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AEC RESEARCH AND DEVELOPMENT REPORT

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CARBIDE AND CARBON CHEMICALS CORPORATION

ENGINEERING DEVELOPMENT DIVISION

THEORETICAL ANALYSIS DEPARTMENT

Date: January 15, 1947
Report No: A-3672

MEMO ON THE CERTAINTY OF TOP CONCENTRATION MEASUREMENTS

Written by: J. P. Kelly

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CARBIDE AND CARBON CHEMICALS CORPORATION

ENGINEERING DEVELOPMENT DIVISION

THEORETICAL ANALYSIS DEPARTMENT

Date: January 15, 1947

To: S. Cromer

Report No. A-3672

MEMO ON THE CERTAINTY OF

TOP CONCENTRATION MEASUREMENTS

Written by: J. P. Kelly

Introduction:

The gradient assays above a concentration of 39400094% from November 5, 1946 through December 15, 1946 were based on absolute spectrometer measurements. However, it was felt that the samples for December 18, 1946 should be analysed by a different method so as to check the above mentioned work. For this reason fission-counted standards were prepared from 39400094% to the concentration at the top of the cascade, and the gradient samples were evaluated by relative spectrometric comparison with these standards. When evaluated by the use of new standards, the top concentration for December 18, 1946 appeared to be very much higher than was thought possible. As a check the samples of December 15, 1946 were analysed by the use of these new standards and the results obtained were compared with those previously obtained by absolute spectrometer. Top concentration was found to be

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about 1.5% higher by the use of the fission-counted standards than by absolute spectrometer.

It was this disagreement that gave rise to the study of the precision attainable by absolute spectrometer. In a discussion with L. A. Smith it was learned that the method to be presented in this memo is now in use, but that a study of its precision has not been reported.

Discussion and Calculations:

It is desirable to study the precision attainable in measuring the mol fraction of 25 in product by absolute spectrometer measurements of 24, 25, and 28, i.e. without the 24 correction based on alpha count.

Symbols

X = peak height of 25

Y = " " " 28

Z = " " " 24

$x = \frac{X}{X+Y+Z}$ = mol fraction of 25 in product

$y = \frac{Y}{X+Y+Z}$ = " " " 28 " "

$z = \frac{Z}{X+Y+Z}$ = " " " 24 " "

The factor whose precision is to be examined is x, the mol fraction of 25 in the product

$$x = \frac{X}{X+Y+Z} \qquad (1)$$

The variance of x can be found by the propagation of error through Equation (1):

$$V(x) = \left[\frac{X}{(X+Y+Z)^2}\right]^2 \left[V(Y) + V(Z)\right] + \left[\frac{Y+Z}{(X+Y+Z)^2}\right]^2 V(X) \qquad (2)$$

hence

$$V(x) = \frac{1}{(X+Y+Z)^2}\left\{\left[\frac{X}{X+Y+Z}\right]^2 \left[V(Y) + V(Z)\right] + \left[\frac{Y}{X+Y+Z} + \frac{Z}{X+Y+Z}\right]^2 V(X)\right\} \qquad (3)$$

By the use of the assumptions:

$$V(Y) \doteq V(Z)$$

$$X + Y + Z \doteq X$$

and the approximate concentration of product, Equation (3) becomes:

$$V(x) = 0.0020\,\frac{V(Y)}{Y^2} + 0.0036\,\frac{V(X)}{X^2} \qquad (4)$$

Let P_X = percent uncertainty in X

P_Y = " " " Y and in Z

P_x = " " " Mol fraction of 25

Then $P_x \doteq \sqrt{0.0020\, P_Y^2 + 0.0036\, P_Z^2}$

$$\doteq 0.044 \sqrt{P_Y^2 + 1.5\, P_Z^2} \qquad (5)$$

The table below contains the results of calculations based on Equation (5).

25 Peak (X)	Percent Precisions 24 & 26 Peaks (Z & Y)	Mol Fraction of 25 in Product
2	0	0.12
	5	0.25
	10	0.46
	15	0.68
	20	0.90
4	0	0.24
	5	0.33
	10	0.51
	15	0.71
	20	0.93
6	0	0.36
	5	0.42
	10	0.58
	15	0.76
	20	0.96

In Figure 1 the percent precision of the mol fraction of 25 in the product (x) is plotted against the percent precision of the 24 and 26 peaks (Z and Y). The parameter for each curve is the 25 peak (X).

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Conclusions:

It seems quite possible that a precision of about 0.2% to 0.3% is now being attained in the absolute spectrometer measurement of the mol fraction of 25 in the product. However, an uncertainty of bias of 0.23% is desired, and this cannot be checked by a single method such as the one just considered. This method should be an excellent check to be used with the methods employing alpha and beta counting.

J. P. Kelly

J. P. Kelly

Approved by: G. A. Garrett

G. A. Garrett

JPK:mh

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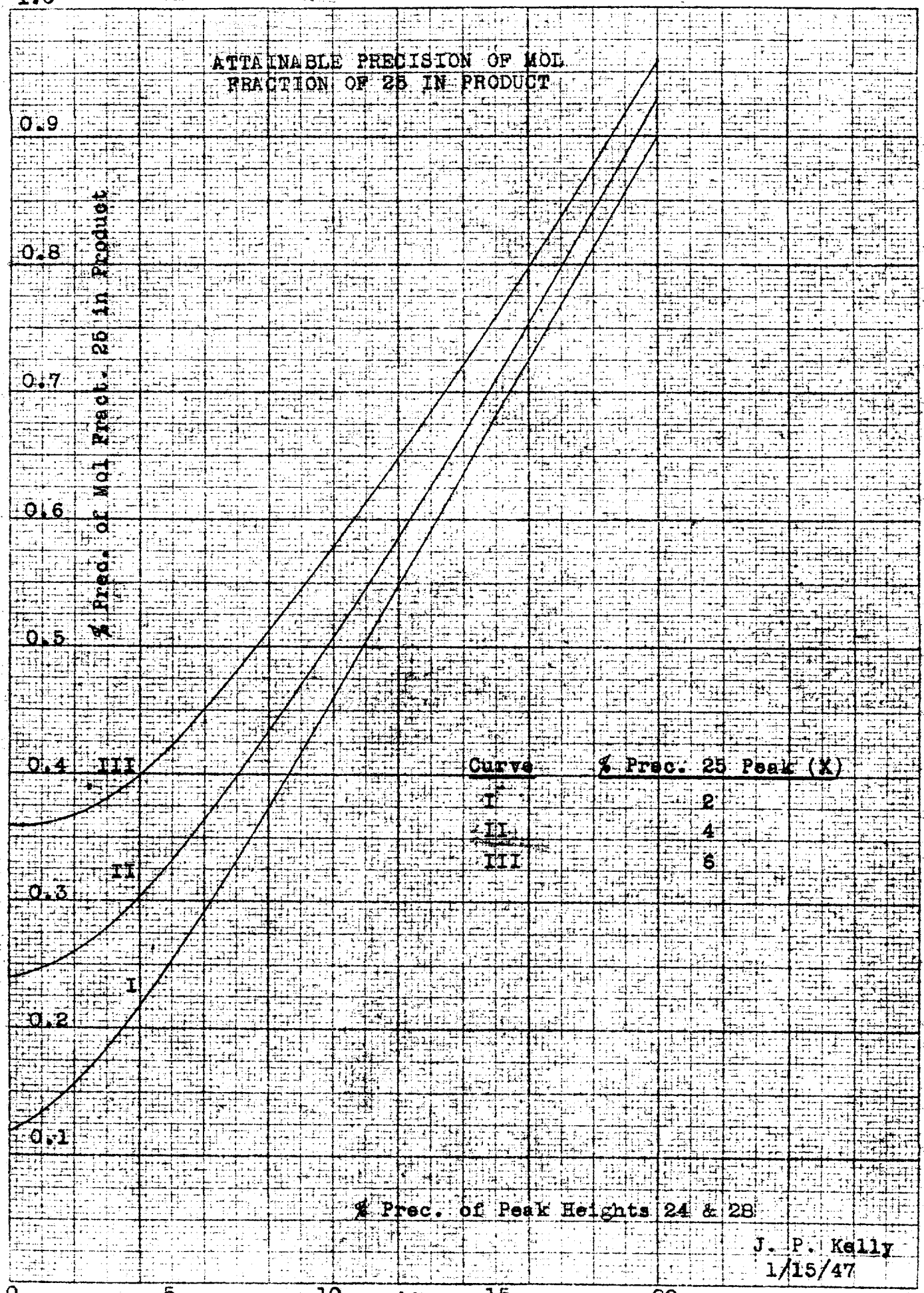

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Figure 1

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