F I G. 1

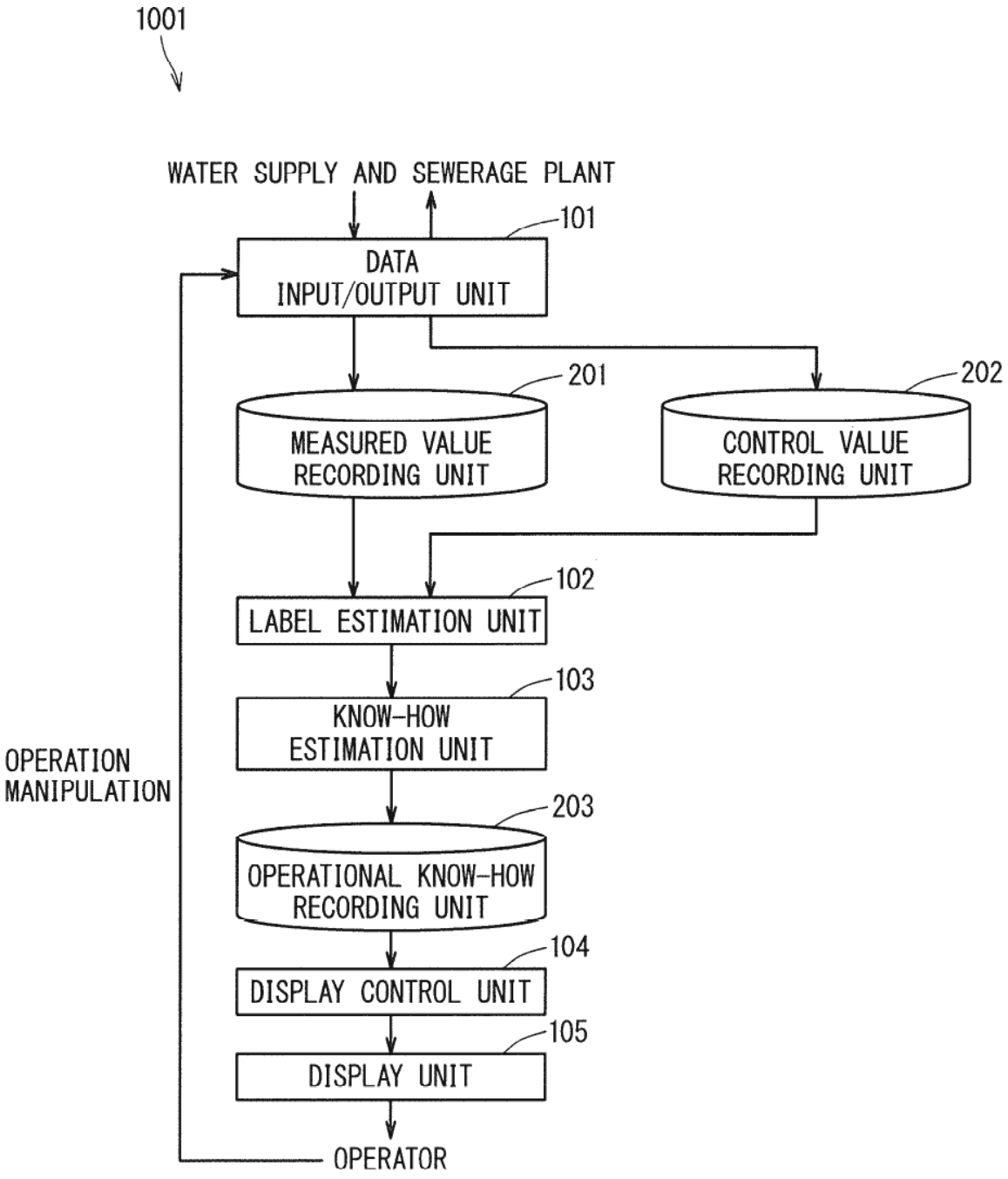

1001
WATER SUPPLY AND SEWERAGE PLANT
101
DATA INPUT/OUTPUT UNIT
201
MEASURED VALUE RECORDING UNIT
202
CONTROL VALUE RECORDING UNIT
102
LABEL ESTIMATION UNIT
103
KNOW-HOW ESTIMATION UNIT
203
OPERATIONAL KNOW-HOW RECORDING UNIT
104
DISPLAY CONTROL UNIT
105
DISPLAY UNIT
OPERATOR
OPERATION MANIPULATION

FIG. 2

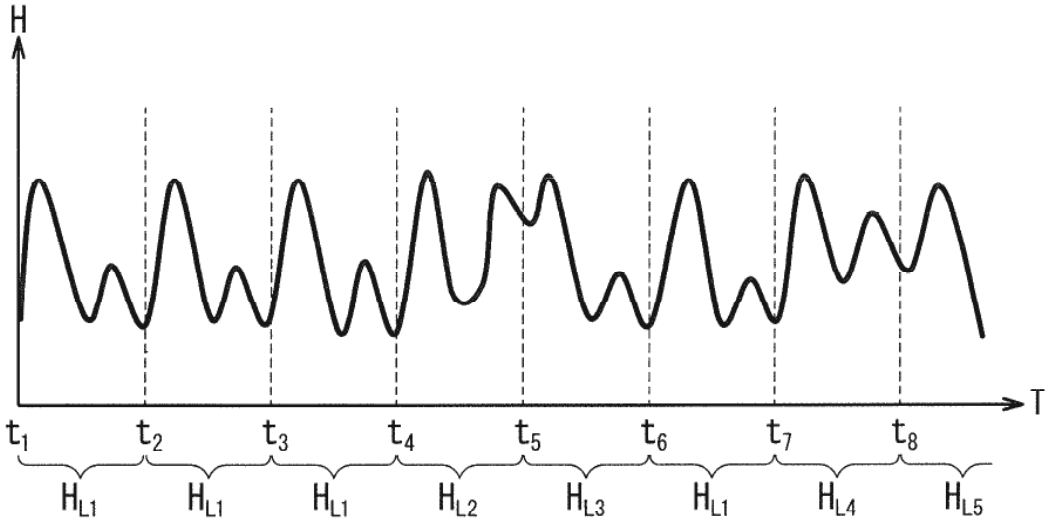

H
T
t1
t2
t3
t4
t5
t6
t7
t8
HL1
HL1
HL1
HL2
HL3
HL1
HL4
HL5

FIG. 3

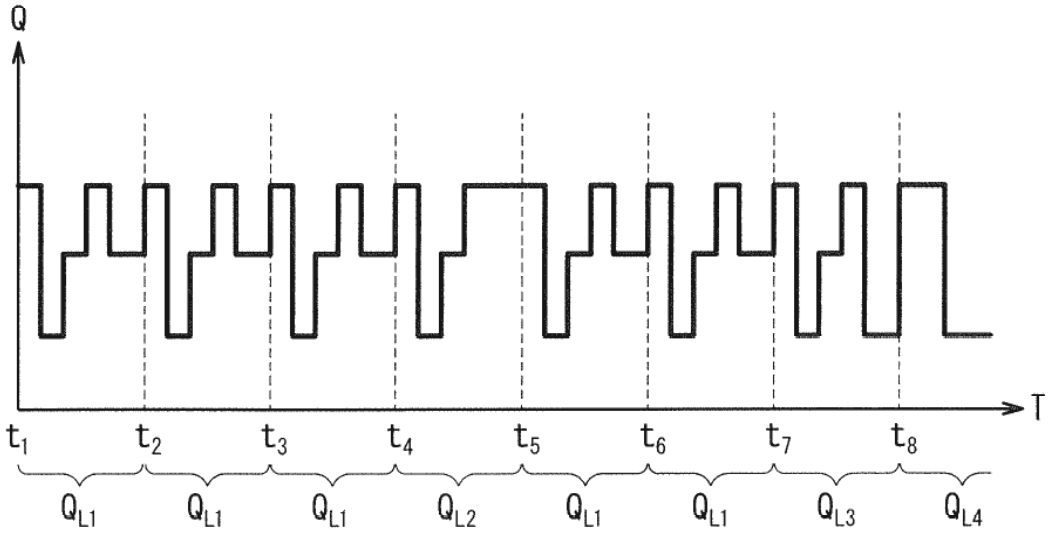

Q
T
t1
t2
t3
t4
t5
t6
t7
t8
QL1
QL1
QL1
QL2
QL1
QL1
QL3
QL4

FIG. 4

T	H	LABEL FOR H	Q	LABEL FOR Q
t_1	h_{t1}	H_{L1}	q_{t1}	Q_{L1}
⋮	⋮		⋮	
t_2	h_{t2}	H_{L1}	q_{t2}	Q_{L1}
⋮	⋮		⋮	
t_3	h_{t3}	H_{L1}	q_{t3}	Q_{L1}
⋮	⋮		⋮	
t_4	h_{t4}	H_{L2}	q_{t4}	Q_{L2}
⋮	⋮		⋮	

F I G. 5

EVENT X	EVENT Y	$n(X_i \times Y_j)$	$p(Y\|X)$
$H_L=\{ H_{L1}, H_{L2}, H_{L3}, H_{L4}, H_{L5} \}$	$Q_L=\{ Q_{L1}, Q_{L2}, Q_{L3}, Q_{L4} \}$	$n(H_{Li} \times Q_{Lj})$	$p(Q_L \mid H_L)=n(H_{Li} \times Q_{Lj})/n(H_{Li})$
H_{L1}	Q_{L1}	$n(H_{L1} \times Q_{L1})$	$n(H_{L1} \times Q_{L1})/n(H_{L1})$
H_{L1}	Q_{L2}	$n(H_{L1} \times Q_{L2})$	$n(H_{L1} \times Q_{L2})/n(H_{L1})$
H_{L1}	Q_{L3}	$n(H_{L1} \times Q_{L3})$	$n(H_{L1} \times Q_{L3})/n(H_{L1})$
H_{L1}	Q_{L4}	$n(H_{L1} \times Q_{L4})$	$n(H_{L1} \times Q_{L4})/n(H_{L1})$
H_{L2}	Q_{L1}	$n(H_{L2} \times Q_{L1})$	$n(H_{L2} \times Q_{L1})/n(H_{L2})$
H_{L2}	Q_{L2}	$n(H_{L2} \times Q_{L2})$	$n(H_{L2} \times Q_{L2})/n(H_{L2})$
⋮	⋮	⋮	⋮
H_{L5}	Q_{L4}	$n(H_{L5} \times Q_{L4})$	$n(H_{L5} \times Q_{L4})/n(H_{L5})$

FIG. 6

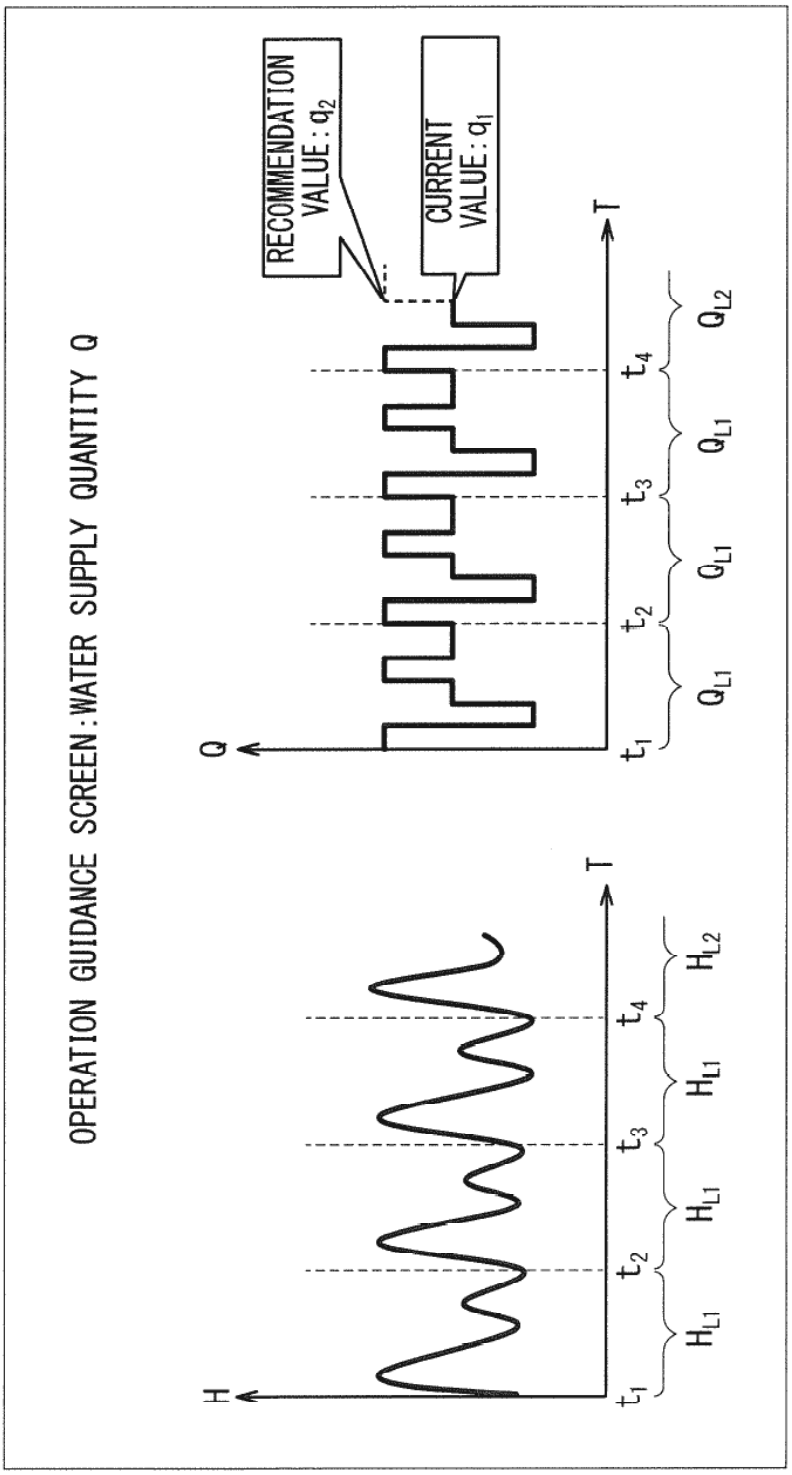

OPERATION GUIDANCE SCREEN:WATER SUPPLY QUANTITY Q
RECOMMENDATION VALUE: q_2
CURRENT VALUE: q_1
Q
T
t_1 t_2 t_3 t_4
Q_{L1} Q_{L1} Q_{L1} Q_{L2}
H
T
t_1 t_2 t_3 t_4
H_{L1} H_{L1} H_{L1} H_{L2}

FIG. 7

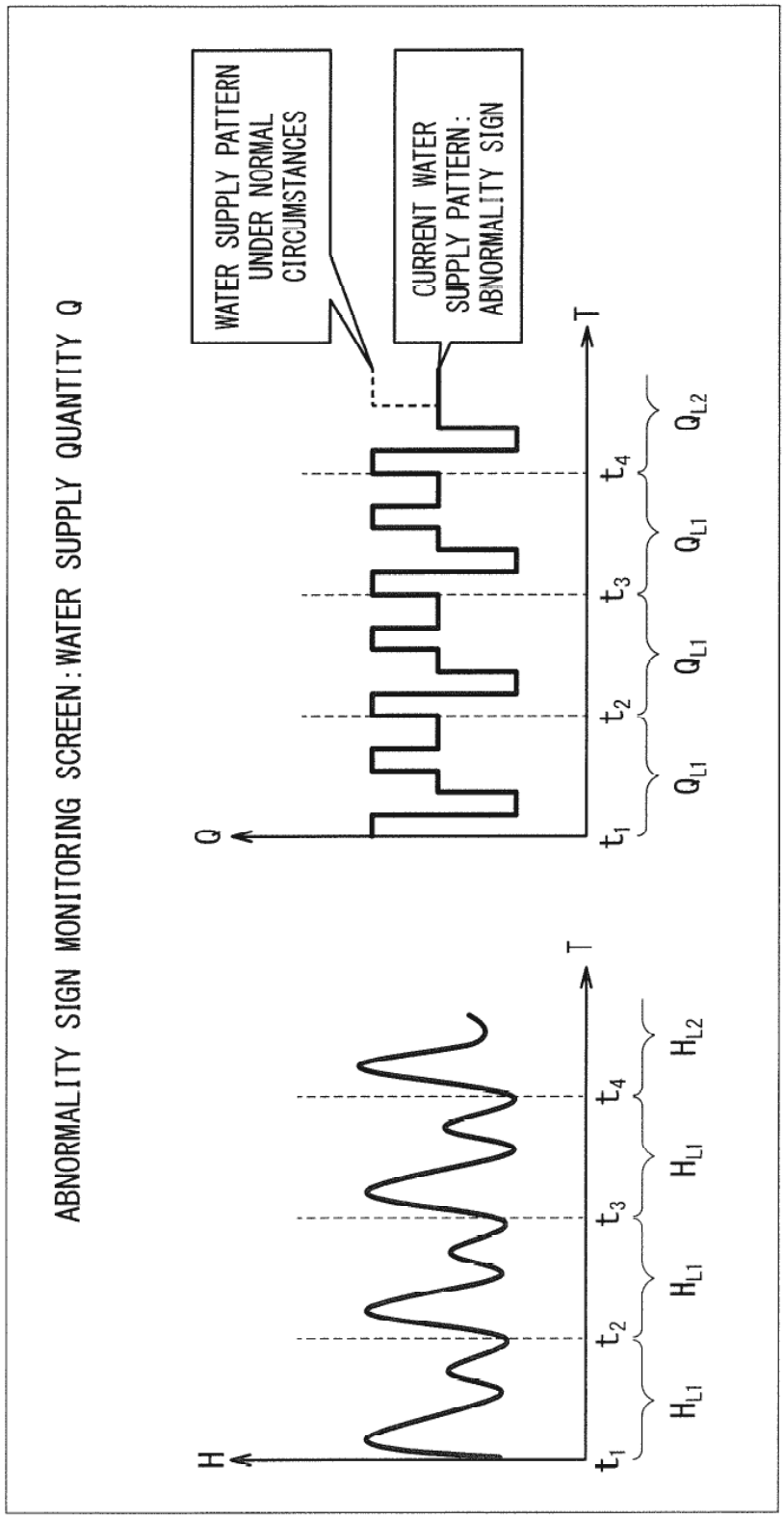

ABNORMALITY SIGN MONITORING SCREEN: WATER SUPPLY QUANTITY Q
WATER SUPPLY PATTERN UNDER NORMAL CIRCUMSTANCES
CURRENT WATER SUPPLY PATTERN: ABNORMALITY SIGN
Q
T
H
T
t_1 t_2 t_3 t_4
Q_{L1} Q_{L1} Q_{L1} Q_{L2}
t_1 t_2 t_3 t_4
H_{L1} H_{L1} H_{L1} H_{L2}

FIG. 8

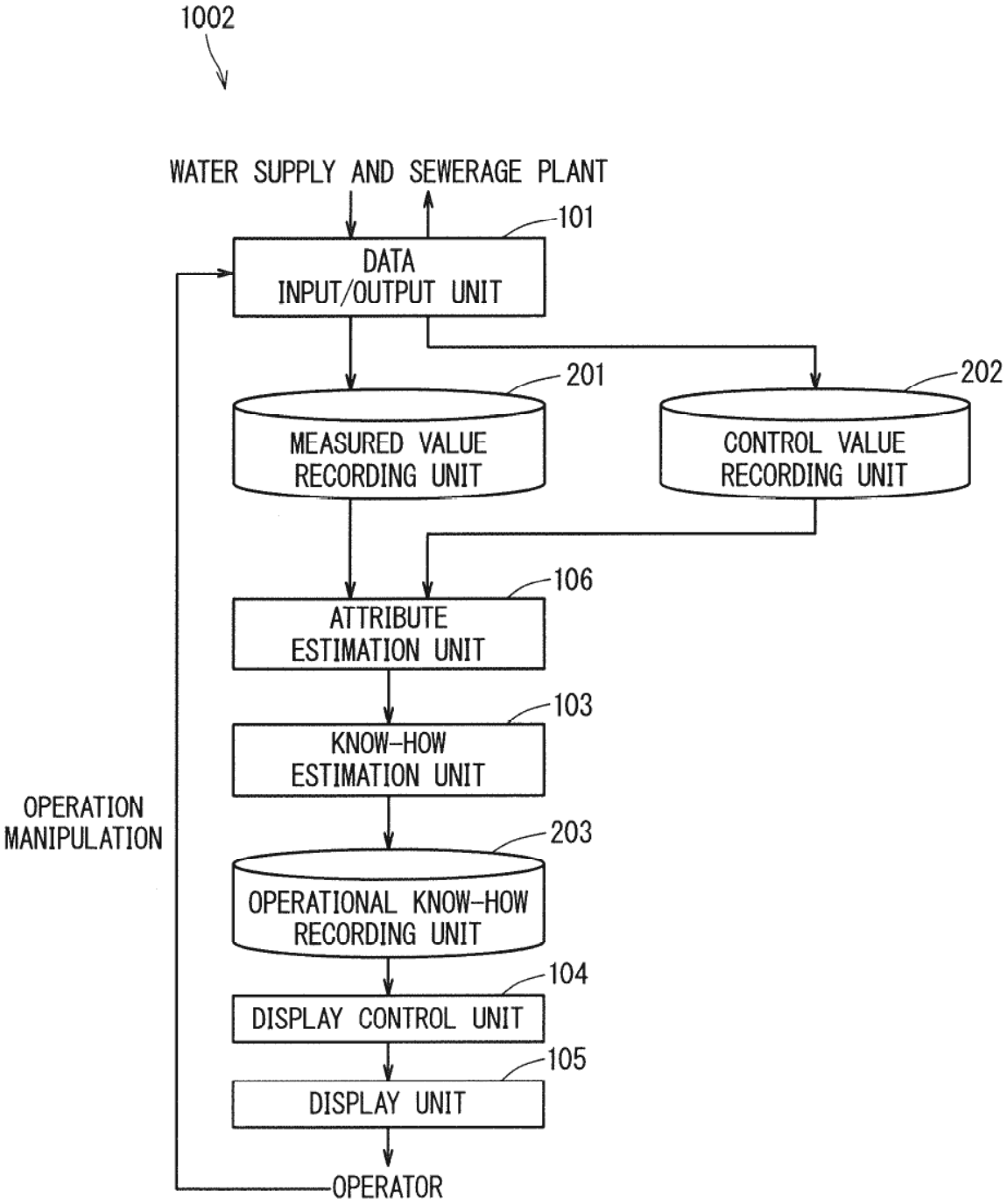

1002
WATER SUPPLY AND SEWERAGE PLANT
101
DATA INPUT/OUTPUT UNIT
201
MEASURED VALUE RECORDING UNIT
202
CONTROL VALUE RECORDING UNIT
106
ATTRIBUTE ESTIMATION UNIT
103
KNOW-HOW ESTIMATION UNIT
203
OPERATIONAL KNOW-HOW RECORDING UNIT
104
DISPLAY CONTROL UNIT
105
DISPLAY UNIT
OPERATOR
OPERATION MANIPULATION

FIG. 9

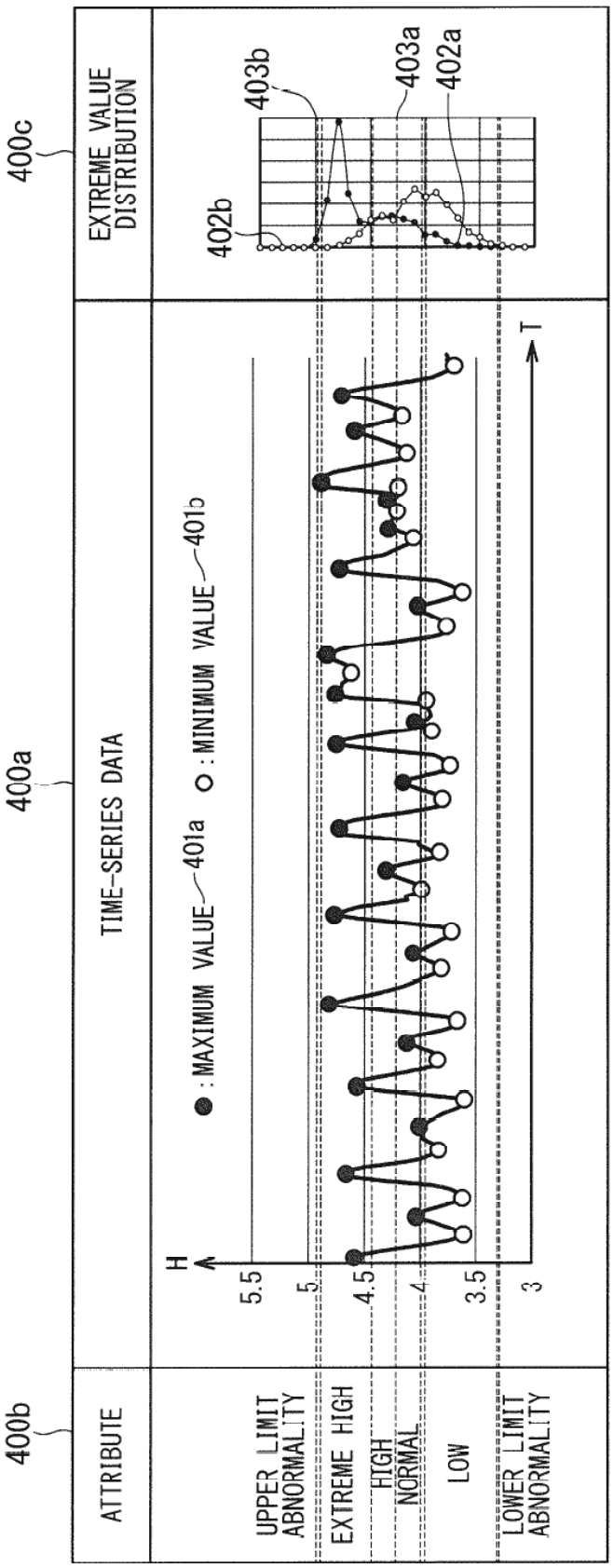
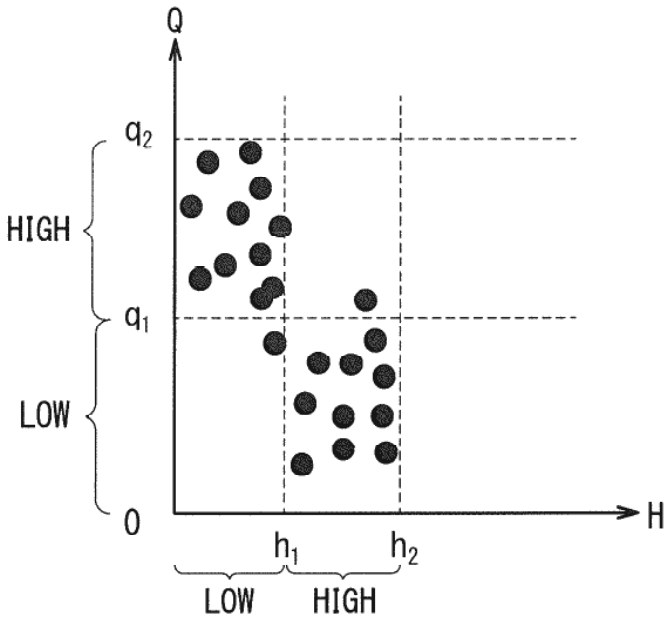

400b
ATTRIBUTE
400a
TIME-SERIES DATA
400c
EXTREME VALUE DISTRIBUTION
UPPER LIMIT ABNORMALITY
EXTREME HIGH
HIGH
NORMAL
LOW
LOWER LIMIT ABNORMALITY
H
5.5
5
4.5
4
3.5
3
● : MAXIMUM VALUE 401a
○ : MINIMUM VALUE 401b
T
402b
403b
403a
402a

FIG. 10



F I G. 1 1

EVENT X	EVENT Y	$n(X_i \times Y_j)$	$p(Y\|X)$
$H_A=\{H_{A1}=LOW, H_{A2}=HIGH\}$	$Q_A=\{Q_{A1}=LOW, Q_{A2}=HIGH\}$	$n(H_{Ai} \times Q_{Aj})$	$p(Q_A\|H_A)=n(H_{Ai} \times Q_{Aj})/n(H_{Ai})$
$H_{A1}=LOW$	$Q_{A1}=LOW$	$n(H_{A1} \times Q_{A1})=1$	$n(H_{A1} \times Q_{A1})/n(H_{A1})=1/12$
$H_{A1}=LOW$	$Q_{A2}=HIGH$	$n(H_{A1} \times Q_{A2})=11$	$n(H_{A1} \times Q_{A2})/n(H_{A1})=11/12$
$H_{A2}=HIGH$	$Q_{A1}=LOW$	$n(H_{A2} \times Q_{A1})=10$	$n(H_{A2} \times Q_{A1})/n(H_{A2})=10/11$
$H_{A2}=HIGH$	$Q_{A2}=HIGH$	$n(H_{A2} \times Q_{A2})=1$	$n(H_{A2} \times Q_{A2})/n(H_{A2})=1/11$

FIG. 12

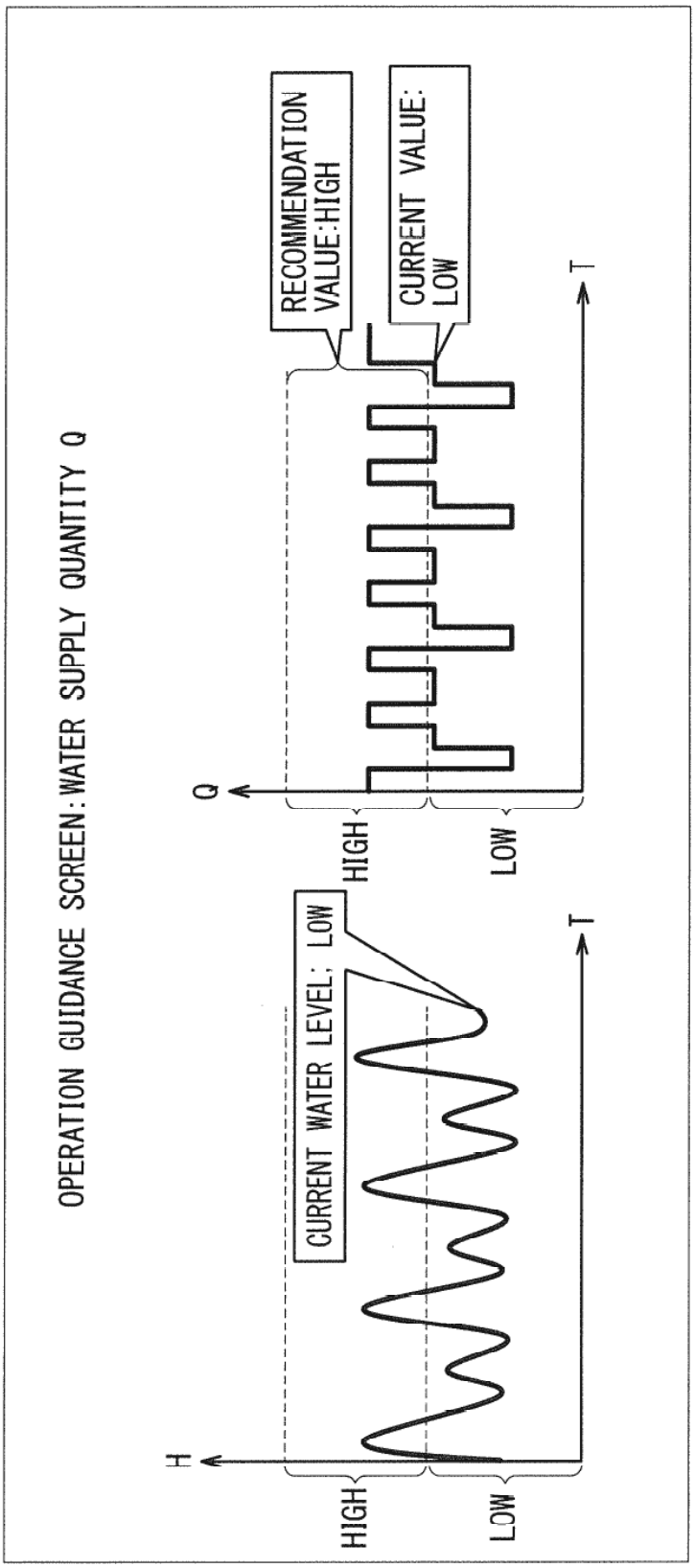

OPERATION GUIDANCE SCREEN: WATER SUPPLY QUANTITY Q
RECOMMENDATION VALUE: HIGH
CURRENT VALUE: LOW
Q
T
HIGH
LOW
CURRENT WATER LEVEL: LOW
H
T
HIGH
LOW

FIG. 13

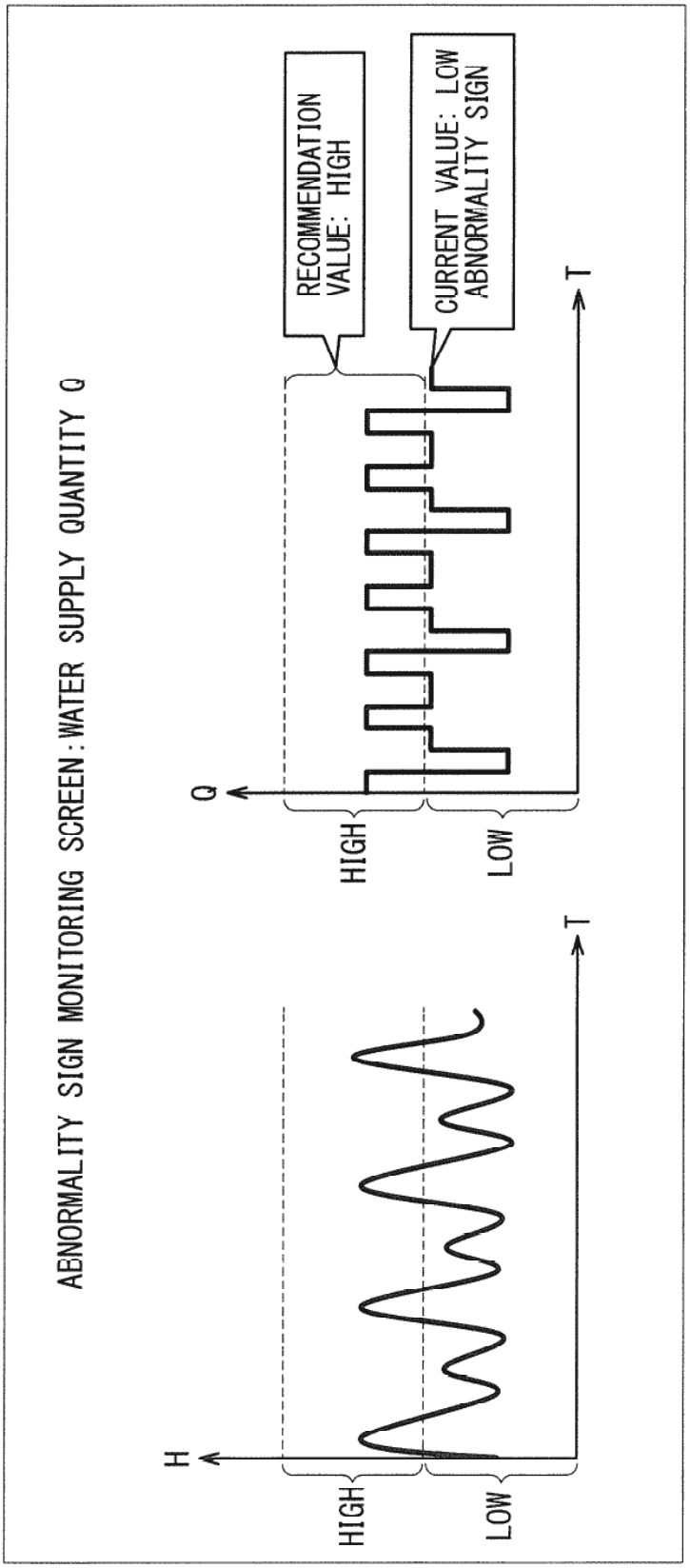

ABNORMALITY SIGN MONITORING SCREEN : WATER SUPPLY QUANTITY Q
RECOMMENDATION VALUE: HIGH
CURRENT VALUE: LOW ABNORMALITY SIGN
Q
T
HIGH
LOW
H
T
HIGH
LOW

FIG. 14

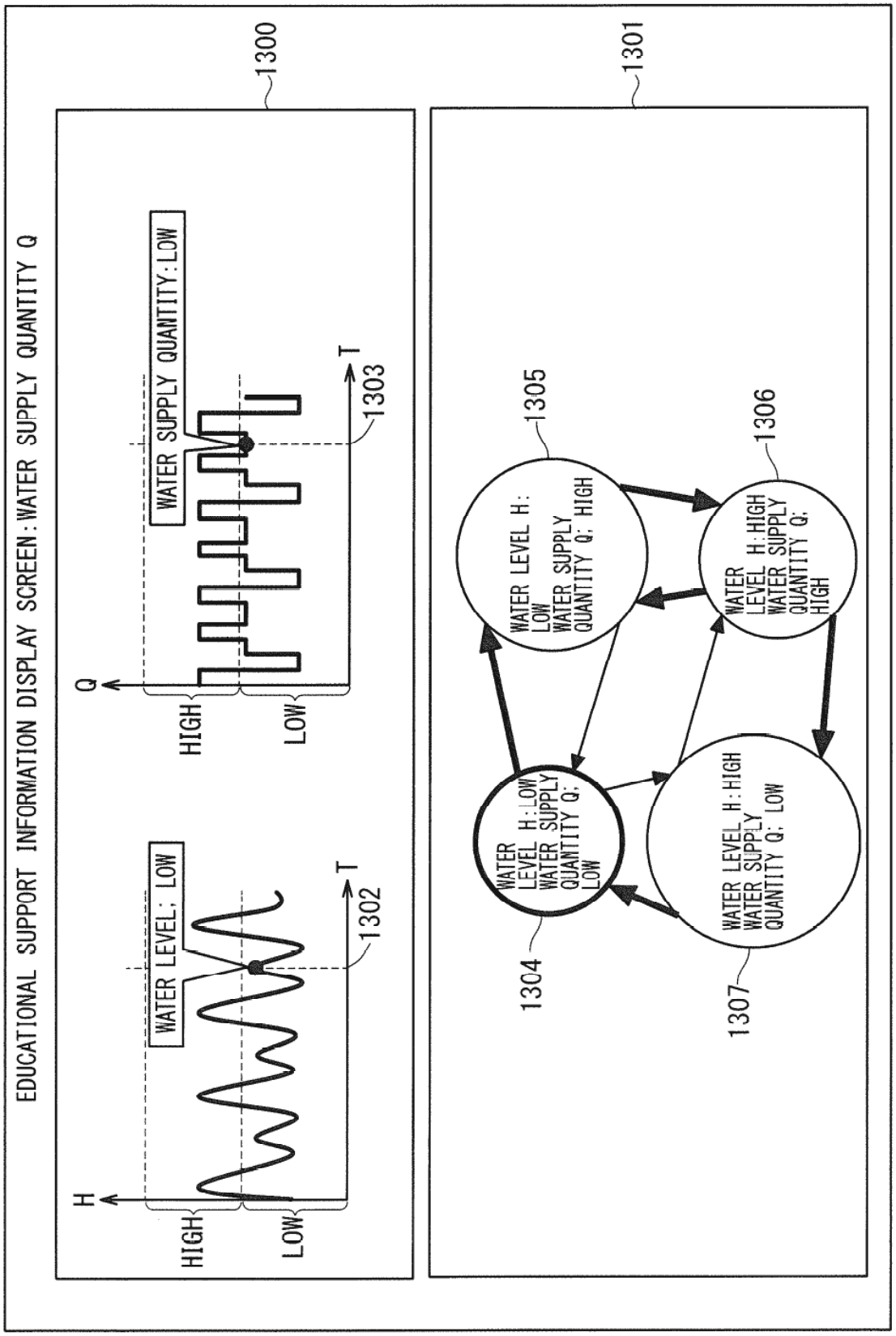

EDUCATIONAL SUPPORT INFORMATION DISPLAY SCREEN: WATER SUPPLY QUANTITY Q
1300
1301
H
HIGH
LOW
WATER LEVEL: LOW
T
1302
Q
HIGH
LOW
WATER SUPPLY QUANTITY: LOW
T
1303
1304
WATER LEVEL H: LOW
WATER SUPPLY QUANTITY Q: LOW
1305
WATER LEVEL H: LOW
WATER SUPPLY QUANTITY Q: HIGH
1306
WATER LEVEL H: HIGH
WATER SUPPLY QUANTITY Q: HIGH
1307
WATER LEVEL H: HIGH
WATER SUPPLY QUANTITY Q: LOW

FIG. 15

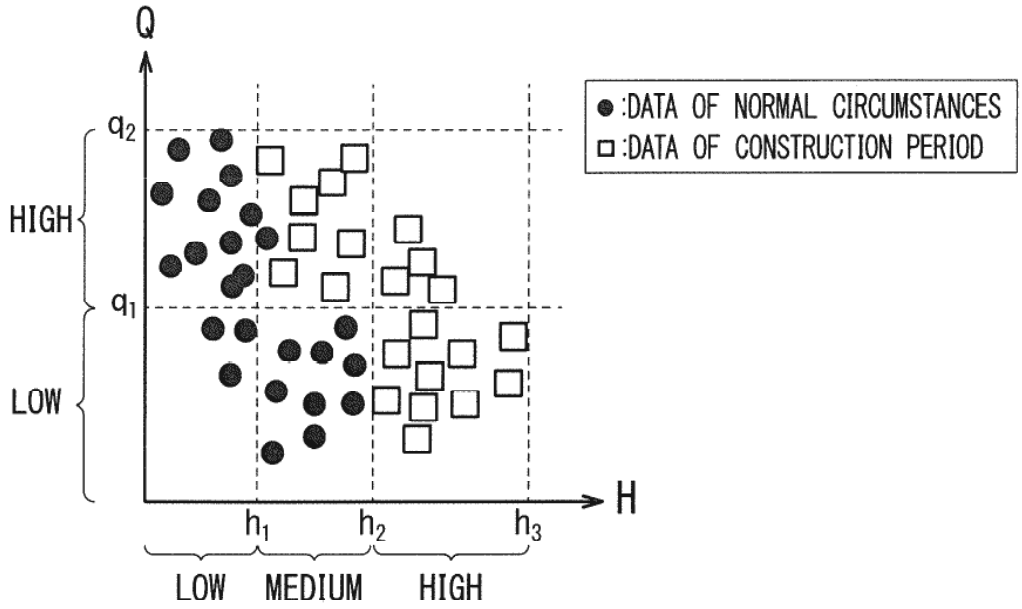

Q
H
q_2
q_1
HIGH
LOW
h_1
h_2
h_3
LOW
MEDIUM
HIGH
●:DATA OF NORMAL CIRCUMSTANCES
□:DATA OF CONSTRUCTION PERIOD

FIG. 16

EVENT X	EVENT Y	$n(X_i \times Y_j)$	$p(Y\|X)$
$H_A=\{H_{A1}(LOW), H_{A2}(MEDIUM), H_{A3}(HIGH)\}$	$Q_A=\{Q_{A1}(LOW), Q_{A2}(HIGH)\}$	$n(H_{Ai} \times Q_{Aj})$	$p(Q_A\|H_A)=n(H_{Ai} \times Q_{Aj})/n(H_{Ai})$
$H_{A1}(LOW)$	$Q_{A1}(LOW)$	$n(H_{A1} \times Q_{A1})=3$	$n(H_{A1} \times Q_{A1})/n(H_{A1})=3/14$
$H_{A1}(LOW)$	$Q_{A2}(HIGH)$	$n(H_{A1} \times Q_{A2})=11$	$n(H_{A1} \times Q_{A2})/n(H_{A1})=11/14$
$H_{A2}(MEDIUM)$	$Q_{A1}(LOW)$	$n(H_{A2} \times Q_{A1})=9$	$n(H_{A2} \times Q_{A1})/n(H_{A2})=9/17$
$H_{A2}(MEDIUM)$	$Q_{A2}(HIGH)$	$n(H_{A2} \times Q_{A2})=8$	$n(H_{A2} \times Q_{A2})/n(H_{A2})=8/17$
$H_{A3}(HIGH)$	$Q_{A1}(LOW)$	$n(H_{A3} \times Q_{A1})=10$	$n(H_{A3} \times Q_{A1})/n(H_{A3})=10/14$
$H_{A3}(HIGH)$	$Q_{A2}(HIGH)$	$n(H_{A3} \times Q_{A2})=4$	$n(H_{A3} \times Q_{A2})/n(H_{A3})=4/14$

F I G. 1 7

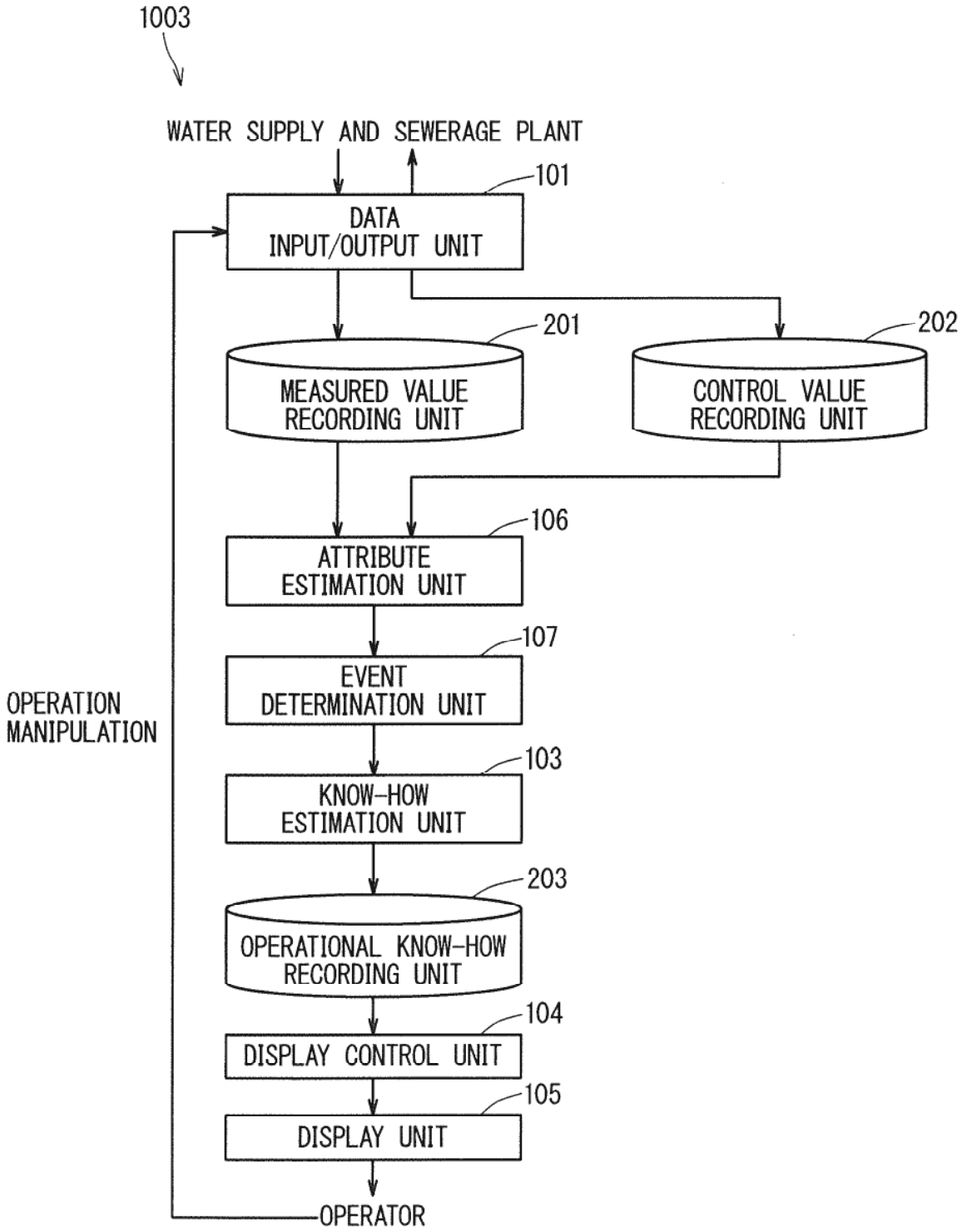

1003
WATER SUPPLY AND SEWERAGE PLANT
101
DATA INPUT/OUTPUT UNIT
201
MEASURED VALUE RECORDING UNIT
202
CONTROL VALUE RECORDING UNIT
106
ATTRIBUTE ESTIMATION UNIT
107
EVENT DETERMINATION UNIT
103
KNOW-HOW ESTIMATION UNIT
203
OPERATIONAL KNOW-HOW RECORDING UNIT
104
DISPLAY CONTROL UNIT
105
DISPLAY UNIT
OPERATOR
OPERATION MANIPULATION

FIG. 18

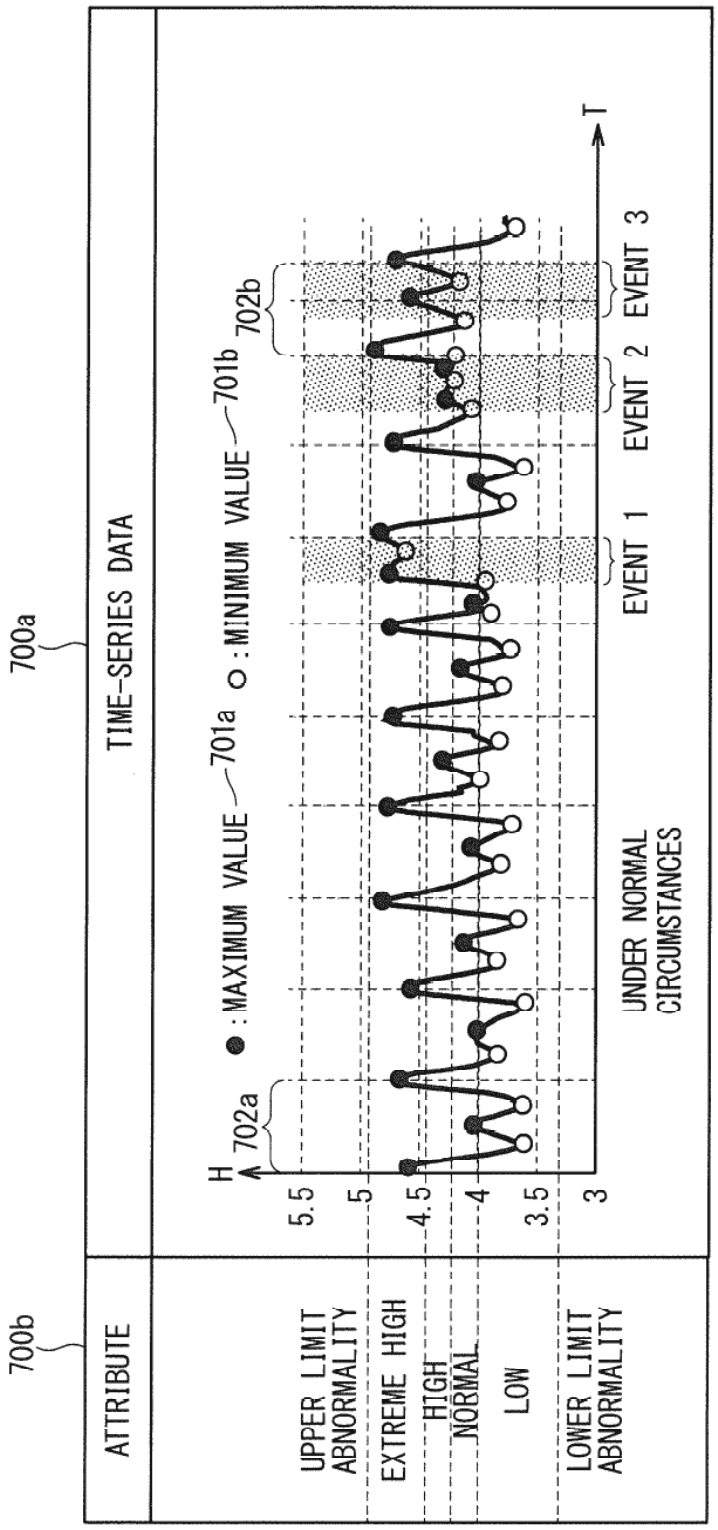

700a
700b
ATTRIBUTE
TIME-SERIES DATA
UPPER LIMIT ABNORMALITY
EXTREME HIGH
HIGH
NORMAL
LOW
LOWER LIMIT ABNORMALITY
H
5.5
5
4.5
4
3.5
3
● : MAXIMUM VALUE 701a
○ : MINIMUM VALUE 701b
702a
702b
T
EVENT 1
EVENT 2
EVENT 3
UNDER NORMAL CIRCUMSTANCES

FIG. 19

EVENT X		EVENT Y	$n(X_i \times Y_j)$	$p(Y\|X)$
$E_A=\{E_{A1}(NORMAL), E_{A2}(CONSTRUCTION)\}$	$H_A=\{H_{A1}(LOW), H_{A2}(MEDIUM), H_{A3}(HIGH)\}$	$Q_A=\{Q_{A1}(LOW), Q_{A2}(HIGH)\}$	$n(E_{Ak} \times H_{Ai} \times Q_{Aj})$	$p(Q_A\|H_A, E_A) = n(E_{Ak} \times H_{Ai} \times Q_{Aj})/n(H_{Ai} \times E_{Ak})$
$E_{A1}(NORMAL)$	$H_{A1}(LOW)$	$Q_{A1}(LOW)$	$n(E_{A1} \times H_{A1} \times Q_{A1})=3$	$n(E_{A1} \times H_{A1} \times Q_{A1})/n(E_{A1} \times H_{A1})=3/14$
$E_{A1}(NORMAL)$	$H_{A1}(LOW)$	$Q_{A2}(HIGH)$	$n(E_{A1} \times H_{A1} \times Q_{A2})=11$	$n(E_{A1} \times H_{A1} \times Q_{A2})/n(E_{A1} \times H_{A1})=11/14$
$E_{A1}(NORMAL)$	$H_{A2}(MEDIUM)$	$Q_{A1}(LOW)$	$n(E_{A1} \times H_{A2} \times Q_{A1})=9$	$n(E_{A1} \times H_{A2} \times Q_{A1})/n(E_{A1} \times H_{A2})=9/10$
$E_{A1}(NORMAL)$	$H_{A2}(MEDIUM)$	$Q_{A2}(HIGH)$	$n(E_{A1} \times H_{A2} \times Q_{A2})=1$	$n(E_{A1} \times H_{A2} \times Q_{A2})/n(E_{A1} \times H_{A2})=1/10$
$E_{A1}(NORMAL)$	$H_{A3}(HIGH)$	$Q_{A1}(LOW)$	$n(E_{A1} \times H_{A3} \times Q_{A1})=0$	–
$E_{A1}(NORMAL)$	$H_{A3}(HIGH)$	$Q_{A2}(HIGH)$	$n(E_{A1} \times H_{A3} \times Q_{A2})=0$	–
$E_{A2}(CONSTRUCTION)$	$H_{A1}(LOW)$	$Q_{A1}(LOW)$	$n(E_{A2} \times H_{A1} \times Q_{A1})=0$	–
$E_{A2}(CONSTRUCTION)$	$H_{A1}(LOW)$	$Q_{A2}(HIGH)$	$n(E_{A2} \times H_{A1} \times Q_{A2})=0$	–
$E_{A2}(CONSTRUCTION)$	$H_{A2}(MEDIUM)$	$Q_{A1}(LOW)$	$n(E_{A2} \times H_{A2} \times Q_{A1})=0$	$n(E_{A2} \times H_{A2} \times Q_{A1})/n(E_{A2} \times H_{A2})=0/8$
$E_{A2}(CONSTRUCTION)$	$H_{A2}(MEDIUM)$	$Q_{A2}(HIGH)$	$n(E_{A2} \times H_{A2} \times Q_{A2})=8$	$n(E_{A2} \times H_{A2} \times Q_{A2})/n(E_{A2} \times H_{A2})=8/8$
$E_{A2}(CONSTRUCTION)$	$H_{A3}(HIGH)$	$Q_{A1}(LOW)$	$n(E_{A2} \times H_{A3} \times Q_{A1})=10$	$n(E_{A2} \times H_{A3} \times Q_{A1})/n(E_{A2} \times H_{A3})=10/14$
$E_{A2}(CONSTRUCTION)$	$H_{A3}(HIGH)$	$Q_{A2}(HIGH)$	$n(E_{A2} \times H_{A3} \times Q_{A2})=4$	$n(E_{A2} \times H_{A3} \times Q_{A2})/n(E_{A2} \times H_{A3})=4/14$

FIG. 20

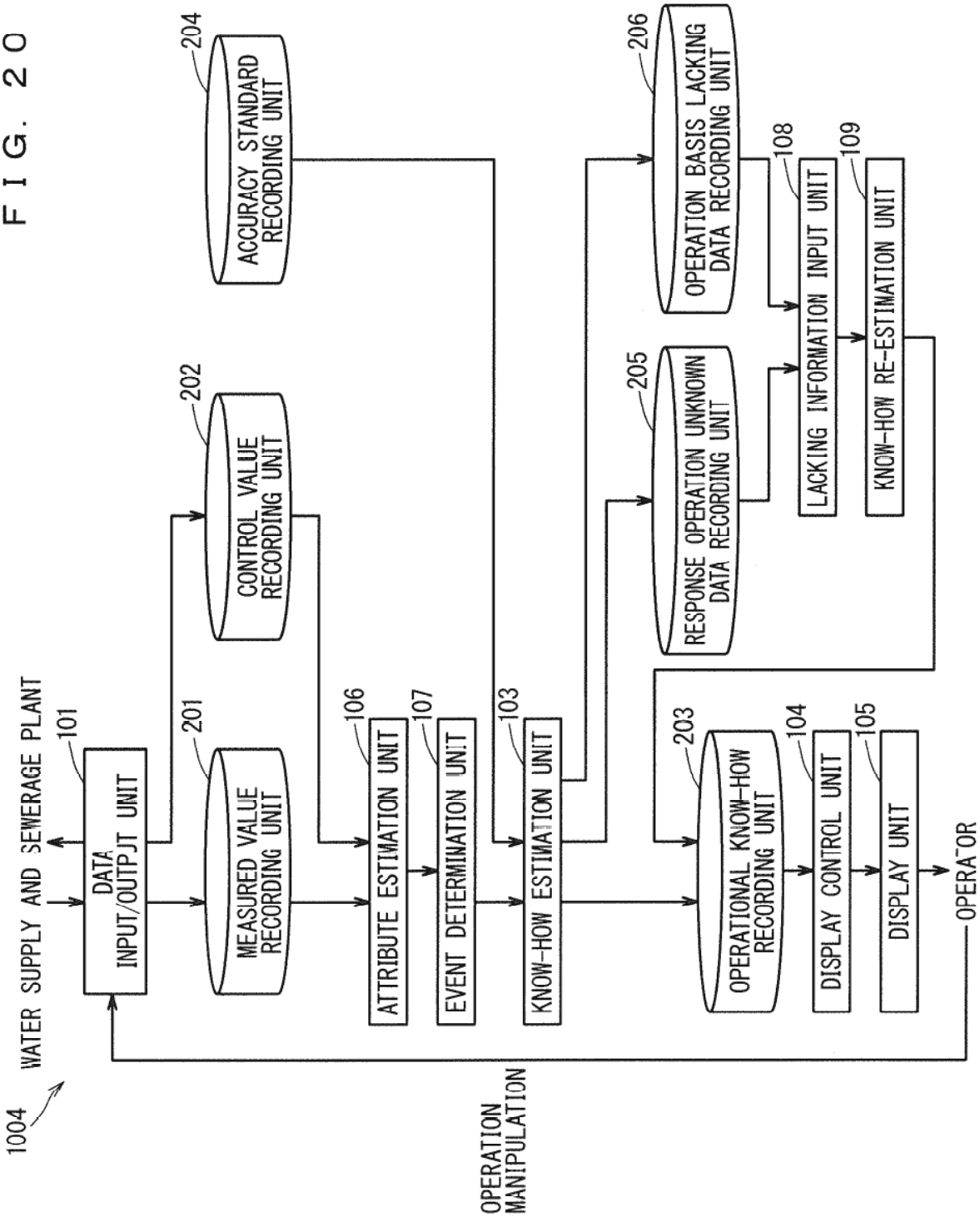
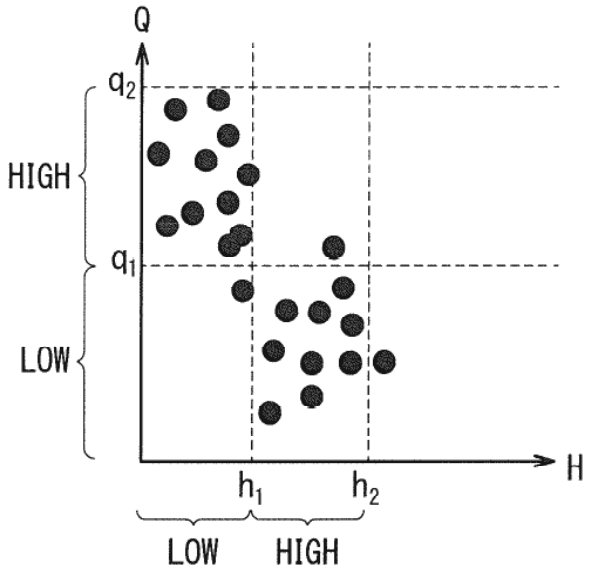
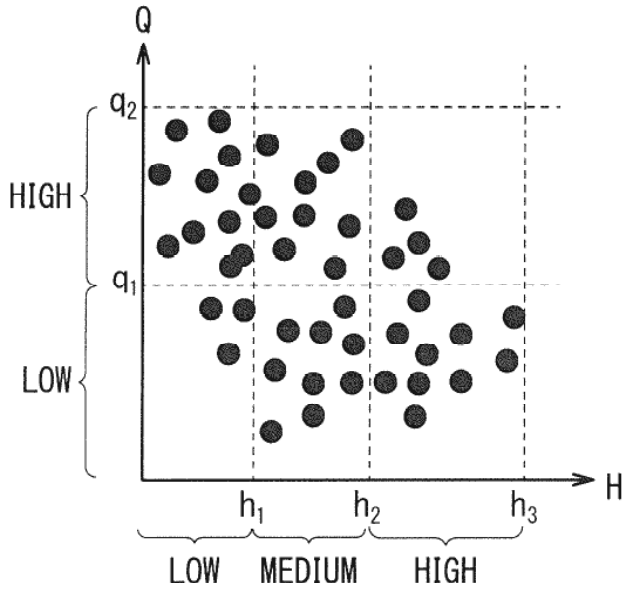

1004
WATER SUPPLY AND SEWERAGE PLANT
101
DATA INPUT/OUTPUT UNIT
201
MEASURED VALUE RECORDING UNIT
202
CONTROL VALUE RECORDING UNIT
204
ACCURACY STANDARD RECORDING UNIT
106
ATTRIBUTE ESTIMATION UNIT
107
EVENT DETERMINATION UNIT
103
KNOW-HOW ESTIMATION UNIT
205
RESPONSE OPERATION UNKNOWN DATA RECORDING UNIT
206
OPERATION BASIS LACKING DATA RECORDING UNIT
203
OPERATIONAL KNOW-HOW RECORDING UNIT
104
DISPLAY CONTROL UNIT
105
DISPLAY UNIT
108
LACKING INFORMATION INPUT UNIT
109
KNOW-HOW RE-ESTIMATION UNIT
OPERATOR
OPERATION MANIPULATION

FIG. 21



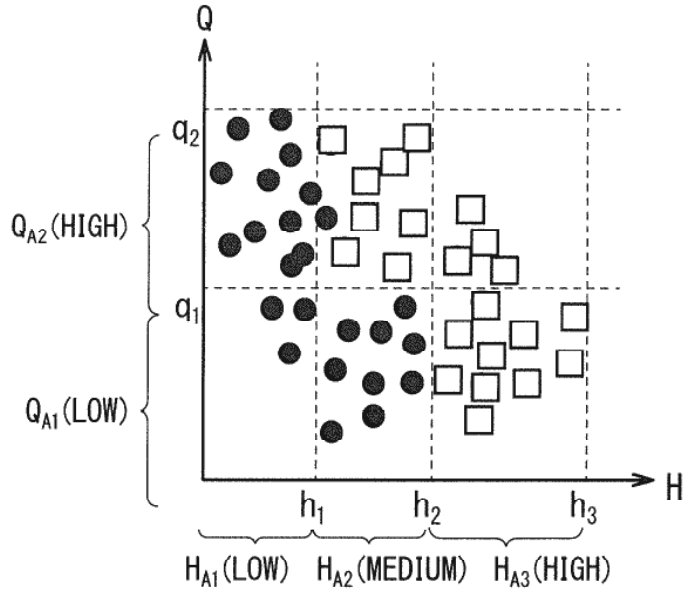
$I(Q_A;H_A) \geqq I_{TH}$

FIG. 22



$I(Q_A;H_A) < I_{TH}$

F I G. 2 3


Q
q_2
q_1
Q_{A2}(HIGH)
Q_{A1}(LOW)
H
h_1
h_2
h_3
H_{A1}(LOW)
H_{A2}(MEDIUM)
H_{A3}(HIGH)

F I G. 2 4

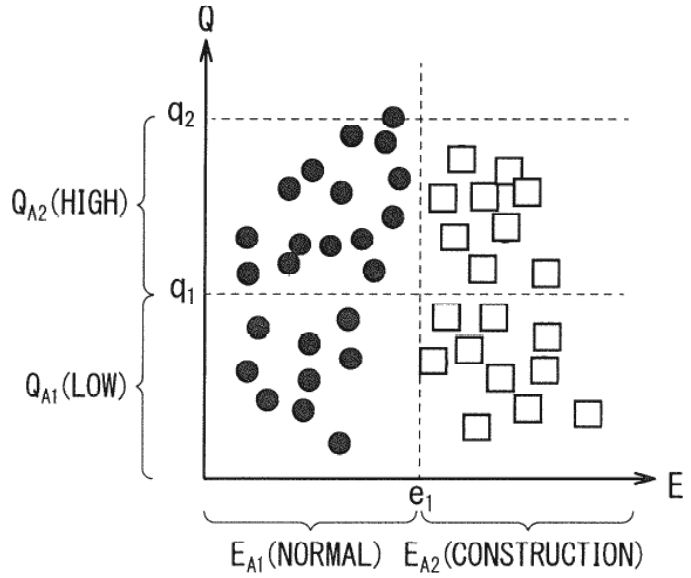

Q
q_2
q_1
Q_{A2}(HIGH)
Q_{A1}(LOW)
E
e_1
E_{A1}(NORMAL)
E_{A2}(CONSTRUCTION)

FIG. 25

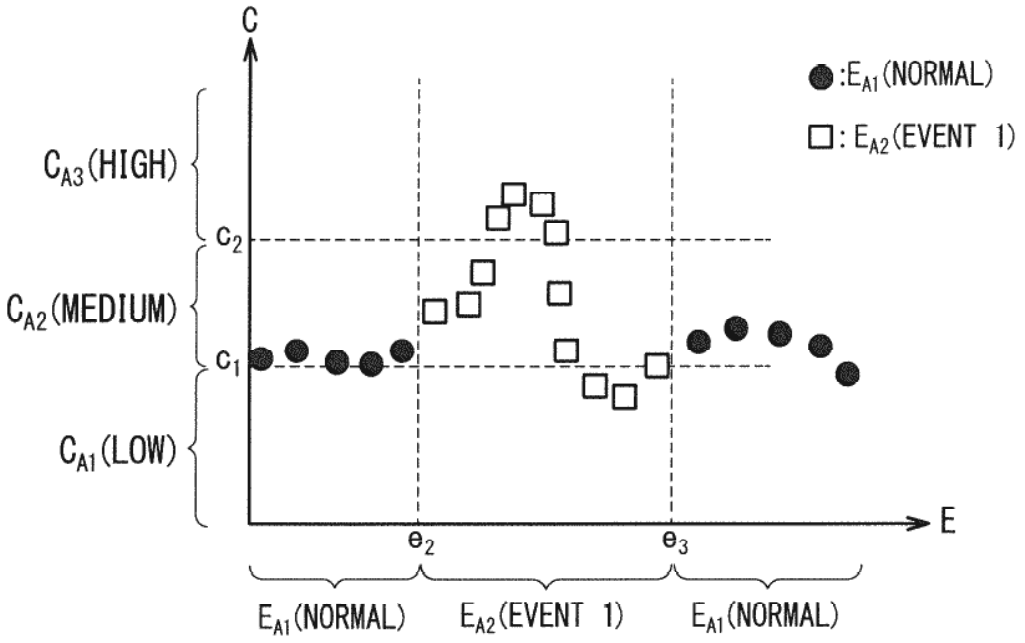

C
●:E_{A1}(NORMAL)
□: E_{A2}(EVENT 1)
C_{A3}(HIGH)
c_2
C_{A2}(MEDIUM)
c_1
C_{A1}(LOW)
E
e_2
e_3
E_{A1}(NORMAL)
E_{A2}(EVENT 1)
E_{A1}(NORMAL)

FIG. 26

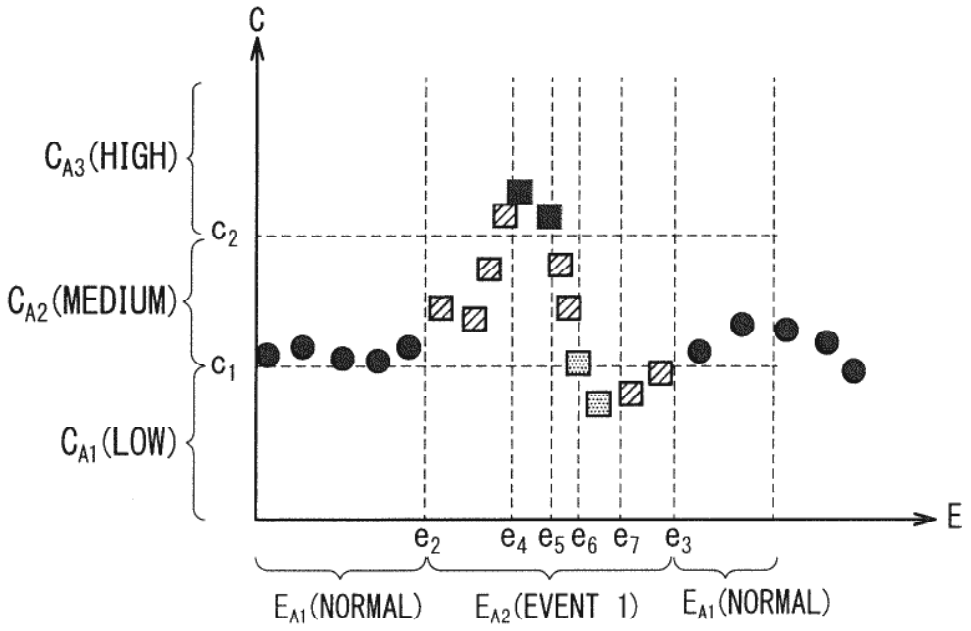

C
C_{A3}(HIGH)
c_2
C_{A2}(MEDIUM)
c_1
C_{A1}(LOW)
E
e_2
e_4
e_5
e_6
e_7
e_3
E_{A1}(NORMAL)
E_{A2}(EVENT 1)
E_{A1}(NORMAL)

FIG. 27

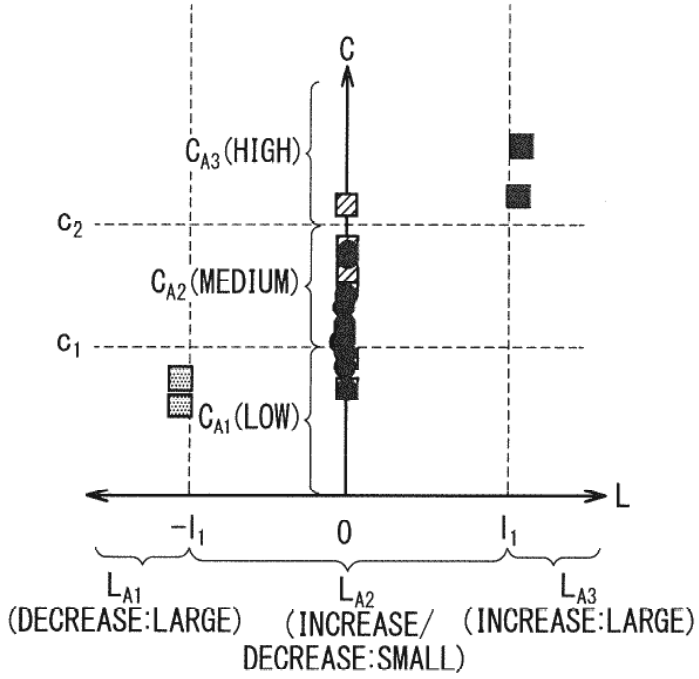

C
C_{A3}(HIGH)
c_2
C_{A2}(MEDIUM)
c_1
C_{A1}(LOW)
L
$-l_1$
0
l_1
L_{A1}
(DECREASE:LARGE)
L_{A2}
(INCREASE/
DECREASE:SMALL)
L_{A3}
(INCREASE:LARGE)

FIG. 28

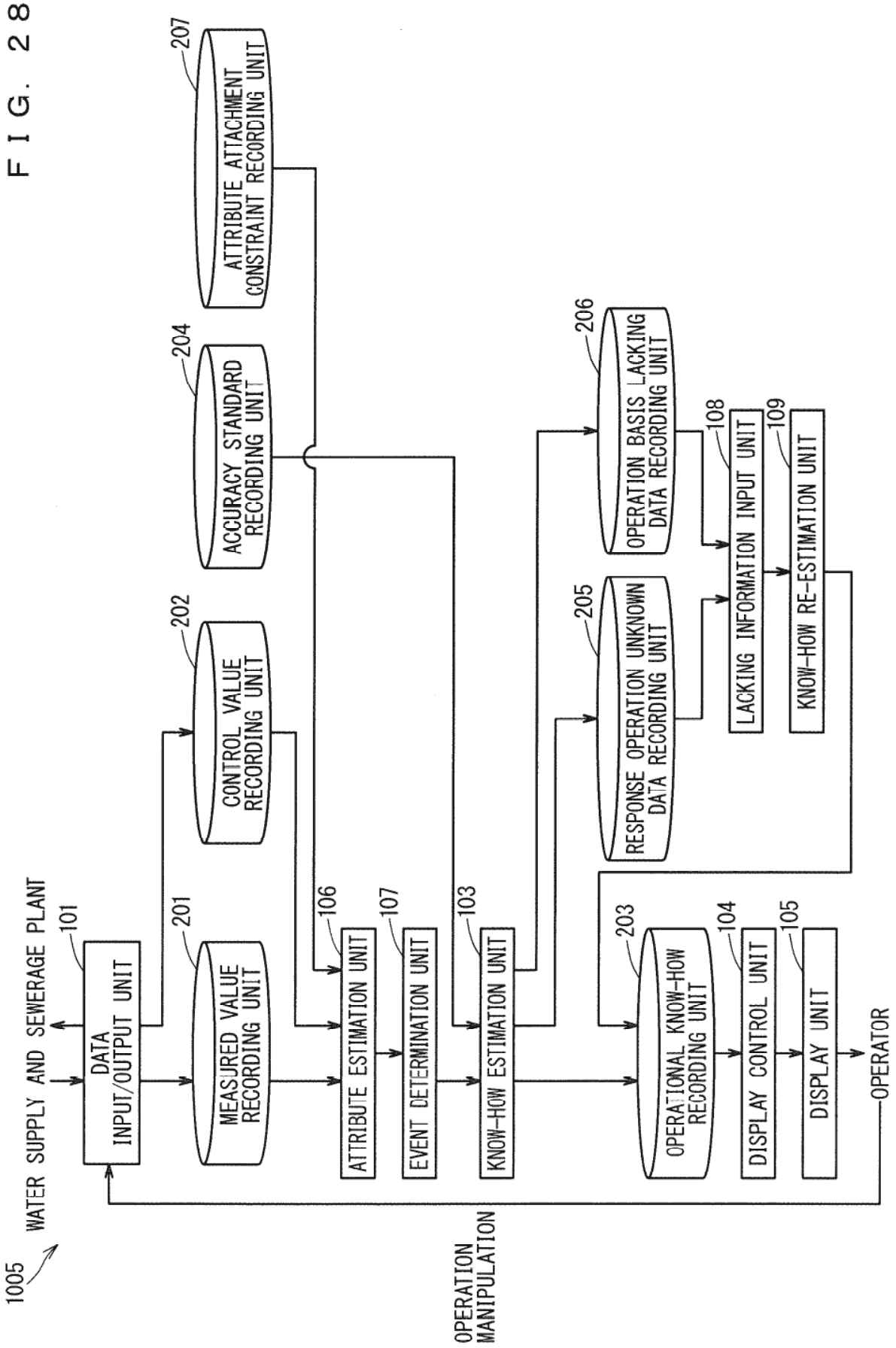
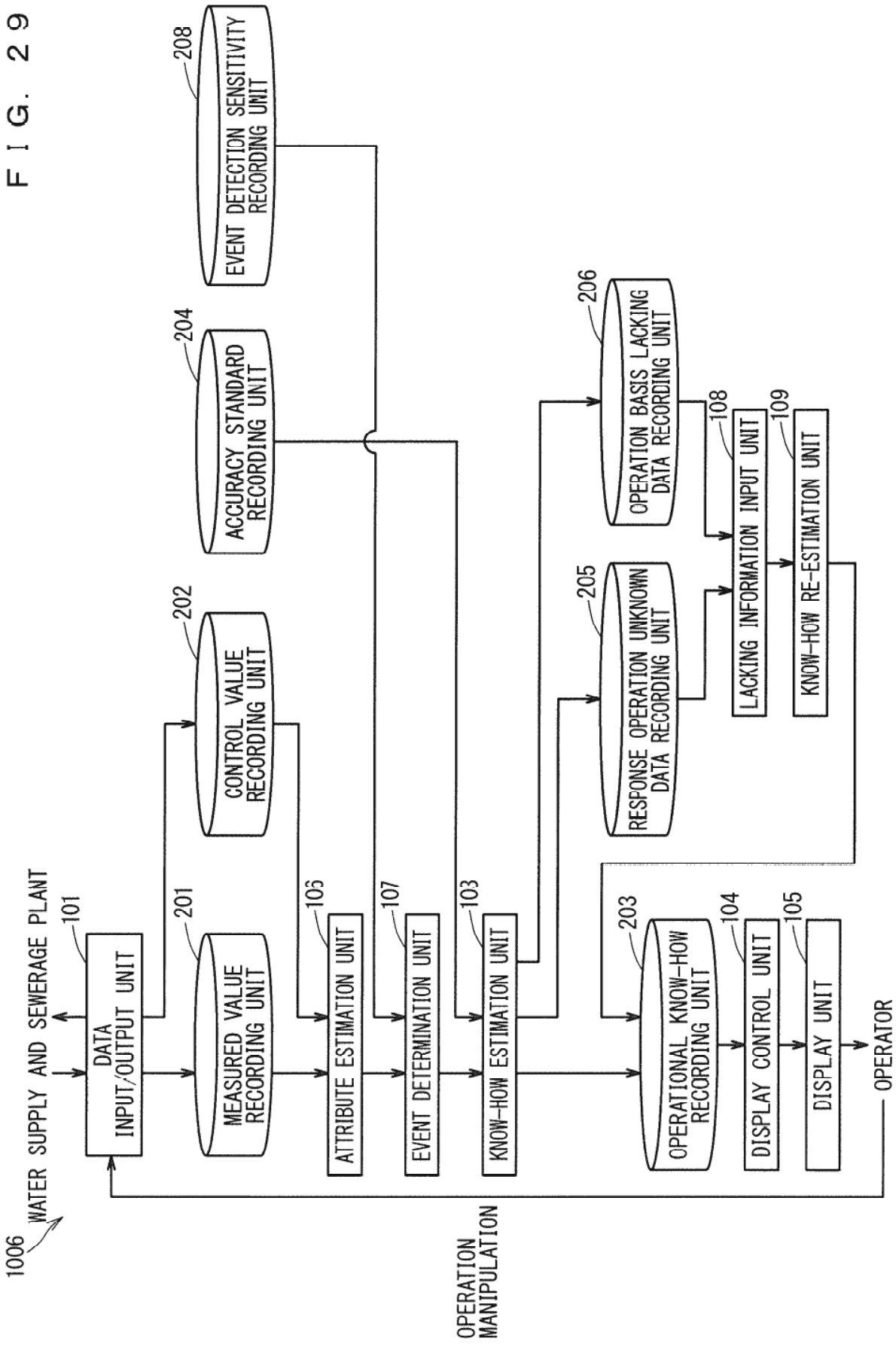

1005
WATER SUPPLY AND SEWERAGE PLANT
101
DATA INPUT/OUTPUT UNIT
201
MEASURED VALUE RECORDING UNIT
202
CONTROL VALUE RECORDING UNIT
204
ACCURACY STANDARD RECORDING UNIT
207
ATTRIBUTE ATTACHMENT CONSTRAINT RECORDING UNIT
106
ATTRIBUTE ESTIMATION UNIT
107
EVENT DETERMINATION UNIT
103
KNOW-HOW ESTIMATION UNIT
205
RESPONSE OPERATION UNKNOWN DATA RECORDING UNIT
206
OPERATION BASIS LACKING DATA RECORDING UNIT
108
LACKING INFORMATION INPUT UNIT
109
KNOW-HOW RE-ESTIMATION UNIT
203
OPERATIONAL KNOW-HOW RECORDING UNIT
104
DISPLAY CONTROL UNIT
105
DISPLAY UNIT
OPERATOR
OPERATION MANIPULATION

FIG. 29


1006
WATER SUPPLY AND SEWERAGE PLANT
OPERATION MANIPULATION
DATA INPUT/OUTPUT UNIT
101
MEASURED VALUE RECORDING UNIT
201
CONTROL VALUE RECORDING UNIT
202
ACCURACY STANDARD RECORDING UNIT
204
EVENT DETECTION SENSITIVITY RECORDING UNIT
208
ATTRIBUTE ESTIMATION UNIT
106
EVENT DETERMINATION UNIT
107
KNOW-HOW ESTIMATION UNIT
103
OPERATIONAL KNOW-HOW RECORDING UNIT
203
DISPLAY CONTROL UNIT
104
DISPLAY UNIT
105
OPERATOR
RESPONSE OPERATION UNKNOWN DATA RECORDING UNIT
205
OPERATION BASIS LACKING DATA RECORDING UNIT
206
LACKING INFORMATION INPUT UNIT
108
KNOW-HOW RE-ESTIMATION UNIT
109