FIG. 1

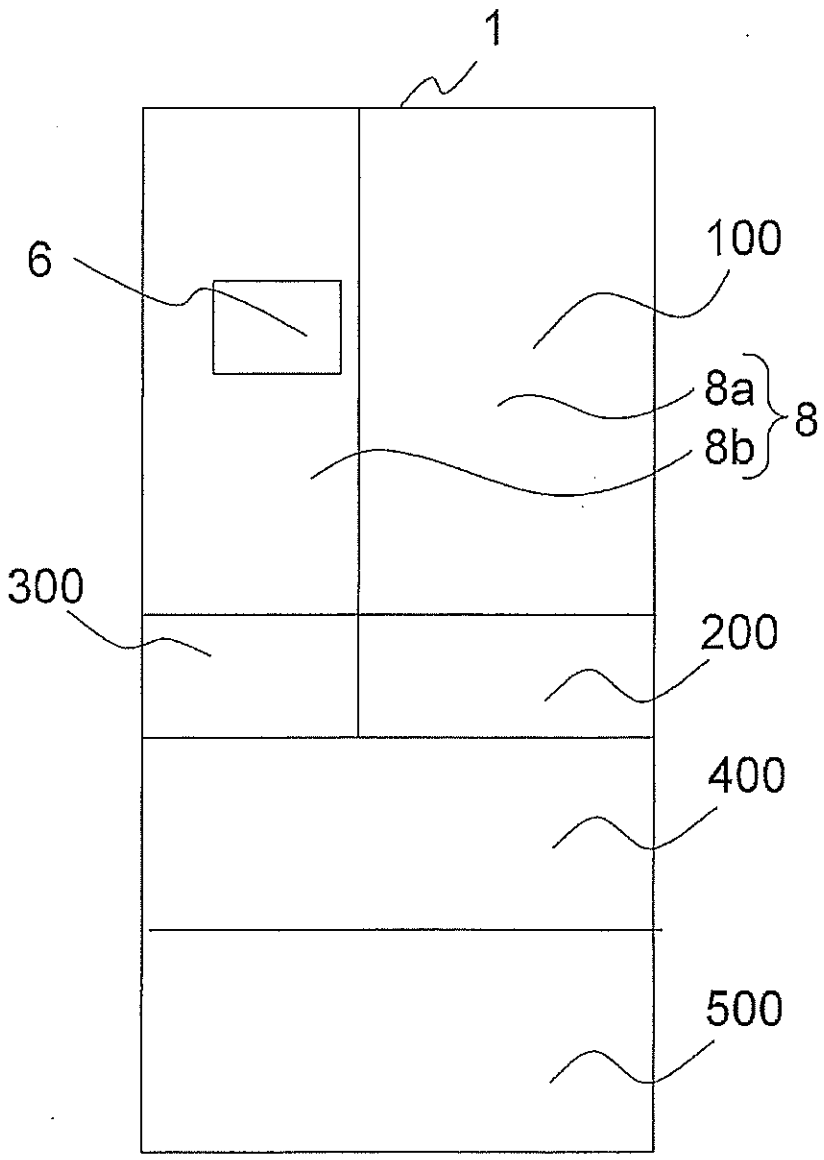


FIG. 2

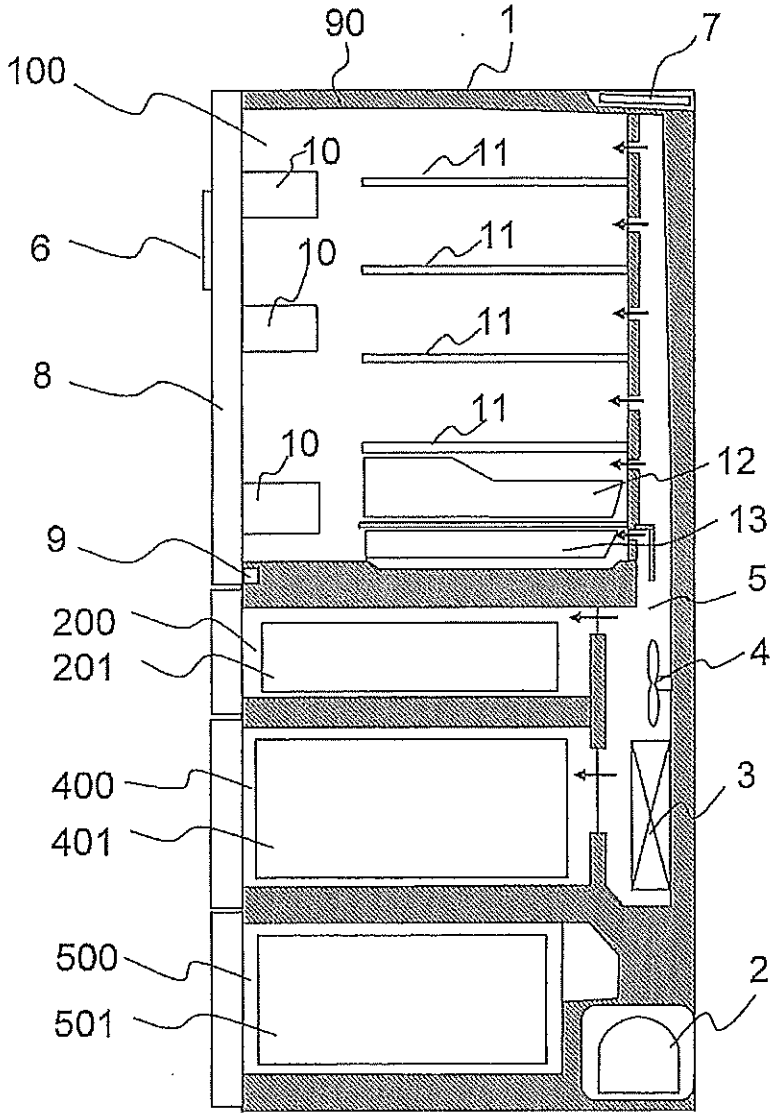

90
1
7
100
10
11
6
10
11
11
8
11
10
12
13
9
5
200
201
4
400
3
401
500
2
501

FIG. 3

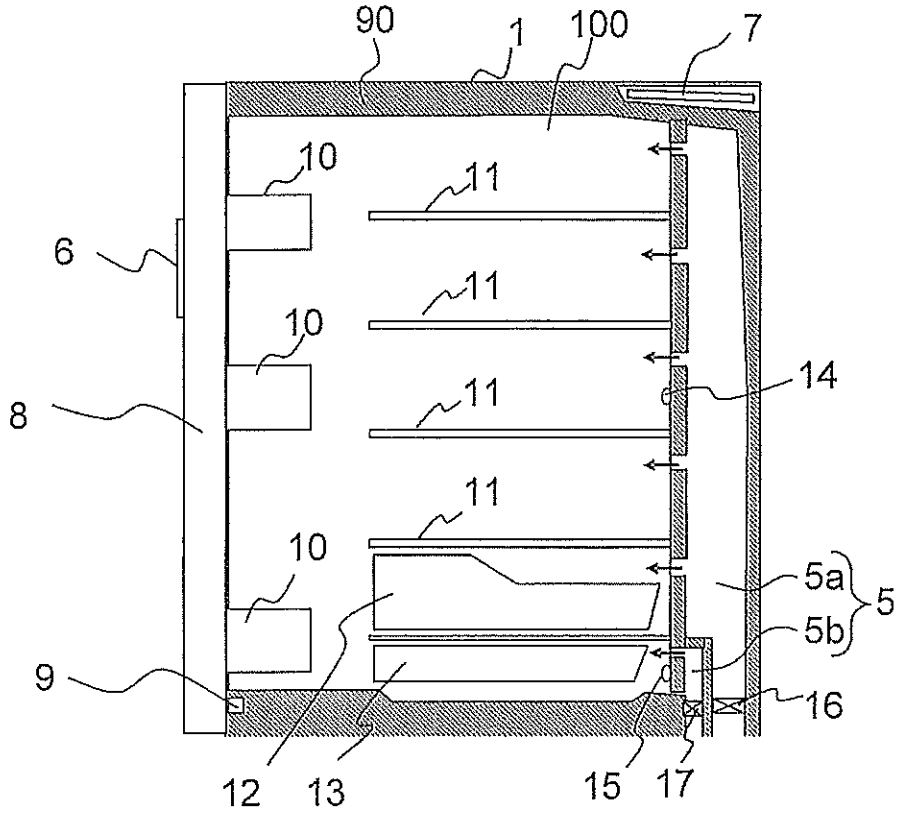

90
1
100
7
10
11
6
11
10
14
8
11
11
10
5a
5
5b
9
16
12
13
15
17

FIG. 4

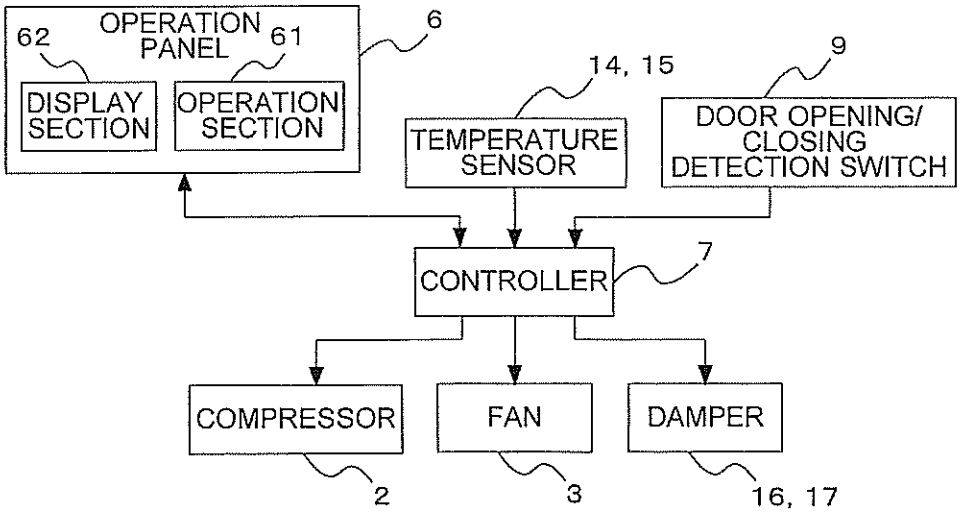

OPERATION PANEL
62
61
6
DISPLAY SECTION
OPERATION SECTION
14, 15
9
TEMPERATURE SENSOR
DOOR OPENING/ CLOSING DETECTION SWITCH
CONTROLLER
7
COMPRESSOR
FAN
DAMPER
2
3
16, 17
100

FIG. 5

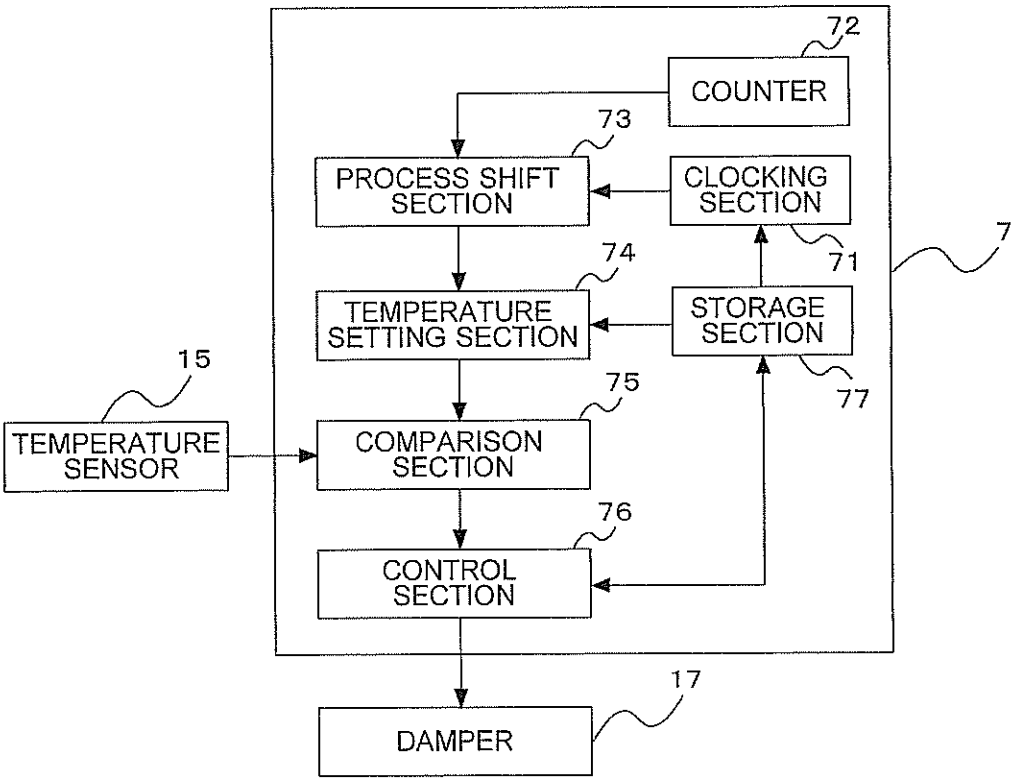

72
COUNTER
73
PROCESS SHIFT SECTION
CLOCKING SECTION
71
7
74
TEMPERATURE SETTING SECTION
STORAGE SECTION
77
15
TEMPERATURE SENSOR
75
COMPARISON SECTION
76
CONTROL SECTION
17
DAMPER

FIG. 6

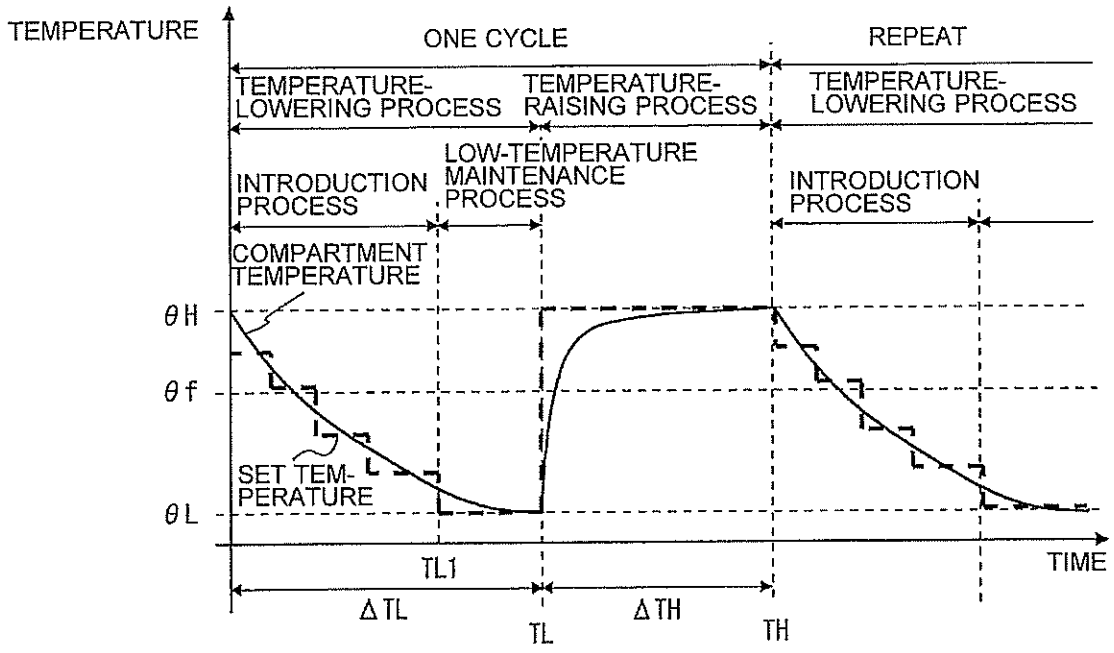

TEMPERATURE
ONE CYCLE
REPEAT
TEMPERATURE-LOWERING PROCESS
TEMPERATURE-RAISING PROCESS
TEMPERATURE-LOWERING PROCESS
INTRODUCTION PROCESS
LOW-TEMPERATURE MAINTENANCE PROCESS
INTRODUCTION PROCESS
COMPARTMENT TEMPERATURE
θH
θf
SET TEM-PERATURE
θL
TIME
TL1
ΔTL
ΔTH
TL
TH

FIG. 7

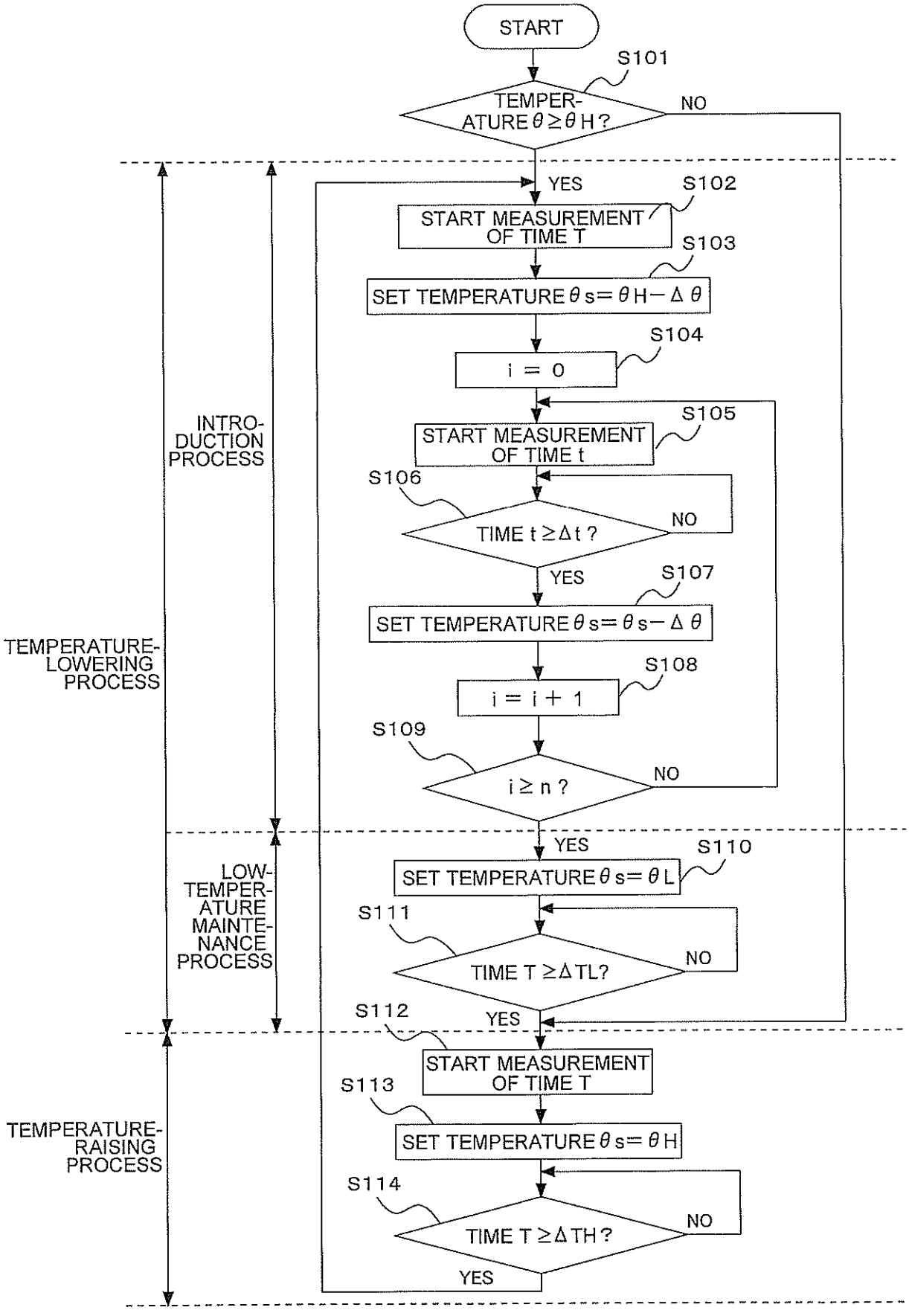

START
S101
TEMPERATURE θ ≥ θH?
NO
YES
S102
START MEASUREMENT OF TIME T
S103
SET TEMPERATURE θs = θH − Δθ
S104
i = 0
S105
START MEASUREMENT OF TIME t
S106
TIME t ≥ Δt?
NO
YES
S107
SET TEMPERATURE θs = θs − Δθ
S108
i = i + 1
S109
i ≥ n?
NO
YES
S110
SET TEMPERATURE θs = θL
S111
TIME T ≥ ΔTL?
NO
S112
YES
START MEASUREMENT OF TIME T
S113
SET TEMPERATURE θs = θH
S114
TIME T ≥ ΔTH?
NO
YES
INTRODUCTION PROCESS
TEMPERATURE-LOWERING PROCESS
LOW-TEMPERATURE MAINTENANCE PROCESS
TEMPERATURE-RAISING PROCESS

FIG. 8

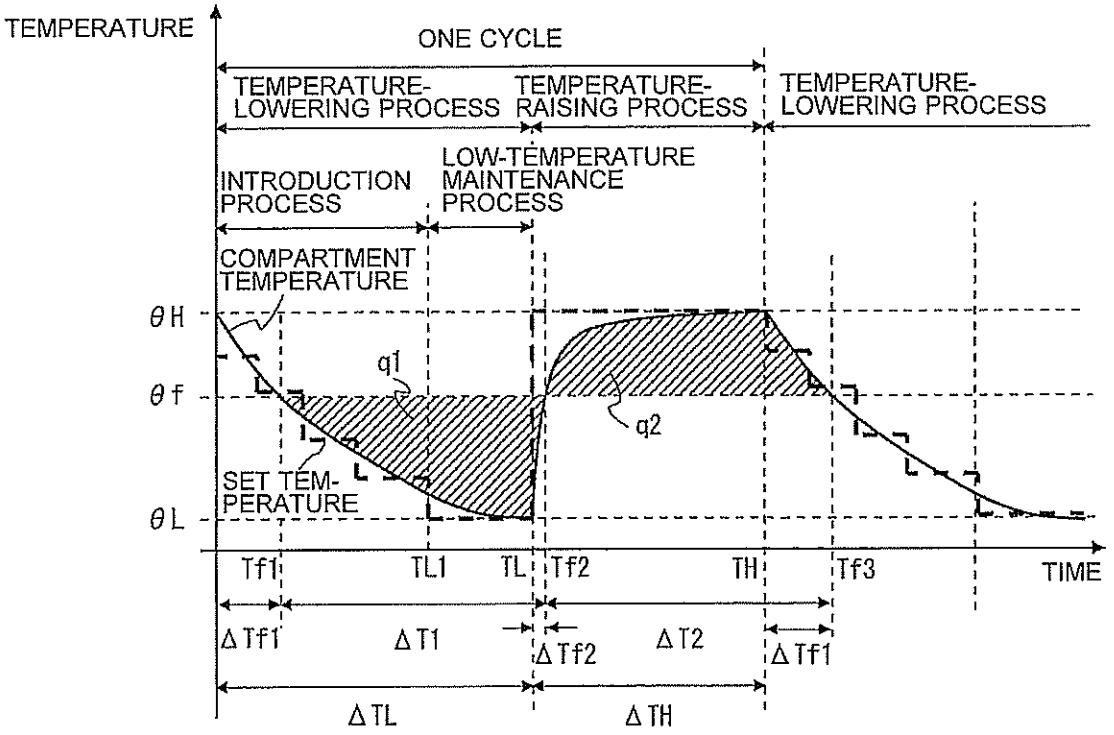

TEMPERATURE
ONE CYCLE
TEMPERATURE-LOWERING PROCESS
TEMPERATURE-RAISING PROCESS
TEMPERATURE-LOWERING PROCESS
INTRODUCTION PROCESS
LOW-TEMPERATURE MAINTENANCE PROCESS
COMPARTMENT TEMPERATURE
θH
θf
θL
q1
q2
SET TEM-PERATURE
Tf1
TL1
TL
Tf2
TH
Tf3
TIME
ΔTf1
ΔT1
ΔTf2
ΔT2
ΔTf1
ΔTL
ΔTH

FIG. 9

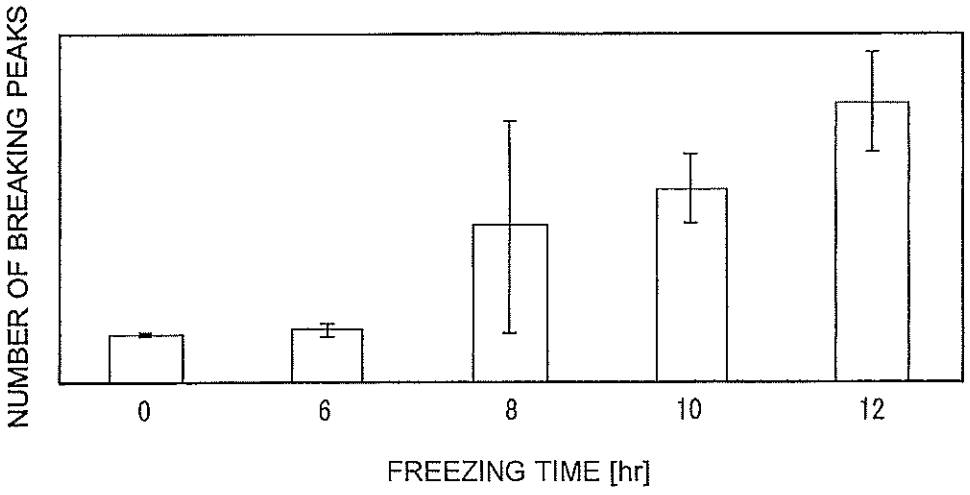

NUMBER OF BREAKING PEAKS
0
6
8
10
12
FREEZING TIME [hr]

FIG. 10

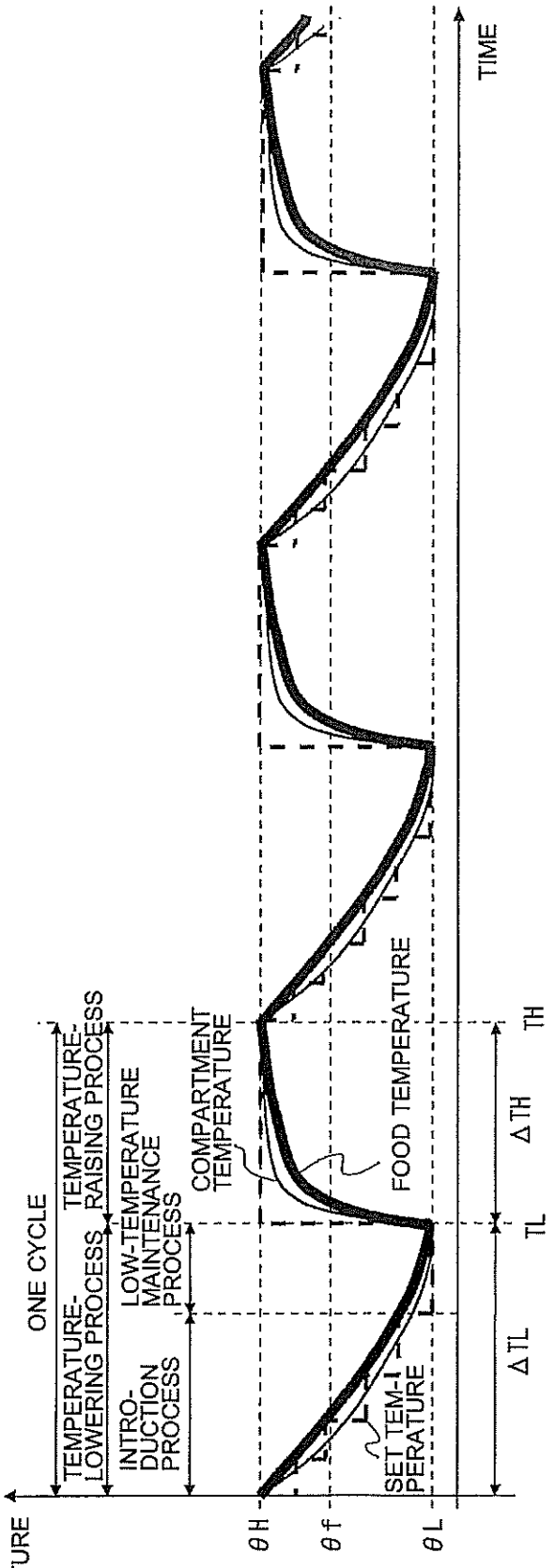

TEMPERATURE
TIME
ONE CYCLE
TEMPERATURE-LOWERING PROCESS
TEMPERATURE-RAISING PROCESS
INTRO-DUCTION PROCESS
LOW-TEMPERATURE MAINTENANCE PROCESS
COMPARTMENT TEMPERATURE
FOOD TEMPERATURE
SET TEM-PERATURE
θH
θf
θL
ΔTL
ΔTH
TL
TH

FIG. 11

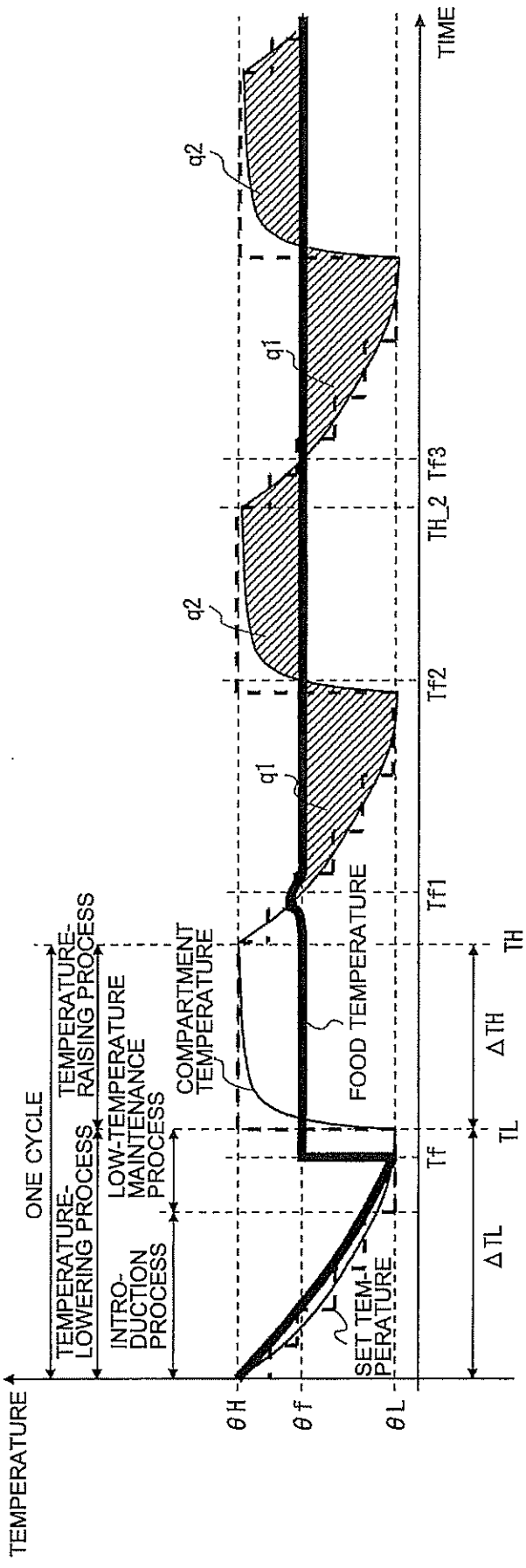

TEMPERATURE
TIME
ONE CYCLE
TEMPERATURE-LOWERING PROCESS
TEMPERATURE-RAISING PROCESS
INTRO-DUCTION PROCESS
LOW-TEMPERATURE MAINTENANCE PROCESS
COMPARTMENT TEMPERATURE
FOOD TEMPERATURE
SET TEM-PERATURE
θH
θf
θL
Tf
TL
TH
ΔTL
ΔTH
Tf1
Tf2
TH_2
Tf3
q1
q2

FIG. 12

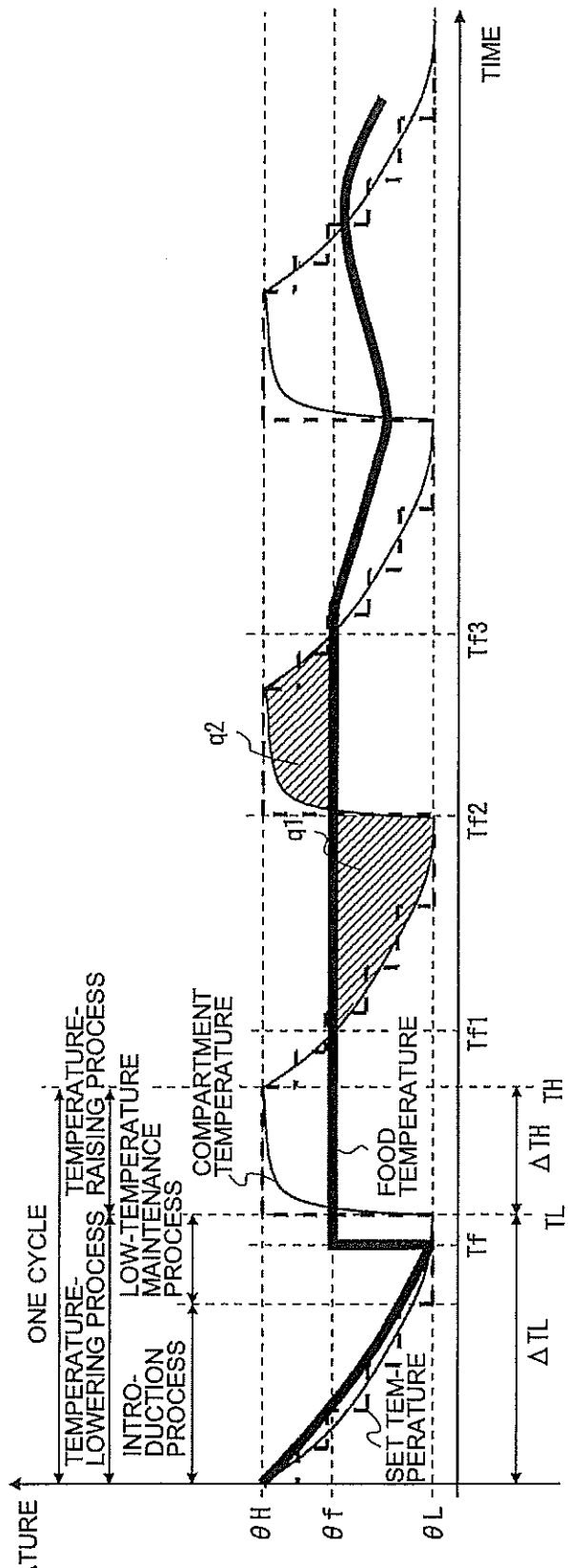

TEMPERATURE
ONE CYCLE
TEMPERATURE-LOWERING PROCESS
TEMPERATURE-RAISING PROCESS
INTRO-DUCTION PROCESS
LOW-TEMPERATURE MAINTENANCE PROCESS
COMPARTMENT TEMPERATURE
FOOD TEMPERATURE
SET TEM-PERATURE
θH
θf
θL
q2
q1
Tf3
Tf2
Tf1
Tf
TL
ΔTH
TH
ΔTL
TIME

FIG. 13

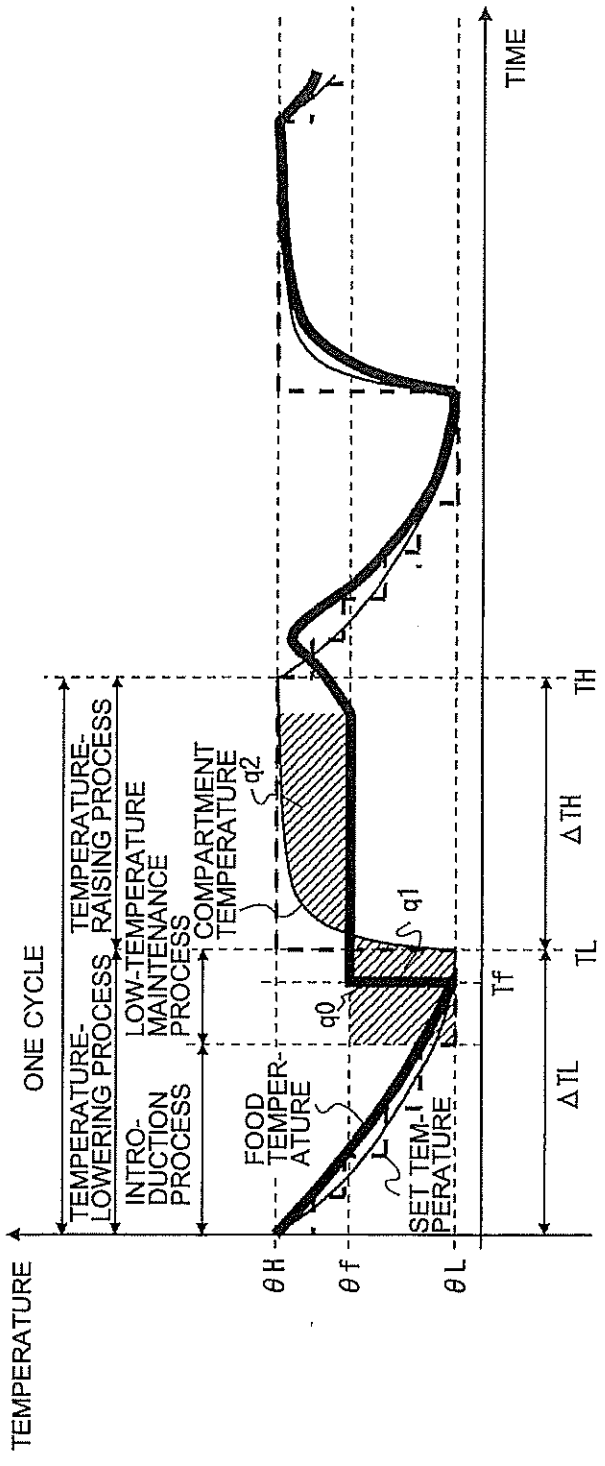

TEMPERATURE
ONE CYCLE
TEMPERATURE-LOWERING PROCESS
TEMPERATURE-RAISING PROCESS
INTRO-DUCTION PROCESS
LOW-TEMPERATURE MAINTENANCE PROCESS
COMPARTMENT TEMPERATURE
FOOD TEMPER-ATURE
SET TEM-PERATURE
θH
θf
θL
q0
q1
q2
Tf
TL
TH
ΔTL
ΔTH
TIME

FIG. 14

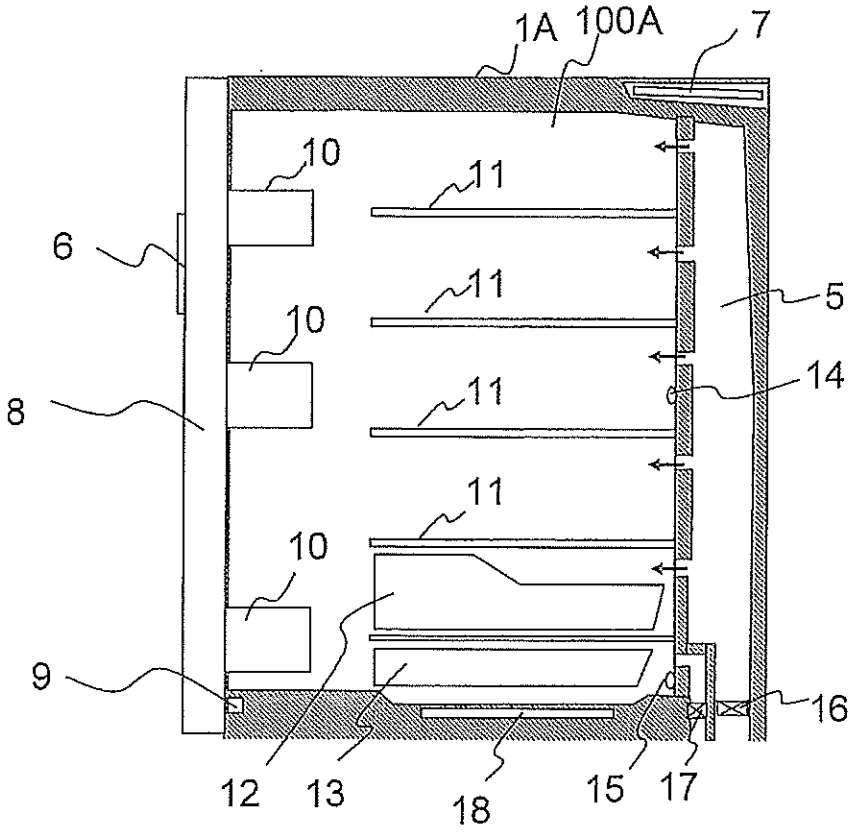
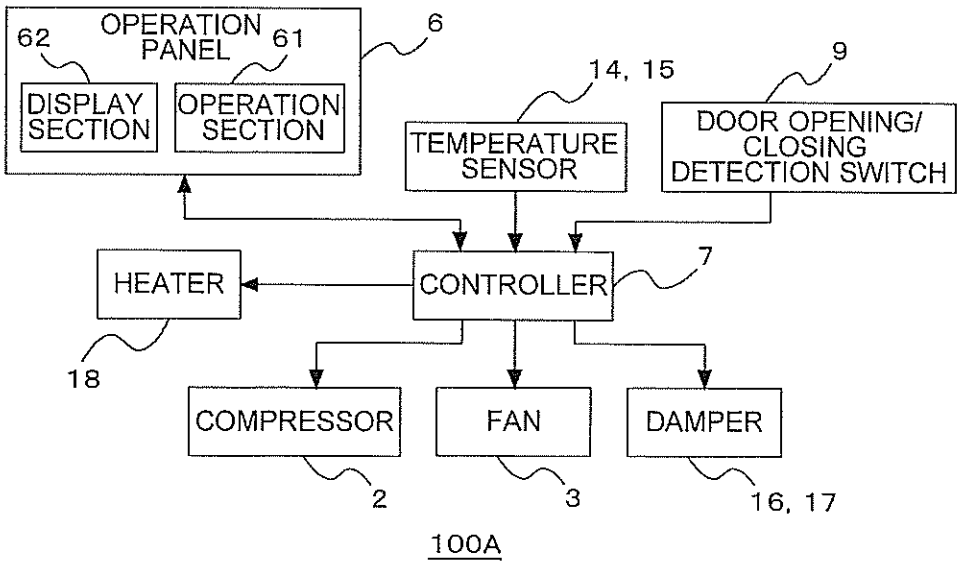

1A
100A
7
10
11
6
5
14
8
9
12
13
18
15
17
16

FIG. 15


OPERATION PANEL
62
61
6
DISPLAY SECTION
OPERATION SECTION
14, 15
9
TEMPERATURE SENSOR
DOOR OPENING/ CLOSING DETECTION SWITCH
HEATER
CONTROLLER
7
18
COMPRESSOR
FAN
DAMPER
2
3
16, 17
100A