

**RELAXATION CALCULATIONS FOR
MULTI-COMPONENT DISTILLATION**

By

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MULTI-COMPONENT DISTILLATION

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PREFACE

A critical evaluation of a rigorous relaxation procedure for determining the tray compositions for complex fractionators was made. In order to conduct this study, a program handling columns which have from one to three feeds, up to four side cuts, and a maximum of six intercoolers was written. Using this program, a number of solutions to published problems were obtained to verify the reliability of the procedure. An improved convergence technique was developed to decrease the convergence time and to improve the reliability of the program. Two different types of initial starting profiles were studied to determine if the reliability and convergence time are affected by the starting conditions. The effect of the ratio of time interval to tray holdup on the speed of convergence was also studied.

I wish to express my sincere thanks for the advice and guidance given by Professor J. H. Erbar and Professor R. N. Maddox, and to thank the Dow Chemical Company for their fellowship grant which made this work possible. I am also grateful to Continental Oil Company and W. L Banks of Honeywell Inc. for the use of their computing facilities, as well as the Oklahoma State University Computing Center.

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CHAPTER I

INTRODUCTION

Rigorous procedures for calculating tray and product compositions for multi-component distillation columns are time consuming and usually require the use of a digital computer in order to obtain a solution. A number of rigorous approaches to multi-component distillation problems work very well until the column configuration becomes complex, or the compositions of one or more components approach zero. At this point, the calculations become very sensitive to small changes in composition, and these calculations may break down.

A different approach to multi-component distillation was first presented by Rose (24). This procedure is an attempt to determine steady state conditions existing in a distillation column through an unsteady state approach. In this method, a system of simultaneous material balance equations for each component on each tray are solved starting with an assumed initial tray composition. The calculations are repeated until the differences in tray compositions, and temperature and vapor profiles from pass to pass are insignificant. No assumptions of key component splits or individual product rates need be made. The composition of any component can approach zero at any point in the column without significantly affecting the stability of the procedure.

The object of this study was to examine the reliability of Rose's procedure and to develop an improved convergence procedure. The purpose

of the convergence procedure is two-fold. The first objective was to decrease the total number of iterations required to reach steady state and the second to increase the reliability of the procedure. In order to evaluate the procedure and the new convergence procedure, a program based on Ball's (3) modification of Rose's unsteady state approach was written for use on the IBM 7090. This program was tested for several different types of columns including multi-feed and multi-product configurations. Comparisons were made to determine the effect that the starting conditions and the ratio of the time interval to the tray hold-up had on convergence time.

CHAPTER II

LITERATURE SURVEY

Three basic assumptions are made in most distillation calculations. They are: (1) each tray acts as an equilibrium stage, (2) there are no heat losses in the column, and (3) the reboiler and partial condenser each act as a theoretical stage. These assumptions will be employed throughout this thesis.

Also, throughout this paper reference is made to rigorous distillation procedures. Rigorous procedures are defined to be those methods which make the assumption of equilibrium stages, steady state operation, and no heat losses in the column. Any procedure assuming constant relative volatility or constant overflow is not considered to be rigorous.

The simplest methods for estimating tray compositions for distillation columns were developed by McCabe and Thiele (23) and Ponchon and Savarit (22). Their methods are based on graphical techniques. Unfortunately, these methods are usually limited to binary mixtures, and more tedious methods must be used for multi-component systems.

The McCabe-Thiele method is a graphical solution of simultaneous mass and equilibrium balances assuming constant molal overflow. A typical McCabe-Thiele diagram is shown in Figure 1. In this procedure, the operating line for the rectifying section of the column begins with the distillate composition and extends through the feed line. The equation

of this line is

$$y_{n-1} = (L/V)_r x_n + (D/V)x_d \quad (1)$$

The operating line for the stripping section of the column is extended from the intersection of the rectifying operating line with the feed line to the bottom composition. The equation of this operating line is

$$y_n = (L/V)_s x_{n-1} - (B/V)x_b \quad (2)$$

The slope of the feed line is based on the fraction of feed vaporized and is

$$\text{slope} = \frac{f'}{1-f'} \quad (3)$$

This procedure may be extended to complex column solutions by the use of pseudo products. Figure 2 is an illustration of a solution to a two-feed-three-product column.

The Ponchon-Savarit method uses an enthalpy composition plot which eliminates the assumption of constant molal overflow. This method is a graphical solution of simultaneous enthalpy and material balances. A typical plot of a Ponchon-Savarit solution for a simple column is presented in Figure 3. The location of the difference points ΔD and ΔB are given as follows:

$$\Delta D = H_d + \frac{Q_c}{D} \quad (4)$$

$$\Delta B = H_b - \frac{Q_r}{B} \quad (5)$$

The tie lines on the Ponchon-Savarit diagram connect the equilibrium compositions of the vapor and liquid lines, and the stage lines extend from the difference points to the opposite enthalpy-composition line.

A number of short-cut techniques have been proposed for estimating the product compositions and/or the number of trays that are required

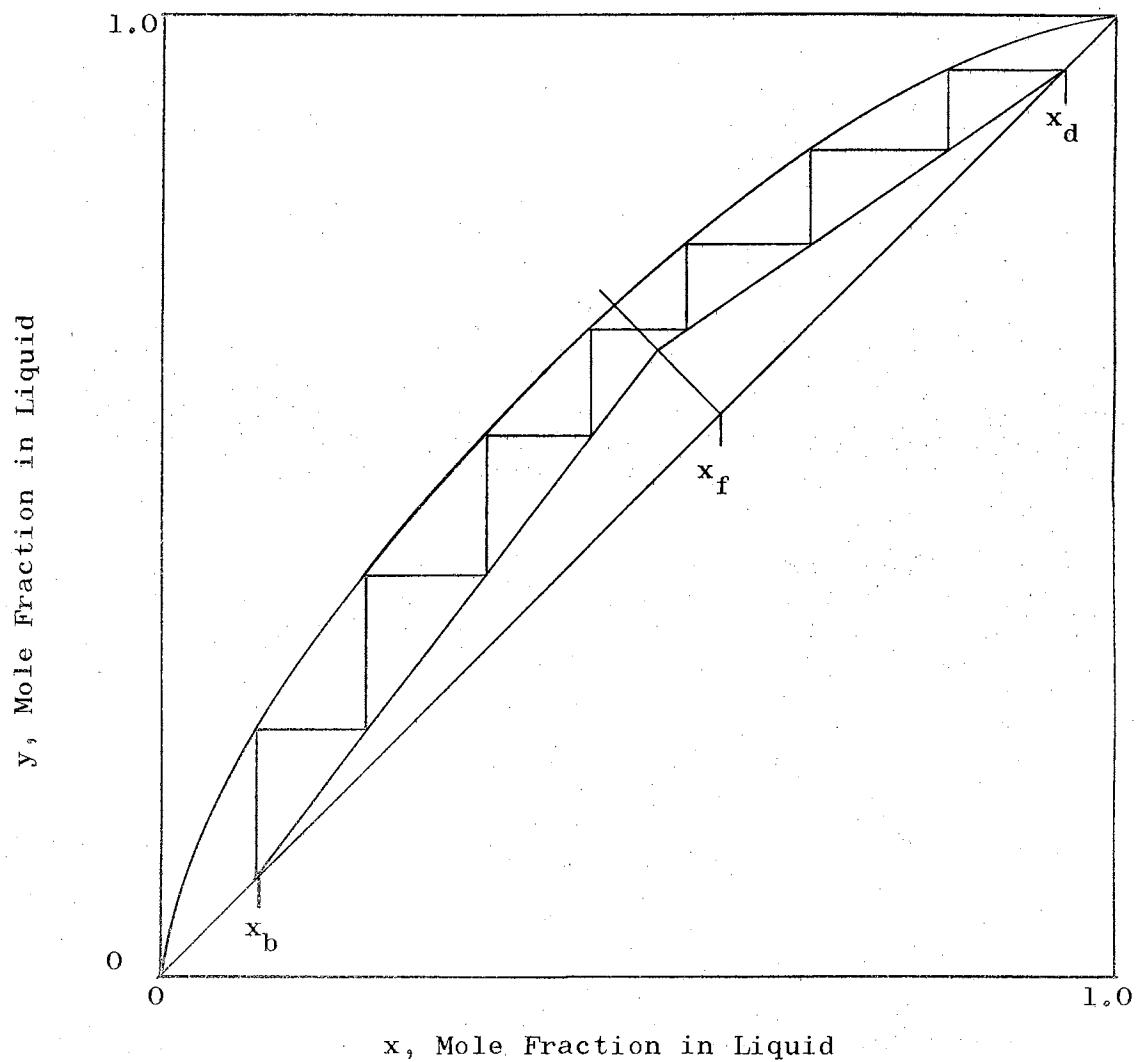


Figure 1. Typical McCabe-Thiele Diagram for a Simple Column.

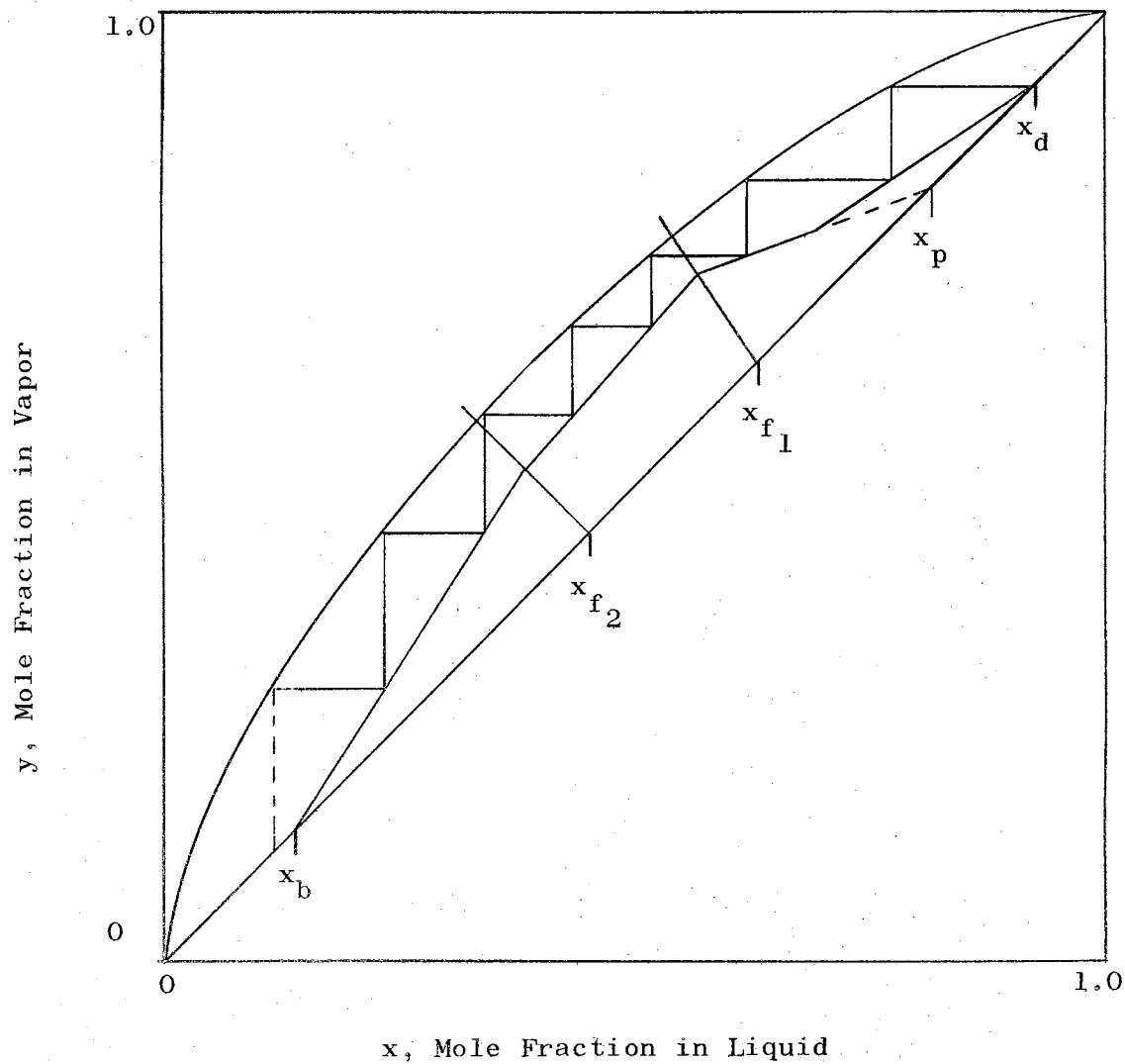


Figure 2. Typical McCabe-Thiele Diagram for a Complex Column

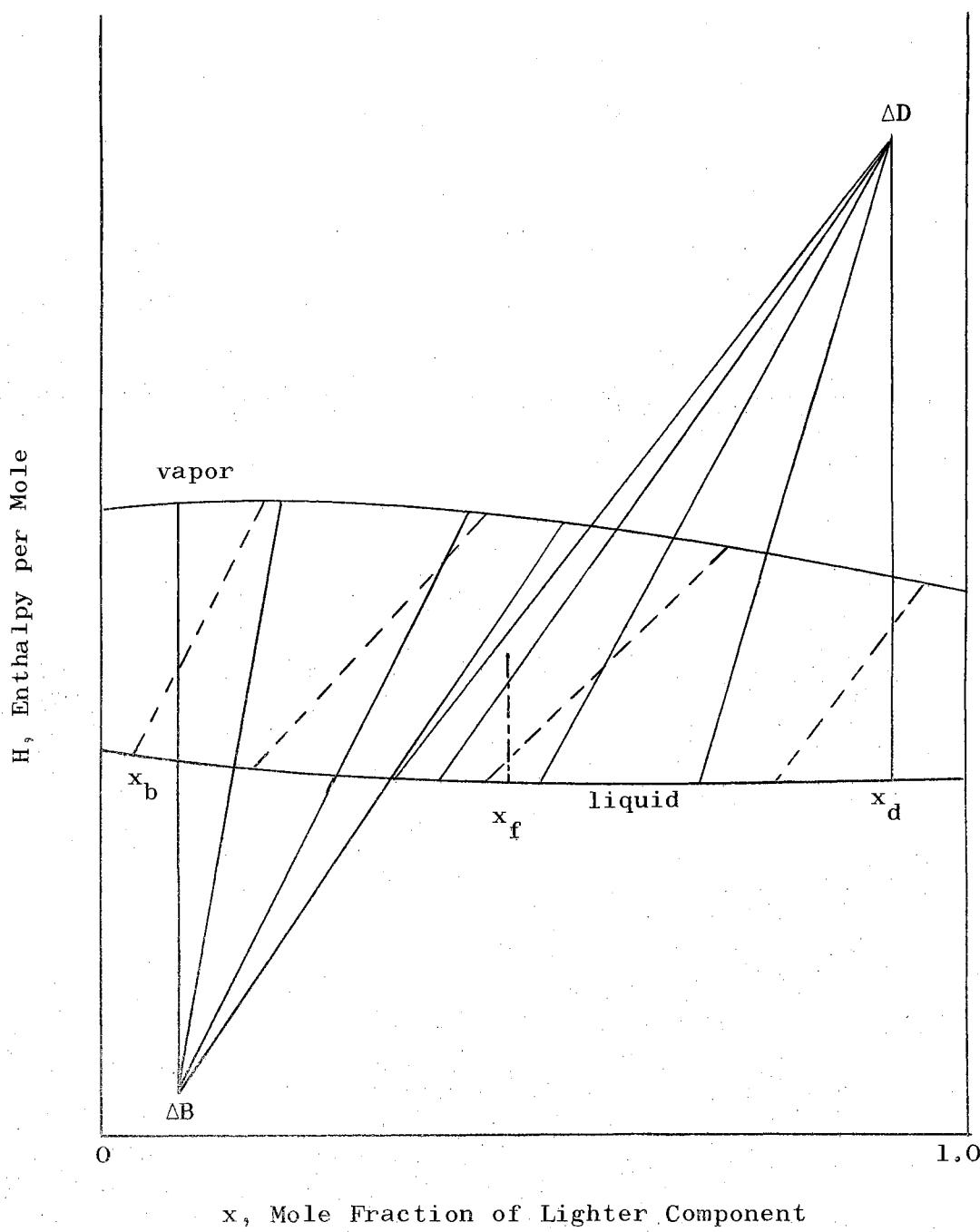


Figure 3. Ponchon-Savarit Diagram for a Simple Column

to obtain a desired product composition. Although these short-cut techniques are not rigorous, they are advantageous in that they do not require the large amount of time that is necessary to obtain a rigorous solution.

Fenske (11) derived the following equation for a simple fractionator operating at total reflux.

$$\alpha^{\frac{S_m}{m}} = (d/b)_{LK} (b/d)_{HK} \quad (6)$$

The relative volatility, α , is usually evaluated at some average column temperature and assumed to be constant. This equation can be used to predict the minimum number of theoretical stages required to make a specified separation of light and heavy key components. This procedure can also be used to predict the product compositions when the minimum number of stages is known.

Winn (30) proposed that a log-log plot of equilibrium K values of the light key component versus the heavy key component at constant pressure results in a straight line which can be represented by the following equation.

$$K = \beta(K')^\gamma \quad (7)$$

where β is the intercept of the line and γ is the slope of the line. Using the above relationship he derived the following equation for simple columns which eliminates the assumption of constant relative volatility.

$$\beta_{LK}^{\frac{S_m}{m}} = (x_d/x_b)_{LK} (x_b/x_d)_{HK}^\gamma \quad (8)$$

and

$$\beta_{LK}^{\frac{S_m}{m}} = (d/b)_{LK} (b/d)_{HK}^\gamma (B/D)^{1-\gamma} \quad (9)$$

In a study of short-cut procedures for complex columns Joyner, J. H. Erbar, and Maddox (18) pointed out that short cut procedures can be used to save computer time and expense by providing the estimates of column parameters needed for starting a rigorous calculation. They also extended the above equation to handle complex fractionators operating at total reflux.

$$\beta_{LK}^{\bar{s}_m I} = (d/p)_{LK} \frac{\tau}{(p/d)_{LK}} (P/D)^{1-\tau} \quad (10)$$

$$\beta_{LK}^{\bar{s}_m II} = (D/b)_{LK} \frac{\tau}{(b/p)_{LK}} (B/P)^{1-\tau} \quad (11)$$

These equations can also be used to predict the minimum number of stages for a desired key split and to estimate the product compositions at total reflux.

Maddox and Takaoka (26) extended the Beta Method, originally developed by Underwood (28) and Gilliland (12) who worked simultaneously but independently, for determining the number of theoretical trays required to give the desired key component split and the product distributions at a specified reflux rate. This method is summarized in the following equations,

$$x_d_{LK} / x_d_{HK} = (\alpha/\bar{\beta})_{av}^N x_n_{LK} / x_n_{HK} \quad (12)$$

$$x_m_{LK} / x_m_{HK} = (\alpha/\bar{\beta})_{av}^M x_b_{LK} / x_b_{HK} \quad (13)$$

where equations (12) and (13) are for the rectifying and stripping sections respectively.

The terms α and $\bar{\beta}$ are defined as follows.

$$\alpha = K_{LK}/K_{HK} \quad (14)$$

$$\tilde{\beta} = \frac{1 + D/L_n (x_d/x_n)_{LK}}{1 + D/L_n (x_d/x_n)_{LK}} \quad (15)$$

Gilliland (13) proposed that

$$(\alpha/\tilde{\beta})_{av} = \frac{\alpha_1 + (\alpha/\beta)_n}{2} \quad (16)$$

This method assumes constant molal overflow and that the feed is located where the ratio of the light and heavy key is the same as the feed.

Underwood (28) developed a method for determining the minimum reflux rate of a simple column assuming constant molal overflow and constant relative volatility. He defined the function ϕ_j such that

$$V_{RP} = \sum_{i=1}^{ncp} \frac{\alpha_i d_i}{\alpha_i - \phi_j} \quad (17)$$

$$-V_{SP} = \sum_{n=1}^{ncp} \frac{\alpha_i b_i}{\alpha_i - \phi_j} \quad (18)$$

For these equations, there are $n-1$ values of ϕ_j . These values of ϕ_j are bounded by and fall between the values of α for adjacent components. Each of these $n-1$ values of ϕ_j can be calculated from the following equation

$$V_f = \sum \frac{\alpha_i f_i}{\alpha_i - \phi_j} \quad (19)$$

by solving $n-1$ equations, one for each value of ϕ_j .

Since the product splits for the key components are specified, there are $n-2$ compositions and V_{RP} or $n-1$ variables to determine using equation (17). With these values, the bottoms composition and reflux rate can be determined by material balance equations. However, for non-distributed systems, which can occur when the column is operating at or below minimum reflux, results may be obtained whereby a product component rate is greater than that of the feed, or negative.

This situation may occur when

$$(L/KV)_{RP} > 1.0 \quad (20)$$

for the rectifying section or

$$(KV/L)_{SP} > 1.0 \quad (21)$$

for the stripping section. The Underwood equations can be used for estimating the minimum reflux rate (7).

An important procedure for estimating the number of ideal stages required for a given reflux rate was developed by Erbar and Maddox (8). This procedure is a correlation based on the Winn minimum number of stages and Underwood minimum reflux method and is presented in the form of a plot with the minimum and operating reflux rate and the minimum number of stages and operating number of stages. Figure 4 is a representation of this plot.

Lewis and Matheson (19) developed one of the first rigorous procedures for multi-component distillation calculations. This method is based on a series of simultaneous heat and mass balances beginning with assumed light and heavy key product rates and working toward the feed tray to determine the number of stages required. The following equations are typical equations used in the Lewis and Matheson technique for the n^{th} tray in the rectifying section of the column.

$$v_{n-1,i} = l_{n,i} + d_i \quad (22)$$

$$V_{n-1} = L_n + D \quad (23)$$

$$V_{n-1} H_V = Q_c + H_d D + H_L L_n \quad (24)$$

To begin calculations, individual distillate compositions are assumed. The corresponding tray temperatures and liquid and vapor rates are found by trial and error calculations around each tray. These

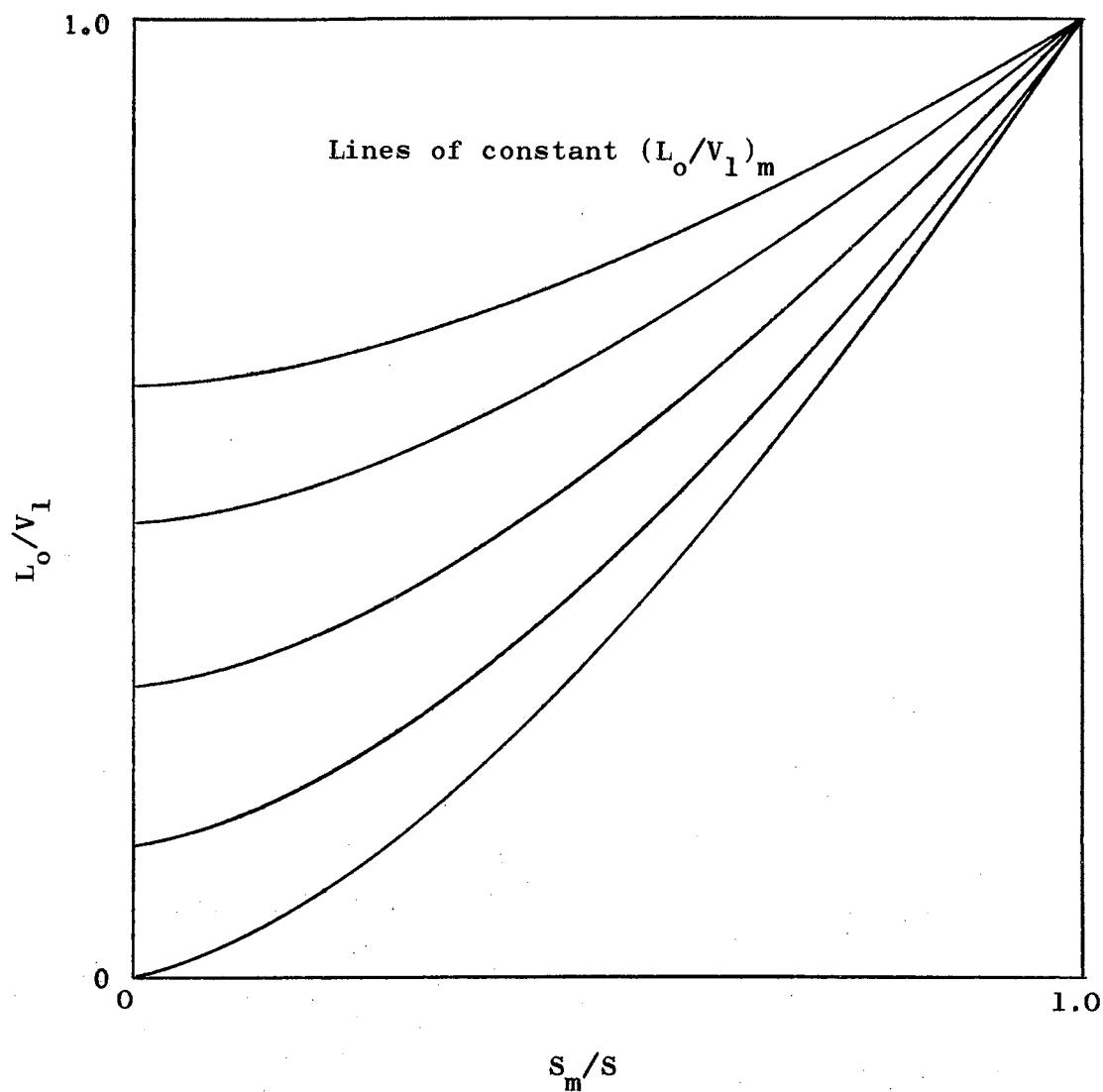


Figure 4. Correlation of Minimum and Operating Reflux Rate with Number of Trays

calculations are continued until the feed plate is reached. The recommended feed plate location is the point where the ratio of the light key to the heavy key rates in the liquid leaving the tray is the same as the ratio of key component rates in the feed. However, the feed plate may be located anywhere. The calculations are repeated starting with the bottoms and working up to the feed plate. The compositions at the feed plate are then compared. If they are not the same, the terminal compositions are adjusted, and the procedure is repeated.

Bonner (4) modified the Lewis and Matheson method. His modification differs from the Lewis and Matheson method in that the temperature, liquid, and vapor profiles are assumed. The basic difference is that Bonner predicts terminal compositions rather than specifying a split. The calculations are similar to those for the Lewis and Matheson method, and the feed plate match is forced in the same manner as in the Lewis and Matheson method.

Thiele and Geddes (27) developed a rigorous tray-by-tray procedure based on material balance relationships around the terminals and the n^{th} tray in the column. The equations for a simple column as presented by Holland (17) are

$$\frac{d}{b} = \frac{v_{m-1}/b}{v_{n+i}/d} \quad (25)$$

Rectifying section:

$$l_{n+1}/d = l_n/d (A_n + 1) \quad (26)$$

Stripping section:

$$l_{m+1}/b = S_m(l_m/b) + 1 \quad (27)$$

A_n and S_m are the absorption and stripping factors respectively and are defined as follows:

$$A_n = (L/KV)_n \quad (28)$$

$$S_m = (KV/L)_m \quad (29)$$

The calculational procedure begins by predicting terminal compositions from an assumed temperature, and L/V profile. The temperature and L/V profiles are corrected by a calculation similar to the Lewis and Matheson. When the feed plate is reached, the terminal compositions are adjusted, and the calculations are repeated. This procedure is continued until there are no changes in distillate composition.

Lyster (20) proposed a convergence technique which makes the Thiele and Geddes method useful for machine solution. This procedure is based on equations (25) through (29) and the following definitions.

$$d_i = \frac{f_i}{1 + b_i/d_i} \quad (30)$$

By employing a multiplier $\bar{\theta}$, equation (30) can be written as follows

$$(d_i)_{co} = \frac{f_i}{1 + \bar{\theta}(b_i/d_i)_{ca}} \quad (31)$$

where $\bar{\theta}$ is used to force the column into material balance. The same value of $\bar{\theta}$ is used for all components. Its numerical value can be found by using Newton's method as shown below.

$$\bar{\theta} = \bar{\theta}_a - g(\bar{\theta}_a)/g'(\bar{\theta}_a) \quad (32)$$

where

$$g(\bar{\theta}) = \sum_{i=1}^{ncp} \frac{f_i}{1 + \bar{\theta}(b_i/d_i)} - D \quad (33)$$

$$g'(\bar{\theta}) = dg(\bar{\theta})/d\bar{\theta} = - \sum_{i=1}^{ncp} \frac{f_i(b_i/d_i)}{[1 + \bar{\theta}(b_i/d_i)]^2} \quad (34)$$

Edmister (5) proposed a rigorous procedure for determining product

and tray compositions using absorption and stripping factors as defined in equations (28) and (29). By comparing these equations for each stage in the column, equations can be obtained for the component liquid and vapor rates on a tray in the column. The following equations show this relationship.

$$l_n = d(A_0 A_1 A_2 A_3 \dots A_n + A_1 A_2 A_3 \dots A_n + A_2 A_3 \dots A_n + \dots + A_n) \quad (35)$$

$$\begin{aligned} v_m &= d(S_1 S_2 S_3 \dots S_m + S_2 S_3 \dots S_m + S_3 \dots S_m + \dots + S_m) - v_o (S_2 S_3 \dots S_m \\ &\quad + S_3 \dots S_m + \dots S_m) \end{aligned} \quad (36)$$

Extending this procedure, Edmister defined ϕ_A in terms of the absorption factors and ϕ_S in terms of the stripping factors. The equations are:

$$\phi_A = \frac{1}{A_1 A_2 A_3 \dots A_n + A_2 A_3 \dots A_n + A_3 \dots A_n + \dots + A_n + 1} \quad (37)$$

$$\phi_S = \frac{1}{S_1 S_2 S_3 \dots S_m + S_2 S_3 \dots S_m + S_3 \dots S_m + \dots + S_m + 1} \quad (38)$$

The term ϕ_A can be shown to be the fraction of any rich-gas component not recovered in the absorber, and ϕ_S is the fraction of any rich oil component not recovered in the stripper.

By rearranging equations (35), (36), (37), and (38), Edmister obtained the following equations for determining product and tray compositions.

$$v_{n+1}/d = (A_o \phi_{SE} + 1/\phi_{AE}) A_E \quad (39)$$

$$l_{m+1}/b = S_o \phi_{AX} / \phi_{SX} + 1/\phi_{SX} \quad (40)$$

$$b/d = A_f \left(\frac{v_f/d}{l_f/b} \right) \quad (41)$$

The second subscripts E and X designate enriching and exhausting sections respectively.

Greenstadt et al (15) developed a rigorous distillation program using Newton's method to solve the corresponding simultaneous heat and material balance equations for each plate. This calculational procedure is carried out using material balance equations starting with the bottom of the column and working up to the tray above the feed plate and from the top of the column down to the feed plate. The total liquid and vapor rates are calculated by enthalpy balances. Newton's method is used to find a correct set of product component rates that satisfies both the material balance equations and the specified total product rates. However, this procedure has failed in a wide variety of cases (10). The usual reason for failure has been the instability of the differential equations required for use in Newton's method.

All of the tray-by-tray procedures mentioned above use the feed plate mismatch to adjust the product compositions between passes and to eventually converge to a solution. Theoretically, all components must appear in all products, except at minimum reflux. However, the range of allowable number size in a computer and the number of significant digits are limited, and a composition may approach zero within an operating column. Thus, a program that uses an adjusting procedure which requires all components to appear in all products may fail. A procedure which will automatically introduce a small amount of a component on a tray and will allow any component to approach zero at any point in the column should be more reliable.

Amundson and Pontinen (1, 2) proposed a method whereby the system of simultaneous mass balance equations are solved by the use of matrices. The distillate rate, reflux rate, and number of trays in each section of the column are fixed. The temperature and vapor profiles and product

compositions are assumed. These assumptions are then readjusted from pass to pass until a converged solution is obtained.

Rose and co-workers (24, 25) studied the transient conditions of a column from start-up to steady state. In his study, Rose used the following equation which describes the change in composition of a given component on a given tray with respect to time.

$$H' \frac{dx_n}{d\theta} = L_{n+1}x_{n+1} + V_{n-1}x_{n-1} - L_n x_n - V_n y_n \quad (42)$$

This equation is modified slightly for handling either a feed tray, side draw tray, condenser, or reboiler. A problem arises in solving this equation to arrive at the steady state conditions. The system of equations is a complex set of non-linear differential equations. Solution of these equations by hand is virtually impossible.

An important factor in this procedure is the time required for all of the column compositions to reach their steady state values. Since the steady state condition is approached asymptotically, the final steady state solution is usually never obtained. In order to avoid this problem, Rose uses a "pseudo" equilibrium time which is defined as the time required for the plate compositions to come within ± 0.001 of their final values. The procedure for determining the steady state compositions begins by assuming initial tray compositions. From this assumed composition profile, a new composition profile is determined at some later time.

Rose studied the effect of the initial composition on the time required to reach steady state. He compared these effects by running two problems: one starting with feed composition on all trays; the other was taken from a problem that was allowed to reach steady state, the column operating conditions were changed slightly. The number of passes

required to converge for the new problem was used for comparison. He found that the effect of the initial composition profile is small. Rose also found that feed composition, reflux ratio, and the number of plates have an effect on the convergence time.

In this procedure, no simplifying assumptions or approximations are needed, thus enabling the procedure to arrive at a solution regardless of the complexity of the problem. Although this procedure is reliable, certain precautions must be taken. The time interval must be small enough, in comparison with the tray holdup, that the composition profile does not become so distorted that the solution becomes unstable. Rose found that the vapor and liquid flow rates should be between one-fifth and one-tenth of the tray holdup in order to avoid instability of the calculations. An over-all material balance is needed after each pass in order to eliminate errors resulting from the assumptions of tray temperatures and vapor and liquid rates. These assumptions are corrected by subsequent calculations.

Ball (3) modified the transient approach presented by Rose et al (24, 25). His major contribution was the modification of equation (42).

$$x_{n,i} \Big|_{\theta+\Delta\theta} = x_{n,i} \Big|_{\theta} + \Delta\theta \left(\frac{dx_{n,i}}{d\theta} \right) \Big|_{\theta} \quad (43)$$

In this study, Ball found that Rose's procedure was very reliable for complicated problems. However, the size of $\Delta\theta$ required for solution was so small that a large amount of machine time was required to reach a solution. In order to eliminate this problem, Ball used the mean value theorem of differential calculus (17) to write the following equivalent form of equation (43).

$$x_{n,i} \Big|_{\theta+\Delta\theta} = x_{n,i} \Big|_{\theta} + \Delta\theta \left[\beta' \left(\frac{dx_{n,i}}{d\theta} \right) \Big|_{\theta+\Delta\theta} + (1-\beta') \left(\frac{dx_{n,i}}{d\theta} \right) \Big|_{\theta} \right] \quad (44)$$

where $0 \leq \beta' \leq 1.0$. Ball reports that if a value of $\beta' > 0.5$ is used, the above equation remains stable for all values of $\Delta\theta$.

The use of the mean value theorem has an advantage in that it enables one to evaluate the slope of the change in composition with respect to time at a point where the slope is between times θ and $\theta + \Delta\theta$. A graphical interpretation of this theorem is shown in Figure 5.

By comparing equations (42) and (44) and assuming that

$$K_{n,i} \Big|_{\theta+\Delta\theta} = K_{n,i} \Big|_{\theta}$$

$$v_{n-1} \Big|_{\theta+\Delta\theta} = v_{n-1} \Big|_{\theta}$$

$$L_{n+1} \Big|_{\theta+\Delta\theta} = L_{n+1} \Big|_{\theta}$$

the following working equation can be written

$$a_{n,i}^{\prime} x_{n-1,i} \Big|_{\theta+\Delta\theta} + b_{n,i}^{\prime} x_{n,i} \Big|_{\theta+\Delta\theta} + c_{n,i}^{\prime} x_{n+1,i} \Big|_{\theta+\Delta\theta} = d_{n,i}^{\prime} \quad (45)$$

where

$$\begin{aligned} a_{n,i}^{\prime} &= -(\beta' \Delta\theta / H') v_{n-1} K_{n-1,i} \Big|_{\theta} \\ b_{n,i}^{\prime} &= (\beta' \Delta\theta / H') v_n K_n \Big|_{\theta} + (\beta' \Delta\theta / H') L_n \Big|_{\theta} + 1.0 \\ c_{n,i}^{\prime} &= -(\beta' \Delta\theta / H') L_{n+1} \Big|_{\theta} \end{aligned} \quad (46)$$

$$d_{n,i}^{\prime} = x_{n,i} \Big|_{\theta} + \frac{(1-\beta') \Delta\theta}{H'} (H' \frac{dx_{n,i}}{d\theta}) \Big|_{\theta}$$

These assumptions imply that the temperature and vapor profiles do not change significantly from pass to pass. This modification gives a more complex procedure than Rose's original procedure, but by increasing the size of $\Delta\theta$, the total number of iterations and machine time may be significantly reduced.

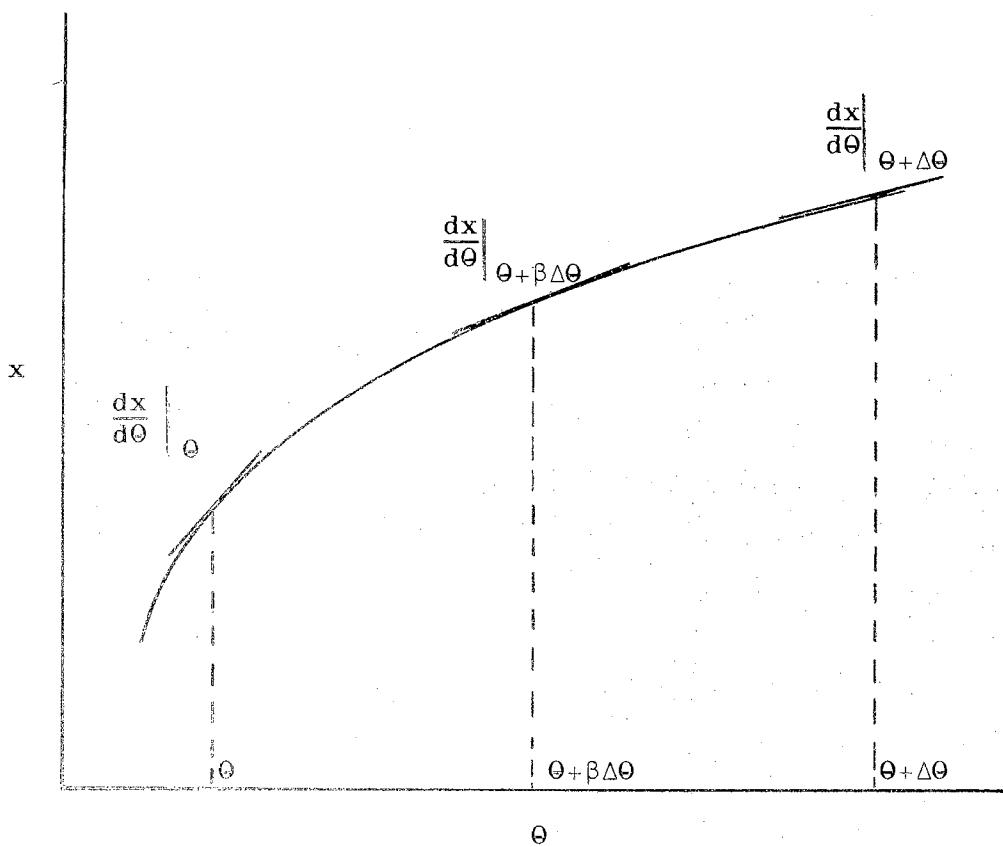


Figure 5. Graphical Interpretation of Equation (44)

By writing equation (45) for all trays in the column and the i^{th} component, a tri-diagonal matrix is obtained. This matrix can be solved for the tray composition of the i^{th} component. Tray numbers start with the bottom tray equal to one, the reboiler being tray zero, and the condenser tray $n+1$. The equations are solved using a method reported by Grabbe (14). The details of the solution are:

The reboiler:

$$h_0 = c'_0/b'_0 \quad (47)$$

$$g = d'_0/b'_0 \quad (48)$$

Each tray and condenser:

$$h_K = c'_K/b'_K - a'_K h'_{K-1} \quad (49)$$

$$g_K = d'_K - a'_K g'_{K-1}/b'_K - a'_K h'_{K-1} \quad (50)$$

where $K = 1, 2, \dots, n+1$.

The composition of i is then found for the condenser by

$$x_{n+1} = g_{n+1} \quad (51)$$

and for each tray and reboiler

$$x_K = g_K - h_K x_{K+1} \quad (52)$$

where $K = n, n-1, n-2, \dots, 0$.

These calculations are repeated for all components and for each iteration until

$$\left| x_0 - x_{0+\Delta\theta} \right|_{\text{all } n \text{ and } i} \leq \epsilon \quad (53)$$

where ϵ is some arbitrarily acceptable error. The column temperature and vapor profiles are re-evaluated after each pass.

The procedures which are presented here are the ones that are most pertinent to this thesis. There are many other procedures for calculating

distillation column performance. However, they are not important to this work, and no attempt has been made to cover them.

CHAPTER III

THE PROPOSED METHOD

Virtually all of the rigorous procedures for distillation calculations are based on simultaneous heat and mass balances. These balances are solved by starting either with the terminals and working toward the feed plate, or by starting at the feed plate and working toward the terminals. A difficulty in these procedures occurs with extremes in composition. For instance, if the composition of a component is large in the distillate and extremely small in the bottoms, the feed plate composition may be very sensitive to small changes in the bottoms composition. This sensitivity can cause wide fluctuations in the adjusted terminal streams compositions. As these fluctuations get larger the calculations can become unstable.

The proposed method traces a column through start-up to steady state conditions using a relaxation technique. The procedure is started with an assumed tray composition, temperature and vapor profiles. Key split specifications are not allowed in this procedure.

A typical transient state component balance equation around any tray (n) can be written as follows:

$$H^e \frac{dx_{n,i}}{d\theta} = V_{n-1}y_{n-1,i} + L_{n+1}x_{n+1,i} - L_n x_{n,i} - V_n y_{n,i} \quad (42)$$

If a feed or side-draw plate is encountered, an additional term must be added to the right-hand side of equation (42) in order to account for

this condition. If the amount of liquid holdup on the plate, n , is constant and the amount of vapor holdup assumed negligible, this equation describes the change in liquid composition on the n^{th} tray with respect to time.

Using equation (42), the following equation can be used to determine the composition after a time interval of $\Delta\theta$:

$$x_{n,i} \Big|_{\theta+\Delta\theta} = x_{n,i} \Big|_{\theta} + \Delta\theta \left(\frac{dx_{n,i}}{d\theta} \right) \Big|_{\theta} \quad (43)$$

This equation is valid for all components on all trays in the column. After repeated passes, the tray compositions will approach steady state values, thus making a close approximation of the steady state composition possible.

Between each pass the liquid and vapor rates between each tray can be calculated using the previously determined compositions and the corresponding bubble point temperatures. These new temperatures and flow rates will then be used in calculating the new component compositions for the next time interval, $\Delta\theta$.

Ball (3) found that this procedure worked very well for complicated problems that could not be solved by the IBM program (15). However, in order to maintain a steady solution, he found that the size of $\Delta\theta$ had to be so small that the program required an extremely large amount of machine time. In order to alleviate this problem, Ball developed the following equivalent form of equation (43),

$$x_{n,i} \Big|_{\theta+\Delta\theta} = x_{n,i} \Big|_{\theta} + \Delta\theta \left[\beta' \left(\frac{dx_{n,i}}{d\theta} \right) \Big|_{\theta+\Delta\theta} + (1 - \beta') \left(\frac{dx_{n,i}}{d\theta} \right) \Big|_{\theta} \right] \quad (44)$$

where β' can have any arbitrary value between zero and one. However, if the size of β' is greater than one-half, any reasonable value for $\Delta\theta$ can

be used, and the procedure will remain stable. If β' is set equal to one, the procedure will be simplified.

By using equation (42) to evaluate the term $(\frac{dx}{d\theta})_{\theta+\Delta\theta}$ in equation (44) and making the assumptions that

$$K_{n,i}|_{\theta+\Delta\theta} = K_{n,i}|_{\theta}$$

$$v_{n-1}|_{\theta+\Delta\theta} = v_n|_{\theta}$$

$$L_{n+1}|_{\theta+\Delta\theta} = L_{n+1}|_{\theta}$$

equation (43) can be written as

$$a'_{n,i}x_{n-1,i}|_{\theta+\Delta\theta} + b'_{n,i}x_{n,i}|_{\theta+\Delta\theta} + c'_{n,i}x_{n+1,i}|_{\theta+\Delta\theta} = d'_{n,i}|_{\theta} \quad (45)$$

The constants a' , b' , c' , and d' are known quantities and are represented by equations (46). An analysis of equation (44) shows that if β' equals one, the second term on the right-hand side of the equation can be eliminated completely, thus simplifying the equation.

If equation (44) is written for the i^{th} component on all trays, a tri-diagonal matrix is generated which can be solved using equations (47) through (52). The dependence of the compositions of one tray on all other trays can be seen by expanding the terms h_n and g_n for a given component.

Although the relaxation procedure is based entirely on material balance relationships, the over-all material balance was being violated during the first few iterations. To correct this problem, a forcing procedure was developed to bring the column into external material balance. The objectives of using this additional material balance are two-fold. First, the column is kept in external material balance from pass to pass. Secondly, the total number of iterations required to

obtain a converged solution are decreased. The material balance method used is a modification of Lyster's (20) technique. This procedure uses the following external material balance equation:

$$d_i = \frac{f_i}{1 + p_{1,i}/d_i + p_{2,i}/p_{1,i} + \dots + p_{n,i}/p_{n-1,i} + b_i/p_{n,i}} \quad (54)$$

If the column is not in complete material balance, a forcing function, $\bar{\theta}_n$, can be used to determine a corrected value for d_i as follows:

$$d_i = \frac{f_i}{1 + \bar{\theta}_1 p_{1,i}/d_i + \bar{\theta}_2 p_{2,i}/p_{1,i} + \dots + \bar{\theta}_{n-1} p_{n-1,i}/p_{n,i} + \bar{\theta}_n b_i/p_{n,i}} \quad (55)$$

In order to simplify this procedure for multi-product columns and to make the determination of $\bar{\theta}_n$ simple, temporary bottom products and feed component rates are used. The calculations start with the distillate and work down the column through the bottom side product. The product in question is treated as the distillate and the temporary bottoms product is used as the bottoms; thus the determination of $\bar{\theta}_n$ is the same as for a two-product column. The temporary bottoms product rate for the i^{th} component is the sum of the i^{th} component rates in all products below the one in question. When a value of $\bar{\theta}_n$ is found for a product and the component product rates are adjusted, the individual component rates are subtracted from the feed component rates forming a temporary feed rate. This temporary feed rate is then used in adjusting the component rates in the next product. The temporary component feed and product rates are presented as

$$\tilde{f}_i = f_i - (p_{1,i_{\text{co}}} + p_{2,i_{\text{co}}} + \dots + p_{n-1,i_{\text{co}}}) \quad (56)$$

$$\tilde{p}_i = p_{n+1,i} + p_{n+2,i} + \dots + p_{N,i} \quad (57)$$

where the subscript co stands for the corrected composition. By letting the terms $p_{1,i}$ and $p_{N,i}$ stand for the distillate and bottoms component rates respectively, a generalized equation can be written for any column having any number of side streams. The bottoms rate is determined by a simple material balance after determining all other product rates. The following equation represents this generalized form.

$$(p_{n,i})_{co} = \frac{f_i}{1 + \bar{\theta} (\bar{p}_i/p_{n,i})} \quad (58)$$

The value of $\bar{\theta}$ can be determined by using Newton's method. The equations are:

$$\bar{\theta}_{co} = \bar{\theta}_{co} - \frac{g(\bar{\theta})}{g'(\bar{\theta})} \quad (59)$$

where

$$g(\bar{\theta}) = \sum_{i=1}^{ncp} \frac{\bar{f}_i}{1 + \bar{\theta} (\bar{p}_i/p_{n,i})_{ca}} - P_n \quad (60)$$

$$g'(\bar{\theta}) = - \sum_{i=1}^{ncp} \frac{\bar{f}_i (\bar{p}_i/p_{n,i})_{ca}}{[1 + \bar{\theta} (\bar{p}_i/p_{n,i})_{ca}]^2} \quad (61)$$

The term P_n stands for total product rate.

A close examination of this convergence procedure shows that two very important facts must be kept in mind. The first fact is that all computers have a definite range in number size. Since the procedure is based on product ratios, numerical problems can be encountered if the ratios exceed 10^{35} for the IBM 7090. However, these problems can be eliminated by setting the ratio equal to 10^{35} and $p_{n,i}$ to zero. If an arbitrary definition of a perfect split is encountered, the ratio, $\bar{p}_i/p_{n,i}$, will be either zero or greater than the numerical range of the computer, thus causing more complications. However, the problem with

perfect splits can be eliminated without producing a significant deviation in the over-all results by moving a small per cent of the bottoms product into the distillate.

As presented earlier, the relaxation procedure begins with an assumed initial composition, temperature, and vapor profile. The most logical initial vapor profile is constant molal overflow. However, a number of initial composition and temperature profiles may be used. One of the easiest profiles to determine and perhaps the most widely used is based on the assumption that liquid composition leaving each tray is equal to the combined feed composition. The temperature profile can be found by calculating the bubble point for each tray. An alternate procedure is to assume that the composition of the liquid leaving each tray is linear between the terminal composition and the feed composition. A more sophisticated approach to determining an initial composition profile would be using one of the short-cut techniques outlined in Chapter II. However, these short-cut procedures are so time consuming that their use is not justified.

The final convergence of a problem is determined by three factors. These three factors are the vapor, temperature, and composition profiles. When the change of each of these factors, from pass to pass is within the desired tolerances, the problem is considered to be converged. Although steady state conditions can never be reached, the amount of fluctuation in these profiles from pass to pass becomes very small after several passes.

CHAPTER IV

RESULTS AND DISCUSSION OF RESULTS

A comparison of the results obtained by the relaxation program for single and two-feed and two-and three-product systems was made with those obtained using some other procedure (6, 9, 16, 21). A large number of problems were solved in order to test each option of the program. These include constant molal overflow, non-constant molal overflow, partial condenser, total condenser, single feed, multi-feed, two-product, multi-product, bubble point, dew point and flash feeds. Because of the large number of combinations that can be formed using these different conditions, no attempt was made to test special combinations of these conditions. However, these special combinations should not present a problem to the validity of the program.

A solution was obtained for all but one of the problems that were tested. The total number of passes required to obtain a solution ranged from 18 to 45. Also, the amount of IBM 7090 time required for execution of the problems tested ranged from approximately 7×10^{-3} to 8.5×10^{-2} seconds per pass per tray per component, depending on the complexity of the column and the amount of output.

In order to test the basic operation of the program, two problems, Problem I and II, were solved and compared to solutions of the same problems that were found by Erbar (6). These problems were run at both constant and non-constant molal overflow. The description and results

are given in Tables I and II respectively. The differences between the answers obtained by the relaxation method and those obtained by Erbar may be explained by differences in the form of the equations of the enthalpy and equilibrium data.

Problems III and IV were run to test the partial condenser option. These problems were solved using the same feed conditions as those in Tables I and II but with one tray removed from the rectifying section of the column. The solutions should be approximately the same as those shown in Tables I and II. Comparing the solutions for the partial and total condenser will show that the program functions equally well with either type of condenser.

Problem V is a solution to a column with a side cut (21). The same enthalpy data equations were used in both solutions; however, the form of the equilibrium data was changed. Extreme care was used in refitting the equilibrium data to hold the deviation between the two solutions to a minimum. The results of this comparison (Table III) show only slight differences in the results of the two solutions.

Problems VI and VII were solved to test the validity of the relaxation program for two-feed columns. These problems were taken from Holland (16). Holland's enthalpy data were refitted to the proper equation form. However, the equilibrium data equations used by Holland were not in the proper form to be used in the relaxation program. Additional checking of Holland's data showed that one of the equations went through a minimum within the temperature range covered by the column. Therefore, equilibrium data from the NGSMA Data Book (31) were used to develop new equations for the K values. Comparisons of the relaxation method solutions with Holland's solutions are given in Tables VI and VII.

The last problem run was an industrial problem (9). This problem, Problem VIII, could not be solved by the company from which it was obtained. The relaxation procedure did not solve the problem either. The distillate composition at the end of 60 passes and a description of the problem are given in Table VIII.

Two types of initial profiles were tested to determine the effect that the starting condition has on convergence. One of these initial profiles is a linearized composition and temperature profile, while the other starting condition assumes that the compositions and temperatures of all trays are equal to the combined feed composition and bubble point temperature. Solutions for Problems I, II, VI, and VII were obtained with each of the two different initial profiles. The two starting conditions did not affect the solution of the problem, but did have an affect on the number of passes required to reach a solution. A comparison of the number of passes required for a solution using each of these two starting conditions is given in Table IX. By using a linear profile, the number of passes was less for one of the problems than when using a constant composition profiles. Two problems required more passes to converge with the linear starting profile, and one problem required the same number of passes with each starting condition.

In order to determine the effect of each of the two starting profiles, intermediate results after the end of every six passes were obtained for Problem I. Figures 6, 7, and 8 are plots of the composition of a specific component on a given tray versus the pass number. Figure 8 is a plot of the component and the corresponding tray that was the last point to converge. These figures show that the composition may converge either asymptotically or in a damped sinusoidal curve.

Problem II was run at several different values of the ratio of the time interval to the holdup, $\Delta\theta/H'$, in order to determine the effect of this ratio on the total number of passes required for convergence. This test was made using an initial composition profile with every tray having the same composition as the feed. However, an improved vapor rate subroutine was adopted after the tests presented in Table IV were made. The use of this new subroutine will account for the difference in the number of passes that appear in Tables IX and X. The results of this test are presented in Table X. As can be seen in this table, the number of passes required reach a constant number after a certain ratio is reached. Initial tests of the relaxation program indicate that this ratio is different for different problems.

TABLE I

PROBLEM I: RESULTS OF COMPARISON OF EIGHTEEN-TRAY COLUMN

Component	Feed moles/hr	Ref. No. (7)	Cst.	Distillate 0/flow	moles/hr Non-cst. 0/flow
n-Butane	25.0000	24.19612		24.4286	23.9091
i-Pentane	25.0000	0.91698		0.6243	1.0783
n-Pentane	25.0000	0.08917		0.0602	0.1257
Hexanes	25.0000	0.00000		0.0000	0.0000

Operating Conditions:

Number of stages including reboiler	19
Feed tray number	9
Reflux ratio (V_1/F)	2.25367
Type of condenser	Total
Feed condition	Bubble point
Pressure psia	25.0
Distillate rate (D/F)	0.251131

TABLE II

PROBLEM II: RESULTS OF COMPARISON OF THIRTY EIGHT-TRAY COLUMN

Component	Feed moles/hr	Ref. No. (7)	Distillate moles/hr By Relaxation			
			Cst.	0/flow	Non-cst.	0/flow
n-Butane	25.0000	25.00000	25.0000		25.0000	
i-Pentane	25.0000	23.64628	22.9190		22.7916	
n-Pentane	25.0000	1.35838	2.0857		2.2131	
Hexanes	25.0000	0.00000	0.0000		0.0000	

Operating Conditions:

Number of stages including reboiler	39
Feed tray number	19
Reflux ratio (V_1/F)	6.25932
Type of condenser	Total
Feed condition	Bubble point
Pressure psia	25.0
Distillate rate (D/F)	0.500047

TABLE III

PROBLEM III: RESULTS OF SEVENTEEN-TRAY COLUMN WITH PARTIAL CONDENSER

Component	Feed moles/hr	Distillate moles/hr
n-Butane	25.0000	24.1133
i-Pentane	25.0000	0.8818
n-Pentane	25.0000	0.1180
Hexanes	25.0000	0.0000

Operating Conditions:

Number of stages including reboiler	18
Feed tray number	8
Reflux ratio (V_1/F)	2.25367
Type of condenser	Partial
Feed condition	Bubble point
Pressure psia	25.0
Distillate rate (D/F)	0.251131

TABLE IV

PROBLEM IV: RESULTS OF THIRTY SEVEN-TRAY COLUMN WITH PARTIAL CONDENSER

Component	Feed moles/hr	Distillate moles/hr
n-Butane	25.0000	25.0000
i-Pentane	25.0000	22.8853
n-Pentane	25.0000	2.1194
Hexanes	25.0000	0.0000

Operating Conditions:

Number of stages including reboiler	38
Feed tray number	18
Reflux ratio (V_1/F)	6.25932
Type of condenser	Partial
Feed condition	Bubble point
Pressure psia	25.0
Distillate (D/F)	0.500047

TABLE V

PROBLEM V: RESULTS OF COMPARISON OF NINTY-TRAY COLUMN WITH SIDE CUT

Component	Feed moles/hr	Distillate Ref. No. (21)	moles/hr By Relaxation	Side Cut Ref. No. (21)	moles/hr By Relaxation
Propane	5.60	5.55988	5.5598	0.040155	0.0402
i-Butane	8.00	7.46768	7.4679	0.531444	0.5311
i-Butylene	6.80	5.46104	5.4689	1.27617	1.2683
Butene-1	341.00	220.759	220.3918	97.7111	97.5775
Butadiene	0.80	0.51780	0.5170	0.22919	0.2289
n-Butane	24.00	0.030465	0.0299	0.16909	0.1637
Butene-2	13.20	0.0051717	0.0049	0.042817	0.0402

Operating Conditions:

Number of stages including reboiler	91
Feed tray number	55
Side cut tray number	23
Type of condenser	Subcooled to 88.8°F
Reflux ratio (V_1/F)	22.98
Feed condition	Subcooled
Feed temperature	83.0°F
Feed bubble point temperature	124.5°F
Pressure psia	84.0
Distillate rate (D/F)	0.5995
Side cut rate (S/F)	0.2500

TABLE VI
PROBLEM VI: RESULTS OF COMPARISON
OF NINETEEN-TRAY COLUMN WITH TWO FEEDS

Component	Feed I moles/hr	Feed II moles/hr	Distillate Ref. No. (16)	moles/hr By Relaxation
Methane	2.0	0.0	2.0	2.0000
Ethane	10.0	0.0	10.0	10.0000
Propylene	6.0	1.0	6.930	6.9471
Propane	12.0	7.0	17.95	18.1063
i-Butane	1.0	4.0	0.7398	0.7175
n-Butane	3.0	17.0	0.3810	0.2290
n-Pentane	0.5	15.2	0.00004	0.0000
n-Hexane	0.0	9.0	0.0000	0.0000
n-Heptane	0.0	4.5	0.0000	0.0000
n-Octane	0.0	4.3	0.0000	0.0000
360 b.p. oil	0.0	3.5	0.0000	0.0000

Operating Conditions:

Number of stages including reboiler	20
Feed I tray number	7
Feed II tray number	12
Type of condenser	Partial
Reflux ratio (V_1/F)	0.948
Feed I condition	Dew point
Feed II condition	Bubble point
Feed I dew point temperature	128.0°F
Feed II bubble point temperature	267.6°F

TABLE VI (continued)

Pressure	264.7
Distillate rate (D/F)	0.38

TABLE VII
PROBLEM VII: RESULTS OF COMPARISON OF NINETEEN-TRAY
COLUMN WITH TWO FEEDS AND ONE SIDE CUT

Component	Feed I moles/hr	Feed II moles/hr	Distillate moles/hr Ref. No. (16)	By Relaxation	Side Cut moles/hr Ref. No. (16)	By Relaxation
Methane	2.0	0.0	1.973	1.9732	0.02653	0.0268
Ethane	10.0	0.0	9.079	9.1013	0.9207	0.8987
Propylene	6.0	1.0	3.758	4.1477	3.150	2.7846
Propane	12.0	7.0	8.135	7.7392	9.554	10.1445
i-Butane	1.0	4.0	0.03961	0.0309	0.6545	0.6356
n-Butane	3.0	17.0	0.01478	0.0077	0.6917	0.5076
n-Pentane	0.5	15.2	0.0000	0.0000	0.00317	0.0023
n-Hexane	0.0	9.0	0.0000	0.0000	0.0000	0.0000
n-Heptane	0.0	4.5	0.0000	0.0000	0.0000	0.0000
n-Octane	0.0	4.3	0.0000	0.0000	0.0000	0.0000
360 b.p. oil	0.0	3.5	0.0000	0.0000	0.0000	0.0000

Operating Conditions:

Number of stages including reboiler	20
Feed I tray number	7
Feed II tray number	12
Type of condenser	Partial
Reflux ratio (V_1/F)	0.9480
Feed I condition	Dew point
Feed II condition	Bubble point
Feed I dew point temperature	128.0°F
Feed II bubble point temperature	267.6°F

TABLE VII (continued)

Pressure psia	264.7
Distillate rate (D/F)	0.23
Side cut rate (S/F)	0.15

TABLE VIII

PROBLEM VIII: RESULTS OF TEST OF SPECIAL PROBLEM
OF TWENTY SEVEN-TRAY COLUMN

Component	Feed moles/hr	Distillate moles/hr
Methane	0.15	0.1500
Ethane	7.28	7.2800
Propane	98.80	98.8000
i-Butane	15.67	15.6700
n-Butane	46.24	46.2400
i-Pentane	18.55	18.5500
n-Pentane	18.84	18.8400
Hexane	9.07	9.0700
Heptane	21.23	21.2300
Octane	35.79	35.7841
Nonane	245.62	57.3060
Decane	33.09	0.0123

Operating Conditions:

Number of stages including reboiler	28
Feed tray number	15
Type of condenser	Subcooled to 120°F
Reflux ratio (V_1/F)	1.1954
Feed temperature	285°F
Feed flash ratio (L/F)	0.8545
Pressure psia	150
Distillate rate (D/F)	0.5977

TABLE IX
THE EFFECT OF INITIAL TRAY COMPOSITIONS ON CONVERGENCE

Problem No.	Passes Required Using	
	Linear Profile	Constant Profile
I	45	32
II	29	35
VI	28	28
VII	37	36

TABLE X
THE EFFECT OF $\Delta\theta/H^0$ ON CONVERGENCE

$\Delta\theta/H^0$	Passes Required
0.00001	≥ 60
0.001	> 60
0.01	> 60
1.0	41
10.0	33
10000.0	33
100000.0	33
1000000.0	33

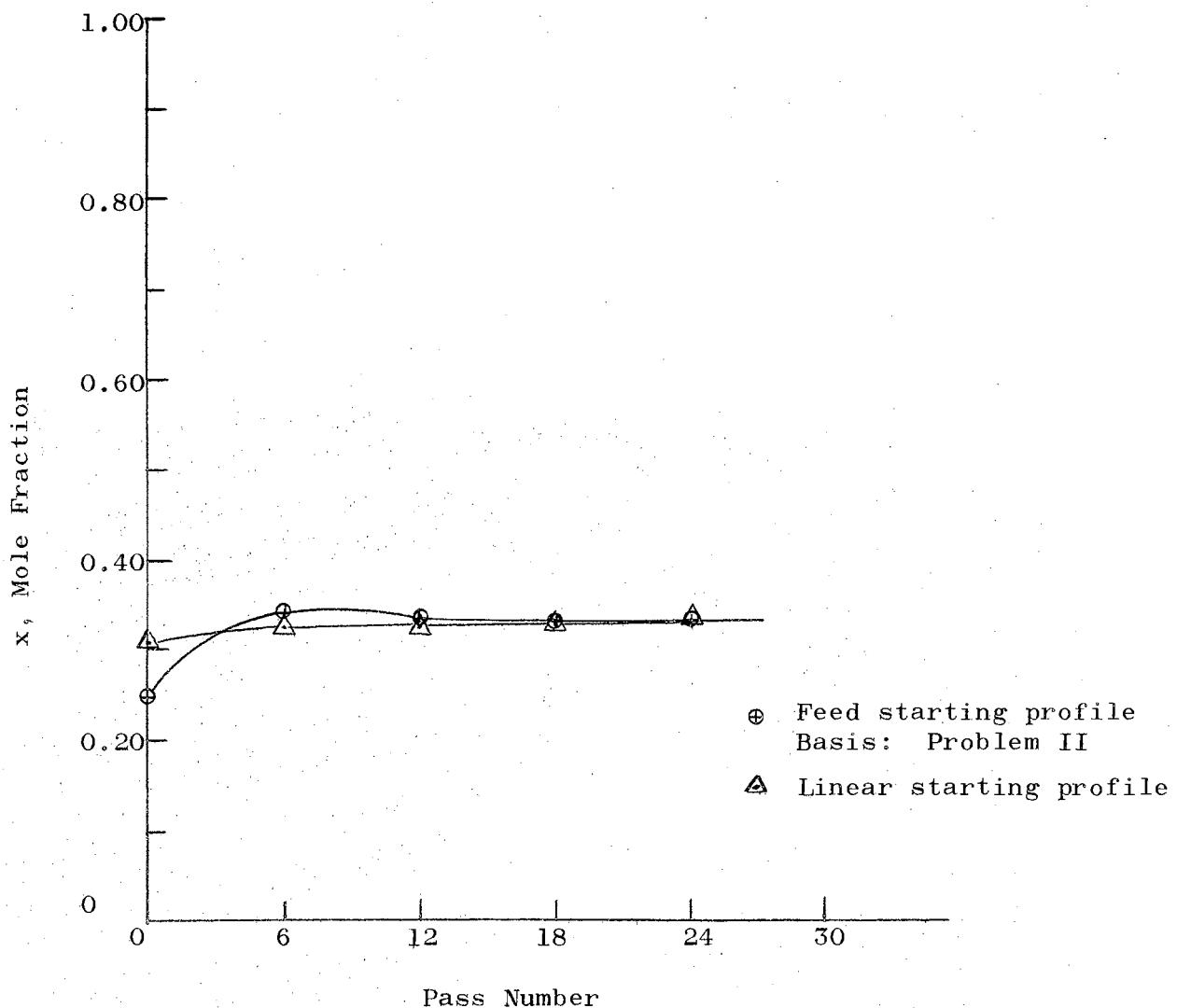


Figure 6. Variation of Concentration of Component Three on Tray Sixteen from Trial to Trial

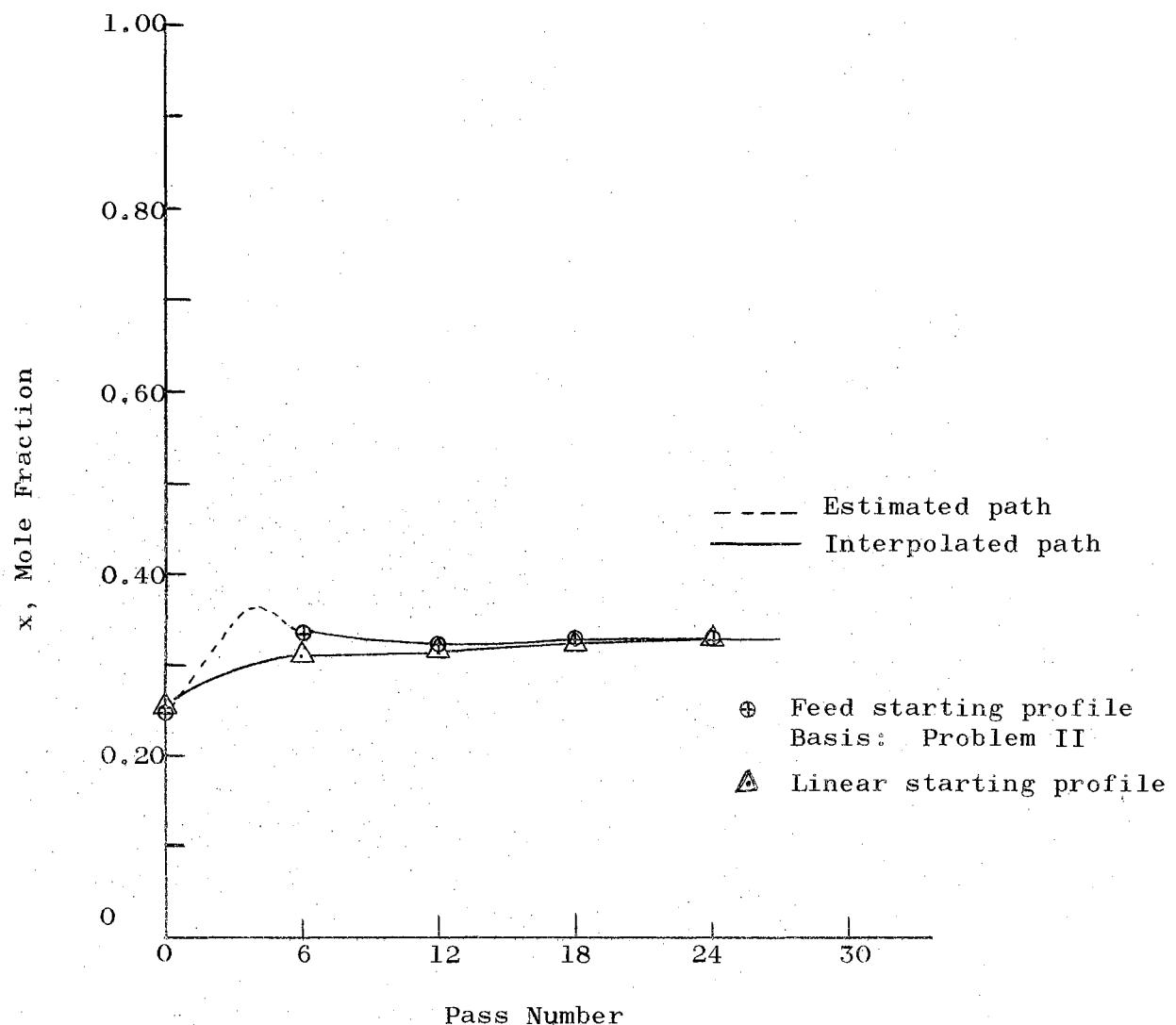


Figure 7. Variation of Concentration of Component Two on Tray Eleven from Trial to Trial

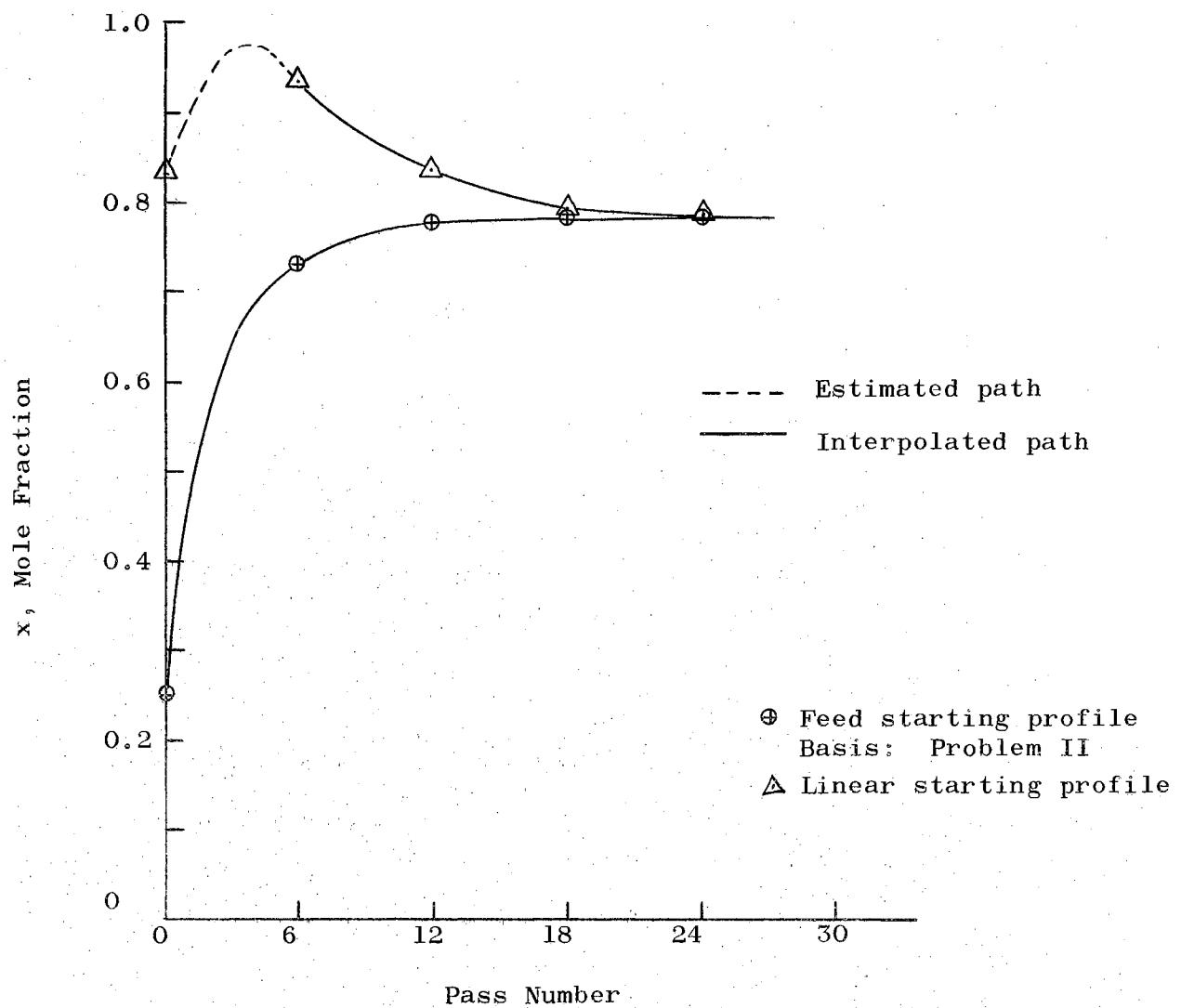


Figure 8. Variation of Concentration of Component One on Tray Two from Trial to Trial

CHAPTER V

CONCLUSIONS

A critical evaluation of a rigorous relaxation procedure for tray and product compositions for complex fractionators was made. In order to make this study, a computer program for the IBM 7090 of Ball's (3) modification of Rose's relaxation technique (22, 23) was written. An improved convergence technique was developed in order to improve the reliability of the program and to decrease the number of passes required to obtain a solution.

Several problems were solved in order to test the accuracy of the relaxation procedure against published solutions. The results of this study show that the relaxation procedure is reliable for simple or complex distillation columns with multi-component feeds. In fact, the only problem that could not be solved by the relaxation procedure was one that could not be solved by the company from which it was obtained (10).

Tests were made to determine the effect of the initial composition and temperature profiles on the number of passes required for convergence. A linear initial composition profile with a corresponding linear initial temperature profile was compared against an initial profile where each tray had the same composition as the total feed and each tray temperature was the bubble point temperature of the total feed. The results of these tests indicate that the initial profiles have some effect on convergence, but the best type of profile depends on the individual problem.

Results of tests of the ratio of the time interval over the holdup, $\Delta\theta/H'$, show that the ratio has a large effect on the number of passes required to reach a solution. However, these tests also show that a maximum value of $\Delta\theta/H'$ is reached where a further increase in this ratio has no effect on the convergence.

LIST OF NOMENCLATURE

- A - absorption factor defined by $A = L/KV$
a' - constant defined by equation (46)
B - molar flow rate of the total bottoms product
b - molal flow rate of any component in the bottoms product
b' - constant defined by equation (46)
c' - constant defined by equation (46)
D - molar flow rate of total distillate product
d - molar flow rate of any component in distillate product
d' - constant defined by equation (46)
F - molar flow rate of total feed
f - molar flow rate of any component in feed
 \bar{f} - pseudo molar flow rate of any component in feed
f' - fraction of total feed vaporized
g - variable used in solving tri-diagonal matrix
H - enthalpy per mole
H' - holdup in any individual tray
h - variable used in solving tri-diagonal matrix
K - vapor liquid equilibrium constant defined by $K = y/x$
K' - equilibrium constant for reference component
L - total molar flow rate of a liquid stream
l - molar flow rate of any component in liquid stream
M - number of trays in stripping section
N - number of trays in rectifying section

ncp - number of components

P - total molar flow rate of side product

p - molar flow rate of any component in side stream

\bar{P} - temporary molar flow rate of any product

\bar{p} - temporary molar flow rate of any component in product

Q - heat flow rate

S - stripping factor defined by $S = KV/L$

S_m - minimum number of stages in any section of a column

V - total molar flow rate of a vapor stream

v - molar flow rate of any component in a vapor stream

x - mole fraction of any component in liquid stream

y - mole fraction of any component in vapor stream

Greek Symbols

α - relative volatility

β - constant in Winn equation defined by equation (7)

β' - coefficient used in equation (44)

$\tilde{\beta}'$ - coefficient defined by equation (15)

γ - constant used in Winn equation defined by equation (7)

ϵ - error

θ - time

$\tilde{\theta}$ - forcing factor used in convergence procedure

\emptyset_A - fraction of entering gas stream not recovered in absorbing section

\emptyset_S - fraction of entering liquid stream not recovered in stripping section

\emptyset_j - constant used in Underwood Equations

a - assumed
av - average
b - bottoms
c - condenser
ca - calculated
co - corrected
d - distillate
E - rectifying section
HK - heavy key
i - component reference
l - liquid
K - individual tray number
LK - light key
n - individual tray number
R - reboiler
RP - rectifying pinch zone
SP - stripping pinch zone
X - stripping section

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APPENDIX A

VAPOR AND TEMPERATURE PROFILES

TABLE XI

PROBLEM I: VAPOR AND TEMPERATURE PROFILES WITH HEAT BALANCE

<u>Tray Number</u>	<u>Temperature °R</u>	<u>Vapor Rate (moles/hr)</u>
Condenser	520.0	0.0
1	523.49	82.71000
2	528.86	81.55318
3	535.55	80.25312
4	542.29	78.96915
5	547.85	77.90504
6	551.83	77.16169
7	554.55	76.68482
8	556.78	76.29446
9	559.86	75.67426
10	566.43	74.22920
11	568.21	73.96090
12	570.41	73.76626
13	572.98	73.58529
14	575.77	73.45327
15	578.60	73.39880
16	581.31	73.43019
17	583.93	73.49610
18	587.21	73.42192
Reboiler	594.20	72.60570

Operating Conditions:

Number of stages including reboiler	19
Feed tray number	9
Reflux ratio (V_1/F)	2.25367
Type of condenser	Total
Feed condition	Bubble point
Pressure psia	25.0
Distillate rate (D/F)	0.251131

TABLE XII

PROBLEM II: VAPOR AND TEMPERATURE PROFILES WITH HEAT BALANCE

<u>Tray Number</u>	<u>Temperature °R</u>	<u>Vapor Rate (moles/hr)</u>
Condenser	542.21	0.0
1	554.79	363.00000
2	563.37	355.63921
3	568.00	352.40939
4	570.25	351.39131
5	571.36	351.11574
6	571.98	351.06166
7	572.40	351.07893
8	572.74	351.12206
9	573.05	351.17756
10	573.35	351.23859
11	573.64	351.30366
12	573.93	351.37097
13	574.20	351.43953
14	574.47	351.50731
15	574.73	351.57299
16	574.98	351.63023
17	575.24	351.66302
18	575.54	351.62512
19	576.02	351.37157
20	577.04	350.48480
21	579.64	347.86170
22	582.20	348.07401
23	583.50	348.56738
24	584.22	348.93342
25	584.69	349.19622
26	585.05	349.40561
27	585.36	349.59253
28	585.65	349.77285
29	585.94	349.95064
30	586.22	350.12715
31	586.50	350.30059
32	586.78	350.46491
33	587.07	350.60035
34	587.42	350.65822
35	587.95	350.49498
36	589.04	349.71408
37	591.64	347.32132
38	597.74	341.47429
Reboiler	609.56	331.25837

Operating Conditions:

Number of stages including reboiler

39

TABLE XII (continued)

Feed tray number	19
Reflux ratio (V_1/F)	6.25932
Type of condenser	Total
Feed condition	Bubble point
Pressure psia	25.0
Distillate rate (D/F)	0.500047

TABLE XIII
PROBLEM III: VAPOR AND TEMPERATURE PROFILES

<u>Tray Number</u>	<u>Temperature °R</u>	<u>Vapor Rate (moles/hr)</u>
Condenser	522.61	25.11310
1	527.44	82.71000
2	533.85	81.42800
3	540.76	80.10252
4	546.83	78.93720
5	551.44	78.06227
6	554.97	77.40692
7	558.84	76.63107
8	565.88	75.08485
9	567.48	74.80617
10	569.49	74.61503
11	571.88	74.42835
12	574.53	74.27402
13	577.28	74.18609
14	579.94	74.18234
15	582.39	74.25182
16	584.73	74.34069
17	587.74	74.26132
Reboiler	594.49	73.42160

Operating Conditions:

Number of stages including reboiler	18
Feed tray number	8
Reflux ratio (V_i/F)	2.25367
Type of condenser	Partial
Feed condition	Bubble point
Pressure psia	25.0
Distillate rate (D/F)	0.251131

TABLE XIV
PROBLEM IV: VAPOR AND TEMPERATURE PROFILES

<u>Tray Number</u>	<u>Temperature °R</u>	<u>Vapor Rate (moles/hr)</u>
Condenser	554.75	50.00470
1	563.34	363.0000
2	567.99	359.66764
3	570.25	358.61576
4	571.36	358.32826
5	571.98	358.27053
6	572.40	358.28748
7	572.74	358.33094
8	573.05	358.38646
9	573.35	358.45168
10	573.64	358.51800
11	573.93	358.58685
12	574.21	358.65566
13	574.49	358.71695
14	574.78	358.75761
15	575.12	358.72969
16	575.62	358.48987
17	576.67	357.62296
18	579.28	354.99422
19	581.77	355.16100
20	583.03	355.61387
21	583.73	355.95518
22	584.18	356.19614
23	584.52	356.39841
24	584.82	356.57613
25	585.11	356.75176
26	585.40	356.92484
27	585.68	357.10320
28	585.96	357.28109
29	586.24	357.46061
30	586.52	357.63449
31	586.79	357.80045
32	587.08	357.93665
33	587.42	357.99172
34	587.79	357.81359
35	589.05	357.01041
36	589.65	354.54151
37	597.76	348.54022
Reboiler	609.59	338.08413

Operating Conditions:

Number of stages including reboiler	38
Feed tray number	18

TABLE XIV (continued)

Reflux ratio (V_1/F)	6.25932
Type of condenser	Partial
Feed condition	Bubble point
Pressure psia	25.0
Distillate rate (D/F)	0.500047

TABLE XV
PROBLEM V: VAPOR AND TEMPERATURE PROFILES

<u>Tray Number</u>	<u>Temperature °R</u>	<u>Vapor Rate (moles/hr)</u>
Condenser	548.00	0.0
1	584.03	8227.440
2	585.72	9409.651
3	585.02	9412.764
4	585.16	9410.716
5	585.23	9407.034
6	585.27	9404.948
7	585.30	9402.555
8	585.32	9400.413
9	585.33	9398.522
10	585.35	9396.906
11	585.36	9394.948
12	585.37	9393.792
13	585.37	9394.376
14	585.38	9392.809
15	585.39	9391.724
16	585.40	9390.734
17	585.41	9389.822
18	585.41	9388.962
19	585.41	9390.035
20	585.42	9389.299
21	585.42	9388.880
22	585.43	9387.178
23	585.43	9388.408
24	585.44	9386.140
25	585.44	9387.723
26	585.45	9386.918
27	585.45	9386.552
28	585.46	9386.189
29	585.47	9385.770
30	585.46	9387.168
31	585.47	9386.473
32	585.48	9385.990
33	585.48	9385.876
34	585.49	9385.703
35	585.49	9386.310
36	585.50	9386.044
37	585.51	9385.549
38	585.52	9385.440
39	585.53	9385.247
40	585.54	9385.027
41	585.55	9384.796
42	585.56	9385.485
43	585.58	9384.955
44	585.59	9384.771
45	585.61	9384.183

TABLE XV (continued)

46	585.63	9383.929
47	585.65	9383.607
48	585.67	9383.256
49	585.69	9382.468
50	585.71	9383.291
51	585.74	9382.760
52	585.77	9381.956
53	585.81	9381.539
54	585.84	9380.974
55	585.88	9380.374
56	585.93	9450.709
57	585.98	9450.738
58	586.01	9449.153
59	587.05	9448.149
60	587.09	9447.101
61	587.13	9446.043
62	587.17	9445.793
63	587.21	9444.668
64	587.27	9443.306
65	587.33	9442.280
66	587.39	9441.143
67	587.47	9438.979
68	587.54	9439.662
69	587.64	9437.886
70	587.74	9436.230
71	587.85	9434.681
72	587.97	9432.961
73	587.11	9431.105
74	587.27	9428.141
75	587.43	9426.031
76	587.61	9425.390
77	588.81	9422.548
78	588.02	9219.857
79	588.25	9416.638
80	588.50	9413.608
81	588.77	9410.359
82	589.05	9406.964
83	589.35	9403.421
84	589.66	9399.778
85	589.99	9395.336
86	590.32	9391.666
87	590.66	9387.866
88	591.00	9384.057
89	591.35	9380.306
90	591.69	9376.672
Reboiler	592.02	9374.184

Operating Conditions:

Number of stages including reboiler

91

TABLE XV (continued)

Feed tray number	55
Side cut tray number	23
Type of condenser	Subcooled to 88.8° F
Reflux ratio (V_1/F)	22.98
Feed condition	Subcooled
Feed temperature	83.0° F
Feed bubble point temperature	124.5° F
Pressure psia	84.0
Distillate rate (D/F)	0.5995
Side cut rate (S/F)	0.2500

TABLE XVI
PROBLEM VI: VAPOR AND TEMPERATURE PROFILES

<u>Tray Number</u>	<u>Temperature °R</u>	<u>Vapor Rate (moles/hr)</u>
Condenser	562.60	38.00000
1	577.61	94.80000
2	585.71	94.76300
3	592.99	93.52702
4	600.10	92.14200
5	606.69	90.90222
6	612.57	89.81487
7	634.02	54.06847
8	646.22	55.34187
9	654.91	55.55139
10	662.81	55.11015
11	674.24	53.47320
12	706.28	47.25849
13	708.00	44.41909
14	710.01	44.99640
15	712.31	45.67053
16	714.94	46.42955
17	718.11	47.22683
18	727.53	47.93772
19	730.93	48.16822
Reboiler	756.30	46.02955

Operating Conditions:

Number of stages including reboiler	20
Feed I tray number	7
Feed II tray number	12
Type of condenser	Partial
Reflux ratio (V_1/F)	0.948
Feed I condition	Dew point
Feed II condition	Bubble point
Feed I dew point temperature	128.0°F
Feed II bubble point temperature	267.6°F
Pressure psia	264.7
Distillate rate (D/F)	0.38

TABLE XVII
PROBLEM VII: VAPOR AND TEMPERATURE PROFILES

<u>Tray Number</u>	<u>Temperature °R</u>	<u>Vapor Rate (moles/hr)</u>
Condenser	541.18	23.00000
1	562.46	94.80000
2	570.48	97.03485
3	575.59	97.10231
4	581.45	95.41581
5	588.62	93.74126
6	597.21	91.70544
7	617.60	54.79064
8	632.05	55.13255
9	644.31	54.75523
10	655.72	55.07894
11	670.04	52.30245
12	704.58	46.28568
13	706.12	43.04042
14	708.01	43.54036
15	710.27	44.15095
16	712.97	44.87240
17	716.32	45.67320
18	721.01	46.44194
19	729.72	46.79616
Reboiler	755.39	44.87992

Operating Conditions:

Number of stages including reboiler	20
Feed I tray number	7
Feed II tray number	12
Type of condenser	Partial
Reflux ratio (V_1/F)	0.9480
Feed I condition	Dew point
Feed II condition	Bubble point
Feed I dew point temperature	128.0°F
Feed II bubble point temperature	126.6°F
Pressure psia	264.7
Distillate rate (D/F)	0.23
Side cut rate (S/F)	0.15

TABLE XVIII

PROBLEM VIII: VAPOR AND TEMPERATURE PROFILES AFTER SIXTY PASSES

<u>Tray Number</u>	<u>Temperature °R</u>	<u>Vapor Rate (moles/hr)</u>
Condenser	580.00	0.00000
1	694.96	388.66619
2	785.80	329.93223
3	828.77	329.93223
4	845.07	329.93223
5	853.53	329.93223
6	861.81	329.93223
7	870.70	329.93223
8	879.93	329.99223
9	888.70	329.93223
10	896.40	329.93223
11	903.05	329.93223
12	909.18	329.93223
13	915.42	329.93223
14	922.21	329.93223
15	933.60	249.85492
16	947.17	732.16971
17	951.83	847.17067
18	955.10	878.91467
19	957.82	895.60583
20	960.00	910.35013
21	960.00	934.53320
22	960.00	923.62558
23	960.00	912.73195
24	960.00	901.64571
25	960.00	890.09650
26	960.00	877.63260
27	960.00	863.49689
Reboiler	960.00	846.55124

Operating Conditions:

Number of stages including reboiler	28
Feed tray number	15
Type of condenser	Subcooled to 120°F
Reflux ratio (V_1/F)	1.1954
Feed temperature	285°F
Feed flash ratio (L/F)	0.8545
Pressure psia	150
Distillate rate (D/F)	0.5977

APPENDIX B

COMPUTER PROGRAM

COMPUTER PROGRAM

A program was written for the IBM 7090 in Fortran II for the proposed method presented in this work. It was written to handle a maximum of 25 components, 200 trays, three feeds, four side draws, and six intercoolers.

The input data requirements and a brief discussion of each item are listed below. Also, an input data sheet which specifies the location of each item on the individual card and the order of cards is included.

Input Format Specifications

There are four types of input data format statements used in this program. They are as follows:

Fw.d - This type of format is used for floating point numbers, such as F14.6 where a decimal is used. The total word length is specified by w, and the decimal point is located by d where there are d digits to the right of the decimal. However, if a decimal point is punched on the card, the specified decimal point location is overridden.

Ew.d - This type of format specification is used for floating point numbers where an exponent is specified. The terms w and d have the same meaning as in the F type format. The term E is used to indicate the exponent, and the numbers following the E indicate the power of ten to which the number preceding

the E is raised. An example of this type of format is 0.1746E-03. This number would be written as 0.0001746 using an F type format.

In - This type of format is used for fixed point numbers where no decimals are included. An example of a number to be read under this type of format is 74.

An - This format is used for ready alphabetic information such as the problem identification or component names. The width of the field is specified by n. By using this type of format, alphabetic, numeric, and special characters can be read. An example of this type of format is "PID *** TEST RUN NO. 2."

For a more detailed discussion of the various formats listed above, the reader is referred to the IBM Fortran Manual (32).

Input Data

The input data are punched in the following order:

Card 1

This card is used for identification purposes only. Any type of identification information can be punched on this card.

Card 2

This card contains the eight convergence limits used by the program, and the specified condenser temperature if required. For a brief discussion of these limits, the reader is referred to the first page of the input data sheet. Each of these items is a floating point variable with a format of F8.6.

Card 3

This card contains seven variables. The variables are, in order of their location on the card, maximum temperature, minimum temperature, convergence factor, vapor rate (V_1/F), pressure, distillate rate (D/F), and time interval. Each of these variables has a specified format of F8.6. The convergence factor corresponds to β' in equation (43), Chapter III, and is usually set equal to one. The pressure is used for identification purposes only.

Card 4

This card contains ten fixed point constants. The first nine are read under an I3 type format, and an I4 format is used for the tenth. These constants, in chronological order are, the number of side streams (zero to four), the number of intercoolers (zero to six), the number of feeds (one to three), the maximum number of passes divided by 30, condenser type (one if total condenser or two if partial condenser), the number of components (two to 25), holdup test (zero if all the trays have the same holdup throughout the column or one if the holdup is not constant), output test (one if every sixth pass and final results are printed or two if only the final results are printed), vapor test (one if constant molal overflow or two if non-constant molal overflow), and the maximum number of trays (three to 200) which includes the condenser and reboiler.

Card 5

This card is used only if the column has one or more side streams. It gives the location of the side stream using an I4 format and the stream rate (S/F) using an F8.5 format. There will be one card for each side stream, and they are loaded starting with the top side stream.

Card 6

This card is used only if the column has one or more intercoolers. It gives the tray number of each intercooler using an I4 type format, and the amount of heat removed per unit of time using an E14.8 type format. There is one card per intercooler, and they are loaded starting with the top intercooler.

Card 7

This card is used to read the component rates in each feed and the component identification. The rates are read under an F8.5 type format, and the identification is read under a 2A6 format. The component rate in the top feed is located in the first eight spaces on the card and the second rate in the second eight spaces, etc. If there are not three feeds, the corresponding location for the missing feed is left blank or set equal to zero. The component identification is located in column 25 through 36. There is a card for each component, and they are located in order of the lightest component first.

Card 8

This card is used to read data about each individual feed stream. The variables used here are the feed location, feed condition (the reader is referred to Input Data Sheet 4 for an explanation of this test), feed enthalpy (set equal to zero, if it is to be calculated or if dew point or bubble point feed), and the feed temperature (set equal to zero if it is to be calculated). There is one card for each feed, and they are loaded in order of the top feed first. The formats used are I4 for the first number and F8.6 for the last three variables.

Card 9

These data are the coefficients used for calculating the equilibrium

K values in the following form:

$$K = A + B(T) + C(T^2) + D(T^3) + E(T^4) + F(T^5)$$

These coefficients are all read under an E12.6 type format. If some of the coefficients are not used, they should be set equal to zero.

These cards are loaded in the same order as the feed component cards.

Cards 10 and 11

Card 10 is used to read the coefficients of the liquid enthalpy, and Card 11 is for the vapor enthalpy. The equation using these coefficients is of the following form:

$$H = A + B(T) + C(T^2) + D(T^3) + E(T^4)$$

Each of these coefficients is read under an E12.6 type format. There is one card for each component, and they are loaded in the same order as the feed with alternate liquid and vapor coefficients, starting with the liquid.

Card 12

This card is used to load the holdup for each tray. If the holdup test is set equal to zero in Card 3, only one card is used; if the test is one, there must be one card for each tray, including the condenser and reboiler. The format used is F8.1. Because the holdup and time interval are fictitious numbers used for convergence, only the ratio of the time interval in Card 3 and the holdup in Card 12 are of importance. In order to arrive at a stable solution, this ratio should be about 100.0. If the ratio is less than 100, the convergence time is greater. If the ratio is larger than 100, the convergence time will generally be smaller. The user may experiment with the size of this ratio for a given set of conditions to determine the maximum size ratio that will give a suitable solution.

As many problems as desired may be loaded at one time. Each of the problems is independent of the other, and a complete set of data for each problem must be used. The only three conditions that can occur that will call the program to exit without completing all of the problem(s) are: (1) the maximum execution time is exceeded, (2) the convergence subroutine of the program cannot converge, or (3) the flash feed subroutine cannot converge. If the maximum number of passes have occurred, the program will print the final results and then proceed to the next problem.

The tray numbering system used starts with the top tray as tray one. The condenser is tray zero, and the reboiler is the maximum number of trays as read in Card 4 minus one.

Error Comments

The following error comments are given if they should occur in the program:

- A. ***** WARNING ***** THIS PROBLEM DID NOT CONVERGE, THE ABOVE RESULTS ARE NOT A FINAL SOLUTION TO THIS PROBLEM:

This comment is written if the maximum number of passes has been exceeded without the problem converging. The program will proceed to the next problem.

- B. MAXIMUM NUMBER OF TRIALS EXCEEDED FOR FEED - n WILL CALL EXIT:

This comment is printed if the condition of a flash feed cannot converge. The problem is terminated by calling EXIT.

- C. PROBLEM CANNOT CONVERGE WILL PRINT RESULTS THEN CALL EXIT:

This comment is printed if the over-all material balance does not converge. The results are printed, and the program is

stopped by calling EXIT.

D. DEW POINT DID NOT CONVERGE FOR FEED n WILL SET TEMPERATURE AT
 AND CONTINUE:

This comment occurs only while calculating the feed dew point. If this comment is printed, the temperature is set at the one stated and the program continues.

E. BUBBLE POINT DID NOT CONVERGE FOR TRAY OR FEED n WILL SET TEMPERATURE AT AND CONTINUE:

This comment can occur while calculating the feed or tray bubble point. The bubble point temperature will be set equal to the one stated, and the program will continue.

F. MAXIMUM CHANGE IN COMPOSITION ERROR FROM PASS TO PASS IS NOT SIGNIFICANT - WILL SET COMPOSITION TEST AS CONVERGED AND RETURN:

This comment can occur if the maximum change in composition from one pass to the next is insignificant. The composition convergence test constant will be set to the converged condition, and the program will continue.

Output

The output consists of a statement describing the conditions of convergence, a listing of composition, and the component rate of passing liquids and vapor streams between each tray, a table of product compositions and component rates, and a tabular listing of tray temperature, vapor rates, and vapor enthalpy. The programmer has the option of printing the results of every six passes and the final results or printing only the final results.

**FOR
OSU TRAY BY TRAY PROGRAM**

PROBLEM IDENTIFICATION

1	10 11	20 21	30 31	40 41	50 51	60 61	70

CONVERGENCE LIMITS (See Note)

DEW POINT	MATERIAL BALANCE	COMPOSITION PROFILE	TEMPERATURE PROFILE	VAPOR PROFILE	BUBBLE POINT	L/F FOR FLASH FEEDS	HEAT BALANCE FLASH FEEDS	FIXED CONDENSER TEMPERATURE SET TO 0.0 IF NOT FIXED
1	8.9	16 17	24 25	32 33	40 41	48 49	56 57	64 65

MAXIMUM TEMPERATURE	MINIMUM TEMPERATURE	CONVERGENCE FACTOR	VAPOR RATE TOP TRAY(V/F)	PRESSURE	DISTILLATE RATE(D/F)	TIME INTERVAL
1	8.9	16 17	24 25	32 33	40 41	48 49

1	34	67	9 10	12 13	15 16	18 19	21 22	24 25	27 28	32

NUMBER OF SIDE STREAMS

NUMBER OF INTER COOLERS

NUMBER OF FEEDS

MAXIMUM NUMBER OF TRIALS/30

CONDENSER TYPE • 1-TOTAL; 2-PARTIAL

NUMBER OF COMPONENTS

CONSTANT HOLDUP • 0-YES; 1-NO

INTERMEDIATE PASSES PRINTED • 1-NO ; 2-YES

CONSTANT MOLAL OVERFLOW • 1-YES; 2-NO

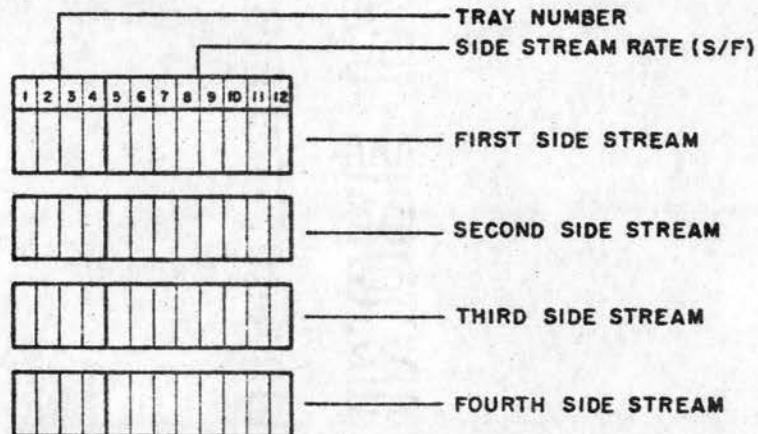
NUMBER OF TRAYS INCLUDING CONDENSER AND REBOILER

NOTE: CONVERGENCE LIMITS

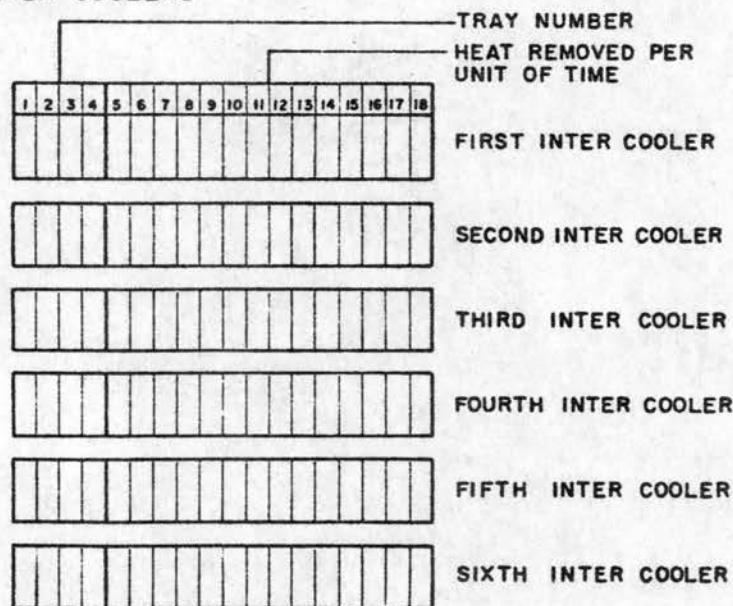
IF THESE ARE LEFT BLANK OR SET EQUAL TO 0.0,
THE PROGRAM WILL ASSUME THE FOLLOWING LIMITS:

DEW POINT	0.001
MATERIAL BALANCE	0.0001
COMPOSITION PROFILE	0.0001
TEMPERATURE PROFILE	0.001
VAPOR PROFILE	0.001
BUBBLE POINT	0.001
L/F FOR FLASH FEED	0.001
ENTHALPY BALANCE FOR FLASH FEEDS	10.0

SIDE STREAMS



INTER COOLERS

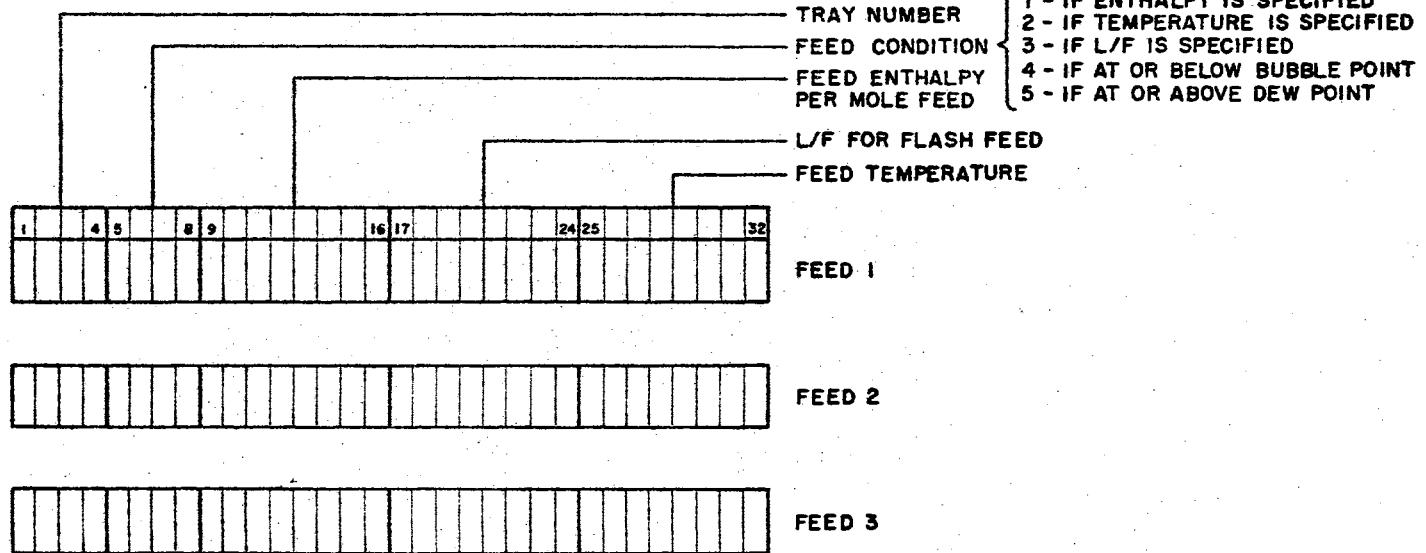


COMPONENT FEED RATES

FEED₁ **FEED₂**

FEED₃

COMPONENT NAME

FEED DATA

COEFFICIENTS FOR EQUILIBRIUM VALUES

A

B

c

6

1

F

COEFFICIENTS FOR VAPOR AND LIQUID ENTHALPY

A	B	C	D	E	
1	12 13	24 25	36 37	48 49	60
LIQUID } VAPOR }	COMPONENT 1				
LIQUID } VAPOR }	COMPONENT 2				
LIQUID } VAPOR }	COMPONENT 3				
LIQUID } VAPOR }	COMPONENT 4				
LIQUID } VAPOR }	COMPONENT 5				
LIQUID } VAPOR }	COMPONENT 6				
LIQUID } VAPOR }	COMPONENT 7				
LIQUID } VAPOR }	COMPONENT 8				
LIQUID } VAPOR }	COMPONENT 9				
LIQUID } VAPOR }	COMPONENT 10				
LIQUID } VAPOR }	COMPONENT 11				
LIQUID } VAPOR }	COMPONENT 12				

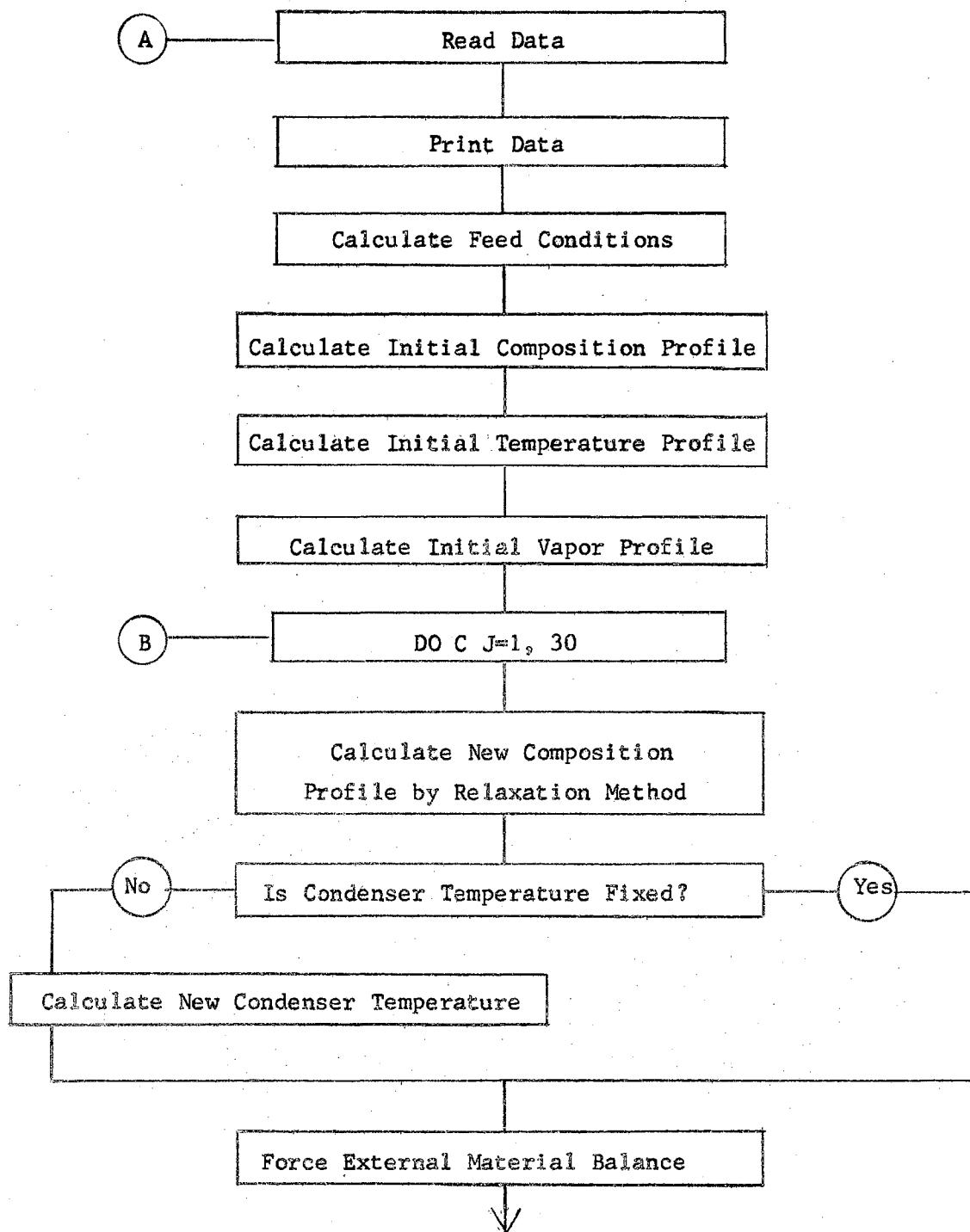
1	2	3	4	5	6	7	8
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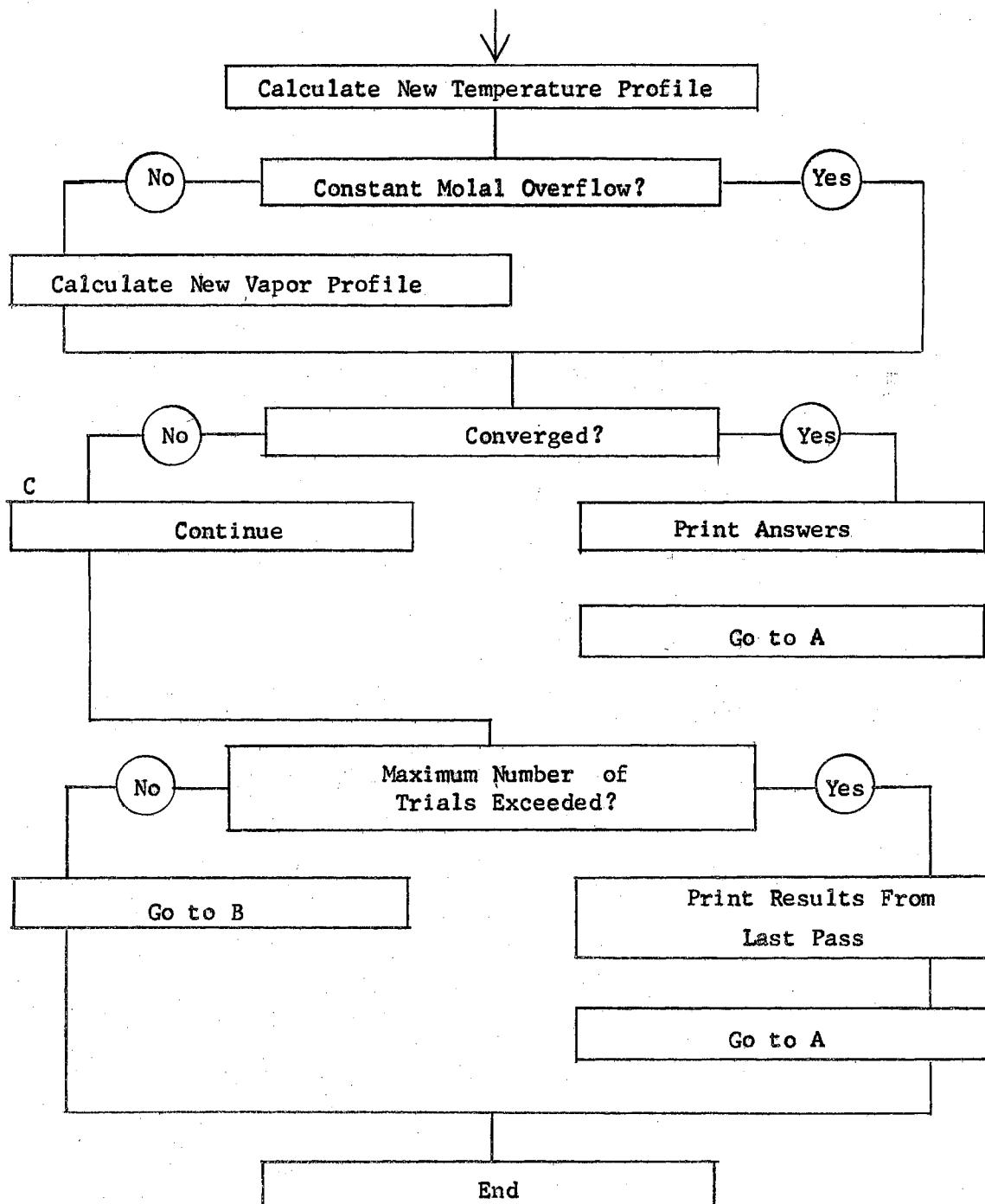
ONE CARD IF HOLDUP TEST IS 0
ONE CARD FOR EACH TRAY IF HOLDUP TEST IS 1

APPENDIX C

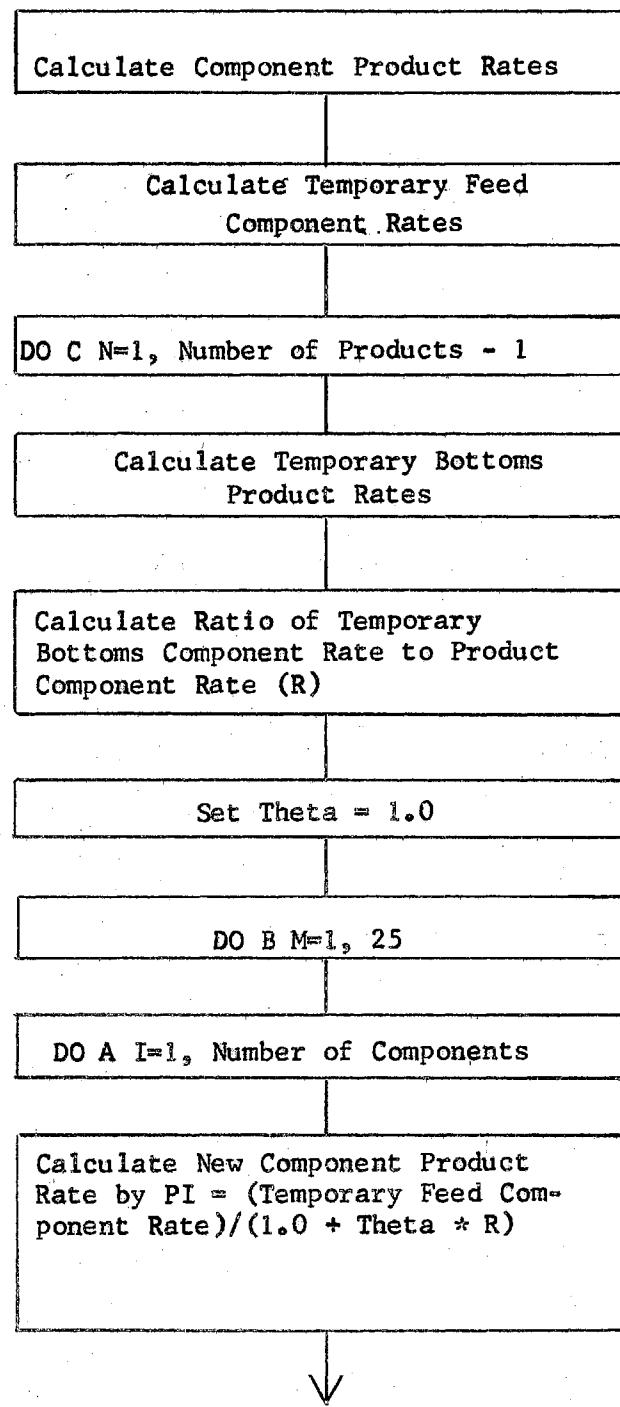
BLOCK DIAGRAMS

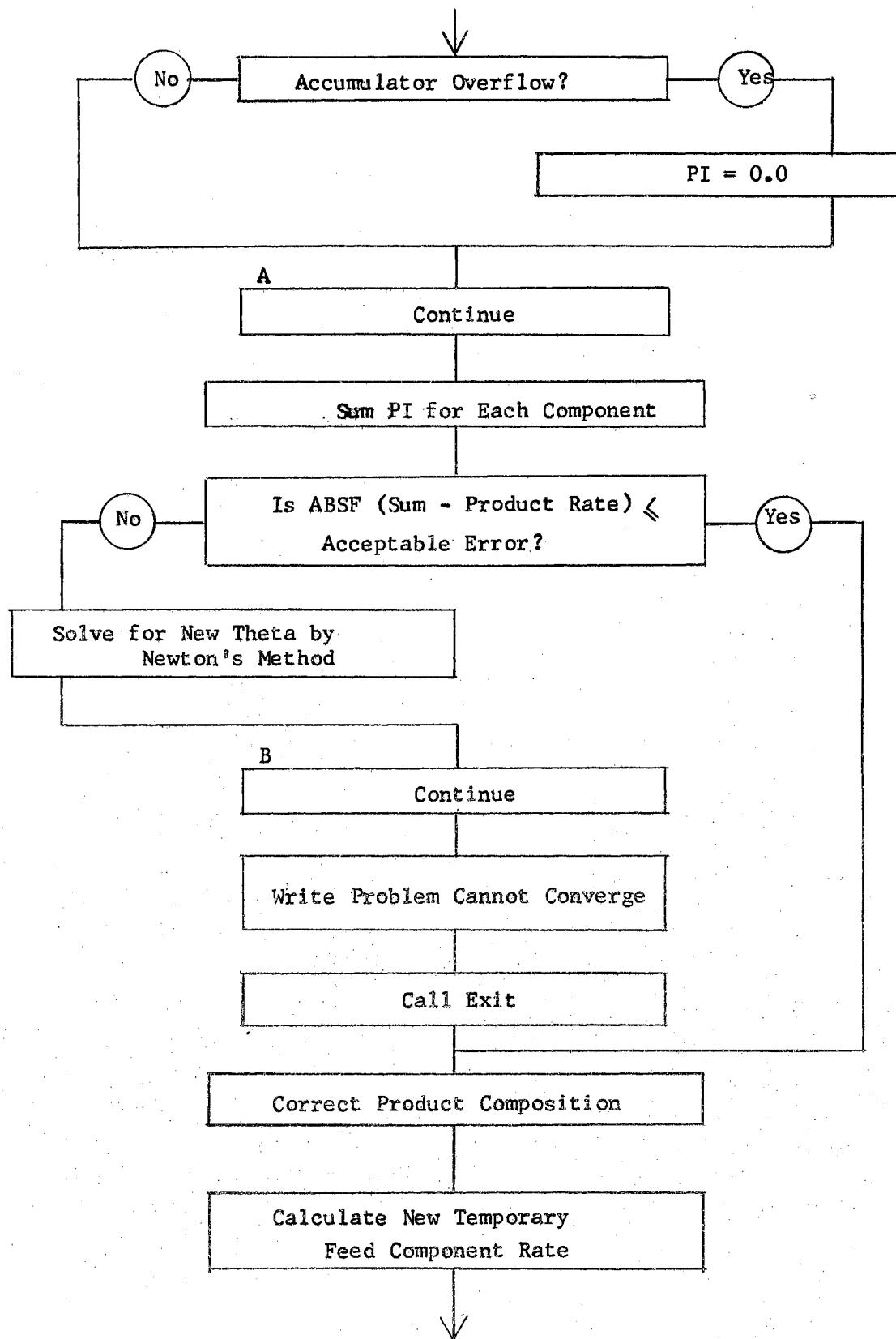
BLOCK DIAGRAM FOR ENTIRE PROGRAM

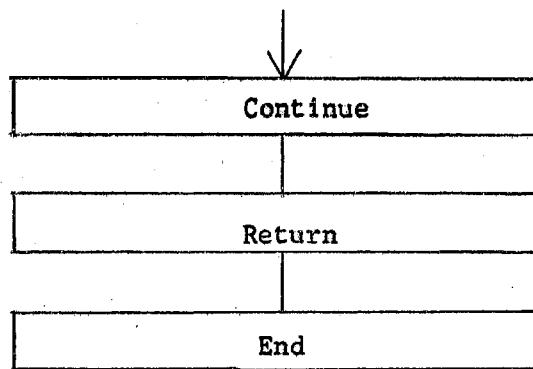




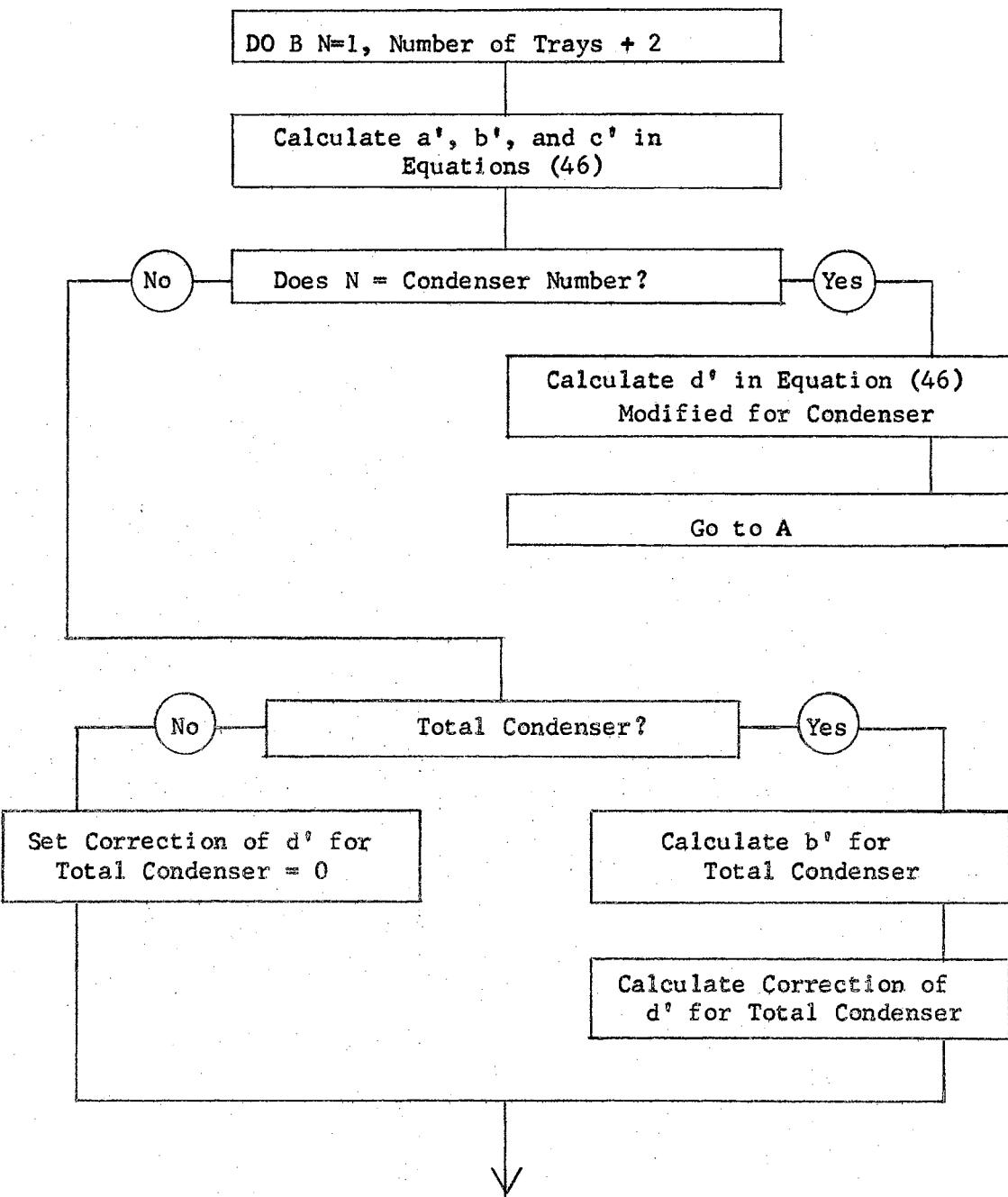
BLOCK DIAGRAM OF CONVERGENCE PROCEDURE (SUBROUTINE CNVRG)

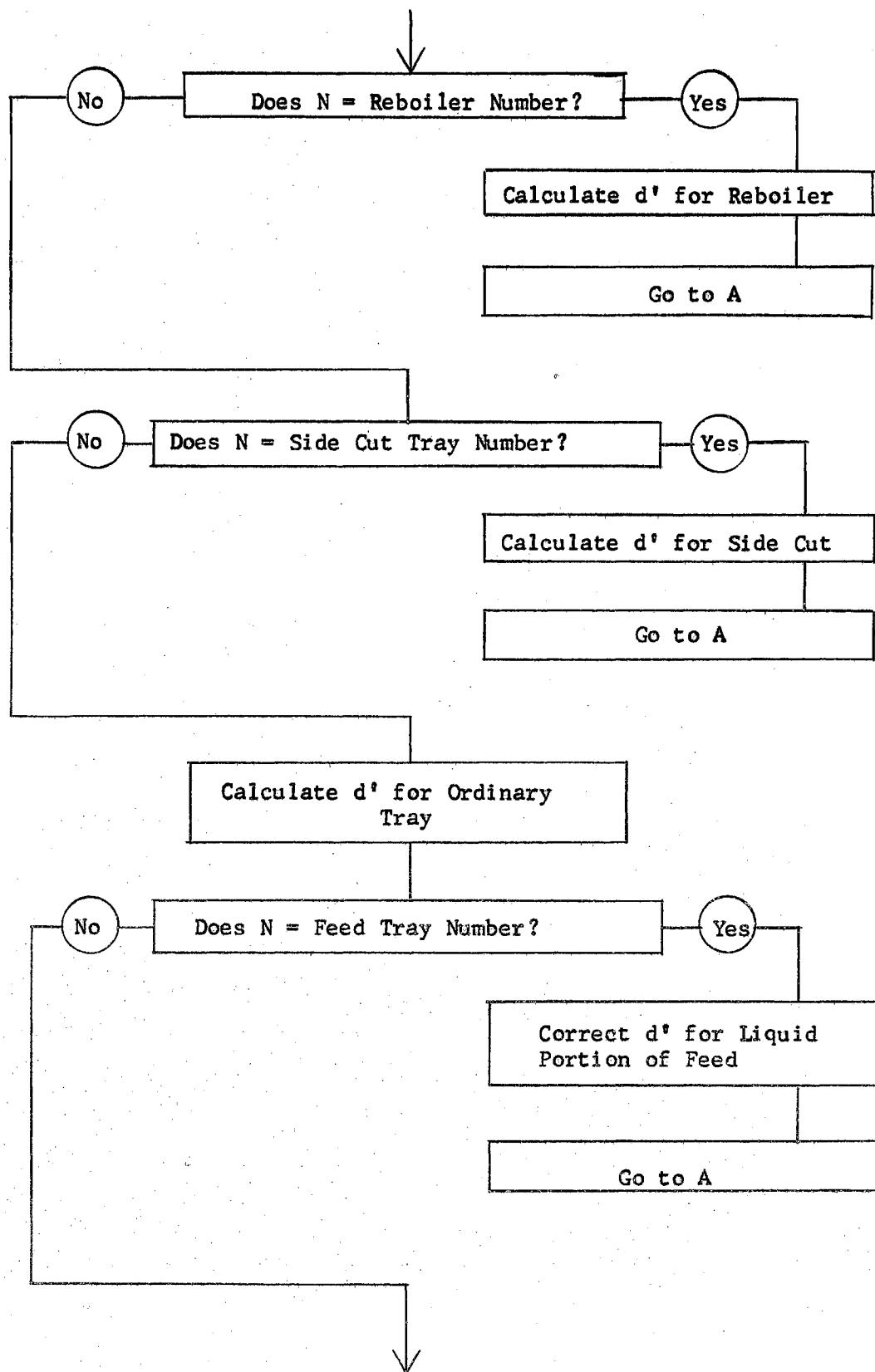


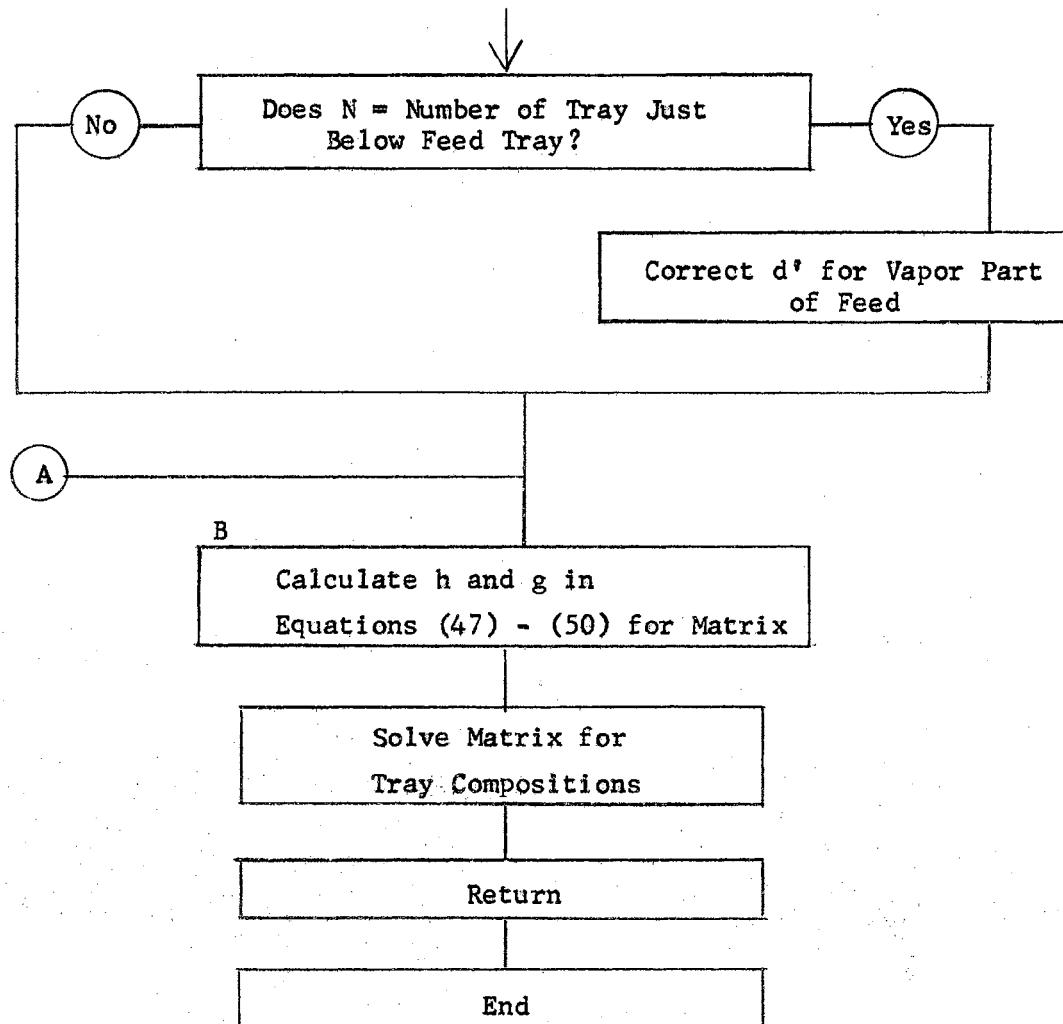




BLOCK DIAGRAM FOR RELAXATION TECHNIQUE (SUBROUTINE XVAL)







APPENDIX D

PROGRAM LISTING

*	XEQ	1
#	LIST8	2
#	LABEL	3
CMAIN	O.S.U. TRAY BY TRAY	0004
C	*****	*****
C	NOMENCLATURE OF FORTRAN SYMBOLS	0005
C	AK COEFFICIENT IN EQUILIBRIUM K VALUE EQUATION	0006
C	ALIM1 ERROR TOLERANCE FOR DEW POINT	0007
C	ALIM2 ERROR TOLERANCE FOR CONVERGENCE SUBROUTINE	0008
C	ALIM3 ERROR TOLERANCE FOR COMPOSITION PROFILE	0009
C	ALIM4 ERROR TOLERANCE FOR TEMPERATURE PROFILE	0010
C	ALIM5 ERROR TOLERANCE FOR VAPOR PROFILE	0011
C	ALIM6 ERROR TOLERANCE FOR BUBBLE POINT	0012
C	ALIM7 ERROR TOLERANCE FOR LOF FOR FLASH FEEDS	0013
C	ALIM8 ERROR TOLERANCE FOR ENTHALPY BALANCE FOR FLASH FEEDS	0014
C	BETA CONSTANT IN COMPOSITION SUBROUTINE	0015
C	BI BOTTOMS COMPONENT RATE	0016
C	BK COEFFICIENT IN EQUILIBRIUM K VALUE EQUATION	0017
C	BTMS BOTTOMS FLOW RATE	0018
C	CFD TEMPORARY FEED COMPONENT RATE	0019
C	CK COEFFICIENT IN EQUILIBRIUM K VALUE EQUATION	0020
C	DELT TIME INTERVAL	0021
C	DI DISTILLATE COMPONENT RATE	0022
C	DK COEFFICIENT IN EQUILIBRIUM K VALUE EQUATION	0023
C	DOF RATIO OF DISTILLATE TO FEED RATE	0024
C	DSPEC DISTILLATE RATE	0025
C	EK COEFFICIENT IN EQUILIBRIUM K VALUE EQUATION	0026
C	ENL0 COEFFICIENT IN LIQUID ENTHALPY EQUATION	0027
C	ENL1 COEFFICIENT IN LIQUID ENTHALPY EQUATION	0028
C	ENL2 COEFFICIENT IN LIQUID ENTHALPY EQUATION	0029
C	ENL3 COEFFICIENT IN LIQUID ENTHALPY EQUATION	0030
C	ENL4 COEFFICIENT IN LIQUID ENTHALPY EQUATION	0031
C	ENVO COEFFICIENT IN VAPOR ENTHALPY EQUATION	0032
C	ENV1 COEFFICIENT IN VAPOR ENTHALPY EQUATION	0033
C	ENV2 COEFFICIENT IN VAPOR ENTHALPY EQUATION	0034
C	ENV3 COEFFICIENT IN VAPOR ENTHALPY EQUATION	0035
C	ENV4 COEFFICIENT IN VAPOR ENTHALPY EQUATION	0036
C	EQUI1 EQUILIBRIUM K VALUE	0037
C	EQUI EQUILIBRIUM K VALUE	0038
C	F TERM FOR SOLVING MATRIX IN COMPOSITION SUBROUTINE	0039
C	FDRT FEED RATE	0040
C	FK COEFFICIENT IN EQUILIBRIUM K VALUE EQUATION	0041
C	FLDR1 LIQUID FLOW RATE	0042
C	FLDR2 LIQUID FLOW RATE	0043
C	FRACT FRACTION OF FEED AS LIQUID	0044
C	G TERM FOR SOLVING MATRIX IN COMPOSITION SUBROUTINE	0045
C	Hfed FEED ENTHALPY	0046
C	HFLQD ENTHALPY OF LIQUID PORTION OF FEED	0047
C	HFUPR ENTHALPY OF VAPOR PORTION OF FEED	0048
C	HHST HEAT REMOVED BY INTERCOOLER	0049
C	HLDP TRAY HOLDUP	0050
C	ICON TYPE OF CONDENSER TEST	0051
C	IDHDP HOLDUP TEST	0052
C	IFLIP CONSTANT TO SET MAXIMUM NUMBER OF TRIALS	0053
		0054

C	IMAX	NUMBER OF COMPONENTS	0055
C	IOTP	TEST FOR PRINTING INTERMEDIATE RESULTS	0056
C	ITMST	FEED CONDITION	0057
C	IVPR	TEST CONSTANT FOR CONSTANT MOLAL OVERFLOW	0058
C	LTEST	CONVERGENCE TEST	0059
C	MTEST	CONVERGENCE TEST	0060
C	NFDS	NUMBER OF FEEDS	0061
C	NFPT	FEED PLATE NUMBER	0062
C	NHTM	INTERCOOLER TRAY NUMBER	0063
C	NHTMS	NUMBER OF INTERCOOLERS	0064
C	NIN	INPUT TAPE DRIVE NUMBER	0065
C	NMAX	NUMBER OF TRAYS INCLUDING CONDENSER AND REBOILER	0066
C	NOUT	OUTPUT TAPE DRIVE NUMBER	0067
C	NSTM	SIDE STREAM TRAY NUMBER	0068
C	NSTMS	NUMBER OF SIDE STREAMS	0069
C	NTEST	CONVERGENCE TEST	0070
C	PID	PROBLEM IDENTIFICATION	0071
C	PI	PRODUCT COMPONENT RATE	0072
C	POP	RATIO OF TEMPORARY BOTTOMS AND DISTILLATE COMPONENT RATES	0073
C	PRESS	PRESSURE	0074
C	QREB	REBOILER HEAT DUTY	0075
C	REFLX	RATIO OF TOP TRAY VAPOR RATE TO FEED RATE	0076
C	RTFX	SINGLE FEED COMPONENT RATE	0077
C	SDSR	SIDE STREAM RATE	0078
C	SFDJ	TOTAL COMPONENT FEED RATE	0079
C	SMFD	TOTAL FEED RATE	0080
C	SOF	RATIO OF SIDE STREAM RATE TO FEED RATE	0081
C	TCON	CONDENSER TEMPERATURE	0082
C	TFED	FEED TEMPERATURE	0083
C	THETA	FORCING FUNCTION IN CONVERGENCE SUBROUTINE	0084
C	TMAX	MAXIMUM TEMPERATURE	0085
C	TMIN	MINIMUM TEMPERATURE	0086
C	TOTI	TEMPORARY BOTTOMS COMPONENT RATE	0087
C	T	TRAY TEMPERATURE	0088
C	VPRR	VAPOR RATE	0089
C	X	LIQUID MOLE FRACTION	0090
C	XFED	MOLE FRACTION OF LIQUID PART OF FEED	0091
C	XNAME	COMPONENT NAME	0092
C	YFED	MOLE FRACTION OF VAPOR PART OF FEED	0093
C	*****		0094
C	LIST OF DUMMY VARIABLES		
C	A	J N6	0095
C	ABC	JB N7	0096
C	ABUG	JFD N8	0097
C	AKPRM	JHE N879	0098
C	ALK	JHE1 PROD	0099
C	ALOT	JJ Q	0100
C	ALRT	JJMP QBT	0101
C	AVG	JK QCOND	0102
C	AVGT	JPH QII	0103
C	AXXA	JRJ QREB	0104
C	B	JSA QSTM	0105
C	BKPRM	JSB RTX	0106
C	BLOT	JX SMH1	0107
			0108

C	BXXXB	J3X	SMH2	0109
C	C	J4X	SMI	0110
C	CON1	J5	SMIX	0111
C	CXXC	J5X	SMIZ	0112
C	D	J7	SMST	0113
C	DA	J12	SMX1	0114
C	DB	K	SS	0115
C	DD	KB	SSS	0116
C	DEL	KBX	SUFD	0117
C	DELB	KBY	SUM	0118
C	DELD	KC	SUM1	0119
C	DELLT	KD	SUMD	0120
C	DIF	KHB	SUML	0121
C	DTL	KJ	SUMX	0122
C	FB	KK	T	0123
C	FD	KONT	TBOT	0124
C	FL	KX	TBUB	0125
C	FLOV	KXXX	TDEP	0126
C	FV	K1	TDP2	0127
C	FX	L	THET	0128
C	H	LKB	TOTX	0129
C	HBT	LL	TOTY	0130
C	HBTX	LLL	TREB	0131
C	HDIST	LN	TSR	0132
C	HFLX	LOOKE	TT	0133
C	HLQD	LOP	TTOP	0134
C	HLQDI	LX	T1	0135
C	HLQ01	L1	T1T	0136
C	HLT1	M.	T2	0137
C	HLT2	MM	T3	0138
C	HRFX	MMM	T4	0139
C	HVAL	MVPR	T5	0140
C	HV1	MM1	T7	0141
C	HVPR	M1	V	0142
C	HVPRI	M5	VAP	0143
C	HVPR2	N	XAX	0144
C	HVTI	NCVG	XF	0145
C	HX	NFDSP	XFLX	0146
C	H1I	NI	XMAX	0147
C	I	NIP	XNO	0148
C	ICON	NM	XSTG	0149
C	IDHM	NN	XX	0150
C	IDSM	NNN	XXX	0151
C	IFDC	NPDS	YFLX	0152
C	IFLG	NS	YY	0153
C	IFLX	NTIME	YY	0154
C	IHBAL	NUFH	Y1	0155
C	INC	NXX	Y11	0156
C	INCX	NYX	Y2	0157
C	INDI	NYZ	Y22	0158
C	IPAGE	N1		0159
C	IX	N1S1N		0160
C	IX5	N2		0161
C	18	N2X		0162

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C      19          N5          0163
C      *****
C      LIST OF REQUIRED SUBROUTINES          *****
C      MAIN          MAIN PROGRAM          0164
C      REDIN         READ INPUT DATA        0165
C      DATA          PRINT INPUT DATA       0166
C      GNRL          CALCULATES DISTILLATE,BOTTOMS,AND FEED RATES 0167
C      FSTVP         CALCULATES INITIAL VAPOR PROFILE     0168
C      FRSTX         CALCULATES INITIAL COMPOSITION PROFILE   0169
C      FRSTT         CALCULATES INITIAL TEMPERATURE PROFILE 0170
C      XFEED         CALCULATES FLASH FEED CONDITIONS    0171
C      FLASH         CALCULATES FLASH EQUATION      0172
C      XVAL          CALCULATES NEW COMPOSITION PROFILE   0173
C      CNVRG         FORCES EXTERNAL MATERIAL BALANCE    0174
C      DEWPT         DETERMINES DEW POINT      0175
C      ENTHL         DETERMINES ENTHALPY      0176
C      TDFLD         DETERMINES LIQUID RATE     0177
C      PAGE          NUMBERS PAGES        0178
C      FLDRT         DETERMINES LIQUID RATE     0179
C      KVAL          DETERMINES K VALUES      0180
C      BUBPT         DETERMINES BUBBLE POINT    0181
C      OTPT          PRINTS ANSWERS        0182
C      VPRRT         CALCULATES NEW VAPOR PROFILE    0183
C      *****
C      *****          RTFX(3,25),SDSR(4),PID(12),SFDJ(25), 0184
C      1   T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 0185
C      2,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 0186
C      325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 0187
C      4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 0188
C      5,EQUI1(25)      ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 0189
C      6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 0190
C      7(3),PI(5,25),TOTI(25),CFD(25),POP(25)          0191
C      COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDSMS,NSTMS,SOF,NFDS,IMAX,NMAX, 0192
C      1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 0193
C      28,NHTMS,PRESS,IDLHM,      QREB,BTMS,SMST,IFLIP,THETA      ,RTFX,PID, 0194
C      3SSDR,SFDJ      ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 0195
C      4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 0196
C      5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 0197
C      6ME,QII,TSR,EQUI1,      XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX, 0198
C      7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1SIN,XXX          0199
C      TEST CONSTANTS VALUE          MEANING          0200
C      IVPR          1          CONSTANT MOLAL OVERFLOW 0201
C      IVPR          2          NON CONSTANT MOLAL OVERFLOW 0202
C      IFLIP         N          MAXIMUM NUMBER OF PASSES = 30*N 0203
C      ICON          1          TOTAL CONDENSER        0204
C      ICON          2          PARTIAL CONDENSER      0205
C      IDHDP         0          ALL TRAYS HAVE SAME HOLDUP READ 1 CARD 0206
C      IDHDP         1          NOT ALL TRAYS HAVE SAME HOLDUP READ 0207
C                           NMAX CARDS          0208
C      IOTPT         1          INTERMEDIATE RESULTS ARE NOT PRINTED 0209
C      IOTPT         2          RESULTS FROM EVERY 6 PASSES ARE PRINTED 0210
C      IOTPT         3          RESULTS FROM EVERY 6 PASSES ARE PRINTED 0211
C                           AND TERMINAL COMPOSITIONS ARE PRINTED 0212
C                           EVERY PASS          0213
C                           AND TERMINAL COMPOSITIONS ARE PRINTED 0214
C                           EVERY PASS          0215
C                           AND TERMINAL COMPOSITIONS ARE PRINTED 0216

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C	FEED CONDITIONS FOR FEED N		
C	ITMST(N)	1 ENTHALPY IS GIVEN CALC. LOF AND TEMP.	0217
C	ITMST(N)	2 TEMP IS GIVEN CALC. LOF AND ENTHALPY	0218
C	ITMST(N)	3 LOF IS GIVEN CALC. TEMP. AND ENTHALPY	0219
C	ITMST(N)	4 FEED IS AT OR BELOW BUBBLE POINT	0220
C	ITMST(N)	5 FEED IS AT OR ABOVE DEW POINT	0221
	907 IPAGE=0		0222
	N1S1N=0		0223
	NIN=5		0224
	NOUT=6		0225
	CALL REDIN(ICON)		0226
	ICON=ICON		0227
	NMAX=NMAX		0228
	IVPR=IVPR		0229
	IOTP=IOTP		0230
	CALL GNRL		0231
	CALL DATA(ICON)		0232
	CALL XFEED		0233
	CALL FRSTX		0234
	CALL FRSTT		0235
	CALL FSTVP(ICON)		0236
	MVPR=0		0237
	KBY=0		0238
	IHBAL=1		0239
	LOP=0		0240
	JJMP=1		0241
	IF(TCON)821,909,B21		0242
821	T(NMAX)=TCON		0243
909	DO 4 KB=1,30		0244
	KBY=KBY+1		0245
	MVPR=MVPR+1		0246
	LTEST=0		0247
	MTEST=0		0248
	NTEST=0		0249
	CALL XVAL(ICON)		0250
	GO TO(21,22),ICON		0251
22	IF(TCON)23,23,21		0252
23	TT=T(NMAX)		0253
	INDI=0		0254
	CALL BUBPT(NMAX,TT,INDI,XX)		0255
	T(NMAX)=TT		0256
21	CALL CNVRG(ICON)		0257
	NXX=NMAX		0258
	IF(TCON)24,24,25		0259
25	NXX=NXX-1		0260
24	DO 3 N=1,NXX		0261
	TT=T(N)		0262
	INDI=0		0263
	CALL BUBPT(N,TT,INDI,XX)		0264
3	T(N)=TT		0265
	GO TO(40,45),IVPR		0266
45	IHBAL=2		0267
	GO TO(101,102),JJMP		0268
102	MVPR=3		0269
		0270	

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101 NTEST=1          0271
    IF(MVPR=3)40,41,40
41 MVPR=0          0272
    NTEST=0          0273
    CALL VPRRT(ICON) 0274
40 JJ=1           0275
    IF(LTEST)908,902,908 0276
902 IF(MTEST)908,903,908 0277
903 JJMP=2          0278
    IF(NTEST)908,904,908 0279
904 JJ=2           0280
    GO TO 31          0281
908 GO TO(901,31,31),IOTPT 0282
31 LOP=LOP+1        0283
    IF(LOP-6)901,33,901 0284
33 LOP=0           0285
    CALL OTPT(JJ,KBY,ICON) 0286
    GO TO(901,907),JJ 0287
901 CONTINUE        0288
4 CONTINUE          0289
    IFLIP=IFLIP-1      0290
    IF(IFLIP)906,906,909 0291
906 N6=3           0292
    CALL OTPT(N6,KBX,ICON) 0293
    WRITE OUTPUTTAPE NOUT,6 0294
6 FORMAT(107H ****WARNING**** THIS PROBLEM DID NOT CONVERGE, THE AB 0295
10VE RESULTS ARE NOT A FINAL SOLUTION TO THIS PROBLEM///25H WILL G 0296
10 TO NEXT PROBLEM)
    GO TO 907          0297
    END                0298
* LIST8             0299
* LABEL              0300
CREDIN      O.S.U. TRAY BY TRAY 0301
SUBROUTINE REDIN(ICON) 0302
DIMENSION      RTFX(3,25),SDSR(4),PID(12),SFDJ(25), 0303
1 T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 0304
2 ,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 0305
325),ENL3(25),ENL4(25),ENVO(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 0306
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 0307
5,EQUI1(25)      ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 0308
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 0309
7(3),PI(5,25),TOTI(25),CFD(25),POP(25) 0310
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDSMS,NSTMS,SOF,NFDS,IMAX,NMAX, 0311
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 0312
28,NHTMS,PRESS,IDLH,      QREB,BTMS,SMST,IFLIP,THETA      ,RTFX,PID, 0313
3SDSR,SFDJ      ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 0314
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENVO,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 0315
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 0316
6ME,QII,TSR,EQUI1,      XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX, 0317
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX 0318
READ INPUTTAPE NIN,100,(PID(I),I=1,12) 0319
100 FORMAT(12A6) 0320
READ INPUTTAPE NIN,1,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALI 0321
1M8,TCON 0322
                                         0323
                                         0324

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      IF(ALIM1)70,70,71          0325
70 ALIM1=0.001                0326
71 IF(ALIM2)72,72,73          0327
72 ALIM2=0.0001               0328
73 IF(ALIM3)74,74,75          0329
74 ALIM3=0.0001               0330
75 IF(ALIM4)76,76,77          0331
76 ALIM4=0.001                0332
77 IF(ALIM5)78,78,79          0333
78 ALIM5=0.001                0334
79 IF(ALIM6)80,80,81          0335
80 ALIM6=0.0001               0336
81 IF(ALIM7)82,82,83          0337
82 ALIM7=0.001                0338
83 IF(ALIM8)84,84,85          0339
84 ALIM8=10.0                 0340
85 READ INPUTTAPE NIN,3,TMAX,TMIN,BETA,REFLX,PRESS,DOF,DELT 0341
  3 FORMAT(7F8.6)              0342
  1 FORMAT(9F8.6)              0343
    READ INPUTTAPE NIN,2,NSTMS,NHTMS,NFDS,IFLIP,ICON,IMAX, 0344
    IDHDP,IOTPT,1IVPR,NMAX   0345
  2 FORMAT(9I3,I4)              0346
    IF(NSTMS)66,66,5           0347
  5 DO 4 KK=1,NSTMS            0348
    K= NSTMS -KK+1             0349
    READ INPUTTAPE NIN,6,NN,SOF(K) 0350
    NSTM(K)=NMAX-NN            0351
  6 FORMAT(I4,F8.5)             0352
  4 CONTINUE                   0353
66 IF(NHTMS)67,67,8           0354
  8 DO 7 LL =1,NHTMS          0355
    L=NHTMS-LL+1               0356
    READ INPUTTAPE NIN,9,NN,HHST(L) 0357
    NHTM(L)=NMAX-NN            0358
  9 FORMAT(I4,E14.8)            0359
  7 CONTINUE                   0360
67 DO 10 I=1,IMAX              0361
105 READ INPUTTAPE NIN,106,(RTX(K),K=1,3),(XNAME(I,J),J=1,2) 0362
106 FORMAT(3F8.5,2A6)           0363
  DO 10 LL=1,NFDS              0364
    LLL=NFDS-LL+1               0365
    RTFX(LL,I)=RTX(LL)         0366
10 CONTINUE                     0367
  DO 46 KK=1,NFDS              0368
    K=NFDS-KK+1                0369
103 READ INPUTTAPE NIN,104,NN,ITMST(K),HFED(K),FRACT(K),TFED(K) 0370
    NFPT(K)=NMAX-NN            0371
104 FORMAT(2I4,3F8.6)           0372
  46 CONTINUE                   0373
  DO 20 I=1,IMAX               0374
107 READ INPUTTAPE NIN,108,AK(I),BK(I),CK(I),DK(I),EK(I),FK(I) 0375
108 FORMAT(6E12.6)              0376
  20 CONTINUE                   0377
  DO 21 I=1,IMAX               0378

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```

READ INPUTTAPE NIN,22,ENL0(I),ENL1(I),ENL2(I),ENL3(I),ENL4(I)          0379
READ INPUTTAPE NIN,22,ENV0(I),ENV1(I),ENV2(I),ENV3(I),ENV4(I)          0380
22 FORMAT(5E12.6)                                                       0381
21 CONTINUE                                                               0382
IF(IDHDP)13,13,11                                                       0383
13 READ INPUTTAPE NIN,14,HLDP(1)                                         0384
14 FORMAT(F8.1)                                                       0385
DO 15 N=1,NMAX                                                       0386
15 HLDP(N)=HLDP(1)                                         0387
GO TO 16                                                               0388
11 DO 33 NN=1,NMAX                                         0389
N=NMAX-NN+1                                                       0390
33 READ INPUTTAPE NIN,145,HLDP(N)                                         0391
145 FORMAT(F8.1)                                                       0392
16 CONTINUE                                                               0393
RETURN                                                               0394
END                                                               0395
* LIST8                                                               0396
* LABEL                                                               0397
C DATA      O.S.U. TRAY BY TRAY                                         0398
SUBROUTINE DATA(ICON)                                                 0399
DIMENSION      RTFX(3,25),SDSR(4),PID(12),SFDJ(25),                 0400
1   T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 0401
2,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 0402
325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 0403
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 0404
5,EQUI1(25) ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF        0405
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 0406
7(3),PI(5,25),TOTI(25),CFD(25),POP(25)                                0407
COMMON NOUT,NIN,SMFD,DSPEC,DOF,1DSM,NSTMS,SOF,NFDS,IMAX,NMAX,           0408
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 0409
28,NHTMS,PRESS,1DHM,          QREB,BTMS,SMST,IFLIP,THETA ,RTFX,PID,    0410
3SDSR,SFDJ ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK,    0411
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 0412
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 0413
6ME,QII,TSR,EQUI1,           XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTP,T,RTX 0414
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX                                0415
CALL PAGE                                                               0416
WRITE OUTPUTTAPE NOUT,1                                               0417
1 FORMAT(5H DATA)                                                 0418
WRITE OUTPUTTAPE NOUT,3,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,    0419
1ALIM8                                                               0420
3 FORMAT(37H LIMITS FOR CONVERGENCE OF DEW POINT=,F8.6/25X,24H CONVE 0421
1RGENCE SUBROUTINE=,F8.6/25X,21H COMPOSITION PROFILE=,F8.6/25X,21H 0422
2TEMPERATURE PROFILE=,F8.6/25X,15H VAPOR PROFILE=,F8.6/25X,14H BUBB 0423
3LE POINT=,F8.6/25X,21H LOF FOR FLASH FEEDS=,F8.6/25X,34H ENTHALPY 0424
4BALANCE FOR FLASH FEEDS=,F8.4)                                     0425
WRITE OUTPUTTAPE NOUT,4,NSTMS,NHTMS,NFDS,IFLIP,IMAX,NMAX,ICON          0426
4 FORMAT(24H NUMBER OF SIDE STREAMS=,I3/10X,15H INTER COOLERS=I3/10X 0427
1,7H FEEDS=,I3/10X,11H PASSES/30=,I4/10X,12H COMPONENTS=,I3/10X,41H 0428
2 STAGES INCLUDING CONDENSER AND REBOILER=,I4/19H TYPE OF CONDENSER 0429
3=I3)                                                               0430
WRITE OUTPUTTAPE NOUT,5,TMAX,TMIN,BETA,REFLX,PRESS,      DOF,DELT       0431
5 FORMAT(6H TMAX=,F8.3/6H TMIN=,F8.3/20H CONVERGENCE FACTOR=,F6.4/20 0432

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1H REFLUX RATIO (V/F)=F8.5/10H PRESSURE=F8.3/19H RATIO OF D OVER F= 0433
2F8.6/15H TIME INTERVAL=F10.5) 0434
GO TO(60,61),IVPR 0435
61 WRITE OUTPUTTAPE NOUT,67 0436
GO TO 70 0437
60 WRITE OUTPUTTAPE NOUT,66 0438
66 FORMAT(26H CST MOLAL O/FL IS ASSUMED) 0439
67 FORMAT(28H NON CST. MOLAL O/FL ASSUMED) 0440
70 IF(TCON)162,162,163 0441
163 WRITE OUTPUTTAPE NOUT,164,TCON 0442
164 FORMAT(32H CONDENSER TEMPERATURE IS SET AT F10.4) 0443
162 IF(NSTMS)7,8,7 0444
7 DO 89 KK=1,NSTMS 0445
K=NSTMS-KK+1 0446
MMM=NMAX-NSTM(K) 0447
9 WRITE OUTPUTTAPE NOUT,6,K,MMM,SOF(K) 0448
6 FORMAT(27H SIDE STREAM NUMBER=,I4/27H TRAY NUMBER OF SIDE STREAM,I 0449
14/34H RATIO OF SIDE STREAM RATE TO FEED,F10.6) 0450
89 CONTINUE 0451
8 IF(NHTMS)111,111,10 0452
10 DO 11 LL=1,NHTMS 0453
L=NHTMS-LL+1 0454
NN=NMAX-NHTM(L) 0455
11 WRITE OUTPUTTAPE NOUT,12,NN,HHST(L),L 0456
12 FORMAT(29H TRAY NUMBER OF INTER COOLER=I4/24H HEAT REMOVED BY COOL 0457
1ER=,E14.8/15H COOLER NUMBER=I4) 0458
111 CALL PAGE 0459
WRITE OUTPUTTAPE NOUT,16 0460
16 FORMAT(36H COEFFICIENTS FOR EQUILIBRIUM VALUES) 0461
DO 17 I=1,IMAX 0462
17 WRITE OUTPUTTAPE NOUT,18,(XNAME(I,J),J=1,2),AK(I),BK(I),CK(I),DK(I 0463
1),EK(I),FK(I) 0464
18 FORMAT(1H ,2A6,2H ,6E12.4) 0465
CALL PAGE 0466
WRITE OUTPUTTAPE NOUT,19 0467
19 FORMAT(42H COEFFICIENTS FOR LIQUID ENTHALPY EQUATION) 0468
DO 20 I=1,IMAX 0469
20 WRITE OUTPUTTAPE NOUT,24,(XNAME(I,J),J=1,2),ENL0(I),ENL1(I),ENL2(I 0470
1),ENL3(I),ENL4(I) 0471
CALL PAGE 0472
WRITE OUTPUTTAPE NOUT,22 0473
22 FORMAT(41H COEFFICIENTS FOR VAPOR ENTHALPY EQUATION) 0474
DO 23 I=1,IMAX 0475
23 WRITE OUTPUTTAPE NOUT,24,(XNAME(I,J),J=1,2),ENV0(I),ENV1(I),ENV2(I 0476
1),ENV3(I),ENV4(I) 0477
24 FORMAT(1H ,2A6,2X,5E16.8) 0478
CALL PAGE 0479
WRITE OUTPUTTAPE NOUT,25 0480
25 FORMAT(22H TRAY HOLDUP TRAY NO) 0481
DO 26 NN=1,NMAX 0482
N=NMAX-NN+1 0483
NNN=NN-1 0484
26 WRITE OUTPUTTAPE NOUT,27,HLDP(N),NNN 0485
27 FORMAT(1X,F11.4,7X,I4) 0486

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NN=NMAX-1 0487
WRITE OUTPUTTAPE NOUT,121,NN 0488
121 FORMAT(19H REBOILER IS NUMBER I4/22H CONDENSER NUMBER IS 0) 0489
    RETURN
    END
*
* LIST8 0490
* LABEL 0491
CFRSTX O.S.U. TRAY BY TRAY 0492
SUBROUTINE FRSTX 0493
    DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25),
1 T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 0494
2 ,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 0495
325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 0496
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 0497
5,EQUI1(25) ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 0498
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 0499
7(3),PI(5,25),TOTI(25),CFD(25),POP(25) 0500
    COMMON NOUT,NIN,SMFD,DSPEC,DOF,DSM,NSTMS,SOF,NFDS,IMAX,NMAX, 0501
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 0502
28,NHTMS,PRESS,IDHM, QREB,BTMS,SMST,IFLIP,THETA ,RTFX,PID, 0503
3SDSR,SFDJ ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 0504
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 0505
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 0506
6ME,QII,TSR,EQUI1, XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTP,RTX, 0507
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX 0508
    DO 1 I=1,IMAX 0509
    BI(I)=0.0 0510
1 DI(I)=0.0 0511
    DIF=DSPEC
    DO 2 I=1,IMAX 0512
    DIF=DIF-SFDJ(I) 0513
    IF(DIF)20,20,3 0514
20 DI(I)=DIF+SFDJ(I) 0515
    GO TO 6 0516
3 DI(I)=SFDJ(I) 0517
2 CONTINUE 0518
6 DIF=BTMS 0519
    DO 4 I=1,IMAX 0520
    NI=IMAX-I+1 0521
    DIF=DIF-SFDJ(NI) 0522
    IF(DIF)21,21,5 0523
21 BI(NI)=DIF+SFDJ(NI) 0524
    GO TO 7 0525
5 BI(NI)=SFDJ(NI) 0526
4 CONTINUE 0527
7 DO 8 I=1,IMAX 0528
    X(1,I)=BI(I)/BTMS 0529
    IF(X(1,I))23,23,24 0530
23 X(1,I)=1.0E-8 0531
24 X(NMAX,I)=DI(I)/DSPEC 0532
    IF(X(NMAX,I))25,25,8 0533
25 X(NMAX,I)=1.0E-8 0534
8 CONTINUE 0535
    DO 10 K=1,NFDS 0536

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L=NFPT(K)                                0541
DO 10 I=1,IMAX                            0542
10 X(L,I)=XFED(K,I)
NFDSP=NFDSP+1                            0543
DO 14 K=1,NFDSP                            0544
IF(K-1)11,71,11                           0545
71 N=1                                     0546
GO TO 13                                   0547
11 IF(K-NFDSP)26,12,12                   0548
26 N=NFPT(K-1)                            0549
13 M=NFPT(K)
XSTG=M-N                                 0550
GO TO 15                                   0551
12 N=NFPT(K-1)                            0552
M=NMAX                                    0553
XSTG=M-N                                 0554
15 NN=N+1                                 0555
MM=M-1                                    0556
DO 14 I=1,IMAX                            0557
DEL=(X(M,I)-X(N,I))/XSTG                0558
DO 14 L=NN,MM                            0559
14 X(L,I)=X(L-1,I)+DEL                 0560
DO 16 N=1,NMAX                            0561
SUM=0.0                                    0562
DO 17 I=1,IMAX                            0563
17 SUM=SUM+X(N,I)                         0564
DO 16 I=1,IMAX                            0565
16 X(N,I)=X(N,I)/SUM                   0566
CALL PAGE                                 0567
LL=1                                      0568
DO 81 M=1,NMAX                            0569
N=NMAX-M+1                               0570
NS=M-1                                    0571
IF(N-1)31,32,31                           0572
32 WRITE OUTPUTTAPE NOUT,33               0573
33 FORMAT(34H INITIAL COMPOSITIONS IN REBOILER)
GO TO 111                                 0574
31 IF(N-NMAX)121,131,121
131 CALL PAGE                            0575
WRITE OUTPUTTAPE NOUT,141
141 FORMAT(34H INITIAL COMPOSITION IN CONDENSER)
GO TO 111                                 0576
121 WRITE OUTPUTTAPE NOUT,151,NS
151 FORMAT(29H INITIAL COMPOSITION OF TRAY ,14)
111 WRITE OUTPUTTAPE NOUT,161
161 FORMAT(23H COMPONENT LIQUID MF)
DO 171 I=1,IMAX
171 WRITE OUTPUTTAPE NOUT,181,(XNAME(I,J),J=1,21),X(N,I)
181 FORMAT(1H *2A6,F10.6)
81 CONTINUE
RETURN
END
* LIST8
* LABEL

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CFSTVP      O.S.U. TRAY BY TRAY                               0595
SUBROUTINE FSTVP(ICON)                                         0596
  DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25),          0597
    1 T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 0598
    2,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 0599
    325),ENL3(25),ENL4(25),ENVO(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 0600
    4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 0601
    5,EQUI1(25)           ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 0602
    6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 0603
    7(3),PI(5,25),TOTI(25),CFD(25),POP(25)                   0604
    COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDS, NSTMS,SOF,NFDS,IMAX,NMAX,          0605
    1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 0606
    28,NHTMS,PRESS, IDHM,          QREB,BTMS,SMST,IFLIP,THETA      ,RTFX,PID, 0607
    3SDSR,SFDJ           ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 0608
    4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENVO,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 0609
    5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 0610
    6ME,QII,TSR,EQUI1,           XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX, 0611
    7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX                   0612
    IHBAL=0                                                 0613
    GO TO(2,1),ICON                                         0614
  1 VPRR(NMAX)=DOF*SMFD                                     0615
    GO TO 3                                               0616
  2 VPRR(NMAX)=0.0                                         0617
  3 MM=NMAX-1                                           0618
    VPRR(MM)=REFLX*SMFD                                    0619
    DO 4 J=2,MM                                         0620
    K=MM-J+1                                             0621
    DO 5 N=1,NFDS                                         0622
    IF(K-NFPT(N))5,7,5                                  0623
  7 VPRR(K)=VPRR(K+1)-(1.0-FRACT(N))*FDRT(N)          0624
    GO TO 4                                              0625
  5 CONTINUE                                            0626
  6 VPRR(K)=VPRR(K+1)                                    0627
  4 CONTINUE                                            0628
    DO 514 N=1,NMAX                                      0629
  514 CONTINUE                                           0630
    RETURN                                              0631
    END                                                 0632
  * LIST8                                              0633
  * LABEL                                              0634
CFRSTT      O.S.U. TRAY BY TRAY                               0635
SUBROUTINE FRSTT                                         0636
C   CALCULATION OF FIRST TEMPERATURE PROFILE             0637
  DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25),          0638
    1 T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 0639
    2,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 0640
    325),ENL3(25),ENL4(25),ENVO(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 0641
    4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 0642
    5,EQUI1(25)           ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 0643
    6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 0644
    7(3),PI(5,25),TOTI(25),CFD(25),POP(25)                   0645
    COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDS, NSTMS,SOF,NFDS,IMAX,NMAX,          0646
    1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 0647
    28,NHTMS,PRESS, IDHM,          QREB,BTMS,SMST,IFLIP,THETA      ,RTFX,PID, 0648

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3SDSR,SFDJ    ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK,      0649
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENVO,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT      0650
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA      0651
6ME,QII,TSR,EQUI1,      XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX,      0652
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX                                0653
     TT=TMIN
     INDI=0
     JK=1
     CALL BUBPT(JK,TT,INDI,XX)
     T(1)=TT
     TREB=TT
     KJ=NMAX
     IF(TCON)11,11,12
12  KJ=KJ-1
     T(NMAX)=TCON
11   CALL BUBPT(KJ,TT,INDI,XX)
     TTOP=TT
     XMAX=KJ-1
     DELTT=(TREB-TTOP)/XMAX
     DO 651 N=2,KJ
     XNO=N
     T(N)=TREB-DELT*XNO
651  CONTINUE
     CALL PAGE
     WRITE OUTPUTTAPE NOUT,1
1    FORMAT(28H INITIAL TEMPERATURE PROFILE,/4X,21H      TRAY      TEMPERATUR 0674
1E)
     NM=NMAX-1
     DO 2 M=1,NMAX
     L=M-1
     N=NMAX-M+1
7    WRITE OUTPUTTAPE NOUT,3,L,T(N)                                      0675
3    FORMAT(1H +I5,F14.5)                                              0676
2    CONTINUE
     NN=NMAX-1
     WRITE OUTPUTTAPE NOUT,9,NN
9    FORMAT(20H CONDENSER IS TRAY 0/17H REBOILER IS TRAY,I3)          0677
     RETURN
     END
*    LIST8
*    LABEL
CGNRL      O.S.U.  TRAY BY TRAY
     SUBROUTINE GNRL
     DIMENSION      RTFX(3,25),SDSR(4),PID(12),SFDJ(25),
1     T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 0678
2     ,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 0679
325),ENL3(25),ENL4(25),ENVO(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 0680
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 0681
5,EQUI1(25)      ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 0682
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 0683
7(3),PI(5,25),TOTI(25),CFD(25),POP(25)                                0684
     COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDSMS,NSTMS,SOF,NFDS,IMAX,NMAX,      0685
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 0686
28,NHTMS,PRESS,IDHM,      QREB,BTMS,SMST,IFLIP,THETA      ,RTFX,PID, 0687
                                         0688
                                         0689
                                         0690
                                         0691
                                         0692
                                         0693
                                         0694
                                         0695
                                         0696
                                         0697
                                         0698
                                         0699
                                         0700
                                         0701
                                         0702

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3SDSR,SFDJ ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, . 0703
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT . 0704
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 0705
6ME,QII,TSR,EQUI1, XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX, 0706
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX 0707
    SMFD=0.0 0708
    DO 1 J=1,NFDS 0709
      FDRT(J)=0.0 0710
      DO 1 I=1,IMAX 0711
        FDRT(J)=FDRT(J)+RTFX(J,I) 0712
1  SMFD=SMFD+RTFX(J,I) 0713
  DSPEC=SMFD*DOF 0714
  TSR=0.0 0715
  IF(NSTMS)2,2,3 0716
3  DO 4 N=1,NSTMS 0717
  SDSR(N)=SMFD*SOF(N) 0718
4  TSR=TSR+SDSR(N) 0719
2  BTMS=SMFD-TSR-DSPEC 0720
  DO 6 J=1,NFDS 0721
6  CONTINUE 0722
  DO 9 I=1,IMAX 0723
    SFDJ(I)=0.0 0724
  DO 9 N=1,NFDS 0725
9  SFDJ(I)=SFDJ(I)+RTFX(N,I) 0726
  RETURN 0727
  END 0728
*  LIST8 0729
*  LABEL 0730
CXFEED O.S.U. TRAY BY TRAY 0731
SUBROUTINE XFEED 0732
  DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25), 0733
1  T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),NHTM(6),HHST(6) 0734
2 ,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 0735
325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 0736
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 0737
5,EQUI1(25) ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 0738
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 0739
7(3),PI(5,25),TOTI(25),CFD(25),POP(25) 0740
  COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDS, NSTMS,SOF,NFDS,IMAX,NMAX, 0741
  ITMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 0742
28,NHTMS,PRESS,IDHM, QREB,BTMS,SMST,IFLIP,THETA ,RTFX,PID, 0743
3SDSR,SFDJ ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 0744
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 0745
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 0746
6ME,QII,TSR,EQUI1, XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX, 0747
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX 0748
25 FORMAT(46H MAXIMUM NUMBER OF TRIALS EXCEEDED FOR FEED- ,I5,17H 0749
  1WILL CALL EXIT) 0750
1001 FORMAT(47H FEED SPECIFIED OUTSIDE OF FLASH RANGE FOR FEED,I3) 0751
C   ITMST=1 ENTHALPY IS GIVEN CALCULATE LOF AND TFED 0752
C   ITMST=2 TFED IS GIVEN CALCULATE LOF AND HFED 0753
C   ITMST=3 LOF IS GIVEN CALCULATE TFED AND HFED 0754
C   ITMST=4 FEED IS AT OR BELOW BUBBLE POINT 0755
C   ITMST=5 FEED IS AT OR ABOVE DEW POINT 0756

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C IF FEED ENTHALPY IS TO BE COMPUTED FOR OPTIONS 4 OR 5 READ	0757
C ENTHALPY AS 0.0	0758
INDI=1	0759
DO 101 N=1,NFDS	0760
JRJ=1	0761
IF(TFED(N))921,920,921	0762
920 IF(HFED(N))921,1920,921	0763
1920 JRJ=2	0764
921 HFLQD(N)=0.0	0765
HFVPR(N)=0.0	0766
BLOT=0.0	0767
ALOT=1.0	0768
JHE=ITMST(N)	0769
DO 401 I=1,IMAX	0770
XFED(N,I)=RTFX(N,I)/FDRT(N)	0771
401 YFED(N,I)=XFED(N,I)	0772
TT=TMIN	0773
CALL BUBPT(N,TT,INDI,XX)	0774
TBUB=TT	0775
T1=TT	0776
CALL DEWPT(N,TT,INDI,XX)	0777
TDEP=TT	0778
T2=TT	0779
JFD=5	0780
JPH=2	0781
CALL ENTHL(JFD,HVPR,JPH,TT,N)	0782
HVPR2=HVPR	0783
TT=T1	0784
JPH=1	0785
CALL ENTHL(JFD,HLQD,JPH,TT,N)	0786
HLQD1=HLQD	0787
GO TO(402,402,402,863,863),JHE	0788
863 IF(JHE-5)867,601,867	0789
601 FRACT(N)=0.0	0790
GO TO 891	0791
867 FRACT(N)=1.0	0792
891 GO TO(402,402,402,403,404),JHE	0793
403 IF(TFED(N))406,406,407	0794
406 TFED(N)=T1	0795
407 IF(HFED(N))790,408,790	0796
408 TT=TFED(N)	0797
JPH=1	0798
CALL ENTHL(JFD,HLQD,JPH,TT,N)	0799
HFED(N)=HLQD	0800
790 HFLQD(N)=HFED(N)	0801
HFVPR(N)=0.0	0802
GO TO 412	0803
404 IF(TFED(N))411,410,411	0804
410 TFED(N)=T2	0805
411 IF(HFED(N))791,862,791	0806
862 TT=TFED(N)	0807
JPH=2	0808
CALL ENTHL(JFD,HVPR,JPH,TT,N)	0809
HFED(N)=HVPR	0810

791	HFVPR(N)=HFED(N)	0811
	HFLQD(N)=0.0	0812
412	TT=TFED(N)	0813
	CALL KVAL(TT)	0814
	DO 409 I=1,IMAX	0815
	JHE1=JHE-3	0816
	GO TO(760,761),JHE1	0817
760	YFED(N,I)=XFED(N,I)*EQUI(I)	0818
	GO TO 409	0819
761	XFED(N,I)=YFED(N,I)/EQUI(I)	0820
409	CONTINUE	0821
	GO TO 10	0822
402	GO TO(413,414,415),JHE	0823
413	IF(HLQD1-HFED(N))416,417,417	0824
417	JHE=4	0825
	GO TO 863	0826
416	IF(HVPR2-HFED(N))418,418,415	0827
418	JHE=5	0828
	GO TO 863	0829
414	IF(T2-TFED(N))420,420,419	0830
420	JHE=5	0831
	GO TO 863	0832
419	IF(TFED(N)-T1)421,421,415	0833
421	JHE=4	0834
	GO TO 863	0835
415	KONT=0	0836
492	GO TO(422,423,424),JHE	0837
422	AVGT=(T1+T2)/2.0	0838
	GO TO 425	0839
423	AVGT=TFED(N)	0840
425	CALL KVAL(AVGT)	0841
426	AVG=(ALOT+BLOT)/2.0	0842
	GO TO 427	0843
424	AVGT=(T1+T2)/2.0	0844
	CALL KVAL(AVGT)	0845
	AVG=FRACT(N)	0846
427	KONT=KONT+1	0847
	IF(KONT-50)430,430,431	0848
431	WRITE OUTPUTTAPE NOUT,25,N	0849
	CALL EXIT	0850
430	CALL FLASH(N,AVG,SUM)	0851
	IF(ABSF(SUM)-ALIM7)432,432,433	0852
433	GO TO(434,434,435),JHE	0853
435	IF(SUM)437,436,436	0854
436	T1=AVGT	0855
	GO TO 424	0856
437	T2=AVGT	0857
	GO TO 424	0858
434	IF(SUM)441,441,440	0859
440	BLOT=AVG	0860
	GO TO 492	0861
441	ALOT=AVG	0862
	GO TO 492	0863
432	SUML=FDRT(N)*AVG	0864

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SUMV=FDRT(N)-SUML          0865
TOTX=0.0                   0866
TOTY=0.0                   0867
BVG=AVG/(1.0-AVG)          0868
DO 11 I=1,IMAX             0869
V=RTFX(N,I)/(1.0+BVG/EQUI(I)) 0870
YFED(N,I)=V/SUMV           0871
XFED(N,I)=(V*BVG/EQUI(I))/SUML 0872
TOTX=TOTX+XFED(N,I)       0873
11 TOTY=TOTY+YFED(N,I)     0874
DO 18 I=1,IMAX             0875
XFED(N,I)=XFED(N,I)/TOTX   0876
18 YFED(N,I)=YFED(N,I)/TOTY 0877
CALL ENTHL(5,HLQD,1,AVGT,N) 0878
CALL ENTHL(5,HVPR,2,AVGT,N) 0879
HFLQD(N)=HLQD              0880
HFVPR(N)=HVPR              0881
HLQD=HLQD*AVG              0882
HVPR=HVPR*(1.0-AVG)        0883
GO TO(64,65,65),JHE         0884
65 HFED(N)=HLQD+HVPR       0885
64 H=HFED(N)-(HVPR+HLQD)    0886
GO TO(63,13,13),JHE         0887
63 IF(ALIM8-ABSF(H))12,12,13 0888
12 IF(H)14,14,15            0889
14 T2=AVGT                  0890
IFLG=IFLG+1                 0891
GO TO 110                   0892
15 T1=AVGT                  0893
IFLG=IFLG+1                 0894
110 BLOT=0.0                 0895
ALOT=1.0                     0896
IF(30-IFLG)40,40,415        0897
13 GO TO(501,502,501),JHE   0898
501 TFED(N)=AVGT            0899
GO TO(502,502,10),JHE       0900
502 FRACT(N)=AVG            0901
10 CONTINUE                  0902
DTL=(TMAX-TMIN)/75.0        0903
GO TO(922,101),JRJ           0904
922 GO TO(101,101,101,901,902),JHE 0905
901 T2=TBUB+DTL             0906
T1=TMIN                      0907
JPH=1                         0908
GO TO 903                   0909
902 T1=TDEP-DTL             0910
T2=TMAX                      0911
JPH=2                         0912
903 DO 906 JB=1,25           0913
ABVG=(T1+T2)/2.0              0914
CALL ENTHL(JFD,H,JPH,ABVG,N) 0915
IF(ABSF(H-HFED(N))-ALIM8)904,904,905 0916
905 IF(H-HFED(N))908,904,909 0917
908 T1=ABVG                  0918

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GO TO 906	0919
909 T2=ABVG	0920
906 CONTINUE	0921
904 TFED(N)=ABVG	0922
101 CONTINUE	0923
GO TO 26	0924
40 WRITE OUTPUTTAPE NOUT,25,N	0925
CALL EXIT	0926
26 CONTINUE	0927
DO 620 N1=1,NFDS	0928
N=NFDS-N1+1	0929
LN=NMAX-NFPT(N)	0930
CALL PAGE	0931
WRITE OUTPUTTAPE NOUT,621,N1,HFED(N),FRACT(N),TFED(N),LN	0932
621 FORMAT(19H CONDITIONS OF FEED,I3/3X,10H ENTHALPY=,E16.8/3X,5H LOF=	0933
1F10.8/3X,13H TEMPERATURE=,F14.5/21H FEED PLATE LOCATION=I4)	0934
WRITE OUTPUTTAPE NOUT,622	0935
622 FORMAT(17H FEED COMPOSITION/28X,7H LIQUID,38X,6H VAPOR/10H COMPONE	0936
1NT,11X,5HMOLES,22X,2HMF,18X,5HMOLES,20X,2HMF)	0937
Y1=FRACT(N)	0938
Y2=(1.0-FRACT(N))	0939
DO 630 I=1,IMAX	0940
YY=XFED(N,I)*FDRT(N)*Y1	0941
YY=YFED(N,I)*FDRT(N)*Y2	0942
630 WRITE OUTPUTTAPE NOUT,631,(XNAME(I,J),J=1,2),YY,XFED(N,I),YY,YFED(0943
1N,I)	0944
631 FORMAT(1H 2A6,F16.8,11X,F10.8,13X,F16.8,11X,F10.8)	0945
Y22=Y2*FDRT(N)	0946
Y11=Y1*FDRT(N)	0947
620 WRITE OUTPUTTAPE NOUT,636,Y11,Y22	0948
636 FORMAT(13X,F16.8,10X,8H 1.00000,16X,F16.8,10X,8H 1.00000)	0949
RETURN	0950
END	0951
* LIST8	0952
* LABEL	0953
CFLASH O.S.U. TRAY BY TRAY	0954
SUBROUTINE FLASH(N,AVG,SUM)	0955
DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25),	0956
1 T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6)	0957
2 ,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2(0958
325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25)	0959
4 ,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200+25),VPRR(200)	0960
5 ,EQUI1(25) ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF	0961
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX	0962
7(3),PI(5,25),TOTI(25),CFD(25),POP(25)	0963
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDSMS,NSTMS,SOF,NFDS,IMAX,NMAX,	0964
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM	0965
28,NHTMS,PRESS,IDLHM, QREB,BTMS,SMST,IFLIP,THETA ,RTFX,PID,	0966
3SDSR,SFDJ ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK,	0967
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT	0968
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA	0969
6ME,QII,TSR,EQUI1, XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX,	0970
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX	0971
SUM=0.0	0972

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DO 1 I=1,IMAX                                     0973
XF=RTFX(N,I)/FDRT(N)                           0974
SUM=SUM+(XF*(1.0-EQUI(I)))/(AVG#(1.0-EQUI(I))+EQUI(I)) 0975
1 CONTINUE                                         0976
RETURN                                            0977
END                                              0978
* LIST8                                           0979
* LABEL                                           0980
CCNVRG      O.S.u. TRAY BY TRAY                 0981
SUBROUTINE CNVRG(ICON)                           0982
DIMENSION          RTFX(3,25),SDSR(4),PID(12),SFDJ(25), 0983
1   T(200),HLDP(1200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 0984
2,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 0985
325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 0986
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 0987
5,EQUI1(25)           ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 0988
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 0989
7(3),PI(5,25),TOTI(25),CFD(25),POP(25)          0990
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDSMS,NSTMS,SOF,NFDS,IMAX,NMAX, 0991
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 0992
28,NHTMS,PRESS,IDHM,          QREB,BTMS,SMST,IFLIP,THETA      ,RTFX,PID, 0993
3SDSR,SFDJ    ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 0994
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 0995
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 0996
6ME,QII,TSR,EQUI1,           XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTP,RTX, 0997
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX          0998
LKB=NSTMS+1                                      0999
NPDS=NSTMS+2                                     1000
NTIME=0                                         1001
DO 2 I=1,IMAX                                     1002
PI(1,I)=X(NMAX,I)*DSPEC                         1003
GO TO(3,70),ICON                                 1004
70 TT=T(NMAX)                                    1005
CALL KVAL(TT)                                    1006
PI(1,I)=PI(1,I)*EQUI(I)                         1007
3 PI(NPDS,I)=X(1,I)*BTMS                        1008
IF(NSTMS)2,2,71                                  1009
71 DO 131 J=2,LKB                             1010
K=NPDS-J                                      1011
L=NSTM(K)                                      1012
131 PI(J,I)=X(L,I)*SDSR(K)                     1013
2 CONTINUE                                         1014
SUFD=0.0                                         1015
DO 6 I=1,IMAX                                     1016
CFD(I)=SFDJ(I)                                1017
6 SUFD=SUFD+CFD(I)                            1018
9 DO 4 K=1,LKB                                1019
KXXX=K                                         1020
KHB=K+1                                       1021
DO 5 I=1,IMAX                                     1022
TOTI(I)=0.0                                     1023
DO 5 KJ=KHB,NPDS                               1024
5 TOTI(I)=TOTI(I)+PI(KJ,I)                    1025
DO 7 I=1,IMAX                                     1026

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101 POP(I)=TOT(I)/PI(K+I)          1027
    IF ACCUMULATOR OVERFLOW 8,7      1028
    8 POP(I)=1.0E+35                1029
    7 CONTINUE                      1030
        GO TO(10,11,11,11,11),KXXX   1031
10 PROD=DSPEC                      1032
    GO TO 14                         1033
11 M5=NPDS-K                       1034
    PROD=SDSR(M5)                  1035
14 THETA=1.0                         1036
    SMI=0.0                          1037
    DO 15 M=1,50                     1038
        SMIX=SMI                      1039
        SMI=0.0                        1040
        SMIZ=0.0                        1041
        DO 16 I=1,IMAX                 1042
            IF(POP(I)-1.0E+35)72,17,72  1043
72 Q=THETA*POP(I)                  1044
    IF ACCUMULATOR OVERFLOW 17,60     1045
60 Q=1.0+Q                          1046
    IF ACCUMULATOR OVERFLOW 17,61     1047
61 DI(I)=CFD(I)/Q                  1048
    Q=DI(I)*POP(I)/Q                1049
    IF ACCUMULATOR OVERFLOW 40,62     1050
62 SMIZ=SMIZ+Q                      1051
    IF ACCUMULATOR OVERFLOW 40,63     1052
63 SMI=SMI+DI(I)                  1053
    GO TO 16                         1054
17 DI(I)=0.0                         1055
16 BI(I)=CFD(I)-DI(I)              1056
    IF(SMIZ)22,74,22                 1057
74 SMIZ=1.0                         1058
22 IF(ABSF(SMI-PROD)-ALIM2)24,24,23 1059
23 IF(SMIX-SMI)75,67,75             1060
75 THET=THETA+(SMI-PROD)/SMIZ      1061
    IF ACCUMULATOR OVERFLOW 43,76     1062
76 IF(THET)77,78,78                 1063
77 THET=THETA/3.0                   1064
78 THETA=THET                      1065
    IF(THETA-1.0E-15)40,79,79       1066
79 IF(THETA-1.0E+35)15,15,43       1067
15 CONTINUE                         1068
67 IF(PROD-SMI)143,40,40           1069
24 GO TO(96,93),ICON               1070
93 TT=T(NMAX)                      1071
    CALL KVAL(TT)                   1072
96 DO 30 I=1,IMAX                 1073
    PI(K,I)=DI(I)                  1074
    IF(K-1)81,81,31                 1075
81 X(NMAX,I)=PI(K,I)/SMI          1076
    GO TO(31,92),ICON               1077
92 X(NMAX,I)=X(NMAX,I)/EQUI(I)    1078
31 IF(K-LKB)32,82,82               1079
82 PI(NPDS,I)=BI(I)               1080

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X(1,I)=BI(I)/(SUFD-SMI)          1081
32 IF(NSTMS)30,30,83              1082
83 MM=NSTMS-K+2                  1083
MM1=NSTM(MM)                     1084
X(MM1,I)=PI(K,I)/SMI            1085
30 CONTINUE                       1086
DO 35 I=1,IMAX                  1087
35 CFD(I)*BI(I)
SUFD=SUFD-SMI
4 CONTINUE                         1088
GO TO 65                           1089
40 K=KXXX                          1090
45 Q=1.0E35                         1091
      WRITE OUTPUTTAPE NOUT,200,THETA 1092
NTIME=NTIME+1                      1093
IF(NTIME-10)84,84,44               1094
84 DO 41 I=1,IMAX                 1095
IF(PI(K,I))85,41,85               1096
85 IF(PI(K,I)-Q)86,41,41         1097
86 Q=PI(K,I)                      1098
41 CONTINUE                         1099
SMI=Q                             1100
ABC=10.0*Q                         1101
DO 42 I=1,IMAX                  1102
IF(PI(K,I)-ABC)87,42,42         1103
87 PI(K,I)=(PI(K,I)+SMI)        1104
42 CONTINUE                         1105
GO TO 9                            1106
43 K=KXXX+1                        1107
GO TO 45                           1108
44 CALL PAGE                        1109
KB=-10                            1110
NCVG=1                            1111
      WRITE OUTPUTTAPE NOUT,57       1112
57 FORMAT(5BH PROBLEM CANNOT CONVERGE WILL PRINT RESULTS THEN CALL EX
1IT)
      CALL OTPT(NCVG,KB,ICON)       1113
      CALL EXIT                      1114
65 CONTINUE                         1115
      WRITE OUTPUTTAPE NOUT,200,THETA 1116
200 FORMAT(7H THETA=E16.8)          1117
1007 FORMAT(33H CORRECTED DISTILLATE COMPOSITION) 1118
1009 FORMAT(30H CORRECTED BOTTOMS COMPOSITION)    1119
1008 FORMAT(1H 7E16.8)              1120
      GO TO(1001,1001,1002),IOTPPT 1121
1002 WRITE OUTPUTTAPE NOUT,1007     1122
      WRITE OUTPUTTAPE NOUT,1008,(X(NMAX,I),I=1,IMAX) 1123
      WRITE OUTPUTTAPE NOUT,1009     1124
      WRITE OUTPUTTAPE NOUT,1008,(X(1,I),I=1,IMAX)    1125
1001 RETURN                         1126
      END                           1127
* LISTB                           1128
* LABEL                           1129
CXVAL      O.S.U. TRAY BY TRAY   1130
                                1131
                                1132
                                1133
                                1134

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SUBROUTINE XVAL(ICON) 1135
DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25), 1136
1 T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 1137
2 ,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 1138
325),ENL3(25),ENL4(25),ENVO(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 1139
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 1140
5,EQUI1(25) ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 1141
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 1142
7(3),PI(5,25),TOTI(25),CFD(25),POP(25) 1143
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDSM,NSTMS,SOF,NFDS,IMAX,NMAX, 1144
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 1145
28,NHTMS,PRESS,IDLH, ,GREB,BTMS,SMST,IFLIP,THETA ,RTFX,PID, 1146
3SDSR,SFDJ ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 1147
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENVO,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 1148
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 1149
6ME,QII,TSR,EQUI1, ,XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTP,T,RTX, 1150
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX 1151
CXXC=BXXB 1152
BXXB=0.0 1153
DO 20 N=1,NMAX 1154
CALL FLDR(N,FLDR1,FLDR2) 1155
IF(N-1)100,100,101 1156
101 DO 856 I=1,IMAX 1157
856 EQUI1(I)=EQUI (I) 1158
100 TT=T(N) 1159
CALL KVAL(TT) 1160
DO 20 I=1,IMAX 1161
DELD=0.0 1162
DELB=0.0 1163
79 IF(N-1)1,1,2 1164
1 A=0.0 1165
GO TO 31 1166
2 A=-BETA*DELT/HLDP(N)*(EQUI1(I)*VPRR(N-1)) 1167
31 B=BETA*DELT/HLDP(N)*(EQUI (I)*VPRR(N)+FLDR1)+1.0 1168
IF(NSTMS)301,301,302 1169
302 DO 303 NI=1,NSTMS 1170
IF(N-NSTM(NI))303,304,303 1171
304 B=B+Beta*DELT/HLDP(N)*SDSR(NI) 1172
GO TO 301 1173
303 CONTINUE 1174
301 IF(NMAX-N)3,3,4 1175
3 C=0.0 1176
GO TO 33 1177
4 C=-BETA*DELT/HLDP(N)*FLDR2 1178
33 CONTINUE 1179
IF(NMAX-N)5,5,6 1180
5 DD=X(N,I)+(1.0-BETA)*DELT/HLDP(N)*(VPRR(N-1)*EQUI1(I)*X(N-1,I)-VPR 1181
1R(N)*EQUI (I)*X(N,I)-FLDR1*X(N,I)) 1182
GO TO(51,17),ICON 1183
51 DELB=BETA*DELT/HLDP(N)*DSPEC 1184
DELD=(1.0-BETA)*DELT/HLDP(N)*DSPEC*X(N,I) 1185
DD=DD+DELD 1186
GO TO 17 1187
6 CONTINUE 1188

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1 IF(N-1)7,7,808 1189
7 DD=X(N,I)+(1.0-BETA)*DELT/HLDP(N)*(FLDR2*X(N+1,I)-VPRR(N)*EQUI (I)
1*X(N,I)-FLDR1*X(N,I)) 1190
1 GO TO 17 1191
808 IF(NSTMS)8,8,809 1192
809 DO 16 L=1,NSTMS 1193
1 IF(N-NSTM(L))16,14,16 1194
14 DD=X(N,I)+(1.-BETA)*DELT/HLDP(N)*(VPRR(N-1)*EQUI1(I)*X(N-1,I)+FLDR
12*X(N+1,I)-VPRR(N)*EQUI (I)*X(N,I)-(FLDR1+SDSR(L))*X(N,I)) 1195
1 GO TO 17 1196
16 CONTINUE 1197
8 D=X(N,I)+(1.0-BETA)*DELT/HLDP(N)*(VPRR(N-1)*EQUI1(I)*X(N-1,I)+FLDR
12*X(N+1,I)-VPRR(N)*EQUI (I)*X(N,I)-FLDR1*X(N,I)) 1198
DB=0.0 1199
DA=0.0 1200
152 DO 13 K=1,NFDS 1201
1 IF(N-NFPT(K))15,10,15 1202
10 DA=DELT/HLDP(N)*(FDRT(K)*XFED(K,I)*FRACT(K)) 1203
15 IF(N-1-NFPT(K))13,12,13 1204
12 DB=DELT/HLDP(N)*(FDRT(K)*YFED(K,I)*(1.0-FRACT(K))) 1205
13 CONTINUE 1206
34 DD=D+DA+DB 1207
17 CONTINUE 1208
B=B+DELB 1209
C MATRIX SOLUTION AND CALCULATION OF X(N,I) 1210
1 IF(N-1)18,18,19 1211
18 F(N,I)=C/B 1212
G(N,I)=DD/B 1213
GO TO 20 1214
19 F(N,I)=C/(B-A*F(N-1,I)) 1215
G(N,I)=(DD-A*G(N-1,I))/(B-A*F(N-1,I)) 1216
20 CONTINUE 1217
DO 32 N1=1,NMAX 1218
N=NMAX-N1+1 1219
DO 801 I=1,IMAX 1220
801 XXX(I)=X(N,I) 1221
SUMX=0.0 1222
DO 28 I=1,IMAX 1223
IF(NMAX-N)21,21,22 1224
21 X(N,I)=G(N,I) 1225
GO TO 23 1226
22 X(N,I)=G(N,I)-F(N,I)*X(N+1,I) 1227
23 IF(X(N,I))24,24,27 1228
24 X(N,I)=0.0 1229
27 SUMX=SUMX+X(N,I) 1230
28 CONTINUE 1231
DO 29 I=1,IMAX 1232
29 X(N,I)=X(N,I)/SUMX 1233
DO 999 I=1,IMAX 1234
AXXA=ABSF(XXX(I)-X(N,I)) 1235
IF(AXXA-BXXB)82,82,83 1236
83 BXXB=AXXA 1237
NYX=I 1238
NYZ=N 1239

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82 IF(ABSF(XXX(I)-X(N,I))-ALIM3)999,960,960          1243
960 LTEST=1                                         1244
999 CONTINUE                                         1245
32 CONTINUE                                         1246
N1S1N=N1S1N+1                                         1247
IF(N1S1N-6)615,493,493                               1248
493 AXXA=ABSF(BXXB-CXXC)/CXXC                      1249
IF(AXXA-0.0001)614,614,615                           1250
614 LTEST=0                                         1251
WRITE OUTPUTTAPE NOUT,616                            1252
616 FORMAT(73H MAXIMUM CHANGE IN COMPOSITION ERROR FROM PASS TO PASS I   1253
      IS NOT SIGNIFICANT/50H WILL SET COMPOSITION TEST AS CONVERGED AND R   1254
      RETURN)                                         1255
615 WRITE OUTPUTTAPE NOUT,86,BXXB,NYX,NYZ             1256
86 FORMAT(27H MAXIMUM COMPOSITION ERROR=E16.8,10H COMPONENT,I5,5H TRA    1257
      1Y 15)                                         1258
GO TO(1001,1001,1002),IOTPT                         1259
1002 CALL PAGE                                         1260
WRITE OUTPUTTAPE NOUT,1007                           1261
WRITE OUTPUTTAPE NOUT,1008,(X(NMAX,I),I=1,IMAX)       1262
WRITE OUTPUTTAPE NOUT,1009                           1263
WRITE OUTPUTTAPE NOUT,1008,(X(1,I),I=1,IMAX)         1264
1007 FORMAT(35H UNCORRECTED DISTILLATE COMPOSITION)   1265
1009 FORMAT(32H UNCORRECTRD BOTTOMS COMPOSITION)     1266
1008 FORMAT(1H 7E16.8)                                1267
1001 RETURN                                         1268
      END                                           1269
* LIST8                                         1270
* LABEL                                         1271
CVPRRT      O.S.U. TRAY BY TRAY                     1272
SUBROUTINE VPRRT(ICON)                                1273
DIMENSION      RTFX(3,25),SDSR(4),PID(12),SFDJ(25),  1274
1, T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 1275
2,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 1276
325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 1277
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 1278
5,EQUI1(25)      ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 1279
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 1280
7(3),PI(5,25),TOTI(25),CFD(25),POP(25)           1281
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDSMS,NSTMS,SOF,NFDS,IMAX,NMAX, 1282
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 1283
28,NHTMS,PRESS,IDHM,      QREB,BTMS,SMST,IFLIP,THFTA      ,RTFX,PID, 1284
3SDSR,SFDJ      ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 1285
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 1286
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 1287
6ME,QII,TSR,EQUI1,      XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX, 1288
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX             1289
C   IF ICON=1,TOTAL CONDENSER                         1290
C   IF ICON=2,PARTIAL CONDENSER                       1291
C   FOR INTERCOOLERS                                 1292
C   HEAT REMOVER IS (+)                            1293
C   HEAT ADDED IS (-)                             1294
CXXC=0.0                                         1295
VPRR(NMAX-1)=REFLX*SMFD                           1296

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IFLX=2 1297
DO 22 J=1,2 1298
K=NMAX-J+1 1299
22 CALL TDFLD(K,FLDR1,FLDR2,IFLX,XFLX) 1300
TT=T(NMAX) 1301
IFDC=1 1302
GO TO(1,2),ICON 1303
1 INC=1 1304
VPRR(NMAX)=0.0 1305
TDP2=T(NMAX) 1306
CALL ENTHL(IFDC,HVAL,INC,TT,NMAX) 1307
GO TO 3 1308
2 INC=2 1309
VPRR(NMAX)=DSPEC 1310
TDP2=T(NMAX) 1311
CALL ENTHL(IFDC,HVAL,INC,TT,NMAX) 1312
3 HDIST=HVAL*DSPEC 1313
INC=1 1314
TT=TDP2 1315
J12=NMAX-1 1316
CALL ENTHL(IFDC,HVAL,INC,TT,NMAX) 1317
HRFX=HVAL*(VPRR(NMAX-1)-DSPEC) 1318
TT=T(J12) 1319
INC=2 1320
CALL ENTHL(IFDC,HVAL,INC,TT,J12) 1321
HV1=HVAL*VPRR(J12) 1322
QCOND=HV1-HDIST-HRFX 1323
HFLX=QCOND+HDIST 1324
DO 4 J=3,NMAX 1325
K=NMAX-J+1 1326
BXXB=VPRR(K) 1327
CALL TDFLD(K,FLDR1,FLDR2,IFLX,XFLX) 1328
K1=K+1 1329
TT=T(K1) 1330
INC=1 1331
CALL ENTHL(IFDC,HLQD,INC,TT,K1) 1332
IF(NSTMSI5,5,71 1333
71 DO 6 M=1,NSTMS 1334
L=NSTM(M) 1335
K1=K+1 1336
IF(K1-L)6,72,6 1337
72 INC=1 1338
TT=T(L) 1339
CALL ENTHL(IFDC,HVAL,INC,TT,L) 1340
QSTM=HVAL*SDSR(M) 1341
HFLX=HFLX+QSTM 1342
GO TO 8 1343
6 CONTINUE 1344
5 DO 7 M1=1,NFDS 1345
M=NFDS-M1+1 1346
L=NFPT(M)-1 1347
L1=L+1 1348
IF(K-L1)20,73,20 1349
73 HFLX=HFLX-(1.0-FRACT(M))*HFVPR(M)*FDRT(M) 1350

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20 IF(K-L)7,74,7          1351
74 HFLX=HFLX-FRACT(M)*FDRT(M)*HFLQD(M) 1352
7 CONTINUE                1353
8 IF(NHTMS)10,10,75       1354
75 DO 11 KC=1,NHTMS      1355
  KD=NHTMS-KC+1           1356
  L=NHTM(KD)-1            1357
  IF(K-L)11,77,11          1358
77 HFLX=HFLX+HHST(KD)    1359
11 CONTINUE                1360
10 VAP=VPRR(K)             1361
  T1=T(K)                  1362
  T2=T1*T1                  1363
  T3=T1*T2                  1364
  T4=T1*T3                  1365
  T7=T(NMAX)                1366
  SMH1=0.0                  1367
  SMH2=0.0                  1368
  GO TO(2002,2003),ICON     1369
2003 CALL KVAL(T7)          1370
2002 DO 2001 IX=1,IMAX      1371
  SMX1=X(NMAX,IX)*DSPEC    1372
  GO TO(2004,2005),ICON     1373
2005 SMX1=SMX1*EQUI(IX)      1374
2004 DO 3002 J3X=1,NFDS      1375
  J4X=NFDS-J3X+1            1376
  J5X=NFPT(J4X) +1          1377
  IF(J5X-1-K)3001,4001,4001 1378
4001 SMX1=SMX1-YFED(J4X,IX)*(1.0-FRACT(J4X))*FDRT(J4X) 1379
3001 IF(J5X-2-K)3002,4002,4002 1380
4002 SMX1=SMX1-XFED(J4X,IX)*FRACT(J4X)*FDRT(J4X) 1381
3002 CONTINUE                1382
  H1I=ENV0(IX)+ENV1(IX)*T1+ENV2(IX)*T2+ENV3(IX)*T3+ENV4(IX)*T4 1383
  IF(INSTMS)2011,2011,2007 1384
2007 DO 2010 JX=1,NSTMS      1385
  KX=NSTMS-JX+1             1386
  LX=NSTM(KX) -1            1387
  IF(LX-K )2011,2010,2010 1388
2010 SMX1=SMX1+X(LX,IX)*SDSR(KX) 1389
2011 SMH1=H1I*SMX1+SMH1      1390
  N2X=K+1                  1391
2001 SMH2=SMH2+X(N2X,IX)*H1I 1392
  VPRR(K)=XFLX+(HFLX-SMH1)/(SMH2-HLQD) 1393
  IF(VPRR(K))81,81,82      1394
  81 VPRR(K)=1.0             1395
  82 IF(VPPR(K)-XFLX)83,83,40 1396
  83 VPRR(K)=XFLX+1.0      1397
  40 AXXA=ABSF(BXXB-VPRR(K)) 1398
  IF(AXXA-CXXC)4,4,41      1399
  41 CXXC=AXXA              1400
  N879=K                   1401
  4 CONTINUE                1402
  IF(CXXC-ALIM5)100,100,101 1403
101 NTEST=1                 1404

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100 WRITE OUTPUTTAPE NOUT,44,CXXC,N879 1405
 44 FORMAT(27H MAXIMUM VAPOR RATE CHANGE=E14.8,8H AT TRAYI4) 1406
    RETURN 1407
    END 1408
*   LIST8 1409
*   LABEL 1410
CBUBPT      Q,S,U, TRAY BY TRAY 1411
SUBROUTINE BUBPT(N,TT,INDI,XX) 1412
  DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25), 1413
    T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 1414
    ,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 1415
    325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 1416
    ,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 1417
    ,EQUI1(25)      ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 1418
    6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 1419
    7(3),PI(5,25),TOTI(25),CFD(25),POP(25) 1420
    COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDS,MS,NS,MS,SO,NS,FD,IM,MAX,NMAX, 1421
    TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 1422
    28,NHTMS,PRESS,IM,  QREB,BTMS,SMST,IFLIP,THETA,RTFX,PID, 1423
    3SDSR,SFDJ,  SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 1424
    4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 1425
    5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 1426
    6ME,QII,TSR,EQUI1,  XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX, 1427
    7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX 1428
    J5=0 1429
    I8=0 1430
    J7*2 1431
    SUM=0.0 1432
    DO 1 I=1,IMAX 1433
    IF(INDI)2,2,3 1434
    2 SUM=SUM+X(N,I) 1435
    GO TO 4 1436
    3 SUM=SUM+XFED(N,I) 1437
    4 IF(SUM-0.3)1,1,5 1438
    5 IF(I-1)6,6,7 1439
    6 LOOKE=2 1440
    GO TO 8 1441
    7 LOOKE=I 1442
    GO TO 8 1443
    1 CONTINUE 1444
    8 T1T=TT 1445
    18 CALL KVAL(T1T) 1446
    I8=I8+1 1447
    IF(I8-30)25,25,16 1448
    25 SUM=0.0 1449
    DO 11 I=1,IMAX 1450
    IF(INDI)9,9,10 1451
    9 SUM=SUM+X(N,I)*EQUI(I) 1452
    GO TO 11 1453
    10 SUM=SUM+XFED(N,I)*EQUI(I) 1454
    11 CONTINUE 1455
    GO TO(13,21),J7 1456
    21 IF(ABSF(1.0-SUM)-ALIM6)12,12,13 1457
    13 AKPRM=EQUI(LOOKE)/SUM 1458

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BKPRM=BK(LOOKE)+2.0*CK(LOOKE)*T1T+3.0*DK(LOOKE)*T1T*T1T+4.0*EK(LOO
1KE)*(T1T**3)+5.0*FK(LOOKE)*(T1T**4) 1459
19=0 1460
T2=T1T+(AKPRM-EQUI(LOOKE))/BKPRM 1461
IF(T2-TMAX)61,61,71 1462
71 T5=TMAX 1463
GO TO 63 1464
61 IF(T2-TMIN)72,72,62 1465
72 T5=TMIN 1466
63 J5=J5+1 1467
T2=T5 1468
IF(J5-4)62,16,62 1469
62 19=19+1 1470
IF(19-30)15,15,16 1471
15 CALL KVAL(T2) 1472
T1=T1T 1473
T1T=T2 1474
IF(ABSF(T2-T1)-ALIM6)17,17,19 1475
19 J7=1 1476
GO TO 18 1477
17 J7=2 1478
GO TO 18 1479
16 WRITE OUTPUTTAPE NOUT,100,N,T1T 1480
100 FORMAT(47H BUBBLE POINT DID NOT CONVERGE FOR TRAY OR FEED 14,18H W
     1ILL SET TEMP. AT F10.4,13H AND CONTINUE) 1481
12 TT=T1T 1482
RETURN 1483
END 1484
* LIST8 1485
* LABEL 1486
CDEWPT O.S.U. TRAY BY TRAY 1487
SUBROUTINE DEWPT(N,TT,INDI,XX) 1488
DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25),
1   T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6)
2,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2(1
325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25)
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200)
5,EQUI1(25),XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX
7(3),PI(5,25),TOTI(25),CFD(25),POP(25) 1489
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDSMS,NSTMS,SOF,NFDS,IMAX,NMAX,
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM
28,NHTMS,PRESS,IDHM,,QREB,BTMS,SMST,IFLIP,THETA,,RTFX,PID,
3SDSR,SFDJ,,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK,
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA
6ME,QII,TSR,EQUI1,,XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX,
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX 1490
J5=0 1491
I8=0 1492
J7=2 1493
SUM=0.0 1494
DO 1 I=i,IMAX 1495
3 SUM=SUM+YFED(N,I) 1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512

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4 IF(SUM-0.3)1,1,5          1513
5 IF(I-1)6,6,7          1514
6 LOOKE=2          1515
   GO TO 8
7 LOOKE=I          1516
   GO TO 8
1 CONTINUE
8 T1T=TT
18 CALL KVAL(T1T)
   I8=I8+1
   IF(I8-30)25,25,16
25 SUM=0.0          1517
   DO 11 I=1,IMAX
10 SUM=SUM+YFED(N,I)/EQUI(I) 1518
11 CONTINUE
   GO TO(13,21),J7
21 IF(ABSF(1.0-SUM)-ALIM4)12,12,13 1519
13 AKPRM=EQUI(LOOKE)*SUM          1520
   BKPRM=BK(LOOKE)+2.0*CK(LOOKE)*T1T+3.0*DK(LOOKE)*(T1T**2)+4.0*EK(LO
   OKE)*(T1T**3)+5.0*FK(LOOKE)*(T1T**4) 1521
   I9=0          1522
   T2=T1T+(AKPRM-EQUI(LOOKE))/BKPRM 1523
   IF(T2-TMAX)61,61,71          1524
71 T5=TMAX          1525
   GO TO 63          1526
61 IF(T2-TMIN)72,72,62          1527
72 T5=TMIN          1528
63 J5=J5+1          1529
   T2=T5          1530
   IF(J5-3)62,122,62          1531
122 T1T=T2          1532
   GO TO 16          1533
62 I9=I9+1          1534
   IF(I9-30)15,15,16          1535
15 CALL KVAL(T2)
   T1=T1T          1536
   T1T=T2          1537
   IF(ABSF(T2-T1)-ALIM4)17,17,19 1538
19 J7=1          1539
   GO TO 18          1540
17 J7=2          1541
   GO TO 18          1542
16 WRITE OUTPUTTAPE NOUT,100,N,T1T 1543
100 FORMAT(36H DEW POINT DID NOT CONVERGE FOR FEED,I3,18H WILL SET TEM
   1P,AT,F10.4,I3H AND CONTINUE) 1544
12 CONTINUE          1545
   TT=T1T          1546
   RETURN          1547
   END          1548
* LIST8          1549
* LABEL          1550
CKVAL      O.S.U. TRAY BY TRAY          1551
SUBROUTINE KVAL(TT)          1552
DIMENSION      RTFX(3,25),SDSR(4),PID(12),SFDJ(25) 1553

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1   T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6)      1567
2,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2(    1568
325),ENL3(25),ENL4(25),ENVO(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25)     1569
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200)    1570
5,EQUI1(25)           ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF    1571
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX    1572
7(3),PI(5,25),TOTI(25),CFD(25),POP(25)                                1573
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDS,MS,NS,SO,NFDS,IMAX,NMAX,                1574
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM     1575
28,NHTMS,PRESS,IDHM,          QREB,BTMS,SMST,IFLIP,THETA      ,RTFX,PID,  1576
3SDSR,SFDJ   ,SSS,T,HLDP,NS,MS,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK,    1577
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENVO,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT    1578
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA    1579
6ME,QII,TSR,EQUI1,           XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTP,RTX  1580
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX                                1581
T1=TT
IF(T1-TMAX)201,202,202
202 T1=TMAX
TT=T1
201 IF(T1-TMIN)204,204,206
204 T1=TMIN
TT=T1
206 T2=T1*T1
T3=T2*T1
T4=T3*T1
T5=T4*T1
DO 207 I=1,IMAX
207 EQUI(I)=AK(I)+BK(I)*T1+CK(I)*T2+DK(I)*T3+EK(I)*T4+FK(I)*T5
RETURN
END
*   LIST8
*   LABEL
CENTHL      O.S.U. TRAY BY TRAY
SUBROUTINE ENTHL(IFDC,HVAL,INC,TT,N)                                     1599
DIMENSION      RTFX(3,25),SDSR(4),PID(12),SFDJ(25),                         1600
1   T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6)      1601
2,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2(    1602
325),ENL3(25),ENL4(25),ENVO(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25)     1603
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200)    1604
5,EQUI1(25)           ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF    1605
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX    1606
7(3),PI(5,25),TOTI(25),CFD(25),POP(25)                                1607
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDS,MS,NS,SO,NFDS,IMAX,NMAX,                1608
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM     1609
28,NHTMS,PRESS,IDHM,          QREB,BTMS,SMST,IFLIP,THETA      ,RTFX,PID,  1610
3SDSR,SFDJ   ,SSS,T,HLDP,NS,MS,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK,    1611
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENVO,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT    1612
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA    1613
6ME,QII,TSR,EQUI1,           XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTP,RTX  1614
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX                                1615
C   IFDC=5, CALCULATE FEED ENTHALPY                                         1616
C   IFDC NE 5 CALCULATE TRAY ENTHALPY                                         1617
C   INC=1,CALCULATE LIQUID ENTHALPY                                         1618
C   INC=2,CALCULATE VAPOR ENTHALPY                                         1619
C   INC=2,CALCULATE VAPOR ENTHALPY                                         1620

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T1=TT	1621
T2=T1*T1	1622
T3=T2*T1	1623
T4=T3*T1	1624
HVPR=0.0	1625
HLQD=0.0	1626
GO TO(301,302),INC	1627
301 DO 3 I=1,IMAX	1628
HLQDI=ENL0(I)+ENL1(I)*T1+ENL2(I)*T2+ENL3(I)*T3+ENL4(I)*T4	1629
IF(5-IFDC)303,2,303	1630
2 HLQD=HLQD+HLQDI*XFED(N,I)	1631
GO TO 3	1632
303 HLQD=HLQD+HLQDI*X(N,I)	1633
3 CONTINUE	1634
HVAL=HLQD	1635
RETURN	1636
302 IF(IFDC-5)11,12,11	1637
11 CALL KVAL(TT)	1638
12 DO 6 I=1,IMAX	1639
HVPRI=ENV0(I)+ENV1(I)*T1+ENV2(I)*T2+ENV3(I)*T3+ENV4(I)*T4	1640
IF(IFDC-5)305,5,305	1641
5 HVPR=HVPR+HVPRI*YFED(N,I)	1642
GO TO 6	1643
305 HVPR=HVPR+HVPRI*X(N,I)*EQUI(I)	1644
6 CONTINUE	1645
HVAL=HVPR	1646
RETURN	1647
END	1648
* LIST8	1649
* LABEL	1650
CFLDR1 O.S.U. TRAY BY TRAY	1651
SUBROUTINE FLDRT(N,FLDR1,FLDR2)	1652
C CALCULATION OF LIQUID RATES FOR CONSTANT AND NON-CONSTANT OVERFLOW	1653
DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25),	1654
1 T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6)	1655
2 ,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2(1656
325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25)	1657
4,EQUI(25),FRACT(3),FDRT(3)*X(200,25),F(200,25),G(200,25),VPRR(200)	1658
5,EQUI1(25),XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF	1659
6ED(13),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX	1660
7(3),PI(5,25),TOTI(25),CFD(25),POP(25)	1661
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDSMS,NSTMS,SOF,NFDS,IMAX,NMAX,	1662
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM	1663
28,NHTMS,PRESS,IDHM,QREB,BTMS,SMST,IFLIP,THETA,RTFX,PID,	1664
3SDSR,SFDJ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK,	1665
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRAC,FDRT	1666
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA	1667
6ME,QII,TSR EQUI1,XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX,	1668
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX	1669
IF(N-1)1,1,2	1670
1 XFLX=BTMS	1671
FLDR1=BTMS	1672
GO TO 3	1673
2 FLDR1=FLDR2	1674

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3 IF(NMAX-N)4,5,4          1675
5 FLDR2=0.0                 1676
   GO TO 6                  1677
4 IF(NSTMS)11,11,8          1678
8 DO 9 I=1,NSTMS            1679
   IF(N-NSTM(I))9,10,9      1680
10 XFLX=XFLX+SDSR(I)       1681
   GO TO 11                 1682
9 CONTINUE                   1683
11 DO 12 I=1,NFDS            1684
   IF(N-NFPT(I))16,13,16     1685
13 XFLX=XFLX-FDRT(I)*FRACT(I) 1686
16 IF(N-1-NFPT(I))12,17,12     1687
17 XFLX=XFLX-FDRT(I)*(1.0-FRACT(I)) 1688
12 CONTINUE                   1689
14 FLDR2=XFLX+VPRR(N)       1690
   IF(NMAX-1-N)6,53,6         1691
53 FLDR2=VPRR(N)-DSPEC      1692
6 CONTINUE                   1693
   RETURN                     1694
   END                       1695
* LIST8                      1696
* LABEL                      1697
CTDFLD          O.S.U. TRAY BY TRAY          1698
SUBROUTINE TDFLD(M,FLDR1,FLDR2,IFLX,XFLX) 1699
DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25),
1 T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6)
2 ,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2(25),
3 ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25)
4 ,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200)
5 ,EQUI1(25)                ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF
6 ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX
7 (3),PI(5,25),TOTI(25),CFD(25),POP(25)
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDS,NSMS,SOF,NFDS,IMAX,NMAX,
1 TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM
2 8,NHTMS,PRESS,IDHM,           QREB,BTMS,SMST,IFLIP,THETA ,RTFX,PID,
3 SDSR,SFDJ ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK,
4 EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT
5 ,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,TEST,MTEST,NTEST,IHBAL,XNA
6 ME,QII,TSR,EQUI1,           XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX,
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N151N,XXX
C   IFLX=1,CALCULATE LIQUID RATE          1716
C   IFLX=2 CALCULATE FLUX FOR VAPOR RATE    1717
IF(NMAX-M)1,1,2               1718
1 XFLX=DSPEC                  1719
YFLX=XFLX                     1720
FLDR2=0.0                      1721
FLDR1=VPRR(M-1)-XFLX          1722
   GO TO 11                     1723
2 FLDR2=FLDR1                  1724
3 IF(NSTMS)6,6,10                1725
10 DO 4 J=1,NSTMS                1726
   K=NSTMS-J+1                  1727
   L=NSTM(K)-1                  1728

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IF(M+1-NSTM(K))17,18,17          1729
18 YFLX=YFLX+SDSR(K)             1730
17 IF(M-L)4,5,4                   1731
  5 XFLX=XFLX+SDSR(K)            1732
  4 CONTINUE                       1733
  6 DO 7 J=1,NFDS                 1734
    K=NFDS-J+1                    1735
    N=M-1                         1736
    L=M                           1737
    L1=M+1                        1738
    IF(N-NFPT(K))21,22,21         1739
22 YFLX=YFLX-FDRT(K)*(1.0-FRACT(K)) 1740
21 IF(L-NFPT(K))13,14,13           1741
14 YFLX=YFLX-FDRT(K)*FRACT(K)     1742
13 IF(L-NFPT(K))31,8,31           1743
  8 XFLX=XFLX-FDRT(K)*(1.0-FRACT(K)) 1744
31 IF(L1-NFPT(K))7,20,7           1745
20 XFLX=XFLX-FDRT(K)*FRACT(K)     1746
  7 CONTINUE                       1747
12 GO TO(9,11),IFLX               1748
  9 FLDR1=VPRR(M-1)-YFLX          1749
11 RETURN                          1750
  END                            1751
* LIST8                           1752
* LABEL                           1753
COTPT   O.S.U. TRAY BY TRAY        1754
        SUBROUTINE OTPT(NCVG,KB,ICON) 1755
C PRINT OUT OF X,Y,L,V,K          1756
C DIMENSION   RTFX(3,25),SDSR(4),PID(12),SFDJ(25),      1757
1 T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 1758
2 ,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 1759
325),ENL3(25),ENL4(25),ENV0(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 1760
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 1761
5,EQUI1(25)           ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 1762
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 1763
7(3),PI(5,25),TOTI(25),CFD(25),POP(25) 1764
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDS,NSTMS,SOF,NFDS,IMAX,NMAX, 1765
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 1766
28,NHTMS,PRESS,1DHM,      QREB,BTMS,SMST,IFLIP,THETA      ,RTFX,PID, 1767
3SDSR,SFDJ,      SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 1768
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENV0,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 1769
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,LTEST,MTEST,NTEST,IHBAL,XNA 1770
6ME,QII,TSR,EQUI1,      XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX, 1771
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX 1772
C IF IOTPT=1,INTERMEDIATE RESULTS ARE NOT PRINTED 1773
C IF IOTPT=2,INTERMEDIATE RESULTS ARE PRINTED 1774
C IF NCVG=1,PROGRAM IS IN INTERMEDIATE CALCULATIONS 1775
C NCVG=2,PROGRAM HAS CONVERGED 1776
C NCVG=3,MAXIMUM PASSES COMPLETED,PROGRAM DID NOT CONVERGE 1777
IFLX=1 1778
IF(KB)4,307,307 1779
307 CALL PAGE 1780
GO TO(1,2,40),NCVG 1781
2 WRITE OUTPUTTAPE NOUT,3,KB 1782

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3 FORMAT(42H FINAL RESULTS,PROBLEM HAS CONVERGED AFTER,I4,7H PASSES) 1783
  GO TO 4 1784
1 WRITE OUTPUTTAPE NOUT,5,KB 1785
5 FORMAT(12H END OF PASS,I4,26H PROBLEM HAS NOT CONVERGED) 1786
  GO TO 4 1787
40 WRITE OUTPUTTAPE NOUT,41 1788
41 FORMAT(106H PROBLEM HAS COMPLETED MAXIMUM NUMBER OF PASSES WITHOUT 1789
  1 CONVERGING, THE RESULTS FROM THE FINAL PASS FOLLOW) 1790
  4 DO 12 M=1,NMAX 1791
    N=NMAX-M+1 1792
    IF(N-NMAX)8,12,8 1793
  8 CALL PAGE 1794
    K1=M-2 1795
    K=M-1 1796
    WRITE OUTPUTTAPE NOUT,13,K,T(N) 1797
13 FORMAT(5H TRAY,I5,18H TRAY TEMPERATURE=,F8.3) 1798
9 WRITE OUTPUTTAPE NOUT,14,K1,K 1799
14 FORMAT(12X,20H LIQUID LEAVING TRAYI4,7X,19H VAPOR LEAVING TRAYI4/ 1800
  110H COMPONENT,9X,5HMOLES,10X,2HMF,9X,5HMOLES,10X,2HMF,7X,8H K VALU 1801
  2E) 1802
  K=N+1 1803
  CALL TDFLD(K,FLDR1,FLDR2,IFLX,XFLX) 1804
  TT=T(N) 1805
  CALL KVAL(TT) 1806
  DO 15 I=1,IMAX 1807
    YY=EQUI(I)*X(N,I) 1808
    FL=FLDR1*X(N+1,I) 1809
18 FV=VPRR(N)*YY 1810
15 WRITE OUTPUTTAPE NOUT,20,(XNAME(I,J),J=1,2),FL,X(N+1,I),FV,YY,EQUI 1811
  1(I) 1812
20 FORMAT(1H ,2A6,F13.4,F13.6,F13.4,F13.6,F13.6) 1813
  WRITE OUTPUTTAPE NOUT,22,FLDR1,VPRR(N) 1814
22 FORMAT(3X,4H SUM,9X,F10.4,4X,9H 1.000000,3X,F10.4,4X,9H 1.000000) 1815
  DO 610 J=1,NFDS 1816
    J1=NFDS-J+1 1817
    IF(N-NFPT(J1))610,612,610 1818
612 CALL PAGE 1819
  K=M-1 1820
  K1=M-2 1821
  WRITE OUTPUTTAPE NOUT,613,K,J,K1 1822
613 FORMAT(5H TRAY,I4,23H IS A FEED TRAY OF FEED I2/77H THE LIQUID COM 1823
  10SITION ENTERING THIS TRAY AND VAPOR CAMPOSITION ENTERING TRAY I4, 1824
  27H FOLLOW/20X,6HLIQUID,35X,5HVAPOR/10H COMPONENT,8X,5HMOLES,11X,2H 1825
  3MF,8X,5HMOLES,11X,2HMF) 1826
  SUM1=VPRR(N)+FDRT(J1)*(1.0-FRACT(J1)) 1827
  SUM=FLDR1+FDRT(J1)*FRACT(J1) 1828
  DO 643 I=1,IMAX 1829
    C=VPRR(N)*EQUI(I)*X(N,I)+YFED(J1,I)*(SUM1-VPRR(N)) 1830
    A=FLDR1*X(N+1,I)+XFED(J1,I)*FDRT(J1)*FRACT(J1) 1831
    D=C/SUM1 1832
    B=A/SUM 1833
643 WRITE OUTPUTTAPE NOUT,615,(XNAME(I,J),J=1,2),A,B,C,D 1834
615 FORMAT(1H 2A6,F13.4,F13.6,F13.4,F13.6) 1835
  WRITE OUTPUTTAPE NOUT,616,SUM,SUM1 1836

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616 FORMAT(3X,4H SUM,9X,F10.4,4X,9H 1.000000,3X,F10.4,4X,9H 1.000000) 1837
610 CONTINUE 1838
1004 FORMAT(5H TRAY,I5,46H IS A SIDE DRAW TRAY, THE LIQUID ENTERING TRA 1839
    1Y,I5,8H FOLLOWS/10H COMPONENT,8X,5HMOLES,11X,2HMF) 1840
1006 FORMAT(3X,4H SUM,9X,F10.4,4X,9H 1.000000) 1841
    IF(NSTMS)12,12,1001 1842
1001 CALL PAGE 1843
    DO 1002 IX5=1,NSTMS 1844
    NIP=N+1 1845
    IF(NIP-NSTM(IX5))1002,1003,1002 1846
1003 WRITE OUTPUTTAPE NOUT,1004,NIP,N 1847
    DO 1005 I7A=1,IMAX 1848
    XAX=(FLDR1-SDSR(IX5))*X(N+1,I) 1849
1005 WRITE OUTPUTTAPE NOUT, 1010,(XNAME(I,J),J=1,2),XAX,X(N+1,I) 1850
1010 FORMAT(1H 2A6,F13.4,F13.6) 1851
    XAX=FLDR1-SDSR(IX5 ) 1852
    WRITE OUTPUTTAPE NOUT,1006,XAX 1853
1002 CONTINUE 1854
12 CONTINUE 1855
    ALRT=FLDR1 1856
    CALL PAGE 1857
    WRITE OUTPUTTAPE NOUT,25 1858
25 FORMAT(21H PRODUCT COMPOSITIONS,16X,11H DISTILLATE,13X,7HBOTTOMS/1 1859
    19X,49H COMPONENT MOLES MF MOLES MF) 1860
    SUM=0.0 1861
    SUMX=0.0 1862
    NPDS=NSTMS+2 1863
    DO 26 I=1,IMAX 1864
    SUM=SUM+PI(I,I) 1865
    SUMX=SUMX+PI(NPDS,I) 1866
    GO TO(28,27),ICON 1867
28 FX=X(NMAX+I) 1868
    GO TO 26 1869
27 TT=T(NMAX) 1870
    CALL KVAL(TT) 1871
    FX=X(NMAX,I)*EQUI(I) 1872
26 WRITE OUTPUTTAPE NOUT,30,(XNAME(I,J),J=1,2),PI(I,I),FX,PI(NPDS,I), 1873
    1X(1,I) 1874
30 FORMAT(18X,2A6,F10.4,F10.6,F10.4,F10.6) 1875
    WRITE OUTPUTTAPE NOUT,31,SUM,SUMX 1876
31 FORMAT(23X,4H SUM,5X,F10.4,8H 1.0000,2X,F10.4,8H 1.0000) 1877
    GO TO(33,32),ICON 1878
33 WRITE OUTPUTTAPE NOUT,34 1879
34 FORMAT(39H DISTILLATE LEAVES THE COLUMN AS LIQUID) 1880
    GO TO 697 1881
32 WRITE OUTPUTTAPE NOUT,36 1882
36 FORMAT(38H DISTILLATE LEAVES THE COLUMN AS VAPOR) 1883
697 IF(NSTMS)35,35,107 1884
107 CALL PAGE 1885
    WRITE OUTPUTTAPE NOUT,121 1886
121 FORMAT(25X,18H PRODUCT SIDE CUTS) 1887
    DO 131 N6=1,NSTMS 1888
    NN=N6+1 1889
    CALL PAGE 1890

```

N5=NSTM-N6+1	1891
N7=NSTM(N5)	1892
N8=NMAX-N7	1893
WRITE OUTPUTTAPE NOUT,122,N8	1894
122 FORMAT(17H SIDE CUT AT TRAY I5/19X,30H COMPONENT	MOLES
1MF)	1895
SUM=0.0	1896
DO 130 I=1,IMAX	1897
SUM=SUM+PI(NN,I)	1898
130 WRITE OUTPUTTAPE NOUT,151,(XNAME(I,J),J=1,2),PI(NN,I)*X(N7,I)	1899
151 FORMAT(19X,2A6,F10.4,F10.6)	1900
131 WRITE OUTPUTTAPE NOUT,152,SUM	1901
152 FORMAT(23X,4H SUM,6X,8H 1.0000,F10.6)	1902
35 CONTINUE	1903
IFDC=1	1904
TT=T(2)	1905
NS=2	1906
INCX=1	1907
CALL ENTHL(IFXC,HVAL,INCX,TT,NS)	1908
HLT2=HVAL	1909
NS=1	1910
TT=T(1)	1911
CALL ENTHL(IFDC,HVAL,INCX,TT,NS)	1912
HLT1=HVAL	1913
INCX=2	1914
CALL ENTHL(IFDC,HVAL,INCX,TT,NS)	1915
HVT1=HVAL	1916
HBT=HLT1*BTMS	1917
HBTX=HBT	1918
QREB=HVT1*VPRR(1)+HBT-HLT2*ALRT	1919
CALL PAGE	1920
WRITE OUTPUTTAPE NOUT,507,QREB	1921
507 FORMAT(20H COLUMN HEAT BALANCE//5X,21H HEAT ADDED TO COLUMN/5X,19H	1922
1 REBOILER HEAT DUTY E16.8)	1923
SUM=QREB	1924
DO 550 J=1,NFDS	1925
NM=NFDS-J+1	1926
HX=HFED(NM)*FDRT(NM)	1927
WRITE OUTPUTTAPE NOUT,556,J,HX	1928
550 SUM=SUM+HX	1929
556 FORMAT(5X,18H ENTHALAPY OF FEED I3,E16.8)	1930
IF(NSTM)557,557,558	1931
558 DO 560 J=1,NHTMS	1932
NM=NHTMS-J+1	1933
IF(HHST(NM))561,560,560	1934
561 SUM=SUM-HHST(NM)	1935
WRITE OUTPUTTAPE NOUT,562,J,HHST(NM)	1936
562 FORMAT(5X,26H HEAT ADDED BY SIDE HEATER I3,E16.8)	1937
560 CONTINUE	1938
557 WRITE OUTPUTTAPE NOUT,559,SUM	1939
559 FORMAT(5X,27H TOTAL HEAT ADDED TO COLUMN E16.8//)	1940
NS=NMAX-1	1941
TT=T(NS)	1942
INCX=2	1943
	1944

```

CALL ENTHL(IFDC,HVAL,INCX,TT,NS)          1945
HVT1=HVAL*VPRR(NS)                      1946
TT=T(NMAX)                                1947
NS=NMAX                                     1948
INCX=1                                      1949
CALL ENTHL(IFDC,HVAL,INCX,TT,NS)          1950
HBT=HVAL*(VPRR(NMAX-1)-DSPEC)             1951
GO TO(571,570),ICON                        1952
570 INCX=2                                  1953
CALL ENTHL(IFDC,HVAL,INCX,TT,NS)          1954
571 QBT=DSPEC*HVAL                         1955
QCOND=HVT1-QBT-HBT                        1956
WRITE OUTPUTTAPE NOUT,576,QCOND,QBT,HBTX   1957
576 FORMAT(5X,25H HEAT REMOVED FROM COLUMN/5X,10H CONDENSER,E16.8/5X,1
11H DISTILLATE E16.8/5X,8H BOTTOMS E16.8) 1958
SUM=QBT+QCOND+HBTX                        1959
IF(NSTMS)580,580,581                      1960
581 DO 582 J=1,NSTMS                      1961
NM=NSTMS-J+1                             1962
NS=NSTM(NM)                               1963
TT=T(NS)                                   1964
INCX=1                                      1965
CALL ENTHL(IFDC,HVAL,INCX,TT,NS)          1966
QBT=HVAL*SDSR(NM)                         1967
SUM=SUM+QBT                               1968
582 WRITE OUTPUTTAPE NOUT,583,J,QBT        1969
583 FORMAT(5X,28H HEAT REMOVED BY SIDE STREAM,I3,E16.8) 1970
584 IF(NHTMS)584,584,585                  1971
585 DO 590 J=1,NHTMS                      1972
NM=NHTMS-J+1                            1973
IF(HHST(NM))590,590,586                  1974
586 WRITE OUTPUTTAPE NOUT,591,J,HHST(NM)   1975
591 FORMAT(5X,28H HEAT REMOVED BY INTERCOOLER I3,E16.8) 1976
SUM=SUM+HHST(NM)                          1977
590 CONTINUE                                1978
584 WRITE OUTPUTTAPE NOUT,592,SUM          1979
592 FORMAT(5X,19H TOTAL HEAT REMOVED E16.8) 1980
CALL PAGE                                 1981
WRITE OUTPUTTAPE NOUT,66                  1982
66 FORMAT(14H TRAY PROFILES/7H TRAY,6X,11HTEMPERATURE,4X,10HVAPOR R
1ATE,6X,19HENHALPY/MOLE VAPOR)           1983
DO 60 N1=1,NMAX                           1984
N=NMAX-N1+1                             1985
N2=N1-1                                 1986
62 JSA=1                                  1987
JSB=2                                    1988
TT=T(N)                                   1989
CALL ENTHL(JSA,HVAL,JSB,TT,N)            1990
60 WRITE OUTPUTTAPE NOUT,63,N2,T(N),VPRR(N),HVAL 1991
63 FORMAT(3X,I4,3X,F14.4,F14.5,E24.8)    1992
JX=NMAX-1                               1993
WRITE OUTPUTTAPE NOUT,462,JX              1994
462 FORMAT(20H CONDENSER IS TRAY 0./17H REBOILER US TRAY,I4) 1995
RETURN                                    1996
                                         1997
                                         1998

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END 1999
#
LIST8 2000
#
LABEL 2001
CPAGE 2002
O.S.U. TRAY BY TRAY 2003
SUBROUTINE PAGE 2004
DIMENSION RTFX(3,25),SDSR(4),PID(12),SFDJ(25),
1 T(200),HLDP(200),NSTM(4),SOF(4),NFPT(3),HFED(3),NHTM(6),HHST(6) 2005
2,AK(25),BK(25),CK(25),DK(25),EK(25),FK(25),ENL0(25),ENL1(25),ENL2( 2006
325),ENL3(25),ENL4(25),ENVO(25),ENV1(25),ENV2(25),ENV3(25),ENV4(25) 2007
4,EQUI(25),FRACT(3),FDRT(3),X(200,25),F(200,25),G(200,25),VPRR(200) 2008
5,EQUI1(25) ,XFED(3,25),YFED(3,25),DI(25),BI(25),XXX(25),TF 2009
6ED(3),XNAME(25,2),QII(25),SSS(25),HFLQD(25),HFVPR(25),ITMST(3),RTX 2010
7(3),PI(5,25),TOTI(25),CFD(25),POP(25) 2011
COMMON NOUT,NIN,SMFD,DSPEC,DOF,IDSMS,NSTMS,SOF,NFDS,IMAX,NMAX, 2012
1TMAX,TMIN,BETA,DELT,ALIM1,ALIM2,ALIM3,ALIM4,ALIM5,ALIM6,ALIM7,ALIM 2013
28,NHTMS,PRESS,IDHM, QREB,BTMS,SMST,IFLIP,THETA ,RTFX,PID, 2014
3SDSR,SFDJ ,SSS,T,HLDP,NSTM,NFPT,FLOV,HFED,NHTM,HHST,AK,BK,CK,DK, 2015
4EK,FK,ENL0,ENL1,ENL2,ENL3,ENL4,ENVO,ENV1,ENV2,ENV3,ENV4,FRACT,FDRT 2016
5,EQUI,X,F,G,VPRR,CON1,REFLX,BI,DI,TFED,TEST,MTEST,NTEST,IHBAL,XNA 2017
6ME,QII,TSR,EQUI1, XFED,YFED,HFLQD,HFVPR,ITMST,TCON,IOTPT,RTX, 2018
7 PI,TOTI,CFD,POP,IVPR,IPAGE,N1S1N,XXX 2019
IPAGE=IPAGE+1 2020
WRITE OUTPUTAPE NOUT,1,IPAGE 2021
1 FORMAT(1H1,80X,19H0.S.U. TRAY BY TRAY,/86X,4HPAGE,I5) 2022
WRITE OUTPUTAPE NOUT,2,(PID(I),I=1,12) 2023
2 FORMAT(1H ,12A6,//)
RETURN 2024
END 2025
DATA 2026
*
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VITA

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