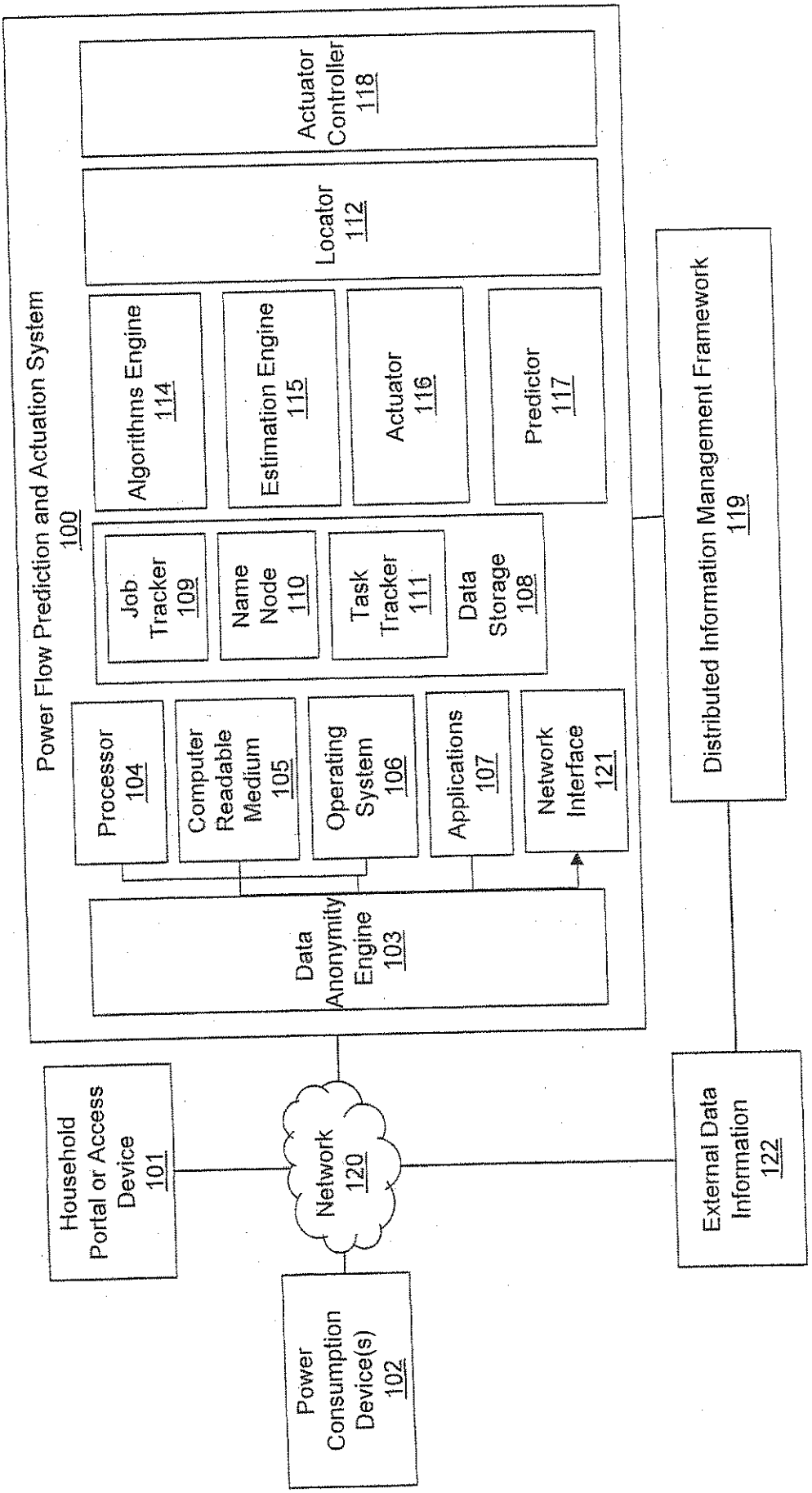

Power Flow Prediction and Actuation System
100
Actuator Controller
118
Locator
112
Algorithms Engine
114
Estimation Engine
115
Actuator
116
Predictor
117
Job Tracker
109
Name Node
110
Task Tracker
111
Data Storage
108
Processor
104
Computer Readable Medium
105
Operating System
106
Applications
107
Network Interface
121
Data Anonymity Engine
103
Distributed Information Management Framework
119
Household Portal or Access Device
101
Network
120
External Data Information
122
Power Consumption Device(s)
102

FIG. 1

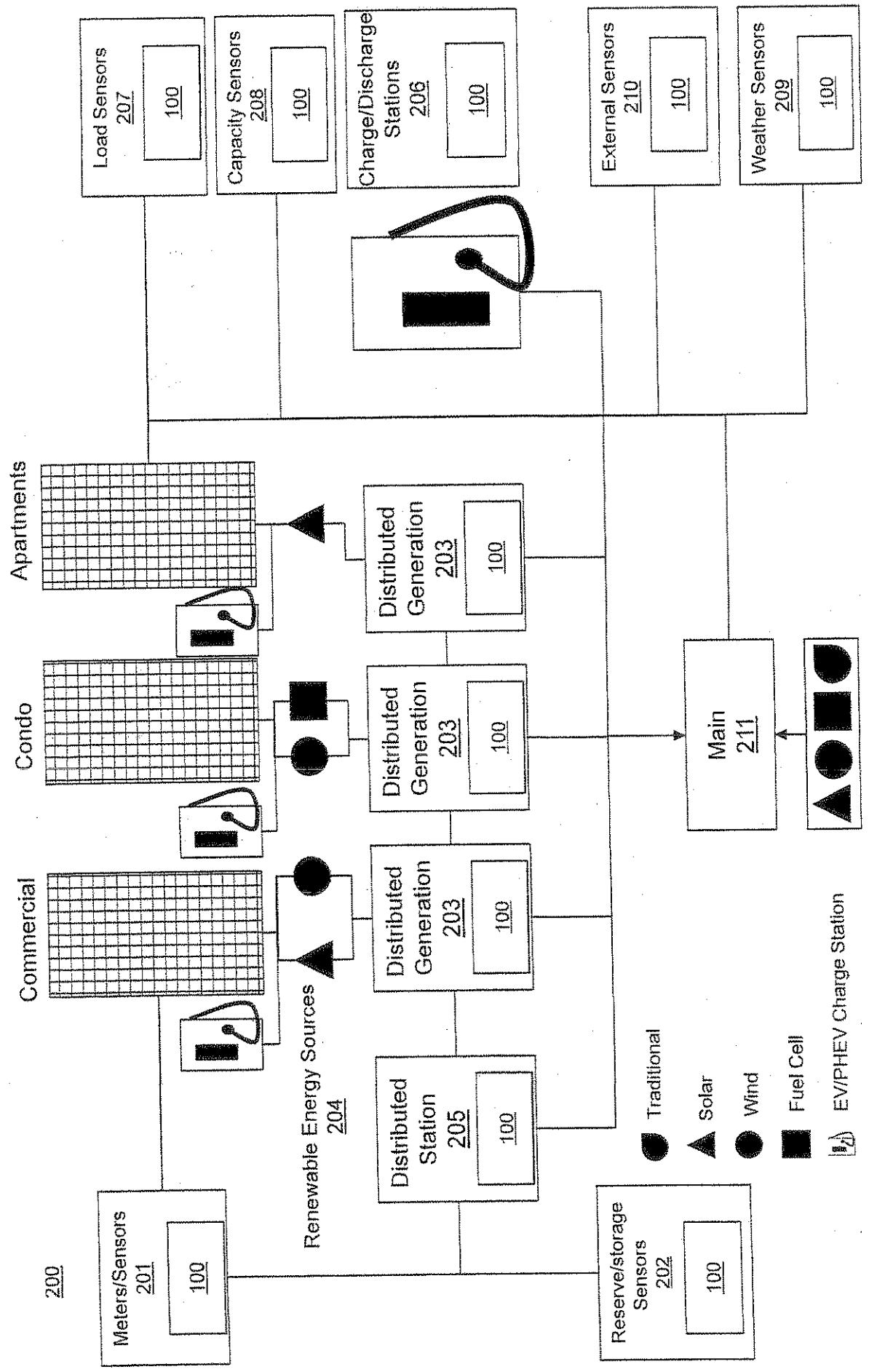

200
Meters/Sensors 201
100
Reserve/storage Sensors 202
100
Distributed Station 205
100
Distributed Generation 203
100
Distributed Generation 203
100
Distributed Generation 203
100
Distributed Generation 203
100
Renewable Energy Sources 204
Commercial
Condo
Apartments
Main 211
Load Sensors 207
100
Capacity Sensors 208
100
Charge/Discharge Stations 206
100
External Sensors 210
100
Weather Sensors 209
100
Traditional
Solar
Wind
Fuel Cell
EV/PHEV Charge Station

FIG. 2

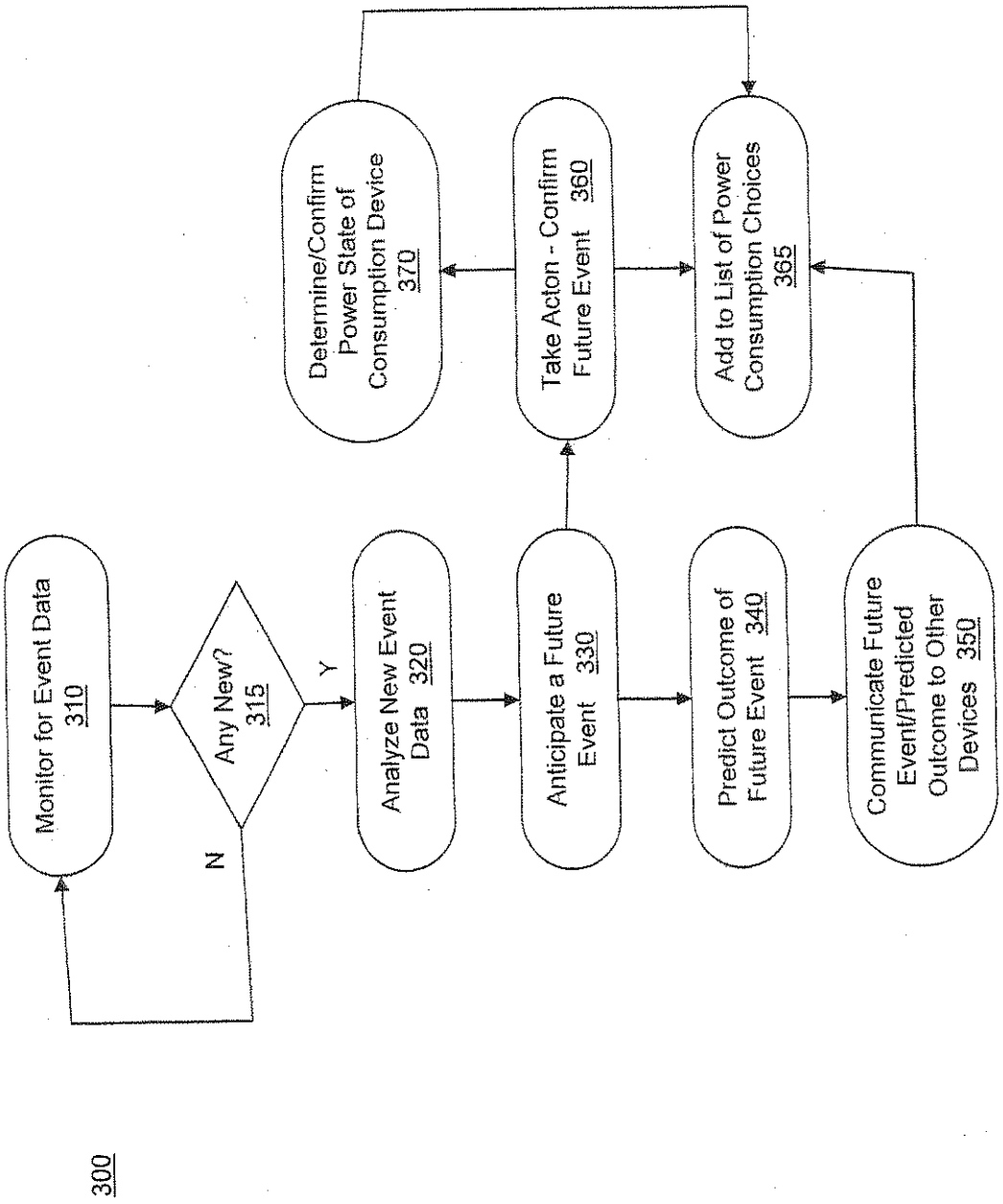

300
Monitor for Event Data 310
Any New? 315
Y
N
Analyze New Event Data 320
Anticipate a Future Event 330
Predict Outcome of Future Event 340
Communicate Future Event/Predicted Outcome to Other Devices 350
Determine/Confirm Power State of Consumption Device 370
Take Acton - Confirm Future Event 360
Add to List of Power Consumption Choices 365

FIG. 3

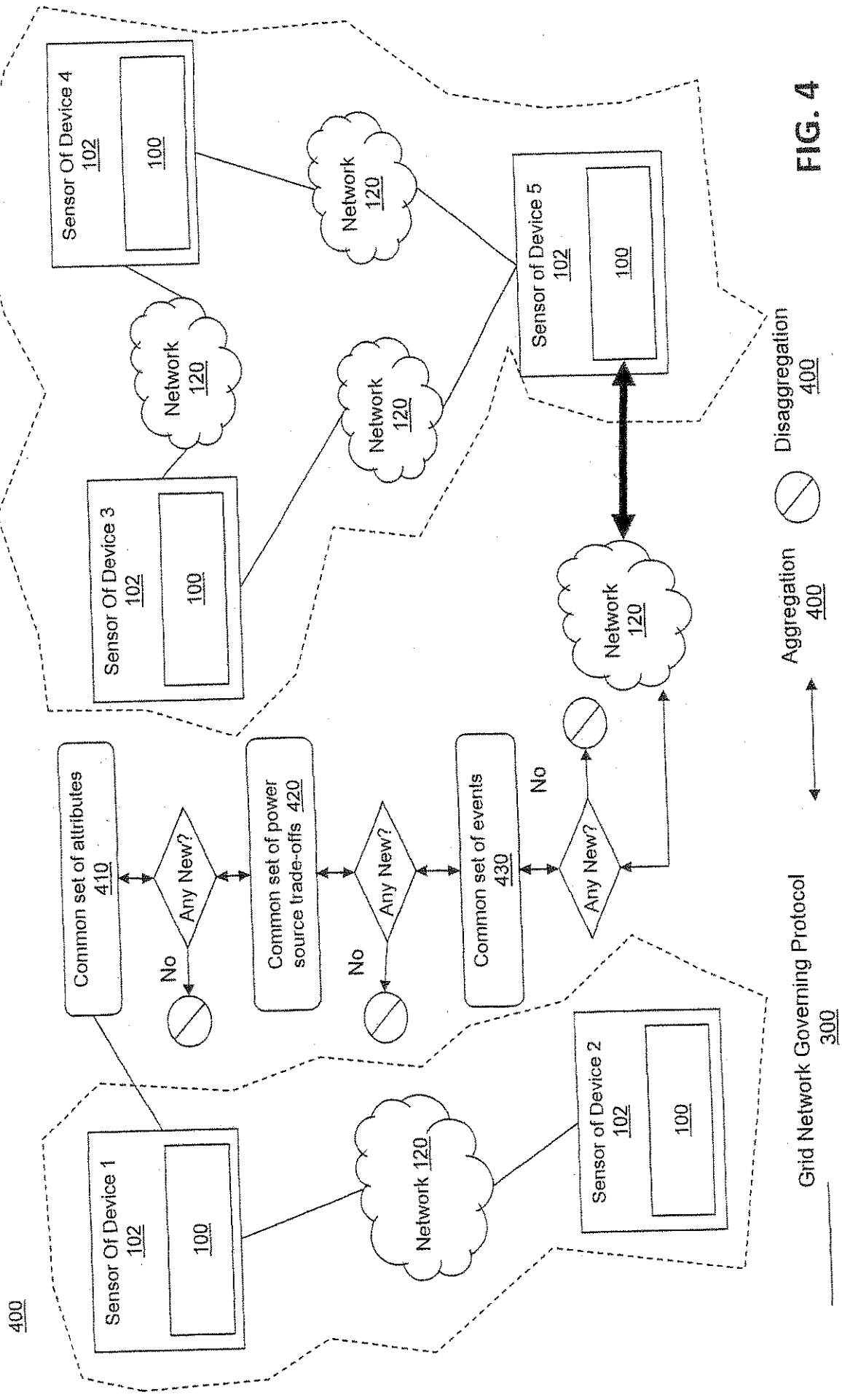

400
Sensor Of Device 1
102
100
Sensor Of Device 3
102
100
Sensor Of Device 4
102
100
Sensor of Device 5
102
100
Sensor of Device 2
102
100
Network
120
Network 120
Network
120
Network
120
Network
120
Common set of attributes
410
Any New?
No
Common set of power
source trade-offs 420
Any New?
No
Common set of events
430
Any New?
No
Grid Network Governing Protocol
300
Aggregation
400
Disaggregation
400

FIG. 4

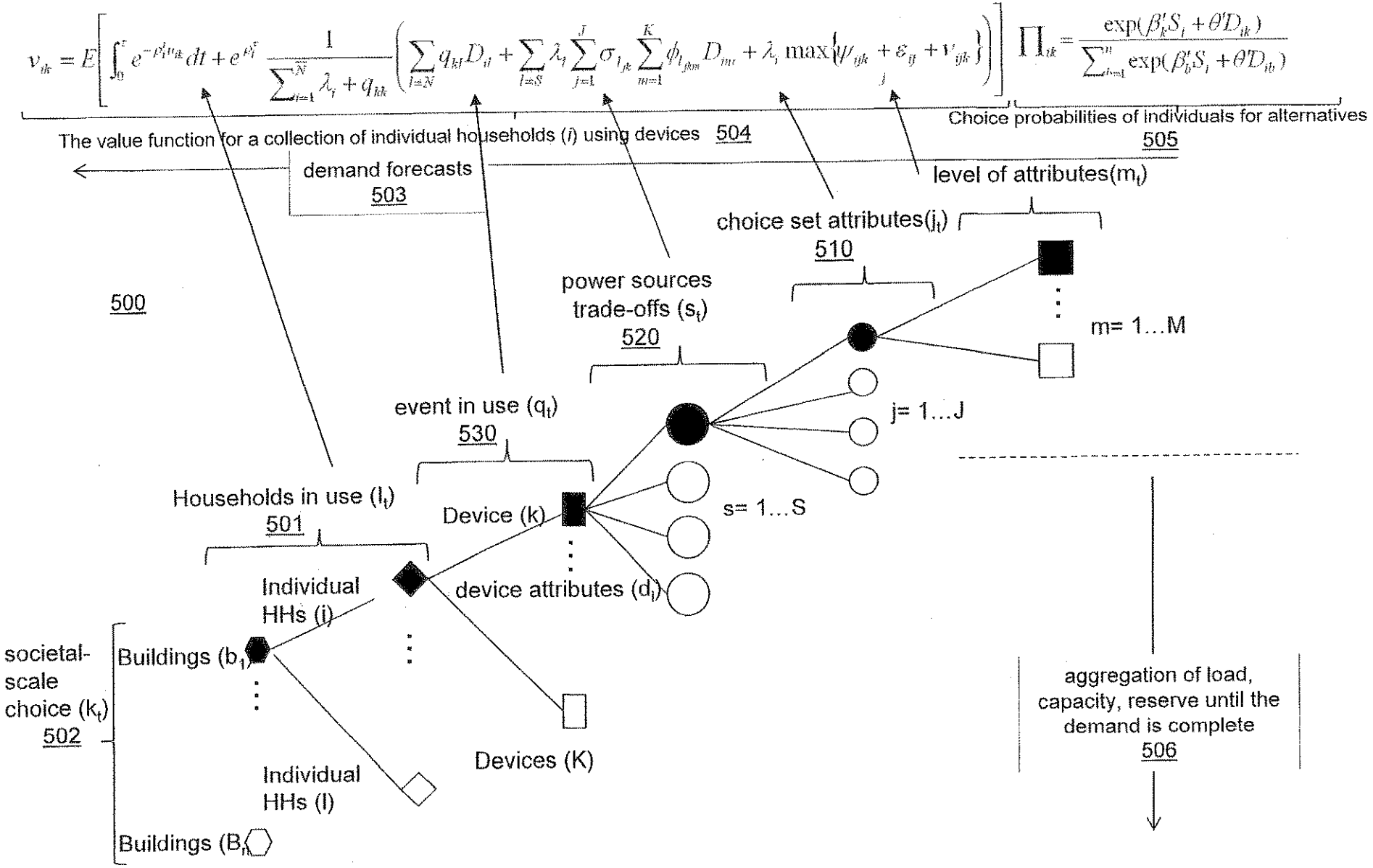

$v_{ik} = E\left[\int_0^\tau e^{-\rho t} u_{ik}\, dt + e^{\rho\tau} \frac{1}{\sum_{i=1}^{\bar{N}} \lambda_i + q_{ik}} \left(\sum_{l=N} q_{kl} D_{il} + \sum_{l=S} \lambda_l \sum_{j=1}^{J} \sigma_{ijk} \sum_{m=1}^{K} \phi_{ijkm} D_{imr} + \lambda_i \max_j \{ \psi_{ijk} + \varepsilon_{ij} + v_{ijk} \} \right)\right]$
$\prod_{ik} = \frac{\exp(\beta_k' S_i + \theta' D_{ik})}{\sum_{b=1}^{B} \exp(\beta_b' S_i + \theta' D_{ib})}$
The value function for a collection of individual households (i) using devices 504
Choice probabilities of individuals for alternatives 505
demand forecasts 503
level of attributes(m_t)
choice set attributes(j_t) 510
power sources trade-offs (s_t) 520
event in use (q_t) 530
Households in use (l_t) 501
Device (k)
device attributes (d_t)
Individual HHs (i)
Individual HHs (I)
Buildings (b_1)
Buildings (B_t)
societal-scale choice (k_t) 502
Devices (K)
m= 1…M
j= 1…J
s= 1…S
500
aggregation of load, capacity, reserve until the demand is complete 506

FIG. 5

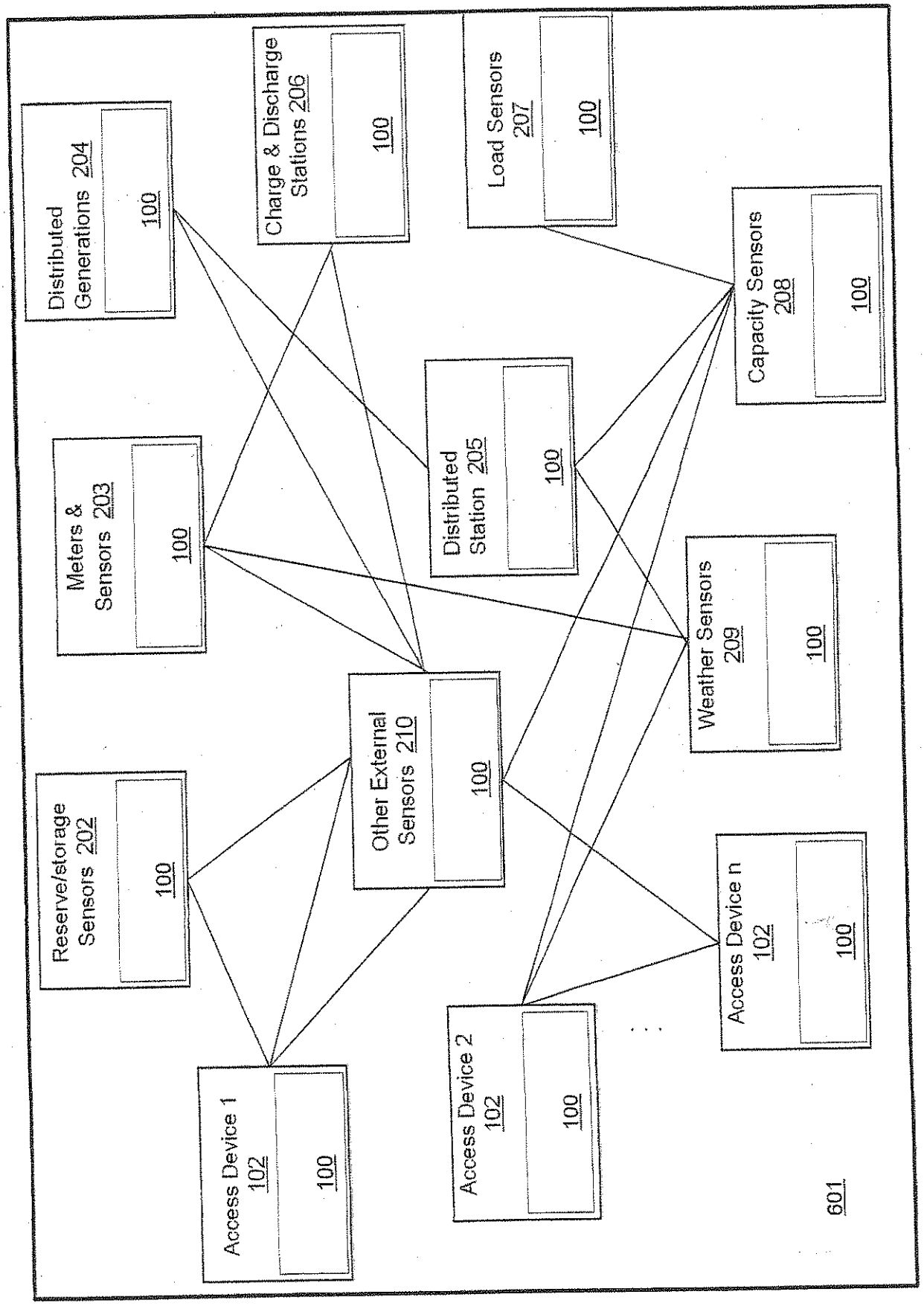

Distributed Generations 204
100
Charge & Discharge Stations 206
100
Load Sensors 207
100
Capacity Sensors 208
100
Meters & Sensors 203
100
Distributed Station 205
100
Weather Sensors 209
100
Reserve/storage Sensors 202
100
Other External Sensors 210
100
Access Device 1 102
100
Access Device 2 102
100
Access Device n 102
100
601

FIG. 6A

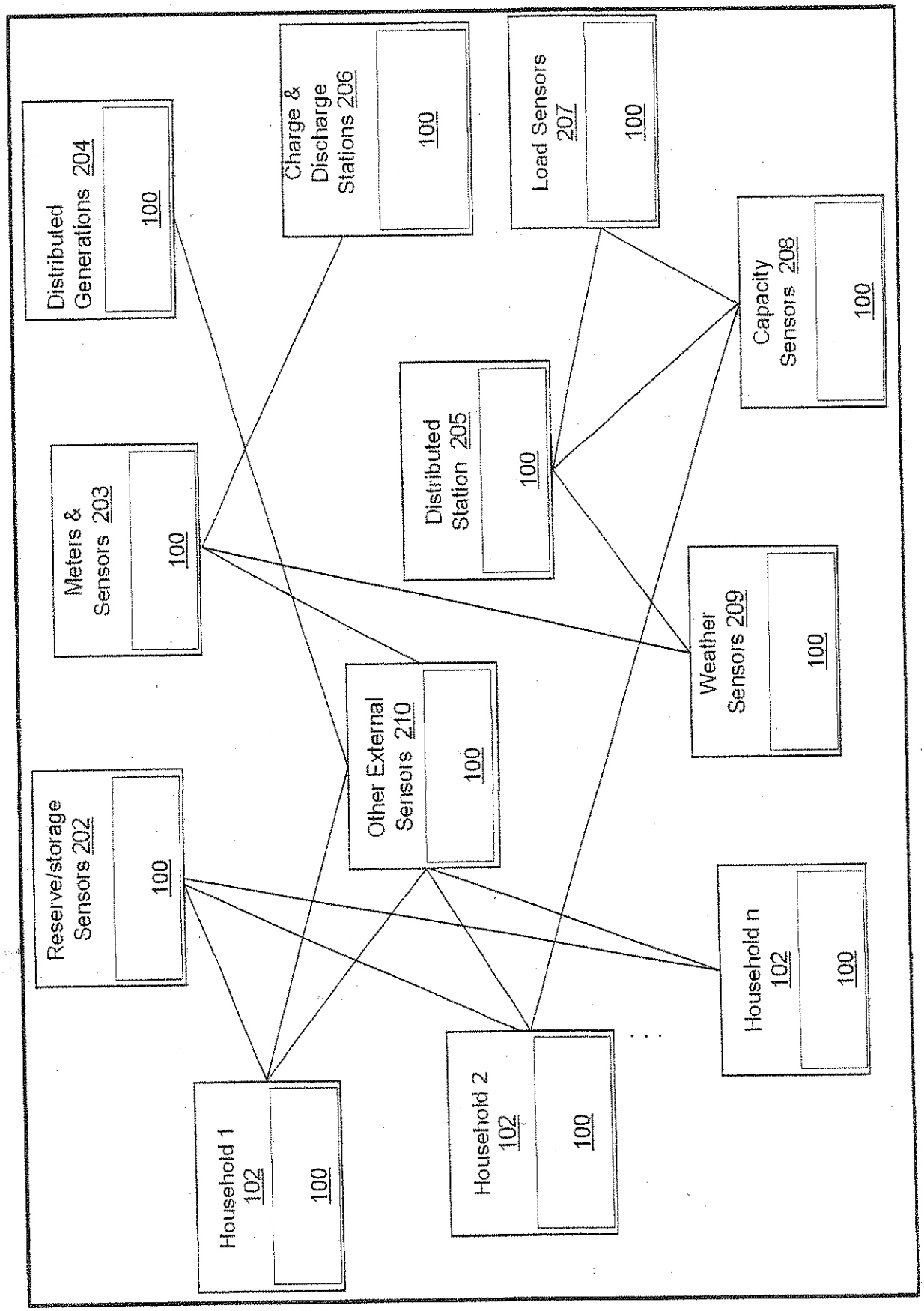

Distributed Generations 204
100
Charge & Discharge Stations 206
100
Load Sensors 207
100
Capacity Sensors 208
100
Meters & Sensors 203
100
Distributed Station 205
100
Weather Sensors 209
100
Other External Sensors 210
100
Reserve/storage Sensors 202
100
Household 1 102
100
Household 2 102
100
Household n 102
100
602

FIG. 6B

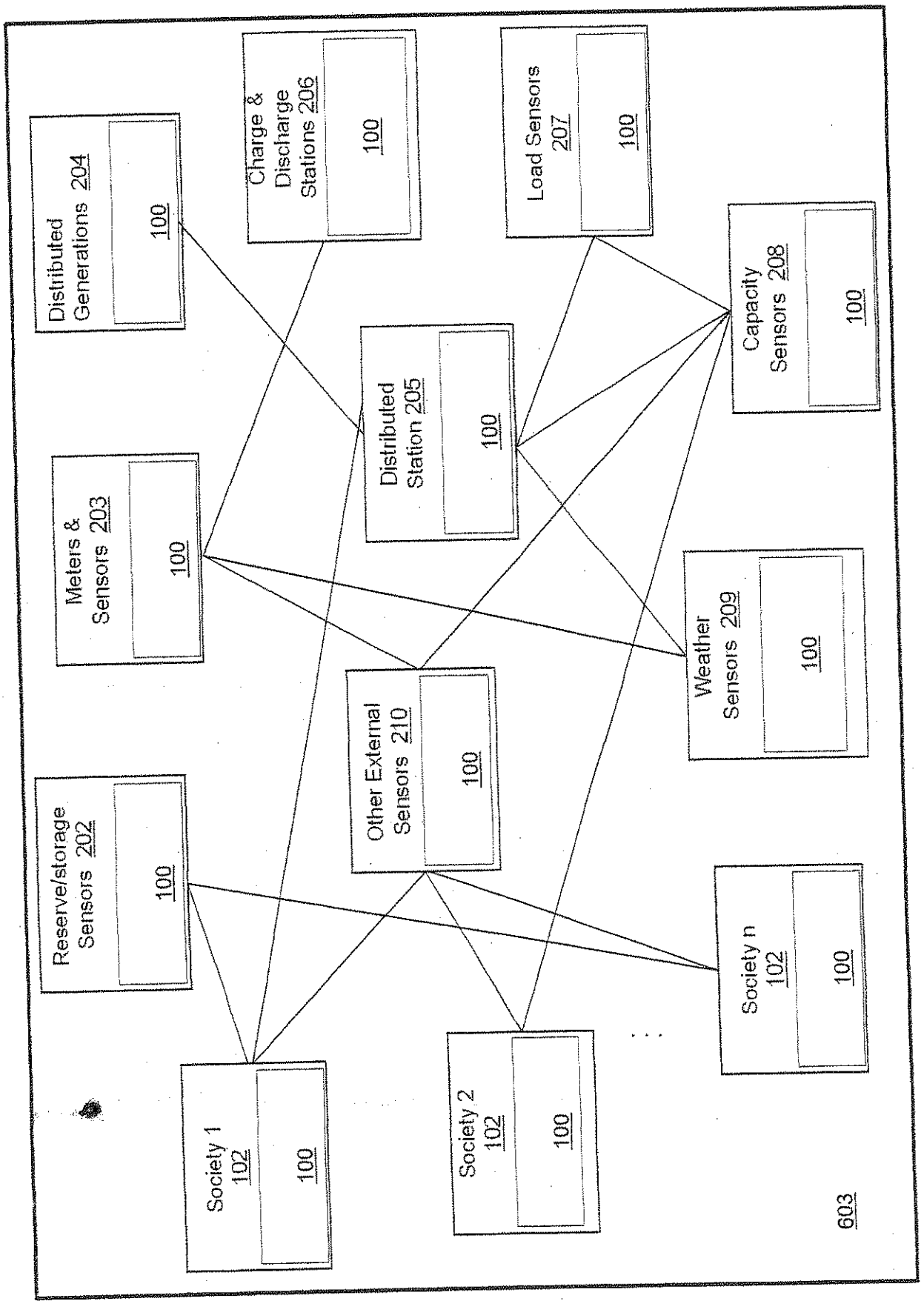

Distributed Generations 204
100
Charge & Discharge Stations 206
100
Load Sensors 207
100
Capacity Sensors 208
100
Distributed Station 205
100
Meters & Sensors 203
100
Weather Sensors 209
100
Other External Sensors 210
100
Reserve/storage Sensors 202
100
Society n 102
100
Society 2 102
100
Society 1 102
100
603

FIG. 6C

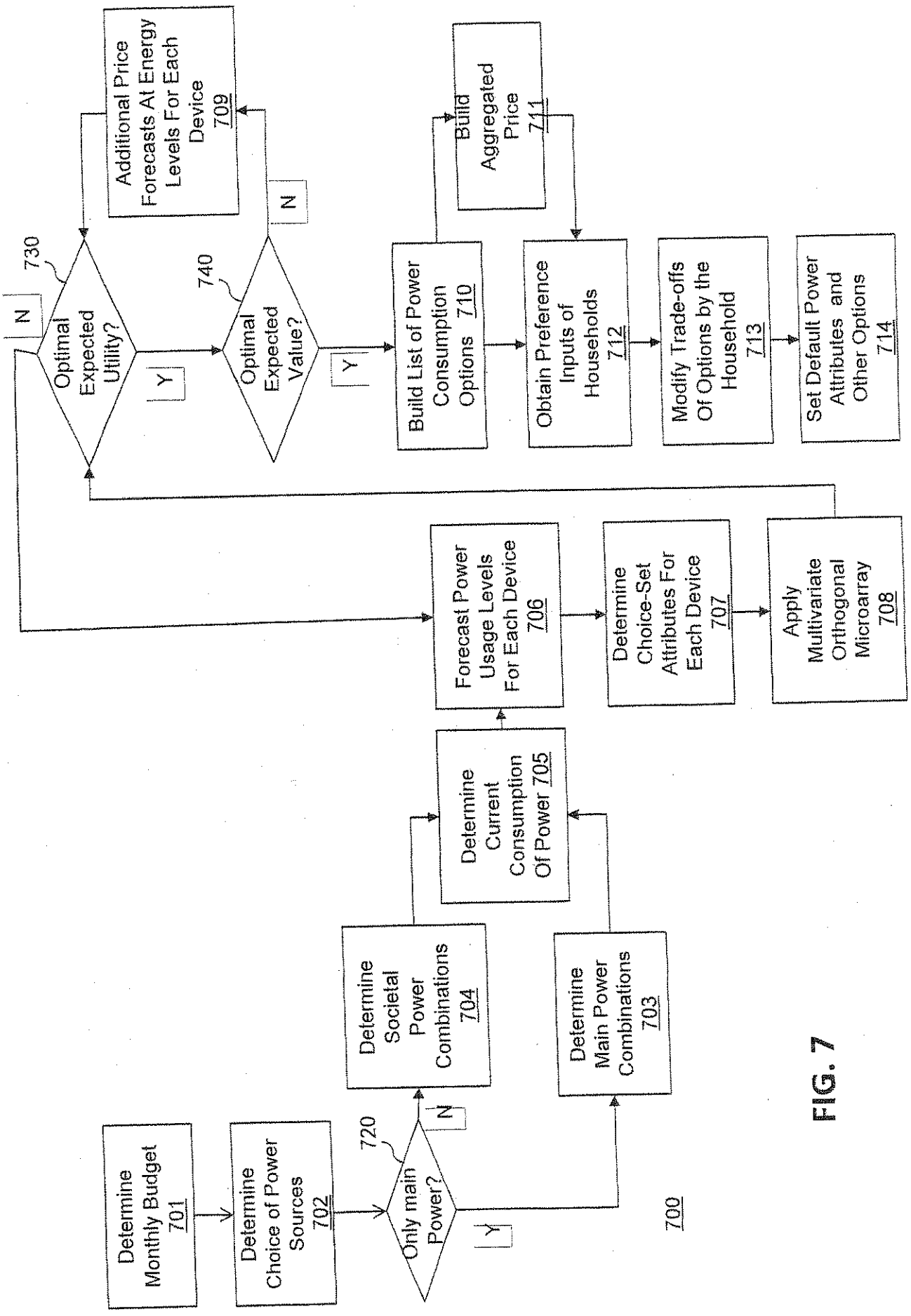

Determine Monthly Budget 701
Determine Choice of Power Sources 702
720
Only main Power?
N
Y
Determine Societal Power Combinations 704
Determine Main Power Combinations 703
Determine Current Consumption Of Power 705
Forecast Power Usage Levels For Each Device 706
Determine Choice-Set Attributes For Each Device 707
Apply Multivariate Orthogonal Microarray 708
730
Optimal Expected Utility?
N
Y
740
Optimal Expected Value?
N
Y
Additional Price Forecasts At Energy Levels For Each Device 709
Build List of Power Consumption Options 710
Build Aggregated Price 711
Obtain Preference Inputs of Households 712
Modify Trade-offs Of Options by the Household 713
Set Default Power Attributes and Other Options 714
700

FIG. 7

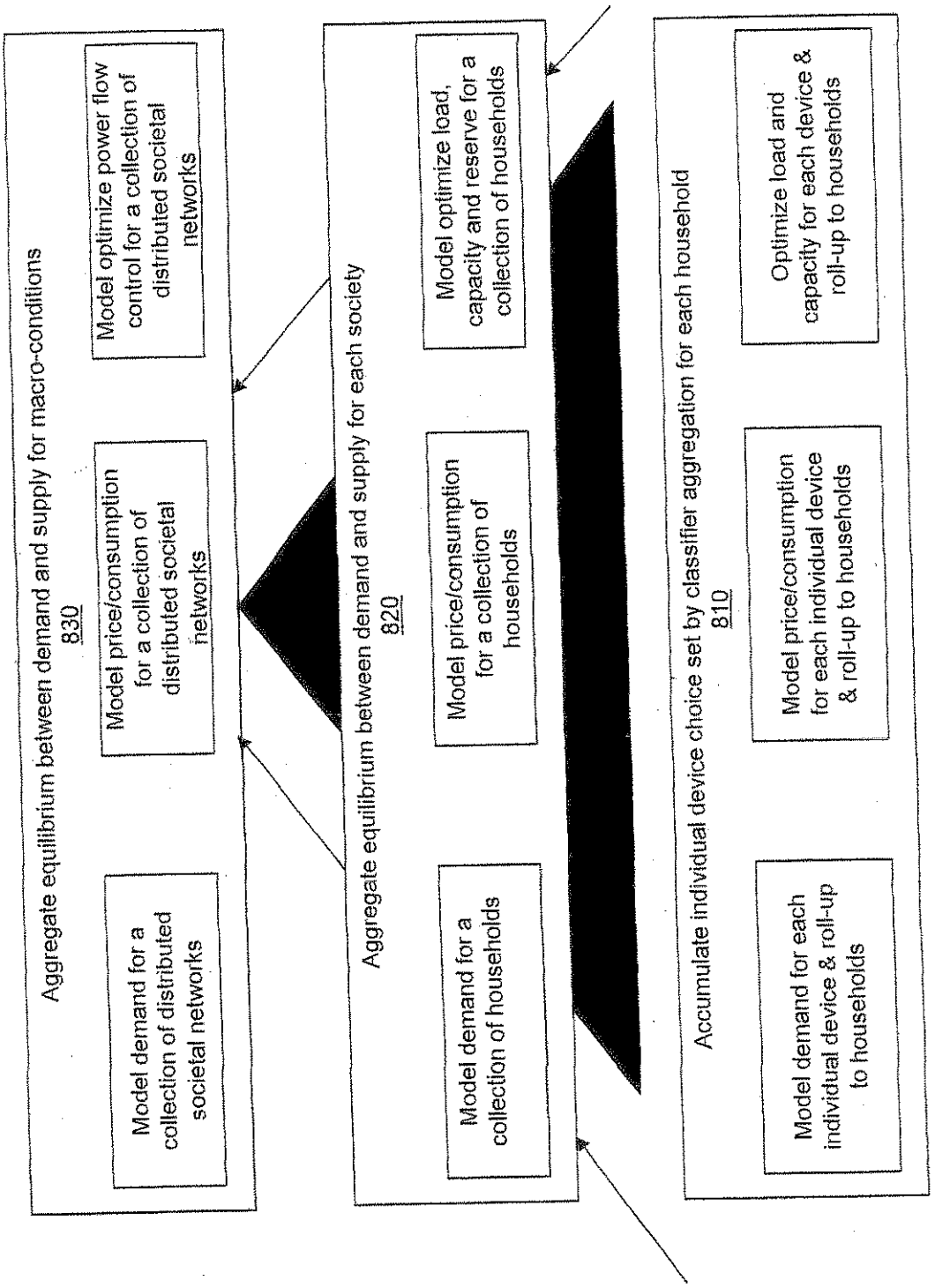

800
Aggregate equilibrium between demand and supply for macro-conditions
830
Model demand for a collection of distributed societal networks
Model price/consumption for a collection of distributed societal networks
Model optimize power flow control for a collection of distributed societal networks
Aggregate equilibrium between demand and supply for each society
820
Model demand for a collection of households
Model price/consumption for a collection of households
Model optimize load, capacity and reserve for a collection of households
Accumulate individual device choice set by classifier aggregation for each household
810
Model demand for each individual device & roll-up to households
Model price/consumption for each individual device & roll-up to households
Optimize load and capacity for each device & roll-up to households

FIG. 8

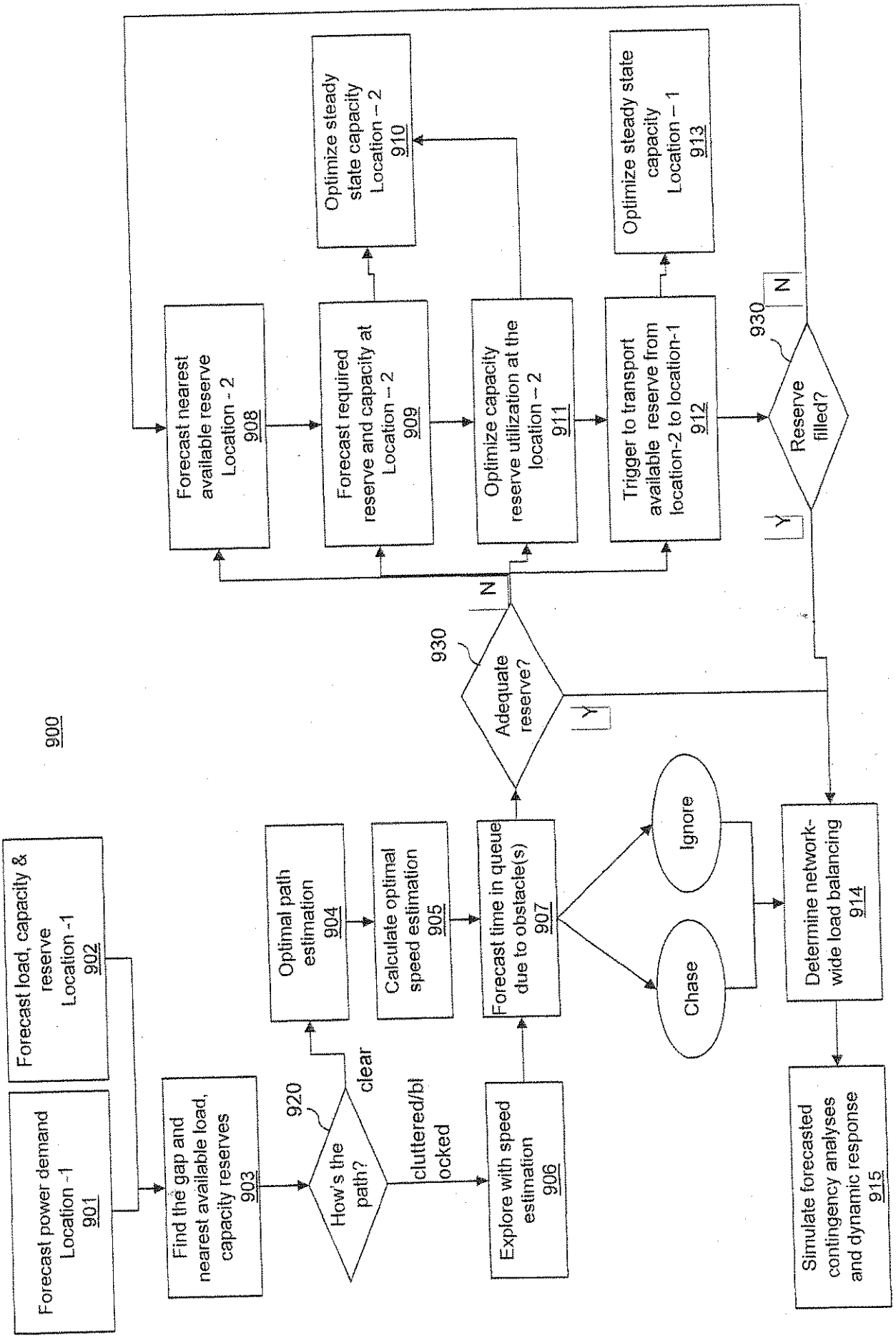

900
Forecast power demand Location -1 901
Forecast load, capacity & reserve Location -1 902
Find the gap and nearest available load, capacity reserves 903
920
How's the path?
clear
cluttered/blocked
Optimal path estimation 904
Calculate optimal speed estimation 905
Explore with speed estimation 906
Forecast time in queue due to obstacle(s) 907
Chase
Ignore
Determine network-wide load balancing 914
Simulate forecasted contingency analyses and dynamic response 915
930
Adequate reserve?
N
Y
Forecast nearest available reserve Location - 2 908
Forecast required reserve and capacity at Location – 2 909
Optimize steady state capacity Location – 2 910
Optimize capacity reserve utilization at the location – 2 911
Trigger to transport available reserve from location-2 to location-1 912
Optimize steady state capacity Location – 1 913
930
Reserve filled?
N
Y

FIG. 9

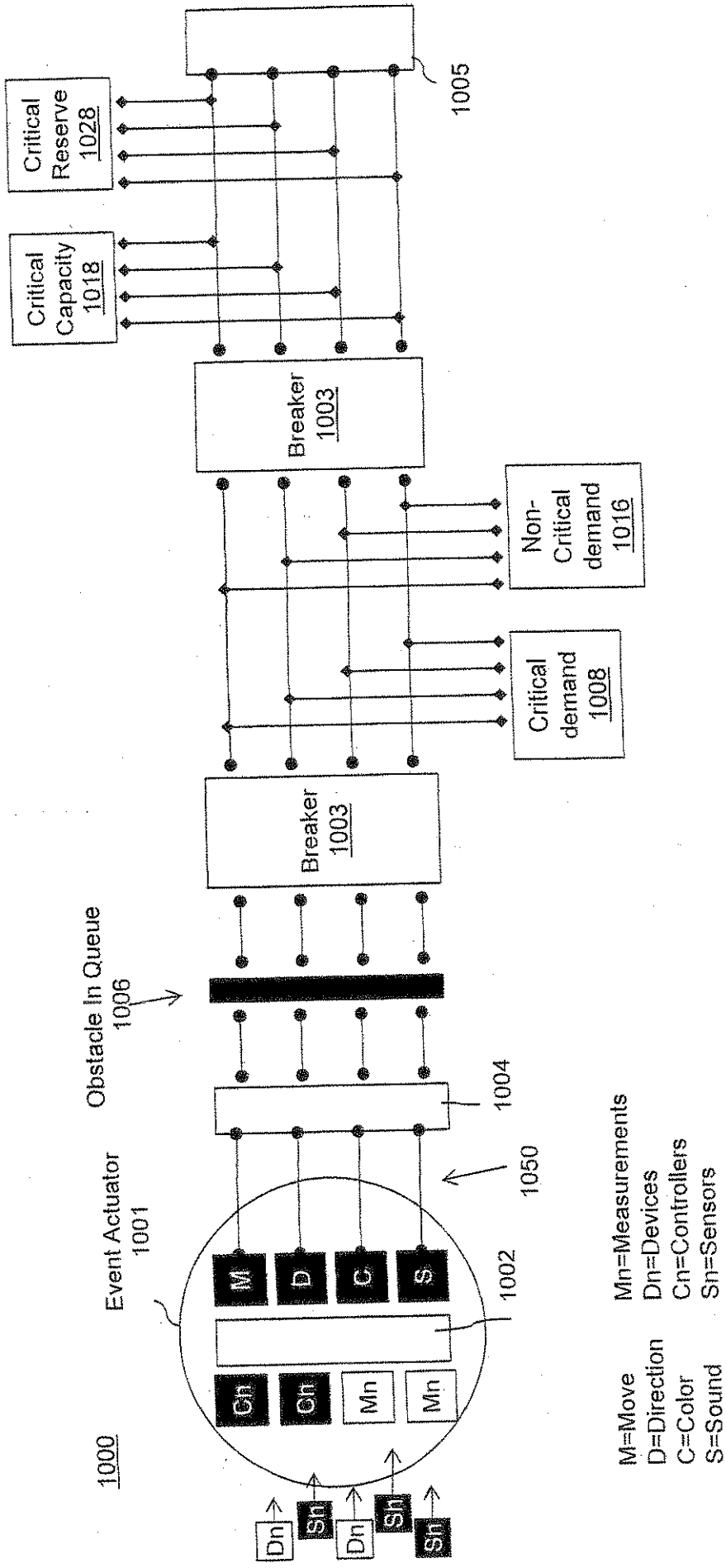

1000
Event Actuator
1001
Obstacle In Queue
1006
1002
1004
1050
1005
Breaker
1003
Breaker
1003
Critical
demand
1008
Non-
Critical
demand
1016
Critical
Capacity
1018
Critical
Reserve
1028
M
D
C
S
Cn
Cn
Mn
Mn
Dn
Sn
Dn
Sn
Sn
M=Move
D=Direction
C=Color
S=Sound
Mn=Measurements
Dn=Devices
Cn=Controllers
Sn=Sensors

FIG. 10

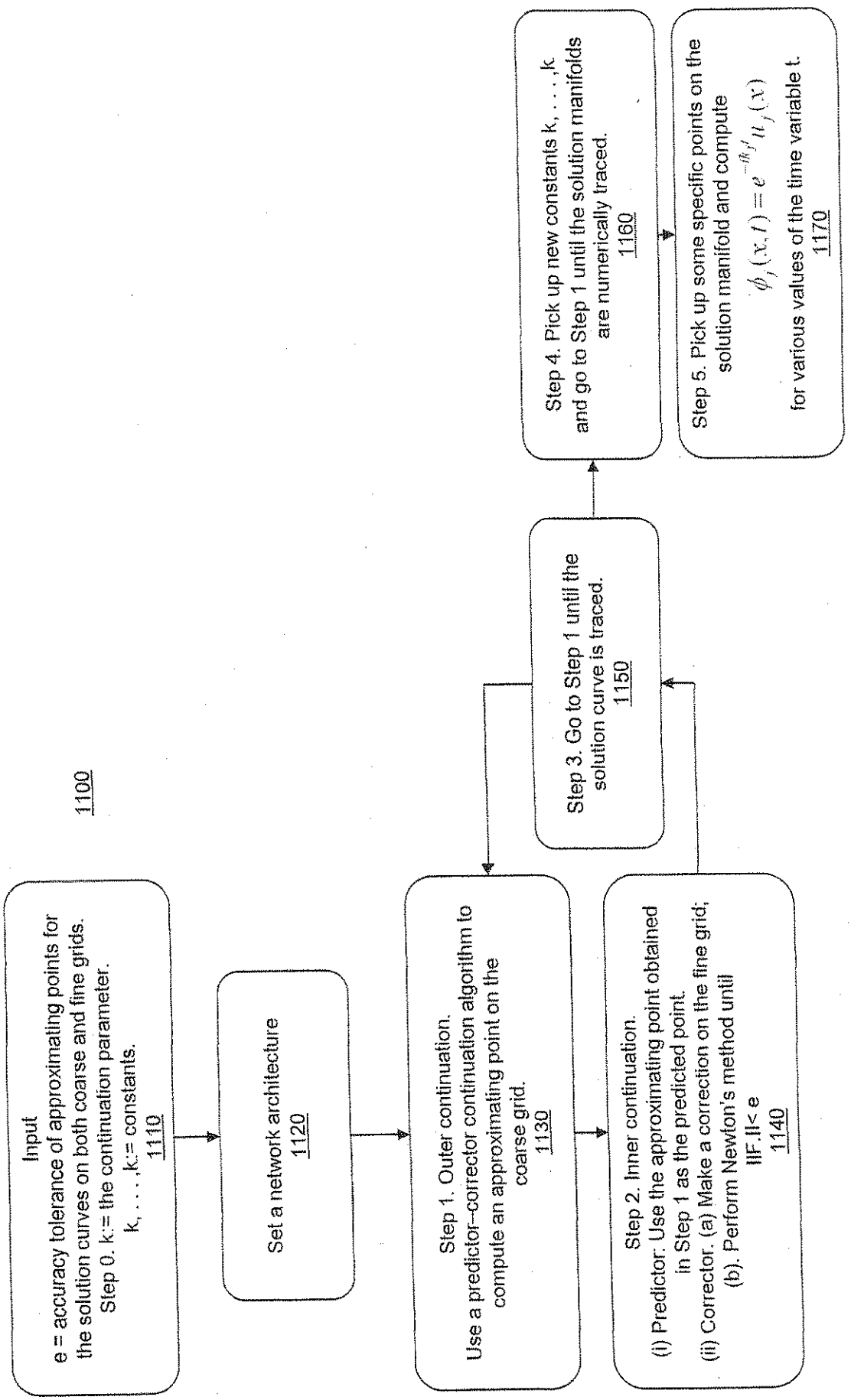

1100
Input
e = accuracy tolerance of approximating points for the solution curves on both coarse and fine grids.
Step 0. k:= the continuation parameter.
k, . . . ,k:= constants.
1110
Set a network architecture
1120
Step 1. Outer continuation.
Use a predictor–corrector continuation algorithm to compute an approximating point on the coarse grid.
1130
Step 2. Inner continuation.
(i) Predictor. Use the approximating point obtained in Step 1 as the predicted point.
(ii) Corrector. (a) Make a correction on the fine grid;
(b). Perform Newton's method until
IIF.II< e
1140
Step 3. Go to Step 1 until the solution curve is traced.
1150
Step 4. Pick up new constants k, . . . ,k and go to Step 1 until the solution manifolds are numerically traced.
1160
Step 5. Pick up some specific points on the solution manifold and compute
$\phi_j(x,t) = e^{-ik_j t} u_j(x)$
for various values of the time variable t.
1170

FIG. 11

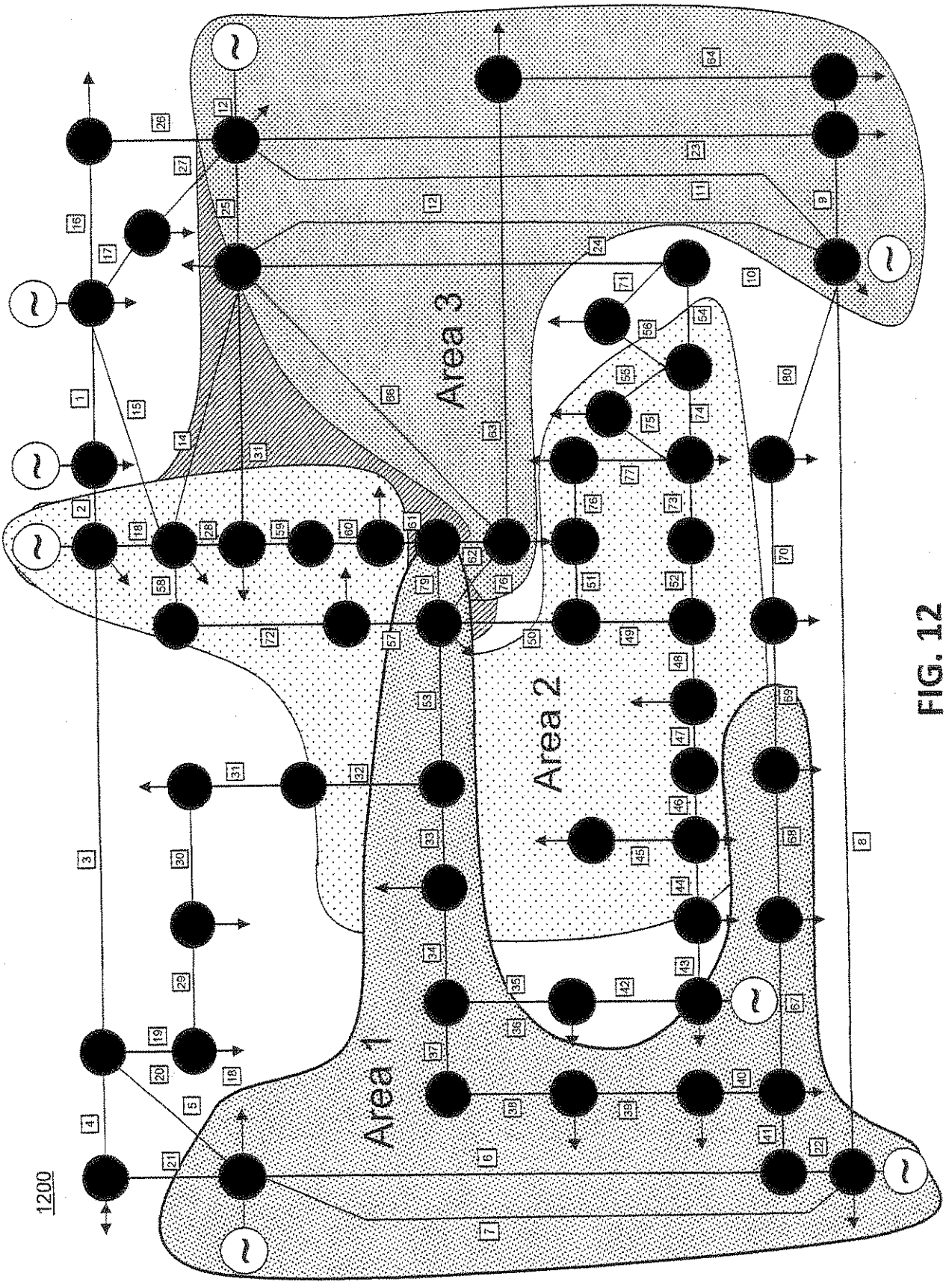


FIG. 12

1300

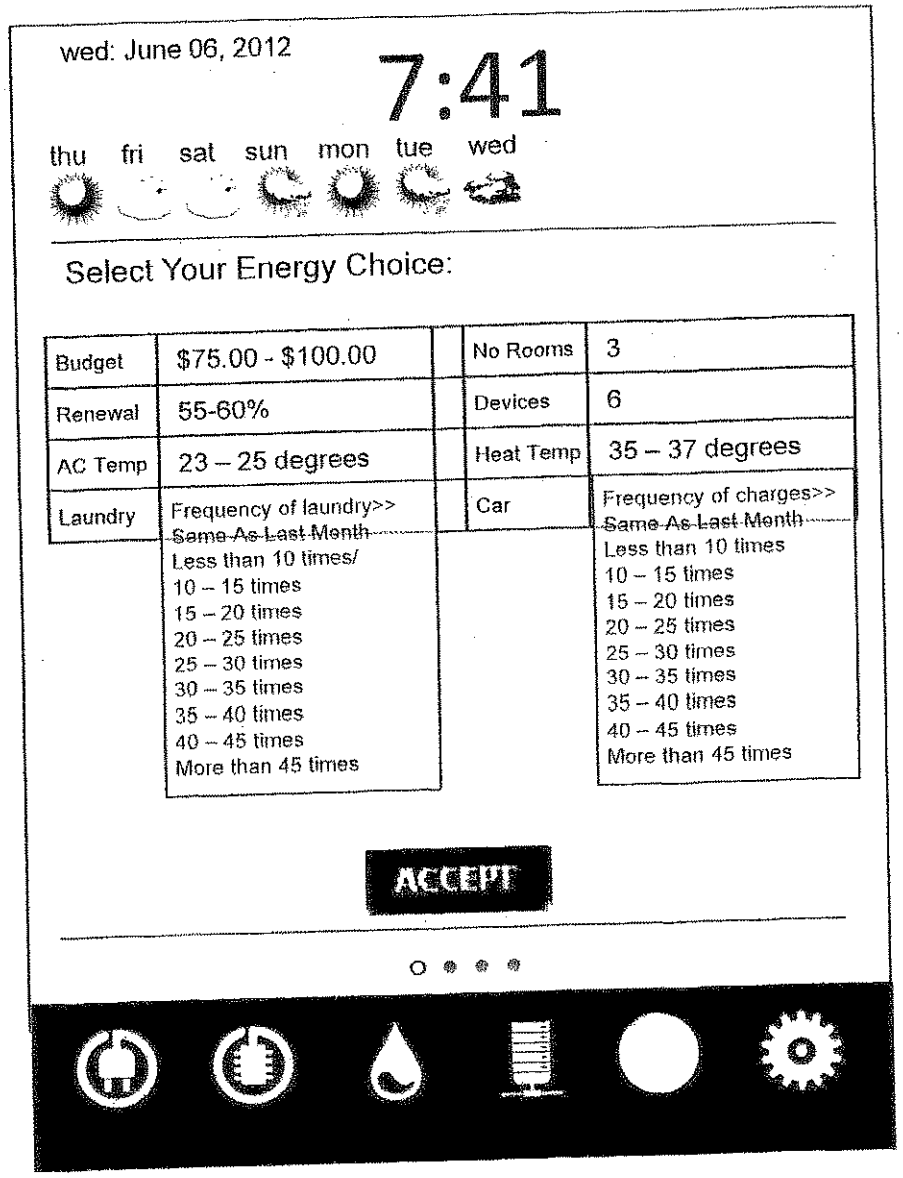

wed: June 06, 2012
7:41
thu fri sat sun mon tue wed
Select Your Energy Choice:
Budget
$75.00 - $100.00
No Rooms
3
Renewal
55-60%
Devices
6
AC Temp
23 – 25 degrees
Heat Temp
35 – 37 degrees
Laundry
Frequency of laundry>>
Same As Last Month
Less than 10 times/
10 – 15 times
15 – 20 times
20 – 25 times
25 – 30 times
30 – 35 times
35 – 40 times
40 – 45 times
More than 45 times
Car
Frequency of charges>>
Same As Last Month
Less than 10 times
10 – 15 times
15 – 20 times
20 – 25 times
25 – 30 times
30 – 35 times
35 – 40 times
40 – 45 times
More than 45 times
ACCEPT

Fig 13

1400

No	Est. Bill	main power	bldg. power	self power	grid	green	Save ($)	
1	$98.00	55%	35%	10%	48%	51%	48%	Accept
2	$98.50	54%	36%	10%	48%	51%	51%	Accept
3	$99.00	54%	36%	12%	47%	52%	51%	Accept
4	$99.50	54%	37%	9%	47%	52%	52%	Accept
5	$100.00	53%	37%	10%	47%	53%	52%	Accept
6	$101.00	52%	38%	10%	45%	53%	53%	Accept
7	$101.50	54%	38%	8%	45%	54%	54%	Accept
8	$102.50	55%	45%	-	40%	55%	56%	Accept
8	103.50	52%	48%	-	41%	54%	56%	Accept

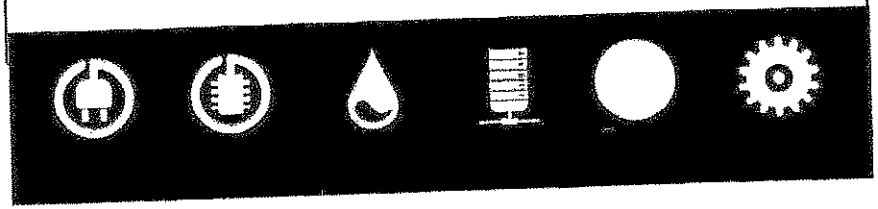


Fig 14

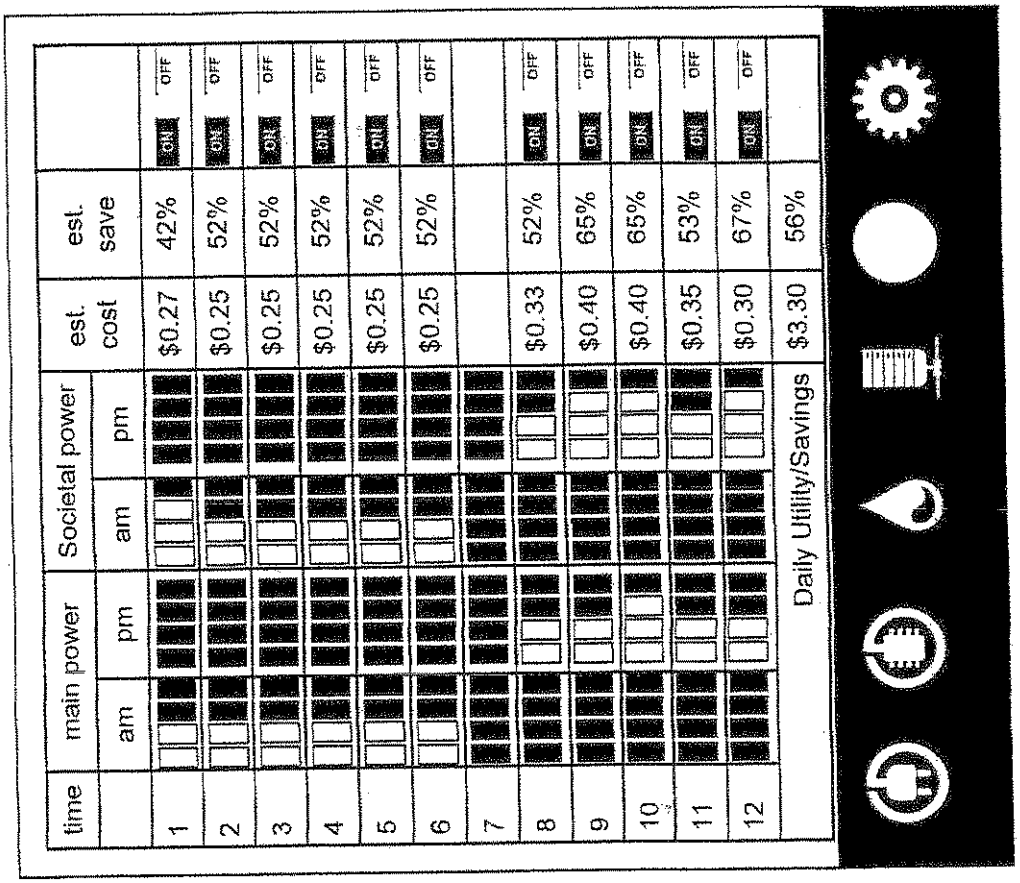

1500
time
main power
Societal power
est. cost
est. save
am
pm
am
pm
1
2
3
4
5
6
7
8
9
10
11
12
$0.27
$0.25
$0.25
$0.25
$0.25
$0.25
$0.33
$0.40
$0.40
$0.35
$0.30
$3.30
42%
52%
52%
52%
52%
52%
52%
65%
65%
53%
67%
56%
ON
OFF
Daily Utility/Savings

Fig 15

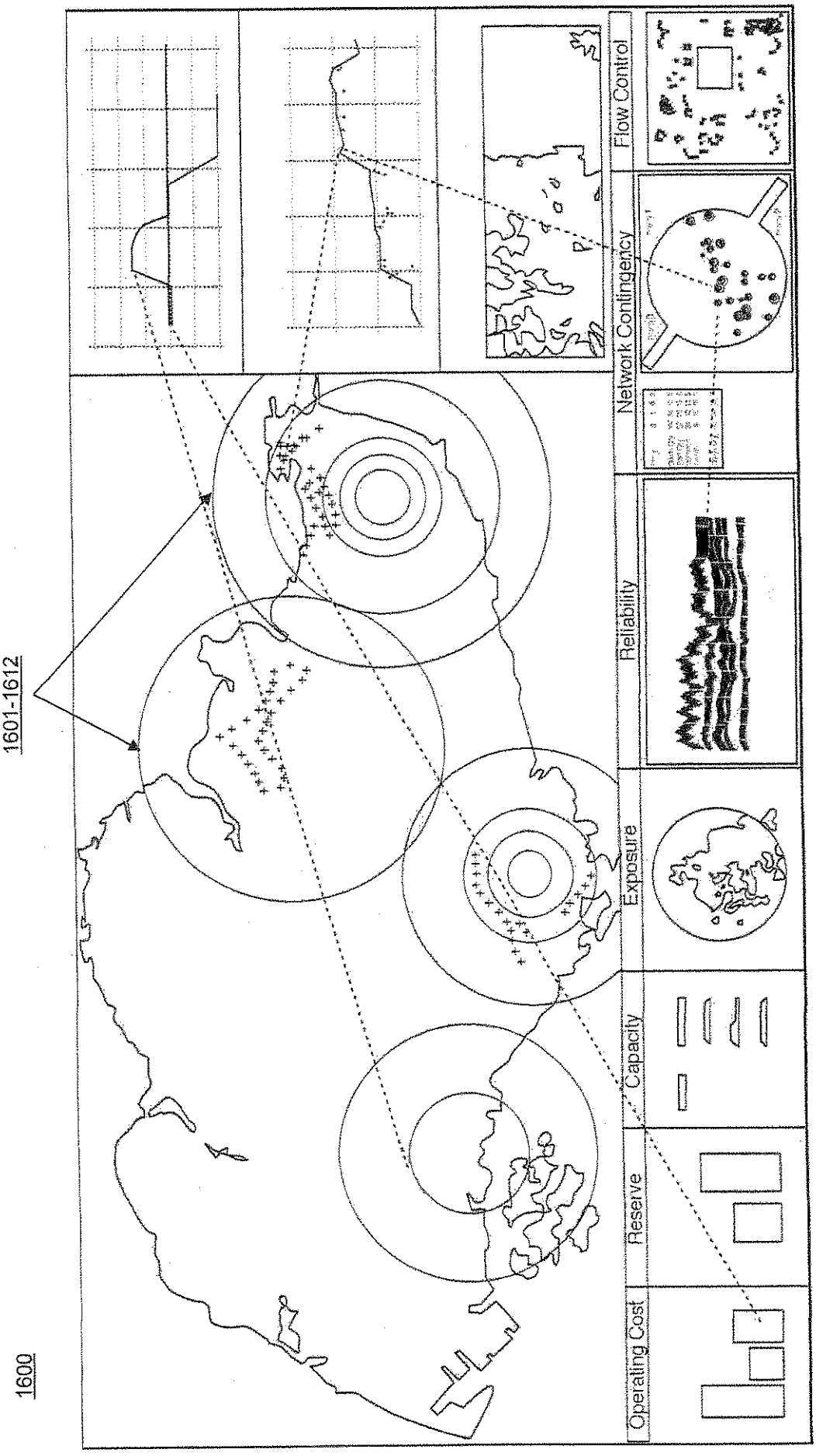
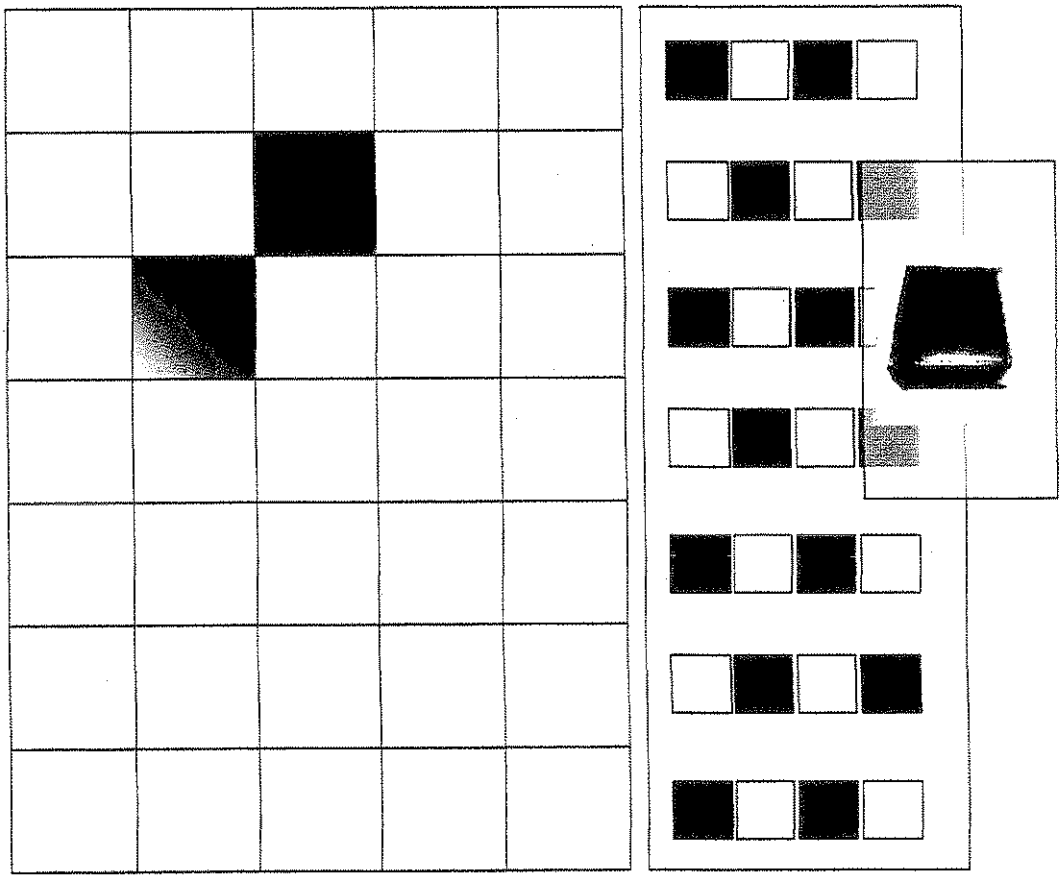
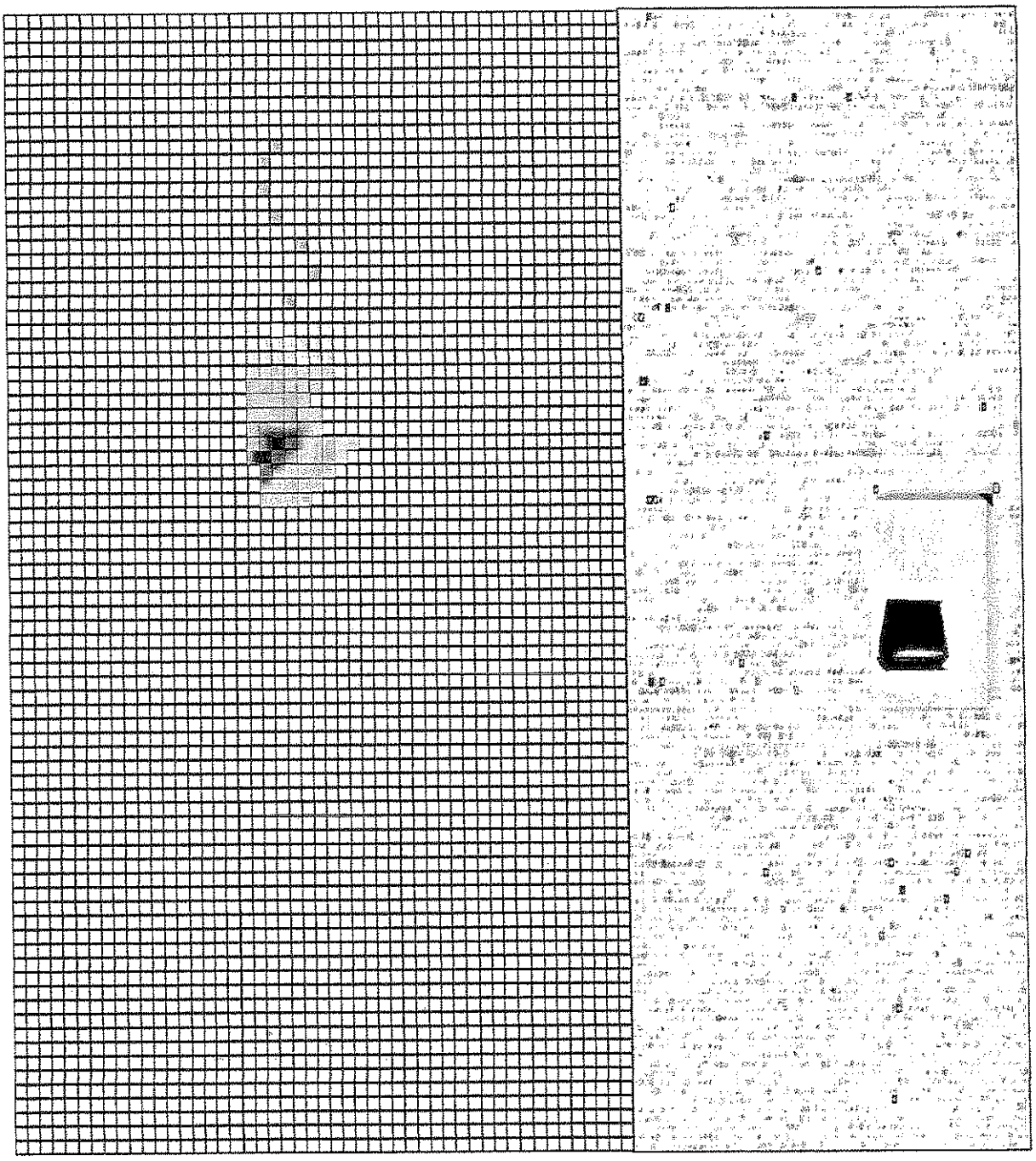

1600
1601-1612
Operating Cost
Reserve
Capacity
Exposure
Reliability
Network Contingency
Flow Control

FIG. 16



1700

FIG. 17



1800

FIG. 18