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A COMPUTER SOLUTION FOR
ABSORBERS AND STRIPPERS USING
THE NEWTON - RAPHSON ITERATIVE METHOD

BY

ROBERT JOHN LUKACH

A THESIS

PRESENTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE

OF

MASTER OF SCIENCE IN CHEMICAL ENGINEERING

AT

NEWARK COLLEGE OF ENGINEERING

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Newark, New Jersey
1973

ABSTRACT

The solution of absorber or stripper calculations by traditional methods can be a tedious, time consuming, if not a completely fruitless procedure. Hence a computer solution of these calculations is both desirable and, as the complexity of chemical process plants increases, necessary.

The component oriented Newton-Raphson procedure was programmed to perform this calculation, and makes full use of the material and enthalpy balance equations to perform the iterative equilibrium stage calculations. A Newton-Raphson stage oriented method was also developed as a verification program to check the solutions obtained from the Newton-Raphson component oriented procedure.

APPROVAL OF THESIS
A COMPUTER SOLUTION FOR
ABSORBERS AND STRIPPERS USING
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BY

ROBERT JOHN LUKACH

FOR

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NEWARK COLLEGE OF ENGINEERING

BY

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PREFACE

The writer has attempted in this work to present a useful comparison between traditional calculation methods for absorbers and strippers and more sophisticated computer techniques.

The primary effort was to provide two computer programs using different iteration techniques for solution of absorber and stripper calculation. These programs should most likely be used by students in the Chemical Engineering Department at the Newark College of Engineering as a learning tool.

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I would also like to thank Mr. E. Wells of the Foster Wheeler Corporation for running one of the sample problems using Foster Wheeler's facilities and program. This aided greatly in verifying the solutions obtained from the program developed here.

I would also like to thank several people at American Cyanamid Company for reproductions of portions of the paper and especially Mr. E. Perez for the graphics included in one of the chapters, and Miss D. De Maio for the typing.

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TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	ii
APPROVAL	iii
PREFACE	iv
ACKNOWLEDGEMENTS	v
LIST OF FIGURES	viii
LIST OF TABLES	ix
LIST OF COMPUTER PROGRAMS	x
LIST OF TEST PROBLEMS	xi
LIST OF PROBLEM SOLUTIONS	xii
 CHAPTER	
1. INTRODUCTION	1
2. TRADITIONAL CALCULATION METHODS	6
3. COMPUTER METHODS	22
4. PROGRAM DEVELOPMENT	26
5. PROGRAM PROCEDURE	45
6. DISCUSSION OF RESULTS AND CONCLUSIONS	58
7. RECOMMENDATIONS	66
 APPENDIX	
I. NEWTON-RAPHSON ITERATION SUBROUTINES -	
COMPONENT ORIENTED	68
II. COMPLETE NEWTON-RAPHSON PROGRAM -	
COMPONENT ORIENTED	83

	<u>Page</u>
III. COMPLETE NEWTON-RAPHSON PROGRAM -	
STAGE ORIENTED	138
IV. PROBLEM STATEMENTS AND DATA	183
V. SOLUTIONS	197
REFERENCES	276

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1-1. Flow Diagram for Absorption and Stripping ...	3
2-1. X-Y Diagram for Absorption	7
4-1. Representation of One Stage	31
4-2. Heat Balance on One Stage	33
4-3. Newton-Raphson System for a 3-Component, 4-Stage Tower	39
4-4. Newton-Raphson System for a 3-Component, M-Stage Tower	40
4-5. Results of the Partial Triangularization of the Newton-Raphson Matrix	43
5-1. Computer Program Flowsheet	46

LIST OF TABLES

<u>Table</u>	<u>Page</u>
2-1. Location of Effective Absorption Factor	18

LIST OF COMPUTER PROGRAMS

	<u>Page</u>
Newton-Raphson Matrix Subroutines -	
Component Oriented	69
Complete Newton-Raphson Program -	
Component Oriented	83
Complete Newton-Raphson Program -	
Stage Oriented	138

LIST OF TEST PROBLEMS

	<u>Page</u>
Sample Input Data Form	184
Problem One - Simple Absorption	
Statement	186
Data	188
Problem Two - Intercooled Absorption	
Statement	189
Data	191
Problem Three - Steam Stripper	
Statement	192
Data	193
Problem Four - Simple Absorption	
Statement	194
Data	196

LIST OF PROBLEM SOLUTIONS

	<u>Page</u>
Problem One Solution	198
Problem Two Solution	228
Problem Three Solution	254
Problem Four Solution	264

CHAPTER 1

INTRODUCTION

Absorption and stripping are two similar processes which are used to recover the more volatile components from a gas or oil stream respectively. In absorption, the more volatile components are concentrated in the oil and leave the bottom of the column and in stripping they are concentrated in the gas and leave the top.

Basic Principles

Absorption and stripping are related processes because they both function due to a concentration difference between enriched and lean streams of liquid and vapor. The processes are aided by a multiplication of this difference by a countercurrent contact of these streams. At each stage, a transfer of material takes place such that each stream is in equilibrium with the other. This equilibrium is dependent on the temperature, pressure, enthalpy, and relative volatility of those components present. The process by which this transfer takes place is diffusion, although some vaporization and condensation takes place. Even though these are called "equilibrium" processes, they operate far from equilibrium conditions. This occurs since the temperature and relative volatility of the liquid phase is far below

those necessary for true equilibrium. In practice an equilibrium condition is somewhat reversible, while absorption and stripping are not due to the wide variation in temperature and composition of the streams involved.

The streams present are defined as follows:

Wet gas - feed to an absorber containing
condensables

Lean gas - stripping gas fed to a stripper,
sometimes an inert

Residue gas - off-gas leaving an absorber after
condensables have been removed

Rich gas - lean gas plus recovered components
leaving a stripper

Lean oil - stripped and denuded solvent going to
the top of an absorber and leaving a stripper

Rich oil - lean oil plus recovered components
leaving an absorber and being fed to a
stripper

The overall flow of material is illustrated in Figure 1-1.

Since the overall flow of material is in one direction, one encounters rapid phase rate changes across the column if an appreciable amount of material is being transferred. This rapid and massive transfer of material

also causes a rapid fluctuation of temperature from stage to stage. In extreme cases, a temperature inversion may result in the column, especially in strippers.

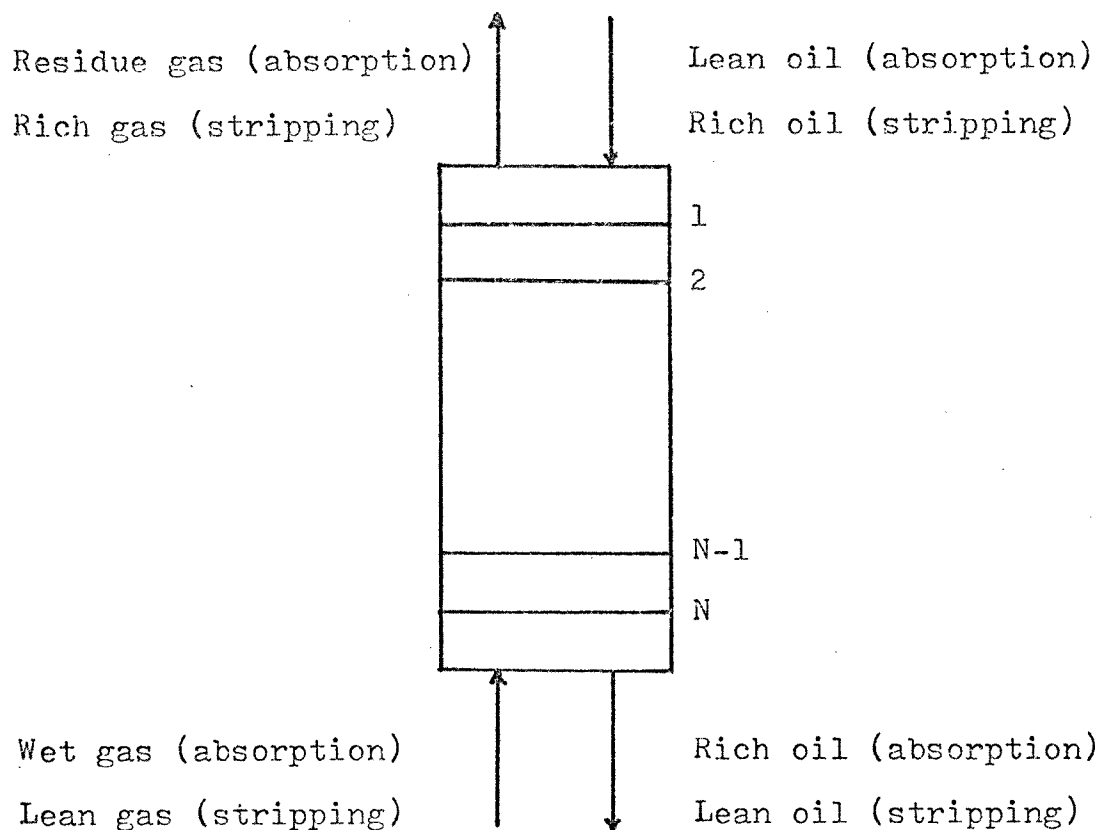


Figure 1-1. Flow Diagram for Absorption and Stripping

Referring to Figure 1-1, one can see that the flow of material is from the gas phase to the oil phase for absorption, while the reverse is true for stripping. During absorption, the wet gas rises through the column

while it loses material to the descending oil phase. Very little of the oil, being relatively nonvolatile, passes to the gas phase. The resulting effect is a decrease in the gas and an equal increase in the oil phase. During stripping, the volatile components present in the oil phase are transferred to the gas phase. In this case the oil phase decreases while the gas phase increases a like amount.

This unidirectional transfer of material is what causes the wide variation in temperature. The material being transferred undergoes a phase change as it diffuses into the opposite phase. When this occurs, the heats of vaporization or condensation plus heat of solution to a smaller extent are involved. In absorption, the heat release due to condensation of the gas as it enters the oil phase causes an increase in the sensible heat of the oil. Since only a small quantity of vaporization occurs, being insufficient to absorb all the heat, the temperature of the oil phase increases as it passes down the column. In some cases this temperature rise may be considerable. This rise in liquid temperature occurs even though the liquid is at its bubble point (in an equilibrium stage). A relatively large increase in the bubble point is caused by the vaporization of even a small amount of a light

component. The heat required to vaporize this small amount of material is small compared to the amount of sensible heat required to raise the temperature of the material. In stripping, the opposite is true. As the light components pass from the liquid to the gas phase, the heat of vaporization is supplied by the sensible heat of the liquid. This, then is the cause of the liquid decreasing in temperature as it travels down the column. (1)

Use of Absorbers and Strippers

These two operations, in practice, normally complement each other. Absorption is used for gas purification and component recovery. When used for component recovery, a stripper usually follows so as to recover the valuable components from the rich oil. Today, this type of equipment may be used to recover propane and ethane. In some instances as many as four absorber-stripper units may be operated in series each recovering a separate dry gas. (2)

(1) Buford D. Smith, Design of Equilibrium Stage Processes, McGraw-Hill Book Company, Inc., New York: 1963, pp. 258-259.

(2) Wayne C. Edmister, Hydrocarbon Absorption and Fractionation Process Design Methods, The Petroleum Engineer, Texas, p. 123.

CHAPTER 2

TRADITIONAL CALCULATION METHODS

Calculation procedures for absorption and stripping used prior to the use of computers were primarily of the short-cut type. Use of short-cut methods enabled process designers to design a piece of equipment in much less time than use of a rigorous method would. In using these methods, a designer must use considerable judgment during the calculation to obtain a meaningful prediction of performance.

Sherwood Graphical Method

This procedure was first presented by W. K. Lewis (Trans. AIChE 1927). However, it is known as Sherwood's method because of the wide usage it acquired after presentation in Sherwood's "Absorption and Extraction" text by McGraw-Hill.

This method is based on the concept of theoretical plates but involves a graphical solution for the "key" component. The key component is one whose absorption or stripping factor is close to unity. The Sherwood graphical method of solving absorption and stripping problems illustrates the diffusional driving force

graphically in a way that makes the concept very clear.⁽³⁾

For this method, the following are defined:

X - Mols Solute/Mol Lean Oil

Y - Mols Solute/Mol Inlet Gas

Since these quantities are defined in this manner, the equilibrium lines are determined by the temperature and pressure conditions and by the amounts absorbed. These lines are curves with the amount of curvature dependent on the quantity absorbed or stripped. Only for the special case of a lean gas with a low oil/gas ratio are they straight. The equilibrium line is plotted based on the slope of the origin and at least one additional point. This is shown plotted in Figure 2-1.

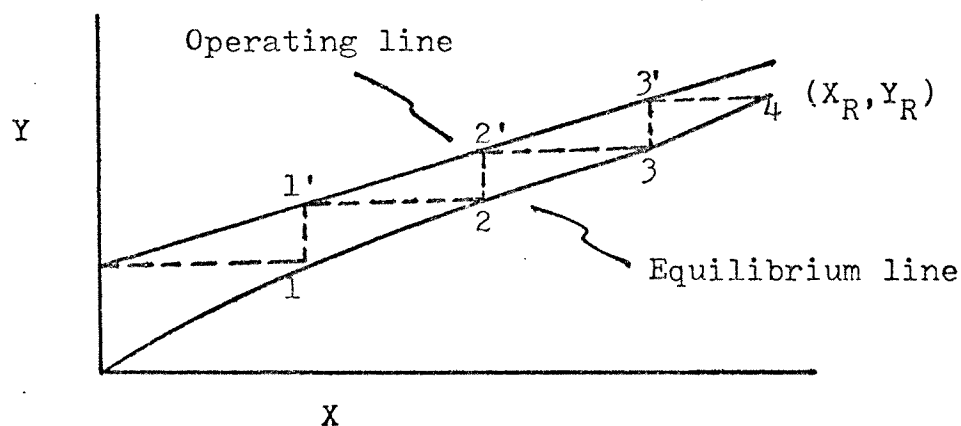


Figure 2-1. XY Diagram for Absorption

⁽³⁾Edmister, *ibid.*, p. 38.

The "equilibrium" line represents the relationship between the liquid and vapor leaving the same plate. The "operating" line represents the relationship between the gas leaving a plate and the liquid going to the same plate which are in fact passing streams. The operating line plots as shown in Figure 2-1 for the key component with each stage being a theoretical or equilibrium stage.

The equation for the equilibrium line for absorption can be developed in the following manner. Defining y_i as:

$$(y_a)_i = \left[\frac{V_a}{V_a + V_b + V_c + \dots} \right]_i \quad (2-1)$$

Dividing by $V_{n+1} + 1$ gives:

$$(y_a)_i = \left[\frac{\frac{V_a}{V_{n+1}}}{\frac{V_a}{V_{n+1}} + \frac{V_b}{V_{n+1}} + \dots} \right]_i \quad (2-2)$$

then:

$$(y_a)_i = \frac{Y_i}{\sum Y_i} \quad (2-3)$$

An expression for x_i can be similarly derived:

$$(x_a)_i = \left[\frac{l_a}{k_0 + l_a + l_b + \dots} \right] \quad (2-4)$$

Dividing by L_0 gives:

$$(x_a)_i = \left[\frac{\frac{l_a}{k_0}}{1 + \frac{l_a}{k_0} + \frac{l_b}{k_0} + \dots} \right] \quad (2-5)$$

than:

$$(x_a)_i = \frac{x_i}{1 + \sum x_i} \quad (2-6)$$

Combining equations 2-3 and 2-6 yields:

$$\frac{Y}{X} = K \frac{\sum Y}{(1 + \sum X)} \quad (2-7)$$

where:

$\sum Y$ - sum of Y values for vapor phase components

$\sum X$ - sum of X values for liquid phase components

K - slope of equilibrium line

A similar procedure can be followed for the stripping equilibrium line.

The operating line for absorbers is simply a straight line having the slope L_0/V_{n-1} , i.e. mols of lean oil entering divided by mols of wet gas entering. On the XY plot the distance between the two lines represents the driving force for the transfer.

As part of this procedure, analytical calculations are needed to approximate the amount of material absorbed and to locate the equilibrium lines for the graphical calculations to check the analytical approximation. The Kremser-Brown relation may be used in these calculations. For absorption:

$$E_a = \frac{Y_R - Y_L}{Y_R - Y_0} = \frac{A^{n+1} - A}{A^{n+1} - 1} \quad (2-8)$$

and for stripping:

$$E_s = \frac{X_R - X_L}{X_R - X_0} = \frac{S^{m+1} - S}{S^{m+1} - 1} \quad (2-9)$$

where:

A = average absorption factor

S = average stripping factor

The left sides of equations 2-8 and 2-9 may be called the efficiency of absorption or stripping, since they represent the ratio of the amount actually absorbed or stripped to that which would have been absorbed or stripped if the exit stream was in equilibrium with the entering stream. The average absorption factor can be estimated by using:

$$A = \left[\frac{L_0}{KV_{n+1}} (1 + \Sigma x) \right] \quad (2-10)$$

which is based on equation 2-7.

Combining equation 2-8 and 2-10 gives:

$$E_a = \frac{Y_R - Y_L}{Y_R - Y_0} = \frac{\left[\frac{L_0}{KV_{n+1}} (1 + \Sigma x) \right]^{n+1} - \left[\frac{L_0}{KV_{n+1}} (1 + \Sigma x) \right]}{\left[\frac{L_0}{KV_{n+1}} (1 + \Sigma x) \right]^{n+1} - 1} \quad (2-11)$$

where: L_0 = mols of lean oil

V_{n+1} = mols of wet gas

Y_0 = mols of component in vapor in equilibrium with the lean oil per mol of entering wet gas

K = equilibrium constant at average conditions

Σx = 0 at lean end

Σx = Σx_R at rich end

Similar equations may be developed for stripping.

The procedure to be used is as follows:

1. find equilibrium constants, K
2. compute L/KV for each component, A
3. estimate fraction absorbed using equation 2-11, neglecting $\bar{z}X$
4. compute $\bar{z}X$ from first estimate of absorption and then use equation 2-10
5. compute fraction absorbed from equation 2-11 using $\bar{z}X$
6. construct the equilibrium curve using equation 2-7 and the slope at the origin
7. construct the operating line and step off stages
8. compare intersection of operating line and Y axis with value obtained for amount absorbed for key component on step 5. If they do not compare repeat step 5 using an adjusted X .

This procedure is repeated until the result obtained for the amount of the key component absorbed is the same for both the analytical and graphical procedures. A similar procedure can be followed for strippers.

This procedure has several inherent difficulties when applied to certain systems. If the lean oil is not completely denuded, the graphical procedure becomes quite awkward. This is because of the presence of the solute in the solvent introduces another convergence region. Another problem is that for a multicomponent system the procedure becomes quite tedious. This is due to the necessity of plotting an X-Y diagram for each component to check the analytical equations. In a system where the phase rates change markedly at each stage, the plotting of a straight operating line may not be correct either. A wide variation in temperature also has an effect on the procedure.

Kremser-Brown Approximation

The above heading refers to a process calculation method developed by Souder and Brown from Kremser's theoretical analysis of the absorption process. The equations for this method are developed from the following:

$$\frac{Y_{n+1} - Y_1}{Y_{n+1}} = \left(\frac{A_1 A_2 \dots A_n + A_2 \dots A_n + \dots + A_n}{A_1 A_2 \dots A_n + A_2 \dots A_n + \dots + A_{n+1}} \right) \quad (2-12)$$

$$- \frac{L_0 X_0}{V_{n+1} Y_{n+1}} \left(\frac{A_2 \dots A_n + \dots + A_{n+1}}{A_1 A_2 \dots A_n + A_2 \dots A_n + \dots + A_{n+1}} \right)$$

and:

$$A_0 Y_0 = \frac{k_0 X_0}{V_{n+1}} \quad (2-13)$$

An average value for the absorption (or stripping) factor A (or S) is used. Also the expression for the sums of the resulting series is used. This series is as follows:

$$\frac{A^{n+1} - A}{A-1} = A^n + A^{n-1} + \dots + A^2 + A \quad (2-14)$$

$$\frac{A^{n+1} - 1}{A-1} = A^n + A^{n-1} + \dots + A^2 + A + 1 \quad (2-15)$$

and is a simple power series convergent as long as $A < 1$. These are combined into what are known as the Kresmer-Brown relations. These are for absorption:

$$E_A = \frac{Y_{n+1} - Y_1}{Y_{n+1} - Y_0} = \frac{A^{n+1} - A}{A^{n+1} - 1} \quad (2-16)$$

and for stripping:

$$E_S = \frac{X_{m+1} - X_1}{X_{m+1} - X_0} = \frac{S^{m+1} - S}{S^{m+1} - 1} \quad (2-17)$$

These equations are used by neglecting Y_0 and X_0 since these are usually near zero. An average value for the absorption or stripping factor is used which is computed from the entering wet gas and lean oil streams at an average temperature estimated from the temperatures of the wet gas and lean oil.

Two drawbacks of this system are that the absorption effect of the absorbed components are neglected, and the heat of absorption is also neglected. For absorbers with very rich gas feeds and wide variations in temperature and phase rates, these assumptions may lead to relatively large errors.

Series Application of Absorption/Stripping Factors

The Series Application method revolves around equation 2-12 for absorption and equation 2-18

$$\frac{X_{m+1} - X_1}{X_{m+1}} = \left(\frac{S_1 S_2 \dots S_m + S_2 \dots S_m + \dots + S_m}{S_1 S_2 \dots S_m + S_2 \dots S_m + \dots + S_m + 1} \right) \quad (2-18)$$

$$= \frac{V_0 Y_0}{L_{m+1} X_{m+1}} \left(\frac{S_2 \dots S_m + \dots S_m + \dots + S_m + 1}{S_1 S_2 \dots S_m + S_2 \dots S_m + \dots + S_m + 1} \right)$$

for stripping. This method involves the use of separate absorption (or stripping) factor for each component on each stage of the column. These factors are then substituted in the general equations.

A rough estimate is made of the amounts of each component absorbed which is then used to calculate the rich oil temperature. A distribution of knockout, the amount absorbed, and temperature on each plate is then calculated using:

$$\left(\frac{V_i}{V_{n+1}} \right)^{1/n} = \frac{V_i}{V_{i+1}} \quad (2-19)$$

and:

$$\frac{V_{n+1} - V_{i+1}}{V_{n+1} - V_i} = \frac{T_n - T_i}{T_n - T_o} \quad (2-20)$$

These equations assume constant percent absorption through the column and temperature proportional to the contraction. Once the vapor, overflow rates, and temperature are computed from the above; the L/V ratio can be computed. Then the values of $K(=y/x)$ can be obtained for every component on every plate and subsequently the absorption factor, $A(=L/VK)$, can be

calculated. These values are then substituted into equation 2-12 which gives us the absorption efficiencies from which the residue gas composition and total mols absorbed can be calculated. A similar procedure is followed for strippers.

The primary drawback to this procedure is the tediousness of the calculation for complicated absorbers or strippers. Again large changes in phase rate and temperature would make this procedure difficult. If absorption is high, the initial assumed value of total mols absorbed may be quite different from actual. This would require several passes through the procedure to obtain the correct results.

Horton-Franklin Method

The Horton-Franklin method is also based on effective absorption factors for each component in the mixture (equation 2-8 and 2-9). These factors are evaluated at different plates for each component. Horton and Franklin proposed the following table for locating the effective absorptions (or stripping) factor in a tower and their short cut method:⁽⁴⁾

⁽⁴⁾ Edmister, *ibid.*, p. 34.

Table 2-1

Location of Effective Absorption Factor

Value of A (or S)	Ratio (i/n)*
0-0.1	1.0
0.1-0.4	0.9
0.4-1.0	0.8
1.0-4.0	0.7
Above 4.0	0.6

* "i" plate numbering from top to bottom
for absorbers, and bottom to top
for strippers.

In this method the amount of material absorbed is approximated and then the rich oil temperature is calculated by heat balance. Then from K_{-P}/π (assuming ideal liquid and vapor phases) on each stage and the L/V ratio the absorption factor is calculated. This is then used to determine the location (i) of the effective absorption factor from Table 2-1. Once this is done, the following equations:

$$V_i = V_1 \frac{n+1-i}{n} \quad (2-21)$$

$$\frac{T_n - T_i}{T_n - T_o} = \frac{V_{n+1} - V_{i+1}}{V_{n+1} - V_1} \quad (2-22)$$

and:

$$L_i = V_{i+1} + L_0 - V_i \quad (2-23)$$

along with $K=P/\pi$ (P = vapor pressure, π = total pressure) are used to calculate $L/V, T$, and A at the effective points. Using equation 2-8 the absorption recovery efficiencies are calculated with:

$$Y_0 = K_0 X_0 \frac{V}{V_{n+1}} \quad (2-24)$$

The mols absorbed are calculated and then compared with the initial assumption at which point the calculation is ended or repeated. A similar procedure may be followed for strippers.

In this method it is assumed that the per cent absorption is constant on each stage and that the temperature change is proportional to the contraction. As in the other methods no allowance can be made for wide variations in phase rates and temperatures. The procedure also becomes tedious for a many component system. Sidestreams would also be difficult to handle.

Edmister Method

This method also makes use of effective absorption and stripping factors; however, the approach differs from that of Horton and Franklin. Edmister uses average values

instead of plate or stage values. The development of the equations and necessary charts will not be dealt with here. The reader is referred to Edmister's work reprinted from the Petroleum Refiner. However, the calculation procedure is presented here for the sake of completeness.

The procedure begins by making an approximation of the quantity of material being absorbed and by performing a component material balance to determine the lean gas and rich oil rates. Using the results from the above calculations and the temperature of the feeds, an enthalpy balance is used to determine the rich oil temperature.

Using:

$$\left(\frac{V_i}{V_{n+1}} \right)^{1/n} = \frac{V_i}{V_i + 1} \quad (2-25)$$

and the material balance equation, the liquid leaving the top plate and the vapor leaving the bottom are estimated. Using equation 2-22, the top and bottom plate temperatures are estimated. The absorption factor for the wet gas component on the top and bottom plate is then calculated. If the lean oil contains large amounts of light components, the stripping factor must be used.

Using the charts or:

$$A_e = \sqrt{A_n(A_{n+1}) + .25} - .5 \quad (2-26)$$

and:

$$A' = \frac{A_n(A_{n+1})}{A_n + 1} \quad (2-27)$$

determine the effective absorption factors. These are substituted into:

$$E_a = \frac{Y_{n+1} - Y_1}{Y_{n+1}} = \left[1 - \frac{L_0 x_0}{A' V_{n+1} Y_{n+1}} \right] \quad (2-28)$$

$$* \left[\frac{A_e^{n+1} - A_e}{A_e^{n+1} - 1} \right]$$

to determine the absorption efficiency, E_a . The calculation is completed by using a material balance to compute the lean gas and rich oil compositions and quantities. These are then compared with the initial assumptions.

The major drawback to this method is that it becomes a tedious calculation for most applications. Also, sidestreams become unwieldy. As in all other cases, a column with large material flows and temperature variations could be difficult to evaluate with this procedure.

Chapter 3

COMPUTER METHODS

This chapter is primarily intended to give the reader a synopsis of calculation methods that have been programmed for computer use. A brief description of the methods used will be given along with the more important equations. No attempt will be made to prove or substantiate the procedures. An article by Burningham and Otto (Which Computer Design for Absorbers?) has compared several methods for absorbers. The basis for these calculations are the following equations:

$$L_{n-1}x_{n-1} + V_{n+1}y_{n+1} + F_n z_{i,n} - (V_n + SV_n)y_{i,n} - (L_n + SL_n)x_{i,n} = 0 \quad (3-1)$$

$$y_{i,n} = k_{i,n}x_{i,n} \quad (3-2)$$

$$E_n = -Q_n - FH_{F,n} - L_{n-1}h_{n-1} + (L_n + SL_n)h_n + (V_n + SV_n)H_n - V_{n+1}H_{n+1} = 0 \quad (3-3)$$

$$\sum x_{i,n} = 1 \quad \sum y_{i,n} = 1 \quad (3-4)$$

$$L_{n-1} + V_{n+1} + F_n - (V_n + SV_n) - (L_n + SL_n) = 0 \quad (3-5)$$

These equations, which are the material, energy, equilibrium, and sum relationships; around an equilibrium stage n , are manipulated so as to be applicable for different procedures.

Bubble Point Method

The bubble point method is started by making initial assumptions for temperature and liquid and vapor rates. The iteration procedure is as follows:

1. combine equations (3-1) and (3-2) and then solve for phase compositions
2. use bubble point calculations to correct stage temperatures
3. use the energy balance to correct the liquid and vapor flows
4. check for convergence and repeat calculation

The use of the bubble point to correct temperatures is preferred since the use of dew points leads to a very slow rate of convergence. This is due to the fact that the rate of change of K with temperature for a heavy oil is very large while the change of K for a relatively light component is almost zero. Bubble point usage tends to overcorrect, but this can be dampened easier than it is to speed up a slow convergence.⁽⁵⁾

(5) C. D. Holland, Multicomponent Distillation, Prentice-Hall, Inc., Englewood Cliffs, 1963, pp. 211-212.

This method has been programmed using the Thiele-Geddes method with theta convergence and the Tri-diagonal Matrix of Amundson-Pontinen using both material and energy balance equations. The Thiele-Geddes method is described in Holland and will not be dealt with here. The Tri-diagonal Matrix procedure will be discussed briefly in the next chapter.

Sum-Rates

This method is also initiated by making initial assumptions of temperature and vapor and liquid flow rates. The procedure is continued as follows:

1. use material balance and equilibrium ratio to solve for compositions
2. estimate new liquid and vapor flows using unnormalized compositions
3. correct temperature such that the energy balance is satisfied.
4. check for convergence and then repeat calculation if necessary

This method was tested using the Thiele-Geddes and Tri-Diagonal methods by Burmingham and Otto. Their conclusions were that the Sum-Rates Tri-Diagonal Matrix method was the fastest of the four methods tested.

Other Approaches

Several other approaches to the solution of absorbers and strippers calculations have been developed. One developed by C. R. McNeese, in his article "Gas Absorber Solution by Digital Computer", uses trial-and-error calculations of the heat and material balance equations. In his material balance equation he makes use of the traditional absorption factor ($A = L/KV$). The concept of specific heat is used in the heat balance equations. The reader is referred to the original article for a discussion of the entire method.

CHAPTER 4
PROGRAM DEVELOPMENT

In this section the Wang-Henke method, as programmed by Dr. E. C. Roche, Jr. for distillation, will be described briefly. This program was modified so as to be usable for absorbers and strippers. This was done so as to obtain a solution to a problem. This solution was then used as data during the development of the program for the Newton-Raphson technique. It was also used to compare the two methods. The Newton-Raphson method is described fully including the derivation of the specific equations used.

Wang-Henke Method

The Wang-Henke Method uses the tri-diagonal matrix method for the solution of the linearized material balance equations and uses Muller's method for temperature convergence via a bubble point calculation. The original method developed for a distillation column assumed the column had n equilibrium stages, a condenser, and a reboiler. The stages were numbered from top to bottom with the condenser as the first stage and reboiler as the last. For absorption, it was considered to have n equilibrium stages and a reboiler. The method solves the so-called MESH equations:

Material balance:

(4-1)

$$M_j(x_j, V_j, T_j) = L_{j-1} x_{j-1} - (V_j + W_j) x_j \\ - (L_j + U_j) x_j + V_{j+1} y_{j+1} + F_j z_j = 0$$

Equilibrium equation:

(4-2)

$$E_j(x_j, V_j, T_j) = y_j - K_{ij} x_j = 0$$

Sum equation:

(4-3)

$$S_j(x_j, V_j, T_j) = \sum_{i=1}^m x_{ij} - 1.0 = 0$$

Heat equation:

(4-4)

$$H_j(x_j, V_j, T_j) = L_{j-1} h_{j-1} - (V_j + W_j) H_j \\ - (L_j + U_j) h_j + V_{j+1} H_{j+1} + F_j H_{Fj} - Q_j = 0$$

The material balance and equilibrium equations are combined into the following:

$$L_j = V_{j+1} + \sum_{k=2}^j (F_k - W_k - U_k) - D \\ 2 \leq j \leq n-1 \quad (4-5)$$

where:

$$D = V_1 + u_1 \quad (4-6)$$

for distillation.

For absorption, the constraint $2 \leq j \leq n-1$ is replaced with $1 \leq j \leq n-1$ since no condenser is present.

Equation (4-5) then becomes:

$$L_j = V_{j+1} + \sum_{k=1}^j (F_k - W_k - u_k) - V_1 \quad (4-7)$$

where V_1 is the lean gas leaving the column overhead.

This equation is then reduced to the tridiagonal form:

$$B_1 x_{i1} + C_1 x_{i2} = D_1 \quad (4-8)$$

$$A_j x_{ij} + B_j x_{i,j+1} + C_j x_{i,j+2} = D_j \quad (4-9)$$

$$A_n x_{in} + B_n x_{i,n+1} = D_n \quad (4-10)$$

for distillation.

Since an absorber or stripper calculation differs slightly from that of a distillation column, i.e. no condenser load, the tridiagonal procedure was modified. Sections of the program containing references to a condenser load were deleted. The Wang-Henke method is used to calculate an initial column profile of stage compositions, temperatures, and vapor and liquid flow rates. Since the procedure is somewhat simpler than that

for a distillation column, the bubble point calculation needed and the Wang-Henke method are simpler. These sections have been modified accordingly.

Newton-Raphson Technique

The Newton-Raphson Technique is a matrix method which involves the elimination of matrices within the framework of a much larger matrix. This method is applicable to the problem of general, reliable, and flexible computer codes for the solution of chemical engineering design problems.⁽⁶⁾ The primary objective of Goldstein and Stanfield was to develop a system that was general, reliable, and flexible. Their method was developed using the most general form of the heat and material balance equations. This procedure could be as easily programed for superfractionators as it was for absorbers and strippers.

A column consisting of i stages and separating j components can, at steady state, be fully described by j component material balances, an enthalpy balance, a mole fraction definition, and an overall material balance on every stage. These equations (defining out-in = 0) are:

(6) Goldstein and Stanfield, Industrial Engineering Chemistry Process Design and Development, Vol. 9, No. 1, Jan. 1970, p. 78.

Component Material Balance

$$\begin{aligned}
 & -L_{i-1} x_{j,i-1} + (L_i + SSL_i) x_{j,i} + (V_i + SSV_i) K_{j,i} x_{j,i} \\
 & - V_{i+1} K_{j,i+1} x_{j,i+1} = F_j z_{j,i}
 \end{aligned} \tag{4-11}$$

Enthalpy Balance

$$\begin{aligned}
 & -\sum L_{i-1} h_{j,i-1} x_{j,i-1} + \sum (L_i + SSL_i) h_{j,i} x_{j,i} \\
 & + \sum (V_i + SSV_i) H_{j,i} K_{j,i} x_{j,i} \\
 & - \sum V_{i+1} H_{j,i+1} K_{j,i+1} x_{j,i+1} = Q_i
 \end{aligned} \tag{4-12}$$

Liquid Mole Fraction Definition

$$\sum x_{j,i} = 1 \tag{4-13}$$

Overall Material Balance

$$-L_{i-1} + L_i + SSL_i + V_i + SSV_i - V_{i+1} = F_i \tag{4-14}$$

The Component Material Balance equation will be developed fully for component j on stage i . A representation of one tower stage is shown in Figure 4-1. The component material balance, equation (4-11) is completely differentiated:

$$\begin{aligned}
 & -L_{i-1}^{\circ} x_{j,i-1}^{\circ} - L_{i-1}^{\circ} \Delta x_{j,i-1} - x_{j,i-1}^{\circ} \Delta L_{i-1} \\
 & + (L_i^{\circ} + SSL_i) x_{j,i}^{\circ} + (L_i^{\circ} + SSL_i) \Delta x_{j,i} \\
 & + x_{j,i}^{\circ} \Delta L_i + (V_i^{\circ} + SSV_i) K_{j,i}^{\circ} x_{j,i}^{\circ}
 \end{aligned} \tag{4-15}$$

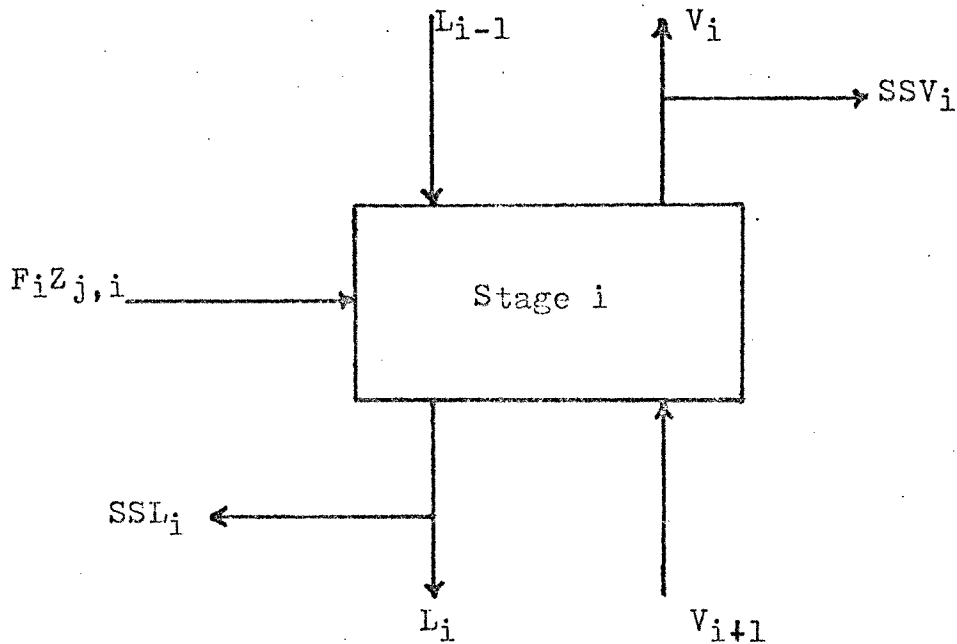


Figure 4-1. Representation of One Stage

$$\begin{aligned}
 & + (V_i^{\circ} + SSV_i) k_{j,i}^{\circ} \Delta x_{j,i} + k_{j,i}^{\circ} x_{j,i}^{\circ} \Delta V_i \\
 & + (V_i^{\circ} + SSV_i) x_{j,i}^{\circ} \frac{dk_{j,i}^{\circ}}{dT} \Delta T_i \\
 & - V_{i+1}^{\circ} k_{j,i+1}^{\circ} \Delta x_{j,i+1} - V_{i+1}^{\circ} k_{j,i+1}^{\circ} x_{j,i+1}^{\circ} \\
 & - k_{j,i+1}^{\circ} x_{j,i+1}^{\circ} \Delta V_{i+1} \\
 & - V_{i+1}^{\circ} x_{j,i+1}^{\circ} \frac{dk_{j,i+1}^{\circ}}{dT} \Delta T_{i+1} = F_i z_{j,i}
 \end{aligned}$$

(4-15)
Cont'd

The following are defined:

$$x_{j,i-1} \equiv x_{j,i-1}^{\circ} + \Delta x_{j,i-1} \quad (4-16)$$

$$x_{j,i} \equiv x_{j,i}^{\circ} + \Delta x_{j,i} \quad (4-17)$$

$$x_{j,i+1} \equiv x_{j,i+1}^{\circ} + \Delta x_{j,i+1} \quad (4-18)$$

Substituting into equation 4-15 and combining like terms, we obtain:

$$\begin{aligned} & \left[-k_{i-1}^{\circ} \right] x_{j,i-1} + \left[(k_i + SSk_i) + (V_i^{\circ} + SSV_i) k_{j,i}^{\circ} \right] x_{j,i} \\ & + \left[-V_{i+1}^{\circ}, k_{j,i+1}^{\circ} \right] x_{j,i+1} + \left[(V_i + SSV_i) x_{j,i}^{\circ} \frac{dk_{j,i}}{dT} \right] \Delta T_i \\ & + \left[-V_{i+1}^{\circ}, x_{j,i+1}^{\circ} \frac{dk_{j,i+1}}{dT} \right] \Delta T_{i+1} + \left[k_{j,i}^{\circ} x_{j,i}^{\circ} \right] \Delta V_i \quad (4-19) \\ & + \left[-k_{j,i+1}^{\circ}, x_{j,i+1}^{\circ} \right] \Delta V_{i+1} + \left[-x_{j,i-1}^{\circ} \right] \Delta k_{i-1} \\ & + \left[x_{j,i}^{\circ} \right] \Delta k_i = F_i z_{j,i} \end{aligned}$$

Referring to Figure 4-2 and equation 4-12 one can see that a similar approach can be taken for the heat balance equation. Completely differentiating equation 4-12 we obtain:

$$-\sum k_{i-1}^{\circ}, h_{j,i-1}^{\circ}, x_{j,i-1}^{\circ} - \sum k_{i-1}^{\circ}, h_{j,i-1}^{\circ}, \Delta x_{j,i-1} \quad (4-20)$$

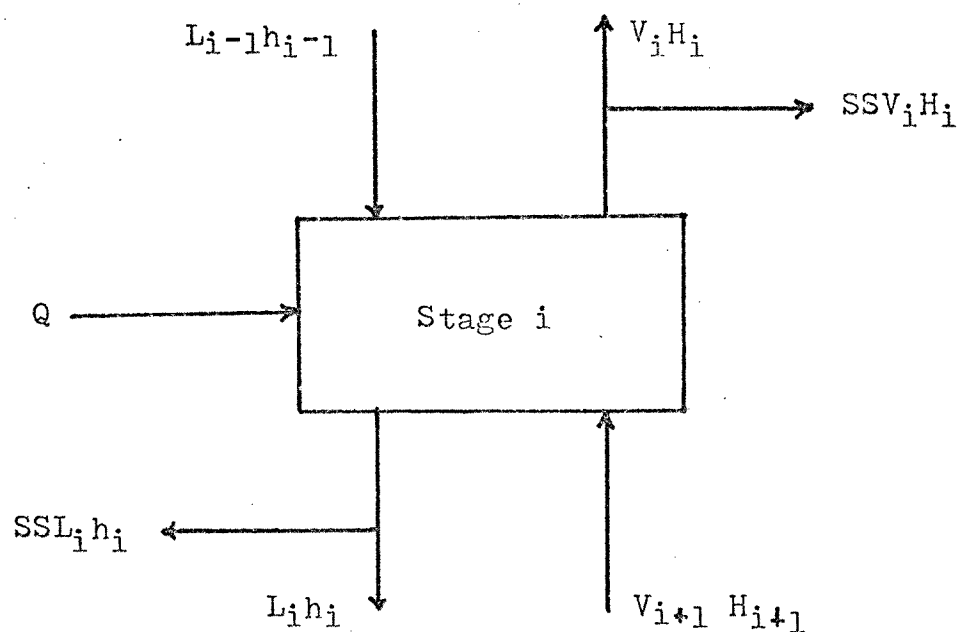


Figure 4-2. Heat Balance on One Stage

$$\begin{aligned}
 & - \sum \Delta h_{i-1} h_{j,i-1}^{\circ} x_{j,i-1}^{\circ} + \sum (L_i^{\circ} + SSL_i) h_{j,i}^{\circ} x_{j,i}^{\circ} \\
 & + \sum (L_i^{\circ} + SSL_i) h_{j,i}^{\circ} \Delta x_{j,i} + \sum \Delta h_i h_{j,i}^{\circ} x_{j,i}^{\circ} \\
 & + \sum (L_i^{\circ} + SSL_i) x_{j,i}^{\circ} \frac{dh_{j,i}^{\circ}}{dT} \Delta T_i \\
 & - \sum L_{i-1}^{\circ} x_{j,i-1}^{\circ} \frac{dh_{j,i-1}^{\circ}}{dT} \Delta T_{i-1} \\
 & + \sum (V_i^{\circ} + SSV_i) H_{j,i}^{\circ} k_{j,i}^{\circ} x_{j,i}^{\circ} \\
 & + \sum H_{j,i}^{\circ} k_{j,i}^{\circ} x_{j,i}^{\circ} \Delta V_i + \sum (V_i^{\circ} + SSV_i) H_{j,i}^{\circ} k_{j,i}^{\circ} \Delta x_{j,i}
 \end{aligned}$$

(4-20)
Cont'd

$$\begin{aligned}
& + \sum (V_i^{\circ} + SSV_i) K_{j,i}^{\circ} x_{j,i}^{\circ} \frac{dH_{j,i}^{\circ}}{dT} \Delta T_i \\
& + \sum (V_i^{\circ} + SSV_i) x_{j,i}^{\circ} H_{j,i}^{\circ} \frac{dk_{j,i}}{dT} \Delta T_i \\
& - \sum V_{i+1}^{\circ}, H_{j,i+1}^{\circ}, K_{j,i+1}^{\circ}, x_{j,i+1}^{\circ}, - \sum H_{j,i}^{\circ} K_{j,i+1}^{\circ} x_{j,i+1}^{\circ} \Delta V_{i+1} \\
& - \sum V_{i+1}^{\circ}, K_{j,i+1}^{\circ}, x_{j,i+1}^{\circ} \frac{dH_{j,i+1}^{\circ}}{dT} \Delta T_{i+1} \\
& - \sum V_{i+1}^{\circ}, H_{j,i+1}^{\circ}, x_{j,i+1}^{\circ} \frac{dk_{j,i+1}}{dT} \Delta T_{i+1} \\
& - \sum V_{i+1}^{\circ}, H_{j,i+1}^{\circ}, K_{j,i+1}^{\circ} \Delta x_{j,i+1} = Q
\end{aligned}$$

(4-20)
Cont'd

Substituting equations 4-16, 4-17, and 4-18 into equation 4-20, and combining like terms, we obtain:

$$\begin{aligned}
& \left[- \sum L_{i-1}^{\circ}, h_{j,i-1}^{\circ} \right] x_{j,i-1} \\
& + \left[\sum (L_i^{\circ} + SSL_i) h_{j,i}^{\circ} + \sum (V_i^{\circ} + SSV_i) H_{j,i}^{\circ} K_{j,i}^{\circ} \right] x_{j,i}
\end{aligned}$$

(4-21)

$$\begin{aligned}
& + \left[-\sum V_{i+1}^{\circ} H_{j,i+1}^{\circ} K_{j,i+1}^{\circ} \right] x_{j,i+1}^{\circ} \\
& + \left[-\sum L_{i-1}^{\circ} \frac{dh_{j,i-1}}{dT} x_{j,i-1}^{\circ} \right] \Delta T_{i-1} \\
& + \left[\sum (L_i^{\circ} + SSL_i) \frac{dh_{j,i}}{dT} + \sum (V_i^{\circ} + SSL_i) \right. \\
& \quad \left. \left(K_{j,i}^{\circ} \frac{dh_{j,i}}{dT} + H_{j,i}^{\circ} \frac{dK_{j,i}}{dT} \right) \right] x_{j,i}^{\circ} \Delta T_i \\
& + \left[-\sum V_{i+1}^{\circ} x_{j,i+1}^{\circ} \left(K_{j,i+1}^{\circ} \frac{dH_{j,i+1}}{dT} \right. \right. \\
& \quad \left. \left. + H_{j,i+1}^{\circ} \frac{dK_{j,i+1}}{dT} \right) \right] \Delta T_{i+1} \\
& + \left[\sum H_{j,i}^{\circ} K_{j,i}^{\circ} x_{j,i}^{\circ} \right] \Delta V_i \\
& + \left[-\sum H_{j,i+1}^{\circ} K_{j,i+1}^{\circ} x_{j,i+1}^{\circ} \right] \Delta V_{i+1} \\
& + \left[-\sum h_{j,i-1}^{\circ} x_{j,i-1}^{\circ} \right] \Delta L_{i-1} \\
& + \left[\sum h_{j,i}^{\circ} x_{j,i}^{\circ} \right] \Delta L_i = Q
\end{aligned}$$

(4-21)
Cont'd

In order to make use of the equations developed above for the heat and material balance, coefficients must be assigned to the x , ΔL , ΔV , and ΔT terms.

Referring to equation (4-19), the component balance, the coefficients are assigned. The subscripts 1, 2, 3 refer to the position of the variable in the matrix which will become more readily apparent later. For the component material balance equation the coefficients are:

$$a_{j,1} = -L \quad (4-22)$$

$$a_{j,2} = L + SSL + (V + SSV)K \quad (4-23)$$

$$a_{j,3} = -VK \quad (4-24)$$

$$b_{j,1} = (V + SSV) \times \frac{dk}{dT} \quad (4-25)$$

$$b_{j,2} = -V \times \frac{dk}{dT} \quad (4-26)$$

$$c_{j,1} = kx \quad (4-27)$$

$$c_{j,2} = -kx \quad (4-28)$$

$$d_{j,1} = -x \quad (4-29)$$

$$d_{j,2} = x \quad (4-30)$$

The subscripts have been omitted for clarity.

After developing the heat balance equation, equation 4-21

the coefficients are assigned:

$$e_{j,1} = -Lh \quad (4-31)$$

$$e_{j,2} = (L+SSL)h + (V+SSV)KH \quad (4-32)$$

$$e_{j,3} = -VKH \quad (4-33)$$

$$f_1 = -\sum L \frac{dh}{dT} x \quad (4-34)$$

$$f_2 = \sum \left[(L+SSL) \frac{dh}{dT} + (V+SSV) \left(K \frac{dH}{dT} + H \frac{dK}{dT} \right) \right] x \quad (4-35)$$

$$f_3 = -\sum V \left(K \frac{dH}{dT} + H \frac{dK}{dT} \right) x \quad (4-36)$$

$$g_1 = \sum KH x \quad (4-37)$$

$$g_2 = -\sum KH x \quad (4-38)$$

$$h_1 = -\sum h x \quad (4-39)$$

$$h_2 = \sum h x \quad (4-40)$$

The one other equation needed is the overall material

balance:

$$K_i = L_i + SSL_i + V_i + SSV_i - L_{i-1} - V_{i+1} - F_i \quad (4-41)$$

The ordering of these terms is shown in Figure 4-3 for a three component, four stage tower. The upper portion of the matrix contains the component material balance (coefficients a, b, c, and d) and are numbered 1 through NC. The line containing e, f, g, and h contain the enthalpy balance equation and is identified as N1 (NC+1). Line number N2 (NC+2) contains the coefficients of the sum equation and line N3 (NC+3) contains the coefficients of the overall material balance equation. The subscripts of 1, 2, and 3 given the coefficients, which determine their position in the matrix, refer to stage i-1, i, and i+1, respectively. Figure 4-4 gives the generalized picture of the matrix for a 3 component, n stage tower.

In this procedure, for the size tower represented, the matrix has been partitioned into a 6x6 matrix of submatrices. This is done to take full advantage of the regular structure of the problem. The method of ordering the component balances by component is more efficient for a tower with many components and few trays. The overall matrix will expand to the left and towards the top as more components are added. As trays are added, the submatrices will increase in size. The large overall size of the matrix makes direct inversion somewhat impractical. This is

FIGURE 4-3
NEWTON-RAPHSON SYSTEM FOR
A 3-COMPONENT, 4 STAGE TOWER

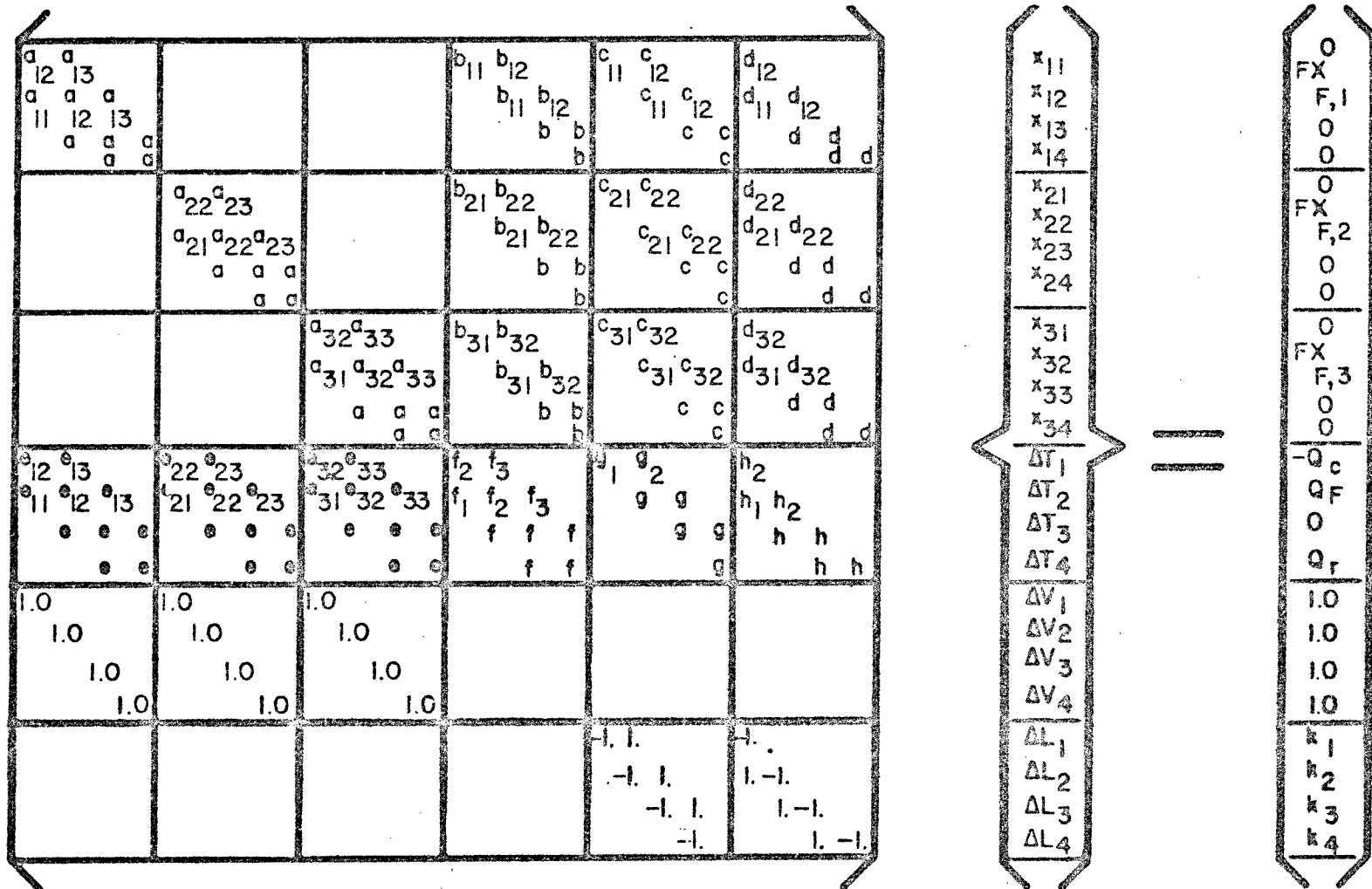
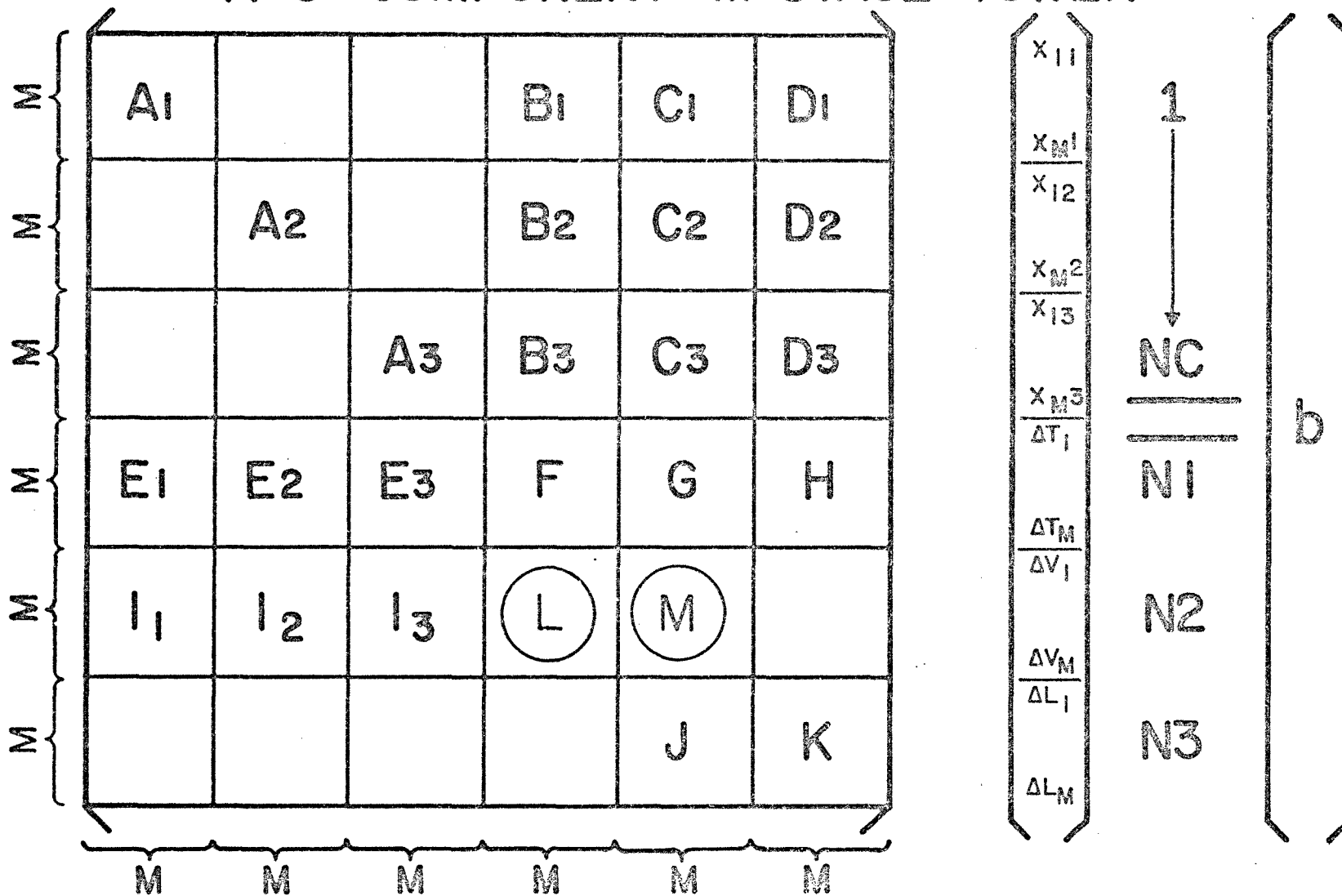


FIGURE 4-4
 NEWTON-RAPHSON SYSTEM FOR
 A 3-COMPONENT M STAGE TOWER



primarily due to time and storage limitations on most computers. Therefore, the inversion is done by performing a partial triangularization of the large matrix. This procedure produces a much smaller matrix which requires subsequent inversion.

The initialization and partial triangulation of the matrix proceeds as follows:

1. develop the overall stage material balance entries, J , K , and k ; (equation 4-41)
2. invert K and multiply the bottom row by it
3. generate submatrices C and D on a component basis and the corresponding right hand side (RHS) entries
4. multiply the bottom row by D and subtract the result from the top row on a component basis - the result being the elimination of D
5. generate F , G , and H entries
6. multiply the bottom row by H and subtract from row $N1$ - thus H is eliminated
7. generate A , B , E , and I on a component by component basis - I is not actually generated since it is the entry for the sum equation and equal to the identity matrix
8. invert A matrix and multiply the j component row by it

9. multiply the j component row by E and subtract the result from row N1-E is eliminated
10. multiply the j component row by I and subtract the result from row N2-I is eliminated

As each step above is completed, for all the components on all the stages, the calculation proceeds. The result is shown in Figure 4-5. The area outlined in bold lines is the only area which requires inversion to calculate the ΔT and ΔV values.

The inversion procedure that was finally used proceeds as follows:

1. invert F and multiply G and the RHS (-,N1) term by the inverse
2. multiply G and the N1 term by L and subtract from M and the RHS (-,N2) term, respectively
3. invert M and multiply the RHS (-,N2) term by the inverse
4. multiply G by the RHS (-,N2) term and subtract from the RHS (-,N1) term

Once the inversion is complete, the delta T terms are located in RHS (-,N1) and the delta V terms in RHS (-,N2).

FIGURE 4-5
RESULTS OF THE PARTIAL TRIANGULARIZATION
OF THE NEWTON-RAPHSON MATRIX

I			$A_1^{-1} B_1$	$A_1^{-1} [C_1$ $-D_1 K^{-1} J]$	0
	I		$A_2^{-1} B_2$	$A_2^{-1} [C_2$ $-D_2 K^{-1} J]$	0
		I	$A_3^{-1} B_3$	$A_3^{-1} [C_3$ $-D_3 K^{-1} J]$	0
0	0	0	$\sum_{i=1}^3 E_i A_i^{-1} B_i$	$\sum_{i=1}^3 \{ E_i A_i^{-1} [C_i$ $-D_i K^{-1} J] \}$ $-H K^{-1} J$	0
0	0	0	$-\sum_{i=1}^3 A_i^{-1} B_i$	$-\sum_{i=1}^3 \{ A_i^{-1} [C_i$ $-D_i K^{-1} J] \}$	
				$K^{-1} J$	I

I = identity matrix

$$\left. \begin{array}{c} \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \end{array} \right\} \Psi = \left. \begin{array}{c} \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \\ \text{---} \end{array} \right\} b'$$

The new x's and delta L's are now calculated by back substitution. The J term is multiplied by the delta V term and the result subtracted from RHS (-, N3) to obtain the delta L's. The B and C terms are multiplied component by component by the delta T and delta V terms, respectively. The result is subtracted from the old compositions to obtain the new compositions.

The above procedure represents one Newton-Raphson iteration. The computational procedure is continued until the convergence criteria are satisfied. The procedure represents a more generalized or hierarchical Gaussian elimination of matrices, rather than elimination of elements.⁽⁷⁾ The Fortran listing of this procedure is given in Appendix I.

(7) Goldstein and Stanfield, *ibid.*, p. 80.

CHAPTER 5

PROGRAM PROCEDURE

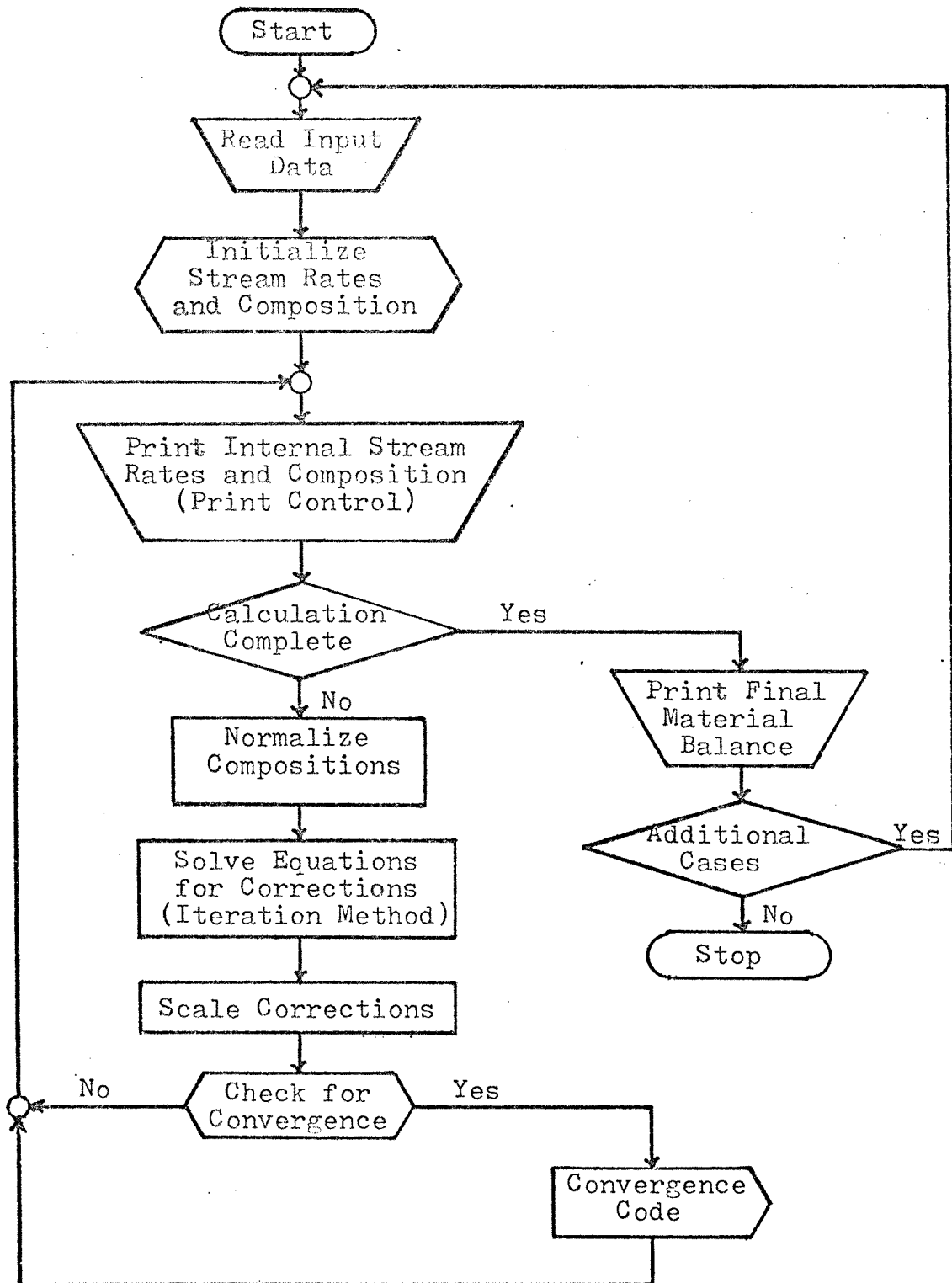
A necessary part of any iterative method is the input and output information plus any supporting subroutines. In this chapter a flowsheet for the program will be given along with a short description of the other subroutines used. The input information necessary will be described in detail with an example given.

Program Flowsheet

A computer program must follow a logical sequence of events during the calculation. In Figure 5-1, the flowsheet for the program is presented. Referring to the figure, the procedure is as follows:

1. initialize program
2. read input data and print
3. initialize stream rates
4. print initial rates and compositions
5. normalize compositions
6. solve iteration method
7. scale corrections
8. check for convergence
9. return
10. print stream rates and compositions
11. a. if converged, print final output

Figure 5-1. Computer Program Flowsheet



- b. if not converged, repeat 5-10
- 12. do next problem or stop

Each of the above functions is performed by one or more subroutines. These subroutines can be broken into major and minor groups. The major ones perform basic steps as detailed above and the minor ones fulfill supporting rules. All of the subroutines are listed in the appendix.

The following will be considered as major subroutines that are common to both iteration procedures:

- INPUT - reads necessary control data, initial temperatures, pressures, heat loads, and calculates initial profile by Amundson's method
- CDATA - reads component data, K-data, enthalpy data, and curve fits data
- FEED - reads feed data: rates, temperature, pressure, entering point of feed
- OUTPUT - prints final material balance

The minor subroutines are described:

- KGEN - uses K-data to calculate K as function of temperature
- HGEN - uses enthalpy data to calculate it as function of temperature

EQUA - evaluates polynomial coefficients, used
for data

FITIT - curve fits data by regression analysis

WAYA - converges on a single value

MWRITE - prints out tray summary during calculation

FLASH - performs flash calculation on column feeds

MINV - matrix inversion

ALNUM - develops integer equivalents of numbers

There are also subroutines which are needed separately for each method. The subroutines used for the stage oriented Newton-Raphson method are:

ABSR1 - main calling program

INR - stage oriented Newton-Raphson and
convergence check

ABCD - stage oriented Newton-Raphson

GET(I) - calculates K and enthalpy data plus
derivatives on a stage by stage basis

The subroutines for the Newton-Raphson component oriented method are as follows:

ABSR2 - main calling program

MATRIX - Newton-Raphson procedure and convergence
check

INI - Newton-Raphson procedure

ENTHAL - Newton-Raphson procedure

COMP - Newton-Raphson procedure
SUBST - Newton-Raphson procedure
ZERO - sets a matrix equal to zero
EQUAL - sets one matrix equal to another
MPLYM - matrix and vector multiplication
GET - calculates K and enthalpy data plus
derivatives for all stages

The subroutines which form the Newton-Raphson iteration procedure are given in Appendix I. In order to give the reader a cohesive picture of both programs, a listing of both in their entirety has been included. In Appendix II, is located the program using the Newton-Raphson component oriented procedure with Amundson's initialization procedure. Appendix III contains the Newton-Raphson stage oriented procedure with Amundson's initialization procedure. Either program may be used to obtain a problem solution.

Input Information

The following section describes the input requirements for both programs and the sequence of the data cards.

1. Title card, columns 1-80

Any information desired to describe the problem may be included on this card.

2. Control card

All data on this card must be punched within the specified space right justified.

- a. Columns 1-5 Number of contact stages.
excluding reboiler $1 \leq N \leq 20$
- b. Columns 6-10 Number of components $2 \leq C \leq 15$
- c. Columns 11-15 Number of feeds $2 \leq F \leq 6$
- d. Columns 16-20 Number of side stream and/or interstage heat exchanges $0 \leq SS/Q \leq 5$
- e. Column 21-25 Number of vapor-liquid equilibrium data points supplied as a function of temperature and pressure for each component $2 \leq K \leq 8$
Two (2) has been found to be best
- f. Column 26-30 Number of vapor-liquid enthalpy data points supplied as a function of temperature and pressure for each component $2 \leq H \leq 8$. Two (2) has been found to be best

- g. Columns 31-35 Number of iterations
 - h. Columns 36-40 Design variable - always
equal to 2
 - i. Columns 41-45 Print output code
 - 1 Input and Output
 - 2 1 + trial data
 - 3 2 + all data
 - 4 3 + error print out
 - j. Columns 46-50 Column type
 - 1 simple absorber
 - 2 sidestream and/or interstage heat
exchanger
 - 3 strippers
 - 4 reboiled absorbers
3. Design parameter card
- a. Columns 1-10 Reboiler heat load MM Btu/hr
 - b. Columns 11-20 Overhead vapor rate, mols/hr
4. Temperature card
- All temperatures must be entered with a decimal point and are in degrees F
- a. Columns 1-10 Column top tray temperature
 - b. Columns 11-20 Column bottom tray temperature
 - c. Columns 21-30, 31-40 If desired, a temperature at some midpoint in the column may be specified so as to allow for a two straight

line temperature estimation

Columns 21-30 tray number

Columns 31-40 temperature

5. Pressure card

Pressure is specified in psia and it is assumed pressure drop per stage is uniform. All data must be entered with a decimal point.

- a. Columns 1-10 Top tray pressure
- b. Columns 11-20 Pressure drop across the
column

6. Feed definition cards

For each feed stream there will be one complete set of cards. For absorbers and strippers the oil will be fed at the top tray (tray no. 1) and the gas at the bottom (tray no. N). If any other feeds enter the column, at a location other than top or bottom, they will be listed as entering on the higher numbered tray

a. Specific feed data

- 1 Columns 1-12 Feed name
- 2 Columns 19-20 Feed stage number, right
justified
- 3 Feed conditions

Columns 21-30 Pressure, psia

Columns 31-40 Temperature, °F

Columns 41-50 Heat content, MMBtu/hr

4 Columns 51-60 Feed preheat duty,
MMBtu/hr

+ heat added

- heat removed

b. Feed component data, mols/hr

Columns 1-10 Component 1

Columns 11-20 Component 2

etc. etc.

If more than 8 components are present,
additional cards should be used, maximum of
eight components per card

c. Feed equilibrium data

If the feed heat content is not given, the
battery limit liquid-vapor equilibrium data
must be supplied so that the necessary feed
flash can be performed so as to determine
the associated enthalpy. If the heat content
is specified, then this card must be
omitted

Columns 1-10 Component 1

Columns 11-20 Component 2

etc. etc.

7. Sidestream and/or interstage heat exchangers

If there are no sidestreams and/or interstage heat exchangers present, this data is to be omitted. The following data is supplied on one card for each sidestream and/or interstage heat exchanger.

- a. Columns 1-5 Tray number, right justified
- b. Columns 11-20 Vapor withdrawal, mols/hr
- c. Columns 21-30 Liquid withdrawal, mols/hr
- d. Columns 31-40 Heat exchanger duty, MMBtu/hr
 - + heat removed from stage
 - heat added to stage

8. Component data

The following data is supplied for each component, one card per component.

- a. Columns 1-8 Component name
- b. Columns 11-20 Molecular weight
- c. Columns 21-30 Density, lb/gal

9. Liquid-vapor equilibrium data

At least 2 data points must be supplied per component, the maximum being 8

- a. Temperature data (one card)

- Columns 1-10 Temperature #1, °F
Columns 11-20 Temperature #2, °F
 etc. etc.
- b. Pressure data (one card)
Columns 1-10 Pressure #1, psia
 etc. etc.
- c. Componential liquid-vapor equilibrium data
(one card per component)
Columns 1-10 K-data corresponding to
 Temperature #1 and Pressure #1
Columns 11-20 K-data corresponding to
 Temperature #2 and Pressure #2
 etc. etc.

The program will interpolate and extrapolate the data based on the K-data temperature relationship

$$\ln K \sim \frac{1}{T(^{\circ}R)}$$

If all of the K-data is specified at the same pressure then all the data will be pressure corrected assuming that

$$\text{Pressure} * K\text{-data} = \text{constant}$$

10. Liquid-vapor enthalpy data

At least 2 data points must be supplied per component, the maximum being 8

a. Temperature data (one card)

Column 1 Enthalpy units code

1 Btu/lb-mole

2 Btu/lb

Columns 2-10 Temperature #1, °F

Columns 11-20 Temperature #2, °F

etc. etc.

b. Pressure data (one card)

Columns 1-10 Pressure #1, psia

Columns 11-20 Pressure #2, psia

etc. etc.

c. Enthalpy data (two cards per component)

1 Vapor enthalpy data (one card)

Columns 1-10 Enthalpy data corresponding to Temperature #1 and Pressure #1

Columns 11-20 Enthalpy data corresponding to Temperature #2 and Pressure #2

etc. etc.

2 Liquid enthalpy data (one card)

Columns 1-10 Enthalpy data corresponding to Temperature #1 and Pressure #1

Columns 11-20 Enthalpy data corresponding to Temperature #2 and Pressure #2

etc.

etc.

The program will interpolate and extrapolate the data based on the following relationship

$$H \sim T$$

11. Problem Termination

At the end of each problem, a control card must be placed consisting of

Columns 1-4 \$\$\$\$

Located in Appendix IV is a sample Fortran input coding form. A listing of the data used for each problem is also located in this Appendix.

CHAPTER 6

DISCUSSION OF RESULTS AND CONCLUSIONS

The original intent was to make the necessary modifications to a distillation program using the stage oriented Newton-Raphson matrix procedure so as to obtain a solution to a simple absorber problem. Once the problem was solved, a comparison solution was available during the debugging of the Newton-Raphson matrix method that is component oriented.

The initial coding of the component oriented procedure involved a total inversion of that portion of the matrix shown in Figure 4-4 labeled FGLM, after an initial compaction. For a total inversion, a compaction is necessary in order to eliminate the zero terms remaining in each matrix if a column contains less than twenty (20) stages so as to obtain a valid inverse. The corresponding right hand side terms (N1 and N2) are also compacted to eliminate zeros. The resulting inverted matrix and vector, respectively, are then multiplied to yield the delta T and delta V terms for each stage for that iteration. Indicated delta values on the order of 10^4 - 10^7 were obtained from this procedure after several iterations.

Since it was obvious that an error was present, each portion of the procedure was individually checked. The solution from the stage oriented program was used for this purpose. In theory, if a calculation procedure is correct, then supplying the solution as input data should yield identical output. However, this did not occur with the component oriented procedure. In order to locate the errors in the procedure and to verify the coding, the material and enthalpy balance entries were set equal to zero so that no modifications to the input would result. Here, again, no solution was obtained. By varying the entries which were set equal to zero, we were able to determine that the equations were derived correctly and also were able to uncover errors in coding.

Once it was proven that the equations and coding were correct, the only other source of problems could have been the inversion procedure. At this point, it was decided to perform a partial, instead of total, inversion of FGLM without a compaction of the respective submatrices. The procedure is described in a previous chapter. The incorporation of a partial inversion into the system yielded output results very nearly identical to the solution answers used as input.

The solution to the first problem obtained from the component oriented method is included in the appendix. A total of seven iterations was required versus the six needed using the stage oriented method.

A second simple absorber problem, labeled number four in the appendix, was run using both procedures. Initially, this problem would not converge using either procedure. A check of various data sources revealed that, for the heavier components especially, there was a discrepancy in the k and enthalpy data. The initial source of data was the appendix contained in Design of Equilibrium Stage Processes by Buford Smith. Smith's original source of data was the Data Book on Hydrocarbons by J. B. Maxwell. The difficulty was that the data in Smith's book is only a partial representation of the original data. For many components, Smith indicates a dashed line for liquid enthalpies at temperatures past the critical point. For most materials an extrapolation of the saturation line tangent to it will yield more realistic results. Similar variations in k data, due to different methods of plotting, were also present but were not as extreme.

Since no data for the oil phase was included in the problem statement other than molecular weight and API gravity, it was assumed to have a very high enthalpy and

very low volatility. After using information obtained from Maxwell which correlate the molecular weight and API gravity with the mean average boiling point to yield the enthalpy, it was found that the above assumptions were not necessarily valid and caused large errors in calculation. The first set of data used also caused problems with the feed flash calculation in that it would not converge. Once a correct and consistent set of data was used, this error disappeared.

The conclusions to be drawn from this problem are that if the column conditions, temperature and pressure, fall near or just beyond the critical point on the enthalpy graph, it is best to assume a tangential extrapolation of the saturation line instead of using the dashed line as is normally presented. If problems with feed flash do arise, this is a good indication of an error in feed heat content and in the liquid enthalpy data.

Both procedures should be able to handle a column with side streams and/or heat trays. In order to verify this, an absorber with an intercooler on two stages was tested, problem number two in the appendix. Initially this calculation would not converge using either method. It was felt that the initialization procedure used gave a poor initial column profile for this type of problem. A

linear interpolation of the input conditions across the column was made using the following assumptions:

1. liquid compositions on stage 1 equal to feed composition to stage 1
2. liquid compositions on stage NT equal to composition on stage 1 plus a varying percentage of the vapor feed to stage NT from light to heavy components
3. liquid flow leaving the column 30% higher than entering
4. a linear change in compositions and flows from top to bottom

This procedure was coded and was made a part of the component oriented procedure. By using a "logical if statement", the program would bypass the original profile calculation and use the above. This procedure did not work and was subsequently abandoned; however, the coding is still present in the program but does not form part of the calculation.

At this point Dr. Roche requested Mr. E. Wells of the Foster-Wheeler Corporation to run the problem using their program from which a converged solution was obtained. The enthalpy and k data used with the programs at Foster-Wheeler were compared with that used with these programs given here.

The comparison revealed problems with both the enthalpy data and the k data. The discrepancy in the enthalpy data was due to the same problem as discussed for the previous example. The k data used with the Newton-Raphson procedure was observed to contain a discontinuity which caused large errors in compositions. The composition errors were caused since the derivatives of the k data, due to temperature conditions in the column, were being taken at a point with a very large derivative with respect to temperature. The large derivative was due to a difference in the pressures used to evaluate the data. Once the correct data set was used, both the stage and component oriented methods converged to a solution.

With respect to k data, one can draw the conclusion that it is imperative that a consistent set of vapor-liquid equilibrium data be used, representative of the actual column operating conditions.

Since a stripping operation is analogous to absorption, except with the mass transfer being in the opposite direction, a steam stripping example was tried; but would not converge using either procedure. The same problem with discrepancies in data was discovered but corrections here did not improve the calculation. Again, it was felt that a linear interpolation of the input data

would yield a better starting point than that being used.

The following method was used:

1. a uniform liquid composition was assumed on all the stages
2. condensed steam was assumed to be not present
3. liquid rate entering the column was equal to the value obtained after the flash calculation
4. liquid leaving was equal to 80% of that entering
5. a linear change in flow rates across the column from top to bottom

The linear interpolation was coded with the component oriented procedure and entered by using a "logical if statement". This procedure did provide a better initial point for the calculation and did yield smaller errors in temperatures and flow rates but did not converge.

However, the component oriented method did get closer to the desired overhead product rate than the stage oriented procedure. The temperatures calculated with either procedure oscillated badly from iteration to iteration.

Generally, both procedures presented in this paper are capable of solving absorber calculations with equal

efficiency as related to number of iterations required. The stage oriented procedure appears to be much more efficient for the solution of absorbers with sidestreams and/or heat trays requiring on the order of 65% as many iterations as the component oriented method requires. In their present form, neither procedure is applicable to strippers.

It is recommended that two point data be used for any particular problem as long as the temperature range is not large. The program performs a smooth interpolation of the input data by a regression analysis and since absorbers operate under somewhat pseudo-equilibrium conditions, greater accuracy obtained by using more than two data points over a narrow temperature range is not especially warranted.

CHAPTER 7
RECOMMENDATIONS

In order to further verify the procedures, several other solved absorber problems should possibly be run. These may be obtained either from sources in the literature or possibly from industry.

Since neither procedure is now applicable in its present form for the solution of stripping columns, further work should possibly be done to determine what problems exist in the programs. Once these problem areas are defined, a solution to them should be incorporated into the programs.

The case using a reboiled absorber was not attempted with these programs. Possible modifications to them should be considered so as to expand the area of use for these programs.

As discussed earlier, a total inversion of FGIM would not result in a usable procedure. Since the work of Goldstein and Stanfield indicates a total inversion can be used for distillation, further studies should be undertaken to determine the reasons behind its failure to work here. The use of the total inversion may have an effect on the total number of iterations required for a particular problem. It may be possible to reduce the required

computing time by changing the inversion technique.

Lastly, it may be worthwhile to further streamline the program to gain more efficiency of operation.

APPENDIX I

1		SUBROUTINE MATRIX (*,*)		0001
2	C			0002
3		COMMON //	X(15,20),V(20),XL(20),U(20),W(20),	0003
4	1		Q(20),HL(20),HV(20),TA(20),F(15,20),	0004
5	2		HF(20),PP(20),QG,DIST	0005
6	COMMON	/CONTRL/	NC,NT,LDC,NIQ,NTM1,KTOP,	0006
7	1		N1,N2,N3,N3N3,NT20	0007
8	COMMON	/DATA/	WK(15,20),DK(15,20),HVV(15,20),	0008
9	1		HLL(15,20),DHV(15,20),DHL(15,20),	0009
10	2		Y(15,20)	0010
11	COMMON	/FIX/	A(20,20),B(20,20,15),C(20,20,15),	0011
12	1		E(20,20),AF(20,20),	0012
13	2		AJ(20,20),RHS(20,18),	0013
14	3		G(20,20),AL(20,20),AM(20,20)	0014
15	C			0015
16	REAL		CXL(20),CTA(20),CV(20)	0016
17	C			0017
18	DATA		OVMAX/0.001/,OLMAX/0.001/,DTMAX/0.05/	0018
19	C			0019
20	C			0020
21		WRITE (6,2)		0021
22		CALL HWRITE		0022
23	2	FORMAT (1H1)		0023
24	4	FORMAT (/)		0024
25		NDONE=0		0025
26		DO 399 NIT=1,NIQ		0026
27	C			0027
28		DO 10 I=1,NT		0028
29		SUM=0.0		0029
30		DO 11 J=1,NC		0030
31	11	SUM=SUM+X(J,I)		0031
32		DO 12 J=1,NC		0032
33	12	X(J,I)=X(J,I)/SUM		0033
34	10	CONTINUE		0034
35		CALL GET		0035
36	C			0036
37		CALL INI		0037
38		CALL ENTBAL		0038
39		CALL COMP		0039
40		CALL SUBST		0040
41		GO TO (501,501,501,502),LDC		0041
42	502	CONTINUE		0042
43	C			0043
44	C	THE ERRORS ON EACH STAGE ARE PRINTED		0044
45		WRITE(6,2)		0045
46		WRITE(6,4)		0046
47	C			0047
48		DO 80 I=1,NT		0048
49	80	WRITE(6,402) I,RHS(I,N3),RHS(I,N2),RHS(I,N1)		0049
50	402	FORMAT(//10X' UNSCALED COMPUTED CORRECTIONS,OL-DV-DT,ON STAGE'		0050

20

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51      1 I5//10X(1P3E13.5))
52 C
53 C      CALCULATE CORRECTIONS FOR EACH STAGE
54 C
55      DO 135 I=1,NT
56      CTA(I)=TA(I)+RHS(I,N1)
57      CXL(I)=XL(I)+RHS(I,N3)
58      CV(I)=V(I)+RHS(I,N2)
59 135  CONTINUE
60      IF(LDDC.GT.2) WRITE(6,2)

61 C
62 C      PRINT CORRECTIONS FOR EACH STAGE
63 C
64      WRITE(6,4)
65      DO 136 I=1,NT
66 136  WRITE(6,403) I,CXL(I),CV(I),CTA(I)
67 403  FORMAT(/10X' CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE'
68      1 I5//10X(1P3E13.5))
69 C
70 501 CONTINUE
71 C
72 C      CHECK FOR CONVERGENCE
73 C      (1) MAXIMUM ABS(DV),LT,DVMAX V= VAPOR FLOW
74 C      (2) MAXIMUM ABS(DL),LT,DLMAX L= LIQUID FLOW
75 C      (3) MAXIMUM ABS(DT),LT,DTMAX T= TEMPERATURE
76 C      SCALE CORRECTIONS IF TOO LARGE ----CAUSE FOR SCALING
77 C      (1) DV.GT.0.20*V
78 C      (2) DL.GT.0.20*L
79 C      (3) DT.GT.20.0
80 C
81      DV=0.0
82      DL=0.0
83      DT=0.0
84      SUMSQ=0.0

85 C
86      DO 145 M=1,NT
87      SUMSQ=SUMSQ+RHS(M,N1)**2
88      DV=AMAX1(ABS(RHS(M,N2))/V(M),DV)
89      DL=AMAX1(ABS(RHS(M,N3))/XL(M),DL)
90 145  DT=AMAX1(ABS(RHS(M,N1)),DT)
91 C
92      IF(DV.LT.DVMAX.AND.DL.LT.DLMAX.AND.DT.LT.DTMAX) NBONE=1
93 C
94 505  DO 150 I=1,NT
95      DO 150 J=1,NC
96      CX=RHS(I,J)-X(J,I)
97      IF(RHS(I,J).LT.1.0E-6) GO TO 506
98      IF(RHS(I,J).LE.0.0.OR.RHS(I,J).GE.1.0) GO TO 509
99      GO TO 150
100 506 IF(RHS(I,J).LE.0.0) RHS(I,J)=X(J,I)/2.0

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Line	Column	Code	Page
101	150	CONTINUE	71 0101
102		GO TO 507	0102
103	509	NDONE=0	0103
104		DO 155 I=1,NT	0104
105		DO 155 J=1,NC	0105
106		CX=RHS(I,J)-X(J,I)	0106
107		RHS(I,J)=X(J,I)+SIGN(CX/2.,CX)	0107
108	155	CONTINUE	0108
109		GO TO 505	0109
110	C		0110
111	507	DO 158 I=1,NT	0111
112		IF(ABS(RHS(I,N3)).GT.0.20*XL(I).OR.ABS(RHS(I,N2)).	0112
113		GT.0.20*V(I)) GO TO 508	0113
114	158	CONTINUE	0114
115		GO TO 510	0115
116	508	NDONE=0	0116
117		DO 160 I=1,NT	0117
118		RHS(I,N3)=RHS(I,N3)*.5	0118
119		RHS(I,N2)=RHS(I,N2)*.5	0119
120	160	CONTINUE	0120
121		GO TO 507	0121
122	C		0122
123	510	DO 165 I=1,NT	0123
124		IF(ABS(RHS(I,N1)).GT.20.0) GO TO 511	0124
125	165	CONTINUE	0125
126		GO TO 512	0126
127	511	NDONE=0	0127
128	C		0128
129		DO 168 I=1,NT	0129
130		RHS(I,N1)=RHS(I,N1)*.5	0130
131	168	CONTINUE	0131
132		GO TO 510	0132
133	512	DO 170 I=1,NT	0133
134		DO 171 J=1,NC	0134
135	171	X(J,I)=RHS(I,J)	0135
136		XL(I)=XL(I)+RHS(I,N3)	0136
137		V(I)=V(I)+RHS(I,N2)	0137
138		TA(I)=TA(I)+RHS(I,N1)	0138
139	170	CONTINUE	0139
140	C		0140
141		IF(LDQC.EQ.1) GO TO 513	0141
142		IF(LDQC.GT.2) WRITE(6,2)	0142
143		WRITE(6,4) NIT,SUMSQ,DT,DV,DL	0143
144		WRITE(6,4)	0144
145	404	FORMAT(//10X' ITERATION NUMBER' I5//	0145
146		112X' SUM DT SQUARED' F20.6/	0146
147		212X' DT MAX' F28.6/12X' MAX DV/V' F26.6/	0147
148		312X' MAX DL/L' F26.6)	0148
149		IF(LDQC.EQ.2.AND.MOD(NIT,15).EQ.0) WRITE(6,2)	0149
150	C		0150

151		GO TO (513,513,514,514), LD0C	72	0151
152	514	CALL MWRITE		0152
153	513	IF(NDONE.NE.0) GO TO 515		0153
154	C			0154
155	399	CONTINUE		0155
156	C			0156
157		GO TO 515		0157
158	C			0158
159	515	IF(NDONE.NE.0) GO TO 516		0159
160		WRITE (6,405)		0160
161	405	FORMAT(///20X! NO CLOSURE OBTAINED ON PROBLEM!/ 120X! FOR SPECIFIED NUMBER OF TRIALS!///)		0161
162				0162
163		WRITE (6,2)		0163
164		CALL MWRITE		0164
165		RETURN 2		0165
166	C			0166
167	516	GO TO (600,600,700,700), LD0C		0167
168	600	WRITE (6,2)		0168
169		CALL MWRITE		0169
170	C			0170
171	700	RETURN		0171
172		END		0172

1		SUBROUTINE INI		73	0173
2	C				0174
3		COMMON //	X(15,20),V(20),XL(20),U(20),W(20),		0175
4	1		Q(20),HL(20),HV(20),TA(20),F(16,20),		0176
5	2		HF(20),PP(20),QG,DIST		0177
6		COMMON /CONTRL/	NC,NT,LDC,NI0,NTM1,KTDP,		0178
7	1		N1,N2,N3,N3,N3,NT20		0179
8		COMMON /DATA/	WK(15,20),DK(15,20),HVV(15,20),		0180
9	1		HLL(15,20),DHV(15,20),DHL(15,20),		0181
10	2		Y(15,20)		0182
11		COMMON /FIX/	A(20,20),R(20,20,15),C(20,20,15),		0183
12	1		E(20,20),AF(20,20),		0184
13	2		AJ(20,20),RHS(20,18),		0185
14	3		G(20,20),AL(20,20),AM(20,20)		0186
15		REAL	SM(20,20),SV(400),		0187
16	+		AK(20,20),D(20,20)		0188
17	C				0189
18		EQUIVALENCE	(SM(1,1),SV(1)),		0190
19	+		(A(1,1),AK(1,1),D(1,1))		0191
20	C				0192
21	C	DEVELOP OVERALL MATERIAL BALANCE ENTRIES ----- BLOCK N3			0193
22	C				0194
23	C	AJ MATRIX IS SET EQUAL TO ZERO AND THEN THE			0195
24	C	NON-ZERO TERMS ARE COMPUTED			0196
25	C				0197
26		CALL ZERO(RHS,360)			0198
27		CALL ZERO(AJ,NT20)			0199
28	C				0200
29		DO 10 I=1,NTM1			0201
30		AJ(I,I)=-1.			0202
31		AJ(I,I+1)=1.			0203
32	10	CONTINUE			0204
33		AJ(NT,NT)=-1.			0205
34	C				0206
35	C	AK MATRIX IS SET EQUAL TO ZERO AND THEN THE			0207
36	C	NON-ZERO TERMS ARE COMPUTED			0208
37		CALL ZERO(AK,NT20)			0209
38		AK(1,1)=-1.			0210
39		DO 20 I=2,NT			0211
40		AK(I,I-1)=1.			0212
41		AK(I,I)=-1.			0213
42	20	CONTINUE			0214
43	C				0215
44	C	THE RIGHT HAND SIDE OF THE MATERIAL BALANCE IS DEVELOPED			0216
45	C				0217
46		RHS(1,N3)=XL(1)+U(1)+V(1)+W(1)-F(NC+1,1)-V(2)			0218
47		DO 30 I=2,NTM1			0219
48		RHS(I,N3)=XL(I)+U(I)+V(I)+W(I)-F(NC+1,I)-XL(I-1)-V(I+1)			0220
49	30	CONTINUE			0221
50		RHS(NT,N3)=XL(NT)+U(NT)+V(NT)+W(NT)-F(NC+1,NT)-XL(NTM1)			0222

74

51 C		02230
52 C	GENERATE RHS OF SUM EQUATION	02240
53	DD 31 I=1,NT	02250
54	RHS(I,N2)=1	02260
55	31 CONTINUE	02270
56 C		02280
57 C	INVERT AK	02290
58	L=0	02300
59	DD 34 N=1,NT	02310
60	DD 33 M=1,NT	02320
61	L=L+1	02330
62	SV(L)=AK(M,N)	02340
63	33 CONTINUE	02350
64	34 CONTINUE	02360
65 C		02370
66 C	MATRIX AK IS INVERTED	02380
67 C		02390
68	CALL MINV(SV,NT,DETRM,AK(1,1),AK(1,2))	02400
69 C		02410
70	L=0	02420
71	DD 38 N=1,NT	02430
72	DD 37 M=1,NT	02440
73	L=L+1	02450
74	AK(M,N)=SV(L)	02460
75	37 CONTINUE	02470
76	38 CONTINUE	02480
77 C		02490
78 C	AK AND AJ ARE MULTIPLIED TOGETHER ALONG WITH ASSOCIATED	02500
79 C	RHS FOR MATERIAL BALANCE EQUATION	02510
80 C		02520
81	CALL MPLYM(AK,AJ,SM,NT)	02530
82	CALL EQUAL(AJ,SM,NT)	02540
83	CALL MPLYV(AK,RHS(1,N3),SV,NT)	02550
84	CALL EQUALV(RHS(1,N3),SV,NT)	02560
85 C		02570
86 C	GENERATE C PART OF COMPONENT MATERIAL	02580
87 C	BALANCE WHICH IS ORDERED COMPONENT WISE	02590
88 C		02600
89 C	SET C MATRIX EQUAL TO ZERO FOR COMPONENT	02610
90 C	J AND GENERATE NON-ZERO TERMS	02620
91 C		02630
92	DD 53 J=1,NC	02640
93	CALL ZERO (C(1,1,J),NT20)	02650
94	DD 41 I=1,NTM1	02660
95	C(I,I,J)=WK(J,I)*X(J,I)	02670
96	C(I,I+1,J)=-WK(J,I+1)*X(J,I+1)	02680
97	41 CONTINUE	02690
98	C(NT,NT,J)=WK(J,NT)*X(J,NT)	02700
99 C		02710
100 C	GENERATE D MATRIX	02720

A	FORTRAN IV (VER L30) SOURCE LISTING:	INI	SUBROUTINE	04/10/73	PAGE
101	C	----- ONLY NEEDED AT THIS TIME			0273
102	C	TO MODIFY C MATRIX AND ASSOCIATED RHS			0274
103	C				0275
104		CALL ZERO (D,NT20)			0276
105	C				0277
106		D(1,1)=X(J,1)			0278
107		DD 42 I=2,NT			0279
108		D(I,I-1)=-X(J,I-1)			0280
109		D(I,I)=X(J,I)			0281
110	42	CONTINUE			0282
111	C				0283
112	C	GENERATE RHS FOR EACH COMPONENT			0284
113	C				0285
114		DD 45 I=1,NT			0286
115		RHS(I,J)=F(J,I)			0287
116	45	CONTINUE			0288
117	C				0289
118	C	MULTIPLY D * RHS(-,N3) AND			0290
119	C	SUBTRACT FROM RHS(I,J)			0291
120	C				0292
121		DD 48 I=1,NT			0293
122		DD 48 K=1,NT			0294
123		RHS(I,J)=RHS(I,J)-D(I,K)*RHS(K,N3)			0295
124	48	CONTINUE			0296
125	C				0297
126	C	MULTIPLY D * AJ AND SUBTRACT FROM C			0298
127	C				0299
128		CALL MPLYM (D,AJ,SM,NT)			0300
129	C				0301
130		DD 50 I=1,NT			0302
131		DD 50 K=1,NT			0303
132		C(I,K,J)=C(I,K,J)-SM(I,K)			0304
133	50	CONTINUE			0305
134	C				0306
135	53	CONTINUE			0307
136	C				0308
137		RETURN			0309
138		END			0310

75

1		SUBROUTINE EPTHAL		03110
2	C			03120
3		COMMON //	X(15,20),V(20),XL(20),U(20),W(20),	03130
4	1		Q(20),HL(20),HV(20),TA(20),F(15,20),	03140
5	2		HF(20),PP(20),QC,DIST	03150
6		COMMON /CONTRL/	NC,NT,LPBC,NID,NTM1,KTOP,	03160
7	1		H1,N2,N3,BN3,NT20	03170
8		COMMON /DATA/	WK(15,20),DK(15,20),HV(15,20),	03180
9	1		HLL(15,20),DHV(15,20),DHL(15,20),	03190
10	2		Y(15,20)	03200
11		COMMON /FIX/	A(20,20),B(20,20,15),C(20,20,15),	03210
12	1		E(20,20),AF(20,20),	03220
13	2		AJ(20,20),RHS(20,18),	03230
14	3		G(20,20),AL(20,20),AM(20,20)	03240
15		REAL	SM(20,20),SV(400),H(20,20)	03250
16	C			03260
17		EQUIVALENCE	(SM(1,1),SV(1)),	03270
18	+		(A(1,1),d(1,1))	03280
19	C			03290
20		CALL ZERO (AF,400)		03300
21		CALL ZERO (G,400)		03310
22	C			03320
23	C	GENERATE AF,G,H,AND RHS(-,1)		03330
24	C			03340
25	C			03350
26	C	GENERATE AF ENTRIES		03360
27	C			03370
28		DO 64 J=1,NC		03380
29	C			03390
30		AF(1,1)=AF(1,1)+(XL(1)+U(1))*X(J,1)*DHL(J,1)		03400
31		1+(V(1)+W(1))*(WK(J,1)*DHV(J,1)+HV(1)*DK(J,1))*X(J,1)		03410
32		AF(1,2)=AF(1,2)-(V(2)*X(J,2))*(WK(J,2)*		03420
33		1DHV(J,2)+HV(2)*DK(J,2))		03430
34		DO 61 I=2,NTM1		03440
35		AF(I,I-1)=AF(I,I-1)-(XL(I-1)*X(J,I-1)*DHL(J,I-1))		03450
36		AF(I,I)=AF(I,I)+(XL(I)+U(I))*X(J,I)*DHL(J,I)		03460
37		1+(V(I)+W(I))*(WK(J,I)*DHV(J,I)+HV(I)*DK(J,I))*X(J,I)		03470
38		AF(I,I+1)=AF(I,I+1)-(V(I+1)*X(J,I+1))*		03480
39		1(WK(J,I+1)*DHV(J,I+1)+HV(I+1)*DK(J,I+1))		03490
40	61	CONTINUE		03500
41		AF(NT,NTM1)=AF(NT,NTM1)-(XL(NTM1)*X(J,NTM1)*DHL(J,NTM1))		03510
42		AF(NT,NT)=AF(NT,NT)+(XL(NT)+U(NT))*X(J,NT)*DHL(J,NT)		03520
43		1+(V(NT)+W(NT))*(WK(J,NT)*DHV(J,NT)+HV(NT)*DK(J,NT))*X(J,NT)		03530
44	64	CONTINUE		03540
45	C			03550
46	C			03560
47	C	GENERATE G ENTRIES		03570
48	C			03580
49		DO 65 I=1,NTM1		03590
50		G(I,I)=HV(I)		03600

51		G(I,I+1)=-HV(I+1)	>>	0361
52	65	CONTINUE		0362
53		G(NT,NT)=HV(NT)		0363
54	C			0364
55	C	GENERATE n ENTRIES		0365
56	C			0366
57		CALL ZERO (H,NT20)		0367
58		H(1,1)=HL(1)		0368
59		DO 72 I=2,NT		0369
60		H(I,I-1)=-HL(I-1)		0370
61		H(I,I)=HL(I)		0371
62	72	CONTINUE		0372
63	C			0373
64		DO 74 I=1,NT		0374
65	74	RHS(I,N1)=-Q(I)+F(N1,I)*HF(I)		0375
66	C			0376
67	C	MULTIPLY H BY AJ AND SUBTRACT FROM G		0377
68	C			0378
69		DO 76 I=1,NT		0379
70		DO 76 L=1,NT		0380
71		DO 75 K=1,NT		0381
72	75	G(I,L)=G(I,L)-H(I,K)*AJ(K,L)		0382
73	C			0383
74	C	MULTIPLY H BY RHS(I,N3) AND SUBTRACT FROM RHS(I,N1)		0384
75	C			0385
76		RHS(I,N1)=RHS(I,N1)-H(I,L)*RHS(L,N3)		0386
77	76	CONTINUE		0387
78	C			0388
79	C			0389
80	C			0390
81		RETURN		0391
82		END		0392

1		SUBROUTINE COMP		0393
2	C			0394
3		COMMON //	X(15,20),V(20),XL(20),U(20),W(20),	0395
4	1		Q(20),HL(20),HV(20),TA(20),P(16,20),	0396
5	2		HF(20),PP(20),QG,DIST	0397
6		COMMON /CONTRL/	NC,NT,LDDC,NID,NTM1,KTOP,	0398
7	1		N1,N2,N3,N3N3,NT20	0399
8		COMMON /DATA/	WK(15,20),DK(15,20),HVV(15,20),	0400
9	1		HLL(15,20),DHV(15,20),DHL(15,20),	0401
10	2		Y(15,20)	0402
11		COMMON /FIX/	A(20,20),B(20,20,15),C(20,20,15),	0403
12	1		E(20,20),AF(20,20),	0404
13	2		AJ(20,20),RHS(20,18),	0405
14	3		G(20,20),AL(20,20),AM(20,20)	0406
15		REAL	SM(20,20),SV(400)	0407
16	C			0408
17		EQUIVALENCE	(SM(1,1),SV(1))	0409
18	C			0410
19	C	GENERATE COMPONENT BY COMPONENT A,B,E,AND I		0411
20	C	I IS NOT ACTUALLY GENERATED SINCE IT IS THE		0412
21	C	COMPONENTIAL ENTRIES FOR THE SUM EQUATION		0413
22	C			0414
23	C	COMPUTE INVERSE OF A AND MULTIPLY TOP ROW BY IT		0415
24	C			0416
25		CALL ZERO (AL,400)		0417
26		CALL ZERO (AM,400)		0418
27	C			0419
28		DO 150 J=1,NC		0420
29	C			0421
30	C	F + G ARE ADJUSTED AS A RESULT OF E ELIMINATION		0422
31	C	L AND M ARE ADJUSTED BY I ELIMINATION		0423
32	C			0424
33		CALL ZERO (A,NT20)		0425
34		CALL ZERO (B(1,1,J),NT20)		0426
35		CALL ZERO (E,NT20)		0427
36	C			0428
37		A(1,1)=(V(1)+W(1))*WK(J,1)+XL(1)+U(1)		0429
38		A(1,2)=-V(2)*WK(J,2)		0430
39		E(1,1)=(V(1)+W(1))*WK(J,1)*HVV(J,1)+		0431
40		1(XL(1)+U(1))*HLL(J,1)		0432
41		E(1,2)=-V(2)*WK(J,2)*HVV(J,2)		0433
42		DO 82 I=2,NTM1		0434
43		A(I,I-1)=-XL(I-1)		0435
44		A(I,I)=(V(I)+W(I))*WK(J,I)+XL(I)+U(I)		0436
45		A(I,I+1)=-V(I+1)*WK(J,I+1)		0437
46	C			0438
47		E(I,I-1)=-XL(I-1)*HLL(J,I-1)		0439
48		E(I,I)=(V(I)+W(I))*WK(J,I)*HVV(J,I)+		0440
49		1(XL(I)+U(I))*HLL(J,I)		0441
50		E(I,I+1)=-V(I+1)*WK(J,I+1)*HVV(J,I+1)		0442

51	82	CONTINUE	0443
52		A(NT,NTM1)=-XL(NTM1)	0444
53		A(NT,NT)=(V(NT)+W(NT))*WK(J,NT)+XL(NT)+U(NT)	0445
54		E(NT,NTM1)=-XL(NTM1)*HLL(J,NTM1)	0446
55		E(NT,NT)=(V(NT)+W(NT))*WK(J,NT)*HVV(J,NT)+	0447
56		I(XL(NT)+U(NT))*HLL(J,NT)	0448
57	C		0449
58		DO 83 I=1,NTM1	0450
59		B(I,I,J)=(V(I)+W(I))*X(J,I)*DK(J,I)	0451
60		B(I,I+1,J)=-V(I+1)*X(J,I+1)*DK(J,I+1)	0452
61	83	CONTINUE	0453
62		B(NT,NT,J)=(V(NT)+W(NT))*X(J,NT)*DK(J,NT)	0454
63	C		0455
64	C	MATRIX A IS INVERTED	0456
65	C		0457
66		L=0	0458
67		DO 90 M=1,NT	0459
68		DO 90 N=1,NT	0460
69		L=L+1	0461
70		SV(L)=A(M,N)	0462
71	90	CONTINUE	0463
72	C		0464
73		CALL MINV(SV,NT,DETRH,A(1,1),A(1,2))	0465
74		L=0	0466
75		DO 91 M=1,NT	0467
76		DO 91 N=1,NT	0468
77		L=L+1	0469
78		A(M,N)=SV(L)	0470
79	91	CONTINUE	0471
80	C		0472
81	C	MULTIPLY A BY B	0473
82		CALL MPLYM(A,B(1,1,J),SM,NT)	0474
83		CALL EQUAL(B(1,1,J),SM,NT)	0475
84	C		0476
85	C	MULTIPLY A BY C	0477
86		CALL MPLYM(A,C(1,1,J),SN,NT)	0478
87		CALL EQUAL(C(1,1,J),SN,NT)	0479
88	C		0480
89	C	MULTIPLY A BY RHS(I,J)	0481
90		CALL MPLYV(A,RHS(1,J),SV,NT)	0482
91		CALL EQUALV(RHS(1,J),SV,NT)	0483
92	C		0484
93	C	MULTIPLY ROW J BY E AND SUBTRACT FROM ROW N1	0485
94	C		0486
95		DO 95 I=1,NT	0487
96		DO 95 K=1,NT	0488
97		DO 94 L=1,NT	0489
98		AF(I,K)=AF(I,K)-E(I,L)*B(L,K,J)	0490
99	94	G(I,K)=G(I,K)-E(I,L)*C(L,K,J)	0491
100		RHS(I,N1)=RHS(I,N1)-E(I,K)*RHS(K,J)	0492

101	95	CONTINUE	80	04930
102		C		04940
103		C		04950
104		C MULTIPLY ROW J BY I AND SUBTRACT FROM ROW N2		04960
105		C		04970
106		DO 110 I=1,NT		04980
107	110	BHS(I,N2)=BHS(I,N2)-BHS(I,J)		04990
108		DO 120 I=1,NT		05000
109		DO 120 K=1,NT		05010
110	120	AL(I,K)=AL(I,K)-B(I,K,J)		05020
111		DO 130 I=1,NT		05030
112		DO 130 K=1,NT		05040
113	130	AM(I,K)=AM(I,K)-C(I,K,J)		05050
114		C		05060
115		C		05070
116	150	CONTINUE		05080
117		C		05090
118		C		05100
119		RETURN		05110
120		END		05120

Line	Code	Statement	Column
1		SUBROUTINE SUBST	0513
2	C		0514
3		COMMON // X(15,20),V(20),XL(20),U(20),W(20),	0515
4	1	Q(20),HL(20),RV(20),TA(20),F(16,20),	0516
5	2	HF(20),PP(20),QG,DIST	0517
6	COMMON	/CONTROL/ NC,NT,LDC,NTB,NTM1,KTDP,	0518
7	1	H1,N2,N3,N3N3,NT20	0519
8	COMMON	/DATA/ WK(15,20),DK(15,20),HVV(15,20),	0520
9	1	HLL(15,20),DHV(15,20),DHL(15,20),	0521
10	2	Y(15,20)	0522
11	COMMON	/FIX/ A(20,20),B(20,20,15),C(20,20,15),	0523
12	1	E(20,20),AF(20,20),	0524
13	2	AJ(20,20),RHS(20,18),	0525
14	3	G(20,20),AL(20,20),AM(20,20)	0526
15	C		0527
16	REAL	SM(20,20),SV(400)	0528
17	C		0529
18	EQUIVALENCE	(SM(1,1),SV(1))	0530
19	C		0531
20	C	INVERT AF	0532
21		L=0	0533
22		DD 10 N=1,NT	0534
23		DD 10 N=1,NT	0535
24		L=L+1	0536
25	10	SV(L)=AF(M,N)	0537
26		CALL MINV (SV,NT,DETRM,AF(1,1),AF(1,2))	0538
27		L=0	0539
28		DD 20 N=1,NT	0540
29		DD 20 M=1,NT	0541
30		L=L+1	0542
31	20	AF(M,N)=SV(L)	0543
32	C		0544
33	C	MULTIPLY G AND RHS(-,N1) BY AF INVERSE	0545
34		CALL MPLYM (AF,G,SM,NT)	0546
35		CALL EQUAL (G,SM,NT)	0547
36		CALL MPLYV (AF,RHS(1,N1),SV,NT)	0548
37		CALL EQUALV (RHS(1,N1),SV,NT)	0549
38	C		0550
39	C	MULTIPLY G AND RHS(-,N1) BY AL AND SUBTRACT	0551
40	C	FROM AM AND RHS(-,N2) RESPECTIVELY	0552
41		CALL MPLYM (AL,G,SM,NT)	0553
42		CALL MPLYV (AL,RHS(1,N1),SV,NT)	0554
43		DD 40 I=1,NT	0555
44		DD 30 J=1,NT	0556
45	30	AM(I,J)=AM(I,J)-SM(I,J)	0557
46	40	RHS(I,N2)=RHS(I,N2)-SV(J)	0558
47	C		0559
48	C	INVERT AM	0560
49		L=0	0561
50		DD 50 N=1,NT	0562

51	DD 50 M=1,NT	05630
52	L=L+1	05640
53	50 SV(L)=AM(M,N)	05650
54	CALL MINV (SV,NT,DETRM,AM(1,1),AM(1,2))	05660
55	L=0	05670
56	DD 60 N=1,NT	05680
57	DD 60 M=1,NT	05690
58	L=L+1	05700
59	60 AM(M,N)=SV(L)	05710
60	C	05720
61	C MULTIPLY RHS(-,N2) BY AM INVERSE	05730
62	CALL MPLYV (AM,RHS(1,N2),SV,NT)	05740
63	CALL EQUALV (RHS(1,N2),SV,NT)	05750
64	C	05760
65	C MULTIPLY G BY RHS(-,N2) AND SUBSTRACT FROM RHS(-,N1)	05770
66	CALL MPLYV (G,RHS(1,N2),SV,NT)	05780
67	DD 70 I=1,NT	05790
68	70 RHS(I,N1)=RHS(I,N1)-SV(I)	05800
69	C	05810
70	C THE X'S AND DELTA L'S	05820
71	C ARE CALCULATED BY BACK SUBSTITUTION	05830
72	DD 111 I=1,NT	05840
73	DD 111 K=1,NT	05850
74	111 RHS(I,N3)=RHS(I,N3)-AJ(I,K)*RHS(K,N2)	05860
75	C	05870
76	DD 116 J=1,NC	05880
77	DD 116 I=1,NT	05890
78	DD 116 K=1,NT	05900
79	RHS(I,J)=RHS(I,J)-B(I,K,J)*RHS(K,N1)-C(I,K,J)*RHS(K,N2)	05910
80	116 CONTINUE	05920
81	C	05930
82	C	05940
83	C	05950
84	RETURN	05960
85	END	05970

APPENDIX II

84

```
1      PROGRAM ABSR2
2 C
3 C
4 C
5      REAL      A(20)
6      DATA     ZEND / '$$$$' /
7 C
8      NTIME = 0
9      2 READ (5,100,END=999) A
10     100 FORMAT (20A4)
11     WRITE (6,102) A
12     102 FORMAT (1H|/12X,20A4)
13     CALL INPUT (&B)
14     CALL MATRIX (&B,&I0)
15     4 CALL DTPUT
16     GO TO 10
17 C
18     8 WRITE (6,104)
19     104 FORMAT (/////10X 'PROBLEM FLUSHED'/10X 'PROCEEDING TO NEXT PROBLEMOC
20     1'/////))
21 C
22     10 READ (5,100,END=999) A(1)
23     IF (A(1).EQ.ZEND) GO TO 2
24     GO TO 10
25 C
26     999 WRITE (6,106)
27     106 FORMAT ('1')
28     STOP
29     END
```

85

```

1      SUBROUTINE KGEN (T,E,M)
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4      1 Q(20),HL(20),HV(20),TA(20),F(16,20),
5      2 HF(20),PP(20),QG,DIST
6      COMMON /CONTRL/ NC, NT, LDDC, NID, NTM1, KTOP,
7      1 N1,N2,N3,N3N3,NT20
8      COMMON /DATA1/ NK,EKTABL(8,15),TK(8),
9      1 PA,PK(8),KCODE
10 C
11     REAL E(1)
12     DOUBLE PRECISION XX
13 C
14     1 IF (NK.GT.2) GO TO 3
15     J=1
16     GO TO 9
17     3 DO 6 L=2,NK
18     IF (T.LT.TK(L)) GO TO 7
19     6 CONTINUE
20     L=NK
21     7 J=L-1
22     9 K=J+1
23 C
24     10 XX=(1.0/(T+460.0)-1.0/(TK(J)+460.0)) /
25     1 (1.0/(TK(K)+460.0)-1.0/(TK(J)+460.0))
26     DO 14 I=1,NC
27     14 E(I)=DEXP(EKTABL(J,I)+(EKTABL(K,I)-EKTABL(J,I))*XX)
28 C
29     IF(KCODE.EQ.0) GO TO 41
30     31 GO TO (41,32), KCODE
31     32 PRATIO=PA/PP(M)
32     DO 33 I=1,NC
33     33 E(I)=E(I)*PRATIO
34 C
35     41 RETURN
36     END

```

86

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1      SUBROUTINE HGEN (T,ZV,ZL)
2 C
3      COMMON /CNTRL/ NC, NT, LDDC, NID, NTH1, KTOP,
4      1      NI, N2, N3, N3N3, NT20
5      COMMON /DATA2/ NH, HLTABL(8,15), HVTABL(8,15), TH(8), PH(8)
6 C
7      REAL          ZV(1), ZL(1)
8 C
9      IF (NH.GT.2) GO TO 3
10     J=1
11     GO TO 8
12     3 DD 6 L=2, NH
13     IF (T.LT.TH(L)) GO TO 7
14     6 CONTINUE
15     L=NH
16     7 J=L-1
17     8 K=J+1
18 C
19     9 XX=(T-TH(J))/(TH(K)-TH(J))
20     DD 10 N=1, NC
21     ZV(N)=HVTABL(J,N)+(HVTABL(K,N)-HVTABL(J,N))*XX
22     10 ZL(N)=HLTABL(J,N)+(HLTABL(K,N)-HLTABL(J,N))*XX
23 C
24     RETURN
25     END

```

87

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1      FUNCTION      EQUA ( X, C )      00
2 C      00
3 C      THIS FUNCTION EVALUATES A SET OF POLYNOMIAL COEFFICIENTS BY      00
4 C      NESTED EXPANSION ---- AS GENERATED BY FUNCTION FITIT.      00
5 C      00
6 C      Y = A0 + A1*X + A2*X**2 + ..... + AM*X**M      00
7 C      00
8 C      M = C(1)      00
9 C      00
10 C      A0 = C(2)      01
11 C      A1 = C(3)      01
12 C      A2 = C(4)      01
13 C      .. .      01
14 C      .. .      01
15 C      AM = C(M+2)      01
16 C      01
17      REAL      C(1)      01
18 C      01
19      M = C(1)+0.1      01
20      Y = C(M+2)      01
21      MM = M+2      01
22      DO 1 J=1,M      01
23      MMJ=MM-J      01
24      Y=Y*X+C(MMJ)      01
25      1 CONTINUE      01
26      EQUA = Y      01
27      RETURN      01
28      END      01

```

88

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1      FUNCTION FITIT ( X, Y, ND, MAX, C, LN, A )
2 C
3 C      WILL FIT POLYNOMIAL OF ORDER MAX ( MAX .LT. 7 ) TO ND Y VS. X DATA
4 C      POINTS SUPPLIED IN ARRAYS Y AND X. COEFFICIENTS RETURNED IN ARRAY
5 C      C IN FORM NEEDED BY FUNCTION EQUA. STANDARD DEVIATION OF Y RETURNED
6 C      D AS FITIT.
7 C
8 C      LN = LOG TRANSFORMATION CODE 1 = Y VS. X
9 C                                     2 = LN Y VS. X
10 C                                    3 = Y VS. LN X
11 C                                    4 = LN Y VS. LN X
12 C
13 C      A = INTERCEPT CODE ZERO = INTERCEPT = 0.0
14 C      NONZERO = INTERCEPT CALCULATED
15 C
16      REAL X(1), Y(1), C(1), D(7), S(7), XY(7,7)
17 C
18 C      SET CONTROLS AND ZEROS AND XY.
19 C
20      N = ND
21      M = MINO ( MAX + 1, N, 7)
22      L = MINO ( 4, MAXO ( 1, LN ) )
23      Z = N
24      DO 10 I = 1, M
25          S(I) = 0.0
26      DO 10 J = 1, M
27          10 XY(I, J) = 0.0
28 C
29 C      FOR EACH DATUM, MOVE Y AND X TO D(1) AND D(2), GET LOGS IF NEEDED
30 C      AND POWERS OF X, AND ACCUMULATE SUMS, SQUARES, AND CROSS PRODUCTS
31 C      IN S AND XY.
32 C
33      DO 80 K = 1, N
34          D(1) = Y(K)
35          D(2) = X(K)
36          GO TO ( 50, 20, 40, 30 ), L
37          20 D(1) = ALDG ( D(1) )
38              GO TO 50
39          30 D(1) = ALDG ( D(1) )
40          40 D(2) = ALDG ( D(2) )
41          50 DO 60 I = 3, M
42              60 D(I) = D(2) * D(I - 1)
43              DO 70 I = 1, M
44                  S(I) = S(I) + D(I)
45              DO 70 J = 1, M
46                  70 XY(I, J) = XY(I, J) + D(I) * D(J)
47          80 CONTINUE
48 C
49 C      GET REDUCED SQUARES AND CROSS PRODUCTS IF A NONZERO AND FOLD XY
50 C      OVER.

```

89

```
51 C 01
52 IF ( A .EQ. 0.0 ) GO TO 110 01
53 DO 100 I = 1, M 01
54 Q = S(I) / Z 01
55 DO 90 J = 1, M 01
56 90 XY(I, J) = XY(I, J) - Q * S(J) 01
57 100 S(I) = Q 01
58 110 DO 120 J = 1, M 01
59 DO 120 I = J, M 01
60 120 XY(I, J) = XY(J, I) 01
61 C 01
62 C SOLVE REGRESSION MATRIX AND GET STANDARD DEVIATION OF Y. 01
63 C 01
64 DO 160 I = 2, M 01
65 Q = XY(I, I) 01
66 XY(I, I) = 1.0 01
67 DO 130 J = 1, M 01
68 130 XY(I, J) = XY(I, J) / Q 01
69 DO 150 K = 1, M 01
70 IF ( K .EQ. I ) GO TO 150 01
71 Q = XY(K, I) 01
72 XY(K, I) = 0.0 01
73 DO 140 J = 1, M 01
74 140 XY(K, J) = XY(K, J) - XY(I, J) * Q 01
75 150 CONTINUE 01
76 160 CONTINUE 01
77 Q = MAX0 ( N - M, 1 ) 01
78 FITIT = SQRT ( AMAX1 ( XY ( 1, 1 ) / Q, 0.0 ) ) 01
79 C 01
80 C STORE COEFFICIENTS IN C ARRAY. 01
81 C 01
82 C(1) = M - 1 02
83 C(2) = 0.0 02
84 DO 170 I = 2, M 02
85 S(1) = S(1) - S(I) * XY(I, 1) 02
86 170 C(I + 1) = XY(I, 1) 02
87 IF ( A .NE. 0.0 ) C(2) = S(1) 02
88 RETURN 02
89 C 02
90 END 02
```

```

1      FUNCTION WAYA(A,ANS,TOL,START,STOP,LEVEL)
2 C
3 C      ROUTINE TO CONVERGE ON SINGLE VALUED FUNCTION
4 C
5 C      A      =CURRENT VALUE OF DEPENDENT VARIABLE
6 C      ANS    =DESIRED VALUE OF DEPENDENT VARIABLE
7 C      TOL    =TOLERANCE
8 C      START  =CURRENT VALUE OF INDEPENDENT VARIABLE. A BETTER VALUE RETURNED
9 C      STOP   =LIMIT OF INDEPENDENT VARIABLE. ANSWER BETWEEN START AND STOP,
10 C     LEVEL= 1,2, OR 3 AS AN INDEX FOR MULTILEVEL USE.
11 C
12 C     WAYA WILL VARY START BETWEEN ITS INITIAL VALUE AND STOP UNTIL
13 C     ABS( ANS- A) .LE. TOL OR 30 TRIALS TAKEN.
14 C
15 C     ON EXIT WAYA IS:
16 C     - FOR NOT CONVERGED. REPEAT CALCULATION WITH NEW VALUE IN START.
17 C     0 FOR CONVERGED IN LIMITS OR 30 TRIALS TAKEN.
18 C     + FOR CANNOT CONVERGE. START WILL BE ITS INITIAL VALUE OR STOP,
19 C     WHICHEVER GIVES LESSER ERROR, OR ITS INITIAL VALUE IF LEVEL
20 C     IS NEGATIVE.
21 C
22 C     DIMENSION X1(3),X2(3),Y1(3),Y2(3),KOUNT(3)
23 C
24 C     DATA KOUNT/ 3*0 /
25 C
26 C     SET X,Y & LEVEL
27 C     X=START
28 C     Y=ANS-A
29 C     L=IABS(LEVEL)
30 C     WAYA=1.0
31 C
32 C     SEE IF CONVERGED
33 C
34 C     IF(ABS(Y).LE. TOL) GO TO 70
35 C
36 C     NOT CONVERGED. SEE WHICH CALL.
37 C
38 C     IF(KOUNT(L)) 80,30,10
39 C
40 C     SECOND OR HIGHER CALL. SEE IF Y AND Y1(L) BRACKET ANSWER.
41 C
42 C 10 IF(Y*Y1(L) .LT. 0.0) GO TO 20
43 C
44 C     NO Y-Y1 BRACKET. SEE IF SECOND OR HIGHER CALL.
45 C
46 C     IF(KOUNT(L) .GT. 1) GO TO 30
47 C
48 C     NO BRACKET AT ALL. RE=DD AT START IF THAT LIMIT IS CLOSER OR IF
49 C     LEVEL IS MINUS
50 C

```



```

51            IF (ABS(Y) .LE. ABS(Y1(L)) .AND. LEVEL .GT. 0) GO TO 80      91      02
52            X=X1(L)      02
53            KOUNT(L)= -1      02
54            GO TO 60      02
55 C      02
56 C            Y-Y1 BRACKET. STORE X & Y IN X2(L) AND Y2(L)      02
57 C      02
58        20    X2(L)=X      02
59            Y2(L)=Y      02
60            GO TO 40      02
61 C      02
62 C            FIRST CALL OR CONVERGING Y-Y2 BRACKET CALL. STORE X & Y IN X1      02
63 C            & Y1.      02
64 C      02
65        30    X1(L)=X      02
66            Y1(L)=Y      02
67            X=STOP      02
68            IF (KOUNT(L).EQ. 0) GO TO 50      02
69 C      02
70 C            INTERPOLATE NEW X AND CONTINUE OR QUIT DEPENDING ON KOUNT(L).      02
71 C      02
72        40    X=(X1(L)*(3.*Y2(L)-Y1(L))+X2(L)*(Y2(L)-3.*Y1(L)))/(4.*(Y2(L)-Y1(L)      02
73            1))      02
74            IF (KOUNT(L) .GE. 30) GO TO 70      02
75        50    KOUNT(L)=KOUNT(L)+1      02
76        60    WAYA=-1.0      02
77            GO TO 90      02
78 C      02
79 C            CONVERGED OR TOO MANY TRIALS      02
80 C      02
81        70    WAYA=0.0      02
82        80    KOUNT(L)=0      02
83 C      02
84 C            SET NEW VALUE OF INDEPENDENT VARIABLE.      02
85 C      02
86        90    START=X      02
87            RETURN      02
88 C      02
89            END      02

```

```

1      SUBROUTINE MWRITE
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4      1 Q(20),HL(20),HV(20),TA(20),F(16,20),
5      2 HF(20),PP(20),QG,DIST
6      COMMON /CONTRL/ NC, NT, LDDC, NID, NTM1, KTOP,
7      1 N1,N2,N3,N3N3,NT20
8      COMMON /PROP/ CNAME(2,15),XNW(15),RHD(15)
9      COMMON /FIX/ SPACE(4845),AX(20)
10 C
11     WRITE (6,101)(V(J),J=1,NT)
12 101  FORMAT(//10X' CALCULATED VAPOR RATES'/4(9X,4F11.3/))
13     WRITE (6,102) (XL(J),J=1,NT)
14 102  FORMAT ( 11X,26HCORRESPONDING LIQUID RATES/4(9X,4F11.3/))
15     WRITE (6,103) (TA(J),J=1,NT)
16 103  FORMAT (10X' CALCULATED TEMPERATURES ' / 4(9X,4F11.3/))
17 C
18 C      NBL      NUMBER OF BLOCKS OF 4 OR PART THEREOF
19 C      NPP      NUMBER OF LINES ALREADY PRINTED
20     KN=0
21     KM=NT
22     NBL=(NT+3)/4
23     NPP=(7+3)+(NBL*3)+(NC+5)
24 C
25     2 IF (KM.LE.4) GO TO 6
26     KN=4+KN
27     L=KN-3
28     KM=KM-4
29     KE=KN
30     GO TO 10
31     6 KN=KM+KN
32     L=KN-KM+1
33     KM=0
34     KE=KN
35     10 LE=L
36     WRITE(6,1)
37     1  FORMAT(//)
38 C
39     WRITE(6,115) (J,J=LE,KE)
40 115  FORMAT(10X' LIQUID COMPOSITIONS,MOL FRACTIONS' /10X' TRAY #110,
41     +      9I11)
42     DO 12 I=1,NC
43     12 WRITE(6,116) (CNAME(K,I),K=1,2),(X(I,J),J=L,KN)
44 116  FORMAT (12X,2A4,1X,4F11.8)
45     DO 15 J=L,KN
46     AX(J)=0.
47     DO 15 I=1,NC
48     15 AX(J)=AX(J)+X(I,J)
49     WRITE (6,126) (AX(J),J=L,KN)
50 126  FORMAT(10X' TOTAL ' /4F11.8/)

```

```

51      IF (KM.LE.0) GO TO 31
52      IF ( 57-NPP-NC-5 ) 22,22,23
53      22 WRITE(6,154)
54      154 FORMAT (1H1)
55      NPP=0
56      23 NPP=NPP+NC+5
57      GO TO 2
58 C      PRINT REBOILER DUTY
59 C
60 C
61      31 QNT=ABS(Q(NT))
62      WRITE (6,220) QNT
63      220 FORMAT(//11X,19HREBOILER DUTY, BTUS, F16.1/)
64      RETURN
65      END

```

```

1      SUBROUTINE INPUT (*)
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4      1 Q(20),HL(20),HV(20),TA(20),F(16,20),
5      2 HF(20),PP(20),QG,DIST
6      COMMON /CONTRL/ NC, NT, LDDC, NID, NTM1, KTOP,
7      1 N1,N2,N3,N3N3,NT20
8      2 ,KTYPE
9      COMMON /FIX/ EK(15,20),A(20),B(20),C(20),D(20),
10     1 AX(20),BX(20)
11     COMMON /SSDATA/ NSS,NSTRAY(5),XW(5),XU(5),QSS(5)
12     COMMON /FFDATA/ NF,NAMEF(3,6),NFTRAY(6),ZF(16,6),ZK(15,6),
13     1 QFN(6),TF(6),PF(6),QQQ(6),QEX(6),TTF(6)
14     COMMON /PROP/ CHAME(2,15),XMW(15),RHO(15)
15     COMMON /DATA1/ NK,EKTABL(8,15),TK(8),
16     1 PA,PK(8),KCODE
17     COMMON /DATA2/ NH,HLTABL(8,15),HVTABL(8,15),TH(8),PH(8)
18     COMMON /DATA3/ BXX(6),XXL(15,6)
19 C
20 C      KTOP --- DESIGN VARIABLE
21 C      2 0 REBDILER
22 C      HEAT LOADS ARE IN MMBTU/HR
23 C
24 C      LDDC --- PRINT CODE
25 C      1 INPUT & OUTPUT
26 C      2 1 + TRIAL DATA
27 C      3 2 + ALL DATA
28 C      4 3 + ERROR PRINT OUT
29 C
30 C      KTYPE ---- COLUMN TYPE
31 C      1 -- SIMPLE ABSORPTION
32 C      2 -- INTERCOOLERS/SIDESTREAMS
33 C      3 -- STRIPPER
34 C      4 -- REBOILED ABSORBER
35 C
36     NOGD=0
37     READ (5,101) NT,NC,NF,NSS,NK,NH,NID,KTOP,LDDC,KTYPE
38 101  FORMAT (10I5)
39 C
40     READ(5,102) QR,DIST
41 102  FORMAT(8F10.0)
42     READ (5,102) TTOP, TBTOT, DTRAY, TMID
43     READ(5,102) PTOP, DPTWR
44 C
45     NTM1=NT-1
46 C
47     N1=NC+1
48     N2=N1+1
49     N3=N2+1
50     N3N3=N3*N3

```

```

51      NT20=NT*20
52 C
53      PP(1)=PTOP
54      DP=DPTWR/FLDQAT(NTM1)
55      DO 9 J=2,NT
56      9 PP(J)=PP(J-1)+DP
57 C
58      IF(NID.LE.0)NID=25
59      IF (LDOC.LE.0 .OR. LDOC.GE.5) LDOC=2
60 C
61      WRITE (6,105) NT,NC,NF,NSS,NK,NH,NID,KTOP,LDOC,KTYPE
62 105  FORMAT (//12X,'NUMBER OF TRAYS' I20, /12X,'NUMBER OF COMPONENTS' I04,
63         115, //12X,'NUMBER OF FEEDS' I20, /12X,'SIDESTREAM AND/OR HEAT TRAYS' I04,
64         2' I7, //12X,'NUMBER OF K-DATA POINTS' I12, /12X,'NUMBER OF H-DATA POINTS' I12,
65         3'DINTS' I12, //12X,'NUMBER OF ITERATIONS' I15,
66         4//12X,'QR CODE' I28, //
67         512X'DOCUMENTATION LEVEL' I16 ,//12X,'COLUMN TYPE' I24)
68 C
69      14 DO 16 J=1,NT
70      HF(J)=0.0
71      U(J)=0.0
72      W(J)=0.0
73      Q(J)=0.0
74      DO 15 I=1,NC
75      15 X(I,J)=0.0
76      DO 16 I=1,N1
77      16 F(I,J)=0.0
78 C
79 C
80      TA(1)=TTOP
81      TA(NT)=TBDT
82      NDTRAY = DTRAY
83      IF (NDTRAY.EQ.0) GO TO 41
84      NTMID=NDTRAY+1
85      IF(NTMID.GE.NT)GOTO41
86      DT=(TMID-TA(1))/FLDQAT(NTMID-1)
87      DO 31 J=2,NTMID
88      31 TA(J)=TA(J-1)+DT
89      DT=(TA(NT)-TMID)/FLDQAT(NT-NTMID)
90      NTMIDP=NTMID+1
91      DO 32 J=NTMIDP,NTM1
92      32 TA(J+1)=TA(J)+DT
93      GOTO50
94 C
95      41 DT=(TBDT-TTOP)/FLDQAT(NTM1)
96      DO 42 J=2,NTM1
97      42 TA(J)=TA(J-1)+DT
98 C
99      50 QG=QR*1.0E6
100     IF (QR.EQ.0.0) GO TO 60

```

```

101      WRITE (6,112) OR
102 112  FORMAT (/12X,'REBOILER DUTY, MMBTU/HR' F20.6)
103      Q(NT)=-QG
104 C
105      60 IF (DIST.GT.0.0) GO TO 62
106      WRITE (6,121)
107 121  FORMAT (///30X,'INVALID DISTILLATE RATE'///)
108      NDCO=1
109 C
110      62 WRITE (6,122) DIST
111 122  FORMAT (/12X,'OVERHEAD VAPOR PRODUCT, MOLS/HR' F10.3)
112 C
113      WRITE (6,123) TTOP,TBOT
114 123  FORMAT (/12X,'INPUT TEMPERATURES, DEG F' /
115      117X 'TOP TRAY' F12.1 / 17X 'BOTTOM TRAY' F9.1 )
116      IF (NDTRAY.EQ.0) GO TO 64
117      WRITE (6,124) TMID,NDTRAY
118 124  FORMAT (12X 'TEMPERATURE ESTIMATED AS' F8.1,2X'DEG F ON TRAY'I4)
119 C
120      64 WRITE (6,125) PTOP, DPTWR, PP(1), PP(NT)
121 125  FORMAT (/12X, 'INPUT PRESSURES, PSIA' / 17X'OVERHEAD'F18.4
122      1/17X 'TOWER DELTA P' F13.4/ 17X 'TOWER TOP' F17.4
123      2/17X 'TOWER BOTTOM' F14.4 )
124 C
125 C
126 C      READ GAS FEED IN FIRST
127 C      OIL FEED IN SECOND
128 C
129 C
130      DO 68 J=1,NF
131      READ (5,131) (NAMEF(I,J),I=1,3),NFTRAY(J),PF(J),TF(J),QFN(J),
132      1 QEX(J)
133 131  FORMAT (3A4,I8,4F10.0)
134      READ (5,102) (ZF(I,J),I=1,NC)
135      IF(QFN(J).NE.0.0)GOTO68
136      READ (5,102) (ZK(I,J),I=1,NC)
137 C
138      68 CONTINUE
139      IF(NSS.EQ.0)GOTO70
140      DO 69 J=1,NSS
141 69  READ (5,133) NSTRAY(J),XW(J),XU(J),QSS(J)
142 133  FORMAT (I5,5X,3F10.0)
143 C
144      70 CALL CDATA
145      CALL ZFEED (SUMFD)
146 C
147      IF(NSS.EQ.0)GOTO80
148      WRITE(6,4)
149 4    FORMAT(/////////)
150      WRITE(6,141)

```

```

151 141 FORMAT(1H1 12X 'SIDESTREAM AND HEAT TRAY DATA'// 17X 'TRAY NO'17X'V05
152      1APOR MOL/HR' 7X 'LIQUID MOL/HR' 7X 'HEAT OUT MMBTU/HR') 05
153      DO 79 N=1,NSS 05
154      79 WRITE (6,142) N,NSTRAY(N),XW(N),XU(N),QSS(N) 05
155      142 FORMAT (10X,I4,2X,I5,9X,F12.2,9X,F12.2,9X,F15.6) 05
156 C 05
157 C Q IS HEAT OUT FROM STAGE (+) 05
158      80 SUM=DIS 05
159      IF(NSS.EQ.0)GOTO90 05
160      DO 81 J=1,NSS 05
161      K=NSTRAY(J) 05
162      U(K)=XU(J) 05
163      W(K)=XW(J) 05
164      Q(K)=QSS(J)*1.0E6 05
165      81 SUM=SUM+U(K)+W(K) 05
166 C 05
167      90 IF(SUMFD-SUM .GT. 0.0)GOTO92 05
168      WRITE (6,145) 05
169      145 FORMAT (///30X 'BOTTOMS RATE IS INVALID') 05
170      NOGD=1 05
171 C 05
172      92 V(1)=DIS 05
173      V(NT)=0.8*(SUMFD-DIST) 05
174      XL(1)=0.9*F(N1,1) 05
175      XL(NT)=SUMFD-SUM 05
176      IF (NOGD.NE.0) RETURN 1 05
177 C 05
178      DV=(V(NT)-V(1))/FLOAT(NTM1) 05
179      DL=(XL(NT)-XL(1))/FLOAT(NTM1) 05
180      DO 93 J=2,NTM1 05
181      V(J)=V(J-1)+DV 05
182      93 XL(J)=XL(J-1)+DL 05
183      DO 94 J=1,NT 05
184      94 CALL KGEN (TA(J),EK(1,J),J) 05
185 C 05
186 C 05
187      IF (KTYPE.GT.2) GO TO 190 05
188 C 05
189 C W = VAPOR U = LIQUID 05
190      DO 99 I=1,NC 05
191      A(1)=0.0 05
192      B(1)=V(1)*(1.0-EK(I,1))-V(2)-F(N1,1) 05
193      C(1)=V(2)*EK(I,2) 05
194      D(1)=-F(I,1) 05
195      SUMJM1=F(N1,1)-DIST 05
196      SUMJ=F(N1,2)-W(2)-U(2)+F(N1,1)-DIST 05
197      DO 95 J=2,NTM1 05
198      A(J)=V(J)+SUMJM1 05
199      B(J)=-((V(J)+W(J))*EK(I,J)+V(J+1)+SUMJ+U(J)) 05
200      C(J)=V(J+1)*EK(I,J+1) 05

```

98

```

201      D(J)=-F(I,J)
202      SUMJM1=SUMJM1+F(N1,J)-W(J)-U(J)
203  95    SUMJ=SUMJ+F(N1,J+1)-W(J+1)-U(J+1)
204      A(NT)=V(NT)+XL(NT)-F(N1,NT)
205      B(NT)=-V(NT)*EK(I,NT)-XL(NT)
206      C(NT)=0.0
207      D(NT)=-F(N1,NT)
208      AX(1)=C(1)/B(1)
209      BX(1)=D(1)/B(1)
210      DO 96 J=2,NTM1
211  96    AX(J)=C(J)/(B(J)-A(J)*AX(J-1))
212      DO 97 J=2,NT
213  97    BX(J)=(D(J)-A(J)*BX(J-1))/(B(J)-A(J)*AX(J-1))
214      X(I,NT)=BX(NT)
215      IF( X(I,NT) .LE. 0.0 ) X(I,NT)= 1.0E-25
216      DO 98 K=1,NTM1
217      J=NT-K
218      X(I,J)=BX(J)-AX(J)*X(I,J+1)
219      IF ( X(I,J) .LE. 0.0 ) X(I,J) = 1.0E-25
220  98    CONTINUE
221  99    CONTINUE
222 C
223 C
224      GO TO 800
225 C
226  190  AC=0.0
227      ANTM1=NTM1
228      ANC=NC
229      ANT=0.0
230      IF (KTYPE.EQ.3) GO TO 300
231      DO 200 I=1,NC
232      DO 200 J=2,NTM1
233      X(I,1)=ZF(I,2)/ZF(N1,2)
234      AC=AC+(1./ANC)/2.
235      X(I,NT)=X(I,1)+(ZF(I,1)/ZF(N1,1))*AC
236      ANT=ANT+(1./ANTM1)/2.
237  200  X(I,J)=X(I,1)+ANT*(X(I,NT)-X(I,1))
238      XL(1)=ZF(N1,2)
239      XL(NT)=ZF(N1,2)+.3*ZF(N1,1)
240      ANT=0.0
241      DO 210 J=2,NTM1
242      ANT=ANT+1./ANTM1
243  210  XL(J)=XL(1)+ANT*(XL(NT)-XL(1))
244      DO 220 J=2,NT
245  220  V(J)=XL(J)+V(1)-XL(1)+W(J)+U(J)
246 C
247      GO TO 800
248 C
249  300  NCM1=NC-1
250      DO 310 I=1,NCM1

```



```

251      DO 310 J=1,NT
252 310  X(I,J)=XXL(I,2)/BXX(2)
253      DO 320 J=1,NT
254 320  X(NC,J)=0.0
255      XL(1)=BXX(2)
256      XL(NT)=.8*BXX(2)
257      ANT=0.0
258      DO 330 J=2,NTM1
259      ANT=ANT+(1./ANTM1)/2.
260 330  XL(J)=XL(1)+ANT*(XL(NT)-XL(1))
261      DO 340 J=2,NT
262 340  V(J)=XL(J)+V(1)-XL(1)+W(J)+U(J)
263 C
264 800  CONTINUE
265 C
266 C
267      RETURN
268      END
    
```

100

```

1      SUBROUTINE CDATA
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4      1 Q(20),HL(20),HV(20),TA(20),F(16,20),
5      2 HF(20),PP(20),QG,DIST
6      COMMON /CONTRL/ NC, NT, LDDC, NID, NTM1, KTOP,
7      1 N1,N2,N3,N3N3,NT20
8      COMMON /PROP/ CNAME(2,15),XMW(15),RHD(15)
9      COMMON /DATA1/ NK,EKTABL(8,15),TK(8),
10     1 PA,PK(8),KCODE
11     COMMON /DATA2/ NH,HLTABL(8,15),HVTABL(8,15),TH(8),PH(8)
12     COMMON /CDEF/ CK(8,15),DCK(7,15),CHV(6,15),
13     1 DCHV(5,15),CHL(6,15),DCHL(5,15),
14     2 PPA,KCODE
15 C
16     REAL T(20),AK(20,20),AHV(20,20),AHL(20,20)
17     EQUIVALENCE (AK(1,1),AHV(1,1))
18 C
19     WRITE (6,100)
20     100 FORMAT (1H1)
21 C
22     READ (5,101) ((CNAME(K,J),K=1,2),XMW(J),RHD(J),J=1,NC)
23     101 FORMAT (2A4,2X,2F10.0)
24     WRITE (6,102)
25     102 FORMAT (12X,'DATA ON COMPONENTS'// 18X,'NAME',17X,'MOL WT',8X,
26     1 'LBS/GAL' /)
27     WRITE (6,103) (J,(CNAME(K,J),K=1,2),XMW(J),RHD(J),J=1,NC)
28     103 FORMAT (10X,I6,2X,2A4,F18.3,F15.4)
29 C
30     21 READ (5,115) (TK(J),J=1,NK)
31     115 FORMAT (8F10.0)
32     READ (5,115) (PK(J),J=1,NK)
33     READ (5,115) ((EKTABL(K,J),K=1,8),J=1,NC)
34 C
35     WRITE (6,100)
36 C
37     41 WRITE (6,122) (TK(J),J=1,NK)
38     122 FORMAT (//12X 'MAIN COLUMN K-TABLE' //14X,'TEMPERATURE, F' 8F14.2)
39     WRITE (6,123) (PK(J),J=1,NK)
40     123 FORMAT ( 14X 'PRESSURE, PSIA ' 8F14.4)
41     WRITE (6,125)
42     125 FORMAT (/)
43     DO 43 J=1,NC
44     43 WRITE (6,124) (CNAME(K,J),K=1,2),(EKTABL(K,J),K=1,NK)
45     124 FORMAT (15X,2A4,6X,8F14.5)
46 C
47     DO 45 J=1,NC
48     DO 45 K=1,NK
49     45 EKTABL(K,J)=ALOG(EKTABL(K,J))
50 C

```

```

51 C          KCODE --- PRESSURE CORRECT K-DATA
52 C          1      K-DATA ALREADY CORRECTED
53 C          2      PRESSURE CORRECT K-DATA
54 C
55          PA=PK(1)
56      48 KCODE=1
57          NKM1=NK-1
58          DO 49 J=1,NKM1
59          IF (ABS(PK(J)-PK(J+1)).GT.0.001) GO TO 50
60      49 CONTINUE
61          KCODE = 2
62          WRITE (6,126)
63      126 FORMAT (//12X, 'K-DATA WILL BE PRESSURE CORRECTED TO THE TRAY PRESSURE'
64          'URE'/12X, ' USING THE K-DATA REFERENCE PRESSURE AS THE DATUM')
65 C
66      50 WRITE (6,100)
67 C
68          READ (5,127) JCODE,(TH(J),J=1,NH)
69      127 FORMAT (I1,F9.0,7F10.0)
70 C
71 C          JCODE --- UNITS OF ENTHALPY DATA
72 C          1      BTU/MOLE
73 C          2      BTU/LB
74 C
75          READ (5,115) (PH(K),K=1,NH)
76          READ (5,115) ((HVTABL(K,J),K=1,8),(HLTABL(K,J),K=1,8),J=1,NC)
77          GO TO (55,51),JCODE
78      51 DO 52 J=1,NC
79          DO 52 K=1,NH
80          HVTABL(K,J)=HVTABL(K,J)*XMW(J)
81      52 HLTABL(K,J)=HLTABL(K,J)*XMW(J)
82 C
83      55 WRITE (6,128) (TH(J),J=1,NH)
84      128 FORMAT (//12X 'ENTHALPY TABLE'// 14X 'TEMPERATURE, F' 8F14.2)
85          WRITE (6,129) (PH(J),J=1,NH)
86      129 FORMAT (14X 'PRESSURE, PSIA' 8F14.4)
87          WRITE (6,130)
88      130 FORMAT (10X, ' VAPOR, BTU/MOLE')
89          DO 56 J=1,NC
90      56 WRITE (6,131) (CNAME(K,J),K=1,2),(HVTABL(K,J),K=1,NH)
91      131 FORMAT (15X,2A4,6X,8F14.1)
92          WRITE (6,133)
93      133 FORMAT (10X, ' LIQUID, BTU/MOLE')
94          DO 57 J=1,NC
95      57 WRITE (6,131) (CNAME(K,J),K=1,2),(HLTABL(K,J),K=1,NH)
96 C
97          PPA=PA
98          MCODE=KCODE
99          KCODE=0
100         DT=AMAX1((TA(NT)-T(1))/2.0,50.)

```

```

101      T(1)=TA(1)-DT
102      T(20)=TA(NT)+DT
103      DT=(T(20)-T(1))/19.
104      DO 62 J=2,19
105  62   T(J)=T(J-1)+DT
106      DO 63 K=1,20
107  63   CALL KGEN(T(K),AK(1,K),K)
108      DO 65 J=2,20
109      JM1=J-1
110      DO 65 K=1,JM1
111      HOLD=AK(J,K)
112      AK(J,K)=AK(K,J)
113  65   AK(K,J)=HOLD
114      NPWR=4
115      DO 66 J=1,NC
116      HOLD=1.0
117  66   HOLD=FITIT(T,AK(1,J),20,NPWR,CK(1,J),1,HOLD)
118      KCODE=MCODE
119      NPWRM1=NPWR-1
120      DO 67 J=1,NC
121      DCK(1,J)=CK(1,J)-1.0
122      DO 67 K=2,NPWRM1
123  67   DCK(K,J)=CK(K+1,J)*FLOAT(K-1)
124      DO 68 K=1,20
125  68   CALL HGEN(T(K),AHV(1,K),AHL(1,K))
126      DO 71 J=2,20
127      JM1=J-1
128      DO 71 K=1,JM1
129      HOLD=AHV(J,K)
130      AHV(J,K)=AHV(K,J)
131      AHV(K,J)=HOLD
132      HOLD=AHL(J,K)
133      AHL(J,K)=AHL(K,J)
134  71   AHL(K,J)=HOLD
135      NPWR=3
136      DO 73 J=1,NC
137      HOLD=1.0
138      HOLD=FITIT(T,AHV(1,J),20,NPWR,CHV(1,J),1,HOLD)
139      HOLD=1.0
140  73   HOLD=FITIT(T,AHL(1,J),20,NPWR,CHL(1,J),1,HOLD)
141      NPWRM1=NPWR-1
142      DO 75 J=1,NC
143      DCHV(1,J)=CHV(1,J)-1.0
144      DCHL(1,J)=CHL(1,J)-1.0
145      DO 75 K=2,NPWRM1
146      DCHV(K,J)=CHV(K+1,J)*FLOAT(K-1)
147  75   DCHL(K,J)=CHL(K+1,J)*FLOAT(K-1)
148 C
149      RETURN
150      END

```

```

1      SUBROUTINE ZFEED ( SUMT )
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4      1 Q(20),HL(20),HV(20),TA(20),F(16,20),
5      2 HF(20),PP(20),QG,DIST
6      COMMON /CONTRL/ NC, NT, LDDC, NID, NTM1, KTOP,
7      1 N1,N2,N3,N3N3,NT20
8      COMMON /PROPF/ CNAME(2,15),XMW(15),RHO(15)
9      COMMON /FFDATA/ NF,NAMEF(3,6),NFTRAY(6),ZF(16,6),ZK(15,6),
10     1 QFN(6),TF(6),PF(6),QQQ(6),QEX(6),TTF(6)
11     COMMON /DATA3/ BXX(6),XXL(15,6)
12 C
13     REAL QFG(6),QFC(6),AX(6),BX(6),QV(6),QL(6),
14     1 XLL(15),VV(15),YK(15)
15 C
16     WRITE (6,100)
17 100 FORMAT (1H1)
18 C
19     WRITE (6,111) (J,J=1,NF)
20 111 FORMAT (//15X,15HINPUT FEED DATA/17X,7HFEED NO,14X,6I14)
21     WRITE (6,112) ((NAMEF(I,J),I=1,3),J=1,NF)
22 112 FORMAT (17X,9HFEED NAME,21X,6(3A4,2X))
23     WRITE (6,116) (NFTRAY(J),J=1,NF)
24 116 FORMAT (17X,19HENTERING AT TRAY NO,2X,6I14/)
25 C
26     DO 10 N=1,NF
27     ZF(N1,N)=0.0
28     DO 10 I=1,NC
29     10 ZF(N1,N)=ZF(N1,N)+ZF(I,N)
30 C
31     WRITE (6,117)
32 117 FORMAT (17X,19HCOMPOSITION,MOLS/HR)
33 C
34 C
35 C     STEAM MUST BE LAST COMPONENT GIVEN
36 C
37 C
38     DO 19 I=1,NC
39     19 WRITE (6,120) (CNAME(K,I),K=1,2),(ZF(I,K),K=1,NF)
40 120 FORMAT (18X,2A4,14X,6F14.2)
41     WRITE (6,121) (ZF(N1,N),N=1,NF)
42 121 FORMAT (17X,5HTOTAL,18X,6F14.2)
43 C
44 C     FEED HEAT CONTENT NOT GIVEN IF QFN = 0.0
45 C
46     SUMT=0.0
47     DO 40 N=1,NF
48     IF (QFN(N).NE.0.0) GO TO 21
49 C
50 C     FEED ENTHALPY IS NOT GIVEN AND MUST BE CALCULATED.

```

```

51 C
52 CALL FLASH (ZF(1,N),ZK(1,N),TF(N),VV,XLL,QV(N),QL(N),QFN(N))
53 C
54 QFG(N)=0.
55 QFC(N)=QFN(N)
56 GO TO 22
57 C
58 21 QFN(N)=QFN(N)*1.0E6
59 QFG(N)=QFN(N)
60 QFC(N)=0.
61 C
62 C ADIABATIC FLASH ON FEEDS TO DETERMINE VAPORIZATION AT ENTRY
63 C
64 22 K=NFTRAY(N)
65 QEX(N)=QEX(N)*1.0E6
66 QQQ(N)=QFN(N)+QEX(N)
67 C
68 C QQQ(N) IS TOTAL FEED ENTHALPY AT ENTRY TO TOWER.
69 C
70 TTT=TA(1)-100.
71 TBIG=TA(NT)+100.
72 TDL=QQQ(N)*1.0E-4
73 C
74 23 CALL KGEN (TTT,YK,K)
75 CALL FLASH (ZF(1,N),YK,TTT,VV,XLL,QV(N),QL(N),QQ)
76 C WRITE (6,200) QQ,QQQ(N),TDL,TTT
77 C 200 FORMAT (10X,4E25.7)
78 C
79 IF ( WAYA(QQ,QQQ(N),TDL,TTT,TBIG,2) ) 23,27,26
80 C
81 26 WRITE (6,122) N
82 122 FORMAT (// 15X 'FEED FLASH FAILED TO CONVERGE FOR FEED #' I3 //)
83 C
84 27 QV(N)=QV(N)/QQQ(N)*QQ
85 QL(N)=QL(N)/QQQ(N)*QQ
86 28 TTF(N)=TTT
87 AX(N)=0.0
88 BX(N)=0.0
89 DO 29 I=1,NC
90 XXL(I,N)=XLL(I)
91 AX(N)=AX(N)+VV(I)
92 29 BX(N)=BX(N)+XLL(I)
93 BXX(N)=BX(N)
94 C
95 IF (K=2) 34,38,32
96 32 IF (K=NTM1) 38,38,34
97 34 AXBX=ZF(N1,N)
98 QFK=F(N1,K)*HF(K)
99 DO 37 I=1,NC
100 37 F(I,K)=F(I,K)+ ZF(I,N)

```

```

101      F(N1,K)=F(N1,K)+AXBX
102      IF(F(N1,K).NE.0.0) HF(K)=(QFK+QQ)/F(N1,K)
103      GO TO 40
104 C
105      38 QFKM1=F(N1,K-1)*HF(K-1)
106      QFK=F(N1,K)*HF(K)
107      DO 39 I=1,NC
108      F(I,K-1)=F(I,K-1)+VV(I)
109      39 F(I,K)=F(I,K)+XLL(I)
110      F(N1,K-1)=F(N1,K-1)+AX(N)
111      F(N1,K)=F(N1,K)+BX(N)
112      IF (F(N1,K-1).NE.0.0) HF(K-1)=(QFKM1+QV(N))/F(N1,K-1)
113      IF (F(N1,K).NE.0.0) HF(K)=(QFK+QL(N))/F(N1,K)
114      40 SUMT=SUMT+ZF(N1,N)
115 C
116 C
117      WRITE (6,123)(TF(N),N=1,NF)
118      123 FORMAT (/17X 'TEMPERATURE, F' 9X 6F14.1)
119      WRITE (6,124)(PF(N),N=1,NF)
120      124 FORMAT (17X 'PRESSURE, PSIA' 9X 6F14.4)
121      WRITE (6,125)(QFC(N),N=1,NF)
122      125 FORMAT (/17X 'HEAT CONTENT, BTUS (CALC)' F12.0,5F14.0)
123      WRITE (6,126) (QFG(N),N=1,NF)
124      126 FORMAT ( 17X 'HEAT CONTENT, BTUS (GIVEN)' F11.0,5F14.0)
125      WRITE (6,127) (QEX(N),N=1,NF)
126      127 FORMAT (/17X 'ADDITIONAL HEAT, BTUS' 2X 6F14.0)
127      WRITE (6,128) (QQQ(N),N=1,NF)
128      128 FORMAT (/17X 'HEAT CONTENT, BTUS (INLET)' F11.0,5F14.0)
129      WRITE (6,129) (TTF(N),N=1,NF)
130      129 FORMAT (17X 'TEMPERATURE, F (INLET)' 1X 6F14.2)
131      WRITE (6,130) (AX(N),N=1,NF)
132      130 FORMAT (/17X 'VAPOR, MOLS (INLET)' 4X 6F14.3)
133      WRITE (6,131) (BX(N),N=1,NF)
134      131 FORMAT (17X 'LIQUID, MOLS (INLET)' 3X 6F14.3)
135 C
136      RETURN
137      END

```

```

1      SUBROUTINE FLASH (XX,ZK,TT,XV,XL,QV,QL,QQT)
2 C
3      COMMON /CONTRL/ NC, NT, LDDC, NID, NTM1, KTOP,
4      1      N1,N2,N3,N3N3,NT20
5 C
6      REAL      XX(1),ZK(1),XV(1),XL(1),HVAP(15),HLIQ(15)
7 C
8 C          SUM      TOTAL FEED
9 C          SUMX     TOTAL LIQUID
10 C         SUMY     TOTAL VAPOR
11 C
12      SUM=0.0
13      SUMX=0.
14      SUMY=0.
15      DO 1 I=1,NC
16      IF(XX(I).EQ.0.0)GOTO1
17      SUM=SUM+XX(I)
18      SUMY=SUMY+XX(I)*ZK(I)
19      SUMX=SUMX+XX(I)/ZK(I)
20      1 CONTINUE
21 C      WRITE (6,310) SUMX,SUMY,SUM
22 C 310 FORMAT ('1' /3E25.7)
23      IF (SUM -SUMY)4,2,2
24 C
25 C      SUBCOOLED LIQUID
26 C
27      2 DO 3 I=1,NC
28      XL(I)=XX(I)
29      3 XV(I)=0.
30      SUMX=SUM
31      SUMY=0.0
32 C      WRITE (6,300)
33 C 300 FORMAT ('////' SUBCOOLED LIQUID')
34 C      WRITE (6,20) (XX(J),ZK(J),XV(J),XL(J),J=1,NC)
35 C 20  FORMAT (4E20.6)
36      GO TO 30
37      4 IF (SUM -SUMX)7,5,5
38 C
39 C      SUPERHEATED VAPOR
40 C
41      5 DO 6 I=1,NC
42      XV(I)=XX(I)
43      6 XL(I)=0.
44      SUMY=SUM
45      SUMX=0.0
46 C      WRITE (6,301)
47 C 301 FORMAT ('////' SUPERHEATED VAPOR')
48 C      WRITE (6,20) (XX(J),ZK(J),XV(J),XL(J),J=1,NC)
49      GO TO 30
50 C

```


107

```

51 C      TWO-PHASE SYSTEM
52 C
53       7 XLF=0.9999999
54       XLF%=0.0000001
55 C
56       8 XVF=1.0-XLF
57         SUMY=SUM*XVF
58         SUMX=SUM*XLF
59         YTOT=0.0
60         XTOT=0.0
61         DO 9 I=1,NC
62           FAC=XLF+XVF*ZK(I)
63           XV(I)=XX(I)/SUM *ZK(I)/FAC
64           YTDT=YTDT+XV(I)
65           XL(I)=XX(I)/SUM /FAC
66       9 XTDT=XTDT+XL(I)
67 C
68 C  13 WRITE (6,200)
69 C 200 FORMAT (////' MIXED PHASE!')
70 C      WRITE (6,410) SUMX,SUMY,SUM ,YTDT,XTDT
71 C 410 FORMAT (5E25.7)
72 C      WRITE (6,20) (XX(J),ZK(J),XV(J),XL(J),J=1,NC)
73       IF ( WAYA ( (YTDT-XTDT),0.0,0.000005,XLF,XLF$,1) ) 8,22,18
74 C
75       18 WRITE (6,100)
76      100 FORMAT (//5X 'FEED FLASH CALCULATION FAILED TO CONVERGE'
77      + /5X 'LIQUID FRACTION EITHER > 0.999999 OR < 0.000001' / 5X 'CALCUO
78      2LATION CONTINUING' //)
79 C
80       22 DO 24 I=1,NC
81         XL(I)=XL(I)*SUMX
82       24 XV(I)=XV(I)*SUMY
83 C
84       30 QV=0.0
85         QL=0.0
86         CALL HGEN (TT,HVAP,HLIQ)
87         DO 32 I=1,NC
88           QV=QV+HVAP(I)*XV(I)
89       32 QL=QL+HLIQ(I)*XL(I)
90         QQT=QV+QL
91 C
92         RETURN
93         END

```

108

```

1      SUBROUTINE MPLYM (A,B,C,N)
2 C
3 C      MATRIX MULTIPLICATION
4 C      A*B=C
5 C      N=ACTUAL SIZE OF MATRIX
6 C
7      REAL          A(20,20),B(20,20),C(20,20)
8 C
9      M=N
10     5  DO 10 J=1,M
11         DO 20 I=1,N
12             C(I,J)=0.0
13             DO 30 K=1,N
14                 C(I,J)=C(I,J)+A(I,K)*B(K,J)
15             30 CONTINUE
16         20 CONTINUE
17     10 CONTINUE
18 C
19     RETURN
20 C
21     ENTRY MPLYV (A,B,C,N)
22     M=1
23     GO TO 5
24 C
25     END

```

1		SUBROUTINE ZERO(A,K)	109	10
2		REAL A(1)		10
3		DO 10 J=1,K		10
4	10	A(J)=0.0		10
5		RETURN		10
6		END		10

110

```
1 SUBROUTINE EQUAL (A,B,M)
2 C
3 C MATRIX A = MATRIX B, WHERE MATRIX B IS GIVEN
4 REAL A(20,1),B(20,1)
5 C
6 N=M
7 5 DO 10 J=1,N
8 DO 10 I=1,M
9 10 A(I,J)=B(I,J)
10 RETURN
11 C
12 ENTRY EQUALV (A,B,M)
13 N=1
14 GO TO 5
15 C
16 END
```

```

1      SUBROUTINE MATRIX (*,*)
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4      1          Q(20),HL(20),HV(20),TA(20),F(16,20),
5      2          HF(20),PP(20),QG,DIST
6      COMMON /CNTRL/ NC,NT,LDDC,NID,NTM1,KTOP,
7      1          N1,N2,N3,N3N3,NT20
8      COMMON /DATA/ WK(15,20),DK(15,20),HVV(15,20),
9      1          HLL(15,20),DHV(15,20),DHL(15,20),
10     2          Y(15,20)
11     COMMON /FIX/ A(20,20),B(20,20,15),C(20,20,15),
12     1          E(20,20),AF(20,20),
13     2          AJ(20,20),RHS(20,18),
14     3          G(20,20),AL(20,20),AM(20,20)
15 C
16     REAL          CXL(20),CTA(20),CV(20)
17 C
18     DATA          DVMAX/0.001/,DLMAX/0.001/,DTMAX/0.05/
19 C
20 C
21     WRITE (6,2)
22     CALL MWRITE
23     2          FORMAT (1H1)
24     4          FORMAT (/)
25     NDDNE=0
26     DD 399 NIT=1,NID
27 C
28     DO 10 I=1,NT
29     SUM=0.0
30     DO 11 J=1,NC
31     11        SUM=SUM+X(J,I)
32     DO 12 J=1,NC
33     12        X(J,I)=X(J,I)/SUM
34     10        CONTINUE
35     CALL GET
36 C
37     CALL INI
38     CALL ENTHAL
39     CALL COMP
40     CALL SUBST
41     GO TO (501,501,501,502),LDDC
42     502        CONTINUE
43 C
44 C      THE ERRORS ON EACH STAGE ARE PRINTED
45     WRITE(6,2)
46     WRITE(6,4)
47 C
48     DO 80 I=1,NT
49     80        WRITE(6,402) I,RHS(I,N3),RHS(I,N2),RHS(I,N1)
50     402        FORMAT(//10X' UNSCALED COMPUTED CORRECTIONS,DL=DV=DT,ON STAGE'

```

112

```

51      1 I5//10X(1P3E18.5))
52 C
53 C   CALCULATE CORRECTIONS FOR EACH STAGE
54 C
55      DO 135 I=1,NT
56      CTA(I)=TA(I)+RHS(I,N1)
57      CXL(I)=XL(I)+RHS(I,N3)
58      CV(I)=V(I)+RHS(I,N2)
59 135  CONTINUE
60      IF(LDDC.GT.2) WRITE(6,2)
61 C
62 C   PRINT CORRECTIONS FOR EACH STAGE
63 C
64      WRITE(6,4)
65      DO 136 I=1,NT
66 136  WRITE(6,403) I,CXL(I),CV(I),CTA(I)
67 403  FORMAT(/10X! CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE'
68      1 I5//10X(1P3E18.5))
69 C
70 501  CONTINUE
71 C
72 C   CHECK FOR CONVERGENCE
73 C      (1) MAXIMUM ABS(DV),LT,DVMAX  V= VAPOR FLOW
74 C      (2) MAXIMUM ABS(DL),LT,DLMAX  L= LIQUID FLOW
75 C      (3) MAXIMUM ABS(DT),LT,DTMAX  T= TEMPERATURE
76 C   SCALE CORRECTIONS IF TOO LARGE ----CAUSE FOR SCALING
77 C      (1) DV.GT.0.20*V
78 C      (2) DL.GT.0.20*L
79 C      (3) DT.GT.20.0
80 C
81      DV=0.0
82      DL=0.0
83      DT=0.0
84      SUMSQ=0.0
85 C
86      DO 145 M=1,NT
87      SUMSQ=SUMSQ+RHS(M,N1)**2
88      DV=AMAX1(ABS(RHS(M,N2))/V(M),DV)
89      DL=AMAX1(ABS(RHS(M,N3))/XL(M),DL)
90 145  DT=AMAX1(ABS(RHS(M,N1)),DT)
91 C
92      IF(DV.LT.DVMAX.AND.DL.LT.DLMAX.AND.DT.LT.DTMAX) NDONE=1
93 C
94 505  DO 150 I=1,NT
95      DO 150 J=1,NC
96      CX=RHS(I,J)-X(J,I)
97      IF(RHS(I,J).LT.1.0E-6) GO TO 506
98      IF(RHS(I,J).LE.0.0.OR.RHS(I,J).GE.1.0) GO TO 509
99      GO TO 150
100 506  IF(RHS(I,J).LE.0.0) RHS(I,J)=X(J,I)/2.0

```

113

```
101 150 CONTINUE
102      GO TO 507
103 509 NDONE=0
104      DO 155 I=1,NT
105          DO 155 J=1,NC
106              CX=RHS(I,J)-X(J,I)
107              RHS(I,J)=X(J,I)+SIGN(CX/2.,CX)
108 155 CONTINUE
109      GO TO 505
110 C
111 507 DO 158 I=1,NT
112      IF(ABS(RHS(I,N3)).GT.0.20*XL(I).OR.ABS(RHS(I,N2)).
113      1GT.0.20*V(I)) GO TO 508
114 158 CONTINUE
115      GO TO 510
116 508 NDONE=0
117      DO 160 I=1,NT
118          RHS(I,N3)=RHS(I,N3)*.5
119          RHS(I,N2)=RHS(I,N2)*.5
120 160 CONTINUE
121      GO TO 507
122 C
123 510 DO 165 I=1,NT
124      IF(ABS(RHS(I,N1)).GT.20.0) GO TO 511
125 165 CONTINUE
126      GO TO 512
127 511 NDONE=0
128 C
129      DO 168 I=1,NT
130          RHS(I,N1)=RHS(I,N1)*.5
131 168 CONTINUE
132      GO TO 510
133 512 DO 170 I=1,NT
134          DO 171 J=1,NC
135              X(J,I)=RHS(I,J)
136              XL(I)=XL(I)+RHS(I,N3)
137              V(I)=V(I)+RHS(I,N2)
138              TA(I)=TA(I)+RHS(I,N1)
139 170 CONTINUE
140 C
141      IF(LDDC.EQ.1) GO TO 513
142      IF(LDDC.GT.2) WRITE(6,2)
143      WRITE (6,404) NIT,SUMSQ,DT,DV,DL
144      WRITE(6,4)
145 404  FORMAT(//10X' ITERATION NUMBER' I5//
146      112X' SUM DT SQUARED' F20.6/
147      212X' DT MAX' F28.6/12X' MAX DV/V'F26.6/
148      312X' MAX DL/L'F26.6)
149      IF(LDDC.EQ.2.AND.MOD(NIT,15).EQ.0) WRITE(6,2)
150 C
```

114

```
151      GO TO (513,513,514,514), LDDC 1
152 514  CALL MWRITE 1
153 513  IF(NDDONE.NE.0) GO TO 515 1
154 C 1
155 399  CONTINUE 1
156 C 1
157      GO TO 515 1
158 C 1
159 515  IF(NDDONE.NE.0) GO TO 516 1
160      WRITE (6,405) 1
161 405  FORMAT(///20X! NO CLOSURE OBTAINED ON PROBLEM!// 1
162      120X! FOR SPECIFIED NUMBER OF TRIALS!///) 1
163      WRITE (6,2) 1
164      CALL MWRITE 1
165      RETURN 2 1
166 C 1
167 516  GO TO (600,600,700,700), LDDC 1
168 600  WRITE (6,2) 1
169      CALL MWRITE 1
170 C 1
171 700  RETURN 1
172      END 1
```


115

```

1      SUBROUTINE INI
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4      1 Q(20),HL(20),HV(20),TA(20),F(16,20),
5      2 HF(20),PP(20),QG,DIST
6      COMMON /CONTRL/ NC,NT,LDDC,NID,NTM1,KTOP,
7      1 N1,N2,N3,N3N3,NT20
8      COMMON /DATA/ WK(15,20),DK(15,20),HVV(15,20),
9      1 HLL(15,20),DHV(15,20),DHL(15,20),
10     2 Y(15,20)
11     COMMON /FIX/ A(20,20),B(20,20,15),C(20,20,15),
12     1 E(20,20),AF(20,20),
13     2 AJ(20,20),RHS(20,18),
14     3 G(20,20),AL(20,20),AM(20,20)
15     REAL SM(20,20),SV(400),
16     + AK(20,20),D(20,20)
17 C
18     EQUIVALENCE (SM(1,1),SV(1)),
19     + (A(1,1),AK(1,1),D(1,1))
20 C
21 C DEVELOP OVERALL MATERIAL BALANCE ENTRIES ---- BLOCK N3
22 C
23 C AJ MATRIX IS SET EQUAL TO ZERO AND THEN THE
24 C NON-ZERO TERMS ARE COMPUTED
25 C
26     CALL ZERO(RHS,360)
27     CALL ZERO(AJ,NT20)
28 C
29     DO 10 I=1,NTM1
30     AJ(I,I)=-1.
31     AJ(I,I+1)=1.
32 10 CONTINUE
33     AJ(NT,NT)=-1.
34 C
35 C AK MATRIX IS SET EQUAL TO ZERO AND THEN THE
36 C NON-ZERO TERMS ARE COMPUTED
37     CALL ZERO(AK,NT20)
38     AK(1,1)=-1.
39     DO 20 I=2,NT
40     AK(I,I-1)=1.
41     AK(I,I)=-1.
42 20 CONTINUE
43 C
44 C THE RIGHT HAND SIDE OF THE MATERIAL BALANCE IS DEVELOPED
45 C
46     RHS(1,N3)=XL(1)+U(1)+V(1)+W(1)-F(NC+1,1)-V(2)
47     DO 30 I=2,NTM1
48     RHS(I,N3)=XL(I)+U(I)+V(I)+W(I)-F(NC+1,I)-XL(I-1)-V(I+1)
49 30 CONTINUE
50     RHS(NT,N3)=XL(NT)+U(NT)+V(NT)+W(NT)-F(NC+1,NT)-XL(NTM1)

```

```

51 C
52 C GENERATE RHS OF SUM EQUATION
53 DO 31 I=1,NT
54 RHS(I,N2)=1.
55 31 CONTINUE
56 C
57 C INVERT AK
58 L=0
59 DO 34 N=1,NT
60 DO 33 M=1,NT
61 L=L+1
62 SV(L)=AK(M,N)
63 33 CONTINUE
64 34 CONTINUE
65 C
66 C MATRIX AK IS INVERTED
67 C
68 CALL MINV(SV,NT,DETRM,AK(1,1),AK(1,2))
69 C
70 L=0
71 DO 38 N=1,NT
72 DO 37 M=1,NT
73 L=L+1
74 AK(M,N)=SV(L)
75 37 CONTINUE
76 38 CONTINUE
77 C
78 C AK AND AJ ARE MULTIPLIED TOGETHER ALONG WITH ASSOCIATED
79 C RHS FOR MATERIAL BALANCE EQUATION
80 C
81 CALL MPLYM(AK,AJ,SM,NT)
82 CALL EQUAL(AJ,SM,NT)
83 CALL MPLYV(AK,RHS(1,N3),SV,NT)
84 CALL EQUALV(RHS(1,N3),SV,NT)
85 C
86 C GENERATE C PART OF COMPONENT MATERIAL
87 C BALANCE WHICH IS ORDERED COMPONENT WISE
88 C
89 C SET C MATRIX EQUAL TO ZERO FOR COMPONENT
90 C J AND GENERATE NON-ZERO TERMS
91 C
92 DO 53 J=1,NC
93 CALL ZERO (C(1,1,J),NT20)
94 DO 41 I=1,NTM1
95 C(I,I,J)=WK(J,I)*X(J,I)
96 C(I,I+1,J)=-WK(J,I+1)*X(J,I+1)
97 41 CONTINUE
98 C(NT,NT,J)=WK(J,NT)*X(J,NT)
99 C
100 C GENERATE D MATRIX

```

117

```

101 C ----- ONLY NEEDED AT THIS TIME
102 C TO MODIFY C MATRIX AND ASSOCIATED RHS
103 C
104 CALL ZERO (D,NT20)
105 C
106 D(1,1)=X(J,1)
107 DO 42 I=2,NT
108 D(I,I-1)=-X(J,I-1)
109 D(I,I)=X(J,I)
110 42 CONTINUE
111 C
112 C GENERATE RHS FOR EACH COMPONENT
113 C
114 DO 45 I=1,NT
115 RHS(I,J)=F(J,I)
116 45 CONTINUE
117 C
118 C MULTIPLY D * RHS(=,N3) AND
119 C SUBTRACT FROM RHS(I,J)
120 C
121 DO 48 I=1,NT
122 DO 48 K=1,NT
123 RHS(I,J)=RHS(I,J)-D(I,K)*RHS(K,N3)
124 48 CONTINUE
125 C
126 C MULTIPLY D * AJ AND SUBTRACT FROM C
127 C
128 CALL MPLYM (D,AJ,SM,NT)
129 C
130 DO 50 I=1,NT
131 DO 50 K=1,NT
132 C(I,K,J)=C(I,K,J)-SM(I,K)
133 50 CONTINUE
134 C
135 53 CONTINUE
136 C
137 RETURN
138 END

```

118

```

1      SUBROUTINE ENTHAL
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4 1      Q(20),HL(20),HV(20),TA(20),F(16,20),
5 2      HF(20),PP(20),QG,DIST
6      COMMON /CONTRL/ NC,NT,LDBC,NID,NTM1,KTOP,
7 1      N1,N2,N3,N3N3,NT20
8      COMMON /DATA/ WK(15,20),DK(15,20),HVV(15,20),
9 1      HLL(15,20),DHV(15,20),DHL(15,20),
10 2      Y(15,20)
11     COMMON /FIX/ A(20,20),B(20,20,15),C(20,20,15),
12 1      E(20,20),AF(20,20),
13 2      AJ(20,20),RHS(20,18),
14 3      G(20,20),AL(20,20),AM(20,20)
15     REAL SM(20,20),SV(400),H(20,20)
16 C
17     EQUIVALENCE (SM(1,1),SV(1)),
18 +              (A(1,1),H(1,1))
19 C
20     CALL ZERD (AF,400)
21     CALL ZERD (G,400)
22 C
23 C     GENERATE AF,G,H,AND RHS(-,N1)
24 C
25 C
26 C     GENERATE AF ENTRIES
27 C
28     DO 64 J=1,NC
29 C
30     AF(1,1)=AF(1,1)+(XL(1)+U(1))*X(J,1)*DHL(J,1)
31 1+(V(1)+W(1))*(WK(J,1)*DHV(J,1)+HVV(J,1)*DK(J,1))*X(J,1)
32     AF(1,2)=AF(1,2)-(V(2)*X(J,2))*(WK(J,2)*
33 1DHV(J,2)+HVV(J,2)*DK(J,2))
34     DO 61 I=2,NTM1
35     AF(I,I-1)=AF(I,I-1)-(XL(I-1)*X(J,I-1)*DHL(J,I-1))
36     AF(I,I)=AF(I,I)+(XL(I)+U(I))*X(J,I)*DHL(J,I)
37 1+(V(I)+W(I))*(WK(J,I)*DHV(J,I)+HVV(J,I)*DK(J,I))*X(J,I)
38     AF(I,I+1)=AF(I,I+1)-(V(I+1)*X(J,I+1))*
39 1(WK(J,I+1)*DHV(J,I+1)+HVV(J,I+1)*DK(J,I+1))
40 61 CONTINUE
41     AF(NT,NTM1)=AF(NT,NTM1)-(XL(NTM1)*X(J,NTM1)*DHL(J,NTM1))
42     AF(NT,NT)=AF(NT,NT)+(XL(NT)+U(NT))*X(J,NT)*DHL(J,NT)
43 1+(V(NT)+W(NT))*(WK(J,NT)*DHV(J,NT)+HVV(J,NT)*DK(J,NT))*X(J,NT)
44 64 CONTINUE
45 C
46 C
47 C     GENERATE G ENTRIES
48 C
49     DO 65 I=1,NTM1
50     G(I,I)=HV(I)

```

119

```

51      G(I,I+1)=-HV(I+1)
52      65  CONTINUE
53      G(NT,NT)=HV(NT)
54      C
55      C  GENERATE H ENTRIES
56      C
57      CALL ZERO (H,NT20)
58      H(1,1)=HL(1)
59      DO 72 I=2,NT
60      H(I,I-1)=-HL(I-1)
61      H(I,I)=HL(I)
62      72  CONTINUE
63      C
64      DO 74 I=1,NT
65      74  RHS(I,N1)=-Q(I)+F(N1,I)*HF(I)
66      C
67      C  MULTIPLY H BY AJ AND SUBTRACT FROM G
68      C
69      DO 76 I=1,NT
70      DO 76 L=1,NT
71      DO 75 K=1,NT
72      75  G(I,L)=G(I,L)-H(I,K)*AJ(K,L)
73      C
74      C  MULTIPLY H BY RHS(I,N3) AND SUBTRACT FROM RHS(I,N1)
75      C
76      RHS(I,N1)=RHS(I,N1)-H(I,L)*RHS(L,N3)
77      76  CONTINUE
78      C
79      C
80      C
81      RETURN
82      END

```

120

```

1      SUBROUTINE COMP
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4      1 Q(20),HL(20),HV(20),TA(20),F(16,20),
5      2 HF(20),PP(20),QG,DIST
6      COMMON /CONTRL/ NC,NT,LDDC,NID,NTM1,KTOP,
7      1 N1,N2,N3,N3N3,NT20
8      COMMON /DATA/ WK(15,20),DK(15,20),HVV(15,20),
9      1 HLL(15,20),DHV(15,20),DHL(15,20),
10     2 Y(15,20)
11     COMMON /FIX/ A(20,20),B(20,20,15),C(20,20,15),
12     1 E(20,20),AF(20,20),
13     2 AJ(20,20),RHS(20,18),
14     3 G(20,20),AL(20,20),AM(20,20)
15     REAL SM(20,20),SV(400)
16 C
17     EQUIVALENCE (SM(1,1),SV(1))
18 C
19 C     GENERATE COMPONENT BY COMPONENT A,B,E,AND I
20 C     I IS NOT ACTUALLY GENERATED SINCE IT IS THE
21 C     COMPONENTIAL ENTRIES FOR THE SUM EQUATION
22 C
23 C     COMPUTE INVERSE OF A AND MULTIPLY TOP ROW BY IT
24 C
25     CALL ZERO (AL,400)
26     CALL ZERO (AM,400)
27 C
28     DO 150 J=1,NC
29 C
30 C     F + G ARE ADJUSTED AS A RESULT OF E ELIMINATION
31 C     L AND M ARE ADJUSTED BY I ELIMINATION
32 C
33     CALL ZERO (A,NT20)
34     CALL ZERO (B(1,1,J),NT20)
35     CALL ZERO (E,NT20)
36 C
37     A(1,1)=(V(1)+W(1))*WK(J,1)+XL(1)+U(1)
38     A(1,2)=-V(2)*WK(J,2)
39     E(1,1)=(V(1)+W(1))*WK(J,1)*HVV(J,1)+
40     1(XL(1)+U(1))*HLL(J,1)
41     E(1,2)=-V(2)*WK(J,2)*HVV(J,2)
42     DO 82 I=2,NTM1
43     A(I,I-1)=-XL(I-1)
44     A(I,I)=(V(I)+W(I))*WK(J,I)+XL(I)+U(I)
45     A(I,I+1)=-V(I+1)*WK(J,I+1)
46 C
47     E(I,I-1)=-XL(I-1)*HLL(J,I-1)
48     E(I,I)=(V(I)+W(I))*WK(J,I)*HVV(J,I)+
49     1(XL(I)+U(I))*HLL(J,I)
50     E(I,I+1)=-V(I+1)*WK(J,I+1)*HVV(J,I+1)

```

```

51 82 CONTINUE
52 A(NT,NTM1)=-XL(NTM1)
53 A(NT,NT)=(V(NT)+W(NT))*WK(J,NT)+XL(NT)+U(NT)
54 E(NT,NTM1)=-XL(NTM1)*HLL(J,NTM1)
55 E(NT,NT)=(V(NT)+W(NT))*WK(J,NT)*HVV(J,NT)+
56 1(XL(NT)+U(NT))*HLL(J,NT)
57 C
58 DO 83 I=1,NTM1
59 B(I,I,J)=(V(I)+W(I))*X(J,I)*DK(J,I)
60 B(I,I+1,J)=-V(I+1)*X(J,I+1)*DK(J,I+1)
61 83 CONTINUE
62 B(NT,NT,J)=(V(NT)+W(NT))*X(J,NT)*DK(J,NT)
63 C
64 C MATRIX A IS INVERTED
65 C
66 L=0
67 DO 90 N=1,NT
68 DO 90 M=1,NT
69 L=L+1
70 SV(L)=A(M,N)
71 90 CONTINUE
72 C
73 CALL MINV(SV,NT,DETRM,A(1,1),A(1,2))
74 L=0
75 DO 91 N=1,NT
76 DO 91 M=1,NT
77 L=L+1
78 A(M,N)=SV(L)
79 91 CONTINUE
80 C
81 C MULTIPLY A BY B
82 CALL MPLYM(A,B(1,1,J),SM,NT)
83 CALL EQUAL(B(1,1,J),SM,NT)
84 C
85 C MULTIPLY A BY C
86 CALL MPLYM(A,C(1,1,J),SM,NT)
87 CALL EQUAL(C(1,1,J),SM,NT)
88 C
89 C MULTIPLY A BY RHS(I,J)
90 CALL MPLYV(A,RHS(1,J),SV,NT)
91 CALL EQUALV(RHS(1,J),SV,NT)
92 C
93 C MULTIPLY ROW J BY E AND SUBTRACT FROM ROW N1
94 C
95 DO 95 I=1,NT
96 DO 95 K=1,NT
97 DO 94 L=1,NT
98 AF(I,K)=AF(I,K)-E(I,L)*B(L,K,J)
99 94 G(I,K)=G(I,K)-E(I,L)*C(L,K,J)
100 RHS(I,N1)=RHS(I,N1)-E(I,K)*RHS(K,J)

```

122

```

101 95 CONTINUE
102 C
103 C
104 C MULTIPLY ROW J BY I AND SUBTRACT FROM ROW N2
105 C
106 DO 110 I=1,NT
107 110 RHS(I,N2)=RHS(I,N2)-RHS(I,J)
108 DO 120 I=1,NT
109 DO 120 K=1,NT
110 120 AL(I,K)=AL(I,K)-B(I,K,J)
111 DO 130 I=1,NT
112 DO 130 K=1,NT
113 130 AM(I,K)=AM(I,K)-C(I,K,J)
114 C
115 C
116 150 CONTINUE
117 C
118 C
119 RETURN
120 END
    
```


123

```

1      SUBROUTINE SUBST
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4      1 Q(20),HL(20),HV(20),TA(20),F(16,20),
5      2 HF(20),PP(20),QG,DIST
6      COMMON /CONTRL/ NC,NT,LDOC,NID,NTM1,KTOP,
7      1 N1,N2,N3,N3N3,NT20
8      COMMON /DATA/ WK(15,20),DK(15,20),HVV(15,20),
9      1 HLL(15,20),DHV(15,20),DHL(15,20),
10     2 Y(15,20)
11     COMMON /FIX/ A(20,20),B(20,20,15),C(20,20,15),
12     1 E(20,20),AF(20,20),
13     2 AJ(20,20),RHS(20,18),
14     3 G(20,20),AL(20,20),AM(20,20)
15 C
16     REAL SM(20,20),SV(400)
17 C
18     EQUIVALENCE (SM(1,1),SV(1))
19 C
20 C      INVERT AF
21     L=0
22     DO 10 N=1,NT
23     DO 10 M=1,NT
24     L=L+1
25 10     SV(L)=AF(M,N)
26     CALL MINV (SV,NT,DETRM,AF(1,1),AF(1,2))
27     L=0
28     DO 20 N=1,NT
29     DO 20 M=1,NT
30     L=L+1
31 20     AF(M,N)=SV(L)
32 C
33 C      MULTIPLY G AND RHS(=,N1) BY AF INVERSE
34     CALL MPLYM (AF,G,SM,NT)
35     CALL EQUAL (G,SM,NT)
36     CALL MPLYV (AF,RHS(1,N1),SV,NT)
37     CALL EQUALV (RHS(1,N1),SV,NT)
38 C
39 C      MULTIPLY G AND RHS(=,N1) BY AL AND SUBTRACT
40 C      FROM AM AND RHS(=,N2) RESPECTIVELY
41     CALL MPLYM (AL,G,SM,NT)
42     CALL MPLYV (AL,RHS(1,N1),SV,NT)
43     DO 40 I=1,NT
44     DO 30 J=1,NT
45 30     AM(I,J)=AM(I,J)-SM(I,J)
46 40     RHS(I,N2)=RHS(I,N2)-SV(I)
47 C
48 C      INVERT AM
49     L=0
50     DO 50 N=1,NT

```

```

51      DO 50 M=1,NT
52      L=L+1
53 50    SV(L)=AM(M,N)
54      CALL MINV (SV,NT,DETRM,AM(1,1),AM(1,2))
55      L=0
56      DO 60 N=1,NT
57      DO 60 M=1,NT
58      L=L+1
59 60    AM(M,N)=SV(L)
60 C
61 C      MULTIPLY RHS(-,N2) BY AM INVERSE
62      CALL MPLYV (AM,RHS(1,N2),SV,NT)
63      CALL EQUALV (RHS(1,N2),SV,NT)
64 C
65 C      MULTIPLY G BY RHS(-,N2) AND SUBSTRACT FROM RHS(-,N1)
66      CALL MPLYV (G,RHS(1,N2),SV,NT)
67      DO 70 I=1,NT
68 70    RHS(I,N1)=RHS(I,N1)-SV(I)
69 C
70 C      THE X'S AND DELTA L'S
71 C      ARE CALCULATED BY BACK SUBSTITUTION
72      DO 111 I=1,NT
73      DO 111 K=1,NT
74 111   RHS(I,N3)=RHS(I,N3)-AJ(I,K)*RHS(K,N2)
75 C
76      DO 116 J=1,NC
77      DO 116 I=1,NT
78      DO 116 K=1,NT
79      RHS(I,J)=RHS(I,J)-B(I,K,J)*RHS(K,N1)-C(I,K,J)*RHS(K,N2)
80 116   CONTINUE
81 C
82 C
83 C
84      RETURN
85      END

```

125

```

1 SUBROUTINE MINV(A,N,D,L,M)
2 C
3 C PURPOSE
4 C INVERT A MATRIX
5 C
6 C USAGE
7 C CALL MINV(A,N,D,L,M)
8 C
9 C DESCRIPTION OF PARAMETERS
10 C A - INPUT MATRIX, DESTROYED IN COMPUTATION AND REPLACED BY
11 C RESULTANT INVERSE.
12 C N - ORDER OF MATRIX A
13 C D - RESULTANT DETERMINANT
14 C L - WORK VECTOR OF LENGTH N
15 C M - WORK VECTOR OF LENGTH N
16 C
17 C REMARKS
18 C MATRIX A MUST BE A GENERAL MATRIX
19 C
20 C SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
21 C NONE
22 C
23 C METHOD
24 C THE STANDARD GAUSS-JORDAN METHOD IS USED. THE DETERMINANT
25 C IS ALSO CALCULATED. A DETERMINANT OF ZERO INDICATES THAT
26 C THE MATRIX IS SINGULAR.
27 C
28 C .....
29 C
30 DIMENSION A(1),L(1),M(1)
31 C
32 C .....
33 C
34 C IF A DOUBLE PRECISION VERSION OF THIS ROUTINE IS DESIRED, THE
35 C C IN COLUMN 1 SHOULD BE REMOVED FROM THE DOUBLE PRECISION
36 C STATEMENT WHICH FOLLOWS.
37 C
38 C DOUBLE PRECISION A,D,BIGA,HOLD
39 C
40 C THE C MUST ALSO BE REMOVED FROM DOUBLE P-ECISION STATEMENTS
41 C APPEARING IN OTHER ROUTINES USED IN CONJUNCTION W&TH TH&S
42 C ROUTINE.
43 C
44 C THE DOUBLE PRECISION VERSION OF THIS SUBROUTINE MUST ALSO
45 C CONTAIN DOUBLE PRECISION FORTRAN FUNCTIONS. ABS IN STATEMENT
46 C 10 MUST BE CHANGED TO DABS.
47 C
48 C .....
49 C
50 C SEARCH FOR LARGEST ELEMENT

```

```

51 C
52     D=1.0
53     NK=-N
54     DO 80 K=1,N
55     NK=NK+N
56     L(K)=K
57     M(K)=K
58     KK=NK+K
59     BIGA=A(KK)
60     DO 20 J=K,N
61     IZ=N*(J-1)
62     DO 20 I=K,N
63     IJ=IZ+I
64     10 IF( ABS(BIGA)-ABS(A(IJ))) 15,20,20
65     15 BIGA=A(IJ)
66     L(K)=I
67     M(K)=J
68     20 CONTINUE
69 C
70 C     INTERCHANGE ROWS
71 C
72     J=L(K)
73     IF(J-K) 35,35,25
74     25 KI=K-N
75     DO 30 I=1,N
76     KI=KI+N
77     HOLD=-A(KI)
78     JI=KI-K+J
79     A(KI)=A(JI)
80     30 A(JI) =HOLD
81 C
82 C     INTERCHANGE COLUMNS
83 C
84     35 I=M(K)
85     IF(I-K) 45,45,38
86     38 JP=N*(I-1)
87     DO 40 J=1,N
88     JK=NK+J
89     JI=JP+J
90     HOLD=-A(JK)
91     A(JK)=A(JI)
92     40 A(JI) =HOLD
93 C
94 C     DIVIDE COLUMN BY MINUS PIVOT (VALUE OF PIVOT ELEMENT IS
95 C     CONTAINED IN BIGA)
96 C
97     45 IF(BIGA) 48,46,48
98     46 D=0.0
99     RETURN
100    48 DO 55 I=1,N

```

127

```

101      IF(I-K) 50,55,50
102      50 IK=NK+I
103      A(IK)=A(IK)/(-BIGA)
104      55 CONTINUE
105 C
106 C      REDUCE MATRIX
107 C
108      DO 65 I=1,N
109      IK=NK+I
110      HOLD=A(IK)
111      IJ=I-N
112      DO 65 J=1,N
113      IJ=IJ+N
114      IF(I-K) 60,65,60
115      60 IF(J-K) 62,65,62
116      62 KJ=IJ-I+K
117      A(IJ)=HOLD*A(KJ)+A(IJ)
118      65 CONTINUE
119 C
120 C      DIVIDE ROW BY PIVOT
121 C
122      KJ=K-N
123      DO 75 J=1,N
124      KJ=KJ+N
125      IF(J-K) 70,75,70
126      70 A(KJ)=A(KJ)/BIGA
127      75 CONTINUE
128 C
129 C      PRODUCT OF PIVOTS
130 C
131      D=D*BIGA
132 C
133 C      REPLACE PIVOT BY RECIPROCAL
134 C
135      A(KK)=1.0/BIGA
136      80 CONTINUE
137 C
138 C      FINAL ROW AND COLUMN INTERCHANGE
139 C
140      K=N
141      100 K=(K-1)
142      IF(K) 150,150,105
143      105 I=L(K)
144      IF(I-K) 120,120,108
145      108 JQ=N*(K-1)
146      JR=N*(I-1)
147      DO 110 J=1,N
148      JK=JQ+J
149      HOLD=A(JK)
150      JI=JR+J

```

128

151		A(JK)=-A(JI)	1
152	110	A(JI) =HOLD	1
153	120	J=M(K)	1
154		IF(J-K) 100,100,125	1
155	125	KI=K-N	1
156		DO 130 I=1,N	1
157		KI=KI+N	1
158		HOLD=A(KI)	1
159		JI=KI-K+J	1
160		A(KI)=-A(JI)	1
161	130	A(JI) =HOLD	1
162		GO TO 100	1
163	150	RETURN	1
164		END	1

129

```

1      SUBROUTINE GET
2 C
3      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
4      1 Q(20),HL(20),HV(20),TA(20),F(15,20),
5      2 HF(20),PP(20),QG,DIST
6      COMMON /CONTRL/ NC, NT, LDDC, NID, NTM1, KTOP,
7      1 N1,N2,N3,N3N3,NT20
8      COMMON /DATA/ WK(15,20),DK(15,20),HVV(15,20),
9      1 HLL(15,20),DHV(15,20),DHL(15,20),
10     2 Y(15,20)
11     COMMON /CDEF/ CK(8,15),DCK(7,15),CHV(6,15),
12     1 DCHV(5,15),CHL(6,15),DCHL(5,15),
13     2 PPA,MCODE
14 C
15     DO 22 I=1,NT
16     T=TA(I)
17     SUM=0.0
18     HV(I)=0.0
19     HL(I)=0.0
20     DO 11 J=1,NC
21     WK(J,I)=EQUA(T,CK(1,J))
22     DK(J,I)=EQUA(T,DCK(1,J))
23     HVV(J,I)=EQUA(T,CHV(1,J))
24     DHV(J,I)=EQUA(T,DCHV(1,J))
25     HLL(J,I)=EQUA(T,CHL(1,J))
26     11 DHL(J,I)=EQUA(T,DCHL(1,J))
27     IF(MCODE.EQ.0) GO TO 19
28     GO TO (19,14), MCODE
29     14 PRATIO=PPA/PP(I)
30     DO 17 J=1,NC
31     WK(J,I)=WK(J,I)*PRATIO
32     DK(J,I)=DK(J,I)*PRATIO
33     17 CONTINUE
34     19 DO 21 J=1,NC
35     Y(J,I)=WK(J,I)*X(J,I)
36     SUM=SUM+Y(J,I)
37     HV(I)=HV(I)+HVV(J,I)*Y(J,I)
38     HL(I)=HL(I)+HLL(J,I)*X(J,I)
39     21 CONTINUE
40     HV(I)=HV(I)/SUM
41     22 CONTINUE
42 C
43     RETURN
44     END

```

130

```

1      SUBROUTINE DTPUT
2 C
3 C
4      COMMON // X(15,20),V(20),XL(20),U(20),W(20),
5      1 Q(20),HL(20),HV(20),TA(20),F(16,20),
6      2 HF(20),PP(20),QG,DIST
7      COMMON /CONTRL/ NC, NT, LOCC, NID, NTM1, KTOP,
8      1 N1,N2,N3,N3N3,NT20
9      COMMON /FFDATA/ NF,NAMEF(3,6),NFTRAY(6),ZF(16,6),ZK(15,6),
10     + QFN(6),TF(6),PF(6),QQQ(6),QEX(6),TTF(6)
11     COMMON /PROP/ CNAME(2,15),XMW(15),RHO(15)
12     COMMON /FIX/ EK(15,20),Z(15),XX(15,11),IAA(2,9),
13     + IBB(2,9),ICC(2,9),IDD(9),SUMM(11),SUMP(9),
14     + SUMG(9),TEMP(9),QQS(9),NTT(9),NNN(9),
15     + SLOP(14552)
16     COMMON /COEF/ CK(8,15),DCK(7,15),CHV(6,15),
17     1 DCHV(5,15),CHE(6,15),DCHL(5,15),
18     2 PPA,MCODE
19 C
20     DATA NOUT /6/
21 C
22     INTEGER BLANK /' /, MOLS /'MOLS'/,
23     + FONO(2) /'FEED', ' NO '/, TRND(2) /'TRAY', ' NO '/,
24     + COMB(2) /'COMB', ' LINED'/, FD(2) /' FE', ' ED '/,
25     + DVHD(2) /'OVER', ' HEAD'/, LIQ(2) /' LIQ', ' UID '/,
26     + VAP(2) /' VAP', ' DR '/, PROD(2) /' PRO', ' DUCT'/,
27     + BTM(2) /' BOT', ' TONS'/,
28     + SSND(2) /' SS ', ' NO '/
29 C
30 C
31     NBLK=0
32     TA(1)=TA(1)+ABS(DTSUB)
33     DO 10 N=1,NT
34     PRATID=1.0
35     IF(MCODE.EQ.0) GO TO 8
36     GO TO ( 8,6), MCODE
37     6 PRATID=PPA/PP(N)
38     8 DO 10 J=1,NC
39     10 EK(J,N)=EQUA(TA(N),CK(1,J))*PRATID
40     TA(1)=TA(1)-ABS(DTSUB)
41 C
42     WRITE (NOUT,201)
43     201 FORMAT (1H1,//////10X ' FEED AND PRODUCT COMPOSITIONS' // )
44 C
45     ASSIGN 15 TO INDEX
46 C
47     11 K=0
48     DO 12 J=1,9
49     SUMM(J)=0.0
50     SUMP(J)=0.0

```



```

51      SUMG(J)=0.0
52      QQS(J)=0.0
53      TEMP(J)=0.0
54 C
55      NTT(J)=BLANK
56      NNN(J)=BLANK
57      IDD(J)=MUL5
58      DO 12 I=1,NC
59      12 XX(I,J)=0.0
60 C
61      DO 13 J=1,2
62      DO 13 I=1,9
63      IAA(J,I)=BLANK
64      IBB(J,I)=BLANK
65      13 ICC(J,I)=BLANK
66 C
67      GO TO INDEX, (15,41,47,61,70)
68 C
69 C      CALCULATE SEPARATE FEEDS
70 C
71      15 DO 17 N=1,NF
72      K=K+1
73      L=NFTRAY(N)
74      CALL ALNUM (L,NTT(K))
75      CALL ALNUM (N,NNN(K))
76      DO 16 I=1,NC
77      16 XX(I,K)=ZF(I,N)
78      SUMM(K)=ZF(N1,N)
79      TEMP(K)=TTF(N)
80      QQS(K)=QQQ(N)
81      DO 17 J=1,2
82      IAA(J,K)=FDND(J)
83      17 ICC(J,K)=TRND(J)
84 C
85 C      CALCULATE TOTAL FEED --- ONLY IF MORE THAN ONE FEED
86 C
87      IF (NF.EQ.1) GO TO 30
88      K=K+1
89      DO 19 N=1,NF
90      SUMM(K)=SUMM(K)+SUMM(N)
91      QQS(K)=QQS(K)+QQS(N)
92      DO 19 I=1,NC
93      19 XX(I,K)=XX(I,K)+XX(I,N)
94      DO 20 J=1,2
95      IAA(J,K)=COMB(J)
96      20 IBB(J,K)=FD(J)
97 C
98 C      CALCULATE OVERHEAD DISTILLATE   ***VAPOR***
99 C
100     30 IF(V(1).EQ.0.0) GO TO 39

```

```

101      K=K+1
102      KK=KK+1
103      DO 31 I=1,NC
104      31 XX(I,K)=X(I,1)*EK(I,1)*V(1)
105      SUMM(K)=V(1)
106      TEMP(K)=TA(1)
107      QQS(K)=SUMM(K)*HL(1)
108      DO 32 J=1,2
109      IAA(J,K)=BVHD(J)
110      IBB(J,K)=VAP(J)
111      32 ICC(J,K)=PRDD(J)
112 C
113 C
114 C      CALCULATE SIDESTREAMS
115 C
116      39 KK=0
117      DO 58 M=2,NTM1
118 C
119 C      *** LIQUID SIDESTREAMS ***
120 C
121      IF (U(M).EQ.0.0) GO TO 46
122      IF (K.LT.9) GO TO 41
123      ASSIGN 41 TO INDEX
124      GO TO 64
125      41 K=K+1
126      DO 44 I=1,NC
127      44 XX(I,K)=U(M)*X(I,M)
128      SUMM(K)=U(M)
129      QQS(K)=HL(M)*U(M)
130      DO 45 J=1,2
131      45 IBB(J,K)=LIQ(J)
132      GO TO 53
133 C
134 C      *** VAPOR SIDESTREAMS ***
135 C
136      46 IF (W(M).EQ.0.0) GO TO 58
137      IF (K.LT.9) GO TO 47
138      ASSIGN 47 TO INDEX
139      GO TO 64
140      47 K=K+1
141      DO 49 I=1,NC
142      49 XX(I,K)=X(I,M)*EK(I,M)
143      SUMM(K)=W(M)
144      QQS(K)=W(M)*HV(M)
145      DO 52 J=1,2
146      52 IBB(J,K)=VAP(J)
147 C
148      53 CALL ALNUM (M-1,NTT(K))
149      CALL ALNUM (KK+2,NNN(K))
150      DO 54 J=1,2

```

```

151      IAA(J,K)=SSND(J)
152      54 ICC(J,K)=TRND(J)
153      TEMP(K)=TA(M)
154      58 CONTINUE
155 C
156 C      CALCULATE BOTTOMS
157 C
158      IF (K.LT.9) GO TO 61
159      ASSIGN 61 TO INDEX
160      GO TO 64
161      61 K=K+1
162      DO 62 I=1,NC
163      62 XX(I,K)=X(I,NT)*XL(NT)
164      SUMM(K)=XL(NT)
165      QQS(K)=SUMM(K)*HL(NT)
166      TEMP(K)=TA(NT)
167      DO 63 J=1,2
168      IAA(J,K)=BTM(J)
169      63 IBB(J,K)=PRDD(J)
170      ASSIGN 70 TO INDEX
171 C
172 C      PRINT OUT DATA SUMMARY
173 C
174      64 NL=K
175 C
176      WRITE (NDOUT,111) ((IAA(N,K),N=1,2),NNN(K),K=1,NL)
177      111 FORMAT (24X,27A4)
178      WRITE (NDOUT,112) ((IBB(N,K),N=1,2),K=1,NL)
179      112 FORMAT (25X,8(2A4,4X),2A4)
180      WRITE (NDOUT,111) ((ICC(N,K),N=1,2),NTT(K),K=1,NL)
181      WRITE (NDOUT,113) (IDD(K),K=1,NL)
182      113 FORMAT (10X ' COMPONENT' 7X,A4, 8(8X,A4))
183      DO 65 I=1,NC
184      65 WRITE (NDOUT,121) (CNAME(K,I),K=1,2),(XX(I,K),K=1,NL)
185      121 FORMAT ( 11X,2A4,1X,9F12.4 )
186 C
187      WRITE (NDOUT,123) (SUMM(K),K=1,NL)
188      123 FORMAT (10X ' TOTAL' 4X,9F12.4 )
189      DO 67 K=1,NL
190      DO 66 I=1,NC
191      FAC=XX(I,K)*XMW(I)
192      SUMP(K)=SUMP(K)+FAC
193      66 SUMG(K)=SUMG(K)+FAC/RHD(I)
194      67 QQS(K)=QQS(K)/1000.0
195      WRITE (NDOUT,124) (SUMP(K),K=1,NL)
196      124 FORMAT (/10X ' POUNDS' 3X,9F12.2 )
197      WRITE (NDOUT,126) (SUMG(K),K=1,NL)
198      126 FORMAT (10X ' GALLONS' 2X,9F12.2 )
199      WRITE (NDOUT,128) (QQS(K),K=1,NL)
200      128 FORMAT (/10X ' Q, MBTU' 2X,9F12.3 )

```

134

```

201 WRITE (NDOUT,129) (TEMP(K),K=1,NL)
202 129 FORMAT (/10X ' TEMP, F' 2X,9F12.2 )
203 C
204 NBLK=NBLK+1
205 GO TO (69,68), NBLK
206 C
207 68 WRITE (NDOUT,136)
208 136 FORMAT ( '1' // )
209 GO TO 11
210 C
211 69 WRITE (NDOUT,137)
212 137 FORMAT (////)
213 NBLK=0
214 GO TO 11
215 C
216 C CALCULATE AND PRINT-OUT TRAY SUMMARY
217 C
218 70 WRITE (NDOUT,140)
219 140 FORMAT ( '1' 15X 'NET LIQUID & VAPOR LEAVING EACH STAGE' // )
220 C
221 NL=4
222 DO 71 J=8,10
223 71 SUMM(J)=100.0
224 C
225 DO 98 N=1,NT
226 K=N
227 IF(NL+NC+9.LT.58) GO TO 73
228 WRITE (NDOUT,140)
229 NL=4
230 C
231 73 IF (N.EQ.NT .AND. QG.NE.0.0) GO TO 74
232 WRITE (NDOUT,143) K,TA(N),PP(N)
233 143 FORMAT(6X' TRAY NO' I4,5X'TEMP,F' F8.2,5X 'PRESS,PSIA' F8.2)
234 GO TO 76
235 74 WRITE (NDOUT,144) TA(N),PP(N)
236 144 FORMAT(6X' REBOILER' 8X 'TEMP,F' F8.2,5X 'PRESS,PSIA' F8.2 )
237 C
238 76 WRITE (NDOUT,149)
239 149 FORMAT ( 23X 7(' - '), 'VAPOR' 7(' - '), 8X 12(' - '), 'LIQUID' 12(' - ')
240 +/3X ' NO COMP' 10X 'MOLS' 7X 'LBS' 6X 'MOL%' 6X 'WT %' 8X 'MOLS' 2
241 + 7X 'LBS' 6X 'GALS' 6X 'MOL%' 7X 'WT%' 5X 'VOL%' 7X 'K-DATA' )
242 DO 77 J=1,7
243 77 SUMM(J)=0.0
244 SUMM(3)=100.0
245 SUMM(4)=100.0
246 SHL=0.0
247 SHV=0.0
248 SUMV=0.0
249 DO 78 I=1,NC
250 DO 78 J=1,11

```

135

```

251      78 XX(I,J)=0.0
252 C
253      DO 79 I=1,NC
254      Z(I)=EK(I,N)*X(I,N)
255      79 SUMV=SUMV+Z(I)
256      IF (V(N).EQ.0.0) GO TO 85
257      FAC=V(N)/SUMV
258      DO 81 I=1,NC
259      XX(I,1)=Z(I)*FAC
260      XX(I,2)=XX(I,1)*XMW(I)
261      SUMM(1)=SUMM(1)+XX(I,1)
262      81 SUMM(2)=SUMM(2)+XX(I,2)
263      FAC=100.0/SUMM(1)
264      FBC=100.0/SUMM(2)
265      DO 83 I=1,NC
266      XX(I,3)=XX(I,1)*FAC
267      83 XX(I,4)=XX(I,2)*FBC
268 C
269      85 DO 87 I=1,NC
270      XX(I,5)=X(I,N)*XL(N)
271      XX(I,6)=XX(I,5)*XMW(I)
272      XX(I,7)=XX(I,6)/RHD(I)
273      SUMM(5)=SUMM(5)+XX(I,5)
274      SUMM(6)=SUMM(6)+XX(I,6)
275      SUMM(7)=SUMM(7)+XX(I,7)
276      87 XX(I,11)=EK(I,N)
277      FAC=100.0/SUMM(5)
278      FBC=100.0/SUMM(6)
279      FCC=100.0/SUMM(7)
280      DO 88 I=1,NC
281      XX(I,8)=XX(I,5)*FAC
282      XX(I,9)=XX(I,6)*FBC
283      88 XX(I,10)=XX(I,7)*FCC
284 C
285      WRITE (NOUT,152) (I,(CNAME(K,I),K=1,2),(XX(I,K),K=1,11),I=1,NC)
286 152  FORMAT(3X,I3,2X,2A4,F11.3,F10.1,2F10.4,F12.3,2F10.1,3F10.4,F12.5)
287      WRITE (NOUT,153) (SUMM(K),K=1,10)
288 153  FORMAT(3X,'TOTAL',8X,F10.3,F10.1,2F10.4,F12.3,2F10.1,3F10.4)
289      VMW=0.0
290      IF (V(N).EQ.0.0) GO TO 91
291      VMW=SUMM(2)/SUMM(1)
292      SHV=HV(N)*V(N)
293      91 XLMW=SUMM(6)/SUMM(5)
294      ZDEN=SUMM(6)/SUMM(7)
295      SHL=HL(N)*XL(N)
296      WRITE (NOUT,161) VMW,SHV,XLMW,ZDEN,SHL
297 161  FORMAT ('01' 9X 'VAPOR MW =' F7.3,5X 'VAPOR ENTHALPY =' F11.0,' BT
298      +US' / 9X 'LIQUID MW =' F7.3,5X 'LIQUID LB/GAL =' F7.3,5X 'LIQUID E
299      +NTHALPY =' F11.0,' BTUS' / )
300 C

```

301	98 NL=NL+9+NC	136	21
302	C		21
303	RETURN		21
304	END		21

137

```

1      SUBROUTINE ALNUM (NN, MM)
2 C
3 C      THIS SUBROUTINE DEVELOPS INTEGER EQUIVALENTS OF NUMBERS
4 C      FROM 0 TO 99, LEFT JUSTIFIED WITHIN 4 COLUMN FIELD.
5 C      NN = NUMBER TO BE CONVERTED.  MM = INTEGER EQUIVALENT.
6 C
7      IF(NN-9) 1, 1, 2
8 C
9 C      NUMBER IS 9 OR LESS.
10 C
11 1    MM=-268435456+NN*16777216
12      RETURN
13 C
14 C      NUMBER IS BETWEEN 10 AND 99, INCLUSIVE.
15 C
16 2    M=NN/10
17      L=NN-M*10
18      MM=-252690368+M*16777216+L*65536
19      RETURN
20 C
21      END

```

APPENDIX III

139

1		PROGRAM ABSR1	0001
2	C		0002
3	C		0003
4		DEFINE FILE 10 (100, 520, U, NBLOCK)	0004
5	C		0005
6		REAL A(20)	0006
7		DATA ZEND / '####' /	0007
8	C		0008
9		NTIME = 0	0009
10	2	READ (5,100,END=999) A	0010
11	100	FORMAT (20A4)	0011
12		WRITE (6,102) A	0012
13	102	FORMAT (1,172X,20A4)	0013
14		CALL INPUT (&)	0014
15		CALL INR (&, &10)	0015
16	4	CALL OUTPUT	0016
17		GO TO 10	0017
18	C		0018
19	3	WRITE (6,104)	0019
20	104	FORMAT (/////10X 'PROBLEM FLUSHED'//10X 'PROCEEDING TO NEXT PROBLEM	0020
21		1'/////)	0021
22	C		0022
23	10	READ (5,100,END=999) A(1)	0023
24		IF (A(1).EQ.ZEND) GO TO 2	0024
25		GO TO 10	0025
26	C		0026
27	999	WRITE (6,106)	0027
28	106	FORMAT (,1,)	0028
29		STOP	0029
30		END	0030

```

1      SUBROUTINE KGEN (T,E,M)
2 C
3      COMMON // X(20,100), V(100), XL(100), U(100), W(100),
4      1 Q(100), HL(100), HV(100), TA(100), F(21,100),
5      2 HF(100), PP(100), QG, DIST
6      COMMON /CONTRL/ NC, NT, LDDC, NID, NTH1, KTOP,
7      1 N1, N2, N3, N3N3
8      COMMON /DATA1/ NK, EKTABL(8,20), TK(8),
9      1 PA, PK(8), KCODE
10 C
11     REAL E(1)
12     DOUBLE PRECISION XK
13 C
14     1 IF (NK.GT.2) GO TO 3
15     J=1
16     GO TO 9
17     3 DO 6 L=2,NK
18     IF (T.LT.TK(L)) GO TO 7
19     6 CONTINUE
20     L=NK
21     7 J=L-1
22     9 K=J+1
23 C
24     10 XX=(1.0/(T+460.0)-1.0/(TK(J)+460.0)) /
25     1 (1.0/(TK(K)+460.0)-1.0/(TK(J)+460.0))
26     DO 14 I=1,NC
27     14 E(I)=DEXP(EKTABL(J,I)+(EKTABL(K,I)-EKTABL(J,I))*XX)
28 C
29     IF(KCODE.EQ.0) GO TO 41
30     31 GO TO (41,32), KCODE
31     32 PRATIO=PA/PP(M)
32     DO 33 I=1,NC
33     33 E(I)=E(I)*PRATIO
34 C
35     41 RETURN
36     END

```

1		SUBROUTINE HGEN (T,ZV,ZL)	141	0067
2	C			0068
3		COMMON /CONTRL/ NC, NT, LBDC, NID, NTH1, KTOP,		0069
4	1	N1, N2, N3, N3N3		0070
5		COMMON /GATA2/ NH, HLTABL(8,20), HVTABL(8,20), TH(8), PH(8)		0071
6	C			0072
7		REAL ZV(1), ZL(1)		0073
8	C			0074
9		IF (NH.GT.2) GO TO 3		0075
10		J=1		0076
11		GO TO 4		0077
12	3	DO 6 L=2,NH		0078
13		IF (T.LT.TH(L)) GO TO 7		0079
14	6	CONTINUE		0080
15		L=NH		0081
16	7	J=L-1		0082
17	8	K=J+1		0083
18	C			0084
19	9	XX=(T-TH(J))/(TH(K)-TH(J))		0085
20		DO 10 N=1,NC		0086
21		ZV(N)=HVTABL(J,N)+(HVTABL(K,N)-HVTABL(J,N))*XX		0087
22	10	ZL(N)=HLTABL(J,N)+(HLTABL(K,N)-HLTABL(J,N))*XX		0088
23	C			0089
24		RETURN		0090
25		END		0091

Line	Code	Text	Page
1		FUNCTION EQUA (X, C)	142 0092
2	C		0093
3	C	THIS FUNCTION EVALUATES A SET OF POLYNOMIAL COEFFICIENTS BY	0094
4	C	NESTED EXPANSION ---- AS GENERATED BY FUNCTION FITT.	0095
5	C		0096
6	C	Y = A0 + A1*X + A2*X**2 + + AM*X**M	0097
7	C		0098
8	C	M = C(1)	0099
9	C		0100
10	C	A0 = C(2)	0101
11	C	A1 = C(3)	0102
12	C	A2 = C(4)	0103
13	C		0104
14	C	:: : ::::	0105
15	C	AM = C(M+2)	0106
16	C		0107
17		REAL C(1)	0108
18	C		0109
19		M = C(1)	0110
20		Y = C(M+2)	0111
21		MM = M+2	0112
22		DO 1 J=1,M	0113
23		MMJ=MM-J	0114
24		Y=Y*X+C(MM,J)	0115
25	1	CONTINUE	0116
26		EQUA = Y	0117
27		RETURN	0118
28		END	0119

1	FUNCTION FITIT (X, Y, ND, MAX, C, LN, A)	143	0120
2	C		0121
3	C	WILL FIT POLYNOMIAL OF ORDER MAX (MAX .LT. 7) TO ND Y VS. X DATA	0122
4	C	POINTS SUPPLIED IN ARRAYS Y AND X. COEFFICIENTS RETURNED IN ARRAY	0123
5	C	C IN FORM NEEDED BY FUNCTION EQUA. STANDARD DEVIATION OF Y RETURNED	0124
6	C	AS FITIT.	0125
7	C		0126
8	C	LN = LOG TRANSFORMATION CODE 1 = Y VS. X	0127
9	C	2 = LN Y VS. X	0128
10	C	3 = Y VS. LN X	0129
11	C	4 = LN Y VS. LN X	0130
12	C		0131
13	C	A = INTERCEPT CODE ZERO = INTERCEPT = 0.0	0132
14	C	NONZERO = INTERCEPT CALCULATED	0133
15	C		0134
16		REAL X(1), Y(1), C(1), D(7), S(7), XY(7,7)	0135
17	C		0136
18	C	SET CONTROLS AND ZEROS AND XY.	0137
19	C		0138
20		N = ND	0139
21		M = MINO (MAX + 1, N, 7)	0140
22		L = MINO (4, MAXO (1, LN))	0141
23		Z = N	0142
24		DO 10 I = 1, M	0143
25		S(I) = 0.0	0144
26		DO 10 J = I, M	0145
27	10	XY(I, J) = 0.0	0146
28	C		0147
29	C	FOR EACH DATUM, MOVE Y AND X TO D(1) AND D(2), GET LOGS IF NEEDED	0148
30	C	AND POWERS OF X, AND ACCUMULATE SUMS, SQUARES, AND CROSS PRODUCTS	0149
31	C	IN S AND XY.	0150
32	C		0151
33		DO 80 K = 1, N	0152
34		D(1) = Y(K)	0153
35		D(2) = X(K)	0154
36		GO TO (50, 20, 40, 30), L	0155
37	20	D(1) = ALOG (D(1))	0156
38		GO TO 50	0157
39	30	D(1) = ALOG (D(1))	0158
40	40	D(2) = ALOG (D(2))	0159
41	50	DO 60 I = 3, N	0160
42	60	D(I) = D(2) * D(I - 1)	0161
43		DO 70 I = 1, M	0162
44		S(I) = S(I) + D(I)	0163
45		DO 70 J = I, M	0164
46	70	XY(I, J) = XY(I, J) + D(I) * D(J)	0165
47	80	CONTINUE	0166
48	C		0167
49	C	GET REDUCED SQUARES AND CROSS PRODUCTS IF A NONZERO AND FOLD XY	0168
50	C	OVER.	0169

51	C			144	01700
52		IF (A .EQ. 0.0) GO TO 110			01710
53		DD 100 I = 1, M			01720
54		S = S(I) / Z			01730
55		DD 90 J = 1, M			01740
56	90	XY(I, J) = XY(I, J) - Q * S(J)			01750
57	100	S(I) = W			01760
58	110	DD 120 J = 1, M			01770
59		DD 120 I = J, M			01780
60	120	XY(I, J) = XY(J, I)			01790
61	C				01800
62	C	SOLVE REGRESSION MATRIX AND GET STANDARD DEVIATION OF Y.			01810
63	C				01820
64		DD 160 I = 2, M			01830
65		Q = XY(I, 1)			01840
66		XY(I, 1) = 1.0			01850
67		DD 130 J = 1, M			01860
68	130	XY(I, J) = XY(I, J) / Q			01870
69		DD 150 K = 1, M			01880
70		IF (K .EQ. 1) GO TO 150			01890
71		Q = XY(K, 1)			01900
72		XY(K, 1) = 0.0			01910
73		DD 140 J = 1, M			01920
74	140	XY(K, J) = XY(K, J) - XY(I, J) * Q			01930
75	150	CONTINUE			01940
76	160	CONTINUE			01950
77		Q = MAX0 (M - M, 1)			01960
78		FITIT = SQRT (AMAX1 (XY (1, 1) / Q, 0.0))			01970
79	C				01980
80	C	STORE COEFFICIENTS IN C ARRAY.			01990
81	C				02000
82		C(1) = M - 1			02010
83		C(2) = 0.0			02020
84		DD 170 I = 2, M			02030
85		S(1) = S(1) - S(I) * XY(I, 1)			02040
86	170	C(I + 1) = XY(I, 1)			02050
87		IF (A .NE. 0.0) C(2) = S(1)			02060
88		RETURN			02070
89	C				02080
90		END			02090

```

1      FUNCTION WAYA(A,ANS,TOL,START,STOP,LEVEL)
2      C
3      C      ROUTINE TO CONVERGE ON SINGLE VALUED FUNCTION
4      C
5      C      A      =CURRENT VALUE OF DEPENDENT VARIABLE
6      C      ANS   =DESIRED VALUE OF DEPENDENT VARIABLE
7      C      TOL  =TOLerANCE
8      C      START=CURRENT VALUE OF INDEPENDENT VARIABLE. A BETTER VALUE RETURNED
9      C      STOP  =LIMIT OF INDEPENDENT VARIABLE, ANSWER BETWEEN START AND STOP.
10     C      LEVEL= 1,2, OR 3 AS AN INDEX FOR MULTILEVEL USE.
11     C
12     C      WAYA WILL VARY START BETWEEN ITS INITIAL VALUE AND STOP UNTIL
13     C      ABS( ABS_ A ) .LE. TOL OR 30 TRIALS TAKEN.
14     C
15     C      ON EXIT WAYA IS:
16     C      - FOR NOT CONVERGED, REPEAT CALCULATION WITH NEW VALUE IN START.
17     C      0 FOR CONVERGED IN LIMITS OR 30 TRIALS TAKEN.
18     C      + FOR CANNOT CONVERGE, START WILL BE ITS INITIAL VALUE OR STOP,
19     C      WHICHEVER GIVES LESSER ERROR, OR ITS INITIAL VALUE IF LEVEL
20     C      IS NEGATIVE.
21     C
22     C      DIMENSION X1(3),X2(3),Y1(3),Y2(3),KOUNT(3)
23     C
24     C      DATA KOUNT/ 3*0 /
25     C
26     C      SET X,Y & LEVEL
27     C      X=START
28     C      Y=ANS-A
29     C      L=IABS(LEVEL)
30     C      WAYA=1.0
31     C
32     C      SEE IF CONVERGED
33     C
34     C      IF(ABS(Y).LE. TOL) GO TO 70
35     C
36     C      NOT CONVERGED, SEE WHICH CALL.
37     C
38     C      IF(KOUNT(L)) 80,30,10
39     C
40     C      SECOND OR HIGHER CALL, SEE IF Y AND Y1(L) BRACKET ANSWER.
41     C
42     C      IF(Y*Y1(L) .LT. 0.0) GO TO 20
43     C
44     C      NO Y-Y1 BRACKET, SEE IF SECOND OR HIGHER CALL.
45     C
46     C      IF(KOUNT(L) .GT. 1) GO TO 30
47     C
48     C      NO BRACKET AT ALL, RE-DO AT START IF THAT LIMIT IS CLOSER OR IF
49     C      LEVEL IS MINUS
50     C

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51 IF(ABS(Y) .LE. ABS(Y1(L)) .AND. LEVEL .GT. 0) GO TO 80
52 X=X1(L)
53 KOUNT(L)= -1
54 GO TO 60
55 C
56 C Y-Y1 BRACKET. STORE X & Y IN X2(L) AND Y2(L)
57 C
58 20 X2(L)=X
59 Y2(L)=Y
60 GO TO 40
61 C
62 C FIRST CALL OR COMPLETING Y-Y2 BRACKET CALL. STORE X & Y IN X1
63 C & Y1.
64 C
65 30 X1(L)=X
66 Y1(L)=Y
67 X=STOP
68 IF(KOUNT(L).EQ. 0) GO TO 50
69 C
70 C INTERPOLATE NEW X AND CONTINUE OR QUIT DEPENDING ON KOUNT(L).
71 C
72 40 X=(X1(L)*(3.*Y2(L)-Y1(L))+X2(L)*(Y2(L)-3.*Y1(L)))/(4.*(Y2(L)-Y1(L)
73 1))
74 IF (KOUNT(L) .GE. 30) GO TO 70
75 50 KOUNT(L)=KOUNT(L)+1
76 60 WAYA=-1.0
77 GO TO 90
78 C
79 C CONVERGED OR TOO MANY TRIALS
80 C
81 70 WAYA=0.0
82 80 KOUNT(L)=0
83 C
84 C SET NEW VALUE OF INDEPENDENT VARIABLE.
85 C
86 90 START=X
87 RETURN
88 C
89 END

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1      SUBROUTINE NWRITE
2 C
3      COMMON // X(20,100), V(100), XL(100), U(100), W(100),
4 1      Q(100), NL(100), HV(100), TA(100), F(21,100),
5 2      HF(100), PP(100), QQ, DIST
6      COMMON /CONTRL/ NC, NT, LOOC, NID, NTM1, KTOP,
7 1      N1, N2, N3, N3N3
8      COMMON /PROP/ CNAME(2,20), XMW(20), RHD(20)
9      COMMON /FIX/ SPACE(4845), AX(100)
10 C
11     WRITE (6,101)(V(J),J=1,NT)
12 101  FORMAT (// ' CALCULATED VAPOR RATES' /10(9X,10F11.3/))
13     WRITE (6,102) (XL(J),J=1,NT)
14 102  FORMAT ( 1X,26HCORRESPONDING LIQUID RATES/10(9X,10F11.3/))
15     WRITE (6,103) (TA(J),J=1,NT)
16 103  FORMAT ( ' CALCULATED TEMPERATURES ' / 10(9X,10F11.3/))
17 C
18 C      NBL      NUMBER OF BLOCKS OF 10 OR PART THEREOF
19 C      NPP      NUMBER OF LINES ALREADY PRINTED
20     KN=0
21     KM=NT
22     NBL=(NT+9)/10
23     NPP=(7+3)+(NBL*3)+(NC+5)
24 C
25 2   IF (KM.LE.10) GO TO 6
26     KN=10+KN
27     L=KN-9
28     KM=KN-10
29     KE=KN
30     GO TO 10
31 6   KN=KN+KN
32     L=KN-KM+1
33     KM=0
34     KE=KN
35 10  LE=L
36 C
37     WRITE(6,115) (J,J=L,KE)
38 115  FORMAT (' LIQUID COMPOSITIONS, MOL FRACTIONS' / ' TRAY #' 110,
39 +      @111)
40     DD 12 I=1,NC
41 12  WRITE (6,116) (CNAME(K,1),K=1,2), (X(I,J),J=L,KN)
42 116  FORMAT (2X,2A4,1X,10F11.8)
43     DD 15 J=L,KN
44     AX(J)=0
45     DD 15 I=1,NC
46 15  AX(J)=AX(J)+X(I,J)
47     WRITE (6,126) (AX(J),J=L,KN)
48 126  FORMAT(' TOTAL ' 10F11.8)
49     IF (KM.LE.0) GO TO 31
50     IF ( 57-NPP-NC-5 ) 22,22,23

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51	22	WRITE(6,154)	03490
52	154	FORMAT (1H1)	03500
53		NPP=0	03510
54	23	NPP=NPP+NC+5	03520
55		GO TO 2	03530
56	C	PRINT REBOILER DUTY	03540
57	C		03550
58	C		03560
59	31	QNT=ABS(Q(MT))	03570
60		WRITE (6,220) QNT	03580
61	220	FORMAT (//1X,19HREBOILER DUTY, BTUS, F16.1/)	03590
62		RETURN	03600
63		END	03610

```

1      SUBROUTINE INPUT (*)
2 C
3      COMMON // X(20,100), V(100), XL(100), U(100), W(100),
4      1 Q(100), HL(100), HV(100), TA(100), F(21,100),
5      2 HF(100), PP(100), QG, DIST
6      COMMON /CONTRL/ NC, NT, LDDC, MID, NTH1, KTOP,
7      1 N1, N2, N3, N3N3
8      COMMON /FIX/ EK(20,100), A(100), B(100), C(100), D(100),
9      1 AX(100), BX(100)
10     COMMON /SSDATA/ NSS, NSTRAY(10), XW(10), XU(10), QSS(10)
11     COMMON /FFDATA/ NF, NAF(3,6), NFTRAY(6), ZF(21,6), ZK(20,6),
12     1 QFN(6), TF(6), PF(6), QQQ(6), SEX(6), TTF(6)
13     COMMON /PROP/ CHAME(2,20), XMW(20), RHO(20)
14     COMMON /DATA1/ NK, EKTABL(8,20), TK(8),
15     1 PA, PK(8), KCODE
16     COMMON /DATA2/ NH, HLTABL(8,20), HVTABL(8,20), TH(8), PH(8)
17 C
18 C      KTOP --- DESIGN VARIABLE
19 C      2 9 REQUILER
20 C      HEAT LOADS ARE IN MMBTU/HR
21 C
22 C      LDDC --- PRINT CODE
23 C      1 INPUT & OUTPUT
24 C      2 1 + TRIAL DATA
25 C      3 2 + ALL DATA
26 C      4 3 + ERROR PRINT OUT
27 C
28     NOGD=0
29     READ (5,101) NT,NC,NE,NSS,NK,NH,NID,KTOP,LDDC
30 101  FORMAT (9I5)
31 C
32     READ(5,102) QR,DIST
33 102  FORMAT(BF10.0)
34     READ (5,102) TTOP, TBOT, DTRAY, TMID
35     READ(5,102) PTOP, DPTWR
36 C
37     NTH1=NT-1
38 C
39     N1=NC+1
40     N2=N1+1
41     N3=N2+1
42     N3N3=N3*N3
43 C
44     PP(1)=PTOP
45     DP=DPTWR/FLOAT(NTH1)
46     DP & J=2,NT
47     9 PP(J)=PP(J-1)+DP
48 C
49     IF(NID.LE.0)NID=25
50     IF (LDDC.LE.0 .OR. LDDC.GE.5) LDDC=2

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51	C			04130
52		WRITE (6,105) NT,NC,HF,NSS,NK,NH,NID,KTOP,LDDC		04130
53		105 FORMAT (//2X,'NUMBER OF TRAYS' I20, /2X,'NUMBER OF COMPONENTS' I15		04140
54		1, //2X,'NUMBER OF FEEDS' I20, /2X,'SIDESTREAM AND/OR HEAT TRAYS'		04150
55		2 I7, //2X,'NUMBER OF K-DATA POINTS' I12, /2X,'NUMBER OF H-DATA POINTS'		04160
56		3TS' I12, //2X,'NUMBER OF ITERATIONS' I15,		04170
57		4//2X,'OP CODE' I28, //		04180
58		52X'DOCUMENTATION LEVEL' I16)		04190
59	C			04200
60		14 DO 16 J=1,NT		04210
61		HF(J)=0.0		04220
62		U(J)=0.0		04230
63		W(J)=0.0		04240
64		Q(J)=0.0		04250
65		DO 15 I=1,NC		04260
66		15 X(I,J)=0.0		04270
67		DO 16 I=1,M1		04280
68		16 F(I,J)=0.0		04290
69	C			04300
70	C			04310
71		TA(1)=TTOP		04320
72		TA(NT)=TBOT		04330
73		NDTRAY = DTRAY		04340
74		IF (NDTRAY.EQ.0) GO TO 41		04350
75		NTMID=NTTRAY+1		04360
76		IF (NTMID.GE.NT)GOTO41		04370
77		DT=(TMID-TA(1))/FLOAT(NTMID-1)		04380
78		DO 31 J=2,NTMID		04390
79		31 TA(J)=TA(J-1)+DT		04400
80		DT=(TA(NT)-TMID)/FLOAT(NT-NTMID)		04410
81		NTMIDP=NTMID+1		04420
82		DO 32 J=NTMIDP,NTM1		04430
83		32 TA(J+1)=TA(J)+DT		04440
84		GOTO50		04450
85	C			04460
86		41 DT=(TBOT-TTOP)/FLOAT(NTM1)		04470
87		DO 42 J=2,NTM1		04480
88		42 TA(J)=TA(J-1)+DT		04490
89	C			04500
90		50 QG=QR*1.0E6		04510
91		IF (QR.EQ.0.0) GO TO 60		04520
92		WRITE (6,112) QR		04530
93		112 FORMAT (/2X,'REBOILER DUTY, MMBTU/HR' F20.6)		04540
94		Q(NT)=-QG		04550
95	C			04560
96		60 IF (DIST.GT.0.0) GO TO 62		04570
97		WRITE (6,121)		04580
98		121 FORMAT (///20X,'INVALID DISTILLATE RATE'///)		04590
99		NOGO=1		04600
100	C			04610

Line	Code	Statement	Page
101	62	WRITE (6,122) DIST	0462
102	122	FORMAT (/2X,'OVERHEAD VAPOR PRODUCT, MDLS/HR' F10.3)	0463
103	C		0464
104		WRITE (6,123) TTOP,TBOT	0465
105	123	FORMAT (/2X,'INPUT TEMPERATURES, DEG F' /	0466
106		17X 'TOP TRAY' F12.1 / 7X 'BOTTOM TRAY' F6.1)	0467
107		IF (NDTRAY.EQ.0) GO TO 64	0468
108		WRITE (6,124) TMID,NDTRAY	0469
109	124	FORMAT (2X 'TEMPERATURE ESTIMATED AS' F8.1,2X'DEG F ON TRAY' I4)	0470
110	C		0471
111	64	WRITE (6,125) PTOP, PPTW, PP(1), PP(NT)	0472
112	125	FORMAT (/2X,'INPUT PRESSURES, PSIA' / 7X'OVERHEAD' F18.4	0473
113		17X 'TOWER DELTA P' F13.4 / 7X 'TOWER TOP' F17.4	0474
114		27X 'TOWER BOTTOM' F14.4)	0475
115	C		0476
116		DO 68 J=1,NF	0477
117		READ (5,131) (NAMEF(I,J),I=1,3),NFTRAY(J),PF(J),TF(J),QFN(J),	0478
118		QEX(J)	0479
119	131	FORMAT (3A4,1B,4F10.0)	0480
120		READ (5,102) (ZF(I,J),I=1,NC)	0481
121		IF(QFN(J).NE.0.0)GOTO68	0482
122		READ (5,102) (ZK(I,J),I=1,NC)	0483
123	C		0484
124	68	CONTINUE	0485
125		IF(NSS.EQ.0)GOTO70	0486
126		DO 69 J=1,NSS	0487
127	69	READ (5,133) NSTRAY(J),XW(J),XU(J),QSS(J)	0488
128	133	FORMAT (15,5X,3E10.0)	0489
129	C		0490
130	70	CALL CDATA	0491
131		CALL ZFEED (SUMFD)	0492
132	C		0493
133		IF(NSS.EQ.0)GOTO80	0494
134		WRITE(6,141)	0495
135	141	FORMAT(10I2X 'SIDESTREAM AND HEAT TRAY DATA' / 7X 'TRAY NO' 7X 'VAPOR	0496
136		10R MDLS/HR' 7X 'LIQUID MDLS/HR' 7X 'HEAT OUT MMBTU/HR')	0497
137		DO 79 N=1,NSS	0498
138	79	WRITE (6,142) N,NSTRAY(N),XW(N),XU(N),QSS(N)	0499
139	142	FORMAT (I4,I5,2F12.2,F15.6)	0500
140	C		0501
141	80	SUM=DISI	0502
142		IF(NSS.EQ.0)GOTO90	0503
143		DO 81 J=1,NSS	0504
144		K=NSTRAY(J)	0505
145		U(K)=XU(J)	0506
146		W(K)=XW(J)	0507
147		Q(K)=QSS(J)*1.0E6	0508
148	81	SUM=SUM+U(K)+W(K)	0509
149	C		0510
150	90	IF(SUMFD-SUM.GT.0.0)GOTO92	0511

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151 WRITE (6,145)
152 145 FORMAT (///20X 'BOTTOMS RATE IS INVALID')
153 NGGD=1
154 C
155 92 V(1)=DIST
156 V(NT)=0.8*(SUMFD-DIST)
157 XL(1)=0.5*F(V1,1)
158 XL(NT)=SUMFD-SUM
159 IF (NGGD.NE.0) RETURN 1
160 C
161 DV=(V(NT)-V(1))/FLOAT(NTM1)
162 DL=(XL(NT)-XL(1))/FLOAT(NTM1)
163 DO 93 J=2,NTM1
164 V(J)=V(J-1)+DV
165 93 XL(J)=XL(J-1)+DL
166 DO 94 J=1,NT
167 94 CALL KGEK (TA(J),EK(1,J),J)
168 C
169 C
170 C
171 C W = VAPOR U = LIQUID
172 DO 99 I=1,NC
173 A(1)=0.0
174 B(1)=V(1)*(1.0-EK(I,1))-V(2)-F(N1,1)
175 C(1)=V(2)*EK(I,2)
176 D(1)=-F(I,1)
177 SUMJM1=F(N1,1)-DIST
178 SUMJ=F(N1,2)-W(2)-U(2)+F(N1,1)-DIST
179 DO 95 J=2,NTM1
180 A(J)=V(J)+SUMJM1
181 B(J)=-((V(J)+W(J))*EK(I,J)+V(J+1)+SUMJ+U(J))
182 C(J)=V(J+1)*EK(I,J+1)
183 D(J)=-F(I,J)
184 SUMJM1=SUMJM1+F(N1,J)-W(J)-U(J)
185 95 SUMJ=SUMJ+F(N1,J+1)-W(J+1)-U(J+1)
186 A(NT)=V(NT)+XL(NT)-F(N1,NT)
187 B(NT)=-V(NT)*EK(I,NT)-XL(NT)
188 C(NT)=0.0
189 D(NT)=-F(N1,NT)
190 AX(1)=C(1)/B(1)
191 BX(1)=D(1)/B(1)
192 DO 96 J=2,NTM1
193 96 AX(J)=C(J)/(B(J)-A(J)*AX(J-1))
194 DO 97 J=2,NT
195 97 BX(J)=(D(J)-A(J)*BX(J-1))/(B(J)-A(J)*AX(J-1))
196 X(I,NT)=BX(NT)
197 IF (X(I,NT).LE.0.0) X(I,NT)=1.0E-25
198 DO 98 K=1,NTM1
199 J=NT-K
200 X(I,J)=BX(J)-AX(J)*X(I,J+1)

```

201		IF (X(I,J) .LE. 0.0) X(I,J) = 1.0E-25	153	0562
202	98	CONTINUE		0563
203	99	CONTINUE		0564
204	C			0565
205	C			0566
206	C			0567
207	C			0568
208		RETURN		0569
209		END		0570

Line	Code	Statement	Address
1		SUBROUTINE CDATA	154 05710
2	C		05720
3		COMMON // X(20,100), V(100), XL(100), U(100), W(100),	05730
4	1	Q(100), HL(100), HV(100), TA(100), F(21,100),	05740
5	2	HF(100), PP(100), QG, DIST	05750
6		COMMON /CTRL/ NC, NT, LDDC, MID, NTM ₁ , KTOP,	05760
7	1	N1, N2, N3, N3N3	05770
8		COMMON /PROP/ CNAME(2,20), XMW(20), RHD(20)	05780
9		COMMON /DATA1/ NK, EKTABL(8,20), TK(8),	05790
10	1	PA, PK(8), KCODE	05800
11		COMMON /DATA2/ N ₁ , HLTABL(8,20), HVTABL(8,20), TH(8), PH(8)	05810
12		COMMON /DEF/ CK(8,20), DCK(7,20), CHV(6,20),	05820
13	1	DCHV(8,20), CHL(6,20), DCHL(5,20),	05830
14	2	PPA, HCODE	05840
15	C		05850
16		REAL T(20), AK(20,20), AHV(20,20), AHL(20,20)	05860
17		EQUIVALENCE (AK(1,1), AHV(1,1))	05870
18	C		05880
19		WRITE (6,100)	05890
20	100	FORMAT (1H1)	05900
21	C		05910
22		READ (5,101) ((CNAME(K,J), K=1,2), XMW(J), RHD(J), J=1, NC)	05920
23	101	FORMAT (2A4, 2X, 2F10.0)	05930
24		WRITE (6,102)	05940
25	102	FORMAT (2X, 'DATA ON COMPONENTS, // 8X, 'NAME, '17X, 'MOL WT, ' 8X,	05950
26	1	'LBS/GAL' /)	05960
27		WRITE (6,103) (J, (CNAME(K,J), K=1,2), XMW(J), RHD(J), J=1, NC)	05970
28	103	FORMAT (16, 2X, 2A4, F10.3, F15.4)	05980
29	C		05990
30	21	READ (5,115) (TK(J), J=1, NK)	06000
31	115	FORMAT (8F10.0)	06010
32		READ (5,115) (PK(J), J=1, NK)	06020
33		READ (5,115) ((EKTABL(K,J), K=1,8), J=1, NC)	06030
34	C		06040
35		WRITE (6,100)	06050
36	C		06060
37	41	WRITE (6,122) (TK(J), J=1, NK)	06070
38	122	FORMAT (7/2X 'MAIN COLUMN K-TABLE' //4X, 'TEMPERATURE, F '8F14.2)	06080
39		WRITE (6,123) (PK(J), J=1, NK)	06090
40	123	FORMAT (4X 'PRESSURE, PSIA '8F14.4)	06100
41		WRITE (6,125)	06110
42	125	FORMAT (/)	06120
43		DO 43 J=1, NC	06130
44	43	WRITE (6,124) (CNAME(K,J), K=1,2), (EKTABL(K,J), K=1, NK)	06140
45	124	FORMAT (5X, 2A4, 6X, 8F14.5)	06150
46	C		06160
47		DO 45 J=1, NC	06170
48		DO 45 K=1, NK	06180
49	45	EKTABL(K,J)=ALOG(EKTABL(K,J))	06190
50	C		06200


```

51 C          KCODE --- PRESSURE CORRECT K-DATA 155 0621
52 C          1          K-DATA ALREADY CORRECTED 0622
53 C          2          PRESSURE CORRECT K-DATA 0623
54 C 0624
55          PA=PK(1) 0625
56      48 KCODE=1 0626
57          N,K1=N,K=1 0627
58          DO 49 J=1,N,K1 0628
59          IF (ABS(PK(J)-PK(J+1)).GT,D,001) GO TO 50 0629
60      49 CONTINUE 0630
61          KCODE = 2 0631
62          WRITE (6,126) 0632
63      126 FORMAT (//2X, 'K-DATA WILL BE PRESSURE CORRECTED TO THE TRAY PRESSURE 0633
64          1 RE USING THE K-DATA REFERENCE PRESSURE AS THE DATUM') 0634
65 C 0635
66      50 WRITE (6,100) 0636
67 C 0637
68          HEAD (5,127) JCODE,(TH(J),J=1,NH) 0638
69      127 FORMAT (I),F9.0,7F10.0) 0639
70 C 0640
71 C          JCODE --- UNITS OF ENTHALPY DATA 0641
72 C          1          BTU/MOLE 0642
73 C          2          BTU/LB 0643
74 C 0644
75          READ (5,115) (PH(K),K=1,NH) 0645
76          READ (5,115) ((HVTABL(K,J),K=1,8),(HLTABL(K,J),K=1,8),J=1,NC) 0646
77          GO TO (55,51),JCODE 0647
78      51 DO 52 J=1,NC 0648
79          DO 52 K=1,NH 0649
80          HVTABL(K,J)=HVTABL(K,J)*XHW(J) 0650
81      52 HLTABL(K,J)=HLTABL(K,J)*XHW(J) 0651
82 C 0652
83      55 WRITE (6,128) (TH(J),J=1,NH) 0653
84      128 FORMAT (//2X 'ENTHALPY TABLE',// 4X 'TEMPERATURE, F '8F14.2, 0654
85          WRITE (6,129) (PH(J),J=1,NH) 0655
86      129 FORMAT (4X 'PRESSURE, PSIA '8F14.4) 0656
87          WRITE (6,130) 0657
88      130 FORMAT ('O VAPOR, BTU/MOLE') 0658
89          DO 56 J=1,NC 0659
90      56 WRITE (6,131) (NAME(K,J),K=1,2),(HVTABL(K,J),K=1,NH) 0660
91      131 FORMAT (5X,2A4,6X,8F14.1) 0661
92          WRITE (6,133) 0662
93      133 FORMAT ('O LIQUID, BTU/MOLE') 0663
94          DO 57 J=1,NC 0664
95      57 WRITE (6,131) (NAME(K,J),K=1,2),(HLTABL(K,J),K=1,NH) 0665
96 C 0666
97          PPA=PA 0667
98          KCODE=KCODE 0668
99          KCODE=0 0669
100          BT=AMAX1((TA(NT)-T(1))/2.0,50.) 0670

```

156

101		T(1)=TA(1)-DT	06710
102		T(20)=TA(NT)+DT	06720
103		DT=(T(20)-T(1))/19.	06730
104		DO 62 J=2,19	06740
105	62	T(J)=T(J-1)+DT	06750
106		DO 63 K=1,20	06760
107	63	CALL KGER(T(K),AK(1,K),K)	06770
108		DO 65 J=2,20	06780
109		JM1=J-1	06790
110		DO 65 K=1,JM1	06800
111		HOLD=AK(J,K)	06810
112		AK(J,K)=AK(K,J)	06820
113	65	AK(K,J)=HOLD	06830
114		NPWR=4	06840
115		DO 66 J=1,NC	06850
116		HOLD=1.0	06860
117	66	HOLD=FITIT(T,AK(1,J),20, NPWR,CK(1,J),1,HOLD)	06870
118		KCODE=RCODE	06880
119		NPWRM1=NPWR-1	06890
120		DO 67 J=1,NC	06900
121		DCK(1,J)=CK(1,J)-1.0	06910
122		DO 67 K=2, NPWRM1	06920
123	67	DCK(K,J)=CK(K+1,J)*FLOAT(K-1)	06930
124		DO 68 K=1,20	06940
125	68	CALL HGER(T(K),AHV(1,K),AHL(1,K))	06950
126		DO 71 J=2,20	06960
127		JM1=J-1	06970
128		DO 71 K=1,JM1	06980
129		HOLD=AHV(J,K)	06990
130		AHV(J,K)=AHV(K,J)	07000
131		AHV(K,J)=HOLD	07010
132		HOLD=AHL(J,K)	07020
133		AHL(J,K)=AHL(K,J)	07030
134	71	AHL(K,J)=HOLD	07040
135		NPWR=3	07050
136		DO 73 J=1,NC	07060
137		HOLD=1.0	07070
138		HOLD=FITIT(T,AHV(1,J),20, NPWR,CHV(1,J),1,HOLD)	07080
139		HOLD=1.0	07090
140	73	HOLD=FITIT(T,AHL(1,J),20, NPWR,CHL(1,J),1,HOLD)	07100
141		NPWRM1=NPWR-1	07110
142		DO 75 J=1,NC	07120
143		DCHV(1,J)=CHV(1,J)-1.0	07130
144		DCHL(1,J)=CHL(1,J)-1.0	07140
145		DO 75 K=2, NPWRM1	07150
146		DCHV(K,J)=CHV(K+1,J)*FLOAT(K-1)	07160
147	75	DCHL(K,J)=CHL(K+1,J)*FLOAT(K-1)	07170
148	C		07180
149		RETURN	07190
150		END	07200

```

1 SUBROUTINE ZFEED (SUMT) 157 0721
2 C 0722
3 COMMON // X(20,100), V(100), XL(100), U(100), W(100),
4 1 Q(100), HL(100), MV(100), TA(100), F(21,100), 0724
5 2 HF(100), PP(100), QG, DIST 0725
6 COMMON /CNTRL/ NC, NT, LDDC, NID, NTR1, KTOP, 0726
7 1 N1, N2, N3, NaNa 0727
8 COMMON /PROP/ CNAME(2,20), XNH(20), RHO(20) 0728
9 COMMON /FFDATA/ NF, NAMEF(3,6), NFTRAY(6), ZF(21,6), ZK(20,6), 0729
10 1 QFN(6), TF(6), PF(6), QQQ(6), QEX(6), TTF(6) 0730
11 C 0731
12 REAL QFG(6), QFC(6), AX(6), BX(6), QV(6), QL(6),
13 1 XLL(20), VV(20), YK(20) 0732
14 C 0734
15 WRITE (6,100) 0735
16 100 FORMAT (1H1) 0736
17 C 0737
18 WRITE (6,111) (J,J=1,NF) 0738
19 111 FORMAT (/5X,15HINPUT FEED DATA/7X,7HFEEED NO,14X,6I14) 0739
20 WRITE (6,112) ((NAMEF(I,J),I=1,3),J=1,NF) 0740
21 112 FORMAT (7X,9HFEEED NAME,21X,6(3A4,2X)) 0741
22 WRITE (6,116) (NFTRAY(J),J=1,NF) 0742
23 116 FORMAT (7X,19HENTERING AT TRAY NO,2X,6I14/) 0743
24 C 0744
25 DO 10 I=1,NF 0745
26 ZF(N1,I)=0.0 0746
27 DO 10 I=1,NC 0747
28 10 ZF(N1,I)=ZF(N1,I)+ZF(I,I) 0748
29 C 0749
30 WRITE (6,117) 0750
31 117 FORMAT (7X,19HCOMPOSITION,NDLS/Hr) 0751
32 DO 19 I=1,NC 0752
33 19 WRITE (6,120) (CNAME(K,I),K=1,2),(ZF(I,K),K=1,NF) 0753
34 120 FORMAT (5X,2A4,14X,6F14.2) 0754
35 WRITE (6,121) (ZF(N1,I),I=1,NF) 0755
36 121 FORMAT (7X,5HTOTAL,16X,6F14.2) 0756
37 C 0757
38 C FEED HEAT CONTENT NOT GIVEN IF QFN = 0.0 0758
39 C 0759
40 SUMT=0.0 0760
41 DO 40 I=1,NF 0761
42 IF (QFN(I).NE.0.0) GO TO 21 0762
43 C 0763
44 C FEED ENTHALPY IS NOT GIVEN AND MUST BE CALCULATED, 0764
45 C 0765
46 CALL FLASH (ZF(1,N),ZK(1,N),TF(N),VV,XLL,QV(N),QL(N),QFN(N)) 0766
47 C 0767
48 QFG(N)=0. 0768
49 QFC(N)=QFN(N) 0769
50 GO TO 22 0770

```

```

51 C
52 21 QFN(N)=QFN(N)*1.0E6
53 QFG(N)=QFN(N)
54 QFC(N)=0.
55 C
56 C ADIABATIC FLASH ON FEEDS TO DETERMINE VAPORIZATION AT ENTRY
57 C
58 22 K=NFTRAY(N)
59 QEX(N)=QEX(H)*1.0E6
60 QQQ(N)=QFH(N)+QEX(N)
61 C
62 C QQQ(N) IS TOTAL FEED ENTHALPY AT ENTRY TO TOWER.
63 C
64 TTT=TA(1)-100.
65 TBIG=TA(NT)+100.
66 TDL=QQQ(N)*1.0E-4
67 C
68 23 CALL KGEV (TTT,YK,K)
69 CALL FLASH (ZF(1,N),YK,TTT,VV,XLL,QV(N),QL(N),QQ)
70 C WRITE (6,200) QQ,QQQ(N),TDL,TTT
71 C 200 FORMAT (4E25.7)
72 C
73 IF ( WAYA(QQ,QQQ(N),TDL,TTT,TBIG,2) ) 23,27,26
74 C
75 26 WRITE (6,122) N
76 122 FORMAT (// BX 'FEED FLASH FAILED TO CONVERGE FOR FEED #' I3 //)
77 C
78 27 QV(N)=QV(N)/QQQ(N)*QQ
79 QL(N)=QL(N)/QQQ(N)*QQ
80 28 TTF(N)=TTT
81 AX(N)=0.0
82 BX(N)=0.0
83 DO 29 I=1,NC
84 AX(N)=AX(N)+VV(I)
85 29 BX(N)=BX(N)+XLL(I)
86 C
87 IF (K=2) 34,38,32
88 32 IF (K=NTN1) 38,38,34
89 34 AXBX=ZF(N1,N)
90 QFK=F(N1,K)*HF(K)
91 DO 37 I=1,NC
92 37 F(I,K)=F(I,K)+ZF(I,N)
93 F(N1,K)=F(N1,K)+AXBX
94 IF (F(N1,K).NE.0.0) HF(K)=(QFK+QQ)/F(N1,K)
95 GO TO 40
96 C
97 38 QFKM1=F(N1,K-1)*HF(K-1)
98 QFK=F(N1,K)*HF(K)
99 DO 39 I=1,NC
100 F(I,K-1)=F(I,K-1)+VV(I)

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101 39 F(I,K)=F(I,K)+XLL(I)                                0821
102      F(N1,K-1)=F(N1,K-1)+AX(N)                      0822
103      F(N1,K)=F(N1,K)+BX(N)                          0823
104      IF (F(N1,K-1).NE.0.0) HF(K-1)=(QEKM1+QV(N))/F(N1,K-1) 0824
105      IF (F(N1,K).NE.0.0) HF(K)=(QFK+QL(N))/F(N1,K)     0825
106 40 SUNT=SUNT+ZF(N1,K)                                0826
107 C                                                    0827
108 C                                                    0828
109      WRITE (6,123)(TF(N),N=1,NF)                    0829
110 123 FORMAT (/7X 'TEMPERATURE, F' 9X 6F14.1)         0830
111      WRITE (6,124)(PF(N),N=1,NF)                    0831
112 124 FORMAT (7X 'PRESSURE, PSIA' 9X 6F14.4)         0832
113      WRITE (6,125)(QFC(N),N=1,NF)                   0833
114 125 FORMAT (/7X 'HEAT CONTENT, BTUS (CALC)' F12.0,5F14.0) 0834
115      WRITE (6,126)(QFG(N),N=1,NF)                   0835
116 126 FORMAT (/7X 'HEAT CONTENT, BTUS (GIVEN)' F11.0,5F14.0) 0836
117      WRITE (6,127)(QEX(N),N=1,NF)                   0837
118 127 FORMAT (/7X 'ADDITIONAL HEAT, BTUS' 2X 6F14.0) 0838
119      WRITE (6,128)(QQQ(N),N=1,NF)                   0839
120 128 FORMAT (/7X 'HEAT CONTENT, BTUS (INLET)' F11.0,5F14.0) 0840
121      WRITE (6,129)(TTF(N),N=1,NF)                   0841
122 129 FORMAT (7X 'TEMPERATURE, F (INLET)' 1X 6F14.2) 0842
123      WRITE (6,130)(AX(N),N=1,NF)                    0843
124 130 FORMAT (/7X 'VAPOR, MOLS (INLET)' 4X 6F14.3)   0844
125      WRITE (6,131)(BX(N),N=1,NF)                    0845
126 131 FORMAT (7X 'LIQUID, MOLS (INLET)' 3X 6F14.3)   0846
127 C                                                    0847
128      RETURN                                          0848
129      END                                            0849

```

1		SUBROUTINE	FLASH (XX,ZK,TT,XV,XL,QV,QL,QQT)	160	0850
2	C				0851
3		COMMON	/CONTROL/ NC, NT, LDDC, NID, NTM1, KTOP,		0852
4			N1, N2, N3, N3N3		0853
5	C				0854
6		REAL	XX(1), ZK(1), XV(1), XL(1), HV&P(20), HLIQ(20)		0855
7	C				0856
8	C	SUM	TOTAL FEED		0857
9	C	SUMX	TOTAL LIQUID		0858
10	C	SUMY	TOTAL VAPOR		0859
11	C				0860
12		SUM=0.0			0861
13		SUMX=0			0862
14		SUMY=0.			0863
15		DO 1 I=1,NC			0864
16		IF (XX(I).EQ.0.0) GOTO 1			0865
17		SUM =SUM+XX(I)			0866
18		SUMY =SUMY+XX(I)*ZK(I)			0867
19		SUMX =SUMX+XX(I)/ZK(I)			0868
20		CONTINUE			0869
21	C	WRITE (6,310) SUMX,SUMY,SUM			0870
22	C	FORMAT (11,' /aE25.7)			0871
23	C	IF (SUM -SUMY)4,2,2			0872
24	C				0873
25	C	SUBCOOLED LIQUID			0874
26	C				0875
27	C	2 DO 3 I=1,NC			0876
28		XL(I)=XX(I)			0877
29	C	3 XV(I)=0.			0878
30		SUMX=SUM			0879
31		SUMY=0.0			0880
32	C	WRITE (6,300)			0881
33	C	300 FORMAT (////, SUBCOOLED LIQUID,)			0882
34	C	WRITE (6,20) (XX(J),ZK(J),XV(J),XL(J),J=1,NC)			0883
35	C	20 FORMAT (4E20.6)			0884
36		GO TO 30			0885
37	C	4 IF (SUM -SUMX)7,5,5			0886
38	C				0887
39	C	SUPERHEATED VAPOR			0888
40	C				0889
41	C	5 DO 6 I=1,NC			0890
42		XV(I)=XX(I)			0891
43	C	6 XL(I)=0.			0892
44		SUMY=SUM			0893
45		SUMX=0.0			0894
46	C	WRITE (6,301)			0895
47	C	301 FORMAT (////, SUPERHEATED VAPOR,)			0896
48	C	WRITE (6,20) (XX(J),ZK(J),XV(J),XL(J),J=1,NC)			0897
49		GO TO 30			0898
50	C				0899

```

51 C      TWO-PHASE SYSTEM 161 0900
52 C 0901
53      7 XLF=0.9999999 0902
54      XLF=0.0000001 0903
55 C 0904
56      8 XVF=1.0-XLF 0905
57      SUMY=SUM*XVF 0906
58      SUMX=SUM*XLF 0907
59      YTOT=0.0 0908
60      XTOT=0.0 0909
61      DO 9 I=1,NC 0910
62      FAC=XLF+XVF*ZK(I) 0911
63      XV(I)=XX(I)/SUM *ZK(I)/FAC 0912
64      YTOT=YTOT+XV(I) 0913
65      XL(I)=XX(I)/SUM /FAC 0914
66      9 XTOT=XTOT+XL(I) 0915
67 C 0916
68 C 13 WRITE (6,200) 0917
69 C 200 FORMAT (////' MIXED PHASE!') 0918
70 C WRITE (6,410) SUMX,SUMY,SUM ,YTOT,XTOT 0919
71 C 410 FORMAT (5E25,7) 0920
72 C WRITE (6,20) (XX(J),ZK(J),XV(J),XL(J),J=1,NC) 0921
73      IF ( WAYA ( (YTOT-XTOT),0.0,0.000005,XLF,XLF$,1) ) 8,22,18 0922
74 C 0923
75      18 WRITE (6,100) 0924
76      100 FORMAT (//5X 'FEED FLASH CALCULATION FAILED TO CONVERGE' 0925
77      + /5X 'LIQUID FRACTION EITHER > 0.999999 OR < 0.000001' / 5X 'CALCU 0926
78      2LATION CONTINUING! //) 0927
79 C 0928
80      22 DO 24 I=1,NC 0929
81      XL(I)=XL(I)*SUMX 0930
82      24 XV(I)=XV(I)*SUMY 0931
83 C 0932
84      30 QV=0.0 0933
85      QL=0.0 0934
86      CALL HGEN (TT,HVAP,HLIQ) 0935
87      DO 32 I=1,NC 0936
88      QV=QV+HVAP(I)*XV(I) 0937
89      32 QL=QL+HLIQ(I)*XL(I) 0938
90      QOT=QV+QL 0939
91 C 0940
92      RETURN 0941
93      END 0942

```

```

1 SUBROUTINE INR (**)
2 C
3 COMMON // X(20,100), V(100), XL(100), U(100), W(100),
4 1 Q(100), HL(100), HV(100), TA(100), F(21,100),
5 2 HF(100), PP(100), QG, DIST
6 COMMON /CONTRL/ NC, NT, LDDC, NID, NTA1, KTOP,
7 1 N1, N2, N3, N3N3
8 COMMON /FIX/ A(23,23), B(23,23), C(23,23,3), D(23,100)
9 C
10 REAL Z(1), CC(5290)
11 EQUIVALENCE (Z,A)
12 C
13 DATA DXMAX/0.00050/, DLVMAX/0.001/, DTMAX/0.05/
14 C
15 WRITE (6,102)
16 CALL MWRITE
17 IF (LDDC.LE.2) WRITE (6,102)
18 C
19 DO 1 J=1,NT
20 IF ( XL(J) GT 0.0) GO TO 1
21 WRITE (6,100)
22 100 FORMAT (///20X ,AN INITIAL LIQUID FLOW IS ZERO OR NEGATIVE,///)
23 RETURN 1
24 1 CONTINUE
25 C
26 2 NN=0
27 NNN=-9
28 NMAX=5290/M3N3
29 NCHECK=0
30 NDDNE=0
31 C
32 C
33 DO 90 NIT=1,NID
34 C
35 DO 14 J=1,NT
36 SUM = 0.0
37 DO 12 K=1,NC
38 12 SUM=SUM+X(K,J)
39 DO 13 K=1,NC
40 13 X(K,J)=X(K,J)/SUM
41 14 CONTINUE
42 C
43 C GENERAL PROCEDURE IS TO SOLVE A TRIDIAGONAL MATRIX BY
44 C (1) CLEARING THE LOWER LEFT ELEMENTS AND MAKING THE
45 C DIAGONAL ELEMENTS THE IDENTITY MATRIX
46 C (2) CLEARING THE UPPER RIGHT ELEMENTS BY BACK SUBSTITUTION
47 C
48 DO 40 I=1,NT
49 C
50 CALL ABCD (I)

```


Line	Code	Address	Page
51	IF (I, EQ, 1) GO TO 23		0993
52	C		0994
53	DO 22 L=1, N3		0995
54	DPM=0.0		0996
55	DO 21 K=1, N3		0997
56	DPM=DPM+A(L, K)*D(K, I-1)		0998
57	DDH=0.0		0999
58	DO 20 M=1, N3		1000
59	20 DDH=DDH+A(K, M)*C(M, L, 1)		1001
60	21 B(K, L)=B(K, L)-DDH		1002
61	22 D(L, I)=B(L, I)-DPM		1003
62	C		1004
63	23 L=0		1005
64	DO 24 M=1, N3		1006
65	DO 24 M=1, N3		1007
66	L=L+1		1008
67	24 Z(L)=B(M, N)		1009
68	CALL MIMV (Z, N3, DETRM, B(1, 1), B(1, 2))		1010
69	IF (DETRM, EQ, 0.0) GO TO 41		1011
70	L=0		1012
71	DO 25 N=1, N3		1013
72	DO 25 M=1, N3		1014
73	L=L+1		1015
74	25 B(M, N)=Z(L)		1016
75	IF (L, EQ, NT) GO TO 30		1017
76	C		1018
77	DO 27 L=1, N3		1019
78	DO 27 K=1, N3		1020
79	A(K, L)=0.		1021
80	DO 27 M=1, N3		1022
81	27 A(K, L)=A(K, L)+B(K, M)*C(M, L, 2)		1023
82	DO 28 L=1, N3		1024
83	DO 28 K=1, N3		1025
84	28 C(K, L, 2)=A(K, L)		1026
85	C		1027
86	30 DO 31 K=1, N3		1028
87	Z(K)=0.0		1029
88	DO 31 M=1, N3		1030
89	31 Z(K)=Z(K)+B(K, M)*D(M, I)		1031
90	DO 33 K=1, N3		1032
91	33 D(K, I)=Z(K)		1033
92	IF (I, EQ, NT) GO TO 41		1034
93	C		1035
94	L=NN*N3		1036
95	DO 36 N=1, N3		1037
96	DO 36 M=1, N3		1038
97	L=L+1		1039
98	36 CC(L)=C(M, N, 2)		1040
99	NN=NN+1		1041
100	IF (NN, LT, NMAX) GO TO 37		1042

164

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101 IF ( NTH1.LE.NMAX ) GO TO 37 1043
102 NN=0 1044
103 NNN=NNN+10 1045
104 WRITE (10,NNN) CC 1046
105 37 DO 38 L=1,N3 1047
106 DO 38 K=1,N3 1048
107 C(K,L,1)=C(K,L,2) 1049
108 38 C(K,L,2)=0.0 1050
109 40 CONTINUE 1051
110 C 1052
111 41 DO 46 N=1,NTH1 1053
112 I=NT-N 1054
113 IF ( NN.GT.D ) GO TO 42 1055
114 READ (10,NN) CC 1056
115 NN=NMAX 1057
116 NNN=NNN-10 1058
117 42 L=(NN-1)*N3N3 1059
118 DO 43 K=1,N3 1060
119 DO 43 M=1,N3 1061
120 L=L+1 1062
121 43 C(K,K,2)=CC(L) 1063
122 NN=NN-1 1064
123 DO 45 K=1,N3 1065
124 DPM=0.0 1066
125 DO 44 M=1,N3 1067
126 44 DPM=DPM+C(K,M,2)*D(M,I+1) 1068
127 45 D(K,I)=D(K,I)-DPM 1069
128 46 CONTINUE 1070
129 C 1071
130 IF ( LDCC.NE.4 ) GO TO 50 1072
131 WRITE (6,102) 1073
132 DO 49 N=1,NT 1074
133 WRITE (6,119) N,(D(J,N),J=1,N3) 1075
134 119 FORMAT (//1 COMPUTED CORRECTIONS ON STAGE! I10/(105E20,5)) 1076
135 49 CONTINUE 1077
136 C 1078
137 C CHECK FOR CONVERGENCE 1079
138 C (1) MAXIMUM ABS(DX) .LT. DXMAX X = COMPOSITION 1080
139 C (2) MAXIMUM ABS(DP)/F .LT. DPMAX F = FLDW L & V 1081
140 C (3) MAXIMUM ABS(DT) .LT. DTMAX T = TEMPERATURE 1082
141 C SCALE CORRECTIONS IF TOO LARGE --- CAUSE FOR SCALING 1083
142 C (1) X .LE. 0.0 .AND. X .GE. 1.0 1084
143 C (2) DP .GT. 0.2U*F 1085
144 C (3) DT .GT. 20.0 1086
145 C 1087
146 50 DX=0.0 1088
147 DT=0.0 1089
148 DLV=0.0 1090
149 SUMSQ=0.0 1091
150 C 1092

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165

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151      DD 52 N=1,NT
152 C    IF (ABS(D(N3,N)).GT.5000.) GO TO 53
153      SUNSQ=SUNSQ+D(N3,N)**2
154      DLV=AMAX1(ABS(D(N1,N))/XL(N),ABS(D(N2,N))/V(N),DLV)
155      DT=AMAX1(ABS(D(N3,N)),DT)
156      DD 51 J=1,NC
157      51 DX=AMAX1(ABS(D(J,N)),DX)
158      52 CONTINUE
159 C
160      IF(DX.LT.DXMAX .AND. DLV.LT.DLVMAX .AND. DT.LT.DTMAX)NDONE=1
161      IF(NDONE.EQ.1) GO TO 54
162      53 NCHECK=NCHECK+1
163      GO TO 55
164      54 IF (NCHECK.EQ.0) GO TO 55
165      NDONE=0
166      NCHECK=0
167 C
168      55 DD 57 N=1,NT
169      DD 57 J=1,NC
170      CK=X(J,N)+D(J,N)
171      IF(X(J,N).LT.1.E-6) GO TO 56
172      IF(CK.LE.0.0 .OR. CK.GE.1.0) GO TO 59
173      GO TO 57
174      56 IF (CK.LE.0.0) D(J,N)=SIGN(X(J,N)/2.0,D(J,N))
175      57 CONTINUE
176      GOTO61
177      59 NDONE=0
178      DD 60 N=1,NT
179      DD 60 J=1,NC
180      60 D(J,N)=D(J,N)*0.5
181      GOTO55
182 C
183      61 DD 62 N=1,NT
184      IF (ABS(D(N1,N)).GT.0.20*XL(N) .OR. ABS(D(N2,N)).GT.0.20*V(N))
185      1 GOTO65
186      62 CONTINUE
187      GOTO71
188      65 NDONE=0
189      DD 67 N=1,NT
190      DD 67 K=N1,N2
191      67 D(K,N)=D(K,N)*0.5
192      GOTO61
193 C
194      71 DD 72 N=1,NT
195      IF (ABS(D(N3,N)).GT.20.0) GO TO 75
196      72 CONTINUE
197      GOTO81
198      75 NDONE=0
199      DD 76 R=1,RT
200      76 D(N3,N)=D(N3,N)*0.5

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201		GO TO 71	1143
202	C		1144
203	81	DO 84 N=1,NT	1145
204		DO 83 J=1,NC	1146
205	83	X(J,N)=X(J,N)+D(J,N)	1147
206		XL(N)=XL(N)+D(N1,N)	1148
207		V(N)=V(N)+D(N2,N)	1149
208	84	TA(N)=TA(N)+D(N3,N)	1150
209	C		1151
210	85	IF (LDDC.EQ.1) GO TO 89	1152
211		IF (LDDC.GT.2) WRITE (6,102)	1153
212		WRITE (6,108) NIT,NCHECK,SUMSQ,DT,DLV,DX	1154
213	108	FORMAT (' ITERATION NUMBER' I5,I6/ ' SUM DT SQUARED' F20.6, 10X	1155
214		I ' DT MAX' F20.6/ ' MAX DF/F' F26.6, 10X ' MAX DX' F20.6)	1156
215		IF (LDDC.EQ.2 .AND. MOD(NIT,15).EQ.0) WRITE (6,102)	1157
216	C		1158
217	87	GO TO (89,89,88,88), LDDC	1159
218	88	CALL MWRITE	1160
219	89	IF (NDONE.EQ.0) GO TO 93	1161
220	C		1162
221	C		1163
222	90	CONTINUE	1164
223		GO TO 93	1165
224	C		1166
225	C		1167
226	91	WRITE (6,101) I	1168
227	101	FORMAT (/// 20X 'PROBLEM CANNOT INVERT MATRIX ON STAGE' I5, 20X	1169
228		I 'CHECK INPUT DATA'///)	1170
229		WRITE (6,102)	1171
230	102	FORMAT (1H1)	1172
231		CALL MWRITE	1173
232		RETURN 1	1174
233	C		1175
234	C	CONVERGENCE CHECK	1176
235	C		1177
236	93	IF (NDONE.NE.0) GO TO 95	1178
237		WRITE (6,111)	1179
238	111	FORMAT (///20X 'NO CLOSURE OBTAINED ON PROBLEM FOR SPECIFIED NUMBE	1180
239		IB OF TRIALS'///)	1181
240		WRITE (6,102)	1182
241		CALL MWRITE	1183
242		RETURN 2	1184
243	C		1185
244	95	GO TO (96,96,999,999), LDDC	1186
245	96	WRITE (6,102)	1187
246		CALL MWRITE	1188
247	C		1189
248	999	RETURN	1190
249		END	1191

1		SUBROUTINE ABCD (1)	1192
2	C		1193
3		COMMON // X(20,100), V(100), XL(100), U(100), W(100),	1194
4	1	Q(100), HL(100), HV(100), TA(100), F(21,100),	1195
5		HF(100), PF(100), QG, DIST	1196
6	2	COMMON /CTRL/ NC, NT, LDCC, NIU, NTM ₁ , KTOP,	1197
7	1	N ₁ , N ₂ , N ₃ , N ₃	1198
8		COMMON /DATA/ WK(20), DK(20), HVV(20), HLL(20), DHV(20),	1199
9	1	DHL(20), Y(20)	1200
10		COMMON /FIX/ A(23,23), B(23,23), C(23,23,3), D(23,100)	1201
11	C		1202
12		REAL Z(1)	1203
13		EQUIVALENCE (Z(1),Z(1))	1204
14			1205
15	C	ASSIGN 46 TO JJ	1206
16	C		1207
17		IF (I.GT.1) GO TO 14	1208
18		IF (LDCC.EQ.4) WRITE (9,101)	1209
19	101	FORMAT ('1')	1210
20	C		1211
21	C	CLEAR AREA /FIX/ -- B, C, AND D ONLY	1212
22	C		1213
23		DO 11 J=1,4416	1214
24	11	Z(J)=0.0	1215
25		CALL GET(1)	1216
26		GO TO 25	1217
27	14	IF (I.EQ.NT) ASSIGN 61 TO JJ	1218
28	C		1219
29	C	CLEAR B BEFORE GENERATING NON-ZERO ENTRIES	1220
30	C	TRANSFER STAGE (I-1) DATA FROM C(K,J,3) INTO A	1221
31	C	A CONTAINS STAGE (I-1) DATA	1222
32	C		1223
33		DO 21 J=1,N3	1224
34		DO 21 K=1,N3	1225
35		B(K,J)=0.0	1226
36		A(K,J)=C(K,J,3)	1227
37	21	C(K,J,3)=0.0	1228
38	C		1229
39	C	B CONTAINS STAGE (I) DATA	1230
40	C	D CONTAINS ERROR TERMS	1231
41	C		1232
42	25	VW=V(I)+R(I)	1233
43		XLH=XL(I)+D(I)	1234
44		DO 32 J=1,NC	1235
45		B(J,J)=-VW*WK(J)-XL _J	1236
46		B(J,N1)=-X(J,I)	1237
47		B(J,N2)=-Y(J)	1238
48		B(J,N3)=-VW*X(J,I)*DK(J)	1239
49		D(J,I)=D(J,I)+(VW*DK(J)+XL _U)*X(J,I)-F(J,I)	1240
50		B(N2,J)=1.0	1241

51		D(N2,I)=B(N2,I)-X(J,I)	124
52		B(N3,J)=-VW*WK(J)*HVV(J)-XLU*HLL(J)	124
53		B(N3,N1)=B(N3,N1)-X(J,I)*HLL(J)	124
54		B(N3,N2)=B(N3,N2)-Y(J)*HVV(J)	124
55		P(N3,N3)=B(N3,N3)-VW*(Y(J)*DHV(J)+HVV(J)*DK(J)*X(J,I))	124
56	1	-XLU*DHL(J)*X(J,I)	124
57		D(N3,I)=D(N3,I)+VW*Y(J)*HVV(J)+XLU*X(J,I)*HLL(J)	124
58	32	CONTINUE	124
59	C		125
60		B(N1,N1)=-1.0	125
61		B(N1,N2)=-1.0	125
62		D(N1,I)=D(N1,I)+VW+XLU-F(N1,I)	125
63		B(N2,I)=D(N2,I)+1.0	125
64		D(N3,I)=D(N3,I)+O(I)-F(N1,I)*HF(I)	125
65	C		125
66	C	SINCE DATA FOR STAGE (I) IS NEEDED FOR NEXT ENTRY INTO FIXUP ---	125
67	C	GENERATE INFORMATION AND STORE A DATA IN NEXT C AND D VALUES WHERE	125
68	C	THEY BELONG	125
69	C		126
70		GO TO JJ, (46,61)	126
71	46	DD 49 J=1,NC	126
72		C(J,J,3)=XL(I)	126
73		C(J,N1,3)=X(J,I)	126
74		D(J,I+1)=D(J,I+1)-XL(I)*X(J,I)	126
75		C(N3,J,3)=XL(I)*HLL(J)	126
76		C(N3,N1,3)=C(N3,N1,3)+X(J,I)*HLL(J)	126
77		C(N3,N3,3)=C(N3,N3,3)+XL(I)*X(J,I)*DHL(J)	126
78		D(N3,I+1)=D(N3,I+1)-XL(I)*X(J,I)*HLL(J)	126
79	49	CONTINUE	126
80		C(N1,N1,3)=1.0	126
81		D(N1,I+1)=-XL(I)	126
82	C		126
83	C	GENERATE THERMODYNAMIC DATA FOR STAGE (I+1)	126
84	C	C CONTAINS STAGE (I+1) DATA	126
85	C	NOTE: THE STAGE (I+1) THERMODYNAMIC DATA WILL BE USED	126
86	C	ON NEXT ENTRY INTO FIXUP	126
87	C		126
88		CALL GET(I+1)	126
89		DD 51 J=1,NC	126
90		C(J,J,2)=V(I+1)*WK(J)	126
91		C(J,N2,2)=Y(J)	126
92		C(J,N3,2)=V(I+1)*X(J,I+1)*DK(J)	126
93		D(J,I)=D(J,I)-V(I+1)*Y(J)	126
94		C(N3,J,2)=V(I+1)*WK(J)*HVV(J)	126
95		C(N3,N2,2)=C(N3,N2,2)+Y(J)*HVV(J)	126
96		C(N3,N3,2)=C(N3,N3,2)+V(I+1)*(Y(J)*DHV(J)+X(J,I+1)*HVV(J)*DK(J))	126
97		D(N3,I)=D(N3,I)-V(I+1)*Y(J)*HVV(J)	126
98	51	CONTINUE	126
99		C(N1,N2,2)=1.0	126
100		D(N1,I)=D(N1,I)-V(I+1)	126

101	C				1292
102		61	GO TO (71,71,71,67), LDDC		1293
103		67	WRITE (6,102) I, (D(J,I), J=1, NB)		1294
104		102	FORMAT (// ' ERRORS ON STAGE! ', 110 // (1P5E20.5))		1295
105	C				1296
106	C				1297
107		71	RETURN		1298
108			END		1299

1	SUBROUTINE MINV(A,N,D,L,M)	1300
2	C	1301
3	C PURPOSE	1302
4	C INVERT A MATRIX	1303
5	C	1304
6	C USAGE	1305
7	C CALL MINV(A,N,D,L,M)	1306
8	C	1307
9	C DESCRIPTION OF PARAMETERS	1308
10	C A - INPUT MATRIX, DESTROYED IN COMPUTATION AND REPLACED BY	1309
11	C RESULTANT INVERSE.	1310
12	C N - ORDER OF MATRIX A	1311
13	C D - RESULTANT DETERMINANT	1312
14	C L - WORK VECTOR OF LENGTH N	1313
15	C M - WORK VECTOR OF LENGTH N	1314
16	C	1315
17	C REMARKS	1316
18	C MATRIX A MUST BE A GENERAL MATRIX	1317
19	C	1318
20	C SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED	1319
21	C NONE	1320
22	C	1321
23	C METHOD	1322
24	C THE STANDARD GAUSS-JORDAN METHOD IS USED. THE DETERMINANT	1323
25	C IS ALSO CALCULATED. A DETERMINANT OF ZERO INDICATES THAT	1324
26	C THE MATRIX IS SINGULAR.	1325
27	C	1326
28	C	1327
29	C	1328
30	C DIMENSION A(1),L(1),M(1)	1329
31	C	1330
32	C	1331
33	C	1332
34	C IF A DOUBLE PRECISION VERSION OF THIS ROUTINE IS DESIRED, THE	1333
35	C IF COLUMN 1 SHOULD BE REMOVED FROM THE DOUBLE PRECISION	1334
36	C STATEMENT WHICH FOLLOWS.	1335
37	C	1336
38	C DOUBLE PRECISION A,D,BIGA,HOLD	1337
39	C	1338
40	C THE C MUST ALSO BE REMOVED FROM DOUBLE PRECISION STATEMENTS	1339
41	C APPEARING IN OTHER ROUTINES USED IN CONJUNCTION WITH THIS	1340
42	C ROUTINE.	1341
43	C	1342
44	C THE DOUBLE PRECISION VERSION OF THIS SUBROUTINE MUST ALSO	1343
45	C CONTAIN DOUBLE PRECISION FORTRAN FUNCTIONS. ABS IN STATEMENT	1344
46	C 10 MUST BE CHANGED TO DABS.	1345
47	C	1346
48	C	1347
49	C	1348
50	C SEARCH FOR LARGEST ELEMENT	1349

51	C			1350
52		D=1.0		1351
53		NK=-N		1352
54		DD 20 K=1,N		1353
55		NK=NK+N		1354
56		L(K)=K		1355
57		B(K)=K		1356
58		KK=NK+K		1357
59		BIGA=A(KK)		1358
60		DD 20 J=K,N		1359
61		IZ=N*(J-1)		1360
62		DD 20 I=K,N		1361
63		IJ=IZ+I		1362
64	10	IF(ABS(BIGA)-ABS(A(IJ))) 15,20,20		1363
65	15	BIGA=A(IJ)		1364
66		L(K)=I		1365
67		M(K)=J		1366
68	20	CONTINUE		1367
69	C			1368
70	C	INTERCHANGE ROWS		1369
71	C			1370
72		J=L(K)		1371
73		IF(J_K) 25,35,25		1372
74	25	KI=K_N		1373
75		DD 30 I=1,N		1374
76		KI=KI+N		1375
77		HOLD=-A(KI)		1376
78		JI=KI-K+J		1377
79		A(KI)=A(JI)		1378
80	30	A(JI)=HOLD		1379
81	C			1380
82	C	INTERCHANGE COLUMNS		1381
83	C			1382
84	35	I=M(K)		1383
85		IF(I_K) 45,45,38		1384
86	38	JP=N*(I-1)		1385
87		DD 40 J=1,N		1386
88		JK=NK+J		1387
89		JJ=JP+J		1388
90		HOLD=-A(JK)		1389
91		A(JK)=A(JJ)		1390
92	40	A(JJ)=HOLD		1391
93	C			1392
94	C	DIVIDE COLUMN BY MINUS PIVOT (VALUE OF PIVOT ELEMENT IS		1393
95	C	CONTAINED IN BIGA)		1394
96	C			1395
97	45	IF(BIGA) 48,46,48		1396
98	46	D=0.0		1397
99		RETURN		1398
100	48	DD 55 I=1,N		1399

171

101		IF(I-K) 50,55,50	1400
102	50	IK=NK+I	1401
103		A(IK)=A(IK)/(-BIGA)	1402
104	55	CONTINUE	1403
105	C		1404
106	C	REDUCE MATRIX	1405
107	C		1406
108		DO 65 I=1,N	1407
109		IK=NK+I	1408
110		HOLD=A(IK)	1409
111		IJ=I-N	1410
112		DO 65 J=1,N	1411
113		IJ=IJ+N	1412
114		IF(I-K) 60,65,60	1413
115	60	IF(J-K) 62,65,62	1414
116	62	KJ=IJ-I+K	1415
117		A(IJ)=HOLD*A(KJ)+A(IJ)	1416
118	65	CONTINUE	1417
119	C		1418
120	C	DIVIDE ROW BY PIVOT	1419
121	C		1420
122		KJ=K-N	1421
123		DO 75 J=1,N	1422
124		KJ=KJ+1	1423
125		IF(J-K) 70,75,70	1424
126	70	A(KJ)=A(KJ)/BIGA	1425
127	75	CONTINUE	1426
128	C		1427
129	C	PRODUCT OF PIVOTS	1428
130	C		1429
131		D=D*BIGA	1430
132	C		1431
133	C	REPLACE PIVOT BY RECIPROCAL	1432
134	C		1433
135		A(KK)=1.0/BIGA	1434
136	80	CONTINUE	1435
137	C		1436
138	C	FINAL ROW AND COLUMN INTERCHANGE	1437
139	C		1438
140		K=N	1439
141	100	K=(K-1)	1440
142		IF(K) 150,150,105	1441
143	105	I=L(K)	1442
144		IF(I-K) 120,120,108	1443
145	108	JQ=N*(K-1)	1444
146		JR=N*(I-1)	1445
147		DO 110 J=1,N	1446
148		JK=JQ+J	1447
149		HOLD=A(JK)	1448
150		JI=JR+J	1449

172

151		A(JK)=-A(JI)	1450
152	110	A(JI) =HOLD	1451
153	120	J=K(K)	1452
154		IF(J-K, 100,100,125)	1453
155	125	KI=K-N	1454
156		DO 130 I=1,N	1455
157		KI=KI+N	1456
158		HOLD=A(KI)	1457
159		JI=KI-K+J	1458
160		A(KI)=-A(JI)	1459
161	130	A(JI) =HOLD	1460
162		GO TO 100	1461
163	150	RETURN	1462
164		END	1463

173

1		SUBROUTINE GET(I)		14640
2	C			14650
3		COMMON //	X(20,100), V(100), XL(100), U(100), W(100),	14660
4	1		Q(100), HL(100), HV(100), TA(100), F(21,100),	14670
5	2		HF(100), PP(100), QG, DIST	14680
6		COMMON /CONTRL/	NC, NT, LDDC, NID, HTM1, KTOP,	14690
7	1		N1, N2, N3, N3N3	14700
8		COMMON /DATA/	WK(20), DK(20), HVV(20), HLL(20), DHV(20),	14710
9	1		DHL(20), Y(20)	14720
10		COMMON /DEF/	CK(8,20), DCK(7,20), CHV(6,20),	14730
11	1		DCHV(5,20), CHL(6,20), DCHL(5,20),	14740
12	2		PPA, MCODE	14750
13	C			14760
14		T=TA(I)		14770
15		SUM=0.0		14780
16		HV(I)=0.0		14790
17		HL(I)=0.0		14800
18		DO 11 J=1,NC		14810
19		WK(J)=EQUA(T,CK(1,J))		14820
20		DK(J)=EQUA(T,DCK(1,J))		14830
21		HVV(J)=EQUA(T,CHV(1,J))		14840
22		DHV(J)=EQUA(T,DCHV(1,J))		14850
23		HLL(J)=EQUA(T,CHL(1,J))		14860
24	11	DHL(J)=EQUA(T,DCHL(1,J))		14870
25		IF(MCODE.EQ.0) GO TO 19		14880
26		GO TO (19,14), MCODE		14890
27	14	PRATIO=PPA/PP(I)		14900
28		DO 17 J=1,NC		14910
29		WK(J)=WK(J)*PRATIO		14920
30	17	DK(J)=DK(J)*PRATIO		14930
31	19	DO 21 J=1,NC		14940
32		Y(J)=WK(J)*X(J,I)		14950
33		SUM=SUM+Y(J)		14960
34		HV(I)=HV(I)+HVV(I)*Y(J)		14970
35	21	HL(I)=HL(I)+HLL(I)*X(J,I)		14980
36		HV(I)=HV(I)/SUM		14990
37	C			15000
38	C			15010
39		RETURN		15020
40		END		15030

175

1		SUBROUTINE	OUTPUT		1504
2	C				1505
3	C				1506
4		COMMON	//	X(20,100), V(100), XL(100), U(100), W(100),	1507
5	+			Q(100), HL(100), HV(100), TA(100), F(21,100),	1508
6	+			HF(100), PP(100), QG, DIST	1509
7		COMMON	/CONTROL/	NC, NT, LDDC, NI, N1, N2, N3, N3N3, N1M1, KTOP,	1510
8	1				1511
9		COMMON	/FEEDDATA/	NE, NAMEF(3,6), NETRAY(6), ZF(21,6), ZK(20,6),	1512
10	+			QFN(6), TF(6), PF(6), QQQ(6), QEX(6), TTF(6)	1513
11		COMMON	/PROP/	CNAME(2,20), XMW(20), RHD(20)	1514
12		COMMON	/FIX/	EK(20,100), Z(20), XX(20,11), IAA(2,9),	1515
13	+			IBBT(2,9), ICC(2,9), IDO(9), SUMN(11), SUMP(9),	1516
14	+			SUMG(9), TEMP(9), QQS(9), NTT(9), NNN(9),	1517
15	+			SLDP(2577)	1518
16		COMMON	/COEF/	CK(8,20), DCK(7,20), CHV(6,20),	1519
17	1			DCHV(5,20), CHL(6,20), DCHL(5,20),	1520
18	2			PRA, MCODE	1521
19	C				1522
20		DATA		NOUT /6/	1523
21	C				1524
22		INTEGER	BLANK //	MDLS /'MDLS'/,	1525
23	+		FQND(2) /'FEED', 'NO' //,	TRND(2) /'TRAY', 'NO' //,	1526
24	+		COMB(2) /'COMB', 'LINED' //,	FD(2) /' FE', 'IED' //,	1527
25	+		OVHD(2) /'OVER', 'HEAD' //,	LIQ(2) /' LIQ', 'UID' //,	1528
26	+		VAP(2) /' VAP', 'DR' //,	PROD(2) /' PRD', 'DUCT' //,	1529
27	+		BTM(2) /' BOT', 'TQMS' //,		1530
28	+		SSND(2) /' SS', 'NO' //		1531
29	C				1532
30	C				1533
31			NBLK=0		1534
32			TA(1)=TA(1)+ABS(DTSUB)		1535
33			DO 10 N=1,NT		1536
34			PRATIO=1.0		1537
35			IF(MCODE.EQ.0) GO TO 8		1538
36			GO TO (8,6), MCODE		1539
37	6		PRATIO=PRA/PP(N)		1540
38	8		DO 10 J=1,NC		1541
39	10		EK(J,N)=EQUA(TA(N),CK(1,J))*PRATIO		1542
40			TA(1)=TA(1)-ABS(DTSUB)		1543
41	C				1544
42			WRITE (NOUT,201)		1545
43	201		FORMAT (' FEED AND PRODUCT COMPOSITIONS' //)		1546
44	C				1547
45			ASSIGN 15 TO INDEX		1548
46	C				1549
47	11		K=0		1550
48			DO 12 J=1,9		1551
49			SUMN(J)=0.0		1552
50			SUMP(J)=0.0		1553

51		SUMG(J)=0.0	15540
52		QQS(J)=0.0	15550
53		TEMP(J)=0.0	15560
54	C		15570
55		NTT(J)=BLANK	15580
56		NNN(J)=BLANK	1559
57		IDD(J)=M0L5	1560
58		DD 12 I=1,NC	1561
59	12	XX(I,J)=0.0	1562
60	C		1563
61		DD 13 J=1,2	1564
62		DD 13 I=1,9	1565
63		IAA(J,I)=BLANK	1566
64		IRB(J,I)=BLANK	1567
65	13	ICC(J,I)=BLANK	1568
66	C		1569
67		GO TO INDEX, (15,41,47,61,70)	1570
68	C		1571
69	C	CALCULATE SEPARATE FEEDS	1572
70	C		1573
71	15	DD 17 N=1,NF	1574
72		K=K+1	1575
73		L=NFTRAY(N)	1576
74		CALL ALNUM (L,NTT(K))	1577
75		CALL ALNUM (L,NNN(K))	1578
76		DD 16 I=1,NC	1579
77	16	XX(I,K)=ZF(I,N)	1580
78		SUMM(K)=ZF(N1,N)	1581
79		TEMP(K)=TTF(N)	1582
80		QQS(K)=QQQ(N)	1583
81		DD 17 J=1,2	1584
82		IAA(J,K)=FDND(J)	1585
83	17	ICC(J,K)=TRND(J)	1586
84	C		1587
85	C	CALCULATE TOTAL FEED --- ONLY IF MORE THAN ONE FEED	1588
86	C		1589
87		IF (NF.EQ.1) GO TO 30	1590
88		K=K+1	1591
89		DD 19 N=1,NF	1592
90		SUMM(K)=SUMM(K)+SUMM(N)	1593
91		QQS(K)=QQS(K)+QQS(N)	1594
92		DD 19 I=1,NC	1595
93	19	XX(I,K)=XX(I,K)+XX(I,N)	1596
94		DD 20 J=1,2	1597
95		IAA(J,K)=CDBB(J)	1598
96	20	IRB(J,K)=FD(J)	1599
97	C		1600
98	C	CALCULATE OVERHEAD DISTILLATE ***VAPOR***	1601
99	C		1602
100	30	IF(V(1).EQ.0.0) GO TO 39	1603

101	K=K+1	1604
102	KK=KK+1	1605
103	DO 31 I=1,NC	1606
104	31 XX(I,K)=X(I,1)*EK(I,1)*V(1)	1607
105	SUMM(K)=V(1)	1608
106	TEMP(K)=TA(1)	1609
107	QQS(K)=SUMM(K)*HL(1)	1610
108	DO 32 J=1,2	1611
109	IAA(J,K)=QVHD(J)	1612
110	IBB(J,K)=VAP(J)	1613
111	32 ICC(J,K)=pRDD(J)	1614
112	C	1615
113	C	1616
114	C CALCULATE SIDESTREAMS	1617
115	C	1618
116	39 KK=0	1619
117	DO 58 M=2,NTM1	1620
118	C	1621
119	C *** LIQUID SIDESTREAMS ***	1622
120	C	1623
121	IF (U(M).EQ.0.0) GO TO 46	1624
122	IF (K.LT.9) GO TO 41	1625
123	ASSIGN 41 TO INDEX	1626
124	GO TO 64	1627
125	41 K=K+1	1628
126	DO 44 I=1,NC	1629
127	44 XX(I,K)=U(M)*X(I,M)	1630
128	SUMM(K)=U(M)	1631
129	QQS(K)=HL(M)*U(M)	1632
130	DO 45 J=1,2	1633
131	45 IBB(J,K)=LIQ(J)	1634
132	GO TO 53	1635
133	C	1636
134	C *** VAPOR SIDESTREAMS ***	1637
135	C	1638
136	46 IF (W(M).EQ.0.0) GO TO 58	1639
137	IF (K.LT.9) GO TO 47	1640
138	ASSIGN 47 TO INDEX	1641
139	GO TO 64	1642
140	47 K=K+1	1643
141	DO 49 I=1,NC	1644
142	49 XX(I,K)=X(I,M)*EK(I,M)	1645
143	SUMM(K)=W(M)	1646
144	QQS(K)=W(M)*HV(M)	1647
145	DO 52 J=1,2	1648
146	52 IBB(J,K)=VAP(J)	1649
147	C	1650
148	53 CALL ALNUM (M-1,NTT(K))	1651
149	CALL ALNUM (KK+2,NNN(K))	1652
150	DO 54 J=1,2	1653

FORTRAN IV (VER L38) SOURCE LISTING:	OUTPUT	SUBROUTINE	04/10/73	PAGE
151		IAA(J,K)=SSND(J)	178	16540
152	54	ICC(J,K)=TRND(J)		16550
153		TEMP(K)=TA(M)		16560
154	58	CONTINUE		16570
155	C			16580
156	C	CALCULATE BOTTOMS		16590
157	C			16600
158		IF (K.LT.9) GO TO 61		16610
159		ASSIGN 61 TO INDEX		16620
160		GO TO 64		16630
161	61	K=K+1		16640
162		GO 62 I=1,NC		16650
163	62	XX(I,K)=X(I,NT)*XL(NT)		16660
164		SUMM(K)=XL(NT)		16670
165		QOS(K)=SUMM(K)*HL(NT)		16680
166		TEMP(K)=TA(NT)		16690
167		GO 63 J=1,2		16700
168		IAA(J,K)=BTM(J)		16710
169	63	IBB(J,K)=PRDD(J)		16720
170		ASSIGN 70 TO INDEX		16730
171	C			16740
172	C	PRINT OUT DATA SUMMARY		16750
173	C			16760
174	64	NL=K		16770
175	C			16780
176		WRITE (NDOUT,111) ((IAA(N,K),N=1,2),NNN(K),K=1,NL)		16790
177	111	FORMAT (14X,27A4)		16800
178		WRITE (NDOUT,112) ((IBB(N,K),N=1,2),K=1,NL)		16810
179	112	FORMAT (15X,8(2A4,4X),2A4)		16820
180		WRITE (NDOUT,111) ((ICC(N,K),N=1,2),NTT(K),K=1,NL)		16830
181		WRITE (NDOUT,113) (IDD(K),K=1,NL)		16840
182	113	FORMAT (' COMPONENT' 7X,A4, 8(BX,A4))		16850
183		GO 65 I=1,NC		16860
184	65	WRITE (NDOUT,121) (CNAME(K,I),K=1,2),(XX(I,K),K=1,NL)		16870
185	121	FORMAT (1X,2A4,1X,9F12.4)		16880
186	C			16890
187		WRITE (NDOUT,123) (SUMM(K),K=1,NL)		16900
188	123	FORMAT (' TOTAL' 4X,9F12.4)		16910
189		GO 67 K=1,NL		16920
190		GO 66 I=1,NC		16930
191		FAC=XX(I,K)*XMW(I)		16940
192		SUMP(K)=SUMP(K)+FAC		16950
193	66	SUNG(K)=SUNG(K)+FAC/RHD(I)		16960
194	67	QOS(K)=QOS(K)/1000.0		16970
195		WRITE (NDOUT,124) (SUMP(K),K=1,NL)		16980
196	124	FORMAT (' POUNDS' 3X,9F12.2)		16990
197		WRITE (NDOUT,126) (SUNG(K),K=1,NL)		17000
198	126	FORMAT (' GALLONS' 2X,9F12.2)		17010
199		WRITE (NDOUT,128) (QOS(K),K=1,NL)		17020
200	128	FORMAT (' Q, MBTU' 2X,9F12.3)		17030

201		WRITE (NDOUT,129) (TEMP(K),K=1,NL)	1704
202	129	FORMAT ('0TEMP, F' 2X,9F12.2)	1705
203	C		1706
204		NBLK=NBLK+1	1707
205		GO TO (69,68), NBLK	1708
206	C		1709
207	68	WRITE (NDOUT,136)	1710
208	136	FORMAT ('1' //)	1711
209		GO TO 11	1712
210	C		1713
211	69	WRITE (NDOUT,137)	1714
212	137	FORMAT (////)	1715
213		NBLK=0	1716
214		GO TO 11	1717
215	C		1718
216	C	CALCULATE AND PRINT-OUT TRAY SUMMARY	1719
217	C		1720
218	70	WRITE (NDOUT,140)	1721
219	140	FORMAT ('1' 10X 'NET LIQUID & VAPOR LEAVING EACH STAGE' //)	1722
220	C		1723
221		NL=4	1724
222		DO 71 J=6,10	1725
223	71	SUMM(J)=100.0	1726
224	C		1727
225		DO 98 H=1,NT	1728
226		K=N	1729
227		IF(NL+NC+9.LT.58) GO TO 73	1730
228		WRITE (NDOUT,140)	1731
229		NL=4	1732
230	C		1733
231	73	IF (N.EQ.NT .AND. QG.NE.0.0) GO TO 74	1734
232		WRITE (NDOUT,143) K,TA(N),PP(N)	1735
233	143	FORMAT ('0 TRAY NO' 14,5X 'TEMP, F' F8.2,5X 'PRESS, PSIA' F8.2)	1736
234		GO TO 76	1737
235	74	WRITE (NDOUT,144) TA(N),PP(N)	1738
236	144	FORMAT ('0 REBDILER' 8X 'TEMP, F' F8.2,5X 'PRESS, PSIA' F8.2)	1739
237	C		1740
238	76	WRITE (NDOUT,149)	1741
239	149	FORMAT (20X 7(' - '), 'VAPOR' 7(' - '), 8X 12(' - '), 'LIQUID' 12(' - ')	1742
240		+ / ' NO COMP' 10X 'MOLS' 7X 'LBS' 6X 'MOL%' 6X 'WT %' 8X 'MOLS'	1743
241		+ 7X 'LBS' 6X 'GALS' 6X 'MOL%' 7X 'WT%' 5X 'VOL%' 7X 'K-DATA')	1744
242	C		1745
243		DO 77 J=1,7	1746
244	77	SUMM(J)=0.0	1747
245		SUMM(3)=100.0	1748
246		SUMM(4)=100.0	1749
247		SHL=0.0	1750
248		SHV=0.0	1751
249		SUXV=0.0	1752
250		DO 78 I=1,NC	1753

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251      DD 78 J=1,11
252      78 XX(I,J)=0.0
253 C
254      DD 79 I=1,NC
255      Z(I)=EK(I,N)*X(I,N)
256      79 SUMV=SUMV+Z(I)
257      IF (V(N).EQ.0.0) GO TO 86
258      FAC=V(N)/SUMV
259      DD 81 I=1,NC
260      XX(I,1)=Z(I)*FAC
261      XX(I,2)=XX(I,1)*XMM(I)
262      SUMM(1)=SUMM(1)+XX(I,1)
263      81 SUMM(2)=SUMM(2)+XX(I,2)
264      FAC=100.0/SUMM(1)
265      FBC=100.0/SUMM(2)
266      DD 83 I=1,NC
267      XX(I,3)=XX(I,1)*FAC
268      83 XX(I,4)=XX(I,2)*FBC
269 C
270      85 DD 87 I=1,NC
271      XX(I,5)=X(I,N)*XL(N)
272      XX(I,6)=XX(I,5)*XMM(I)
273      XX(I,7)=XX(I,6)/RHU(I)
274      SUMM(5)=SUMM(5)+XX(I,5)
275      SUMM(6)=SUMM(6)+XX(I,6)
276      SUMM(7)=SUMM(7)+XX(I,7)
277      87 XX(I,11)=EK(I,N)
278      FAC=100.0/SUMM(5)
279      FBC=100.0/SUMM(6)
280      FCC=100.0/SUMM(7)
281      DD 88 I=1,NC
282      XX(I,8)=XX(I,5)*FAC
283      XX(I,9)=XX(I,6)*FBC
284      88 XX(I,10)=XX(I,7)*FCC
285 C
286      WRITE (NOUT,152) (I,(CNAME(K,I),K=1,2),(XX(I,K),K=1,11),I=1,NC)
287      152 FORMAT ( I3,2X 2A4, F11.3,F10.1,2F10.4, F12.3,2F10.1,3F10.4,F12.3)
288      WRITE (NOUT,153) (SUMM(K),K=1,10)
289      153 FORMAT ( ' TOTAL' 8X F10.3,F10.1,2F10.4, F12.3,2F10.1,3F10.4 )
290      VAW=0.0
291      IF (V(N).EQ.0.0) GO TO 91
292      VMW=SUMM(2)/SUMM(1)
293      SHV=HV(N)*V(N)
294      91 XL MW=SUMM(6)/SUMM(5)
295      ZDEN=SUMM(6)/SUMM(7)
296      SHL=HL(N)*XL(N)
297      WRITE (NOUT,161) VAW,SHV,XLMW,ZDEN,SHL
298      161 FORMAT ( 10I 6X ' VAPOR MW = ' F7.3,5X ' VAPOR ENTHALPY = ' F11.0, ' BT1801
299      +US1 / 6X ' LIQUID MW = ' F7.3,5X ' LIQUID LP/GAL = ' F7.3,5X ' LIQUID E1802
300      +NTHALPY = ' F11.0, ' BTUST / )

```

301 C					1804
302	98	NL=NL+9+NC		181	1805
303 C					1806
304		RETURN			1807
305		END			1808

1	SUBROUTINE ALNUM (NN, MM)	18090
2	C	18100
3	C	18110
4	C	18120
5	C	18130
6	C	18140
7	C	18150
8	C	18160
9	C	18170
10	C	18180
11	1	18190
12	C	18200
13	C	18210
14	C	18220
15	C	18230
16	2	18240
17	C	18250
18	C	18260
19	C	18270
20	C	18280
21	C	18290

182

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1      SUBROUTINE ALNUM (NN, MM)
2 C
3 C      THIS SUBROUTINE DEVELOPS INTEGER EQUIVALENTS OF NUMBERS
4 C      FROM 0 TO 99, LEFT JUSTIFIED WITHIN 4 COLUMN FIELD.
5 C      NN = NUMBER TO BE CONVERTED, MM = INTEGER EQUIVALENT.
6 C
7      IF(NN-9) 1, 1, 2
8 C
9 C      NUMBER IS 9 OR LESS.
10 C
11 1    MM=-268425456+NN*16777216
12     RETURN
13 C
14 C      NUMBER IS BETWEEN 10 AND 99, INCLUSIVE.
15 C
16 2    M=NN/10
17     L=NN-M*10
18     MM=-252690368+M*16777216+L*65536
19     RETURN
20 C
21     END
    
```

APPENDIX IV

PROGRAM	Simple Absorption - Data File Example	PUNCHING INSTRUCTIONS	GRAPHIC						
PROGRAMMER	R.J. Lukach	DATE	March, 1973	PUNCH					

STATEMENT NUMBER		CONT.	FORTRAN STATEMENT																																																																									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67										
PROBLEM NUMBER ONE - SIMPLE ABSORPTION																																																																												
8	6	2	0	2	2	20	2	4	1																																																																			
0.0					51.78																																																																							
95.					110.																																																																							
60.					0.0																																																																							
WET GAS																				8											60.											95.	1.288										0.0																							
25.5					15.8										24.					16.9										14.8																																														
LEAN OIL																				1											60.											90.	1.655										0.0																							
0.0					0.0										0.0					2.21										5.52					102.67																																									
METHANE										16.042										2.5																																																								
ETHANE										30.06										3.144																																																								
PROPANE										44.094										4.22																																																								
N BUTANE										58.12										4.865																																																								
NPENTANE										72.146										5.253																																																								
OIL										114.224										5.883																																																								
90.					110.																																																																							
60.					65.																																																																							
37.					37.																																																																							
7.4					8.1																																																																							
2.55					2.45																																																																							
.76					.93																																																																							
.242					.32																																																																							
.0125					.019																																																																							
40.					110.																																																																							

481

*A standard card form, IBM electro 889157, is available for punching statements from this form

Problem Number One - Simple Absorption

An absorber containing 20 trays (efficiency 20%) operates at 60 psia and is fed a wet gas at 90 degrees F with the following composition:

<u>Component</u>	<u>Mole Fraction</u>
C ₁	0.285
C ₂	0.158
C ₃	0.240
n-C ₄	0.169
n-C ₅	0.148
	<hr/>
	1.000

The lean oil has the properties of normal octane and is fed at 1.104 times the wet gas rate. The oil is at 90 degrees F and contains 2 mol per cent n-C₄ and 5 mol per cent n-C₅. Estimate the recovery of each of the gas components at the oil rate given and determine the product rates and compositions.

Initial assumptions:

overhead vapor - 51.78 mols/hr

top temperature - 95 degrees F

bottom temperature - 110 degrees F

column pressure - 60 psia

wet gas heat content - 1.288 MM Btu/hr

lean oil heat content - 1.655 MM Btu/hr

Source - Smith p. 266.

Problem Number Two - Intercooled Absorption

A wet gas and lean oil are feed to an absorber operating at 50 psig with the feeds entering at 90 degrees

F. The feed compositions are as follows:

<u>Component</u>	<u>Wet Gas Mols/Hr</u>	<u>Lean Oil Mols/Hr</u>
C ₁	10	
C ₂	30	
C ₃	40	
C ₄	30	10
C ₅	10	50
C ₆		15
C ₇		5
	—	—
Total	120	80

A portion of the material in the oil is stripped out and is lost overhead. Intercoolers are used on two stages.

Initial assumptions:

overhead - 79.93 mols/hr

top temperature - 102 degrees F

bottom temperature - 94 degrees F

column pressure - 64.7 psia

wet gas heat content - 1.667 MM Btu/hr

lean oil heat content - .886 MM Btu/hr

intercooler load - .125 MM Btu/hr

Compute the off gas and the rich oil rates and compositions.

Source - Edmister p. 57.

Problem Number Three - Steam Stripping

The rich oil produced in Problem Number One is stripped with steam in a 12 tray column (20% efficiency) operating at 45 psia. The steam is superheated and enters at 290 degrees F at 45 psia. The oil enters at 250 degrees F. A steam/rich oil ratio of 0.1 will be assumed.

Initial assumptions:

overhead vapor - 23.5 mols/hr

top temperature - 250 degrees F

bottom temperature - 290 degrees F

column pressure - 45 psia

steam heat content - .221 MM Btu/hr

rich oil heat content - 3.7 MM Btu/hr

Calculate the rich gas and the lean oil rates and compositions.

Source - Smith p. 271.

Problem Number Four - Simple Absorption

A 30 plate absorber (20% efficiency) operates at 60 psig treating 18×10^6 scf (atm and 60 degrees F) per 24 hours of the following gas (1975 lb mols/hr).

<u>Component</u>	<u>Mole per cent</u>
C ₁	83.0
C ₂	8.4
C ₃	4.8
i-C ₄	.9
n-C ₄	1.7
i-C ₅	.4
n-C ₅	.8
	<hr/>
	100.0

The tower will be supplied with 300,000 gallons per 24 hour (534 lb mols/hr) of a denuded oil having a gravity of 40 degrees API and an average molecular weight of 161. The tower will operate at an average oil temperature of 90 degrees F.

Initial assumptions:

overhead vapor - 1906.46 mols/hr

top temperature - 90 degrees F

bottom temperature - 90 degrees F

column pressure - 74.7 psia

rich gas heat content - 13.82 MM Btu/hr

lean oil heat content - 3.45 MM Btu/hr

Find the recovery of each component in the wet gas.

Source - Edmister p. 44.

APPENDIX V

PROBLEM NUMBER ONE - SIMPLE ABSORPTION

198

NUMBER OF TRAYS	4
NUMBER OF COMPONENTS	6
NUMBER OF FEEDS	2
SIDESTREAM AND/OR HEAT TRAYS	0
NUMBER OF K-DATA POINTS	2
NUMBER OF H-DATA POINTS	2
NUMBER OF ITERATIONS	20
QR CODE	2
DOCUMENTATION LEVEL	4
COLUMN TYPE	1
OVERHEAD VAPOR PRODUCT, MOLES/HR	51.780
INPUT TEMPERATURES, DEG F	
TOP TRAY	95.0
BOTTOM TRAY	110.0
INPUT PRESSURES, PSIA	
OVERHEAD	60.0000
TOWER DELTA P	0.0000
TOWER TOP	60.0000
TOWER BOTTOM	60.0000

DATA ON COMPONENTS

199

	NAME	MOL WT	LBS/GAL
1	METHANE	16.042	2.5000
2	ETHANE	30.060	3.1440
3	PROPANE	44.094	4.2200
4	N BUTANE	58.120	4.8650
5	NPENTANE	72.146	5.2530
6	OIL	114.224	5.8830

MAIN COLUMN K-TABLE

TEMPERATURE, F	90.00	110.00
PRESSURE, PSIA	60.0000	65.0000
METHANE	37.00000	39.00000
ETHANE	7.40000	8.10000
PROPANE	2.55000	2.95000
N BUTANE	0.76000	0.93000
NPENTANE	0.24200	0.32000
OIL	0.01250	0.01900

ENTHALPY TABLE		
TEMPERATURE, F	90.00	110.00
PRESSURE, PSIA	14.7000	14.7000
VAPOR, BTU/MOLE		
METHANE	5610.0	5800.0
ETHANE	10000.0	10250.0
PROPANE	13850.0	14200.0
N BUTANE	17900.0	18400.0
NPENTANE	21900.0	22400.0
DIL	32400.0	33400.0
LIQUID, BTU/MOLE		
METHANE	4200.0	4500.0
ETHANE	6600.0	7300.0
PROPANE	7200.0	7850.0
N BUTANE	8850.0	9600.0
NPENTANE	10600.0	11400.0
DIL	15000.0	16200.0

INPUT FEED DATA		
FEED NO	1	2
FEED NAME	WET GAS	LEAN OIL
ENTERING AT TRAY NO	4	1
COMPOSITION, MOLES/HR		
METHANE	28.50	0.00
ETHANE	15.80	0.00
PROPANE	24.00	0.00
N BUTANE	16.90	2.21
NPENTANE	14.80	5.52
OIL	0.00	102.67
TOTAL	100.00	110.40
TEMPERATURE, F	95.0	90.0
PRESSURE, PSIA	60.0000	60.0000
HEAT CONTENT, BTUS (CALC)	0.	0.
HEAT CONTENT, BTUS (GIVEN)	1288000.	1654999.
ADDITIONAL HEAT, BTUS	0.	0.
HEAT CONTENT, BTUS (INLET)	1288000.	1654999.
TEMPERATURE, F (INLET)	96.59	95.70
VAPOR, MOLES (INLET)	100.000	0.000
LIQUID, MOLES (INLET)	0.000	110.400

CALCULATED VAPOR RATES			
51.780	76.819	101.857	126.896
CORRESPONDING LIQUID RATES			
99.360	119.113	138.867	158.620
CALCULATED TEMPERATURES			
95.000	100.000	105.000	110.000

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.04981844	0.03544871	0.02611839	0.02052750
ETHANE	0.21202391	0.18794030	0.14039153	0.10623455
PROPANE	0.34662634	0.44774753	0.41159320	0.33089966
N BUTANE	0.06874756	0.20847487	0.38724118	0.62118155
NPENTANE	0.04613956	0.06300557	0.17115998	0.66132134
DIL	0.75965041	0.64254308	0.56703895	1.27425570
TOTAL	1.50300590	1.58815930	1.70354270	3.01441950

REBILER DUTY, BTUS	0.0
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UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE			1
-8.39388E 00	-8.46500E-02	8.52031E 01	
UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE			2
7.89758E 01	-4.45572E 01	-2.42371E 01	
UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE			3
-1.64760E 01	3.75272E 01	4.79396E 00	
UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE			4
9.47111E-02	-6.32099E 01	1.46506E 01	

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 1

9.09661E 01 5.16953E 01 1.80203E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 2

1.98089E 02 3.22615E 01 7.57629E 01

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 3

1.22391E 02 1.39384E 02 1.09794E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 4

1.58705E 02 6.36860E 01 1.24651E 02

 ITERATION NUMBER 1

SUM DT SQUARED	8084.621000
DT MAX	85.203125
MAX DV/V	0.580031
MAX DL/L	0.663031

CALCULATED VAPOR RATES			
51.759	65.679	111.239	111.093

CORRESPONDING LIQUID RATES			
97.262	138.857	134.748	158.641

CALCULATED TEMPERATURES			
105.650	96.970	105.599	111.831

LIQUID COMPOSITIONS, MOL FRACTIONS

TRAY #	1	2	3	4
METHANE	0.01797779	0.02340372	0.00875623	0.00764510
ETHANE	0.10579991	0.10616958	0.04524532	0.03107982
PROPANE	0.17296654	0.24667889	0.16961426	0.10135341
N BUTANE	0.04428503	0.08749187	0.14658689	0.16041285
NPENTANE	0.04005245	0.03810142	0.07805252	0.17059964
OIL	0.78668165	0.50133634	0.55606157	0.53137910
TOTAL	1.16776270	1.00318140	1.00431060	1.00246900

REBILDER DUTY, BTUS	0.0
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UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE			1
3.74524E 01	5.39719E-01	3.58920E 00	
UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE			2
-3.07002E 01	1.09331E 01	4.71373E 01	
UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE			3
1.00379E 01	-6.11835E 01	3.73489E 01	
UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE			4
-5.39490E-01	-2.44094E 01	2.96461E 01	

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 1

1.34714E 02

5.22986E 01

1.09240E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 2

1.08157E 02

7.66124E 01

1.44108E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 3

1.44786E 02

5.00556E 01

1.42948E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 4

1.58102E 02

8.66841E 01

1.41477E 02

ITERATION NUMBER	2
SUM DT SQUARED	4508.628900
DT MAX	47.137268
MAX DV/V	0.550018
MAX DL/L	0.385069

CALCULATED VAPOR RATES			
51.894	68.413	95.943	104.991

CORRESPONDING LIQUID RATES			
106.625	131.182	137.257	158.506

CALCULATED TEMPERATURES			
106.548	108.755	114.936	119.243

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.01330709	0.00352344	0.00979255	0.00735244
ETHANE	0.02781873	0.00162604	0.02975905	0.02240159
PROPANE	0.08045042	0.01708783	0.06888872	0.07134277
N BUTANE	0.04072978	0.04771616	0.07577872	0.10874712
NPENTANE	0.04902871	0.05311573	0.06317341	0.12370801
OIL	0.80017269	0.85312986	0.72599453	0.64427501
TOTAL	1.01150700	0.97619903	0.97338694	0.97782689

REBOILER DUTY, BTUS	0.0
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UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE			1
2.00082E 01	8.79482E-01	6.88274E 00	
UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE			2
2.43451E 00	5.93400E-01	1.41994E 01	
UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE			3
4.33356E 00	-1.99533E 01	1.57955E 01	
UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE			4
-8.79466E-01	-2.10272E 01	2.09419E 01	

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 1

1.26633E 02 5.27732E 01 1.13430E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 2

1.33617E 02 6.90060E 01 1.22954E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 3

1.41591E 02 7.59899E 01 1.30732E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 4

1.57627E 02 8.39639E 01 1.40185E 02

ITERATION NUMBER	3
SUM DT SQUARED	937.055660
DT MAX	20.941925
MAX DV/V	0.207970
MAX DL/L	0.187651

CALCULATED VAPOR RATES			
52.333	68.709	85.967	94.478

CORRESPONDING LIQUID RATES			
116.629	132.399	139.424	158.067

CALCULATED TEMPERATURES			
109.989	115.854	122.834	129.714

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.01301061	0.01063915	0.00901100	0.00767069
ETHANE	0.02897529	0.02909213	0.02537867	0.02132758
PROPANE	0.07261246	0.10295445	0.09254611	0.07820815
N BUTANE	0.03380306	0.05653752	0.08246166	0.11041069
NPENTANE	0.04660762	0.04979523	0.06494147	0.12388849
DIL	0.81746930	0.77060044	0.72948146	0.64627159
TOTAL	1.01247780	1.01961800	1.00381940	0.98777717

REBOILER DUTY, BTUS 0.0

UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE			1
1.02742E 01	1.17838E 00	3.45577E 00	
UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE			2
2.04735E 00	1.30542E 00	7.93841E 00	
UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE			3
3.02478E 00	-8.40792E 00	1.08107E 01	
UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE			4
-1.17841E 00	-8.91698E 00	1.03337E 01	

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 1

1.26903E 02 5.35119E 01 1.13445E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 2

1.34447E 02 7.00147E 01 1.23793E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 3

1.42449E 02 7.75587E 01 1.33645E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 4

1.56888E 02 8.55605E 01 1.40048E 02

ITERATION NUMBER	4
SUM DT SQUARED	298.617910
DT MAX	10.810722
MAX DV/V	0.097805
MAX DL/L	0.088093

CALCULATED VAPOR RATES			
53.512	70.015	77.559	85.561

CORRESPONDING LIQUID RATES			
126.903	134.447	142.449	156.888

CALCULATED TEMPERATURES			
113.445	123.793	133.645	140.048

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.01289319	0.01009189	0.00874649	0.00777133
ETHANE	0.02869716	0.02717537	0.02375031	0.02061760
PROPANE	0.07257050	0.09136182	0.08861440	0.07815909
N BUTANE	0.03585767	0.05699636	0.08241206	0.11019778
NPENTANE	0.04725346	0.05059981	0.06615412	0.12424171
DIL	0.81238359	0.76872623	0.72653562	0.64903086
TOTAL	1.00965490	1.00495050	0.99621296	0.99001837

REBOILER DUTY, BTUS 0.0

UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE	1	
1.48213E 00	2.51552E 00	5.94460E-01
UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE	2	
9.91147E-01	3.99764E 00	6.68585E-01
UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE	3	
-9.86719E-02	3.50665E 00	7.90126E-01
UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE	4	
-2.51550E 00	2.41685E 00	-6.62132E-01

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 1

1.28385E 02 5.60274E 01 1.14039E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 2

1.35438E 02 7.40124E 01 1.24461E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 3

1.42350E 02 8.10653E 01 1.34435E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 4

1.54373E 02 8.79774E 01 1.39385E 02

ITERATION NUMBER	5
SUM DT SQUARED	1.863167
DT MAX	0.790126
MAX DV/V	0.057097
MAX DL/L	0.016034

CALCULATED VAPOR RATES			
56.027	74.012	81.065	87.977

CORRESPONDING LIQUID RATES			
128.385	135.438	142.350	154.373

CALCULATED TEMPERATURES			
114.039	124.461	134.435	139.385

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.01233577	0.00962156	0.00850198	0.00774933
ETHANE	0.02761304	0.02551393	0.02224639	0.01972985
PROPANE	0.07139552	0.08822554	0.08526331	0.07684052
N BUTANE	0.03808303	0.06019706	0.08465654	0.11050493
NPENTANE	0.04758063	0.05212813	0.06889588	0.12581730
OIL	0.80356044	0.76442719	0.72849822	0.65905440
TOTAL	1.00056740	1.00011250	0.99806231	0.99969631

REBOILER DUTY, BTUS	0.0
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UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE 1

3.92105E-02 -1.74707E-02 8.00418E-02

UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE 2

-5.49950E-02 2.17246E-02 -2.67627E-02

UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE 3

-5.03174E-01 -7.24809E-02 -3.07226E-01

UNSCALED COMPUTED CORRECTIONS, DL-DV-DT, ON STAGE 4

1.74859E-02 -5.20660E-01 -5.67835E-02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 1

1.28424E 02 5.60099E 01 1.14119E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 2

1.35383E 02 7.40341E 01 1.24435E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 3

1.41847E 02 8.09928E 01 1.34128E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 4

1.54390E 02 8.74567E 01 1.39329E 02

 ITERATION NUMBER 6

SUM DT SQUARED	0.104735
DT MAX	0.307226
MAX DV/V	0.005918
MAX DL/L	0.003535

CALCULATED VAPOR RATES			
56.010	74.034	80.993	87.457

CORRESPONDING LIQUID RATES			
128.424	135.383	141.847	154.390

CALCULATED TEMPERATURES			
114.119	124.435	134.128	139.329

 LIQUID COMPOSITIONS, MOL FRACTIONS

TRAY #	1	2	3	4
METHANE	0.01236350	0.00965250	0.00854423	0.00778864
ETHANE	0.02757856	0.02552375	0.02229482	0.01986302
PROPANE	0.07110542	0.08802301	0.08541262	0.07712656
N BUTANE	0.03798582	0.05985243	0.08418763	0.11044449
NPENTANE	0.04759488	0.05212724	0.06872320	0.12577921
OIL	0.80337244	0.76482362	0.73083705	0.65899426
TOTAL	1.00000000	1.00000190	0.99999952	0.99999613

REBOILER DUTY, BTUS	0.0
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UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE 1

-6.23208E-03 -9.94985E-04 -1.42278E-02

UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE 2

-1.66358E-02 -7.22706E-03 -2.98311E-02

UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE 3

-7.33652E-04 -1.76308E-02 1.54456E-03

UNSCALED COMPUTED CORRECTIONS, DL=DV-DT, ON STAGE 4

1.01024E-03 -1.72864E-03 2.70118E-03

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 1

1.28418E 02 5.60089E 01 1.14105E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 2

1.35366E 02 7.40268E 01 1.24405E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 3

1.41846E 02 8.09752E 01 1.34129E 02

CORRECTED L-V-T USING UNSCALED CORRECTIONS ON STAGE 4

1.54391E 02 8.74550E 01 1.39331E 02

ITERATION NUMBER	7
SUM DT SQUARED	0.001162
DT MAX	0.029831
MAX DV/V	0.000218
MAX DL/L	0.000123

CALCULATED VAPOR RATES			
56.009	74.027	80.975	87.455
CORRESPONDING LIQUID RATES			
128.418	135.366	141.846	154.391
CALCULATED TEMPERATURES			
114.105	124.405	134.129	139.331

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.01236610	0.00965429	0.00854108	0.00778795
ETHANE	0.02757603	0.02552749	0.02230842	0.01986721
PROPANE	0.07111448	0.08805048	0.08542252	0.07712865
N BUTANE	0.03796019	0.05981379	0.08418876	0.11045200
NPENTANE	0.04758339	0.05209249	0.06870914	0.12577778
DIL	0.80339921	0.76486081	0.73082906	0.65898532
TOTAL	0.99999928	0.99999923	0.99999893	0.99999887

REBOILER DUTY, BTUS

0.0

FEED AND PRODUCT COMPOSITIONS

COMPONENT	FEED NO 1	FEED NO 2	COMBINED	OVERHEAD	BOTTOMS
	TRAY NO 4	TRAY NO 1	FEED	VAPOR	PRODUCT
	MOLS	MOLS	MOLS	MOLS	MOLS
METHANE	28,5000	0,0000	28,5000	27,2982	1,2024
ETHANE	15,8000	0,0000	15,8000	12,7325	3,0673
PROPANE	24,0000	0,0000	24,0000	12,0920	11,9080
N BUTANE	16,9000	2,2100	19,1100	2,0571	17,0528
NPENTANE	14,8000	5,5200	20,3200	0,9009	19,4190
OIL	0,0000	102,6700	102,6700	0,9283	101,7414
TOTAL	100,0000	110,4000	210,4000	56,0089	154,3911
POUNDS	4040,39	12254,06	16294,45	1644,42	14649,98
GALLONS	989,88	2095,65	3085,53	478,22	2607,30
Q, MBTU	1288,000	1654,999	2942,999	838,109	2390,271
TEMP, F	96,59	95,70	0,00	114,11	139,33

NET LIQUID & VAPOR LEAVING EACH STAGE

TRAY NO 1		TEMP,F 114.11		PRESS,PSIA 60.00		VAPOR				LIQUID			
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%	K-DATA	
1	METHANE	27.298	437.9	48.7390	26.6305	1.588	25.5	10.2	1.2366	0.1953	0.4460	39.41347	
2	ETHANE	12.732	382.7	22.7329	23.2749	3.541	106.5	33.9	2.7576	0.8161	1.4819	8.24373	
3	PROPANE	12.092	533.2	21.5894	32.4238	9.132	402.7	95.4	7.1115	3.0873	4.1764	3.03588	
4	N BUTANE	2.057	119.6	3.6727	7.2704	4.875	283.3	58.2	3.7960	2.1721	2.5489	0.96753	
5	NPENTANE	0.901	65.0	1.6085	3.9525	6.111	440.9	83.9	4.7583	3.3799	3.6732	0.33804	
6	OIL	0.928	106.0	1.6574	6.4479	103.171	11784.6	2003.2	80.3400	90.3492	87.6736	0.02063	
TOTAL		56.009	1644.4	100.0000	100.0000	128.418	13043.4	2284.8	100.0000	100.0000	100.0000		

VAPOR MW = 29.360 VAPOR ENTHALPY = 552707. BTUS
 LIQUID MW = 101.570 LIQUID LB/GAL = 5.709 LIQUID ENTHALPY = 1921628. BTUS

TRAY NO 2		TEMP,F 124.40		PRESS,PSIA 60.00		VAPOR				LIQUID			
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%	K-DATA	
1	METHANE	28.887	463.4	39.0225	19.0414	1.307	21.0	8.4	0.9654	0.1558	0.3539	40.41980	
2	ETHANE	16.273	489.2	21.9830	20.1003	3.456	103.9	33.0	2.5528	0.7720	1.3942	8.61148	
3	PROPANE	21.225	935.9	28.6716	38.4554	11.919	525.6	124.5	8.8051	3.9057	5.2553	3.25626	
4	N BUTANE	4.722	274.4	6.3782	11.2758	8.097	470.6	96.7	5.9814	3.4972	4.0817	1.06634	
5	NPENTANE	1.491	107.6	2.0145	4.4209	7.052	508.7	96.8	5.2093	3.7808	4.0868	0.38672	
6	OIL	1.429	163.2	1.9302	6.7062	103.536	11826.3	2010.3	76.4861	87.8885	84.8282	0.02524	
TOTAL		74.027	2433.7	100.0000	100.0000	135.366	13456.1	2369.8	100.0000	100.0000	100.0000		

VAPOR MW = 32.876 VAPOR ENTHALPY = 819345. BTUS
 LIQUID MW = 99.405 LIQUID LB/GAL = 5.678 LIQUID ENTHALPY = 2065880. BTUS

TRAY NO 3		TEMP,F 134.13		PRESS,PSIA 60.00		VAPOR				LIQUID			
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%	K-DATA	
1	METHANE	28.604	458.9	35.3249	16.1208	1.212	19.4	7.8	0.8541	0.1400	0.3168	41.35870	
2	ETHANE	16.188	486.6	19.9917	17.0957	3.164	95.1	30.3	2.2308	0.6850	1.2329	8.96148	
3	PROPANE	24.011	1058.7	29.6524	37.1952	12.117	534.3	126.6	8.5423	3.8473	5.1594	3.47125	
4	N BUTANE	7.944	461.7	9.8163	16.2202	11.942	694.1	142.7	8.4189	4.9979	5.8137	1.16528	
5	NPENTANE	2.433	175.5	3.0041	6.1656	9.746	703.1	133.9	6.8709	5.0633	5.4548	0.43722	
6	OIL	1.795	205.0	2.2166	7.2025	103.665	11841.1	2012.8	73.0830	85.2666	82.0224	0.03033	
TOTAL		80.975	2846.5	100.0000	100.0000	141.846	13887.1	2453.9	100.0000	100.0000	100.0000		

VAPOR MW = 35.152 VAPOR ENTHALPY = 963339. BTUS
 LIQUID MW = 97.903 LIQUID LB/GAL = 5.659 LIQUID ENTHALPY = 2211793. BTUS

NET LIQUID & VAPOR LEAVING EACH STAGE

TRAY NO		TEMP, F		PRESS, PSIA		VAPOR		LIQUID					K-DATA
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%		
			139.33		60.00								
1	METHANE	28.509	457.3	32.5984	13.9539	1.202	19.3	7.7	0.7788	0.1317	0.2959	41.85744	
2	ETHANE	15.897	477.9	18.1775	14.5802	3.067	92.2	29.3	1.9867	0.6294	1.1248	9.14948	
3	PROPANE	24.209	1067.5	27.6814	32.5693	11.908	525.1	124.4	7.7129	3.5841	4.7721	3.58899	
4	N BUTANE	11.789	685.2	13.4802	20.9056	17.053	991.1	203.7	11.0452	6.7653	7.8135	1.22046	
5	NPENTANE	5.127	369.9	5.8627	11.2863	19.419	1401.0	266.7	12.5778	9.5632	10.2292	0.46611	
6	OIL	1.924	219.7	2.1998	6.7048	101.741	11621.3	1975.4	65.8986	79.3264	75.7644	0.03338	
TOTAL		87.455	3277.5	100.0000	100.0000	154.391	14650.0	2607.3	100.0000	100.0000	100.0000		

VAPOR MW = 37.477

VAPOR ENTHALPY = 1109479. BTUS

LIQUID MW = 94.889

LIQUID LB/GAL = 5.619 LIQUID ENTHALPY = 2390271. BTUS

PROBLEM NUMBER TWO - ABSORPTION WITH INTERCOOLERS

228

NUMBER OF TRAYS	4
NUMBER OF COMPONENTS	7
NUMBER OF FEEDS	2
SIDESTREAM AND/OR HEAT TRAYS	2
NUMBER OF K-DATA POINTS	2
NUMBER OF H-DATA POINTS	2
NUMBER OF ITERATIONS	20
QR CODE	2
DOCUMENTATION LEVEL	3
COLUMN TYPE	2
OVERHEAD VAPOR PRODUCT, MOLES/HR	79.930
INPUT TEMPERATURES, DEG F	
TOP TRAY	102.0
BOTTOM TRAY	94.0
INPUT PRESSURES, PSIA	
OVERHEAD	64.7000
TOWER DELTA P	0.0000
TOWER TOP	64.7000
TOWER BOTTOM	64.7000

DATA ON COMPONENTS

229

	NAME	MOLE WT	LBS/GAL
1	METHANE	16.042	2.5000
2	ETHANE	30.068	3.1440
3	PROPANE	44.094	4.2200
4	BUTANE	58.120	4.8650
5	PENTANE	72.146	5.2530
6	HEXANE	86.172	5.5260
7	HEPTANE	100.198	5.7280

MAIN COLUMN K-TABLE

TEMPERATURE, F	90.00	120.00
PRESSURE, PSIA	65.0000	65.0000
METHANE	39.47000	43.16000
ETHANE	7.47000	9.32000
PROPANE	2.27800	3.12000
BUTANE	0.69500	1.04600
PENTANE	0.21900	0.36100
HEXANE	0.07310	0.13110
HEPTANE	0.02560	0.04990

K-DATA WILL BE PRESSURE CORRECTED TO THE TRAY PRESSURE
USING THE K-DATA REFERENCE PRESSURE AS THE DATUM

ENTHALPY TABLE

TEMPERATURE, F	90.00	120.00
PRESSURE, PSIA	65.0000	65.0000
VAPOR, BTU/MOLE		
METHANE	5593.0	5861.7
ETHANE	9837.4	10255.0
PROPANE	13307.1	13989.5
BUTANE	16459.6	17460.1
PENTANE	19110.3	20433.0
HEXANE	20797.3	22482.7
HEPTANE	22500.6	24524.0
LIQUID, BTU/MOLE		
METHANE	4343.4	4671.9
ETHANE	6101.3	7438.3
PROPANE	7228.0	8191.9
BUTANE	8859.8	9959.0
PENTANE	10475.1	11781.0
HEXANE	12002.6	13503.4
HEPTANE	13515.6	15194.9

INPUT FEED DATA		
FEED NO	1	2
FEED NAME	WET GAS	LEAN OIL
ENTERING AT TRAY NO	4	1
COMPOSITION, MOLS/HR		
METHANE	10.00	0.00
ETHANE	30.00	0.00
PROPANE	40.00	0.00
BUTANE	30.00	10.00
PENTANE	10.00	50.00
HEXANE	0.00	15.00
HEPTANE	0.00	5.00
TOTAL	120.00	80.00
TEMPERATURE, F	90.0	90.0
PRESSURE, PSIA	65.0000	65.0000
HEAT CONTENT, BTUS (CALC)	0.	0.
HEAT CONTENT, BTUS (GIVEN)	1666999.	886000.
ADDITIONAL HEAT, BTUS	0.	0.
HEAT CONTENT, BTUS (INLET)	1666999.	886000.
TEMPERATURE, F (INLET)	124.58	97.27
VAPOR, MOLS (INLET)	120.000	0.000
LIQUID, MOLS (INLET)	0.000	80.000

SIDESTREAM AND HEAT TRAY DATA

233

	TRAY NO	VAPOR MOL/HR	LIQUID MOL/HR	HEAT OUT MMBTU/HR
1	2	0.00	0.00	0.125000
2	3	0.00	0.00	0.125000

CALCULATED VAPOR RATES			
79.930	85.305	90.681	96.056
CORRESPONDING LIQUID RATES			
72.000	88.023	104.047	120.070
CALCULATED TEMPERATURES			
102.000	99.333	96.667	94.000

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.03535945	0.03426662	0.03252360	0.03096121
ETHANE	0.15390068	0.16622043	0.16226614	0.15702432
PROPANE	0.30626363	0.41623384	0.45502579	0.46814013
BUTANE	0.25044084	0.41095084	0.62988126	0.94489545
PENTANE	0.58749866	0.58302641	0.69687963	1.31007480
HEXANE	0.17542809	0.17025793	0.23106241	1.11342900
HEPTANE	0.05848650	0.05574131	0.07969803	1.03973960
TOTAL	1.56737610	1.83669560	2.28733530	5.06426420

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	1
SUM DT SQUARED	15318.160000
DT MAX	110.540770
MAX DV/V	2.079558
MAX DL/L	2.116372

CALCULATED VAPOR RATES			
79.958	86.138	78.895	98.396

CORRESPONDING LIQUID RATES			
73.641	76.380	105.864	120.042

CALCULATED TEMPERATURES			
107.787	113.151	93.195	92.304

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.01127982	0.00932833	0.03411578	0.00184942
ETHANE	0.02638151	0.00393470	0.16344839	0.04743491
PROPANE	0.09769946	0.11331046	0.22009575	0.19042063
BUTANE	0.13672078	0.16381848	0.16198766	0.26066250
PENTANE	0.69884372	0.92538750	0.30697221	0.34619051
HEXANE	0.18835497	0.33806902	0.11328709	0.11210364
HEPTANE	0.05869898	0.11760843	0.03906637	0.04080715
TOTAL	1.21797840	1.67145630	1.03897280	0.99946868

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	2
SUM DT SQUARED	2595247.000000
DT MAX	1430.717000
MAX DV/V	6.463747
MAX DL/L	6.646581

CALCULATED VAPOR RATES			
79.962	86.826	70.927	103.485

CORRESPONDING LIQUID RATES			
74.520	68.448	110.833	120.038

CALCULATED TEMPERATURES			
112.628	124.328	90.790	90.243

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00810346	0.00279048	0.09802258	0.00402779
ETHANE	0.01895257	0.00510677	0.41170800	0.06802630
PROPANE	0.07018763	0.03389570	0.42756271	0.37406635
BUTANE	0.11429137	0.13483387	0.20805174	0.27175176
PENTANE	0.89554453	0.85443884	0.14772868	0.14238149
HEXANE	0.20918834	0.48908818	0.02207673	0.10009032
HEPTANE	0.05523516	0.18054795	0.01041822	0.03939841
TOTAL	1.37150190	1.70070070	1.32556720	0.99974239

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	3
SUM DT SQUARED	8994.187500
DT MAX	91.209884
MAX DV/V	0.251351
MAX DL/L	0.318827

CALCULATED VAPOR RATES			
80.868	93.439	69.085	116.491

CORRESPONDING LIQUID RATES			
86.400	66.958	119.278	119.132

CALCULATED TEMPERATURES			
113.714	112.927	87.849	91.087

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00228065	0.00381925	0.02116251	0.00202481
ETHANE	0.03604642	0.03443059	0.09053320	0.03456081
PROPANE	0.08782834	0.14331281	0.37890667	0.14793521
BUTANE	0.14111704	0.11244035	0.17535186	0.24706089
PENTANE	0.45912606	0.64227563	0.40321267	0.39036769
HEXANE	0.15789396	0.21884298	0.12880266	0.11364341
HEPTANE	0.05464050	0.07591671	0.04341152	0.04060775
TOTAL	0.93893290	1.23103710	1.24137970	0.97620052

REBILER DUTY, BTUS	0.0
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 ITERATION NUMBER 4

SUM DT SQUARED	5184.375000
DT MAX	67.706192
MAX DV/V	0.109493
MAX DL/L	0.151873

 CALCULATED VAPOR RATES

82.573	101.433	75.344	103.736
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CORRESPONDING LIQUID RATES

98.859	72.771	101.163	117.427
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CALCULATED TEMPERATURES

109.715	96.001	88.873	95.400
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LIQUID COMPOSITIONS, MOL FRACTIONS

TRAY #	1	2	3	4
METHANE	0.00313469	0.00416068	0.00160952	0.00202385
ETHANE	0.03569372	0.03587460	0.04797536	0.03628649
PROPANE	0.13210720	0.29343611	0.23464888	0.13380581
BUTANE	0.12265754	0.12443137	0.17869788	0.25452131
PENTANE	0.50608635	0.63232803	0.46281880	0.40832961
HEXANE	0.15305775	0.19922954	0.13872087	0.11615449
HEPTANE	0.04992651	0.06817877	0.04695746	0.04119619
TOTAL	1.00266360	1.35763740	1.11142820	0.99231768

REBOILER DUTY, BTUS

 0.0

ITERATION NUMBER	5
SUM DT SQUARED	315.669180
DT MAX	13.515660
MAX DV/V	0.285507
MAX DL/L	0.282358

CALCULATED VAPOR RATES			
83.055	99.408	86.100	108.759

CORRESPONDING LIQUID RATES			
96.353	83.044	105.704	116.945

CALCULATED TEMPERATURES			
104.940	82.485	92.802	105.134

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00290361	0.00290872	0.00291240	0.00204696
ETHANE	0.03626821	0.03905398	0.03983932	0.03318976
PROPANE	0.11583608	0.21261662	0.18116134	0.13526881
BUTANE	0.12743652	0.15659714	0.20675224	0.25915986
PENTANE	0.51222301	0.51324111	0.45223367	0.40669447
HEXANE	0.15728685	0.15847838	0.13470101	0.11684358
HEPTANE	0.05277086	0.05368626	0.04537852	0.04145243
TOTAL	1.00472640	1.13658140	1.06297680	0.99465585

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	6
SUM DT SQUARED	370.405270
DT MAX	17.511550
MAX DV/V	0.310332
MAX DL/L	0.301933

CALCULATED VAPOR RATES			
83.878	98.442	99.459	120.037

CORRESPONDING LIQUID RATES			
94.564	95.561	116.159	116.122

CALCULATED TEMPERATURES			
107.514	99.997	99.724	102.099

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00271684	0.00232317	0.00191300	0.00185081
ETHANE	0.03755793	0.04166494	0.03484641	0.02749884
PROPANE	0.10722691	0.10517339	0.11510092	0.12262911
BUTANE	0.13332236	0.19338500	0.24633157	0.26289660
PENTANE	0.51248592	0.45134121	0.41185850	0.41105872
HEXANE	0.15749842	0.13561618	0.11857468	0.11847156
HEPTANE	0.05328732	0.04550844	0.03914852	0.04192387
TOTAL	1.00409500	0.97501272	0.96777356	0.98632944

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	7
SUM DT SQUARED	1455.327600
DT MAX	27.560348
MAX DV/V	0.401177
MAX DL/L	0.298251

CALCULATED VAPOR RATES			
86.701	108.316	98.833	114.381

CORRESPONDING LIQUID RATES			
101.615	92.137	107.680	113.299

CALCULATED TEMPERATURES			
111.680	86.216	87.315	100.487

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00221407	0.00208384	0.00289645	0.00243029
ETHANE	0.03088976	0.02350013	0.03769829	0.03521131
PROPANE	0.06244937	0.14446354	0.20279610	0.16524172
BUTANE	0.15521771	0.18682665	0.22934866	0.25973439
PENTANE	0.41419858	0.57238603	0.54301232	0.44603044
HEXANE	0.11796755	0.17690867	0.16409266	0.12987804
HEPTANE	0.03774678	0.05900529	0.05483475	0.04587441
TOTAL	0.82068372	1.16517350	1.23467730	1.08439920

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	8
SUM DT SQUARED	321.051020
DT MAX	11.305599
MAX DV/V	0.098620
MAX DL/L	0.100632

CALCULATED VAPOR RATES			
87.145	99.175	107.728	125.661

CORRESPONDING LIQUID RATES			
92.030	100.583	118.516	112.855

CALCULATED TEMPERATURES			
100.375	95.931	97.040	102.556

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00292524	0.00238736	0.00219112	0.00188441
ETHANE	0.03529822	0.03887666	0.03811737	0.03003887
PROPANE	0.12255895	0.14400214	0.13525909	0.12294006
BUTANE	0.12067443	0.16025406	0.22709620	0.26433128
PENTANE	0.51721466	0.47206950	0.42928356	0.41626769
HEXANE	0.15708351	0.14394474	0.12517595	0.11994833
HEPTANE	0.05297557	0.04892877	0.04191767	0.04268390
TOTAL	1.00872990	1.01046270	0.99904090	0.99809450

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	9
SUM DT SQUARED	92.402069
DT MAX	9.187446
MAX DV/V	0.027405
MAX DL/L	0.036267

CALCULATED VAPOR RATES			
86.449	97.138	110.680	124.581

CORRESPONDING LIQUID RATES			
90.689	104.230	118.131	113.551

CALCULATED TEMPERATURES			
109.562	98.191	96.071	101.160

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00253830	0.00250171	0.00225520	0.00197716
ETHANE	0.03711668	0.03904118	0.03499129	0.02997626
PROPANE	0.08880812	0.13211042	0.14467072	0.13238168
BUTANE	0.14737308	0.18486345	0.22776091	0.26180822
PENTANE	0.53138661	0.46660000	0.42988622	0.41313487
HEXANE	0.16327393	0.14239216	0.12746507	0.12025189
HEPTANE	0.05482188	0.04772452	0.04245869	0.04258510
TOTAL	1.02531810	1.01523300	1.00948710	1.00211420

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	10
SUM DT SQUARED	14.467209
DT MAX	2.840320
MAX DV/V	0.027205
MAX DL/L	0.034973

CALCULATED VAPOR RATES			
85.920	99.781	111.856	125.692

CORRESPONDING LIQUID RATES			
93.861	105.935	119.772	114.080

CALCULATED TEMPERATURES			
108.038	95.350	94.216	100.364

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00273581	0.00252949	0.00225526	0.00196003
ETHANE	0.03569158	0.03778982	0.03494602	0.03001474
PROPANE	0.10453957	0.14596474	0.15227693	0.13432080
BUTANE	0.13416982	0.16822946	0.21628278	0.25795025
PENTANE	0.51012307	0.45330697	0.42046380	0.40968031
HEXANE	0.15687484	0.13870460	0.12453890	0.11879748
HEPTANE	0.05284408	0.04677957	0.04170224	0.04224851
TOTAL	0.99697870	0.99330455	0.99246591	0.99497205

REBILDER DUTY, BTUS	0.0
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ITERATION NUMBER	11
SUM DT SQUARED	0.590084
DT MAX	0.579760
MAX DV/V	0.007013
MAX DL/L	0.011635

CALCULATED VAPOR RATES			
86.523	99.612	111.226	125.072

CORRESPONDING LIQUID RATES			
93.089	104.703	118.549	113.477

CALCULATED TEMPERATURES			
107.459	95.078	94.382	100.754

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00271106	0.00250288	0.00224306	0.00195449
ETHANE	0.03576000	0.03841316	0.03546476	0.03026955
PROPANE	0.10529536	0.14470071	0.14992481	0.13227987
BUTANE	0.13314342	0.16975993	0.21976620	0.26134992
PENTANE	0.51328725	0.45841622	0.42511529	0.41227990
HEXANE	0.15800840	0.14028430	0.12588149	0.11956018
HEPTANE	0.05326991	0.04732377	0.04214201	0.04249381
TOTAL	1.00147530	1.00139990	1.00053690	1.00018690

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	12
SUM DT SQUARED	0.469827
DT MAX	0.444800
MAX DV/V	0.001765
MAX DL/L	0.003456

CALCULATED VAPOR RATES			
86.377	99.788	111.414	125.178

CORRESPONDING LIQUID RATES			
93.411	105.037	119.801	113.623

CALCULATED TEMPERATURES			
107.864	95.523	94.705	100.817

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00269686	0.00248508	0.00223485	0.00195575
ETHANE	0.03591394	0.03839362	0.03536465	0.03018137
PROPANE	0.10391051	0.14225239	0.14814317	0.13205093
BUTANE	0.13405812	0.17132533	0.22108167	0.26136672
PENTANE	0.51255679	0.45819485	0.42520571	0.41225255
HEXANE	0.15761447	0.14004207	0.12581342	0.11953485
HEPTANE	0.05310774	0.04720173	0.04208054	0.04245730
TOTAL	0.99985838	0.99989522	0.99992394	0.99979943

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER 13

SUM DT SQUARED	0.116431
DT MAX	0.218900
MAX DV/V	0.001971
MAX DL/L	0.001499

CALCULATED VAPOR RATES

86.547	99.893	111.523	125.242
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CORRESPONDING LIQUID RATES

93.345	104.976	118.695	113.453
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CALCULATED TEMPERATURES

107.758	95.374	94.486	100.629
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LIQUID COMPOSITIONS, MOL FRACTIONS

TRAY #	1	2	3	4
METHANE	0.00270042	0.00249116	0.00224036	0.00195858
ETHANE	0.03578144	0.03827395	0.03528563	0.03016325
PROPANE	0.10416096	0.14306533	0.14926738	0.13278186
BUTANE	0.13410878	0.17116350	0.22057515	0.26100028
PENTANE	0.51259893	0.45800543	0.42504609	0.41236240
HEXANE	0.15768796	0.14006668	0.12584656	0.11961973
HEPTANE	0.05313997	0.04722154	0.04210775	0.04250795
TOTAL	1.00017830	1.00028700	1.00036810	1.00039380

REBOILER DUTY, BTUS

0.0

ITERATION NUMBER	14
SUM DT SQUARED	0.020070
DT MAX	0.128272
MAX DV/V	0.001671
MAX DL/L	0.001275

CALCULATED VAPOR RATES			
86.403	99.804	111.441	125.176

CORRESPONDING LIQUID RATES			
93.401	105.038	118.773	113.597

CALCULATED TEMPERATURES			
107.782	95.383	94.540	100.757

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00270272	0.00249143	0.00223863	0.00195552
ETHANE	0.03584873	0.03833534	0.03534512	0.03020092
PROPANE	0.10431176	0.14317238	0.14907098	0.13229406
BUTANE	0.13382798	0.17069471	0.22029024	0.26115370
PENTANE	0.51240301	0.45783961	0.42491299	0.41214997
HEXANE	0.15760624	0.13998872	0.12576854	0.11951178
HEPTANE	0.05311007	0.04719428	0.04208010	0.04245971
TOTAL	0.99981052	0.99971640	0.99970651	0.99972558

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	15
SUM DT SQUARED	0.004488
DT MAX	0.062445
MAX DV/V	0.001028
MAX DL/L	0.000762

CALCULATED VAPOR RATES			
86.491	99.844	111.475	125.221

CORRESPONDING LIQUID RATES			
93.353	104.984	118.730	113.509

CALCULATED TEMPERATURES			
107.759	95.385	94.545	100.695

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.00270088	0.00249039	0.00223841	0.00195718
ETHANE	0.03581633	0.03831875	0.03532628	0.03017599
PROPANE	0.10423303	0.14301610	0.14895862	0.13250846
BUTANE	0.13396239	0.17101598	0.22064728	0.26113850
PENTANE	0.51258087	0.45802355	0.42505318	0.41231430
HEXANE	0.15767443	0.14005494	0.12582195	0.11958444
HEPTANE	0.05313565	0.04721792	0.04209692	0.04249027
TOTAL	1.00010290	1.00013730	1.00014200	1.00016880

REBOILER DUTY, BTUS	0.0
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 ITERATION NUMBER 16

SUM DT SQUARED	0.002022
DT MAX	0.034398
MAX DV/V	0.000654
MAX DL/L	0.000499

 CALCULATED VAPOR RATES

86.435	99.820	111.456	125.193
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CORRESPONDING LIQUID RATES

93.386	105.021	118.758	113.565
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CALCULATED TEMPERATURES

107.785	95.398	94.543	100.729
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LIQUID COMPOSITIONS, MOL FRACTIONS

TRAY #	1	2	3	4
METHANE	0.00270165	0.00249081	0.00223889	0.00195640
ETHANE	0.03583840	0.03832636	0.03533057	0.03018853
PROPANE	0.10423183	0.14304793	0.14904374	0.13240731
BUTANE	0.13393050	0.17089492	0.22043699	0.26112318
PENTANE	0.51247972	0.45792407	0.42496514	0.41220361
HEXANE	0.15763146	0.14001614	0.12579036	0.11953884
HEPTANE	0.05311874	0.04720259	0.04208638	0.04247094
TOTAL	0.99993223	0.99990278	0.99989206	0.99988878

REBOILER DUTY, BTUS

 0.0

FEED AND PRODUCT COMPOSITIONS

	FEED NO 1	FEED NO 2	COMBINED	OVERHEAD	BOTTOMS
	TRAY NO 4	TRAY NO 1	FEED	VAPOR	PRODUCT
COMPONENT	MOLS	MOLS	MOLS	MOLS	MOLS
METHANE	10.0000	0.0000	10.0000	9.7763	0.2222
ETHANE	30.0000	0.0000	30.0000	26.5754	3.4284
PROPANE	40.0000	0.0000	40.0000	24.9558	15.0368
BUTANE	30.0000	10.0000	40.0000	10.3494	29.6545
PENTANE	10.0000	50.0000	60.0000	13.1907	46.8119
HEXANE	0.0000	15.0000	15.0000	1.4250	13.5754
HEPTANE	0.0000	5.0000	5.0000	0.1769	4.8232
TOTAL	120.0000	80.0000	200.0000	86.4349	113.5651
POUNDS	5291.27	5982.06	11273.34	3749.98	7523.59
GALLONS	1264.77	1127.55	2392.32	907.77	1484.59
Q, MBTU	1666.999	886.000	2552.998	943.384	1162.330
TEMP, F	124.58	97.27	0.00	107.79	100.73

NET LIQUID & VAPOR LEAVING EACH STAGE

TRAY NO 1		TEMP, F 107.79		PRESS, PSIA 64.70		VAPOR				LIQUID				K-DATA
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%			
1	METHANE	9.775	156.8	11.3087	4.1822	0.252	4.0	1.6	0.2702	0.0625	0.1287	41.86563		
2	ETHANE	26.571	738.9	30.7409	21.3086	3.347	100.6	32.0	3.5841	1.5532	2.5436	8.57911		
3	PROPANE	24.952	1100.2	28.8675	29.3441	9.734	429.2	101.7	10.4239	6.6244	8.0824	2.77001		
4	BUTANE	10.348	601.4	11.9716	16.0402	12.507	726.9	149.4	13.3940	11.2194	11.8739	0.89402		
5	PENTANE	13.189	951.5	15.2583	25.3777	47.858	3452.8	657.3	51.2514	53.2910	52.2339	0.29779		
6	HEXANE	1.425	122.8	1.6484	3.2746	14.720	1268.5	229.6	15.7642	19.5783	18.2419	0.10459		
7	HEPTANE	0.177	17.7	0.2046	0.4725	4.961	497.0	86.8	5.3122	7.6714	6.8957	0.03852		
TOTAL		86.435	3749.4	100.0000	100.0000	93.379	6479.1	1258.4	100.0000	100.0000	100.0000			

VAPOR MW = 43.378 VAPOR ENTHALPY = 1140512. BTUS
 LIQUID MW = 69.385 LIQUID LB/GAL = 5.149 LIQUID ENTHALPY = 1019246. BTUS

TRAY NO 2		TEMP, F 95.40		PRESS, PSIA 64.70		VAPOR				LIQUID				K-DATA
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%			
1	METHANE	10.029	160.9	10.0469	3.7885	0.262	4.2	1.7	0.2491	0.0594	0.1209	40.33849		
2	ETHANE	29.918	899.6	29.9721	21.1838	4.025	121.0	38.5	3.8330	1.7132	2.7732	7.82074		
3	PROPANE	34.690	1529.6	34.7526	36.0204	15.023	662.4	157.0	14.3062	9.3772	11.3067	2.42959		
4	BUTANE	12.854	747.1	12.8771	17.5924	17.948	1043.1	214.4	17.0911	14.7661	15.4466	0.75356		
5	PENTANE	11.047	797.0	11.0664	18.7672	48.092	3469.6	660.5	45.7969	49.1155	47.5839	0.24168		
6	HEXANE	1.145	98.7	1.1472	2.3238	14.705	1267.1	229.3	14.0030	17.9373	16.5194	0.08194		
7	HEPTANE	0.137	13.8	0.1376	0.3240	4.957	496.7	86.7	4.7207	7.0313	6.2472	0.02915		
TOTAL		99.820	4246.6	100.0000	100.0000	105.011	7064.2	1388.1	100.0000	100.0000	100.0000			

VAPOR MW = 42.542 VAPOR ENTHALPY = 1273927. BTUS
 LIQUID MW = 67.271 LIQUID LB/GAL = 5.089 LIQUID ENTHALPY = 1064535. BTUS

TRAY NO 3		TEMP, F 94.54		PRESS, PSIA 64.70		VAPOR				LIQUID				K-DATA
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%			
1	METHANE	10.039	161.1	9.0074	3.3331	0.266	4.3	1.7	0.2239	0.0543	0.1099	40.23221		
2	ETHANE	30.596	920.0	27.4510	19.0396	4.196	126.2	40.1	3.5334	1.6048	2.5838	7.76993		
3	PROPANE	39.986	1763.1	35.8760	36.4904	17.700	780.5	184.9	14.9060	9.9277	11.9086	2.40713		
4	BUTANE	18.292	1063.2	16.4121	22.0032	26.179	1521.5	312.7	22.0461	19.3537	20.1375	0.74454		
5	PENTANE	11.279	813.8	10.1201	16.8419	50.468	3641.1	693.1	42.5011	46.3149	44.6310	0.23814		
6	HEXANE	1.129	97.3	1.0131	2.0138	14.939	1287.3	233.0	12.5804	16.3745	14.9997	0.08054		
7	HEPTANE	0.134	13.4	0.1203	0.2780	4.998	500.8	87.4	4.2091	6.3702	5.6296	0.02858		
TOTAL		111.456	4831.8	100.0000	100.0000	118.746	7861.6	1553.0	100.0000	100.0000	100.0000			

VAPOR MW = 43.352 VAPOR ENTHALPY = 1444235. BTUS
 LIQUID MW = 66.205 LIQUID LB/GAL = 5.062 LIQUID ENTHALPY = 1184764. BTUS

NET LIQUID & VAPOR LEAVING EACH STAGE

TRAY NO 4		TEMP, F 100.73		PRESS, PSIA 64.70								
		VAPOR				LIQUID						
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%	K-DATA
1	METHANE	10.041	191.1	8.0208	2.8614	0.222	3.6	1.4	0.1957	0.0474	0.0960	40.99907
2	ETHANE	30.772	925.2	24.5794	16.4355	3.428	103.1	32.8	3.0192	1.3701	2.2085	8.14227
3	PROPANE	42.646	1880.4	34.0639	33.4027	15.037	663.0	157.1	13.2422	8.8127	10.5832	2.57276
4	BUTANE	26.536	1542.3	21.1962	27.3963	29.654	1723.5	354.3	26.1152	22.9082	23.8631	0.81176
5	PENTANE	13.659	985.5	10.9106	17.5052	46.812	3377.3	642.9	41.2249	44.8894	43.3066	0.26470
6	HEXANE	1.364	117.5	1.0894	2.0876	13.575	1169.8	211.7	11.9552	15.5487	14.2594	0.09113
7	HEPTANE	0.175	17.5	0.1398	0.3114	4.823	483.3	84.4	4.2476	6.4235	5.6831	0.03291
TOTAL		125.193	5629.6	100.0000	100.0000	113.552	7523.6	1484.6	100.0000	100.0000	100.0000	
VAPOR MW = 44.967		VAPOR ENTHALPY = 1689264. BTUS										
LIQUID MW = 66.256		LIQUID LB/GAL = 5.068		LIQUID ENTHALPY = 1162330. BTUS								

PROBLEM NUMBER THREE - STEAM STRIPPING

254

NUMBER OF TRAYS	3
NUMBER OF COMPONENTS	7
NUMBER OF FEEDS	2
SIDESTREAM AND/OR HEAT TRAYS	0
NUMBER OF K-DATA POINTS	2
NUMBER OF H-DATA POINTS	2
NUMBER OF ITERATIONS	20
QR CODE	2
DOCUMENTATION LEVEL	2
COLUMN TYPE	3
OVERHEAD VAPOR PRODUCT, MOLES/HR	23,500
INPUT TEMPERATURES, DEG F	
TOP TRAY	250.0
BOTTOM TRAY	290.0
INPUT PRESSURES, PSIA	
OVERHEAD	45.0000
TOWER DELTA P	0.0000
TOWER TOP	45.0000
TOWER BOTTOM	45.0000

DATA ON COMPONENTS

255

	NAME	MOL WT	LBS/GAL
1	METHANE	16.042	2.5000
2	ETHANE	20.068	3.1440
3	PROPANE	44.094	4.2200
4	N BUTANE	58.120	4.8650
5	NPENTANE	72.146	5.2530
6	OIL	114.224	5.8830
7	STEAM	18.000	8.3300

MAIN COLUMN K-TABLE

TEMPERATURE, F	250.00	290.00
PRESSURE, PSIA	45.0000	45.0000
METHANE	80.00000	81.00000
ETHANE	26.00000	30.00000
PROPANE	12.00000	14.50000
N BUTANE	5.40000	7.00000
NPENTANE	2.50000	3.50000
DIL	0.34000	0.54000
STEAM	68.00000	71.00000

K-DATA WILL BE PRESSURE CORRECTED TO THE TRAY PRESSURE
USING THE K-DATA REFERENCE PRESSURE AS THE DATUM

ENTHALPY TABLE		
TEMPERATURE, F	250.00	290.00
PRESSURE, PSIA	45.0000	45.0000
VAPOR, BTU/MOLE		
METHANE	7100.0	7500.0
ETHANE	11600.0	12200.0
PROPANE	17000.0	17800.0
N BUTANE	21500.0	22800.0
NPENTANE	26200.0	27600.0
OIL	40000.0	42200.0
STEAM	21000.0	21400.0
LIQUID, BTU/MOLE		
METHANE	6200.0	6700.0
ETHANE	8700.0	9300.0
PROPANE	13400.0	14000.0
N BUTANE	14500.0	16900.0
NPENTANE	17300.0	19300.0
OIL	24600.0	27600.0
STEAM	3600.0	3920.0

INPUT FEED DATA		
FEED NO	1	2
FEED NAME	STEAM	RICH DIL
ENTERING AT TRAY NO	3	1
COMPOSITION, MOL/HR		
METHANE	0.00	1.19
ETHANE	0.00	3.01
PROPANE	0.00	11.83
N BUTANE	0.00	17.92
NPENTANE	0.00	19.51
DIL	0.00	101.82
STEAM	10.41	0.00
TOTAL	10.41	155.27
TEMPERATURE, F	290.0	250.0
PRESSURE, PSIA	45.0000	45.0000
HEAT CONTENT, BTUS (CALC)	0.	0.
HEAT CONTENT, BTUS (GIVEN)	221000.	3699999.
ADDITIONAL HEAT, BTUS	0.	0.
HEAT CONTENT, BTUS (INLET)	221000.	3699999.
TEMPERATURE, F (INLET)	272.92	245.41
VAPOR, MOL/HR (INLET)	10.410	51.750
LIQUID, MOL/HR (INLET)	0.000	103.519

CALCULATED VAPOR RATES		
23.500	18.324	2.796
CORRESPONDING LIQUID RATES		
103.519	98.343	82.815
CALCULATED TEMPERATURES		
250.000	270.000	290.000

LIQUID COMPOSITIONS, MOL FRACTIONS			
TRAY #	1	2	3
METHANE	0.00028037	0.00028037	0.00028037
ETHANE	0.00210905	0.00210905	0.00210905
PROPANE	0.01665909	0.01665909	0.01665909
N BUTANE	0.04787193	0.04787193	0.04787193
NPENTANE	0.08567554	0.08567554	0.08567554
DIL	0.84740406	0.84740406	0.84740406
STEAM	0.00000000	0.00000000	0.00000000
TOTAL	1.00000000	1.00000000	1.00000000

REBOILER DUTY, BTUS	0.0
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ITERATION NUMBER	1
SUM DT SQUARED	325.310300
DT MAX	16.376434
MAX DV/V	12.396779
MAX DL/L	0.793419

ITERATION NUMBER	2
SUM DT SQUARED	65573.750000
DT MAX	252.678930
MAX DV/V	3.523100
MAX DL/L	0.534874

ITERATION NUMBER	3
SUM DT SQUARED	56893.957000
DT MAX	236.495040
MAX DV/V	2.618818
MAX DL/L	0.520697

ITERATION NUMBER	4
SUM DT SQUARED	35357.296000
DT MAX	186.155190

ITERATION NUMBER	5
SUM DT SQUARED	251165.180000
DT MAX	496.305170
MAX DV/V	4.352040
MAX DL/L	0.443115

ITERATION NUMBER	6
SUM DT SQUARED	34721.878060
DT MAX	179.734860
MAX DV/V	1.292465
MAX DL/L	0.396691

ITERATION NUMBER	7
SUM DT SQUARED	5990.359300
DT MAX	66.849136
MAX DV/V	0.957675
MAX DL/L	0.335657

ITERATION NUMBER	8
SUM DT SQUARED	1038561.200000
DT MAX	1014.893000
MAX DV/V	9.359883
MAX DL/L	3.095642

ITERATION NUMBER	9
SUM DT SQUARED	2336.619300
DT MAX	36.568344
MAX DV/V	0.397224
MAX DL/L	0.353115

ITERATION NUMBER	10
SUM DT SQUARED	4429.839800
DT MAX	55.144241
MAX DV/V	1.429289
MAX DL/L	0.222071

SUM DT SQUARED	1770.963300
DT MAX	34.630874
MAX DV/V	1.102293
MAX DL/L	0.182795

261

ITERATION NUMBER 12

SUM DT SQUARED	1275.026300
DT MAX	26.928421
MAX DV/V	1.420276
MAX DL/L	0.249944

ITERATION NUMBER 13

SUM DT SQUARED	37161.878000
DT MAX	130.902020
MAX DV/V	4.625005
MAX DL/L	0.429507

ITERATION NUMBER 14

SUM DT SQUARED	55370.089000
DT MAX	157.457150
MAX DV/V	7.768880
MAX DL/L	1.408155

ITERATION NUMBER 15

SUM DT SQUARED	33231.441000
DT MAX	122.777190
MAX DV/V	0.399387
MAX DL/L	0.030510

ITERATION NUMBER 16

SUM DT SQUARED	14499.191060
DT MAX	73.939651
MAX DV/V	2.235490
MAX DL/L	0.155541

ITERATION NUMBER 17

SUM DT SQUARED	10921.847000
DT MAX	71.256271
MAX DV/V	0.751208
MAX DL/L	0.070527

ITERATION NUMBER 18

SUM DT SQUARED	2994248.000000
DT MAX	1060.786100
MAX DV/V	27.149475
MAX DL/L	5.374336

ITERATION NUMBER 19

SUM DT SQUARED	1408.881100
DT MAX	25.468978
MAX DV/V	7.750542
MAX DL/L	0.233829

ITERATION NUMBER 20

SUM DT SQUARED	111984.560000
DT MAX	277.847650
MAX DV/V	4.569650
MAX DL/L	1.204160

NO CLOSURE OBTAINED ON PROBLEM
FOR SPECIFIED NUMBER OF TRIALS

CALCULATED VAPOR RATES		
23.957	6.368	0.573
CORRESPONDING LIQUID RATES		
134.639	129.520	137.847
CALCULATED TEMPERATURES		
256.290	260.847	272.844

LIQUID COMPOSITIONS, MOL FRACTIONS			
TRAY #	1	2	3
METHANE	0.00560410	0.00098729	0.00074083
ETHANE	0.04106759	0.00947283	0.00826426
PROPANE	0.18123549	0.03679108	0.03154382
N BUTANE	0.24880725	0.07733881	0.07702440
NPENTANE	0.29407650	0.23527342	0.22317564
OIL	0.14724386	0.39929271	0.41409045
STEAM	0.00988762	0.01309348	0.04936618
TOTAL	0.92792237	0.77024961	0.80420554

REBOILER DUTY, BTUS	0.0
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PROBLEM NUMBER FOUR - SIMPLE ABSORPTION

264

NUMBER OF TRAYS	6
NUMBER OF COMPONENTS	8
NUMBER OF FEEDS	2
SIDESTREAM AND/OR HEAT TRAYS	0
NUMBER OF K-DATA POINTS	2
NUMBER OF H-DATA POINTS	2
NUMBER OF ITERATIONS	20
QR CODE	2
DOCUMENTATION LEVEL	2
COLUMN TYPE	1
OVERHEAD VAPOR PRODUCT, MOLS/HR	1906.460
INPUT TEMPERATURES, DEG F	
TOP TRAY	90.0
BOTTOM TRAY	90.0
INPUT PRESSURES, PSIA	
OVERHEAD	74.7000
TOWER DELTA P	0.0000
TOWER TOP	74.7000
TOWER BOTTOM	74.7000

DATA ON COMPONENTS

265

	NAME	MOL WT	LBS/GAL
1	METHANE	16.042	2.5000
2	ETHANE	30.060	3.1440
3	PROPANE	44.094	4.2200
4	I BUTANE	58.120	4.6860
5	N BUTANE	58.120	4.8650
6	IPENTANE	72.146	5.1990
7	NPENTANE	72.146	5.2530
8	OIL	161.000	6.8700

MAIN COLUMN K-TABLE

TEMPERATURE, F	60.00	90.00
PRESSURE, PSIA	75.0000	75.0000
METHANE	34.00000	39.00000
ETHANE	5.00000	6.60000
PROPANE	1.40000	1.96000
I BUTANE	0.55000	0.82000
N BUTANE	0.38000	0.61000
IPENTANE	0.15500	0.25000
NPENTANE	0.12500	0.20000
OIL	0.00300	0.00600

K-DATA WILL BE PRESSURE CORRECTED TO THE TRAY PRESSURE
USING THE K-DATA REFERENCE PRESSURE AS THE DATUM

ENTHALPY TABLE

TEMPERATURE, F	60.00	90.00
PRESSURE, PSIA	75.0000	75.0000
VAPOR, BTU/MOLE		
METHANE	5900.0	6200.0
ETHANE	9600.0	9950.0
PROPANE	12950.0	13650.0
I BUTANE	16200.0	16800.0
N BUTANE	16700.0	17400.0
IPENTANE	19500.0	20300.0
NPENTANE	20200.0	21200.0
OIL	29800.0	31400.0
LIQUID, BTU/MOLE		
METHANE	4100.0	4500.0
ETHANE	5150.0	7200.0
PROPANE	6050.0	6850.0
I BUTANE	7650.0	8700.0
N BUTANE	7550.0	8450.0
IPENTANE	9830.0	9200.0
NPENTANE	8500.0	10100.0
OIL	4000.0	6450.0

INPUT FEED DATA		
FEED NO	1	2
FEED NAME	WET GAS	OIL
ENTERING AT TRAY NO	6	1
COMPOSITION, MOLS/HR		
METHANE	1639.20	0.00
ETHANE	165.80	0.00
PROPANE	94.90	0.00
I BUTANE	17.80	0.00
N BUTANE	33.53	0.00
IPENTANE	7.90	0.00
NPENTANE	15.80	0.00
OIL	0.00	534.00
TOTAL	1974.93	534.00
TEMPERATURE, F	60.0	90.0
PRESSURE, PSIA	74.7000	74.7000
HEAT CONTENT, BTUS (CALC)	0.	0.
HEAT CONTENT, BTUS (GIVEN)	13819999.	3449999.
ADDITIONAL HEAT, BTUS	0.	0.
HEAT CONTENT, BTUS (INLET)	13819999.	3449999.
TEMPERATURE, F (INLET)	60.32	90.13
VAPOR, MOLS (INLET)	1974.929	0.000
LIQUID, MOLS (INLET)	0.000	534.000

CALCULATED VAPOR RATES			
1906.460	1621.563	1336.666	1051.769
766.872	481.975		
CORRESPONDING LIQUID RATES			
480.600	504.974	529.347	553.721
578.095	602.469		
CALCULATED TEMPERATURES			
90.000	90.000	90.000	90.000
90.000	90.000		

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.02566045	0.03026948	0.03657829	0.04622788
ETHANE	0.13495857	0.16179854	0.19183487	0.23580188
PROPANE	0.38796973	0.48641962	0.54673380	0.61852980
I BUTANE	0.86679035	1.18081470	1.19787880	1.12753100
N BUTANE	1.16932580	1.66806790	1.59485340	1.32555580
IPENTANE	0.00000000	0.00000000	0.00000000	0.00000000
NPENTANE	0.00000000	0.00000000	0.00000000	0.00000000
OIL	2.04921240	0.00000000	0.00000000	0.00000000
TOTAL	4.63391680	3.52736940	3.56787870	3.35364620

LIQUID COMPOSITIONS, MOL FRACTIONS		
TRAY #	5	6
METHANE	0.06286013	0.09853435
ETHANE	0.30740887	0.44811940
PROPANE	0.71629047	0.86211526
I BUTANE	1.07335750	1.01985740
N BUTANE	1.19781580	1.01184840
IPENTANE	0.00000000	3.68937960
NPENTANE	0.00000000	3.40175620
OIL	0.00000000	4.13539880
TOTAL	3.35773270	14.66700900

REBOILER DUTY, BTUS 0.0

ITERATION NUMBER 1	
SUM DT SQUARED	2442568.000000
DT MAX	1319.303400
MAX DV/V	8.915141
MAX DL/L	10.250596

ITERATION NUMBER 2	
SUM DT SQUARED	32510.332000
DT MAX	130.058190
MAX DV/V	3.424022

ITERATION NUMBER 3

270

SUM DT SQUARED	115125.000000
DT MAX	193.542230
MAX DV/V	2.562323
MAX DL/L	1.533284

ITERATION NUMBER 4

SUM DT SQUARED	13133.367000
DT MAX	100.582700
MAX DV/V	2.077899
MAX DL/L	0.340913

ITERATION NUMBER 5

SUM DT SQUARED	10315.398000
DT MAX	96.463088
MAX DV/V	1.848833
MAX DL/L	0.391049

ITERATION NUMBER 6

SUM DT SQUARED	1018.617100
DT MAX	17.049331
MAX DV/V	1.493426
MAX DL/L	0.102749

ITERATION NUMBER 7

SUM DT SQUARED	1574.073200
DT MAX	37.790100
MAX DV/V	1.064797
MAX DL/L	0.161610

ITERATION NUMBER 8

SUM DT SQUARED	827.959470
DT MAX	21.732574
MAX DV/V	0.835420
MAX DL/L	0.115103

ITERATION NUMBER 9

SUM DT SQUARED
DT MAX 7.663537
MAX DV/V 0.643421
MAX DL/L 0.122588

271

ITERATION NUMBER 10

SUM DT SQUARED 147.475580
DT MAX 11.895473
MAX DV/V 0.431728
MAX DL/L 0.067402

ITERATION NUMBER 11

SUM DT SQUARED 68.946075
DT MAX 8.207462
MAX DV/V 0.287677
MAX DL/L 0.039744

ITERATION NUMBER 12

SUM DT SQUARED 14.324841
DT MAX 3.240744
MAX DV/V 0.121780
MAX DL/L 0.038358

ITERATION NUMBER 13

SUM DT SQUARED 1.944264
DT MAX 1.234169
MAX DV/V 0.002925
MAX DL/L 0.008458

ITERATION NUMBER 14

SUM DT SQUARED 0.022962
DT MAX 0.114763
MAX DV/V 0.000130
MAX DL/L 0.000413

ITERATION NUMBER 15

SUM DT SQUARED 0.000835
DT MAX 0.023584
MAX DV/V 0.000036
MAX DL/L 0.000118

CALCULATED VAPOR RATES			
1901.266	1944.389	1951.392	1955.055
1958.623	1964.466		
CORRESPONDING LIQUID RATES			
577.123	584.126	587.789	591.356
597.200	607.662		
CALCULATED TEMPERATURES			
96.045	97.163	96.754	94.750
90.030	79.723		

LIQUID COMPOSITIONS, MOL FRACTIONS				
TRAY #	1	2	3	4
METHANE	0.02127617	0.02086376	0.02082313	0.02096124
ETHANE	0.01184822	0.01197555	0.01198500	0.01217251
PROPANE	0.01973928	0.02183568	0.02218544	0.02268552
I BUTANE	0.00632322	0.00818325	0.00884467	0.00929651
N BUTANE	0.01243345	0.01738233	0.01968070	0.02133007
IPENTANE	0.00115504	0.00233801	0.00363295	0.00519379
NPENTANE	0.00121373	0.00278226	0.00492401	0.00807023
OIL	0.92601061	0.91463870	0.90792370	0.90028960
TOTAL	0.99999970	0.99999946	0.99999946	0.99999934

LIQUID COMPOSITIONS, MOL FRACTIONS		
TRAY #	5	6
METHANE	0.02135188	0.02228287
ETHANE	0.01266909	0.01388119
PROPANE	0.02389970	0.02686603
I BUTANE	0.01003069	0.01175504
N BUTANE	0.02370349	0.02913623
IPENTANE	0.00746256	0.01200691
NPENTANE	0.01339864	0.02516712
OIL	0.88748354	0.85890418
TOTAL	0.99999946	0.99999940

REBDILER DUTY, BTUS

0.0

FEED AND PRODUCT COMPOSITIONS

COMPONENT	FEED NO 1	FEED NO 2	COMBINED	OVERHEAD	BOTTOMS
	TRAY NO 6	TRAY NO 1	FEED	VAPOR	PRODUCT
	MOLS	MOLS	MOLS	MOLS	MOLS
METHANE	1639.2000	0.0000	1639.2000	1625.6772	13.5405
ETHANE	165.8000	0.0000	165.8000	157.3679	8.4351
PROPANE	94.9000	0.0000	94.9000	78.5693	16.3255
I BUTANE	17.8000	0.0000	17.8000	10.6561	7.1431
N BUTANE	33.5300	0.0000	33.5300	15.8245	17.7050
IPENTANE	7.9000	0.0000	7.9000	0.6039	7.2961
NPENTANE	15.8000	0.0000	15.8000	0.5069	15.2931
OIL	0.0000	534.0000	534.0000	12.0761	521.9236
TOTAL	1974.9290	534.0000	2508.9290	1901.2664	607.6624
POUNDS	40157.68	85974.00	126131.63	37837.45	88294.19
GALLONS	14043.20	12514.41	26557.61	13376.76	13180.91
Q, MBTU	13819.996	3449.999	17269.980	13200.488	3568.620
TEMP, F	60.32	90.13	0.00	96.05	79.72

NET LIQUID & VAPOR LEAVING EACH STAGE

TRAY NO 1		TEMP, F 96.05		PRESS, PSIA 74.70		LIQUID						K=DATA
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%	
1	METHANE	1625.665	26078.9	85.5043	68.9241	12.279	197.0	78.8	2.1276	0.2247	0.6090	40.18814
2	ETHANE	157.367	4730.4	8.2769	12.5021	6.838	205.5	65.4	1.1848	0.2344	0.5053	6.98587
3	PROPANE	78.569	3464.4	4.1324	9.1561	11.392	502.3	119.0	1.9739	0.5729	0.9201	2.09353
4	I BUTANE	10.656	619.3	0.5605	1.6368	3.649	212.1	45.3	0.6323	0.2419	0.3499	0.88637
5	N BUTANE	15.824	919.7	0.8323	2.4307	7.176	417.0	85.7	1.2433	0.4757	0.6626	0.66941
6	IPENTANE	0.604	43.6	0.0318	0.1151	0.667	48.1	9.3	0.1155	0.0549	0.0715	0.27497
7	NPENTANE	0.507	36.6	0.0267	0.0967	0.700	50.5	9.6	0.1214	0.0576	0.0744	0.21966
8	OIL	12.076	1944.2	0.6352	5.1384	534.422	86041.9	12524.3	92.6011	98.1379	96.8072	0.00686
TOTAL		1901.266	37837.2	100.0000	100.0000	577.122	87674.4	12937.3	100.0000	100.0000	100.0000	

VAPOR MW = 19.901 VAPOR ENTHALPY = 13702953. BTUS
 LIQUID MW = 151.917 LIQUID LB/GAL = 6.777 LIQUID ENTHALPY = 4006963. BTUS

TRAY NO 2		TEMP, F 97.16		PRESS, PSIA 74.70		LIQUID						K=DATA
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%	
1	METHANE	1637.979	26276.5	84.2413	66.4624	12.187	195.5	78.2	2.0864	0.2220	0.6006	40.37775
2	ETHANE	164.220	4936.4	8.4458	12.4860	6.995	210.3	66.9	1.1976	0.2388	0.5137	7.05271
3	PROPANE	89.926	3965.2	4.6249	10.0293	12.755	562.4	133.3	2.1836	0.6386	1.0235	2.11808
4	I BUTANE	14.299	831.1	0.7354	2.1021	4.780	277.8	59.3	0.8183	0.3155	0.4553	0.89871
5	N BUTANE	22.996	1336.5	1.1827	3.3805	10.153	590.1	121.3	1.7382	0.6701	0.9316	0.68041
6	IPENTANE	1.271	91.7	0.0653	0.2319	1.366	98.5	19.0	0.2338	0.1119	0.1455	0.27951
7	NPENTANE	1.208	87.1	0.0621	0.2204	1.625	117.3	22.3	0.2782	0.1331	0.1714	0.22322
8	OIL	12.493	2011.4	0.6425	5.0875	534.264	86016.4	12520.6	91.4639	97.6701	96.1584	0.00702
TOTAL		1944.390	39535.9	100.0000	100.0000	584.125	88068.3	13020.8	100.0000	100.0000	100.0000	

VAPOR MW = 20.333 VAPOR ENTHALPY = 14261380. BTUS
 LIQUID MW = 150.770 LIQUID LB/GAL = 6.764 LIQUID ENTHALPY = 4119298. BTUS

TRAY NO 3		TEMP, F 96.75		PRESS, PSIA 74.70		LIQUID						K=DATA
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%	
1	METHANE	1637.871	26274.7	83.9334	65.8009	12.240	196.3	78.5	2.0823	0.2225	0.6013	40.30833
2	ETHANE	164.369	4940.9	8.4232	12.3738	7.045	211.8	67.4	1.1985	0.2400	0.5157	7.02820
3	PROPANE	91.306	4026.0	4.6790	10.0826	13.040	575.0	136.3	2.2185	0.6516	1.0432	2.10907
4	I BUTANE	15.433	897.0	0.7909	2.2463	5.199	302.2	64.5	0.8845	0.3424	0.4937	0.89418
5	N BUTANE	25.975	1509.7	1.3311	3.7808	11.568	672.3	138.2	1.9681	0.7619	1.0581	0.67637
6	IPENTANE	1.970	142.1	0.1009	0.3559	2.135	154.1	29.6	0.3633	0.1746	0.2269	0.27785
7	NPENTANE	2.132	153.8	0.1093	0.3853	2.894	208.8	39.8	0.4924	0.2366	0.3044	0.22191
8	OIL	12.338	1986.4	0.6323	4.9746	533.667	85920.4	12506.6	90.7924	97.3703	95.7566	0.00696
TOTAL		1951.393	39930.7	100.0000	100.0000	587.788	88240.8	13060.8	100.0000	100.0000	100.0000	

VAPOR MW = 20.463 VAPOR ENTHALPY = 14370312. BTUS
 LIQUID MW = 150.124 LIQUID LB/GAL = 6.756 LIQUID ENTHALPY = 4135016. BTUS

NET LIQUID & VAPOR LEAVING EACH STAGE

TRAY NO 4		TEMP, F 94.75		PRESS, PSIA 74.70		LIQUID						K-DATA
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%	
1	METHANE	1637.914	26275.4	83.7784	65.5189	12.396	198.8	79.5	2.0961	0.2251	0.6075	39.96860
2	ETHANE	164.415	4942.3	8.4097	12.3239	7.198	216.4	68.8	1.2173	0.2449	0.5257	6.90886
3	PROPANE	91.600	4039.0	4.6853	10.0715	13.415	591.5	140.2	2.2686	0.6696	1.0707	2.06534
4	I BUTANE	15.853	921.4	0.8109	2.2975	5.498	319.5	68.2	0.9297	0.3617	0.5208	0.87224
5	N BUTANE	27.391	1592.0	1.4010	3.9697	12.614	733.1	150.7	2.1330	0.8299	1.1510	0.65684
6	IPENTANE	2.739	197.6	0.1401	0.4928	3.071	221.6	42.6	0.5194	0.2508	0.3255	0.26978
7	NPENTANE	3.401	245.4	0.1740	0.6119	4.772	344.3	65.5	0.8070	0.3898	0.5006	0.21558
8	OIL	11.742	1890.4	0.6006	4.7139	532.392	85715.0	12476.7	90.0290	97.0282	95.2981	0.00667
TOTAL		1955.055	40103.5	100.0000	100.0000	591.355	88340.3	13092.3	100.0000	100.0000	100.0000	

VAPOR MW = 20.513 VAPOR ENTHALPY = 14385958. BTUS
 LIQUID MW = 149.386 LIQUID LB/GAL = 6.748 LIQUID ENTHALPY = 4079602. BTUS

TRAY NO 5		TEMP, F 90.03		PRESS, PSIA 74.70		LIQUID						K-DATA
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%	
1	METHANE	1638.060	26277.8	83.6333	65.3618	12.751	204.6	81.8	2.1352	0.2312	0.6227	39.16916
2	ETHANE	164.565	4946.8	8.4021	12.3044	7.566	227.4	72.3	1.2669	0.2571	0.5506	6.63198
3	PROPANE	91.984	4056.0	4.6964	10.0885	14.273	629.3	149.1	2.3900	0.7114	1.1350	1.96504
4	I BUTANE	16.153	938.8	0.8247	2.3352	5.990	348.2	74.3	1.0031	0.3936	0.5655	0.82221
5	N BUTANE	28.438	1652.8	1.4519	4.1111	14.156	822.7	169.1	2.3704	0.9300	1.2871	0.61254
6	IPENTANE	3.675	265.2	0.1876	0.6595	4.457	321.5	61.8	0.7463	0.3635	0.4707	0.25145
7	NPENTANE	5.279	380.9	0.2695	0.9474	8.002	577.3	109.9	1.3399	0.6526	0.8364	0.20117
8	OIL	10.468	1685.3	0.5345	4.1920	530.005	85330.8	12420.8	88.7484	96.4606	94.5320	0.00602
TOTAL		1958.623	40203.6	100.0000	100.0000	597.199	88461.8	13139.2	100.0000	100.0000	100.0000	

VAPOR MW = 20.526 VAPOR ENTHALPY = 14330522. BTUS
 LIQUID MW = 148.128 LIQUID LB/GAL = 6.733 LIQUID ENTHALPY = 3923295. BTUS

TRAY NO 6		TEMP, F 79.72		PRESS, PSIA 74.70		LIQUID						K-DATA
NO	COMP	MOLS	LBS	MOL%	WT %	MOLS	LBS	GALS	MOL%	WT%	VOL%	
1	METHANE	1638.415	26283.5	83.4025	65.1789	13.540	217.2	86.9	2.2283	0.2460	0.6592	37.42903
2	ETHANE	164.932	4957.9	8.3958	12.2947	8.435	253.6	80.6	1.3881	0.2872	0.6119	6.04832
3	PROPANE	92.844	4093.8	4.7262	10.1521	16.325	719.9	170.6	2.6866	0.8153	1.2942	1.75916
4	I BUTANE	16.646	967.5	0.8474	2.3992	7.143	415.2	88.6	1.1755	0.4702	0.6721	0.72087
5	N BUTANE	29.980	1742.4	1.5261	4.3210	17.705	1029.0	211.5	2.9136	1.1654	1.6047	0.52379
6	IPENTANE	5.061	365.1	0.2576	0.9054	7.296	526.4	101.2	1.2007	0.5962	0.7681	0.21455
7	NPENTANE	8.509	613.9	0.4331	1.5223	15.293	1103.3	210.0	2.5167	1.2496	1.5935	0.17210
8	OIL	8.081	1301.0	0.4114	3.2264	521.924	84029.7	12231.4	85.8905	95.1701	92.7963	0.00479
TOTAL		1964.467	40325.1	100.0000	100.0000	607.662	88294.2	13180.9	100.0000	100.0000	100.0000	

VAPOR MW = 20.527 VAPOR ENTHALPY = 14174921. BTUS
 LIQUID MW = 145.301 LIQUID LB/GAL = 6.699 LIQUID ENTHALPY = 3568620. BTUS

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