FIG.1

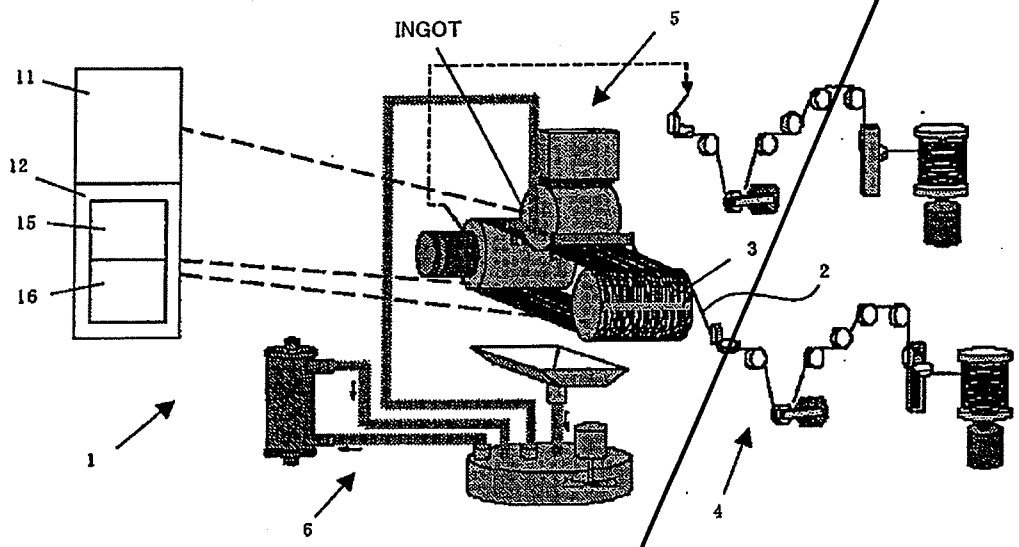

INGOT
5
11
12
15
16
3
2
1
6
4

FIG.2

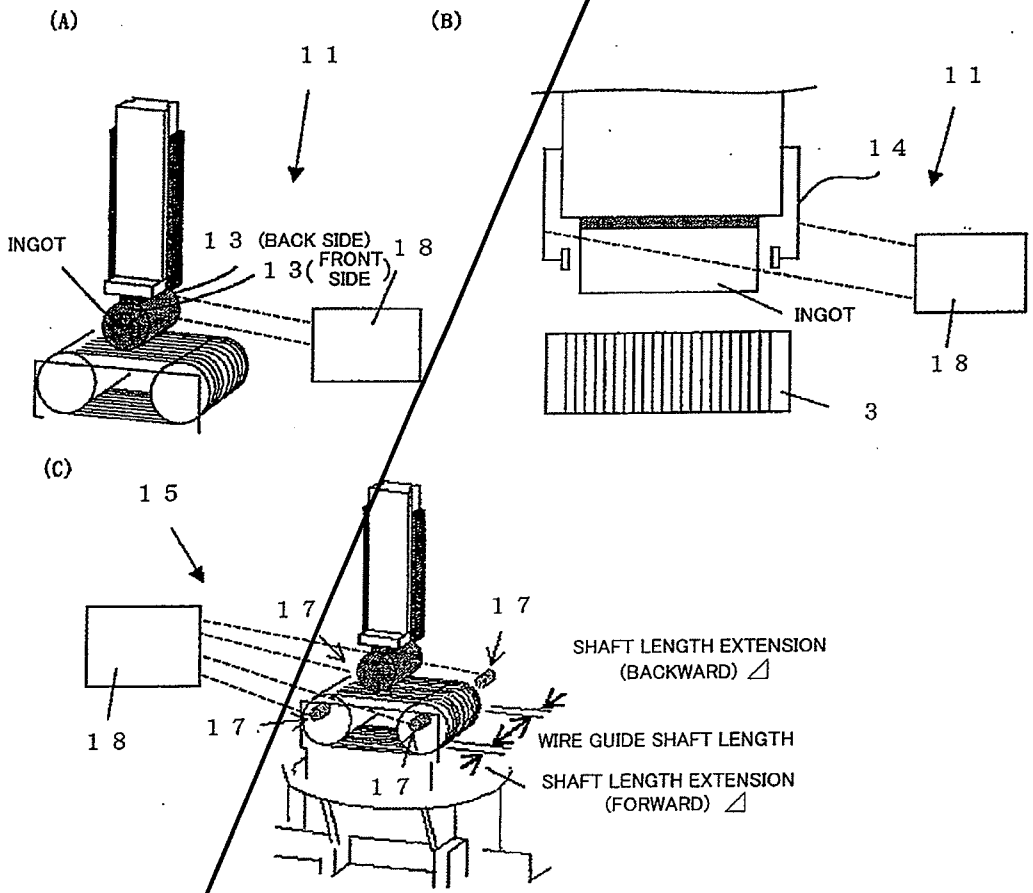

(A)
(B)
11
INGOT
13 (BACK SIDE)
13 (FRONT SIDE)
18
14
INGOT
18
3
(C)
15
17
17
18
17
17
SHAFT LENGTH EXTENSION (BACKWARD)
WIRE GUIDE SHAFT LENGTH
SHAFT LENGTH EXTENSION (FORWARD)

FIG.3

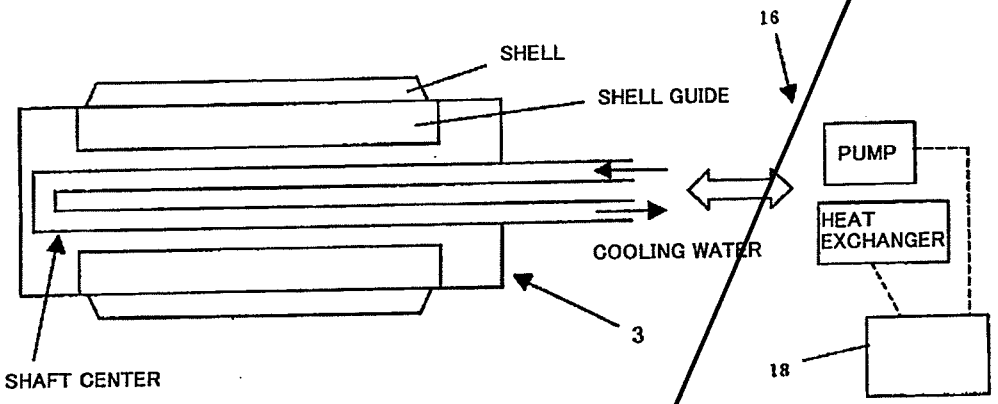

16
SHELL
SHELL GUIDE
PUMP
HEAT EXCHANGER
COOLING WATER
3
18
SHAFT CENTER

FIG.4

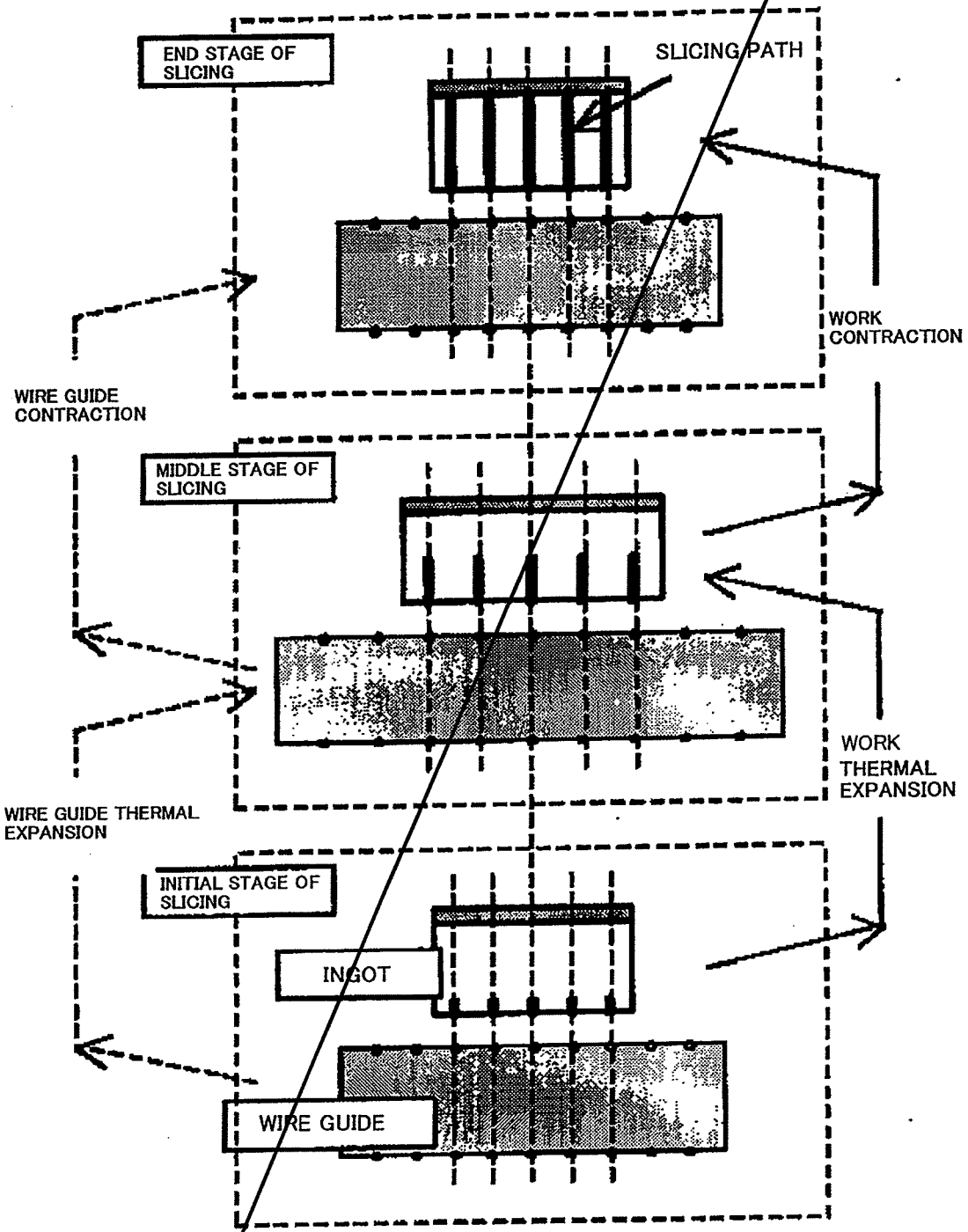

END STAGE OF SLICING
SLICING PATH
WORK CONTRACTION
WIRE GUIDE CONTRACTION
MIDDLE STAGE OF SLICING
WORK THERMAL EXPANSION
WIRE GUIDE THERMAL EXPANSION
INITIAL STAGE OF SLICING
INGOT
WIRE GUIDE

FIG.5

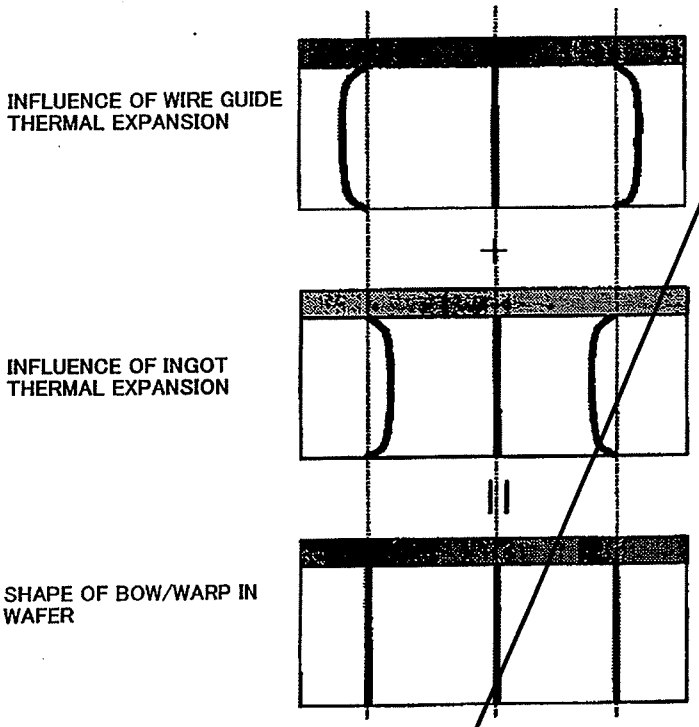

INFLUENCE OF WIRE GUIDE THERMAL EXPANSION
INFLUENCE OF INGOT THERMAL EXPANSION
SHAPE OF BOW/WARP IN WAFER

FIG.6

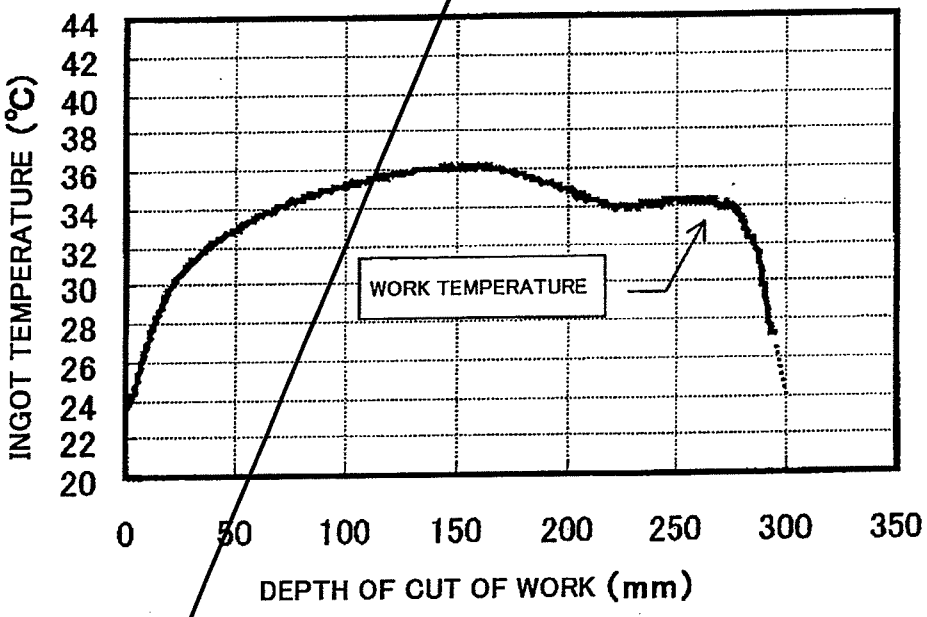

INGOT TEMPERATURE (°C)
44
42
40
38
36
34
32
30
28
26
24
22
20
WORK TEMPERATURE
0
50
100
150
200
250
300
350
DEPTH OF CUT OF WORK (mm)

FIG.7

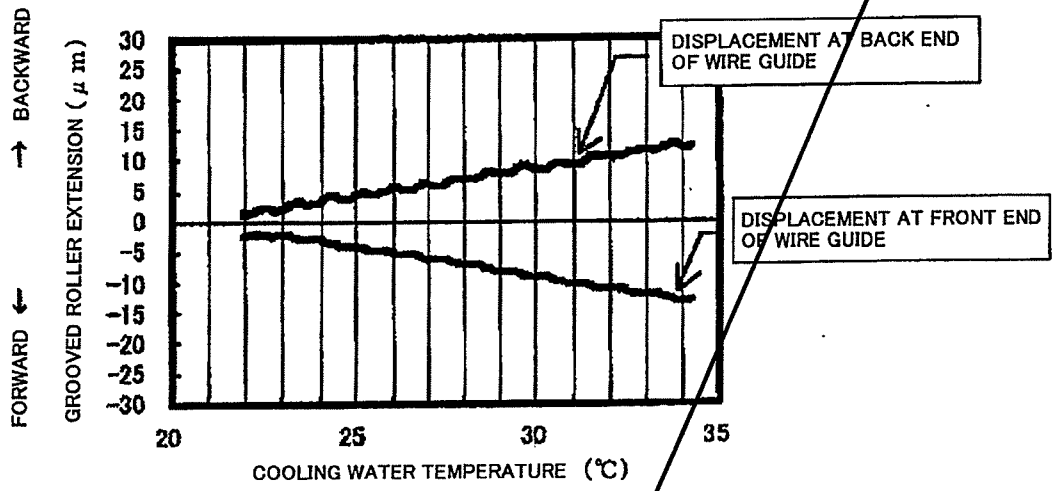

DISPLACEMENT AT BACK END OF WIRE GUIDE
DISPLACEMENT AT FRONT END OF WIRE GUIDE
→ BACKWARD
FORWARD ←
GROOVED ROLLER EXTENSION (μm)
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
20
25
30
35
COOLING WATER TEMPERATURE (℃)

FIG.8

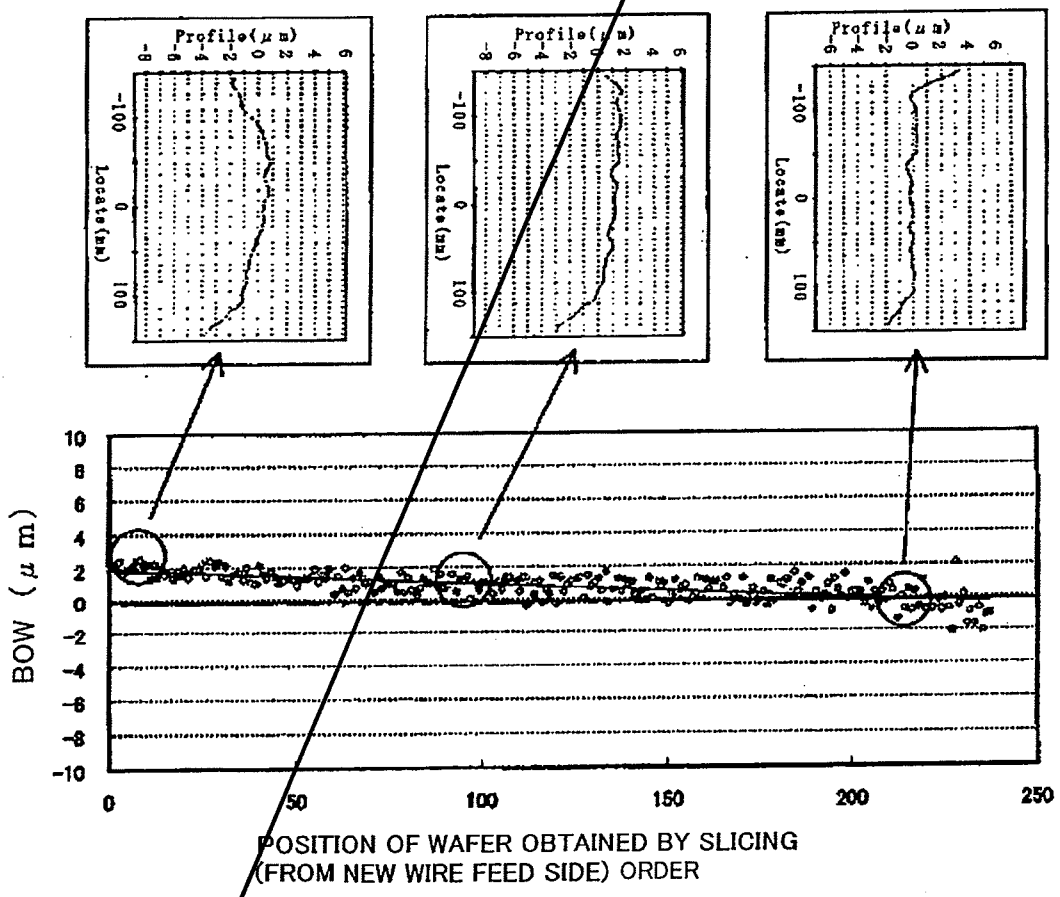

Profile(μm)
Locate(mm)
BOW (μm)
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
50
100
150
200
250
POSITION OF WAFER OBTAINED BY SLICING
(FROM NEW WIRE FEED SIDE) ORDER

FIG.9

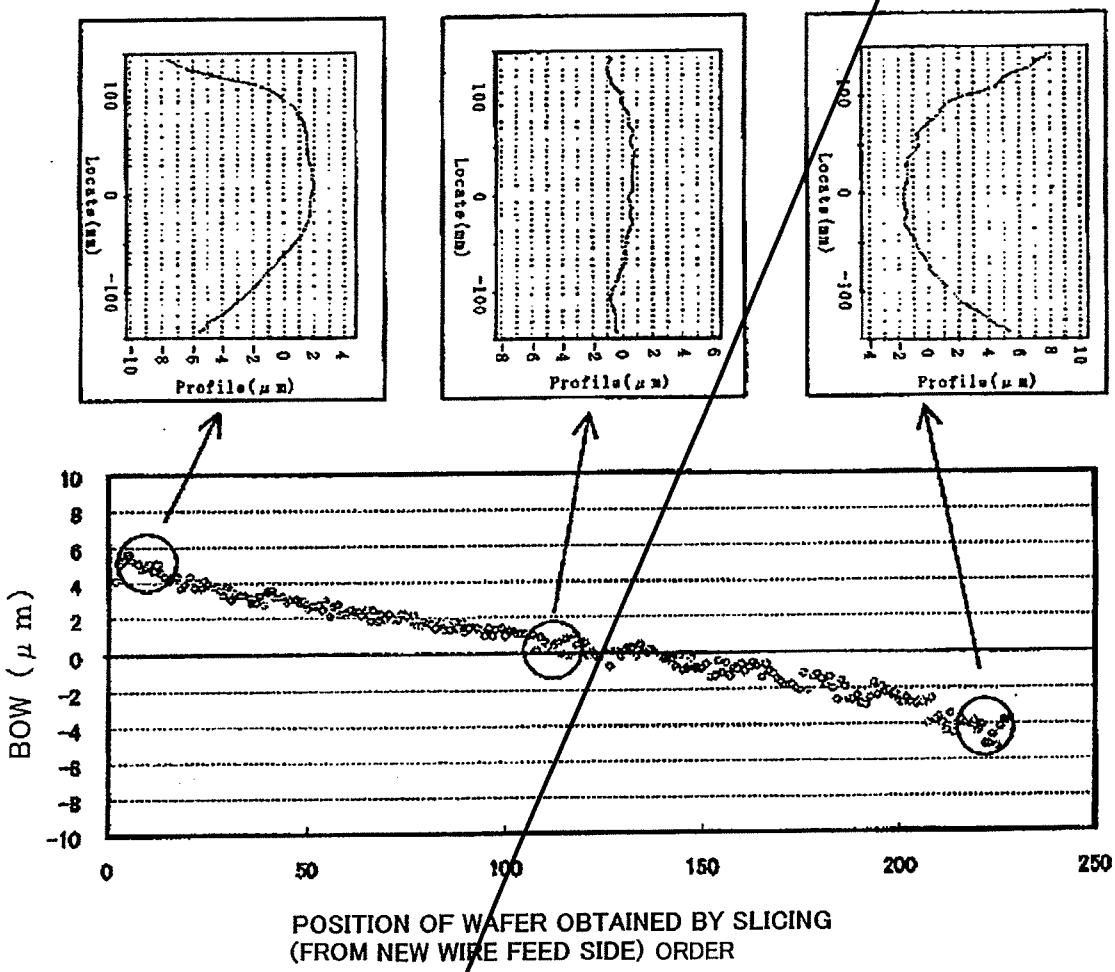

Locate(mm)
Profile(μm)
BOW (μm)
POSITION OF WAFER OBTAINED BY SLICING
(FROM NEW WIRE FEED SIDE) ORDER

FIG.10

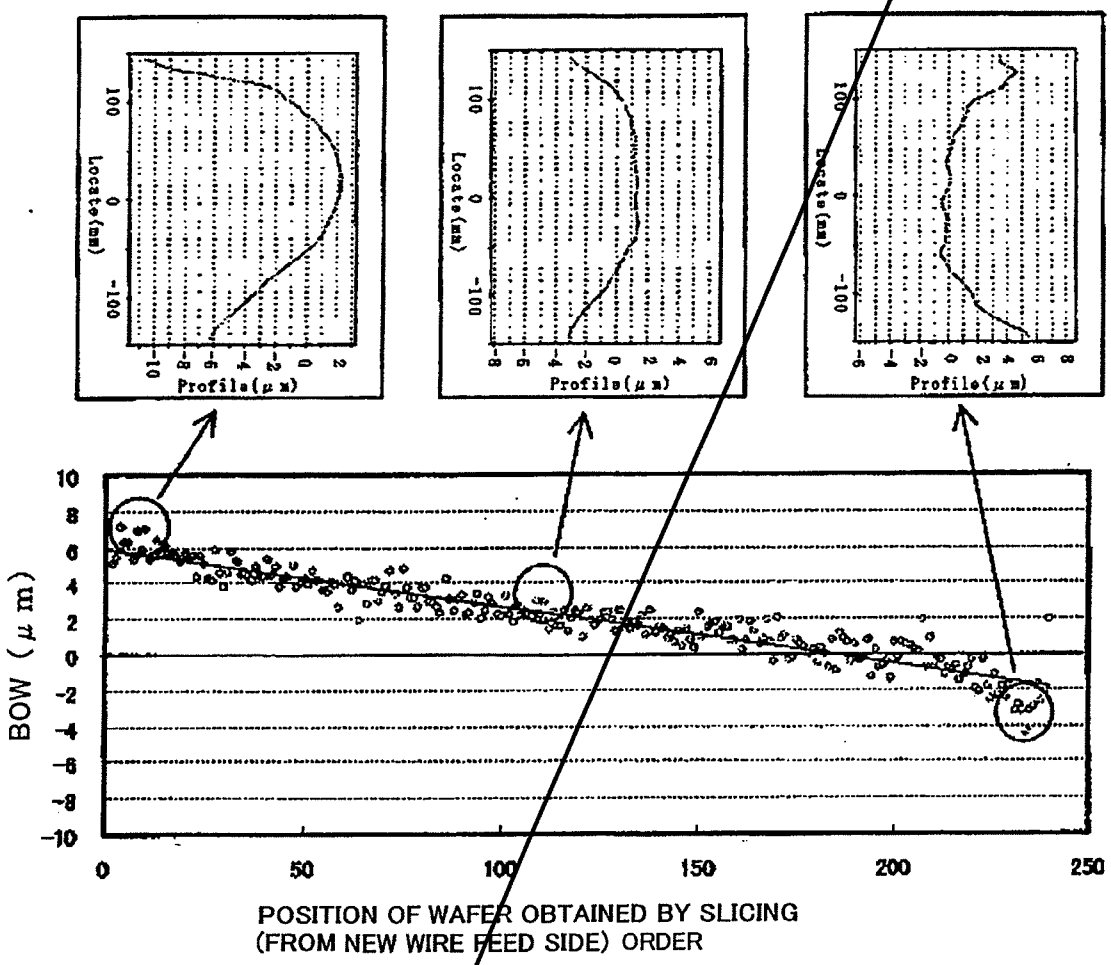

Locate(mm)
Profile(μm)
BOW (μm)
POSITION OF WAFER OBTAINED BY SLICING
(FROM NEW WIRE FEED SIDE) ORDER

FIG.11

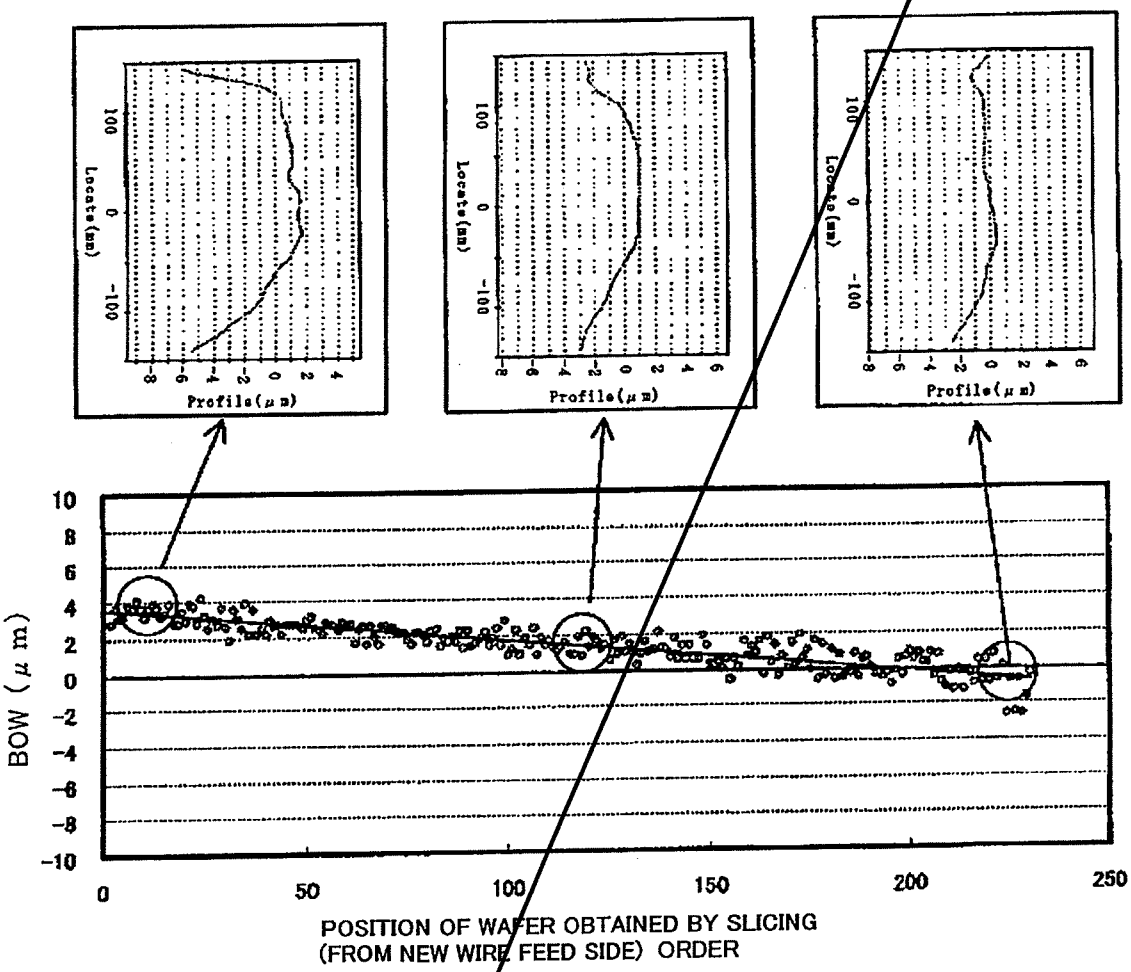
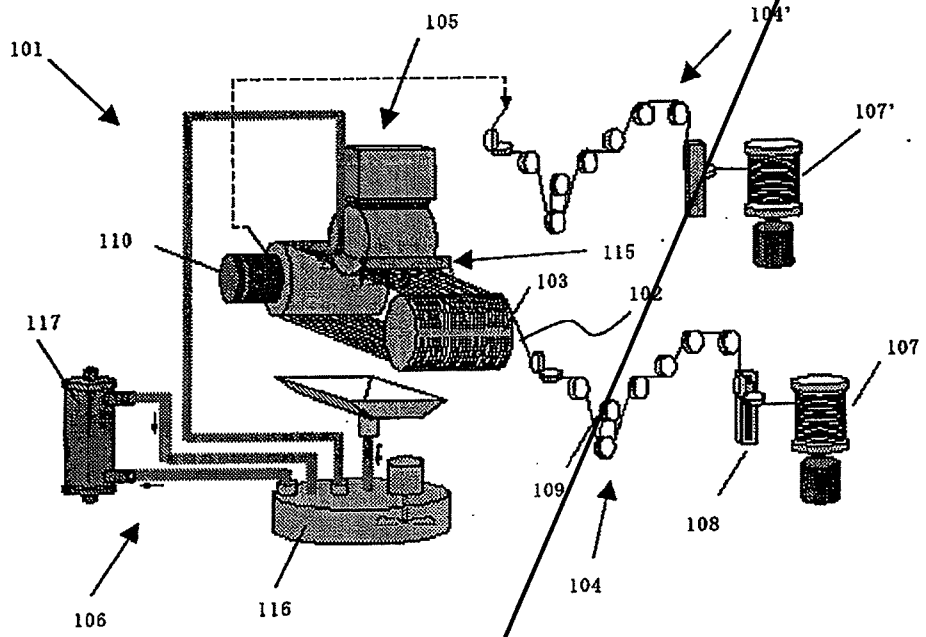

Locate(mm)
Profile(μm)
BOW (μm)
POSITION OF WAFER OBTAINED BY SLICING
(FROM NEW WIRE FEED SIDE) ORDER

FIG.12

(A)


101
105
104'
107'
110
115
103
102
117
107
109
108
104
106
116

(B)

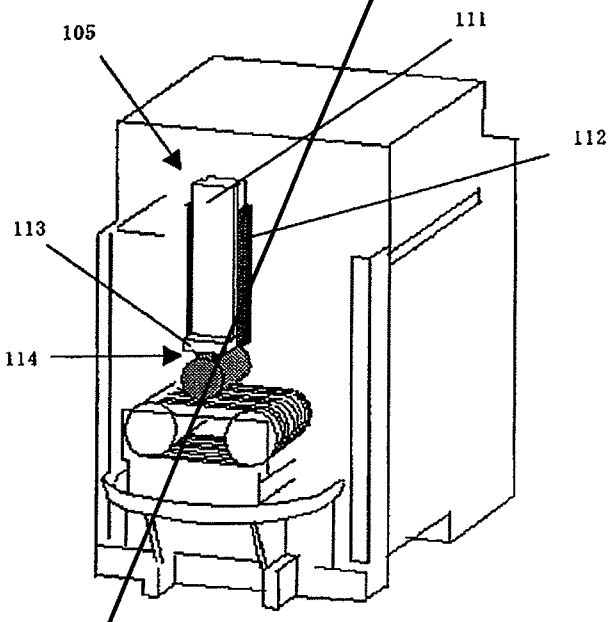

105
111
112
113
114

FIG.13

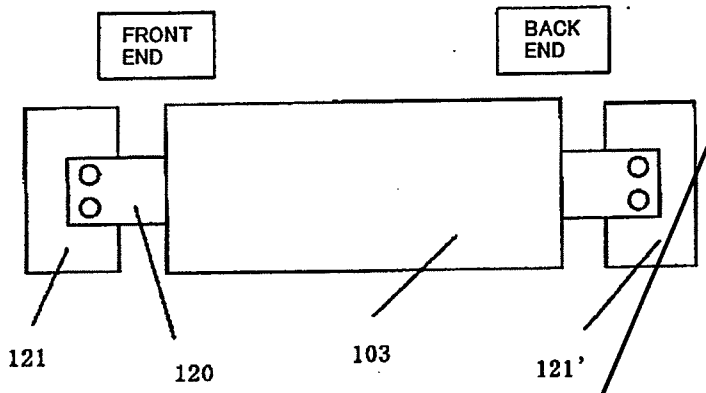

FRONT END
BACK END
121
120
103
121'

FIG.14

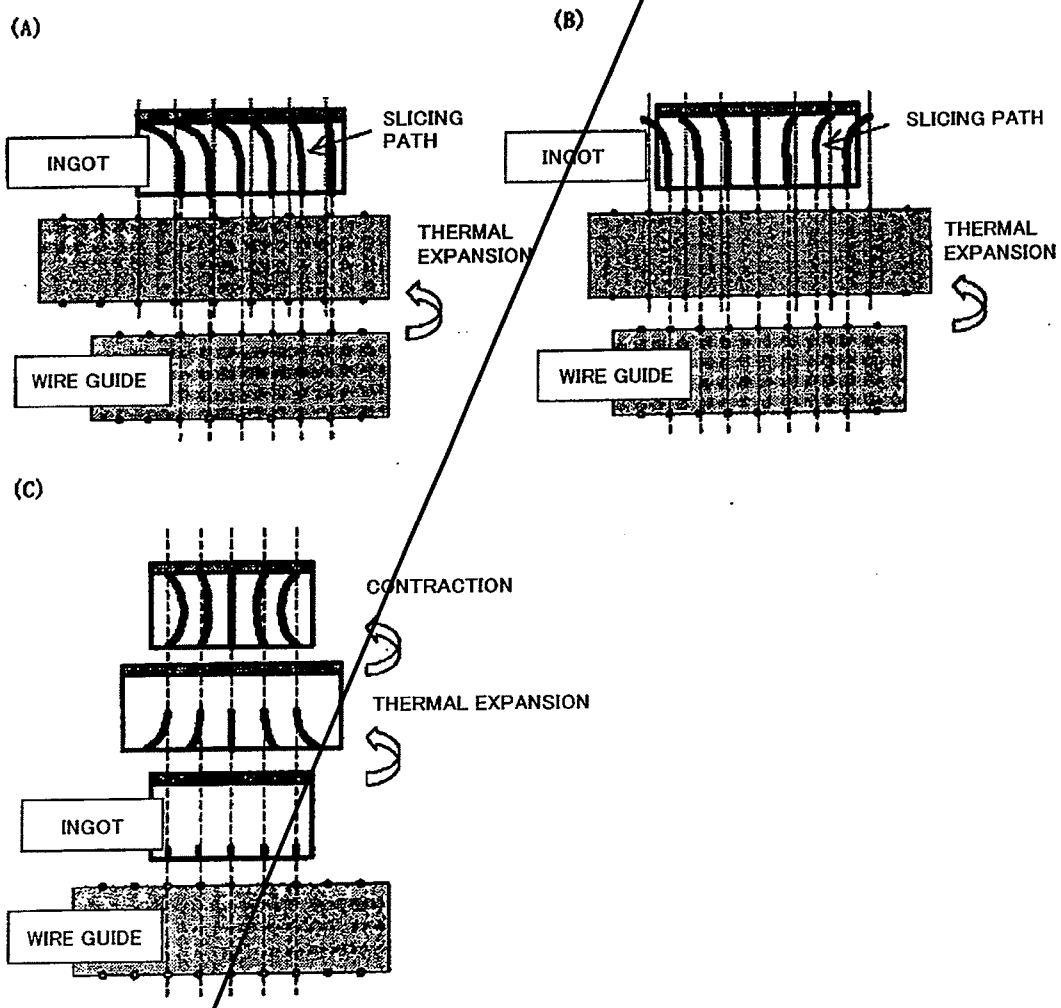
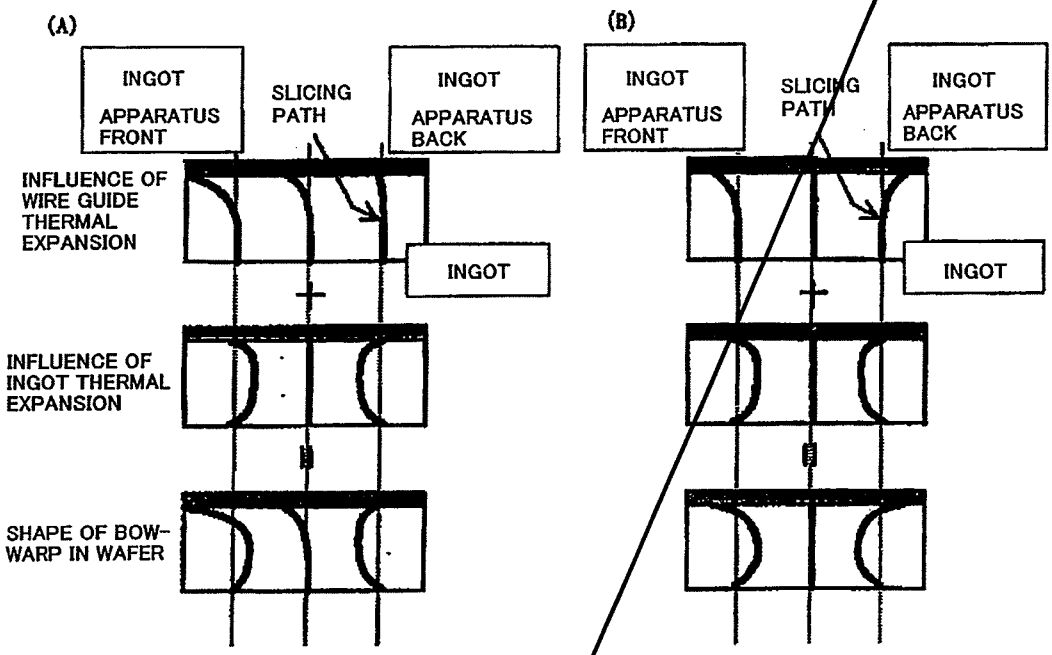
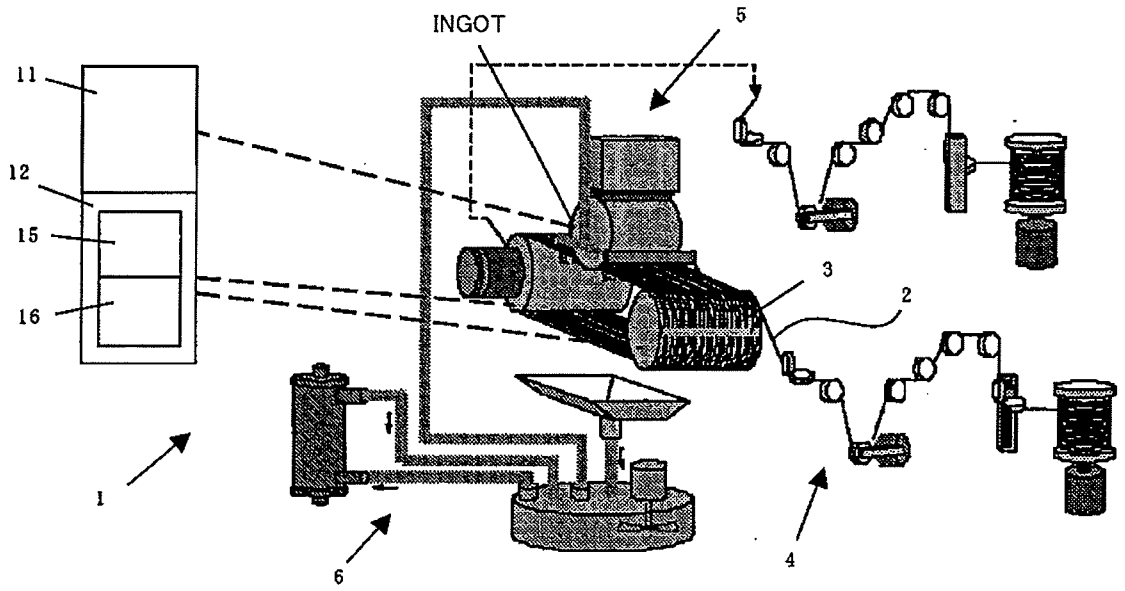

(A)
(B)
(C)
INGOT
SLICING PATH
THERMAL EXPANSION
WIRE GUIDE
CONTRACTION

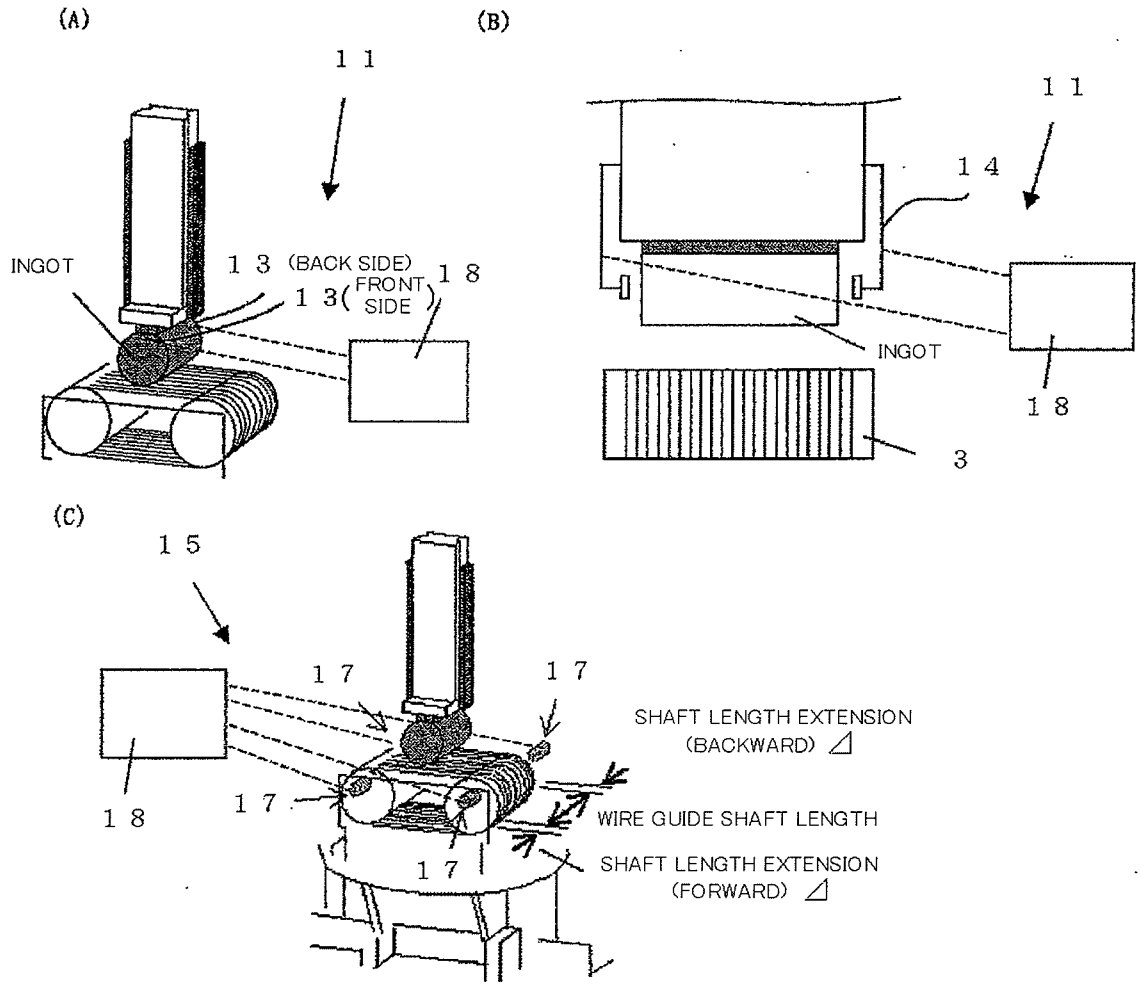
FIG.15


(A)
INGOT
APPARATUS FRONT
SLICING PATH
INGOT
APPARATUS BACK
INFLUENCE OF WIRE GUIDE THERMAL EXPANSION
INGOT
INFLUENCE OF INGOT THERMAL EXPANSION
SHAPE OF BOW-WARP IN WAFER
(B)
INGOT
APPARATUS FRONT
SLICING PATH
INGOT
APPARATUS BACK
INGOT

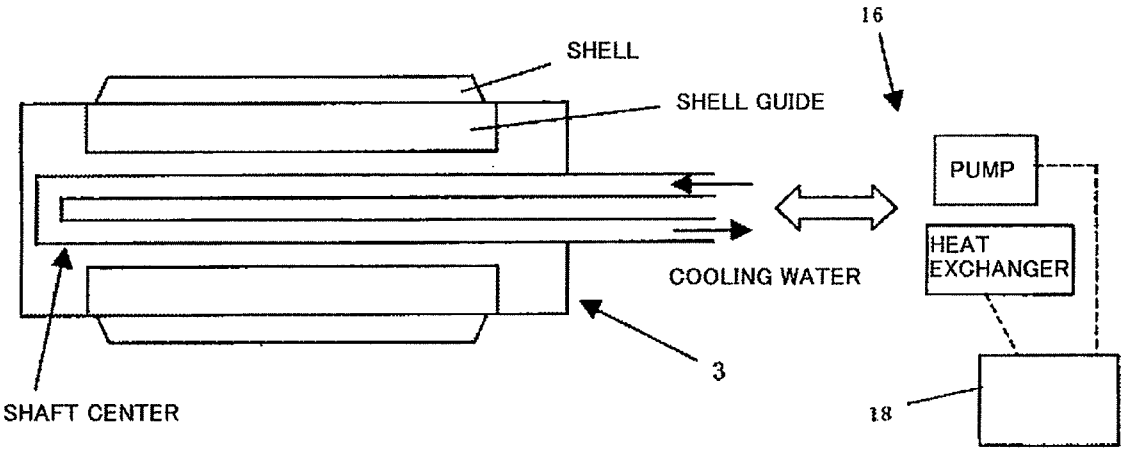
[FIG. 1]


INGOT
5
11
12
15
16
3
2
1
4
6

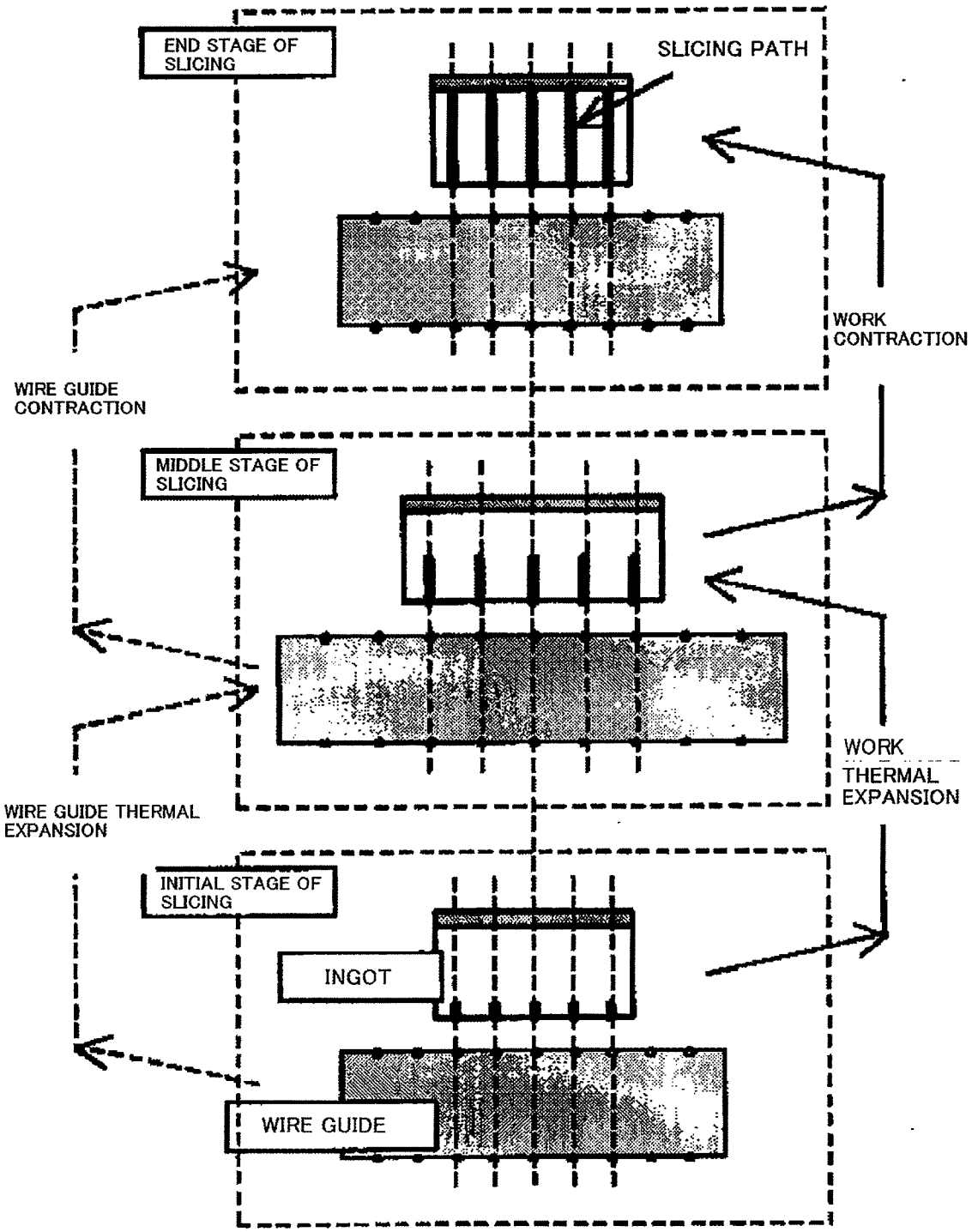
[FIG. 2]


(A)
11
INGOT
13 (BACK SIDE)
13(FRONT SIDE)
18
(B)
11
14
INGOT
18
3
(C)
15
17
17
18
17
SHAFT LENGTH EXTENSION
(BACKWARD)
WIRE GUIDE SHAFT LENGTH
SHAFT LENGTH EXTENSION
(FORWARD)

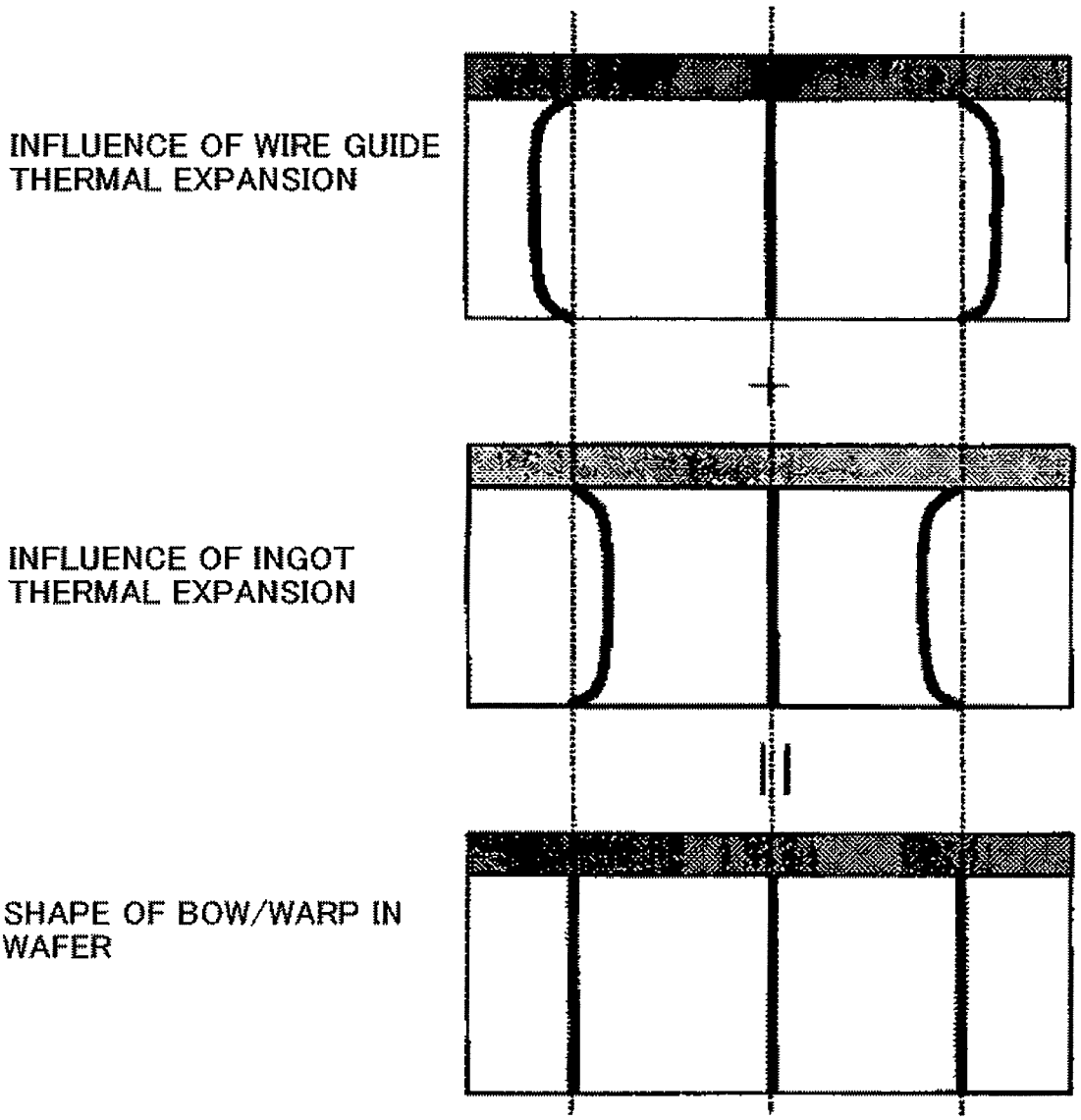
[FIG. 3]


16
SHELL
SHELL GUIDE
PUMP
HEAT EXCHANGER
COOLING WATER
3
SHAFT CENTER
18

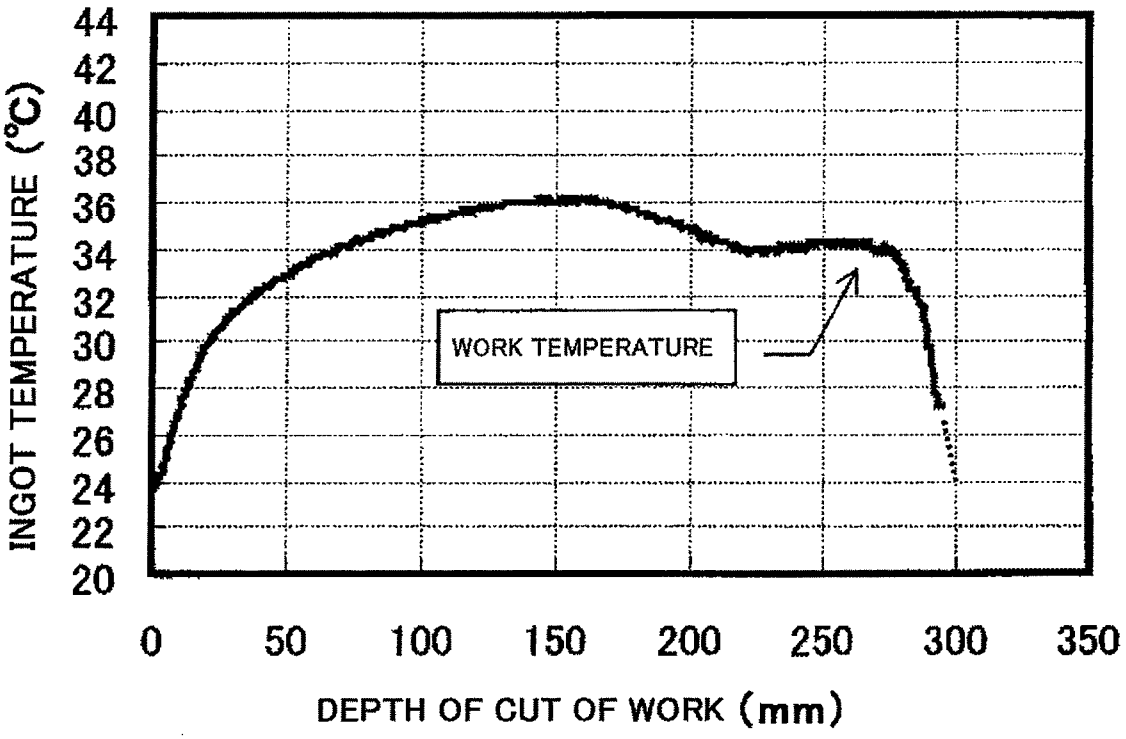
[FIG. 4]


END STAGE OF SLICING
SLICING PATH
WORK CONTRACTION
WIRE GUIDE CONTRACTION
MIDDLE STAGE OF SLICING
WORK THERMAL EXPANSION
WIRE GUIDE THERMAL EXPANSION
INITIAL STAGE OF SLICING
INGOT
WIRE GUIDE

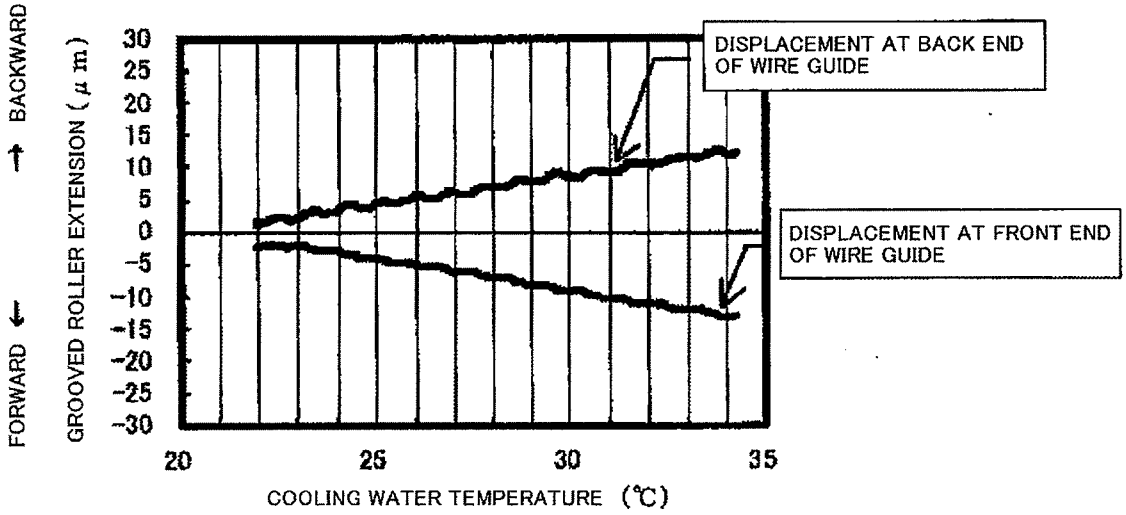
[FIG. 5]


INFLUENCE OF WIRE GUIDE THERMAL EXPANSION
INFLUENCE OF INGOT THERMAL EXPANSION
SHAPE OF BOW/WARP IN WAFER

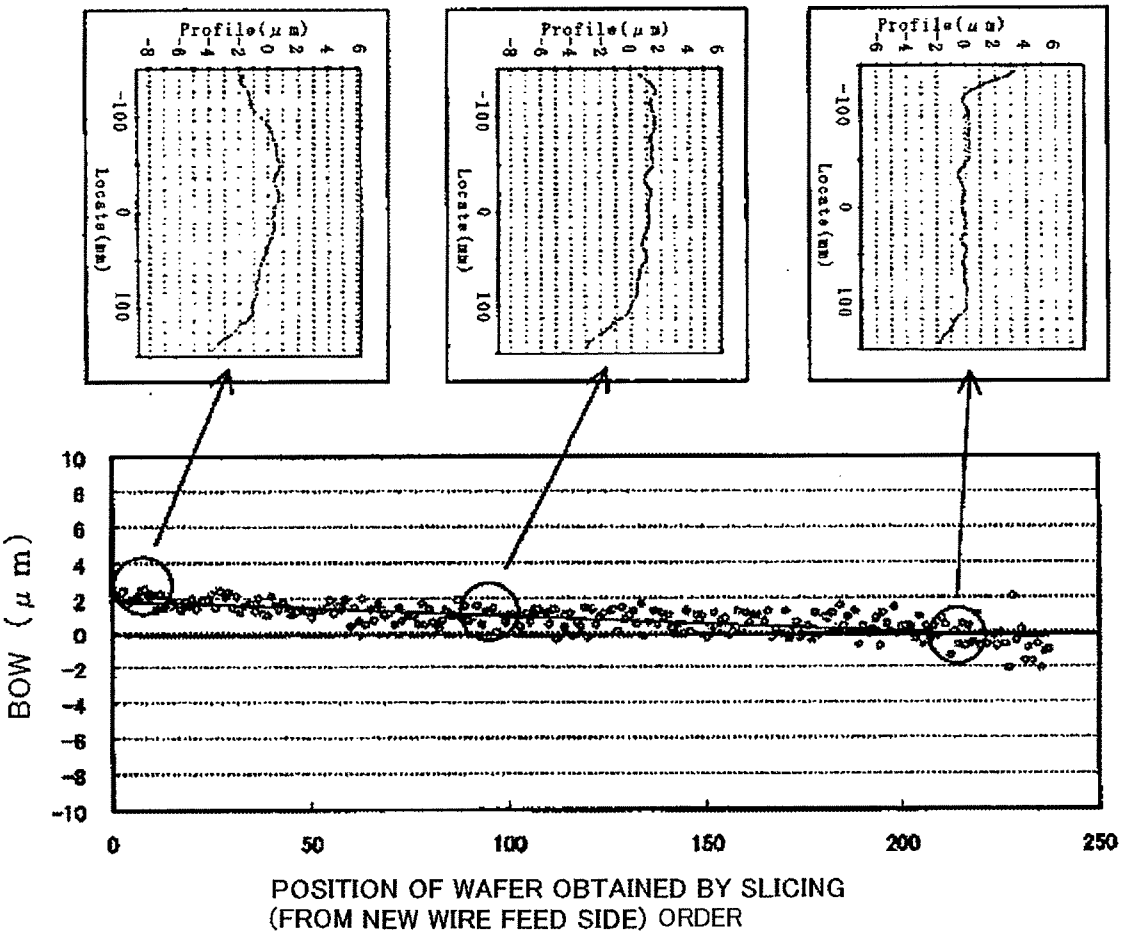
[FIG. 6]


INGOT TEMPERATURE (℃)
44
42
40
38
36
34
32
30
28
26
24
22
20
WORK TEMPERATURE
0
50
100
150
200
250
300
350
DEPTH OF CUT OF WORK (mm)

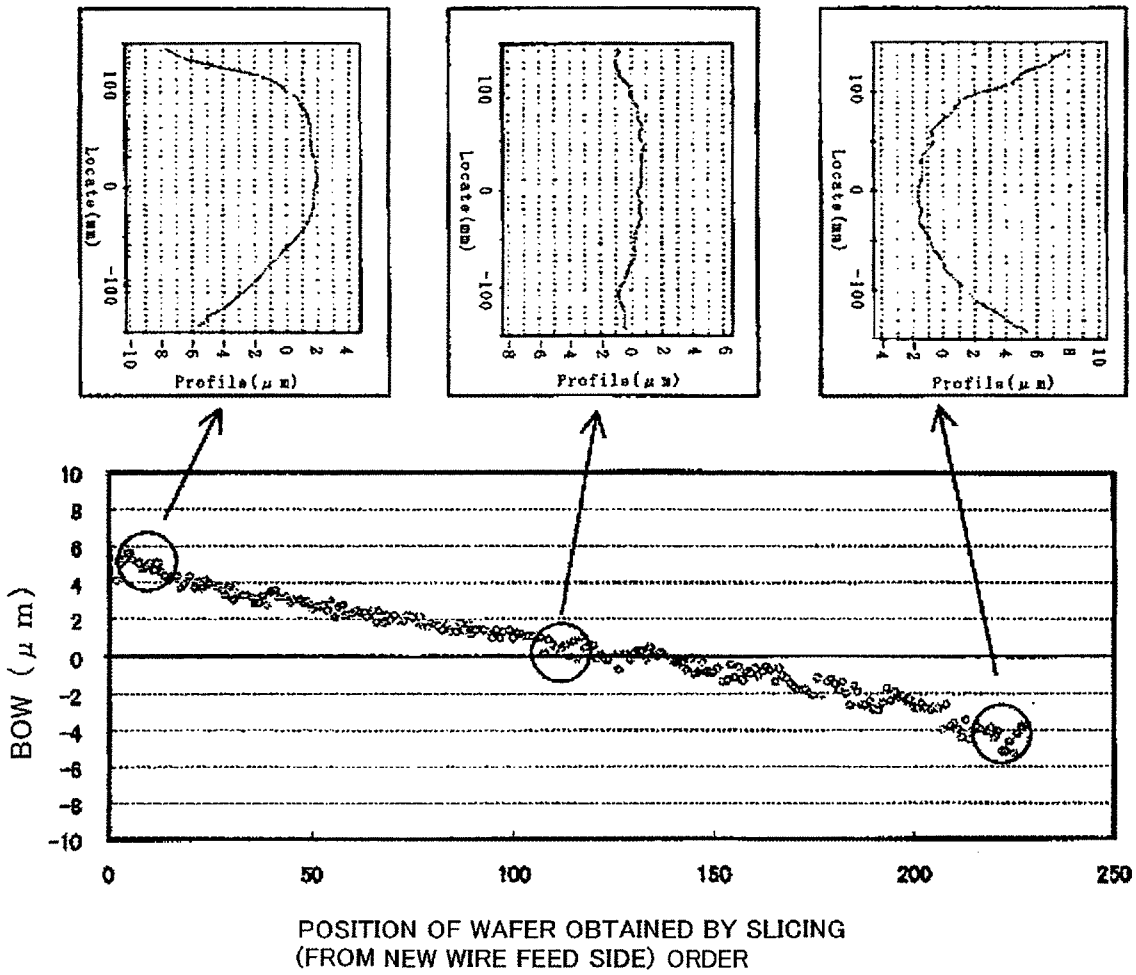
[FIG. 7]


→ BACKWARD
← FORWARD
GROOVED ROLLER EXTENSION (μm)
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
DISPLACEMENT AT BACK END OF WIRE GUIDE
DISPLACEMENT AT FRONT END OF WIRE GUIDE
20
25
30
35
COOLING WATER TEMPERATURE (℃)

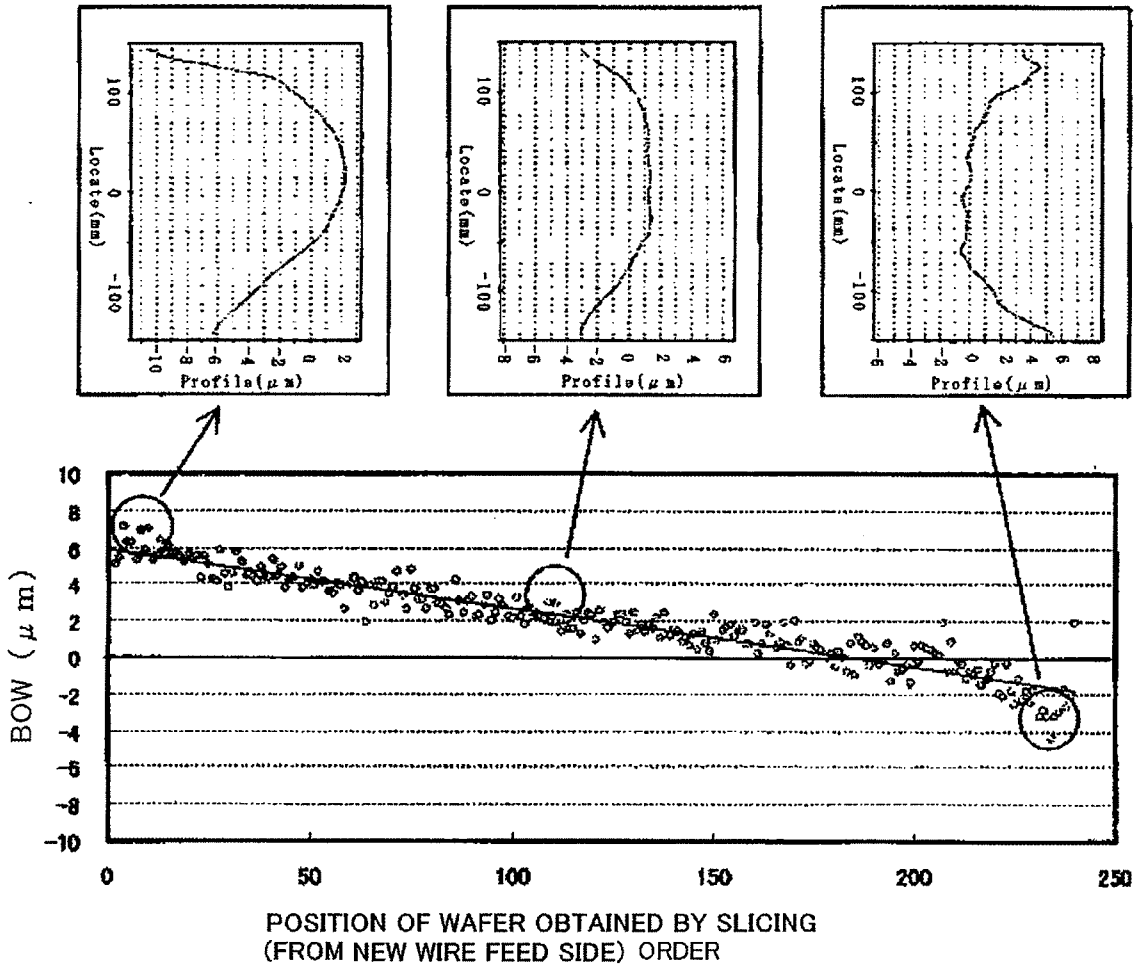
[FIG. 8]


Profile(μm)
Locate(mm)
BOW (μm)
POSITION OF WAFER OBTAINED BY SLICING
(FROM NEW WIRE FEED SIDE) ORDER

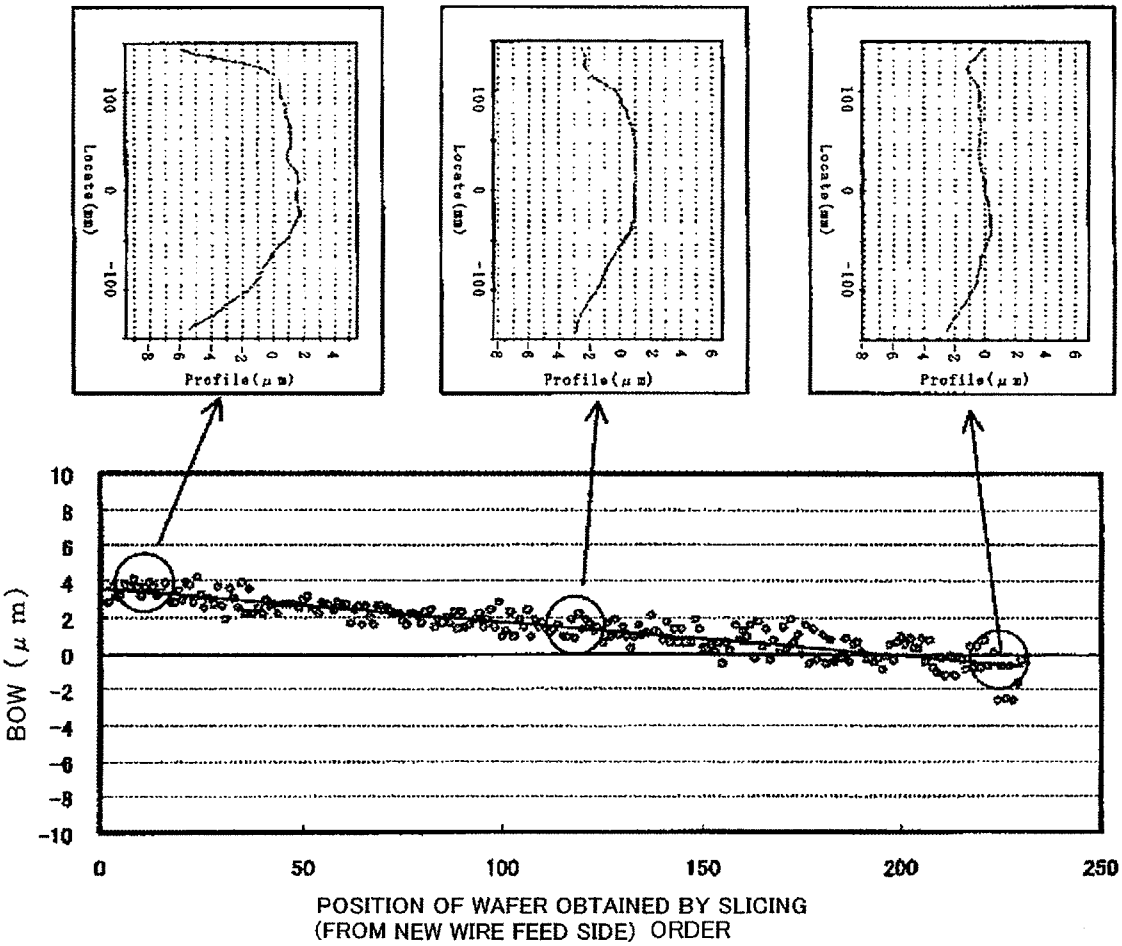
[FIG. 9]


Locate(mm)
Profile(μm)
BOW (μm)
POSITION OF WAFER OBTAINED BY SLICING
(FROM NEW WIRE FEED SIDE) ORDER

[FIG. 10]

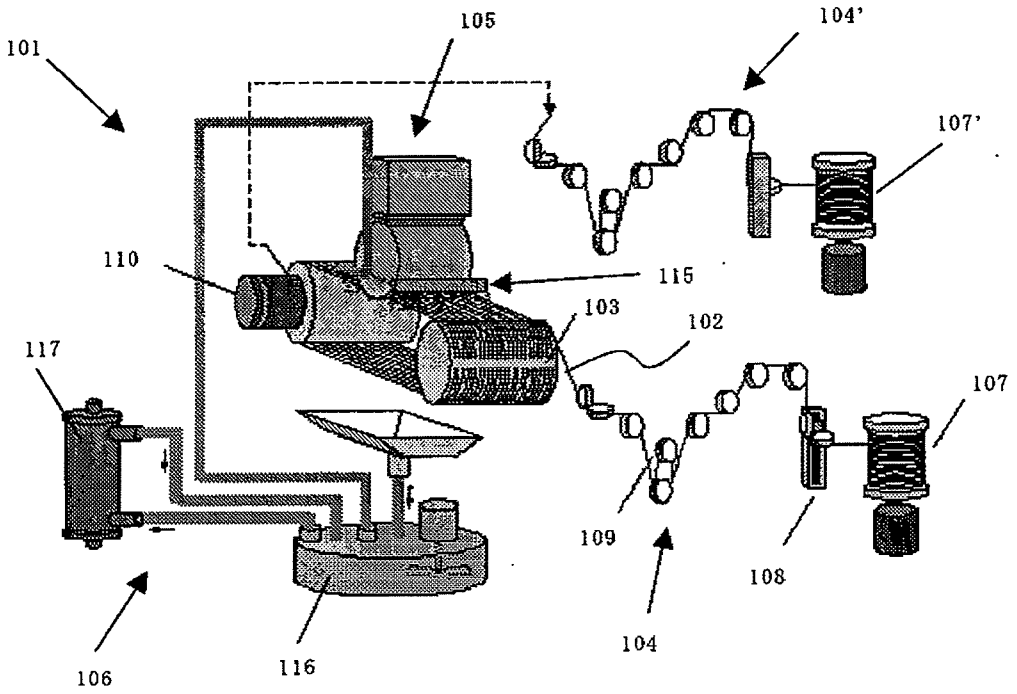

Profile(μm)
Locate(mm)
100
0
-100
BOW (μm)
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
50
100
150
200
250
POSITION OF WAFER OBTAINED BY SLICING
(FROM NEW WIRE FEED SIDE) ORDER

[FIG. 11]

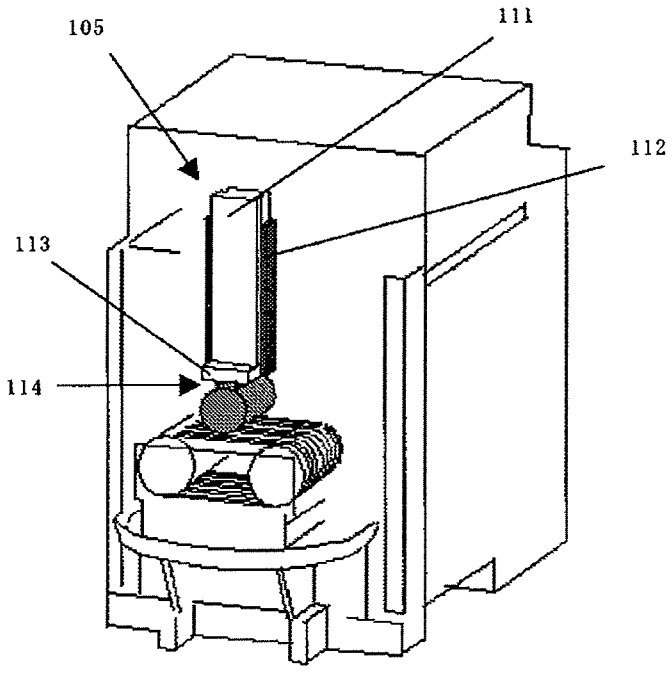

Locate(mm)
100
0
-100
Profile(μm)
BOW (μm)
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
50
100
150
200
250
POSITION OF WAFER OBTAINED BY SLICING
(FROM NEW WIRE FEED SIDE) ORDER

[FIG. 12]

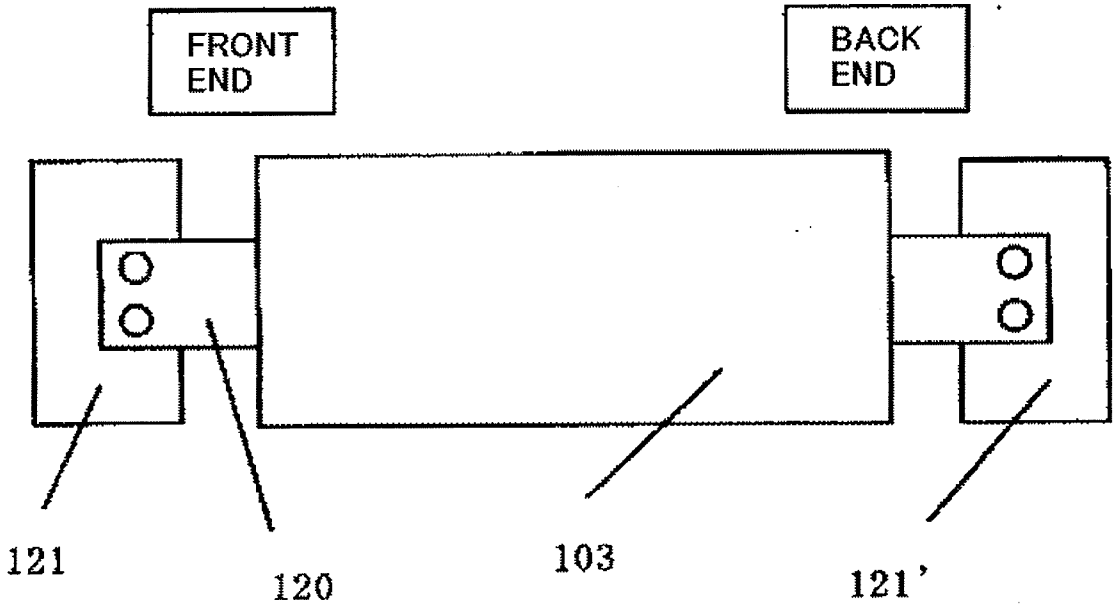
(A)


101
105
104'
107'
110
115
103
102
117
107
109
108
106
116
104

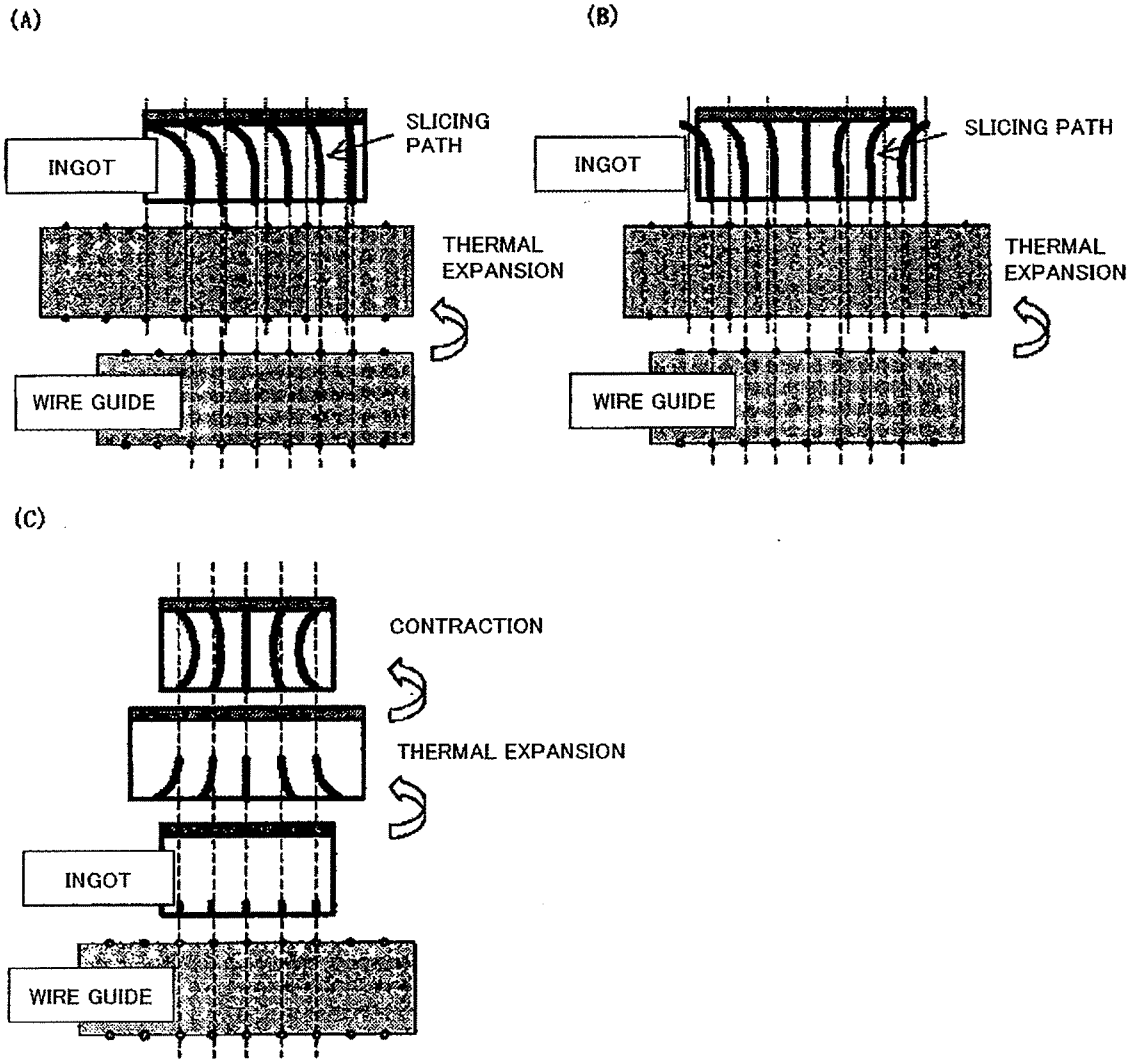
(B)


105
111
112
113
114

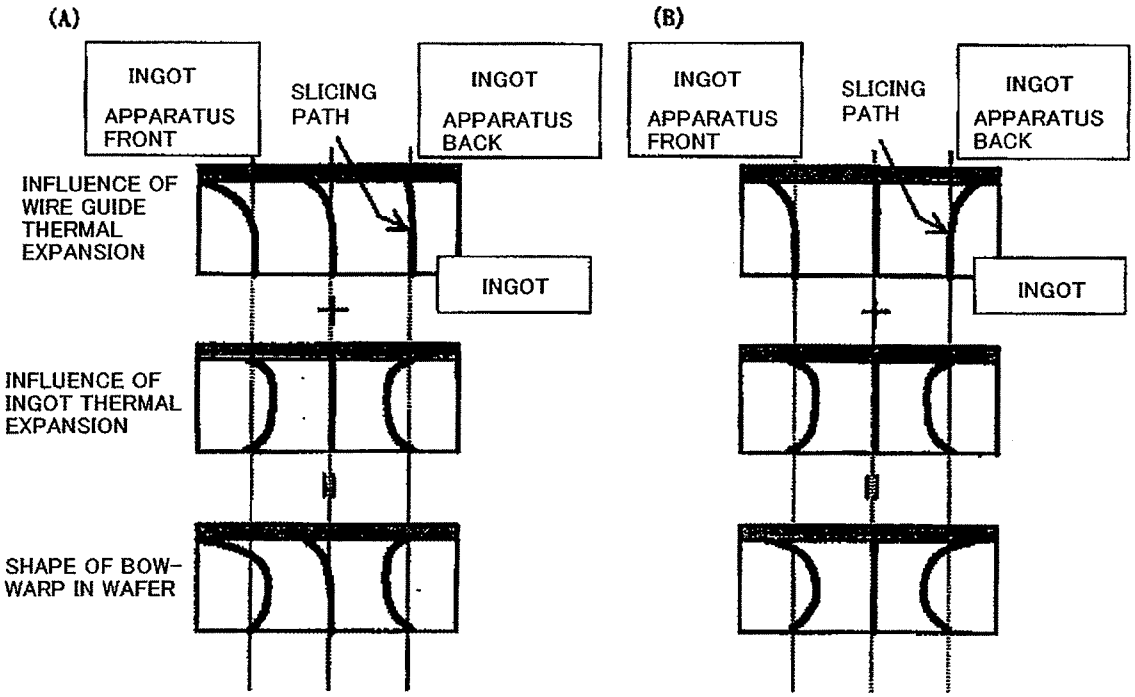
[FIG. 13]



[FIG. 14]


(A)
INGOT
SLICING PATH
THERMAL EXPANSION
WIRE GUIDE
(B)
INGOT
SLICING PATH
THERMAL EXPANSION
WIRE GUIDE
(C)
CONTRACTION
THERMAL EXPANSION
INGOT
WIRE GUIDE

[FIG. 15]


(A)
INGOT
APPARATUS FRONT
SLICING PATH
INGOT
APPARATUS BACK
INFLUENCE OF WIRE GUIDE THERMAL EXPANSION
INGOT
INFLUENCE OF INGOT THERMAL EXPANSION
SHAPE OF BOW-WARP IN WAFER
(B)
INGOT
APPARATUS FRONT
SLICING PATH
INGOT
APPARATUS BACK
INGOT