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DETERMINATION OF THE CAPTURE CROSS SECTION OF 25

PRELIMINARY REPORT

WORK DONE BY:

Dudley Williams

Philip Yuster

REPORT WRITTEN BY:

Dudley Williams

Philip Yuster

LAMOS NATIONAL LABORATORY
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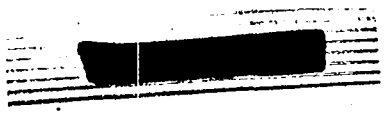
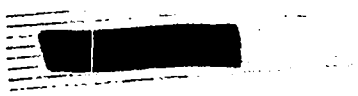


ABSTRACT

From mass-spectrographic data on irradiated samples of enriched material capture cross sections have been determined in terms of estimated irradiation. The value for the capture cross section obtained from irradiation estimates based on power dissipation in the pile was $\sigma_c = 148 \pm 48 \times 10^{-24}$ (8) cm^2, which gives $\alpha = 0.27 \pm 0.09$. The value for the capture cross section based on Deutsch's measurement of irradiation was $\sigma_c = 106 \pm 7 \times 10^{-24}$ cm^2, which gives $\alpha = 0.196 \pm 0.013$. An independent method based on mass-spectrographic determination of 25 creation and 25 depletion gives $\alpha = 0.23 \pm 0.05$.



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DETERMINATION OF THE CAPTURE CROSS SECTION OF 25

PRELIMINARY REPORT

INTRODUCTION

In an earlier note[1] the writers gave a preliminary report on mass-spectrographic studies of irradiated β-stage materials. The data reported at that time were obtained with a sample irradiated in the Clinton pile. In that work a small peak was observed at the mass position corresponding to 26, but the resolution obtainable at the time was not sufficient to permit an accurate determination of the abundance of 26 relative to 25. Indeed, there was even a possibility that the small peak observed might have been partially due to a fluorocarbon impurity. Since the time these data were reported, the resolving power of the mass-spectrograph has been improved and more reliable data have been obtained on the 26 content of the sample from Clinton and also on samples from Site W. Although the work on all the samples irradiated at Site W has not yet been completed, sufficient progress has been made to warrant the publication of another preliminary report on the problem.

PRESENT RESULTS

The spectrum obtained for the original material before irradiation is shown in Fig. 1. The peaks shown are produced by the UF_5^+ ions formed by electronic bombardment of UF_6 vapor. It will be noted that the background near the 331 (26) mass position is negligible even in comparison with 329 (24). Hence, it might be concluded that fluorocarbon impurities of this mass are not produced during the preparation of UF_6 by the methods now used. The spectrum obtained for the sample irradiated at Clinton is shown in Fig. 2; in this spectrum the small peak at 331 (26)

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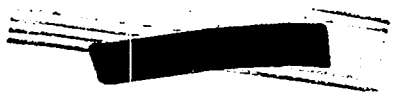

is well separated from the neighboring 330 (25) peak. Figs. 3 and 4 show the mass spectra obtained with the more intensely irradiated samples from W. In these spectra the 331 (26) peaks are much larger and without reasonable doubt can be attributed to 26 formed from neutron capture by 25.

CALCULATION OF CAPTURE CROSS SECTION

From the observed ratio of 25 to 26 it is possible to determine the capture cross section of 25 provided the irradiation of the sample is known. Estimates of the irradiation have been made by two methods. The first method involves a knowledge of the power dissipation in the particular part of the pile in which the sample was placed. The second method is that described by Deutsch[2]. The cross sections obtained from the measured abundances and the irradiation data obtained by the methods mentioned above are shown in Table I. It will be noted that the values of σ_c obtained from irradiation estimates based on power dissipation show wide variations. The values of σ_c obtained from Deutsch's estimates of the irradiation for the first two samples are in excellent agreement, while the value obtained from the third sample is in fair agreement with the values obtained on the other two samples for which the irradiation was actually measured by Deutsch. Deutsch[2] believes that the values for the irradiation for the first two samples have a probable error of approximately ± 5%. The uncertainties in the ratios of 25 to 26 are indicated in the table.

If the mean deviation of the individual determinations is taken as the uncertainty in values of σ_c obtained from the two types of irradiation estimates, the capture cross section as determined from power-dissipation data may be taken as

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2) LAMS-256, p. 10.

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148 ± 48 x 10^{-24} cm^2, while the cross section as obtained from Deutsch's estimates is 106 ± 7 x 10^{-24} cm^2.

INDEPENDENT DETERMINATION OF α

It was hoped that the mass-spectrographic measurements for sample CW-2 would afford a means of determining α which would be independent of estimates of irradiation. The scheme under consideration can be described briefly. The quantity α is defined by the following relation:

$$\alpha = \sigma_a/\sigma_f \qquad (1)$$

In a sample which has received a given amount of irradiation α can be obtained from the following quantities:

$$\alpha = \frac{\text{atoms of 26 formed}}{\text{atoms of 25 destroyed - atoms of 26 formed}} \qquad (2)$$

Since the sample contained 28 and since the change in the number of 28 atoms is small (approximately 1% for sample CW-2), the amount of 26 and the change in the amount of 25 can be referred to 28 as follows:

$$\alpha = \frac{26/28}{(\Delta 25)/28 - 26/28} \qquad (3)$$

All the ratios in Eq. (3) are easily determined. Unfortunately, it was found that the amount of 28 in the sample had increased by a factor of 2 and it is believed that sample CW-2 was at some time during preparation contaminated with a small quantity of normal uranium, and hence it was impossible to determine α from Eq. (3). However, since the 24 content was not changed appreciably by addition of normal material, an approximate value for α could be determined by referring 26 and $\Delta 25$ to 24[3]. These ratios are not as easily determined, but by taking special precautions and by determining ratios without altering the "tuning" of the spectrometer the

3) The method assumes that the change in 24 during irradiation was not large.

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ratios in Table II were obtained.

TABLE II

Isotopic Analysis of Sample Before and After Irradiation

	$\gamma = 25/24$	$t = 26/24$	$R = 28/25$
Original Material	168.0 ± 0.8	--	0.560
Irradiated Sample CW-2	154.5 ± 1.0	2.53 ± 0.08	1.014

The value obtained for α from these ratios is 0.23 with an estimated error of as much as 20%. This value for α is 17% higher than the mean value for α obtained from Deutsch's irradiation measurements.

There are other samples of irradiated material from Site W which will be available in the near future and it is hoped that a more accurate measurement of α can be made by the methods described above.

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TABLE I

Capture Cross Sections

Sample	γ = 25/26	Calculations Based on Power Dissipation in Pile			Calculations Based on Deutsch's Measurements of Irradiation		
		nvt neutrons/cm^2	σ_{o_2} (cm^2)	$\alpha = \sigma_c/\sigma_f$**	nvt neutrons/cm^2	σ_{o_2} cm^2	$\alpha = \sigma_c/\sigma_f$
Clinton	3800 ± 50	3.5×10^{18}	75×10^{-24}	0.14	2.6×10^{18}	101×10^{-24}	0.187
CW 1	464 ± 10	13.4	161	0.30	21.2	102	0.189
CW 2	60.5 ± 1.0	80.0	207	0.38	126*	131†	0.243
		Mean Value	118×10^{-24}	0.27	Mean Value	106×10^{-24}	0.196

$N_{25} = N_{25}\ \sigma\ nvt$

$$\sigma = \frac{N_{26}}{N_{25} \cdot nvt} = \frac{1}{\gamma \cdot nvt}$$

* This sample was not actually measured by Deutsch. The nvt given is based on Deutsch's value for CW-1.

† Weighted 1/3 in taking average.

**The value of σ_f is assumed to be 540×10^{-24} cm^2.

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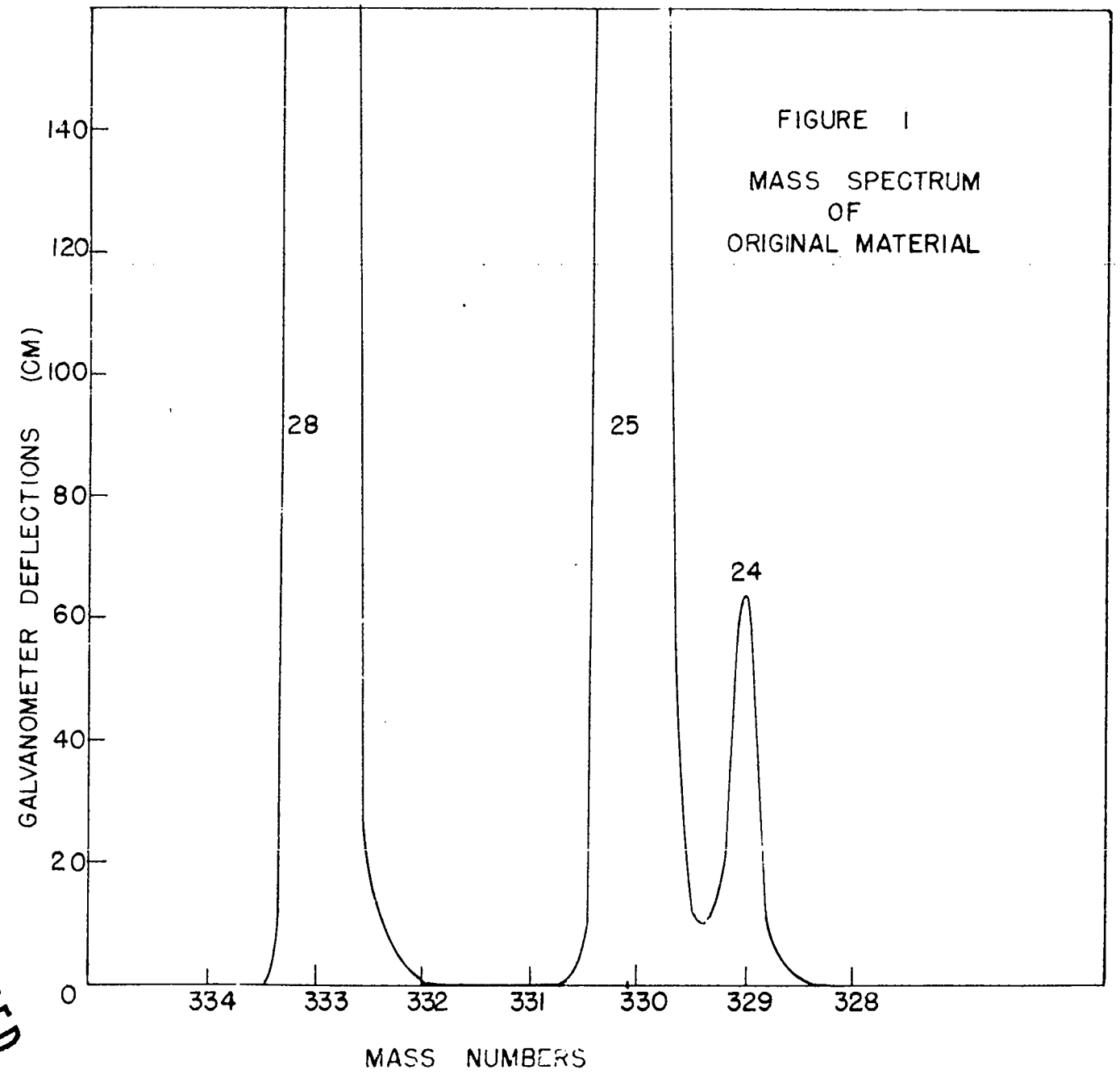

FIGURE 1

MASS SPECTRUM
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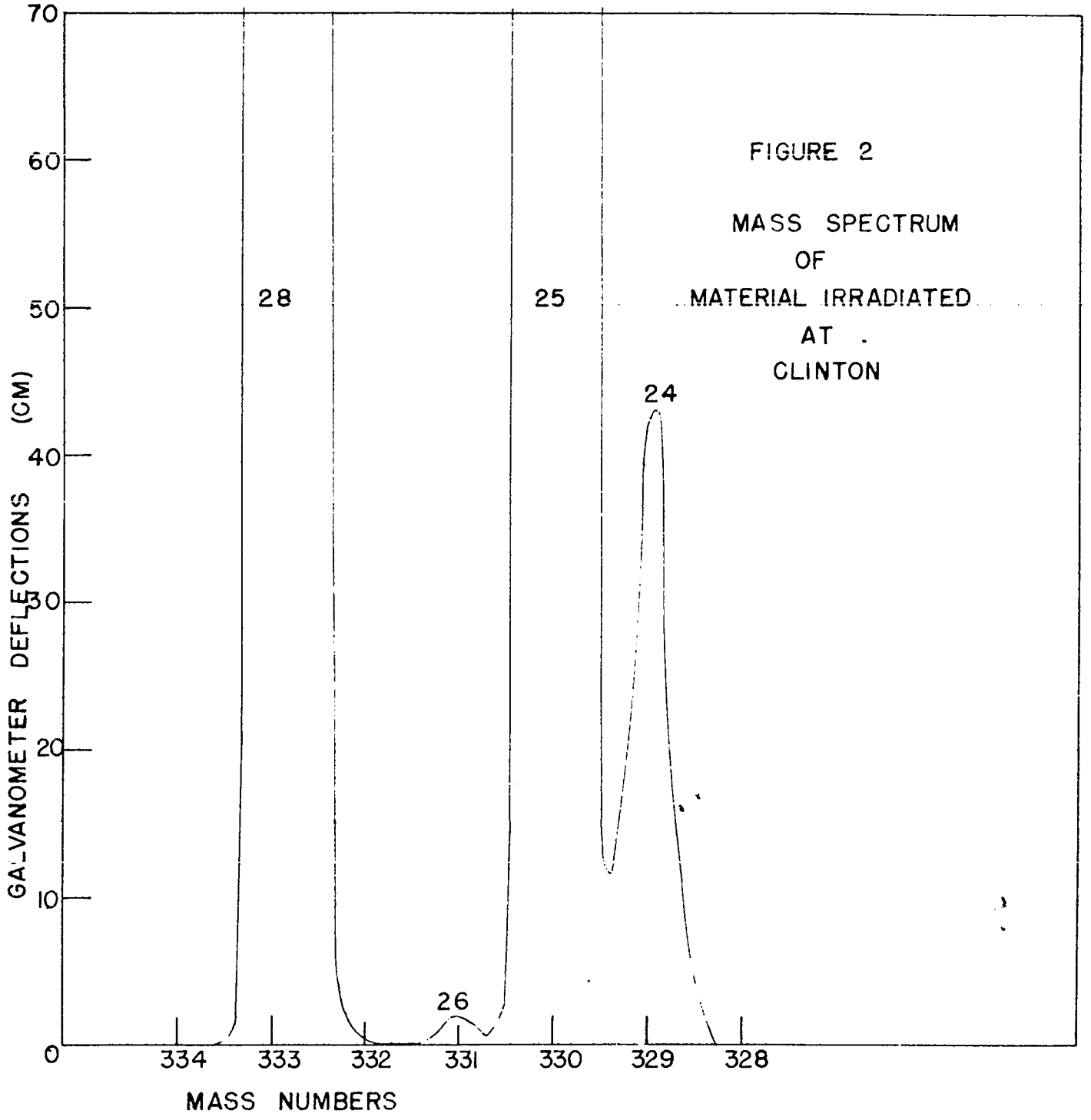

FIGURE 2

MASS SPECTRUM
OF
MATERIAL IRRADIATED
AT
CLINTON

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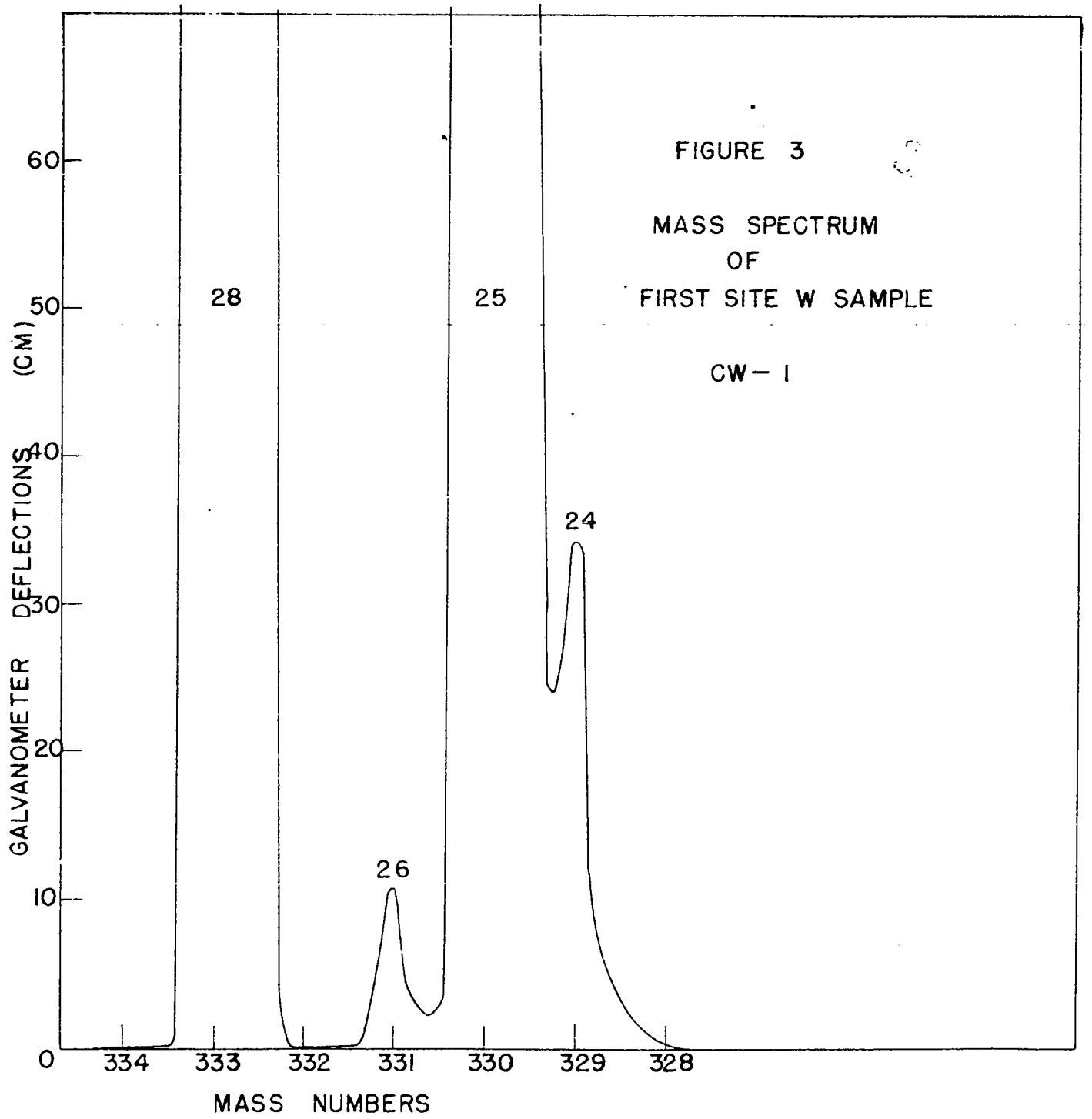

FIGURE 3

MASS SPECTRUM
OF
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CW – 1

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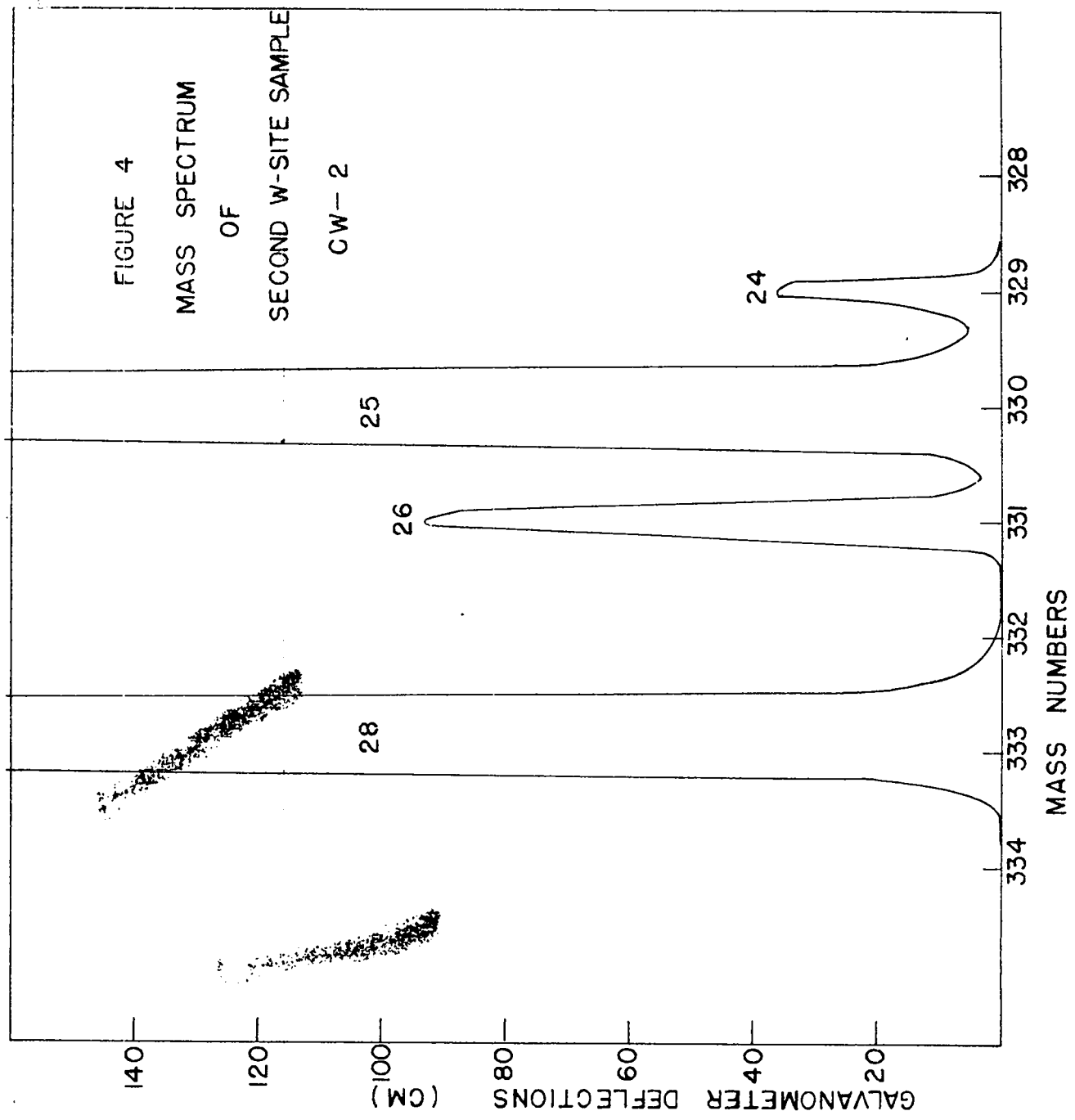

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