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CAPTURE CROSS SECTION OF U-235 FOR PILE NEUTRONS

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ABSTRACT

From mass-spectrographic data on irradiated samples of enriched material the capture cross section of U-235 has been determined in terms of Deutsch's irradiation measurements. The data obtained give $\sigma_f = 101 \pm 5 \times 10^{-24}$ cm^2, which gives a value of 0.186 ± 0.008 for α. An independent mass-spectrographic method involving measurement of U-236 creation and U-235 depletion gives a value of $\alpha = 0.183 \pm 0.006$, corresponding to $\sigma_r = 99 \pm 4 \times 10^{-24}$ cm^2. Agreement between results obtained by the two methods is satisfactory.

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CAPTURE CROSS SECTION OF U-235 FOR PILE NEUTRONS

INTRODUCTION

Several samples of enriched materials have been irradiated in the Clinton and Hanford piles for varying lengths of time. Mass-spectrographic measurements on the resulting material have enabled the writers to determine a value for the capture cross section of 25σ_f for two samples for which the irradiation was determined by Deutsch and to determine $\alpha = \sigma_r/\sigma_f$ by mass-spectrographic measurements alone.

EXPERIMENTAL RESULTS

The mass spectra obtained for the original material and for four irradiated samples are shown in Figs. 1, 2, 3, 4, and 5, respectively. The material used in each case was uranium hexaflouride, and the UF_5^+ ions formed by electronic bombardment were studied. It will be noted that for each irradiated sample a peak was observed at mass position 331 which can be attributed to U-236 formed by neutron capture by U-235. In every case this peak is sufficiently well resolved for accurate abundance measurements.

The values obtained for relative abundances are given in Table I. These numbers given are ratios of numbers of atoms in every case. These values are qualitatively in agreement with what would be expected for increasing irradiation except for the ratio U-238/U-235 for sample CW-2. This sample was apparently contaminated with normal uranium before reaching this laboratory; this contamination was sufficient to affect ratios involving U-238 quite seriously.

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DETERMINATION OF σ_r IN TERMS OF IRRADIATION MEASUREMENTS

Values of the capture cross section σ_r can be determined from the relationship

$$N_{26} = N_{25} \cdot nvt \cdot \sigma_r$$

where N_{26} and N_{25} are the numbers of U-236 and U-235 atoms respectively and (nvt) is the irradiation. The ratio N_{25}/N_{26} was determined mass spectrographically and nvt was determined by Deutsch by the method described in Report LA - 211. The values of σ_r obtained are given in Table II. The uncertainties indicated in the table are based on added mean deviations. The probable errors are somewhat smaller. The best value obtained for α by this method is $\alpha = 0.186 \pm 0.008$; this probable error does not include uncertainties in σ_f, which is assumed to be $2(0 \times 10)^{-24} cm^2$.*

DETERMINATION OF α FROM MASS SPECTROGRAPHIC DATA

The quantity α is defined as the ratio σ_r/σ_f. For a sample which has been subjected to a given irradiation this quantity can be expressed as follows:

$$\alpha = \frac{N_{26}}{\Delta N_{25} - N_{26}}$$

where N_{26} is the number of U-236 atoms created during irradiation and ΔN_{25} represents the number of U-235 atoms destroyed by fission and radiation capture. Since the change in the number of U-238 atoms during irradiation is small, the quantities N_{26} and ΔN_{25} can be referred to N_{28} in making abundance measurements; thus

$$\alpha = \frac{(N_{26}/N_{28})_f}{(N_{25}/N_{28})_o - (N_{25}/N_{28})_f}$$

[redacted]

* No satisfactory values for [illegible] determined from data on power dissipation in the pile.

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TABLE II

Cross Sections Based On Irradiation Data

Sample	$\frac{N_{25}}{N_{26}}$	nvt neutrons/cm^2	Capture Cross Section σ_r cm^2	$\alpha \equiv \sigma_r/\sigma_f$ *
Clinton	3800±50	2.59±0.13 x 10^{18}	101 ± 6 x 10^{-24}	0.187 ± 0.012
CW - 1	464±10	21.5±0.15	100 ± 9	0.185 ± 0.017
		Average -	101 ± 8 x 10^{-24}	0.186 ± 0.015

* σ_f is assumed to be 540 x 10^{-24} cm^2

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Where the subscripts 0 and f refer to abundance measurements on the original and irradiated materials, respectively. In making the calculation of α a small correction was made for change in the number of U-238 atoms during irradiation; the cross section assumed for destruction of U-238 was 8×10^{-24} cm^2. The value obtained for α from measurements on sample CW-3 and the original material was 0.183 ± 0.006. This value is in excellent agreement with the value obtained from irradiation measurements. Taking $\sigma_f = 540 \times 10^{-24}$ cm^2. This value of α give $\sigma_r = 99 \pm 4 \times 10^{-24}$ cm^2.

A further rough check on these measurements can be made by referring N_{26} and ΔN_{25} to N_{24}. The value obtained by this method cannot be determined with great accuracy since greater experimental difficulties are encountered in making abundance measurements in terms of the rare isotope U-234 and since the capture and fission cross-sections for U-234 are not well known. The value of α obtained from measurements made on samples CW-2 and CW-3 was 0.225 ± 0.045. This value is in rough agreement with the values obtained by other methods.

Summary

Values of α have been determined (1 by a method involving mass-spectrographic measurements of N_{26}/N_{25} and measurements of irradiation and (2 by a method involving mass-spectrographic measurements of N_{26}/N_{28} and $\Delta N_{25}/N_{28}$. The first method gives 0.186 ± 0.008 for α; the second method gives 0.183 ± 0.006 for α.

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TABLE I

Isotopic Abundances For Irradiated Samples

Sample	$t = N_{25}/N_{26}$	$R = N_{28}/N_{25}$	$S = N_{25}/N_{24}$
Original	∞	0.541 ± 0.001	170.0 ± 1.3
Clinton	3800 ± 50	0.545 ± 0.008	170 ± 10
CW - 1	464 ± 10	0.555 ± 0.005	163 ± 10
CW - 2	60.5 ± 1.0	1.008 ± 0.008*	154 ± 1.0
CW - 3	41.5 ± 0.3	$0.625 \pm .001$	150.0 ± 0.4

* Sample contaminated before reaching this laboratory.

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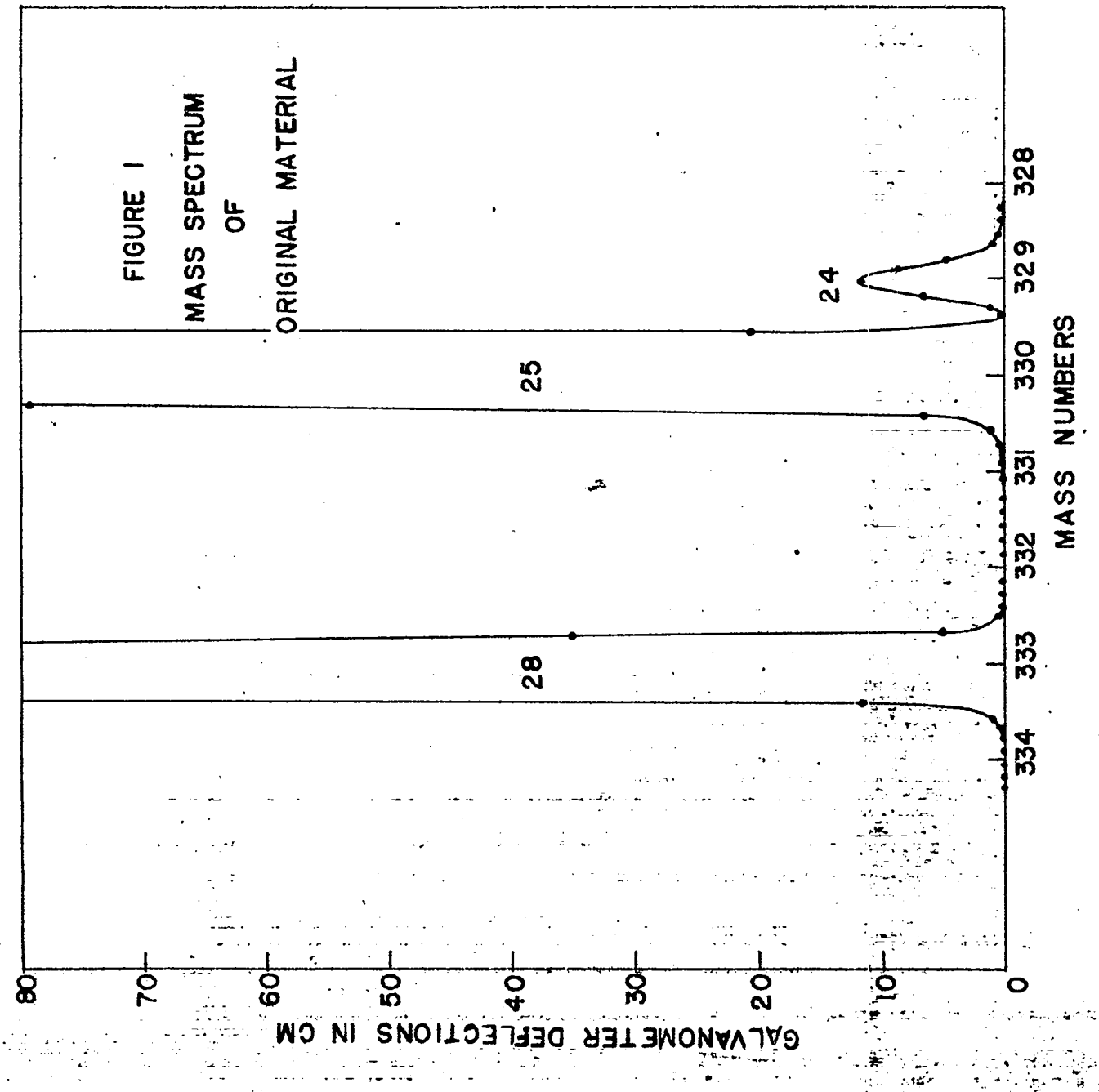

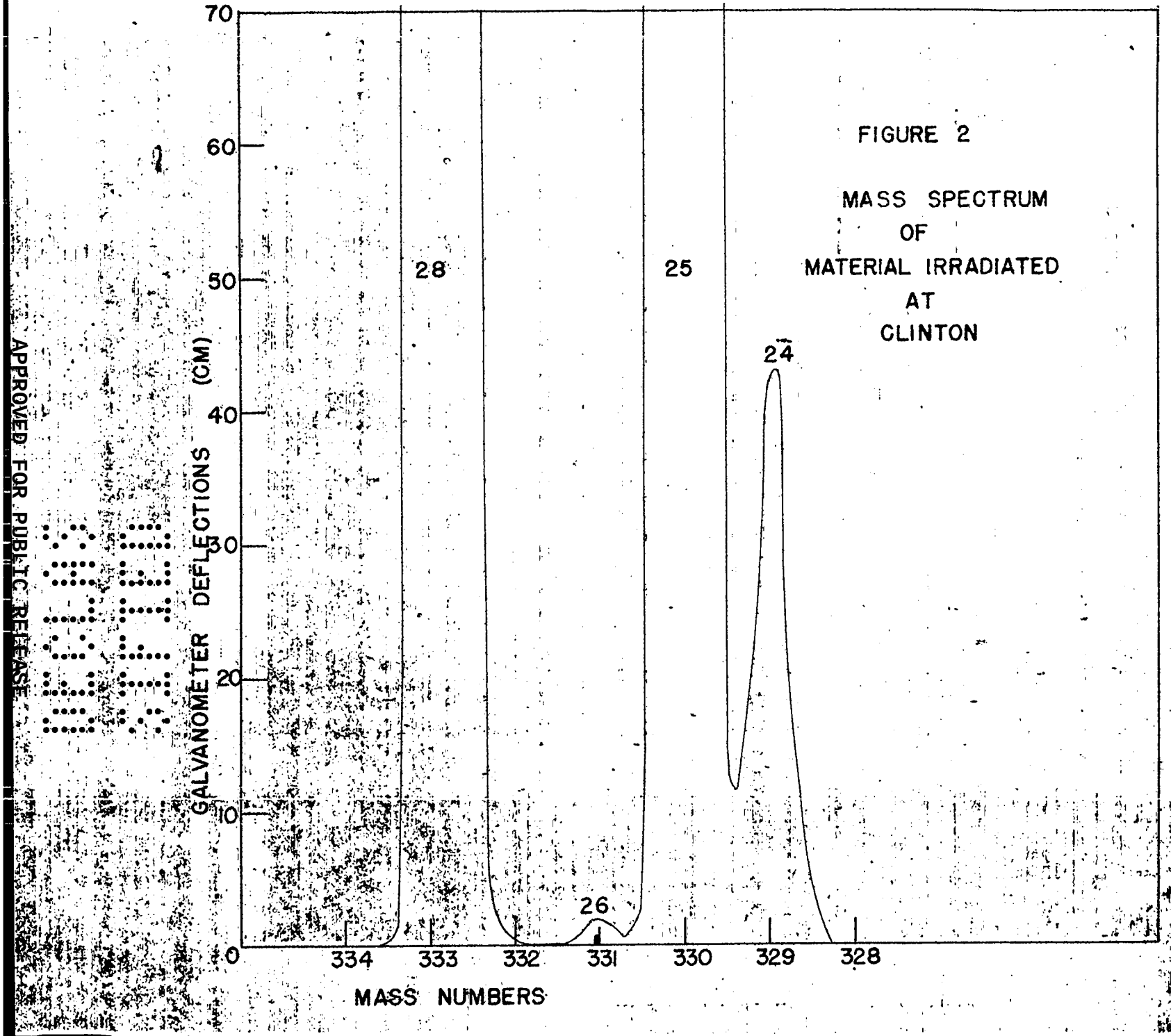

FIGURE 2

MASS SPECTRUM
OF
MATERIAL IRRADIATED
AT
CLINTON

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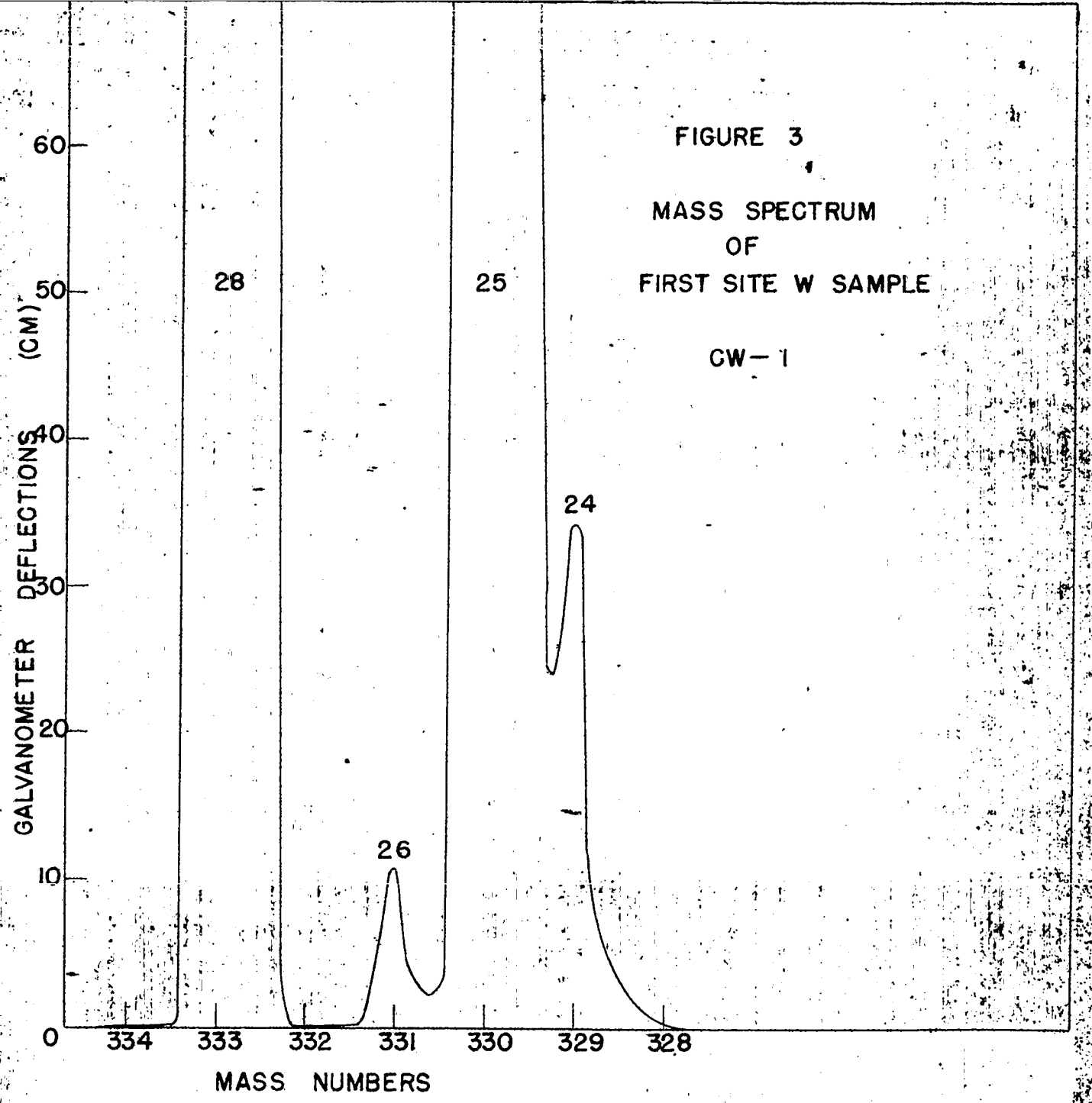

FIGURE 3

MASS SPECTRUM
OF
FIRST SITE W SAMPLE

CW – 1

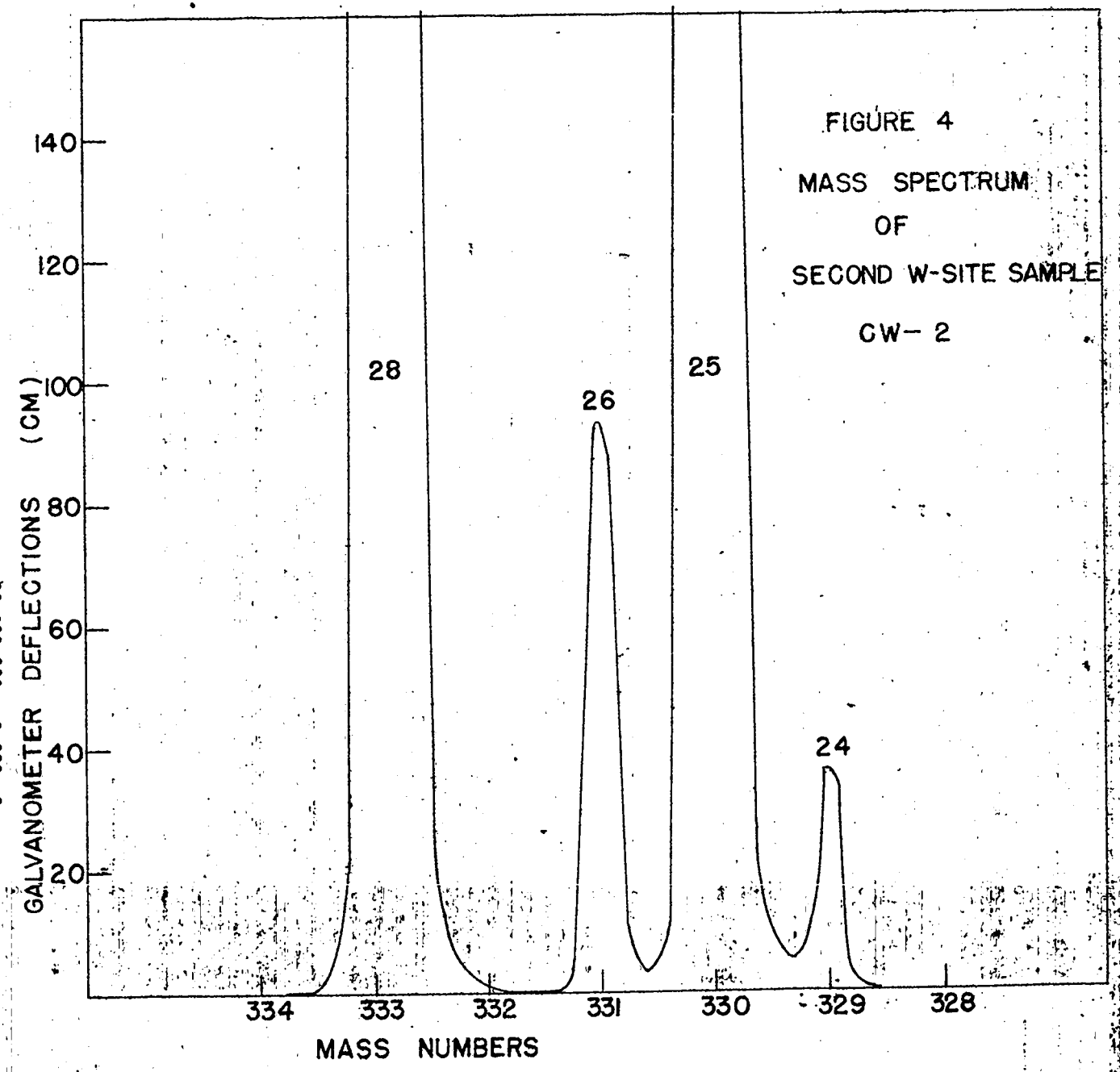

FIGURE 4

MASS SPECTRUM

OF

SECOND W-SITE SAMPLE

CW- 2

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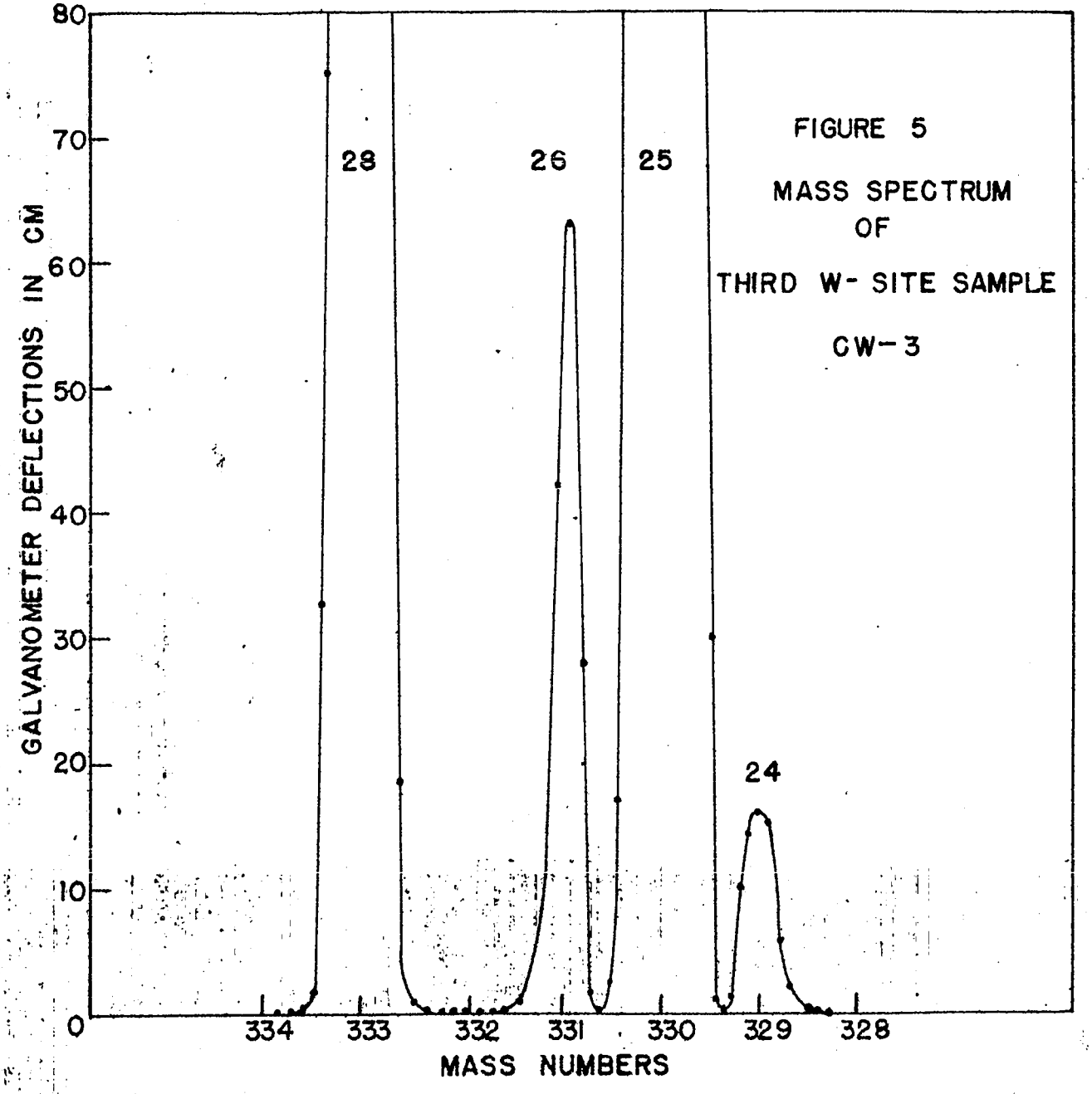

FIGURE 5

MASS SPECTRUM
OF
THIRD W- SITE SAMPLE

CW-3

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