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DATA ACQUISITION AND ANALYSIS
SOFTWARE FOR THERMAL
STRESS STUDIES

R.P. Layton

J. Vorosmarty, CAPT, MC, USN
Commanding Officer
Naval Medical Research Institute

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND

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**TITLE (and Subtitle)**
DATA ACQUISITION AND ANALYSIS SOFTWARE FOR THERMAL STRESS STUDIES

**AUTHOR(s)**
R.P. Layton

**PERFORMING ORGANIZATION NAME AND ADDRESS**
Naval Medical Research Institute
Bethesda, MD 20814

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**ABSTRACT**
A system to monitor cutaneous heat flow and temperature at individual body sites using heat flux transducers has been previously reported. Data acquisition for this system has been automated using a desktop computer. Programs have been developed to aid in the scaling, plotting, and analyzing of experimental data. The details of this software package are the subject of this report.
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I. INTRODUCTION

A system to monitor heat flux and temperature at individual body sites using commercial heat flow transducers and thermistors has been developed at this facility. Details of the amplifier and multiplexer hardware are reported elsewhere (1). Since as many as 32 individual transducer signals (most of them multiplexed on two lines) can be outputed by this system each minute, an accurate and reliable data de-multiplexing and recording technique is a necessity. These functions have been automated with a Hewlett-Packard 9825 desktop computer and associated peripherals. The program that controls the digital data acquisition, "FLUX15," is described in the next section. The raw data recorded consist of the voltage outputs of the amplifier circuits for each transducer. These signals are of little value until they have been scaled into physical units. This function is provided by the program "HEAT15." Analysis of the data is aided by two additional software routines, "PLT15" and "AVG15." The former generates a plot of the output of each sensor as a function of time, while the latter computes the mean value of each transducer signal over a period of time chosen by the operator. Several less frequently used programs which complete the software package for this system are also described.
II. PROGRAM "FLUX15"

A. Introduction

Program "FLUX15" controls the acquisition and storage of data from the system designed to monitor cutaneous heat flux and temperature at individual body sites by means of an array of transducers. It accepts two lines of multiplexed information (heat flux and temperature) and 12 dedicated lines. With the current hardware, the program can accept up to 10 multiplexed heat flow transducers, 12 multiplexed temperature probes, and up to five combination heat flux/temperature non-multiplexed transducers. In addition, there are dedicated inputs from the internal clock of the electronics system and from the programmable voltage source used for calibration.

The program is written for the Hewlett-Packard 9825 computer which uses a software controlled scanner and digital voltmeter combination to select the data lines. Appendix 1b identifies which signal line is connected to each scanner input for proper operation. To stay in synchronization with the multiplexed signals, the program must be able to identify changes in levels of the system clock as well as the occurrence of a synchronization voltage level at the sixteenth multiplexed position. These voltages are defined in lines 42-43 of the program.

"FLUX15" contains a routine that stores information in a calibration file to allow the analysis program to calculate the gain and offset of each circuit. Thus it is not necessary for the operator to make zero and full-scale adjustments to the circuits themselves.

Once the data collection section of the program is running, the system is completely automatic and requires no further operator assistance until the experiment is finished. During a nominal one-minute cycle, each multiplexed sensor is read many times during a three-second period; the
individual readings are averaged to obtain a single value. Each of the auxiliary sensors is similarly measured over a two-second interval. At the end of each cycle the mean output values of all the sensors are stored in the data file on the flexible disk. When the user is ready to terminate the data acquisition routine, he uses the live keyboard to enter the value 1 into the variable V; this causes the program to stop at the end of the current cycle.

Since the calibration procedure is critical to the validity of the experimental data, it is important that this procedure be performed carefully and accurately. The calibration constants of the heat flux transducers are determined using an instrument (Dynateck R/D Co., model Rapid-k) that can maintain a known, fixed value of heat flux through the disks. This process is time-consuming and cannot be done before each experiment. Fortunately, experience at NMRI and elsewhere has shown that the values are stable (2). For the pre-experiment calibration a variable voltage source is connected to the inputs of the system which normally would receive the output signals of the heat flux sensors. The voltage source is set to 0 mV for the low level calibration and to 1.5 mV for the full-scale input. These simulated signals allow the electronic system to be checked and the gain and offset of the individual circuits to be determined.

The temperature probes are calibrated as integral parts of the system before each experiment. They are immersed in a water and ice slush and left there for 10 minutes until the temperature of the mixture has equilibrated. The temperature, as measured by a digital thermometer, is hand entered on the computer and the output of each temperature circuit is then measured automatically. Similarly, the full-scale temperature signals are determined by putting the probes in a 40°C stirred water bath.
The values obtained during calibration are printed for inspection by the user. The heat flux circuits have low offset and a nominal gain of 500; thus, the low level calibration output should be \( \approx 0.005 \) V and the high-level value should equal \( \approx 2.5 \) V. For temperature, the nominal scaling is 100 mV/°C. The low output should read \( \approx 0.1 \) V and the high output \( \approx 4.0 \) V.

A program listing, variable allocations, flow charts, and required equipment are given in Appendix 1.
B. User Instructions

1. Insert: program disk into drive
   Type: drive 0,8
   Press: EXECUTE

2. Type: get "FLUX15"
   Press: EXECUTE
   When end of line symbol (\rightarrow) is displayed
   Press: RUN

3. When "PRINTER SELECT CODE = ?" is displayed;
   a. Type: number
   b. Press: CONTINUE

4. When "REMOVE PROGRAM FLEXIBLE DISK!" is displayed;
   a. Remove disk
   b. Press: CONTINUE

5. When "INSERT DATA FLEXIBLE DISK!" is displayed;
   a. Insert disk on which data is to be recorded
   b. Press: CONTINUE

6. When "Enter # of HFS multiplexed" is displayed;
   a. Type: L, where \( L \leq 15 \) is the number of heat flow transducers
      (normally \( L = 10 \))
   b. Press: CONTINUE

7. When "Enter # of TMP multiplexed" is displayed;
   a. Type: H, where \( L \leq H \leq 15 \) is the number of temperature sensors
      (normally \( H = 12 \) since rectal and ambient temperatures are read
       in addition to the 10 temperatures associated with each heat flow disk)
   b. Press: CONTINUE

8. When "Enter # of Auxiliary sensors" is displayed;
   a. Type: A, where \( 1 \leq A \leq 5 \) (note that \( A + H \) must be \( \leq 17 \))
   b. Press: CONTINUE

9. When "Do you want to calibrate?" is displayed;
   a. If yes,
      1) Press: YES (special function key \( f_0 \))
      2) Go to step 10
   b. If no,
      1) Press: No (special function key \( f_6 \))
      2) Go to step 30

10. When "Enter 6 character cal. file name" is displayed;
    a. Type: name (must contain maximum of six characters; no spaces are
       allowed within name)
    b. Press: CONT."
11. When "Enter heading for cal. file" is displayed;
   a. Type: heading, which may contain a maximum of 80 characters and spaces
   b. Press: CONTINUE

12. When "Calibrate heat flux sensors" is displayed;
   a. Check that all heat flux inputs (multiplexed and auxiliary) are connected to output of calibration voltage source.
   b. Press: CONTINUE

13. When "Cal HFS, LOW voltage (0 mv)" is displayed;
   a. Check that voltage source is set to 0 output
   b. Press: CONTINUE

14. When "Press CONT to read input volts" is displayed;
   a. Check voltage being read on computer system digital voltmeter (DVM). If reading is $\leq 0.050$ mV proceed; if reading is too high, remedy problem before continuing.
   b. Press: CONTINUE
      1) "READING CALIBRATION VOLTAGE" is displayed
      2) Computer reads input voltage
      3) Value is printed

15. When "Press CONTINUE to take reading" is displayed;
   a. Set HFS controller to "SELECT" channel 15
   b. Press: CONTINUE
   c. "Waiting for sync" is displayed
   d. Set HFS controller to "SCAN"; wait $\approx 4$ sec
   e. "Calibration data is being read" is displayed for $\approx 1$ min
   f. Outputs in volts of HFS circuits are printed

16. When "Repeat Calibration?" is displayed;
   a. If calibration results are satisfactory (output $\leq 0.005$ V),
      1) Press: NO
      2) Go to step 17
   b. If results must be repeated,
      1) Press: YES
      2) Go to step 13

17. When "Cal HFS, HIGH voltage (5mV)" is displayed;
   a. Set voltage source output to $\approx 5$ mV
   b. Press: CONTINUE

18. "When Press CONT to read input volts" is displayed;
   a. Check voltage being read on DVM. If it is $\approx 5$ mV, proceed; if not, remedy problem before continuing.
   b. Press: CONTINUE
      1) "READING CALIBRATION VOLTAGE" is displayed;
      2) Computer reads voltage
      3) Value is printed

19. When "Press CONTINUE to take reading" is displayed;
   a. Set HFS controller to "SELECT" channel 15
   b. Press: CONTINUE
c. "Waiting for sync" is displayed
d. Set HFS controller to "SCAN"; wait ~4 sec
e. "Calibration data is being read" is displayed for ~1 min
f. Outputs in volts of HFS circuits are printed

20. When "Repeat Calibration?" is displayed;
a. If calibration results are satisfactory (output ~2.5 V),
   1) Press: NO
   2) Go to step 21
b. If results must be repeated,
   1) Press: YES
   2) Go to step 17

21. When "CALIBRATE TEMPERATURE" is displayed;
a. Check that all temperature sensors are totally immersed in ice/water slush and have had sufficient time (at least 10 min) to equilibrate with bath temperatures.
b. Check that all sensors are properly connected to the electronics of the system.
c. Press: CONTINUE

22. When "Low T in degrees C = ?" is displayed;
a. Read temperature of ice bath on digital thermometer (Note: Check zero of thermometer)
b. Type: number for temperature in °C
c. Press: CONTINUE
d. Value is printed

23. When "Press CONTINUE to take reading" is displayed;
a. Set HFS controller to "SELECT" channel 15
b. Press: CONTINUE
c. "Waiting for sync" is displayed
d. Set HFS controller to "SCAN"; wait ~4 sec
e. "Calibration data is being read" is displayed
f. Outputs in volts of temperature circuits are printed (should be ~0.1 V)

24. When "Repeat Calibration?" is displayed;
a. If yes,
   1) Press: YES
   2) Go to step 22
b. If no,
   1) Press: NO
   2) Go to step 25

25. When "High T in degrees C = ?" is displayed;
a. Remove sensors from ice bath and place in nominal 40°C bath
b. Wait several minutes for equilibration
c. Read bath temperature on digital thermometer
d. Type: number for temperature in °C
e. Press: CONTINUE
f. Value is printed

26. When "Press CONTINUE to take reading" is displayed;
a. Set HFS controller to "SELECT" channel 15
b. Press: CONTINUE
c. "Waiting for sync" is displayed
d. Set HFS controller to "SCAN"; wait ~4 sec
e. "Calibration data is being read" is displayed
f. Outputs in volts of temperature circuits are printed (values should be ~4.0 V)

27. When "Repeat Calibration?" is displayed;
   a. If no,
      1) Press: NO
      2) Go to step 28
   b. If yes,
      1) Press: YES
      2) Go to step 25

28. [Calibration data are recorded on flexible disk.]

29. When "Calibration Completed" is displayed;
   Press: CONTINUE

30. When "Enter 6 character data file name" is displayed;
    a. Type: name (must contain a maximum of six characters; no spaces are
       allowed within name)
    b. Press: CONTINUE

31. When "Number of data records = ? (app. 1.2/min)" is displayed;
    a. Type: n, where n > 1.2T and T is the maximum time in minutes for
       which data collection is to continue
    b. Press: CONTINUE

32. If program stops and computer displays "error D8," flexible disk has
    insufficient room to store data file
    a. Remove disk
    b. Insert new disk
    c. Type: cont 54
    d. Press: EXECUTE
    e. Go to step 30

33. When "Enter first line of heading" is displayed;
    a. Type: up to 80-character line
    b. Press: CONTINUE

34. When "Enter second line of heading" is displayed;
    a. Type: up to 80-character line or leave blank
    b. Press: CONTINUE

35. When "Enter third line of heading" is displayed;
    a. Type: up to 80-character line or leave blank
    b. Press: CONTINUE

36. When "Press Continue to Start Data" is displayed;
    a. Set HFS controller to "SELECT" channel 15
    b. Press: CONTINUE when you are nearly ready to start data collection
    c. "Waiting for sync signal" is displayed
d. When ready to start data acquisition, set HFS controller to "SCAN"; wait "4 sec.
e. "In sync" is displayed (Note: Internal elapsed time clock of computer starts at this time.)

37. [After "1 min, the output signals of each transducer that were stored in memory are recorded on the disk. The current rectal temperature and elapsed time are displayed. This cycle is repeated once per minute during the experiment with no further operator input.]

38. When the experiment is to be terminated;
a. Type: 1 + V
b. Press: EXECUTE
c. The program will complete the current data collection cycle and then display "Data Collection Ended"

39. "Press continue to duplicate data" will be automatically displayed 10 sec later.
a. If you wish to duplicate data using the HP 9885 single flexible disk drive and tape cassette, go to step 40.
b. If you wish to duplicate data using the HP 9895 double flexible disk drive
   1) Remove disk
   2) See instructions for duplication following this program.

40. Press: CONTINUE

41. When "INSERT TAPE FOR DATA DUMP" is displayed;
a. Put tab on cassette in "RECORD" position
b. Insert tape in computer
c. Press: CONTINUE
d. "DATA IS BEING RECORDED ON TAPE" is displayed

42. When "REMOVE ORIGINAL DISK" is displayed;
a. Remove disk
b. Press: CONTINUE

43. When "INSERT DISK FOR DUPLICATE DATA" is displayed;
a. Insert disk
b. Press: CONTINUE
c. "DATA BEING RECORDED ON DISK" is displayed

44. When "DATA DUPLICATION COMPLETED" is displayed;
a. Remove tape
b. Remove disk
c. Program is completed
C. Instructions for Duplicating Data on Dual Disk Drive

1. Insert: double-sided disk onto which data is to be copied into drive 0.

2. Insert: single-sided disk which contains original data into drive 1.

3. Type: copy "NAME", 1, 707, "NAME", 0, 707  
   (where NAME is the calibration file to be copied)  
   Press: EXECUTE

4. Wait for end of line symbol (l-) to be displayed

5. Type: copy "NAME", 1, 707, "NAME", 0, 707 (where NAME is the data file to be copied)  
   Press: EXECUTE

6. When end of line symbol (l-) appears the duplication is completed.
III. Program "HEAT15"

A. Introduction

The data stored by program "FLUX15" consist of the actual voltage signals of the sensors. For this information to be useful it must be properly scaled into physical units. Program "HEAT15" performs this function. It uses values stored in a calibration file, a data file, and in file "ARAY15" to produce a new file containing the scaled data.

The program first calculates a gain for each sensor circuit as follows:

\[
G_H = \frac{1000(H_1 - H_0)}{(V_1 - V_0)}
\]
\[
G_T = \frac{(T_1 - T_0)}{(t_1 - t_0)}
\]

where:

\(G_H\) = gain of heat flux circuit (dimensionless)

\(H_1\) = heat flux high calibration voltage output (V)

\(H_0\) = heat flux low calibration voltage output (V)

\(V_1\) = heat flux high calibration voltage input (mV)

\(V_0\) = heat flux low calibration voltage input (mV)

\(G_T\) = gain of temperature circuit (volts/°C)

\(T_1\) = temperature high calibration voltage output (V)

\(T_0\) = temperature low calibration voltage output (V)

\(t_1\) = actual high temperature calibration value (°C)

\(t_0\) = actual low temperature calibration value (°C).

The offset (output signal with a zero input) is then determined for each circuit by:

\[
D_H = H_0 - (G_H)\left(\frac{V_0}{1000}\right)
\]
\[
D_T = T_0 - (G_T)(t_0)
\]
where:

\[ D_H = \text{offset of heat flux circuit (V)} \]
\[ D_T = \text{offset of temperature circuit (V)} \]

The raw data are then scaled using the equations:

\[ Z_H = 1000 \left( \frac{X_H - D_H}{C_H} \right) (F_H) \]
\[ Z_T = \left( X_T - D_T \right) / G_T \]

where:

\[ Z_H = \text{scaled heat flux (W/M}^2\text{)} \]
\[ X_H = \text{unscaled heat flux transducer output (V)} \]
\[ F_H = \text{calibration constant for heat flux transducer (W/M}^2\text{-mV)} \]

(from "ARAY15")

\[ Z_T = \text{scaled temperature (°C)} \]
\[ X_T = \text{unscaled temperature transducer output (V)} \]

At this point, a regional heat flux and temperature have been computed for each sensor. To obtain a rate of heat loss, both the total body surface area and the fraction represented by each transducer must be known.

The area weighting factors selected by the user are contained in "ARAY15" (3, 4). The total area is calculated with the equation of Dubois and Dubois (5):

\[ S = (A (0.725))(B 0.425))(71.84)(10^{-4}) \]

where:

\[ S = \text{Surface area in M}^2 \]
\[ A = \text{height of subject in cm} \]
\[ B = \text{weight of subject in Kg} \]

The scaled data are recorded on the flexible disk in serial form according to the format:

C$, D$, E$, B$, F$, N[*], r8, U, E, F[*], M[*], P[*]
where the variables are identified in Appendix 2. The first line occurs once in each data file; the second, with different values stored in the variables, is repeated for each nominal one-minute data cycle of the system controller.

User instructions are given in the next section. Program listing, variable allocations, and equipment list are provided in Appendix 2.
B. User Instructions

1. Insert: program disk into drive 0
   Type: drive 0, 707
   Press: EXECUTE

2. Type: get "HEAT15"
   Press: EXECUTE
   When end of line mark (l-) is displayed
   Press: RUN

3. When "Printer Select Code?" is displayed;
   a. Type: number
   b. Press: CONTINUE

4. When "INSERT DATA DISK in drive 0" is displayed;
   a. Remove program disk
   b. Insert double-sided disk containing data files produced by "FLUX15"
      into drive 0
   c. Press: CONTINUE

5. When "INSERT NEW DATA DISK in drive 1" is displayed;
   a. Insert disk in drive 1 on which new data file containing scaled
      values is to be recorded. (Note: This disk must already have
      recorded on it the proper "ARAY15" file created by program "SNSR15")
   b. Press: CONTINUE

6. When "Name of Calibration file?" is displayed;
   a. Type: name of original calibration file
   b. Press: CONTINUE

7. When "Name of Data file wanted?" is displayed;
   a. Type: name of original data file
   b. Press: CONTINUE

8. When "Name for new analyzed data file" is displayed;
   a. Type: name of data file in which new scaled data is to be stored
   b. Press: CONTINUE

9. When "# records in original data file?" is displayed;
   a. Type: number (Note: This number can be found by executing the
      catalogue command for drive 0)
   b. Press: CONTINUE

10. When "Do you want printout?" is displayed;
    a. If no,
       1) Press: NO
       2) Go to step 18
    b. If yes,
       1) Press: YES
       2) Sensor information stored in "ARAY15" is printed
c. When "Do you want to change ARAY15?" is displayed;
   1) If no,
      a) Press: NO
      b) Go to step 18
   2) If yes,
      a) Press: YES
      b) Go to step 11

11. When "Number of MPX HFS = ?" is displayed;
   a. Type: number of multiplexed heat flux sensors
   b. Press: CONTINUE (Note: In this and the following steps 12-15,
      if the information requested in a particular line need not be changed
      from that already stored in "ARAY15," simply press CONTINUE. The
      originally entered number will remain unchanged.)

12. When "Number of T sensors = ?" is displayed;
   a. Type: number of multiplexed temperature sensors
   b. Press: CONTINUE

13. When "Number of AUX sensors = ?" is displayed;
   a. Type: number
   b. Press: CONTINUE

14. When "Sensor # <I>" is displayed (where 1 ≤ I ≤ 10);
   a. Press: CONTINUE
   b. When "Serial # = ?" is displayed;
      1) To enter a new number for multiplexed # I,
         a) Type: number
         b) Press: CONTINUE
      2) To leave number unchanged
         Press: CONTINUE
   c. When "Cal const = ?" is displayed;
      1) To enter a new heat flux calibration constant (W/M²-mV) for
         sensor # I,
         a) Type: number
         b) Press: CONTINUE
      2) To leave unchanged,
         Press: CONTINUE
   d. When "Weighting factor = ?" is displayed;
      1) To enter a new fractional surface area factor (use decimal form)
         for sensor # I,
         a) Type: number
         b) Press: CONTINUE
      2) To leave unchanged
         Press: CONTINUE
   e. Does I = 10?
      1) If yes, go to step 15
      2) If no, I is incremented by 1; go to step 14

15. When "AUX # <I>" is displayed (where 1 ≤ I ≤ 5);
   a. Press: CONTINUE
   b. When "Serial # = ?" is displayed;
1) To enter a new number for auxiliary sensor # I,
a) Type: number  
b) Press: CONTINUE
2) To leave unchanged
Press: CONTINUE

c. When "Cal const = ?" is displayed;
1) To enter new heat flux calibration constant (W/m²-mV) for auxiliary sensor # I,
a) Type: number  
b) Press: CONTINUE
2) To leave unchanged
Press: CONTINUE

d. When "Weighting factor = ?" is displayed;
1) To enter new number for auxiliary sensor # I,
a) Type: number (decimal)  
b) Press: CONTINUE
2) To leave unchanged
Press: CONTINUE

e. Does I = 5?
1) If yes, go to step 16
2) If no, I is incremented by 1; go to step 15

16. [New values are printed and then stored on disk in drive 1 to form new "ARAY15" file.]

17. When "Modify ARAY15 again?" is displayed;
a. If yes,  
1) Press: YES  
2) Go to step 11
b. If no,  
1) Press: NO  
2) Go to step 18

18. When "Height of subject (inches) = ?" is displayed;
a. Type: number in inches  
b. Press: CONTINUE

19. When "Weight of subject (pounds) = ?" is displayed;
a. Type: number in pounds  
b. Press: CONTINUE

20. If you answered "NO" to step 10, go to step 22; otherwise continue with step 20;
a. Parameters used to compute properly scaled values are printed  
b. When "Make necessary changes, then continue" is displayed;
1) If no changes are to be made for the parameters just printed  
a) Press: CONTINUE  
b) Go to step 21
2) If some parameters are to be changed  
a) Use the live keyboard to assign new values (Note: This is done by identifying the variables to be changed with the variable assignment listings and then assigning the number wanted to each. For example, if the operator wants to change the gain of multiplexed temperature circuit # 11 to 0.100, he
finds the appropriate variable to be $S[2, 11]$. He then proceeds with:
1) Type: $0.1 + S[2, 11]$
2) Press: EXECUTE
The process is repeated until all variables selected by the user have been modified.)

b) When finished
Press: CONTINUE

21. When "Did you make any changes?" is displayed;
   a. If no,
      1) Press: NO
      2) Go to step 22
   b. If yes,
      1) Press: YES
      2) New parameters are printed
      3) Go to step 20.b.

22. When "Enter heading (3 lines available)" is displayed;
   a. Type: up to 80 character heading line
   b. Press: CONTINUE
   c. Go to step 22 until three lines have been entered

23. ["DATA ANALYSIS RUNNING" is displayed.] (Process may take several minutes depending on size of data file.)

24. When "Print total heat loss?" is displayed;
   a. If yes,
      1) Press: YES
      2) Total regional and whole body heat losses from beginning to end of experiment are printed.
      3) Go to step 25
   b. If no,
      1) Press: NO
      2) Go to step 25

25. When "ANALYSIS FINISHED; another run?" is displayed;
   a. If another file is to be analyzed,
      1) Press: YES
      2) Go to step 4
   b. If no,
      1) Press: NO
      2) "PROGRAM FINISHED" is displayed
IV. PROGRAM "SNSR15"

A. Introduction

Information concerning the fractional surface area represented by individual sensors as well as their calibration constants is needed by program "HEAT15" to properly scale the raw data. These values are contained in a data file called "ARAY15." While program "HEAT15" enables the operator to make changes in "ARAY15" it cannot create the original file. Program "SNSR15" can be used either to create a new "ARAY15" file or to modify an existing one. An "ARAY15" must exist on each flexible disk on which "HEAT15" is to record scaled data. A program listing appears in Appendix 3. The equipment requirements are the same as for "HEAT15."
B. User Instructions

1. Insert program disk into drive 0
   Type: drive 0, 707
   Press: EXECUTE

2. Type: get "SNSR15"
   Press: EXECUTE

3. When end of line mark (\m) is displayed
   Press: RUN

4. When "Remove Program Disk" is displayed;
   a. Remove disk from drive 0
   b. Press: CONTINUE

5. When "Insert Disk for ARAY15 file" is displayed;
   a. Insert disk into drive 0
   b. Press: CONTINUE

6. When "Printer Select Code = ?" is displayed;
   a. Type: number
   b. Press: CONTINUE

7. When "Create new ARAY15 file?" is displayed;
   a. If previous "ARAY15" file exists,
      1) Press: NO
      2) Go to step 8
   b. If no previous "ARAY15" file exists,
      1) Press: YES
      2) Go to step 10

8. [Current contents of "ARAY15" file are printed.]

9. When "Modify ARAY15 file?" is displayed;
   a. If changes are to be made,
      1) Press: YES
      2) Go to step 10
   b. If file is correct as it stands,
      1) Press: NO
      2) Program stops

10. When "Number of MPX HFS = ?" is displayed;
    a. Type: N, where N is the number of multiplexed heat flux sensors
       (Note: In steps 10-21, if the information requested in a particular
       line need not be changed from that already stored in "ARAY15," simply
       press CONTINUE. The originally entered number will remain unchanged.)
    b. Press: CONTINUE

11. When "Number of MPX TMP sensors = ?" is displayed;
    a. Type: N, where N is the number of multiplexed temperature sensors
    b. Press: CONTINUE
12. When "Number of AUX sensors = ?" is displayed;
   a. Type: N, where N is the number of auxiliary sensors
   b. Press: CONTINUE

13. When "Sensor # <I>" is displayed,
    Press: CONTINUE

14. When "Serial # = ?" is displayed;
    a. Type: number for serial number of sensor # I
    b. Press: CONTINUE

15. When "Cal const = ?" is displayed;
    a. Type: number for heat flux calibration constant (W/M\(^2\)-mV) for sensor # I
    b. Press: CONTINUE

16. When "Weighting factor = ?" is displayed;
    a. Type: number for fractional surface area weighting factor (decimal) for sensor # I
    b. Press: CONTINUE

17. Is I < 10?
    a. If yes,
       1) I is incremented by 1
       2) Go to step 13
    b. If no, go to step 18

18. When "AUX # <I>" is displayed;
    Press: CONTINUE

19. When "Serial # = ?" is displayed;
    a. Type: number for auxiliary sensor # I
    b. Press: CONTINUE

20. When "Cal const = ?" is displayed;
    a. Type: number for heat flux calibration constant (W/M\(^2\)-mV) for auxiliary sensor # I
    b. Press: CONTINUE

21. When "Weighting factor = ?" is displayed;
    a. Type: number for surface area weighting factor (decimal) for auxiliary sensor # I
    b. Press: CONTINUE

22. Is I < 5?
    a. If yes, I is incremented by 1, go to step 18
    b. If no, go to step 23

23. [The contents of file "ARAY15" just entered are printed.]
24. When "Does previous ARAY15 file exist?" is displayed;
   a. If file exists on the flexible disk,
      Press: YES
   b. If file does not already exist on the disk,
      Press: NO

25. [New "ARAY15" file is stored on flexible disk.]

26. ["Program Finished" is displayed.]
V. PROGRAM "PLT15"

A. Introduction

It is often useful to plot data from the individual sensors in order to verify their proper functioning and to look for trends and other features of the data. Program "PLT15" performs this function for scaled data files created by "HEAT15" or "cmbDAT." The program allows the user to select whether he wants to inspect the output of a few sensors or wants all the data to be plotted automatically. Experience has shown that when a heat flux transducer malfunctions it usually outputs a constant, near-zero voltage. The temperature probes, however, often produce wildly varying signals when they become defective. To eliminate these distracting traces from the plots, the program allows individual temperature sensors to be deleted from the automatic cycle. It should be noted that due to restrictions on the memory capacity of the computer, only scaled data files with the number of records <375 can be plotted. This limit usually is not a problem since it represents an elapsed time of ~6 h.

The program listing, variable assignments, and equipment list are given in Appendix 4. Detailed user instructions for "PLT15" are given in the following section.
B. User Instructions

1. Insert program disk in drive 0
   Type: get "PLT15"
   Press: EXECUTE

2. When end of line mark (--) is displayed
   Press: RUN

3. When "Remove Program Disk" is displayed;
   a. Remove disk
   b. Press: CONTINUE

4. When "Insert Data Disk" is displayed;
   a. Insert disk containing scaled data to be plotted in drive 0
   b. Press: CONTINUE

5. When "Enter name of analyzed data file" is displayed;
   a. Type: name
   b. Press: CONTINUE

6. When "Plotter Select Code ?" is displayed;
   a. Type: select code of plotter to be used
   b. Press: CONTINUE
   c. Put paper on plotter and set points P1 and P2 as necessary

7. When "Number of Heat Flux sensors = ?" is displayed;
   a. Type: total number (multiplexed and auxiliary) of flux sensors to be plotted (maximum of 15)

8. When "Max time to be searched = ?" is displayed;
   a. Type: number (in minutes) [Program will find maximum and minimum values of heat flux and temperature; it will search from time zero to the end of data file or to time entered here, whichever is less.]
   b. Press: CONTINUE
   c. "SEARCHING FOR MAXIMUM VALUES" is displayed
   d. Maximum and minimum values are printed

9. When "Plot heat flux data?" is displayed;
   a. If yes,
      1) Press: YES (key f0)
      2) Go to step 10
   b. If no,
      1) Press: NO (key f6)
      2) Go to step 22

10. When "Draw axes?" is displayed;
    a. If you want axes drawn for heat flux plot,
       Press: YES (x-axis is time in minutes, y-axis is heat flux in W/m²)
    b. If you want data plotted without axes being drawn
       Press: NO
11. When "Maximum value of time = ?" is displayed;
a. Type: number for maximum value of time wanted on X-axis of plot
b. Press: CONTINUE

12. When "Maximum value of heat flux = ?" is displayed;
a. Type: number wanted for maximum value of heat flux (W/M²) on Y-axis
   of plot
b. Press: CONTINUE

13. When "Minimum value of heat flux = ?" is displayed;
a. Type: number wanted for minimum value of heat flux (W/M²) on Y-axis
   of plot
b. Press: CONTINUE

14. If you answered "NO" in step 10, go to step 17.

15. When "X-axis tic interval = ?" is displayed;
a. Type: number (in minutes) that represents the time between labelled
   tic marks on the X-axis
b. Press: CONTINUE

16. When "Y-axis tic interval = ?" is displayed;
a. Type: number (in W/M²) that represents the interval between labelled
   tic marks on the Y-axis
b. Press: CONTINUE
c. Axes are drawn

17. When "Plot individual sensors?" is displayed;
a. If you want all sensors automatically plotted,
   1) Press: NO
   2) Go to step 18
b. If you want to select only certain sensors to be plotted,
   1) Press: YES
   2) Go to step 18

18. ["Heat Flux Data is being read" is displayed.]

19. Are individual sensors to be plotted?
a. If you answered "YES" in step 17, then "Sensor HF to be plotted?" is
   displayed;
   1) Type: number (auxiliary HFS # I is selected by entering # [I + 10])
   2) Press: CONTINUE
   3) Go to step 20 (To get out of loop, enter a number >15, then go
to step 22)
b. If you answered "NO" in step 17, then all sensors will be plotted
   automatically. Go to step 20.

20. ["Plotting sensor # <n>" is displayed as the data are plotted.]

21. Are individual sensors being plotted?
a. If yes, return to step 19.a.
b. If sensors are being plotted automatically
   1) If \( n < \) number entered in step 7,
      a) \( n \) is incremented by 1
      b) Go to step 20
   2) If \( n = \) number entered in step 7, go to step 22.

22. When "Plot individual TMP sensors?" is displayed;
   a. If you want to plot only individually selected sensors
      1) Press: YES
      2) Go to step 25
   b. If you want temperatures plotted automatically,
      1) Press: NO
      2) When "Do you want to delete some TMP?" is displayed;
         a) If you want some temperature sensors deleted from the
            automatic plotting routine,
            (1) Press: YES
            (2) Go to step 23
         b) If you want all sensors plotted,
            (1) Press: NO
            (2) Go to step 25

23. When "How many TMPs to be deleted?" is displayed;
   a. Type: number
   b. Press: CONTINUE

24. When "TMP sensor \( # \) to be deleted = ?" is displayed;
   a. Type: number \( (1 \leq n \leq 17) \) of one of the sensors to be deleted
      (auxiliary \( # I \) is selected by \( # (I + 12) \); rectal temperature is \( # 11 \);
      ambient temperature is \( # 12 \))
   b. Press: CONTINUE
   c. Return to step 24.a. until the number of sensors specified in step 23
      have been selected

25. When "Prepare plotter for TEMP plot" is displayed;
   a. Remove heat flux plot
   b. Position paper for temperature plot
   c. Press: CONTINUE

26. When "Draw axes?" is displayed;
   a. If you want axes drawn for temperature plot
      Press: YES (X-axis is time in minutes, Y-axis is temperature \( ^\circ C \))
   b. If you want data plotted without axes being drawn
      Press: NO

27. When "Maximum value of time = ?" is displayed;
   a. Type: number wanted for maximum value of time on X-axis of plot
   b. Press: CONTINUE

28. When "Maximum value of temperature = ?" is displayed;
   a. Type: number wanted for maximum value of temperature \( (^\circ C) \) on Y-axis
      of plot
   b. Press: CONTINUE
29. When "Minimum value of temperature = ?" is displayed;
   a. Type: number wanted for minimum value of temperature (°C) on Y-axis of plot
   b. Press: CONTINUE

30. If you answered "NO" in step 26, go to step 33.

31. When "X-axis tic interval = ?" is displayed;
   a. Type: number (in minutes) that represents the time between labelled tic marks on X-axis
   b. Press: CONTINUE

32. When "Y-axis tic interval = ?" is displayed;
   a. Type: number (°C) that represents the interval between labelled tic marks on Y-axis
   b. Press: CONTINUE
   c. Axes are drawn

33. Are individual sensors to be plotted?
   a. If you answered "YES" in step 22, then "TMP sensor to be plotted = ?" is displayed;
      1) Type: number (auxiliary # I is selected by entering # [I + 12]; rectal temperature = 11; ambient temperature = 12)
      2) Press: CONTINUE
      3) Go to step 34 (To get out of the loop, enter a number >17, then go to step 36)
   b. If you answered "NO" in step 22, then sensors will be plotted automatically, go to step 34

34. ["Plotting sensor # <n>" is displayed as the data are plotted.]

35. Are individual sensors being plotted?
   a. If yes, return to step 33.a.
   b. If sensors are being plotted automatically,
      1) If (n-2) < number entered in step 7,
         a) n is incremented by 1
         b) Go to step 34
      2) If (n-2) = number entered in step 7,
         Go to step 36

36. When "Another set of plots to be run?" is displayed;
   a. If yes,
      1) Press: YES
      2) Go to step 5
   b. If no,
      1) Press: NO
      2) "PLOTTING ROUTINE FINISHED" is displayed
VI. Program "AVG15"

A. Introduction

Often when data are being analyzed, it is desirable to compare the steady-state values obtained under one set of experimental conditions with those found for different conditions. A more accurate comparison can be made if the heat flux and temperature results are averaged over a number of data collection cycles. Program "AVG15" performs this function.

Once the operator has entered the numbers of the first and last data records which specify a time interval, the program finds the arithmetic mean of the output of each sensor for the interval designated. The name of each body site monitored is stored in the data file "SITE" which can be created and/or modified using "AVG15." The output appears on the external printer. It consists of the mean values for each transducer of heat flux, skin temperature, differential temperature between skin and ambient, and convective heat flow coefficient.

The user instructions appear in the following section. Program listing and variable assignments are given in Appendix 5.
B. User Instructions

1. Insert program disk in drive 0
   Type: get "AVG15"
   Press: EXECUTE

2. When end of line mark (\) is displayed
   Press: RUN

3. When "Remove Program Disk" is displayed;
   a. Remove disk
   b. Press: CONTINUE

4. When "Insert Data Disk in drive 0" is displayed;
   a. Insert disk
   b. Press: CONTINUE

5. When "Printer Select Code = ?" is displayed;
   a. Type: select code number
   b. Press: CONTINUE

6. When "Enter name of analyzed data file" is displayed;
   a. Type: name
   b. Press: CONTINUE

7. When "Do you want max time search?" is displayed;
   a. If yes,
      1) Press: YES (key f0)
      2) Go to step 8
   b. If no,
      1) Press: NO (key f6)
      2) Go to step 10

8. ["Finding maximum time" is displayed.]

9. On internal printer is output:
   a. "Max record # = <n>"
   b. "Max time = <m>"

10. When "Create new SITE file?" is displayed;
    a. If a "SITE" file has been previously stored on this disk,
       1) Press: NO
       2) Go to step 13
    b. If a "SITE" file does not already exist on this disk,
       1) Press: YES
       2) Go to step 11

11. When "SENSOR # <I>" is displayed;
    a. Press: CONTINUE
    b. When "Body site name = ?" is displayed;
       1) Type: name (maximum of 10 characters)
       2) Press: CONTINUE
c. Is I < 15?
   1) If yes,
      a) I is incremented by 1
      b) Go to step 11
   2) If no, go to step 12

12. When "Does Previous SITE file exist?" is displayed
    Press: NO

13. When "Do you want SITE printed?" is displayed;
    a. If yes,
       1) Press: YES
       2) Contents of file are printed on external printer
       3) Go to step 14
    b. If no,
       1) Press: NO
       2) Go to step 14

14. When "Do you want to change SITE?" is displayed;
    a. If no,
       1) Press: NO
       2) Go to step 17
    b. If yes,
       1) Press: YES
       2) Go to step 15

15. When "Sensor # <I>" is displayed;
    a. Press: CONTINUE
    b. When "Body site name = ?" is displayed;
       1) If name is not to be changed,
          a) Press: CONTINUE
          b) Go to step c.
       2) If the name is to be changed,
          a) Type: new name
          b) Press: CONTINUE
          c) Go to step c.
    c. Is I < 15?
       1) If yes,
          a) I is incremented by 1
          b) Go to step 15
       2) If no, go to step 16

16. When "Does previous SITE file exist?" is displayed,
    a. Press: YES
    b. New "SITE" file is recorded
    c. Go to step 13

17. When 
    "# of first record wanted = ?" is displayed;
    a. Type: number
    b. Press: CONTINUE

18. When 
    "# of last record wanted = ?" is displayed;
    a. Type: number
    b. Press: CONTINUE
19. ["Averaging Data" is displayed.]
(The time-averaged value for each heat flux and temperature sensor will be computed for the interval between the first and last data records chosen above.)

20. [Average values are printed on external printer using the contents of the "SITE" file to identify each sensor.]

21. When "Average another period?" is displayed;
   a. If yes,
      1) Press: YES
      2) Go to step 17
   b. If no,
      1) Press: NO
      2) Go to step 22

22. When "Analyze another data file?" is displayed;
   a. If yes,
      1) Press: YES
      2) Go to step 6
   b. If no,
      1) Press: NO
      2) Program ends
VII. UTILITY PROGRAMS

A. Introduction

The four programs described in this section are utility programs used to troubleshoot the system or to perform minor editing of the scaled data files. Program listings are given in Appendix 6.

Program "RCAL15" reads the information stored in a calibration file and prints the values on an external printer. Program "RDAT15" performs the same function for an original data file. Note that the numbers printed are the voltages actually measured by the DVM and are not scaled. Thus the operator has access to the raw data, which is often useful in tracking down problems in the system. The printout of "RCAL15" is sufficiently labelled so that there should be no confusion as to the information that is displayed. Note that both these programs assume the printer select code is 706. The format of the printout for "RDAT15" is the following:

heading of data file
\# temperatures multiplexed \# heat flux multiplexed
\# of record
10 values of multiplexed heat flux
time of record (minutes)
12 values of multiplexed temperature
5 values of auxiliary heat flux
5 values of auxiliary temperature

The section in brackets is repeated for each data record in the data file.
Occasionally a data file is closed before an experiment is completed. This situation can arise for a number of reasons, such as reserving too few records on the disk to hold the data or a power outage that causes the computer to lose the program. In such cases, the program can be re-started and the ensuing data recorded in a new file. The fact that data from a given experiment are contained in more than one file can be inconvenient when the user desires a plot of the complete experiment or wants to run an analysis routine. Program "cmbDAT" combines two scaled data files (created by "HEAT15") into a single one. Drive 0 of the dual flexible disk drive must contain the disk with the files to be combined and drive 1 the disk on which the new file is to be recorded. To find the number of records required on the disk for each of the files, the operator can execute a catalogue command for drive 0. When the program has finished, the original files are left unaltered; the new combined file is recorded on the drive 1 disk under the name selected.

The program "negHFS" is helpful whenever heat flux transducers have been reverse-wired or applied to a subject with the wrong surface toward the skin. Since the voltage output of these sensors only changes sign when the direction of heat flow changes, the data collected can have the correct amplitude but the wrong algebraic sign. Any scaled data file produced by "HEAT15" can be corrected for this problem with program "negHFS."

The dual flexible disk drive (HP 9895) is needed; the disk containing the scaled data is placed in drive 0, while a "scratch" disk used for temporary storage is placed in drive 1. The operator selects which heat flux signals are to be reversed. When the program is finished, the original scaled data file has been replaced with the new file (with the appropriate reversed values) and the scratch disk is left with no new files recorded on it.
B. User Instructions for "RCAL15"

1. Insert program disk
   Type: get "RCAL15"
   Press: EXECUTE

2. When "end of line mark (r)" is displayed
   Press: RUN

3. When "Remove Program Disk" is displayed;
   a. Remove disk
   b. Press: CONTINUE

4. When "Insert Data Disk" is displayed;
   a. Insert disk
   b. Press: CONTINUE

5. When "Enter name of file to be read" is displayed;
   a. Type: name
   b. Press: CONTINUE
   c. Contents of file are printed
   d. Program ends

(Note: Program assumes select code of external printer is 706.)
C. User Instructions for "RDAT15"

1. Insert program disk
   Type: get "RDAT15"
   Press: EXECUTE

2. When end of line mark (⇒) is displayed
   Press: RUN

3. When "Remove Program disk" is displayed;
   a. Remove disk
   b. Press: CONTINUE

4. When "Insert Data Disk" is displayed;
   a. Insert disk
   b. Press: CONTINUE

5. When "Enter name of file to be read" is displayed;
   a. Type: name
   b. Press: CONTINUE

6. When "Do you want temperature values?" is displayed;
   a. If yes,
      1) Press: YES (key f₀)
      2) Go to step 7
   b. If no,
      1) Press: NO (key f₆)
      2) Go to step 7

7. [Contents of file are printed.]
   Program ends
D. User Instructions for "cmbDAT"

1. Insert: program disk into drive 0
   Type: get "cmbDAT"
   Press: EXECUTE

2. When end of line mark (→) is displayed
   Press: RUN

3. When "Remove Program Disk" is displayed;
   a. Remove disk
   b. Press: CONTINUE

4. When "Insert Data Disk in drive 0" is displayed;
   a. Insert disk with data files to be combined
   b. Press: CONTINUE

5. When "Insert new file disk in drive 1" is displayed;
   a. Insert disk on which combined file is to be recorded
   b. Press: CONTINUE

6. When "Name of first data file?" is displayed;
   a. Type: name
   b. Press: CONTINUE

7. When "Name of second data file?" is displayed;
   a. Type: name
   b. Press: CONTINUE

8. When "Name of combined data file?" is displayed;
   a. Type: name
   b. Press: CONTINUE

9. When "# of records for combined file?" is displayed;
   a. Type: number (must be ≥ sum of records for files 1 and 2)
   b. Press: CONTINUE

10. When "New header for combined file - ?" is displayed;
    a. Type: alphanumeric line up to 80 characters long
    b. Press: CONTINUE
    c. Return to step 10 until 3 lines have been entered

11. When "Elapsed minutes between files - ?" is displayed;
    a. Type: time in minutes that elapsed between the moment data
collection stopped for first file and restarted for second file.
    b. Press: CONTINUE

12. ["Combining Data Files Now" is displayed.]

13. When "Finished" is displayed;
    a. Program has ended
    b. Remove disks
E. User Instructions for "negHFS"

1. Insert: program disk in drive 0
   Type: get "negHFS"
   Press: EXECUTE

2. When end of line mark (\(\rightarrow\)) is displayed
   Press: RUN

3. When "Remove Program Disk" is displayed;
   a. Remove disk
   b. Press: CONTINUE

4. When "Insert Data Disk in drive 0" is displayed;
   a. Insert disk on which data file is recorded
   b. Press: CONTINUE

5. When "Insert Scratch Disk in drive 1" is displayed;
   a. Insert disk to be used as temporary storage disk during running of program
   b. Press: CONTINUE

6. When "Name of Data file?" is displayed;
   a. Type: name
   b. Press: CONTINUE

7. [Header of file is printed.]

8. When "Number of records in data file?" is displayed;
   a. Type: number
   b. Press: CONTINUE

9. When "How many HFS to be reversed?" is displayed;
   a. Type: number
   b. Press: CONTINUE

10. When "HF sensor # to be reversed = ?" is displayed;
    a. Type: number (from 1 to 15) of one heat flux sensor whose signal is to be inverted. (Note: auxiliary sensor # I is assigned the number [10 + I] in this instance.)

11. ["Program is Running Now" is displayed.]

12. When "Finished" is displayed, remove disks.
The values obtained during calibration are printed for inspection by the user. The heat flux circuits have low offset and a nominal gain of 500; thus, the low level calibration output should be <0.05 V and the high-level value should equal <2.5 V. For temperature, the nominal scaling is 100 mV/°C. The low output should read ~0.1 V and the high output ~4.0 V.

A program listing, variable allocations, flow charts, and required equipment are given in Appendix I.
References


"FLUX15"

EQUIPMENT REQUIRED

1. Hewlett-Packard 9825B desktop computer
   or
   Hewlett-Packard 9825A with the followings ROM's:
   a. general I/O
   b. extended I/O
   c. advanced programming
   d. string variable

2. Hewlett-Packard (HP) 9895/9885 flexible disk drive ROM

3. HP 98034A (HP-IB) interface bus

4. HP 98035A real-time clock

5. Printer for computer (such as HP 7245, HP 9866, or HP 9876)

6. HP 3495A scanner with high speed controller and low-thermal relay options

7. HP 3455A digital voltmeter

8. HP 9885M flexible disk drive
"FLUX15"

IDENTIFICATION OF SCANNER CHANNELS

<table>
<thead>
<tr>
<th>SCANNER CHANNEL</th>
<th>INPUT SIGNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(not used)</td>
</tr>
<tr>
<td>1</td>
<td>Clock from controller</td>
</tr>
<tr>
<td>2</td>
<td>Multiplexed Heat Flux</td>
</tr>
<tr>
<td>3</td>
<td>Multiplexed Temperature</td>
</tr>
<tr>
<td>4</td>
<td>Auxiliary # 1 Heat Flux</td>
</tr>
<tr>
<td>5</td>
<td>Auxiliary # 1 Temperature</td>
</tr>
<tr>
<td>6</td>
<td>Auxiliary # 2 Heat Flux</td>
</tr>
<tr>
<td>7</td>
<td>Auxiliary # 2 Temperature</td>
</tr>
<tr>
<td>8</td>
<td>Auxiliary # 3 Heat Flux</td>
</tr>
<tr>
<td>9</td>
<td>Auxiliary # 3 Temperature</td>
</tr>
<tr>
<td>10</td>
<td>Auxiliary # 4 Heat Flux</td>
</tr>
<tr>
<td>11</td>
<td>Auxiliary # 4 Temperature</td>
</tr>
<tr>
<td>12</td>
<td>Auxiliary # 5 Heat Flux</td>
</tr>
<tr>
<td>13</td>
<td>Auxiliary # 5 Temperature</td>
</tr>
<tr>
<td>14</td>
<td>Calibration Voltage Source</td>
</tr>
<tr>
<td>15-20</td>
<td>(not used)</td>
</tr>
</tbody>
</table>
"FLUX15"

PROGRAM LISTING

0: "This program is called FLUX15; it performs A/D conversion and storage":
1: "of data from the thermal loss system, either in real time or from ":
2: "analog tape. The calibration information and data are stored in two":
3: "separate files, the names of which are selected in the program by ":
4: "the user. Up to 15 sensors may be used":
5: "Version: 2 March 1982 ** RPL ":
6:
7: prt "To resume taking data after program has been stopped during data"
8: prt "collection, execute cont 65";prt ";";prt ""
9:
10:
11: "SCANNER CHANNELS":
12: ";0 --not used":
13: ";1 --clock":
14: ";2 --MPX HFS":
15: ";3 --MPX TMP":
16: ";4 --AUX 1 HF":
17: ";5 --AUX 1 T":
18: ";6 --AUX 2 HF":
19: ";7 --AUX 2 T":
20: ";8 --AUX 3 HF":
21: ";9 --AUX 3 T":
22: ";10--AUX 4 HF":
23: ";11--AUX 4 T":
24: ";12--AUX 5 HF":
25: ";13--AUX 5 T":
26: ";14--calibration voltage source":
27:
28: dim H[15],T[15],A[5],B[5],G[3],S{5},H[40],D[2,5],C[5]
29: dim R[2],A[5],S[3,80],C[6],D[80],X[4,15],E[32],Y[2,5],G[40]
30: getk "KEYS"
31: rem 7;fmt 3,f3.0;110 7;0+U
32: wrt 722, "FlR3T2M3A0H00D0"
33: ent "Printer Select Code=?",N
34: if N$706;goto +2
35: wtb N,27,40,65
36: dsp "REMOVE PROGRAM FLEXIBLE DISK!";stp
37: dsp "INSERT DATA FLEXIBLE DISK!";stp
39: if N=706;wrb 706,27,85
40:
41: "CLOCK LOW":-6.8+G[1]
42: "CLOCK HIGH":5.8+G[2]
43: "SYNC LEVEL":-3.8+G[3]
44:
45: prt "CLOCK LOW",G[1]
46: prt "CLOCK HIGH",G[2]
47: prt "SYNC",G[3];prt **;prt **
48: ent "Enter # of HFS multiplexed",L
49: ent "Enter # of TMP multiplexed",H
50: ent "Enter # of Auxiliary sensors",A
51: ent "Do you want to calibrate?",rl
52: if rl=1;call 'CAL'
53: fmt 2/,78**,/,78**,2;/wrt N;fmt
54: ent "Enter 6 character data file name",A$
55: ent "Number of data records=? (app.1.2/min)",Q;Q+20+Q
56: open A$,Q
57: asgn A$,1
58: ent "Enter first line of heading",B$[1];wrt N,B$[1]
60: ent "Enter third line of heading",B$[3];wrt N,B$[3]
61: for I=1 to 3
62: sprr 1,B$[I]
63: next I
64: sprr 1,H,L
65: dsp "Press Continue to Start Data";stp
66: dsp "Waiting for sync signal"
67: cll 'SYNC'
68: dsp "In Sync"
69: cll 'CLOCK'
70: wrt 9,"U2G"
71: for I=1 to H
72: cll 'MPXSCAN'
74: cll 'CLOCK'
75: next I
76: cll 'AUXSCAN'
77: for I=1 to A;S[I]+A[I];C[I]+B[I];next I
78: wrt 9,"U2V";red 9,E;E/600000+E;fmt 4,E6.2
79: U+1=U
80: sprt 1,u,E,H[*],A[*],T[*],B[*],C,D,F
82: wrt 0,T[I],E;fmt
83: if V=1;jmp 4
84: cll 'SYNC'
85: cll 'CLOCK'
86: gto 71
87: lcl 7;dsp "Data Collection Ended"
88: wait 10000;cll 'DUPE'
89: end
90:
91: "SYNC":
92: fmt 3,f3.0;wrt 709.3,2
93: trg 722;red 722,R;if RXG[3];gto +0
94: wait 5;trg 722;red 722,R;if RXG[3];gto -1
95: wait 5;trg 722;red 722,R;if RXG[3];gto -2
96: trg 722;red 722,R;if RXG[3];gto +0
97: wait 5;trg 722;red 722,R;if RXG[3];gto -1
98: ret
99:
100: "CLOCK":
101: wrt 709.3,1
102: trg 722;red 722,R;if RXG[1];gto +0
103: wait 5;trg 722;red 722,R;if RXG[1];gto -1
104: ret
105: "MPXSCAN":
106:  wrt 9, "ULG"
107:  oni 9, "TIME"
108:  eir 9;0+J;0*S[1];0+S[2]
109:  wrt 709.3, 2;trg 722;red 722,R[1];wrt 709.3, 3;trg 722;red 722,R[2]
111:  gto -2; if P=1;0>P; gto +1
113:  ret
114:
115: "TIME":
116:  1+P
117:  1+P
118:  1+P
119:
120: "AUXSCAN":
121:  oni 9,"TIME"
122:  for I=1 to 5;0*S[I]+C[I];next I
123:  for I=1 to A
124:  wrt 9,"ULG"
125:  eir 9;0+J
126:  2(I-1)+4+B;8+1+G
127:  wrt 709.3,B;trg 722;red 722,R[1];wrt 709.3,G;trg 722;red 722,R[2]
129:  gto -2; if P=1;0>P; gto +1
130:  S[I]/J+S[I];C[I]/J+C[I]
131:  next I
132:  ret
133:
134: "CAL":
135: "Waiting for sync "-G$
136: "Calibration data is being read"-H$
137:  ent "Enter 6 character cal. file name",CS
138:  fmt 4,"CALIBRATION FILE NAME:",2X,C6;N+.4+M;wrt M,C$  
139:  open C$, 3
140:  asgn C$, 2
141: ent "Enter heading for cal. file",D$
142: wrt N,D$;splt 2,D$
143: dsp "Calibrate heat flux sensors";stp
144: dsp "Cal. HFS, LOW voltage (0 mv)";stp
145: cl1 'VOLT'
146: S[l]*r2
147: fmt 4,2,/'HFS LOW CALIBRATION, INPUT V= ".f7.3," MV",/;N+.4+M;wrt M,r2
148: "Press CONTINUE to take reading"+E$
149: dsp E$;stp
150: dsp G$
151: cl1 'SYNC'
152: cl1 'CLOCK'
153: dsp H$
154: for I=1 to L
155: cl1 'CALHFS'
156: S[l]*X[1,I]
157: cl1 'CLOCK'
158: next I
159: cl1 'CALAH'
160: for I=1 to A;S[I]=X[1,I];next I
161: for I=1 to L
162: fmt 1,f2.0,5x,f10.6
163: N+.1+M;wrt M,1,X[1,I]
164: next I
165: fmt 2,/'AUXILIARY HEAT FLUX SENSORS: ",/;N+.2+M;wrt M
166: N+.1+M
167: for I=1 to A;wrt M,1,Y[1,I];next I
168: ent "Repeat Calibration ?",rl
169: if rl=1;goto 144
170: dsp "Cal. HFS, HIGH voltage (5 mv)";stp
171: cl1 'VOLT'
172: S[l]*r3
173: fmt 4,2,/'HFS HIGH CALIBRATION, INPUT V= ".f7.3," MV",/;N+.4+M;wrt M,r3
174: dsp E$;stp
175: dsp G$
176: cl1 'SYNC'
177: cl1 'CLOCK'
178: dsp HS
179: for I=1 to L
180: cl1 'CALHFS'
181: S[I]+X[2,I]
182: cl1 'CLOCK'
183: next I
184: cl1 'CALAH'
185: for I=1 to A;S[I]+Y[2,I];next I
186: for I=1 to L
187: N+.1+M;wrt M,I,X[2,I]
188: next I
189: N+.2+M;wrt M;N+.1+M
190: for I=1 to A;wrt M,I,Y[2,I];next I
191: ent "Repeat Calibration?",rl
192: if rl=1;gto 170
193: dsp "CALIBRATE TEMPERATURE";stp
194: ent "Low T in degrees C = ?",r6
195: fmt 4,2,"Low T CALIBRATION TEMP.= ",f6.2," C",;N+.4+M;wrt M,r6
196: dsp ES;stp
197: dsp GS
198: cl1 'SYNC'
199: cl1 'CLOCK'
200: dsp HS
201: for I=1 to H
202: cl1 'CALTMP'
203: S[I]+X[3,I]
204: cl1 'CLOCK'
205: next I
206: cl1 'CALAT'
207: for I=1 to A;C[I]+D[1,I];next I
208: for I=1 to H
209: N+.1+M;wrt M,I,X[3,I]
210: next I
211: fmt 2,"AUXILIARY TEMPERATURE SENSORS: ",;N+.2+M;wrt M
212: N+.1+M
213: for I=1 to A:wrt M,I,D[1,I];next I
214: ent "Repeat Calibration?",rl
215: if rl=1;gto 194
216: ent "High T in degrees C = ?",r7
218: dsp ES;stp
219: dsp GS
220: cll 'SYNC'
221: cll 'CLOCK'
222: dsp HS
223: for I=1 to H
224: cll 'CALMP'
225: S[I]+X[4,I]
226: cll 'CLOCK'
227: next I
228: cll 'CALAT'
229: for I=1 to A;C[I]+D[2,I];next I
230: for I=1 to H
231: N+.1+M:wrt M,1,X[4,I]
232: next I
233: N+.2+M:wrt M,N+.1+i4
234: for I=1 to A:wrt M,I,D[2,I];next I
235: ent "Repeat Calibration?",rl
236: if rl=1;gto 216
237: sprt 2,r2,r3,r4,r5,r6,r7
238: sprt 2,X[*]
239: sprt 2,Y[*]
240: sprt 2,D[*]
241: dsp "Calibration Completed";stp
242: ret
243:
244: "CALIFS":
245: wrt 9,"ULG"
246: oni 9,"TIMS"
247: eir 9;0+J;0+S[1]
248: wrt 709.3,2
250: gto -1;if P=1;O+P;gto +1
251: S[1]/J+S[1]
252: ret
253:
254: "CALTMP":
255: wrt 9,"ULG"
256: oni 9,"TIME"
257: eir 9;O+J;0+S[1]
258: wrt 709.3,3
260: gto -1;if P=1;0+P;gto +1
261: S[1]/J+S[1]
262: ret
263:
264: "CALAH":
265: oni 9,"TIME"
266: for I=1 to 5;0+S[1];next I
267: for I=1 to A
268: wrt 9,"U3G"
269: eir 9;0+J
270: 2(I-1)+4+8
271: wrt 709.3,8
273: gto -1;if P=1;O+P;gto +1
274: S[1]/J+S[1]
275: next I
276: ret
277:
278: "CALAT":
279: oni 9,"TIME"
280: for I=1 to 5;0+C[1];next I
281: for I=1 to A
282: wrt 9,"U3G"
283: eir 9;0+J
284: 2(I-1)+5+8
285: wrt 709.3,G
287: goto -1;if P=1;0+P;goto +1
288: C[I]/J+C[I]
289: next I
290: ret
291:
292: "VOLT":
293: wrt 722,"R1T1";wrt 709.3,L4
294: dsp "Press CC 1T to read input volts";stp
295: wrt 722,"T2":J*S[1];dsp "READING CALIBRATION VOLTAGE"
296: for I=1 to 10
298: next I
300: wrt 722,"R3"
301: ret
302:
303: "DUPE":
304: dsp "Press continue to duplicate data";stp
305: dsp "INSERT TAPE FOR DATA DUMP";stp
306: dsp "DATA IS BEING RECORDED ON TAPE"
307: trk 0;rew;ert 0
308: dump C$,0
309: dump A$,1
310: rew
311: dsp "REMOVE ORIGINAL DATA DISK";stp
312: dsp "INSERT DISK FOR DUPLICATE DATA";stp
313: dsp "DATA BEING RECORDED ON DISK"
314: open C$,3;open A$,Q
315: load C$,0
316: load A$,1
317: rew
318: dsp "DATA DUPLICATION COMPLETED"
319: ret
Appendix ld

"FLUX15"

VARIABLE ASSIGNMENTS

A
number of auxiliary sensors

B
used

C, D, F
variables stored on flexible disk but currently not assigned

E
elapsed time in minutes

G
used

H
number of temperatures multiplexed

I, J
used as counters

L
number of heat flux sensors multiplexed

M
used as printer and format number

N
select code of printer

P
used as flag for expiration of scan time

Q
number of data records

R
temporary storage of DVM reading

U
number of current data record

V
flag for ending data collection

A[*]:
A[I] is output of auxiliary heat flux sensor # I

B[*]:
B[I] is output of auxiliary temperature sensor # I

C[*]:
used

D[*]:
calibration signals

D[1,I]
auxiliary temperature sensor # I low calibration signal

D[2,I]
auxiliary temperature sensor # I high calibration signal

G[*]:
synchronization signals

G[1]
voltage set as clock low level

G[2]
voltage set as clock high level

G[3]
voltage set as synchronization pulse level

H[*]:
H[I] is output of multiplexed heat flux sensor # I

R[*]:
temporary storage of DVM readings

S[*]:
temporary storage of averaged DVM readings

T[*]:
T[I] is output of multiplexed temperature sensor # I

X[*]:
calibration signals

X[1,I]
multiplexed heat flux sensor # I low calibration signal

X[2,I]
multiplexed heat flux sensor # I high calibration signal

X[3,I]
multiplexed temperature sensor # I low calibration signal

X[4,I]
multiplexed temperature sensor # I high calibration signal

Y[*]:
calibration signals

Y[1,I]
auxiliary heat flux sensor # I low calibration signal

Y[2,I]
auxiliary heat flux sensor # I high calibration signal

A$
data file name

B$
header for data file

C$
calibration file name

D$
header for calibration file

E$
used

G$
used

H$
r1  yes/no flag
r2  HFS low cal input (mV)
r3  HFS high cal input (mV)
r4  currently not assigned
r5  currently not assigned
r6  low temperature cal input (°C)
r7  high temperature cal input (°C)
Subroutine: "CAL"

Start

Enter CAL File Name, Header

Open File on Disk

CAL HFS Amps, Input

Read Voltage Source

Call "SYNC"

Call "CLOCK"

I = 1

Call "CALHFS"

Call "CLOCK"

I < L?

Yes

I = I + 1

No

Call "CALAH"

Print Results

Repeat?

Yes

No

CAL HFS Amps High Input

Read Voltage Source

Call "SYNC"

Call "CLOCK"

I = 1

Call "CALHFS"

Call "CLOCK"

I < L?

Yes

I = I + 1

No

Call "CALAH"

Print Results

Repeat?

Yes

No
Subroutine: "CLOCK"

Start

Read Clock Line

Reading \( \geq G[1] \)?

Yes

No

Wait 5 ms

Read Clock Line

Reading \( \geq G[1] \)?

Yes

No

Return
Subroutine: "CALHFS"

- Start
- Start Timer
- \( J = \emptyset \)
- Select MPX HF Line
- Read HF
- Sum Values
- Time Ended?
  - No: \( J + 1 = J \)
  - Yes: Compute Avg.
- Return
Subroutine: "CALAH"

Start

I = 1, J = 1

Start Timer

Select Aux.of I, HF Line

Read HF

Sum Values

Time Ended?

Yes

Compute Avg.

J = 1, I + 1 = I

I < A?

Yes

No

Return

J + 1 = J

No
Subroutine: "CALTMP"

Start

Start Timer

\( J = 0 \)

Select TMP MPX Line

Read TMP

Sum Values

Time Ended?

Yes

Compute Avg.

Return

No

\( J + 1 = J \)
Subroutine: "MPX SCAN"

Start

Start Timer

\( J = \emptyset \)

Select MPX HF Line

Read HF Value

Select MPX TMP Line

Read TMP Value

Sum HF, TMP Values

Time Ended?

Yes

Compute Average HF, TMP

No

\( J + 1 = J \)

Return
Subroutine: "AUXSCAN"

1. Start
   - I = 1, J = 1
   - Start Timer

2. Select Aux HFS ≠ I
   - Read HF Value

3. Select Aux TMP ≠ I
   - Read TMP Value

4. Sum HF, TMP Values

5. Time Ended?
   - Yes: Compute Average for HF, TMP ≠ I
   - No: J + 1 = J

6. I + 1 = I
   - Yes: I < A?
   - No: Return

7. J = 1

8. End
1. Hewlett-Packard (HP) 9825B desktop computer or HP 9825A computer with the following ROM's:
   a. general I/O
   b. extended I/O
   c. advanced programming
   d. string variable

2. HP 9895/9885 flexible disk drive ROM

3. HP 9895 dual flexible disk drive

4. Printer, such as HP 7245, HP 9866, HP 9876

5. HP 98034A (HP-IB) interface bus
"HEAT15"

PROGRAM LISTING

0: "This program is called HEAT15; it converts voltage values from data":
1: "files created by FLUX15 to actual heat flux and temperatures":
2: "Data must already be on double disk for analysis in this version":
3: "Version: 10 February 1982 ** RPL":
4: 
5: dim C$[6], E$[6], D$[80], X[4, 15], Y[2, 5], V[2, 5], N[3], Z[2, 15], W[15], A[5, 2]
6: dim Q[5], A$[6], S[2, 15], B$[3, 80], F$[3, 80], D[2, 15], E[2, 5], K[2, 5]
7: dim H[15], T[15], C[5], B[5], P[15], M[12], P[5], I[15]
8: 
9: ent "Printer Select Code=", N; if N=706 or N=606; wtb N, 27, 40, 65
10: 
11: getk "KEY3"
12: dsp "INSERT DATA DISK in drive 0"; stp
13: dsp "INSERT NEW DATA DISK in drive 1"; stp
14: 
15: ent "Name of Calibration file?", C$
16: ent "Name of Data file wanted?", E$
17: ent "Name for new analyzed data file?", A$
18: asgn C$; 1; sread L, D$, r2, r3, r4, r5, r6, r7
19: sread L, X[*], Y[*], V[*]
20: ent "; records in original data file?", r 20
21: drive 1, 707; open A$, r 20; drive 0, 707
22: asgn E$, 3; asgn A$, 4, 1
23: cfg 1; ent "Do you want printout?", r 1; if r 1=0; sfg 1
24: 
25: wrt N, "Calibration file: ", C$; wrt N; wrt N, D$; wrt N
26: fmt 1, "/, "HFS Calibration input voltages (mv)", /, 7, x, e7.3, 15x, e7.3, 2/
27: N+1, 1+M; wrt M, r2, r3
28: fmt 2, e2.0, 5x, e10.6, 5x, e10.6, N+. 2+M
29: wrt N, "Low & High cal. output signals for HFS (Volts): "; wrt N
30: for I=1 to 10; wrt M, I, X[1, I], X[2, I]; next I
31: fmt 4, "/, "Auxiliary HFS", /, N+. 4*M; wrt M; N+. 5*M
32: fmt 5, "A", e1.0, 5x, e10.6, 5x, e10.6
33:  for I=1 to 5
34:  wrt M,I,Y[1,I],Y[2,I];next I
35:  fmt ,3,"Temperature Calibration input values (deg. C):";wrt N;fmt
36:  fmt 3,/,f6.2,5x,f6.2,2;/N+.3+M;wrt M,r6,r7
37:  wrt N,"Low & High cal. output signals for TMP (Volts):";wrt N;N+.2+M
38:  for I=1 to 12;wrt M,I,X[3,I],X[4,I];next I
39:  fmt 4,/,"Auxiliary Temperatures Sensors",;/N+.4+M;wrt M;N+.5+M
40:  for I=1 to 5;wrt M,I,V[1,I],V[2,I];next I
41:
42:  "ONE":
43:  asign "ARAY15",2,1
44:  sread 2,N[*],Z[*],W[*],A[*],Q[*]
45:  if flgl;gto "TWO"
46:
47:
48:  if N=706 or N=606;wrb N,27,85
49:  wrt N,"Sensor information stored in ARAY15:"
50:  fmt 1,/,"# HFS=",f2.0,5x,"# TMP sensors= ",f2.0,5x,"# AUX sensors= ",z
51:  N+.1+M;wrt M,N[1],N[2];fmt 1,f2.0;wrt M,N[3]
53:  wrt N;fmt
54:  fmt 1,f2.0,4x,f4.0,5x,f6.2,6x,f6.4
55:  for I=1 to 15
56:  wrt M,I,Z[1,I],Z[2,I],W[1]
57:  next I
58:  wrt N;fmt 1,"A",f1.0,4x,f4.0,5x,f6.2,6x,f6.4
59:  for I=1 to 5;wrt M,I,A[1,I],A[1,2],Q[1];next I
60:
61:  "THREE":
62:  ent "Do you want to change ARAY15?",rl
63:  if rl;cll 'SNSR'
64:  if rl=1;gto "TWO"
65:  ent "Modify ARAY15 again?",rl
66:  if rl;gto 63
67:
68:  "TWO":
69: ent "Height of subject (inches)=?", A; 2.54*A + A
70: ent "Weight of subject (pounds)=?", B; B*.4536 + B
71: A*7.25*B+.425*71.84 + r8; r8/10000 + r8
72: for I=1 to 15; r8=W[I]+W[I]; next I
73: for I=1 to 5; r8=Q[I]+Q[I]; next I
74: cll 'LINE'
75: fmt ,4/"Name of original data file: ", c6, /
76: wrt N,E$
77: fmt ,"Heading from data file: "; wrt N; fmt
78: for I=1 to 3
79: sread 3,B$[I]; next I
80: for I=1 to 3; wrt N,B$[I]; next I
81: sread 3,H,L; 0=P
82: for I=1 to 3
83: ent "Enter heading (3 lines avail.)", F$[I]
84: next I
85: sprt 4,C$,D$,E$,B$,P
86: sprt 4,N[*],r8
87: dsp "DATA ANALYSIS RUNNING"
88: cll 'ALYZE'
89:
90: "LINE":
91: if flg1; gto +7
92: fmt .5/; wrt N; fmt
93: wrt N,"PARAMETERS USED TO CALCULATE HEAT LOSS & TEMP. FROM DATA FILE:"
94: wrt N; wrt N
95: fmt 1,"Height= ",f5.1," cm", 5x,"Weight= ",f6.2," Kg", 5x,z
96: N+.1=M; wrt M,A,B
97: fmt 1,"Body surface area= ",f5.2," square meters",/; wrt N,r8
98: for I=1 to N[1]
99: 1000*(X[2,I]-X[1,I])/(r3-r2)*S[1,I]; if S[1,I]=0; l*S[1,I]
100: X[1,I]=S[1,I]*(r2/1000)+D[1,I]
101: next I
102: for I=1 to N[2]
103: (X[4,I]-X[3,I])/(r7-r6)*S[2,I]; if S[2,I]=0; l*S[2,I]
105:  next I
106:  for I=1 to N[3]
107:  1000*(Y[2,I]-Y[1,I])/(r3-r2)*E[1,I]; if E[1,I]=0; 1+E[1,I]
108:  Y[1,I]=E[1,I]*(r2/1000)*K[1,I]
111:  next I
112:  if flg1; ret
113:
114:  "FOUR":
115:  fmt 1,2,5x,"Ser. #",4x,"Const.",4x,"F Area",5x,"Gain",4x,"Offset",9x,z
116:  N+1+M;wrt 4
117:  fmt 1,"T Gain",4x,"T Offset",2;/;wrt M
118:  fmt 1,f2.0,4x,f4.0,5x,f5.1,5x,f5.3,5x,f5.1,5x,f6.3,10x,f5.3,5x,f5.2
119:  for I=1 to 12
120:  wrt M,I,Z[1,I],Z[2,I],W[1,I],S[1,I],D[1,I],S[2,I],D[2,I]
121:  next I
122:  wrt N
123:  fmt 1,"A",f1.0,4x,f4.0,5x,f5.1,5x,f5.3,5x,f5.1,5x,f6.3,10x,f5.3,5x,f5.2
124:  for I=1 to 5
125:  wrt M,I,A[1,I],A[1,2],Q[1,I],E[1,I],K[1,I],E[2,I],K[2,I]
126:  next I
127:  dsp "Make necessary changes, then continue";stp
128:  ent "Did you make any changes?",rl
129:  if rl;wrt N;wrt N;wrt N;gto "FOUR"
130:  ret
131:
132:  "ALYZE":
133:  on end 3,"LAST"
134:
135:  "FIVE":
136:  sread 3,U,E,H[*],C[*],T[*],B[*],C,D,F
137:  E-P+G;E+P
138:  for I=1 to N[1]
139:  1000((H[I]-D[1,I])/3[1,I])*Z[2,I]+F[I]
140:  F[I]*W[I]*G*60*I[1,I];I[I]+r9+r9
141: next I
142: for I=1 to N[3]
143: 1000*(C[I]-K[1,I])/E[1,I]*A[I,2]*P[10+I]
144: P[I+10]*Q[I]*G*60+I[I+10];I[I+10]+r9+r9
145: next I
146: for I=1 to N[2]
147: (T[I]-D[2,I])/S[2,I]*M[I]
148: next I
149: for I=1 to N[3]
150: (B[I]-K[2,I])/E[2,I]*P[I]
151: next I
152: sqrt 4,U-E,F[*],M[*],P[*]
153: gto "FIVE"
154: ret
155:
156: "LAST":
157: ent "Print total heat losses?",rl
158: gto 173;if rl=1;gto +1
159: fmt 1,2/"Sensor ",3x,"Total Heat Loss (Joules)",5x,"(Kcal)",/
160: N+1.1+M;wrt M
161: fmt 1,3x,f2.0,17x,f10.0,5x,f9.4
162: for I=1 to N[1]
163: wrt M,I,I[I,I[I]/1000*.2389
164: next I
165: wrt N
166: fmt 1,3x,"A",f1.0,17x,f10.0,5x,f9.4
167: wrt N
168: for I=1 to N[3]
169: wrt M,I,I[I[I],I[10]+I]/1000*.2389
170: next I
171: fmt ,2/"Total Body Heat Loss= ",f10.0,5x,f9.4
172: wrt N,r9,r9/1000*.2389;fmt
173: if H=706;wrb N,27,85
174: ent "DATA ANALYSIS FINISHED; another run?",rl
175: if rl;gto 12
176: dsp "PROGRAM FINISHED"
177: end
178:
179: "SN3R":
180: call 'ENTER'
181: call 'PRINT'
182: call 'CREATE'
183: ret
184:
185: "ENTER":
186: ent "Number of MPX HPS = ?",N[1],"Number of T sensors = ?",N[2]
187: ent "Number of AUX sensors= ?",N[3]
188: for I=1 to 10
189: fmt ,"Sensor # ",f2.0,wrt 0,I;stp
190: ent "Serial #=?",Z[1,I],"Cal. const.=?",Z[2,I],"Weighting factor=?",W[I]
191: next I
192: for I=1 to 5
193: fmt ,"AUX # ",f2.0,wrt 0,I;stp
194: ent "Serial #=?",A[1,I],"Cal. const.=?",A[1,2],"Weighting factor=?",Q[I]
195: next I
196: ret
197:
198: "PRINT":
199: fmt 3,3,78**,//;N+.3+M;wrt M
200: N+.1+M;fmt 1,2,**" # of HPS= ",f2.0,5x," # of T sensors= ",f2.0,5x,z
201: wrt M,N[1],N[2]
202: fmt 1," # of AUX sensors= ",f2.0,wrt M,N[3]
203: N+.1+M;fmt 1,7x,2x,"*",5x,"Const.","2x,"F. area";/;wrt M
204: for I=1 to 10
205: fmt 1,f2.0,4x,f4.0,5x,f5.1,5x,f6.4
206: wrt M,I,Z[1,I],Z[2,I],W[I]
207: next I
208: fmt 2,/,"AUXILIARY SENSORS",;N+.2+M;wrt M
209: N+.1+M
210: for I=1 to 5
211: wrt M,I,A[1,I],A[1,2],Q[I]
212: next I
"HEAT15"

**VARIABLE LISTING**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Height of subject in inches</td>
</tr>
<tr>
<td>B</td>
<td>Weight of subject in pounds</td>
</tr>
<tr>
<td>C</td>
<td>used, not currently assigned</td>
</tr>
<tr>
<td>D</td>
<td>used, not currently assigned</td>
</tr>
<tr>
<td>E</td>
<td>elapsed time in minutes</td>
</tr>
<tr>
<td>F</td>
<td>used, not currently assigned</td>
</tr>
<tr>
<td>G</td>
<td>number of temperature sensors multiplexed</td>
</tr>
<tr>
<td>H</td>
<td>used as counter</td>
</tr>
<tr>
<td>I</td>
<td>number of heat flux sensors multiplexed</td>
</tr>
<tr>
<td>L</td>
<td>printer select code plus format number</td>
</tr>
<tr>
<td>M</td>
<td>printer select code</td>
</tr>
<tr>
<td>P</td>
<td>used</td>
</tr>
<tr>
<td>U</td>
<td>number of current original data record</td>
</tr>
</tbody>
</table>

**A**: auxiliary sensors
- **A[I,1]**: serial number of sensor #I
- **A[I,2]**: heat flux calibration constant for sensor #I

**B**: data voltage signal for auxiliary temperatures
- **B[I]**: value for sensor #I

**C**: data voltage signal for auxiliary heat flux sensors
- **C[I]**: value for sensor #I

**D**: offset voltages of multiplexed sensors
- **D[1,I]**: heat flux circuit #I
- **D[2,I]**: temperature sensor #I

**E**: auxiliary sensor amplifier gains
- **E[1,I]**: heat flux circuit #I
- **E[2,I]**: temperature circuit #I

**F**: scaled heat flux (W/M²)
- **F[I]**: 1 ≤ I ≤ 10, multiplexed sensors # I
- **F[I]**: 11 ≤ I ≤ 15, auxiliary sensor # (I-10)

**H**: data voltage signal for multiplexed heat flux sensors
- **H[I]**: sensor # I

**I**: scaled heat loss (W)
- **I[J]**: 1 ≤ J ≤ 10, multiplexed sensor # J
- **I[J]**: 11 ≤ J ≤ 15, auxiliary sensor # (J - 10)

**K**: offset voltages for auxiliary sensors
- **K[1,I]**: heat flux circuit # I
- **K[2,I]**: temperature sensor # I

**M**: scaled multiplexed temperatures (°C)
- **M[I]**: 1 ≤ I ≤ 10, sensor #I
- **M[11]**: rectal temperature
- **M[12]**: ambient temperature

**N**: number of multiplexed heat flux sensors
- **N[1]**
- **N[2]**
- **N[3]**: number of auxiliary sensors
P[*]: scaled auxiliary temperatures (°C)
P[I]: sensor # I value
Q[*]: surface area weighting factors for auxiliary sensors
Q[I]: value for sensor # I
S[*]: gains of multiplexed circuits
S[1,I]: heat flux circuit # I
S[2,I]: temperature circuit # I
T[*]: data voltage signal for multiplexed temperatures
T[I]: \(1 \leq I \leq 10\), sensor # I
T[11]: rectal probe
T[12]: ambient probe

V[*]: auxiliary temperature sensor calibration signals
V[1,I]: low temperature for sensor # I
V[2,I]: high temperature for sensor # I

W[*]: surface area weighting factors for multiplexed sensors
W[I]: value for sensor # I

X[*]: calibration output signals for multiplexed sensors
X[1,1]: low calibration for heat flux # I
X[2,1]: high calibration for heat flux # I
X[3,1]: low calibration for temperature # I
X[4,1]: high calibration for temperature # I

Y[*]: calibration output signals for auxiliary heat flux sensors
Y[1,1]: low calibration for heat flux # I
Y[2,1]: high calibration for heat flux # I

Z[*]: serial numbers and calibration constants for multiplexed sensors
Z[1,I]: serial number of sensor # I
Z[2,I]: calibration constant (W/m²-mV) for sensor # I

A$: name of new file for scaled data
B$: header from original data file
C$: name of calibration file
D$: header of calibration file
E$: name of original data file
F$: header of new file for scaled data

r1: yes/no flag
r2: HFS low calibration input (mV)
r3: HFS high calibration input (mV)
r4: currently not assigned
r5: currently not assigned
r6: temperature low calibration input (°C)
r7: temperature high calibration input (°C)
r20: number of records in original data file
"SNSR15"

PROGRAM LISTING

0: "This program is called SNSR15; it creates the file called ARAY15 ";
1: "which contains the serial numbers, calibration constants, and ";
2: "weighting factors for the HFS ";
3: "This program is to be used in conjunction with program FLUX15 only ";
4: "Version: 27 January 1982 ** RPL ";
5: 
6: dim N[3],Z[2,15],W[15],A[5,2],Q[5]
7: getk "KEYS"
8: dsp "Remove Program Disk";stp
9: dsp "Insert Disk for ARAY15 file";stp
10: ent "Printer Select Code= ?",N
11: if N=706 or N=606;wbt N,27,40,65
12: ent "Create new ARAY15 file?",rl
13: if r1#1;goto 18
14: cll 'ENTER'
15: cll 'PRINT'
16: cll 'CREATE'
17: goto 21
18: asgn "ARAY15",1
19: sread l,N[*];sread 1,2[*],W[*];sread 1,A[*],Q[*]
20: cll 'PRINT'
21: ent "Modify ARAY15 file?",rl
22: if r1=0;goto +4
23: cll 'ENTER'
24: cll 'PRINT'
25: cll 'CREATE'
26: goto 67
27: "ENTER":
28: ent "Number of MPX HFS = ?",N[1],"Number of MPX TMP sensors = ?",N[2]
29: ent "Number of AUX sensors= ?",N[3]
30: for I=1 to 10
31: fmt ,"Sensor # ",f2.0;wrt 0,I;stp
33: ent "Serial #=?",Z[1,I],"Cal. const.=?",Z[2,I],"Weighting factor=?",W[I]
34: next I
35: for I=1 to 5
36: fmt ,"AUX #",f2.0;wrt 0,I;stp
37: ent "Serial #=?",A[I,1],"Cal. const.=?",A[I,2],"Weighting factor=?",Q[I]
38: next I
39: ret
40:
41: "PRINT":
42: fmt 3,3,/78**,/;N+.3*M;wrt M
43: N+.1+M;fmt 1,2,"# of HFS= ",f2.0,5x,"# of T sensors= ",f2.0,5x,z
44: wrt M,N[1],N[2]
45: fmt 1,"# of AUX sensors= ",f2.0;wrt M,N[3]
46: N+.1+M;fmt 1,7x,2x,"#",5x,"Const.",2x,"F. area",/;wrt M
47: for I=1 to 10
48: fmt 1,f2.0,4x,f4.0,5x,f5.1,5x,f6.4
49: wrt M,I,Z[1,I],Z[2,I],W[I]
50: next I
51: fmt 2,/,"AUXILIARY SENSORS",/;N+.2+M;wrt M
52: N+.1+M
53: for I=1 to 5
54: wrt M,I,A[I,1],A[I,2],Q[I]
55: next I
56: N+.3+M;wrt M
57: ret
58:
59: "CREATE":
60: ent "Does previous ARAY15 file exist?",rl
61: if rl=1;kill "ARAY15";open "ARAY15",2;gto +2
62: open "ARAY15",2
63: asgn "ARAY15",l
64: sprt l,N[*];sprt l,Z[*],W[*];sprt l,A[*],Q[*]
65: ret
66:
67: dsp "Program Finished"
68: end
EQUIPMENT REQUIRED

1. Hewlett-Packard (HP) 9825B desktop computer
2. HP 9895/9885 flexible disk drive ROM
3. HP 9895 flexible disk drive
4. HP 9872A X-Y plotter
"PLT15"

PROGRAM LISTING

0: "This program is called PLT15; it plots analyzed data stored in the":
1: "data files created by HEAT15":
2: "Version: 16 February 1982 ** RPL ":
3:
4: dim CS[6],DS[80],ES[6],BS[3,80],N[3],F[15],M[5],P[15],AS[6]
5: dim FS[3,80],A[17],X[375],Y[375,17]
6: getk "KEYS"
7: dsp "Remove Program Disk";stp
8: dsp "Insert Data Disk";stp
9: ent "Enter name of analyzed data file",A$;prt " ";prt A$;prt " 
10: ent "Plotter Select Code=?",P
11: asgn A$,1
12: sread l,CS,DS,ES,BS,FS,N[*],&8
13: 0=A=C+T*J;100=D
14: ent "Number of Heat Flux sensors=?",2
15: Z+2=V
16: ent "Max. time to be searched=?",8
17: dsp "SEARCHING FOR MAXIMUM VALUES"
18: on end 1,"THERE"
19:
20: "START":
21: sread l,U,E,F[*],M[*],P[*]
22: if E>T;E+T;U+J
23: for K=1 to 15
24: if F[K]>A;F[K]+A
26: next K
27: for K=1 to 12
28: if M[K]>C;M[K]+C
29: if M[K]<D;if M[K]>15;M[K]+A
30: next K
31: for K=1 to 5
32: if P[K]>C;P[K]+C
33: if P[K]<D; if P[K]>15; P[K] = 0
34: next K
35: if T>=B; gto "THERE"
36: gto "START"
37:
38: "THERE":
39: fix 2; rread 1, 1
40: prt "# records", J
41: prt "Max time", T
42: prt "Max W/M^2", A
43: prt "Min W/M^2", G
44: prt "Max temp", C
45: prt "Min temp", D
46: prt "",; prnt "",; prnt ""
47: prc P; p clr; fix 0
48: ent "Plot heat flux data?", rl
49: if rl=0; gto "TMP"
50: ent "Draw axes?", rl
51: if rl=0; sfg 1
52: ent "Maximum value of time=?", rl0
53: ent "Maximum value of heat flux=?", rl1
54: ent "Minimum value of heat flux=?", rl5
55: if rl1; gto +4
56: ent "X-axis tic interval=?", rl2
57: ent "Y-axis tic interval=?", rl3
58: pen # 1
59: rl5=30*H; scl -5, rl0, H, rl1; if rl1; gto +4
60: xax rl5, rl2, 0, rl0, 1
61: yax 0, rl3, rl5, rl1, 1
62: lim 0, rl0, rl5, rl1; gto "HERE"
63:
64: "HERE":
65: on end 1, "X"
66: ent "Plot individual sensors?", rl
67: if rl=0; rl=5
68: disp "Heat Flux Data is being read"
69: sread l,C$,D$,E$,J$,F$[*],N[*],r8
70: 0+Q
71: sread l,J,E,F[*],M[*],P[*]
72: Q+1+J;E*X[Q]
73: for S=1 to Z
74: F[S]+Y[J,S]
75: if S>=B:gto "X"
76: next S
77: gto 71
78: "X":
79: fmt ,"Plotting sensor # ",fz.0
80: gto +3;if flg5:gto +1
81: ent "Sensor HF to be plotted?",S:gto +1
82: gto +2;if S>15:gto 94
83: for S=1 to Z
84: cll 'LINE'
85: wrt 0,S
86: plt X[1],Y[1,S],-2
87: for J=2 to Q
88: if X[J]>100:gto +3
89: plt X[J],Y[J,S],0
90: next J
91: pen
92: if flg5:gto 81
93: next S
94: pen# 0;plt 100,111,1;fmt
95: cfl 5
96: "T4":
97: ent "Plot individual TEMP sensors?",rl
98: if rl;0+rl;stg 5
99: if flg5:gto +3
100: if flg5:gto +3
101: ent "Do you want to delete some TEMP?",rl
102: if rl;0+rl;call 'DEL'
103: line ;stg 2
104: dsp "Prepare plotter for TEMP plot";stp
105: fxd 1;cfg 1
106: ent "Draw axes?", r1
107: if r1=0; cfg 1
108: ent "Maximum value of time=?", r10
109: ent "Maximum value of temperature=?", r11
110: ent "Minimum value of temperature=?", r15
111: if r1g1;gto +4
112: ent "X-axis tic interval=?", r12
113: ent "Y-axis tic interval=?", r13
114: pen# 1
115: r15-.5+e;scl -5,r10,e,r11; if r1g1;gto +4
116: lim ; fxd 0;xax r15,r12,0,r10,1
117: yax 0,r13,r15,r11,1
118: lim 0,r10,r15,r11
119: NEXT:
120: rread 1,1
121: on end 1, "Y"
122: dsp "Temperature Data is being read"
123: sread 1,C$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,$,
141: cl1 'LINE'
142: if A[S]=1;gto +8
143: plt X[1],Y[1,S],-2
144: for J=2 to Q
145: if X[J]>r10;gto +3
146: plt X[J],Y[J,S],0
147: next J
148: pen
149: if flg5;gto 137
150: next 3
151: pen# 0;plt r10,r11,1
152: cfg 5
153: ent "Another set of plots to be run?",r1
154: if r1=1;gto 9
155: dsp "PLOTTING ROUTINE FINISHED"
156: end
157:
158: "LINE":
159: if flg2 and S>10;gto "T"
160: if S<5;pen#  1
161: if S>4 and S<9;pen#  2
162: if S>9 and S<13;pen#  3
163: if S>12;pen#  4
164: if S=1 or S=5;line
165: if S=9 or S=13;line
166: if S=2 or S=6;line 3,2
167: if S=10 or S=14;line 3,2
168: if S=3 or S=7;line 5
169: if S=11 or S=15;line 5
170: if S=4 or S=8;line 6
171: if S=12 or S=16;line 6
172: if S=17;line 3,2
173: ret
174:
175: "T":
176: if S=13 or S=14;pen# 3
"PLT15"

SENSOR IDENTIFICATION FOR PLOTS OF
HEAT FLUX AND TEMPERATURE DATA

<table>
<thead>
<tr>
<th>HFS#</th>
<th>TEMP#</th>
<th>PLOTTER PEN#</th>
<th>PLOTTER LINE PATTERN</th>
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<td>AUX2</td>
<td>3</td>
<td>_ _ _</td>
</tr>
<tr>
<td>AUX3</td>
<td>AUX3</td>
<td>4</td>
<td>_ _ _</td>
</tr>
<tr>
<td>AUX4</td>
<td>AUX4</td>
<td>4</td>
<td>_ _ _</td>
</tr>
<tr>
<td>AUX5</td>
<td>AUX5</td>
<td>4</td>
<td>_ _ _</td>
</tr>
</tbody>
</table>
Appendix 5a

"AVG15"

EQUIPMENT REQUIRED

1. Hewlett-Packard 9825B desktop computer
   or
   Hewlett-Packard 9825A with the followings ROM's:
   a. general I/O
   b. extended I/O
   c. advanced programming
   d. string variable

2. HP 98034A (HP-IB) interface bus

3. HP 9895/9885 flexible disk ROM

4. HP 9895 flexible disk drive

5. Printer for computer such as HP 9866, HP 9876, HP 7245
"AVG15"

PROGRAM LISTING

0: "This program is called AVG15; it takes data created by HEAT15 and ":
1: "its various modified versions and produces averaged values over a ":
2: "period chosen by the user":
3: "Version: 16 February 1982 ** RPL ":
4: 
5: dim C$[6], D$[80], E$[6], BS[3,80], F$[3,80], N[3], P[15], M[12], P[5]
6: dim A$[6], A[2], H[17], T[17], N$[17,10], U[2], D[17]
7: getk "KEYS"
8: dsp "Remove Program Disk"; stp
9: dsp "Insert Data Disk in drive 0"; stp
10: ent "Printer Select Code=", N; if N=706 or N=606; wtb N, 27, 40, 65
11: ent "Enter name of analyzed data file", A$
12: asgn A$, 1
13: sread 1, C$, D$, E$, B$, F$, N[*], r8
14: ent "Do you want max time search?", r1; if r1=0; gto 23
15: on end 1, "ONE"
16: dsp "Finding maximum time"
17: sread 1, U, E, F[*], M[*], P[*]
18: gto -1
19: "ONE":
20: prt "Max record # =", U
21: prt "Max time= ", E
22: prt ";prt ";prt "
23: cll 'SITE'
24: rread l, 1
25: sread 1, C$, D$, E$, B$, F$, N[*], r8
26: cll 'AVG'
27: cll 'PRINT'
28: ent "Average another period?", r1
29: if r1; gto 26
30: ent "Analyze another data file?", r1
31: if r1; gto 11
32: end
33:  "AVG":
34:  ent "# of first record wanted=?",A[1]
35:  ent "# of last record wanted=?",A[2]
36:  dsp "Averaging data"
38:  if I=1 to 17;0+H[I]+T[I];next I
39:  sread 1,U,E,F[*],M[*],P[*]
40:  if U<A[1]-1;gto -1
41:  if U-A[1];sfg 3
43:  if flg3;cfg 3;gto +2
44:  sread 1,U,E,F[*],M[*],P[*]
45:  if J=A[1];E+U[1]
47:  for I=1 to 15
48:  H[I]+F[I]=H[I]
49:  next I
50:  for I=1 to 10
52:  next I
53:  for I=1 to 5
55:  next I
56:  for I=1 to 2
58:  next I
59:  next I
60:  for I=1 to 17
61:  H[I]/A=H[I];T[I]/A=T[I];D[I]/A=D[I]
62:  next I
63:  ret
64:  "SITE":
65:  ent "Create new SITE file?",rl
66:  if rl#1;gto +3
69: cl1 'ENTER'
70: cl1 'CREATE'
71: asgn "SITE", 2
72: sread 2,N$
73: ent "Do you want SITE printed?",rl
74: if rl#1;gto +6
75: fmt 3,f2.0,5x,c10
76: for I=1 to 17
77: .3+N$G;wrt G,I,N$[I]
78: next I
79: fmt 3,/.wrtN;fmt
80: ent "Do you want to change SITE?",rl
81: if rl=0;gto +4
82: cl1 'ENTER'
83: cl1 'CREATE'
84: gto 73
85: ret
86:
87: "ENTER":
88: fmt "SENSOR ",f2.0
89: for I=1 to 15
90: wrt 0,I;stp
91: ent "Body site name=?",N$[I]
92: next I
93: "RECTAL"+N$[16];"ENVIRON"+N$[17]
94: ret
95:
96: "CREATE":
97: ent "Does previous SITE file exist?",rl
98: if rl;kill "SITE";open "SITE",2;gto +2
99: open "SITE",2
100: asgn "SITE",2
101: sprt 2,N$
102: ret
103:
104: "PRINT":
105: wtb N,27,38,107,48,83;fmt
106: fmt ,6/wrt N;fmt
107: wrt N,"Name of analyzed data file: ",A$
108: wrt N;wrt N,"Header of analyzed data file: 
109: for I=1 to 3;wrt N,F$[I];next I
110: fmt $2/,"Calibration file name: ",C6;N+.S+r2;wrt r2,C$
111: wrt N;wrt N,"Original data file name: ",E$;wrt N
112: wrt N,"Header of original data file: 
113: for I=1 to 3;wrt N,B$[I];next I
114: wrt N
115: fmt 1,"DATA AVERAGED FROM RECORD ",f3.0," TO RECORD ",f3.0;/
116: N+.1+r2
119: wrt r2,U[1],U[2]
120: wtb N,27,38,107,49,83
121: fmt 1,10x,"REGIONAL HEAT FLUX",2;/wrt r2
123: wrt r2
124: fmt 2,f2.0,3x,f7.2,3x,f5.2,x,f5.2,2x,f5.1,x,c10,/
125: N+.2+r2
126: for I=1 to 17
127: if D[I]#0:H[I]/D[I]+9
128: if D[I]=0:O+8
129: wrt r2,I,H[I],T[I],D[I],B,N$[I]
130: next I
131: wtb N,27,38,107,48,83
132: wtb N,27,85
133: ret
"AVG15"

VARIABLE LISTING

A
Number of records averaged

B
temporary storage for convective heat transfer coefficient

e
counter

J
counter

N
printer select code

U
record number of data

A[*]:
period to be averaged

A[1]
first period to be included in average

A[2]
last period to be included in average

D[*]
D[I] is average value of [(temperature # I) - (ambient temperature)]

F[*]
F[I] is scaled heat flux for sensor # I for current record

H[*]
H[I] is average heat flux for sensor # I

M[*]
M[I] is scaled temperature for multiplexed sensor for current record

N[*]
number of sensors as recorded on data file

P[*]
P[I] is scaled temperature for auxiliary sensor for current record

T[*]
T[I] is average temperature for sensor # I

U[*]:
max and min times

U[1]
time corresponding to period A[1]

U[2]
time corresponding to period A[2]

A$
name of analyzed data file

B$
header of original data file

C$
name of original calibration file

D$
used

E$
name of original data file

F$
header of analyzed data file

N$
"SITE" file names

N$[I], 1 ≤ I ≤ 10, multiplexed sensor # I

N$[I], 11 ≤ I ≤ 15, auxiliary sensor # (I-10)

N$[16], "RECTAL," rectal temperature

N$[17], "ENVIRON," environmental temperature
UTILITY PROGRAMS

"RCAL15" PROGRAM LISTING

0: "Program name: RCAL15":
1: "This program reads numbers from disk Calibration file and prints them":
2: "This program is to be used with data obtained with program FLUX15 only":
3: "Version: 1 February, 1982 ** RPL ":
4: 
5: dim X[4,15], Y[2,5], C$[6], D$[80], D[2,5]
6: dsp "Remove Program Disk"; stp
7: dsp "Insert Data Disk"; stp
8: ent "Enter name of file to be read", C$
9: asgn C$, 1
10: sread 1, D$
11: sread 1, r2, r3, r4, r5, r6, r7
12: sread 1, X[*]
13: sread 1, Y[*]
14: sread 1, D[*]
15: on end 1, "TIME"
16: fmt 1, "HFS calibration input voltages (mv)", /, f10.6, 5x, f10.6, 2/
17: wrt 706.1, r2, r3
18: fmt 2, f2.0, 5x, f10.6, 5x, f10.6
19: for I=1 to 10
20: wrt 706.2, I, X[1, I], X[2, I]
21: next I
22: wrt 706; wrt 706, "AUXILIARY HFS"
23: for I=1 to 5
24: wrt 706.2, I, Y[1, I], Y[2, I]
25: next I
26: fmt 3, "Temperature calibration input values", /, f6.2, 5x, f6.2, 2/
27: wrt 706.3, r6, r7
28: for I=1 to 12
29: wrt 706.2, I, X[3, I], X[4, I]
30: next I
31: wrt 706; wrt 706, "AUXILIARY TEMPERATURE SENSORS"
32: for I=1 to 5
UTILITY PROGRAMS

"RDAT15" PROGRAM LISTING

0: "Program name: RDAT15"
1: "This program reads numbers from the disk data file and prints them"
2: "This program will read data obtained using program FLUX15 only"
3: "Version: 25 February 1982 ** RPL "
4: 
6: getk "KEYS"
7: dim A$[6], B$[3,80]
8: dsp "Remove Program Disk"; stp
9: dsp "Insert Data Disk"; stp
10: ent "Enter name of file to be read", A$
11: asgn A$, I
12: ent "Do you want Temperature values?", rl
13: for I=1 to 3
14: sread 1, B$[I]
15: wrt 706, B$[I]
16: next I
17: sread 1, H, L; wrt 706; wrt 706, H, L
18: sread 1, U, E, H[*], A[*], T[*], B[*], C, D, F
19: wrt 706, U, E; wrt 706
20: fmt 1, f7.3, z
21: for I=1 to 10
22: wrt 706.1, H[I]
23: next I
24: wrt 706
25: if rl=0; gto 31
26: fmt 1, f7.2, z
27: for I=1 to 12
28: wrt 706.1, T[I]
29: next I
30: wrt 706
31: for I=1 to 5; wrt 706.1, A[I]; next I
32: wrt 706
33: for I=1 to 5; wrt 706.1, B[I]; next I
34: wrt 706
35: on end 1,"TIME"
36: gto 18
37: "TIME":
38: stp
39: end
UTILITY PROGRAMS

"cmbDAT" PROGRAM LISTING

0: "This program is called cmbDAT; it combines 2 data files analyzed by":
1: "HEAT15 into a single analyzed data file. It ":
2: "provides for adding time to the clock time in the second file, which ":
3: "is useful when time has elapsed between the end of the first data file":
4: "and the start of the second one. The program uses the 9895 dual disk":
5: "drive. The disk with the original data must be in drive0, the disk ":
6: "for the new combined file must be in drive1. The combined file is ":
7: "stored under the name given on disk in drive1":
8: "Version : 26 February 1982 ** RPL " :
9: 10: dim C$[6], D$[80], E$[6], B$[3,80], N[3], F[15], M[12], P[5], F$[3,80]
11: dim R$[6], S$[6], Q$[3,80], A$[6]
12: dsp "Remove Program Disk"; stp
13: dsp "Insert Data Disk in drive 0"; stp
14: dsp "Insert new file disk in drive 1"; stp
15: ent "Name of first data file?", R$
16: ent "Name of second data file?", S$
17: ent "Name of combined data file?", A$
18: asgn R$, 1, 0
19: asgn S$, 2, 0
20: ent ": of records for combined file?", X
21: drive 1
22: open A$, X
23: drive 0
24: asgn A$, 3, 1
25: sread 1, C$, D$, E$, B$, Q$, N[*], r8
26: for I=1 to 3
27: ent "Elapsed minutes between files=?", Y
28: next I
29: ent "Elapsed minutes between files=?", Y
30: spft 3, C$, D$, E$, B$, Q$, N[*], r8
31: on end 1, "ONE"
32: dsp "Combining Data Files Now."
UTILITY PROGRAMS

"negHFS" PROGRAM LISTING

0: "This program is called negHFS; it reverses the polarity of heat flux"
1: "for a given sensor in an analyzed data file created by HEAT15 or one"
2: "of its various versions."
3: "Version: 26 February 1982 ** RPL"
4: 
5: dim A$[6], C$[6], D$[80], E$[6], B$[3, 80], F$[3, 80], N[3], P[15], M[12], R[5]
6: dim W[15]
7: dsp "Remove Program Disk"; stp
8: dsp "Insert Data Disk in drive 0"; stp
9: dsp "Insert Scratch Disk in drive 1"; stp
10: ent "Name of Data file?", A$
11: asgn A$, 1, 0
12: sread 1, C$, D$, E$, B$, F$, N[*], I8
13: for I=1 to 3; prt F$[I]; next I
14: ent "Number of records in data file?", A
15: drive 1
16: open "TEST", A
17: asgn "TEST", 2, 1
18: drive 0
19: sprt 2, C$, D$, E$, B$, F$, N[*], I8
20: ent "How many HFS to be reversed?", C
21: for I=1 to C
22: ent "HF sensor # to be reversed?", B
23: 1-W[B]
24: next I
25: on end 1, "END"
26: dsp "Program is running now"
27: "ONE"
28: sread 1, U, E, F[*], M[*], P[*]
29: for I=1 to 15
30: if W[I]=1; -P[I]-P[I]
31: next I
32: sprt 2, U, E, F[*], M[*], P[*]
33: 9 to "ONE"
34: 10 to "END"
35: 11 to "KILL" AS
36: 12 to "COPY" "TEST", 1, 1.07, AS, 1.07
37: 13 to "DRIVE" 1, 1.07
38: 14 to "KILL" "TEST"
39: 15 to "DRIVE" 0
40: 16 to "DSG" "FINISHED"
41: 17 to "END"