THE TEMPERATURE OF DRY PIECES AND THEIR RELATIONSHIP WITH THE ENAMELING PROCESS

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SUMMARY

The present work studies the differences in temperatures usually found in raw dry tiles in the manufacturing process by single cooking, as well as their origin and possible influence in the following enameling operation.

The analysis is presented in a systematic way so that it can be used as a control of that variable in the production process.

INTRODUCTION

The drying of ceramic flooring and tiles obtained by single cooking process has normally been done in Vertical or Horizontal Dryers joined compatibly to the Press and Enameler in a continued chain.

Both types, and even the latest single layer and microwave models have maintained the general drying principles but they individualize the tiles during the process.

Compared to the traditional dryers, estatic or dynamic, in which the element to be dried was the tile but regarded as a group (small wagon), the new dryers are always dynamic and separate them; this can be regarded as drying by single layer.

Together with a more regular and uniform drying, there is the novelty of being joined compatibly to the press and enameler forming a chain of constant flow, so that the stoppage of the last one means the automatic start up in the dryer so that we can consider it as a regular and constant flow. Then we have the fact that the piece will be immediately enemeled by any of the normal techniques (disc, bell, etc.) and that it must present the adequate characteristics for this operation.

The pieces must be RESISTANT, DRY and with an ADEQUATE TEMPERATURE. The first two factors can be regulated by manipulating the constants of the dryer (temperature, flow and humidity of the air, cycle, etc.) but the last presents fewer opportunities to be controlled according to the needs of the enameling chain.

Together with the variations in the cycle imposed by the stoppages in the chain are the variations in the design of the machine, and although the ideal for the enameling process would be a constant temperature of the pieces, problems frequently arise. These problems are aggravated when the pieces are enameled with a porous covering by a double bell, as the great quantity of water provided by the enamel, and which deteriorates the physical characteristics of the piece, adds to the difficulty of its application making it one of the greatest problems of the drying stage.

Thus the variations and range of temperatures is a determining factor in the correct production of ceramic flooring and tiles.

The present study tries to analyse the different types of dryers as well as the variations in temperature that are usually found in each one, and how these affect the enameling operation.

The analysis is presented in a systematic way so that it can be used as a control of that variable in the production process.

EXPERIMENTAL

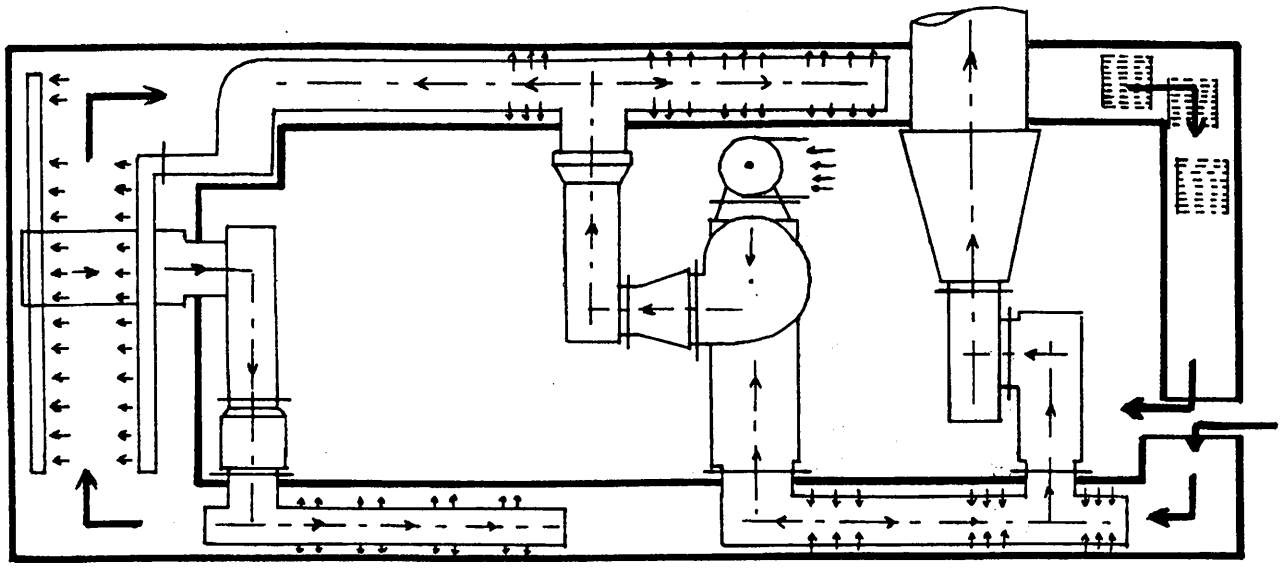
Two types of dryers were studied. One horizontal and the other vertical. Several versions (sizes) of the latter were studied.

Figures I and II show the drawings of the dryers of the brands SITI and SACMI.

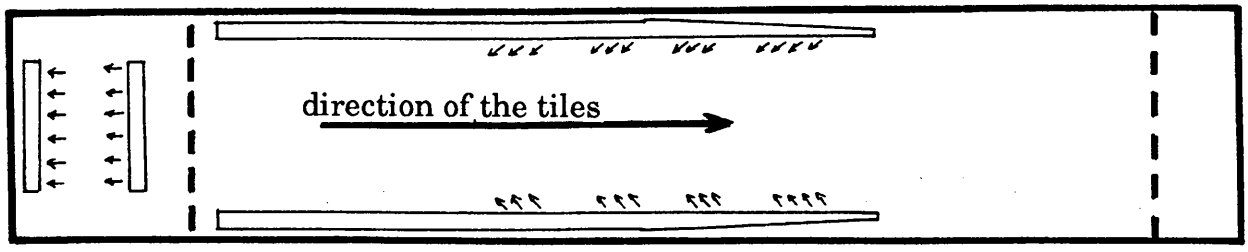
Contact thermometers and infrared thermometers, usual in the Control Department, were used to control the temperature.

FIG I

HORIZONTAL DRYER



upper area



lower area

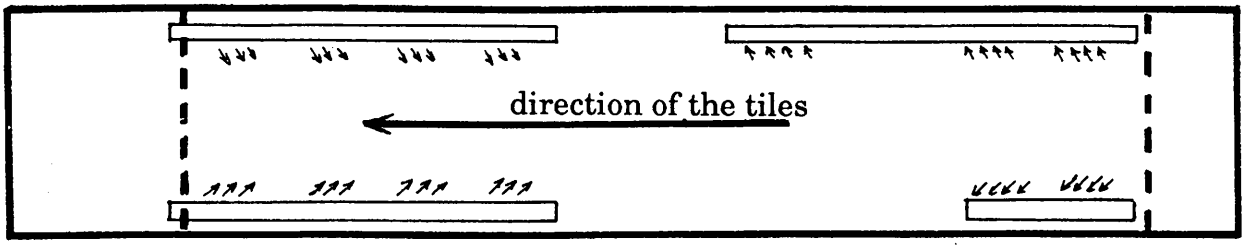


FIG II A

VERTICAL DRYER

1. heat generator
2. ventilator

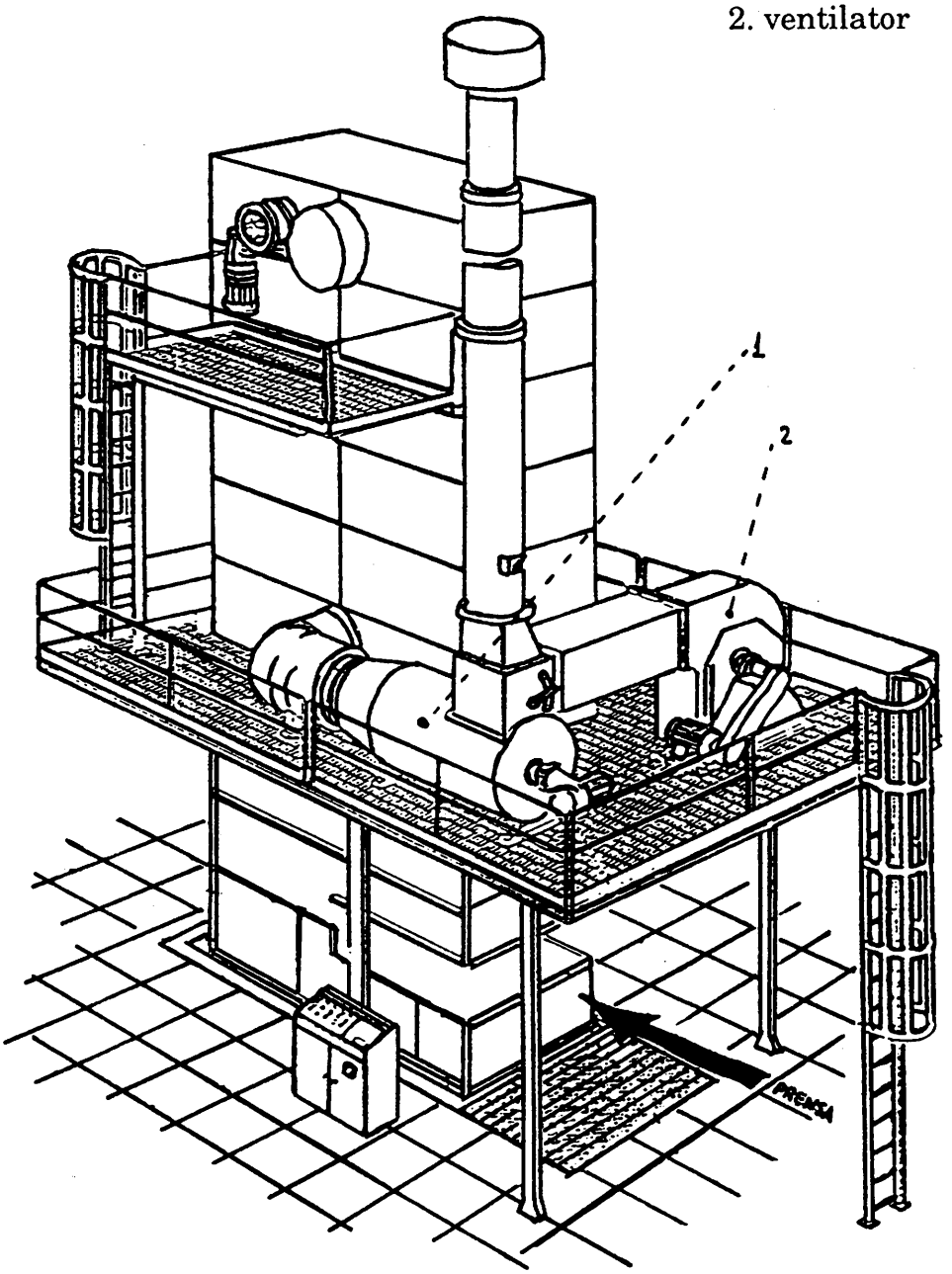
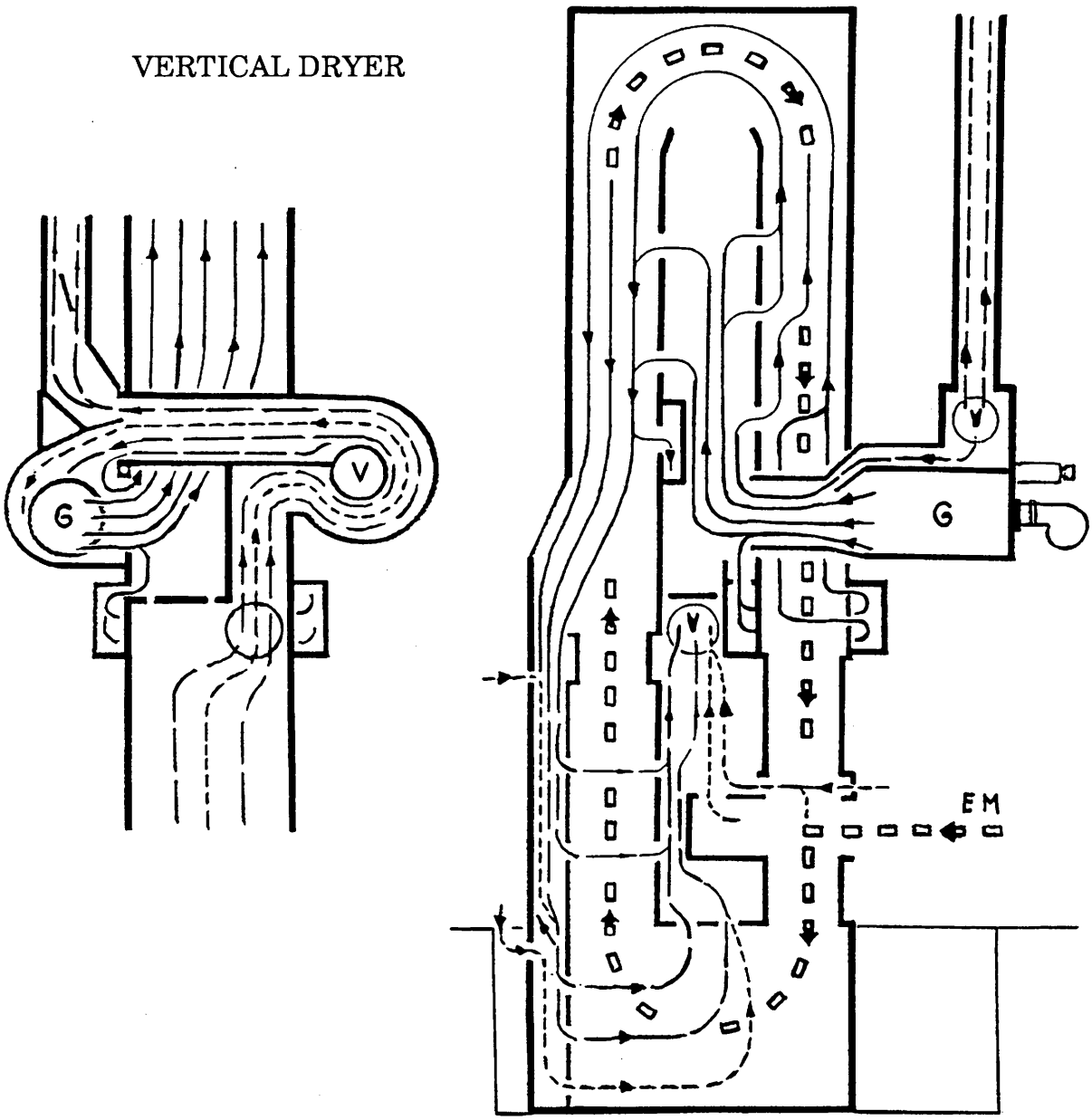


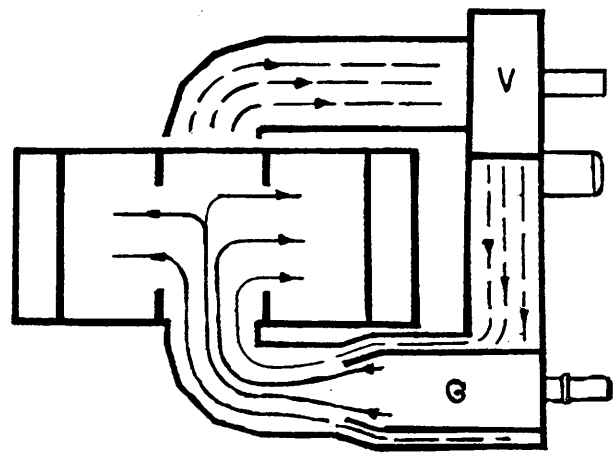
FIG II B

VERTICAL DRYER



-Circulation system of drying air and movement of material

———	Hot air
— —	Humid air
----------	Cold air
EM	Entry of material
G	Generator
V	Ventilator



RESULTS AND DISCUSSION

Carrying out this study has meant determining the variations in temperature of the dry tiles. For this, readings were taken at the exit of the dryer, that is, before enameling, noting the location of the tile in order to determine the eventual relationship between the temperature and other factors related to the installation or the enameling process.

In this way, and having registered the variations in temperature along the length and breadth of the dryer as well as in time we tried to determine their influence on the enameled tile noting their characteristics, functioning and presence of defects.

For taking the temperatures, the dryers were divided into parts according to their structure, that is by baskets and each basket by grills.

TABLE I shows the temperatures taken for the tiles in a basket (14 grills) in normal working operation (14 strokes/minute). The temperature programmed in the VERTICAL DRYER was of 205 degrees Centigrade and the format was of 25 x 40 cm. so that two tiles were placed in front (D) and two behind (T).

Figure 1 shows the temperature curves for the four groups of tiles. We therefore have a map of the temperatures in the basket which will be repetitive for the normal work cycle.

TABLE II shows the temperatures for another vertical dryer loaded with two tiles of 50 x 50 cm. at a speed of 11 strokes per minute and a programmed temperature of 140 degrees centigrade. In this dryer the baskets have 13 grills.

Figure 2 shows the temperature curves for the two groups of tiles.

TABLE I

TEMPERATURES IN A BASKET OF A VERTICAL DRYER

GRILL	PLATE 1-D	PLATE 2-D	PLATE 1-T	PLATE 2-T
1	90	91	95	98
2	86	86	90	91
3	81	81	84	85
4	79	81	82	84
5	79	80	83	84
6	79	83	81	88
7	79	84	81	89
8	80	85	83	89
9	80	85	84	91
10	80	86	83	89
11	79	85	82	88
12	79	84	81	86
13	80	85	81	85
14	92	97	94	99

Maximun Temperature: Grill 14 - Plate 2-T = 999

Minimun Temperature: Grill 7 - Plate 1-D = 79

Variation: 20

FIG - 1

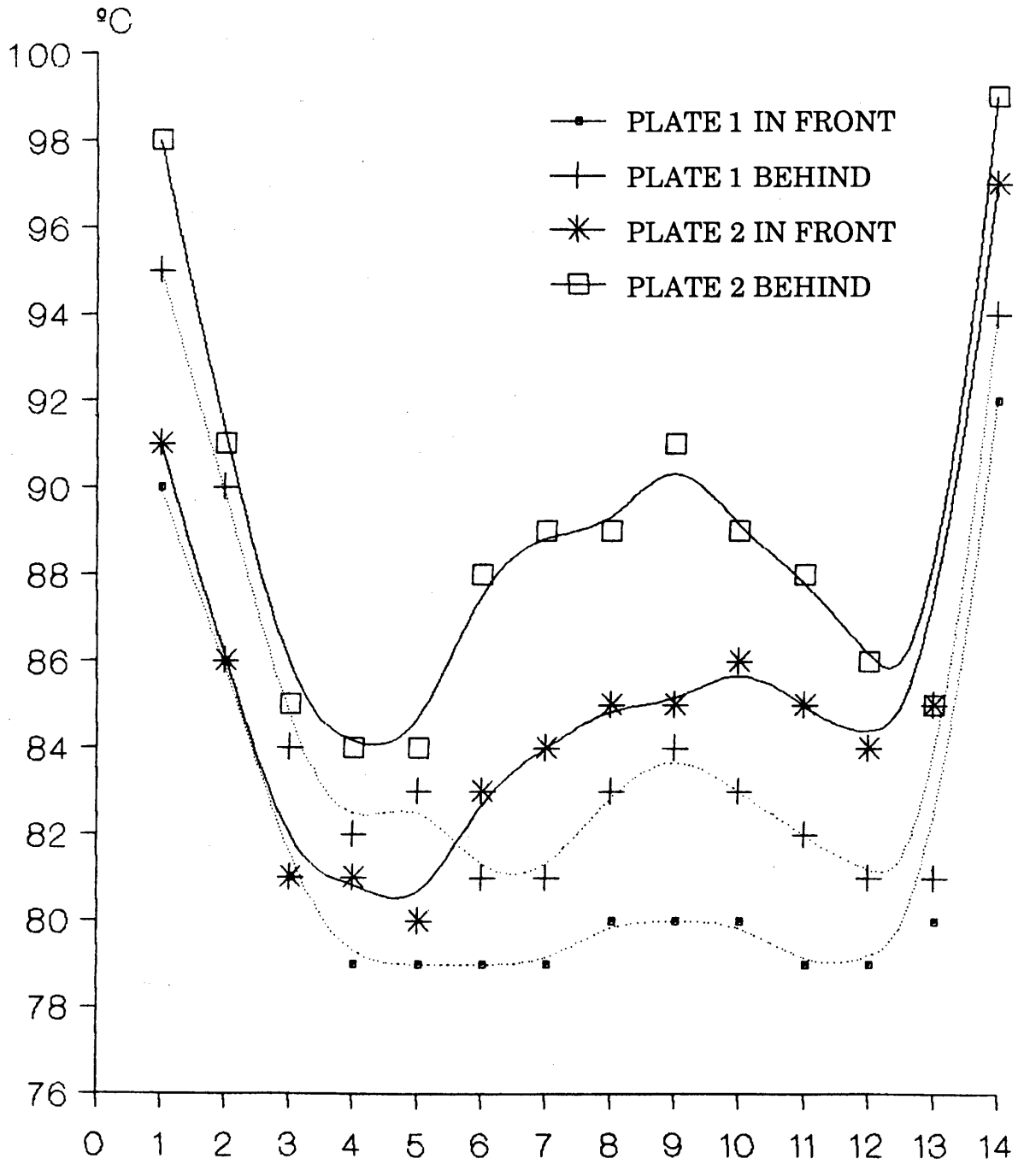

ºC
100
98
96
94
92
90
88
86
84
82
80
78
76
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
PLATE 1 IN FRONT
PLATE 1 BEHIND
PLATE 2 IN FRONT
PLATE 2 BEHIND
GRILL

TABLE II

TEMPERATURES IN A BASKET OF A VERTICAL DRYER

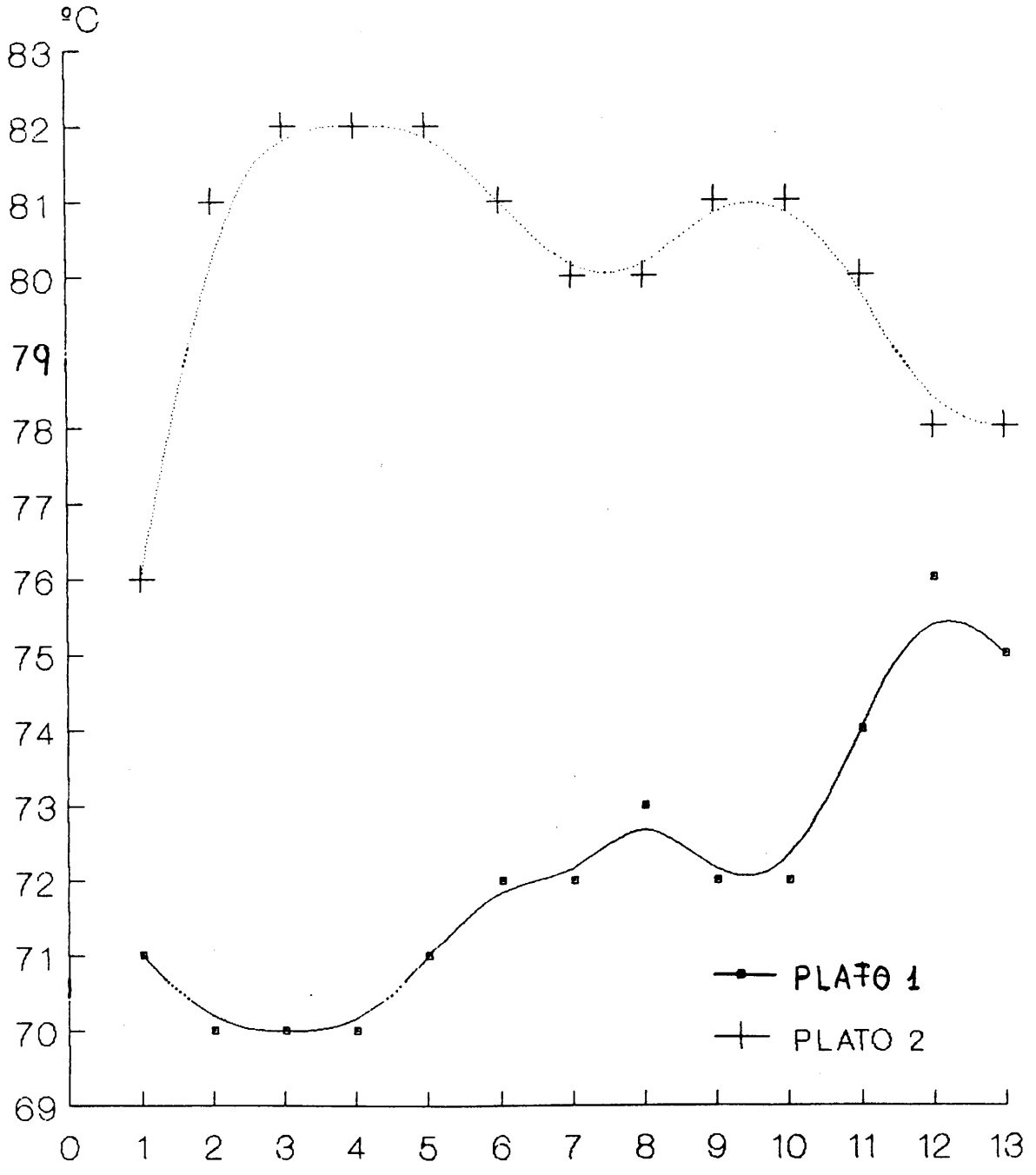
GRILL	PLATE 1	PLATE 2
1	71	76
2	70	81
3	70	82
4	70	82
5	71	82
6	72	81
7	72	80
8	73	80
9	72	81
10	72	81
11	74	80
12	76	78
13	75	78

Maximun Temperature: Grill 4 - Plate 2 = 82

Minimun Temperature: Grill 4 - Plate 1 = 70

Variation: 12

FIG - 2


ºC
83
82
81
80
79
78
77
76
75
74
73
72
71
70
69
0
1
2
3
4
5
6
7
8
9
10
11
12
13
PLATO 1
PLATO 2

GRILL

A third example is presented in TABLE III for another type of dryer, in this case HORIZONTAL, which is loaded with 3 tiles of 33 x 33 cm. at a programmed temperature of 190 degrees Centigrade, speed of 10 cicles/minute and with baskets of 11 grills.

Fig. 3 shows the curves for the three groups of tiles.

Lastly, we present TABLE IV, the last example, with another HORIZONTAL dryer loaded with tiles of 33 x 33 cm. with 14 cicles per minute in baskets of 11 grills with a programmed temperature of 155 degrees Centigrade.

Also for this case we present the curves of temperatures in fig. 4.

Of the examples taken in which we have only controlled the variations in temperature with regard to the location on the basket we have:

	VARIATION
VERTICAL DRYER 1	20°
VERTICAL DRYER 2	12°
HORIZONTAL DRYER 1	27°
HORIZONTAL DRYER 2	27°

Next we took the temperatures in a fixed grill and plate for each and every one of the baskets along the complete drying cycle.

With this we will verify the variations in temperture due to incidents during the operation.

In figures 5, 6 and 7 we show graphs of the temperatures of said point in all of the baskets and at three different moments during the functioning of a VERTICAL DRYER.

In figures 8-A, 8-B and 8-C we show the graphs for temperatures for said point along all of the baskets during the functioning of a HORIZONTAL DRYER.

TABLE III

TEMPERATURES IN A BASKET OF A HORIZONTAL DRYER

GRILL	PLATE 1	PLATE 2	PLATE 3
1	59	52	3
2	52	50	47
3	50	45	46
4	48	46	42
5	45	44	41
6	44	44	39
7	44	43	39
8	47	44	39
9	52	49	44
10	52	54	50
11	58	66	53

Maximun Temperature: Grill 11 - Plate 2 = 66

Minimun Temperature: Grill 6 - Plate 3 = 39

Variation: 27

FIG - 3

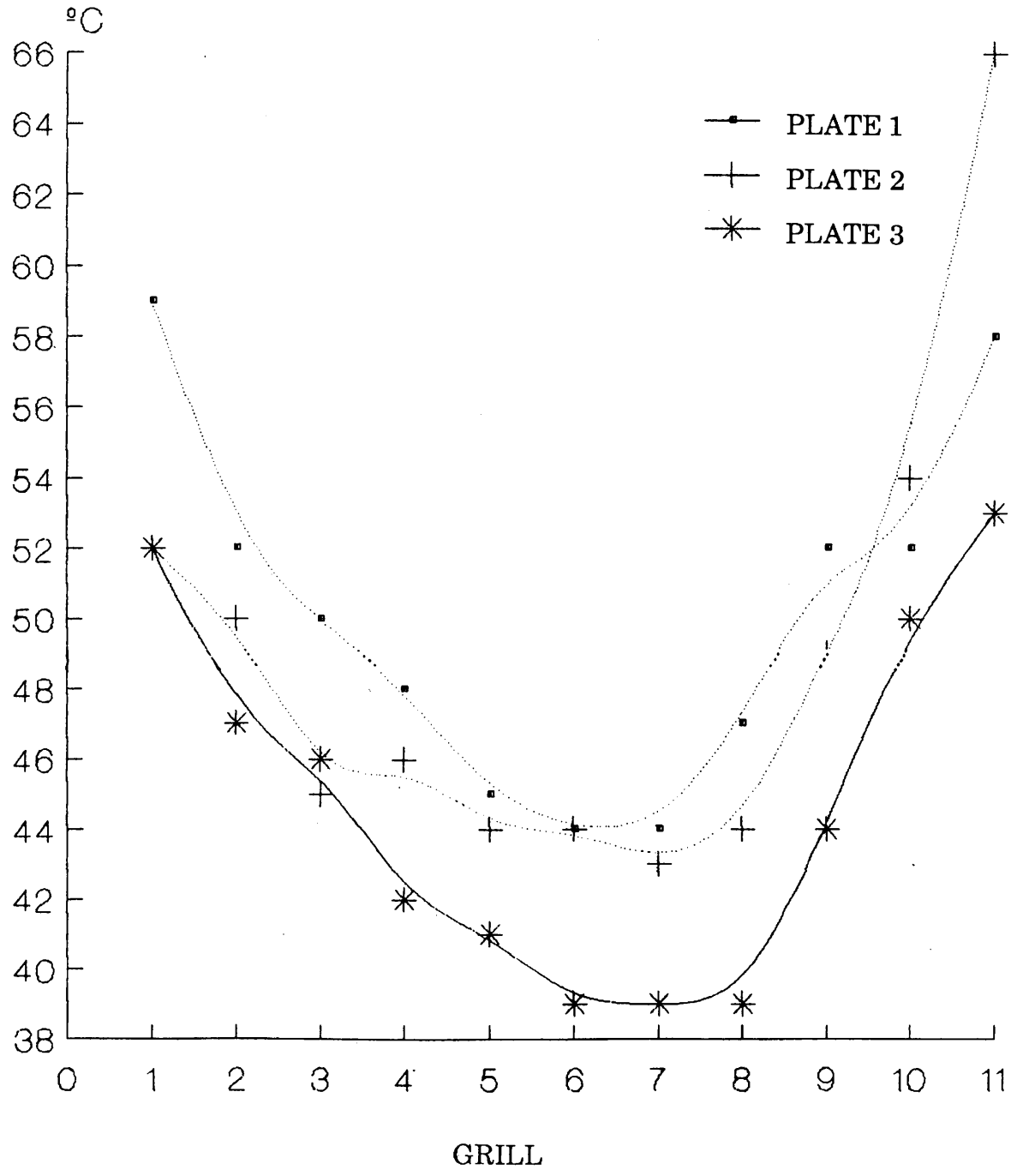

ºC
66
64
62
60
58
56
54
52
50
48
46
44
42
40
38
0
1
2
3
4
5
6
7
8
9
10
11
PLATE 1
PLATE 2
PLATE 3
GRILL

TABLE IV

TEMPERATURES IN A BASKET OF A HORIZONTAL DRYER

GRILL	PLATE 1	PLATE 2
1	79	64
2	75	57
3	74	53
4	74	53
5	74	54
6	73	56
7	74	57
8	72	61
9	71	60
10	76	64
11	80	69

Maximun Temperature: Grill 11 - Plate 1 = 80

Minimun Temperature: Grill 4 - Plate 2 = 53

Variation: 27

FIG - 4

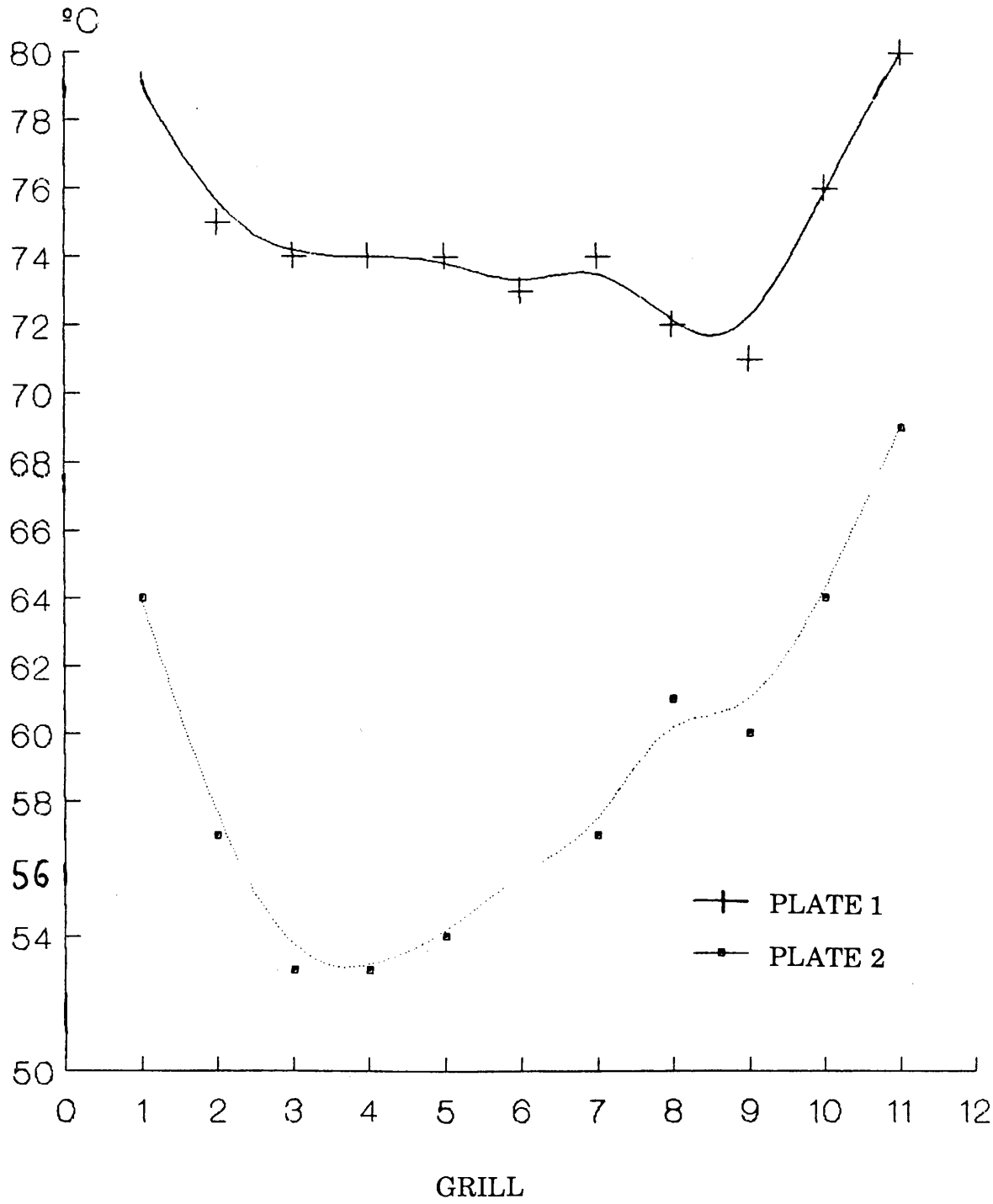
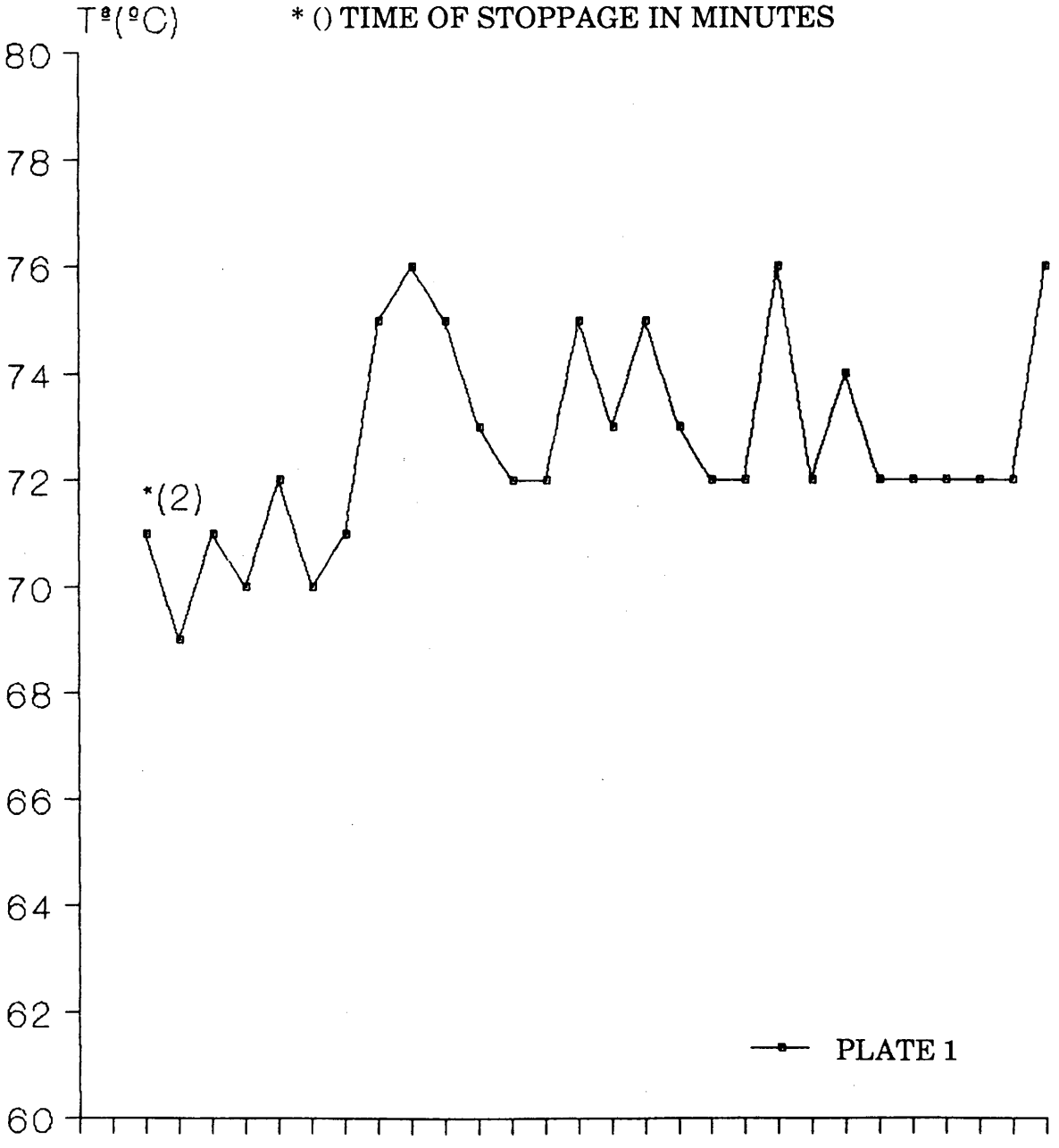

ºC
80
78
76
74
72
70
68
66
64
62
60
58
56
54
50
0
1
2
3
4
5
6
7
8
9
10
11
12
PLATE 1
PLATE 2
GRILL

FIG -5

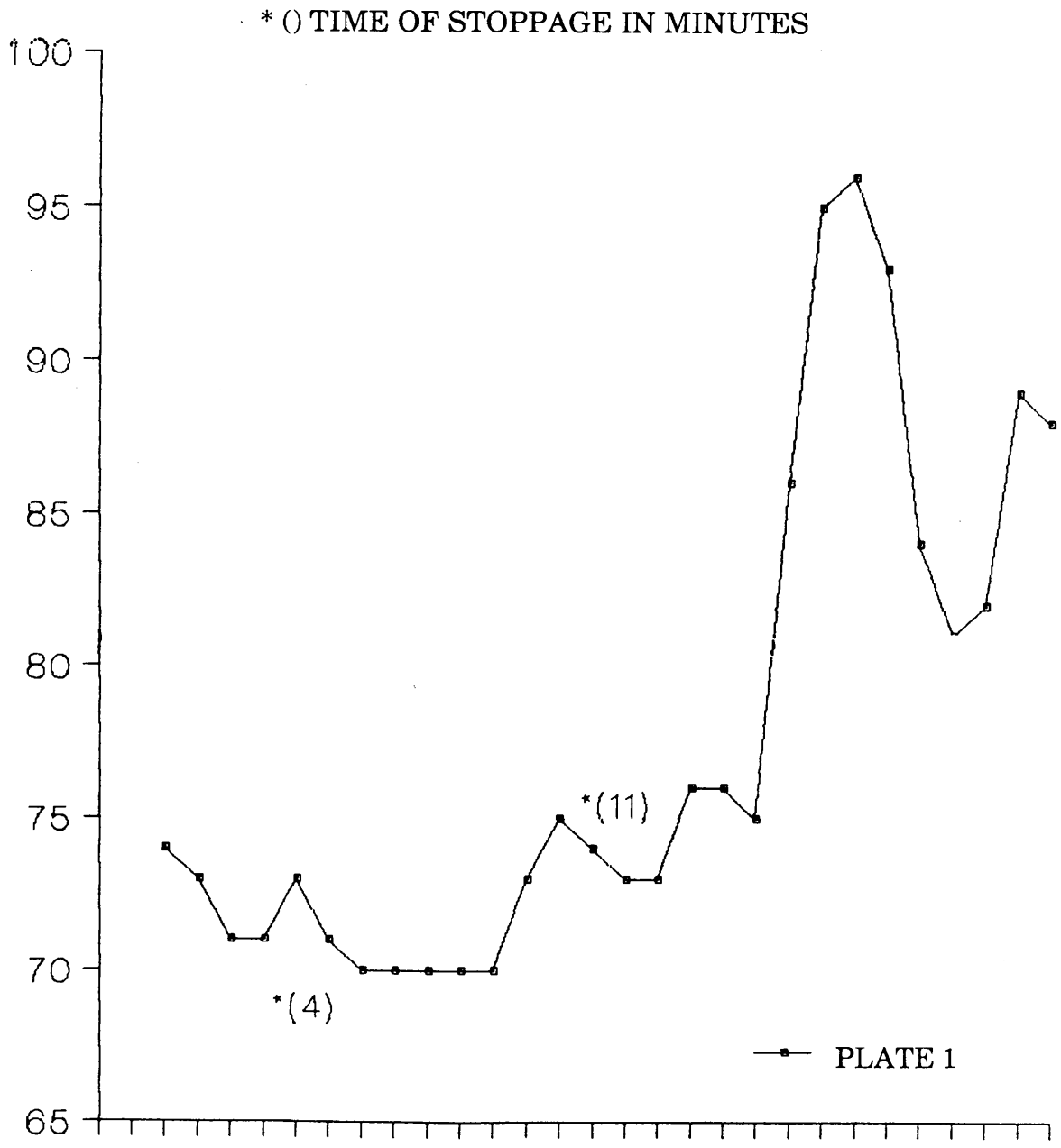
VERTICAL DRYER



FROM BASKET 1 TO 28

FIG - 6

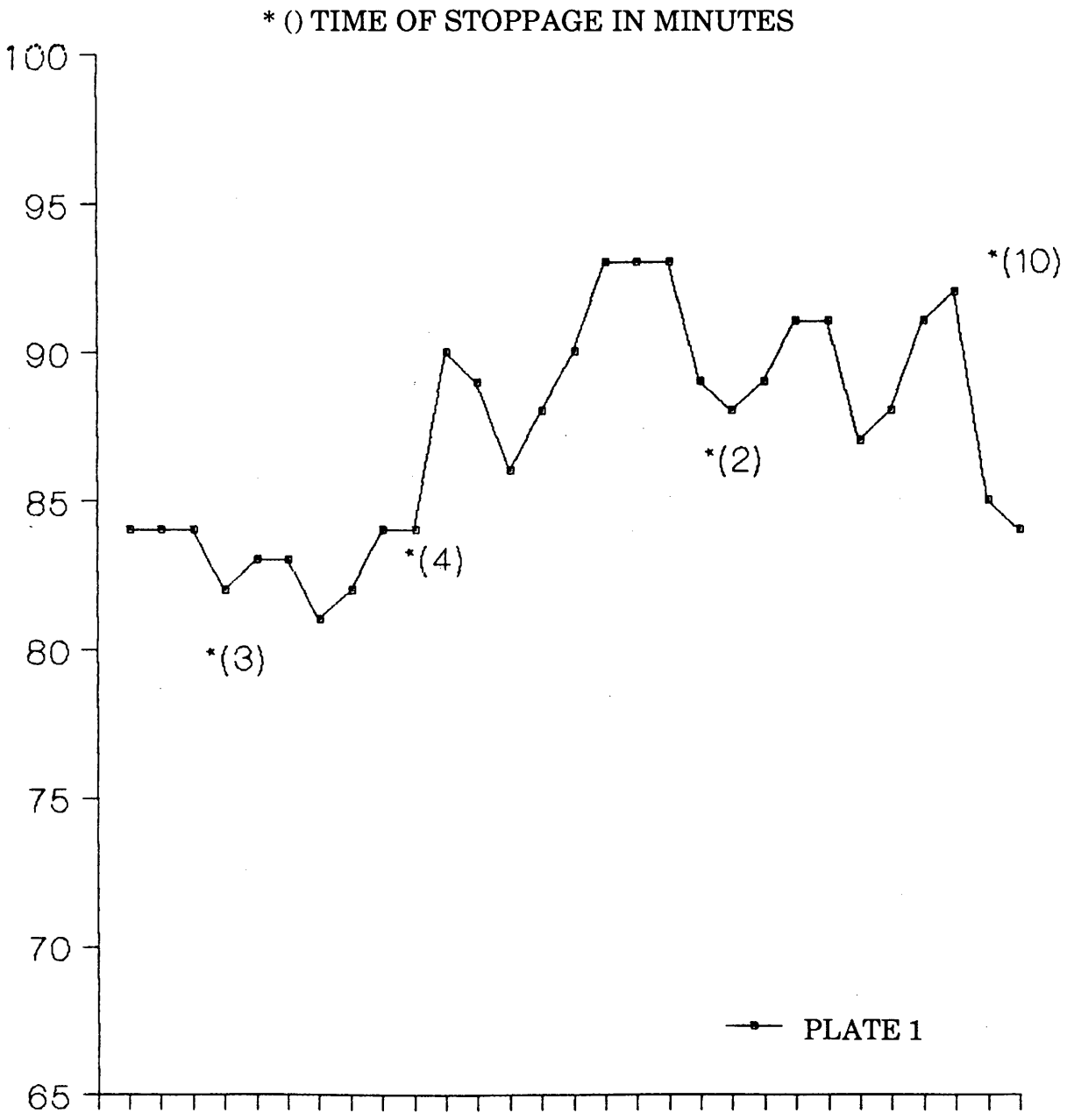
VERTICAL DRYER



FROM BASKET 1 TO 28

FIG - 7

VERTICAL DRYER

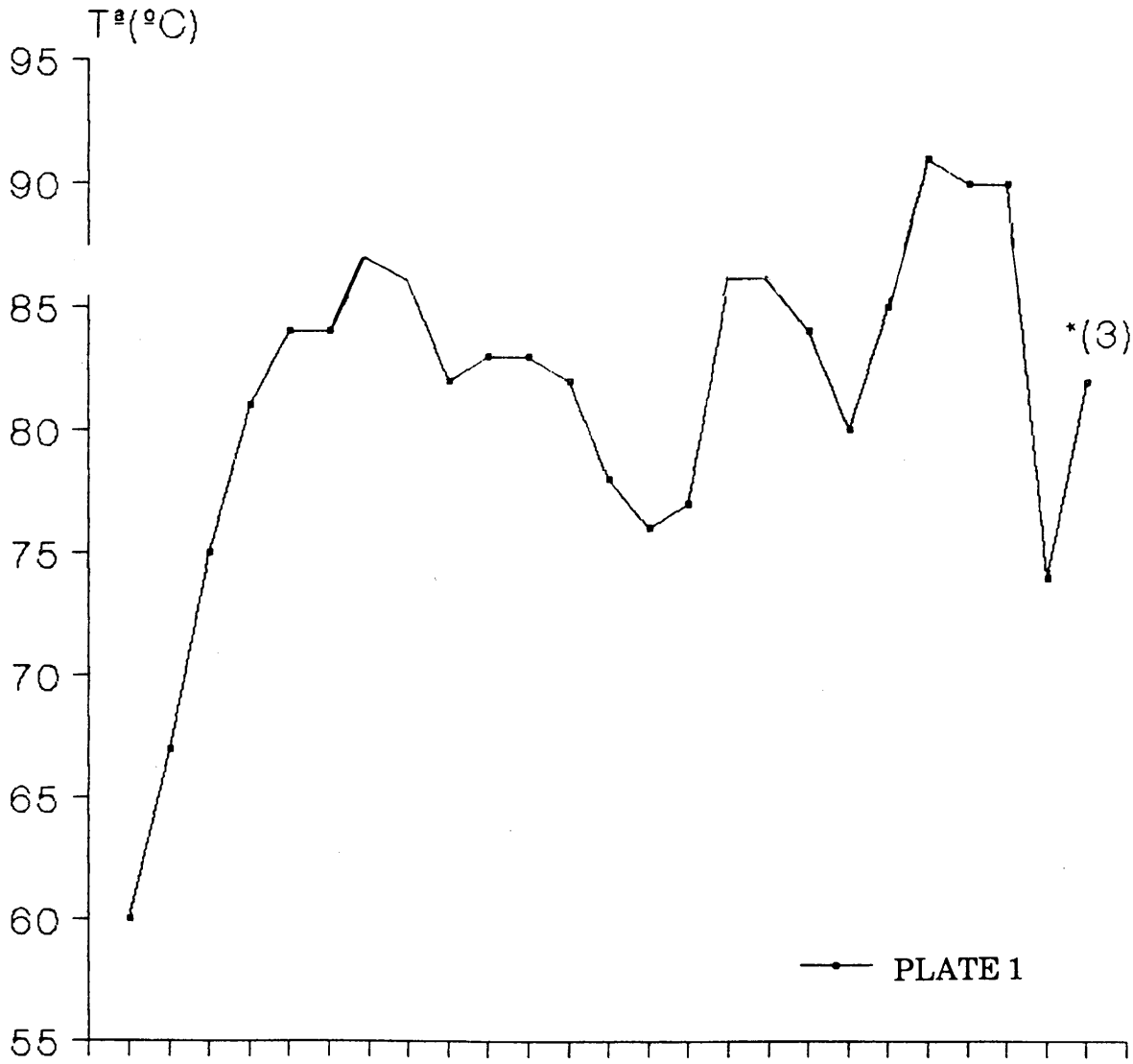


FROM BASKET 1 TO 28

FIG - 8A

HORIZONTAL DRYER

*() TIME OF STOPPAGE IN MINUTES

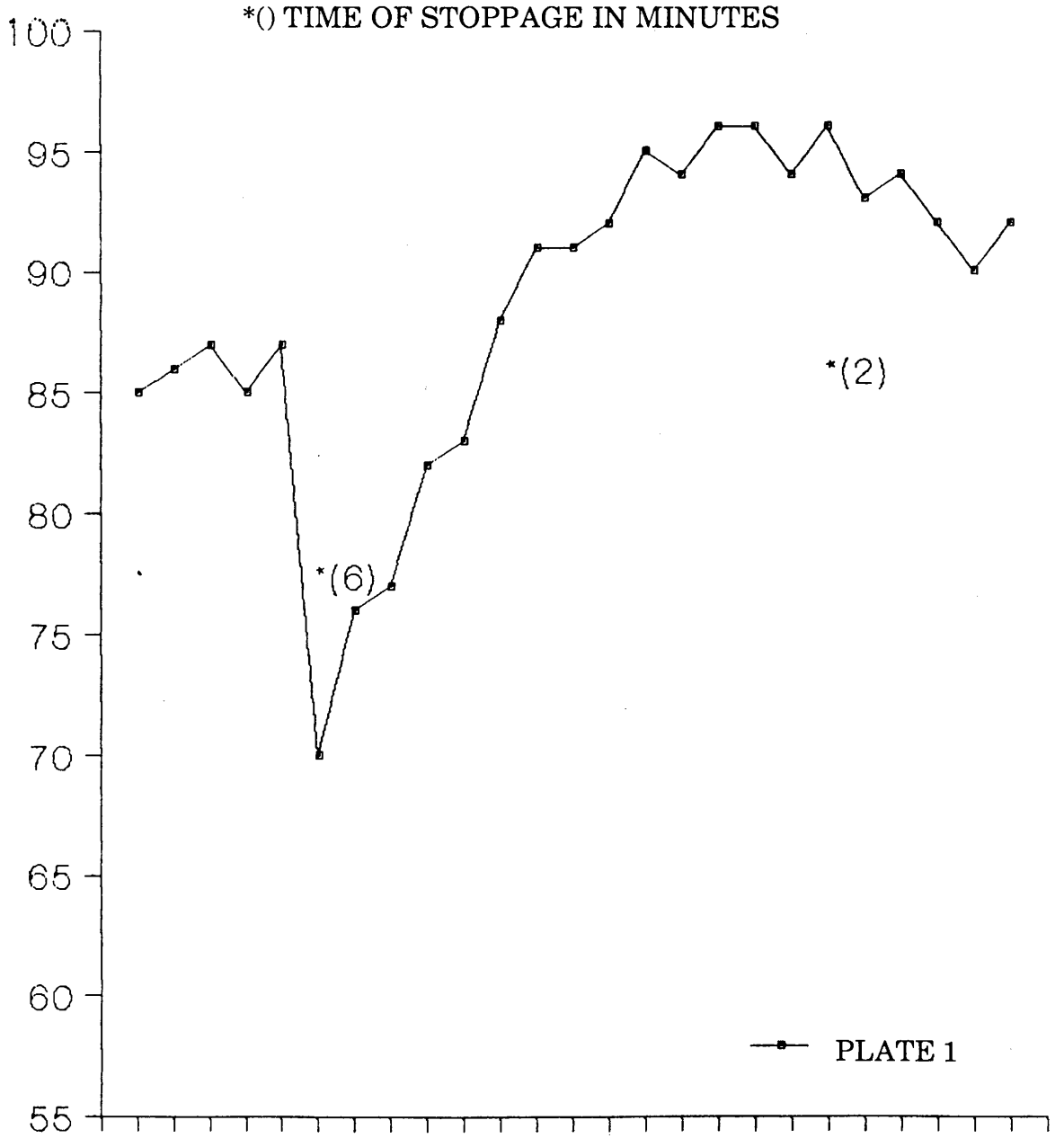


FROM BASKET 1 TO 25

Data taken after a stoppage of 50 minutes.
The temperatures before the stoppage fluctuate between 75 and 80°C.

FIG -8B

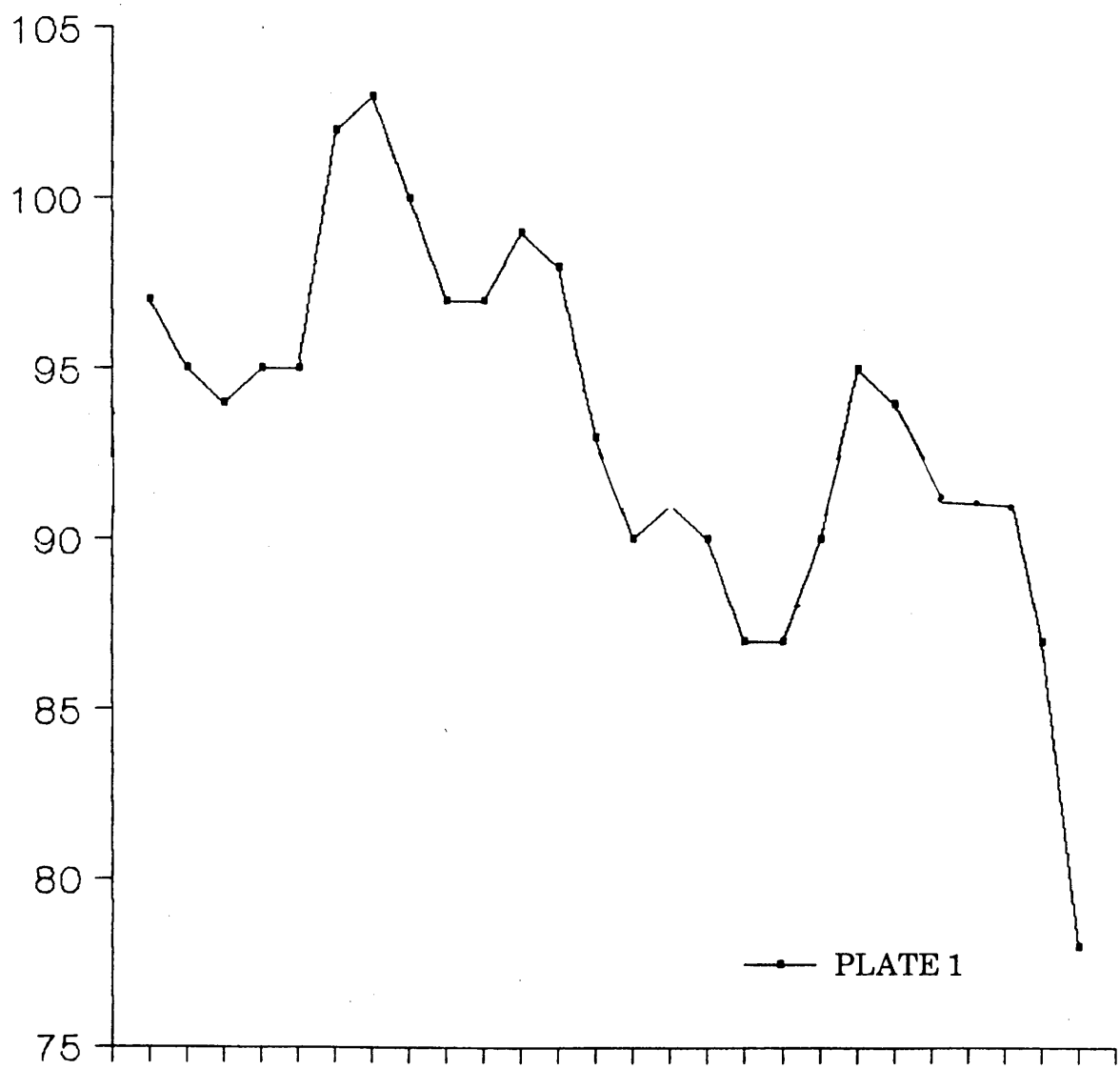
HORIZONTAL DRYER



FROM BASKET 26 TO 50

FIG - 8C

HORIZONTAL DRYER



FROM BASKET 50 TO 76

From all of this data we can now draw several conclusions:

1. The differences in temperature in the best of cases (temperatures in the basket), are in the range of 15-20° for the vertical dryers studies and of 25-30° for the horizontal dryers.

2. The differences in temperature for the most common working case are of 20-25° for the vertical and of 30-35° for the horizotal dryers.

3. The differences in temperature in the worst of cases and unfourtunately all too often is of 25-30° for the vertical and of 30-40° for the horizontal dryers.

Let us now see how these differences in temperature influence two specific or determining factors of the enameling process:

a) Quantity of water of the piece
b) Time of drying of the enamel

The results obtained are represented in figure 9 as a support of white stoneware.

Also, we must indicate that the enameled tiles had a problematic convex curve for the process of serigraphy (silk screen) for all cases of temperatures below 70°C.

With respect to the Mechanical Resistance of these enameled pieces there were also significant variations.

Lastly, and with the end of studying later operations geared to fixing the working conditions, that is creating the OPERATIONAL STANDARDS, we present a specific case of the origin of the problems shown as a different temperature along all of the drying tunnel between the right and the left side and due to an incorrect regulation of the circulation of air. Figures 10-A and 10-B.

FIG - 9

TEMPERATURE OF THE PIECE - TIME OF DRYING

WHITE STONEWARE

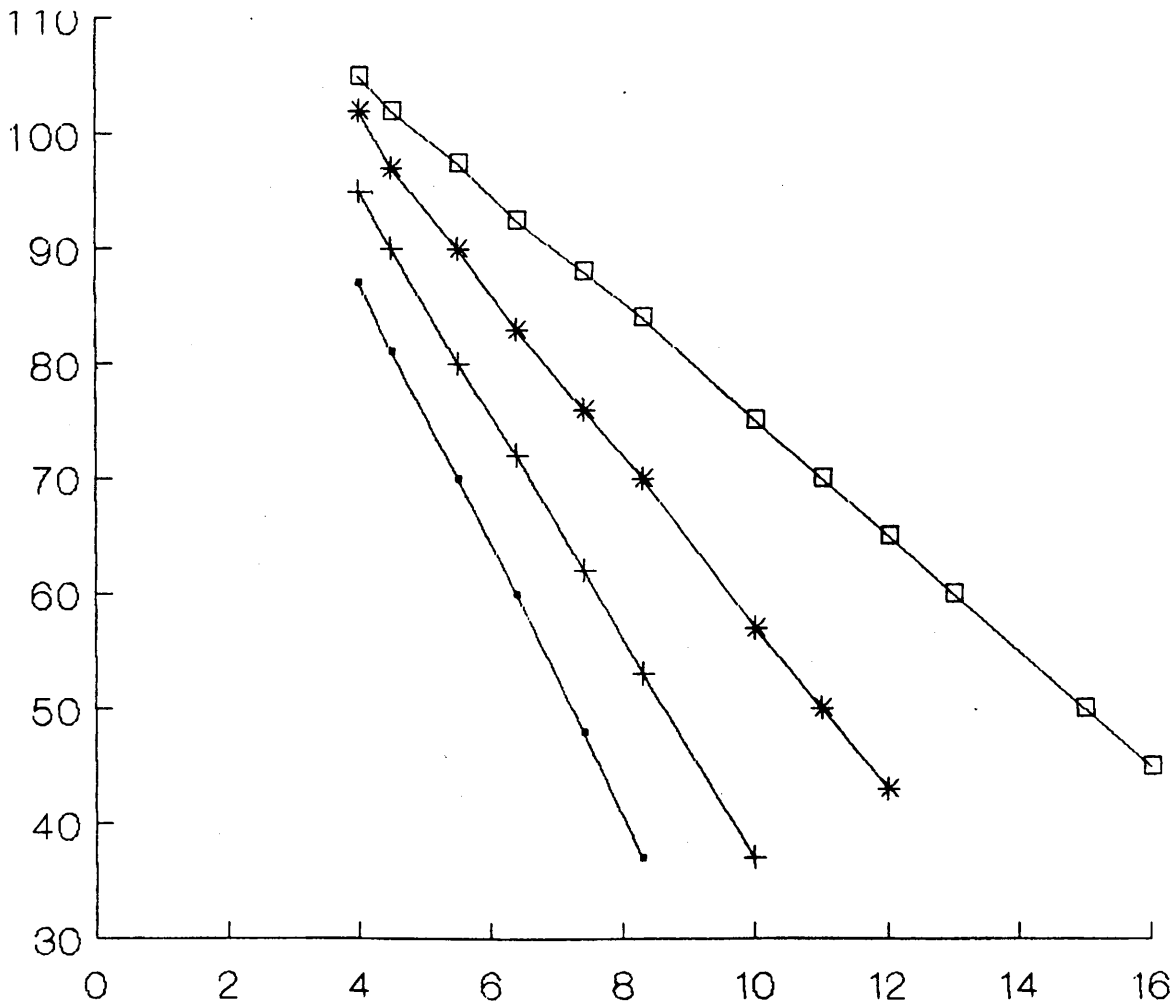


FIG - 10-A

HORIZONTAL DRYER

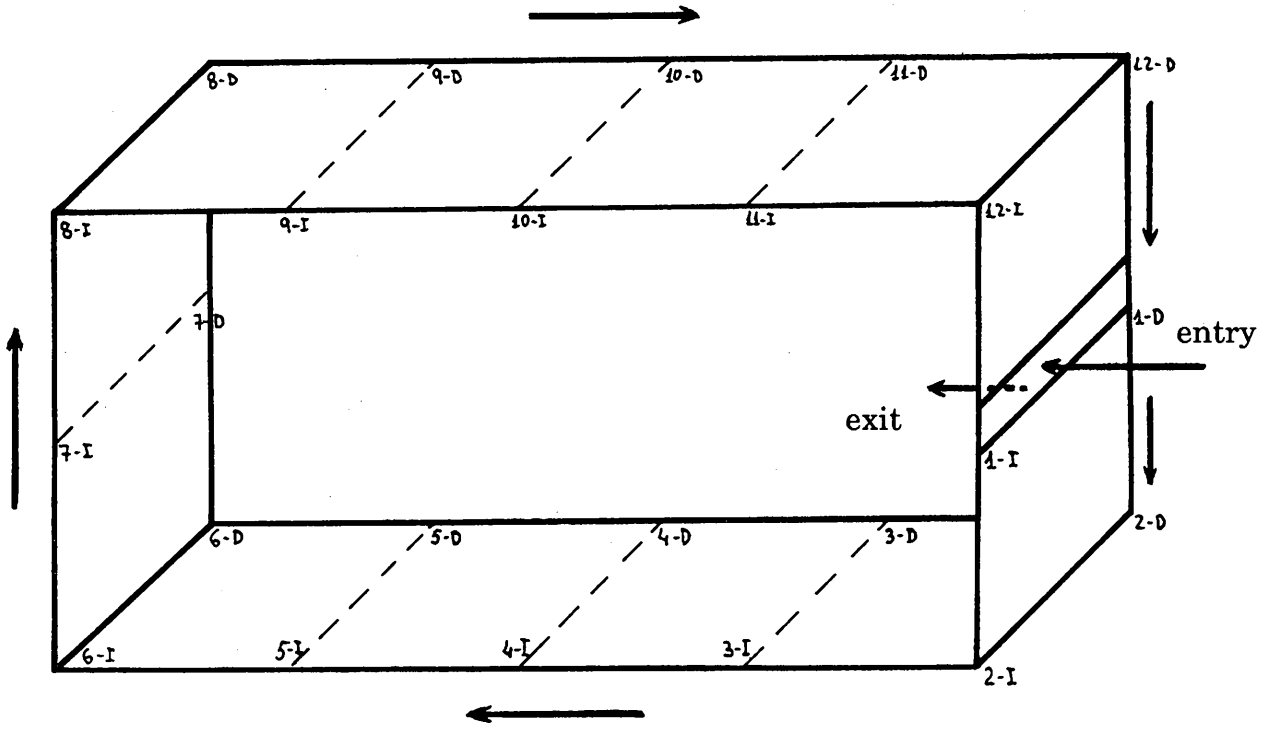
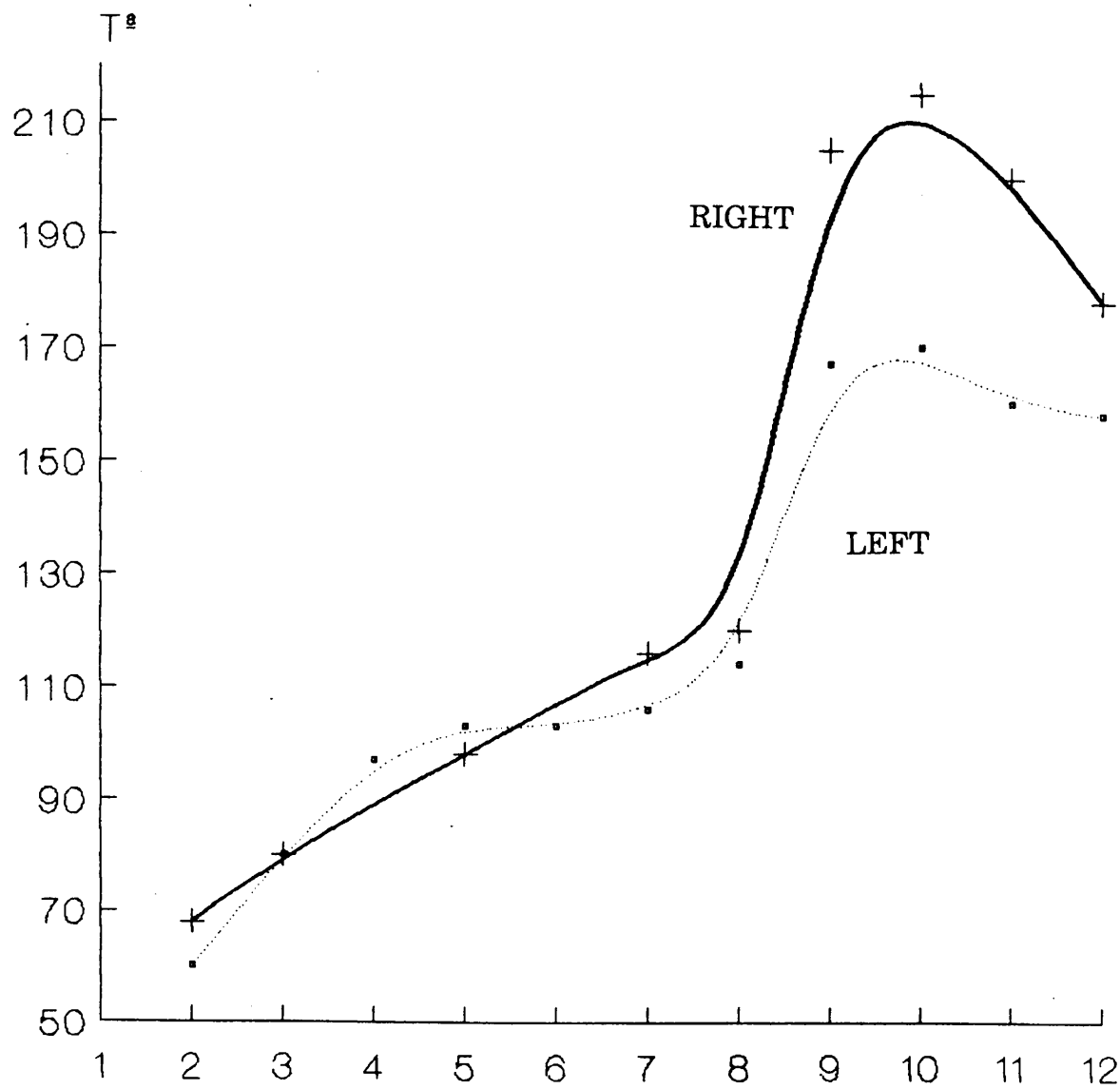


FIG - 10-B

HORIZONTAL DRYER



CONCLUSIONS

Given the importance, determinant in many cases, and the ifluence the temperature has on the dry tile and the correct application of enamel by bell, we need to observe this with reference to the OPERATIONAL STANDARDS.

The temperature of the dry tile is determined by the functioning of the dryer and we have a variety of different construction designs.

The present work tries to specify the differences in the temperatures ususally found in the production process as well as their origin and possible influence in the later enameling process.

We can conclude that the usual differences can be caused by innumerable problems, and their solution requires a careful monitoring of all of the drying/dryer variables with the object of achieving OPERATIONAL STANDARDS both for the regulation of the dryer and for the temperature of the tiles and their control. All of this is specified in figure 11.

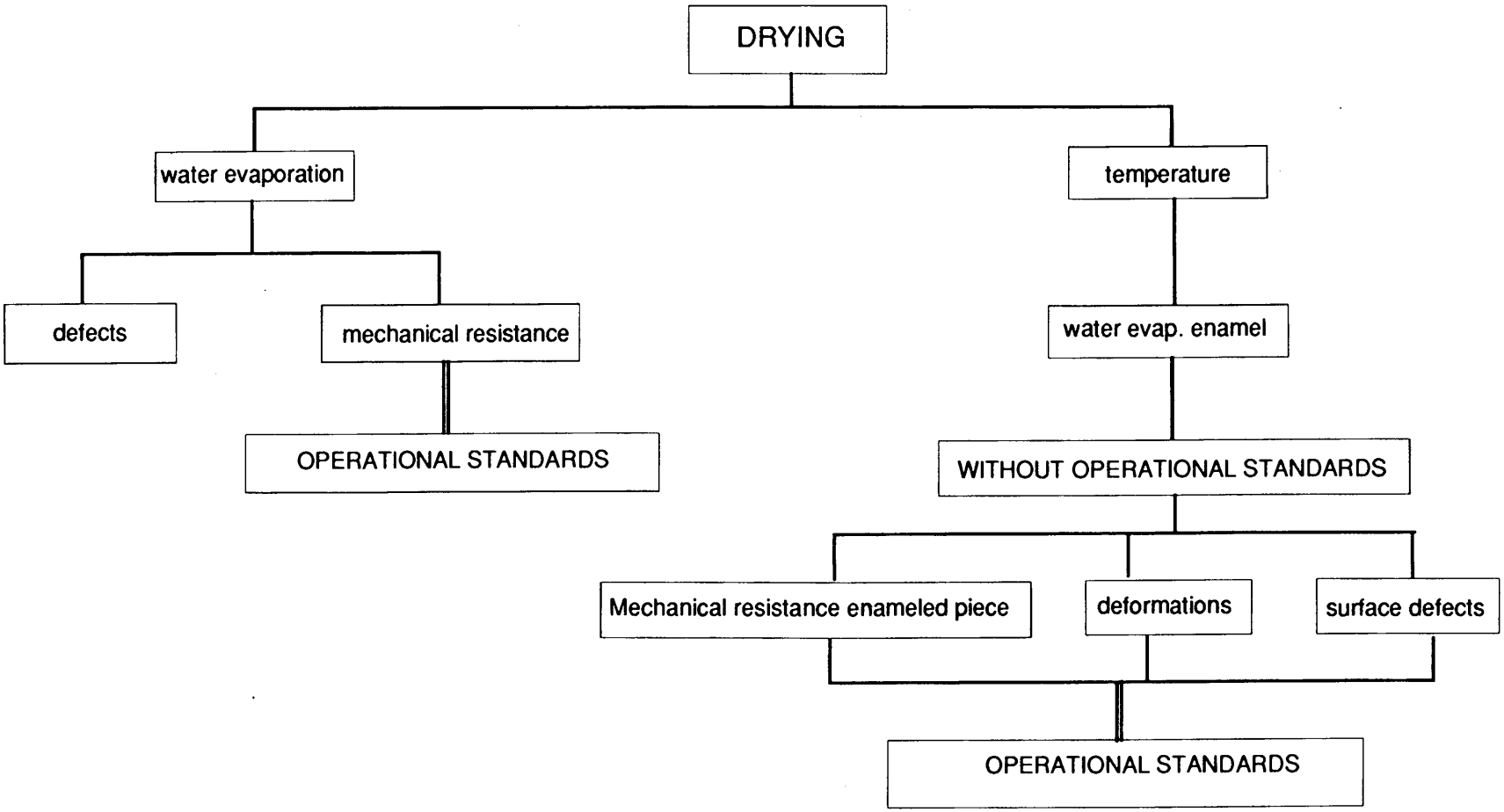

DRYING
water evaporation
temperature
defects
mechanical resistance
water evap. enamel
OPERATIONAL STANDARDS
WITHOUT OPERATIONAL STANDARDS
Mechanical resistance enameled piece
deformations
surface defects
OPERATIONAL STANDARDS

FIG - 11