SEDIMENT SEPARATOR

by

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and

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CER65HWS-RJK28

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I. INTRODUCTION

In the field of sedimentation, researchers have been frequently confronted with the problem of separating sediment into different sizes. Sieving has been the common method for separating coarse sediments but no device to separate fine particles (size less than 100 μ) satisfactorily is available at present.

A new separator based on the principal of centrifugal action for separating fine particles was designed by the United States Geological Survey at Fort Collins, Colorado in 1964.

The main objects of this study are to test and develop this new separator.

II. PREVIOUS WORKS

The following sediment separators are available: 1) Decantation cylinder by Kuhn, Appiani, Atterberg, U.S. Bureau of Mines, Trask, Iowa State University, and Russians; 2) Water elutriator by Schone, Schulze, Hilgard, Yoder, and Gardner; 3) Air elutriator by Peterson, Bureau of Standards, Gonell and Roller.

A review of these different devices can be found in "Method of Analyzing Sediment Samples," by the St. Paul U.S. Engineer District Suboffice, State University of Iowa, Iowa City, Iowa. As stated in this report that "...the greater number of the present methods are not sufficiently sensitive and accurate for analyzing suspended sediment samples of very low concentrations. The need for development of rapid, accurate, and reliable methods adaptable to mass analysis of suspended sediment samples is apparent."

A sediment separator as shown in Figure 1 was designed by the United States Geological Survey.

III. DESCRIPTION OF THE SEPARATOR

A sketch of this separator is given on Figure 1. This separator consists of the following four parts: 1) An air blower to move the sediments, 2) A mixing chamber to mix the fine particles with the flow, 3) An initial separation section to separate the particle by centrifugal actions, and 4) A final particle separation and collection section to collect the particles at different locations according to their fall velocities.

The air blower is a Dayton Model 20841 with 1585 RPM and 1/12 horsepower. The sediment particles are fed through a funnel with controlled outlet. The mixing chamber has three rows of vertical baffles (each 3/8 inch high and 1/16 inch thick) at uniform spacings of 3 inches. A movable curved plastic plate as shown in Figure 2 can be set at different positions of the initial separation section to modify the shape of that section. Figure 3 shows the different restrictions of the section and Figure 4 gives the different positions of this movable plate. As shown in Figure 3d a set of baffle plates was placed in the initial separation section for some experiments.

The particle collection section is filled up with water to eliminate air circulation. Three rows of 3/4 inch diameter test tubes were set at approximately one inch apart for the collection of sediment particles. A screen is placed just under the water surface to prevent the circulation of water and the generation of water waves.

IV. EXPERIMENTAL PROCEDURE

1. Modified the initial separation section with either the curved plastic plate at desired position or the set of inclined baffles.
2. Placed the test tubes into a holder in the particle collection section.
3. Filled all the test tubes and the entire particle collection section with water.
4. Put a certain sediment into the funnel.
5. Turned on the air blower with desired air flow.
6. After a certain period, stop the air blower.
7. Used the V.A. tube as shown on Figure 5 to measure the amounts of sediment in each size range at each of the test tubes.
8. Plotted the amount of each sediment size with distance from the upstream end of the particle collection section.

V. EXPERIMENTAL RESULTS

1. Calibration of the air blower.

   The only way to vary the air speed of the air blower was to change the opening of the air inlet to the blower. With a pitot tube of known coefficient, the variation of air speed with different air inlet openings to the blower is shown on Figure 6.

2. A typical velocity distribution at the downstream end of the final separation section is given on Figure 7. The velocity in the center portion of this section was quite uniform.

3. The effect of different positions of the accessory B on the sediment particle deposition in the particle collection section was investigated with nearly uniform sands (ranges 177-210μ and 210-250μ). As shown in Figures 8-12 inclusive, the curved plastic plate (accessory B) at position V appeared to give the best result. The majority of the sand deposited between 15 inches to 24 inches from the upstream end of the particle collection section as shown on Figure 8.

4. The effect of different accessories on the separation of different sediment sizes was studied. Many experiments were made to investigate this effect and typical results are presented in Figures 13-25. Sediments seemed to deposit according to the different modifications of initial separation section rather than their different fall velocities or masses. In other words, this sediment separator with all different accessories failed to separate sediments according to their respective sizes under the range of flow conditions tested.

VI. DISCUSSIONS

The failure of this separator to separate sediments of different sizes was due to the following reasons:

1. For slow air velocity, the sediment moved only as bed load in the mixing chamber and fell under the influence of gravitation in the initial separation section. Under a separate experiment, it was found that a large percentage of sediment of different sizes hit both the inner and outer walls of the initial separated section irregularly. Since sediment particles were not moved as suspended load, no centrifugal action was involved. The result was that sediment of all sizes deposited in a certain location of the particle collection section.

2. For high air velocity, the turbulence fluctuating velocities were large and sediments could not be deposited according to their respective fall velocities only. The result was that sediment deposited in a wide region of the particle collection section.

3. A set of experiments was then made with inclined baffles (accessory D) which is shown in Figure 3d, to force the sediment into suspension. However, this effort also failed due to the increase of turbulent level by these baffles. The result was the same as case 2 above.

VII. CONCLUSION

This sediment separator failed to separate sediment of different sizes satisfactorily.

VIII. ACKNOWLEDGEMENT

We wish to thank Dr. Fred F. M. Chang of the United States Geological Surveys for his efforts and to the Colorado State University for its financial support.

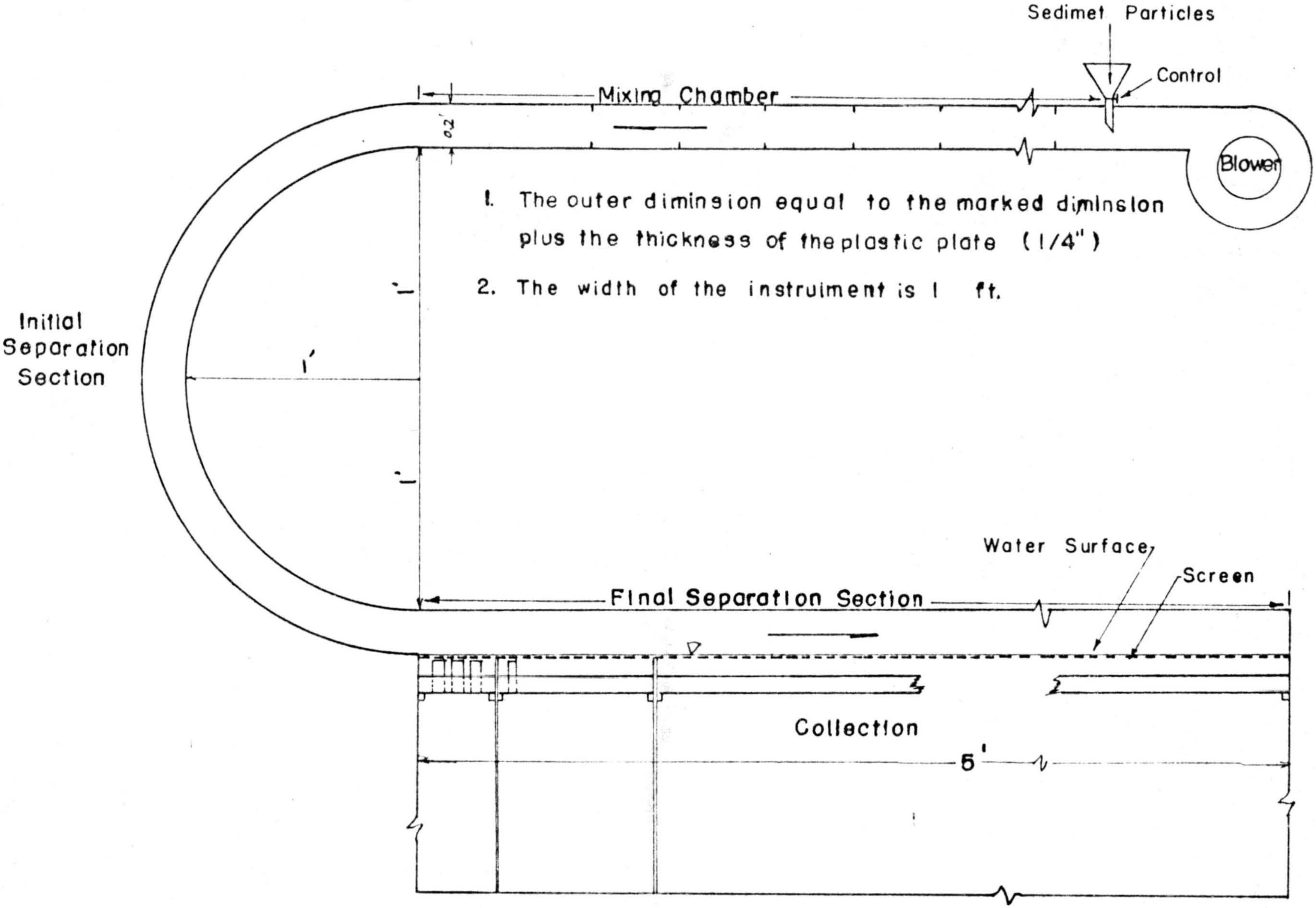


FIGURE 1 Separator

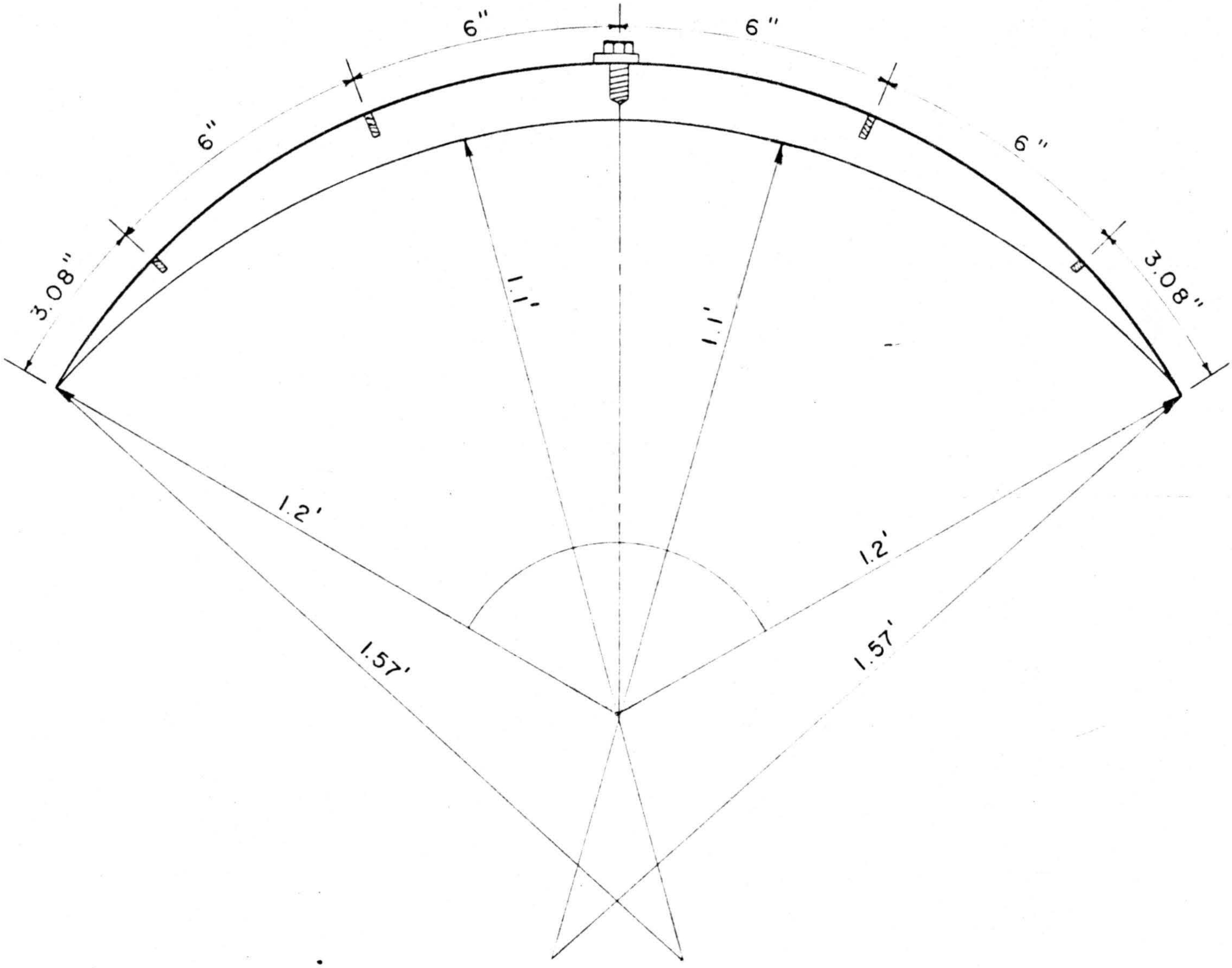


FIGURE 2 DIMENSIONS OF ACCESSARY B

CASE:

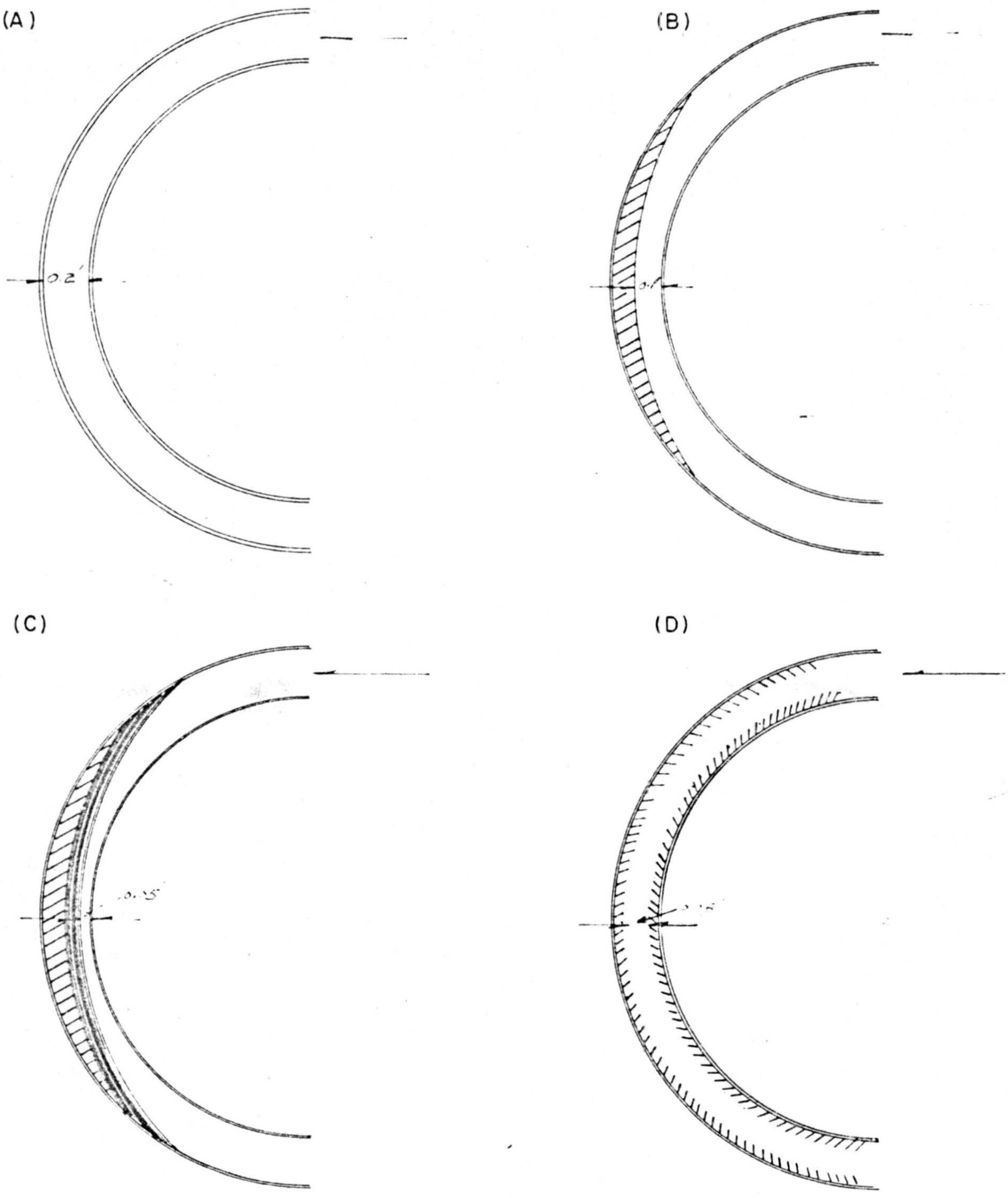


FIGURE 3 ACCESSARIES OF THE SEPARATOR

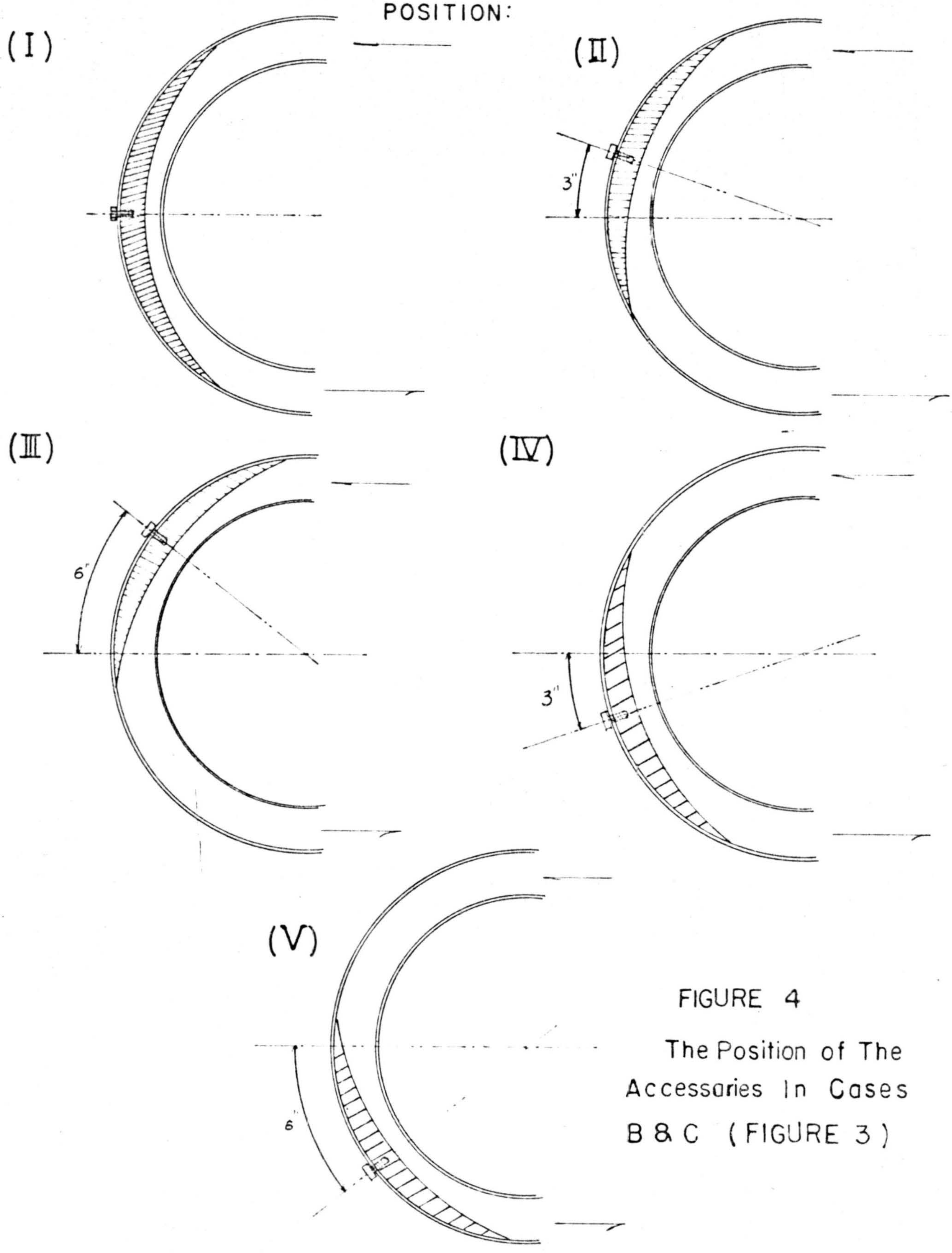


FIGURE 4

The Position of The Accessaries In Cases B & C (FIGURE 3)

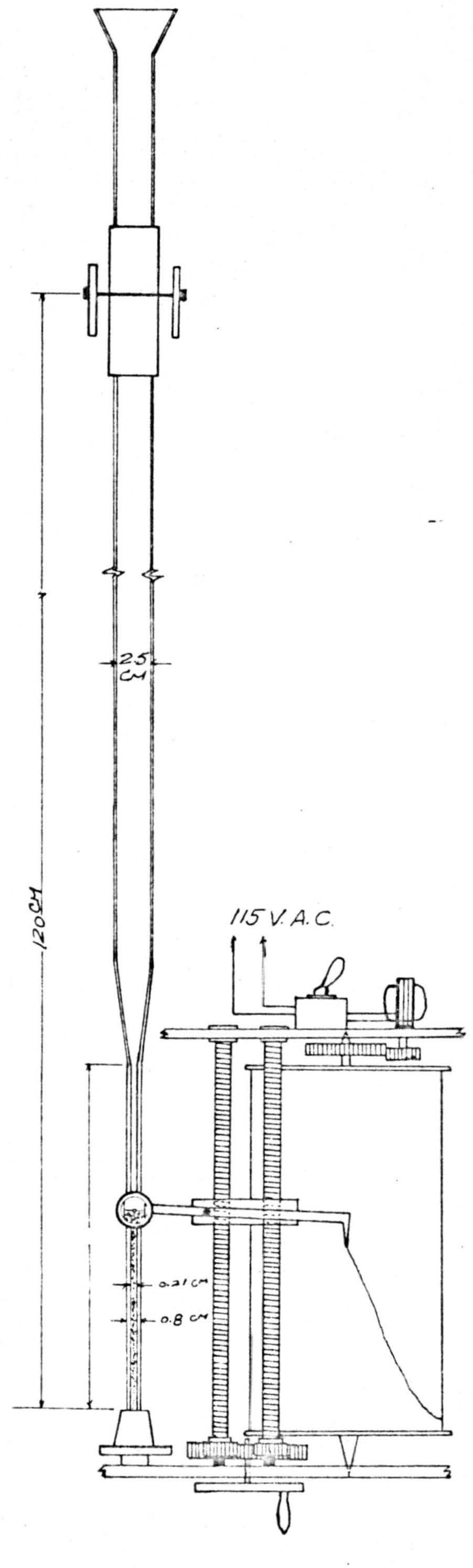


FIGURE 5
THE V. A. TUBE

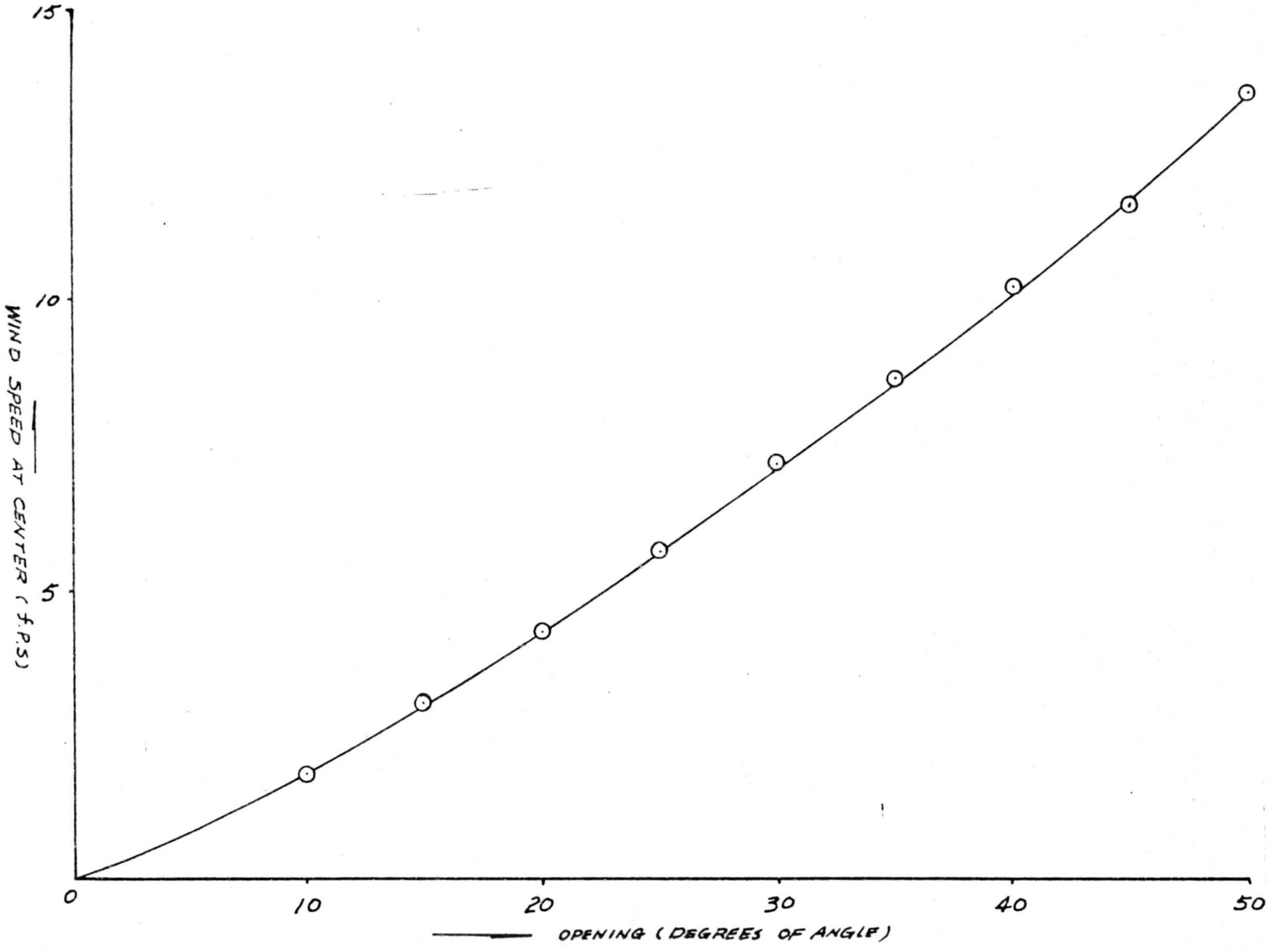


FIGURE 6 BLOWER OPENING AGAINST WIND SPEED.

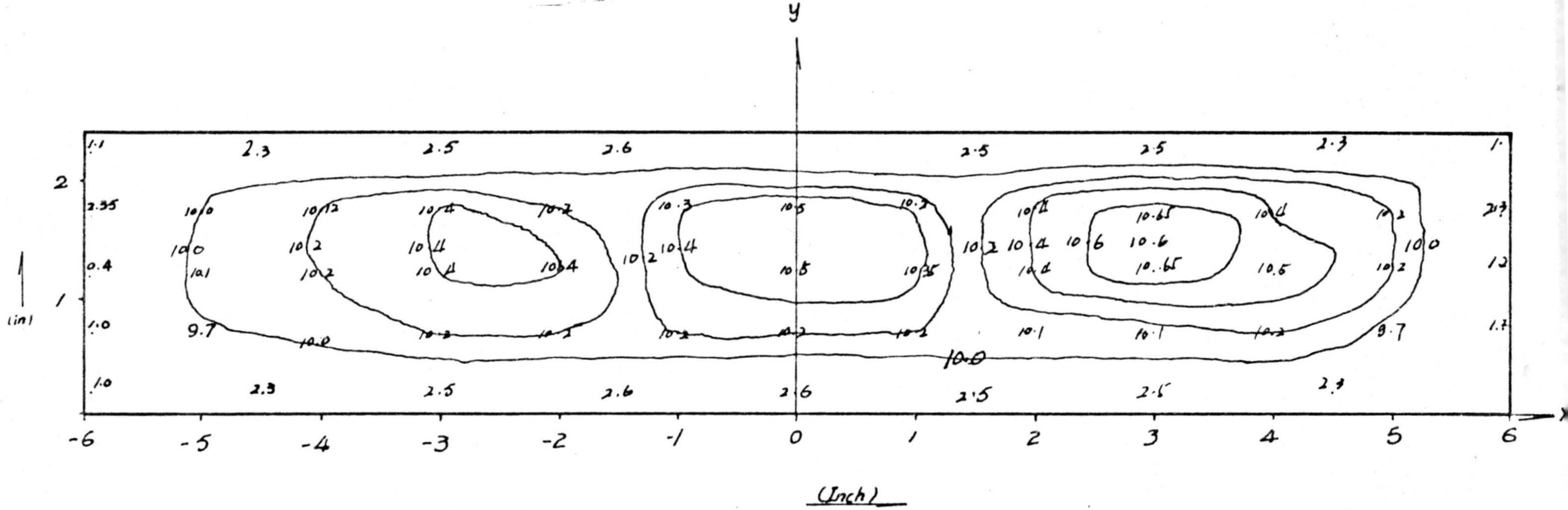


FIGURE 7 VELOCITY DISTRIBUTION AT THE END OF THE FINAL SEPARATION SECTION SECTION WHEN OPENING IS 40° IN CASE "B" POSITION "I"

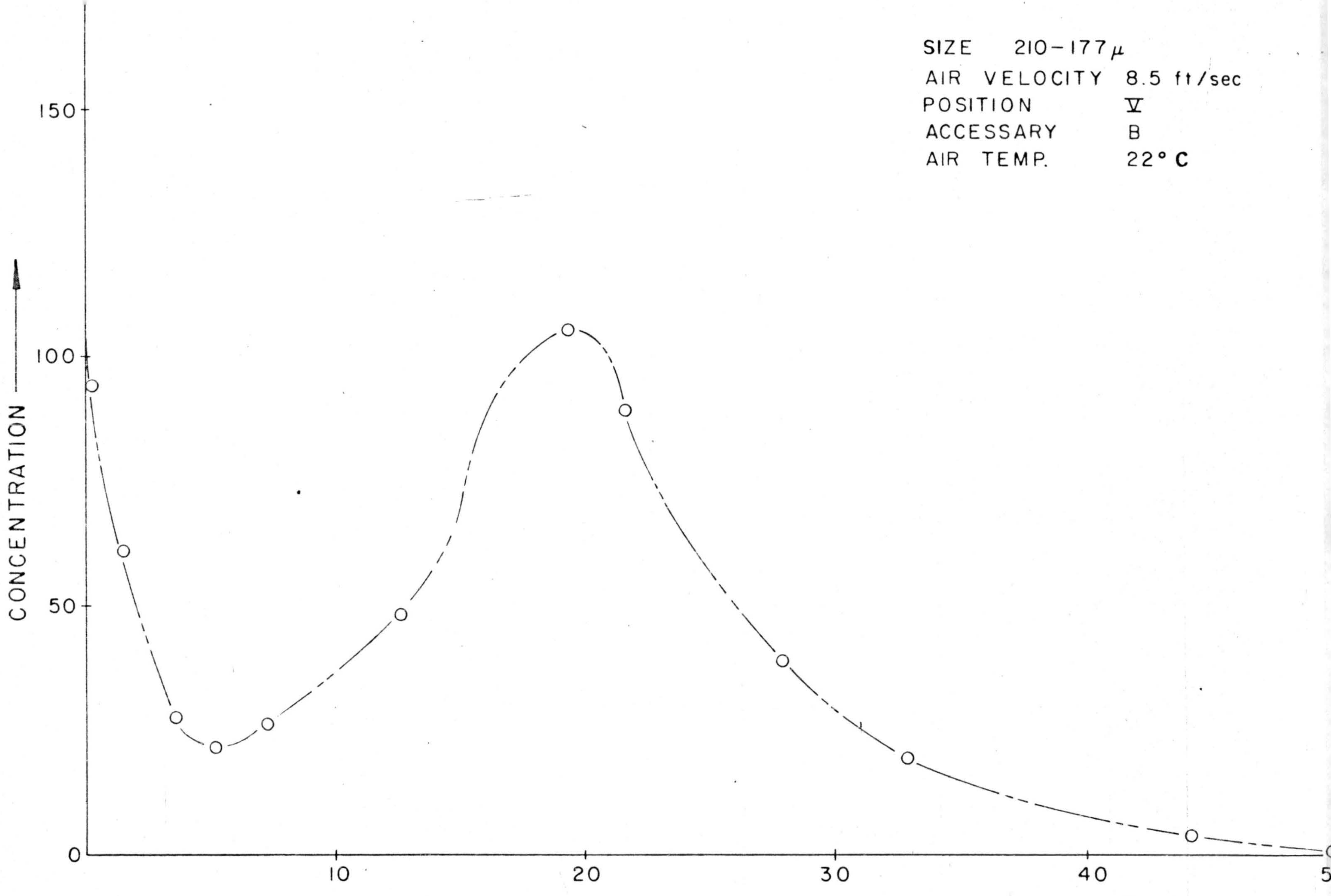
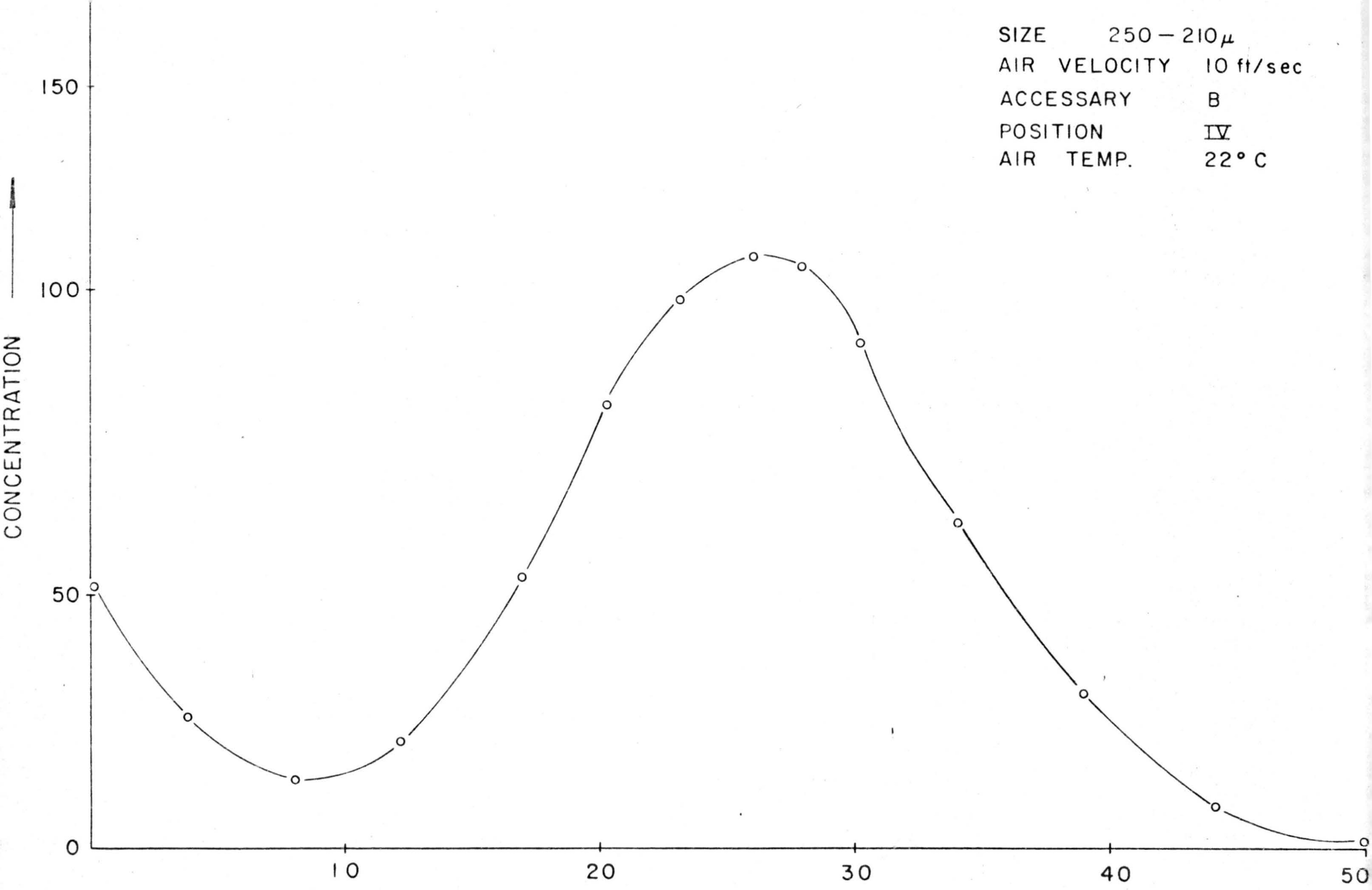


FIGURE 8 DISTANCE FROM THE BEGINING OF THE TANKS ⟶ INCH



SIZE 250 – 210μ
AIR VELOCITY 10 ft/sec
ACCESSARY B
POSITION IV
AIR TEMP. 22° C
CONCENTRATION
150
100
50
0
10
20
30
40
50
DISTANCE → INCH

FIGURE 9

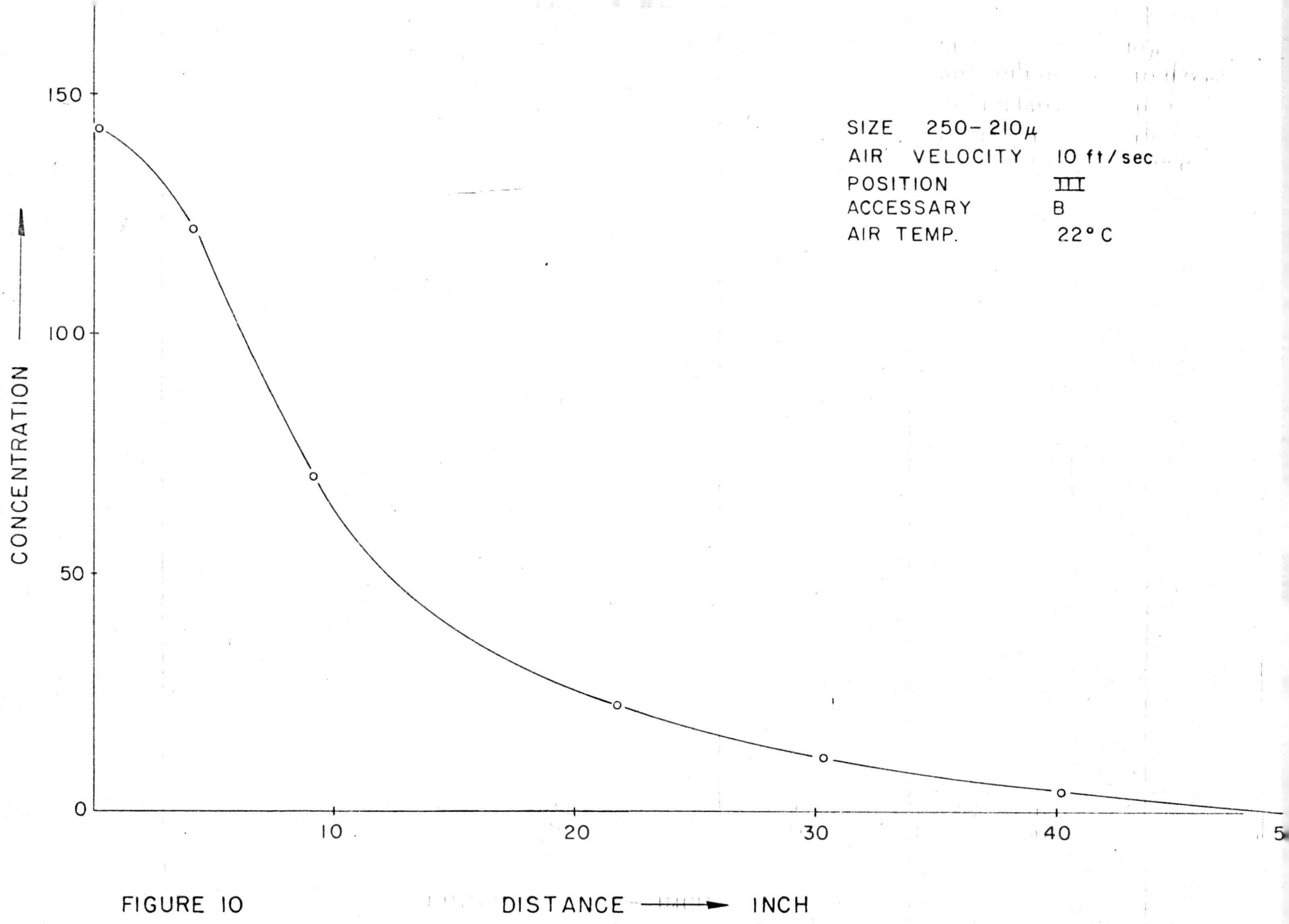

SIZE 250- 210μ
AIR VELOCITY 10 ft/sec
POSITION III
ACCESSARY B
AIR TEMP. 22° C
CONCENTRATION
150
100
50
0
10
20
30
40
DISTANCE INCH

FIGURE 10

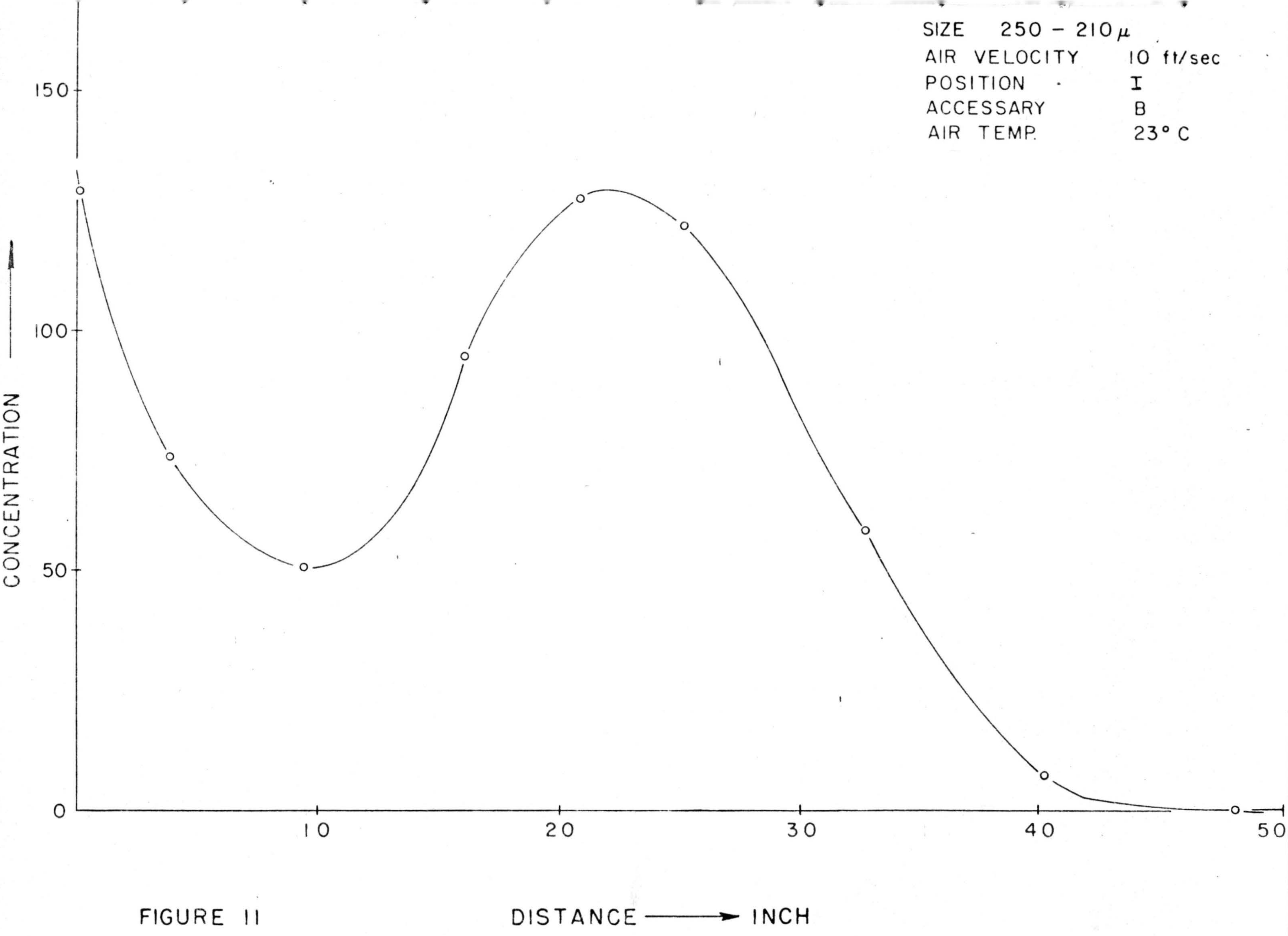

SIZE 250 - 210 μ
AIR VELOCITY 10 ft/sec
POSITION I
ACCESSARY B
AIR TEMP. 23° C
150
100
50
0
CONCENTRATION
10
20
30
40
50
DISTANCE ——► INCH

FIGURE 11

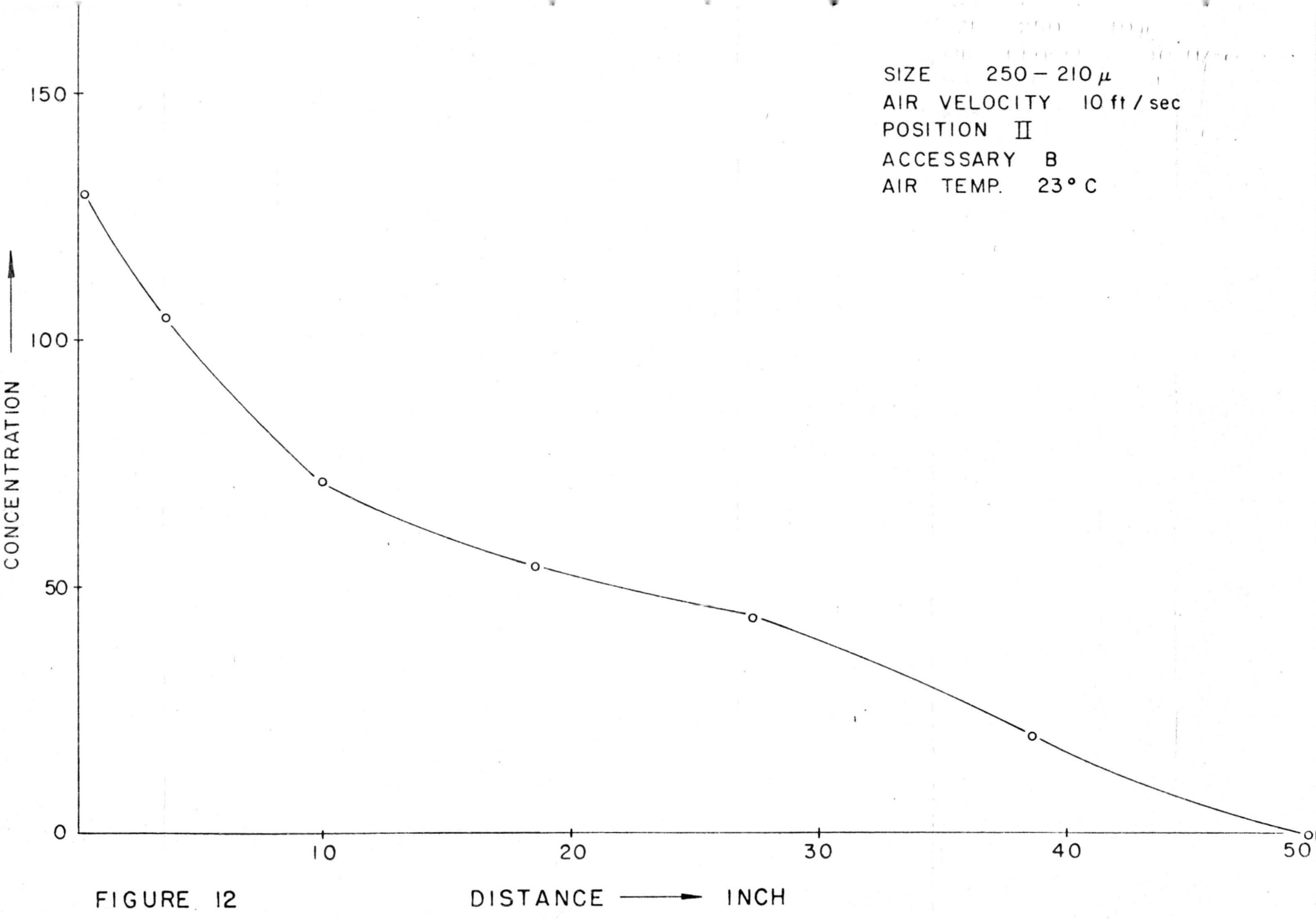

SIZE 250 – 210 μ
AIR VELOCITY 10 ft / sec
POSITION II
ACCESSARY B
AIR TEMP. 23° C
CONCENTRATION
150
100
50
0
10
20
30
40
50
DISTANCE INCH

FIGURE 12

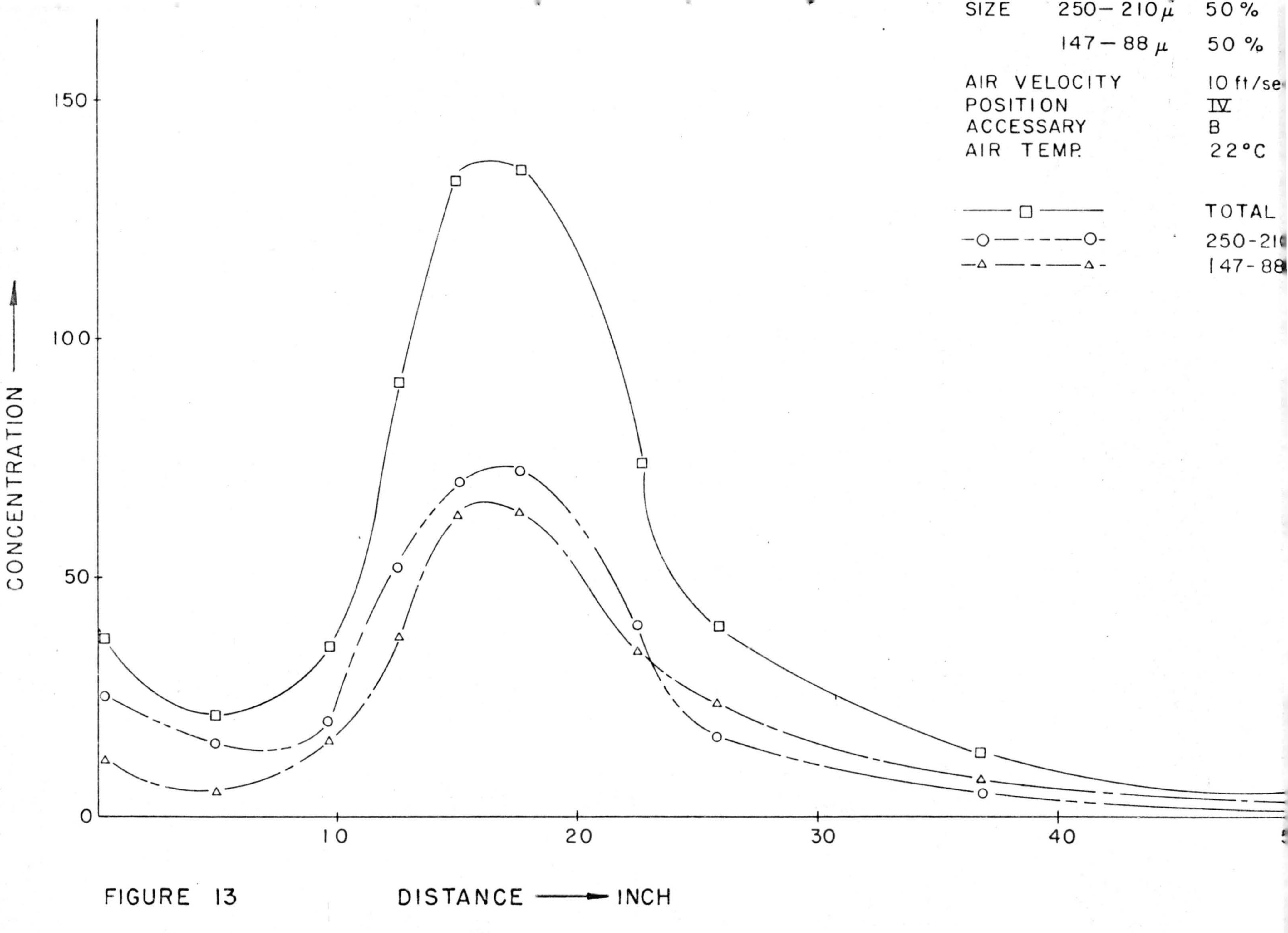

SIZE 250—210 μ 50 %
147—88 μ 50 %
AIR VELOCITY 10 ft/se
POSITION IV
ACCESSARY B
AIR TEMP. 22°C
TOTAL
250-21
147-88
150
100
50
0
10
20
30
40
CONCENTRATION
DISTANCE INCH

FIGURE 13

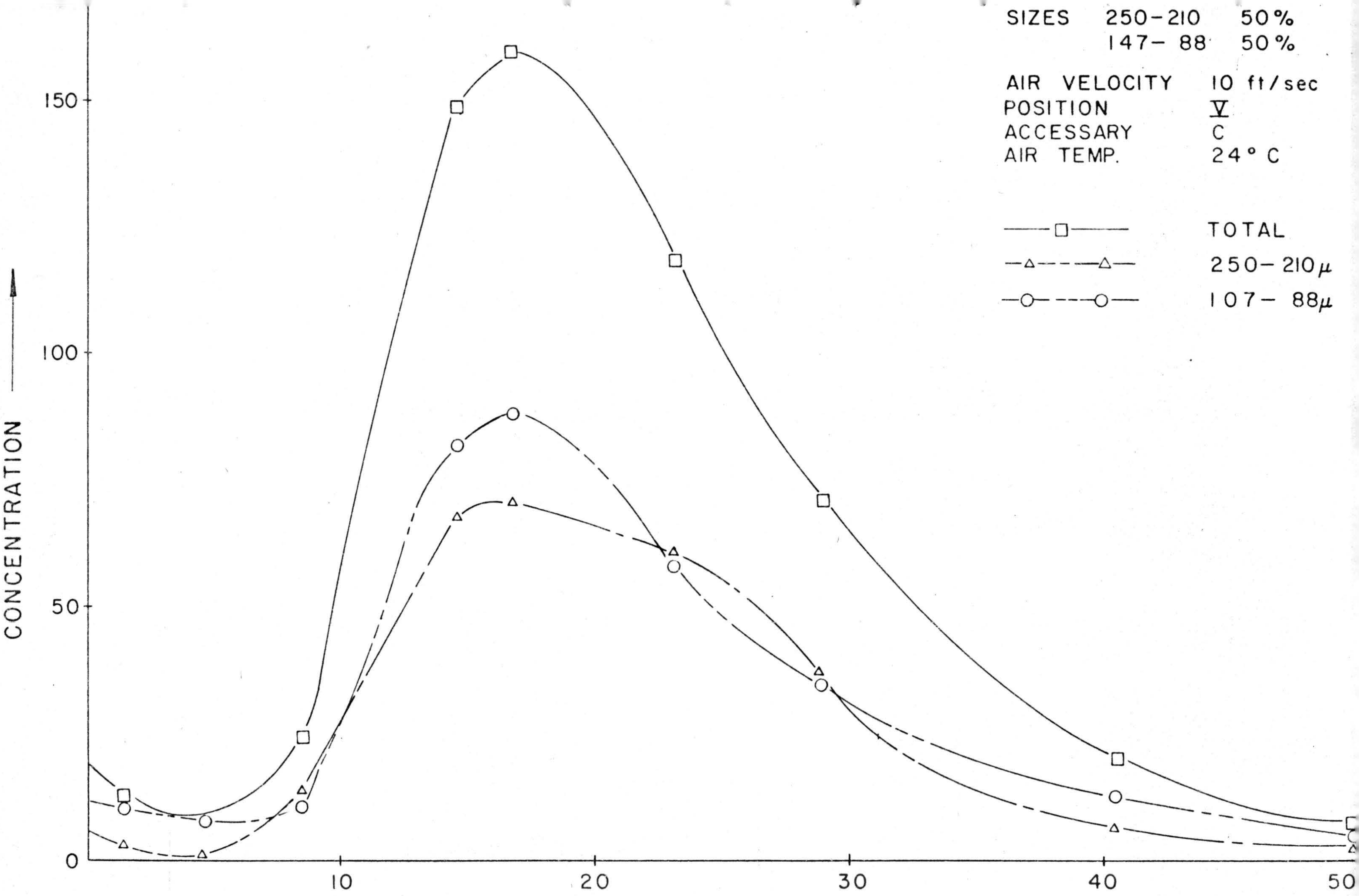


FIGURE 14 DISTANCE ⟶ INCH

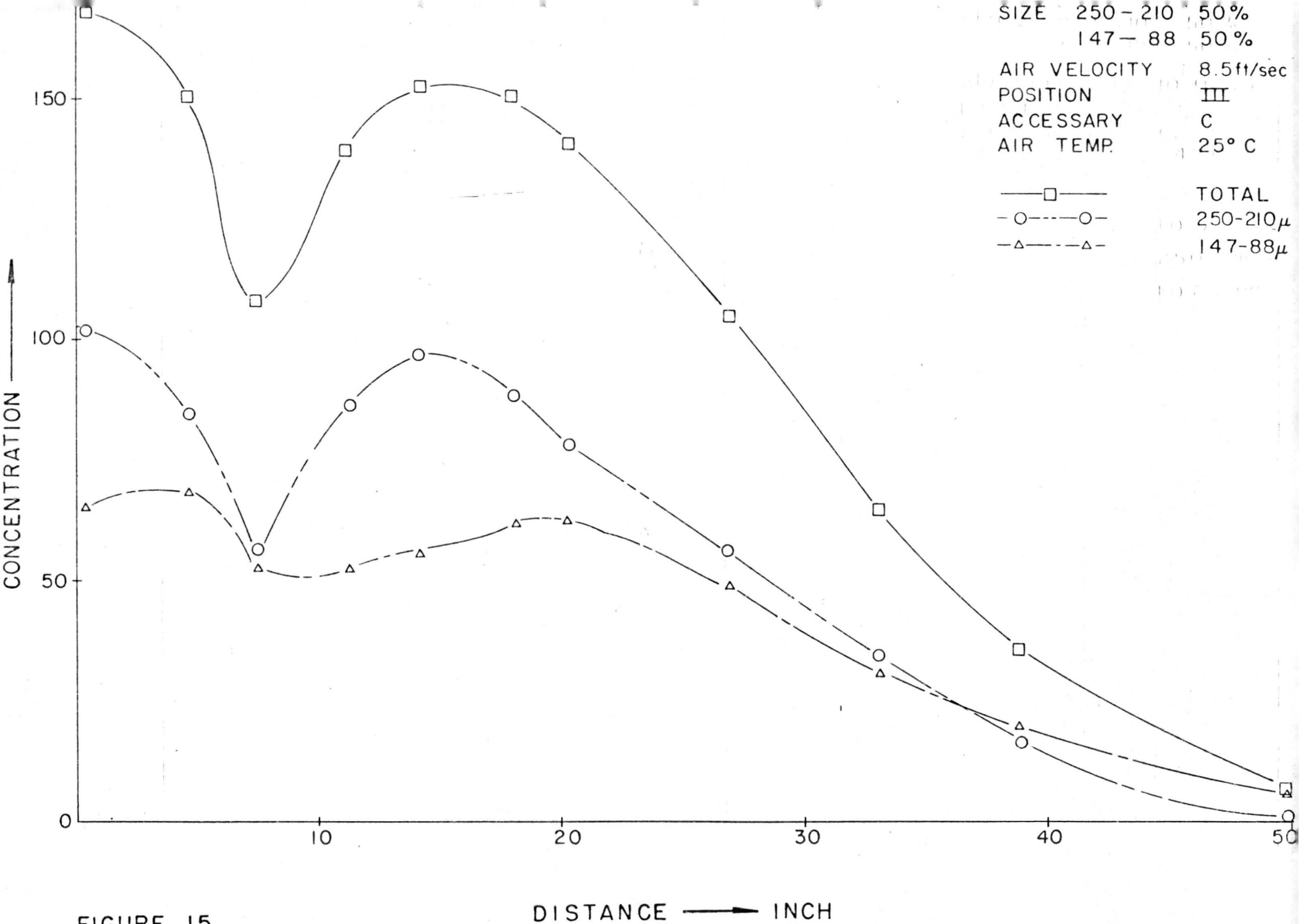

SIZE 250-210 50%
147-88 50%
AIR VELOCITY 8.5ft/sec
POSITION III
ACCESSARY C
AIR TEMP. 25° C
TOTAL
250-210μ
147-88μ
CONCENTRATION
0
50
100
150
10
20
30
40
50
DISTANCE INCH

FIGURE 15

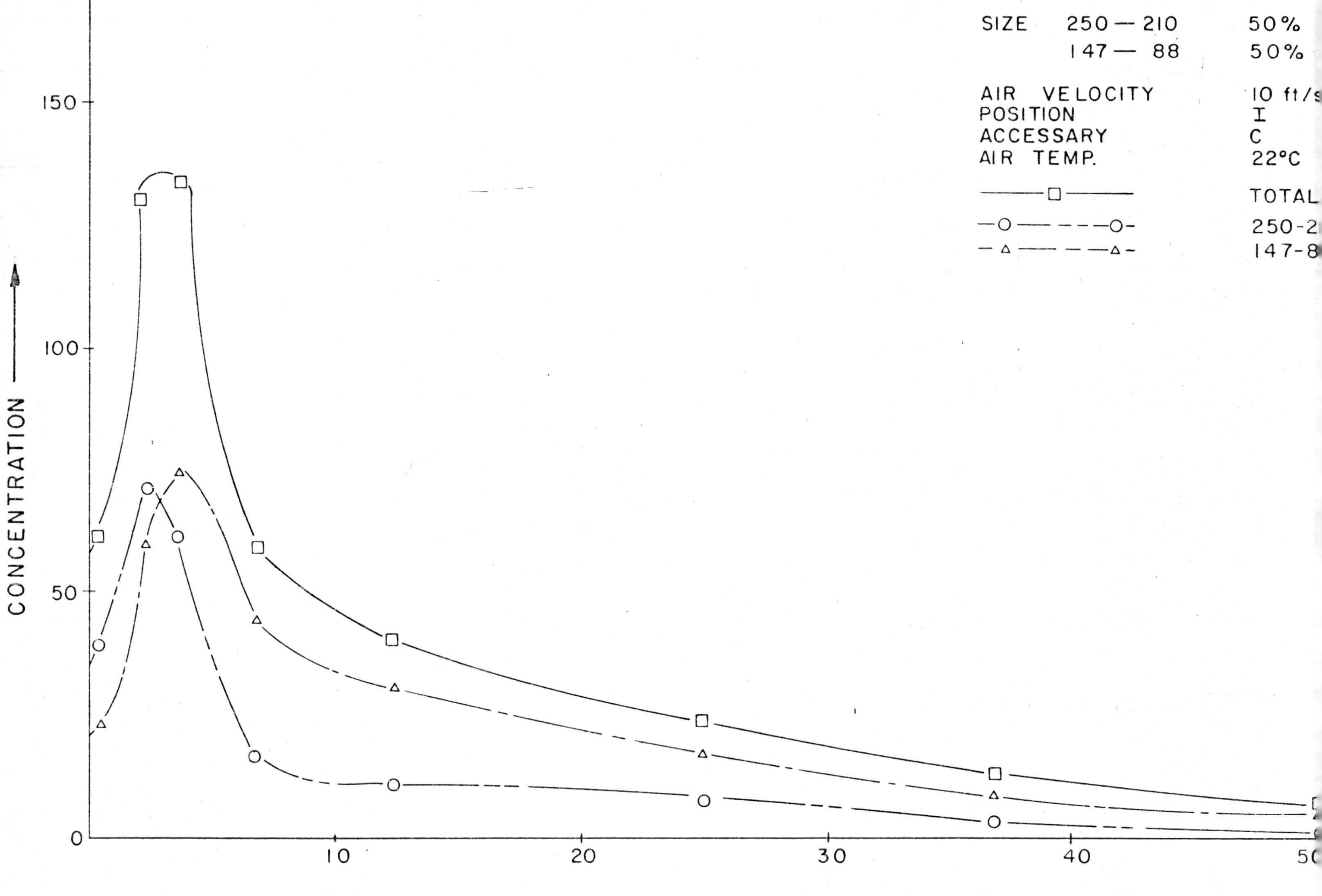

SIZE 250 — 210 50%
147 — 88 50%
AIR VELOCITY 10 ft/s
POSITION I
ACCESSARY C
AIR TEMP. 22°C
TOTAL
250-2
147-8
CONCENTRATION
150
100
50
0
10
20
30
40
DISTANCE INCH

FIGURE 16

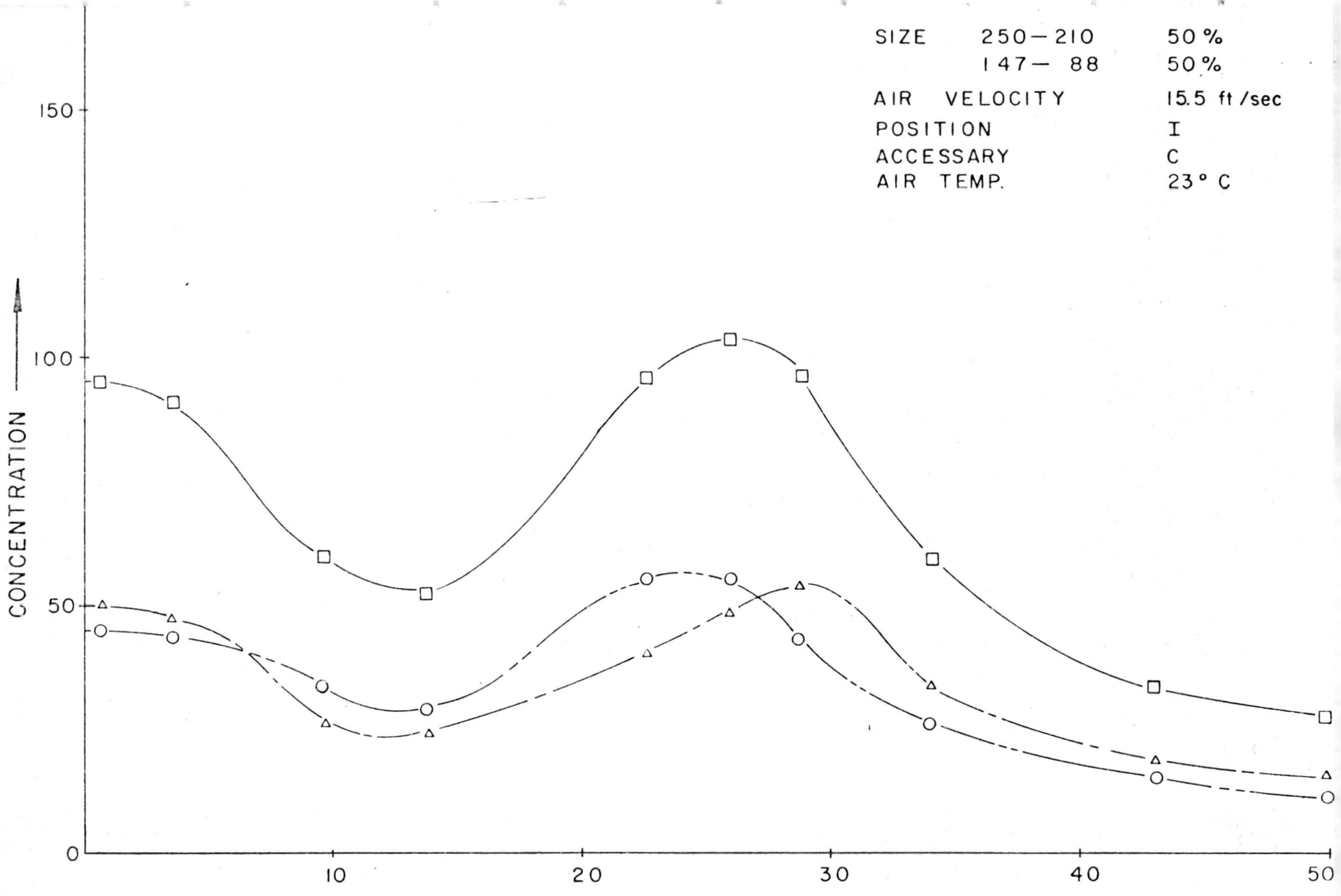


FIGURE 17 DISTANCE ——→ INCH

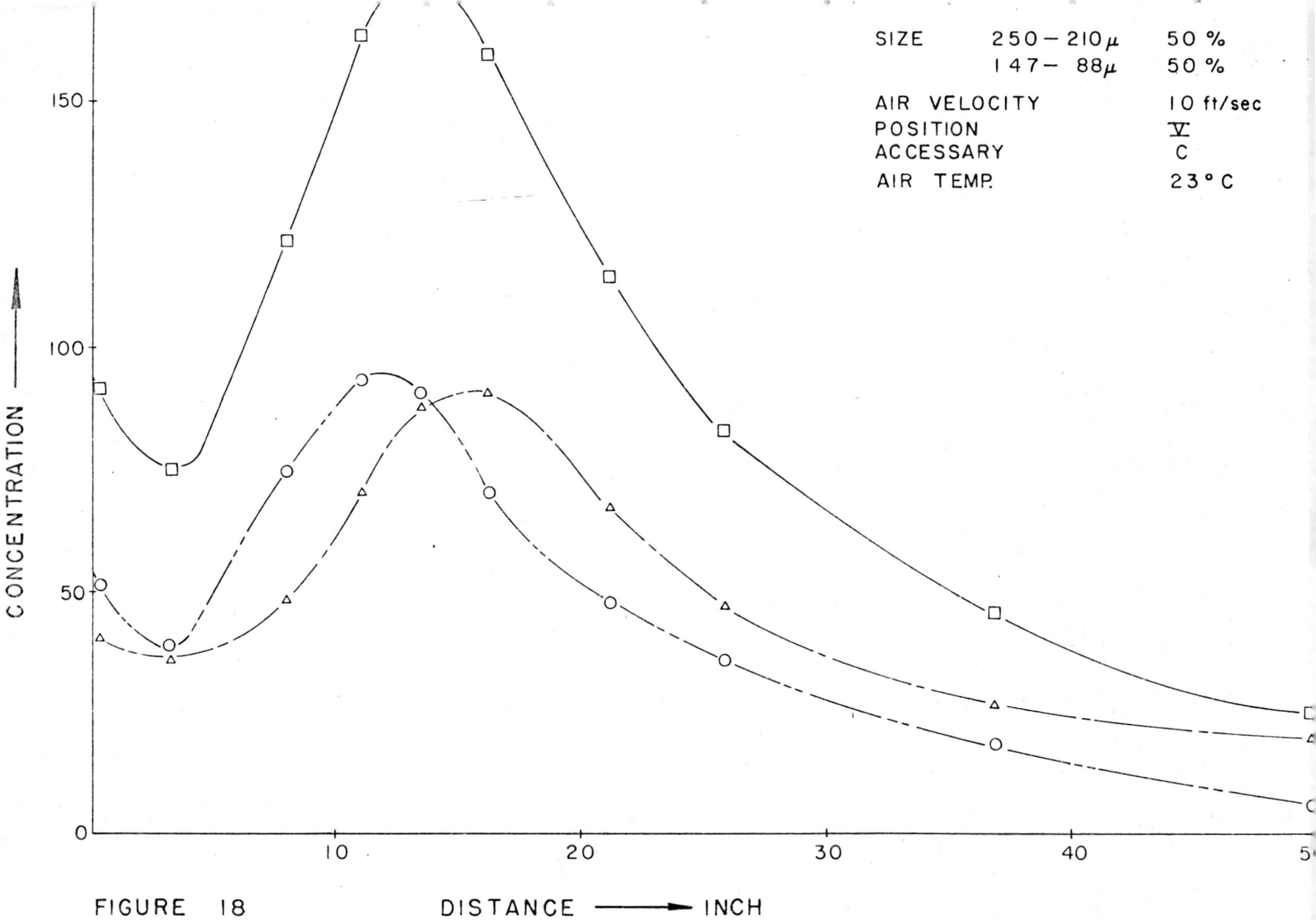

SIZE 250 – 210μ 50 %
147 – 88μ 50 %
AIR VELOCITY 10 ft/sec
POSITION V
ACCESSARY C
AIR TEMP. 23 °C
CONCENTRATION
150
100
50
0
10
20
30
40
5
DISTANCE ⟶ INCH

FIGURE 18

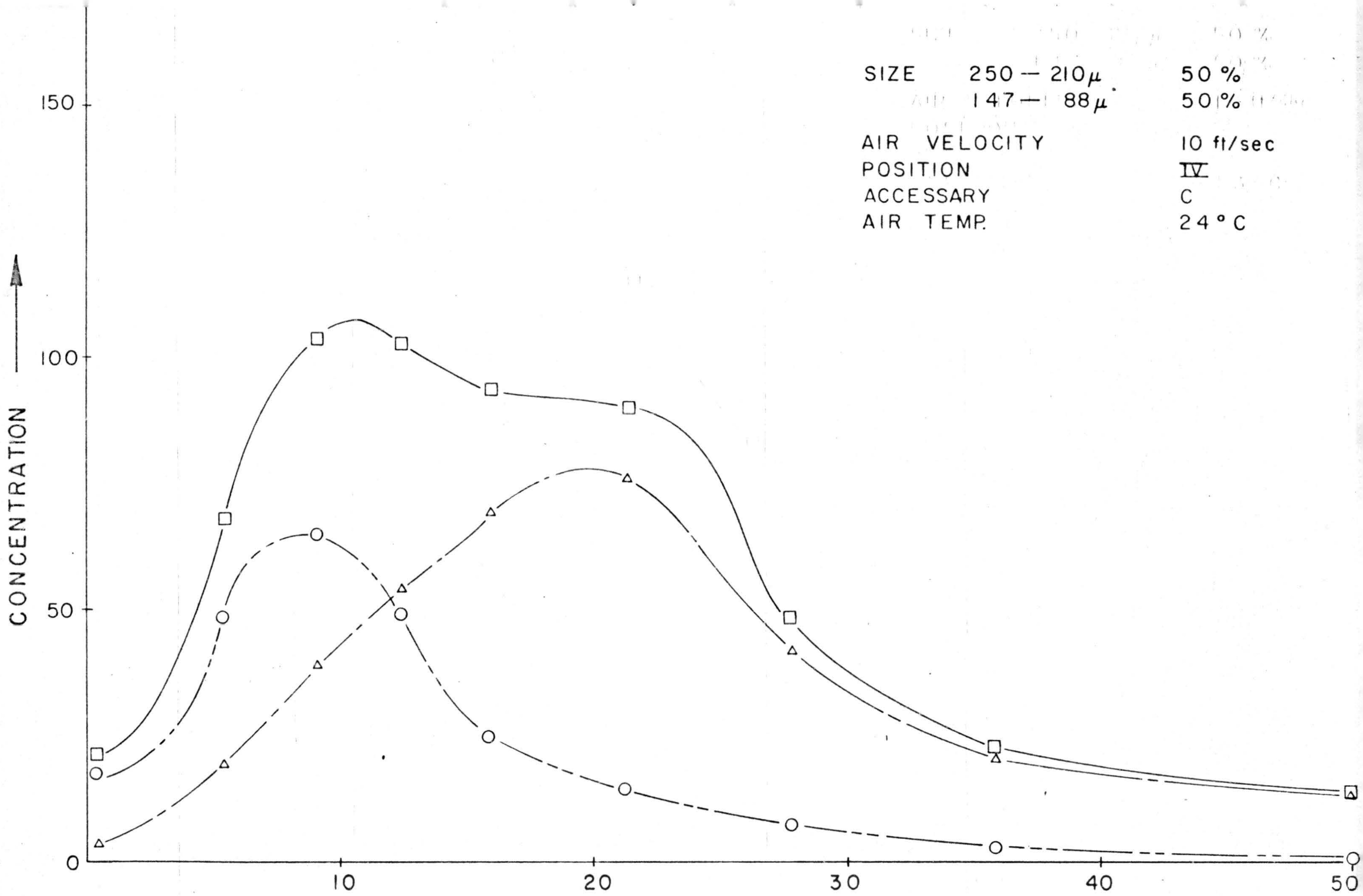
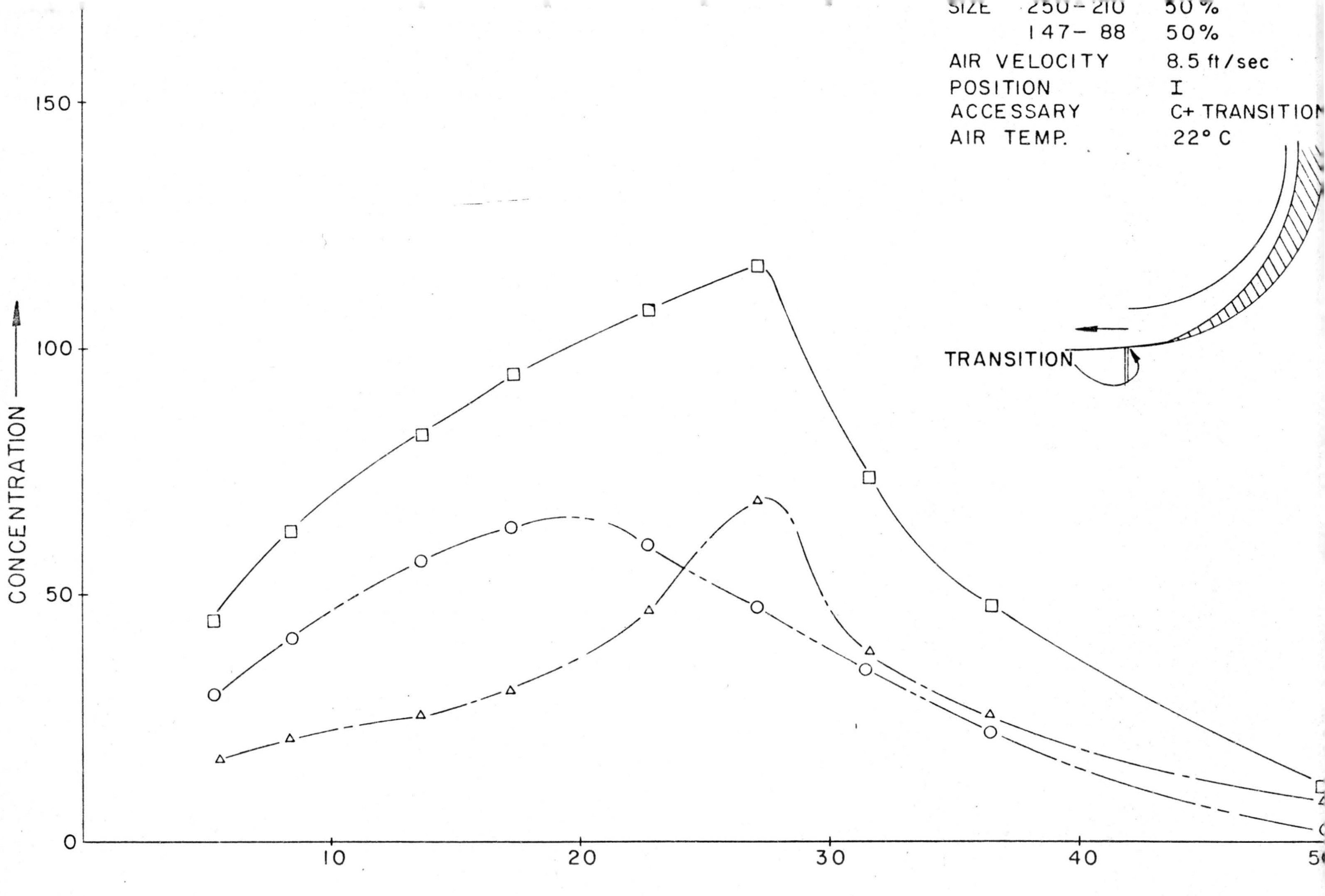

SIZE 250 — 210μ 50 %
147 — 88μ 50 %
AIR VELOCITY 10 ft/sec
POSITION IV
ACCESSARY C
AIR TEMP. 24 ° C
CONCENTRATION
150
100
50
0
10
20
30
40
50
DISTANCE INCH

FIGURE 19



SIZE 250-210 50%
147- 88 50%
AIR VELOCITY 8.5 ft/sec
POSITION I
ACCESSARY C+ TRANSITION
AIR TEMP. 22° C
TRANSITION
CONCENTRATION
150
100
50
0
10
20
30
40
DISTANCE → INCH

FIGURE 20

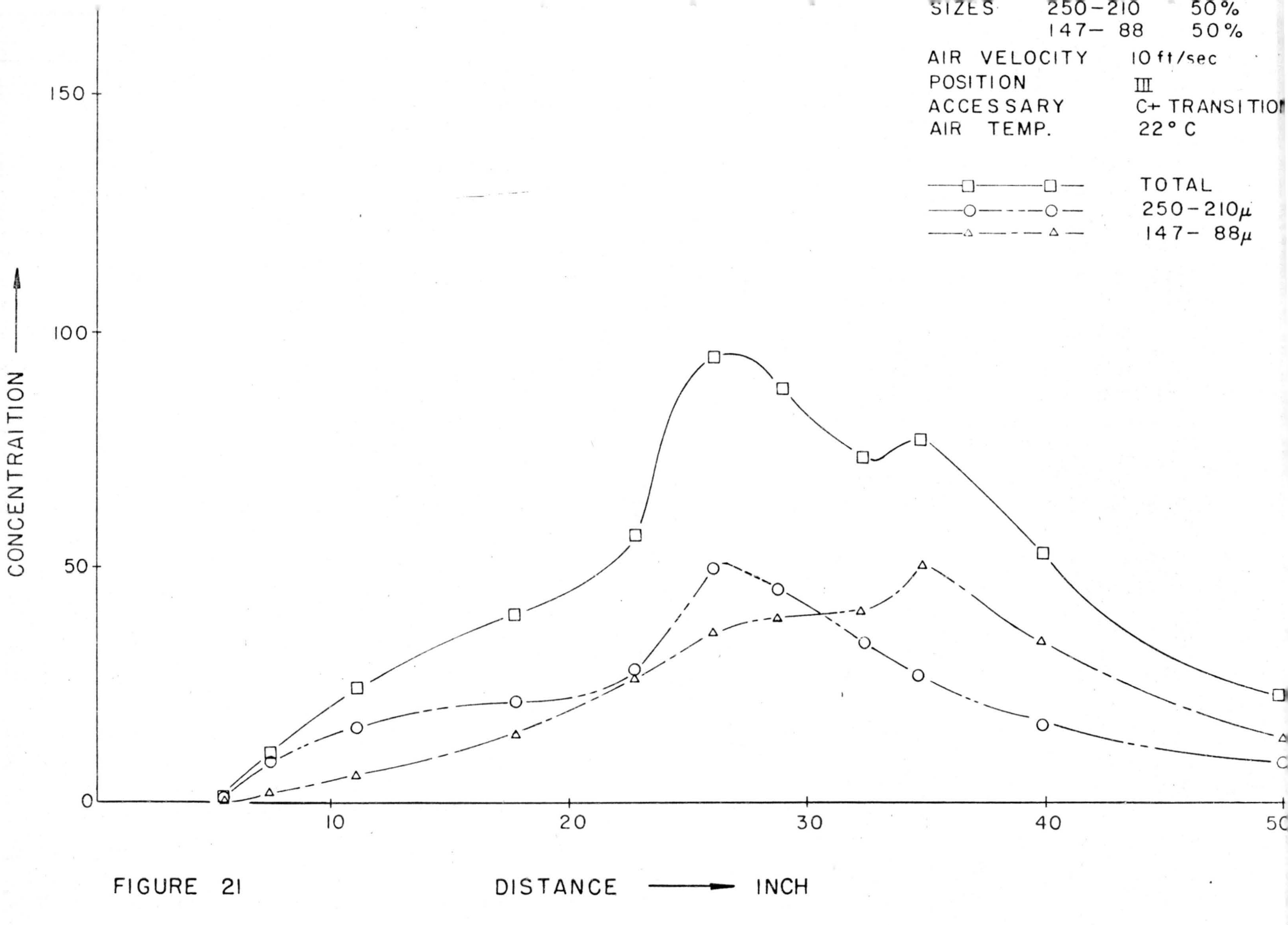
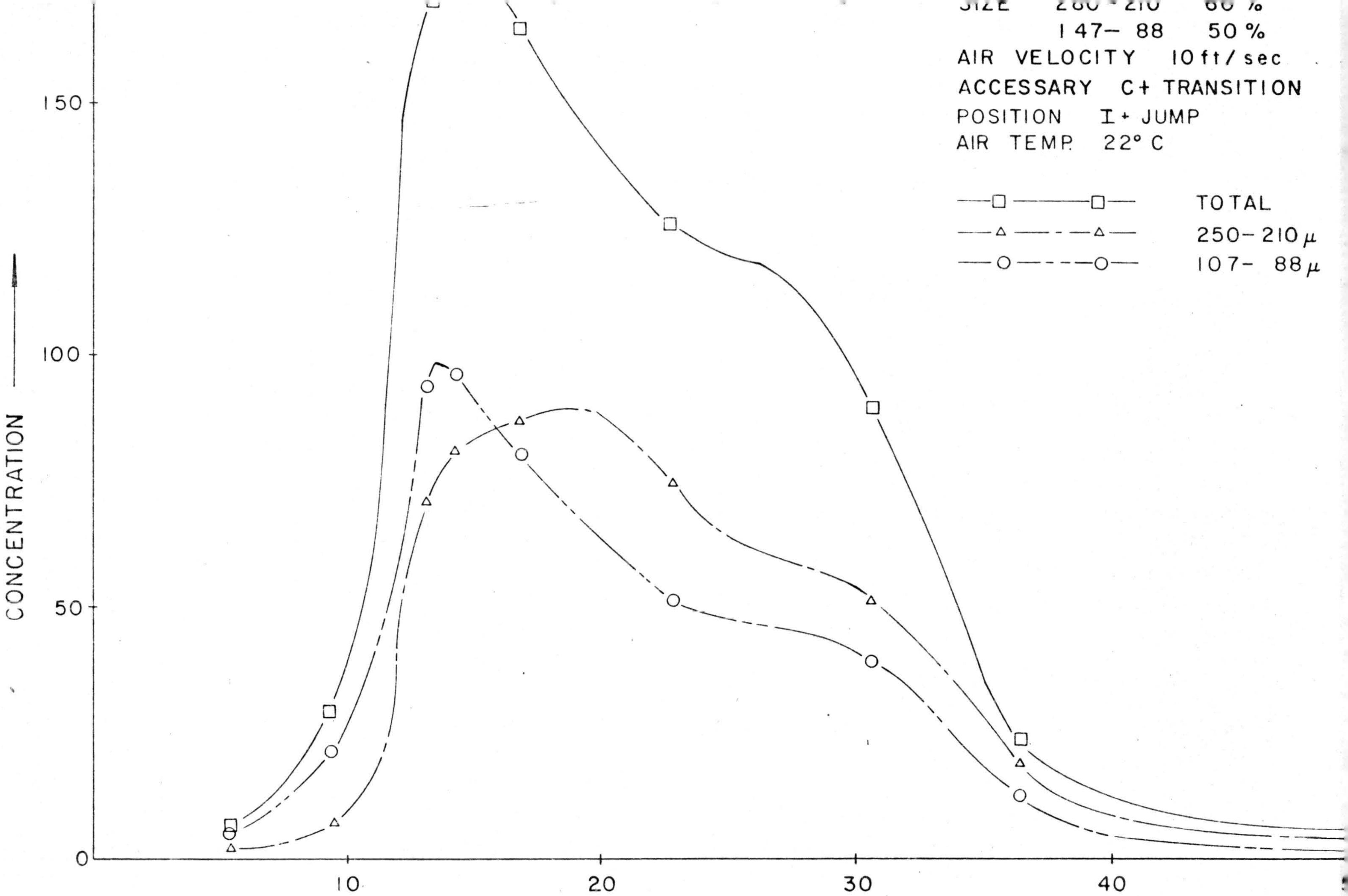

SIZES 250-210 50%
147- 88 50%
AIR VELOCITY 10 ft/sec
POSITION III
ACCESSARY C+ TRANSITION
AIR TEMP. 22° C
TOTAL
250-210μ
147- 88μ
CONCENTRAITION
150
100
50
0
10
20
30
40
50
DISTANCE INCH

FIGURE 21



147- 88 50 %
AIR VELOCITY 10 ft/sec
ACCESSARY C+ TRANSITION
POSITION I + JUMP
AIR TEMP. 22° C
TOTAL
250-210 μ
107- 88 μ
CONCENTRATION
0
50
100
150
10
20
30
40
DISTANCE → INCH

FIGURE 22

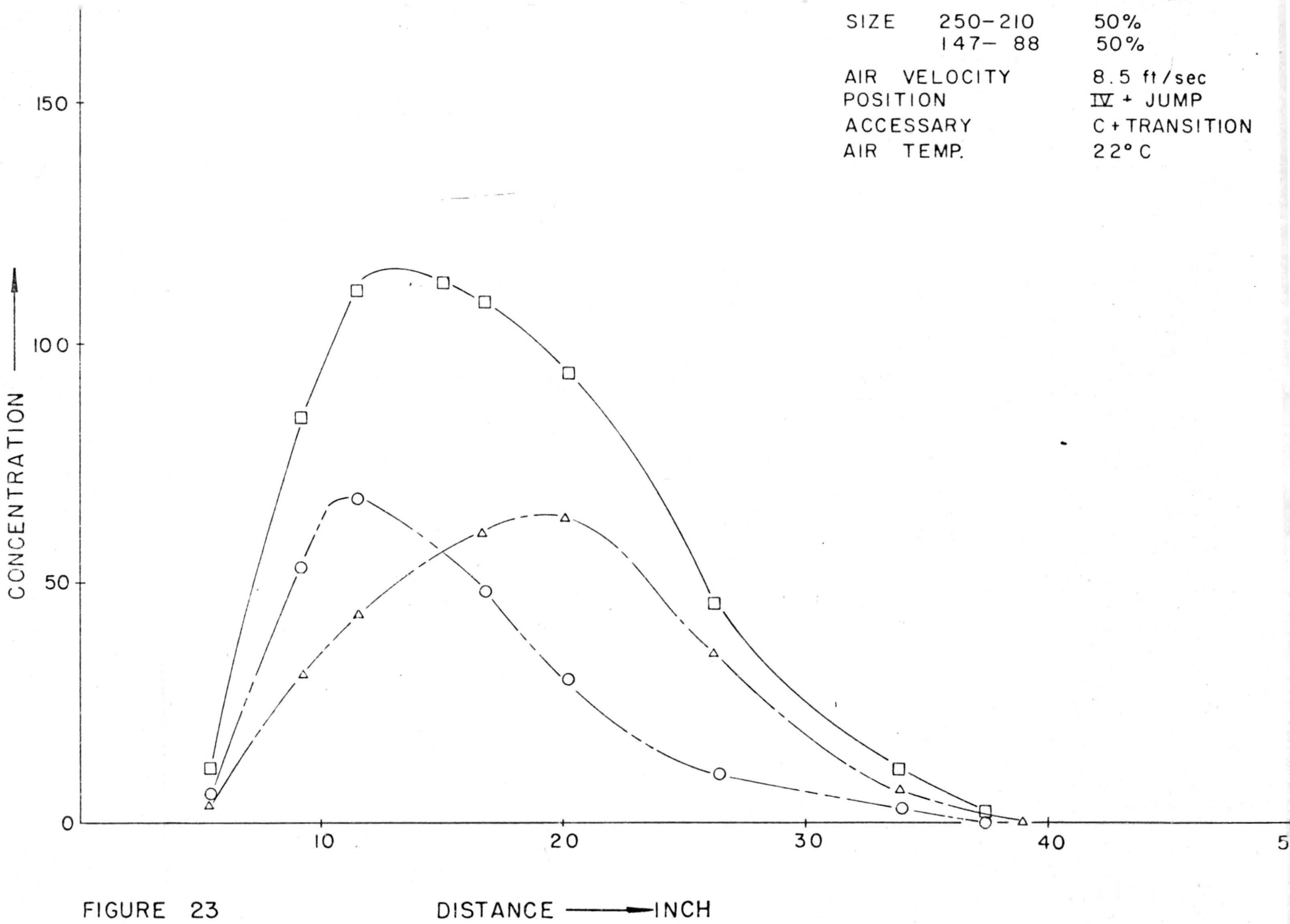
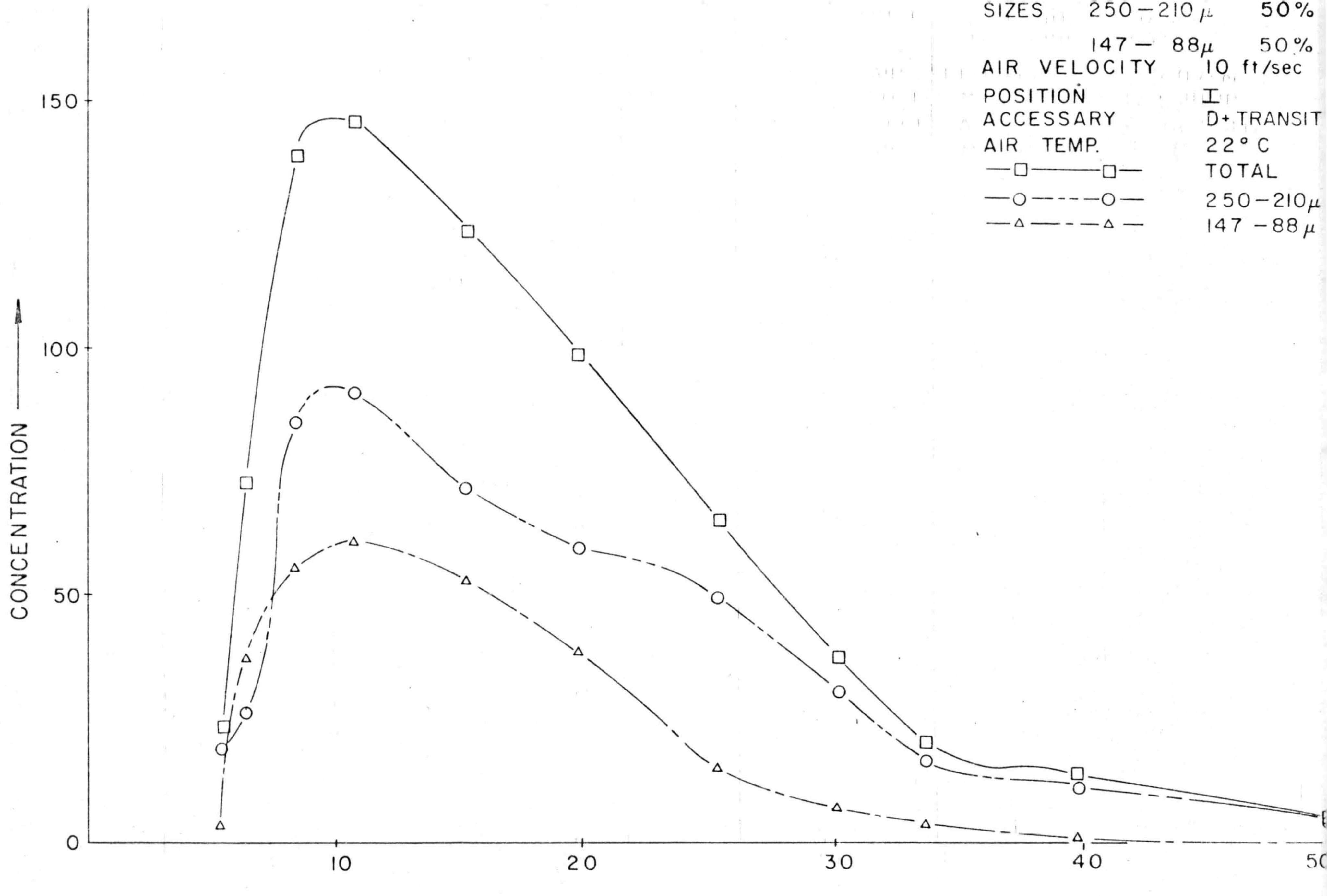

SIZE 250-210 50%
147- 88 50%
AIR VELOCITY 8.5 ft/sec
POSITION IV + JUMP
ACCESSARY C + TRANSITION
AIR TEMP. 22° C
CONCENTRATION
150
100
50
0
10
20
30
40
DISTANCE ⟶ INCH

FIGURE 23



SIZES 250 − 210 μ 50%
147 − 88μ 50%
AIR VELOCITY 10 ft/sec
POSITION I
ACCESSARY D+TRANSIT
AIR TEMP. 22° C
TOTAL
250 − 210μ
147 − 88 μ
CONCENTRATION
150
100
50
0
10
20
30
40
50
DISTANCE → INCH

FIGURE 24

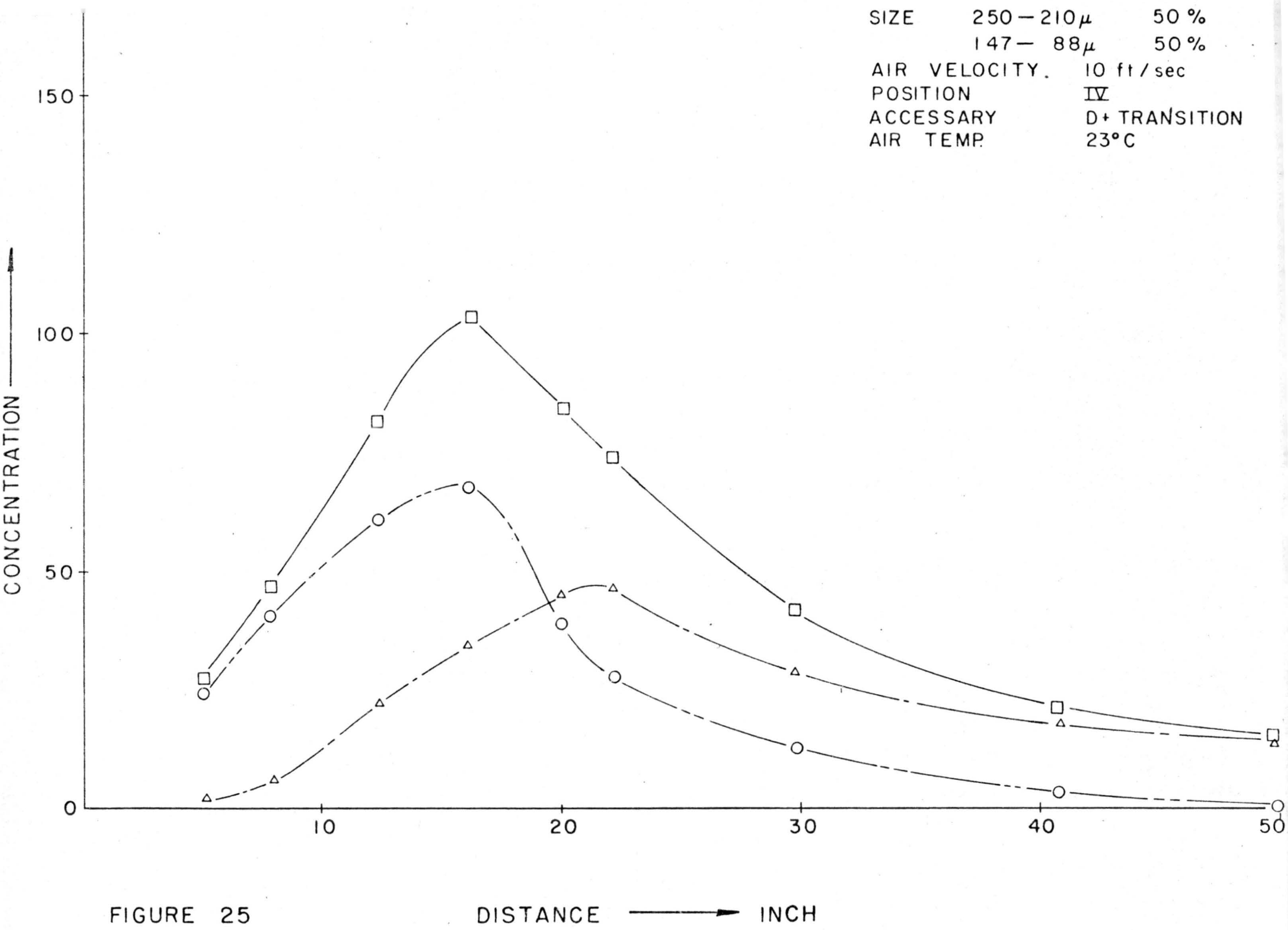

SIZE 250 — 210μ 50 %
147 — 88μ 50 %
AIR VELOCITY. 10 ft / sec
POSITION IV
ACCESSARY D + TRANSITION
AIR TEMP. 23°C
CONCENTRATION
150
100
50
0
10
20
30
40
50
DISTANCE ——→ INCH

FIGURE 25