SVHSER 6529

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SHUTTLE ENVIRONMENTAL AND THERMAL CONTROL/LIFE SUPPORT SYSTEM COMPUTER PROGRAM

INTERIM REPORT

BY

FREDERICK A. ELFERS AND WILLIAM J. AYOTTE

PREPARED UNDER CONTRACT NAS 9-12411

By

HAMILTON STANDARD

DIVISION OF UNITED AIRCRAFT CORPORATION

WINDSOR LOCKS, CONN.

For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LYNDON B. JOHNSON SPACE CENTER

HOUSTON, TEXAS 77058

DECEMBER 1974

Hamilton Standard U A DIVISION OF UNITED AIRCRAFT CORPORATION

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ABSTRACT

SHUTTLE ENVIRONMENTAL AND THERMAL

CONTROL/LIFE SUPPORT SYSTEM COMPUTER

PROGRAM

by

FREDERICK A. ELFERS &

WILLIAM J. AYOTTE

CONTRACT NAS 9-12411

DECEMBER 1974

This user's guide describes the computer programs developed to simulate the RSECS (Representative Shuttle Environmental Control System). These programs have been prepared to provide pretest predictions, post-test analysis and real-time problem analysis for RSECS test planning and evaluation. Hamilton Standard has provided these programs to the NASA on a magnetic tape cassette and on a disk device that is part of Crew Systems Division's WANG-2200 series computer system.

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FOREWORD

This report has been prepared by the Hamilton Standard Division of United Aircraft Corporation for the National Aeronautics and Space Administration's Lyndon B. Johnson Space Center in accordance with the requirements of Contract NAS9-12411, Space Shuttle ECS Computer Program. This interim report covers the work accomplished during calendar year 1974. A previous report SPOZT73, "Users Manual, Space Shuttle Atmospheric Revitalization Subsystem/Active Thermal Control Subsystem Computer Program" covered the work performed under this contract during calendar year 1973.

Appreciation is expressed to the NASA JSC Technical Monitor, Mr. James Jaaxs, for his support during the conduct of this program.

The Hamilton Standard technical personnel responsible for the work described herein are Mr. Frederick A. Elfers and Mr. William J. Ayotte. The program manager is Mr. Fred H. Greenwood.

It is expected that this contract will be continued during calendar year 1975. Another report covering this additional work will be published in December, 1975.

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INTRODUCTION

To fulfill the requirements of Contract NAS 9-12411, for calendar year 1974, Hamilton Standard has developed the computer programs listed below. These programs were written to support the RSECS (Representative Shuttle Environmental Control System) test program presently being conducted.

- "RSECS" - Calculates a steady state heat balance for a combined RSECS ARS (Air Revitalization Subsystem) gas and water coolant loop system. Required input data consists of RSECS heat loads, flow rates and controller settings, and GSE (Ground Support Equipment) flow rate and inlet temperature.
- "RSECS2"- Draws flow charts of RSECS air loop and water loop. This program is used in conjunction with program "RSECS".
- "350-M Hx" - Analyzes 350-M heat exchanger test data. Calculates heat loads and heat transfer coefficients for the heat exchanger. Required input consists of operating temperatures and flow rates at the heat exchanger.
- "CONDEX" -Calculates 350-M RSECS cabin heat exchanger performance using measured inlet air conditions of temperature and dew point, and inlet coolant conditions of temperature and flow. Used to predict results of heat exchanger tests.
- "ARS DP" - Calculates the corrected pressure drop of the Hamilton Standard supplied RSECS ARS gas loop equipment. The calculations are detailed to the package level. Required input data includes the total air flow rate, and the number of RS-11 fans operating.
- "PLOT" - Generalized plot program used to produce plots of results of RSECS analysis or any other desired data, using a WANG 2200 flat bed plotter.

Hamilton Standard has provided these programs to the NASA on a magnetic tape cassette and on a disk device that is part of the Crew Systems Division's WANG 2200 - series computer system. This user's guide is written for the person who has an understanding of the BASIC computer language and is acquainted with the WANG 2200 system.

RSECS STEADY STATE COMPUTER PROGRAM

File Name "RSECS"

Abstract "RSECS" calculates the steady state operating point, for a given set of input data, for the combined RSECS gas and water coolant loops. The program is designed for use with a WANG 2200 - series computer system. A sample case is shown in figure 1.

Program Description

This user's guide is written for the person who has an understanding of the BASIC computer language and is acquainted with the WANG 2200 - series computer system. The program models the functional gas, figure 2, and water loop, figure 3, schematics enclosed.

Rotating equipment characteristics are supplied as input data. However, performance maps for the 350-m and RS-261 heat exchangers are stored in the program as internal data, in addition to Freon-21 and water vapor properties. These data tables are interpolated by using an adaptation of the Hamilton Standard Division's "UNBAR" routine.

As written, the program uses Freon-21 as the RS-261 heat exchanger's cold side fluid. Minor changes to the data tables are required if another fluid is to be considered. The Freon enthalpy table must be revised to reflect the new fluid. A revised RS-261 heat exchanger performance map must be generated and incorporated.

The "Input Data Definition", Table I, provides the user with the information required to supply the program with the appropriate input data. The input data for all the cases is loaded into its storage array prior to the execution of the first case. At the completion of the first case, the results will be printed, the data array cleared and up-dated for the second case, and the second case started. The user has the option of matching the RS-261 heat exchanger's heat load or hot side operating temperatures to Shuttle conditions. When the Shuttle temperatures are duplicated, the NASA-supplied heat sink will compensate for the heat not rejected through the RS-261 heat exchanger.

RSECS STEADY STATE COMPUTER PROGRAM

RUN #: SAMPLE CASE 1 - MIN LOAD 29000 P/L SYS
DATE : 7/3/74

INPUT DATA -

T RS-20 SETPT	= 70.00	Q CHAMBER-S	= 0.00	Q CHAMBER-L	= 1268.00
Q CHAM AVIONICS	= 0.00	CO2 INLET FLOW	= 0.00	RS-11 FLOW	= 317.00
RS-11 POWER	= 970.00	RS-51 FLOW	= 10.00	RS-51 POWER	= 185.00
RS-251 FLOW	= 779.00	RS-251 POWER	= 73.00	H2O BYPASS FLOW	= 281.00
Q H2O AVIONICS	= 11109.00	T RS-261 F21 IN	= 35.50	W RS-261 F21	= 2587.00

GAS LOOP OUTPUT DATA -

T CHAMBER	= 70.00	TOTAL AIR FLOW	= 1418.04	Q RS-11	= 3311.58
T DEWPOINT	= 50.06	WCP RS-11	= 345.21	Q RS-50 -S	= 0.00
T RS-11 IN	= 70.00	WCP 350-M	= 90.68	Q RS-50 -L	= 0.00
T RS-50 IN	= 79.59	V 350-M	= 73.27	Q RS-51	= 631.59
T 350-M IN	= 79.59	V BYPASS	= 233.72	Q 350-M -S	= 3943.17
T 350-M OUT	= 36.10	W CONDENSATE	= 1.19	Q 350-M -L	= 1268.00
T RS-51 OUT	= 94.10	UA 350-M	= 799.27	Q 350-M -TOT	= 5211.17

COOLANT LOOP OUTPUT DATA -

T RS-261 H2O OUT	= 35.99	T 350-M H2O IN	= 35.99	T 350-M H2O OUT	= 46.46
T RS-251 H2O IN	= 54.68	T AVION H2O IN	= 55.00	T RS-261 H2O IN	= 69.27
T RS-261 F21 OUT	= 61.47	W RS-261/350-M	= 498.00	Q H2O HTSINK	= 0.00
Q RS-251	= 249.22	Q RS-261	= 16569.39		

FIGURE 1 RSECS STEADY STATE COMPUTER PROGRAM SAMPLE CASE

RSECS STEADY STATE COMPUTER PROGRAM

RUN #: SAMPLE CASE 2 - PRELAUNCH 21500 P/L SYS
DATE : 7/3/74

INPUT DATA -

T RS-20 SETPT	= 73.00	Q CHAMBER-S	= 6352.00	Q CHAMBER-L	= 2769.00
Q CHAM AVIONICS	= 4190.00	CO2 INLET FLOW	= 0.00	RS-11 FLOW	= 317.00
RS-11 POWER	= 970.00	RS-51 FLOW	= 10.00	RS-51 POWER	= 135.00
RS-251 FLOW	= 697.00	RS-251 POWER	= 69.00	H20 BYPASS FLOW	= 0.00
Q H20 AVIONICS	= 26051.00	T RS-261 F21 IN	= 36.20	W RS-261 F21	= 2843.00

GAS LOOP OUTPUT DATA -

T CHAMBER	= 73.00	TOTAL AIR FLOW	= 1376.47	Q RS-11	= 3311.58
T DEWPOINT	= 55.25	WCP RS-11	= 336.10	Q RS-50 -S	= 0.00
T RS-11 IN	= 85.46	WCP 350-M	= 309.97	Q RS-50 -L	= 0.00
T RS-50 IN	= 95.31	V 350-M	= 282.35	Q RS-51	= 631.59
T 350-M IN	= 95.31	V BYPASS	= 24.64	Q 350-M -S	= 14485.17
T 350-M OUT	= 48.58	W CONDENSATE	= 2.60	Q 350-M -L	= 2769.00
T RS-51 OUT	= 108.15	UA 350-M	= 1309.38	Q 350-M -TOT	= 17254.17

COOLANT LOOP OUTPUT DATA -

T RS-261 H20 OUT	= 42.58	T 350-M H20 IN	= 42.80	T 350-M H20 OUT	= 67.55
T RS-251 H20 IN	= 67.55	T AVION H20 IN	= 67.89	T RS-261 H20 IN	= 105.20
T RS-261 F21 OUT	= 97.24	W RS-261/350-M	= 697.00	Q H20 HTSINK	= -146.99
Q RS-251	= 235.56	Q RS-261	= 43639.79		

FIGURE 1 RSECS STEADY STATE COMPUTER PROGRAM SAMPLE CASE (CONCLUDED)

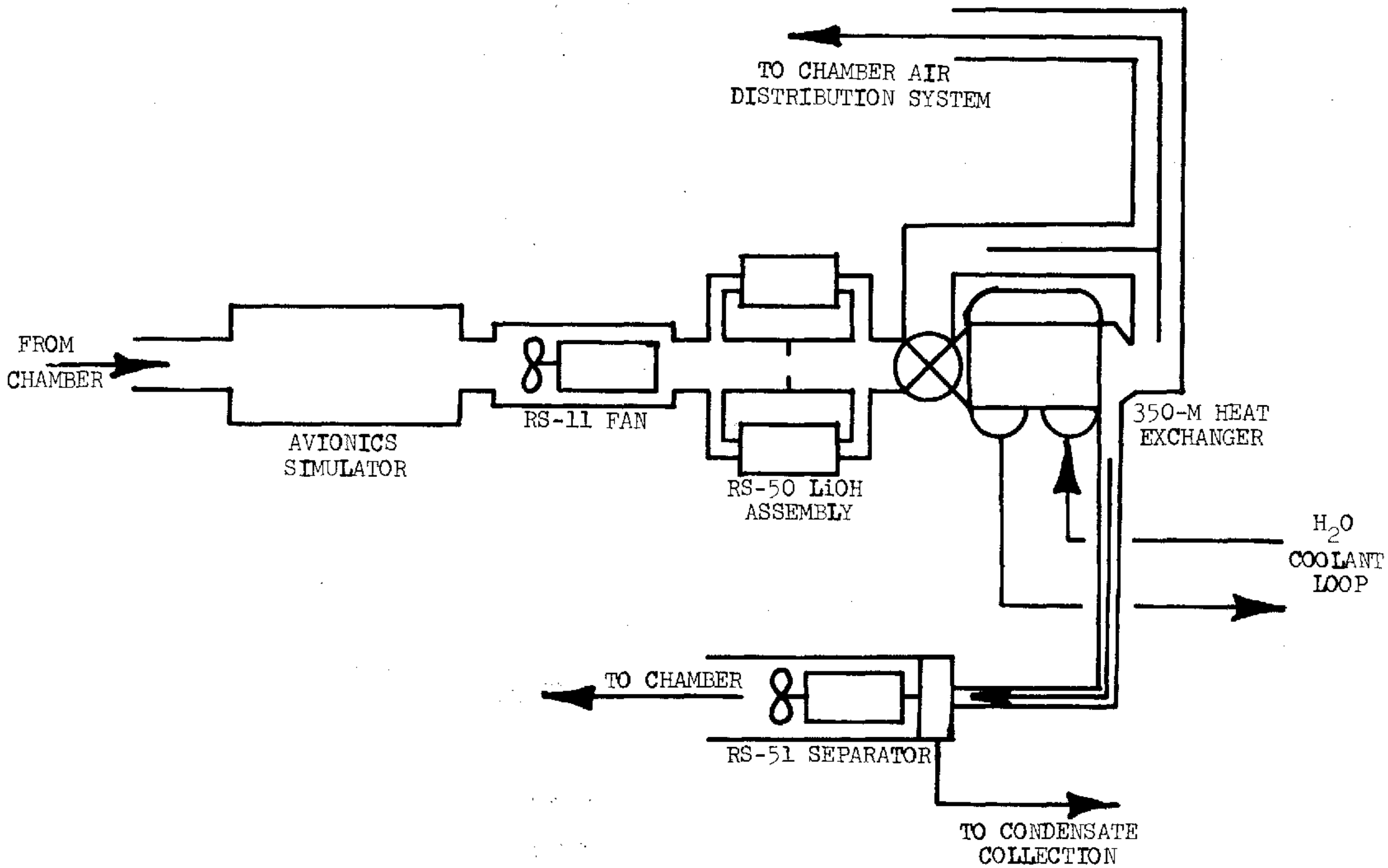

FIGURE 2 RSECS ARS GAS LOOP SCHEMATIC

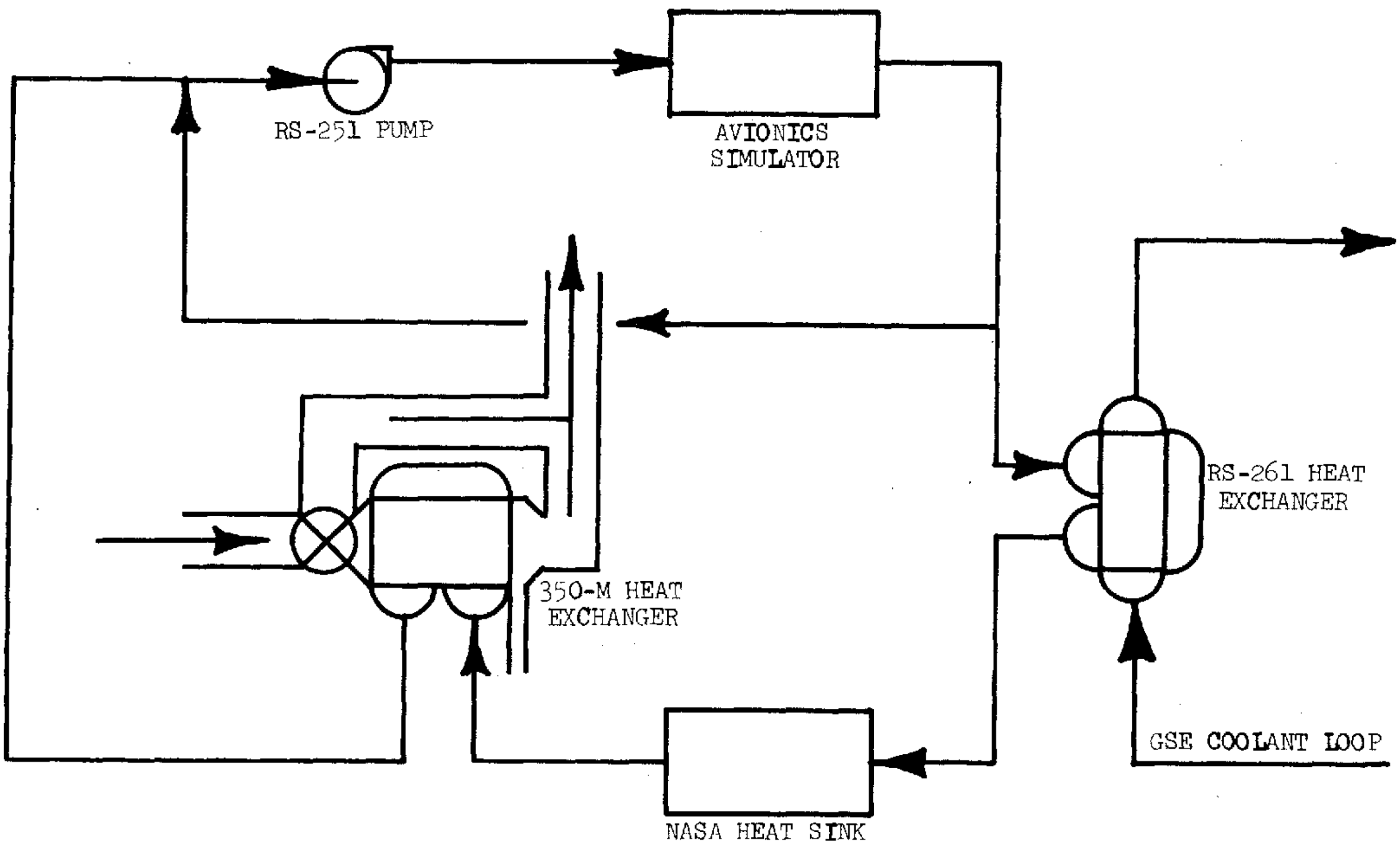

FIGURE 3 RSECS WATER LOOP SCHEMATIC

Table I

INPUT DATA DEFINITION

CRT SYMBOL	PRINTED SYMBOL	DESCRIPTION
# of cases	not printed	number of cases to be run (1 - 10)
date	date	Time identification (16 characters, max)
are flow charts desired	not printed	1 if yes 2 if no
is printout desired	not printed	1 if yes 2 if no
run designation	run #	identifying notation for individual case (64 characters, max)
T RS-20 SETPT	T RS-20 SETPT	RS-20 temperature controller setting for chamber; program will try to balance system at this point (^{o}F)
Q cham-S	Q chamber-S	sum total of all non-RSECS sensible heat added to the chamber (Btu/Hr)
Q cham-L	Q chamber-L	sum total of all non-RSECS latent heat added to the chamber (Btu/Hr)
Q avionics	Q cham avionics	sensible heat supplied by the cabin avionics simulator (Btu/Hr)
CO_2 flow	CO_2 inlet flow	CO_2 injection rate into the chamber (Lb/Hr)
RS-11 flow	RS-11 flow	total air flow generated by the RS-11 fans (cfm)
RS-11 power	RS-11 power	RS-11 fans input power (watts)
RS-51 flow	RS-51 flow	RS-51 separator air flow rate (cfm)
RS-51 power	RS-51 power	RS-51 separator input power (watts)
RS-251 flow	RS-251 flow	RS-251 pump flow rate (Lb/Hr)

Table I

INPUT DATA DEFINITION (CONCLUDED)

CRT SYMBOL	PRINTED SYMBOL	DESCRIPTION
RS-251 power	RS-251 power	RS-251 pump input power (watts)
bypass flow	H_2O bypass flow	RS-251 pump package bypass flow rate (Lb/Hr)
Q simulator	Q H_2O avionics	sensible heat supplied by the H_2O loop avionics simulator (Btu/Hr)
T 350M H_2O in	not printed	desired 350-M HX H_2O inlet temp. If >0 the heat req'd to compensate for the difference between this temp. and the RS-261 HX outlet will be calculated. If = 0 the H_2O heat sink Q will be set at 0 and the RS-261 HX outlet temp. will be used (°F)
T 261 H_2O in	not printed	desired RS-261 HX H_2O inlet temp. must be >0 if T 350M H_2O in is >0 / or must = 0 if T 350M H_2O in = 0 (°F)
T 261 F21 in	T RS-261 F21 IN	RS-261 HX cold side inlet temperature (°F)
261 F21 flow	W RS-261 F21	RS-261 HX cold side flow rate (Lb/Hr)

The "Output Data Definition", Table II, provides the user with a description of the output data's printed symbols. Two sample cases are provided to assist the user in understanding the data tables and the program operation.

For user reference, the following information is enclosed:

1. RS-11 Fan Performance Map, figure 4

2. 350-M Heat Exchanger Performance Curves

   Hot Side Film Coefficient vs. Air Velocity, figure 5

   Cold Side Film Coefficient vs. Water Flow Rate Per Start, figure 6

3. RS-261 Heat Exchanger Performance Maps, Effectiveness vs. Hot and Cold Side Flow Rates.

   Uses Cold Side Fluid of - Freon-21, figure 7

   - Water/Glycol, figure 8

   - Water, figure 9

4. Internal Data Summary, Table III

5. Data Array, Table IV

6. Input Data Array, Table V

7. Logic Key Array, Table VI

8. Scalar Variable Summary List, Table VII

9. Subroutine Descriptions, Table VIII

10. Program Listing, Table IX

Table II

OUTPUT DATA DEFINITION

PRINTED SYMBOL	DESCRIPTION
T chamber	steady state chamber temperature (^{o}F)
total air flow	air weight flow at the RS-11 fans (Lb/Hr)
Q RS-11	sensible heat generated by the RS-11 fans (Btu/Hr)
T dewpoint	chamber dewpoint temperature (^{o}F)
WCP RS-11	air weight flow X specific heat at the RS-11 fans (Btu/Hr - ^{o}F)
Q RS-50-S	sensible heat generated by the LiOH/CO_2 reaction (Btu/Hr)
T RS-11 in	RS-11 fans inlet temperature (^{o}F)
WCP 350-M	air weight flow X specific heat through the 350-M HX (Btu/Hr - ^{o}F)
Q RS-50-L	latent heat generated by the LiOH/CO_2 reaction (Btu/Hr)
T RS-50 in	RS-50 LiOH assembly inlet temperature (^{o}F)
V 350-M	air flow rate exiting the 350-M HX (cfm)
Q RS-51	sensible heat generated by the RS-51 separator (Btu/Hr)
T 350-M in	350-M HX air inlet temperature (^{o}F)
V bypass	air flow rate through the 350-M HX bypass (cfm)
Q 350-M-S	350-M HX sensible heat load (Btu/Hr)
T 350-M out	350-M HX air outlet temperature (^{o}F)
W condensate	condensate flow rate exiting the RS-51 separator (Lb/Hr)
Q 350-M-L	350-M HX latent heat load (Btu/Hr)

Table II

OUTPUT DATA DEFINITION (CONCLUDED)

PRINTED SYMBOL	DESCRIPTION
T RS-51 out	RS-51 separator air outlet temperature (^oF)
UA 350-M	350-M HX UA (Btu/Hr - ^oF)
Q 350-M -TOT	350-M HX total heat load (Btu/Hr)
T RS-261 H_2O out	RS-261 HX H_2O outlet temperature (^oF)
T 350-M H_2O in	350-M HX H_2O inlet temperature (^oF)
T 350-M H_2O out	350-M H_2O outlet temperature (^oF)
T RS-251 H_2O in	RS-251 pump inlet temperature (^oF)
T avion H_2O in	H_2O loop avionics simulator inlet temperature (^oF)
T RS-261 H_2O in	RS-261 HX H_2O inlet temperature (^oF)
T RS-261 F21 out	RS-261 HX cold side outlet temperature
W RS-261/350-M	RS-261/350-M HX H_2O flow rate (Lb/Hr)
Q H_2O HTSINK	H_2O loop heat sink load (Btu/Hr)
Q RS-251	heat generated by the RS-251 pump
Q RS-261	RS-261 HX heat load (Btu/Hr)

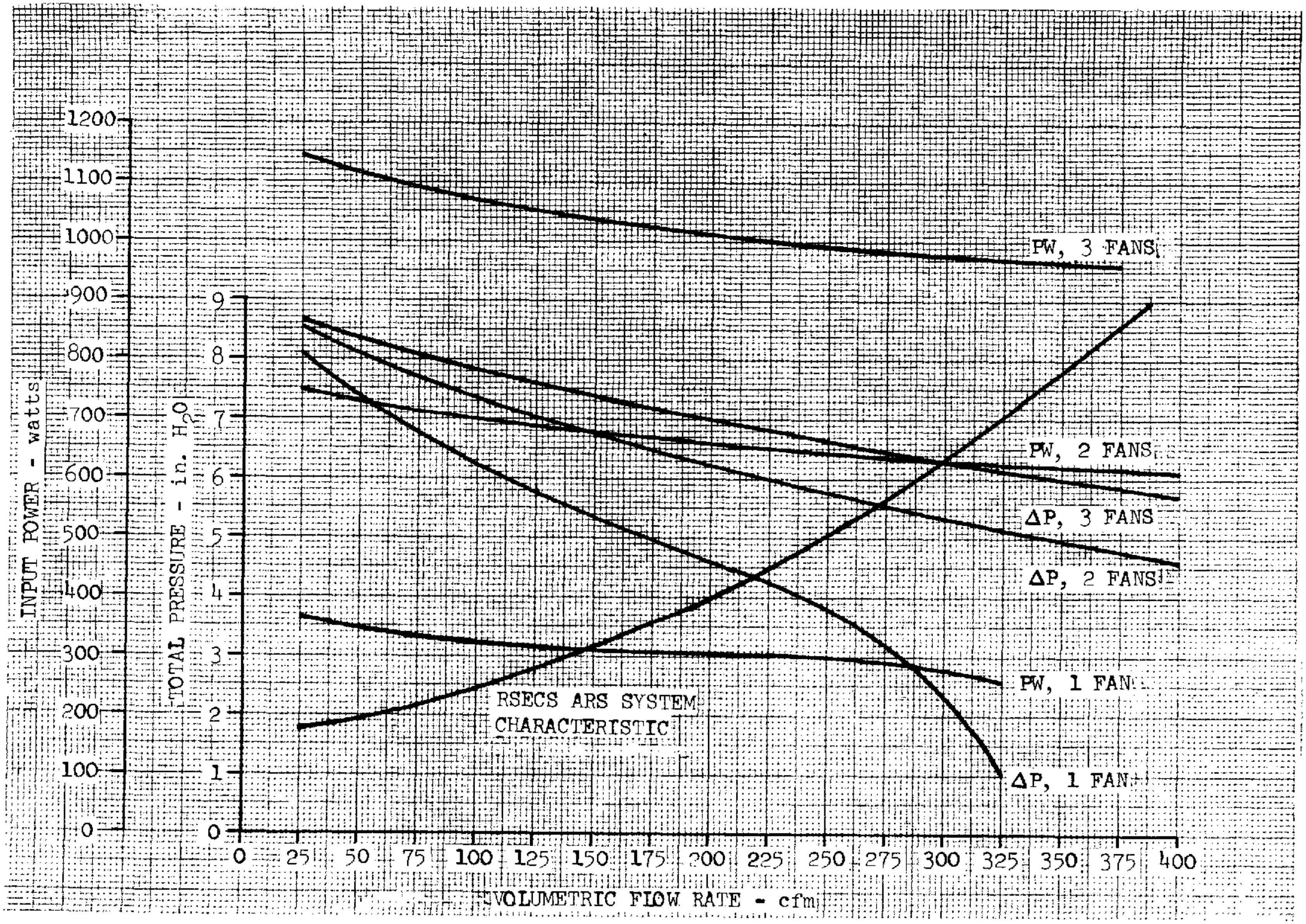

FIGURE 4 RS-11 FAN PERFORMANCE MAP

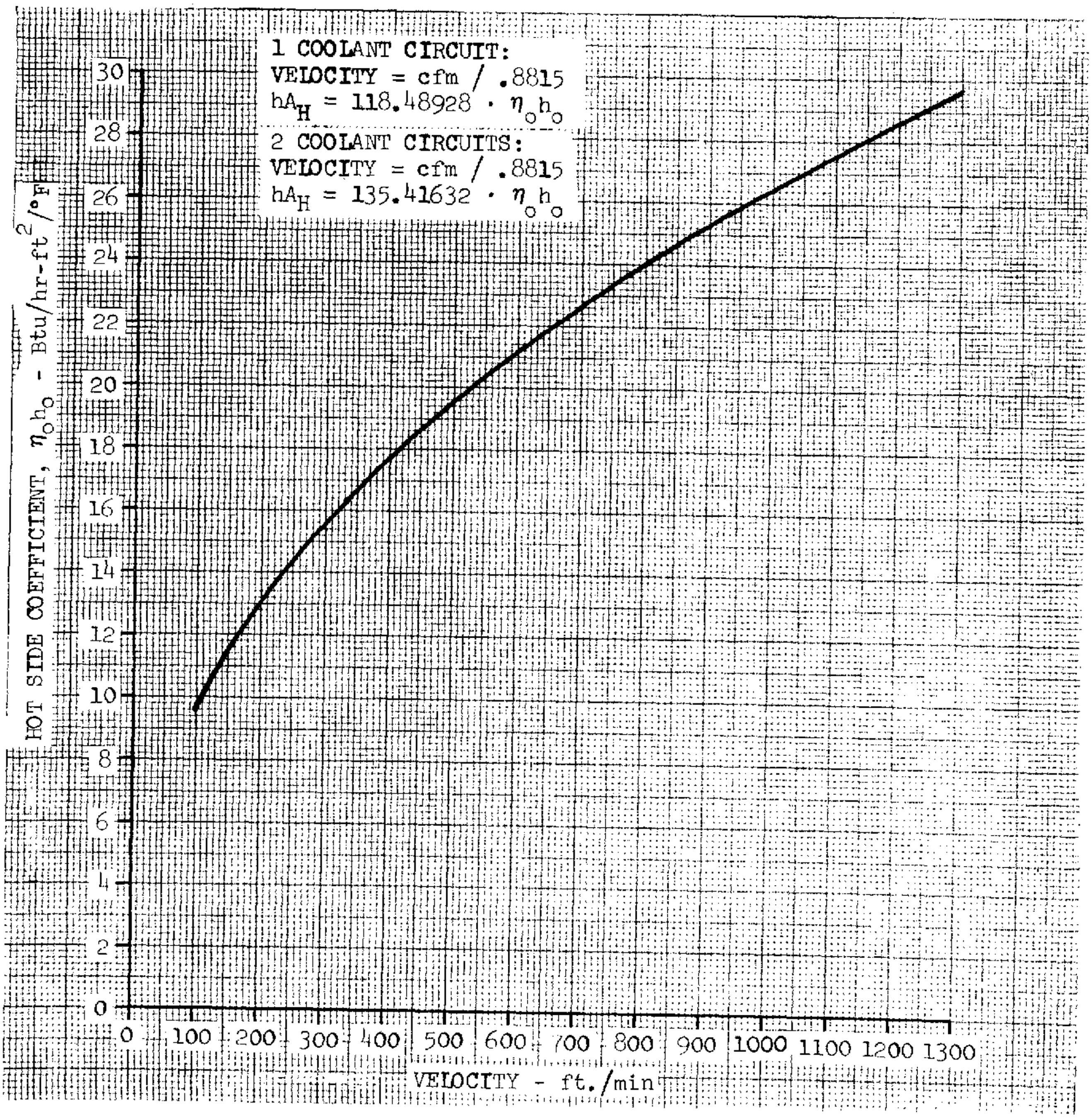

FIGURE 5 RSECS 350-M HEAT EXCHANGER PERFORMANCE

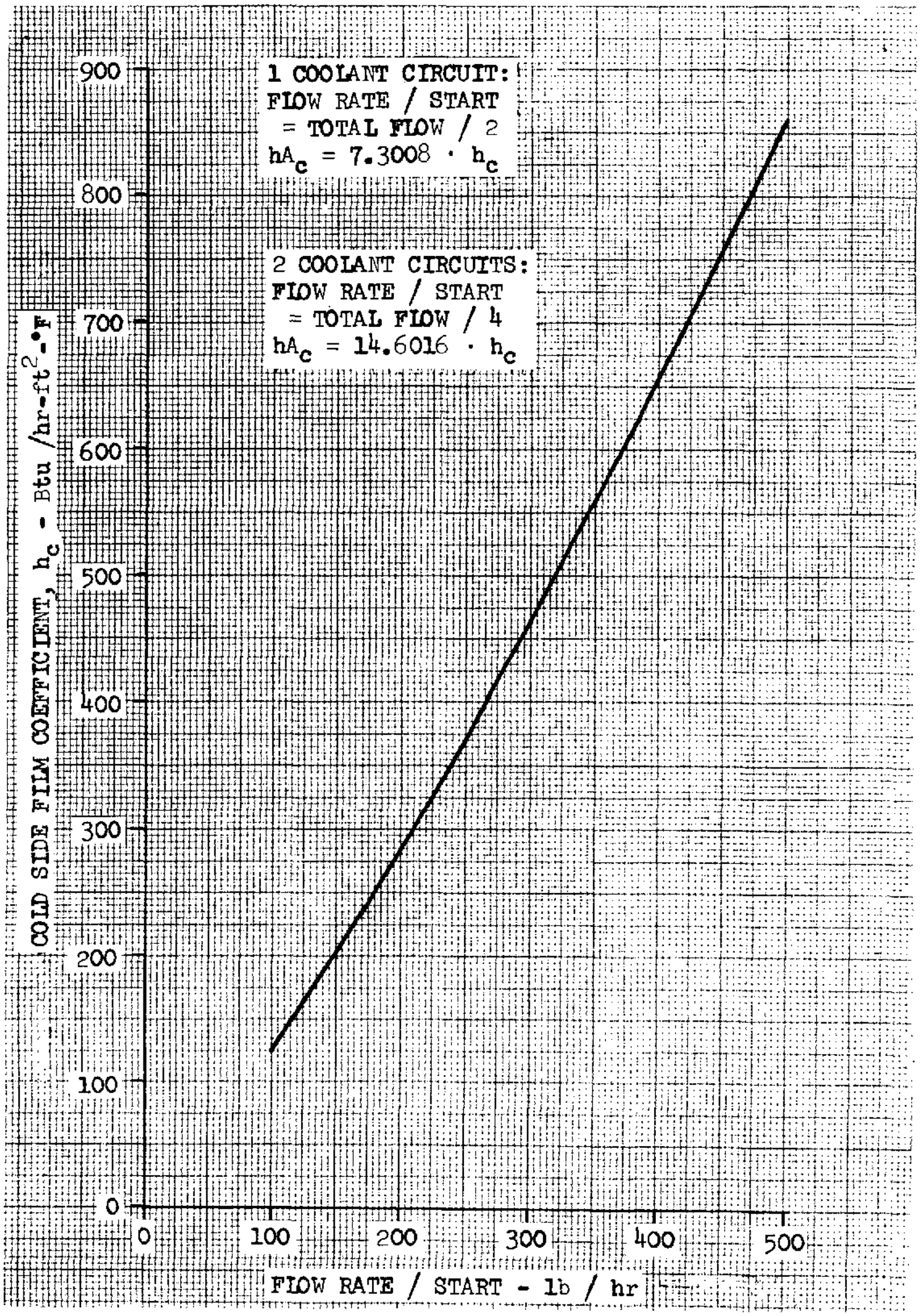

FIGURE 6 RSECS 350-M HEAT EXCHANGER PERFORMANCE

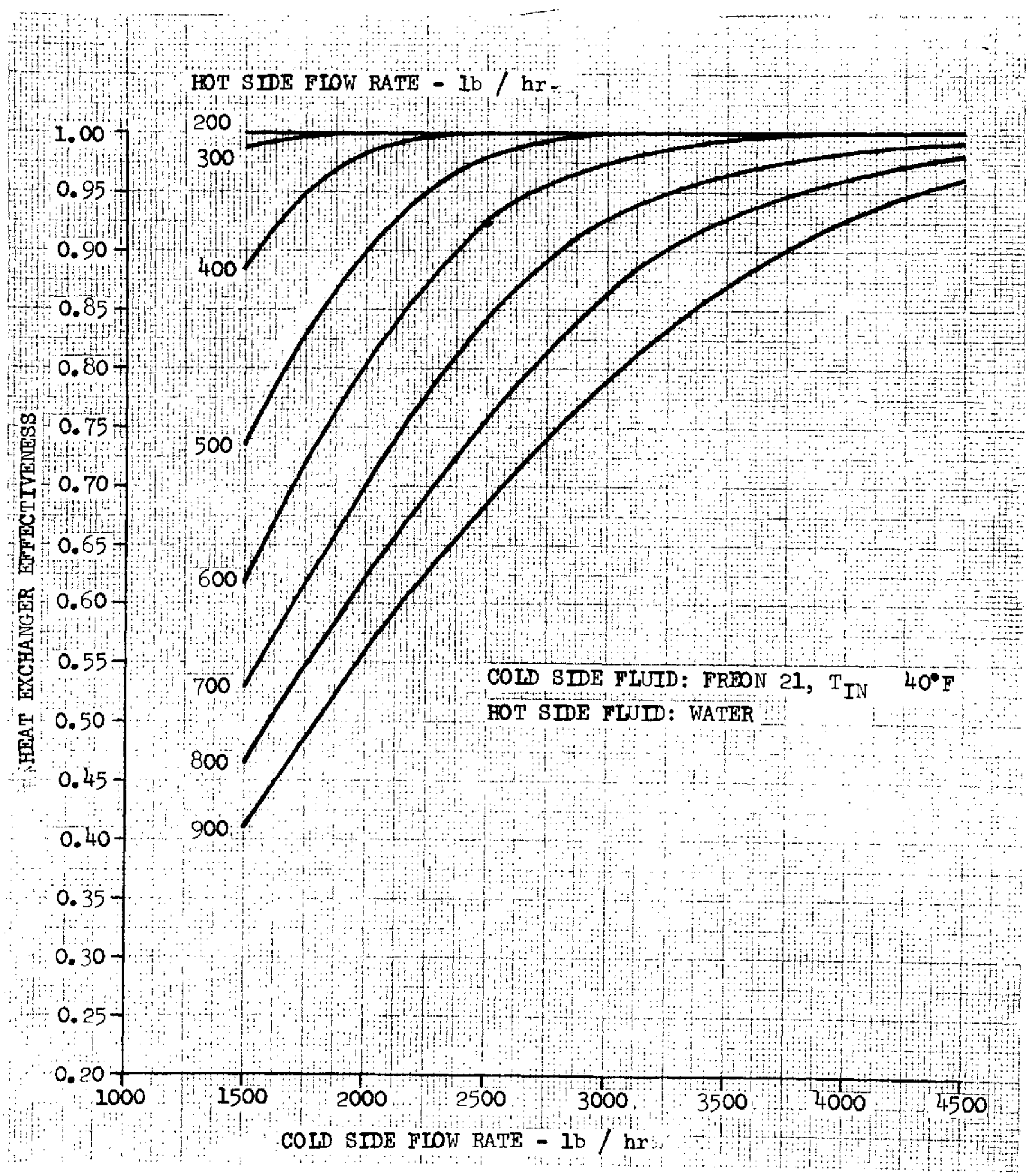

FIGURE 7 RSECS 261 HEAT EXCHANGER PERFORMANCE

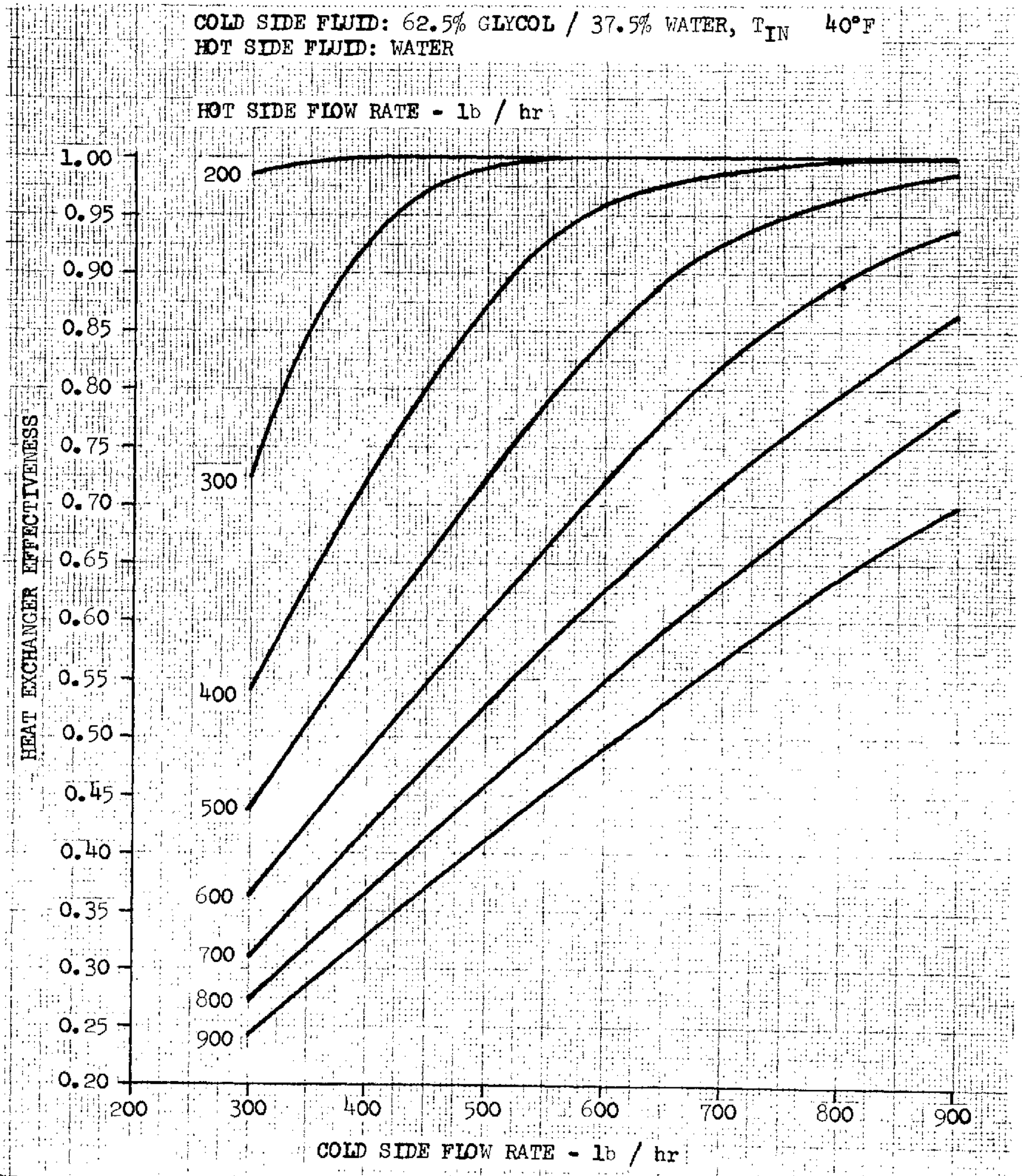

FIGURE 8 RSECS 261 HEAT EXCHANGER PERFORMANCE

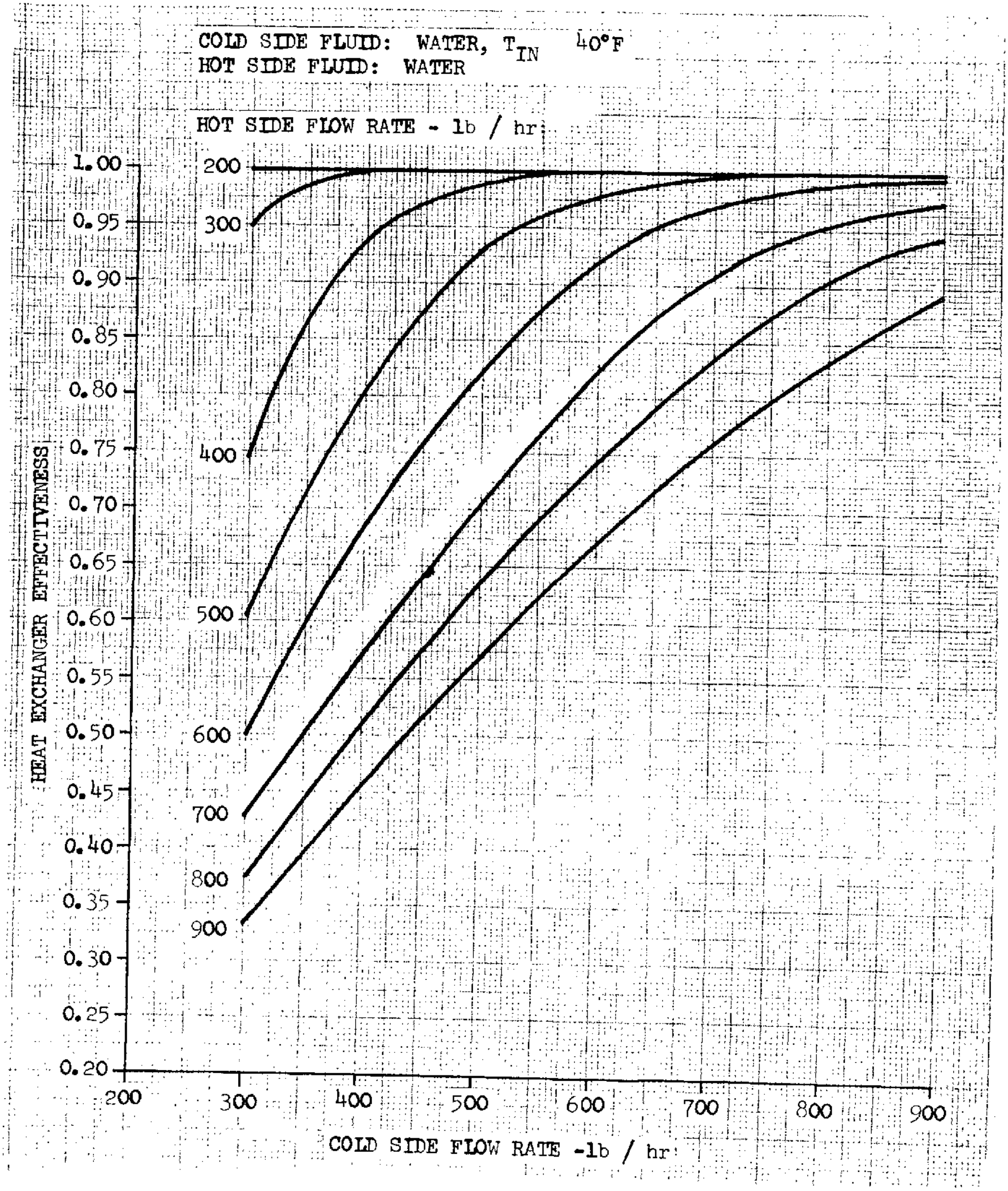

FIGURE 9 RSECS 261 HEAT EXCHANGER PERFORMANCE

Table III

INTERNAL DATA SUMMARY

STORAGE LOCATION	DATA DESCRIPTION
1-25	Freon temperatures, 0-240°F in 10° increments
26-50	Freon enthalpy, Btu/Lb, corresponding to temperatures in locations 1-25
51-70	Water vapor temperatures, 32-70°F in 2° increments
71-90	Water vapor pressure, PSIA, corresponding to temperatures in locations 51-70
91-118	350-M HX air side film coefficient curve, $\eta_o h_o$ vs. velocity 91: # of X values (13) 92: # of Y values (0) 93-103: air velocity, 100-1300 ft/min in 100 ft/min increments 104-118: $\eta_o h_o$, Btu/Hr-Ft^2 - °F, corresponding to air velocities in locations 93-103
119-138	350-M HX H_2O side film coefficient curve, h_c vs. flow/start 119: # of X values (9) 120: # of Y values (0) 121-129: flow/start, 100-500 Lb/Hr in 50 Lb/Hr increments 130-138: h_c, Btu/Hr-Ft^2 °F, corresponding to flow/start in locations 121-129
139-211	RS-261 HX effectiveness map; H_2O/F21, T F21 - in = 40°F 139: # of X values (8) 140: # of Y values (7) 141-148: H_2O flow, 200-900 Lb/Hr in 100 Lb/Hr increments 149-155: F21 flow, 1500-4500 Lb/Hr in 500 Lb/Hr increments 156-211: HX effectiveness in following order: X_1, Y_1, X_1, Y_2, -------X_1Y_7,X_2Y_1----X_2Y_7,----X_8Y_7

Table IV

DATA ARRAY

— Provides storage for individual case calculations

ARRAY LOCATION	DATA DESCRIPTION
1	RS-20 temperature controller set point
2	Non-RSECS sensible heat added to the chamber
3	Non-RSECS latent heat added to the chamber
4	Cabin avionics simulator heat load
5	CO_2 injection flow rate to chamber
6	RS-11 fans total volumetric flow rate
7	RS-11 fans power requirement
8	RS-51 separator volumetric flow rate
9	RS-51 separator power requirement
10	RS-251 pump total mass flow rate
11	RS-251 pump power requirement
12	H_2O bypass mass flow rate
13	H_2O loop avionics simulator heat load
14	350-M HX H_2O inlet temperature
15	RS-261 HX H_2O inlet temperature
16	RS-261 HX F21 inlet temperature
17	RS-261 HX F21 mass flow rate
18	Chamber temperature
19	RS-11 fan heat load
20	Sensible heat generated by the CO_2/LiOH reaction

Table IV

DATA ARRAY (CONTINUED)

- Provides storage for individual case calculations

ARRAY LOCATION	DATA DESCRIPTION
21	Latent heat generated by the CO_2/LiOH reaction
22	RS-51 separator heat load
23	Sensible heat at the 350-M HX inlet - air side
24	350-M HX total sensible heat
25	350-M HX total latent heat
26	350-M HX total heat load
27	RS-251 pump heat load
28	H_2O loop sink heat load
29	RS-261 HX heat load
30	RS-261/350-M HX's H_2O mass flow rate
31	RS-261 HX H_2O outlet temperature
32	RS-261 HX F21 outlet temperature
33	350-M HX H_2O outlet temperature
34	RS-251 pump H_2O inlet temperature
35	H_2O loop avionics simulator inlet temperature
36	RS-11 fan air mass flow rate X specific heat
37	350-M HX air mass flow rate X specific heat
38	RS-11 fan inlet temperature
39	RS-11 fan air mass flow rate
40	Chamber temperature from previous iteration

Table IV

DATA ARRAY (CONCLUDED)

ARRAY LOCATION	DATA DESCRIPTION
41	350-M HX UA req'd from previous iteration
42	Chamber dewpoint
43	350-M HX minimum air flow rate - decimal fraction of total flow
44	350-M HX air inlet temperature
45	350-M HX air outlet temperature
46	350-M HX UA
47	350-M HX volumetric air flow rate
48	350-M HX bypass volumetric air flow rate
49	RS-50 LiOH assembly inlet temperature
50	RS-51 separator air outlet temperature
51	RS-51 separator condensate mass flow rate
101-200	Reserved for internal data storage for table interpolation

Table V

INPUT DATA ARRAY

- Provides input data storage for a maximum of 10 cases

ARRAY LOCATION	DATA DESCRIPTION
1,1 - 1,17	Case #1 input data: corresponds to X-array locations 1-17
2,1 - 2,17	Case #2 input data
10,1 - 10,17	Case #10 input data

Table VI

LOGIC KEY ARRAY

- Provides storage for program keys

ARRAY LOCATION	DATA DESCRIPTION
1	Case # being run
2	Max # of cases to be run
3	Flow chart key
4	Print-out key

Table VII

SCALAR VARIABLES SUMMARY LIST

B$	M2	U2
E1	Q1	U3
E2	Q2	W1
H	T1	Z
H1	T2	Z1
H2	U	
K	U	
M1	U1	

Table VIII

SUBROUTINE DESCRIPTIONS

SUBROUTINE NUMBER	SUMMARY
01	Interpolates data curves that have been transferred to the X-array in locations 101-200 Array must be set-up in following order: X(101) : # of X-values (N) X(102) : # of Y-values (M) X(103) - X (102 + N): X-values in ascending order X(102 + N + 1) - X(102 + N + M) : Y-values in ascending order, omit if M = 0 X(102 + N + M + 1) - X(200) : Z-values in following order - $Z(N_1, M_1)$, $Z(N_1, M_2)$, ----$Z(N_1, M)$, $Z(N_2, M_1)$,------$Z(N_2, M)$,----- Z(N, M) Array and scalar variables used: A1(6) X1(6) Y1(6) C1 C2 C3 C4 D D1 D2 I I1 J J1 J2 J7 J8 J9 K1 K8 L L7 L8 M N N1 N2 N8

Table VIII

SUBROUTINE DESCRIPTIONS (CONTINUED)

SUBROUTINE NUMBER	SUMMARY
	N9 Z1
02	Calculates air flow rate X Cp by iterating 350-M HX air outlet temperature and chamber dewpoint Scalar variables: B
03	Calculates air dewpoint at 350-M HX inlet Scalar variables: A2 C P2 Z1
04	Calculates 350-M HX hA_{hot} and UA Scalar variables: E H1 H2 V1 Z1
05	Calculates 350-M HX NTU's Scalar variables: E3 K M3
06	Calculates chamber dewpoint Scalar variables: A2 F P2 Z1

Table VIII

SUBROUTINE DESCRIPTIONS (CONCLUDED)

SUBROUTINE NUMBER	SUMMARY
07	Calculates air weight flow and Cp by iterating RS-11 fan inlet temperature Scalar variables: C3 G P1 P2 R1 R2 R3 Z1
08	Calculates density of dry air and water vapor Scalar variables: P4 R3 R4
10	Calculates RS-11 fan, RS-50 LiOH assembly and 350-M HX air inlet temperatures
11	Calculates 350-M HX air outlet temperature

Table IX

PROGRAM LISTING

```
10  REM RSECS ARS/H2O LOOP PERFORMANCE
20  COM X(200),A(10,17),A$(10)64,B$,Y(4)
30  IF Y(1)]1 THEN 250: Y(1)=1
40  REM FREON PROPERTIES - TEMPERATURE (1):
    DATA 0  ,10 ,20 ,30 ,40 ,50 ,60 ,70 ,80 ,90 ,100,110,120,
         130,140,150,160,170,180,190,200,210,220,230,240
50  REM FREON PROPERTIES - ENTHALPY (26):
    DATA 9.44 ,11.81,14.21,16.61,19.04,21.49,23.98,26.49,29.03,
         31.59,34.18,36.79,39.46,42.13,44.86,47.62,50.43,53.2
60  DATA 56   ,59   ,62   ,65   ,68   ,71   ,74
70  REM WATER VAPOR PROPERTIES - TEMPERATURE (51):
    DATA 32,34,36,38,40,42,44,46,48,50,52,54,56,58,60,62,64,66,
         68,70
80  REM WATER VAPOR PROPERTIES - PRESSURE (71):
    DATA .08854,.09603,.10401,.11256,.1217 ,.1315 ,.14199,
         .15323,.16525,.17811,.19182,.20642,.222  ,.2386
90  DATA .2563 ,.2751 ,.2951 ,.3164 ,.339  ,.3631
100 REM 350-M HX AIR SIDE FILM COEFFICIENT (91):
    DATA 13  ,0   ,100 ,200 ,300 ,400 ,500 ,600 ,700 ,800 ,
         900 ,1000,1100,1200,1300
110 DATA 9.6 ,13.2,15.6,17.7,19.5,21.2,22.6,24  ,25.3,26.4,
         27.5,28.5,29.6
120 REM 350-M HX H2O SIDE FILM COEFFICIENT (119):
    DATA 9  ,0  ,100,150,200,250,300,350,400,450,500,134,198,
         282,370,463,560,655,765,860
130 REM 261 HX EFFECTIVENESS MAP - F21/H2O, T-F21=40F (139):
    DATA 8    ,7    ,200  ,300  ,400  ,500  ,600  ,700  ,800  ,
         900  ,1500 ,2000 ,2500 ,3000 ,3500 ,4000 ,4500 ,1
140 DATA 1    ,1    ,1    ,1    ,1    ,1    ,.9876,.9995,1    ,
         1    ,1    ,1    ,1    ,.884 ,.9836,.998 ,.9997,.9999,
         1    ,1    ,.736 ,.9113,.9793,.9952,.9987,.9996,.9999
150 DATA .618 ,.8023,.9232,.9743,.9913,.9968,.9987,.5308,.7093,
         .8405,.9274,.9689,.9864,.9937,.4649,.6169,.7556,.862 ,
         .9282,.9635,.981 ,.4132,.5496,.6797,.7914,.8739,.9268
160 DATA .9577
170 INPUT "# OF CASES                          (1-10): ",Y(2):
    INPUT "DATE                                      : ",B$:
    INPUT "ARE FLOW CHARTS DESIRED, (YES=1/NO=2): ",Y(3)
180 INPUT "IS PRINTOUT DESIRED,       (YES=1/NO=2): ",Y(4):
    FOR Z=1 TO Y(2): SELECT PRINT 005: PRINT "CASE # = ";Z:
    INPUT "RUN DESIGNATION           : ",A$(Z)
190 INPUT "T RS-20 SETPT (DEG F) = ",A(Z,1):
    INPUT "Q CHAM-S      (BTU/HR) = ",A(Z,2):
    INPUT "Q CHAM-L      (BTU/HR) = ",A(Z,3)
200 INPUT "Q AVIONICS    (BTU/HR) = ",A(Z,4):
    INPUT "CO2 FLOW       (LB/HR) = ",A(Z,5):
    INPUT "RS-11 FLOW       (CFM) = ",A(Z,6)
```

Table IX

PROGRAM LISTING (CONTINUED)

```
210 INPUT "RS-11 POWER    (WATTS) = ",A(Z,7):
    INPUT "RS-51 FLOW       (CFM) = ",A(Z,8):
    INPUT "RS-51 POWER    (WATTS) = ",A(Z,9)
220 INPUT "RS-251 FLOW    (LB/HR) = ",A(Z,10):
    INPUT "RS-251 POWER   (WATTS) = ",A(Z,11):
    INPUT "BYPASS FLOW    (LB/HR) = ",A(Z,12)
230 INPUT "Q SIMULATOR   (BTU/HR) = ",A(Z,13):
    INPUT "T 350M H20 IN  (DEG F) = ",A(Z,14):
    INPUT "T 261 H20 IN   (DEG F) = ",A(Z,15)
240 INPUT "T 261 F21 IN   (DEG F) = ",A(Z,16):
    INPUT "261 F21 FLOW   (LB/HR) = ",A(Z,17):
    NEXT Z
250 IF Y(1)[=Y(2) THEN 260: Y(1)=0: REWIND : GOTO 840
260 FOR Z=1 TO 17: X(Z)=A(Y(1),Z): NEXT Z: X(18)=X(1):
    X(19)=3.414*X(7): X(20)=875*X(5): X(21)=427.5*X(5):
    X(22)=3.414*X(9): X(23)=X(4)+X(19)+X(20)
270 X(24)=X(2)+X(22)+X(23): X(25)=X(3)+X(21):
    X(26)=X(24)+X(25): X(27)=3.414*X(11): X(30)=X(10)-X(12):
    RESTORE 139: FOR Z=101 TO 173: READ X(Z): NEXT Z
280 GOSUB '01(X(30),X(17)): E1=Z1: IF X(15)=0 THEN 290:
    X(31)=X(15)-E1*(X(15)-X(16)): X(29)=X(30)*(X(15)-X(31)):
    X(28)=X(30)*(X(31)-X(14)): GOTO 300
290 X(28)=0: X(29)=X(26)+X(27)+X(13):
    X(31)=X(16)+X(29)/X(30)*(1/E1-1): X(15)=X(31)+X(29)/X(30):
    X(14)=X(31)
300 X(101)=25: X(102)=0: RESTORE 1: FOR Z=103 TO 152: READ X(Z):
    NEXT Z: GOSUB '01(X(16),0): H1=Z1: H2=H1+X(29)/X(17):
    RESTORE 26: FOR Z=103 TO 127: READ X(Z): NEXT Z
310 RESTORE 1: FOR Z=128 TO 152: READ X(Z): NEXT Z:
    GOSUB '01(H2,0): X(32)=Z1: X(33)=X(14)+X(26)/X(30):
    X(34)=(X(33)*X(30)+X(15)*X(12))/X(10)
320 X(35)=X(34)+X(27)/X(10): X(40)=0: X(41)=0: X(42)=50:
    X(43)=.1271676: X(39)=2380.656*X(6)/(X(18)+459.6):
    X(36)=.24*X(39): X(37)=X(36): W1=X(30)/2: RESTORE 119
330 FOR Z=101 TO 120: READ X(Z): NEXT Z: GOSUB '01(W1,0):
     H1=7.3008*Z1: GOSUB '02: GOSUB '10: GOSUB '11:
    IF X(45)]=X(14) THEN 360
340 X(45)=X(45)+1: X(44)=X(45)+X(24)/X(37):
    X(18)=X(44)-X(23)/X(36): GOSUB '02: GOSUB '10: GOSUB '11
350 IF X(45)[X(14) THEN 340
360 GOSUB '03: GOSUB '04: H=H2/H1:
    T1=(X(37)*X(44)+X(30)*(H*X(42)+X(42)-X(33)))/
       (H*X(30)+X(37))
370 Q1=X(37)*(T1-X(45)): Q2=Q1+X(25): IF Q2[X(26) THEN 380:
    U1=0: T2=X(33): T1=X(44): Q1=X(24): Q2=X(26): GOTO 390
380 T2=X(42)-H*(T1-X(42)): IF T2]=T1 THEN 510:
    E1=(X(44)-T1)/(X(44)-T2): M1=X(30)/X(37): GOSUB '05(E1,M1):
    U1=K*X(37)
```

Table IX

PROGRAM LISTING (CONTINUED)

```
390 E2=(T1-X(45))/(T1-X(14)): M2=X(30)*Q1/X(37)/Q2:
    GOSUB '05(E2,M2): U2=K*X(37)*Q2/Q1:
    U3=((1/H)/(1+1/H))*Q1/Q2+(1/(1+1/H)): U=U1+U2*U3
400 IF U=X(46) THEN 550: IF U]X(46) THEN 510: IF X(14)]=X(45)
    THEN 550: IF X(18)]X(1) THEN 430: IF X(37)]X(43)*X(36)
    THEN 430: X(45)=X(14): X(37)=X(43)*X(36)
410 X(44)=X(45)+X(24)/X(37): X(18)=X(44)-X(23)/X(36): GOSUB '06:
    GOSUB '07: X(37)=X(43)*X(36): GOSUB '10:
    T1=X(44)-X(24)/X(37)
420 E1=(ABS(T1-X(45)))/X(45): IF E1]=.5E-4 THEN 410: GOTO 550
430 IF X(18)=X(1) THEN 440: X(40)=X(18): X(41)=U:
    X(18)=X(18)-.1: GOSUB '02: GOTO 460
440 E1=(ABS(U-X(46)))/X(46): IF E1[.5E-2 THEN 550:
    X(45)=X(14)+(X(45)-X(14))*U/X(46):
    X(37)=X(24)/(X(44)-X(45)): GOSUB '06: GOSUB '07: GOSUB '10
450 X(37)=X(24)/(X(44)-X(45)): IF X(37)]=X(43)*X(36) THEN 460:
    X(37)=X(43)*X(36)
460 GOSUB '10: GOSUB '11: IF X(45)]=X(14) THEN 360:
    IF X(18)]X(1) THEN 490:
    X(37)=X(24)/(X(23)/X(36)+X(18)-X(14)): X(45)=X(14)
470 GOSUB '06: GOSUB '07: GOSUB '10: X(37)=X(24)/(X(44)-X(45)):
    IF X(37)]=X(43)*X(36) THEN 360: X(37)=X(43)*X(36):
    GOSUB '11: GOSUB '06: GOSUB '07: GOSUB '10
480 X(37)=X(43)*X(36): GOSUB '11: GOTO 360
490 X(45)=X(14): X(18)=X(45)+(X(24)-X(23))/X(36): GOSUB '02:
    GOSUB '10: T1=X(44)-X(24)/X(37)
500 E1=(ABS(T1-X(45)))/X(45): IF E1]=.5E-4 THEN 490: GOTO 550
510 IF X(45)=X(44) THEN 530: E1=(ABS(U-X(46)))/X(46):
    IF E1[.5E-2 THEN 550: X(37)=X(24)/(X(44)-X(45)-.1):
    IF X(37)[=X(36) THEN 520: X(37)=X(36)
520 GOSUB '10: GOSUB '11: GOSUB '06: GOSUB '07: GOSUB '10:
    X(37)=X(24)/(X(44)-X(45)): IF X(37)[=X(36) THEN 360:
    X(37)=X(36): GOSUB '11: GOTO 360
530 IF (X(40)-X(18))[].1 THEN 540:
    X(18)=X(18)+.1*((U-X(46))/(U-X(41))): GOSUB '02: GOSUB '10:
    GOSUB '11: GOTO 550
540 X(18)=X(18)+1: GOSUB '02: GOSUB '10: GOSUB '11: GOTO 360
550 GOSUB '06: GOSUB '07: GOSUB '10: GOSUB '11:
    X(48)=X(6)*(X(36)-X(37))/X(36): X(47)=X(6)-X(48)-X(8):
    X(50)=X(45)+X(22)*X(6)/X(36)/X(8): X(51)=X(25)/1065
560 IF Y(4)=1 THEN 570: GOTO 660
570 SELECT PRINT 211(156): PRINT HEX(0D0E):
    PRINT "RSECS STEADY STATE COMPUTER PROGRAM":
    PRINT HEX(0A0A0A)
580 PRINT "RUN #:  ";A$(Y(1)):
    PRINT "DATE :  ";B$: PRINT HEX(0A0A):
    PRINT "INPUT DATA -"
590 PRINTUSING 680,X(1),X(2),X(3):
    PRINTUSING 690,X(4),X(5),X(6):
    PRINTUSING 700,X(7),X(8),X(9)
```

Table IX

PROGRAM LISTING (CONTINUED)

```
600 PRINTUSING 710,X(10),X(11),X(12):
    PRINTUSING 720,X(13),X(16),X(17):
    PRINT HEX(0A0A)
610 PRINT "GAS LOOP OUTPUT DATA -":
    PRINTUSING 730,X(18),X(39),X(19):
    PRINTUSING 740,X(42),X(36),X(20)
620 PRINTUSING 750,X(38),X(37),X(21):
    PRINTUSING 760,X(49),X(47),X(22):
    PRINTUSING 770,X(44),X(48),X(24)
630 PRINTUSING 780,X(45),X(51),X(25):
    PRINTUSING 790,X(50),X(46),X(26):
    PRINT HEX(0A)
640 PRINT "COOLANT LOOP OUTPUT DATA -":
    PRINTUSING 800,X(31),X(14),X(33):
    PRINTUSING 810,X(34),X(35),X(15)
650 PRINTUSING 820,X(32),X(30),X(28):
    PRINTUSING 830,X(27),X(29):
    PRINT HEX(0A0A0A0A0A0A0A0A0A0A)
660 IF Y(3)=2 THEN 670: LOAD "RSECS2"
670 Y(1)=Y(1)+1: GOTO 250
680 %T RS-20 SETPT     =-#####.##  O CHAMBER-S        =-#####.##  O
 CHAMBER-L       =-#####.##
690 %Q CHAM AVIONICS   =-#####.##  CO2 INLET FLOW     =-#####.##  R
S-11 FLOW        =-#####.##
700 %RS-11 POWER       =-#####.##  RS-51 FLOW         =-#####.##  R
S-51 POWER       =-#####.##
710 %RS-251 FLOW       =-#####.##  RS-251 POWER       =-#####.##  H
20 BYPASS FLOW   =-#####.##
720 %Q H2O AVIONICS    =-#####.##  T RS-261 F21 IN    =-#####.##  W
 RS-261 F21      =-#####.##
730 %T CHAMBER         =-#####.##  TOTAL AIR FLOW     =-#####.##  Q
 RS-11           =-#####.##
740 %T DEWPOINT        =-#####.##  WCP RS-11          =-#####.##  Q
 RS-50 -S        =-#####.##
750 %T RS-11 IN        =-#####.##  WCP 350-M          =-#####.##  Q
 RS-50 -L        =-#####.##
760 %T RS-50 IN        =-#####.##  V 350-M            =-#####.##  Q
 RS-51           =-#####.##
770 %T 350-M IN        =-#####.##  V BYPASS           =-#####.##  Q
 350-M -S        =-#####.##
780 %T 350-M OUT       =-#####.##  W CONDENSATE       =-#####.##  Q
 350-M -L        =-#####.##
790 %T RS-51 OUT       =-#####.##  UA 350-M           =-#####.##  Q
 350-M -TOT      =-#####.##
800 %T RS-261 H2O OUT  =-#####.##  T 350-M H2O IN     =-#####.##  T
 350-M H2O OUT   =-#####.##
810 %T RS-251 H2O IN   =-#####.##  T AVION H2O IN     =-#####.##  T
 RS-261 H2O IN   =-#####.##
```

Table IX

PROGRAM LISTING (CONTINUED)

```
820 %T RS-261 F21 OUT =-#####.##  U RS-261/350-M    =-#####.##  Q
 H20 HTSINK      =-#####.##
830 %Q RS-251            =-#####.##  Q RS-261           =-#####.##
840 END
850 DEFFN'01(C1,D1)
860 DIM A1(6),X1(6),Y1(6)
870 I1=101: N=3: N2=2
880 IF X(I1)=3 THEN 920: IF X(I1)]3 THEN 930:
    IF X(I1)[0 THEN 950: IF X(I1)=0 THEN 920:
    IF X(I1)=2 THEN 900: IF X(I1)]2 THEN 920
890 N=1: GOTO 910
900 N=2
910 N2=1
920 I1=I1+1
930 N1=N+1
940 L=I1: IF X(L)]0 THEN 960
950 K1=-1: Z1=0: GOTO 1230
960 N9=X(L):
    IF X(L+1)[0 THEN 950: IF X(L+1)]0 THEN 980
970 N8=0: GOTO 990
980 N8=X(L+1)
990 K1=0: K8=0: C2=C1: J1=I1+2: J2=N9+I1+1:
    IF C2[X(J1) THEN 1030: IF C2=X(J1) THEN 1040
1000 FOR J=J1 TO J2: IF C2[=X(J) THEN 1050: NEXT J
1010 K1=2: C2=X(J2)
1020 J9=J2-N: GOTO 1060
1030 K1=1: C2=X(J1)
1040 J9=J1: GOTO 1060
1050 IF J-J1[1 THEN 1030: IF J-J1=1 THEN 1040:
     IF J=J2 THEN 1020: IF J]J2 THEN 1010:
     J9=J-N2
1060 C3=C2: IF N8]0 THEN 1070: FOR L=1 TO N1: X1(L)=X(J9):
     L8=J9+N9: Y1(L)=X(L8): J9=J9+1: NEXT L: I=1: GOTO 1150
1070 J1=J1+N9: J2=J2+N8: D2=D1: IF D2[X(J1) THEN 1100:
     IF D2=X(J1) THEN 1110: FOR J=J1 TO J2:
     IF D2[=X(J) THEN 1120: NEXT J
1080 K8=6: D2=X(J2)
1090 J8=J2-N: GOTO 1130
1100 K8=3: D2=X(J1)
1110 J8=J1: GOTO 1130
1120 IF J-J1[1 THEN 1100: IF J-J1=1 THEN 1110:
     IF J=J2 THEN 1090: IF J]J2 THEN 1080: J8=J-N2
1130 J7=J9: L8=J8+N8*(J7-I1-1): L7=L8: FOR L=1 TO N1:
     X1(L)=X(J7): Y1(L)=X(L7): L7=L7+N8: J7=J7+1: NEXT L:
     I=0: GOTO 1150
1140 Y1(1)=Z1: FOR I=1 TO N: L7=L8+I: Y1(I+1)=0: FOR M=1 TO N1:
     Y1(I+1)=Y1(I+1)+X(L7)*X1(M): L7=L7+N8: NEXT M: NEXT I:
     FOR L=1 TO N1: X1(L)=X(J8): J8=J8+1: NEXT L: C3=D2: I=1
```

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Table IX

PROGRAM LISTING (CONTINUED)

```
1150 D=1: X1(N+2)=X1(1): X1(N+3)=X1(2): FOR J=1 TO N1:
     A1(J+1)=X1(J+1)-X1(J): C4=C3-X1(J): IF C4[]0 THEN 1170:
     Z1=Y1(J): X1(1)=0: X1(2)=0: X1(3)=0: X1(4)=0
1160 X1(J)=1: GOTO 1220
1170 D=D*C4: ON N GOTO 1180,1190,1200
1180 X1(J)=C4/A1(J+1): GOTO 1210
1190 X1(J)=-C4: GOTO 1210
1200 X1(J)=(X1(J+2)-X1(J))*C4
1210 NEXT J: A1(1)=A1(N+2): Z1=0: FOR J=1 TO N1:
     X1(J)=D/(A1(J)*A1(J+1)*X1(J)): Z1=Z1+Y1(J)*X1(J):
     NEXT J
1220 IF I[=0 THEN 1140
1230 K1=K1+K8: SELECT PRINT 005:
     PRINT "OFF TABLE INDICATOR =";K1
1240 RETURN
1250 DEFFN'02
1260 FOR B=1 TO 4: GOSUB '07: X(37)=X(36):
     X(45)=X(18)-(X(24)-X(23))/X(36): GOSUB '06: GOSUB '07:
     NEXT B: X(37)=X(36)
1270 RETURN
1280 DEFFN'03
1290 X(101)=20: X(102)=0: RESTORE 51: FOR C=103 TO 142:
     READ X(C): NEXT C: GOSUB '01(X(45),0): P2=Z1:
     A2=.622*P2/(14.696-P2)+X(25)*X(36)/1065/X(39)/X(37)
1300 FOR C=1 TO 3: P2=A2*(14.696-P2)/.622: NEXT C:
     RESTORE 71: FOR C=103 TO 122: READ X(C): NEXT C:
     RESTORE 51: FOR C=123 TO 142: READ X(C): NEXT C
1310 GOSUB '01(P2,0): X(42)=Z1:
     RETURN
1320 DEFFN'04
1330 V1=X(6)*X(37)/.8815/X(36): RESTORE 91: FOR E=101 TO 128:
     READ X(E): NEXT E: GOSUB '01(V1,0): H2=118.48928*Z1:
     X(46)=1/(1/H1+1/H2)
1340 RETURN
1350 DEFFN'05(E3,M3)
1360 IF M3=1 THEN 1370: IF M3]1 THEN 1380:
     K=M3/(1-M3)*LOG((1-E3)/(1-E3/M3)): GOTO 1390
1370 K=E3/(1-E3): GOTO 1390
1380 K=M3/(M3-1)*LOG((1-E3/M3)/(1-E3))
1390 RETURN
1400 DEFFN'06
1410 GOSUB '03: A2=A2-X(21)/1065/X(39): FOR F=1 TO 3:
     P2=A2*(14.696-P2)/.622: NEXT F: GOSUB '01(P2,0): X(42)=Z1:
     RETURN
1420 DEFFN'07
1430 X(101)=20: X(102)=0: RESTORE 51: FOR G=103 TO 142:
     READ X(G): NEXT G: GOSUB '01(X(42),0): P1=Z1:
     GOSUB '08(P1,85.76): R1=R3: P2=14.696-P1
```

Table IX

PROGRAM LISTING (CONCLUDED)

```
1440 GOSUB '08(P2,53.35): R2=R3:
     R3=(85.76*R1+53.35*R2)/(R1+R2): C3=.24+.2799*P1/P2:
     FOR G=1 TO 6
1450 X(39)=126973.44*X(6)/R3/(X(18)+X(4)/X(36)+459.6):
     X(36)=C3*X(39): NEXT G:
     RETURN
1460 DEFFN'08(P4,R4):
     R3=144*P4/R4/(X(18)+459.6):
     RETURN
1470 DEFFN'10:
     X(38)=X(18)+X(4)/X(36):
     X(49)=X(18)+(X(4)+X(19))/X(36)
1480 X(44)=X(18)+X(23)/X(36):
     RETURN
1490 DEFFN'11:
     X(45)=X(44)-X(24)/X(37):
     RETURN
```

RSECS FLOW CHART ROUTINE

File Name "RSECS2"

Abstract "RSECS2" automatically produces flow chart output (on previously prepared schematic drawings) of the case currently being analized by the program "RSECS". The flow charts are produced using the WANG 2200 plot bed plotter.

Program Description

A data block containing values generated by "RSECS" is transferred through use of a common block to program "RSECS2". This program then sorts the data and prints out the values in the appropriate location on the schematic. Two separate schematics are used, one for the air loop and one for the water loop. Samples of program output are given in figures 10 and 11 followed by a program listing Table X included for reference.

The only user action required for this program is the loading of the appropriate schematic on the plotter as required.

CASE: MIN ON ORBIT B/P = 500 DATE: 10/17/74

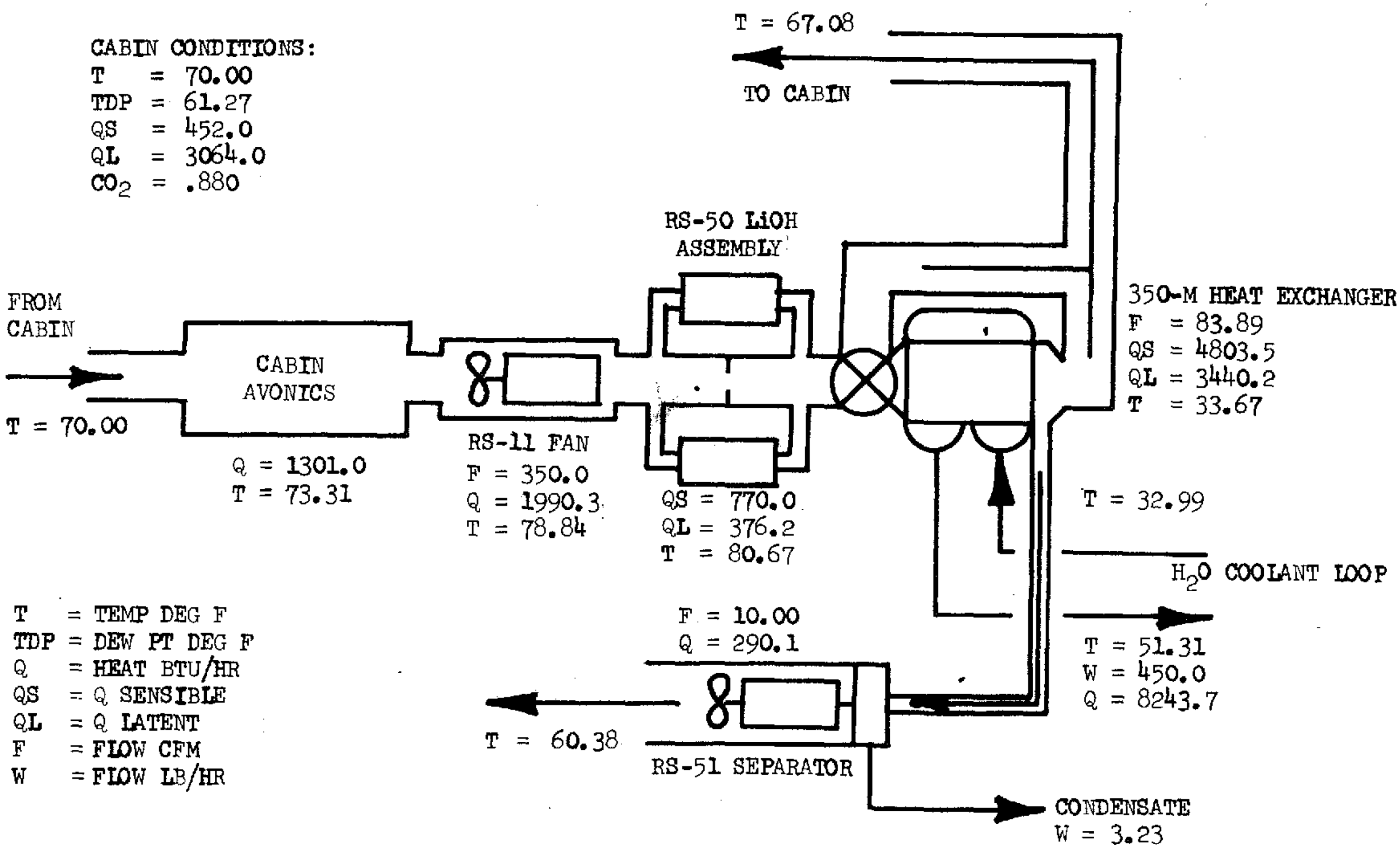
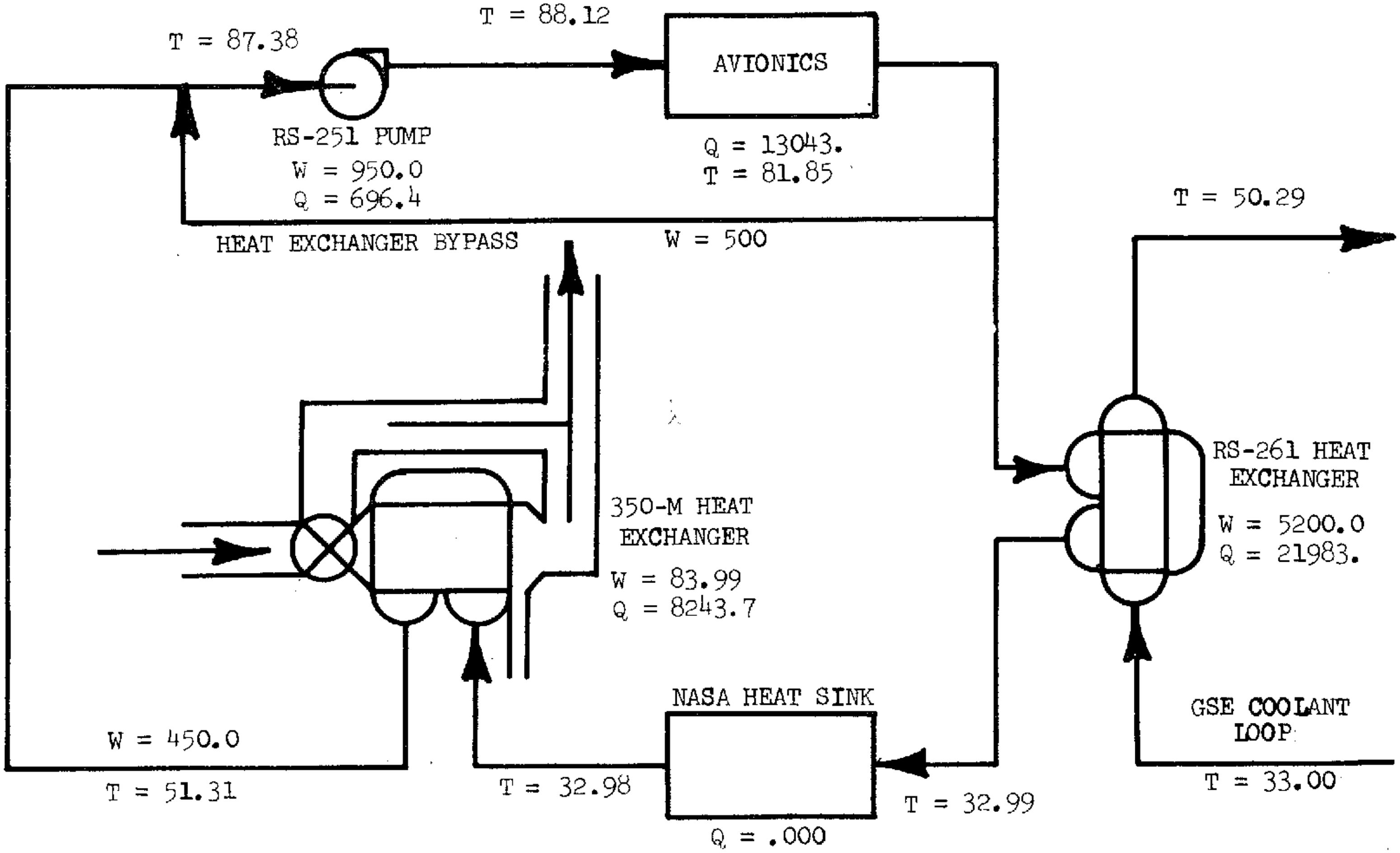


FIGURE 10 RSECS ARS GAS LOOP SCHEMATIC

CASE: MIN ON ORBIT B/P 500 DATE: 10/17/74



Q = HEAT BTU/HR
T = TEMP DEG F
W = FLOW LB/HR

FIGURE 11 RSECS WATER LOOP SCHEMATIC

Table X

PROGRAM LISTING

```
10  REM RSECS2 PROGRAM LABELS DIAGRAM
20  COM X(200),A(10,17),A$(10)64,B$,Y(4)
30  DIM X$(100)8,B(100)
40  SELECT PRINT 005:PRINT HEX(03):
    PRINT "RSECS FLOW CHART ROUTINE":PRINT
50  FOR I=1 TO 51
60  IF ABS(X(I))]=100000 THEN 80:
    IF ABS(X(I))]=10000 THEN 90:
    IF ABS(X(I))]=1000  THEN 100
70  IF ABS(X(I))]=100    THEN 110:
    IF ABS(X(I))]=10    THEN 120:
    IF ABS(X(I))]=1     THEN 130:GOTO 140
80  CONVERT X(I) TO X$(I),(-######):B(I)=0:GOTO 150
90  CONVERT X(I) TO X$(I),(-#####.):B(I)=0:GOTO 150
100  CONVERT X(I) TO X$(I),(-####.#):B(I)=0:GOTO 150
110  CONVERT X(I) TO X$(I),(-###.#) :B(I)=1:GOTO 150
120  CONVERT X(I) TO X$(I),(-##.##) :B(I)=1:GOTO 150
130  CONVERT X(I) TO X$(I),(-#.##)  :B(I)=2:GOTO 150
140  CONVERT X(I) TO X$(I),(-.###)  :B(I)=2:GOTO 150
150  NEXT I
160  SELECT PLOT 414
170  STOP "LOAD GAS LOOP SCHEMATIC ON PLOTTER THEN KEY CONTINUE"
180  PLOT [1,,C],[13,0,S],[,,R]
190  PLOT [19.50*13,29.50*20,U],[,,X$(18)],[B(18)*13,0,U]
200  PLOT [-7*13,-20,U],[,,X$(42)],[B(42)*13,0,U]
210  PLOT [-7*13,-20,U],[,,X$(2)],[B(2)*13,0,U]
220  PLOT [-7*13,-20,U],[,,X$(3)],[B(3)*13,0,U]
230  PLOT [-7*13,-20,U],[,,X$(5)],[B(5)*13,0,U]
240  PLOT [-17*13,-7.25*20,U],[,,X$(18)],[B(18)*13,0,U]
250  PLOT [3*13,-20,U],[,,X$(4)],[B(4)*13,0,U]
260  PLOT [-7*13,-20,U],[,,X$(38)],[B(38)*13,0,U]
270  PLOT [5*13,0,U],[,,X$(6)],[B(6)*13,0,U]
280  PLOT [-7*13,-20,U],[,,X$(19)],[B(19)*13,0,U]
290  PLOT [-7*13,-20,U],[,,X$(49)],[B(49)*13,0,U]
300  PLOT [7*13,2*20,U],[,,X$(20)],[B(20)*13,0,U]
310  PLOT [-7*13,-20,U],[,,X$(21)],[B(21)*13,0,U]
320  PLOT [-7*13,-20,U],[,,X$(44)],[B(44)*13,0,U]
330  T=(X(44)*X(48)+X(45)*X(47))/X(6)
340  IF ABS(T)]=100 THEN 350:IF ABS(T)]=10 THEN 360:IF ABS(T)]=
     1 THEN 370:IF ABS(T)]=0 THEN 380
350  CONVERT T TO T$,(-###.##):T2=0:GOTO 390
360  CONVERT T TO T$,(-##.##):T2=1:GOTO 390
370  CONVERT T TO T$,(-#.##):T2=2: GOTO 390
380  CONVERT T TO T$,(-.###):T2=2: GOTO 390
390  PLOT [-2*13,18.25*20,U],[,,T$],[T2*13,0,U]
400  PLOT [11*13,-10.25*20,U],[,,X$(47)],[B(47)*13,0,U]
410  PLOT [-7*13,-20,U],[,,X$(24)],[B(24)*13,0,U]
420  PLOT [-7*13,-20,U],[,,X$(25)],[B(25)*13,0,U]
430  PLOT [-7*13,-20,U],[,,X$(45)],[B(45)*13,0,U]
440  PLOT [-10*13,-3*20,U],[,,X$(14)],[B(14)*13,0,U]
450  PLOT [-7*13,-4*20,U],[,,X$(33)],[B(33)*13,0,U]
460  PLOT [-7*13,-20,U],[,,X$(30)],[B(30)*13,0,U]
470  PLOT [-7*13,-20,U],[,,X$(26)],[B(26)*13,0,U]
480  PLOT [-29*13,-2*20,U],[,,X$(8)],[B(8)*13,0,U]
```

Table X

PROGRAM LISTING (CONCLUDED)

```
490 PLOT [-7*13,-20,U],[,,X$(22)],[B(22)*13,0,U]
500 PLOT [-21*13,-3.5*20,U],[,,X$(50)],[B(50)*13,0,U]
510 PLOT [25*13,-3.0*20,U],[,,X$(51)],[B(51)*13,0,U]
520 PLOT [,,R],[23*13,34*20,U]
530 K=Y(1):PLOT [,,"CASE:  "],[,,A$(K)]:
    PLOT [3*13,0,U],[,,"DATE:  "],[,,B$],[,,R]
540 SELECT PRINT 005:PRINT :PRINT :STOP " REMOVE GAS LOOP SCHEMA
TIC AND LOAD WATER LOOP SCHEMATIC ON       PLOTTER THEN KEY CONTI
NUE"
550 PLOT [21*13,33*20,U],[,,X$(34)],[B(34)*13,0,U]
560 PLOT [4*13,-.50*20,U],[,,X$(35)],[B(35)*13,0,U]
570 PLOT [-14*13,-6.25*20,U],[,,X$(10)],[B(10)*13,0,U]
580 PLOT [-7*13,-20,U],[,,X$(27)],[B(27)*13,0,U]
590 PLOT [-14*13,-20.50*20,U],[,,X$(30)],[B(30)*13,0,U]
600 PLOT [-7*13,-3*20,U],[,,X$(33)],[B(33)*13,0,U]
610 PLOT [20*13,26.25 *20,U],[,,X$(13)],[B(13)*13,0,U]
620 PLOT [-9*13,-2*20,U],[,,"T="],[,,X$(15)],[B(15)*13,0,U]
630 PLOT [-9*13,-4*20,U],[,,X$(12)],[B(12)*13,0,U]
640 PLOT [-6*13,-8*20,U],[,,X$(47)],[B(47)*13,0,U]
650 PLOT [-7*13,-20,U],[,,X$(26)],[B(26)*13,0,U]
660 PLOT [-16*13,-11.25*20,U],[,,X$(14)],[B(14)*13,0,U]
670 PLOT [3*13,-20,U],[,,X$(28)],[B(28)*13,0,U]
680 PLOT [4*13,20,U],[,,X$(31)],[B(31)*13,0,U]
690 PLOT [5*13,26.5*20,U],[,,X$(32)],[B(32)*13,0,U]
700 PLOT [-5*13,-8*20,U],[,,X$(17)],[B(17)*13,0,U]
710 PLOT [-7*13,-20,U],[,,X$(29)],[B(29)*13,0,U]
720 PLOT [-9*13,-11.5*20,U],[,,X$(16)],[B(16)*13,0,U]
730 PLOT [,,R],[30*13,33.75*20,U], [,,"CASE:  "],[,,A$(K)],
    [3*13,0,U],[,,"DATE:  "],[,,B$],[,,R]
740 SELECT PRINT 005:PRINT HEX(03)
750 Y(1)=Y(1)+1
760 LOAD DC R "RSECS"
770 END
```

350-M HEAT EXCHANGER TEST DATA ANALYSIS PROGRAM

File Name "350-M HX"

Abstract "350-M HX" analyzes test data and provides revised performance curves for the 350-M heat exchanger. The program is designed to be used with a WANG 2200 - series computer system.

Program Description

For a maximum of 50 data points, the program will iterate the hot or cold side hA to obtain a UA balance. Curves of hot side film coefficient verses air velocity and cold side film coefficient versus water flow per start are stored in the program as internal data. These curves and water vapor property tables are interpolated by using an adaptation of the Hamilton Standard Division's "UNBAR" routine.

Expected program operation is as follows.

1. Run all data points for a hot side UA balance.
2. Use calculation results to revise curve of hot side film coefficient versus air velocity.
3. Run data points again for a cold side UA balance.
4. Use calculation results to revise curve of cold side film coefficient versus H_2O flow/start.
5. Repeat steps 1 through 4 until film coefficient curves no longer need revision.

For user reference, sample cases, figure 12, and a program listing, Table XI, are enclosed. The CRT prints the requested input data requirements with notations for the required units. If one of the dewpoint measurements is not available, or the secondary water circuit was not used, zero's should be entered in the appropriate locations. The output data provides all information necessary to revise the performance curves. In addition, a heat balance value is printed to give the user an indication of the data point validity. The heat balance calculation is the air side sensible and latent heat divided by the water side total heat. The program listing will provide the user with the calculation procedures used in the program.

RSECS 350-M HX PERFORMANCE / HOT SIDE BALANCE

CASE #: 1
DATE : 7/8/74

INPUT DATA -

T RS-11 INLET =	70.00	T RS-11 DEWPT =	50.06	T 350-M INLET =	79.59
T 350-M DEWPT =	50.06	T 350-M OUTLET =	36.10	ARS OUTLET FLOW =	73.27
RS-51 FLOW =	10.00	CHAMBER PRESSURE =	29.92	T PRI H20 INLET =	35.99
T SEC H20 INLET =	0.00	T PRI H20 OUTLET =	46.46	T SEC H20 OUTLET =	0.00
PRI H20 FLOW =	498.00	SEC H20 FLOW =	0.00		

OUTPUT DATA -

TOTAL H20 FLOW =	498.00	H20 FLOW/START =	249.00	TOTAL AIR FLOW =	83.27
AIR WEIGHT FLOW =	369.68	AIR VELOCITY =	94.46	TOTAL HX UA =	773.42
COLD SIDE HA =	2688.11	COLD FILM COEFF =	368.19	HOT SIDE HA =	1086.21
HOT FILM COEFF =	9.16	Q SENSIBLE =	3858.63	Q LATENT =	1258.59
Q TOTAL =	5214.06	HEAT BALANCE =	0.981		

RSECS 350-M HX PERFORMANCE / HOT SIDE BALANCE

CASE #: 2
DATE : 7/8/74

INPUT DATA -

T RS-11 INLET =	85.46	T RS-11 DEWPT =	55.25	T 350-M INLET =	95.31
T 350-M DEWPT =	55.25	T 350-M OUTLET =	48.58	ARS OUTLET FLOW =	282.35
RS-51 FLOW =	10.00	CHAMBER PRESSURE =	29.92	T PRI H20 INLET =	42.80
T SEC H20 INLET =	0.00	T PRI H20 OUTLET =	67.55	T SEC H20 OUTLET =	0.00
PRI H20 FLOW =	697.00	SEC H20 FLOW =	0.00		

OUTPUT DATA -

TOTAL H20 FLOW =	697.00	H20 FLOW/START =	348.50	TOTAL AIR FLOW =	292.35
AIR WEIGHT FLOW =	1257.84	AIR VELOCITY =	331.65	TOTAL HX UA =	1283.10
COLD SIDE HA =	4067.19	COLD FILM COEFF =	557.08	HOT SIDE HA =	1874.60
HOT FILM COEFF =	15.82	Q SENSIBLE =	14106.96	Q LATENT =	2744.46
Q TOTAL =	17250.75	HEAT BALANCE =	0.976		

FIGURE 12 RSECS 350-M HEAT EXCHANGER PERFORMANCE/HOT SIDE BALANCE SAMPLE CASES

RSECS 350-M HX PERFORMANCE / COLD SIDE BALANCE

CASE #: 1
DATE : 7/8/74

INPUT DATA -

T RS-11 INLET	= 70.00	T RS-11 DEWPT	= 50.06	T 350-M INLET	= 79.59
T 350-M DEWPT	= 50.06	T 350-M OUTLET	= 36.10	ARS OUTLET FLOW	= 73.27
RS-51 FLOW	= 10.00	CHAMBER PRESSURE	= 29.92	T PRI H20 INLET	= 35.99
T SEC H20 INLET	= 0.00	T PRI H20 OUTLET	= 46.46	T SEC H20 OUTLET	= 0.00
PRI H20 FLOW	= 498.00	SEC H20 FLOW	= 0.00		

OUTPUT DATA -

TOTAL H20 FLOW	= 498.00	H20 FLOW/START	= 249.00	TOTAL AIR FLOW	= 83.27
AIR WEIGHT FLOW	= 369.68	AIR VELOCITY	= 94.46	TOTAL HX UA	= 785.66
COLD SIDE HA	= 2541.08	COLD FILM COEFF	= 348.05	HOT SIDE HA	= 1137.49
HOT FILM COEFF	= 9.60	Q SENSIBLE	= 3858.63	Q LATENT	= 1258.59
Q TOTAL	= 5214.06	HEAT BALANCE	= 0.981		

RSECS 350-M HX PERFORMANCE / COLD SIDE BALANCE

CASE #: 2
DATE : 7/8/74

INPUT DATA -

T RS-11 INLET	= 85.46	T RS-11 DEWPT	= 55.25	T 350-M INLET	= 95.31
T 350-M DEWPT	= 55.25	T 350-M OUTLET	= 48.58	ARS OUTLET FLOW	= 292.35
RS-51 FLOW	= 10.00	CHAMBER PRESSURE	= 29.92	T PRI H20 INLET	= 42.80
T SEC H20 INLET	= 0.00	T PRI H20 OUTLET	= 67.55	T SEC H20 OUTLET	= 0.00
PRI H20 FLOW	= 697.00	SEC H20 FLOW	= 0.00		

OUTPUT DATA -

TOTAL H20 FLOW	= 697.00	H20 FLOW/START	= 348.50	TOTAL AIR FLOW	= 292.35
AIR WEIGHT FLOW	= 1257.94	AIR VELOCITY	= 331.65	TOTAL HX UA	= 1292.36
COLD SIDE HA	= 3906.87	COLD FILM COEFF	= 535.13	HOT SIDE HA	= 1931.92
HOT FILM COEFF	= 16.29	Q SENSIBLE	= 14106.96	Q LATENT	= 2744.46
Q TOTAL	= 17250.75	HEAT BALANCE	= 0.976		

FIGURE 13 RSECS 350-M HEAT EXCHANGER PERFORMANCE/COLD SIDE BALANCE SAMPLE CASES

Table XI

PROGRAM LISTING

```
10  REM - 350-M HX PERFORMANCE:
    DIM A(50,14),X(200),Y(3):
    IF Y(1)]1 THEN 150: Y(1)=1
20  REM - WATER VAPOR PROPERTIES - TEMPERATURE (1):
    DATA 32,34,36,38,40,42,44,46,48,50,52,54,56,58,60,62,64,66,
         68,70
30  REM - WATER VAPOR PROPERTIES - PRESSURE (21):
    DATA .08854,.09603,.10401,.11256,.1217 ,.1315 ,.14199,
         .15323,.16525,.17811,.19182,.20642,.222  ,.2386
40  DATA .2563 ,.2751 ,.2951 ,.3164 ,.339  ,.3631:
    REM - WATER VAPOR PROPERTIES - ENTHALPY (41):
    DATA 1075.8,1074.7,1073.6,1072.4,1071.3,1070.1,1068.9
50  DATA 1067.8,1066.7,1065.6,1064.4,1063.3,1062.2,1061  ,
         1059.9,1058.8,1057.6,1056.5,1055.5,1054.3:
    REM - WATER SIDE FILM COEFFICIENT (61)
60  DATA 9  ,0  ,100,150,200,250,300,350,400,450,500,134,198,
         282,370,463,560,655,765,860:
    REM - AIR SIDE FILM COEFFICIENT (81)
70  DATA 13  ,0   ,100 ,200 ,300 ,400 ,500 ,600 ,700 ,800 ,
         900 ,1000,1100,1200,1300,9.6 ,13.2,15.6,17.7,19.5,
         21.2,22.6,24  ,25.3,26.4,27.5,28.5,29.6
80  INPUT "# OF CASES       (1-50) = ",Y(2):
    INPUT " ATE                     = ",A$:
    INPUT "HT BAL (HOT=1/COLD=2)   = ",Y(3)
90  FOR Z=1 TO Y(2): SELECT PRINT 005:
    PRINT "CASE #                   = ";Z
100 INPUT "T RS-11 IN     (DEG F) = ",A(Z,1):
    INPUT "T RS-11 DEWPT  (DEG F) = ",A(Z,2):
    INPUT "T 350-M IN     (DEG F) = ",A(Z,3)
110 INPUT "T 350-M DEWPT  (DEG F) = ",A(Z,4):
    INPUT "T 350-M OUT    (DEG F) = ",A(Z,5):
    INPUT "ARS OUTLET FLOW (CFM)  = ",A(Z,6)
120 INPUT "RS-51 FLOW      (CFM)  = ",A(Z,7):
    INPUT "P CHAMBER      (IN HG) = ",A(Z,8):
    INPUT "T PRI H20 IN   (DEG F) = ",A(Z,9)
130 INPUT "T SEC H20 IN   (DEG F) = ",A(Z,10):
    INPUT "T PRI H20 OUT  (DEG F) = ",A(Z,11):
    INPUT "T SEC H20 OUT  (DEG F) = ",A(Z,12)
140 INPUT "PRI H20 FLOW   (LB/HR) = ",A(Z,13):
    INPUT "SEC H20 FLOW   (LB/HR) = ",A(Z,14):
    NEXT Z
150 IF Y(1)[=Y(2) THEN 160: Y(1)=0: GOTO 610
160 FOR Z=1 TO 14: X(Z)=A(Y(1),Z): NEXT Z: X(17)=X(13)+X(14):
    X(15)=(X(9)*X(13)+X(10)*X(14))/(X(13)+X(14)):
    X(16)=(X(11)*X(13)+X(12)*X(14))/(X(13)+X(14))
170 X(18)=X(17)*(X(16)-X(15)): IF X(13)=0 THEN 180:
    IF X(14)=0 THEN 180: X(30)=X(17)/4: GOTO 190
180 X(30)=X(17)/2
190 RESTORE 61: FOR Z=101 TO 120: READ X(Z): NEXT Z:
    GOSUB '02(X(30),0): X(31)=Z1: IF X(13)=0 THEN 200:
    IF X(14)=0 THEN 200: X(19)=27*.5408*X(31): GOTO 210
```

Table XI

PROGRAM LISTING (CONTINUED)

```
200 X(19)=27*.5408*X(31)/2
210 X(20)=X(6)+X(7): IF X(2)]0 THEN 220: X(21)=X(4): GOTO 240
220 IF X(4)]0 THEN 230: X(21)=X(2): GOTO 240
230 X(21)=(X(2)+X(4))/2
240 X(101)=20: X(102)=0: RESTORE 1: FOR Z=103 TO 142: READ X(Z):
    NEXT Z: GOSUB '02(X(5),0): P1=Z1: GOSUB '02(X(21),0): P2=Z1:
    X(22)=144*60*(X(8)*.4912-P2)*X(20)/53.35/(X(1)+459.6)
250 X(23)=.24*X(22)*(X(3)-X(5)): A3=.622*P1/(X(8)*.4912-P1):
    A2=.622*P2/(X(8)*.4912-P2): X(24)=1065*X(22)*(A2-A3):
    X(25)=(X(23)+X(24))/X(18): X(26)=X(20)/.8815
260 RESTORE 81: FOR Z=101 TO 128: READ X(Z): NEXT Z:
    GOSUB '02(X(26),0): X(29)=Z1: X(27)=313*.5408*X(29)
270 IF X(13)=0 THEN 280: IF X(14)=0 THEN 280:
    X(27)=.8*X(27): GOTO 290
280 X(27)=.7*X(27)
290 H1=X(19): H2=X(27)
300 ON Y(3) GOTO 310,320
310 X(27)=H2: GOTO 330
320 X(19)=H1
330 H=X(27)/X(19):
    T1=(.24*X(22)*X(3)+X(17)*(H*X(21)+X(21)-X(16)))/
       (H*X(17)+.24*X(22))
340 Q1=.24*X(22)*(T1-X(5)): Q2=Q1+X(24): IF Q2[X(18) THEN 350:
    U1=0: T2=X(16): T1=X(3): Q1=X(23): Q2=X(18): GOTO 360
350 T2=X(21)-H*(T1-X(21)): E1=(X(3)-T1)/(X(3)-T2):
    M1=X(17)/(.24*X(22)): GOSUB '01(E1,M1):
    U1=.24*X(22)*K
360 E2=(T1-X(5))/(T1-X(15)): M2=X(17)*Q1/(.24*X(22))/Q2:
    GOSUB '01(E2,M2): U2=.24*X(22)*K*Q2/Q1:
    U3=((1/H)/(1+1/H))*Q1/Q2+(1/(1+1/H)): X(28)=U1+U2*U3
370 ON Y(3) GOTO 380,400
380 H2=1/(1/X(28)-1/X(19)): IF ABS((X(27)-H2)/X(27))]=.5E-3
    THEN 300: X(29)=X(27)/313/.5408: IF X(13)=0 THEN 390:
    IF X(14)=0 THEN 390: X(29)=X(29)/.8: GOTO 420
390 X(29)=X(29)/.7: GOTO 420
400 H1=1/(1/X(28)-1/X(27)): IF ABS((X(19)-H1)/X(19))]=.5E-3
    THEN 300: IF X(13)=0 THEN 410: IF X(14)=0 THEN 410:
    X(31)=X(19)/27/.5408: GOTO 420
410 X(31)=2*X(19)/27/.5408
420 SELECT PRINT 211(156): PRINT HEX(0D0E):
    ON Y(3) GOTO 430,440
430 PRINT "RSECS 350-M HX PERFORMANCE / HOT SIDE BALANCE":
    PRINT HEX(0A):
    GOTO 450
440 PRINT "RSECS 350-M HX PERFORMANCE / COLD SIDE BALANCE":
    PRINT HEX(0A)
450 PRINT "CASE #: ";Y(1):
    PRINT "DATE   :  ";A$: PRINT HEX(0A):
    PRINT "INPUT DATA -"
460 PRINTUSING 510,X(1),X(2),X(3):
    PRINTUSING 520,X(4),X(5),X(6):
    PRINTUSING 530,X(7),X(8),X(9)
```

Table XI

PROGRAM LISTING (CONTINUED)

```
470 PRINTUSING 540,X(10),X(11),X(12):
    PRINTUSING 550,X(13),X(14):
    PRINT HEX(0A)
480 PRINT "OUTPUT DATA -":
    PRINTUSING 560,X(17),X(30),X(20):
    PRINTUSING 570,X(22),X(26),X(28)
490 PRINTUSING 580,X(19),X(31),X(27):
    PRINTUSING 590,X(29),X(23),X(24):
    PRINTUSING 600,X(18),X(25)
500 PRINT HEX(0A0A0A0A0A):
    Y(1)=Y(1)+1: GOTO 150
510 %T RS-11 INLET      =-#####.##  T RS-11 DEWPT     =-#####.##  T
 350-M INLET     =-#####.##
520 %T 350-M DEWPT      =-#####.##  T 350-M OUTLET    =-#####.##  A
RS OUTLET FLOW  =-#####.##
530 %RS-51 FLOW         =-#####.##  CHAMBER PRESSURE =-#####.##  T
 PRI H20 INLET  =-#####.##
540 %T SEC H20 INLET    =-#####.##  T PRI H20 OUTLET =-#####.##  T
 SEC H20 OUTLET =-#####.##
550 %PRI H20 FLOW       =-#####.##  SEC H20 FLOW     =-#####.##
560 %TOTAL H20 FLOW     =-#####.##  H20 FLOW/START   =-#####.##  T
OTAL AIR FLOW   =-#####.##
570 %AIR WEIGHT FLOW    =-#####.##  AIR VELOCITY     =-#####.##  T
OTAL HC UA      =-#####.##
580 %COLD SIDE HA       =-#####.##  COLD FILM COEFF  =-#####.##  H
OT SIDE HA      =-#####.##
590 %HOT FILM COEFF     =-#####.##  Q SENSIBLE       =-#####.##  Q
 LATENT         =-#####.##
600 %Q TOTAL            =-#####.##  HEAT BALANCE     =-####.###
610 END
620 DEFFN'01(E3,M3)
630 IF M3=1 THEN 640: IF M3]1 THEN 650:
    K=M3/(1-M3)*LOG((1-E3)/(1-E3/M3)): GOTO 660
640 K=E3/(1-E3): GOTO 660
650 K=M3/(M3-1)*LOG((1-E3/M3)/(1-E3))
660 RETURN
670 DEFFN'02(C1,D1)
680 DIM A1(6),X1(6),Y1(6)
690 I1=101: N=3: N2=2
700 IF X(I1)=3 THEN 740: IF X(I1)]3 THEN 750:
    IF X(I1)[0 THEN 770: IF X(I1)=0 THEN 740:
    IF X(I1)=2 THEN 720: IF X(I1)]2 THEN 740
710 N=1: GOTO 730
720 N=2
730 N2=1
740 I1=I1+1
750 N1=N+1
760 L=I1: IF X(L)]0 THEN 780
770 K1=-1: Z1=0: GOTO 1050
780 N9=X(L):
    IF X(L+1)[0 THEN 770: IF X(L+1)]0 THEN 800
```

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Table XI

PROGRAM LISTING (CONCLUDED)

```
790 N8=0: GOTO 810
800 N8=X(L+1)
810 K1=0: K8=0: C2=C1: J1=I1+2: J2=N9+I1+1:
    IF C2[X(J1) THEN 850: IF C2=X(J1) THEN 860
820 FOR J=J1 TO J2: IF C2[=X(J) THEN 870: NEXT J
830 K1=2: C2=X(J2)
840 J9=J2-N: GOTO 880
850 K1=1: C2=X(J1)
860 J9=J1: GOTO 880
870 IF J-J1[1 THEN 850: IF J-J1=1 THEN 860:
    IF J=J2 THEN 840: IF J]J2 THEN 830:
    J9=J-N2
880 C3=C2: IF N8]0 THEN 890: FOR L=1 TO N1: X1(L)=X(J9):
    L8=J9+N9: Y1(L)=X(L8): J9=J9+1: NEXT L: I=1: GOTO 970
890 J1=J1+N9: J2=J2+N8: D2=D1: IF D2[X(J1) THEN 920:
    IF D2=X(J1) THEN 930: FOR J=J1 TO J2:
    IF D2[=X(J) THEN 940: NEXT J
900 K8=6: D2=X(J2)
910 J8=J2-N: GOTO 950
920 K8=3: D2=X(J1)
930 J8=J1: GOTO 950
940 IF J-J1[1 THEN 920: IF J-J1=1 THEN 930:
    IF J=J2 THEN 910: IF J]J2 THEN 900: J8=J-N2
950 J7=J9: L8=J8+N8*(J7-I1-1): L7=L8: FOR L=1 TO N1:
    X1(L)=X(J7): Y1(L)=X(L7): L7=L7+N8: J7=J7+1: NEXT L:
    I=0: GOTO 970
960 Y1(1)=Z1: FOR I=1 TO N: L7=L8+I: Y1(I+1)=0: FOR M=1 TO N1:
    Y1(I+1)=Y1(I+1)+X(L7)*X1(M): L7=L7+N8: NEXT M: NEXT I:
    FOR L=1 TO N1: X1(L)=X(J8): J8=J8+1: NEXT L: C3=D2: I=1
970 D=1: X1(N+2)=X1(1): X1(N+3)=X1(2): FOR J=1 TO N1:
    A1(J+1)=X1(J+1)-X1(J): C4=C3-X1(J): IF C4[]0 THEN 990:
    Z1=Y1(J): X1(1)=0: X1(2)=0: X1(3)=0: X1(4)=0
980 X1(J)=1: GOTO 1040
990 D=D*C4: ON N GOTO 1000,1010,1020
1000 X1(J)=C4/A1(J+1): GOTO 1030
1010 X1(J)=-C4: GOTO 1030
1020 X1(J)=(X1(J+2)-X1(J))*C4
1030 NEXT J: A1(1)=A1(N+2): Z1=0: FOR J=1 TO N1:
    X1(J)=D/(A1(J)*A1(J+1)*X1(J)): Z1=Z1+Y1(J)*X1(J):
    NEXT J
1040 IF I[=0 THEN 960
1050 K1=K1+K8:
    RETURN
```

350-M HEAT EXCHANGER PERFORMANCE PREDICTION PROGRAM

File Name "CONDHX"

Abstract "CONDHX" uses inlet temperature and flow data to predict performance of the RSECS 350-M condensing heat exchanger. This program runs on the WANG 2200 minicomputer system.

Program Description

This program uses predicted curves of air and water side hA's versus flow combined with a "pinch point" analysis to predict performance of a condensing heat exchanger.

The user supplies input temperatures and flow rates as requested and the program generates values for outlet temperatures and total heat exchanger heat load.

Sample output, Figure 14, and a program listing, Table XII, are enclosed for reference.

CONDHX was used to predict performance for test points of the RSECS cabin heat exchanger test.

```
     ****  RESULTS  ****
 PRI COOLANT FLOW (LB/HR)  375
 PRI TIN =  45   PRI TOUT =  59.37423365213
 SEC COOLANT FLOW (LB/HR)  375
 SEC TIN =  45   PRI TOUT =  59.37423365213
 AIR FLOW RATE (CFM)       317
 TIN =  75  TDP =  53  TOUT =  48.59069824218

Q LATENT =  1932.525554251
Q SENS   =  8848.149684856
Q TOTAL  =  10780.6752391
 HAC =  3760.11   HAH =   2262.78   UA =   1412.66
```

FIGURE 14 RSECS 350-M HEAT EXCHANGER PREDICTION SAMPLE RESULTS

Table XII

PROGRAM LISTING

```
10  REM - 350-M HX PERFORMANCE PREDICTION PROGRAM
    - GIVEN TIN FOR GAS AND COOLANT  FIND TOUT AND Q -
20 DIM X(50)
30 DEFFN1(X)=3.10719762E-02+2.71331473E-04*X+4.56164060E-05*X!2
   -7.17044935E-08*X!3+4.01962080E-09*X!4+1.04575064E-11*X!5
40 DEFFN2(X)=106.7019036671-.7925628830407*X+1.42137844E-02*X!2
   -4.08702990E-05*X!3+6.35142232E-08*X!4-4.04697326E-11*X!5
50 DEFFN3(X)=7.304894511852+3.19172743E-02*X-1.83198194E-05*X!2
   +6.78877862E-09*X!3-1.19293620E-12*X!4+7.52444916E-17*X!5
60 FOR I=1 TO 50:X(I)=0:NEXT I
70 PRINT HEX(03):PRINT "INPUT AIR SIDE CONDITIONS"
80 INPUT "AIR FLOW RATE (CFM) = ",X(20):
   INPUT "AIR TEMP IN (F)     = ",X(3) :
   INPUT "AIR DEW POINT IN (F)= ",X(2):PRINT
90 PRINT "INPUT PRI COOLANT LOOP CONDITIONS"
100 INPUT "PRI LOOP FLOW (LB/HR) = ",X(13):
    INPUT "PRI LOOP TEMP IN (F)  = ",X(9):PRINT
110 PRINT "INPUT SEC COOLANT LOOP CONDITIONS"
120 INPUT "SEC LOOP FLOW (LB/HR) = ",X(14):
    INPUT "SEC LOOP TEMP IN (F)  = ",X(10):PRINT
130 PRINT HEX(03):PRINT :PRINT :PRINT :
    PRINT "     ****  COND HX PROGRAM IS RUNNING  ****"
140 PRINT :PRINT "                      T CALC       T GUESS "
150 X(17)=X(13)+X(14)
160 X(15)=(X(9)*X(13)+X(10)*X(14))/(X(13)+X(14))
170 K9=(X(3)-X(15))/2:X(5)=X(15)+K9
180 IF X(13)=0 THEN 200
190 IF X(14)=0 THEN 200:X(30)=X(17)/4:GOTO 210
200 X(30)=X(17)/2
210 X(8)=30:X(1)=X(3)
220 X(31)=FN2(X(30)):
     IF X(13)=0 THEN 230:
     IF X(14)=0 THEN 230: X(19)=27*.5408*X(31): GOTO 240
230 X(19)=27*.5408*X(31)/2
240 X(21)=X(2):X(26)=X(20)/.8815
250 X(29)=FN3(X(26)): X(27)=313*.5408*X(29)
260 IF X(13)=0 THEN 270: IF X(14)=0 THEN 270:
    X(27)=.8*X(27): GOTO 280
270 X(27)=.7*X(27)
280 H1=X(19): H2=X(27)
290 U=H1*H2/(H1+H2)
300 P1=FN1(X(5)):P2=FN1(X(21)):
    X(22)=144*60*(X(8)*.4912-P2)*X(20)/53.35/(X(1)+459.6)
310 L=1
320 IF X(2)]X(15)THEN 330:X(24)=0:L=0:GOTO 620
330 X(23)=.24*X(22)*(X(3)-X(5))
340 A3=.622*P1/(X(8)*.4912-P1):
    A2=.622*P2/(X(8)*.4912-P2): X(24)=1065*X(22)*(A2-A3)
350 IF X(24)]0 THEN 360:X(18)=X(23):X(24)=0:GOTO 370
360 X(18)=X(23)+X(24)
370 X(16)=(X(23)+X(24))/X(17)+X(15)
380 H=X(27)/X(19)
390 M1=X(17)/(.24*X(22))
400 IF X(2)[X(3) THEN 410:T1=X(3):T2=X(16):U1=0:GOTO 480
```

Table XII
PROGRAM LISTING (CONCLUDED)

```
410 T1=(.24*X(22)*X(3)+X(17)*(H*X(21)+X(21)-X(16)))/
        (H*X(17)+.24*X(22))
420 T2=X(21)-H*(T1-X(21))
430 IF T2]X(15) THEN 440:GOTO 620
440 E1=(X(3)-T1)/(X(3)-T2)
450 IF E1[1.0 THEN 460:E1=.99
460 GOSUB '01(E1,M1):U1=.24*X(22)*K
470 IF U1[U THEN 480:GOTO 620
480 U2=U-U1
4 90 Q7=X(18)-X(17)*(X(16)-T2)
500 Q8=Q7-X(24)
510 M2=M1*Q8/Q7
520 K1=1/(1+1/H)+1/H*Q8/Q7/(1+1/H)
530 U3=U2/K1
540 K2=U3*Q8/Q7/(.24*X(22))
550 GOSUB '02(M2,K2)
560 T0=T1-E1*(T1-X(15))
570 Q1=X(18):Q2=X(24)+.24*X(22)*(X(3)-T0)
580 IF ABS(Q1-Q2)[.20 THEN 720:PRINT ,T0,X(5)
590 IF Q1]Q2 THEN 610
600 X(5)=X(5)-K9:K9=K9/2:X(5)=X(5)+K9:GOTO 300
610 X(5)=X(5)+K9:K9=K9/2:X(5)=X(5)-K9:GOTO 300
620 M2=X(17)/(X(22)*.24)
630 K2=U/(X(22)*.24)
640 GOSUB '02(M2,K2)
650 IF L=1 THEN 660: X(5)=X(3)-E1*(X(3)-X(15)):GOTO 680
660 T0=X(3)-E1*(X(3)-X(15))
670 IF T0]=X(2) THEN 690:GOTO 570
680 IF X(5)]=X(2) THEN 690:GOTO 570
690 IF L=0 THEN 700:X(5)=T0
700 X(18)=X(22)*.24*(X(3)-X(5)):X(23)=X(18):X(24)=0
710 X(16)=X(18)/X(17)+X(15)
720 PRINT :PRINT :PRINT :
    INPUT "LOCATION OF OUTPUT  (1=CRT,2=PRINTER)",B
730 SELECT PRINT 005:IF B=1 THEN 740:SELECT PRINT 211(64)
740 PRINT HEX(03),"        ****  RESULTS  ****"
750  PRINT " PRI COOLANT FLOW (LB/HR) ";X(13) :
     PRINT " PRI TIN = ";X(9);"  PRI TOUT = ";X(16)
760  PRINT " SEC COOLANT FLOW (LB/HR) ";X(14) :
     PRINT " SEC TIN = ";X(10);"  PRI TOUT = ";X(16)
770  PRINT " AIR FLOW RATE (CFM)        ";X(20) :
     PRINT " TIN = ";X(3);" TDP = ";X(2);" TOUT = ";X(5) :PRINT

780 PRINT "Q LATENT = ";X(24):
    PRINT "Q SENS   = ";X(23):
    PRINT "Q TOTAL  = ";X(18)
790 PRINTUSING 800,X(19),X(27),U
800% HAC = -#####.##   HAH = -#####.##   UA = -#####.##
810 SELECT PRINT 005
820 GOTO 960
830 DEFFN'01(E1,M1)
840 IF E1[ M1 THEN 850:E1=M1-.01
850 IF M1]1 THEN 860: IF M1[1 THEN 870:GOTO 880
860 K=M1/(M1-1)*LOG((1-E1/M1)/(1-E1)):GOTO 890
870 K=M1/(1-M1)*LOG((1-E1)/(1-E1/M1)):GOTO 890
880 K=E1/(1-E1)
890 RETURN
900 DEFFN'02(M2,K2)
910 IF M2]1 THEN 920:IF M2[ 1 THEN 930:GOTO 940
920 C1=EXP(K2*(M2-1)/M2):E1=(1-C1)/(1/M2-C1):GOTO 950
930 C1=EXP(K2*(1-M2)/M2):E1=(1-C1)/(1-C1/M2):GOTO 950
940 E1=K2/(1+K2)
950 RETURN
960 PRINT :STOP "FOR NEXT CASE KEY CONTINUE":GOTO 60
```

RSECS ARS GAS LOOP ΔP ROUTINE

File Name "ARS DP"

Abstract "ARS DP" calculates the corrected (59°F, 29.92 in Hg) pressure drop through the Hamilton Standard supplied RSECS hardware. The program is designed to be used with a WANG 2200 - series computer system.

Program Description

By inputting total RSECS air flow and the number of RS-11 fans operating, the program will calculate the corrected pressure drop through the RS-193 Filter Package, the RS-191 ARS Fan Package, the RS-190 CO_2/Temperature/Humidity Control Package, the 350-M heat exchanger, and the ARS outlet duct. The results are displayed on the CRT.

A program listing, Table XIII, is enclosed for reference.

Table XIII

PROGRAM LISTING

```
10 REM -    RSECS GAS LOOP PRESSURE DROP
20 INPUT "# RS-11 FANS OPERATING = ",F1
30 INPUT "TOTAL AIR FLOW    (CFM) = ",Q1
40 REM -    RS-193
50 P1=(.0765/.0709)*(.0235*Q1!2/173!2+.3*Q1/167)
60 REM -    RS-191
70 P2=(.0765/.0709)*(.00364*Q1!2/173!2+.61+.11*(Q1/F1)!2/500!2
      +.02055*Q1!2/173!2)
80 REM -    RS-190
90 P3=(.0765/.0709)*(.0685*Q1!2/173!2+.9166+.0125*Q1!2/173!2)
100 REM -   OUTLET DUCT
110 P4=(.0765/.0709)*(.00473*Q1!2/173!2+1.0*Q1!2/200!2)
120 REM -   350-M HX
130 C1=+.91296112368E-4   : C2=+.80685958064E-4:
    C3=+.119613327498E-5: C4=-.1175465209E-7:
    C5=+.70368566031E-10: C6=-.23622558293 8E-12
140 C7=+.41057121725E-15: C8=-.28709107365 8E-18
150 P5=(.0765/.0709)*9.9*(C1+C2*(Q1/.815)+C3*(Q1/.815)!2+
      C4*(Q1/.815)!3+C5*(Q1/.815)!4+C6*(Q1/.815)!5+
      C7*(Q1/.815)!6+C8*(Q1/.815)!7)
160 P6=4*(144*Q1*SQR(.0765)/28.26/1096)!2+P5
170 P7=P1+P2+P3+P4+P6
180 PRINT
190 PRINT
200 PRINT "RS-193 DP        (IN H2O) = ";P1
210 PRINT "RS-191 DP        (IN H2O) = ";P2
220 PRINT "RS-190 DP        (IN H2O) = ";P3
230 PRINT "350-M HX DP      (IN H2O) = ";P6
240 PRINT "OUTLET DUCT DP   (IN H2O) = ";P4
250 PRINT "-----------------------------------------"
260 PRINT "TOTAL DP         (IN H2O) = ";P7
270 END
```

GENERALIZED PLOT PROGRAM

File Name "Plot"

Abstract "Plot" uses the WANG 2200 flat bed plotter to automate production of plotting of any desired set of data. This program can plot point by point or plot a desired function in equation form, and in addition, completely label the resulting plot in any desired format.

Program Description

"Plot" uses the WANG 2200 flat bed plotter and the WANG 2200 minicomputer system commands to produce plots of data or equations. As supplied, the WANG had no software to run the plotter; program "Plot" provides this function.

Required inputs are requested on the CRT and responses are keyed in followed by keying "execute".

Available options of this program are:

1. Point by point plotting.
2. Equation plotting.
3. Matrix point plotting.
4. Regression analysis plotting.

For user reference the following items are included:

Table XIV	Description of input requirements for program and plotter set up procedure
Figures 15 - 17	Samples of results of program use in different modes
Table XV	Program listing.

Table XIV

PLOTTER SETUP AND PROGRAM INPUTS

Plotter Setup and Program Inputs

This example is for operation where the user has generated a set of data points in some other program (RSECS), stored them in an array and a plot of the points is desired.

Initially the user must do two things; 1) set up the plotter and 2) decide what type of plot is wanted.

1. Plotter Set up

- set plotter power switch in "on" position
- set pen switch in "down" position
- set chart switch in "release" position
- insert paper - line it up with bottom ridge and ridge on left of plotting surface
- set chart switch in "hold" position
- using control knobs set pen at 0,0 zero reference position and press check button. Press scale adjust check button and set pen at 10,10 using control knobs, then press scale adjust check button again.

2. Type of Plot

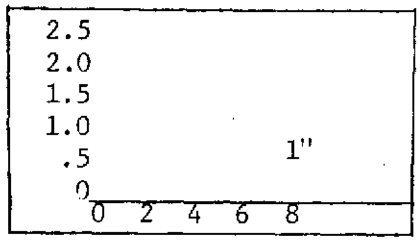
- Determine desired location of axis intersection point on page
- Pick X axis's increment for major divisions (units/in)
- Pick Y axis increment for major divisions
- Pick X and Y axis ranges
- Pick X and Y axis labels

Table XIV

PLOTTER SETUP AND PROGRAM INPUTS (CONTINUED)

Example:

Position 2,2
X axis unit/in 2
Y axis unit/in .5
X axis range 0,8
Y axis range 0,2.5



3. Now proceed to answer questions that appear on the CRT.

Table XIV

PLOTTER SETUP AND PROGRAM INPUTS (CONTINUED)

QUESTION ON CRT	TYPED IN RESPONSE	DESCRIPTION
X axis increment units/in?	2	Delta between major divisions on X axis
Y axis increment units/in?	.5	Delta between major divisions on Y axis
Location of axis intersection (position on page in inches - X, Y)?	2,2	Location of 0,0 point on plot is 2" over and 2" up from pen reference point
Limits of X axis (min value, max value)	0,8	
Limits of Y axis (min value, max value)	0,2.5	
X, Y values at intersection	0,0	
X axis label	Delta dew point (F)	
Y axis label	H_2O flow Lb/Hr	
Location of X axis labels (1=above, 2=below)	2	
Location of Y axis labels (1=left, 2=right)	1	
Plot points or curve (1=point, 2=curve)	1	Purpose is to plot points generated by previous program
Desired plot symbol		Entering nothing causes centered dot to be used as plot symbol

Table XIV

PLOTTER SETUP AND PROGRAM INPUTS (CONCLUDED)

QUESTION ON CRT	TYPED IN RESPONSE	DESCRIPTION
Are data points to be loaded from array	1	Array was loaded for previous program
First and last points to be plotted	1,15	15 points were generated and are to be plotted
Key continue to plot points	Continue	Starts plotting of points
Do you wish to connect points with line segments	1	Connects data points to form desired curve
	Reset	End of plot routine
Do you wish to add labels to plot (0=no, 1=yes)	1	Activates portion of program that makes plotter act like a typewriter
Desired character size	1	Selects size of characters for labels (smallest=1, largest=10)
Do you wish to continue plotting	0	Ends program

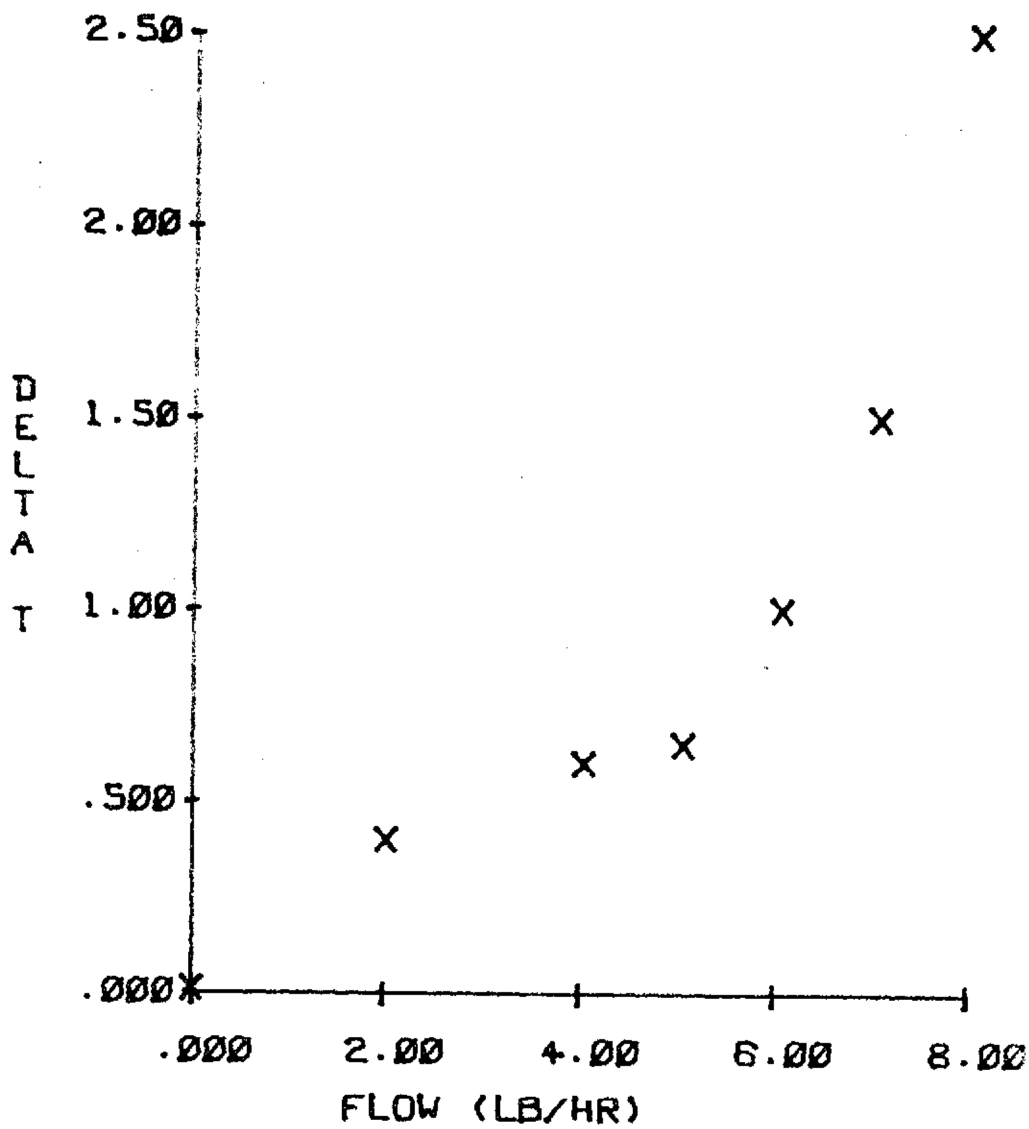


FIGURE 15 SAMPLE PLOT 1

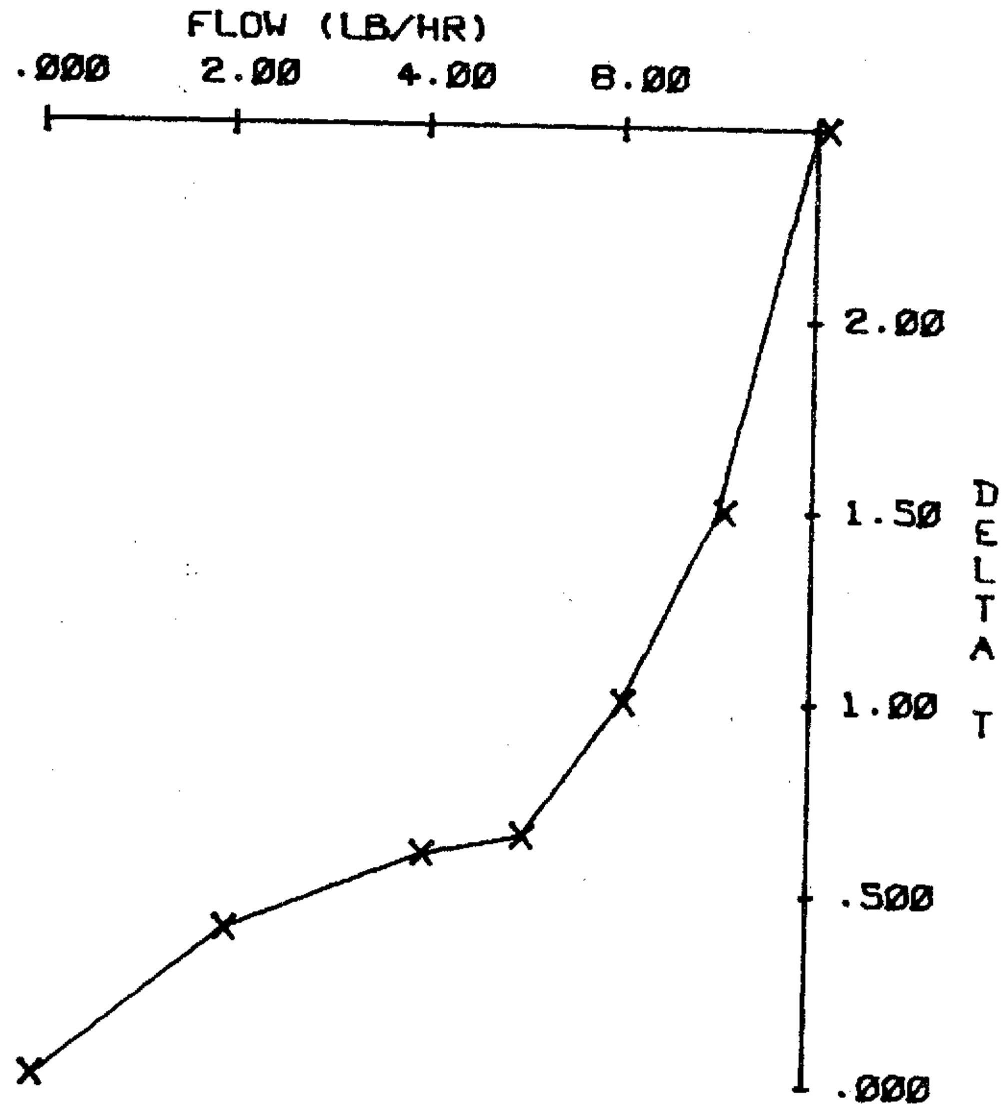


FIGURE 16 SAMPLE PLOT 2

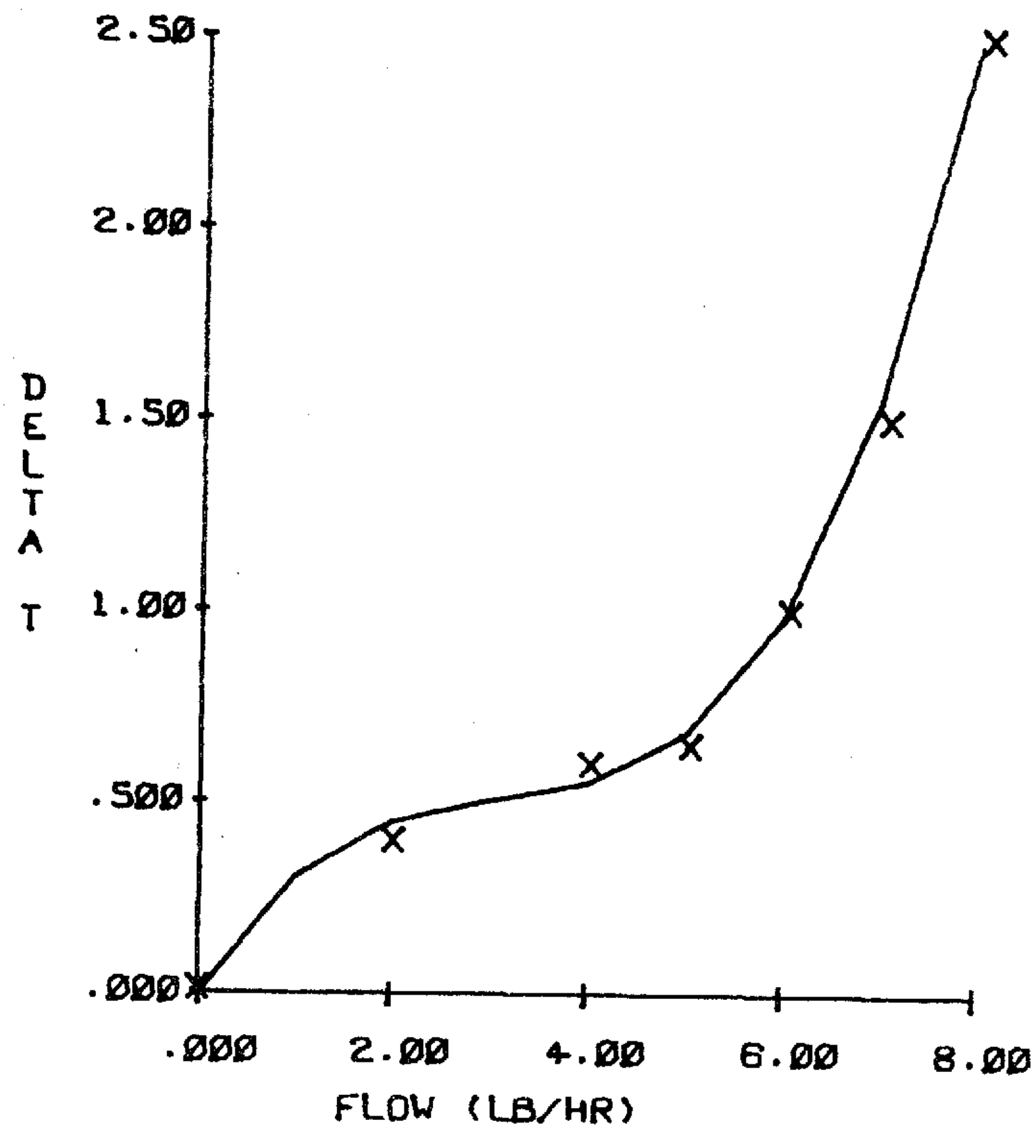


FIGURE 17 SAMPLE PLOT 3

Table XV
PROGRAM LISTING

```
10 REM SUBROUTINE "PLOT"
20 COM X9(100),Y9(100),C(10),X$25,Y$25,P$1
30 DEFFN'00"PLOT["
40 DEFFN'01"CONVERT"
50 SELECT PRINT 005:PRINT HEX(03)
60 PRINT :PRINT "          WANG 2200 GENERAL PLOT ROUTINE ":PRINT
 "        DEVELOPED BY 'WILD' BILL AYOTTE (9/74)":PRINT :PRINT
70 INPUT "X AXIS INCREMENT (UNITS/IN)",X0
80 INPUT "Y AXIS INCREMENT (UNITS/IN)",Y0
90 PRINT "LOCATION OF AXIS INTERSECTION":INPUT "(POSITION ON PAG
E IN INCHES- X, Y )",X1,Y1
100 INPUT "LIMITS OF X AXIS (MIN VALUE, MAX VALUE)",S1,S2
110 INPUT "LIMITS OF Y AXIS (MIN VALUE, MAX VALUE)",T1,T2
120 INPUT "X,Y VALUES OF AXIS INTERSECTION",C1,C2
130 INPUT "X AXIS LABEL",X$
140 INPUT "Y AXIS LABEL",Y$
150 F1=100./X0:F2=100./Y0
160 GOSUB 500
170 PLOT [1,,C],[,,S]
180 INPUT "PLOT POINTS OR CURVE (1=POINT,2=CURVE)",U1
190 IF U1=1 THEN 310
200 PLOT [,,R],[100*X1,100*Y1,U]
210 X4,Y4,E,E3,E4,E6,E8,E7=0:X$=" "
220 INPUT "DESIRED PLOT RANGE (MIN AND MAX VALUES)",W1,W2:INPUT
"DESIRED PLOT INCREMENT",D
230 STOP "INPUT EQUATION TO BE PLOTTED ON LINE 250 THEN KEY RUN
240"
240 FOR X=W1 TO W2 STEP D
250 Y=C(1)+C(2)*X+C(3)*X!2+C(4)*X!3+C(5)*X!4+C(6)*X!5+C(7)*X!6
260 X5=X-C1:Y5=Y-C2
270 IF X[]W1 THEN 280:U1=1:GOSUB '02(X5,Y5,X4,Y4):U1=2:GOTO 290
280 GOSUB '02(X5,Y5,X4,Y4)
290 NEXT X
300 PLOT [,,U]:PLOT [,,R]: GOTO 1350
310 X$=" ":PRINT :PRINT :INPUT "DESIRED PLOT SYMBOL",X$:K=1:X4,Y
4=0:INPUT "ARE DATA POINTS TO BE LOADED FROM ARRAY (NO=0,YES=1)"
 ,D:IF D=1 THEN 340
320 PRINT :PRINT "INPUT DATA POINTS (STOP PLOTTING BY SETTING X,
Y=N,N)":PRINT
330 INPUT "X,Y = ",X9$,Y9$:IF X9$="N"THEN 410:CONVERT X9$ TO X9(
K):CONVERT Y9$ TO Y9(K) :GOTO 360
340 PRINT :INPUT "FIRST AND LAST DATA POINTS TO BE PLOTTED",K,K5

350 STOP "KEY CONTINUE TO START PLOTTING POINTS IN ARRAY"
360 X=X9(K)-C1:Y=Y9(K)-C2:X4,Y4=0
370 IF K]1 THEN 380:PLOT [,,R],[100*X1,100*Y1,U],[F1*X,F2*Y,U],
 [,,D],[,,X$]:GOTO 390
380 GOSUB '02(X,Y,X4,Y4)
390 PLOT [-X*F1,-Y*F2,U]
400 K=K+1:IF D=0 THEN 330:IF K]=K5+1 THEN 410:GOTO 360
410 INPUT "DO YOU WISH TO CONNECT PLOTTED POINTS WITH LINE SEGME
NTS             (YES=1,NO=0)",Q
420 IF Q=0 THEN 1350:INPUT "FIRST AND LAST POINTS TO BE CONNECTE
D",L8,L9
430 X4,Y4,E,E3,E4,E6,E8,E7=0:U1=2:PLOT [,,R],[100*X1,100*Y1,U]
440 FOR I=L8 TO L9
450 X=X9(I)-C1:Y=Y9(I)-C2
460 IF I[]L8 THEN 470:U1=1:GOSUB '02(X,Y,X4,Y4):U1=2:GOTO 480
470 GOSUB '02(X,Y,X4,Y4)
480 NEXT I
490 PLOT [,,U]:PLOT [,,R]:GOTO 1350
500 SELECT PLOT 414
510 REM THIS SUBROUTINE DRAWS AND LABELS AXIS
520 PLOT [1,,C],[12,,S]
530 INPUT "LOCATION OF X AXIS LABELS (1=ABOVE,2=BELOW)",L1
540 INPUT "LOCATION OF Y AXIS LABELS (1=LEFT,2=RIGHT)",L2
```

Table XV

PROGRAM LISTING (CONTINUED)

```
550 A1=F1*ABS(S1-C1):A2=F1*ABS(S2-C1):B1=F2*ABS(T1-C2):B2=F2*ABS
(T2-C2)
560 PLOT [,,R],[100*X1,100*Y1,U],[-A1,0,U],[A1+A2,0,D],[-A2,-B1,
U],[0,B1+B2,D]
570 M5=(ABS(S1-C1)+ABS(S2-C1))/X0:N5=(ABS(T1-C2)+ABS(T2-C2))/Y0
580 K=0
590 S3=S1-X0
600 PLOT [-3,-(B1+B2),U]
610 FOR I3=1 TO N5+1
620 PLOT [6,0,D],[,,U]
630 IF I3=N5+1 THEN 640:PLOT [-6,F2*Y0,U]
640 NEXT I3
650 PLOT [-(A1+3),-(B2+6),U]
660 FOR I4=1 TO M5+1
670 PLOT [0,12,D],[,,U]
680 IF I4=M5+1 THEN 690:PLOT [F1*X0,-12,U]
690 NEXT I4
700 IF L1=2 THEN 710:PLOT [-(A1+A2+24),20,U]:GOTO 720
710 PLOT [-(A1+A2+24),-36,U]
720 FOR I=1 TO M5+1
730 IF I]M5+1 THEN 840
740 S3=S3+X0
750 IF ABS(S3)]=1000.THEN 770:IF ABS(S3)]=100.THEN 780:IF ABS( S
3)]=10.THEN 790:IF ABS(S3)]=1.THEN 800
760 CONVERT S3 TO S3$,(-.###):GOTO 810
770 CONVERT S3 TO S3$,(-####):GOTO 810
780 CONVERT S3 TO S3$,(-###.):GOTO 810
790 CONVERT S3 TO S3$,(-##.#):GOTO 810
800 CONVERT S3 TO S3$,(-#.##):GOTO 810
810 IF K[]0 THEN 820: PLOT [,,S3$]:GOTO 840
820 IF S3[]C1 THEN 830:PLOT [F1*X0,0,U]:GOTO 840
830 PLOT [(F1*X0)-60,0,U],[,,S3$]
840 K=K+1:NEXT I
850 IF L2=1 THEN 860:PLOT [-(A2+20),0,U]:GOTO 870
860 PLOT [-(A2+100),0,U]
870 IF L1=1 THEN 880:PLOT [ 0,-(B1-31),U]:GOTO 890
880 PLOT [0,-(B1+24),U]
890 K=0
900 T3=T1-Y0
910 FOR I2=1 TO N5+1
920 IF I2]N5+1 THEN 1030
930 T3=T3+Y0
940 IF ABS(T3)]=1000.THEN 960:IF ABS(T3)]=100.THEN 970:IF ABS(T3
)]=10.THEN 980:IF ABS(T3)]=1.THEN 990
950 CONVERT T3 TO T3$,(-.###):GOTO 1000
960 CONVERT T3 TO T3$,(-####):GOTO 1000
970 CONVERT T3 TO T3$,(-###.):GOTO 1000
980 CONVERT T3 TO T3$,(-##.#):GOTO 1000
990 CONVERT T3 TO T3$,(-#.##):GOTO 1000
1000 IF K[]0 THEN 1010:PLOT [,,T3$]:GOTO 1030
1010 IF T3[]C2 THEN 1020:PLOT [0,F2*Y0,U]:GOTO 1030
1020 PLOT [-60,F2*Y0,U],[,,T3$]
1030 K=K+1:NEXT I2
1040 PLOT [,,R]
1050 IF X$=" " THEN 1110: PLOT [100*X1,100*Y1,U],[-A1,0,U]
1060 IF L1=2 THEN 1070:PLOT [0,50,U]:GOTO 1080
1070 PLOT [0,-60,U]
```

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Table XV

PROGRAM LISTING (CONCLUDED)

```
1080 IF A2[]0 THEN 1090:PLOT [A1/5,0,U]:GOTO 1100
1090 PLOT [A1+A2/5,0,U]
1100 PLOT [,,X$]
1110 IF Y$=" " THEN 1180
1120 PLOT [,,R],[100*X1,100*Y1,U],[0,-B1,U]
1130 IF L2=1 THEN 1140:PLOT [90,0,U]:GOTO 1150
1140 PLOT [-90,0,U]
1150 IF B2[]0 THEN 1160:PLOT [0,2*B1/3,U]:GOTO 1170
1160 PLOT [0,B1+B2*2/3,U]
1170 PLOT [0,-20,S],[,,Y$],[12,,S],[,,R]
1180 RETURN
1190 DEFFN'02(U,V,X4,Y4)
1200 X3=U:Y3=V
1210 D1=X3-X4:D2=Y3-Y4:X4=X4+D1:Y4=Y4+D2
1220 IF U1=2 THEN 1230:  PLOT [F1*D1,F2*D2,U],[,,D],[,,X$],[,,U]
:E3=INT(F2*D2):E7=INT(F1*D1):GOTO 1340
1230 E1=F2*Y3-INT(F2*Y3)
1240 E=E+E1+E4
1250 P8=F2*D2+E:P9=INT(P8)
1260 E5=F1*X3-INT(F1*X3)
1270 E6=E6+E5+E8
1280 S8=F1*D1+E6:S9=INT(S8)
1290 PLOT [S9,P9,D]
1300 E3=E3+P9
1310 E4=F2*Y3-E3
1320 E7=S9+E7
1330 E8=F1*X3-E7
1340 RETURN
1350 INPUT "DO YOU WISH TO ADD LABELS OR COMMENTS TO PLOT (0=NO,
1=YES)",G
1360 IF G=0 THEN 1480
1370 INPUT "DESIRED CHARACTER SIZE (NUMBER FROM 1 TO 5)",K
1380 PLOT [K,,C],[,,S]
1390 KEYIN P$,1410,1420
1400 GOTO 1390
1410 IF P$=HEX(0D)THEN 1430:IF P$=HEX(02)THEN 1440:IF P$=HEX(08)
 THEN 1450:PLOT [,,P$],[13*K,,U]:GOTO 1390
1420 IF P$=HEX(00) THEN 1460:IF P$=HEX(01)THEN 1470:
     IF P$=HEX(02) THEN 1370:GOTO 1480
1430 PLOT [0,-20*K,U],[-999,0,U]:GOTO 1390
1440 PLOT [13*K,0,U]:GOTO 1390
1450 PLOT [-13*K,0,U]:GOTO 1390
1460 PLOT [0,20*K,U]:GOTO 1390
1470 PLOT [0,-20*K,U]:GOTO 1390
1480 INPUT "DO YOU WISH TO CONTINUE PLOTTING (0=NO,1=YES)",G:
     IF G=1 THEN 180
1490 END
```