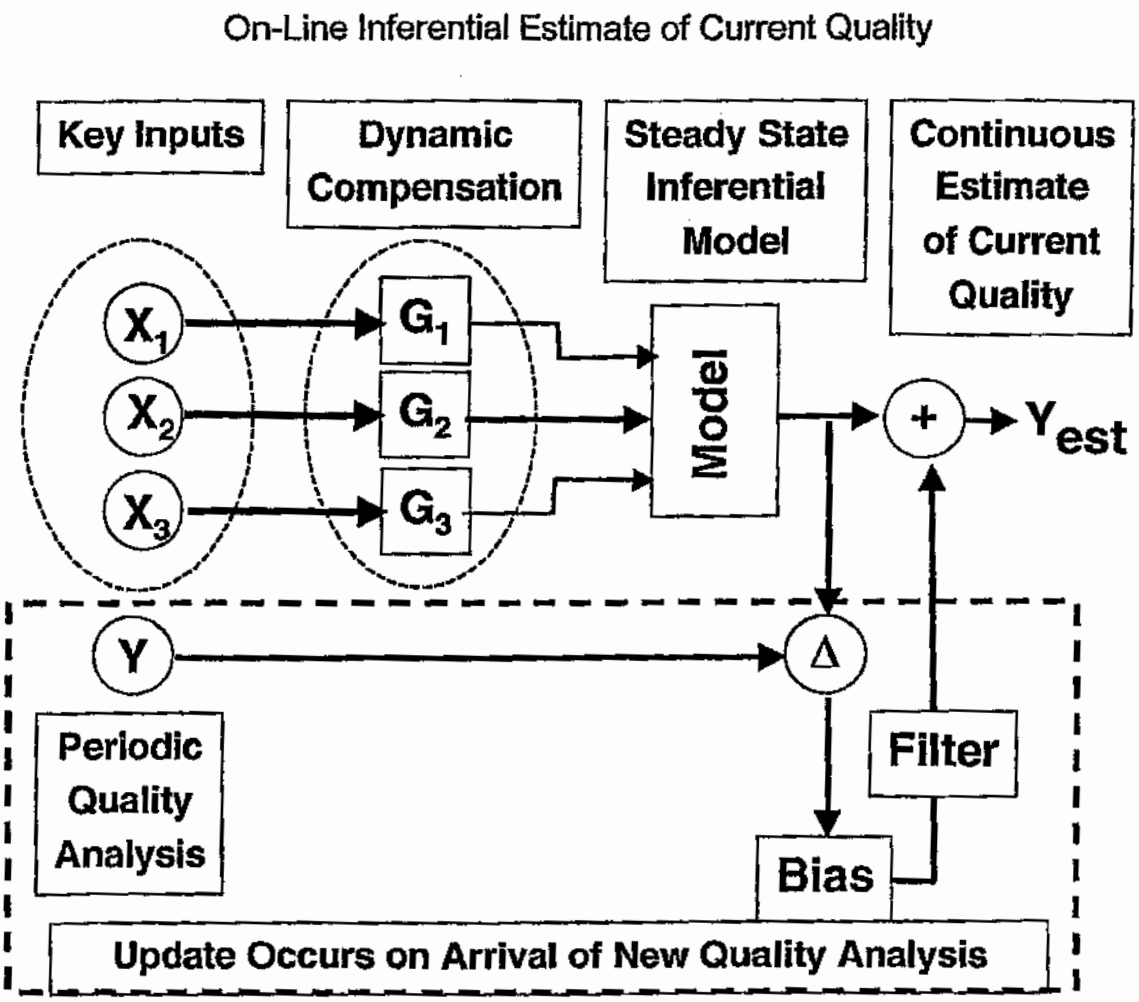

On-Line Inferential Estimate of Current Quality
Key Inputs
Dynamic Compensation
Steady State Inferential Model
Continuous Estimate of Current Quality
X1
X2
X3
G1
G2
G3
Model
+
Yest
Y
Δ
Periodic Quality Analysis
Filter
Bias
Update Occurs on Arrival of New Quality Analysis

FIG. 8

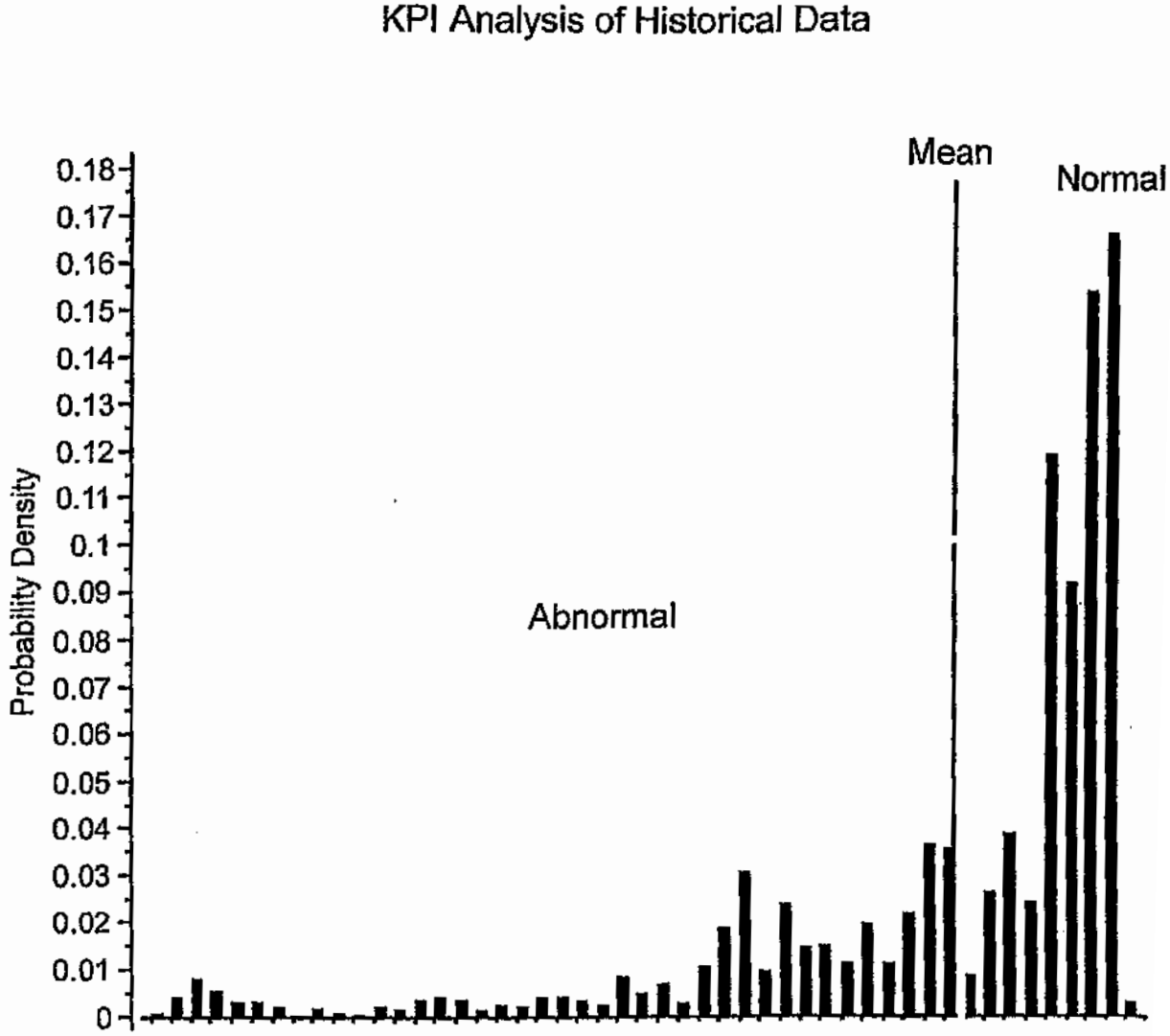

KPI Analysis of Historical Data
Mean
Normal
Abnormal
Probability Density
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0

FIG. 9

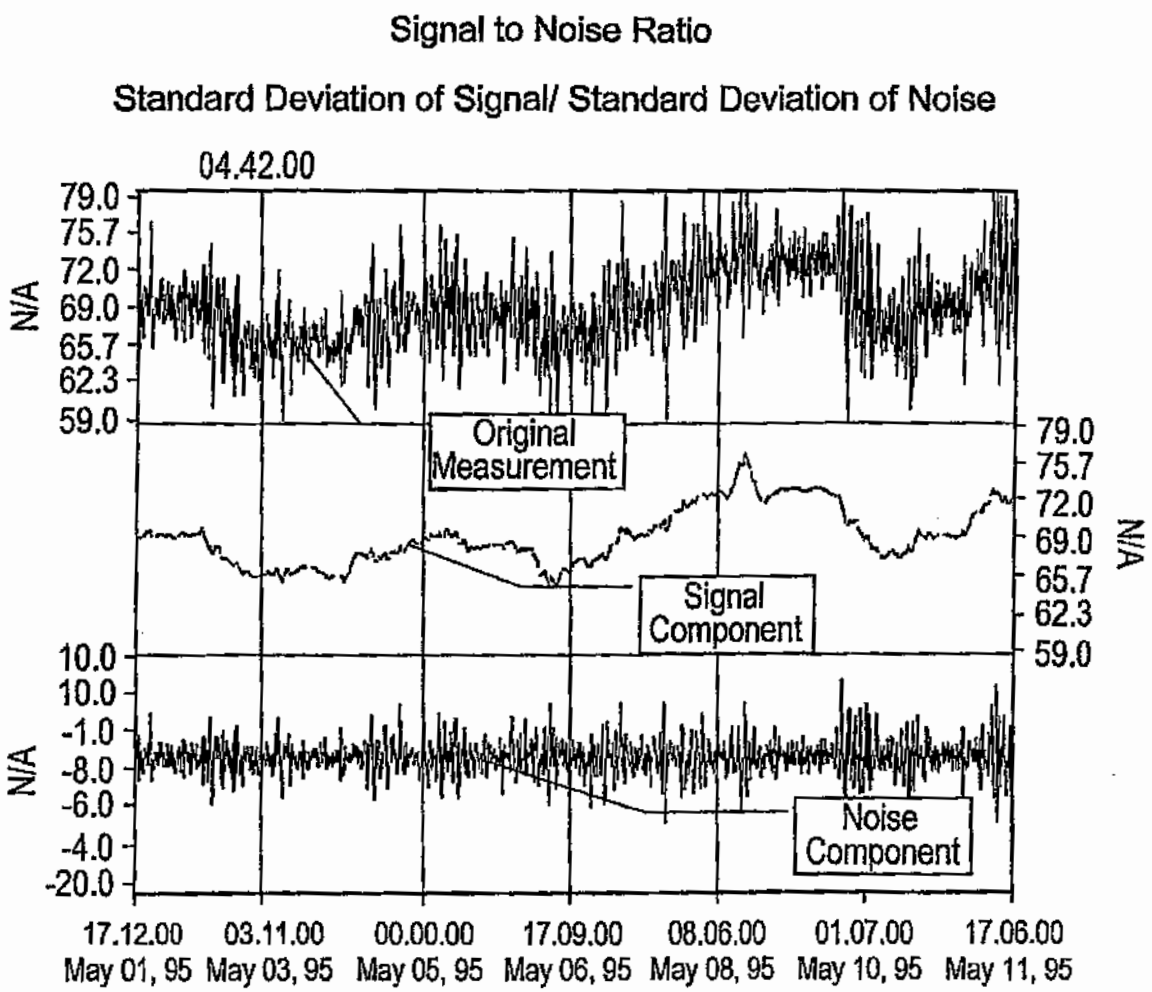

Signal to Noise Ratio
Standard Deviation of Signal/ Standard Deviation of Noise
04.42.00
79.0
75.7
72.0
69.0
65.7
62.3
59.0
N/A
Original Measurement
Signal Component
10.0
10.0
-1.0
-8.0
-6.0
-4.0
-20.0
N/A
Noise Component
17.12.00 May 01, 95
03.11.00 May 03, 95
00.00.00 May 05, 95
17.09.00 May 06, 95
08.06.00 May 08, 95
01.07.00 May 10, 95
17.06.00 May 11, 95

FIG. 10

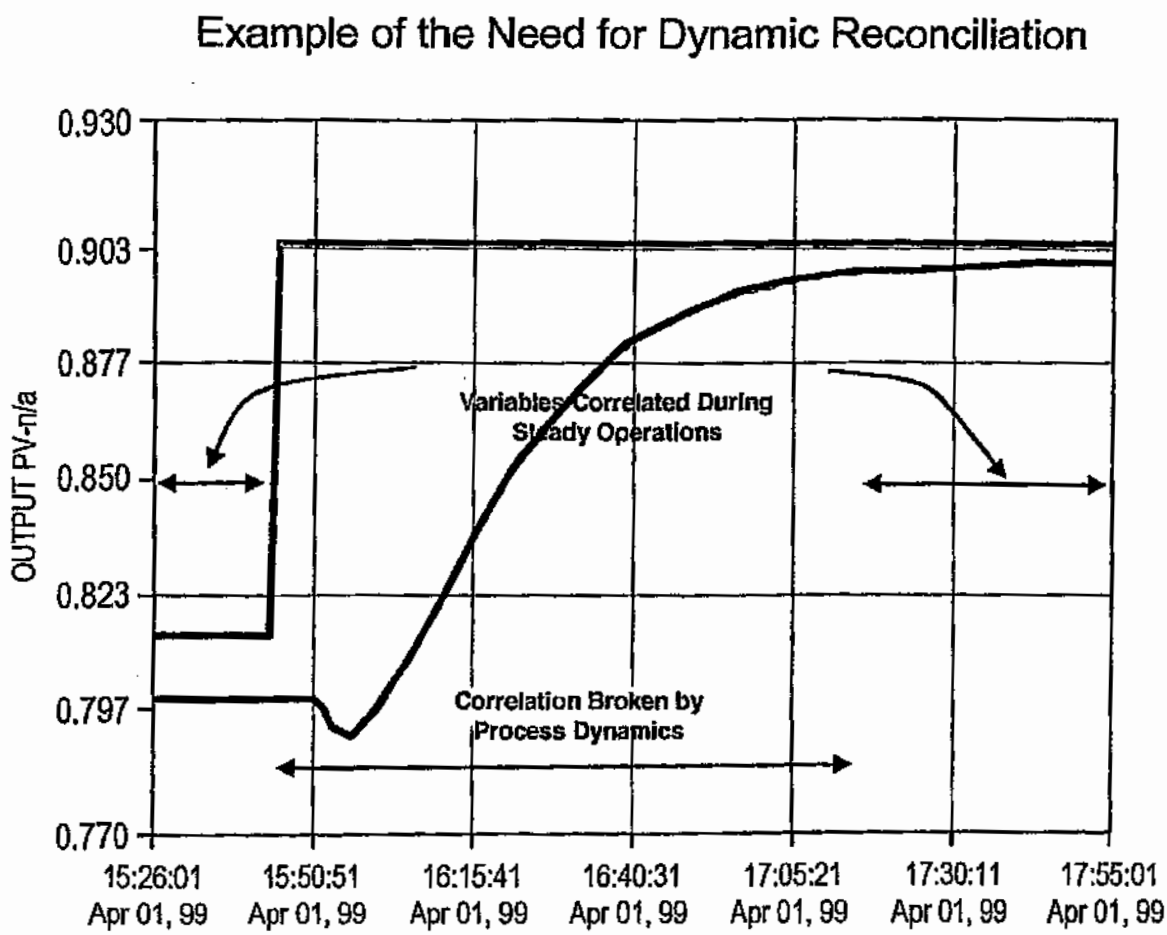
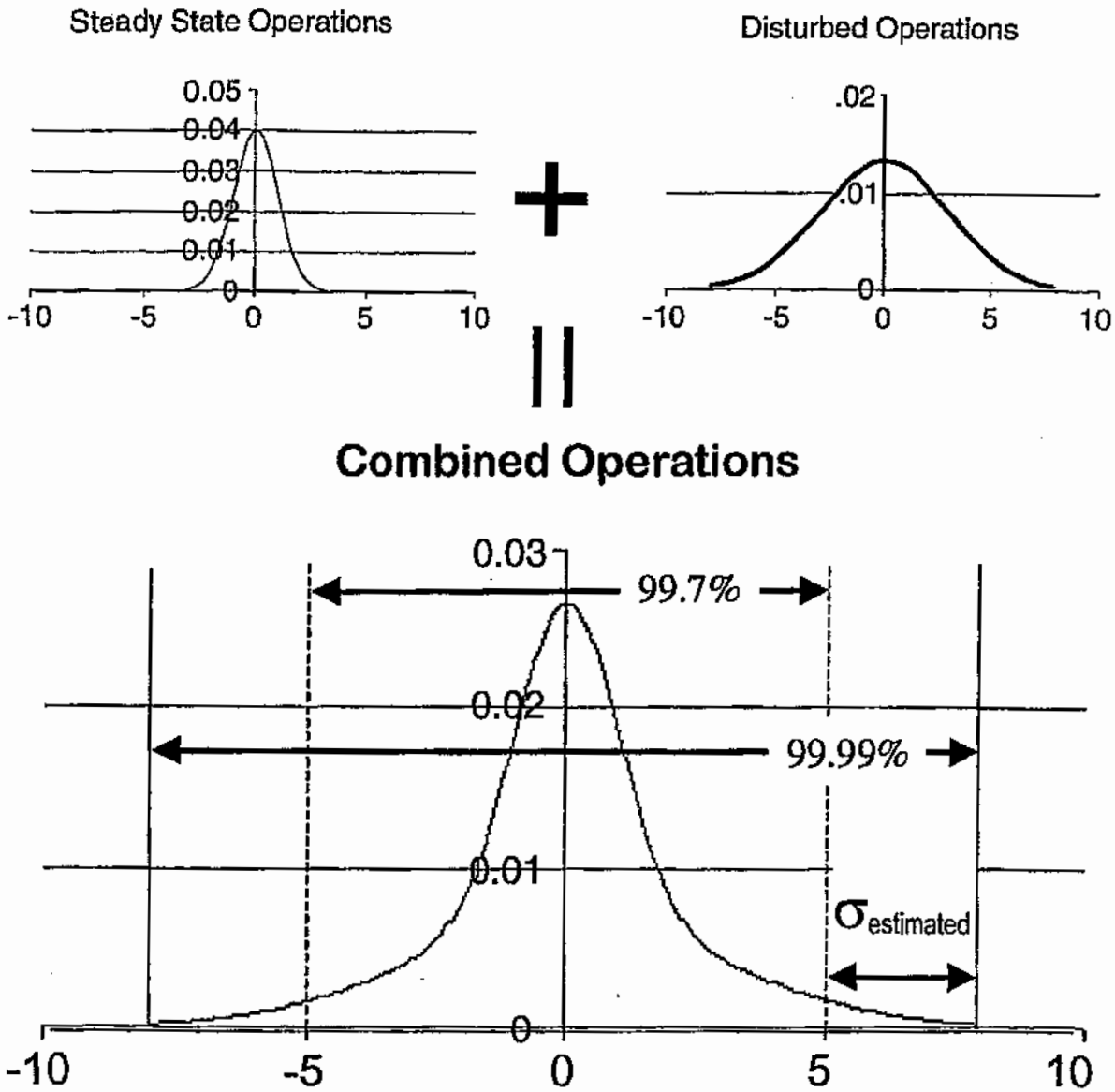

Example of the Need for Dynamic Reconciliation
0.930
0.903
0.877
0.850
0.823
0.797
0.770
OUTPUT PV-η/a
Variables Correlated During Steady Operations
Correlation Broken by Process Dynamics
15:26:01 Apr 01, 99
15:50:51 Apr 01, 99
16:15:41 Apr 01, 99
16:40:31 Apr 01, 99
17:05:21 Apr 01, 99
17:30:11 Apr 01, 99
17:55:01 Apr 01, 99

FIG. 11



Probability Distribution of Process Data
Combined Continuous and Disturbed Operations

FIG. 12

An Illustration of the Press Statistic

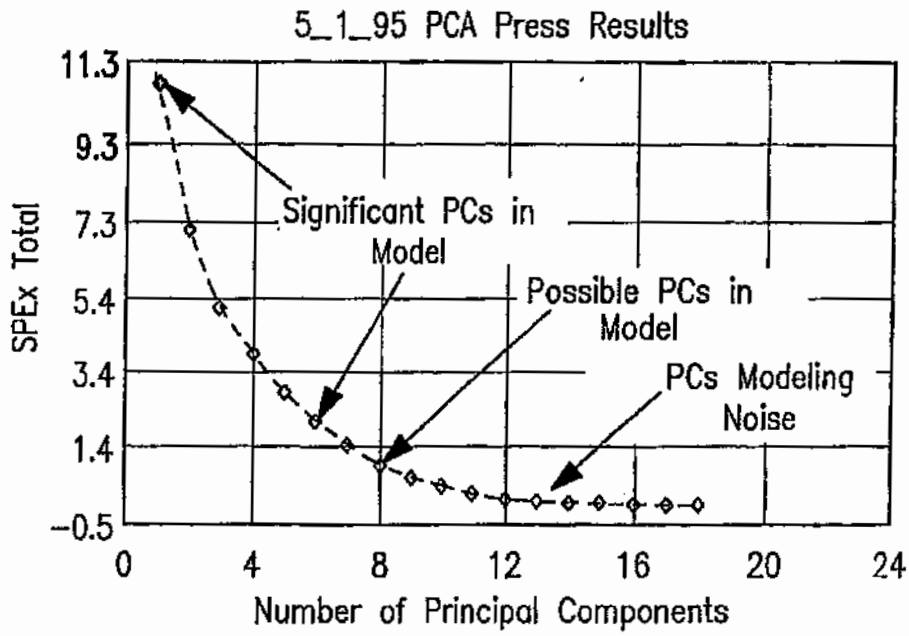


FIG. 13

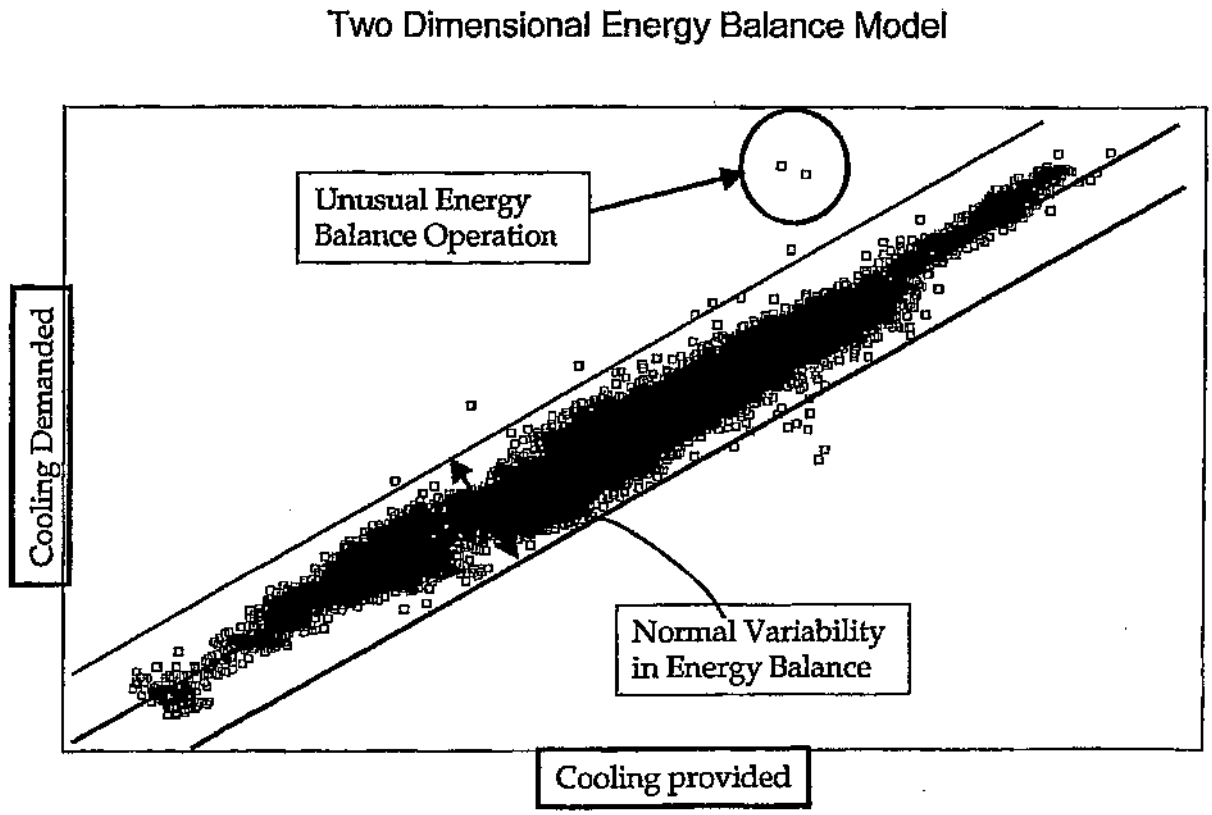

Two Dimensional Energy Balance Model
Unusual Energy Balance Operation
Cooling Demanded
Normal Variability in Energy Balance
Cooling provided

FIG. 14

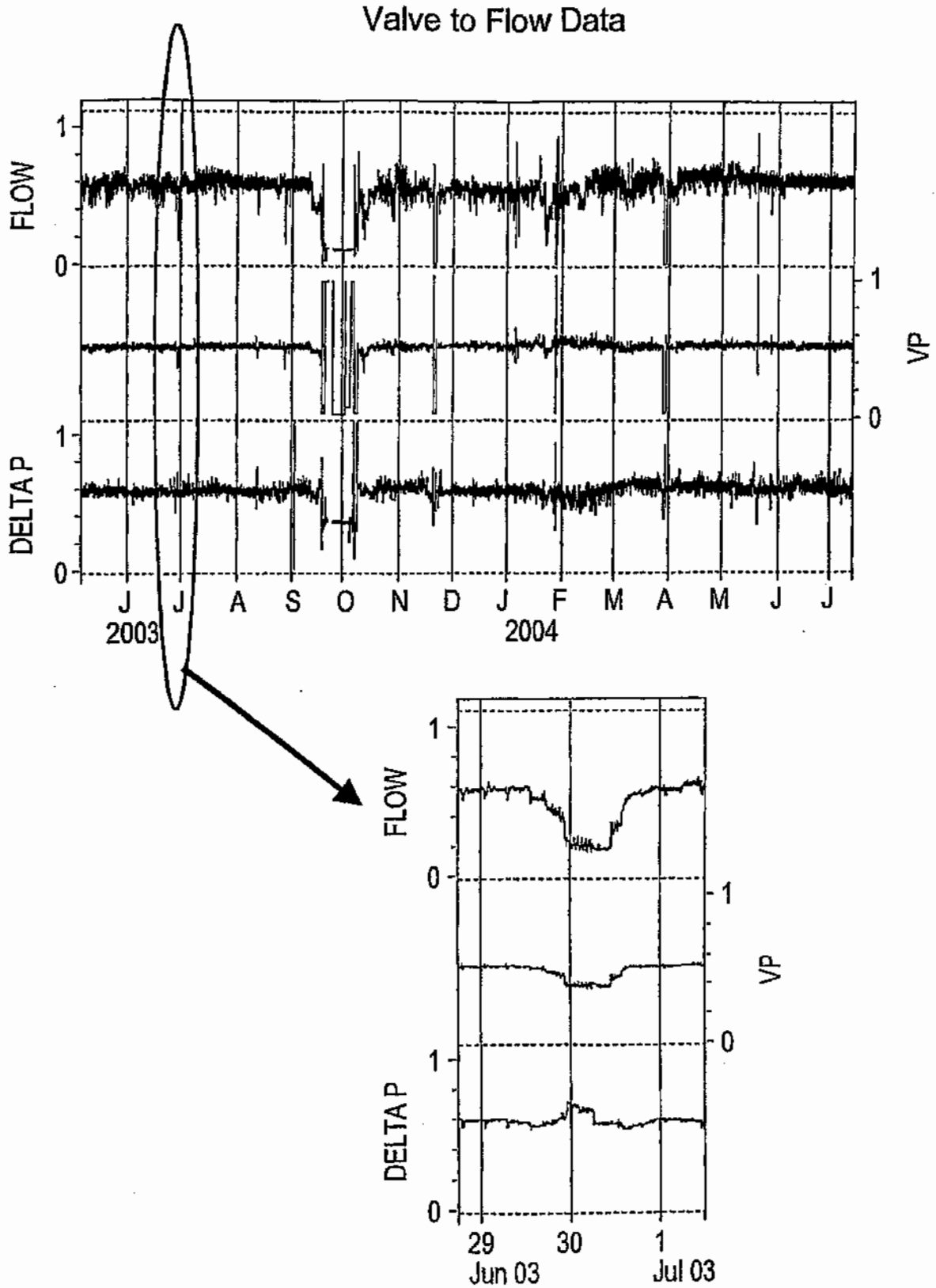

Valve to Flow Data
FLOW
DELTA P
VP
1
0
J
J
A
S
O
N
D
J
F
M
A
M
J
J
2003
2004
29
30
1
Jun 03
Jul 03

FIG. 15

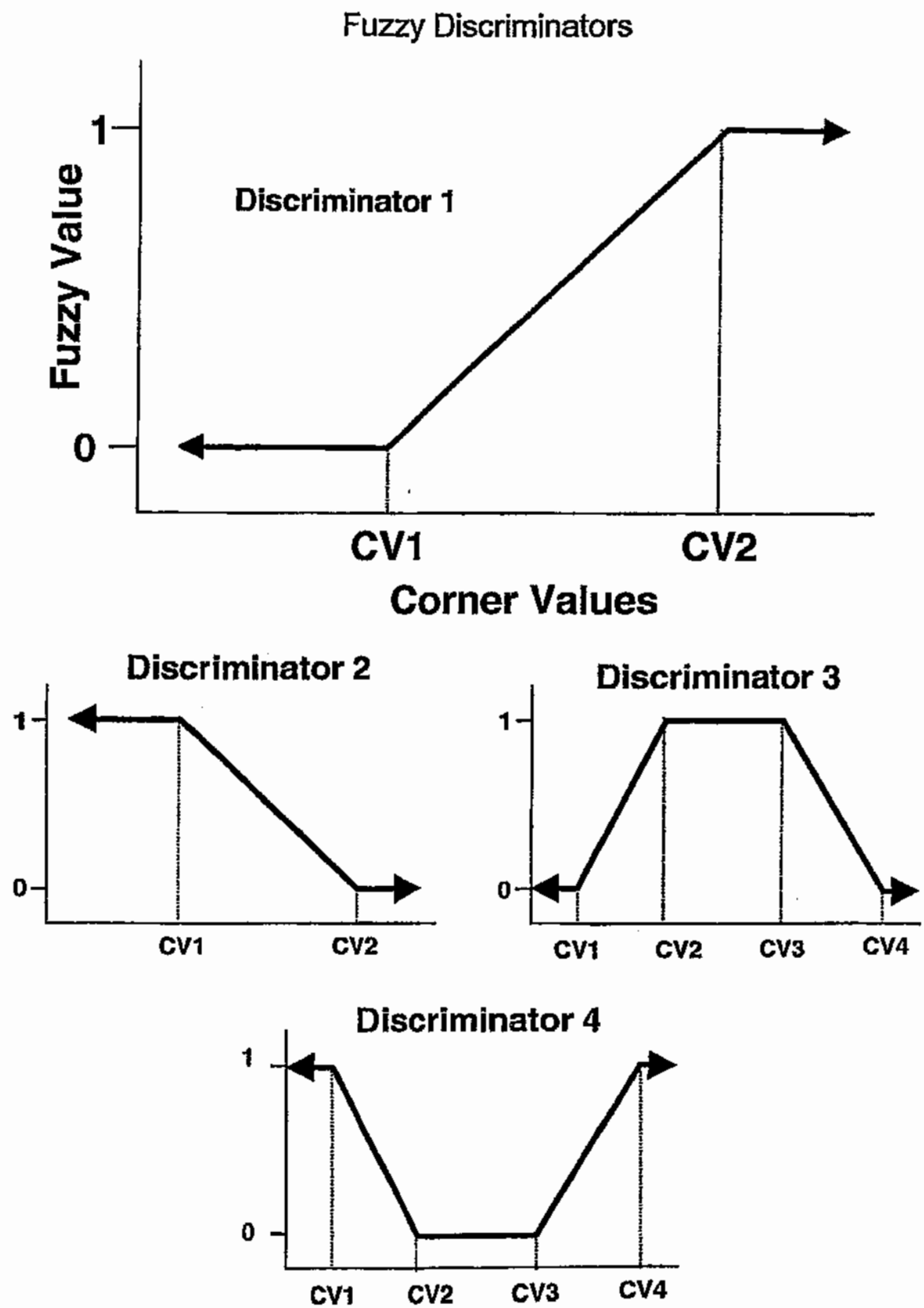

Fuzzy Discriminators
Fuzzy Value
1
0
Discriminator 1
CV1
CV2
Corner Values
Discriminator 2
1
0
CV1
CV2
Discriminator 3
1
0
CV1
CV2
CV3
CV4
Discriminator 4
1
0
CV1
CV2
CV3
CV4

FIG. 16

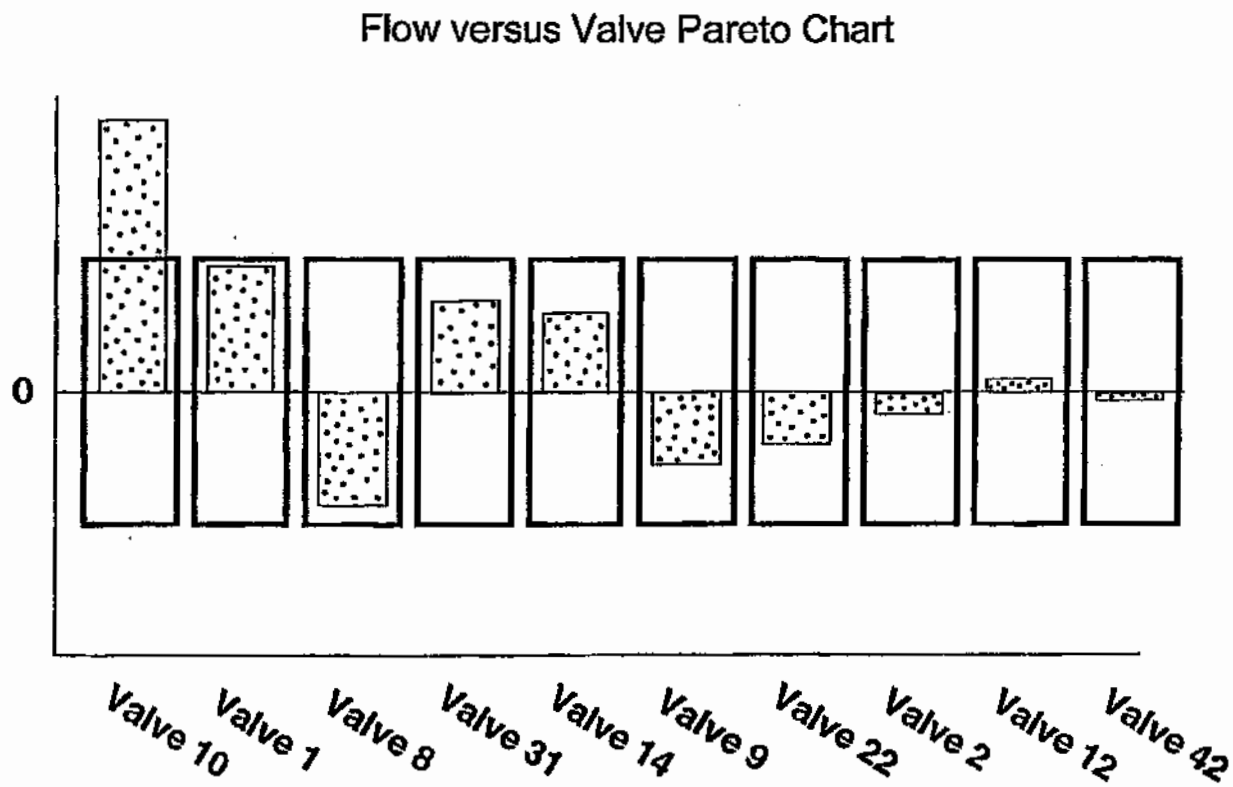

Flow versus Valve Pareto Chart
0
Valve 10
Valve 1
Valve 8
Valve 31
Valve 14
Valve 9
Valve 22
Valve 2
Valve 12
Valve 42

FIG. 17

Operator Suppression Logic

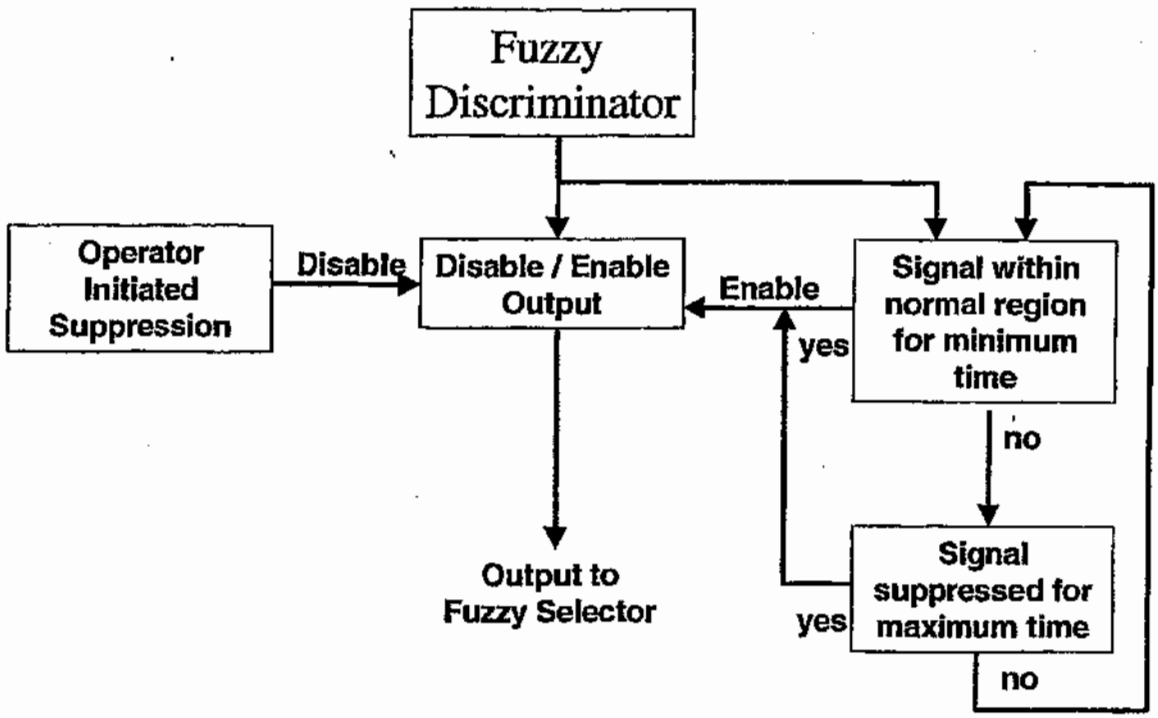


FIG. 18

Event Suppression Logic

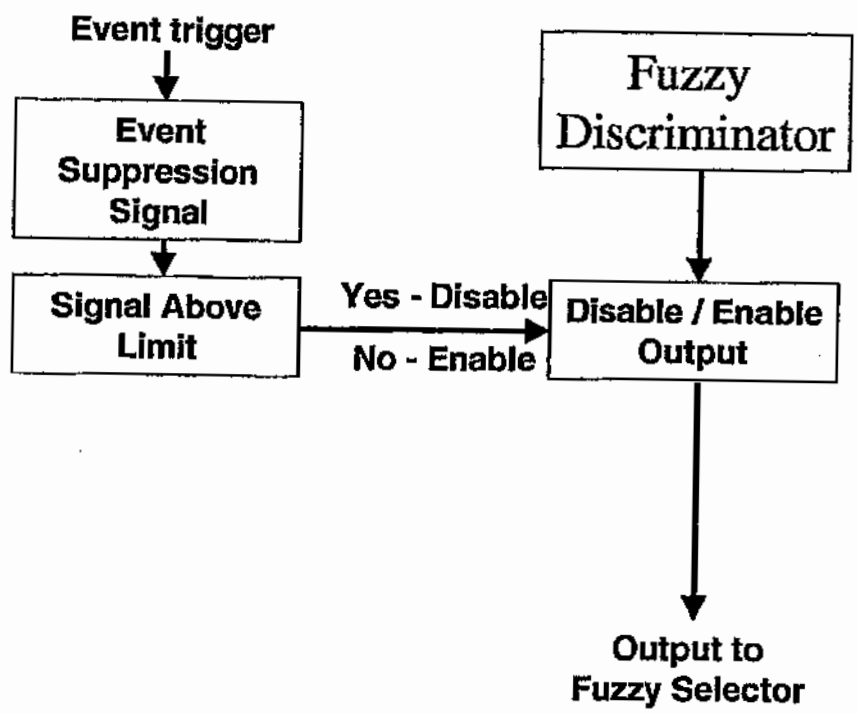


FIG. 19

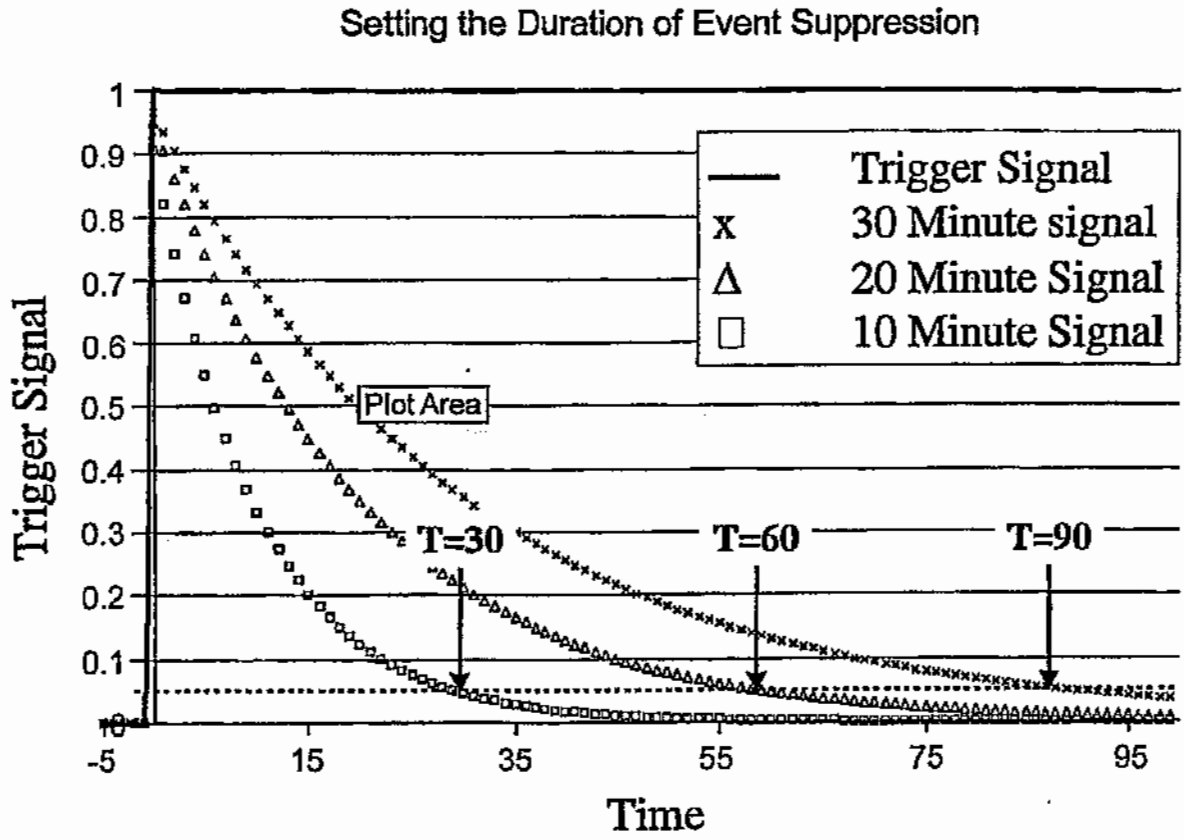

Setting the Duration of Event Suppression
Trigger Signal
30 Minute signal
20 Minute Signal
10 Minute Signal
Plot Area
T=30
T=60
T=90
Trigger Signal
Time
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-5
15
35
55
75
95

FIG. 20

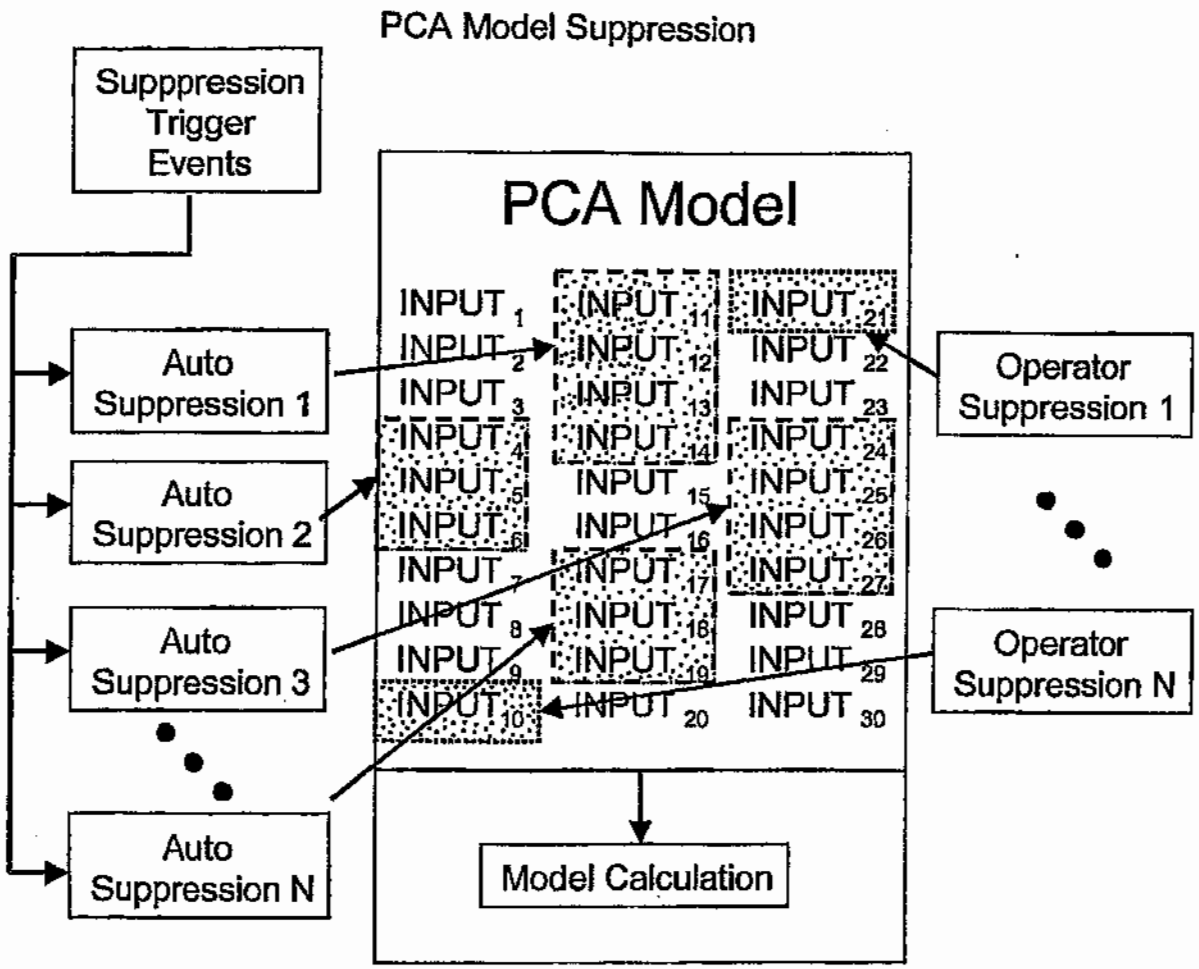

PCA Model Suppression
Supppression Trigger Events
PCA Model
Auto Suppression 1
Auto Suppression 2
Auto Suppression 3
Auto Suppression N
Operator Suppression 1
Operator Suppression N
Model Calculation
INPUT 1
INPUT 2
INPUT 3
INPUT 4
INPUT 5
INPUT 6
INPUT 7
INPUT 8
INPUT 9
INPUT 10
INPUT 11
INPUT 12
INPUT 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

FIG. 21

Primary Operator Interface Design

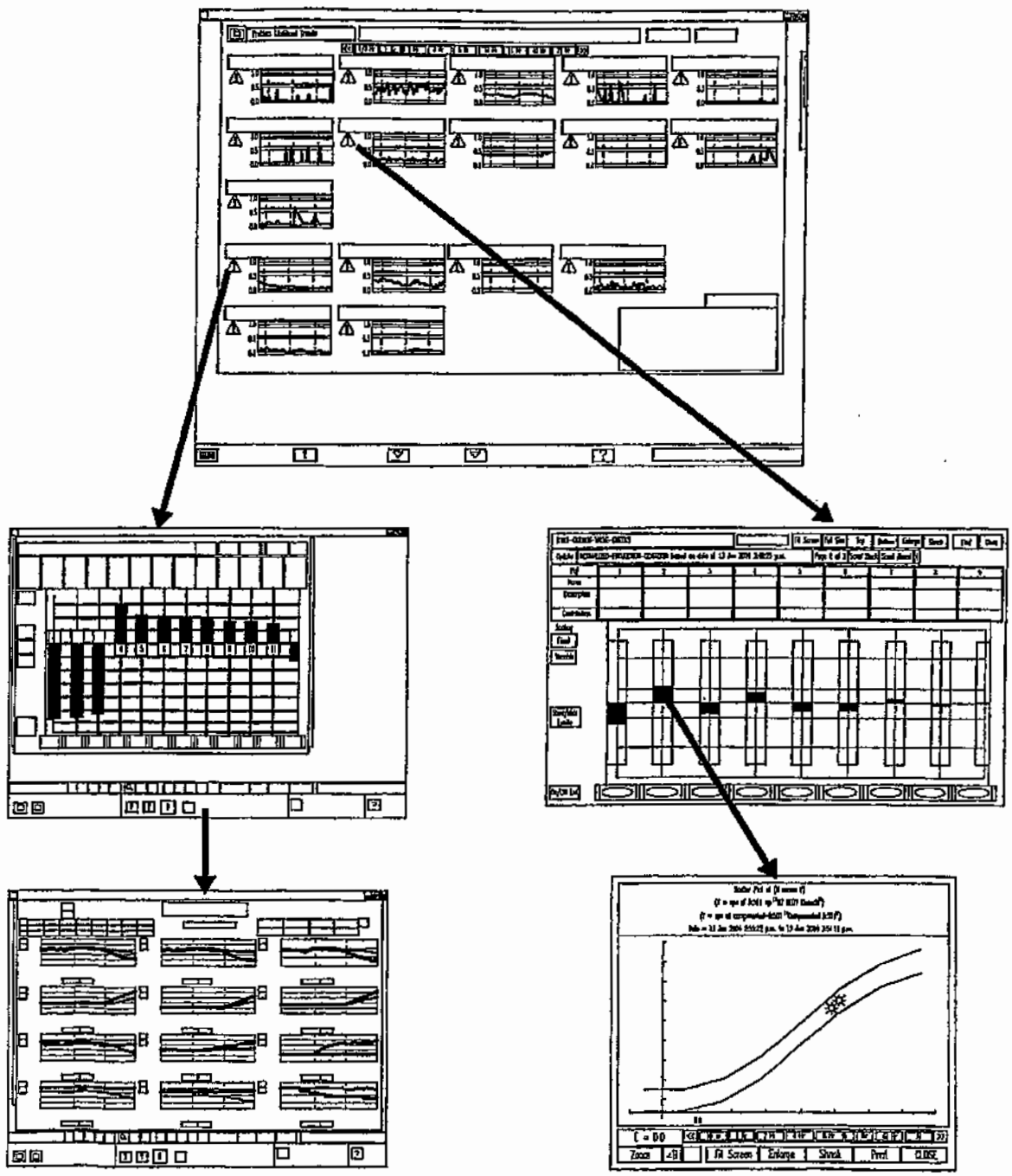


FIG. 22

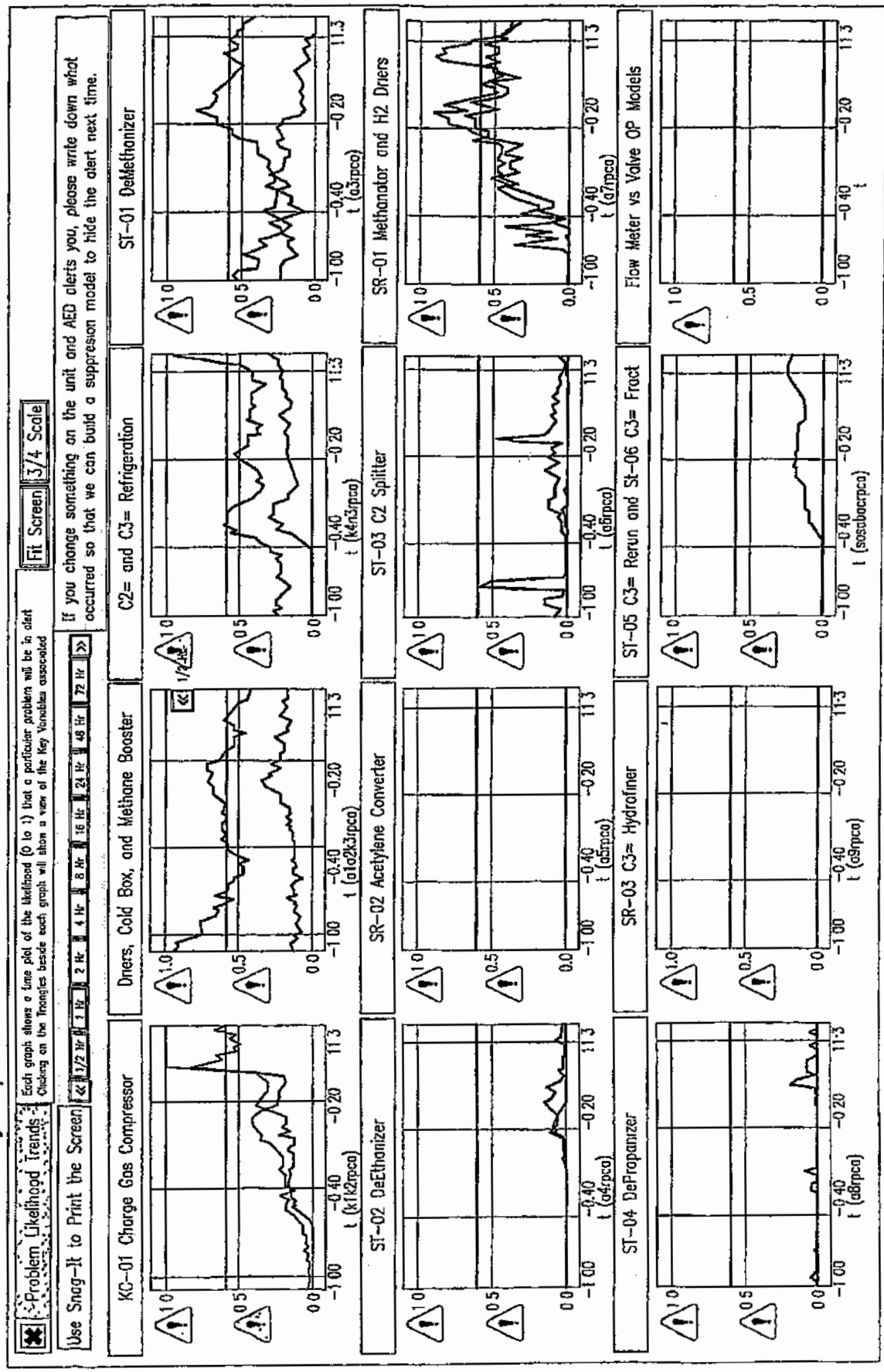

Key Operational Sections of an ORT and Flow versus Valve Monitor
Problem Likelihood Trends
Each graph shows a time plot of the likelihood (0 to 1) that a particular problem will be in alert
Clicking on the Triangles beside each graph will show a view of the Key Variables associated
Fit Screen
3/4 Scale
Use Snag-It to Print the Screen
1/2 Hr
1 Hr
2 Hr
4 Hr
8 Hr
16 Hr
24 Hr
48 Hr
72 Hr
If you change something on the unit and AED alerts you, please write down what occurred so that we can build a suppresion model to hide the alert next time.
KC-01 Charge Gas Compressor
Dryers, Cold Box, and Methane Booster
C2= and C3= Refrigeration
ST-01 DeMethanizer
ST-02 DeEthanizer
SR-02 Acetylene Converter
ST-03 C2 Splitter
SR-01 Methanator and H2 Driers
ST-04 DePropanizer
SR-03 C3= Hydrofiner
ST-05 C3= Rerun and St-06 C3= Fract
Flow Meter vs Valve OP Models

FIG. 23

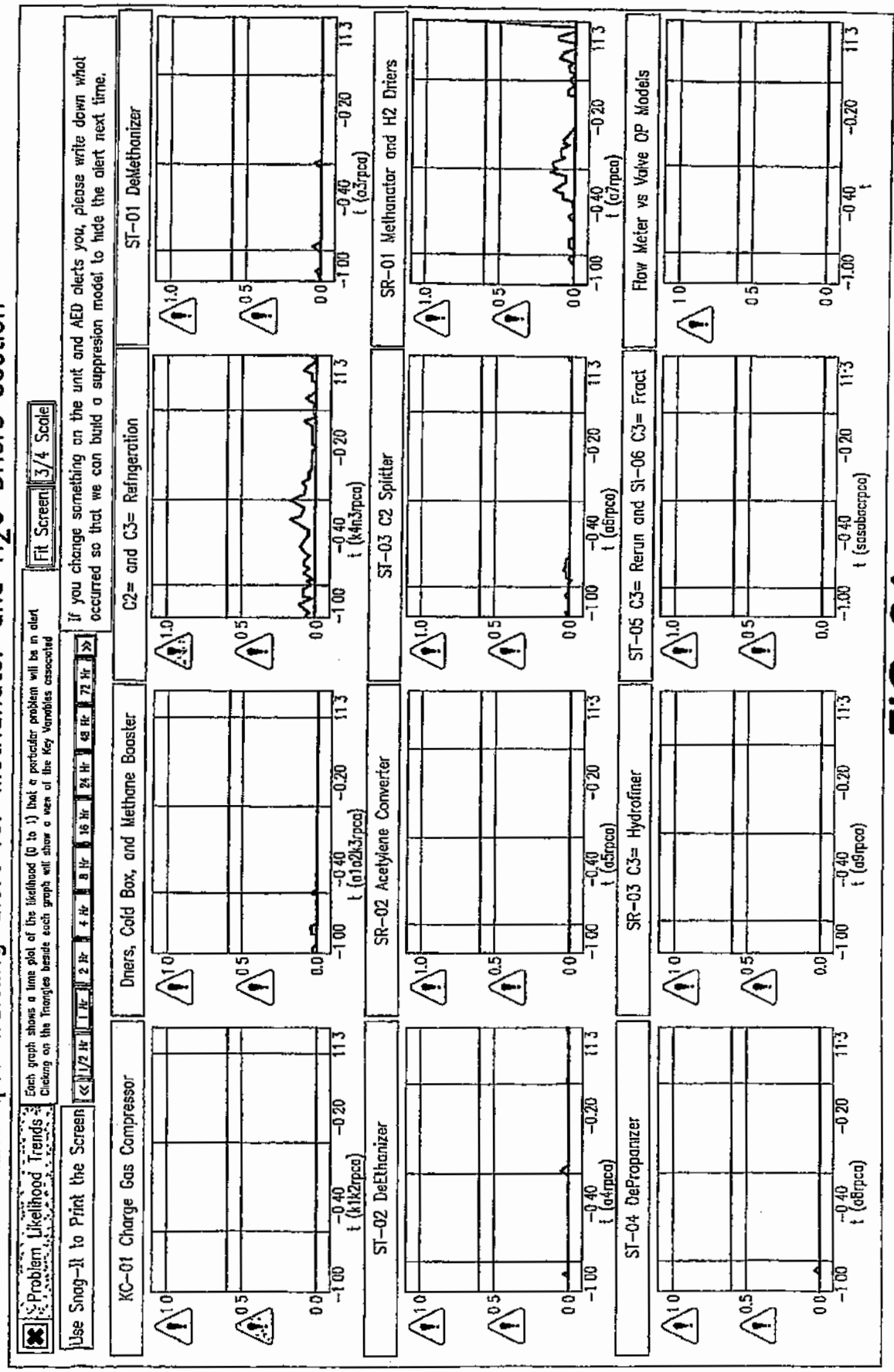

Example warning alert for Methanator and H2O Driers section
Problem Likelihood Trends
Each graph shows a time plot of the likelihood (0 to 1) that a particular problem will be in alert
Clicking on the Triangles beside each graph will show a view of the Key Variables associated
Fit Screen
3/4 Scale
Use Snag-It to Print the Screen
1/2 Hr
1 Hr
2 Hr
4 Hr
8 Hr
16 Hr
24 Hr
48 Hr
72 Hr
If you change something on the unit and AED alerts you, please write down what occurred so that we can build a suppresion model to hide the alert next time.
KC-01 Charge Gas Compressor
Driers, Cold Box, and Methane Booster
C2= and C3= Refrigeration
ST-01 DeMethanizer
ST-02 DeEthanizer
SR-02 Acetylene Converter
ST-03 C2 Splitter
SR-01 Methanator and H2 Driers
ST-04 DePropanizer
SR-03 C3= Hydrofiner
ST-05 C3= Rerun and SI-06 C3= Fract
Flow Meter vs Valve OP Models

FIG. 24

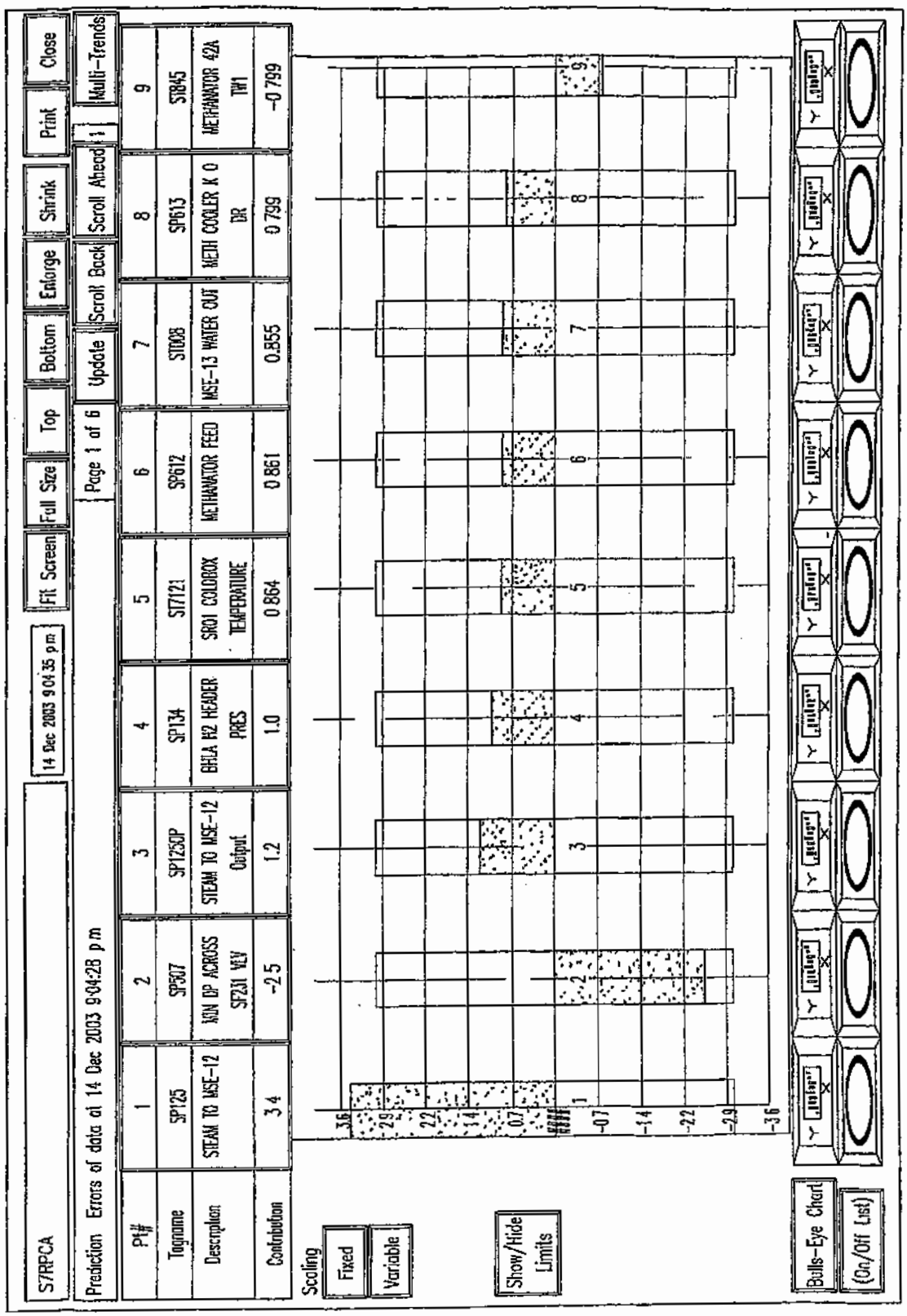

Pareto result of drilldown from Figure 24 warning
S7RPCA
14 Dec 2003 9:04:35 p.m.
Fit Screen
Full Size
Top
Bottom
Enlarge
Shrink
Print
Close
Prediction Errors of data at 14 Dec 2003 9:04:28 p.m.
Page 1 of 6
Update
Scroll Back
Scroll Ahead
Multi-Trends
Pt#
Tagname
Description
Contribution
1
SP125
STEAM TO MSE-12
3.4
2
SP307
MIN DP ACROSS SP31 VLV
-2.5
3
SP1250P
STEAM TO MSE-12 Output
1.2
4
SP134
BHLA H2 HEADER PRES
1.0
5
ST7121
SR01 COLDBOX TEMPERATURE
0.864
6
SP612
METHANATOR FEED
0.861
7
ST008
MSE-13 WATER OUT
0.855
8
SP613
METH COOLER K O DR
0.799
9
ST845
METHANATOR #2A TW1
-0.799
Scaling
Fixed
Variable
Show/Hide Limits
Bulls-Eye Chart
(On/Off List)
36
29
22
14
07
####
1
-07
-14
-22
-29
-36

FIG. 25

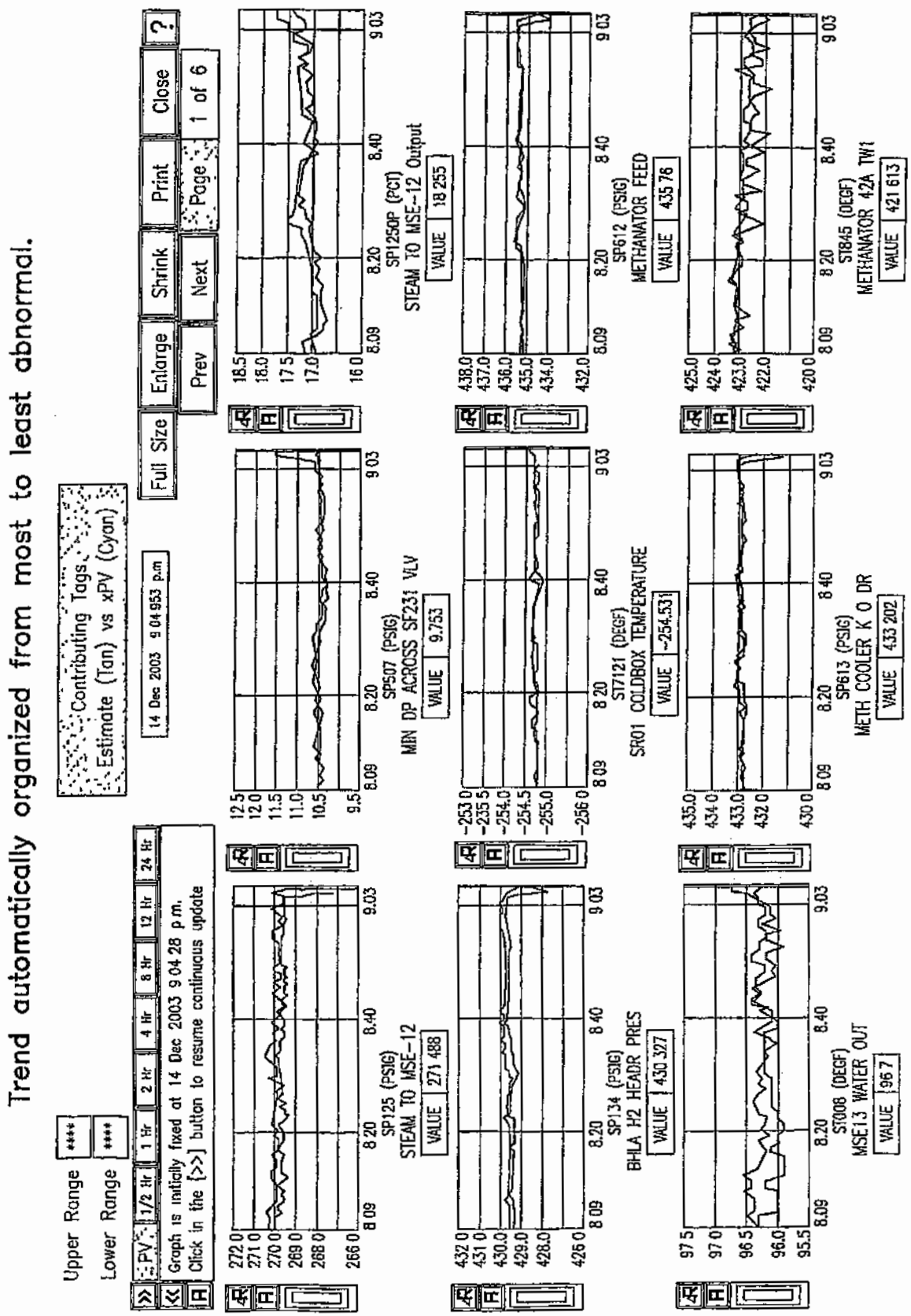

Trend automatically organized from most to least abnormal.
Upper Range ****
Lower Range ****
PV 1/2 Hr 1 Hr 2 Hr 4 Hr 8 Hr 12 Hr 24 Hr
Graph is initially fixed at 14 Dec 2003 9 04 28 p m.
Click in the (>>) button to resume continuous update
Contributing Tags
Estimate (Tan) vs xPV (Cyan)
14 Dec 2003 9 04 953 p.m
Full Size Enlarge Shrink Print Close ?
Prev Next Page 1 of 6
SP125 (PSIG)
STEAM TO MSE-12
VALUE 271 488
SP134 (PSIG)
BHLA H2 HEADR PRES
VALUE 430 327
ST006 (DEGF)
MSE13 WATER OUT
VALUE 96 7
SP507 (PSIG)
MIN DP ACROSS SF231 VLV
VALUE 9.753
ST7121 (DEGF)
SR01 COLDBOX TEMPERATURE
VALUE -254.531
SP613 (PSIG)
METH COOLER K O DR
VALUE 433 202
SP1250P (PCT)
STEAM TO MSE-12 Output
VALUE 18 255
SP612 (PSIG)
METHANATOR FEED
VALUE 435 76
ST845 (DEGF)
METHANATOR 42A TW1
VALUE 421 613

FIG. 26

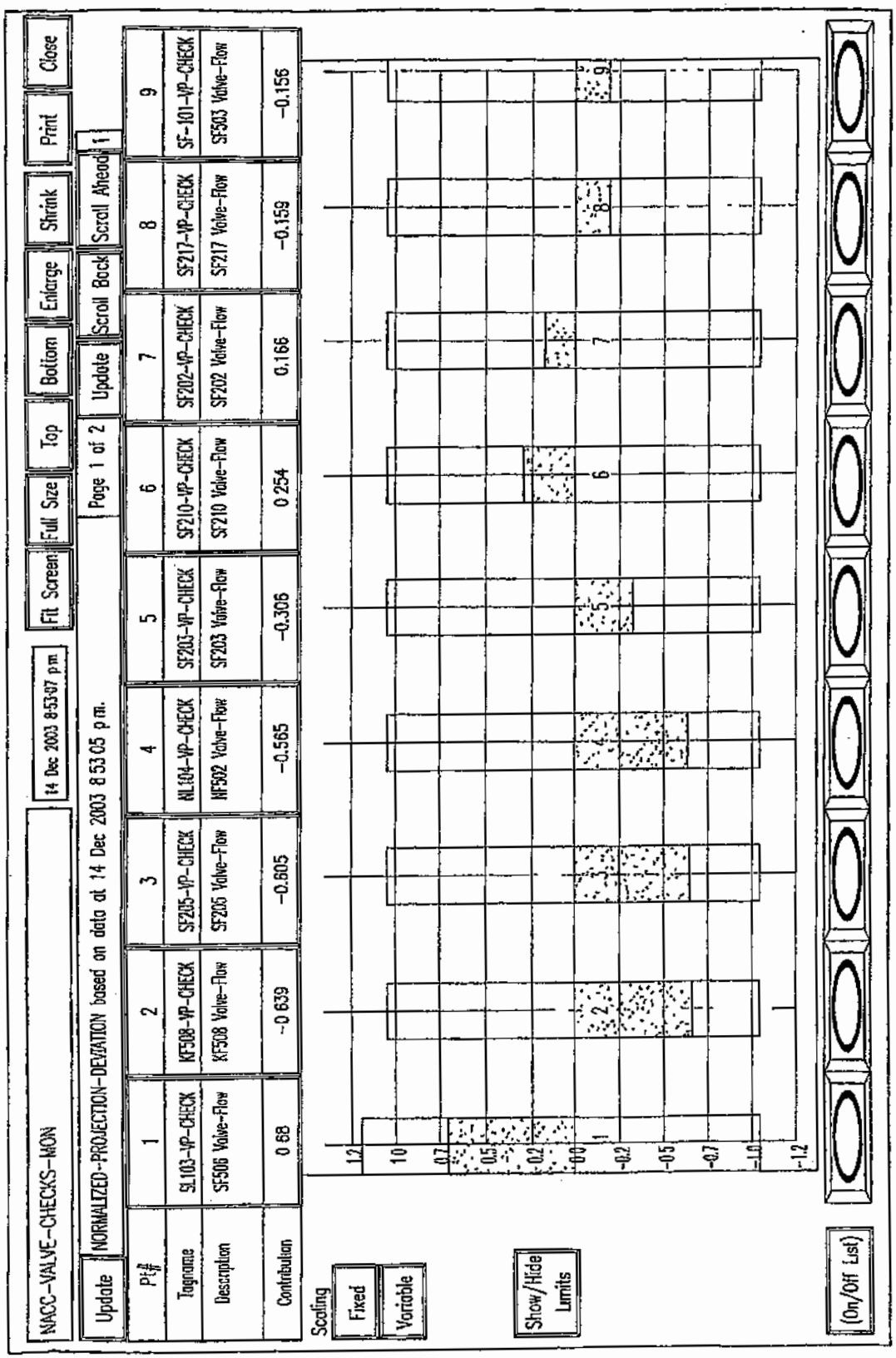

Pareto ranking of the flow versus valve monitors
NACC-VALVE-CHECKS-MON
14 Dec 2003 8:53:07 p.m.
Fit Screen
Full Size
Top
Bottom
Enlarge
Shrink
Print
Close
Update
NORMALIZED-PROJECTION-DEVIATION based on data at 14 Dec 2003 8:53:05 p.m.
Page 1 of 2
Update
Scroll Back
Scroll Ahead
1
Pt#
Tagname
Description
Contribution
1
SL103-VP-CHECK
SF506 Valve-Flow
0.68
2
KF508-VP-CHECK
KF508 Valve-Flow
-0.639
3
SF205-VP-CHECK
SF205 Valve-Flow
-0.605
4
NL104-VP-CHECK
NF502 Valve-Flow
-0.565
5
SF203-VP-CHECK
SF203 Valve-Flow
-0.306
6
SF210-VP-CHECK
SF210 Valve-Flow
0.254
7
SF202-VP-CHECK
SF202 Valve-Flow
0.166
8
SF217-VP-CHECK
SF217 Valve-Flow
-0.159
9
SF-101-VP-CHECK
SF503 Valve-Flow
-0.156
Scaling
Fixed
Variable
Show/Hide Limits
(On/Off List)
1.2
1.0
0.7
0.5
0.2
0.0
-0.2
-0.5
-0.7
-1.0
-1.2

FIG. 27

Flow versus valve monitor example

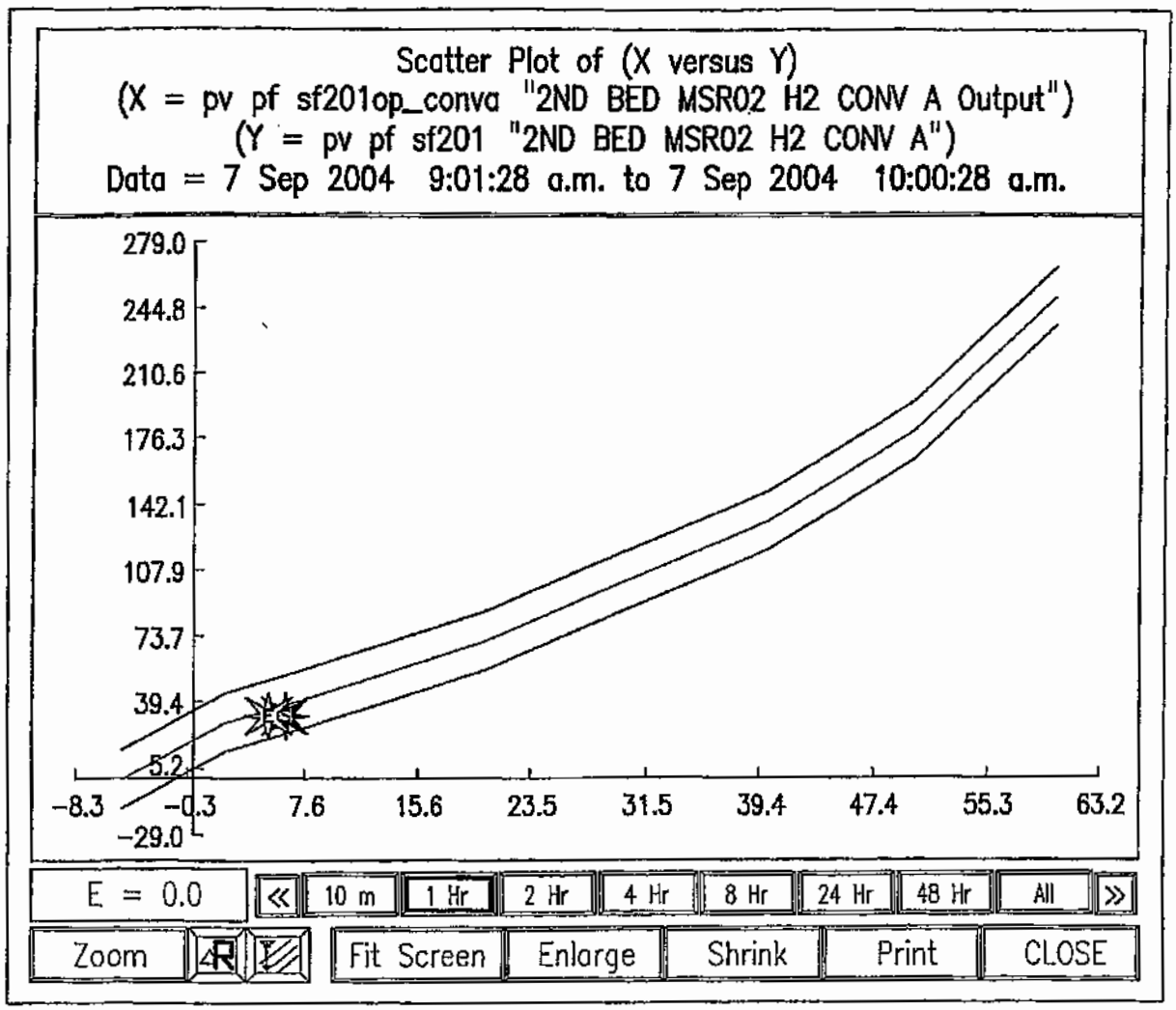


FIG. 28

Fuzzy Logic network example for suppression of procedure–induced abnormal conditions.

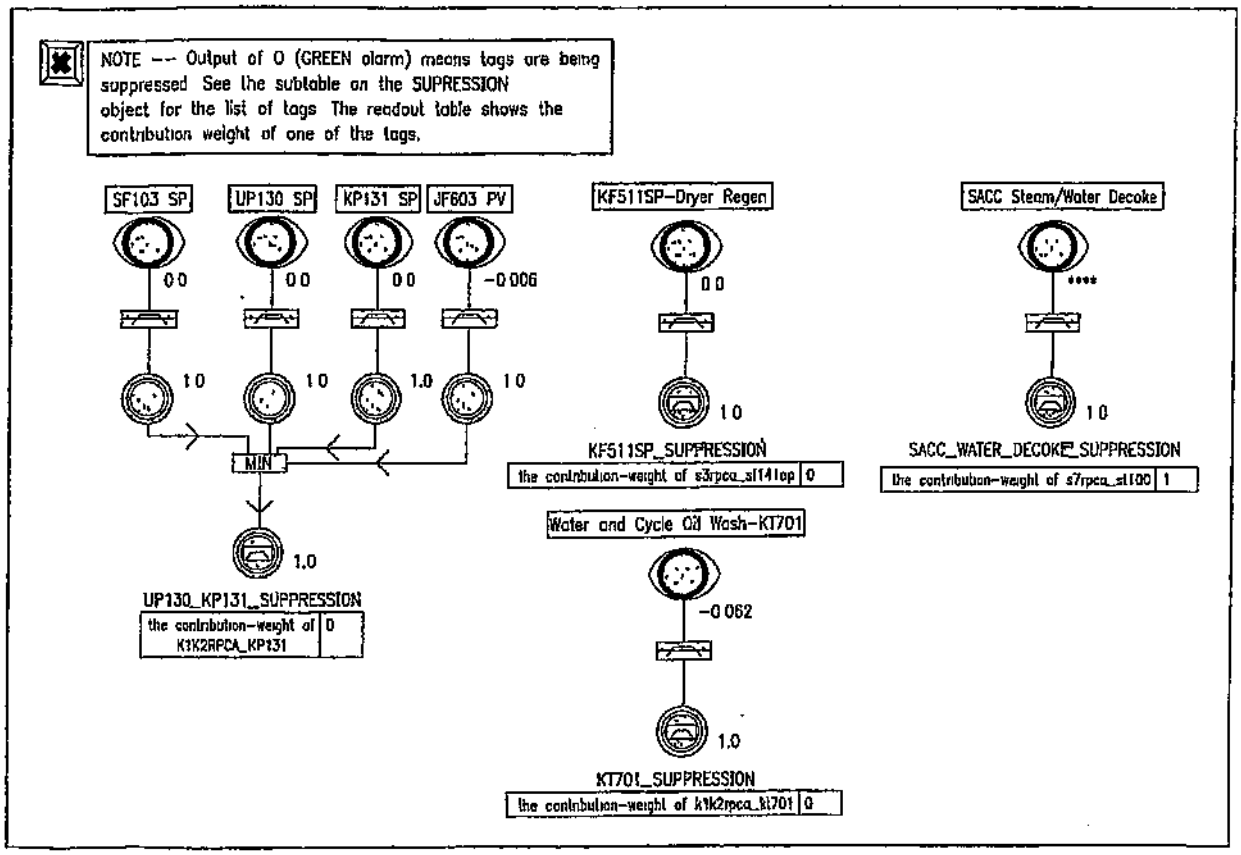


FIG. 29

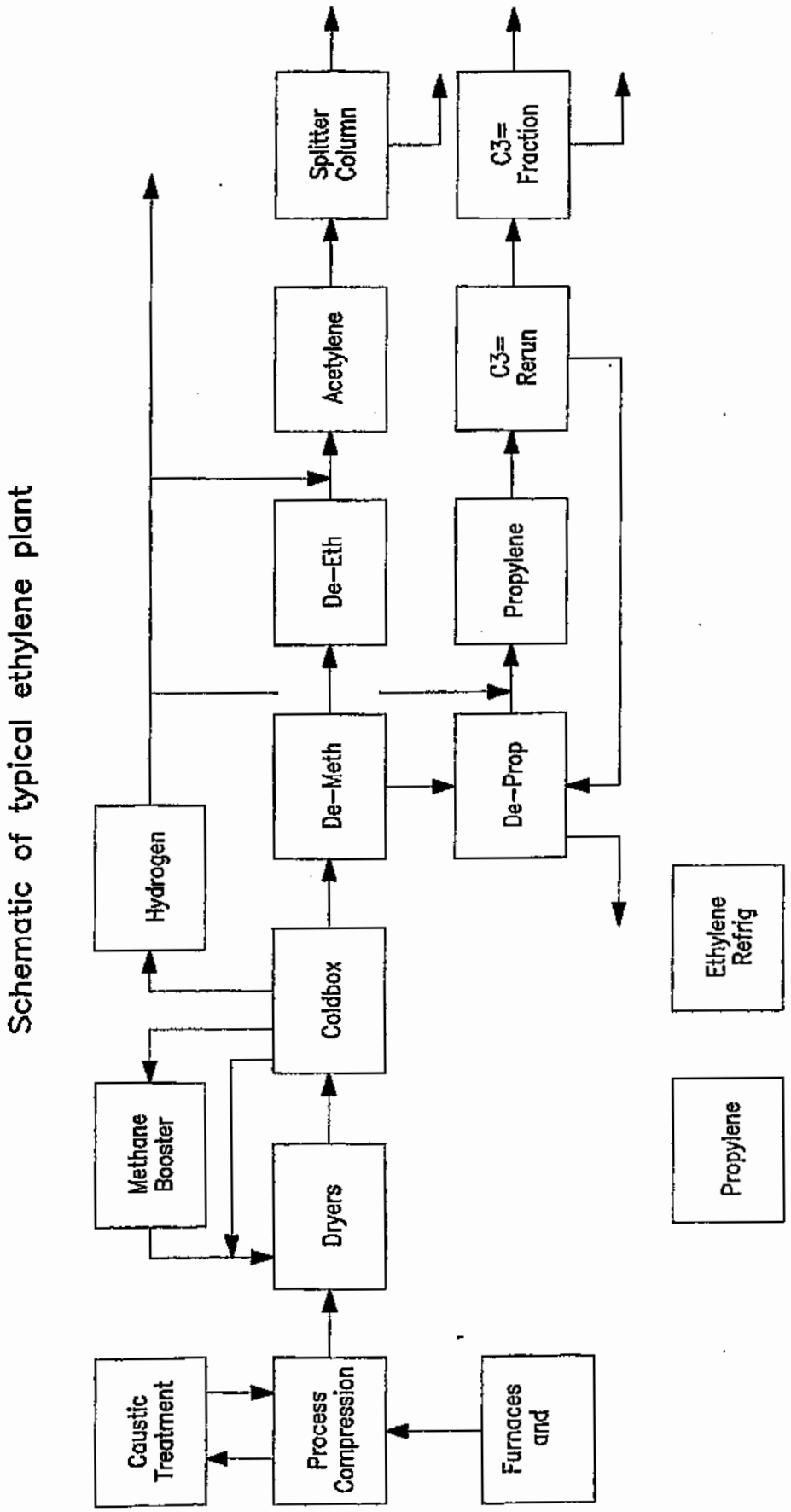

Schematic of typical ethylene plant
Caustic Treatment
Process Compression
Furnaces and
Dryers
Methane Booster
Coldbox
Hydrogen
De-Meth
De-Eth
Acetylene
Splitter Column
De-Prop
Propylene
C3= Rerun
C3= Fraction
Ethylene Refrig
Propylene

FIG. 30