SIMULATION OF A SINGLE FEED FRACTIONAL DISTILLATION COLUMN USING THE THIELE-GEDDES PROCEDURE

BY

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ABSTRACT

SIMULATION OF A SINGLE FEED FRACTIONAL DISTILLATION COLUMN USING THE THIELE-GEDDES PROCEDURE

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This thesis constitutes a simulation model of a single feed frational distillation column consisting of a single phase distillate, liquid or vapor product, an equilibrium stage reboiler, and a cascade consisting of theoretical equilibrium stages. The model limitations in addition to the single feed and the single phase distillate are 20 identifiable components, and 100 theoretical equilibrium stages. The thermodynamic data required are vapor-liquid equilibrium data and vapor-liquid enthalpy data, both assumed to be correlatable as functions of temperature. Compositional dependence of the thermodynamic data is ignored, but minor pressure variations throughout the cascade can be incorporated into the vapor-liquid equilibrium data. The method of solution employed in solving the non-linear equations describing this fundamental unit process is Hummel's variation of the Thiele-Geddes procedure coupled with the constant composition method of performing enthalpy or energy calculations.

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TABLE OF CONTENTS

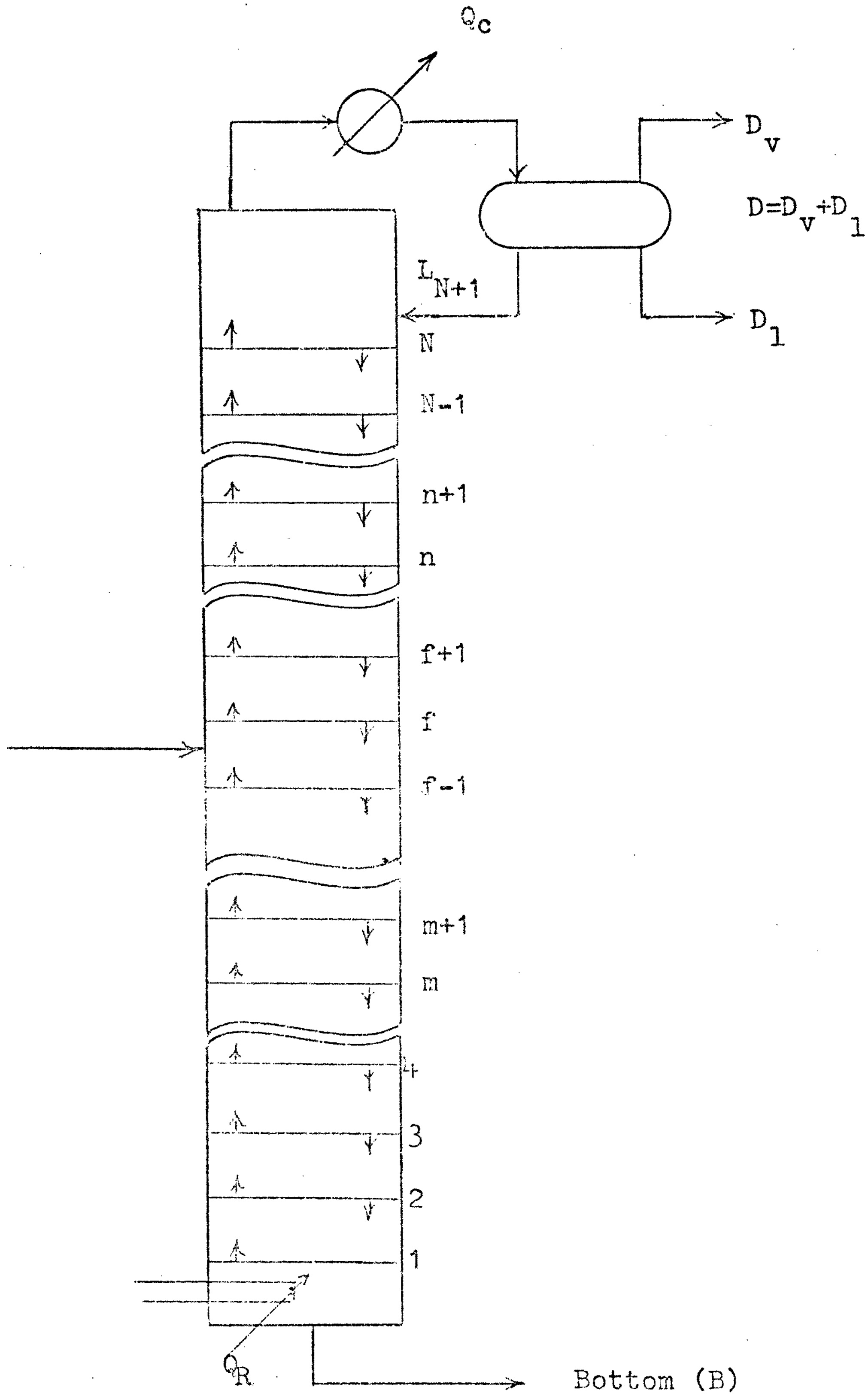
CHAPTER I

INTRODUCTION

A conventional fractional distillation column is defined as one in which a single feed is introduced and two basic product streams are withdrawn, the distillate and the bottom(4). Since the equations which describe the process of distillation of multicomponent mixtures are highly non-linear, this thesis discusses an iterative approach to the solution, using the θ convergence procedure. An alternative is to linearize the equations collectively and solve using the matrix technique known as the Newton Raphson procedure.

The requirements of the iterative procedure are a set of independent variables still maintaining a fixed set of design variables. Thiele and Geddes(9) selected the temperature and the liquid and vapor flow rates of each stage as the set of independent variables. This choice of absorption and stripping factors sets this specific calculational procedure apart from all others.

This project report will present a computer approach in performing the above Thiele-Geddes iterative procedure for the calculation of a single feed fractional


Q_c
D_v
$D=D_v+D_1$
L_{N+1}
D_1
N
N-1
n+1
n
f+1
f
f-1
m+1
m
4
3
2
1
Q_R
Bottom (B)

distillation column using the refinement presented by Hummel(10). This program includes the following options:

One Feed:

1. Liquid Feed:

   a. sub cooled liquid feed

   b. saturated liquid feed (bubble point)

2. Two phase flashed feed

3. Vapor Feed:

   a. saturated vapor feed (dew point)

   b. super heated vapor feed

Distillate:

1. All Liquid Distillate (Bubble Point)
2. All vapor Distillate (Dew point).
3. Two phase distillate option is not available.

The fixed set of design variables are:

1. feed rate, composition, and thermal condition
2. Distillate (phase condition) and bottoms rate
3. Reflux rate
4. stages (theoretical - 100% efficiency) = total stages and feed stage location
5. Pressure in reflux - distillate separator, and pressure drop through condenser and per stage.

6. Adiabatic operation except for condenser and reboiler

CHAPTER II

THEORY

The Thiele-Geddes(9) method is distinguished by the fact that no assumption is required on the component splits (distillate and bottom products). The assumptions required are the temperatures and total internal liquid and vapor flow rates on each stage.

This method of calculation is based on the $(v/b)_{n,i}$ or $(l/b)_{n,i}$ (n refers to the stage and i refers to the component) in the stripping section, and $(v/d)_{n,i}$ or $(l/d)_{n,i}$ in the rectifying section, both of which can be calculated by a component material balance between stage n and the respective bottoms or distillate depending upon whether the calculation is in the stripping or rectifying section of the column.

An overall material balance around the total tower and around the feed zone, combined with the top and bottom component ratios can then be solved simultaneously to give the individual component product rates of d_i and b_i.

In the original hand calculation methods, the problem was converged by direct iteration. Holland and Lyster(8) improved the speed of convergence by use of the theta-convergence procedure. This will be explained later in the convergence section. Other convergence procedures were tried by J. S. Bonner(1) but this was not as fruitful as the Theta method.

For initial temperature profiles one could estimate the stage temperatures using as a basis one of the many short-cut methods; but the most common approach is to use a linear distribution between an estimated top and bottoms temperature. One should be aware that the closer the initial profiles are to the final values, the fewer iterations are required for convergence.

CHAPTER III

CALCULATIONAL PROCEDURES

This chapter is segmented into three main parts; the rectifying section, the stripping section, and the general feed zone match, each of which is discussed fully. The convention used in the development of this simulation program is to number the contact stages from the bottom of the column (reboiler) upward to the top of the column. The condenser-reflux accumulator is considered separately, and may, or may not, be an equilibrium stage depending upon the state of the distillate.

Rectifying Section

Subscript n refers to the stage and subscript i refers to the component; subscript i is dropped for simplicity in the following development.

The start of the calculation depends on the type of condenser, however, the case of the partial condenser can be developed and then used for the general case. The derivation of these equations is found in the appendix, and are written for component i. For any condenser: (Stage N + 1)

$$(l/d)_{N+1} = \frac{L_{N+1}}{D_L + D_v K_{N+1}} \qquad (1)$$

for the total condenser $D_v = 0$ and, $(l/d)_{N+1} = \frac{L_{N+1}}{D_L} = R$,

and for the reflux condenser, $D_L = 0.0$ and,

$$(l/d)_{N+1} = \frac{L_{N+1}}{D_v K_{N+1}}$$

After calculating $(l/d)_{N+1}$ the calculation proceeds to the top stage (N).

$$(l/d)_N = A_N \left[(l/d)_{N+1} + 1.0\right]$$

or

$$(v/d)_N = (l/d)_{N+1} + 1.0$$

for stage n - 1

$$(l/d)_{n-1} = A_{n-1} \left[(l/d)_n + 1.0\right] \qquad N \geq n \geq f$$

or

$$(v/d)_{n-1} = (v/d)_n A_n + 1.0 \qquad N - 1 \geq n \geq f$$

A_n is the absorption factor and is defined as

$$A_n = \frac{L_n}{K(T_n)V_n}$$

(K is evaluated at temperature of stage n). This calculation continues to stage f + 1 which gives

$(l/d)_{f+1}$ or $(\overline{v}/d)_f$ (Refer to figure (1), page 11, where $\overline{v}$ is shown to be the net vapor entering the rectifying section at the feed zone.)

<u>Stripping Section</u>

Starting with the reboiler stage (n = 1) one proceeds upward to the feed stage.

The following equations apply for an equilibrium stage reboiler (kettle type or once through thermo syphon) provided the stages are numbered from the first equilibrium stage. All of these equations are written for component i.

$$l_1 = b$$

Then

$$(l/b)_1 = 1.0$$

or

$$(v/b)_1 = (l/b)_1 S_1 = S_1$$

This calculation then proceeds to stage 2 where:

$$(l/b)_2 = (l/b)_1 S_1 + 1.0$$

or

$$(v/b)_2 = S_2 \left[(v/b)_1 + 1.0 \right]$$

where b is bottoms.

For stage n

$$(l/b)_n = (l/b)_{n-1} S_{n-1} + 1.0 \qquad f + 1 > n > 1$$

$$(v/b)_n = S_n \left[(v/b)_{n-1} + 1.0 \right] \qquad f > n > 1$$

S_n is the stripping factor and is defined as 1.0/A or

$$S_n = \frac{K(T_n)(V_n)}{L_n}$$

(K is evaluated at temperature of stage n).

The calculation continues stage by stage until the feed stage is reached, yielding $(v/b)_f$ and $(\bar{l}/b)_{f+1}$. (Refer to figure (1), where $\bar{l}$ is shown to be the net liquid entering the stripping section at the feed zone.)

General Feed Zone Match

For component i.

$$(b/d) = \frac{(l/d)_{f+1} + l_f/F_z}{(v/b)_f + v_F/F_z} \qquad (2)$$

in equation (2) subscript f + 1 refers to the feed stage plus one.

Equation (2) is applicable for a feed of any thermal condition. For a bubble point liquid or subcooled liquid feed $l_F = F_z$ and $v_F = 0.0$; and for a feed that enters the column at its dew point or as a superheated vapor.feed $v_F = F_z$ and $l_F = 0.0$.

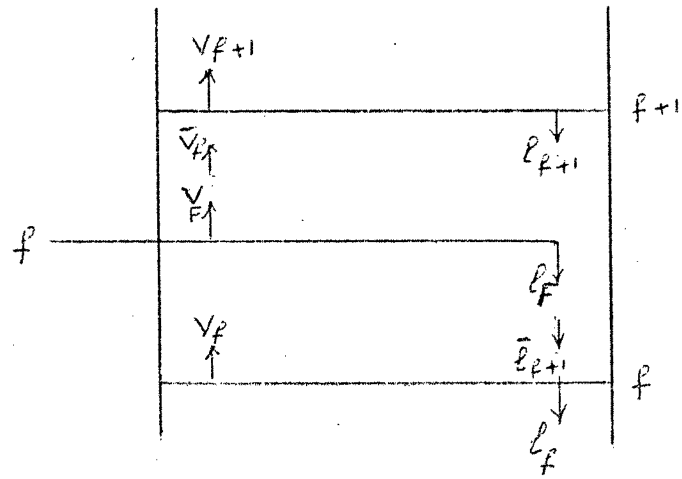


Figure (1)

CHAPTER IV

CONVERGENCE

The equations for the Thiele-Geddes method combine the restrictions of equilibrium and material balance. The calculated ratios $(b/d)_i$ can be used in an overall component material balance to give the value of d_i:

$$d_i = \frac{Fz_i}{1.0 + (b/d)_i} \qquad (1)$$

$$b_i = (b/d)_i d_i \qquad (2)$$

It should be noted that in order to minimize round-off error, b_i is not calculated from $f_i - d_i$ but rather from equation (2).

The values of d_i and b_i obtained by equations (1) and (2) could be scaled so that the specified product rates (distillate and bottoms) are satisfied, and then used to calculate values of v_i or l_i on all stages.

In the rectifying section

$$l_{n,i} = (l/d)_{n,i} \; d_i$$

$$v_{n,i} = (v/d)_{n,i} \; d_i$$

Similarly, the values of v_i and l_i can be determined on all stages in the stripping section:

$$v_{n,i} = (v/b)_{n,i} b_i$$

$$l_{n,i} = (l/b)_{n,i} b_i$$

n refers to the stage and i refers to the component.

The summation of the calculated values of componential flow rates in the rectifying and stripping section stages will not be consistent with the overall material balance until the problem is converged.

To continue with the computational procedure, the component flow rate must be normalized on each stage and a new set of tray temperatures determined by equilibrium calculations. In this program dew points are used on each stage in the rectifying section and Bubble Points are used on each stage in the stripping section (see Appendix for Dew Point and Bubble Point calculation procedure). The dual procedure is used because the net mass transfer in the rectifying section is by vapor transport, and by liquid transport in the stripping section; and because the equilibrium calculations used converge more rapidly than if just dew point or bubble point procedures are used.

Vapor compositions for the dew point calculation in the rectifying section are obtained by:

$$y_i = \frac{v_i}{\sum v_i}$$

Liquid compositions for the bubble point calculation in stripping section are obtained by:

$$x_i = \frac{l_i}{\sum l_i}$$

To increase the rate of convergence one should correct the value of d_i's calculated from the feed stage match to give a correct set that satisfies both the overall material balance for each component and the specified value of D, the total distillate rate. Thus, it is required that the corrected set of d_i's satisfy the following:

$$Fz_i = (d_i)_{co} + (b_i)_{co}$$

and

$$D = \sum (d_i)_{co}$$

Throughout this report the subscript "co" will be used to define the corrected value of the variable and "ca" define the calculated value of the variable.

CHAPTER V

θ METHOD OF CONVERGENCE

In direct iteration (v_i/d_i) and (l_i/b_i) are used with $(d_i)_{ca}$ and $(b_i)_{ca}$ to obtain tray compositions. Even though,

$$\sum (v_i/d_i)(d_i)_{ca} \neq V$$

$$\sum (l_i/b_i)(b_i)_{ca} \neq L$$

these quantities are used to give the next set of stage temperatures via bubble point and dew point equilibrium calculations.

$(b/d)_{ca}$ is not correct because

$$\sum (d_i)_{ca} = \sum \frac{f_i}{1.0 + (b_i/d_i)_{ca}} \neq D$$

where $f_i = Fz_i$.

If $(b/d)_{co}$ is obtainable, then

$$\sum (d_i)_{co} = \sum \frac{f_i}{1.0 + (b_i/d_i)_{co}} = D$$

and

$$(b_i/d_i)_{co} = \theta (b_i/d_i)_{ca}$$

with θ as the factor which is used to correct $(b_i/d_i)_{ca}$,

$$\sum (d_i)_{co} = \sum \frac{f_i}{1.0 + \theta(b_i/d_i)_{ca}} \equiv D$$

The value of θ changes for each trial and is found by Newton's method(8) (when the value of θ is 1.0$\pm$ tolerance of .0001, for two consecutive trials the tower computational procedure is complete). After θ is found

$$(d_i)_{co} = \frac{f_i}{1.0 + \theta(b_i/d_i)_{ca}}$$

$$(b_i)_{co} = \theta(b_i/d_i)_{ca}(d_i)_{co}$$

Then, for stage n

$$y_i = \frac{(v_i/d_i)(d_i)_{co}}{(v_i/d_i)(d_i)_{co}}$$

$$x_i = \frac{(l_i/b_i)(b_i)_{co}}{(l_i/b_i)(b_i)_{co}}$$

where "i" refers to the component. Using these adjusted compositions a new set of stage temperatures can be obtained by using the appropriate equilibrium calculation.

CHAPTER VI

CALCULATION OF Θ

The value of θ is defined implicitly by the following equation:

$$(d_i)_{co} = \frac{f_i}{1.0 + \theta(b_i/d_i)_{ca}} \tag{1}$$

Since the sum of d_i corrected equals the specified distillate D, the following function, $g(\theta)$, may be written:

$$g(\theta) = \sum \frac{f_i}{1.0 + \theta(b_i/d_i)_{ca}} - D \tag{2}$$

This positive root of equation (2) may be found using Newton's method.

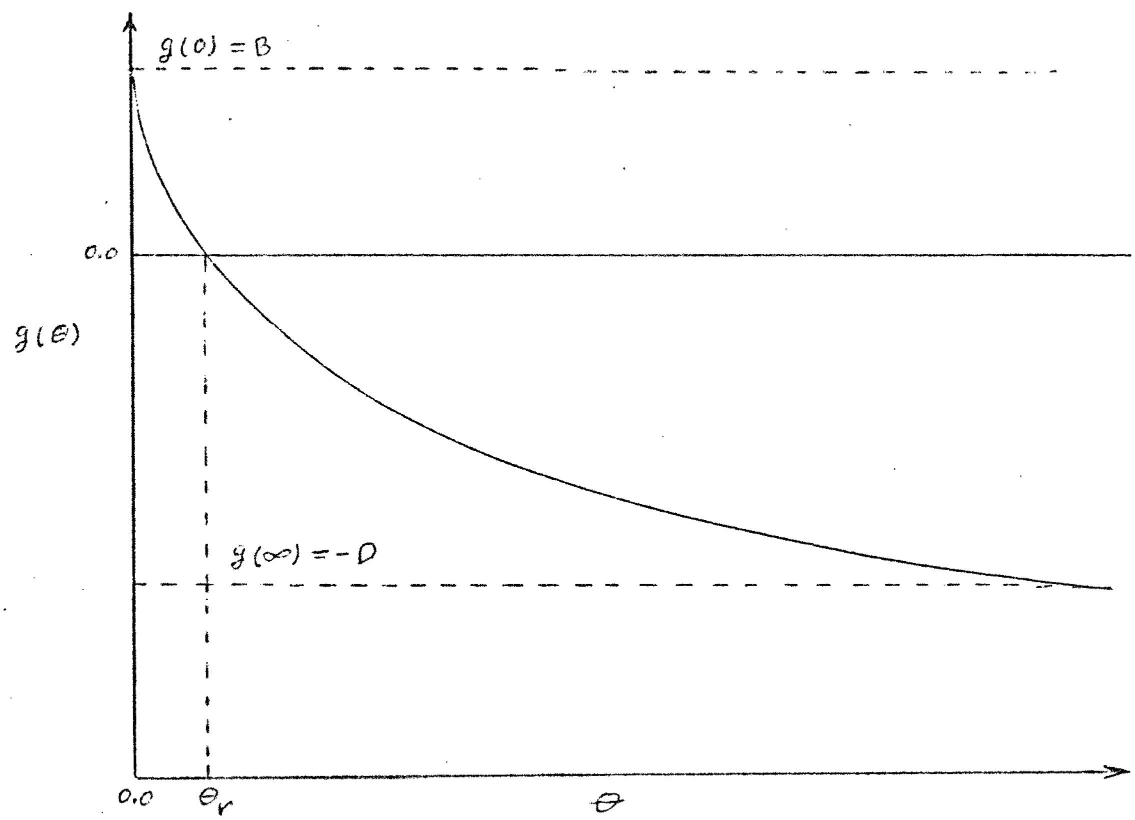
Newton's method is the expansion of a function in terms of a two term Taylor's Series and requires the first derivative of equation (2), with respect to θ:

$$dg(\theta)/d\theta = -\sum \frac{(b_i/d_i)_{ca} f_i}{\left[1.0 + \theta \ (b_i/d_i)_{ca}\right]^2}$$

To find the desired value of θ that is θ_n one must apply Newton's method several times, provided that the first assumed value of Θ satisfies the inequality $0.0 \leq \Theta \leq \Theta_r$.

$$g(\Theta) = g(\Theta_0) + \left[\frac{dg(\Theta_0)}{d\Theta}\right](\Theta_0 - \Theta) = 0.0$$

The necessity of this requirement can be seen from the following sketch of $g(\Theta)$ versus Θ. When $\Theta = 0.0$, then $g(\Theta) = f - D = B$, and when $\Theta = \infty$ then $g(\Theta) = -D$, the value of the derivative $dg/d\Theta$ at $\Theta = 0.0$ is finite and not equal to zero, whereas $\Theta = \infty$ yields a derivative of 0.0 and a $\Delta\Theta$ that is undefined.



$\theta = 0.0$ is a value which satisfies the inequality, and can be used as the first assumed value of θ. After θ_r is found it must be substituted into equation (1) to calculate $(d_i)_{co}$. Finally, the adjusted vapor composition required for the dew point equilibrium calculation in the rectifying section can be obtained from equation (3).

$$y_i = \frac{(v_i/d_i)(d_i)_{co}}{\sum(v_i/d_i)(d_i)_{co}} \tag{3}$$

$$x_i = \frac{(l_i/b_i)(b_i)_{co}}{\sum(l_i/b_i)(b_i)_{co}} \tag{4}$$

and the adjusted liquid composition required for the bubble point equilibrium calculation in the stripping section can be obtained from equation (4).

CHAPTER VII

ENTHALPY BALANCES - CONVENTIONAL METHOD

To determine the total flow rates one must use the approximate form of the first law of thermodynamics. Two different ways are developed for the calculation of the total enthalpy of a stream, the conventional method and the constant composition method(2, 3, 11). In this project report the constant composition method is used, but the conventional method will be briefly discussed so one can see the distinct advantage of the constant composition method.

Using the conventional method one generally assumes that each stage of conventional column operates adiabatically except for the condenser and the reboiler. For stage n vapor and liquid enthalpies are computed by the following relations which assume no heat of mixing:

$$H_n = \sum H_i(T_n) \quad y_{n,i}$$

$$h_n = \sum h_i(T_n) \quad x_{n,i}$$

"H_i" and "h_i" are the enthalpies of the pure component i in the vapor and liquid streams leaving stage n, and are evaluated using the temperature of stage n from either polynominals or tabular interpolation.

Rectifying Section

In the condenser (stage N+1), since D and L_{N+1} are fixed, the value of V_N is also fixed by material balance.

$$V_N = L_{N+1} + D$$

Both a heat balance (Q_c is the condenser duty) and a material balance can be written between rectifying stages n and n + 1 encompassing the stages above n and the condenser-reflux distillate separator, as described by equations (1) and (2).

$$V_n H_n = L_{n+1} h_{n+1} + D_V H_V + D_L h_L + Q_C \qquad (1)$$

$$V_n = L_{n+1} + D \qquad (2)$$

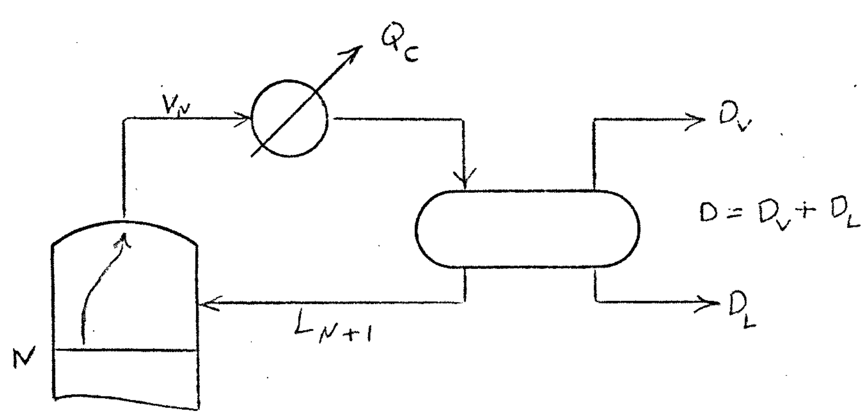


Figure 1

By eliminating V_n using the material balance relationship, equation (2), and letting $M_D = H_D + Q_c/D$ one obtains L_{n+1} from equation (3) and the passing vapor V_n from equation (2).

$$L_{n+1} = \left[\frac{M_D - H_n}{H_n - h_{n+1}}\right] D \qquad f + 1 < n < N - 1 \qquad (3)$$

<u>Stripping Section</u>

Between stages n and n - 1 in the stripping sections both an enthalpy and a material balance can be written encompassing the stages below stage n and the equilibrium stage reboiler (stage 1) having a heat input of Q_R. The resulting equations are presented as equations (4) and (5).

$$V_{n-1}H_{n-1} + Bh_B = Q_R + L_n h_n \qquad (4)$$

$$V_{n-1} + B = L_n \qquad (5)$$

Eliminate L_n using equation (5) and letting $M_B = h_B - Q_R/B$ one obtains

$$V_{n-1} = \left[\frac{h_n - M_B}{H_{n-1} - h_n}\right] B \qquad (6)$$

One can see that the denominators of equations (1) and (2) are extremely sensitive to small changes in composition and temperatures, because "H_{n-1}" and "h_n" can under the condition of very light and very heavy components be approximately equal. The constant composition method virtually eliminates this difficulty, since for a particular iteration the compositions that give H_{n-1} and h_n are not in material balance and changes from iteration to iteration result in large changes in the calculated values of L or V.

To complete the conventional enthalpy balance method one must define Q_c and Q_R, the condenser and reboiler heat loads. The condenser load is obtained via a material and energy balance about the condenser-distillate drum; and the reboiler load is obtained by an overall column energy balance.

CHAPTER VIII

ENTHALPY BALANCE CALCULATIONAL PROCEDURE

Presented in this chapter is the computational procedure used in the simulation problem to modify the internal liquid and vapor flow rates and is termed the constant-composition method.

The constant-composition method was developed because the results are more stable, particularly for systems of very light and very heavy components. Referring to equations (3) and (6) and to Chapter VII (page 23), the value of "H_{n-1}" is not much different from "h_n", which occurs in the denominator. Also, for some non-converged trials this difference can even be negative. The constant-composition method is recommended for all calculations since it works as well or better than the conventional method.

Definitions of stream enthalpies:

$$H_n = \sum H_n(T_n) y_{n,i}$$
$$h_n = \sum h_n(T_n) x_{n,i}$$

"n" refers to the stage and "i" refers to the component.

Condenser Duty (Q_c)

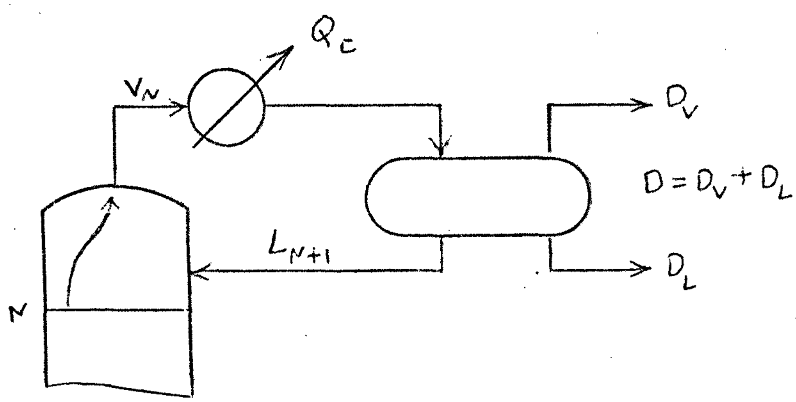


Figure 1

From an energy balance around the condenser-distillate accumulator:

$$V_N H_N = L_{N+1} h_{N+1} + D_V H_V + D_L h_L + Q_c$$

Solving for Q_c

$$Q_c = V_N H_N - L_{N+1} h_{N+1} - D_V H_V - D_L h_L \quad (1)$$

and letting $DH_D = D_V H_V + D_L h_L$ then:

$$Q_c = V_N H_N - L_{N+1} h_{N+1} - DH_D \quad (2)$$

(Reboiler Duty)

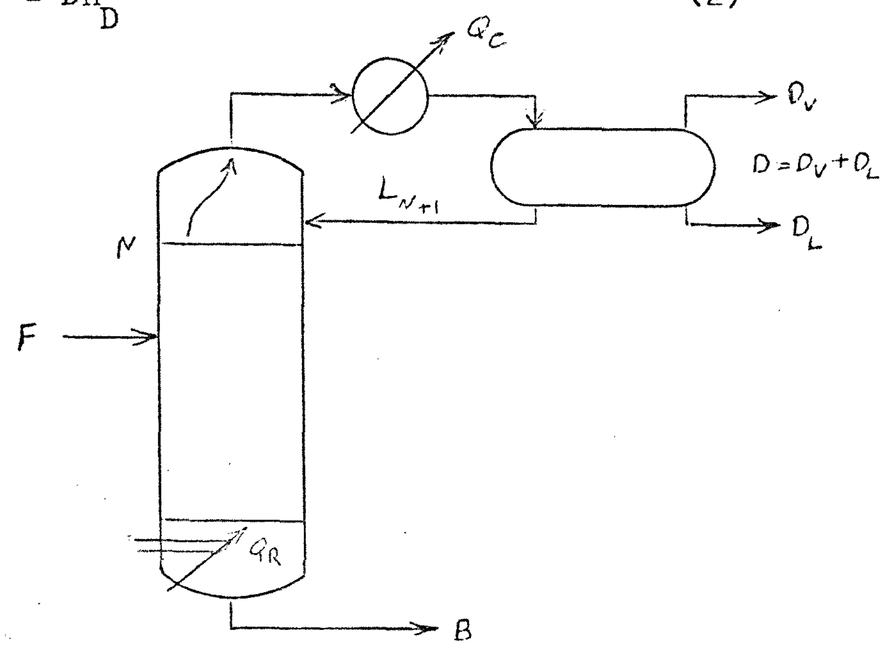


Figure 2

From an overall energy balance around the entire column.

$$F_V H_V + F_L h_L + Q_R = Q_c + Bh_B + DH_D$$

Solving for Q_R

$$Q_R = Q_c + Bh_B + DH_D - F_V H_V - F_L H_L$$

Eliminating Q_c using equation (2) we obtain:

$$Q_R = V_N H_N - L_{N+1} h_{N+1} + Bh_B - F_V H_V - F_L h_L \qquad (3)$$

<u>Rectifying Section</u>

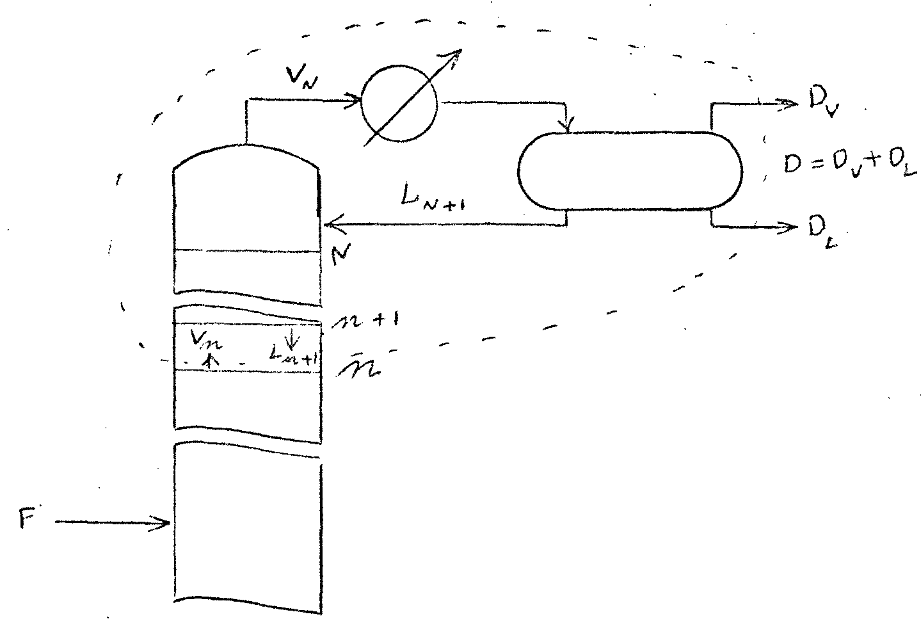


Figure 3

To determine the new internal flow rates in the rectifying section one writes an energy balance below stage "n + 1" including the condenser-distillate accumulator.

$$V_nH_n = L_{n+1}h_{n+1} + DH_D + Q_c \tag{4}$$

Below any rectifying stage n + 1 a material balance (including condenser) gives:

$$V_n = D + L_{n+1}$$

By definition

$$V_nH_n = \sum H_{n,i} v_{n,i}$$

Combining the definition of V_nH_n with $v_i = d_i + l_i$ one obtains:

$$V_nH_n = DH(x_D)_n + L_{n+1}H(x_{n+1})_n \tag{5}$$

Eliminating V_n in equation (4) by applying equation (5) one obtains:

$$L_{n+1} = \frac{Q_c + D\left[H_D - H(x_D)_n\right]}{H(x_{n+1})_n - h_{n+1}} \tag{6}$$

Eliminating Q_c by using equation (2) one obtains for the liquid:

$$L_{n+1} = \frac{V_NH_N - L_{N+1}h_{N+1} - DH(X_D)_n}{H(x_{n+1})_n - h_{n+1}} \tag{7}$$

and the passing vapor V_n:

$$V_n = L_{n+1} + D$$

Definitions:

$$V_N H_N = \left[\sum y_{N,i} H(T_N)\right] V_N$$

$$L_{N+1} H_{N+1} = \left[\sum x_{N+1,i} h_i (T_{N+1})\right] L_{N+1}$$

$$DH(x_D)_n = \left[\sum x_{D,i} H_i (T_n)\right] D$$

$$H(x_{n+1})_n = \sum x_{n+1,i} H_i (T_n)$$

$$h_{n+1} = \sum x_{n+1,i} h_i (T_{n+1})$$

This calculation starts at stage n - 1 and continues stage by stage until stage f is reached. This gives L_{f+2} and V_{f+1} as the final terms.

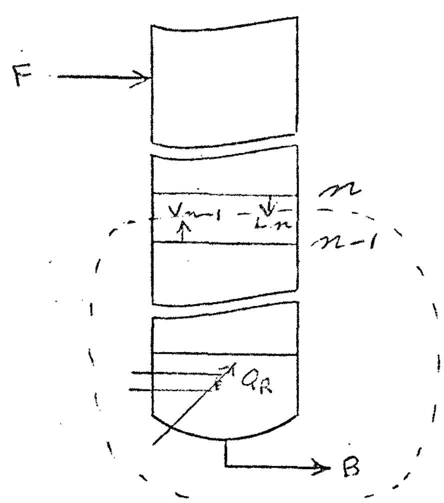


Figure 4

Stripping Section

Writing an energy balance above stage "n-1" including the reboiler and bottoms product, one obtains:

$$V_{n-1}H_{n-1} + Bh_B = Q_R + L_n h_n \tag{8}$$

Below any stripping stage "n" a material balance, (including the bottoms) gives:

$$L_n = V_{n-1} + B$$

By definition:

$$L_n h_n = h_{n,i} l_{n,i}$$

Combining the definition of $L_n h_n$ with $L_n = V_{n-1} + B$ one obtains:

$$L_n h_n = V_{n-1} h(y_{n-1})_n + Bh(x_B)_n \tag{9}$$

Eliminating L_n in equation (8) by applying equation (9) one obtains:

$$V_{n-1} = \frac{Q_R + B\left[h(x_B)_n - h_B\right]}{H_{n-1} - h(y_{n-1})_n}$$

Eliminate Q_R by using equation (3)

$$V_{n-1} = \frac{V_N H_N - L_{N+1} h_{N+1} - F_v H_v - F_L h_L + Bh(x_B)_n}{H_{n-1} - h(y_{n-1})_n} \tag{10}$$

and the passing liquid,

$$L_n = V_{n-1} + B$$

Definitions:

$V_N H_N$ and $L_{N+1} h_{N+1}$ are the same as for the rectifying section.

$$F_v H_v = \left[\sum y_{F,i} H_i (T_f) \right] F_V \text{ at feed temperature}$$

$$F_L H_L = \left[\sum x_{F,i} h_i (T_f) \right] F_L \text{ at feed temperature}$$

$$Bh(x_B)_n = \left[\sum x_{B,i} h_i (T_n) \right] B$$

$$H_{n-1} = \sum y_{n-1,i} H_i (T_{n-1})$$

$$h(y_{n-1})_n = \sum y_{n-1,i} h_i (T_n)$$

This calculation starts at stage two, because $L_1 = B$ the Bottoms product and continues stage by stage until stage f is reached. This yeilds L_f and V_{f-1} as the final terms.

This method is called the "Constant Composition" because in equation (7) the term $H(x_{n+1})_n - h_{n+1}$ and equation (10) the term, $H_{n-1} - h(y_{n-1})_n$ represents the difference between the enthalpy of one mole of vapor at one temperature and one mole of liquid at another temperature both molal enthalpy terms being evaluated using the same composition with the temperature being those of adjacent stages and hence not radically different. The advantage of this method is that variations in the enthalpy difference due to compositional fluctuations during the iterative process of solving the stagewise problem are eliminated, thus increasing the stability of the convergence procedure. The enthalpy difference in the denominator of equations (7) and (10) could be interpreted as a thermodynamic process which occurs at constant composition.

In addition, one can say that the improved convergence tendency of the constant-composition method over the conventional method is because the denominator of equations (7) and (10) is of order of magnitude of a latent heat of vaporization, but in the conventional method the denominator takes on a wide range of values including under certain conditions positive and negative numbers.

Feed Zone

For the feed zone we must still determine V_f (net vapor from stripping section) and L_{f+1} (net liquid from rectifying section). The procedure for determining these streams is outlined below.

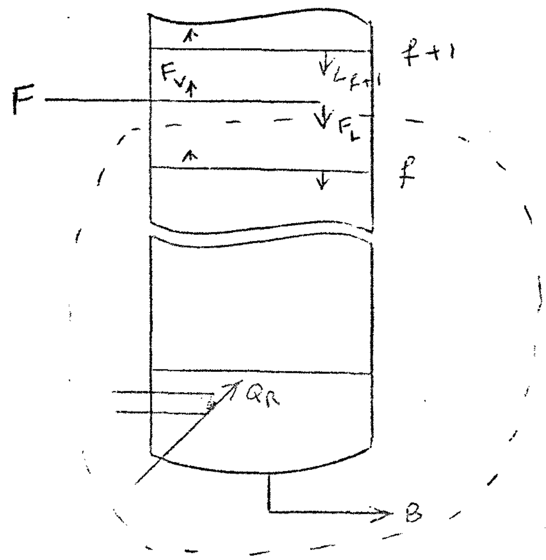


Figure 5

Writing a material balance energy balance below stage f + 1 including the reboiler-bottoms one obtains:

$$V_f H_f + B h_B = Q_R + L_{f+1} h_{f+1} + F_L h_L \qquad (11)$$

$$L_{f+1} + F_L = V_f + B$$

Defining the enthalpy of stream L_{f+1} in terms of the basic stream enthalpy definition coupled with the above material balance yields:

$$L_{f+1} h_{f+1} = V_f h(y_f)_{f+1} + B h(x_B)_{f+1} - F_L h(x_F)_{f+1} \qquad (12)$$

Eliminating L_{f+1} in equation (11) by using equation (12) one obtains:

$$V_f = \frac{Q_R + B\left[h(x_B)_{f+1} - h_B\right] + F_L\left[h_L - h(x_F)_{f+1}\right]}{H_f - h(y_f)_{f+1}}$$

Eliminating Q_R by using equation (3) we obtain:

$$V_f = \frac{V_N H_N - L_{N+1} h_{N+1} - F_V H_V + Bh(x_B)_{f+1} - F_L\left[h(x_F)_{f+1}\right]}{H_f - h(y_f)_{f+1}} \quad (13)$$

Definitions:

$V_N H_N - L_{N+1} h_{N+1}$ and $F_V H_V$ are as before, and $Bh(x_B)_{f+1}$ is the enthalpy of the bottoms product evaluated as a liquid at the temperature of stage f + 1.

$F_L h(x_F)_{f+1} = \left[\sum h_i(T_{f+1}) x_F\right] F_L$

$H_f = \sum y_{F,i} H_i(T_f)$

$h(y_f)_{f+1} = \sum y_{f,i}\ h_i(T_{f+1})$

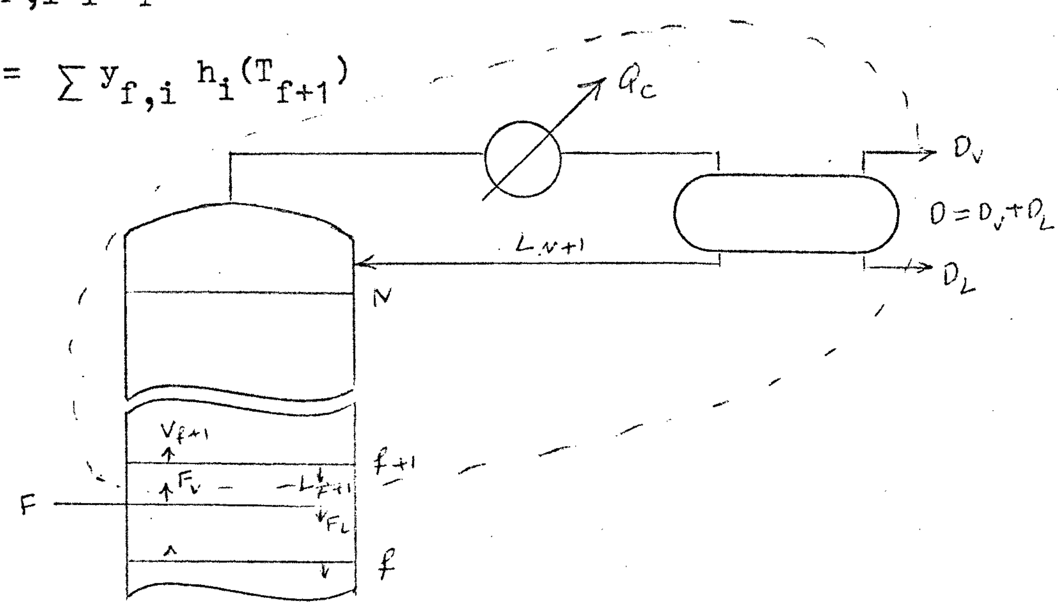


Figure 6

For the stream L_{f+1} one writes a material balance and an energy balance above stage f including condenser distillate drum.

$$V_f H_f + F_V H_V = L_{f+1} h_{f+1} + DH_D + Q_c \tag{14}$$

$$V_f + F_V = L_{f+1} + D$$

Defining $V_f H_f$ via the material balance approach previously used we obtain:

$$V_f H_f = L_{f+1} H(x_{f+1})_f + DH(x_D)_f - F_V H(y_f)_f \tag{15}$$

Eliminating V_f from equation (14) using equation (15) one obtains:

$$L_{f+1} = \frac{Q_c + D\left[H_D - H(x_D)_f\right] + F_V\left[H(y_f)_f - H_V\right]}{H(x_{f+1})_f - h_{f+1}}$$

Eliminating Q_c via equation (1) one obtains:

$$L_{f+1} = \frac{V_N H_N - L_{N+1} h_{N+1} - DH(x_D)_f + F_V\, H(y_f)_f - F_V H_V}{H(x_{f+1})_f + h_{f+1}} \tag{16}$$

Definitions:

$V_N H_N$, $L_{N+1} h_{N+1}$ and $F_V H_V$ are as before

$$DH(x_D)_f = \left[\sum x_{D,i} H_i(T_f)\right] D$$

$$F_V\, H(y_f)_f = \left[\sum y_{f,i} H_i(T_f)\right] F_V$$

$$h_{f+1} = \sum x_{f+1,i} h_i(T_f)$$

$$H(x_{f+1})_f = \sum x_{f+1,i} H_i(T_f)$$

Stabilization of Internal Flow Map

To avoid oscillations of the vapor rates and liquid flow rates the following limits are used:

Trial	Maximum internal vapor and liquid flow rate change
4 - 7	20%
8 - 12	10%
13 - 17	5%
18+	2%

The temperature profile is not stable during approximately the first four trials. No energy balance is made during these trials and hence the vapor and liquid rates are not altered.

CHAPTER IX

TOLERANCES

The temperature profile is not stable during approximately the first four trials. The tolerance on mole fraction for dew points, bubble points is chosen arbitrily to be equal to $10^{(-TRIAL)}$. After the fourth trial the tolerance on dew point and bubble point calculations is set equal to 10^{-6} and if the distillate tolerance (absolute or relative error may be used) has not been read in, it will be set equal to 10^{-4} times the distillate rate.

$$\sum y/K = 1.0 \pm \text{Tolerance} \quad (1)$$

$$\sum KX = 1.0 \pm \text{Tolerance} \quad (2)$$

$$\sum d_i = D_{specified} \pm \text{Tolerance} \quad (3)$$

In some cases during the dew point, bubble point, and distillate calculation, it is possible to oscillate without convergence to the final value as described in equations (1), (2), and (3). When this happens the tight tolerance must be relaxed. To do this trial counters have been used, being initialized to zero for each separate calculation. If the fifteenth iteration is reached without convergence, the tolerance is multiplied by 10, and the counter is reset to zero. The reduction in tolerance continues until the criteria of the specific calculation is satisfied.

The tolerance of dew point, bubble point, and distillate as described in equations (1), (2), and (3) are reset to their initial value and the counters are set equal zero each time these appropriate computational routines are invoked.

CHAPTER X

THERMODYNAMIC DATA

Polynomials of the fourth order are used as a maximum for the K-values (liquid-vapor equilibrium data) and liquid and vapor enthalpies. One could supply the coefficients of these polynomials, or, by supplying 2 to 10 points (temperatures and their corresponding K-values, liquid and vapor enthalpies) the polynomials coefficients will be generated. The units of liquid and vapor enthalpies must be in 1000 BTU/ mole and temperatures in degree Fahreheit.

By supplying 3 point data polynomials of order two will be generated. Four points will give polynomials of order 3, five to ten points yield polynomials of order four.

For K-values one has the obation to use up to 100 points. The minimum number of vapor liquid equilibrium data points required is three, and for liquid and vapor enthalpies two. The form of the equations used is:

K values: $K = a_0 + a_1 t + a_2 t^2 + a_3 t^3 + a_4 t^4$

Liquid Enthalpies: $h = b_0 + b_1 t + b_2 t^2 + b_3 t^3 + b_4 t^4$

vapor enthalpies: $H = C_0 + C_1 t + C_2 t^2 + C_3 t^3 + C_4 t^4$

CHAPTER XI

INPUT-OUTPUT

The first three cards define the problem parameters, and are summarized below.

Card 1 All data on this card must be punched within the specified space right justified (3I5).

A. Column 1 - 5: Number of contact stages, including the equilibrium stage reboiler and excluding the condenser-reflux/distillate separator

B. Columns 6 - 10: Number of components

C. Columns 11-15: Feed stage location (stages numbered from bottom of column upward).

Card 2 All data to be punched with a decimal point (5F10.5).

A. Columns 1 - 10: Temperature profile condition code:

a. "0.0" Temperature profile is not provided. Maximum and minimum temperature must be supplied in ^{o}F.

b. "+1.0" Estimated temperature profile must be supplied in ^{o}F.

B. Columns 11-20:Thermodynamic data code:

a. "0.0" Must supply thermodynamic data for curve fitting by program.

b. "1.0" Coefficients of all polynomials are provided.

C. Columns 21-30:Distillate condition code:

a. "-1.0" All vapor distillate

b. "0.0" Flashed distillate option not available - default is all vapor distillate

c. "1.0" All liquid distillate

D. Columns 31-40:Feed condition code:

a. "-1.0" All vapor feed

b. "0.0" Flashed feed

c. "1.0" All liquid feed

E. Columns 41-50:Vapor-Liquid profile code:

a. "0.0" Estimated vapor and liquid profile need not be provided.

b. "1.0" Vapor and liquid profile is to be provided.

Card 3. All data to be punched with a decimal point (4F10.5, E15.8).

A. Columns 1-10: Vapor damping code:

a. "0.0" Vapor and liquid flow rate will be damped.

b. "+1.0" Vapor and liquid flow rates will not be damped.

B. Columns 11-20: Temperature damping code:

$$T - New = T - old + \frac{(T\text{-}New\text{-}T\text{-}old)}{T\ Damping\ Code}$$

If temperature damping code is set equal to zero, 1.0 will be used.

C. Columns 21-30: Output print code:

a. "0.0" Will not print intermediate trial profiles

b. "1.0" Will print intermediate trial vapor and liquid flow maps and temperature profiles.

D. Columns 31-40: Maximum number of trials:

If maximum number of trials is set

greater than 200, two hundred will be used. If maximum number of trials is set equal to zero, fifty trials will be used.

E. Columns 41-55: Distillate Tolerance:

If it is not provided 10^{-4}* Distillate Rate will be used.

$$\text{Absolute error} = D_{spec} - D_{cal} \qquad (1)$$

$$\text{Relative error} = \frac{D_{spec} - D_{cal}}{D_{spec}} \qquad (2)$$

where:

D_{cal} = calculated distillate rate

D_{spec} = specified distillate rate

By dividing the right side of equation (1) by D_{spec} the absolute error is changed to relative error as defined by equation (2).

The distillate tolerance used in the program is an absolute error; if it is desired to use relative error multiply the desired tolerance by the distillate rate, and input this value within columns 41-55.

The following sequence of cards is dependent on the number of stages and the number of components.

Temperature profile card(s)

A. If estimated temperature profile is not provided the card must contain the maximum and minimum temperature.
   Columns 1 - 10: Maximum "T" and columns 11 - 20 Minimum "T" (2F10.5)

B. If the estimated temperature profile is provided, the next series of cards will contain the temperature profile; eight values per card (8F10.5). N + 1 values must be provided (N is number of stages). If N + 1 is greater than 8 additional cards are to be used.

Pressure profile card

If pressure corrected vapor-liquid equilibrium data is desired ($K_p = K_{Pref}$ Pref/P) the next card must supply reference pressure, accumulator pressure, tower's delta P and condenser delta P. (4F10.5). If reference pressure is set equal to zero, pressure correction will be ignored; but a data card must be supplied.

a. Columns 1-10: Reference Pressure

b. Columns 11-20: Distillate drum pressure

c. Columns 21-30: Pressure drop across the column

d. Columns 31-40: Pressure drop across the condenser

Units of pressure must be consistent.

Polynominals for Thermodynamic Data

A. If coefficients are not to be provided then the following is to be ignored.

B. If coefficients of polynominal for evaluation of equilibrium or K-data, and vapor-liquid enthalpies are provided the next cards must be used for these coefficients (5E15.8).

These polynominals are of the form:

(1) Equilibrium constants:

$$K = A_0 + A_1T + A_2T^2 + A_3T^3 + A_4T^4$$

A. Columns 1-15: A_0

B. Columns 16-30: A_1

C. Columns 31-45: A_2

D. Columns 46-60: A_3

E. Columns 61-75: A_4

(2) Liquid Enthalpies:

$$h = h_0 + h_1 + h_2T^2 + h_3T^3 + h_4T^4$$

A. Columns 1-15 h_0

B. Columns 16-30: h_1

C. Columns 31-45: h_2

D. Columns 46-60: h_3

E. Columns 61-75: h_4

(3) Vapor Enthalpies:

$$H = H_0 + H_1T + H_2T^2 + H_3T^3 + H_4T^4$$

A. Columns 1-15: H_0

B. Columns 16-30: H_1

C. Columns 31-45: H_2

D. Columns 46-60: H_3

E. Columns 61-75: H_4

If fourth order equation is not necessary for enthalpy data, one could put 0.0 in columns 61-75.

Card Sequence

The first card A_0, A_1, A_2, A_3, and A_4 for first component (vapor liquid equilibrium data). Second card A_0, A_1, A_2, A_3, and A_4 for second component, etc..

After vapor liquid equilibrium data is finished liquid enthalpy data is read in as:

First card h_0, h_1, h_2, h_3, and h_4 for first component, second card h_0, h_1, h_2, h_3, and h_4 for second component, etc.. After liquid enthalpy data is read in, vapor enthalpy is read using the same format as the liquid enthalpy (H_0, H_1, H_2, H_3, and H_4).

Thermodynamic Data

A. If coefficient of polynomials are provided then the following is to be ignored.

B. If coefficient of polynomials are not provided, the next card must give the number of thermodynamic data points, maximum of 10 points for each set of thermodynamic data. (Except for K-data, where 100 points are maximum). All data on this card must be punched within the specified space right justified (3I5).

a. Columns 1-5: Number of K data

b. Columns 6-10: Number of liquid enthalpy

c. Columns 11-15: Number of vapor enthalpy

Next cards (8 values per card, 8F10.5)

a. Columns 1-10: Temperature $^{\circ}F$.

b. Columns 11-20: K-data corresponding to temperature in columns 1-10.

c. Columns 21-30: Temperature $^{\circ}F$.

d. Columns 31-40: K-data corresponding to temperature in columns 21-30.

If more than 4 points are given, additional cards are to be used with 4 points per card.

After K-data for component one is finished, start a new card for the next component's K-data.

When K-data for all components is provided, liquid enthalpy data will be inputed (8F10.5).

a. Columns 1-10: Temperature, $^{\circ}F$.

b. Columns 11-20: Liquid enthalpy (M-BTU/mole) corresponding to temperature in columns 1-10.

c. Columns 21-30: Temperature, $^{\circ}F$.

d. Columns 31-40: Liquid enthalpy (M-BTU/mole) corresponding to temperature in columns 21-30.

If more than 4 points are given, additional cards are to be used, 4 points per card.

After liquid enthalpy for component one is finished, start with new card for next component liquid enthalpy. When the liquid enthalpy for all components is finished, the vapor enthalpy will be read using the same format as the liquid enthalpy.

Design Parameters

The design parameter card must be provided for all problems and will contain external reflux rate, distillate rate, and feed temperature (3F10.5).

a. Columns 1-10: External Reflux rate (moles/hr)

b. Columns 11-20: Distillate rate (moles/hr).

c. Columns 21-30: Feed Temperature ($^{\circ}F$). If no temperature is specified, dew point temperature for vapor feed and bubble point temperature for liquid feed will be used and in case of partially flashed feed $T = \frac{(TDEW+TBUBBLE)}{2.0}$

Feed Definition

The feed definition card must be provided for all problems and will contain the feed component (moles/hr).

a. Columns 1-10: Component #1

b. Columns 11-20: Component #2

etc..

If more than 8 components are in the system, additional cards are to be used, 8 components per card.

Internal Vapor - Liquid Flow Map

A. If no flow rates are to be provided, then this option is to be ignored.

B. If flow rates are to be provided, the next set of cards must provide liquid profiles (numbering is from bottom of column to the top of the column, first stage is an equilibrium stage reboiler, last stage (N + 1) is the condenser-distillate drum, and are sequenced as follows:

Columns 1-10:	Liquid Rate (moles/hr) for stage 1
Columns 11-20:	Liquid Rate (moles/hr) for stage 2
Columns 21-30:	Liquid Rate (moles/hr) for stage 3

etc..

8 values per card. If more than 8 values, additional cards are to be used. The associated vapor profile is computed by material balance. Next set of data must be supplied as in the first case.

The source listing of the fortran coding is included in Appendix E, with the program variables included in Appendix F.

CHAPTER XII

ILLUSTRATIVE EXAMPLES

To demonstrate the capabilities of the Distillation Program three examples are included although other problems were tested. The first two examples are both for the same problem and consists of the following:

Problem Specifics:

Number of Stages	11
Number of Components	5
Feed Stage	6
Distillate-All Vapor	45.0 Mols
Feed-All Vapor	
Components #1	5.0
Components #2	15.0
Components #3	25.0
Components #4	20.0
Components #5	35.0
	100.0 Mols

No damping on Temperature Map.

Pressure-constant pressure operation.

Example #1 exhibited oscillation convergence behavior. In example #2 the utilization of a temperature damping factor of 2.0 provided sufficient stability so that convergence was obtained in 43 iterations.

The third example is for a depropanizer operating at approximately 80 PSIA, and consists of the following:

Problem Specifics:

Number of Stages	16
Number of Components	4
Feed Stage	8
Distillate-All Liquid	192.9 Mols
Feed-Partally Vaporized (T=189.11)	
Components #1	60.0
Components #2	170.0
Components #3	320.0
Components #4	450.0
	1000.0 Mols

No damping on Temperature Map.

Pressure (PSIA):

Accumulator P	77.5
Condenser Delta P	5.0
Tower Delta P	5.0
Reference P for supplied K-Data	80.0

The input and associated output are included in Appendix G.

APPENDIX A

FLASH CALCULATION

The general assumption used is flash calculation are:

1. All components are volatile.
2. Flash temperature is between bubble point and dew point.
3. The K's are not adjusted for composition during an iteration, but are corrected for the feed stage pressure.

Method of Holland (5)

Material Balance for i component coupled with the definition of $K = y/x$

$$FZ_F = Vy + Lx$$

$$= Vy + Ly/K$$

substituting $V = F - L$ and solving for y:

$$y = \frac{FZ_F}{F - L + L/K}$$

OR,

$$y = \frac{Z_F}{1.0 - L/F(1.0 - 1.0/K)}$$

The sum of all components must give y = 1.0

$$1.0 = \sum \frac{Z_{F,i}}{1.0 - L/F(1.0 - 1.0/K)}$$

Define L/F as Ψ Function $f(\Psi)$ is:

$$f(\Psi) = \sum \frac{Z_{F,i}}{1.0 - \Psi(1.0 - 1.0/K_i)} - 1.0$$

The desired solution is where $\Psi > 0.$ and $f(\Psi) = 0.0$

Using Newton's Method. The first derivitive of $f(\Psi)$ is:

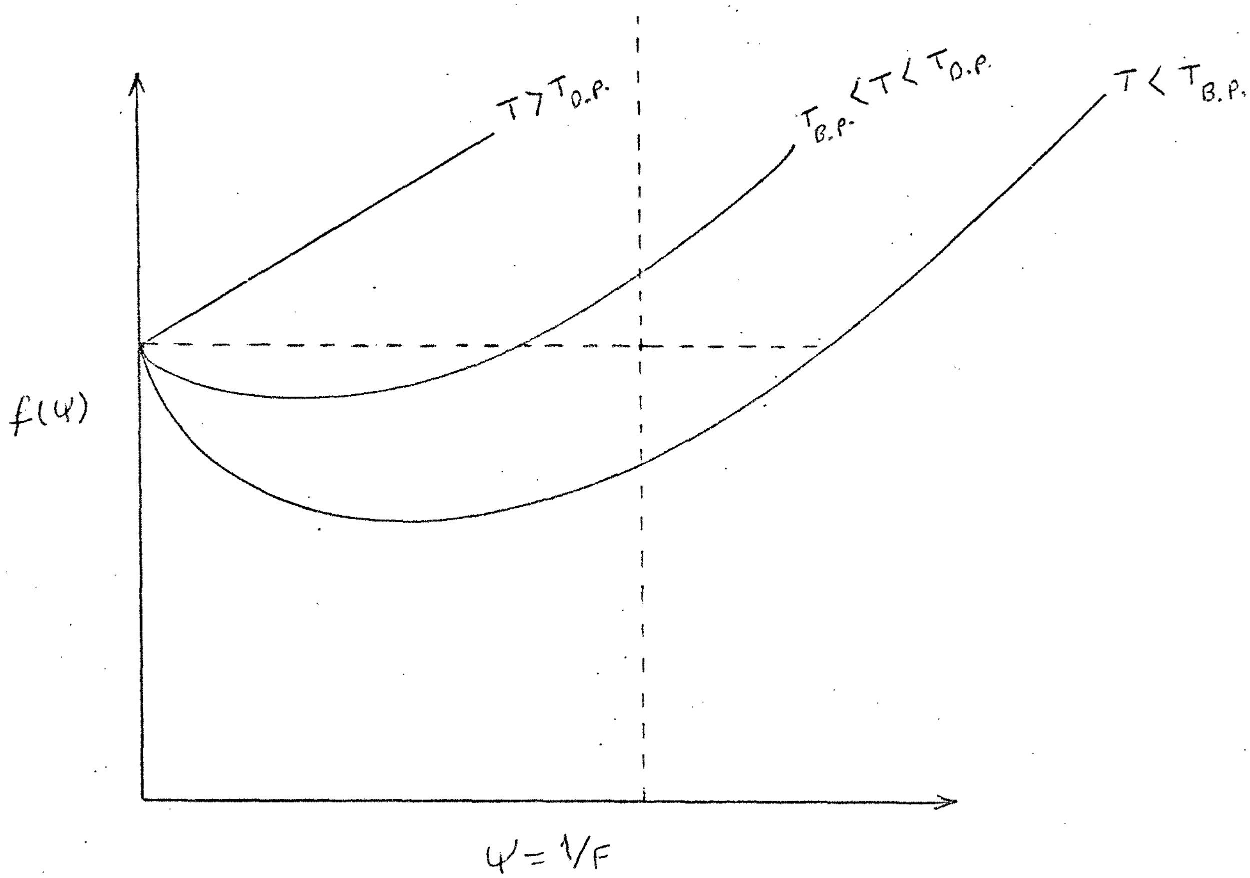
$$f'(\Psi) = \sum \frac{Z_{F,i}(1.0 - 1.0/K_i)}{[1.0 - \Psi(1.0 - 1.0/K_i]^2}$$

and

$$\Psi_{j+1} = \Psi_j - f(\Psi_j)/f'(\Psi_j)$$

The general form of this equation is:

The shape of the curve suggests that a value of $\psi_1 = 1.0$ should be used for the initial trial. The derivative function can then be used to determine ψ_2. The procedure continues untion $f(\psi) = 0.0$ within a specified tolerance of 10-6.



APPENDIX B

CALCULATIONAL PROCEDURES FOR BUBBLE POINT TEMPERATURE

The general assumptions used in bubble point calculations are:

1. Composition of liquid is specified
2. Total pressure is specified by applying the definition of the vapor liquid equilibrium constant $y_i = K_i X_i$; since the sum of y_i is unity then

$$1.0 = \sum K_i X_i \tag{1}$$

The problem is to find a temperature for which equation (1) is satisfied. Let us restate equation (1) in the following functional form:

$$f(T) = \sum K_i X_i - 1.0$$

The desired solution is when $f(T) = 0.0$. Since each of the K_i's increase with temperature, $f(T)$ has only one positive root. Using Newton's method(6) to determine the desired root the first derivative of $f(T)$ is required.

$$f\ (T) = \sum X_i \frac{(dK_i)}{dT}$$

If $K_i = A_o + A_1T + A_2T^2 + A_3T^3 + A_4T^4$ where A_o, A_1, A_2, A_3, and A_4 are constants, then $dK/dT = A_1 + 2A_2T + 3A_3T^2 + 4A_4T^3$. If T_j (j is the trial number) is the assumed temperature, then T_{j+1} is given by

$$T_{j+1} = T_j - f(T_j)/f'(T_j)$$

The procedure continues until f(T) = 0.0 within a specified tolerance (10^{-6}).

Very frequently it is possible to reduce the complexity of a calculation procedure by an alternative calculation. This is particularly true where the calculation can be made on an average component rather than individual components.

In the example of the bubble point equilibrium temperature calculation an average function can be used to give the K^* of a pseudo component and this solved for temperature at $K^* = 1.0$. The pseudo component constants are determined from the function constants for the individual component K data and the component mole fractions. This method requires "K" functions that are explicit for K, in temperature.

In the bubble point calculation one could apply the "pseudo method", and K* could be found as follows:

$$K_1 = (A_o)_1 + (A_1)_1T + (A_2)_1T^2 + (A_3)_1T^3 + (A_4)_1T^4$$

$$K_2 = (A_o)_2 + (A_1)_2T + (A_2)_2T^2 + (A_3)_2T^3 + (A_4)_2T^4$$

Etc.

By multiplying both sides of the above equations by their corresponding component mole fraction (X_i) one gets:

$$X_1K_1 = (X_1A_o)_1 + (X_1A_1)_1T + (X_1A_2)_1T^2 + (X_1A_3)_1T^3 + (X_1A_4)_1 T^4$$

$$X_2K_2 = (X_2A_o)_2 + (X_2A_1)_2T + (X_2A_2T^2 + (X_2A_3)_2T^3 + (X_2A_4)_2T^4$$

Etc.

By summing the above equations one gets:

$$\sum (XK)_i = \sum(XA_o)_i + T\sum(XA_1)_i + T^2\sum(XA_2)_i + T^3\sum(XA_3)_i + T^4\sum(XA_4)_i$$

Let $K^* = \sum(XK)_i$ and factor out T one gets:

$$K^* = \sum(XA_o)_i + T\left\{\sum(XA_1)_i + T\left[\sum(XA_2)_i + T(\sum(XA_3)_i + T\sum(XA_4)_i)\right]\right\} \quad (4)$$

And

$$dK^*/dt = \sum(XA_1)_i + T\left[2\sum(XA_2)_i + T\ (3\sum(XA_3)_i + 4T\sum(XA_4)_i)\right] \quad (5)$$

Using equation (4) and solving for temperature at $K^* = 1.0$,

$$f(T_j) = K^*_{Tj} - 1.0$$

$$f\ (T_j) = K'^{*}_{Tj}$$

$$T_{j+1} = T_j - f(T_j)/f'(T_j)$$

APPENDIX C

CALCULATIONAL PROCEDURES FOR DEW POINT

Dew point calculations are:

1. Compositions of vapor is specified.
2. Total pressure is specified.

Since $X_i = y_i/K_i$ and sum of X_i is unity then:

$$1.0 = \sum y_i/K_i \tag{1}$$

Restating equation (1) to functional notation

$$f(T) = \sum y_i/K_i - 1.0$$

Using Newton's method(7), the first derivative of f(T) is:

$$f'(T) = - \sum (y_i/K_i^2)(dK_i/dT)$$

Dew point temperature may be found the same way as shown previously for bubble point temperatures. In the dew point calculation the pseudo method as used in the bubble point calculation cannot be used.

$$T_{j+1} = T_j - f(T_j)/f'(T_j)$$

APPENDIX D

MATERIAL BALANCE EQUATIONS

Nomenclature:

x, y	Mole fractions of component i
v, l	Moles of component i
V, L	Moles of Vapor and Liquid

For assumed distillate rate (total) one must assume the distribution of the components (moles/hr). Knowing the individual flow rates on overall material balance yields the bottoms

$$F = D + B$$

$$f = d + b$$

<u>v/d and l/b ratios</u>:

For each stage (using n for the stage number and i for components):

$$K_{n,i} = y_{n,i} x_{n,i}$$

$$y_{n,i} = K_{n,i} X_{n,i}$$

$$(V_n L_n) y_{n,i} = (V_n L_n) K_{n,i} x_{n,i} \qquad (1)$$

$$y_{n,i} = v_{n,i}/V_n \quad \text{or} \quad v_{n,i} = V_n y_{n,i}$$

$$X_{n,i} = l_{n,i}/L_n \quad \text{or} \quad l_{n,i} = L_n X_{n,i}$$

substituting for $V_n y_{n,i}$ and $L_n x_{n,i}$ in equation (1)

$$L_n v_{n,i} = V_n K_{n,i} l_{n,i}$$

Dividing by L_n:

$$v_{n,i} = (K_{n,i} V_n / L_n) l_{n,i} \qquad (2)$$

Let $S_{n,i} = K_{n,i} V_n / L_n$ (Stripping factor):

$$v_{n,i} = S_{n,i} l_{n,i} \qquad (3)$$

Dividing by d_i:

$$(v/d)_{n,i} = S_{n,i} (l/d)_{n,i} \qquad (4)$$

Solving equation (2) for $l_{n,i}$:

$$l_{n,i} = v_{n,i} (L_n / K_{n,i} V_n)$$

Let

$$A_{n,i} = L_n / K_{n,i} V_n \qquad \text{(Absorption Factor)}$$

$$l_{n,i} = v_{n,i}A_{n,i} \quad (5)$$

dividing by d_i:

$$(l/d)_{n,i} = (V/d)_{n,i}A_{n,i} \quad (6)$$

as one can see $S_{n,i} = 1.0/A_{n,i}$ applying it to equation (4) and (6) respectively one gets:

$$(v/d)_{n,i} = 1.0/A_{n,i}(l/d)_{n,i} \quad (7)$$

and

$$(l/d)_{n,i} = (v/d)_{n,i}1.0/S_{n,i} \quad (8)$$

The subscript "i" is usually dropped for simplicity.

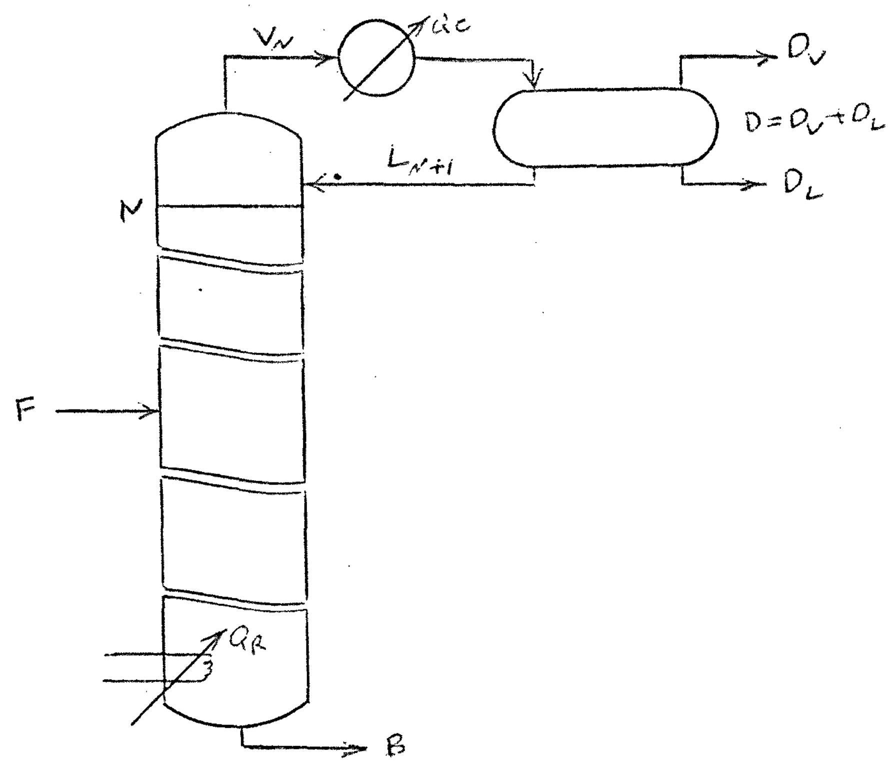


Figure 1

Condenser:

1. Total condenser $D_v = 0.0$

2. Partial condenser (not included in simulation program)

3. Reflux condenser $D_L = 0.0$

In general,

$$l_{N+1} = L_{N+1}X_{N+1} \tag{9}$$

and

$$d = D_L X_{dL} + D_v y_{dv} = D_L x_{N+1} + D_v X_{N+1} K_{N+1} \tag{10}$$

dividing equation (9) by (10) and eliminating x_{N+1}

$$(l/d)_{N+1} = L_{N+1}/(D_L + D_v K_{N+1}) \tag{11}$$

for the total condensed $D_v = 0.0$ and:

$$(l/d)_{N+1} = L_{N+1}/D_L = R$$

For the reflux condenser, $D_v = 0.0$ and:

$$(l/d)_{N+1} = L_{N+1}/D_v K_{N+1} = R/K_{N+1}$$

Rectifying Section - General Material Balance:

A balance around any stage, n, and the top of the tower gives:

$$v_n = l_{n+1} + d$$

dividing by d:

$$(v/d)_n = (l/d)_{n+1} + 1.0$$

Eliminating $(l/d)_n$ by using equation (7):

$$(v/d)_n = (v/d)_{n+1} A_{n+1} + 1.0 \qquad (12)$$

or eliminating $(v/d)_n$ by using equation (7):

$$(l/d)_n = A_n \left[(l/d)_{n+1} + 1.0 \right] \qquad (13)$$

<u>Stripping Section - General Material Balance</u>:

From equation (3) $v_{n,i} = S_{n,i} l_{n,i}$ and from equation (5) $l_{n,i} = A_{n,i} v_{n,i}$ dividing both equations by b_i:

$$(v/b)_{n,i} = S_{n,i} (l/b)_{n,i} \qquad (14)$$

$$(l/b)_{n,i} = A_{n,i} (v/b)_{n,i} \qquad (15)$$

substituting for $A_{n,i}$, $S_{n,i}$

$$(v/b)_{n,i} = 1.0/A_{n,i} (l/b)_{n,i} \qquad (16)$$

$$(l/b)_{n,i} = (1.0/S_{n,i}) (v/b)_{n,i} \qquad (17)$$

subscript "i" is usually dropped for simplicity.

A balance around any stage "m" and the bottom of the tower gives:

$$l_m = v_{m-1} + b$$

dividing by b:

$$(l/b)_m = (v/b)_{m-1} + 1.0$$

Eliminating $(v/b)_{m-1}$ using equation (14)

$$(l/b)_m = (l/b)_{m-1} S_{m-1} + 1.0 \quad f + 1 \geq m \geq 1$$

or by substituting for $(l/b)_m$

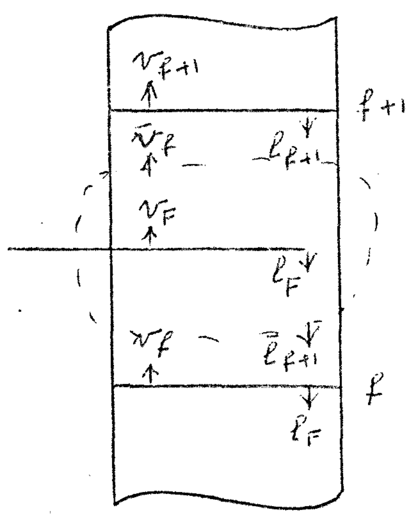
$$(v/b)_m = S_m \left[(v/b)_{m-1} + 1.0 \right] \quad f \geq m \geq 1$$

General Feed Plate Match Equation for Simple Tower (Single Feed)

A balance around the bottom of the tower gives:

$$v_f + b = l_{f+1} = l_{f+1} + l_f$$

Subscript "i" is usually dropped for simplicity.



By overall balance

$$f = b + d$$

Therefore,

$$v_f + b = l_{f+1} + l_f(b+d/f)$$

$$v_f + b - (l_F b)/f = l_{f+1} + (l_F d)/f$$

dividing by b:

$$(v/b)_f + 1.0 - l_F/f = d/b \left[(l/d)_{f+1} + (l_F/f)\right]$$

$$f = V_F + l_F$$

Therefore:

$$1.0 - l_F/f = v_F/f$$

Substituting and solving for (b/d) gives:

$$b/d = \frac{(l/d)_{f+1} + l_F/f}{(v/b)_f + v_F/f}$$

for all liquid feed $v_F = 0.0$ and $l_F = f$, then:

$$b/d = \frac{(l/d)_{f+1} + 1.0}{(v/b)_f}$$

For all vapor feed $l_f = 0.0$ and $v_F = f$, then:

$$b/d = \frac{(l/d)_{f+1}}{(v/b)_f + 1.0}$$

APPENDIX E

SOURCE LISTING OF THE FORTRAN CODING

```
      PROGRAM MAIN
C
C     SMILEY.1   THIELE GEDDES PROGRAM (LIQUID OR VAPOR DISTILATE)
C
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF
      COMMON RDCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON
      COMMON VLDAMP,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCOND,VLCON,ALNP1,D,B
      COMMON TFEED,FTOLD,SUMOPF ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL
      COMMON RVD(101,20),RLD(101,20),OLDV(101),DV,DL,OLDL(101),F(20)
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)
      COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)
C
C     THE FLOWING VARIABLES ARE USED ONLY FOR PLOTING.
C
      DIMENSION THA(200),DD(200),T1(200),TNFP(200),TNFP1(200),TN(200)
      DIMENSION V1(200),VNFP(200),VNFP1(200),TRI(200)
C
C     N IS NUMBER OF PLATES
C     M IS NUMBER OF COMPONENT
C     NFP IS FEED PLATE
C
   24 READ(97,1,END=26)N,M,NFP
    1 FORMAT(3I5)
      NP1=N+1
C
      THCOUN=0.0
      THETA=1.0
      IFAG=1
C
C     IF VAPOR & LIQUID PROFILE IS GIVEN SET VLCON=+1.0
C     IF  VAPOR &LIQUID PROFILE NOT GIVEN SET VLCON= 0.0
C
C     3 CONDITION ON FEED :
C            1- ALL LIQUID FEED SET FCOND=+1.0
C            2-ALL VAPOR FEED SET FCOND=-1.0
C            3- VAPOR&LIQUAD FEED SET FCOND=0.0
C
C     IF GIVEN TEMPERATURE PROFILE MUST BE USED SET TCON=+1.0
C     IF TEMPERATURE PROFILE IS NOT GIVEN SET TCON=0.0
C        AND INPUT VALUES FOR TMAX & TMIN
C
C     IF DISTILLATE IS ALL LIQUID SET DCON= +1.0
C     IF DISTILLATE IS ALL VAPOR SET DCON= -1.0
C     IF TWO PHASE DISTILLATE SET DCON=0.0 (OPTION NOT OPERATIONAL )
C     IF  DCON 0.0 INPUTED DCON=-1.0
C
C     IF PRCON IS SET EQUAL 1. IT WILL PRINT THE INTERMEDIATE TRIAL
```

```
C      IF PRCON IS SET EQUAL 0. IT WILL NOT PRINT THE INTERMEDIATE TRIAL
C      .
       READ 9,TCON,HKCON,DCON,FCOND,VLCON
     9 FORMAT(5F10.5)
C
C      IF ONE WANTS TO DAMP VAPOR & LIQUID RATE SET VLDAMP =0.0
C      LIMIT OF FLOW RATE CHANGE:
C                TRIAL              MAXIMUM VAPOR & LIQUID RATE CHANGE
C                3-7                          20%
C                8-12                         10%
C               13-17                          5%
C                18+                           2%
C
C      IF ONE DOES NOT WANT TO DAMP VAPOR & LIQUID RATE SET VLDAMP = +1.0
C
C      TDAMP IS TO DAMP TEMPERATURES : TNEW=TOLD+(TNEW-TOLD)/TDAMP
C      TDAMP= 1.0 TEMPERATURE WILL NOT BE DAMPED(IF 0. INPUTED TDAMP=1.)
C      TDAMP= OTHER VALUES TEMPERATURE WILL BE DAMPED ACCORDINGLY
C
C      TRIMAX IS THE MAXIMUM NUMBER OF TRIALS .
C
       READ 17,VLDAMP,TDAMP,PRCON,TRIMAX,FTOLD
    17 FORMAT(4F10.5,E15.8)
       IF(TDAMP .EQ. 0.0) TDAMP=1.0
       IF(TRIMAX .GT. 200.) TRIMAX=200.
       IF(TRIMAX .EQ. 0.0) TRIMAX=50.0
C
       PRINT 250
   250 FORMAT('1')
       PRINT 51,IPAG
    51 FORMAT('1',////,'   PROBLEM PARAMETERS !',89X,'PAGE  ',I4,/)
C
       PRINT 35,N,M,NFP
    35 FORMAT('   NUMBER OF STAGES   ',I5,/,3X,'   STAGES COUNT FROM BOT
      1TOM TO TOP OF TOWER',/,9X,'(INCLUDES EQUILIBRUIM-STAGE REBOILER',/
      29X,'EXCLUDES CONDENSER-DISTILATE DRUM)',/,
      3'0  NUMBER OF COMPONENTS   '
      4,I5,/,'0  FEED STAGE LOCATION   ',I6)
C
       PRINT 105,TCON,HKCON,DCON,FCOND
   105 FORMAT('0  TEMPERATURE PROFILE CODE',F5.1,/,
      37X,'0.0 T PROFILE NOT GIVEN',/,
      911X,'(MAX & MIN T MUST BE SUPPLIED)',/,
      A7X,'1.0 T PROFILE MUST BE SUPPLIED',/,
      Q'0  THERMODYNAMIC DATA CODE',F5.1,/,
      B7X,'0.0 COEFFICIENTS OF POLYNOMIALS NOT GIVEN',/,
      S11X,'MUST SUPPLY THERMODYNAMIC DATA POINTS (10 MAX)',/,
      111X,'UNITS DEG F , M-BTU/# MOLE FOR ENTHALPY',/,
      111X,'DIMENSIONLESS FOR V-L EQUILIBRIUM DATA',/,
      17X,'1.0 COEFFICIENT OF POLYNOMIAL MUST BE SUPPLIED',//
```

```
     *'0  DISTILLATE TYPE CODE',F5.1,/,
     F7X,'-1.0 ALL VAPOR ',/,
     G7X,' 0.0 VAPOR & LIQUID (NOT OPERATIONAL)',/,
     H7X,'+1.0 ALL LIQUID ',/,
     *'0  FEED CONDITION CODE',F5.1,/
     17X,'-1.0 ALL VAPOR ',/,
     27X,' 0.0 VAPOR & LIQUID ',/,
     37X,'+1.0 ALL LIQUID ')
C
      PRINT 101,VLCON
  101 FORMAT('0  VAPOR-LIQUID PROFILE CODE',F5.1,/,
     C7X,'1.0 V&L PROFILE MUST BE SUPPLIED',/,
     D7X,'0.0 V&L PROFILE NOT GIVEN')
C
      PRINT 116,VLDAMP,TDAMP,PRCON,TRIMAX
  116 FORMAT('0  VAPOR DAMPING CODE',F5.1,/,
     M7X,'0.0 VAPOR & LIQUID RATE WILL BE DAMPED',/,
     N7X'1.0 VAPOR & LIQUID RATE WILL NOT BE DAMPED',/,
     O'0  TEMPERATURE DAMPING CODE',F5.1,/,
     P7X,'T NEW = T OLD + ( T NEW - T OLD) / ( T DAMPING CODE)',/,
     I'0  PRINT CODE',F5.1,/,
     J7X,'1.0 WILL PRINT INTERMEDIATE TRIAL DATA',/,
     K7X,'0.0 WILL NOT PRINT INTERMEDIATE TRIAL DATA',/,
     U'0  MAX NUMBER OF TRIALS ',F7.2)
C
      IF(TCON .EQ. 0.0) GO TO 5
      READ 4,(TT(I),I=1,NP1)
    4 FORMAT(8F10.5)
      GO TO 8
    5 CONTINUE
      READ 6,TMAX,TMIN
    6 FORMAT(2F10.5)
      AAA=N-1
      DELT=(TMAX-TMIN)/AAA
      TT(1)=TMAX
      DO 7 I=2,N
      TT(I)=TT(I-1)-DELT
    7 CONTINUE
      TT(N+1)=TMIN
    8 CONTINUE
C
      READ 3,PREF,P(N+1),PDROP,CNDPDR
    3 FORMAT(4F10.5)
      IF(PREF .EQ. 0.0) GO TO 11
      CC=N-1
      DELP=PDROP/CC
      P(1)=P(N+1)+CNDPDR+PDROP
      DO 12 I=2,N
   12 P(I)=P(I-1)-DELP
      GO TO 14
```

```
 11   CONTINUE
      DO 23 I=1,NP1
 23   P(I)=1.0
      TREF=1.0
 14   CONTINUE
C
      CALL COEFKH(IPAG)
C
      READ 28,ALRP1,D,TFEED
   28 FORMAT(3F10.5)
C
C     ALRP1 =EXTERNAL REFLUX (MOLS/HR)
C     D= DISTILLATE (MOLS/HR)
C     B=BOTTOM (MOLS/HR)
C     TFEED= TEMPERATURE OF FEED (DEG F)
C        IF NO TEMPERATURE IS SPECIFIED ,
C            DEW POINT TEMPERATURE FOR VAPOR FEED
C            AND BUBBLE POINT FOR LIQUID FEED WILL BE USED
C            AND IN CASE OF PARTIALLY FLASHED TFEED=(TDEW+TBUBBLE)/2.
C
C     TRIAL IS USED IN BUBBLE & DEW POINT SUBROUTINE FOR
C          TOLERANCE CONVERGENCE
C
      TRIAL=7.0
      IF (FCOND) 16,104,22
   16 CONTINUE
      CALL ALLVAP
      GO TO 30
  104 CONTINUE
      CALL VLMEXD
      GO TO 30
   22 CONTINUE
      CALL ALLIQ
   30 CONTINUE
C
C
      IF(VLCON .EQ. 0.0) GO TO 15
      READ 4,(AL(I),I=1,NP1)
      NRM=NFP-1
      DO 20 I=1,NRM
   20 V(I)=AL(I+1)-B
      V(NFP)=TOTFL+AL(NFP+1)-B
      NPP1=NFP+1
      DO 21 I=NPP1,N
   21 V(I)=AL(I+1)+D
      V(N+1)=0.0
      IF (FCOND .LE. 0.0) V(N+1)=D
C     TWO PHASE DISTILLATE IS NOT OPERATIONAL ,
C          ALL VAPOR DISTILLATE WILL BE USED
C
```

```
   15 CONTINUE
C
      PRINT 25,TFEED
   25 FORMAT('   TEMPERATURE OF FEED IS = ',F10.5,'  DEG. F',//)
      PRINT 27
   27 FORMAT(11X,'MOLS/HR',11X,'MOLE FRAC   ',6X,'VAP MOLS/HR',
     18X,'VAP MOL FRAC',8X,'LIQ MOLES/HR',8X,'LIQ MOL FRAC')
C
      TOTXF=0.0
      TOTYF=0.0
      TOTFX=0.0
      DO 32 I=1,N
      FFRAC(I)=F(I)/TOTALF
      PRINT 108,I,F(I),I,FFRAC(I),I,FV(I),I,YF(I),I,FL(I),I,XF(I)
  108 FORMAT('    F(',I2,')=',F10.4,'   FZ(',I2,')=',F10.4,'   FV(',I2,
     1')=',F10.4,'   YF(',I2,')=',F10.7,'   FL(',I2,')=',F10.4
     1,'   XF(',I2,')=',F10.7)
      TOTXF=XF(I)+TOTXF
      TOTYF=YF(I)+TOTYF
      TOTFX=TOTFX+FFRAC(I)
   32 CONTINUE
      PRINT 209
  209 FORMAT(9X,10('-'),10X,10('-'),10X,10('-'),10X,10('-'),10X,10('-')
     1,10X,10('-'))
      PRINT 210,TOTALF,TOTFX,TOTFV,TOTYF,TOTFL,TOTXF
  210 FORMAT('    TOTAL ',F10.4,10X,F10.4,10X,F10.4,10X,F10.7,10X,F10.4,
     110X,F10.7,//)
C
      IF(FTOLD .EQ. 0.0) FTOLD=0.0001*D
C
C     FTOLD IS DISTILLATE TOLERANCE
C
      PRINT 112
  112 FORMAT(10(/))
      PRINT 109,D,ALNP1,FTOLD
  109 FORMAT('   VALUE OF DISTILLATE IS =',F10.4,'   VALUE OF EXTERNAL R
     1EFLUX IS =',F10.4,//,'   DISTILLATE TOLERANCE  ',E15.8,//)
C
      IF(DCON) 31,32,33
   31 DV=D
      DL=0.0
      V(N+1)=D
      PRINT 38
   38 FORMAT('    DISTILLATE IS ALL VAPOR .')
      GO TO 34
C  32 D=DV+DL
   32 CONTINUE
      PRINT 37
   37 FORMAT('    DISTILLATE IS LIQ. & VAP.',/,
     *'   THIS OPTION NOT OPERATIONAL ALL VAPOR DISTILLATE WILL BE USED
```

```
     *')
C
      DV=0
      DL=0.0
      V(N+1)=0
      DCON=-1.0
      GO TO 34
   33 DL=0
      DV=0.0
      V(N+1)=0.0
      PRINT 36
   36 FORMAT('   DISTILLATE IS ALL LIQUID .')
   34 CONTINUE
C
      IF(PREF .EQ. 1.0) GO TO 63
      PRINT 64,P(N+1),CNDPDR,PDROP,P(N),P(1),PREF
   64 FORMAT(//,'   INPUT PRESSURES !',/,
     116X,' ACCUMULATOR P    ',6X,F10.4,/,
     116X,' CONDENSER DELTA P   ',2X,F10.4,/,
     116X,' TOWER DELTA P    ',6X,F10.4,/,
     116X,' TOWER TOP TRAY P    ',3X,F10.4,/,
     116X,' TOWER BOTTOM TRAY P    ',F10.4,//,
     116X,' REFERENCE P FOR SUPPLIED K-DATA  ',F10.4)
      GO TO 66
   63 PRINT 65
   65 FORMAT('0  PRESSURES WERE NOT SUPPLIED .',/,
     1'   K-DATA WILL NOT BE PRESSURE CORRECTED .')
   66 CONTINUE
C
      IPAG=IPAG+1
      PRINT 250
      PRINT 52,IPAG
   52 FORMAT(52X,'***** INITIAL DATA SETTING *****',28X,'PAGE  ',I4,//)
      IF(TCON .EQ. 1.0) GO TO 41
      PRINT 204,TMAX,TMIN
  204 FORMAT('   MAXIMUM TEMPERATURE IS =',F10.5,/,
     *'   MINIMUM TEMPERATURE IS =',F10.5)
   41 CONTINUE
      PRINT 106
  106 FORMAT('0  THE INITIAL VAPOR , LIQUID , & TEMPERATURE PROFILES
     1',/)
      PRINT 110
  110 FORMAT('   NUMBERING IS FROM BOTTOM TO THE TOP OF THE TOWER',/,
     17X,'LAST STAGE IS THE CONDENSER-DISTILLATE DRUM',/,
     27X,'FIRST STAGE IS AN EQUILIBRIUM STAGE REBOILER',//)
      AL(N+1)=ALNP1
      PRINT 208
  208 FORMAT(12X,'MOLS/HR',13X,'MOLS/HR',13X,'DEG. F')
      DO 72 I=1,NP1
      PRINT 107,I,V(I),I,AL(I),I,TT(I)
```

```
          PLPV(I)=V(I)                                                  MAIN 301
          PLPL(I)=AL(I)                                                 MAIN 302
       72 CONTINUE                                                      MAIN 303
      C                                                                 MAIN 304
          TRIAL=0.0                                                     MAIN 305
          IF(VLCON .EQ. 1.0) TRIAL=4.0                                  MAIN 306
      C                                                                 MAIN 307
      C   TRIAL IS USED IN BUBBLE , DEW POINT & DISTILLATE SUBROUTINE FOR MAIN 308
      C     TOLERANCE CONVERGENCE                                       MAIN 309
      C   TRIAL IS ALSO USED IN DETERMINING WHEN TO DO ENTHALPY BALANCE MAIN 310
      C                                                                 MAIN 311
          PRINT 250                                                     MAIN 312
          JJ=1                                                          MAIN 313
          IPAG=IPAG+1                                                   MAIN 314
          PRINT 44,IPAG                                                 MAIN 315
       44 FORMAT(53X,'***** INTERMEDIATE TRIAL *****',29X,'PAGE  ',I4,//) MAIN 316
      C                                                                 MAIN 317
      C                                                                 MAIN 318
      C   THIS IS THE RETURN POINT FOR THE ITERATIVE CALCULATION .      MAIN 319
      C   **************************************************************MAIN 320
      C                                                                 MAIN 321
      111 CONTINUE                                                      MAIN 322
      C                                                                 MAIN 323
          IF(TRIAL .EQ. 0.0) GO TO 171                                  MAIN 324
          IF(PRCON .NE. 1.0) GO TO 172                                  MAIN 325
      C                                                                 MAIN 326
      C   TWO TOLERANCES --                                             MAIN 327
      C       ONE IS A VARIABLE ......TALD                              MAIN 328
      C       ONE IS FIXED ......FTOLD EITHER AS AN                     MAIN 329
      C       ABSOLUTE OR A RELATIVE VALUE IN TERMS OF D SPECIFED       MAIN 330
      C                                                                 MAIN 331
          PRINT 70,TRIAL                                                MAIN 332
       70 FORMAT('  TRIAL=',F5.0)                                       MAIN 333
          PRINT 113,TALD                                                MAIN 334
      113 FORMAT('     DISTILLATE TOLERANCE =',F10.7)                   MAIN 335
          PRINT 205                                                     MAIN 336
          DO 170 I=1,NP1                                                MAIN 337
          PRINT 107,I,V(I),I,AL(I),I,TT(I)                              MAIN 338
      107 FORMAT('    V(',I3,')=',F10.3,'   L(',I3,')=',F10.3,'   T(',I3, MAIN 339
         1')=',F10.4)                                                   MAIN 340
      170 CONTINUE                                                      MAIN 341
          PRINT 212                                                     MAIN 342
      212 FORMAT(//)                                                    MAIN 343
          JJ=JJ+1                                                       MAIN 344
          IF((N+10)*JJ-58) 43,43,42                                     MAIN 345
       42 PRINT 250                                                     MAIN 346
          IPAG=IPAG+1                                                   MAIN 347
          PRINT 44,IPAG                                                 MAIN 348
          JJ=1                                                          MAIN 349
       43 CONTINUE                                                      MAIN 350
```

```
C
C     .THESE VARIABLES ARE USED FOR PLOTING.
C
  172 CONTINUE
      IF(VLCON .EQ. 1.0 .AND. TRIAL .EQ. 4.0) GO TO 171
      I=TRIAL
      THA(I)=THETA
      DD(I)=CALD
      TI(I)=TT(1)
      TNFP(I)=TT(NFP)
      TNFP1(I)=TT(NFP+1)
      TN(I)=TT(N)
      VI(I)=V(1)
      VNFP(I)=V(NFP)
      VNFP1(I)=V(NFP+1)
      TRI(I)=TRIAL
C
C     PLOTTING VARIABLES FINISHED
C
      IF(PRCON .EQ. 1.0) GO TO 47
      JJ=JJ+1
      IF(3*JJ-55) 47,47,46
   46 JJ=1
      IPAG=IPAG+1
      PRINT 250
      PRINT 44,IPAG
   47 CONTINUE
C
  171 CONTINUE
      TRIAL=TRIAL+1.0
      CALL AANDS
      CALL RECTF
      CALL STRIPP
      CALL ECALL(699)
      CALL TEMPRT
      IF(TRIAL-3.0) 61,61,50
   61 CONTINUE
      DO 62 I=1,N
      V(I)=OLDV(I)
      AL(I)=OLDL(I)
   62 CONTINUE
      GO TO 111
   50 CONTINUE
      IF(TRIAL .EQ. TRIMAX) GO TO 9999
      CALL ENT
      IF(VLDAMP .EQ. 1.0) GO TO 402
      CALL DAMPE
  402 GO TO 111
C
   99 CONTINUE
```

```
      IF(THETA) 9999,9999,999
  999 CONTINUE
      TDAMP=1.0
      CALL TEMPRT
      CALL OUTPUT(&1000)
 9999 PRINT 300,TRIAL
  300 FORMAT('1  TOWER DID NOT CONVERGE ; IT STOPED AT TRIAL # ',F7.2)
      PRINT 311
  311 FORMAT('   FINAL VAPOR , LIQUID & TEMPERATURE PROFILE',/)
      PRINT 110
      PRINT 208
      DO 909 I=1,NP1
      PRINT 107,I,V(I),I,AL(I),I,TT(I)
  909 CONTINUE
 1000 CONTINUE
C
      IF(VLCON .EQ. 1.0) TRIAL=TRIAL-4.0
      I=TRIAL-1.0
      CALL XYPLOT(I,TRI,THA)
      PRINT 500
  500 FORMAT('    PLOT OF TRIAL VERSUS THETA')
      CALL XYPLOT(I,TRI,DD)
      PRINT 501
  501 FORMAT('    PLOT OF TRIAL VERSUS DISTILLATE')
      CALL XYPLOT(I,TRI,T1)
      PRINT 502
  502 FORMAT('    PLOT OF TRIAL VERSUS T(1)')
      CALL XYPLOT(I,TRI,TNFP)
      PRINT 503 ,NFP
  503 FORMAT('    PLOT OF TRIAL VERSUS T(',I2,')')
      CALL XYPLOT(I,TRI,TNFP1)
      NFP1=NFP+1
      PRINT 504,NFP1
  504 FORMAT('    PLOT OF TRIAL VERSUS T(',I2,')')
      CALL XYPLOT(I,TRI,TN)
      PRINT 505,N
  505 FORMAT('    PLOT OF TRIAL VERSUS T(',I2,')').
      CALL XYPLOT(I,TRI,V1)
      PRINT 506
  506 FORMAT('    PLOT OF TRIAL VERSUS V(1)')
      CALL XYPLOT(I,TRI,VNFP)
      PRINT 507,NFP
  507 FORMAT('    PLOT OF TRIAL VERSUS V(',I2,')')
      CALL XYPLOT(I,TRI,VNFP1)
      PRINT 508,NFP1
  508 FORMAT('    PLOT OF TRIAL VERSUS V(',I2,')')
      GO TO 24
   26 CONTINUE
      STOP
      END
```

```
       SUBROUTINE COEFKH(IPAG)                                          COFF 451
C                                                                       COFF 452
C      THIS SUBROUTINE WILL CURVE FIT THERMODYNAMIC DATA, OR READ IN    COFF 453
C          THE POLYNOMIAL COEFFICIENTS                                  COFF 454
C                                                                       COFF 455
       COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)     COFF 456
       COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF    COFF 457
       COMMON RBDCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON COFF 458
       COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON      COFF 459
       COMMON VLDAMP,TDAMP,TCON,N,M,HFP,TMAX,TMIN,T,FCON,VLCON,ALMP1,D,B COFF 460
       COMMON TFEED,FTOLD,SUMGPF ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL     COFF 461
       COMMON RVD(101,20),RLD(101,20),DLDV(101),DV,DL,DLDL(101),F(20)   COFF 462
       COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH  COFF 463
       COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XP(20),XD(20)     COFF 464
       COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)      COFF 465
       DIMENSION ZK(100),TS(100),C(10),ZHL(10),ZHV(10)                  COFF 466
C                                                                       COFF 467
C      NUMBER OF K, HL AND HV DATA CORRESPONDING TO T READ IN AS:       COFF 468
C         NK ,NHL AND NHV                                               COFF 469
C                                                                       COFF 470
       IPAG=IPAG+1                                                      COFF 471
C                                                                       COFF 472
       IF(HKCON .EQ. 0.0) GO TO 101                                     COFF 473
C                                                                       COFF 474
C      POLYNOMIALS READ IN (4TH ORDER --MAXIMUM)                        COFF 475
C                                                                       COFF 476
       READ 9,(A0(I),A1(I),A2(I),A3(I),A4(I),I=1,M)                     COFF 477
       READ 9,(HL0(I),HL1(I),HL2(I),HL3(I),HL4(I),I=1,M)                COFF 478
       READ 9,(HV0(I),HV1(I),HV2(I),HV3(I),HV4(I),I=1,M)                COFF 479
     9 FORMAT(5E15.8)                                                   COFF 480
       GO TO 100                                                        COFF 481
C                                                                       COFF 482
   101 CONTINUE                                                         COFF 483
C                                                                       COFF 484
       PRINT 250                                                        COFF 485
       JJJ=1                                                            COFF 486
       PRINT 52,IPAG                                                    COFF 487
       PRINT 64                                                         COFF 488
    64 FORMAT(4X,'GIVEN VAPOR-LIQUID EQUILIBRIUM DATA ',//)             COFF 489
       READ 1,NK,NHL,NHV                                                COFF 490
     1 FORMAT(3I5)                                                      COFF 491
C                                                                       COFF 492
C      TS TEMPERATURE ( DEG F)                                          COFF 493
C      ZK K-DATA ( DIMENSIONLESS )                                      COFF 494
C      ZHL H.LIQUID DATA ( H-BTU/# MOLE )                               COFF 495
C      ZHV H.VAPOR DATA (H-BTU/# MOLE )                                 COFF 496
C                                                                       COFF 497
C      COEFFICIENT OF POLYNOMIALS ARE AS :                              COFF 498
C      K  AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))                COFF 499
C      HL EL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))           COFF 500
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```
C      HV EV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))      COFF 501
C                                                                  COFF 502
C      IN THIS SECTION EQUILIBRIUM DATA (K) IS READ IN AND CURVE FITTED   COFF 503
C                                                                  COFF 504
       DO 80 I=1,10                                                COFF 505
 80    C(I)=0.0                                                    COFF 506
       DO 4 J=1,M                                                  COFF 507
       PRINT 67,J                                                  COFF 508
    67 FORMAT(2X,'COMPONENT #   ',I3)                              COFF 509
       READ 2,(TS(I),ZK(I),I=1,NK)                                 COFF 510
     2 FORMAT(8F10.5)                                              COFF 511
       DO 3 I=1,NK                                                 COFF 512
       PRINT 61,I,TS(I),I,ZK(I)                                    COFF 513
    61 FORMAT(5X,'T(',I2,')=',F10.4,5X,'K(',I2,')=',F10.4)         COFF 514
     3 CONTINUE                                                    COFF 515
       PRINT 70                                                    COFF 516
    70 FORMAT(///)                                                 COFF 517
       IF(J .EQ. M) GO TO 72                                       COFF 518
       JJJ=JJJ+1                                                   COFF 519
       IF((NK+4)*JJJ-48) 71,71,72                                  COFF 520
    72 CONTINUE                                                    COFF 521
       JJJ=1                                                       COFF 522
       IPAG=IPAG+1                                                 COFF 523
       PRINT 250                                                   COFF 524
       PRINT 52,IPAG                                               COFF 525
    71 CONTINUE                                                    COFF 526
       NNT=4                                                       COFF 527
       NNC=1                                                       COFF 528
       VLA=1.0                                                     COFF 529
       CALL FITIT(TS,ZK,NK,NNT,C,NNC,VLA)                          COFF 530
       A0(J)=C(2)                                                  COFF 531
       A1(J)=C(3)                                                  COFF 532
       A2(J)=C(4)                                                  COFF 533
       A3(J)=C(5)                                                  COFF 534
       A4(J)=C(6)                                                  COFF 535
       DO 81 II=1,10                                               COFF 536
 81    C(II)=0.0                                                   COFF 537
     4 CONTINUE                                                    COFF 538
C                                                                  COFF 539
C      IN THIS SECTION LIQUID ENTHALPY IS READ IN AND CURVE FITTED COFF 540
C                                                                  COFF 541
       PRINT 65                                                    COFF 542
    65 FORMAT(15X,'GIVEN LIQUID ENTHALPY',//)                      COFF 543
       DO 6 J=1,M                                                  COFF 544
       PRINT 67,J                                                  COFF 545
       PRINT 53                                                    COFF 546
    53 FORMAT(12X,'DEG. F',11X,'M-BTU/# MOLE')                     COFF 547
       READ 2,(TS(I),ZHL(I),I=1,NHL)                               COFF 548
       DO 5 I=1,NHL                                                COFF 549
       PRINT 62,I,TS(I),I,ZHL(I)                                   COFF 550
```

```
      62 FORMAT(5X,'T(',I2,')=',F10.4,5X,'HL(',I2,')=',F10.4)           COFF 551
       5 CONTINUE                                                        COFF 552
         PRINT 70                                                        COFF 553
         IF(J .EQ. M) GO TO 74                                           COFF 554
         JJJ=JJJ+1                                                       COFF 555
         IF((NHL+5)*JJJ-48) 73,73,74                                     COFF 556
      74 CONTINUE                                                        COFF 557
         JJJ=1                                                           COFF 558
         IPAG=IPAG+1                                                     COFF 559
         PRINT 250                                                       COFF 560
         PRINT 52,IPAG                                                   COFF 561
      73 CONTINUE                                                        COFF 562
         NNT=4                                                           COFF 563
         NNC=1                                                           COFF 564
         VLA=1.0                                                         COFF 565
         CALL FITIT(TS,ZHL,NHL,NNT,C,NNC,VLA)                            COFF 566
         HL0(J)=C(2)                                                     COFF 567
         HL1(J)=C(3)                                                     COFF 568
         HL2(J)=C(4)                                                     COFF 569
         HL3(J)=C(5)                                                     COFF 570
         HL4(J)=C(6)                                                     COFF 571
         DO 82 II=1,10                                                   COFF 572
   82    C(II)=0.0                                                       COFF 573
       6 CONTINUE                                                        COFF 574
C                                                                        COFF 575
C        IN THIS SECTION VAPOR ENTHALPY IS READ IN AND CURVE FITTED      COFF 576
C                                                                        COFF 577
         PRINT 66                                                        COFF 578
      66 FORMAT(15X,'GIVEN VAPOR ENTHALPY',//)                           COFF 579
         DO 8 J=1,M                                                      COFF 580
         PRINT 67,J                                                      COFF 581
         PRINT 53                                                        COFF 582
         READ 2,(TS(I),ZHV(I),I=1,NHV)                                   COFF 583
         DO 7 I=1,NHV                                                    COFF 584
         PRINT 63,I,TS(I),I,ZHV(I)                                       COFF 585
      63 FORMAT(5X,'T(',I2,')=',F10.4,5X,'HV(',I2,')=',F10.4)           COFF 586
       7 CONTINUE                                                        COFF 587
         IF(J .EQ. M) GO TO 75                                           COFF 588
         PRINT 70                                                        COFF 589
         JJJ=JJJ+1                                                       COFF 590
         IF((NHV+5)*JJJ-48) 75,75,76                                     COFF 591
      76 CONTINUE                                                        COFF 592
         JJJ=1                                                           COFF 593
         IPAG=IPAG+1                                                     COFF 594
         PRINT 250                                                       COFF 595
         PRINT 52,IPAG                                                   COFF 596
      75 CONTINUE                                                        COFF 597
         NNT=4                                                           COFF 598
         NNC=1                                                           COFF 599
         VLA=1.0                                                         COFF 600
```

```
          CALL FITIT(TS,ZHV,NHV,NNT,C,NNC,VLA)
          HV0(J)=C(2)
          HV1(J)=C(3)
          HV2(J)=C(4)
          HV3(J)=C(5)
          HV4(J)=C(6)
          DO 63 II=1,10
   63     C(II)=0.0
        8 CONTINUE
C
C         IN THIS SECTION COEFFICIENT OF POLYNOMIALS ARE PRINTED
C
          IPAG=IPAG+1
      100 CONTINUE
          JJ=1
          PRINT 250
      250 FORMAT('1')
          PRINT 52,IPAG
       52 FORMAT(112X,'PAGE  ',I4,//)
          IF(HFCON) 31,33,31
       31 PRINT 30
       30 FORMAT('   GIVEN POLYNOMILALS',//)
          GO TO 34
       33 PRINT 32
       32 FORMAT('   CURVE FITTED POLYNOMIALS',//)
       34 CONTINUE
          PRINT 26
       26 FORMAT('   POLYNOMIALS FOR VAPOR - LIQUID EQUILIBRIUM DATA ARE '
         1,/)
          DO 14 I=1,M
          PRINT 12,I,A0(I),A1(I),A2(I),A3(I),A4(I)
       12 FORMAT('   K(',I2,')=',E15.8,'+T*(',E15.8,'+T*(',E15.8,'+T*(',
         1E15.8,'+(',E15.8,')*T)))')
       14 CONTINUE
          JJ=JJ+1
          IF((4+M)*JJ-55) 44,44,45
       45 CONTINUE
          IPAG=IPAG+1
          PRINT 250
          PRINT 52,IPAG
       44 CONTINUE
          PRINT 17
       17 FORMAT(/)
       28 FORMAT('   POLYNOMIALS FOR  VAPOR ENTHALPY DATA  ARE ',/)
          PRINT 28
          DO 18 I=1,M
          PRINT 15,I,HV0(I),HV1(I),HV2(I),HV3(I),HV4(I)
       15 FORMAT('   HV(',I2,')=',E15.8,'+T*(',E15.8,'+T*(',E15.8,'+T*(',
         1E15.8,'+(',E15.8,')*T)))')
       18 CONTINUE
```

```
      JJ=JJ+1
      IF((4+M)*JJ-55) 40,40,41
   41 CONTINUE
      IPAG=IPAG+1
      PRINT 250
      PRINT 52,IPAG
   40 CONTINUE
      PRINT 17
      PRINT 27
   27 FORMAT('   POLYNOMIALS FOR  LIQUID ENTHALPY  DATA ARE ',/)
      DO 19 I=1,M
      PRINT 16,I,HL0(I),HL1(I),HL2(I),HL3(I),HL4(I)
   16 FORMAT('    HL(',I2,')=',E15.8,'+T*(',E15.8,'+T*(',E15.8,'+T*(',
     1E15.8,'+(',E15.8,')*T)))')
   19 CONTINUE
      IPAG=IPAG+1
      PRINT 250
      PRINT 52,IPAG
      RETURN
      END
```

```
      SUBROUTINE ALLIQ                                                  ALLI 671
C                                                                       ALLI 672
C     WHEN FEED IS ALL LIQUID , THIS SUBROUTINE WILL READ IN            ALLI 673
C       FEED COMPONENTS AND SET UP THE VAPOR AND LIQUID PROFILE         ALLI 674
C                                                                       ALLI 675
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)      ALLI 676
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF     ALLI 677
      COMMON RADCAL(20),HCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON ALLI 678
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON       ALLI 679
      COMMON VLDAMP,TDAMP,TCON,L,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B ALLI 680
      COMMON TFEED,FTOLD,SUMCPR ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL      ALLI 681
      COMMON RVD(101,20),RLD(101,20),DLDV(101),DV,DL,DLDL(101),F(20)    ALLI 682
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH   ALLI 683
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)      ALLI 684
      COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)       ALLI 685
C                                                                       ALLI 686
C     F(I) IS MOLAL RATE OF FLOW OF COMPONENT I IN THE FEED             ALLI 687
C     FV(I) IS MOLAL RATE OF FLOW OF COMPONENT I IN THE VAPOR           ALLI 688
C          PART OF A PARTIALLY VAPORIZED FEED                           ALLI 689
C     FL(I) IS MOLAL RATE OF FLOW OF COMPONENT I IN THE LIQUID          ALLI 690
C          PART OF A PARTIALLY VAPORIZED FEED                           ALLI 691
C     TOTFL IS TOTAL AMOUNT OF LIQUID IN THE FEED                       ALLI 692
C     TOTFV IS TOTAL AMOUNT OF VAPOR IN THE FEED                        ALLI 693
C     TOTALF IS TOTAL FEED ( TOTFL + TOTFV )                            ALLI 694
C     XF(I) IS MOLE FRACTION OF COMPONENT I IN THE LIQUID               ALLI 695
C          PART OF A PARTIALLY VAPORIZED FEED                           ALLI 696
C     YF(I) IS MOLE FRACTION OF COMPONENT I IN THE VAPOR                ALLI 697
C          PART OF A PARTIALLY VAPORIZED FEED                           ALLI 698
C                                                                       ALLI 699
      PRINT 10                                                          ALLI 700
   10 FORMAT('    FEED IS ALL LIQUID .')                                ALLI 701
      TOTALF=0.0                                                        ALLI 702
      READ 102,(F(I),I=1,M)                                             ALLI 703
  102 FORMAT(6F10.5)                                                    ALLI 704
      DO 103 I=1,M                                                      ALLI 705
      TOTALF=TOTALF+F(I)                                                ALLI 706
  103 CONTINUE                                                          ALLI 707
      TOTFL=TOTALF                                                      ALLI 708
      PB=P(NFP)                                                         ALLI 709
      TOTFV=0.0                                                         ALLI 710
      DO 1 I=1,M                                                        ALLI 711
      XF(I)=F(I)/TOTALF                                                 ALLI 712
      FX(I)=F(I)                                                        ALLI 713
      FL(I)=FX(I)                                                       ALLI 714
      FV(I)=0.0                                                         ALLI 715
      X(I)=XF(I)                                                        ALLI 716
      Y(I)=XF(I)                                                        ALLI 717
      YF(I)=0.0                                                         ALLI 718
    1 CONTINUE                                                          ALLI 719
C                                                                       ALLI 720
```

```
      T=TT(NFP)                                                         ALLI 721
      PB=P(NFP)                                                         ALLI 722
      CALL BUBBLE                                                       ALLI 723
      PRINT 29,T                                                        ALLI 724
   29 FORMAT('   FEED BUBBLE POINT TEMPERATURE IS = ',F10.5,'  DEG. F') ALLI 725
C                                                                       ALLI 726
C     ALNP1 =EXTERNAL REFLUX (MOLS/HR)                                  ALLI 727
C     D= DISTILLATE (MOLS/HR)                                           ALLI 728
C     B=BOTTOM (MOLS/HR)                                                ALLI 729
C     TFEED= TEMPERATURE OF FEED (DEG F)                                ALLI 730
C                                                                       ALLI 731
      IF(TFEED .EQ. 0.0) TFEED=T                                        ALLI 732
      PD=P(NFP)                                                         ALLI 733
      CALL DEW                                                          ALLI 734
      PRINT 28,T                                                        ALLI 735
   28 FORMAT('   FEED DEW POINT TEMPERATURE IS = ',F10.5,'  DEG. F')    ALLI 736
      B=TOTALF-D                                                        ALLI 737
C                                                                       ALLI 738
      IF(VLCON .NE. 0.0) GO TO 27                                       ALLI 739
C                                                                       ALLI 740
      DO 24 I=1,NFP                                                     ALLI 741
      AL(I)=TOTALF+ALNP1                                                ALLI 742
   24 CONTINUE                                                          ALLI 743
      NNFP=NFP+1                                                        ALLI 744
      DO 25 I=NNFP,N                                                    ALLI 745
      AL(I)=ALNP1                                                       ALLI 746
   25 CONTINUE                                                          ALLI 747
      DO 26 I=1,N                                                       ALLI 748
      V(I)=ALNP1+D                                                      ALLI 749
   26 CONTINUE                                                          ALLI 750
      AL(1)=B                                                           ALLI 751
   27 CONTINUE                                                          ALLI 752
      RETURN                                                            ALLI 753
      END                                                               ALLI 754
```

```
      SUBROUTINE ALLVAP                                                 ALLV 755
C                                                                       ALLV 756
C     WHEN FEED IS ALL VAPOR , THIS SUBROUTINE WILL READ IN             ALLV 757
C        FEED COMPONENTS AND SET UP THE VAPOR AND LIQUID PROFILE        ALLV 758
C                                                                       ALLV 759
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)      ALLV 760
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF     ALLV 761
      COMMON RBCAL(20),HCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON  ALLV 762
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON       ALLV 763
      COMMON VLDIMP,TDAMP,TCON,NM,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B  ALLV 764
      COMMON TFEED,FTOLD,SUMGPR ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL      ALLV 765
      COMMON RVD(101,20),RLD(101,20),OLDV(101),DV,DL,OLDL(101),F(20)    ALLV 766
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH   ALLV 767
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)      ALLV 768
      COMMON YF(20),XF(20),SUMLF,TOTALF,RCOR,DCOR,DCO(20),BCO(20)       ALLV 769
C                                                                       ALLV 770
C     F(I) IS MOLAL RATE OF FLOW OF COMPONENT I IN THE FEED             ALLV 771
C     FV(I) IS MOLAL RATE OF FLOW OF COMPONENT I IN THE VAPOR           ALLV 772
C         PART OF A PARTIALLY VAPORIZED FEED                            ALLV 773
C     FL(I) IS MOLAL RATE OF FLOW OF COMPONENT I IN THE LIQUID          ALLV 774
C         PART OF A PARTIALLY VAPORIZED FEED                            ALLV 775
C     TOTFL IS TOTAL AMOUNT OF LIQUID IN THE FEED .                     ALLV 776
C     TOTFV IS TOTAL AMOUNT OF VAPOR IN THE FEED                        ALLV 777
C     TOTALF IS TOTAL FEED ( TOTFL + TOTFV )                            ALLV 778
C     XF(I) IS MOLE FRACTION OF COMPONENT I IN THE LIQUID               ALLV 779
C         PART OF A PARTIALLY VAPORIZED FEED                            ALLV 780
C     YF(I) IS MOLE FRACTION OF COMPONENT I IN THE VAPOR                ALLV 781
C         PART OF A PARTIALLY VAPORIZED FEED                            ALLV 782
C                                                                       ALLV 783
      PRINT 10                                                          ALLV 784
   10 FORMAT('   FEED IS ALL VAPOR .')                                  ALLV 785
      TOTALF=0.0                                                        ALLV 786
C     FEED IS ALL VAPOR                                                 ALLV 787
      READ 101,(F(I),I=1,M)                                             ALLV 788
  101 FORMAT(8F10.5)                                                    ALLV 789
      DO 17 I=1,M                                                       ALLV 790
   17 TOTALF=TOTALF+F(I)                                                ALLV 791
      TOTFL=0.0                                                         ALLV 792
      TOTFV=TOTALF                                                      ALLV 793
      DO 1 I=1,M                                                        ALLV 794
      YF(I)=F(I)/TOTALF                                                 ALLV 795
      FX(I)=F(I)                                                        ALLV 796
      FV(I)=FX(I)                                                       ALLV 797
      FL(I)=0.0                                                         ALLV 798
      Y(I)=YF(I)                                                        ALLV 799
      X(I)=YF(I)                                                        ALLV 800
      XF(I)=0.0                                                         ALLV 801
    1 CONTINUE                                                          ALLV 802
C                                                                       ALLV 803
      T=TT(NFP)                                                         ALLV 804
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      PD=P(NFP)                                                  ALLV 805
      CALL DEW                                                   ALLV 806
      PRINT 28,T                                                 ALLV 807
   28 FORMAT('   FEED DEW POINT TEMPERATURE IS = ',F10.5,'  DEG. F')   ALLV 808
C                                                                ALLV 809
C     ALNP1 =EXTERNAL REFLUX (MOLS/HR)                           ALLV 810
C     D= DISTILLATE (MOLS/HR)                                    ALLV 811
C     B=BOTTOM (MOLS/HR)                                         ALLV 812
C     TFEED= TEMPERATURE OF FEED (DEG F)                         ALLV 813
C                                                                ALLV 814
      IF(TFEED .EQ. 0.0) TFEED=T                                 ALLV 815
      PB=P(NFP)                                                  ALLV 816
      CALL BUBBLE                                                ALLV 817
      PRINT 29,T                                                 ALLV 818
   29 FORMAT('   FEED BUBBLE POINT TEMPERATURE IS = ',F10.5,'  DEG. F') ALLV 819
      B=TOTALF-D                                                 ALLV 820
C                                                                ALLV 821
      IF(VLCON .NE. 0.0) GO TO 27                                ALLV 822
C                                                                ALLV 823
      DO 19 I=1,N                                                ALLV 824
      AL(I)=ALNP1                                                ALLV 825
   19 CONTINUE                                                   ALLV 826
      DO 20 I=1,NFP                                              ALLV 827
      V(I)=ALNP1+D-TOTALF                                        ALLV 828
   20 CONTINUE                                                   ALLV 829
      NNFP=NFP+1                                                 ALLV 830
      DO 21 I=NNFP,N                                             ALLV 831
      V(I)=ALNP1+D                                               ALLV 832
   21 CONTINUE                                                   ALLV 833
      AL(1)=0                                                    ALLV 834
   27 CONTINUE                                                   ALLV 835
      RETURN                                                     ALLV 836
      END                                                        ALLV 837
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      SUBROUTINE VLMEXD                                                 VLME 838
C                                                                       VLME 839
C     WHEN FEED IS PARTIALLY VAPORIZED , THIS SUBROUTINE WILL READ IN   VLME 840
C       FEED COMPONENTS , FLASH SUBROUTINE IS CALLED AND SETS UP VAPOR  VLME 841
C       AND LIQUID PROFILE                                              VLME 842
C                                                                       VLME 843
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)      VLME 844
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF     VLME 845
      COMMON REDCAL(20),RCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON VLME 846
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON       VLME 847
      COMMON VLOAMP,TOAMP,TCON,N,M,LFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B VLME 848
      COMMON TFEED,FTHLD,SUMOPR ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL      VLME 849
      COMMON RVD(101,20),RLD(101,20),OLDV(101),DV,DL,OLDL(101),F(20)    VLME 850
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH   VLME 851
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XR(20),XD(20)      VLME 852
      COMMON YF(20),XF(20),SUMLF,TOTALF,RCOR,DCOR,DCO(20),RCO(20)       VLME 853
C                                                                       VLME 854
C     F(I) IS MOLAL RATE OF FLOW OF COMPONENT I IN THE FEED             VLME 855
C     FV(I) IS MOLAL RATE OF FLOW OF COMPONENT I IN THE VAPOR           VLME 856
C          PART OF A PARTIALLY VAPORIZED FEED                           VLME 857
C     FL(I) IS MOLAL RATE OF FLOW OF COMPONENT I IN THE LIQUID          VLME 858
C          PART OF A PARTIALLY VAPORIZED FEED                           VLME 859
C     TOTFL IS TOTAL AMOUNT OF LIQUID IN THE FEED .                     VLME 860
C     TOTFV IS TOTAL AMOUNT OF VAPOR IN THE FEED                        VLME 861
C     TOTALF IS TOTAL FEED ( TOTFL + TOTFV )                            VLME 862
C     XF(I) IS MOLE FRACTION OF COMPONENT I IN THE LIQUID               VLME 863
C          PART OF A PARTIALLY VAPORIZED FEED                           VLME 864
C     YF(I) IS MOLE FRACTION OF COMPONENT I IN THE VAPOR                VLME 865
C          PART OF A PARTIALLY VAPORIZED FEED                           VLME 866
C                                                                       VLME 867
      PRINT 10                                                          VLME 868
   10 FORMAT('   FEED IS PARTIALLY VAPORIZED ,')                        VLME 869
      TOTALF=0.0                                                        VLME 870
      READ 105,(F(I),I=1,M)                                             VLME 871
  105 FORMAT(8F10.5)                                                    VLME 872
      DO 106 I=1,M                                                      VLME 873
      TOTALF=TOTALF+F(I)                                                VLME 874
  106 CONTINUE                                                          VLME 875
      DO 1 I=1,M                                                        VLME 876
      XF(I)=F(I)/TOTALF                                                 VLME 877
      FX(I)=F(I)                                                        VLME 878
    1 CONTINUE                                                          VLME 879
C                                                                       VLME 880
C     ALNP1 =EXTERNAL REFLUX (MOLS/HR)                                  VLME 881
C     D= DISTILLATE (MOLS/HR)                                           VLME 882
C     B= BOTTOM (MOLS/HR)                                               VLME 883
C     TFEED= TEMPERATURE OF FEED (DEG F)                                VLME 884
C                                                                       VLME 885
      B=TOTALF-D                                                        VLME 886
      DO 17 I=1,M                                                       VLME 887
```

```
      X(I)=XF(I)                                                        VLME 888
      Y(I)=XF(I)                                                        VLME 889
   17 CONTINUE                                                          VLME 890
      T=TT(NFP)                                                         VLME 891
      PD=P(NFP)                                                         VLME 892
      CALL DEW                                                          VLME 893
      FDT=T                                                             VLME 894
      PB=P(NFP)                                                         VLME 895
      CALL BUBBLE                                                       VLME 896
      FBT=T                                                             VLME 897
      PRINT 2,FDT                                                       VLME 898
      PRINT 3,FBT                                                       VLME 899
    3 FORMAT('   FEED BUBBLE POINT TEMPERATURE IS = ',F10.5,'  DEG. F') VLME 900
    2 FORMAT('   FEED DEW POINT TEMPERATURE IS = ',F10.5,'  DEG. F')    VLME 901
      IF(TFEED .EQ. 0.0) GO TO 4                                        VLME 902
      IF(TFEED .GT. FDT .OR. TFEED .LT. FBT )GO TO 5                    VLME 903
      GO TO 6                                                           VLME 904
    4 TFEED=(FDT+FBT)/2.0                                               VLME 905
      PRINT 7                                                           VLME 906
    7 FORMAT('   FEED TEMPERATURE WAS NOT SPECIFIED AVERAGE OF DEW & BUBVLME 907
     *BLE POINT T OF FEED WAS USED')                                    VLME 908
      GO TO 6                                                           VLME 909
    5 PRINT 8,TFEED                                                     VLME 910
    8 FORMAT('   SPECIFIED FEED TEMPERATURE =',F10.4,/,                 VLME 911
     *'      THE SPECIFIED T WAS NOT BETWEEN DEW & BUBBLE POINT T OF FEEDVLME 912
     *',/,'      AVERAGE OF DEW & BUBBLE POINT T OF FEED WAS USED')     VLME 913
      TFEED=(FDT+FBT)/2.0                                               VLME 914
    6 CONTINUE                                                          VLME 915
      T=TFEED                                                           VLME 916
      PF=P(NFP)                                                         VLME 917
C                                                                       VLME 918
      CALL FLASH                                                        VLME 919
C                                                                       VLME 920
      IF(VLCOR .LE. 0.0) GO TO 27                                       VLME 921
C                                                                       VLME 922
      DO 28 I=1,NFP                                                     VLME 923
      AL(I)=ALNP1+TOTFL                                                 VLME 924
      V(I)=AL(I)-B                                                      VLME 925
   28 CONTINUE                                                          VLME 926
      NNFP=NFP+1                                                        VLME 927
      DO 29 I=NNFP,N                                                    VLME 928
      AL(I)=ALNP1                                                       VLME 929
      V(I)=V(NFP)+TOTFV                                                 VLME 930
   29 CONTINUE                                                          VLME 931
      AL(1)=B                                                           VLME 932
   27 CONTINUE                                                          VLME 933
      RETURN                                                            VLME 934
      END                                                               VLME 935
```

```
      SUBROUTINE FLASH
C
C     THIS SUBROUTINE WILL DO FLASH CALCULATIONS BY HOLLANDS METHOD
C          ("MULTICOMPONENT DISTILLATION" BY C. D. HOLLAND PAGE 22)
C
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF
      COMMON RABCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON
      COMMON VLDREF,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B
      COMMON TFEED,FTOLD,SUMGPR ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL
      COMMON RVD(101,20),RLD(101,20),OLDV(101),DV,DL,OLDL(101),F(20)
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)
      COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)
C
      IXX=-6
      TOL=(10.0)**IXX
      AMAX=15.0
      COUNT=0.0
      SUMF=0.0
C
C      PHAI=L/F
C
      PHAI=1.0
    1 SUM=0.0
      DSUM=0.0
      DO 2 I=1,M
      AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))
      AK=AK*(PREF/PF)
      YF(I)=XF(I)/(1.0-PHAI*(1.0-1.0/AK))
      SUBSUM=(XF(I)*(1.0-1.0/AK))/((1.0-PHAI*(1.0-1.0/AK))**2)
      SUM=SUM+YF(I)
    2 DSUM=DSUM+SUBSUM
      FPHAI=SUM-1.0
      IF(ABS(FPHAI)-TOL) 3,3,22
   22 PHAI=PHAI-FPHAI/DSUM
C
      COUNT=COUNT+1.0
      IF(COUNT .EW. AMAX) GO TO 15
      GO TO 1
   15 CONTINUE
      TOL=TOL*10.
      COUNT=0.0
      GO TO 1
C
    3 CONTINUE
      TOTFL=TOTALF*PHAI
      TOTFV=TOTALF-TOTFL
      DO 4 I=1,M
```

```
         AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))              FLAS 986
         AK=AK*(PREF/PF)                                             FLAS 987
         XF(I)=YF(I)/AK                                              FLAS 988
         FL(I)=TOTFL*XF(I)                                           FLAS 989
         FV(I)=TOTFV*YF(I)                                           FLAS 990
       4 CONTINUE                                                    FLAS 991
         RETURN                                                      FLAS 992
         END                                                         FLAS 993
```

```
      SUBROUTINE AANDS                                                  AAND 994
C                                                                       AAND 995
C     THIS SUBROUTINE WILL CALCULATE A (ABSORPTION FACTORS)AND          AAND 996
C         S(STRIPPING FACTORS) FOR ALL COMPONENTS ON EACH TRAY          AAND 997
C                                                                       AAND 998
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)      AAND 999
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF     AAND1000
      COMMON RDCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON  AAND1001
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON       AAND1002
      COMMON VLDAMP,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B AAND1003
      COMMON TFEED,FTOLD,SUMGPR ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL      AAND1004
      COMMON RVD(101,20),RLD(101,20),OLDV(101),DV,DL,OLDL(101),F(20)    AAND1005
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH   AAND1006
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)      AAND1007
      COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)       AAND1008
C                                                                       AAND1009
      J=N                                                               AAND1010
    1 CONTINUE                                                          AAND1011
      T=TT(J)                                                           AAND1012
      DO 2 I=1,M                                                        AAND1013
      AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))                    AAND1014
      AK=AK*(PREF/P(J))                                                 AAND1015
      A(J,I)=AL(J)/(V(J)*AK)                                            AAND1016
    6 FORMAT('    A(',I2,',',I2,')=',F10.5)                             AAND1017
    2 CONTINUE                                                          AAND1018
      J=J-1                                                             AAND1019
      IF( J-NFP)3,3,1                                                   AAND1020
C                                                                       AAND1021
    3 CONTINUE                                                          AAND1022
      T=TT(J)                                                           AAND1023
      DO 4 I=1,M                                                        AAND1024
      AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))                    AAND1025
      AK=AK*(PREF/P(J))                                                 AAND1026
      S(J,I)=(V(J)/AL(J))*AK                                            AAND1027
    7 FORMAT('    S(',I2,',',I2,')=',F10.5)                             AAND1028
    4 CONTINUE                                                          AAND1029
      J=J-1                                                             AAND1030
      IF(J) 5,5,3                                                       AAND1031
    5 CONTINUE                                                          AAND1032
      RETURN                                                            AAND1033
      END                                                               AAND1034
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A FORTRAN IV (VER L38) SOURCE LISTING: 02/06/73 PAGE 0024

```
      SUBROUTINE RECTF
C
C     THIS SUBROUTINE WILL CALCULATE V/D AND L/D IN RECTIFYING SECTION
C
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF
      COMMON RFDCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON
      COMMON VLDAMP,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B
      COMMON TFELD,FTOLD,SUMGPL ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL
      COMMON RVD(101,20),RLD(101,20),DLDV(101),DV,DL,DLDL(101),F(20)
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XP(20),XD(20)
      COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)
C
C     RVD = V/D AND RLD = L/D
C     J IS NUMBER OF TRAY
C     I IS NUMBER OF COMPONENT
C     FIRST SUBSCRIPT REFERS TO THE TRAY & SECOND SUBSCRIPT
C           REFERS TO COMPONENT
C
C     RLD AND RVD CALCULATED FOR EACH COMPONENT ON TRAY
C
      T=TT(N+1)
      DO 32 I=1,M
      AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))
      AK=AK*(PREF/P(N+1))
      RLD(N+1,I)=ALNP1/(DL+DV*AK)
      RLD(N,I)=A(N,I)*(RLD(N+1,I)+1.0)
      RVD(N,I)=RLD(N+1,I)+1.0
   32 CONTINUE
C
C     STARTING FROM TOP TO THE FEED TRAY +1
C     NUMBERING THE TRAY FROM BOTTOM UP
      J=N-1
      IF(J-NFP) 36,36,33
   33 CONTINUE
      DO 34 I=1,M
      RVD(J,I)=1.0+A(J+1,I)*RVD(J+1,I)
      RLD(J,I)=A(J,I)*(RLD(J+1,I)+1.0)
   34 CONTINUE
      J=J-1
      IF(J-NFP) 35,35,33
   35 CONTINUE
   36 CONTINUE
      RETURN
      END
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A FORTRAN IV (VER L38) SOURCE LISTING: 02/06/73 PAGE 0025

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      SUBROUTINE STRIPP                                                 STRI1082
C                                                                       STRI1083
C     THIS SUBROUTINE WILL CALCULATE V/B AND L/B IN STRIPPING SECTION   STRI1084
C                                                                       STRI1085
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)      STRI1086
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF     STRI1087
      COMMON RSPCAL(20),DCAL(20),BCAL(20),CRP(20),FFRAC(20),THCOUN,DCON STRI1088
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON       STRI1089
      COMMON VLDAMP,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B STRI1090
      COMMON TFEED,FTOLD,SUMGPR,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL       STRI1091
      COMMON RVD(101,20),RLD(101,20),ULDV(101),DV,DL,ULDL(101),F(20)    STRI1092
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH   STRI1093
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)      STRI1094
      COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCD(20),BCD(20)       STRI1095
C                                                                       STRI1096
C     RLB = L/B AND RVB = V/B                                           STRI1097
C     FIRST SUBSCRIPT REFERS TO THE TRAY & SECOND SUBSCRIPT             STRI1098
C           REFERS TO COMPONENT                                         STRI1099
C                                                                       STRI1100
C     STARTING FROM BOTTOM UP (TRAY #1):                                STRI1101
C                                                                       STRI1102
      DO 36 I=1,M                                                       STRI1103
      RLB(1,I)=1.0                                                      STRI1104
      RVB(1,I)=RLB(1,I)*S(1,I)                                          STRI1105
      RLB(2,I)=1.0+S(1,I)                                               STRI1106
      RVB(2,I)=S(2,I)*(RVB(1,I)+1.0)                                    STRI1107
   36 CONTINUE                                                          STRI1108
C                                                                       STRI1109
C     FROM STAGE 3 UP TO THE FEED TRAY                                  STRI1110
C                                                                       STRI1111
      J=3                                                               STRI1112
      NSPF=NFP+1                                                        STRI1113
      IF(J-NSPF) 37,39,39                                               STRI1114
   37 CONTINUE                                                          STRI1115
      DO 38 I=1,M                                                       STRI1116
      RLB(J,I)=1.0+S(J-1,I)*RLB(J-1,I)                                  STRI1117
      RVB(J,I)=S(J,I)*(RVB(J-1,I)+1.0)                                  STRI1118
   38 CONTINUE                                                          STRI1119
      J=J+1                                                             STRI1120
      IF(J-NSPF) 37,39,39                                               STRI1121
   39 CONTINUE                                                          STRI1122
      RETURN                                                            STRI1123
      END                                                               STRI1124
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      SUBROUTINE DCALL(*)                                                DCAL1125
C                                                                        DCAL1126
C     THIS SUBROUTINE IS USED TO CALCULATE DISTILLATE RATE               DCAL1127
C                                                                        DCAL1128
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)       DCAL1129
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF      DCAL1130
      COMMON RBDCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON  DCAL1131
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON        DCAL1132
      COMMON VLDAMP,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B  DCAL1133
      COMMON TFEED,FTOLD,SUMGPR ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL       DCAL1134
      COMMON RVD(101,20),RLD(101,20),DLDV(101),DV,DL,DLDL(101),F(20)     DCAL1135
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH    DCAL1136
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)       DCAL1137
      COMMON YF(20),XF(20),SUMLF,TOTALF,DCOK,DCOR,DCD(20),BCD(20)        DCAL1138
C                                                                        DCAL1139
C     RBDCAL=B/D CALCULATED                                              DCAL1140
C                                                                        DCAL1141
      IF(TRIAL-5.0) 10,10,11                                             DCAL1142
   10 IXX=-TRIAL                                                         DCAL1143
C                                                                        DCAL1144
C     TALD IS DISTILLATE TOLERANCE WHICH COULD BE CHANGED                DCAL1145
C     FTOLD IS FINAL DISTILLATE TOLERANCE (MUST CONVERGE ON FTOLD)       DCAL1146
C                                                                        DCAL1147
      TALD=(10.0)**IXX                                                   DCAL1148
      GO TO 12                                                           DCAL1149
   11 TALD=FTOLD                                                         DCAL1150
   12 CONTINUE                                                           DCAL1151
      COUNT=0.0                                                          DCAL1152
      AMAX=15.0                                                          DCAL1153
      SUMRBD=0.0                                                         DCAL1154
      CALD=0.0                                                           DCAL1155
      CALB=0.0                                                           DCAL1156
      THETA=1.0                                                          DCAL1157
C                                                                        DCAL1158
      DO 39 I=1,N                                                        DCAL1159
      RBDCAL(I)=(RLD(NFP+1,I)+(FL(I)/FX(I)))/(RVB(NFP,I)+(FV(I)/FX(I)))  DCAL1160
      SUMRBD=SUMRBD+RBDCAL(I)                                            DCAL1161
      DCAL(I)=FX(I)/(1.0+RBDCAL(I)*THETA)                                DCAL1162
      BCAL(I)=RBDCAL(I)*DCAL(I)*THETA                                    DCAL1163
      CALD=DCAL(I)+CALD                                                  DCAL1164
      CALB=BCAL(I)+CALB                                                  DCAL1165
   39 CONTINUE                                                           DCAL1166
      PRINT 21,CALD,THETA                                                DCAL1167
   21 FORMAT('     CALCULATED D=',F10.5,'     FOR THETA =',F5.2)         DCAL1168
      DEFF=CALD-D                                                        DCAL1169
C                                                                        DCAL1170
      IF(ABS(DEFF)-FTOLD) 51,51,40                                       DCAL1171
   40 CONTINUE                                                           DCAL1172
      THCOUN=0.0                                                         DCAL1173
      THETA=0.0                                                          DCAL1174
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    2 SUMGPR=0.0                                                  DCAL1175
      DCOR=0.0                                                    DCAL1176
      BCOR=0.0                                                    DCAL1177
      DO 4 I=1,M                                                  DCAL1178
      DCO(I)=FX(I)/(1.0+RBDCAL(I)*THETA)                          DCAL1179
      BCO(I)=RBDCAL(I)*DCO(I)*THETA                               DCAL1180
      DCOR=DCO(I)+DCOR                                            DCAL1181
      BCOR=BCOR+BCO(I)                                            DCAL1182
      GRP(I)=-(RBDCAL(I)*FX(I))/((1.0+THETA*RBDCAL(I))**2)        DCAL1183
      SUMGPR=SUMGPR+GRP(I)                                        DCAL1184
    4 CONTINUE                                                    DCAL1185
      GTHETA=D-DCOR                                               DCAL1186
C                                                                 DCAL1187
      IF(ABS(GTHETA)-TALD) 5,5,3                                  DCAL1188
    3 CONTINUE                                                    DCAL1189
      THETA=THETA-(DCOR-D)/SUMGPR                                 DCAL1190
      COUNT=COUNT+1.0                                             DCAL1191
      IF(COUNT .EQ. AMAX) GO TO 15                                DCAL1192
      GO TO 2                                                     DCAL1193
   15 TALD=TALD*10.0                                              DCAL1194
      COUNT=0.0                                                   DCAL1195
      GO TO 2                                                     DCAL1196
C                                                                 DCAL1197
    5 CONTINUE                                                    DCAL1198
      PRINT 66,DCOR,THETA,D                                       DCAL1199
   66 FORMAT('     D CORRECTED =',F10.5,'   THETA =',F10.5,'   D SPEC =',DCAL1200
     1F10.5,/)                                                    DCAL1201
      IF(THETA) 8,8,7                                             DCAL1202
    7 CONTINUE                                                    DCAL1203
      GO TO 90                                                    DCAL1204
    8 CONTINUE                                                    DCAL1205
      PRINT 41,THETA                                              DCAL1206
   41 FORMAT(3X,10HTHETA IS =,F10.5)                              DCAL1207
      GO TO 999                                                   DCAL1208
   51 CONTINUE                                                    DCAL1209
      DO 52 I=1,M                                                 DCAL1210
      DCO(I)=DCAL(I)                                              DCAL1211
      BCO(I)=BCAL(I)                                              DCAL1212
   52 CONTINUE                                                    DCAL1213
      DCOR=CALD                                                   DCAL1214
      BCOR=CALB                                                   DCAL1215
      THCOUN=1.0+THCOUN                                           DCAL1216
      IF(THCOUN-2.0) 90,999,999                                   DCAL1217
  999 CONTINUE                                                    DCAL1218
      IF(DCOR .LE. 0.0) V(M+1)=DCOR                               DCAL1219
C     TWO PHASE DISTILLATE IS NOT OPERATIONAL ,                   DCAL1220
C         ALL VAPOR DISTILLATE WILL BE USED                       DCAL1221
C                                                                 DCAL1222
C     RETURN 1 IS USED FOR FINAL RETURN WITH A CONVERGED CASE OR  DCAL1223
C          WHEN THETA IS NEGATIVE                                 DCAL1224
```

```
          RETURN 1                                                  DCAL1225
       90 CONTINUE                                                  DCAL1226
          IF(DCOW .LE. 0.0) V(N+1)=DCUR                             DCAL1227
C         TWO PHASE DISTILLATE IS NOT OPERATIONAL ,                 DCAL1228
C             ALL VAPOR DISTILLATE WILL BE USED                     DCAL1229
          RETURN                                                    DCAL1230
          END                                                       DCAL1231
```

A FORTRAN IV (VER L30) SOURCE LISTING: 02/06/73 PAGE 0029

```
      SUBROUTINE TEMPRT                                                 TEMP1232
C                                                                       TEMP1233
C     THIS SUBROUTINE WILL CALCULATE LIQUID-VAPOR RATE ,                TEMP1234
C           AND TEMPERATURE OF EACH TRAY                                TEMP1235
C                                                                       TEMP1236
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)      TEMP1237
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF     TEMP1238
      COMMON RHOCAL(20),PCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON TEMP1239
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON       TEMP1240
      COMMON VLDAMP,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B TEMP1241
      COMMON TFEED,FTOLD,SUMGPR ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL      TEMP1242
      COMMON RVD(101,20),RLD(101,20),DLDV(101),DV,DL,DLDL(101),F(20)    TEMP1243
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONHH,FEEDH  TEMP1244
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)      TEMP1245
      COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)       TEMP1246
C                                                                       TEMP1247
C     V=(V/B)*B  L=(L/B)*B   USE STORAGE AREA OF RLB & RVB TO STORE     TEMP1248
C        COMPONENTIAL INTERNAL FLOW RATES                               TEMP1249
C                                                                       TEMP1250
C     FROM BOTTOM TO THE FEED TRAY                                      TEMP1251
C                                                                       TEMP1252
      DO 43 J=1,NFP                                                     TEMP1253
      V(J)=0.0                                                          TEMP1254
      AL(J)=0.0                                                         TEMP1255
      DO 42 I=1,N                                                       TEMP1256
      RLB(J,I)=RLB(J,I)*BCO(I)                                          TEMP1257
      RVB(J,I)=RVB(J,I)*BCO(I)                                          TEMP1258
      V(J)=V(J)+RVB(J,I)                                                TEMP1259
      AL(J)=AL(J)+RLB(J,I)                                              TEMP1260
   42 CONTINUE                                                          TEMP1261
   43 CONTINUE                                                          TEMP1262
C                                                                       TEMP1263
C     FROM FEED TRAY TO THE CONDENSER-DISTILLATE DRUM                   TEMP1264
C      V=(V/D)*D & L=(L/D)*D     USING STORAGE AREA OF RVD&RLD .        TEMP1265
C                                                                       TEMP1266
      NCN=NFP+1                                                         TEMP1267
      DO 45 J=NCN,N                                                     TEMP1268
      V(J)=0.0                                                          TEMP1269
      AL(J)=0.0                                                         TEMP1270
      DO 44 I=1,N                                                       TEMP1271
      RVD(J,I)=RVD(J,I)*DCO(I)                                          TEMP1272
      RLD(J,I)=RLD(J,I)*DCO(I)                                          TEMP1273
      V(J)=V(J)+RVD(J,I)                                                TEMP1274
      AL(J)=AL(J)+RLD(J,I)                                              TEMP1275
   44 CONTINUE                                                          TEMP1276
   45 CONTINUE                                                          TEMP1277
C                                                                       TEMP1278
C     COMPONENT OF L &V IS STORED IN AREA OF RLB , RVB , RVD &RLD       TEMP1279
C         X(I)=RVB(J,I)/L(J)                  Y(I)=RVB(J,I)/V(J)        TEMP1280
C         X(I)=VL(I)/SUM OF LIQUID            Y(I)=V(I)/SUM OF VAPOR    TEMP1281
```

```
C
C      TEMPERATURE CALCULATION
C      BUBBLE POINT IN STRIPPING SECITION
C
       DO 47 J=1,NFP
       DO 46 I=1,M
       X(I)=FLB(J,I)/AL(J)
    46 CONTINUE
       T=TT(J)
       PB=P(J)
       CALL BUBBLE
       TT(J)=TT(J)+((T-TT(J))/TDAMP)
    47 CONTINUE
C
C      DEW POINT IN RECTIFYING SECTION
C
       DO 49 J=NCN,N
       DO 48 I=1,M
       Y(I)=RVD(J,I)/V(J)
    48 CONTINUE
   101 CONTINUE
       T=TT(J)
       PD=P(J)
       CALL DEW
       TT(J)=TT(J)+((T-TT(J))/TDAMP)
    49 CONTINUE
       T=TT(J)
C
C      TEMPERATURE OF DISTILLATE
C
       IF(DCOR) 1,2,3
     1 CONTINUE
       DO 5 I=1,M
       Y(I)=DCD(I)/DCOR
     5 CONTINUE
       PD=P(N+1)
       CALL DEW
       GO TO 4
     2 GO TO 1
C      DISTILLATE DRUM FLASH WITH FIXED TEMPERATURE
C      THIS OPTION NOT OPERATIONAL ALL VAPOR DISTILLATE WILL BE USED
     3 CONTINUE
       DO 63 I=1,M
       X(I)=DCD(I)/DCOR
    63 CONTINUE
       PB=P(N+1)
       CALL BUBBLE
     4 CONTINUE
       TT(J)=TT(J)+((T-TT(J))/TDAMP)
       RETURN
```

```
101        END                                                              TEMP1332
```

```
          SUBROUTINE DAMPE                                                DAMP1333
C                                                                         DAMP1334
C         THIS SUBROUTINE WILL DAMP VAPOR & LIQUID RATE AND HELP STOP     DAMP1335
C              OSCILLATION                                                DAMP1336
C                                                                         DAMP1337
          COMMON FT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)    DAMP1338
          COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF   DAMP1339
          COMMON R,DCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON DAMP1340
          COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON     DAMP1341
          COMMON VLDAMP,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B DAMP1342
          COMMON IFLEO,FTOLD,SUMGPR,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL     DAMP1343
          COMMON RVD(101,20),RLD(101,20),OLDV(101),DV,DL,OLDL(101),F(20)  DAMP1344
          COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH DAMP1345
          COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)    DAMP1346
          COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)     DAMP1347
C                                                                         DAMP1348
C         LIMIT OF FLOW RATE CHANGE:                                      DAMP1349
C                   TRIAL           MAXIMUM VAPOR & LIQUID RATE CHANGE    DAMP1350
C                   3-7                              20%                  DAMP1351
C                   8-12                             10%                  DAMP1352
C                  13-17                              5%                  DAMP1353
C                   18+                               2%                  DAMP1354
C                                                                         DAMP1355
          IF(TRIAL-7.0) 1,1,2                                             DAMP1356
        1 TOLV=0.2                                                        DAMP1357
          GO TO 7                                                         DAMP1358
        2 IF(TRIAL-12.0) 3,3,4                                            DAMP1359
        3 TOLV=0.1                                                        DAMP1360
          GO TO 7                                                         DAMP1361
        4 IF(TRIAL-17.0) 5,5,6                                            DAMP1362
        5 TOLV=0.05                                                       DAMP1363
          GO TO 7                                                         DAMP1364
        6 TOLV=0.02                                                       DAMP1365
        7 CONTINUE                                                        DAMP1366
          DO 10 I=1,N                                                     DAMP1367
          PDEF=(V(I)-OLDV(I))/OLDV(I)                                     DAMP1368
          IF(ABS(PDEF)-TOLV) 9,9,8                                        DAMP1369
        8 V(I)=OLDV(I)+SIGN(TOLV*OLDV(I),PDEF)                            DAMP1370
        9 OLDV(I)=V(I)                                                    DAMP1371
          PDFL=(AL(I)-OLDL(I))/OLDL(I)                                    DAMP1372
          IF(ABS(PDFL)-TOLV)11,11,12                                      DAMP1373
       12 AL(I)=OLDL(I)+SIGN(TOLV*OLDL(I),PDFL)                           DAMP1374
       11 OLDL(I)=AL(I)                                                   DAMP1375
       10 CONTINUE                                                        DAMP1376
          RETURN                                                          DAMP1377
          END                                                             DAMP1378
```

```
         SUBROUTINE BUBBLE                                              BUBB1379
   C                                                                    BUBB1380
   C     THIS SUBROUTINE CALCULATE BUBBLE POINT TEMPERATURE USING NEWTONS BUBB1381
   C     METHOD ("MULTICOMPONENT DISTILLATION " BY C. D. HOLLAND, PAGE 15) BUBB1382
   C     AND WITH PSEUDO METHOD OF DR. RALPH CECCHETTI                  BUBB1383
   C                                                                    BUBB1384
         COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)    BUBB1385
         COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF   BUBB1386
         COMMON RBDCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON BUBB1387
         COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON     BUBB1388
         COMMON VLDAMP,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B BUBB1389
         COMMON TFEED,FTOLD,SUMGPP ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL   BUBB1390
         COMMON RV0(101,20),RL0(101,20),DL0V(101),DV,DL,OLDL(101),F(20)  BUBB1391
         COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH BUBB1392
         COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)    BUBB1393
         COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)     BUBB1394
   C                                                                    BUBB1395
         SUMAX=0.0                                                      BUBB1396
         SUMBX=0.0                                                      BUBB1397
         SUMCX=0.0                                                      BUBB1398
         SUMDX=0.0                                                      BUBB1399
         SUMEX=0.0                                                      BUBB1400
         SUM=0.0                                                        BUBB1401
         IF(TRIAL-5.0) 10,10,11                                         BUBB1402
      10 IXX=-TRIAL-2.0                                                 BUBB1403
         GO TO 12                                                       BUBB1404
      11 IXX=-6                                                         BUBB1405
      12 CONTINUE                                                       BUBB1406
         TOL=(10.0)**IXX                                                BUBB1407
   C                                                                    BUBB1408
         DO 2 I=1,M                                                     BUBB1409
         SUMAX=X(I)*A0(I)+SUMAX                                         BUBB1410
         SUMBX=X(I)*A1(I)+SUMBX                                         BUBB1411
         SUMCX=X(I)*A2(I)+SUMCX                                         BUBB1412
         SUMDX=X(I)*A3(I)+SUMDX                                         BUBB1413
         SUMEX=X(I)*A4(I)+SUMEX                                         BUBB1414
       2 CONTINUE                                                       BUBB1415
   C                                                                    BUBB1416
         COUNT=0.0                                                      BUBB1417
         AMAX=15.0                                                      BUBB1418
     111 AK=SUMAX+T*(SUMBX+T*(SUMCX+T*(SUMDX+T*SUMEX)))                 BUBB1419
         AK=AK*(PREF/PB)                                                BUBB1420
         DEL=1.0-AK                                                     BUBB1421
   C                                                                    BUBB1422
         IF(ABS(DEL)-TOL) 99,99,22                                      BUBB1423
      22 DAK=SUMBX+T*(2.*SUMCX+T*(3.*SUMDX+4.*SUMEX*T))                 BUBB1424
         DAK=DAK*(PREF/PB)                                              BUBB1425
         IF(DAK) 3,999,3                                                BUBB1426
       3 T=T-(AK-1.0)/DAK                                               BUBB1427
   C                                                                    BUBB1428
```

```
      COUNT=COUNT+1.0                                                   BUBB1429
      IF(COUNT .EQ. AMAX) GO TO 15                                      BUBB1430
      GO TO 111                                                         BUBB1431
   15 TOL=TOL*10.                                                       BUBB1432
      COUNT=0.0                                                         BUBB1433
      GO TO 111                                                         BUBB1434
   99 CONTINUE                                                          BUBB1435
      GO TO 9999                                                        BUBB1436
  999 PRINT 909,T                                                       BUBB1437
  909 FORMAT(53H   SUBROUTINE BUBBLE DID NOT CONVERGE BECAUSE FOR T =,  BUBB1438
     1F10.5,32H DERIVATIVE OF K EQUATION IS ZERO)                       BUBB1439
      T=T+10.0                                                          BUBB1440
      GO TO 111                                                         BUBB1441
 9999 CONTINUE                                                          BUBB1442
      RETURN                                                            BUBB1443
      END                                                               BUBB1444
```

```
            SUBROUTINE DEW
      C
      C     THIS SUBROUTINE CALCULATE DEW POINT TEMPERATURE USING NEWTONS
      C     METHOD ("MULTICOMPONENT DISTILLATION" BY C. D. HOLLAND, PAGE 18)
      C
            COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)
            COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF
            COMMON RBDCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON
            COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON
            COMMON VEDAMP,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B
            COMMON TFEFD,FTOLD,SUMGP  ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL
            COMMON RVD(101,20),RLD(101,20),OLDV(101),DV,DL,OLDL(101),F(20)
            COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH
            COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)
            COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)
      C
            SUMKY=0.0
            SUMDK=0.0
            SUM=0.0
            IF(TRIAL-5.0) 10,10,11
         10 IXX=-TRIAL-2.0
            GO TO 12
         11 IXX=-6
         12 CONTINUE
            TOL=(10.0)**IXX
            COUNT=0.0
            AMAX=15.0
      C
        222 CONTINUE
            DO 3 I=1,M
            AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))
            AK=AK*(PREF/PD)
            DAK=A1(I)+T*(2.0*A2(I)+T*(3.0*A3(I)+4.0*A4(I)*T))
            DAK=DAK*(PREF/PD)
            SUMKY=SUMKY+Y(I)/AK
          3 SUMDK=SUMDK+(Y(I)/(AK**2))*DAK
      C
            DEL=1.0-SUMKY
      C
            IF(ABS(DEL)-TOL) 99,99,22
         22 T=T-(SUMKY-1.0)/(-SUMDK)
            SUMKY=0.0
            SUMDK=0.0
            COUNT=COUNT+1.0
            IF(COUNT .EQ. AMAX) GO TO 15
            GO TO 222
         15 TOL=TOL*10.
            COUNT=0.0
            GO TO 222
         99 CONTINUE
```

```
 51       RETURN                                                    DEW 1495
 52       END                                                       DEW 1496
```

```
      SUBROUTINE ENT                                                    ENT 1497
C                                                                       ENT 1498
C     THIS SUBROUTINE CALCULATES ENTHALPY BALANCES BY THE               ENT 1499
C         CONSTANT-COMPOSITION METHOD                                   ENT 1500
C                                                                       ENT 1501
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)      ENT 1502
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF     ENT 1503
      COMMON RDCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON  ENT 1504
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON       ENT 1505
      COMMON VLCOMP,TCOMP,FCOM,N,M,NFP,TMAX,TMIN,T,FCOM,VLCON,ALNP1,D,B ENT 1506
      COMMON TFEED,FTOLD,SUMSPR ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL      ENT 1507
      COMMON RVD(101,20),RLD(101,20),DLDV(101),DV,DL,DLDL(101),F(20)    ENT 1508
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH   ENT 1509
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)      ENT 1510
      COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)       ENT 1511
C                                                                       ENT 1512
C     CALCULATION OF VNHN-LN+1HN+1                                      ENT 1513
C                                                                       ENT 1514
      ALHNP1=0.0                                                        ENT 1515
      VNHN=0.0                                                          ENT 1516
      V(N)=AL(N+1)+DCOR                                                 ENT 1517
      DO 1 I=1,M                                                        ENT 1518
      T=TT(N)                                                           ENT 1519
      Y(I)=RVD(N,I)/V(N)                                                ENT 1520
      EV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))               ENT 1521
      VNHN=Y(I)*EV+VNHN                                                 ENT 1522
      T=TT(N+1)                                                         ENT 1523
      XD(I)=DCO(I)/DCOR                                                 ENT 1524
      EL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))               ENT 1525
      ALHNP1=XD(I)*EL+ALHNP1                                            ENT 1526
    1 CONTINUE                                                          ENT 1527
      VNHN=VNHN*V(N)                                                    ENT 1528
      ALHNP1=ALHNP1*AL(N+1)                                             ENT 1529
      CONH=VNHN-ALHNP1                                                  ENT 1530
C                                                                       ENT 1531
C     RECTIFING SECTION          FROM TOP DOWN TO THE FEED TRAY+1       ENT 1532
C                                                                       ENT 1533
      J=N-1                                                             ENT 1534
    2 DEV=0.0                                                           ENT 1535
      EVX=0.0                                                           ENT 1536
      ELX=0.0                                                           ENT 1537
      DO 3 I=1,M                                                        ENT 1538
      T=TT(J)                                                           ENT 1539
      EV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))               ENT 1540
      DEV=XD(I)*EV+DEV                                                  ENT 1541
      X(I)=RLD(J+1,I)/AL(J+1)                                           ENT 1542
      EVX=EV*X(I)+EVX                                                   ENT 1543
      T=TT(J+1)                                                         ENT 1544
      EL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))               ENT 1545
      ELX=EL*X(I)+ELX                                                   ENT 1546
```

```
    3 CONTINUE                                                ENT 1547
      AL(J+1)=(CONH-DCOR*DEV)/(EVX-ELX)                       ENT 1548
      J=J-1                                                   ENT 1549
      V(J+1)=AL(J+2)+DCOR                                     ENT 1550
      IF(J .EQ. NFP) GO TO 4                                  ENT 1551
      GO TO 2                                                 ENT 1552
    4 CONTINUE                                                ENT 1553
C                                                             ENT 1554
C     STRIPPING SECTION     FROM BOTTOM UP TO THE FEED TRAY   ENT 1555
C                                                             ENT 1556
      J=2                                                     ENT 1557
      AL(1)=BCOR                                              ENT 1558
      FVH=0.0                                                 ENT 1559
      FLH=0.0                                                 ENT 1560
      DO 6 I=1,M                                              ENT 1561
      T=TFEED                                                 ENT 1562
      FV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))     ENT 1563
      FVH=FV*YF(I)+FVH                                        ENT 1564
      FL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))     ENT 1565
      FLH=FL*XF(I)+FLH                                        ENT 1566
    6 CONTINUE                                                ENT 1567
      FEEDH=TOTFV*FVH+TOTFL*FLH                               ENT 1568
      CONRH=CONH-TOTFV*FVH-TOTFL*FLH                          ENT 1569
    5 ELY=0.0                                                 ENT 1570
      EVY=0.0                                                 ENT 1571
      ELXB=0.0                                                ENT 1572
      DO 7 I=1,M                                              ENT 1573
      T=TT(J)                                                 ENT 1574
      EL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))     ENT 1575
      XB(I)=BC(I)/BCOR                                        ENT 1576
      ELXB=EL*XB(I)+ELXB                                      ENT 1577
      Y(I)=EVR(J-1,I)/V(J-1)                                  ENT 1578
      ELY=EL*Y(I)+ELY                                         ENT 1579
      T=TT(J-1)                                               ENT 1580
      EV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))     ENT 1581
      EVY=EV*Y(I)+EVY                                         ENT 1582
    7 CONTINUE                                                ENT 1583
      V(J-1)=(CONRH+BCOR*ELXB)/(EVY-ELY)                      ENT 1584
      J=J+1                                                   ENT 1585
      AL(J-1)=V(J-2)+BCOR                                     ENT 1586
      IF(J .EQ. NFP+1) GO TO 8                                ENT 1587
      GO TO 5                                                 ENT 1588
    8 CONTINUE                                                ENT 1589
C                                                             ENT 1590
C     FEED TRAY  VF                                           ENT 1591
C                                                             ENT 1592
      XBT=0.0                                                 ENT 1593
      ELXF=0.0                                                ENT 1594
      ELY=0.0                                                 ENT 1595
      EVY=0.0                                                 ENT 1596
```

A FORTRAN IV (VER L36) SOURCE LISTING: ENT SUBROUTINE 02/06/73 PAGE 0039

```
      DO 9 I=1,M
      T=TT(NFP+1)
      FL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))
      XBH=EL*X(I)+XBH
      ELXF=EL*YF(I)+ELXF
      Y(I)=RV(NFP,I)/V(NFP)
      FLY=EL*Y(I)+FLY
      T=TT(NFP)
      EV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))
      EVY=EV*Y(I)+EVY
    9 CONTINUE
      V(NFP)=(CONH-TOTFV*FVH+BCOR*XBH-TOTFL*ELXF)/(EVY-ELY)
C
C     FEED TRAY LF+1
C
      EVXD=0.0
      EVYF=0.0
      EVX=0.0
      ELX=0.0
      DO 10 I=1,M
      T=TT(NFP)
      EV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))
      EVXD=EV*XD(I)+EVXD
      EVYF=EV*YF(I)+EVYF
      X(I)=RL(NFP+1,I)/AL(NFP+1)
      EVX=EV*X(I)+EVX
      T=TT(NFP+1)
      EL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))
      ELX=EL*X(I)+ELX
   10 CONTINUE
      AL(NFP+1)=(CONH-DCOR*EVXD+TOTFV*EVYF-TOTFV*FVH)/(EVX-ELX)
      RETURN
      END
```

```
      SUBROUTINE OUTPUT(*)                                              OUTP1630
C                                                                       OUTP1631
C     THIS SUBROUTINE WILL PRINT THE FINAL CONVERGED TOWER              OUTP1632
C                                                                       OUTP1633
      COMMON TT(101),V(101),AL(101),FL(20),FV(20),FX(20),A(101,20)      OUTP1634
      COMMON S(101,20),RVB(101,20),RLB(101,20),P(101),PREF,PB,PD,PF     OUTP1635
      COMMON REDCAL(20),DCAL(20),BCAL(20),GRP(20),FFRAC(20),THCOUN,DCON OUTP1636
      COMMON A0(20),A1(20),A2(20),A3(20),A4(20),X(20),Y(20),HKCON       OUTP1637
      COMMON VLDAMP,TDAMP,TCON,N,M,NFP,TMAX,TMIN,T,FCON,VLCON,ALNP1,D,B OUTP1638
      COMMON TFEED,FTOLD,SUMGPK ,TALD,CALD,TOTFL,TOTFV,THETA,TRIAL      OUTP1639
      COMMON RVD(101,20),RLD(101,20),OLDV(101),DV,DL,OLDL(101),F(20)    OUTP1640
      COMMON HL0(20),HL1(20),HL2(20),HL3(20),HL4(20),CONRH,CONH,FEEDH   OUTP1641
      COMMON HV0(20),HV1(20),HV2(20),HV3(20),HV4(20),XB(20),XD(20)      OUTP1642
      COMMON YF(20),XF(20),SUMLF,TOTALF,BCOR,DCOR,DCO(20),BCO(20)       OUTP1643
C                                                                       OUTP1644
C                                                                       OUTP1645
C     CALCULATION OF VNHN-LN+1HN+1 & VNHN-LN+1HN+1-FEED H               OUTP1646
C     FOR CONDENSER & REBOILER DUTY                                     OUTP1647
C                                                                       OUTP1648
      ALHNP1=0.0                                                        OUTP1649
      VNHN=0.0                                                          OUTP1650
      V(N)=AL(N+1)+DCOR                                                 OUTP1651
      DO 29 I=1,M                                                       OUTP1652
      T=TT(N)                                                           OUTP1653
      Y(I)=RVD(N,I)/V(N)                                                OUTP1654
      EV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))               OUTP1655
      VNHN=Y(I)*EV+VNHN                                                 OUTP1656
      T=TT(N+1)                                                         OUTP1657
      XD(I)=DCO(I)/DCOR                                                 OUTP1658
      XB(I)=BCO(I)/BCOR                                                 OUTP1659
      EL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))               OUTP1660
      ALHNP1=XD(I)*EL+ALHNP1                                            OUTP1661
   29 CONTINUE                                                          OUTP1662
      VNHN=VNHN*V(N)                                                    OUTP1663
      ALHNP1=ALHNP1*AL(N+1)                                             OUTP1664
      CONH=VNHN-ALHNP1                                                  OUTP1665
      CONRH=CONH-FEEDH                                                  OUTP1666
C                                                                       OUTP1667
      NP1=N+1                                                           OUTP1668
      IPAG=1                                                            OUTP1669
      IF (VLCON .EQ. 1.0) TRIAL=TRIAL-4.0                               OUTP1670
C                                                                       OUTP1671
C     PRINTING START WITH TOWERS FINAL VAPOR , LIQUID AND TEMPERATURE   OUTP1672
C         PROFILE                                                       OUTP1673
C                                                                       OUTP1674
      PRINT 310,TRIAL,IPAG                                              OUTP1675
  310 FORMAT('1','   TOWER CONVERGED AT TRIAL # ',F7.2,74X,'PAGE  ',I4,/OUTP1676
     1/)                                                                OUTP1677
      PRINT 311                                                         OUTP1678
  311 FORMAT('    FINAL VAPOR , LIQUID & TEMPERATURE PROFILE',/)        OUTP1679
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      PRINT 110                                                          OUTP1680
  110 FORMAT('   NUMBERING IS FROM BOTTOM TO THE TOP OF THE TOWER',/,     OUTP1681
     17X,'LAST STAGE IS THE CONDENSER-DISTILLATE DRUM',/,                 OUTP1682
     27X,'FIRST STAGE IS AN EQUILIBRIUM STAGE REBOILER',//)               OUTP1683
      PRINT 208                                                          OUTP1684
  208 FORMAT(12X,'MOLS/HR',13X,'MOLS/HR',13X,'DEG. F')                   OUTP1685
      DO 999 I=1,NP1                                                     OUTP1686
      PRINT 107,I,V(I),I,AL(I),I,TT(I)                                   OUTP1687
  107 FORMAT('     V(',I3,')=',F10.3,'    L(',I3,')=',F10.3,'    T(',I3,  OUTP1688
     1')=',F10.3)                                                        OUTP1689
  999 CONTINUE                                                           OUTP1690
C                                                                        OUTP1691
      PRINT 212                                                          OUTP1692
  212 FORMAT(//)                                                         OUTP1693
      IF(2*N+2C+N+14-56) 80,80,81                                        OUTP1694
   81 IPAG=IPAG+1                                                        OUTP1695
      PRINT 82,IPAG                                                      OUTP1696
   82 FORMAT('1',109X,'PAGE  ',I4,//)                                    OUTP1697
   80 CONTINUE                                                           OUTP1698
      PRINT 54                                                           OUTP1699
C                                                                        OUTP1700
C     PRINTING DISTILLATE RATE , K-DATA , TEMPERATURE , ENTHALPY AND     OUTP1701
C         CONDENSER DUTY                                                 OUTP1702
C                                                                        OUTP1703
   54 FORMAT('    DISTILLATE')                                           OUTP1704
      PRINT 55                                                           OUTP1705
   55 FORMAT(13X,'MOLS/HR',14X,'MOL FRAC',12X,'K-VALUES')                OUTP1706
      SUMEL=0.0                                                          OUTP1707
      SUMX=0.0                                                           OUTP1708
      DO 56 I=1,M                                                        OUTP1709
      SUMX=SUMX+XD(I)                                                    OUTP1710
      T=TT(N+1)                                                          OUTP1711
      IF(DC(N)) 7,8,9                                                    OUTP1712
    7 EV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))                OUTP1713
      SUMEL=EV*XD(I)+SUMEL                                               OUTP1714
      GO TO 10                                                           OUTP1715
    8 CONTINUE                                                           OUTP1716
      GO TO 7                                                            OUTP1717
C     TWO PHASE DISTILLATE IS NOT OPERATIONAL ,                          OUTP1718
C         ALL VAPOR DISTILLATE WILL BE USED                              OUTP1719
    9 EL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))                OUTP1720
      SUMEL=EL*XD(I)+SUMEL                                               OUTP1721
   10 CONTINUE                                                           OUTP1722
      AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))                     OUTP1723
      AK=AK*(PREF/P(N+1))                                                OUTP1724
      IF(DC(N) .LE. 0.0) GO TO 95                                        OUTP1725
C     TWO PHASE DISTILLATE IS NOT OPERATIONAL ,                          OUTP1726
C         ALL VAPOR DISTILLATE WILL BE USED                              OUTP1727
      PRINT 57,I,DCAL(I),I,XD(I),I,AK                                    OUTP1728
   57 FORMAT(7X,'D(',I2,')=',F10.4,5X,'X(',I2,')=',F10.7,6X,'K(',I2,')='OUTP1729
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      1,F10.7)                                                          OUTP1730
      GO TO 56                                                          OUTP1731
   55 PRINT 95,I,DCAL(I),I,XD(I),I,AK                                   OUTP1732
   95 FORMAT(7X,'D(',I2,')=',F10.4,5X,'Y(',I2,')=',F10.7,6X,'K(',I2,')='OUTP1733
      1,F10.7)                                                          OUTP1734
   56 CONTINUE                                                          OUTP1735
      IF(PCON) 11,12,13                                                 OUTP1736
   11 EVD=CALD*SUMEL                                                    OUTP1737
      ELD=0.0                                                           OUTP1738
      CONDUT=CONH-EVD                                                   OUTP1739
      GO TO 14                                                          OUTP1740
   12 CONTINUE                                                          OUTP1741
      GO TO 11                                                          OUTP1742
C     TWO PHASE DISTILLATE IS NOT OPERATIONAL                           OUTP1743
C         ALL VAPOR DISTILLATE WILL BE USED                             OUTP1744
   13 ELD=CALD*SUMEL                                                    OUTP1745
      EVD=0.0                                                           OUTP1746
      CONDUT=CONH-ELD                                                   OUTP1747
   14 CONTINUE                                                          OUTP1748
      PRINT 58                                                          OUTP1749
   58 FORMAT(13X,10('-'),11X,10('-'))                                   OUTP1750
      PRINT 59,CALD,SUMX                                                OUTP1751
   59 FORMAT(10X,'D =',F10.4,4X,'TOTAL =',F10.7)                        OUTP1752
      PRINT 45,TT(N+1),EVD,ELD                                          OUTP1753
      PRINT 60,CONDUT                                                   OUTP1754
   60 FORMAT('   CONDENSER DUTY = ',F14.4,'  M-BUT/HR')                 OUTP1755
      PRINT 212                                                         OUTP1756
C                                                                       OUTP1757
C     PRINTING BOTTOM RATE , K-DATA , TEMPERATURE , ENTHALPY AND        OUTP1758
C         REBOILER DUTY                                                 OUTP1759
C                                                                       OUTP1760
      PRINT 63                                                          OUTP1761
   63 FORMAT('   BOTTOMS :')                                            OUTP1762
      PRINT 55                                                          OUTP1763
      SUMX=0.0                                                          OUTP1764
      SUMEL=0.0                                                         OUTP1765
      T=TT(1)                                                           OUTP1766
      DO 64 I=1,N                                                       OUTP1767
      SUMX=SUMX+XB(I)                                                   OUTP1768
      FL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))               OUTP1769
      AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))                    OUTP1770
      AK=AK*(PREF/P(1))                                                 OUTP1771
      SUMEL=FL*XB(I)+SUMEL                                              OUTP1772
      PRINT 65,I,BCAL(I),I,XB(I),I,AK                                   OUTP1773
   65 FORMAT(7X,'B(',I2,')=',F10.4,5X,'X(',I2,')=',F10.7,6X,'K(',I2,')='OUTP1774
      1,F10.7)                                                          OUTP1775
   64 CONTINUE                                                          OUTP1776
      PRINT 58                                                          OUTP1777
      PRINT 66,BCOR,SUMX                                                OUTP1778
   66 FORMAT(10X,'B =',F10.4,4X,'TOTAL =',F10.7)                        OUTP1779
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      EV=0.0                                                          OUTP1780
      ELB=SUMEL*BCOR                                                  OUTP1781
      PRINT 45,TT(1),EV,ELB                                           OUTP1782
      REBOUT=CONRB+ELB                                                OUTP1783
      PRINT 75,REBOUT                                                 OUTP1784
   75 FORMAT('   REBOILER DUTY =',F14.4,'  M-BTU/HR')                 OUTP1785
      IPAG=IPAG+1                                                     OUTP1786
C                                                                     OUTP1787
C     PRINTING MATRIAL & ENTHALPY BALANCES                            OUTP1788
C                                                                     OUTP1789
      PRINT 83,IPAG                                                   OUTP1790
   83 FORMAT('1',46X,'***** MATRIAL & ENTHALPY BALANCE *****',25X,    OUTP1791
     1'PAGE ',I4,//)                                                  OUTP1792
      PRINT 212                                                       OUTP1793
      PRINT 84                                                        OUTP1794
   84 FORMAT(11X,10('-'),'IN',10('-'),6X,17('-'),'OUT',18('-'))       OUTP1795
      PRINT 67                                                        OUTP1796
   67 FORMAT('   MATRIAL BALANCE (MOLS/HR) ',/)                       OUTP1797
      DO 68 I=1,M                                                     OUTP1798
      PRINT 69,I,FX(I),I,DCAL(I),I,BCAL(I)                            OUTP1799
   69 FORMAT(11X,'F(',I2,')=',F10.4,12X,'D(',I2,')=',F10.4,6X,'B(',I2,OUTP1800
     1')=',F10.4)                                                     OUTP1801
   68 CONTINUE                                                        OUTP1802
      PRINT 73                                                        OUTP1803
   73 FORMAT(17X,10('-'),13X,10('-'),12X,10('-'))                     OUTP1804
      PRINT 74,TOTALF,DCOR,BCOR                                       OUTP1805
   74 FORMAT(11X,'TOTAL ',F10.4,18X,F10.4,12X,F10.4)                  OUTP1806
      PRINT 76                                                        OUTP1807
   76 FORMAT('0  ENTHALPY BALANCE (M-BTU/HR) ',/)                     OUTP1808
      IF(DCOR .LE. 0.0) ELD=EVD                                       OUTP1809
C     IF(DCOR .EQ. 0.0) ELD=EVD+ELD                                   OUTP1810
C     TWO PHASE DISTILLATE IS NOT OPERATIONAL ,                       OUTP1811
C         ALL VAPOR DISTILLATE WILL BE USED                           OUTP1812
      PRINT 77,FEEDH,ELD,REBOUT,ELB,CONDUT                            OUTP1813
   77 FORMAT(11X,'FEED      ',3X,F14.4,6X,'DISTILLATE      ',3X,F14.4,/,OUTP1814
     111X,'REBOILER',4X,F14.4,6X,'BOTTOM      ',6X,F14.4,/,           OUTP1815
     243X,'CONDENSER',9X,F14.4)                                       OUTP1816
      PRINT 78                                                        OUTP1817
   78 FORMAT(23X,14('-'),24X,14('-'))                                 OUTP1818
      SUMIN=FEEDH+REBOUT                                              OUTP1819
      SUMOUT=ELD+ELB+CONDUT                                           OUTP1820
      PRINT 79,SUMIN,SUMOUT                                           OUTP1821
   79 FORMAT(11X,'TOTAL',7X,F14.4,24X,F14.4)                          OUTP1822
C                                                                     OUTP1823
C     PRINTING  ALL THE TRAYS COMPOSITIONS , K-DATA , TEMPERATURE AND OUTP1824
C         ENTHALPIES                                                  OUTP1825
C                                                                     OUTP1826
C     STARTING FROM PLATE #1 UP TO THE FEED TRAY                      OUTP1827
C                                                                     OUTP1828
      JJ=1                                                            OUTP1829
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      IPAG=IPAG+1                                                       OUTP1830
      PRINT 53,IPAG                                                     OUTP1831
   53 FORMAT('1',53X,'***** TRAY COMPOSITION *****',30X,'PAGE  ',I4,///) OUTP1832
      DO 47 J=1,NP                                                      OUTP1833
      IF(J .EQ. 1) GO TO 1                                              OUTP1834
      PRINT 42,J                                                        OUTP1835
      GO TO 3                                                           OUTP1836
    1 PRINT 2,J                                                         OUTP1837
    2 FORMAT('    PLATE NUMBER = ',I3,'   (EQ. STAGE REBOILER)',/)      OUTP1838
    3 CONTINUE                                                          OUTP1839
   42 FORMAT('    PLATE NUMBER = ',I3,/)                                OUTP1840
      PRINT 44                                                          OUTP1841
   44 FORMAT(13X,'MOLS/HR',14X,'MOL FRAC',18X,'MOLS/HR',14X,'MOL FRAC', OUTP1842
     112X,'K-VALUES')                                                   OUTP1843
      SUMX=0.0                                                          OUTP1844
      SUMY=0.0                                                          OUTP1845
      SUMEV=0.0                                                         OUTP1846
      SUMEL=0.0                                                         OUTP1847
      DO 46 I=1,M                                                       OUTP1848
      X(I)=RLB(J,I)/AL(J)                                               OUTP1849
      SUMX=X(I)+SUMX                                                    OUTP1850
      Y(I)=RVB(J,I)/V(J)                                                OUTP1851
      SUMY=Y(I)+SUMY                                                    OUTP1852
      T=TT(J)                                                           OUTP1853
      AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))                    OUTP1854
      AK=AK*(PREF/P(J))                                                 OUTP1855
      EV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))               OUTP1856
      EL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))               OUTP1857
      SUMEV=EV*Y(I)+SUMEV                                               OUTP1858
      SUMEL=EL*X(I)+SUMEL                                               OUTP1859
      PRINT 43,J,I,RVB(J,I),I,Y(I),J,I,RLB(J,I),I,X(I),I,AK             OUTP1860
   43 FORMAT('    V(',I3,',',I2,')=',F10.4,5X,'Y(',I2,')=',F10.7,6X,'L(',OUTP1861
     1I3,',',I2,')=',F10.4,5X,'X(',I2,')=',F10.7,6X,'K(',I2,')=',F10.6) OUTP1862
   46 CONTINUE                                                          OUTP1863
      PRINT 48                                                          OUTP1864
   48 FORMAT(13X,10('-'),11X,10('-'),16X,10('-'),11X,10('-'))           OUTP1865
      PRINT 49,J,V(J),SUMY,J,AL(J),SUMX                                 OUTP1866
   49 FORMAT(6X,'V(',I3,')=',F10.4,4X,'TOTAL =',F10.7,9X,'L(',I3,')=',F1OUTP1867
     10.4,4X,'TOTAL =',F10.7)                                           OUTP1868
      EV=SUMEV*V(J)                                                     OUTP1869
      EL=SUMEL*AL(J)                                                    OUTP1870
      PRINT 45,TT(J),EV,EL                                              OUTP1871
   45 FORMAT('0   TEMPERATURE = ',F10.2,' DEG. F',' VAPOR ENTHALPY = ',OUTP1872
     1F14.4,'  M-BTU/HR','    LIQ. ENTHALPY =',F14.4,' M-BTU/HR',/)     OUTP1873
      JJ=JJ+1                                                           OUTP1874
      IF((7+M)*JJ-55) 47,47,51                                          OUTP1875
   51 IPAG=IPAG+1                                                       OUTP1876
      JJ=1                                                              OUTP1877
      PRINT 53,IPAG                                                     OUTP1878
   47 CONTINUE                                                          OUTP1879
```

A FORTRAN IV (VER L38) SOURCE LISTING: OUTPUT SUBROUTINE 02/06/73 PAGE 0045

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      C                                                              OUTP1880
      C     PRINTING TRAY COMPOSITION FROM FEED TRAY UP TO THE        OUTP1881
      C         CONDENCER-DISTILLATE DRUM                             OUTP1882
      C                                                              OUTP1883
            NFP1=NFP+1                                                OUTP1884
            NP1=N+1                                                   OUTP1885
            DO 41 J=NFP1,NP1                                          OUTP1886
            IF(J .EQ. NP1) GO TO 4                                    OUTP1887
            PRINT 42,J                                                OUTP1888
            GO TO 6                                                   OUTP1889
          4 PRINT 5,J                                                 OUTP1890
          5 FORMAT('   PLATE NUMBER = ',I3,'   (CONDENSER-DISTILLATE DRUM)',/)OUTP1891
          6 CONTINUE                                                  OUTP1892
            PRINT 44                                                  OUTP1893
            SUMX=0.0                                                  OUTP1894
            SUMY=0.0                                                  OUTP1895
            SUMEV=0.0                                                 OUTP1896
            SUMEL=0.0                                                 OUTP1897
            DO 40 I=1,M                                               OUTP1898
            IF(J .EQ. NP1) GO TO 91                                   OUTP1899
            X(I)=RLD(J,I)/AL(J)                                       OUTP1900
            Y(I)=RVD(J,I)/V(J)                                        OUTP1901
            GO TO 92                                                  OUTP1902
         91 RVD(N+1,I)=0.0                                            OUTP1903
            IF(DCOM .LE.0.0) RVD(N+1,I)=DCAL(I)                       OUTP1904
      C     TWO PHASE DISTILLATE IS NOT OPERATIONAL ,                 OUTP1905
      C         ALL VAPOR DISTILLATE WILL BE USED                     OUTP1906
            AL(N+1)=V(N)-DCOM                                         OUTP1907
            RLD(N+1,I)=RVD(N,I)-DCAL(I)                               OUTP1908
            X(I)=RLD(N+1,I)/AL(N+1)                                   OUTP1909
            Y(I)=0.0                                                  OUTP1910
            IF(DCOM .LE. 0.0) Y(I)=XD(I)                              OUTP1911
      C     TWO PHASE DISTILLATE IS NOT OPERATIONAL ,                 OUTP1912
      C         ALL VAPOR DISTILLATE WILL BE USED                     OUTP1913
         92 CONTINUE                                                  OUTP1914
            SUMX=X(I)+SUMX                                            OUTP1915
            SUMY=Y(I)+SUMY                                            OUTP1916
            T=TT(J)                                                   OUTP1917
            AK=A0(I)+T*(A1(I)+T*(A2(I)+T*(A3(I)+A4(I)*T)))            OUTP1918
            AK=AK*(PREF/P(J))                                         OUTP1919
            EL=HL0(I)+T*(HL1(I)+T*(HL2(I)+T*(HL3(I)+HL4(I)*T)))       OUTP1920
            EV=HV0(I)+T*(HV1(I)+T*(HV2(I)+T*(HV3(I)+HV4(I)*T)))       OUTP1921
            SUMEL=EL*X(I)+SUMEL                                       OUTP1922
            SUMEV=EV*Y(I)+SUMEV                                       OUTP1923
            PRINT 43,J,I,RVD(J,I),I,Y(I),J,I,RLD(J,I),I,X(I),I,AK     OUTP1924
         40 CONTINUE                                                  OUTP1925
            PRINT 48                                                  OUTP1926
            PRINT 49,J,V(J),SUMY,J,AL(J),SUMX                         OUTP1927
            EV=SUMEV*V(J)                                             OUTP1928
            EL=SUMEL*AL(J)                                            OUTP1929
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```
      PRINT 45,TT(J),EV,FL                                              OUTP1930
      JJ=JJ+1                                                           OUTP1931
      IF(J .EQ. NP1) GO TO 41                                           OUTP1932
      IF((7+N)*JJ-55) 41,41,52                                          OUTP1933
   52 IPAG=IPAG+1                                                       OUTP1934
      JJ=1                                                              OUTP1935
      PRINT 53,IPAG                                                     OUTP1936
   41 CONTINUE                                                          OUTP1937
      RETURN 1                                                          OUTP1938
      END                                                               OUTP1939
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      SUBROUTINE FITIT(X,Y,NO,MAX,C,LN,A)                               FITI1940
C                                                                       FITI1941
C     WILL FIT POLYNOMIAL OF ORDER MAX ( MAX .LT. 7 ) TO NO Y VS. X DATAFITI1942
C     POINTS SUPPLIED IN ARRAYS Y AND X. COEFFICIENTS RETURNED IN ARRAY FITI1943
C     C IN FORM NEEDED BY FUNCTION EQUA. STANDARD DEVIATION OF Y RETURNEFITI1944
C     D AS FITIT.                                                       FITI1945
C                                                                       FITI1946
C     LN = LOG TRANSFORMATION CODE 1 = Y VS. X                          FITI1947
C                                  2 = LN Y VS. X                       FITI1948
C                                  3 = Y VS. LN X                       FITI1949
C                                  4 = LN Y VS. LN X                    FITI1950
C                                                                       FITI1951
C     A = INTERCEPT CODE ZERO = INTERCEPT = 0.0                         FITI1952
C     NONZERO = INTERCEPT CALCULATED                                    FITI1953
C                                                                       FITI1954
      REAL X(1), Y(1), C(1), D(7), S(7), XY(7,7)                        FITI1955
C                                                                       FITI1956
C     SET CONTROLS AND ZEROS AND XY.                                    FITI1957
C                                                                       FITI1958
      N = NO                                                            FITI1959
      M = MIN0 ( MAX + 1, N, 7)                                         FITI1960
      L = MIN0 ( 4, MAX0 ( 1, LN ) )                                    FITI1961
      Z = N                                                             FITI1962
      DO 10 I = 1, M                                                    FITI1963
      S(I) = 0.0                                                        FITI1964
      DO 10 J = 1, M                                                    FITI1965
   10 XY(I, J) = 0.0                                                    FITI1966
C                                                                       FITI1967
C     FOR EACH DATUM, MOVE Y AND X TO D(1) AND D(2), GET LOGS IF NEEDED FITI1968
C     AND POWERS OF X, AND ACCUMULATE SUMS, SQUARES, AND CROSS PRODUCTS FITI1969
C     IN S AND XY.                                                      FITI1970
C                                                                       FITI1971
      DO 80 K =1, N                                                     FITI1972
      D(1) = Y(K)                                                       FITI1973
      D(2) = X(K)                                                       FITI1974
      GO TO ( 50, 20, 40, 30 ), L                                       FITI1975
   20 D(1) = ALOG ( D(1) )                                              FITI1976
      GO TO 50                                                          FITI1977
   30 D(1) = ALOG ( D(1) )                                              FITI1978
   40 D(2) = ALOG ( D(2) )                                              FITI1979
   50 DO 60 I =3, M                                                     FITI1980
   60 D(I) = D(2) * D(I - 1)                                            FITI1981
      DO 70 I = 1, M                                                    FITI1982
      S(I) = S(I) + D(I)                                                FITI1983
      DO 70 J = 1, M                                                    FITI1984
   70 XY(I, J) = XY(I, J) + D(I) * D(J)                                 FITI1985
   80 CONTINUE                                                          FITI1986
C                                                                       FITI1987
C     GET REDUCED SQUARES AND CROSS PRODUCTS IF A NONZERO AND FOLD XY   FITI1988
C     OVER.                                                             FITI1989
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```
C
      IF ( A .EQ. 0.0 ) GO TO 110
      DO 100 I = 1, M
      Q = S(I) / Z
      DO 90 J = I, M
   90 XY(I, J) = XY(I, J) - Q * S(J)
  100 S(I) = Q
  110 DO 120 J = 1, M
      DO 120 I = J, M
  120 XY(I, J) = XY(J, I)
C
C     SOLVE REGRESSION MATRIX AND GET STANDARD DEVIATION OF Y.
C
      DO 160 I = 2, M
      Q = XY(I, I)
      XY(I, I) = 1.0
      DO 130 J = 1, M
  130 XY(I, J) = XY(I, J) / Q
      DO 150 K = 1, M
      IF ( K .EQ. I ) GO TO 150
      Q = XY(K, I)
      XY(K, I) = 0.0
      DO 140 J = 1, M
  140 XY(K, J) = XY(K, J) - XY(I, J) * Q
  150 CONTINUE
  160 CONTINUE
      Q = MAX0 ( N - M, 1 )
C     FITIT = SQRT ( AMAX1 ( XY (1, 1) / Q, 0.0 ) )
C
C     STORE COEFFICIENTS IN C ARRAY.
C
      C(1) = M - 1
      C(2) = 0.0
      DO 170 I = 2, M
      S(1) = S(1) - S(I) * XY(I, 1)
  170 C(I + 1) = XY(I, 1)
      IF ( A .NE. 0.0 ) C(2) = S(1)
      RETURN
C
      END
```

APPENDIX F

PROGRAM VARIABLES

TT(I)	Plate Temperature (^{o}F)
V(I)	Plate Vapor Rate (moles/hr)
AL(I)	Plate Liquid Rate (moles/hr)
FL(I)	Molal rate of flow of component (I) in the liquid part of a partially vaporized feed.
FV(I)	Molar rate of flow of component (I) in the vapor part of a partially vaporized feed.
F(I)=	
FX(I)	Molal rate of flow of the entering feed
A(n,I)	Absorption factor of component (I) in stage n.
S(n,I)	Stripping factor of component (I) in stage n.
RVB(n,i)	$(V/b)_{n,i}$
RLB(n,I)	$(L/B)_{n,i}$
P(n)	Pressure of stage n
PREF	Reference pressure for K data pressure correction
PB	Total pressure for pressure correction of K data in bubble point subrouting

PD Total pressure for pressure correction of K data in dew point subroutin.

PF Total pressure for pressure correction of K data in flash subroutin.

RBDCAL(I) Calculated $(B/D)_i$

DCAL(I) Calculated Distillate (D)

BCAL(I) Calculated Bottom (B)

GPR(I) Derivative of B/D equation for applying Newton's method

Ao(I), A1(I),)
A2(I), A3(I),)
A4(I))

Coefficients of polynomials for evaluating equilibrium - K

HL0(I), HL1(I),)
HL2(I), HL3(I),)
HL4(I))

Coefficients of polynomials for evaluating liquid enthalpy.

HV0(I), HV1(I),)
HV2(I), HV3(I),)
HV4(I))

Coefficients of polynomials for evaluating vapor enthalpy

TRIAL	Number of trial
RVD(n,I)	$(V/D)_{n,i}$
RLD(n,I)	$(L/D)_{n,i}$
OLDL(n)	Liquid Rate of Trial - 1
OLDV(n)	Vapor rate of trial - 1
XB(I)	Mole fraction of component i in bottom
XD(I)	Mole fraction of component i in distillate regardless of state in which it is withdrawn
YF(I)	Mole fraction of vapor portion of feed
XF(I)	Mole fraction of liquid portion of feed
TOTALF	Total molal rate of flow of the entering feed regardless of its thermal condition
BCOR	Corrected bottom
DCOR	Corrected distillate
DCO(I)	Corrected molal withdrawal rate of component i in the distillate
BCO(I)	Corrected molal withdrawal rate of component i in the bottom

X(I)	Liquid mole fraction of component i
Y(I)	Vapor mole fraction of component i
FTCON	Feed Temperature Condition
HKCON	Thermodynamic data code
VLDAMP	Vapor damping code
TDAMP	Temperature damping code
TCON	Temperature profile code
N	Number of stages - excludes condenser, includes reboiler
M	Number of components
NFP	Feed Stage location
TMAX	Tower's maximum temperature
TMIN	Tower's minimum temperature
T	temperature (^oF)
FCON	Feed thermal condition code
VLCON	Vapor liquid profile code
$ALNP_1$	External Reflux Rate (L_{N+1})
D	Distillate Rate
TFEED	Feed Temperature Code
FTOLD	Distillate tolerance
CALD	Calculated Distillate Rate
TOTFL	Total liquid portion of feed
TOTFV	Total vapor portion of feed
THETA	Correction factor to correct distillate rate

CONH	$V_N H_N - L_{N+1} H_{N+1}$
CONRH	$V_N H_N - L_{N+1} H_{N+1} - FVH_V - FLh_L$
FEEDH	$FVH_v + FLh_L$

The flowing variables are used only to plot trial versus theta, trial versus distillate rate and etc..

THA(J)	Theta (correction factor to correct distillate rate)
T1(J)	Temperature of stage one from previous trial
TNFP(J)	Temperature of feed stage plus one from previous trial
TNFP1(J)	Temperature of feed stage plus one from previous trial
TN(J)	Temperature of last stage from previous trial
V1(J)	Vapor rate of stage one from previous trial
VNFP1(J)	Vapor rate of feed stage plus one from previous trial
TR1(J)	Number of trial

APPENDIX G

INPUT-OUTPUT OF ILLUSTRATIVE EXAMPLES

```
  11    5    6
1.0       1.0       -1.0      -1.0      0.0
0.0       1.0       0.0       20.0      00.00004500E+00
225.      220.      215.      210.      205.      200.      190.      180.
170.      165.      160.      145.
0.0
00.28531998E+0000.82878992E-0200.37041988E-04-0.63860000E-0700.71090994E-10
00.27804995E+00-0.11602999E-0200.62290987E-04-0.12023997E-0600.10241999E-09
00.22200396E+00-0.16502998E-0200.54022996E-04-0.81239989E-0700.53332991E-10
00.15309995E+00-0.22649998E-0200.31819989E-04-0.20709997E-07-0.40599999E-12
00.16042995E+00-0.26387000E-0200.28703987E-04-0.88699998E-08-0.14969997E-10
00.44835997E+0100.26182999E-0100.64745000E-0500.32505998E-07-0.52879992E-10
00.52091999E+0100.40496999E-01-0.57043988E-0400.25799994E-06-0.32644998E-09
00.64442997E+0100.14100999E-0100.16052999E-03-0.49556996E-0600.61558980E-09
00.67343999E+0100.43812996E-01-0.22595996E-0400.13574999E-06-0.16938999E-09
00.83587997E+0100.80696978E-0200.26773987E-03-0.86588000E-0600.10789998E-08
00.13575999E+02-0.27656998E-0100.37013995E-03-0.12388991E-0500.15431998E-08
00.15275997E+02-0.60739964E-0200.23645999E-03-0.75789995E-0600.94283981E-09
00.13910999E+0200.46711998E-01-0.19568000E-0300.74338999E-06-0.92781982E-09
00.15401993E+02-0.93861994E-0200.30484982E-03-0.97820975E-0600.12168999E-08
00.21092987E+02-0.35334997E-0100.52449992E-03-0.17495995E-0500.21789999E-08
  90.0      45.0
5.        15.       25.       20.       35.
```

```
PROBLEM PARAMETERS :

NUMBER OF STAGES        11
    STAGES COUNT FROM BOTTOM TO TOP OF TOWER
      (INCLUDES EQUILIBRUIM-STAGE REBOILER
      EXCLUDES CONDENSER-DISTILATE DRUM)

NUMBER OF COMPONENTS        5

FEED STAGE LOCATION         6

TEMPERATURE PROFILE CODE  1.0
    0.0 T PROFILE NOT GIVEN
          (MAX & MIN T MUST BE SUPPLIED)
    1.0 T PROFILE MUST BE SUPPLIED

THERMODYNAMIC DATA CODE  1.0
    0.0 COEFFICIENTS OF POLYNOMIALS NOT GIVEN
        MUST SUPPLY THERMODYNAMIC DATA POINTS (10 MAX)
        UNITS DEG F , M-BTU/# MOLE FOR ENTHALPY
        DIMENSIONLESS FOR V-L EQUILIBRIUM DATA
    1.0 COEFFICIENT OF POLYNOMIAL MUST BE SUPPLIED

DISTILLATE TYPE CODE -1.0
    -1.0 ALL VAPOR
     0.0 VAPOR & LIQUID (NOT OPERATIONAL)
    +1.0 ALL LIQUID

FEED CONDITION CODE -1.0
    -1.0 ALL VAPOR
     0.0 VAPOR & LIQUID
    +1.0 ALL LIQUID

VAPOR-LIQUID PROFILE CODE  0.0
    1.0 V&L PROFILE MUST BE SUPPLIED
    0.0 V&L PROFILE NOT GIVEN

VAPOR DAMPING CODE  0.0
    0.0 VAPOR & LIQUID RATE WILL BE DAMPED
    1.0 VAPOR & LIQUID RATE WILL NOT BE DAMPED

TEMPERATURE DAMPING CODE  1.0
    T NEW= T OLD + ( T NEW - T OLD) / ( T DAMPING CODE)

PRINT CODE  0.0
    1.0 WILL PRINT INTERMEDIATE TRIAL DATA
    0.0 WILL NOT PRINT INTERMEDIATE TRIAL DATA

MAX NUMBER OF TRIALS   20.00
```

GIVEN POLYNOMILALS

POLYNOMIALS FOR VAPOR - LIQUID EQUILIBRIUM DATA ARE ;

```
K( 1)= 0.28531998E 00+T*( 0.82878991E-02+T*( 0.37041987E-04+T*(-0.63860000E-07+( 0.71090994E-10)*T)))
K( 2)= 0.27804995E 00+T*(-0.11902999E-02+T*( 0.62290986E-04+T*(-0.12023997E-06+( 0.10241999E-09)*T)))
K( 3)= 0.22200996E 00+T*(-0.18502998E-02+T*( 0.54022995E-04+T*(-0.81239989E-07+( 0.53332991E-10)*T)))
K( 4)= 0.15309995E 00+T*(-0.22649998E-02+T*( 0.31819989E-04+T*(-0.20709997E-07+(-0.40599999E-12)*T)))
K( 5)= 0.16042995E 00+T*(-0.26387000E-02+T*( 0.28703987E-04+T*(-0.38699998E-08+(-0.14969997E-10)*T)))
```

POLYNOMIALS FOR VAPOR ENTHALPY DATA ARE ;

```
HV( 1)= 0.13575000E 02+T*(-0.27656998E-01+T*( 0.37013995E-03+T*(-0.12388991E-05+( 0.15431998E-08)*T)))
HV( 2)= 0.15278999E 02+T*(-0.60739964E-02+T*( 0.23645999E-03+T*(-0.75789995E-06+( 0.94283981E-09)*T)))
HV( 3)= 0.13910999E 02+T*( 0.46811998E-01+T*(-0.19588000E-03+T*( 0.74338999E-06+(-0.92781982E-09)*T)))
HV( 4)= 0.19401992E 02+T*(-0.93661993E-02+T*( 0.30484981E-03+T*(-0.97820975E-06+( 0.12168999E-08)*T)))
HV( 5)= 0.21092987E 02+T*(-0.35334997E-01+T*( 0.52449991E-03+T*(-0.17495995E-05+( 0.21789999E-08)*T)))
```

POLYNOMIALS FOR LIQUID ENTHALPY DATA ARE ;

```
HL( 1)= 0.44835997E 01+T*( 0.26882999E-01+T*( 0.64745000E-05+T*( 0.32505998E-07+(-0.52879992E-10)*T)))
HL( 2)= 0.52091999E 01+T*( 0.40495999E-01+T*(-0.57043987E-04+T*( 0.25799994E-06+(-0.32644998E-09)*T)))
HL( 3)= 0.64442997E 01+T*( 0.14100999E-01+T*( 0.16052999E-03+T*(-0.49556996E-06+( 0.61558980E-09)*T)))
HL( 4)= 0.67343998E 01+T*( 0.43812998E-01+T*(-0.22595995E-04+T*( 0.13574999E-06+(-0.16938999E-09)*T)))
HL( 5)= 0.83587999E 01+T*( 0.80696977E-02+T*( 0.26773987E-03+T*(-0.86588000E-06+( 0.10789998E-08)*T)))
```

FEED IS ALL VAPOR .
FEED DEW POINT TEMPERATURE IS = 203.47604 DEG. F
FEED BUBBLE POINT TEMPERATURE IS = 181.59796 DEG. F
TEMPERATURE OF FEED IS = 203.47604 DEG. F

	MOLS/HR		MOLE FRAC		VAP MOLS/HR		VAP MOL FRAC		LIQ MOLES/HR		LIQ MOL FRAC
F(1)=	5.0000	FZ(1)=	0.0500	FV(1)=	5.0000	YF(1)=	0.0500000	FL(1)=	0.0000	XF(1)=	0.0000000
F(2)=	15.0000	FZ(2)=	0.1500	FV(2)=	15.0000	YF(2)=	0.1500000	FL(2)=	0.0000	XF(2)=	0.0000000
F(3)=	25.0000	FZ(3)=	0.2500	FV(3)=	25.0000	YF(3)=	0.2500000	FL(3)=	0.0000	XF(3)=	0.0000000
F(4)=	20.0000	FZ(4)=	0.2000	FV(4)=	20.0000	YF(4)=	0.2000000	FL(4)=	0.0000	XF(4)=	0.0000000
F(5)=	35.0000	FZ(5)=	0.3500	FV(5)=	35.0000	YF(5)=	0.3500000	FL(5)=	0.0000	XF(5)=	0.0000000
TOTAL	100.0000		1.0000		100.0000		0.9999999		0.0000		0.0000000

VALUE OF DISTILLATE IS = 45.0000 VALUE OF EXTERNAL REFLUX IS = 90.0000

DISTILLATE TOLERANCE 0.44999993E-04

DISTILLATE IS ALL VAPOR .

PRESSURES WERE NOT SUPPLIED .
K-DATA WILL NOT BE PRESSURE CORRECTED .

THE INITIAL VAPOR , LIQUID , & TEMPERATURE PROFILES

NUMBERING IS FROM BOTTOM TO THE TOP OF THE TOWER
LAST STAGE IS THE CONDENSER-DISTILLATE DRUM
FIRST STAGE IS AN EQUILIBRIUM STAGE REBOILER

	MOLS/HR		MOLS/HR		DEG. F
V(1)=	35.000	L(1)=	55.000	T(1)=	225.0000
V(2)=	35.000	L(2)=	90.000	T(2)=	220.0000
V(3)=	35.000	L(3)=	90.000	T(3)=	215.0000
V(4)=	35.000	L(4)=	90.000	T(4)=	210.0000
V(5)=	35.000	L(5)=	90.000	T(5)=	205.0000
V(6)=	35.000	L(6)=	90.000	T(6)=	200.0000
V(7)=	135.000	L(7)=	90.000	T(7)=	190.0000
V(8)=	135.000	L(8)=	90.000	T(8)=	180.0000
V(9)=	135.000	L(9)=	90.000	T(9)=	170.0000
V(10)=	135.000	L(10)=	90.000	T(10)=	165.0000
V(11)=	135.000	L(11)=	90.000	T(11)=	160.0000
V(12)=	45.000	L(12)=	90.000	T(12)=	145.0000

CALCULATED D=	36.57919	FOR THETA = 1.00			
D CORRECTED =	45.02814	THETA =	0.46489	D SPEC =	45.00000
CALCULATED D=	46.31947	FOR THETA = 1.00			
D CORRECTED =	45.00336	THETA =	1.09712	D SPEC =	45.00000
CALCULATED D=	45.19771	FOR THETA = 1.00			
D CORRECTED =	45.00000	THETA =	1.01360	D SPEC =	45.00000
CALCULATED D=	45.00990	FOR THETA = 1.00			
D CORRECTED =	45.00000	THETA =	1.00068	D SPEC =	45.00000
CALCULATED D=	45.26210	FOR THETA = 1.00			
D CORRECTED =	45.00000	THETA =	1.01879	D SPEC =	45.00000
CALCULATED D=	44.68935	FOR THETA = 1.00			
D CORRECTED =	45.00000	THETA =	0.97862	D SPEC =	45.00000
CALCULATED D=	45.37260	FOR THETA = 1.00			
D CORRECTED =	45.00000	THETA =	1.02718	D SPEC =	45.00000
CALCULATED D=	44.60324	FOR THETA = 1.00			
D CORRECTED =	45.00000	THETA =	0.97268	D SPEC =	45.00000
CALCULATED D=	44.74521	FOR THETA = 1.00			
D CORRECTED =	45.00002	THETA =	0.98200	D SPEC =	45.00000
CALCULATED D=	44.92790	FOR THETA = 1.00			
D CORRECTED =	45.00000	THETA =	0.99495	D SPEC =	45.00000
CALCULATED D=	45.20248	FOR THETA = 1.00			
D CORRECTED =	45.00002	THETA =	1.01462	D SPEC =	45.00000
CALCULATED D=	44.76755	FOR THETA = 1.00			
D CORRECTED =	45.00000	THETA =	0.98377	D SPEC =	45.00000
CALCULATED D=	45.25204	FOR THETA = 1.00			
D CORRECTED =	45.00000	THETA =	1.01829	D SPEC =	45.00000
CALCULATED D=	45.25108	FOR THETA = 1.00			
D CORRECTED =	45.00002	THETA =	1.01803	D SPEC =	45.00000
CALCULATED D=	44.99577	FOR THETA = 1.00			
D CORRECTED =	44.99998	THETA =	0.99970	D SPEC =	45.00000
CALCULATED D=	44.90987	FOR THETA = 1.00			
D CORRECTED =	45.00000	THETA =	0.99362	D SPEC =	45.00000
CALCULATED D=	45.10631	FOR THETA = 1.00			
D CORRECTED =	45.00002	THETA =	1.00764	D SPEC =	45.00000
CALCULATED D=	44.88097	FOR THETA = 1.00			
D CORRECTED =	44.99998	THETA =	0.99160	D SPEC =	45.00000

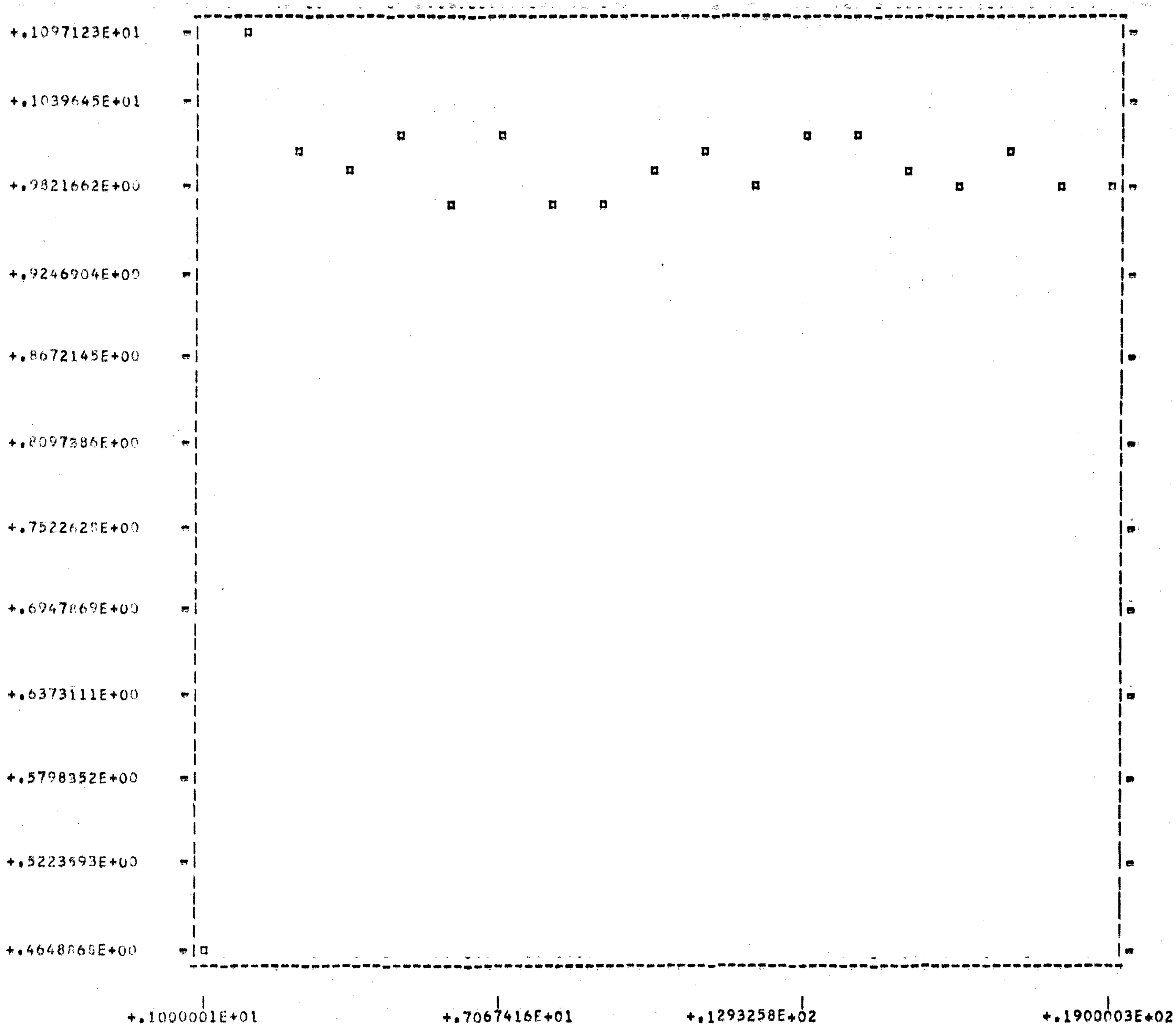
```
CALCULATED D=  44.81931   FOR THETA = 1.00
D CORRECTED =  44.99998   THETA =   0.98724   D SPEC =  45.00000

CALCULATED D=  45.04012   FOR THETA = 1.00
D CORRECTED =  45.00002   THETA =   1.00285   D SPEC =  45.00000
```

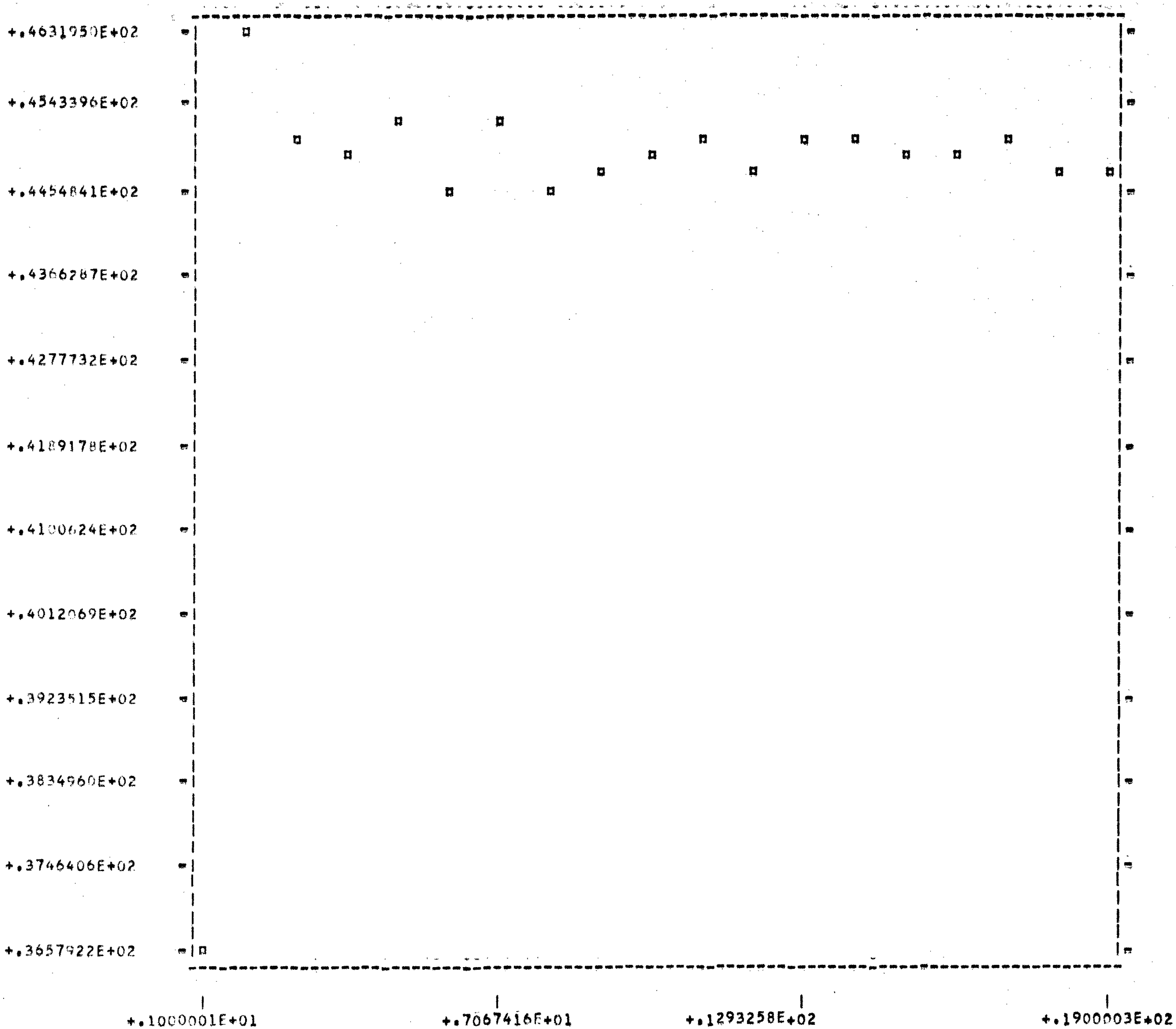
TOWER DID NOT CONVERGE , IT STOPED AT TRIAL #   20.00
FINAL VAPOR , LIQUID & TEMPERATURE PROFILE

NUMBERING IS FROM BOTTOM TO THE TOP OF THE TOWER
LAST STAGE IS THE CONDENSER-DISTILLATE DRUM
FIRST STAGE IS AN EQUILIBRIUM STAGE REBOILER

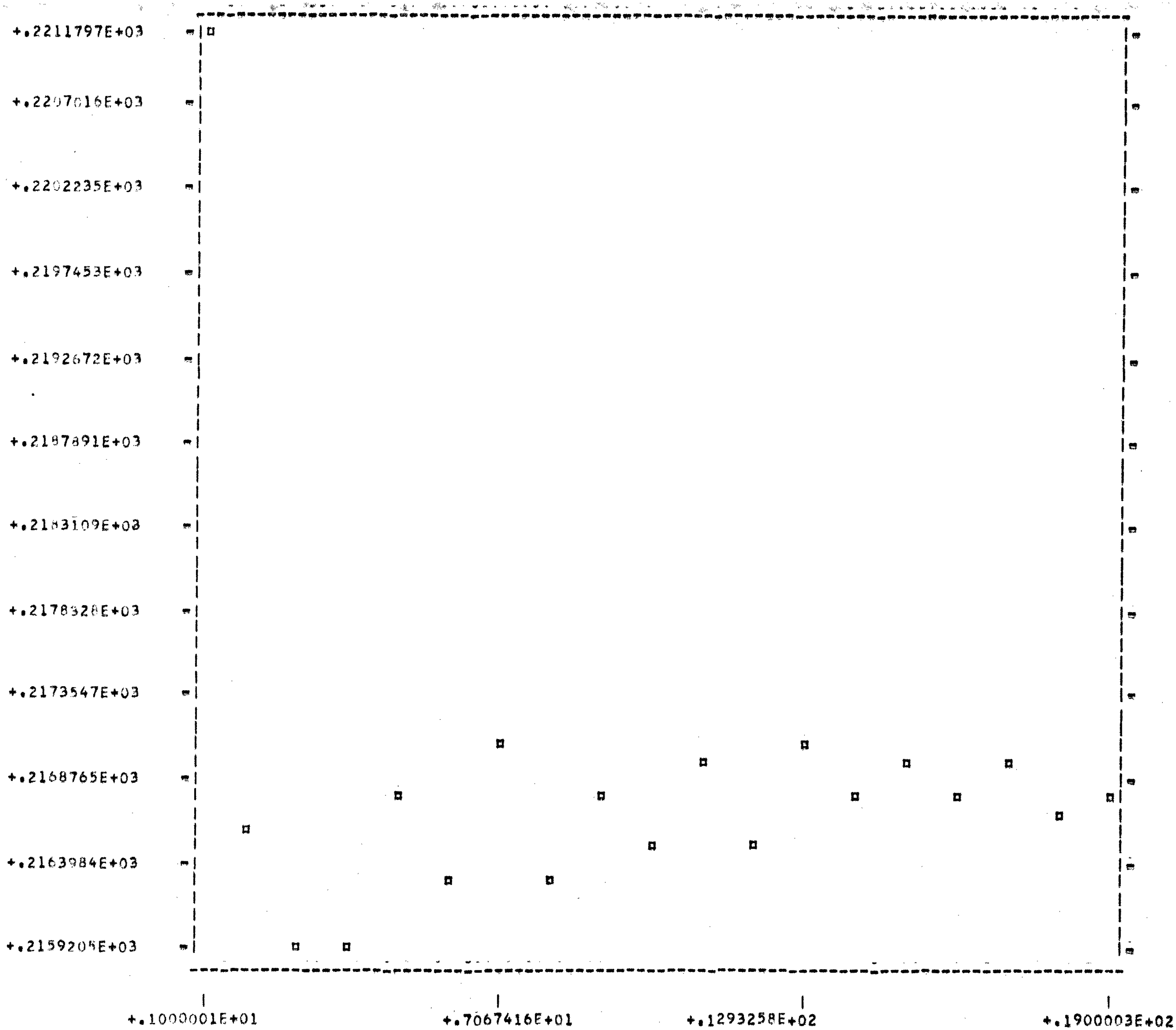
	MOLS/HR		MOLS/HR		DEG. F
V(1)=	38.764	L(1)=	55.000	T(1)=	216.8075
V(2)=	38.627	L(2)=	93.763	T(2)=	211.5517
V(3)=	38.522	L(3)=	93.627	T(3)=	208.2287
V(4)=	38.417	L(4)=	93.522	T(4)=	206.0880
V(5)=	38.296	L(5)=	93.417	T(5)=	204.5969
V(6)=	38.151	L(6)=	93.296	T(6)=	203.4166
V(7)=	138.033	L(7)=	92.836	T(7)=	202.3485
V(8)=	138.299	L(8)=	93.033	T(8)=	200.4881
V(9)=	139.721	L(9)=	93.299	T(9)=	197.2617
V(10)=	139.542	L(10)=	93.721	T(10)=	191.7381
V(11)=	135.012	L(11)=	94.542	T(11)=	182.6057
V(12)=	45.000	L(12)=	90.000	T(12)=	168.7783



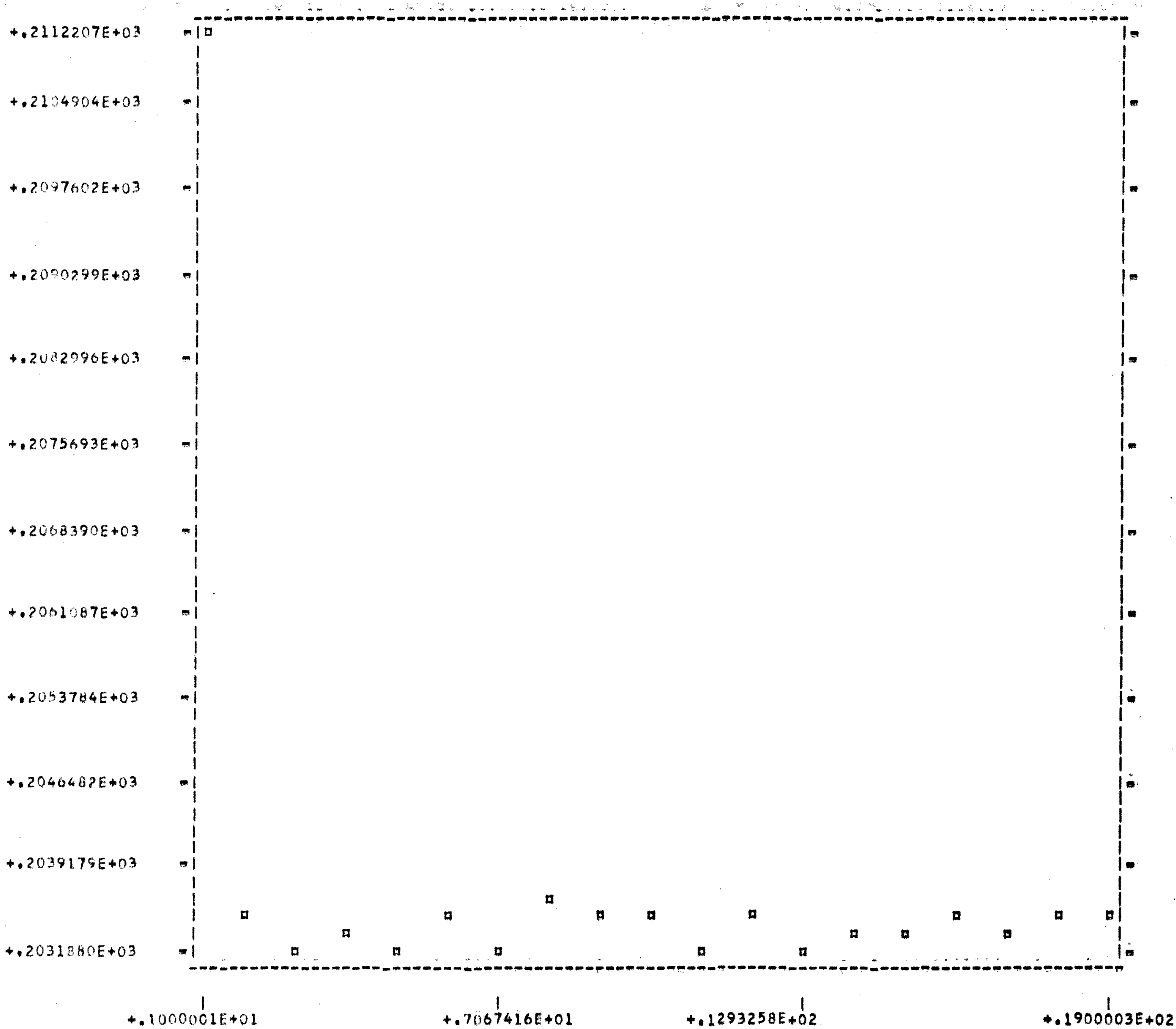
PLOT OF TRIAL VERSUS THETA



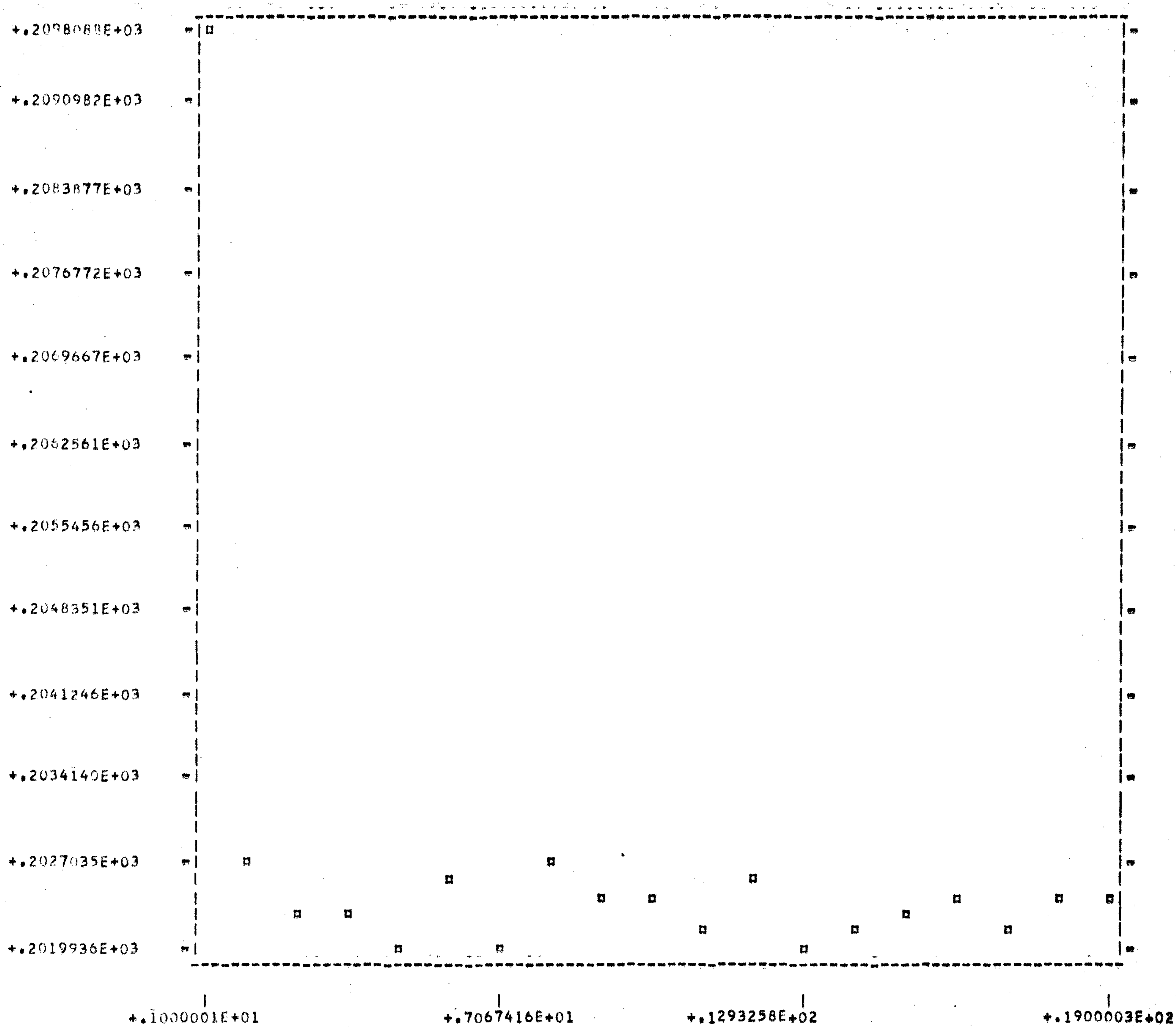
PLOT OF TRIAL VERSUS DISTILLATE



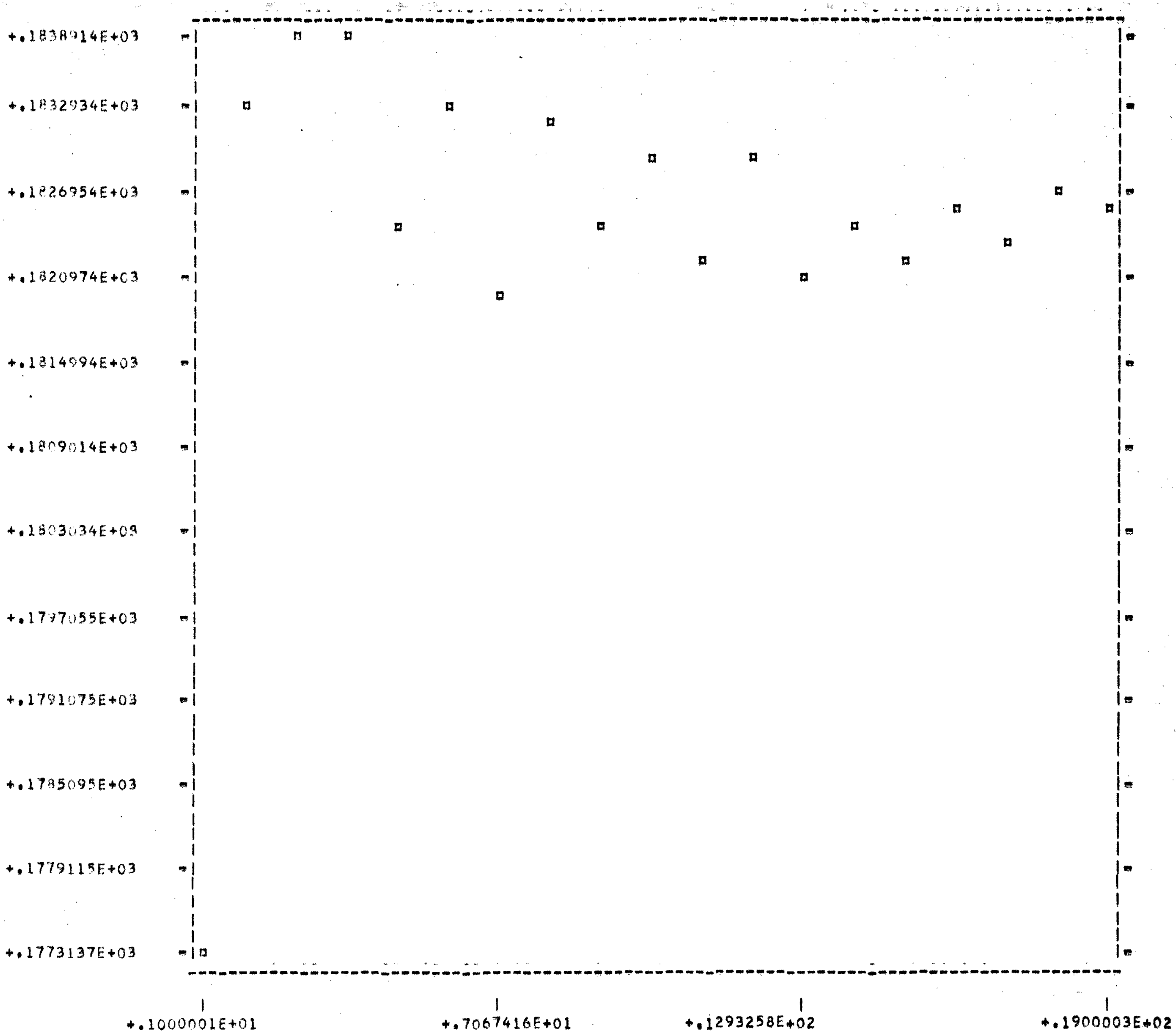
PLOT OF TRIAL VERSUS T(1)



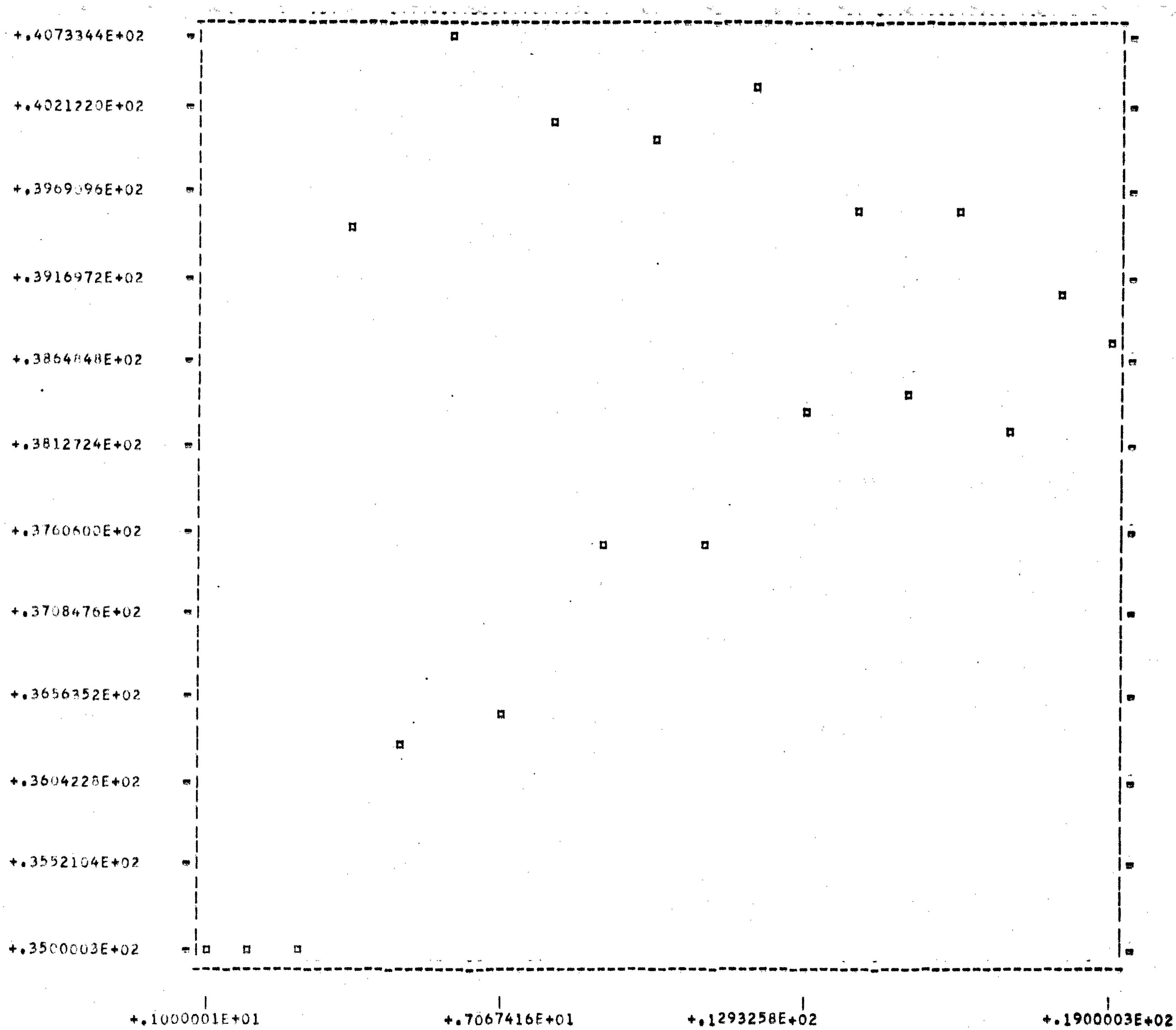
PLOT OF TRIAL VERSUS T(6)



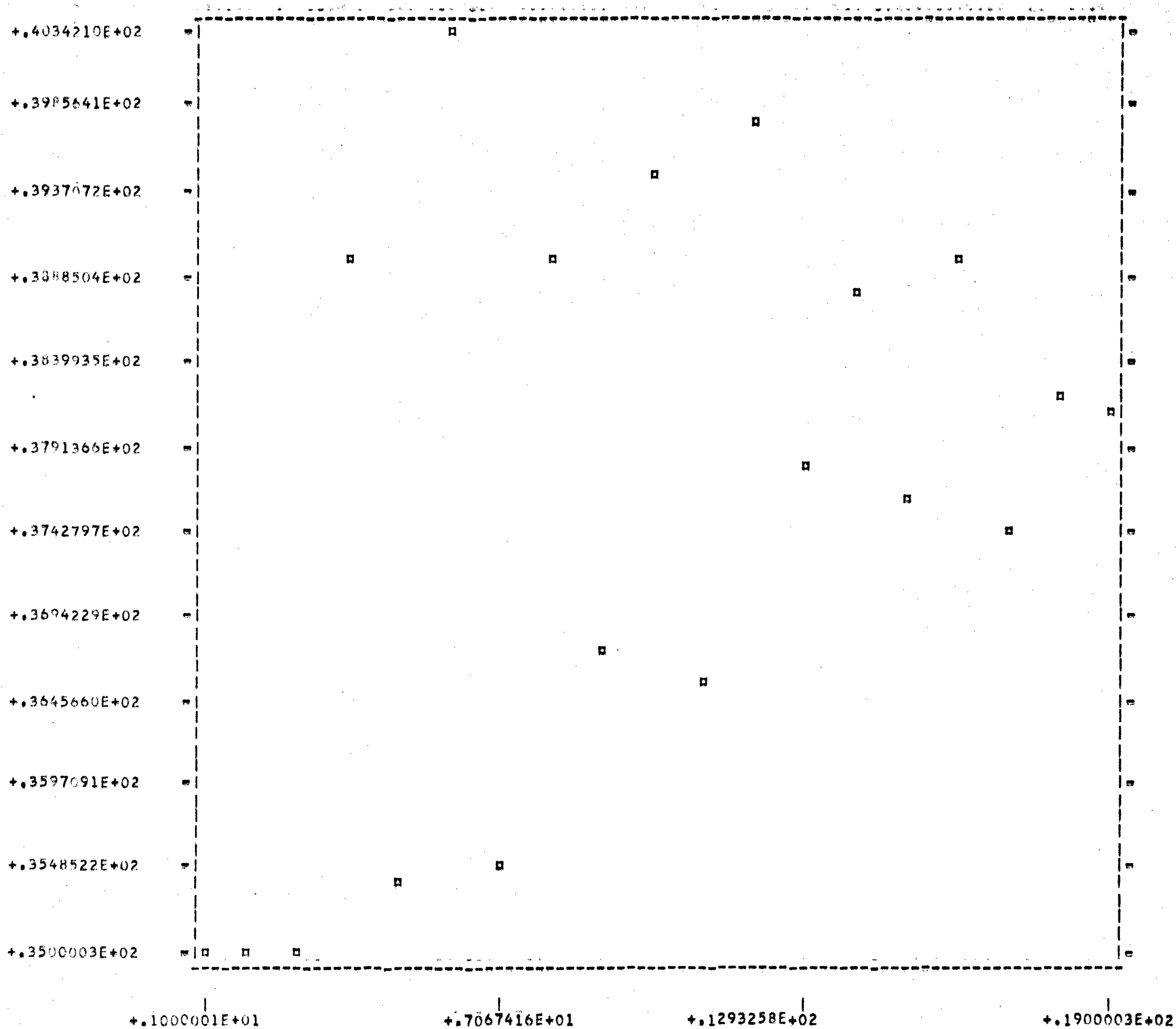
PLOT OF TETAL VERSUS T(7)



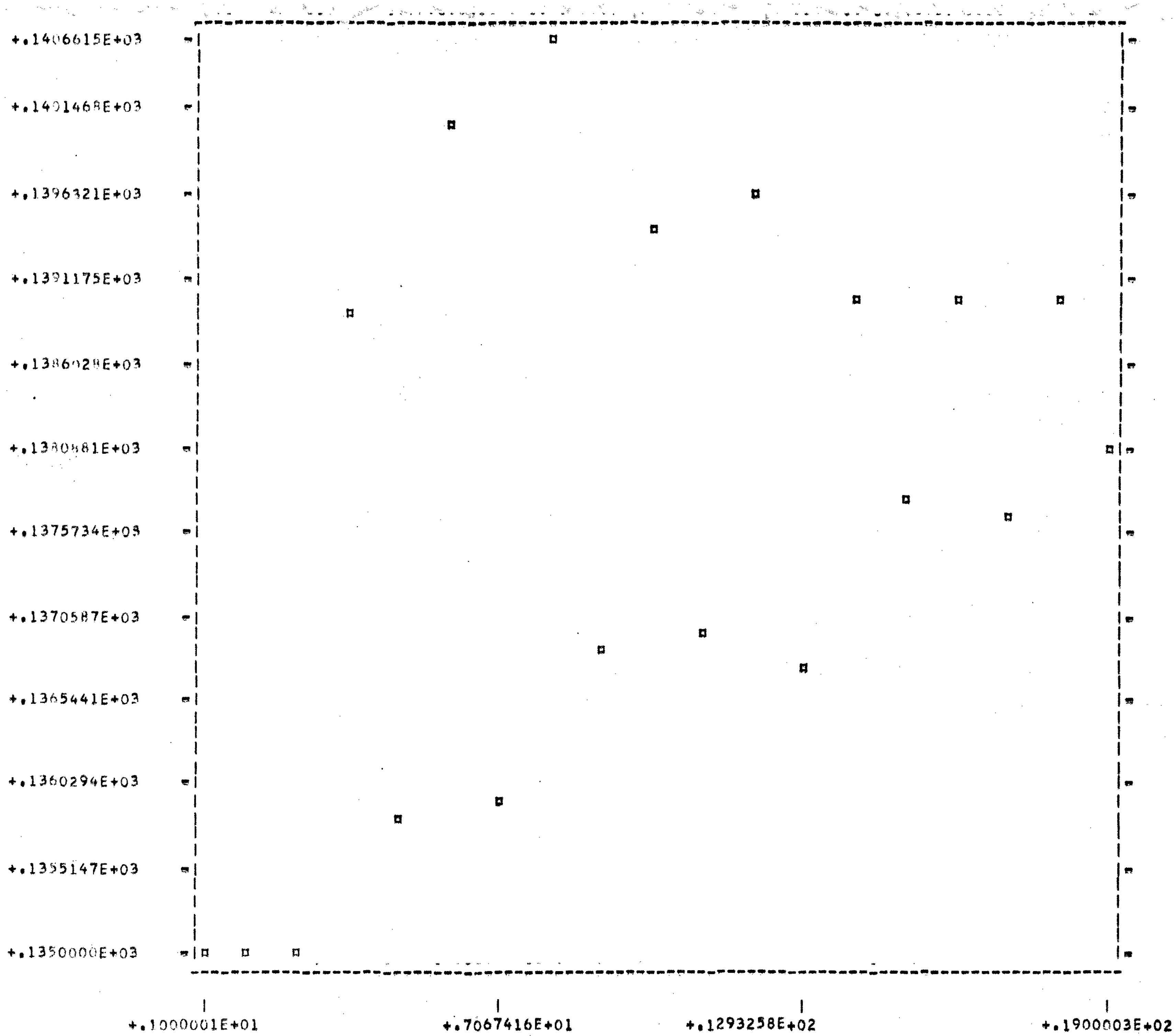
PLOT OF TRIAL VERSUS T(11)



PLOT OF TRIAL VERSUS V(1)



PLOT OF TRIAL VERSUS V(6)



PLOT OF TRIAL VERSUS V(7)

```
   11     5    6
1.0         1.0        -1.0        -1.0        0.0
0.0         +2.0        0.0        200.        00.00045000E+00
225.        220.        215.       210.        205.        200.        190.        180.
170.        165.        160.       145.
0.0
00.28531998E+0000.82675992E-0200.37041988E-04-0.63860000E-0700.71090994E-10
00.27804995E+00-0.11902999E-0200.62290987E-04-0.12023997E-0600,10241999E-09
00.22200996E+00-0.18502978E-0200.54022996E-04-0.81239989E-0700,53332991E-10
00.15369996E+00-0.22649978E-0200.31819989E-04-0.20709997E-07-0.40599799E-12
00.15042995E+00-0.26387000E-0200.28703987E-04-0.88699998E-08-0,14969997E-10
00.44635997E+0100.26482570E-0100.64745000E-0500.32505998E-07-0,52879992E-10
00.52091998E+0100.40495999E-01-0.57043988E-0400.25799994E-06-0.32644998E-09
00.64442997E+0100.14100999E-0100.16052899E-03-0.49556996E-0600,61558980E-09
00.07343995E+0100.43012995E-01-0.22595996E-0400.13574999E-06-0.16938999E-09
00.63587999E+0100.30696978E-0200.26773987E-03-0.86588000E-0600.10789998E-08
00.13575998E+02-0.27656990E-0100.37013995E-03-0.12388991E-0500,15431998E-08
00.15278995E+02-0.60737964E-0200.23645999E-03-0.75789995E-0600.94283981E-09
00.13910999E+0200.46011998E-01-0.19583000E-0300.74338999E-06-0.92781982E-09
00.19401993E+02-0.93461994E-0200.30464982E-03-0.97820975E-0600,12168999E-08
00.21072987E+02-0.35334997E-0100.52449992E-03-0.17495995E-0500.21789999E-08
   90.0      45.0   .
5.          15.        25.         20.         35.
```

```
PROBLEM PARAMETERS :

NUMBER OF STAGES        11
     STAGES COUNT FROM BOTTOM TO TOP OF TOWER
       (INCLUDES EQUILIBRUIM-STAGE REBOILER
       EXCLUDES CONDENSER-DISTILATE DRUM)

NUMBER OF COMPONENTS       5

FEED STAGE LOCATION        6

TEMPERATURE PROFILE CODE  1.0
     0.0 T PROFILE NOT GIVEN
         (MAX & MIN T MUST BE SUPPLIED)
     1.0 T PROFILE MUST BE SUPPLIED

THERMODYNAMIC DATA CODE  1.0
     0.0 COEFFICIENTS OF POLYNOMIALS NOT GIVEN
          MUST SUPPLY THERMODYNAMIC DATA POINTS (10 MAX)
          UNITS DEG F , M-BTU/# MOLE FOR ENTHALPY
          DIMENSIONLESS FOR V-L EQUILIBRIUM DATA
     1.0 COEFFICIENT OF POLYNOMIAL MUST BE SUPPLIED

DISTILLATE TYPE CODE -1.0
    -1.0 ALL VAPOR
     0.0 VAPOR & LIQUID (NOT OPERATIONAL)
    +1.0 ALL LIQUID

FEED CONDITION CODE -1.0
    -1.0 ALL VAPOR
     0.0 VAPOR & LIQUID
    +1.0 ALL LIQUID

VAPOR-LIQUID PROFILE CODE  0.0
     1.0 V&L PROFILE MUST BE SUPPLIED
     0.0 V&L PROFILE NOT GIVEN

VAPOR DAMPING CODE  0.0
     0.0 VAPOR & LIQUID RATE WILL BE DAMPED
     1.0 VAPOR & LIQUID RATE WILL NOT BE DAMPED

TEMPERATURE DAMPING CODE  2.0
     T NEW= T OLD + ( T NEW - T OLD) / ( T DAMPING CODE)

PRINT CODE  0.0
     1.0 WILL PRINT INTERMEDIATE TRIAL DATA
     0.0 WILL NOT PRINT INTERMEDIATE TRIAL DATA

MAX NUMBER OF TRIALS  200.00
```

GIVEN POLYNOMIALS

POLYNOMIALS FOR VAPOR - LIQUID EQUILIBRIUM DATA ARE :

```
K( 1)= 0.28531998E 00+T*( 0.82978991E-02+T*( 0.37041987E-04+T*(-0.63860000E-07+( 0.71090994E-10)*T)))
K( 2)= 0.27804995E 00+T*(-0.11902999E-02+T*( 0.62290986E-04+T*(-0.12023997E-06+( 0.10241999E-09)*T)))
K( 3)= 0.22200996E 00+T*(-0.18502998E-02+T*( 0.54022995E-04+T*(-0.81239989E-07+( 0.53332991E-10)*T)))
K( 4)= 0.15309995E 00+T*(-0.22649998E-02+T*( 0.31819989E-04+T*(-0.20709997E-07+(-0.40599999E-12)*T)))
K( 5)= 0.16042995E 00+T*(-0.26387000E-02+T*( 0.28703987E-04+T*(-0.88699998E-08+(-0.14969997E-10)*T)))
```

POLYNOMIALS FOR VAPOR ENTHALPY DATA ARE :

```
HV( 1)= 0.13575000E 02+T*(-0.27656998E-01+T*( 0.37013995E-03+T*(-0.12388991E-05+( 0.15431998E-08)*T)))
HV( 2)= 0.15278999E 02+T*(-0.60739964E-02+T*( 0.23645999E-03+T*(-0.75789995E-06+( 0.94283981E-09)*T)))
HV( 3)= 0.13910999E 02+T*( 0.46811998E-01+T*(-0.19588000E-03+T*( 0.74338999E-06+(-0.92781982E-09)*T)))
HV( 4)= 0.19401992E 02+T*(-0.93661993E-02+T*( 0.30484981E-03+T*(-0.97820975E-06+( 0.12168999E-08)*T)))
HV( 5)= 0.21092987E 02+T*(-0.35334997E-01+T*( 0.52449991E-03+T*(-0.17495995E-05+( 0.21789999E-08)*T)))
```

POLYNOMIALS FOR LIQUID ENTHALPY DATA ARE :

```
HL( 1)= 0.44335997E 01+T*( 0.26882999E-01+T*( 0.64745000E-05+T*( 0.32505998E-07+(-0.52879992E-10)*T)))
HL( 2)= 0.52091999E 01+T*( 0.40495999E-01+T*(-0.57043987E-04+T*( 0.25799994E-06+(-0.32644998E-09)*T)))
HL( 3)= 0.64442997E 01+T*( 0.14100999E-01+T*( 0.16052999E-03+T*(-0.49556996E-06+( 0.61558980E-09)*T)))
HL( 4)= 0.67343998E 01+T*( 0.43812998E-01+T*(-0.22595995E-04+T*( 0.13574999E-06+(-0.16938999E-09)*T)))
HL( 5)= 0.83587999E 01+T*( 0.80696977E-02+T*( 0.26773987E-03+T*(-0.86588000E-06+( 0.10789998E-08)*T)))
```

FEED IS ALL VAPOR .
FEED DEW POINT TEMPERATURE IS = 203.47604 DEG. F
FEED BUBBLE POINT TEMPERATURE IS = 181.59796 DEG. F
TEMPERATURE OF FEED IS = 203.47604 DEG. F

	MOLS/HR		MOLE FRAC		VAP MOLS/HR		VAP MOL FRAC		LIQ MOLES/HR		LIQ MOL FRAC
F(1)=	5.0000	FZ(1)=	0.0500	FV(1)=	5.0000	YF(1)=	0.0500000	FL(1)=	0.0000	XF(1)=	0.0000000
F(2)=	15.0000	FZ(2)=	0.1500	FV(2)=	15.0000	YF(2)=	0.1500000	FL(2)=	0.0000	XF(2)=	0.0000000
F(3)=	25.0000	FZ(3)=	0.2500	FV(3)=	25.0000	YF(3)=	0.2500000	FL(3)=	0.0000	XF(3)=	0.0000000
F(4)=	20.0000	FZ(4)=	0.2000	FV(4)=	20.0000	YF(4)=	0.2000000	FL(4)=	0.0000	XF(4)=	0.0000000
F(5)=	35.0000	FZ(5)=	0.3500	FV(5)=	35.0000	YF(5)=	0.3500000	FL(5)=	0.0000	XF(5)=	0.0000000
	----------		----------		----------		----------		----------		----------
TOTAL	100.0000		1.0000		100.0000		0.9999999		0.0000		0.0000000

VALUE OF DISTILLATE IS = 45.0000 VALUE OF EXTERNAL REFLUX IS = 90.0000

DISTILLATE TOLERANCE 0.44999993E-03

DISTILLATE IS ALL VAPOR .

PRESSURES WERE NOT SUPPLIED .
K-DATA WILL NOT BE PRESSURE CORRECTED .

THE INITIAL VAPOR , LIQUID , & TEMPERATURE PROFILES

NUMBERING IS FROM BOTTOM TO THE TOP OF THE TOWER
LAST STAGE IS THE CONDENSER-DISTILLATE DRUM
FIRST STAGE IS AN EQUILIBRIUM STAGE REBOILER

	MOLS/HR		MOLS/HR		DEG. F
V(1)=	35.000	L(1)=	55.000	T(1)=	225.0000
V(2)=	35.000	L(2)=	90.000	T(2)=	220.0000
V(3)=	35.000	L(3)=	90.000	T(3)=	215.0000
V(4)=	35.000	L(4)=	90.000	T(4)=	210.0000
V(5)=	35.000	L(5)=	90.000	T(5)=	205.0000
V(6)=	35.000	L(6)=	90.000	T(6)=	200.0000
V(7)=	135.000	L(7)=	90.000	T(7)=	190.0000
V(8)=	135.000	L(8)=	90.000	T(8)=	180.0000
V(9)=	135.000	L(9)=	90.000	T(9)=	170.0000
V(10)=	135.000	L(10)=	90.000	T(10)=	165.0000
V(11)=	135.000	L(11)=	90.000	T(11)=	160.0000
V(12)=	45.000	L(12)=	90.000	T(12)=	145.0000

149

```
CALCULATED D=  36.57919    FOR THETA = 1.00
D CORRECTED =  45.02814    THETA =   0.46489    D SPEC =  45.00000

CALCULATED D=  41.14748    FOR THETA = 1.00
D CORRECTED =  45.00981    THETA =   0.73485    D SPEC =  45.00000

CALCULATED D=  43.40446    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   0.88845    D SPEC =  45.00000

CALCULATED D=  44.41798    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   0.95934    D SPEC =  45.00000

CALCULATED D=  42.65924    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   0.84062    D SPEC =  45.00000

CALCULATED D=  45.51279    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   1.03858    D SPEC =  45.00000

CALCULATED D=  45.07988    FOR THETA = 1.00
D CORRECTED =  45.00003    THETA =   1.00581    D SPEC =  45.00000

CALCULATED D=  45.09149    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   1.00667    D SPEC =  45.00000

CALCULATED D=  44.95998    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   0.99713    D SPEC =  45.00000

CALCULATED D=  45.02974    FOR THETA = 1.00
D CORRECTED =  44.99998    THETA =   1.00215    D SPEC =  45.00000

CALCULATED D=  44.95628    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   0.99688    D SPEC =  45.00000

CALCULATED D=  45.01860    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   1.00133    D SPEC =  45.00000

CALCULATED D=  44.96701    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   0.99765    D SPEC =  45.00000

CALCULATED D=  45.01515    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   1.00108    D SPEC =  45.00000

CALCULATED D=  44.97635    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   0.99832    D SPEC =  45.00000

CALCULATED D=  45.01259    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   1.00090    D SPEC =  45.00000

CALCULATED D=  44.98305    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   0.99879    D SPEC =  45.00000

CALCULATED D=  45.01024    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   1.00073    D SPEC =  45.00000
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```
CALCULATED D=  44.98769    FOR THETA = 1.00
D CORRECTED =  44.99998    THETA =   0.99913    D SPEC =  45.00000

CALCULATED D=  45.00818    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   1.00058    D SPEC =  45.00000

CALCULATED D=  44.99095    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   0.99936    D SPEC =  45.00000

CALCULATED D=  45.00644    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   1.00046    D SPEC =  45.00000

CALCULATED D=  44.99327    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   0.99952    D SPEC =  45.00000

CALCULATED D=  45.00508    FOR THETA = 1.00
D CORRECTED =  45.00003    THETA =   1.00036    D SPEC =  45.00000

CALCULATED D=  44.99501    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   0.99964    D SPEC =  45.00000

CALCULATED D=  45.00391    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   1.00028    D SPEC =  45.00000

CALCULATED D=  44.99619    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   0.99973    D SPEC =  45.00000

CALCULATED D=  45.00302    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   1.00021    D SPEC =  45.00000

CALCULATED D=  44.99715    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   0.99980    D SPEC =  45.00000

CALCULATED D=  45.00229    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   1.00016    D SPEC =  45.00000

CALCULATED D=  44.99788    FOR THETA = 1.00
D CORRECTED =  44.99998    THETA =   0.99985    D SPEC =  45.00000

CALCULATED D=  45.00171    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   1.00012    D SPEC =  45.00000

CALCULATED D=  44.99840    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   0.99988    D SPEC =  45.00000

CALCULATED D=  45.00131    FOR THETA = 1.00
D CORRECTED =  45.00000    THETA =   1.00009    D SPEC =  45.00000

CALCULATED D=  44.99879    FOR THETA = 1.00
D CORRECTED =  44.99998    THETA =   0.99992    D SPEC =  45.00000

CALCULATED D=  45.00098    FOR THETA = 1.00
D CORRECTED =  45.00002    THETA =   1.00007    D SPEC =  45.00000
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```
CALCULATED D=  44.99911   FOR THETA =  1.00
D CORRECTED =  44.99998   THETA =    0.99994   D SPEC =  45.00000

CALCULATED D=  45.00070   FOR THETA =  1.00
D CORRECTED =  45.00000   THETA =    1.00005   D SPEC =  45.00000

CALCULATED D=  44.99933   FOR THETA =  1.00
D CORRECTED =  44.99998   THETA =    0.99995   D SPEC =  45.00000

CALCULATED D=  45.00050   FOR THETA =  1.00
D CORRECTED =  44.99998   THETA =    1.00004   D SPEC =  45.00000

CALCULATED D=  44.99953   FOR THETA =  1.00
D CORRECTED =  44.99998   THETA =    0.99997   D SPEC =  45.00000

CALCULATED D=  45.00034   FOR THETA =  1.00
CALCULATED D=  45.00012   FOR THETA =  1.00
```

TOWER CONVERGED AT TRIAL # 43.00

FINAL VAPOR , LIQUID & TEMPERATURE PROFILE

NUMBERING IS FROM BOTTOM TO THE TOP OF THE TOWER
LAST STAGE IS THE CONDENSER-DISTILLATE DRUM
FIRST STAGE IS AN EQUILIBRIUM STAGE REBOILER

	MOLS/HR		MOLS/HR		DEG. F
V(1)=	38.949	L(1)=	55.000	T(1)=	216.858
V(2)=	38.808	L(2)=	93.948	T(2)=	211.601
V(3)=	38.692	L(3)=	93.808	T(3)=	208.268
V(4)=	38.567	L(4)=	93.692	T(4)=	206.118
V(5)=	38.420	L(5)=	93.567	T(5)=	204.621
V(6)=	38.243	L(6)=	93.420	T(6)=	203.438
V(7)=	138.365	L(7)=	93.243	T(7)=	202.363
V(8)=	138.557	L(8)=	93.365	T(8)=	200.479
V(9)=	138.920	L(9)=	93.557	T(9)=	197.229
V(10)=	139.710	L(10)=	93.920	T(10)=	191.683
V(11)=	135.000	L(11)=	94.710	T(11)=	182.534
V(12)=	45.000	L(12)=	90.000	T(12)=	168.715

DISTILLATE:

	MOLS/HR		MOL FRAC		K-VALUES
D(1)=	4.9333	Y(1)=	0.1096291	K(1)=	2.4889221
D(2)=	12.6924	Y(2)=	0.2820519	K(2)=	1.3558674
D(3)=	18.5537	Y(3)=	0.4123032	K(3)=	1.1006508
D(4)=	4.6317	Y(4)=	0.1029258	K(4)=	0.5769217
D(5)=	4.1891	Y(5)=	0.0930905	K(5)=	0.4775671
	----------		----------		
D =	45.0001	TOTAL =	1.0000000		

TEMPERATURE = 168.72 DEG. F VAPOR ENTHALPY = 859.7388 M-BTU/HR LIQ. ENTHALPY = 0.0000 M-BTU/HR

CONDENSER DUTY = 814.5039 M-BUT/HR

BOTTOMS :

	MOLS/HR		MOL FRAC		K-VALUES
B(1)=	0.0667	X(1)=	0.0012123	K(1)=	3.3305597
B(2)=	2.3076	X(2)=	0.0419571	K(2)=	1.9495716
B(3)=	6.4463	X(3)=	0.1172056	K(3)=	1.6507549
B(4)=	15.3683	X(4)=	0.2794248	K(4)=	0.9462205
B(5)=	30.8109	X(5)=	0.5602001	K(5)=	0.8145106
	----------		----------		
B =	54.9998	TOTAL =	0.9999999		

TEMPERATURE = 216.86 DEG. F VAPOR ENTHALPY = 0.0000 M-BTU/HR LIQ. ENTHALPY = 866.8931 M-BTU/HR

REBOILER DUTY = 337.0403 M-BTU/HR

MATRIAL BALANCE (MOLS/HR) :

----------IN----------		----------OUT----------			
F(1)=	5.0000	D(1)=	4.9333	B(1)=	0.0667
F(2)=	15.0000	D(2)=	12.6924	B(2)=	2.3076
F(3)=	25.0000	D(3)=	18.5537	B(3)=	6.4463
F(4)=	20.0000	D(4)=	4.6317	B(4)=	15.3683
F(5)=	35.0000	D(5)=	4.1891	B(5)=	30.8109
TOTAL	100.0000		45.0001		54.9998

ENTHALPY BALANCE (M-BTU/HR) :

FEED	2204.0955	DISTILLATE	859.7388
REBOILER	337.0403	BOTTOM	866.8931
		CONDENSER	814.5039
TOTAL	2541.1357		2541.1357

154

PLATE NUMBER = 1 (EQ. STAGE REBOILER)

MOLS/HR		MOL FRAC		MOLS/HR		MOL FRAC		K-VALUES	
V(1, 1)=	0.1573	Y(1)=	0.0040377	L(1, 1)=	0.0667	X(1)=	0.0012123	K(1)=	3.330560
V(1, 2)=	3.1859	Y(2)=	0.0817981	L(1, 2)=	2.3076	X(2)=	0.0419571	K(2)=	1.949572
V(1, 3)=	7.5357	Y(3)=	0.1934776	L(1, 3)=	6.4463	X(3)=	0.1172056	K(3)=	1.650755
V(1, 4)=	10.2979	Y(4)=	0.2643974	L(1, 4)=	15.3683	X(4)=	0.2794248	K(4)=	0.946221
V(1, 5)=	17.7718	Y(5)=	0.4562892	L(1, 5)=	30.8109	X(5)=	0.5602001	K(5)=	0.814511
V(1)=	38.9486	TOTAL =	1.0000000	L(1)=	54.9998	TOTAL =	0.9999999		

TEMPERATURE = 216.86 DEG. F VAPOR ENTHALPY = 915.0642 M-BTU/HR LIQ. ENTHALPY = 866.8931 M-BTU/HR

PLATE NUMBER = 2

MOLS/HR		MOL FRAC		MOLS/HR		MOL FRAC		K-VALUES	
V(2, 1)=	0.2993	Y(1)=	0.0077113	L(2, 1)=	0.2239	X(1)=	0.0023837	K(1)=	3.235077
V(2, 2)=	4.2693	Y(2)=	0.1100118	L(2, 2)=	5.4936	X(2)=	0.0584742	K(2)=	1.881378
V(2, 3)=	9.1635	Y(3)=	0.2361236	L(2, 3)=	13.9820	X(3)=	0.1488261	K(3)=	1.586576
V(2, 4)=	9.5581	Y(4)=	0.2462927	L(2, 4)=	25.6662	X(4)=	0.2731947	K(4)=	0.901529
V(2, 5)=	15.5178	Y(5)=	0.3998606	L(2, 5)=	48.5827	X(5)=	0.5171213	K(5)=	0.773244
V(2)=	38.8080	TOTAL =	1.0000000	L(2)=	93.9484	TOTAL =	0.9999999		

TEMPERATURE = 211.60 DEG. F VAPOR ENTHALPY = 890.3899 M-BTU/HR LIQ. ENTHALPY = 1444.9258 M-BTU/HR

PLATE NUMBER = 3

MOLS/HR		MOL FRAC		MOLS/HR		MOL FRAC		K-VALUES	
V(3, 1)=	0.4792	Y(1)=	0.0123855	L(3, 1)=	0.3659	X(1)=	0.0039010	K(1)=	3.174994
V(3, 2)=	4.9675	Y(2)=	0.1289015	L(3, 2)=	6.5770	X(2)=	0.0701111	K(2)=	1.838531
V(3, 3)=	9.9562	Y(3)=	0.2573181	L(3, 3)=	15.6098	X(3)=	0.1664017	K(3)=	1.546367
V(3, 4)=	8.9630	Y(4)=	0.2321654	L(3, 4)=	24.9264	X(4)=	0.2657182	K(4)=	0.873728
V(3, 5)=	14.2863	Y(5)=	0.3692300	L(3, 5)=	46.3287	X(5)=	0.4938682	K(5)=	0.747628
V(3)=	38.6920	TOTAL =	1.0000000	L(3)=	93.8078	TOTAL =	1.0000000		

TEMPERATURE = 208.27 DEG. F VAPOR ENTHALPY = 874.3960 M-BTU/HR LIQ. ENTHALPY = 1420.2505 M-BTU/HR

PLATE NUMBER = 4

MOLS/HR		MOL FRAC		MOLS/HR		MOL FRAC		K-VALUES	
V(4, 1)=	0.7048	Y(1)=	0.0182744	L(4, 1)=	0.5459	X(1)=	0.0058265	K(1)=	3.136421
V(4, 2)=	5.4385	Y(2)=	0.1410133	L(4, 2)=	7.2951	X(2)=	0.0778626	K(2)=	1.811055
V(4, 3)=	10.2672	Y(3)=	0.2662135	L(4, 3)=	16.4025	X(3)=	0.1750680	K(3)=	1.520631
V(4, 4)=	8.5807	Y(4)=	0.2224849	L(4, 4)=	24.3513	X(4)=	0.2599079	K(4)=	0.856015
V(4, 5)=	13.5763	Y(5)=	0.3520147	L(4, 5)=	45.0972	X(5)=	0.4813349	K(5)=	0.731331
V(4)=	38.5674	TOTAL =	1.0000000	L(4)=	93.6919	TOTAL =	0.9999999		

TEMPERATURE = 206.12 DEG. F VAPOR ENTHALPY = 862.9189 M-BTU/HR LIQ. ENTHALPY = 1404.2578 M-BTU/HR

PLATE NUMBER = 5

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(5, 1)= 0.9851	Y(1)= 0.0256394	L(5, 1)= 0.7715	X(1)= 0.0082451	K(1)= 3.109641
V(5, 2)= 5.6998	Y(2)= 0.1483537	L(5, 2)= 7.7461	X(2)= 0.0827870	K(2)= 1.791995
V(5, 3)= 10.3134	Y(3)= 0.2684379	L(5, 3)= 16.7134	X(3)= 0.1786250	K(3)= 1.502803
V(5, 4)= 8.2976	Y(4)= 0.2159698	L(5, 4)= 23.9490	X(4)= 0.2559548	K(4)= 0.843782
V(5, 5)= 13.1243	Y(5)= 0.3415996	L(5, 5)= 44.3872	X(5)= 0.4743882	K(5)= 0.720085
V(5)= 38.4202	TOTAL = 1.0000000	L(5)= 93.5672	TOTAL = 1.0000000	

TEMPERATURE = 204.62 DEG. F VAPOR ENTHALPY = 853.4248 M-BTU/HR LIQ. ENTHALPY = 1392.7798 M-BTU/HR

PLATE NUMBER = 6

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(6, 1)= 1.3298	Y(1)= 0.0347715	L(6, 1)= 1.0517	X(1)= 0.0112583	K(1)= 3.088540
V(6, 2)= 5.8249	Y(2)= 0.1523126	L(6, 2)= 8.0074	X(2)= 0.0857140	K(2)= 1.776986
V(6, 3)= 10.2143	Y(3)= 0.2670889	L(6, 3)= 16.7597	X(3)= 0.1794018	K(3)= 1.488776
V(6, 4)= 8.0816	Y(4)= 0.2113210	L(6, 4)= 23.6659	X(4)= 0.2533279	K(4)= 0.834180
V(6, 5)= 12.7926	Y(5)= 0.3345063	L(6, 5)= 43.9352	X(5)= 0.4702979	K(5)= 0.711265
V(6)= 38.2432	TOTAL = 1.0000000	L(6)= 93.4200	TOTAL = 0.9999999	

TEMPERATURE = 203.44 DEG. F VAPOR ENTHALPY = 844.4016 M-BTU/HR LIQ. ENTHALPY = 1383.2859 M-BTU/HR

PLATE NUMBER = 7

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(7, 1)= 6.3605	Y(1)= 0.0459688	L(7, 1)= 1.3965	X(1)= 0.0149765	K(1)= 3.069390
V(7, 2)= 21.2805	Y(2)= 0.1537994	L(7, 2)= 8.1326	X(2)= 0.0872189	K(2)= 1.763372
V(7, 3)= 36.4929	Y(3)= 0.2637427	L(7, 3)= 16.6606	X(3)= 0.1786796	K(3)= 1.476064
V(7, 4)= 28.7255	Y(4)= 0.2076057	L(7, 4)= 23.4499	X(4)= 0.2514922	K(4)= 0.825495
V(7, 5)= 45.5061	Y(5)= 0.3288833	L(7, 5)= 43.6035	X(5)= 0.4676328	K(5)= 0.703294
V(7)= 138.3655	TOTAL = 0.9999998	L(7)= 93.2430	TOTAL = 0.9999999	

TEMPERATURE = 202.36 DEG. F VAPOR ENTHALPY = 3037.6411 M-BTU/HR LIQ. ENTHALPY = 1374.2617 M-BTU/HR

PLATE NUMBER = 8

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(8, 1)= 6.4300	Y(1)= 0.0464068	L(8, 1)= 1.4272	X(1)= 0.0152859	K(1)= 3.035929
V(8, 2)= 22.1715	Y(2)= 0.1600170	L(8, 2)= 8.5882	X(2)= 0.0919846	K(2)= 1.739604
V(8, 3)= 38.7061	Y(3)= 0.2793513	L(8, 3)= 17.9392	X(3)= 0.1921397	K(3)= 1.453894
V(8, 4)= 28.9761	Y(4)= 0.2091280	L(8, 4)= 24.0938	X(4)= 0.2580593	K(4)= 0.810387
V(8, 5)= 42.2733	Y(5)= 0.3050969	L(8, 5)= 41.3170	X(5)= 0.4425305	K(5)= 0.689436
V(8)= 138.5569	TOTAL = 0.9999999	L(8)= 93.3653	TOTAL = 1.0000000	

TEMPERATURE = 200.48 DEG. F VAPOR ENTHALPY = 3018.3572 M-BTU/HR LIQ. ENTHALPY = 1363.4075 M-BTU/HR

PLATE NUMBER = 9

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(9, 1)= 6.6193	Y(1)= 0.0476479	L(9, 1)= 1.4967	X(1)= 0.0159974	K(1)= 2.978471
V(9, 2)= 23.9118	Y(2)= 0.1721262	L(9, 2)= 9.4791	X(2)= 0.1013193	K(2)= 1.698850
V(9, 3)= 42.3706	Y(3)= 0.3049997	L(9, 3)= 20.1524	X(3)= 0.2154024	K(3)= 1.415952
V(9, 4)= 28.3638	Y(4)= 0.2041733	L(9, 4)= 24.3445	X(4)= 0.2602106	K(4)= 0.784647
V(9, 5)= 37.6547	Y(5)= 0.2710527	L(9, 5)= 38.0842	X(5)= 0.4070703	K(5)= 0.665862
V(9)= 138.9202	TOTAL = 0.9999998	L(9)= 93.5568	TOTAL = 0.9999999	

TEMPERATURE = 197.23 DEG. F　VAPOR ENTHALPY = 2985.6804 M-BTU/HR　LIQ. ENTHALPY = 1344.1223 M-BTU/HR

PLATE NUMBER = 10

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(10, 1)= 7.2258	Y(1)= 0.0517198	L(10, 1)= 1.6859	X(1)= 0.0179508	K(1)= 2.881192
V(10, 2)= 27.2045	Y(2)= 0.1947204	L(10, 2)= 11.2195	X(2)= 0.1194575	K(2)= 1.630037
V(10, 3)= 47.9035	Y(3)= 0.3428771	L(10, 3)= 23.8169	X(3)= 0.2535873	K(3)= 1.352105
V(10, 4)= 26.1830	Y(4)= 0.1874092	L(10, 4)= 23.7321	X(4)= 0.2526842	K(4)= 0.741673
V(10, 5)= 31.1936	Y(5)= 0.2232734	L(10, 5)= 33.4656	X(5)= 0.3563202	K(5)= 0.626608
V(10)= 139.7104	TOTAL = 0.9999998	L(10)= 93.9201	TOTAL = 1.0000000	

TEMPERATURE = 191.68 DEG. F　VAPOR ENTHALPY = 2934.1865 M-BTU/HR　LIQ. ENTHALPY = 1311.4426 M-BTU/HR

PLATE NUMBER = 11

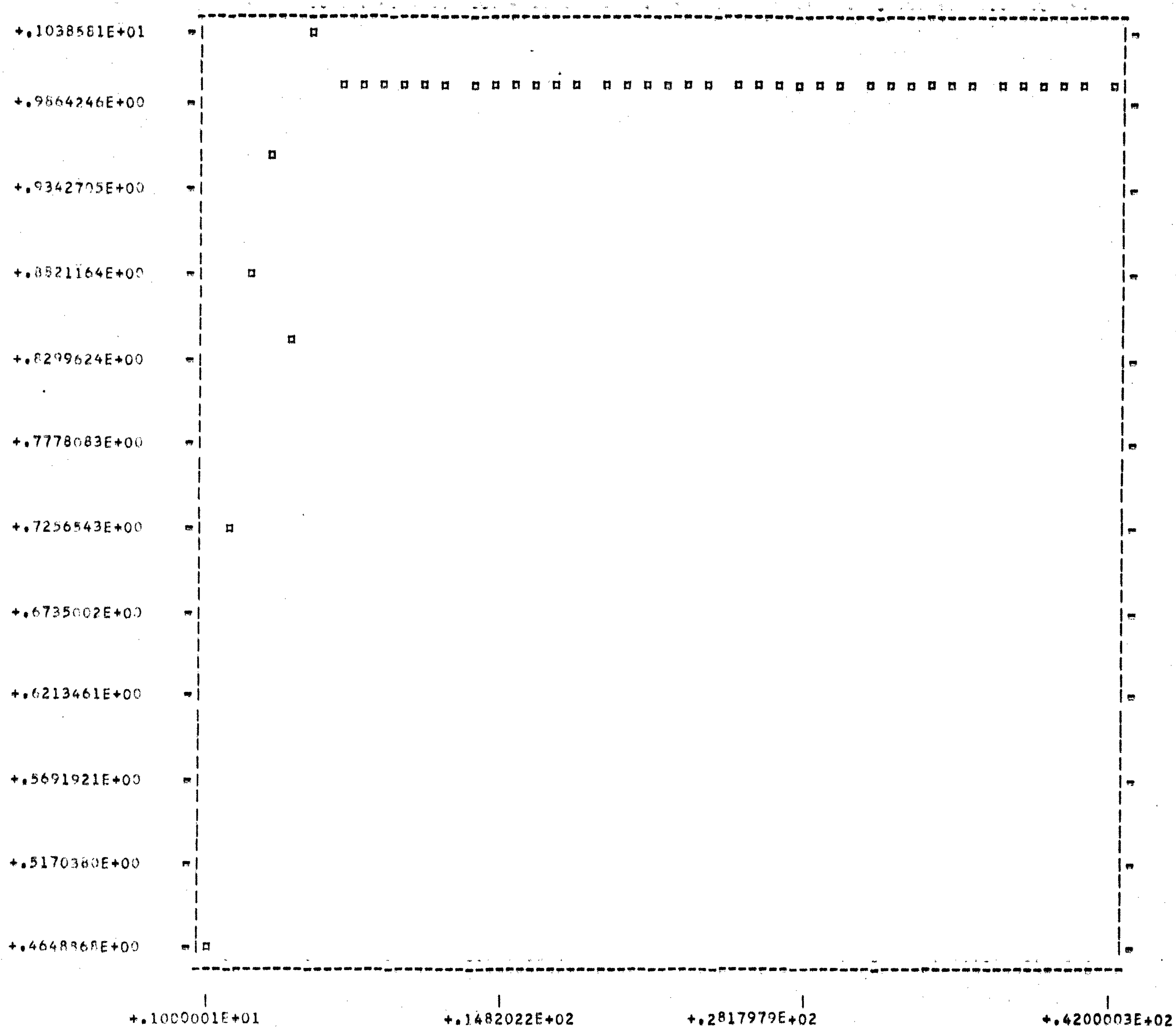
MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(11, 1)= 8.8975	Y(1)= 0.0659077	L(11, 1)= 2.2925	X(1)= 0.0242051	K(1)= 2.722874
V(11, 2)= 31.4145	Y(2)= 0.2326999	L(11, 2)= 14.5121	X(2)= 0.1532264	K(2)= 1.518660
V(11, 3)= 52.2678	Y(3)= 0.3871682	L(11, 3)= 29.3498	X(3)= 0.3098905	K(3)= 1.249365
V(11, 4)= 20.6882	Y(4)= 0.1532459	L(11, 4)= 21.5513	X(4)= 0.2275501	K(4)= 0.673457
V(11, 5)= 21.7326	Y(5)= 0.1609820	L(11, 5)= 27.0045	X(5)= 0.2851279	K(5)= 0.564593
V(11)= 135.0001	TOTAL = 1.0000029	L(11)= 94.7102	TOTAL = 0.9999999	

TEMPERATURE = 182.53 DEG. F　VAPOR ENTHALPY = 2729.9622 M-BTU/HR　LIQ. ENTHALPY = 1259.9480 M-BTU/HR

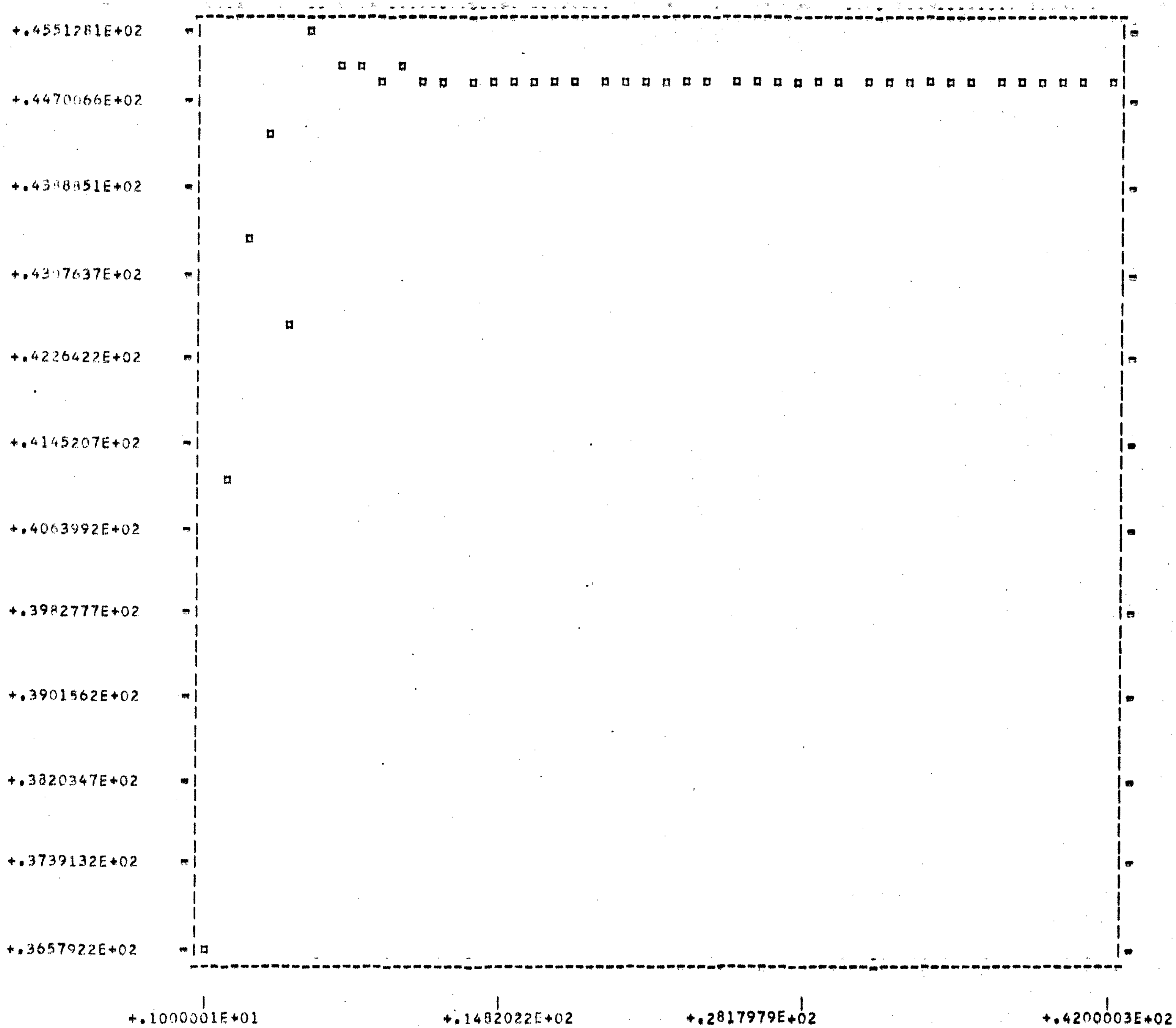
PLATE NUMBER = 12　(CONDENSER-DISTILLATE DRUM)

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(12, 1)= 4.9333	Y(1)= 0.1096291	L(12, 1)= 3.9642	X(1)= 0.0440470	K(1)= 2.488922
V(12, 2)= 12.6924	Y(2)= 0.2820519	L(12, 2)= 18.7221	X(2)= 0.2080237	K(2)= 1.355867
V(12, 3)= 18.5537	Y(3)= 0.4123032	L(12, 3)= 33.7141	X(3)= 0.3746007	K(3)= 1.100651
V(12, 4)= 4.6317	Y(4)= 0.1029258	L(12, 4)= 16.0565	X(4)= 0.1784059	K(4)= 0.576922
V(12, 5)= 4.1891	Y(5)= 0.0930905	L(12, 5)= 17.5435	X(5)= 0.1949278	K(5)= 0.477567
V(12)= 45.0001	TOTAL = 1.0000000	L(12)= 90.0000	TOTAL = 1.0000048	

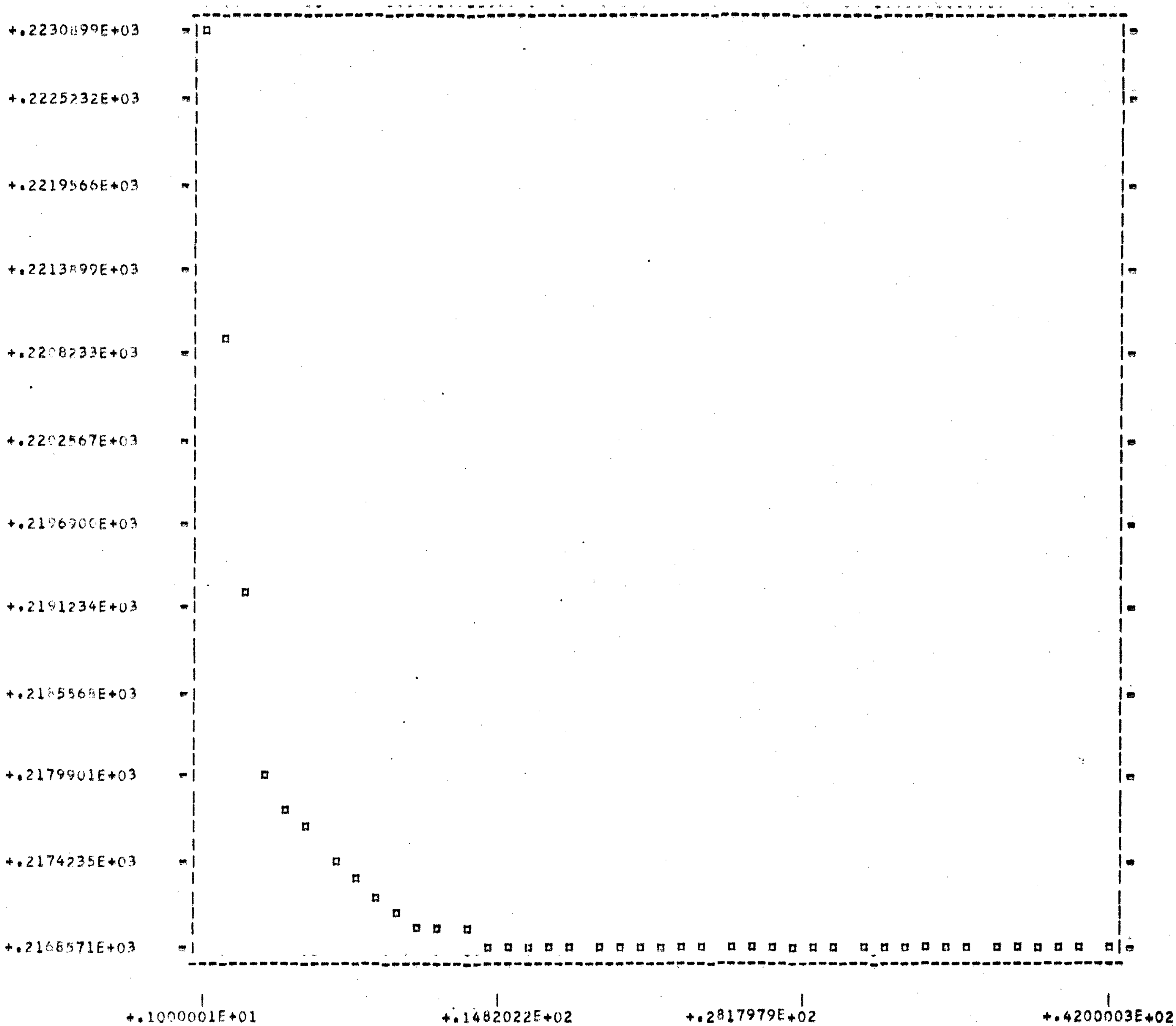
TEMPERATURE = 168.72 DEG. F　VAPOR ENTHALPY = 859.7388 M-BTU/HR　LIQ. ENTHALPY = 1109.6963 M-BTU/HR



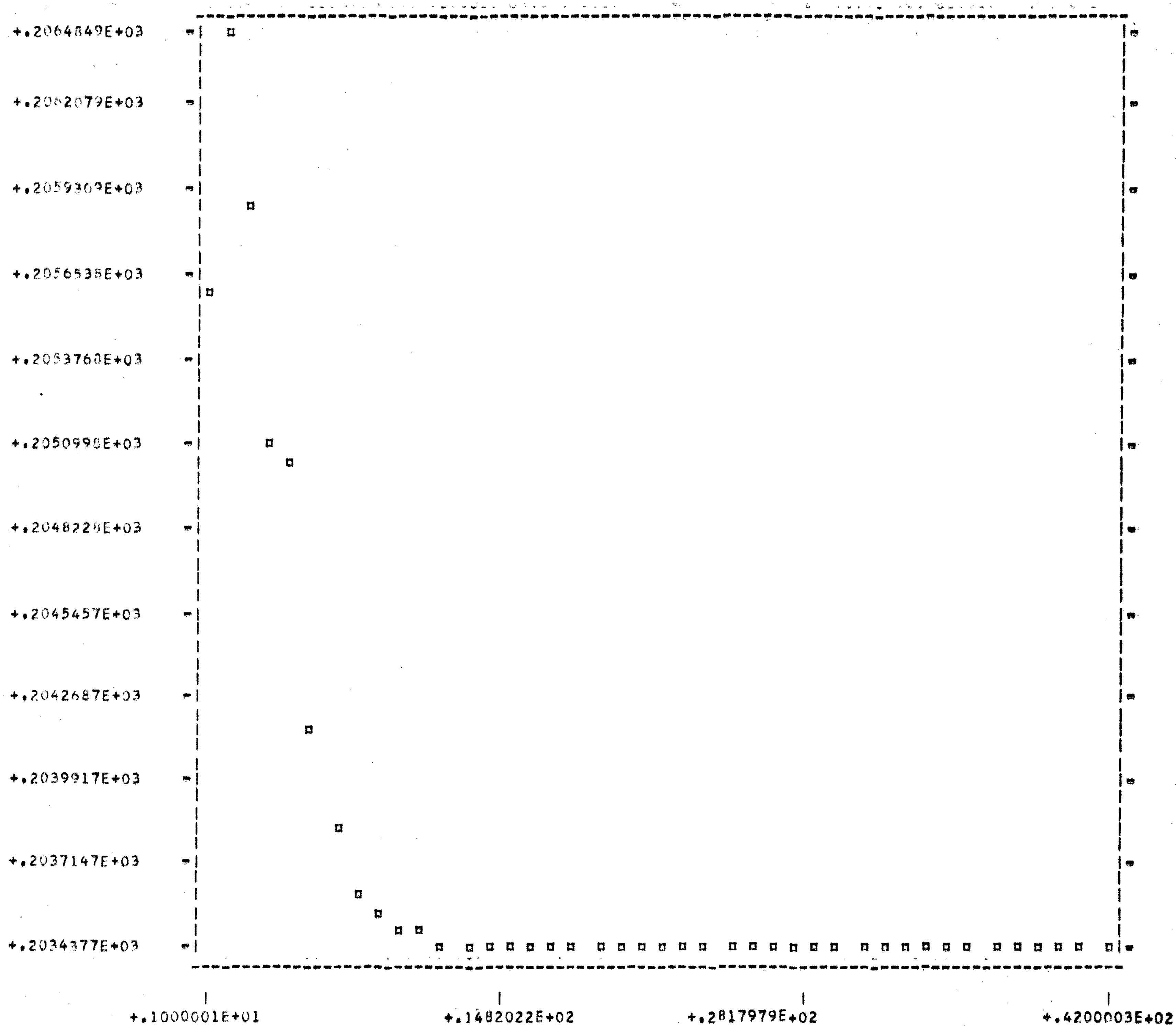
PLOT OF TRIAL VERSUS THETA



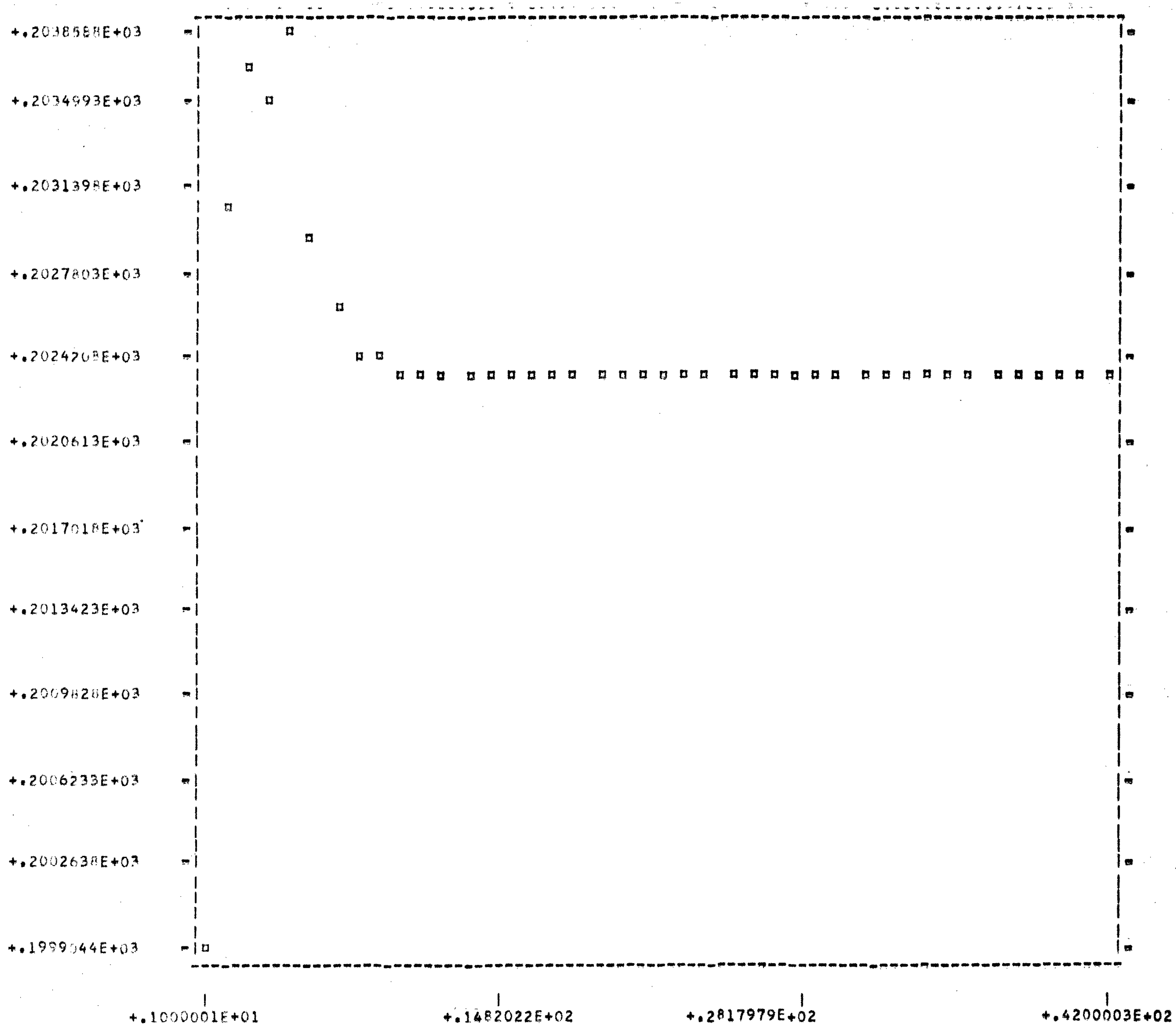
PLOT OF TRIAL VERSUS DISTILLATE



PLOT OF TRIAL VERSUS T(1)

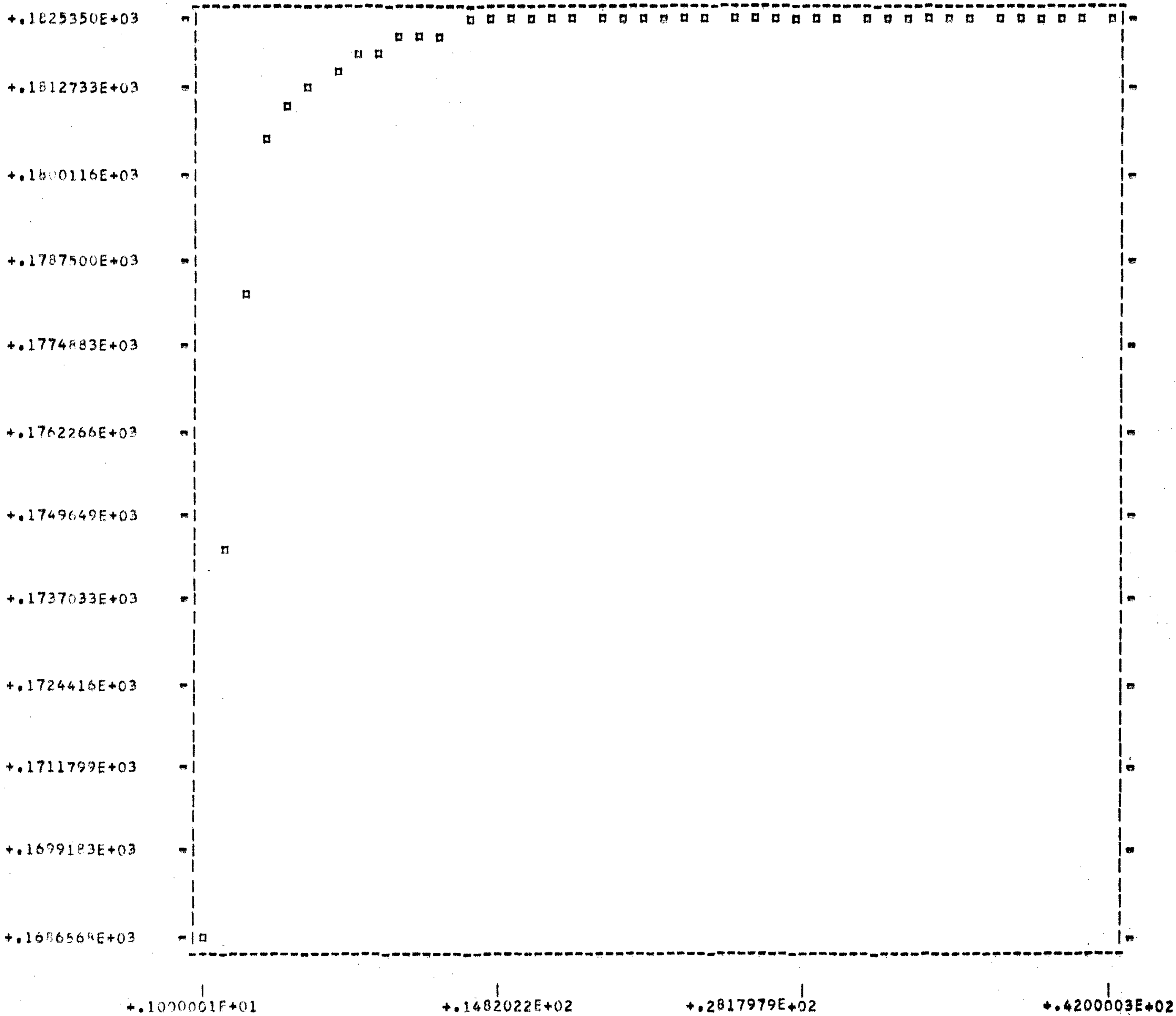


PLOT OF TRIAL VERSUS T(6)

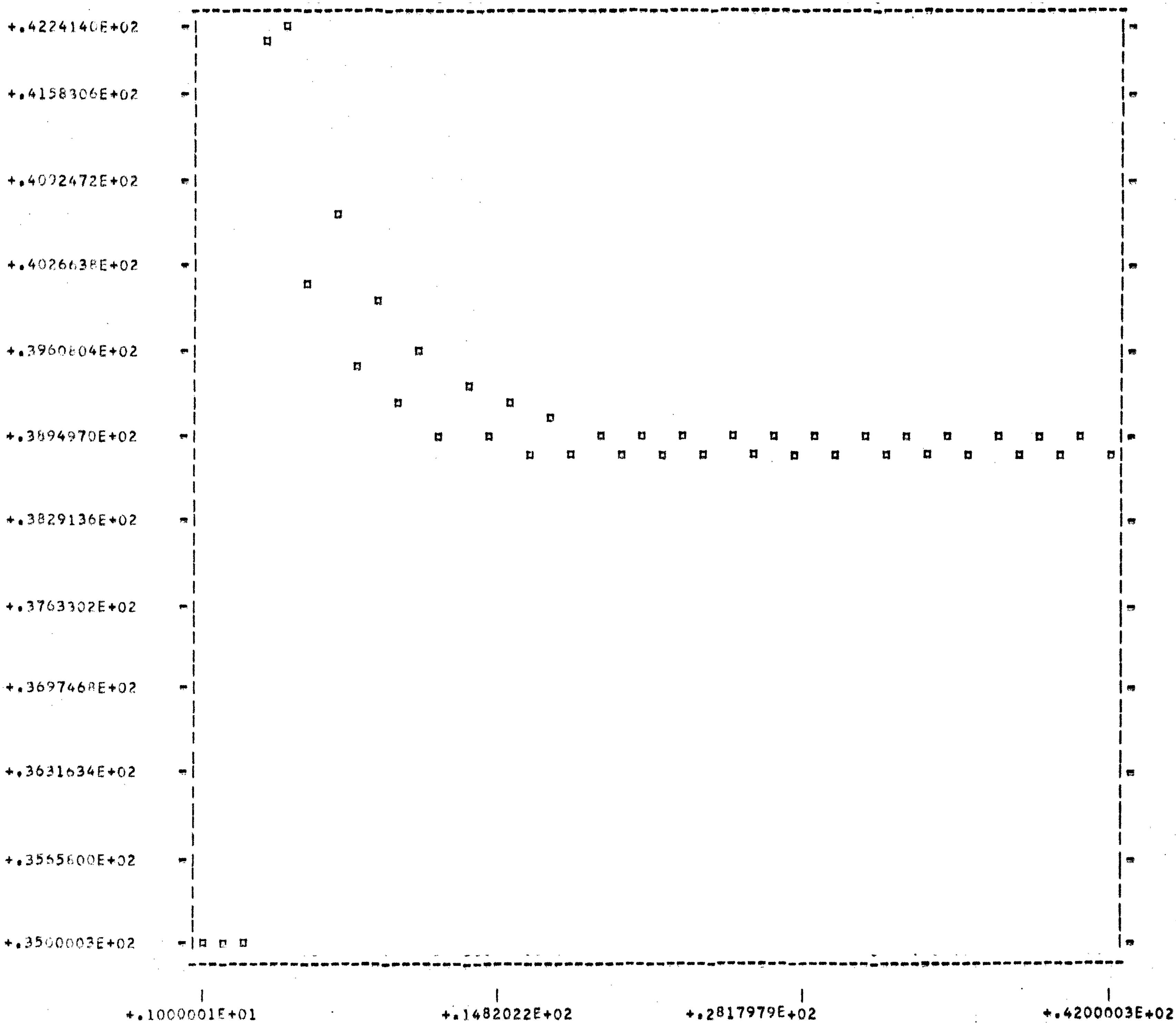


162.

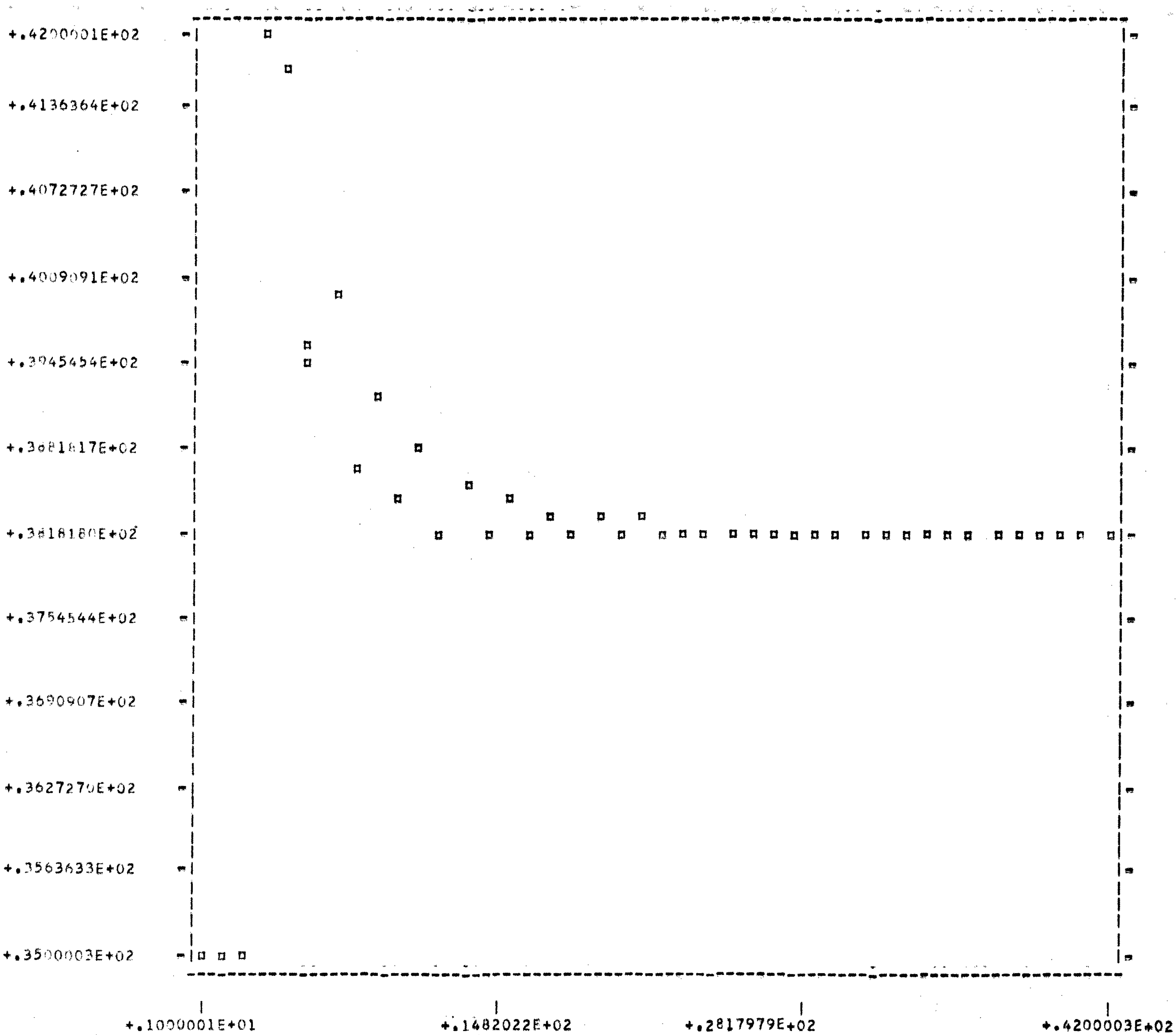
PLOT OF TRIAL VERSUS T(7)



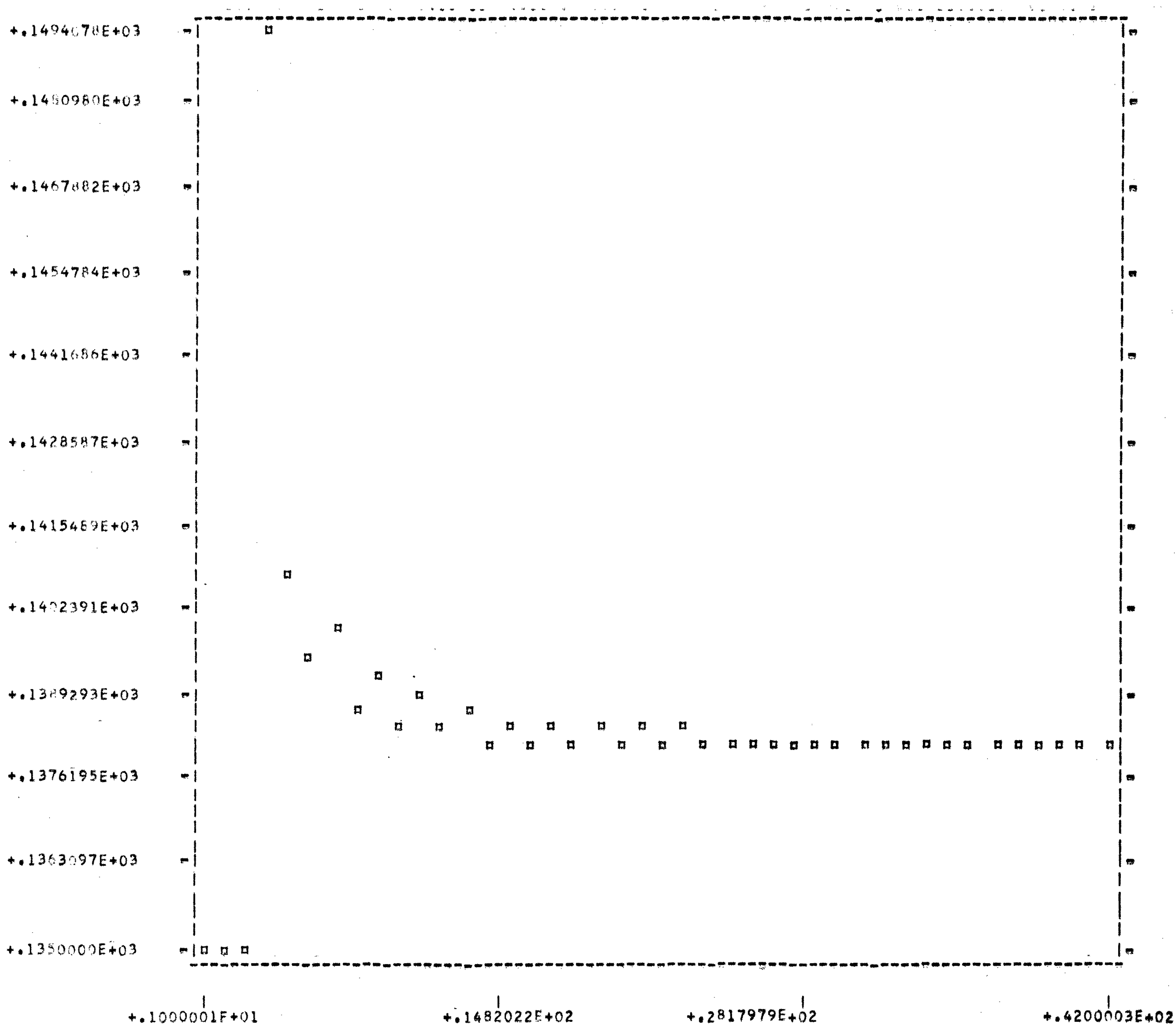
PLOT OF TRIAL VERSUS T(11)



PLOT OF TRIAL VERSUS



PLOT OF TRIAL VERSUS V(6)



PLOT OF TRIAL VERSUS

```
   16    4    8
0.0       0.0       1.0       0.0       0.0
0.0       1.0       0.0       20.0
211.3      132.0
80.0      77.5      5.0       5.0
    6    2    2
100.      .95       125.      1.3       150.      1.75      175.      2.2
200.      2.7       225.      3.25
100.      .69       125.      .95       150.      1.3       175.      1.75
200.      2.125     225.      2.65
100.      .29       125.      .44       150.      .595      175.      .81
200.      1.05      225.      1.375
100.      .235      125.      .345      150.      .49       175.      .68
200.      .885      225.      1.15
100.      009.0667  225.      013.6001
100.      008.8924  225.      013.3676
100.      010.3896  225.      015.7287
100.      010.4617  225.      015.9451
100.      016.3546  225.      020.2490
100.      017.2616  225.      020.6442
100.      020.0000  225.      024.1991
100.      020.7792  225.      025.0360
814.038   192.9000  187.11
60.        170.      320.      450.
```

```
PROBLEM PARAMETERS :

NUMBER OF STAGES       16
    STAGES COUNT FROM BOTTOM TO TOP OF TOWER
      (INCLUDES EQUILIBRUIM-STAGE REBOILER
      EXCLUDES CONDENSER-DISTILATE DRUM)

NUMBER OF COMPONENTS       4

FEED STAGE LOCATION        8

TEMPERATURE PROFILE CODE  0.0
    0.0 T PROFILE NOT GIVEN
        (MAX & MIN T MUST BE SUPPLIED)
    1.0 T PROFILE MUST BE SUPPLIED

THERMODYNAMIC DATA CODE  0.0
    0.0 COEFFICIENTS OF POLYNOMIALS NOT GIVEN
        MUST SUPPLY THERMODYNAMIC DATA POINTS (10 MAX)
        UNITS DEG F , M-BTU/# MOLE FOR ENTHALPY
        DIMENSIONLESS FOR V-L EQUILIBRIUM DATA
    1.0 COEFFICIENT OF POLYNOMIAL MUST BE SUPPLIED

DISTILLATE TYPE CODE  1.0
    -1.0 ALL VAPOR
     0.0 VAPOR & LIQUID (NOT OPERATIONAL)
    +1.0 ALL LIQUID

FEED CONDITION CODE  0.0
    -1.0 ALL VAPOR
     0.0 VAPOR & LIQUID
    +1.0 ALL LIQUID

VAPOR-LIQUID PROFILE CODE  0.0
    1.0 V&L PROFILE MUST BE SUPPLIED
    0.0 V&L PROFILE NOT GIVEN

VAPOR DAMPING CODE  0.0
    0.0 VAPOR & LIQUID RATE WILL BE DAMPED
    1.0 VAPOR & LIQUID RATE WILL NOT BE DAMPED

TEMPERATURE DAMPING CODE  1.0
    T NEW= T OLD + ( T NEW - T OLD) / ( T DAMPING CODE)

PRINT CODE  0.0
    1.0 WILL PRINT INTERMEDIATE TRIAL DATA
    0.0 WILL NOT PRINT INTERMEDIATE TRIAL DATA

MAX NUMBER OF TRIALS   20.00
```

GIVEN VAPOR-LIQUID EQUILIBRIUM DATA

COMPONENT # 1

T(1)=	100.0000	K(1)=	0.9500
T(2)=	125.0000	K(2)=	1.3000
T(3)=	150.0000	K(3)=	1.7500
T(4)=	175.0000	K(4)=	2.2000
T(5)=	200.0000	K(5)=	2.7000
T(6)=	225.0000	K(6)=	3.2500

COMPONENT # 2

T(1)=	100.0000	K(1)=	0.6900
T(2)=	125.0000	K(2)=	0.9500
T(3)=	150.0000	K(3)=	1.3000
T(4)=	175.0000	K(4)=	1.7500
T(5)=	200.0000	K(5)=	2.1250
T(6)=	225.0000	K(6)=	2.6500

COMPONENT # 3

T(1)=	100.0000	K(1)=	0.2900
T(2)=	125.0000	K(2)=	0.4400
T(3)=	150.0000	K(3)=	0.5950
T(4)=	175.0000	K(4)=	0.8100
T(5)=	200.0000	K(5)=	1.0500
T(6)=	225.0000	K(6)=	1.3750

COMPONENT # 4

T(1)=	100.0000	K(1)=	0.2350
T(2)=	125.0000	K(2)=	0.3450
T(3)=	150.0000	K(3)=	0.4900
T(4)=	175.0000	K(4)=	0.6800
T(5)=	200.0000	K(5)=	0.8850
T(6)=	225.0000	K(6)=	1.1500

GIVEN LIQUID ENTHALPY

COMPONENT # 1

	DEG. F		M-BTU/# MOLE
T(1)=	100.0000	HL(1)=	9.0667
T(2)=	225.0000	HL(2)=	13.6001

COMPONENT # 2

	DEG. F		M-BTU/# MOLE
T(1)=	100.0000	HL(1)=	8.8924
T(2)=	225.0000	HL(2)=	13.3676

COMPONENT # 3

	DEG. F		M-BTU/# MOLE
T(1)=	100.0000	HL(1)=	10.3896
T(2)=	225.0000	HL(2)=	15.7287

COMPONENT # 4

	DEG. F		M-BTU/# MOLE
T(1)=	100.0000	HL(1)=	10.4617
T(2)=	225.0000	HL(2)=	15.9451

GIVEN VAPOR ENTHALPY

COMPONENT # 1

	DEG. F		M-BTU/# MOLE
T(1)=	100.0000	HV(1)=	16.8548
T(2)=	225.0000	HV(2)=	20.2490

COMPONENT # 2

	DEG. F		M-BTU/# MOLE
T(1)=	100.0000	HV(1)=	17.2616
T(2)=	225.0000	HV(2)=	20.6442

COMPONENT # 3

	DEG. F		M-BTU/# MOLE
T(1)=	100.0000	HV(1)=	20.0000
T(2)=	225.0000	HV(2)=	24.1991

COMPONENT # 4

	DEG. F		M-BTU/# MOLE
T(1)=	100.0000	HV(1)=	20.7792
T(2)=	225.0000	HV(2)=	25.0360

CURVE FITTED POLYNOMIALS

POLYNOMIALS FOR VAPOR - LIQUID EQUILIBRIUM DATA ARE :

```
K( 1)= 0.22636545E 00+T*(-0.95570832E-03+T*( 0.10156029E-03+T*(-0.22779727E-06+( 0.26908209E-09)*T)))
K( 2)= 0.62274079E 00+T*(-0.15989259E-01+T*( 0.19061862E-03+T*(-0.50465934E-06+( 0.59079230E-09)*T)))
K( 3)=-0.23094201E 00+T*( 0.50661452E-02+T*( 0.32506359E-05+T*(-0.52498876E-07+( 0.35071257E-09)*T)))
K( 4)= 0.98808646E-01+T*(-0.11095745E-02+T*( 0.24785025E-04+T*(-0.59050045E-08+( 0.43610518E-10)*T)))
```

POLYNOMIALS FOR VAPOR ENTHALPY DATA ARE :

```
HV( 1)= 0.14139534E 02+T*( 0.27152997E-01+T*( 0.00000000E 00+T*( 0.00000000E 00+( 0.00000000E 00)*T)))
HV( 2)= 0.14555566E 02+T*( 0.27060498E-01+T*( 0.00000000E 00+T*( 0.00000000E 00+( 0.00000000E 00)*T)))
HV( 3)= 0.16640762E 02+T*( 0.33592500E-01+T*( 0.00000000E 00+T*( 0.00000000E 00+( 0.00000000E 00)*T)))
HV( 4)= 0.17373733E 02+T*( 0.34054499E-01+T*( 0.00000000E 00+T*( 0.00000000E 00+( 0.00000000E 00)*T)))
```

POLYNOMIALS FOR LIQUID ENTHALPY DATA ARE :

```
HL( 1)= 0.43992595E 01+T*( 0.32627310E-01+T*( 0.00000000E 00+T*( 0.00000000E 00+( 0.00000000E 00)*T)))
HL( 2)= 0.53122234E 01+T*( 0.35881686E-01+T*( 0.00000000E 00+T*( 0.00000000E 00+( 0.00000000E 00)*T)))
HL( 3)= 0.61182814E 01+T*( 0.42712998E-01+T*( 0.00000000E 00+T*( 0.00000000E 00+( 0.00000000E 00)*T)))
HL( 4)= 0.60749311E 01+T*( 0.43867499E-01+T*( 0.00000000E 00+T*( 0.00000000E 00+( 0.00000000E 00)*T)))
```

172

FEED IS PARTIALLY VAPORIZED .
FEED DEW POINT TEMPERATURE IS = 196.95827 DEG. F
FEED BUBBLE POINT TEMPERATURE IS = 182.61200 DEG. F
TEMPERATURE OF FEED IS = 187.11000 DEG. F

	MOLS/HR		MOLE FRAC		VAP MOLS/HR		VAP MOL FRAC		LIQ MOLES/HR		LIQ MOL FRAC
F(1)=	60.0000	FZ(1)=	0.0600	FV(1)=	23.6223	YF(1)=	0.1070250	FL(1)=	36.3777	XF(1)=	0.0466810
F(2)=	170.0000	FZ(2)=	0.1700	FV(2)=	57.5338	YF(2)=	0.2606670	FL(2)=	112.4661	XF(2)=	0.1443201
F(3)=	320.0000	FZ(3)=	0.3200	FV(3)=	62.7451	YF(3)=	0.2842776	FL(3)=	257.2551	XF(3)=	0.3301181
F(4)=	450.0000	FZ(4)=	0.4500	FV(4)=	76.8166	YF(4)=	0.3480311	FL(4)=	373.1833	XF(4)=	0.4788809
TOTAL	1000.0000		1.0000		220.7178		1.0000000		779.2822		1.0000000

VALUE OF DISTILLATE IS = 192.9000 VALUE OF EXTERNAL REFLUX IS = 814.0381

DISTILLATE TOLERANCE 0.19290000E-01

DISTILLATE IS ALL LIQUID .

INPUT PRESSURES :

ACCUMULATOR P	77.5000
CONDENSER DELTA P	5.0000
TOWER DELTA P	5.0000
TOWER TOP TRAY P	82.4998
TOWER BOTTOM TRAY P	87.5000

REFERENCE P FOR SUPPLIED K-DATA 80.0000

MAXIMUM TEMPERATURE IS = 211.30000 MINIMUM TEMPERATURE IS = 132.00000

THE INITIAL VAPOR , LIQUID , & TEMPERATURE PROFILES

NUMBERING IS FROM BOTTOM TO THE TOP OF THE TOWER
LAST STAGE IS THE CONDENSER-DISTILLATE DRUM
FIRST STAGE IS AN EQUILIBRIUM STAGE REBOILER

	MOLS/HR		MOLS/HR		DEG. F
V(1)=	786.220	L(1)=	807.100	T(1)=	211.3000
V(2)=	786.220	L(2)=	1593.320	T(2)=	206.0133
V(3)=	786.220	L(3)=	1593.320	T(3)=	200.7267
V(4)=	786.220	L(4)=	1593.320	T(4)=	195.4400
V(5)=	786.220	L(5)=	1593.320	T(5)=	190.1533
V(6)=	786.220	L(6)=	1593.320	T(6)=	184.8667
V(7)=	786.220	L(7)=	1593.320	T(7)=	179.5800
V(8)=	786.220	L(8)=	1593.320	T(8)=	174.2933
V(9)=	1006.938	L(9)=	814.038	T(9)=	169.0067
V(10)=	1006.938	L(10)=	814.038	T(10)=	163.7200
V(11)=	1006.938	L(11)=	814.038	T(11)=	158.4333
V(12)=	1006.938	L(12)=	814.038	T(12)=	153.1467
V(13)=	1006.938	L(13)=	814.038	T(13)=	147.8600
V(14)=	1006.938	L(14)=	814.038	T(14)=	142.5733
V(15)=	1006.938	L(15)=	814.038	T(15)=	137.2867
V(16)=	1006.938	L(16)=	814.038	T(16)=	132.0000
V(17)=	0.000	L(17)=	814.038	T(17)=	132.0000

```
CALCULATED D= 181.00902   FOR THETA = 1.00
D CORRECTED = 192.93997   THETA =   0.73741   D SPEC = 192.89999

CALCULATED D= 192.11601   FOR THETA = 1.00
D CORRECTED = 192.90004   THETA =   0.97870   D SPEC = 192.89999

CALCULATED D= 192.71727   FOR THETA = 1.00
D CORRECTED = 192.90012   THETA =   0.99499   D SPEC = 192.89999

CALCULATED D= 192.75005   FOR THETA = 1.00
D CORRECTED = 192.90001   THETA =   0.99589   D SPEC = 192.89999

CALCULATED D= 184.96341   FOR THETA = 1.00
D CORRECTED = 192.89995   THETA =   0.82092   D SPEC = 192.89999

CALCULATED D= 191.45107   FOR THETA = 1.00
D CORRECTED = 192.91078   THETA =   0.96490   D SPEC = 192.89999

CALCULATED D= 191.87067   FOR THETA = 1.00
D CORRECTED = 192.90726   THETA =   0.97555   D SPEC = 192.89999

CALCULATED D= 192.50420   FOR THETA = 1.00
D CORRECTED = 192.90594   THETA =   0.99057   D SPEC = 192.89999

CALCULATED D= 192.72409   FOR THETA = 1.00
D CORRECTED = 192.90529   THETA =   0.99576   D SPEC = 192.89999

CALCULATED D= 192.82771   FOR THETA = 1.00
D CORRECTED = 192.90508   THETA =   0.99819   D SPEC = 192.89999

CALCULATED D= 192.87206   FOR THETA = 1.00
D CORRECTED = 192.90503   THETA =   0.99923   D SPEC = 192.89999

CALCULATED D= 192.89076   FOR THETA = 1.00
CALCULATED D= 192.87265   FOR THETA = 1.00
D CORRECTED = 192.90492   THETA =   0.99925   D SPEC = 192.89999

CALCULATED D= 192.91437   FOR THETA = 1.00
CALCULATED D= 192.92003   FOR THETA = 1.00
D CORRECTED = 192.90492   THETA =   1.00035   D SPEC = 192.89999

CALCULATED D= 192.89679   FOR THETA = 1.00
CALCULATED D= 192.89052   FOR THETA = 1.00
```

TOWER CONVERGED AT TRIAL # 17.00

FINAL VAPOR , LIQUID & TEMPERATURE PROFILE

NUMBERING IS FROM BOTTOM TO THE TOP OF THE TOWER
LAST STAGE IS THE CONDENSER-DISTILLATE DRUM
FIRST STAGE IS AN EQUILIBRIUM STAGE REBOILER

	MOLS/HR		MOLS/HR		DEG. F
V(1)=	730.322	L(1)=	807.109	T(1)=	206.023
V(2)=	723.412	L(2)=	1537.430	T(2)=	201.898
V(3)=	717.312	L(3)=	1530.521	T(3)=	198.243
V(4)=	712.110	L(4)=	1524.421	T(4)=	195.081
V(5)=	707.687	L(5)=	1519.219	T(5)=	192.411
V(6)=	703.860	L(6)=	1514.796	T(6)=	190.189
V(7)=	700.462	L(7)=	1510.969	T(7)=	188.349
V(8)=	698.759	L(8)=	1507.571	T(8)=	186.814
V(9)=	920.287	L(9)=	726.587	T(9)=	184.187
V(10)=	921.719	L(10)=	727.397	T(10)=	180.061
V(11)=	926.096	L(11)=	728.829	T(11)=	173.782
V(12)=	937.469	L(12)=	733.205	T(12)=	164.930
V(13)=	957.996	L(13)=	744.578	T(13)=	154.213
V(14)=	983.392	L(14)=	765.106	T(14)=	143.628
V(15)=	1006.294	L(15)=	790.501	T(15)=	134.994
V(16)=	1006.928	L(16)=	813.404	T(16)=	128.676
V(17)=	0.000	L(17)=	814.038	T(17)=	119.466

```
DISTILLATE:
          MOLS/HR                     MOL FRAC              K-VALUES
    D( 1)=    55.7444        X( 1)= 0.2889948        K( 1)= 1.2676907
    D( 2)=   129.1476        X( 2)= 0.6695283        K( 2)= 0.9217829
    D( 3)=     6.3047        X( 3)= 0.0326853        K( 3)= 0.4155948
    D( 4)=     1.6939        X( 4)= 0.0087815        K( 4)= 0.3290849
           ----------               ---------
       D =   192.8905      TOTAL = 1.0000000

TEMPERATURE =     119.47 DEG. F   VAPOR ENTHALPY =        0.0000  M-BTU/HR   LIQ. ENTHALPY =    1873.1172 M-BTU/HR

CONDENSER DUTY =      8395.3125  M-BUT/HR


BOTTOMS :
          MOLS/HR                     MOL FRAC              K-VALUES
    B( 1)=     4.2556        X( 1)= 0.0052727        K( 1)= 2.5901604
    B( 2)=    40.8524        X( 2)= 0.0506157        K( 2)= 2.0761061
    B( 3)=   313.6951        X( 3)= 0.3886651        K( 3)= 1.0272264
    B( 4)=   448.3059        X( 4)= 0.5554466        K( 4)= 0.8677942
           ----------               ---------
       B =   807.1089      TOTAL = 1.0000000

TEMPERATURE =     206.02 DEG. F   VAPOR ENTHALPY =        0.0000  M-BTU/HR   LIQ. ENTHALPY =   12028.1090 M-BTU/HR

REBOILER DUTY =     6695.4882  M-BTU/HR
```

MATRIAL BALANCE (MOLS/HR) :

----------IN----------		-----------------OUT-----------------			
F(1)=	60.0000	D(1)=	55.7444	B(1)=	4.2556
F(2)=	170.0000	D(2)=	129.1476	B(2)=	40.8524
F(3)=	320.0000	D(3)=	6.3047	B(3)=	313.6951
F(4)=	450.0000	D(4)=	1.6939	B(4)=	448.3059
TOTAL	1000.0000		192.8905		807.1089

ENTHALPY BALANCE (M-BTU/HR) :

FEED	15601.0500	DISTILLATE	1873.1172
REBOILER	6695.4882	BOTTOM	12028.1090
		CONDENSER	8395.3125
TOTAL	22296.5390		22296.5390

PLATE NUMBER = 1 (EQ. STAGE REBOILER)

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(1, 1)= 9.9740	Y(1)= 0.0136570	L(1, 1)= 4.2556	X(1)= 0.0052727	K(1)= 2.590160
V(1, 2)= 76.7446	Y(2)= 0.1050833	L(1, 2)= 40.8524	X(2)= 0.0506157	K(2)= 2.076106
V(1, 3)= 291.5786	Y(3)= 0.3992469	L(1, 3)= 313.6951	X(3)= 0.3886651	K(3)= 1.027226
V(1, 4)= 352.0244	Y(4)= 0.4820129	L(1, 4)= 448.3059	X(4)= 0.5554466	K(4)= 0.867794
V(1)= 730.3215	TOTAL = 1.0000000	L(1)= 807.1089	TOTAL = 1.0000000	

TEMPERATURE = 206.02 DEG. F VAPOR ENTHALPY = 17197.5580 M-BTU/HR LIQ. ENTHALPY = 12028.1090 M-BTU/HR

PLATE NUMBER = 2

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(2, 1)= 16.8720	Y(1)= 0.0233228	L(2, 1)= 14.2297	X(1)= 0.0092555	K(1)= 2.519907
V(2, 2)= 111.3713	Y(2)= 0.1539527	L(2, 2)= 117.5970	X(2)= 0.0764893	K(2)= 2.012740
V(2, 3)= 281.0137	Y(3)= 0.3884558	L(2, 3)= 605.2734	X(3)= 0.3936917	K(3)= 0.986701
V(2, 4)= 314.1553	Y(4)= 0.4342687	L(2, 4)= 800.3301	X(4)= 0.5205635	K(4)= 0.834228
V(2)= 723.4121	TOTAL = 1.0000000	L(2)= 1537.4302	TOTAL = 0.9999999	

TEMPERATURE = 201.90 DEG. F VAPOR ENTHALPY = 16760.8160 M-BTU/HR LIQ. ENTHALPY = 22529.5310 M-BTU/HR

PLATE NUMBER = 3

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(3, 1)= 24.3491	Y(1)= 0.0339449	L(3, 1)= 21.1277	X(1)= 0.0138042	K(1)= 2.459031
V(3, 2)= 139.6744	Y(2)= 0.1947192	L(3, 2)= 152.2237	X(2)= 0.0994588	K(2)= 1.957793
V(3, 3)= 265.4663	Y(3)= 0.3700848	L(3, 3)= 594.7085	X(3)= 0.3885661	K(3)= 0.952438
V(3, 4)= 287.8223	Y(4)= 0.4012511	L(3, 4)= 762.4609	X(4)= 0.4981709	K(4)= 0.805449
V(3)= 717.3120	TOTAL = 1.0000000	L(3)= 1530.5208	TOTAL = 0.9999999	

TEMPERATURE = 198.24 DEG. F VAPOR ENTHALPY = 16386.7380 M-BTU/HR LIQ. ENTHALPY = 22092.7460 M-BTU/HR

PLATE NUMBER = 4

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(4, 1)= 32.1742	Y(1)= 0.0451814	L(4, 1)= 28.6047	X(1)= 0.0187643	K(1)= 2.407846
V(4, 2)= 161.1990	Y(2)= 0.2263680	L(4, 2)= 180.5269	X(2)= 0.1184232	K(2)= 1.911523
V(4, 3)= 250.0302	Y(3)= 0.3511116	L(4, 3)= 579.1614	X(3)= 0.3799222	K(3)= 0.924168
V(4, 4)= 268.7070	Y(4)= 0.3773390	L(4, 4)= 736.1282	X(4)= 0.4828904	K(4)= 0.781418
V(4)= 712.1104	TOTAL = 1.0000000	L(4)= 1524.4209	TOTAL = 1.0000000	

TEMPERATURE = 195.08 DEG. F VAPOR ENTHALPY = 16075.4290 M-BTU/HR LIQ. ENTHALPY = 21718.6670 M-BTU/HR

PLATE NUMBER = 5

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(5, 1)= 40.1532	Y(1)= 0.0567386	L(5, 1)= 36.4298	X(1)= 0.0239793	K(1)= 2.366156
V(5, 2)= 176.3548	Y(2)= 0.2491988	L(5, 2)= 202.0515	X(2)= 0.1329969	K(2)= 1.873721
V(5, 3)= 236.7095	Y(3)= 0.3344833	L(5, 3)= 563.7251	X(3)= 0.3710625	K(3)= 0.901421
V(5, 4)= 254.4698	Y(4)= 0.3595796	L(5, 4)= 717.0125	X(4)= 0.4719613	K(4)= 0.761884
V(5)= 707.6870	TOTAL = 1.0000000	L(5)= 1519.2188	TOTAL = 0.9999999	

TEMPERATURE = 192.41 DEG. F VAPOR ENTHALPY = 15820.1870 M-BTU/HR LIQ. ENTHALPY = 21407.3550 M-BTU/HR

PLATE NUMBER = 6

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(6, 1)= 48.1421	Y(1)= 0.0683972	L(6, 1)= 44.4088	X(1)= 0.0293167	K(1)= 2.333053
V(6, 2)= 186.0648	Y(2)= 0.2643490	L(6, 2)= 217.2072	X(2)= 0.1433904	K(2)= 1.843565
V(6, 3)= 225.9433	Y(3)= 0.3210058	L(6, 3)= 550.4043	X(3)= 0.3633521	K(3)= 0.883457
V(6, 4)= 243.7102	Y(4)= 0.3462479	L(6, 4)= 702.7754	X(4)= 0.4639407	K(4)= 0.746320
V(6)= 703.8604	TOTAL = 1.0000000	L(6)= 1514.7957	TOTAL = 0.9999999	

TEMPERATURE = 190.19 DEG. F VAPOR ENTHALPY = 15611.2180 M-BTU/HR LIQ. ENTHALPY = 21152.1560 M-BTU/HR

PLATE NUMBER = 7

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(7, 1)= 56.0433	Y(1)= 0.0800090	L(7, 1)= 52.3978	X(1)= 0.0346783	K(1)= 2.307185
V(7, 2)= 191.4382	Y(2)= 0.2733025	L(7, 2)= 226.9173	X(2)= 0.1501800	K(2)= 1.819837
V(7, 3)= 217.4949	Y(3)= 0.3105019	L(7, 3)= 539.6379	X(3)= 0.3571470	K(3)= 0.869396
V(7, 4)= 235.4861	Y(4)= 0.3361866	L(7, 4)= 692.0156	X(4)= 0.4579947	K(4)= 0.734042
V(7)= 700.4624	TOTAL = 0.9999999	L(7)= 1510.9685	TOTAL = 0.9999999	

TEMPERATURE = 188.35 DEG. F VAPOR ENTHALPY = 15438.3550 M-BTU/HR LIQ. ENTHALPY = 20943.2260 M-BTU/HR

PLATE NUMBER = 8

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(8, 1)= 63.9204	Y(1)= 0.0914771	L(8, 1)= 60.2989	X(1)= 0.0399974	K(1)= 2.287077
V(8, 2)= 193.9308	Y(2)= 0.2775362	L(8, 2)= 232.2906	X(2)= 0.1540827	K(2)= 1.801216
V(8, 3)= 211.3366	Y(3)= 0.3024457	L(8, 3)= 531.1897	X(3)= 0.3523481	K(3)= 0.858372
V(8, 4)= 229.5713	Y(4)= 0.3285415	L(8, 4)= 683.7915	X(4)= 0.4535718	K(4)= 0.724343
V(8)= 698.7588	TOTAL = 1.0000000	L(8)= 1507.5706	TOTAL = 1.0000000	

TEMPERATURE = 186.91 DEG. F VAPOR ENTHALPY = 15323.2380 M-BTU/HR LIQ. ENTHALPY = 20770.3750 M-BTU/HR

PLATE NUMBER = 9

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(9, 1)= 90.4726	Y(1)= 0.0983091	L(9, 1)= 31.7984	X(1)= 0.0437641	K(1)= 2.246334
V(9, 2)= 273.3525	Y(2)= 0.2970296	L(9, 2)= 122.3172	X(2)= 0.1683450	K(2)= 1.764408
V(9, 3)= 284.0337	Y(3)= 0.3086360	L(9, 3)= 267.7771	X(3)= 0.3685411	K(3)= 0.837453
V(9, 4)= 272.4285	Y(4)= 0.2960255	L(9, 4)= 304.6941	X(4)= 0.4193499	K(4)= 0.705915
V(9)= 920.2871	TOTAL = 1.0000000	L(9)= 726.5867	TOTAL = 1.0000000	

TEMPERATURE = 184.19 DEG. F VAPOR ENTHALPY = 19998.7730 M-BTU/HR LIQ. ENTHALPY = 9899.6171 M-BTU/HR

PLATE NUMBER = 10

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(10, 1)= 95.8257	Y(1)= 0.1039640	L(10, 1)= 34.7283	X(1)= 0.0477433	K(1)= 2.177558
V(10, 2)= 311.1868	Y(2)= 0.3376156	L(10, 2)= 144.2051	X(2)= 0.1982481	K(2)= 1.702992
V(10, 3)= 282.8181	Y(3)= 0.3068376	L(10, 3)= 277.7290	X(3)= 0.3818121	K(3)= 0.803634
V(10, 4)= 231.8887	Y(4)= 0.2515829	L(10, 4)= 270.7346	X(4)= 0.3721965	K(4)= 0.675941
V(10)= 921.7190	TOTAL = 1.0000000	L(10)= 727.3970	TOTAL = 0.9999999	

TEMPERATURE = 18[illegible].06 DEG. F VAPOR ENTHALPY = 19736.8590 M-BTU/HR LIQ. ENTHALPY = 9729.7578 M-BTU/HR

180

PLATE NUMBER = 11

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(11, 1)= 105.4007	Y(1)= 0.1138119	L(11, 1)= 40.0813	X(1)= 0.0549942	K(1)= 2.069519
V(11, 2)= 371.7996	Y(2)= 0.4014699	L(11, 2)= 182.0393	X(2)= 0.2497696	K(2)= 1.607357
V(11, 3)= 264.4297	Y(3)= 0.2855965	L(11, 3)= 276.5134	X(3)= 0.3793942	K(3)= 0.752769
V(11, 4)= 184.4059	Y(4)= 0.1991218	L(11, 4)= 230.1949	X(4)= 0.3158421	K(4)= 0.630448
V(11)= 926.0957	TOTAL = 1.0000000	L(11)= 728.8289	TOTAL = 1.0000000	

TEMPERATURE = 173.78 DEG. F VAPOR ENTHALPY = 19388.3160 M-BTU/HR LIQ. ENTHALPY = 9467.8476 M-BTU/HR

PLATE NUMBER = 12

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(12, 1)= 121.6889	Y(1)= 0.1298058	L(12, 1)= 49.6564	X(1)= 0.0677251	K(1)= 1.916652
V(12, 2)= 457.0572	Y(2)= 0.4875760	L(12, 2)= 242.6520	X(2)= 0.3309469	K(2)= 1.473274
V(12, 3)= 225.8739	Y(3)= 0.2409403	L(12, 3)= 258.1851	X(3)= 0.3521320	K(3)= 0.684232
V(12, 4)= 132.8189	Y(4)= 0.1416783	L(12, 4)= 182.7120	X(4)= 0.2491962	K(4)= 0.568542
V(12)= 937.4685	TOTAL = 1.0000000	L(12)= 733.2053	TOTAL = 1.0000000	

TEMPERATURE = 164.93 DEG. F VAPOR ENTHALPY = 19022.4450 M-BTU/HR LIQ. ENTHALPY = 9119.3476 M-BTU/HR

PLATE NUMBER = 13

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(13, 1)= 147.2168	Y(1)= 0.1536716	L(13, 1)= 65.9445	X(1)= 0.0885662	K(1)= 1.735099
V(13, 2)= 555.2561	Y(2)= 0.5796016	L(13, 2)= 327.9395	X(2)= 0.4404367	K(2)= 1.315969
V(13, 3)= 171.4502	Y(3)= 0.1789675	L(13, 3)= 219.5692	X(3)= 0.2948909	K(3)= 0.606894
V(13, 4)= 84.0735	Y(4)= 0.0877597	L(13, 4)= 131.1251	X(4)= 0.1761066	K(4)= 0.498335
V(13)= 957.9961	TOTAL = 1.0000000	L(13)= 744.5779	TOTAL = 1.0000000	

TEMPERATURE = 154.21 DEG. F VAPOR ENTHALPY = 18740.6360 M-BTU/HR LIQ. ENTHALPY = 8753.5195 M-BTU/HR

PLATE NUMBER = 14

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(14, 1)= 183.6362	Y(1)= 0.1867375	L(14, 1)= 91.4724	X(1)= 0.1195552	K(1)= 1.561933
V(14, 2)= 639.9187	Y(2)= 0.6507258	L(14, 2)= 426.1086	X(2)= 0.5569278	K(2)= 1.168419
V(14, 3)= 113.8214	Y(3)= 0.1157436	L(14, 3)= 165.1455	X(3)= 0.2158466	K(3)= 0.536230
V(14, 4)= 46.0160	Y(4)= 0.0467932	L(14, 4)= 82.3797	X(4)= 0.1076710	K(4)= 0.434595
V(14)= 983.3921	TOTAL = 1.0000000	L(14)= 765.1057	TOTAL = 1.0000000	

TEMPERATURE = 143.63 DEG. F VAPOR ENTHALPY = 18581.9760 M-BTU/HR LIQ. ENTHALPY = 8471.8046 M-BTU/HR

PLATE NUMBER = 15

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(15, 1)= 232.2510	Y(1)= 0.2307984	L(15, 1)= 127.8919	X(1)= 0.1617857	K(1)= 1.426567
V(15, 2)= 686.1831	Y(2)= 0.6818913	L(15, 2)= 510.7710	X(2)= 0.6461354	K(2)= 1.055337
V(15, 3)= 66.0284	Y(3)= 0.0656154	L(15, 3)= 107.5167	X(3)= 0.1360106	K(3)= 0.482428
V(15, 4)= 21.8317	Y(4)= 0.0216952	L(15, 4)= 44.3221	X(4)= 0.0560684	K(4)= 0.386942
V(15)= 1006.2939	TOTAL = 1.0000000	L(15)= 790.5015	TOTAL = 1.0000000	

TEMPERATURE = 134.99 DEG. F VAPOR ENTHALPY = 18507.4600 M-BTU/HR LIQ. ENTHALPY = 8313.2382 M-BTU/HR

PLATE NUMBER = 16

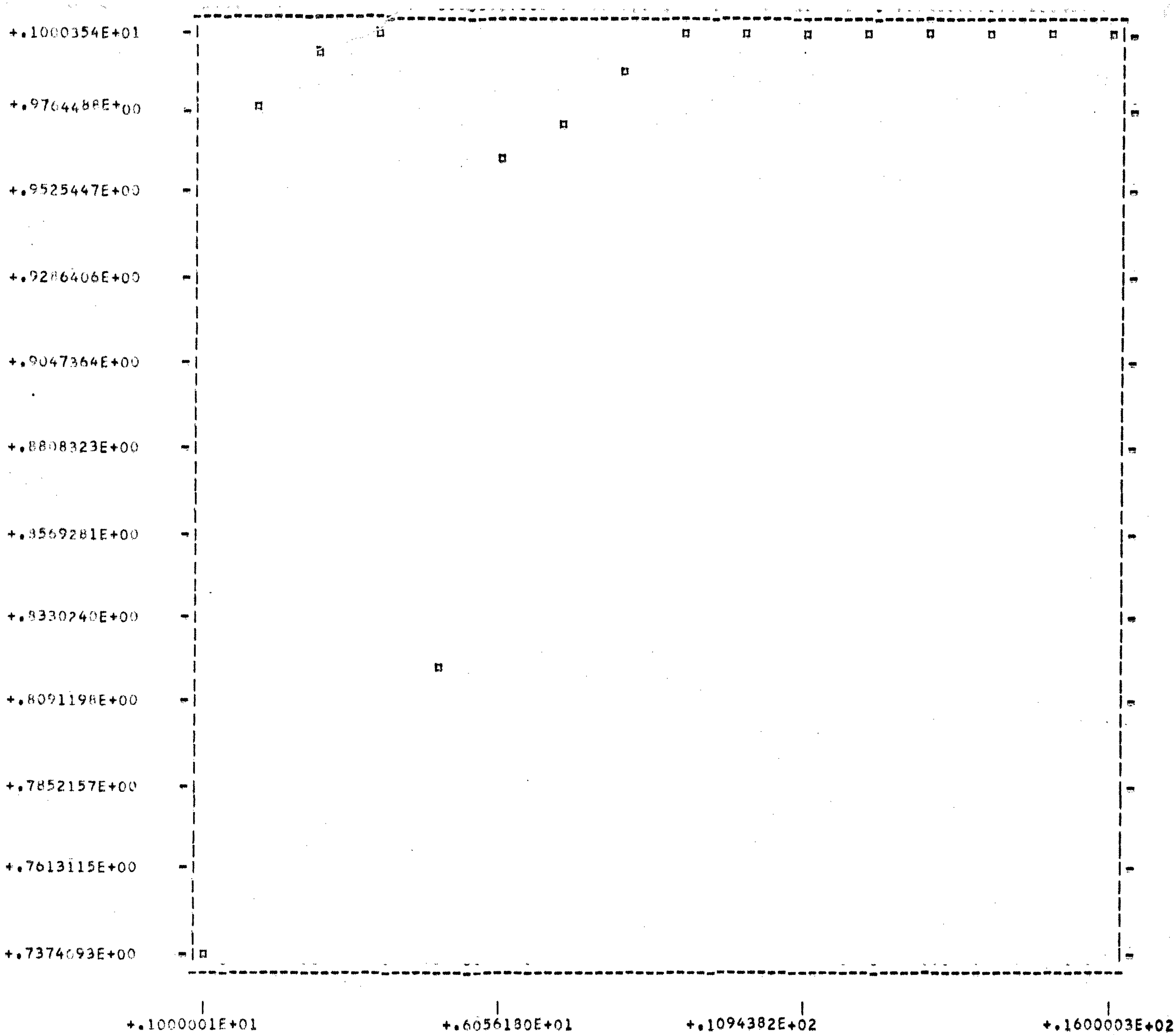
MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(16, 1)= 290.9856	Y(1)= 0.2889633	L(16, 1)= 176.5067	X(1)= 0.2169976	K(1)= 1.331787
V(16, 2)= 674.1504	Y(2)= 0.6695117	L(16, 2)= 557.0356	X(2)= 0.6848207	K(2)= 0.977684
V(16, 3)= 32.9105	Y(3)= 0.0326840	L(16, 3)= 59.7237	X(3)= 0.0734244	K(3)= 0.445156
V(16, 4)= 8.8420	Y(4)= 0.0087812	L(16, 4)= 20.1379	X(4)= 0.0247575	K(4)= 0.354701
----------	----------	----------	----------	
V(16)= 1006.9285	TOTAL = 0.9999602	L(16)= 813.4036	TOTAL = 1.0000000	

TEMPERATURE = 128.68 DEG. F   VAPOR ENTHALPY = 18173.3710 M-BTU/HR   LIQ. ENTHALPY = 8238.8085 M-BTU/HR

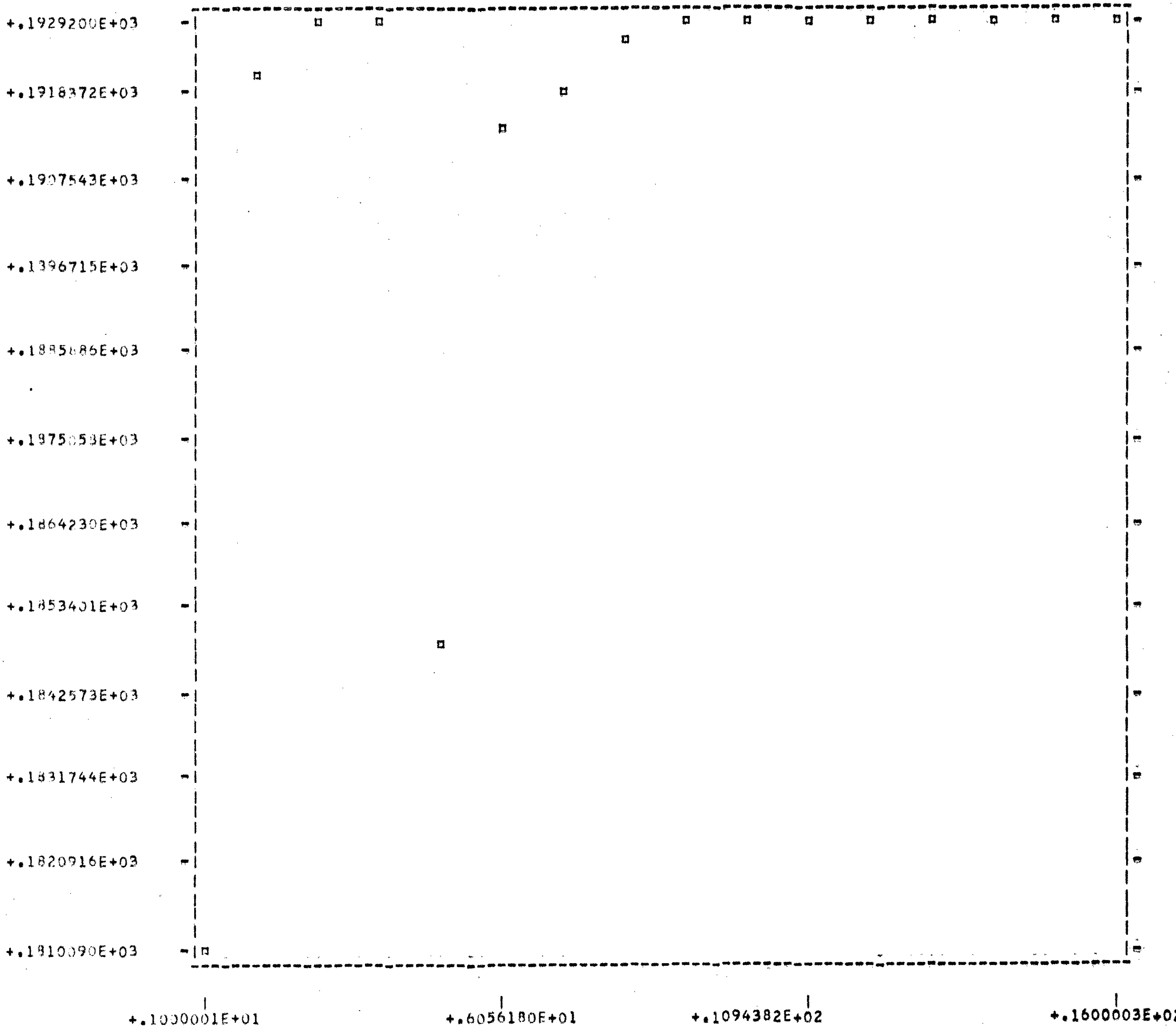
PLATE NUMBER = 17 (CONDENSER-DISTILLATE DRUM)

MOLS/HR	MOL FRAC	MOLS/HR	MOL FRAC	K-VALUES
V(17, 1)= 0.0000	Y(1)= 0.0000000	L(17, 1)= 235.2412	X(1)= 0.2889807	K(1)= 1.287691
V(17, 2)= 0.0000	Y(2)= 0.0000000	L(17, 2)= 545.0027	X(2)= 0.6695053	K(2)= 0.921783
V(17, 3)= 0.0000	Y(3)= 0.0000000	L(17, 3)= 26.6058	X(3)= 0.0326837	K(3)= 0.415595
V(17, 4)= 0.0000	Y(4)= 0.0000000	L(17, 4)= 7.1481	X(4)= 0.0087811	K(4)= 0.329085
----------	----------	----------	----------	
V(17)= 0.0000	TOTAL = 0.0000000	L(17)= 814.0378	TOTAL = 0.9999507	

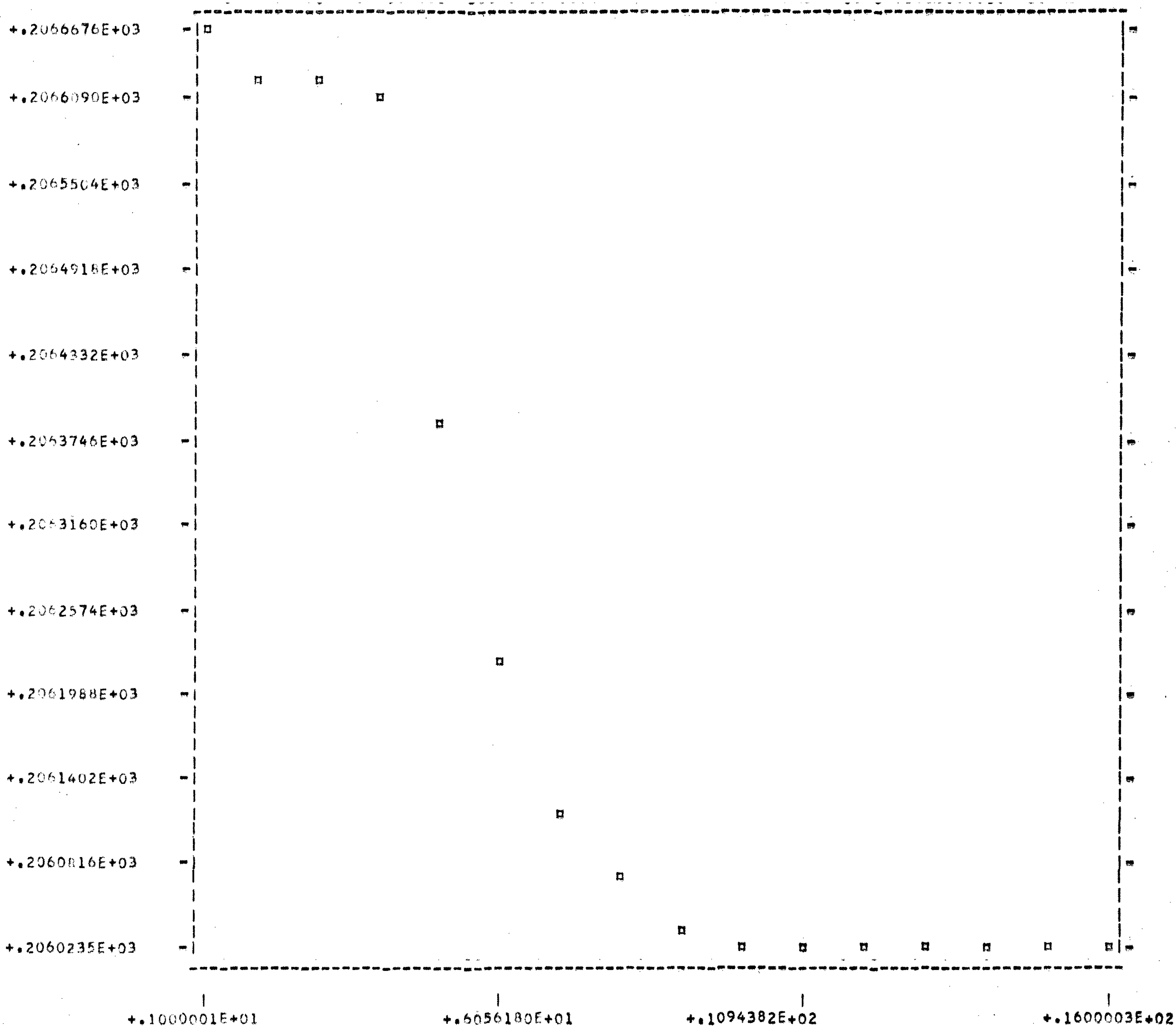
TEMPERATURE = 119.47 DEG. F   VAPOR ENTHALPY = 0.0000 M-BTU/HR   LIQ. ENTHALPY = 7904.5507 M-BTU/HR



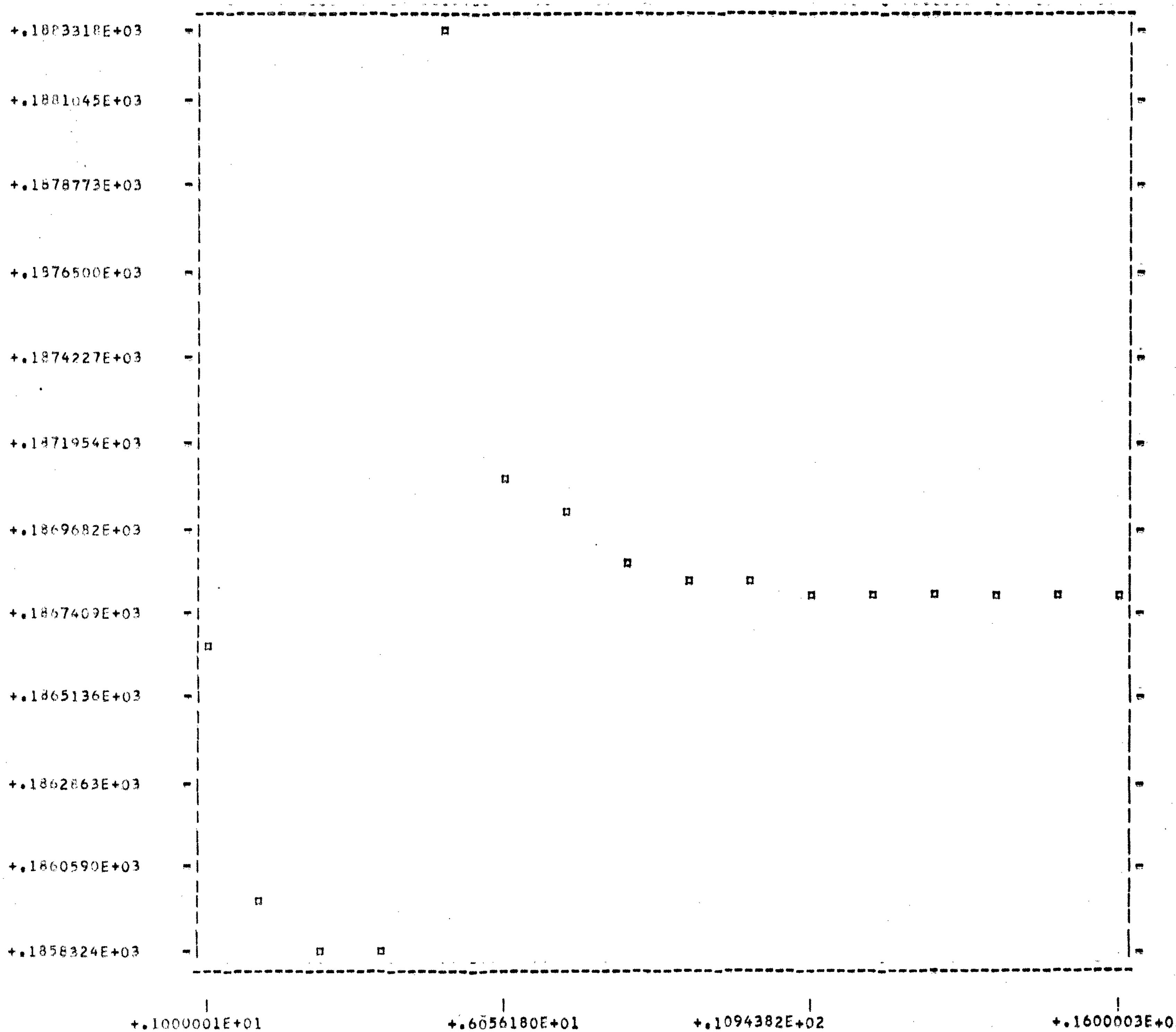
PLOT OF TRIAL VERSUS THETA



PLOT OF TRIAL VERSUS DISTILLATE



PLOT OF TRIAL VERSUS T(1)



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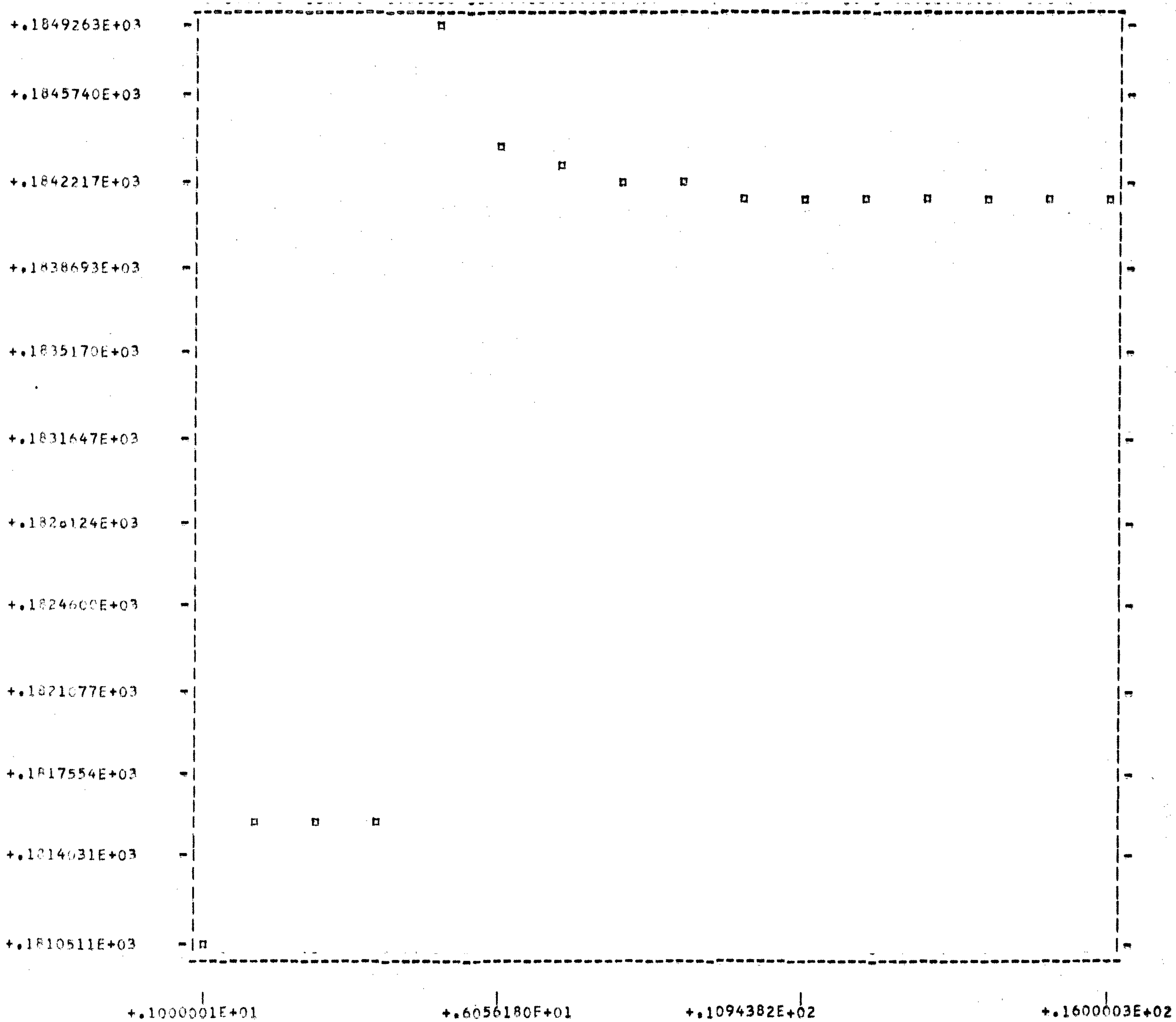
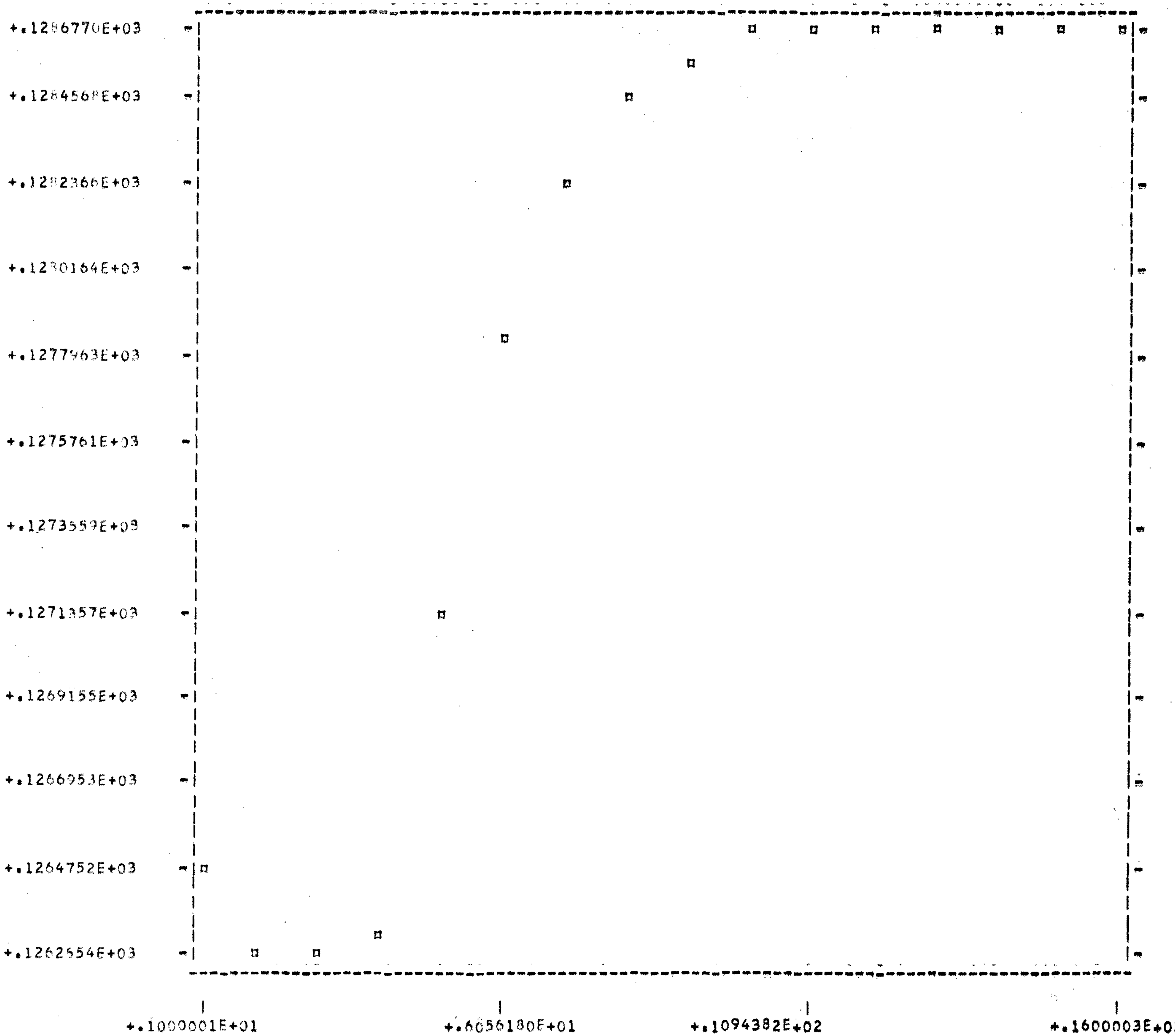
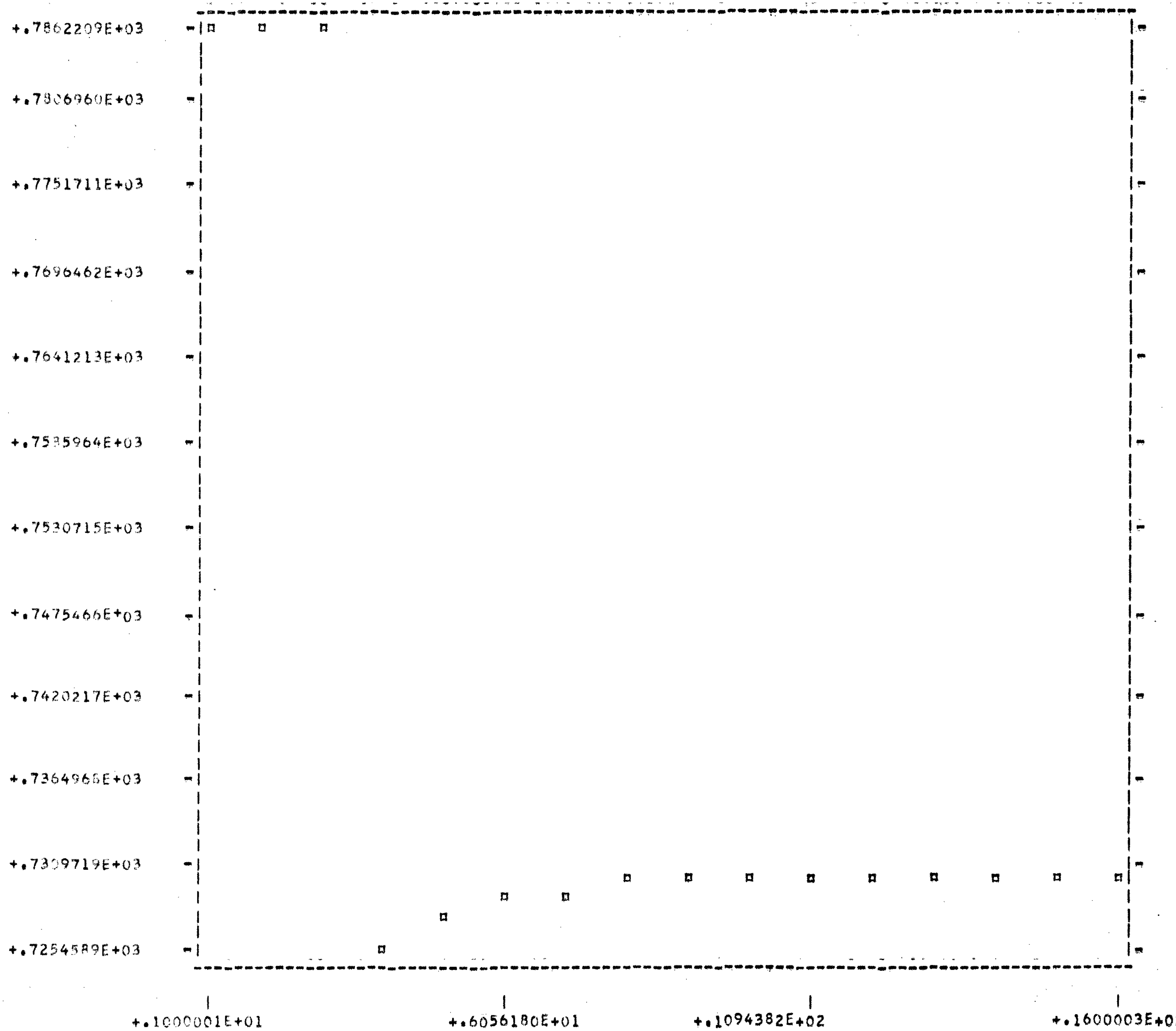


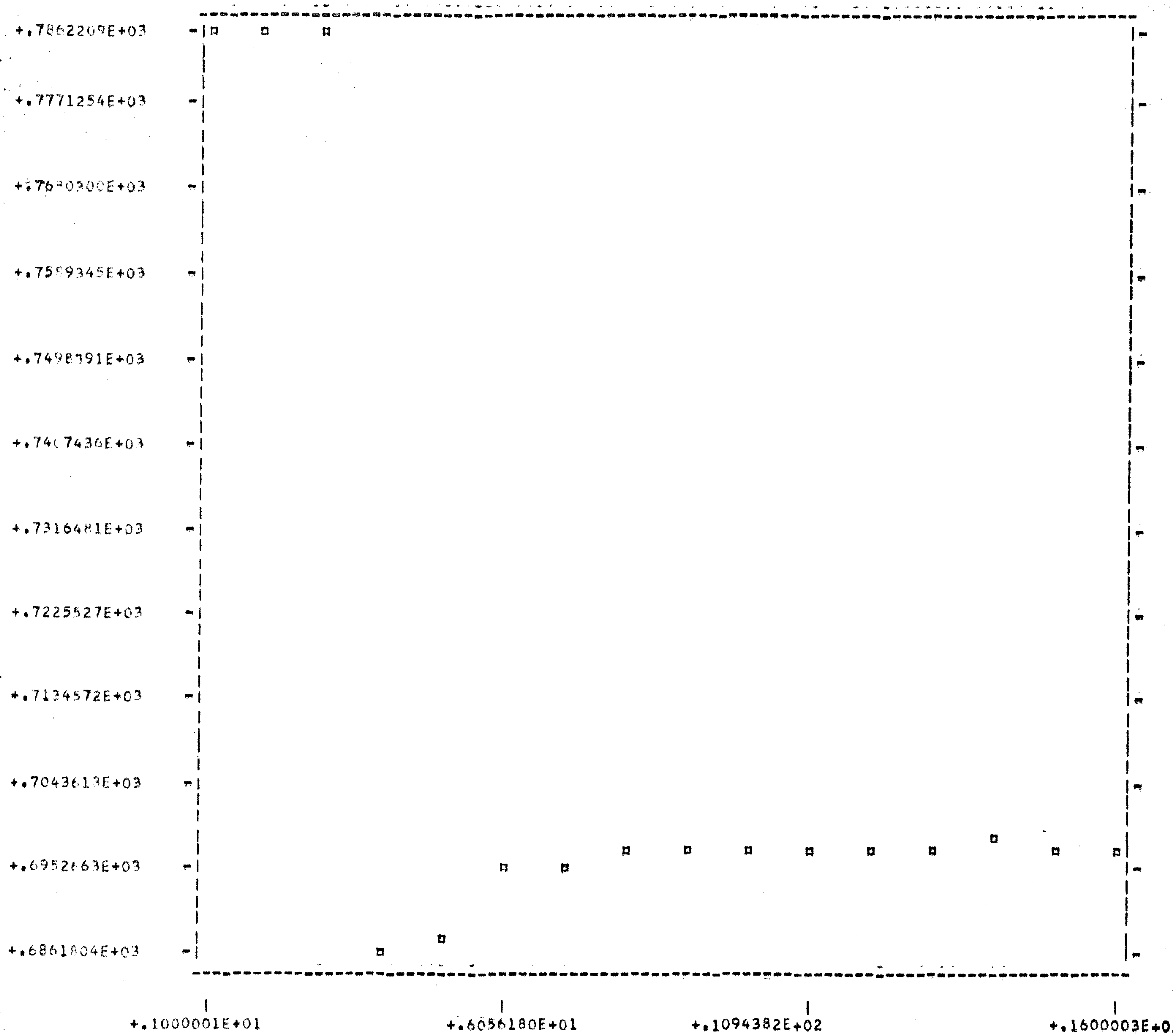
PLOT OF TRIAL VERSUS T(9)



PLOT OF TRIAL VERSUS T(16)



PLOT OF TRIAL VERSUS V(1)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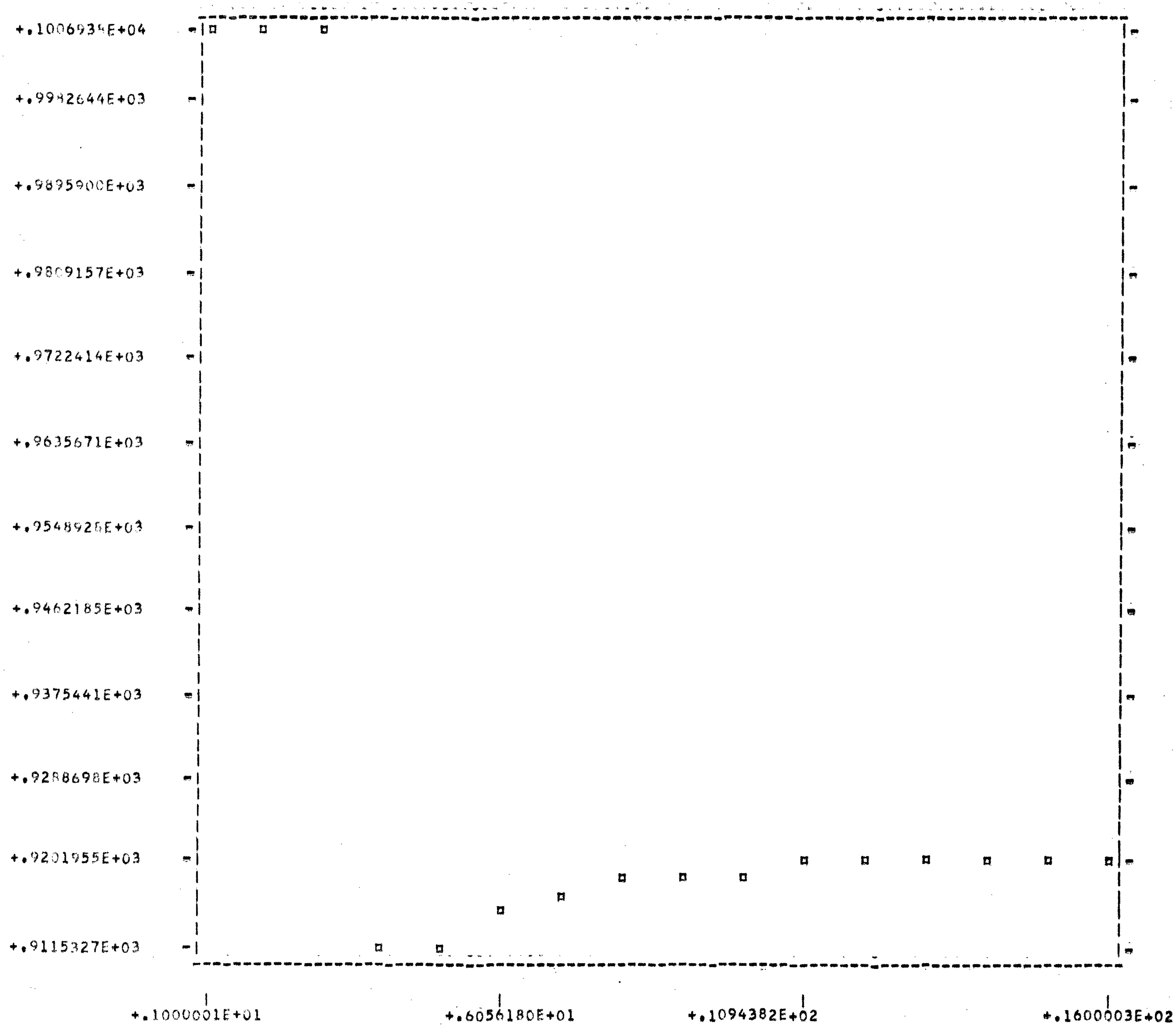

PLOT OF TRIAL VERSUS V(9)

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