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REAL-TIME DATA ACQUISITION FROM A LABORATORY COMBUSTOR

by

Richard Ray Borsheim

A Thesis Submitted to the Faculty of the

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THE UNIVERSITY OF ARIZONA

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6/11/82
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ABSTRACT

This thesis describes an on-line data acquisition system for a laboratory combustor. The data acquisition system monitors the oxidizer flow rates, several thermocouple temperatures, and dry flue gas percentages, and uses these monitored values to calculate residense times, stoichiometric species, and mass balances. This calculated information is stored and reported by a data management system incorporated within the data acquisition system.

The data acquisition system monitors consist of CO_2, CO, O_2, and NO analyzers, an on-line chromatograph, and three pressure transducers. The data acquisition computer hardware consists of a Cromemco microcomputer and a General Automation SPC-16/65 minicomputer.

The microcomputer gathers data from the system monitors and supplies this data to the minicomputer. The minicomputer performs all the data manipulation, the real-time computing, and the operator interactions.

The system provides a flexible means for analyzing the results from a variety of input conditions to the combustor.

CHAPTER 1

INTRODUCTION

With modern computer capabilities growing and in view of falling computer hardware costs, more computers will be utilized in a variety of processes in which the Engineer is involved. This thesis deals with one expanding area of computer application, real time computing. The field of real time computing offers the Engineer a way of monitoring, and in many instances, controlling a given process. The specific process described in this thesis is a laboratory coal-fired furnace. Certain inputs and outputs of this furnace are monitored (Figure 1), and this monitored data is used to further analyze experimental results.

The inputs to the furnace are the fuel flow rate and the oxidizer flow rates. Since the fuel used is pulverized coal, an accurate fuel flow rate would be difficult or expensive to acquire. Therefore, this quantity is calculated from other known quantities. The input oxidizer flow rates are obtained with good accuracy. The air flow rates are manually calculated by knowing a pressure drop across a laminar flow

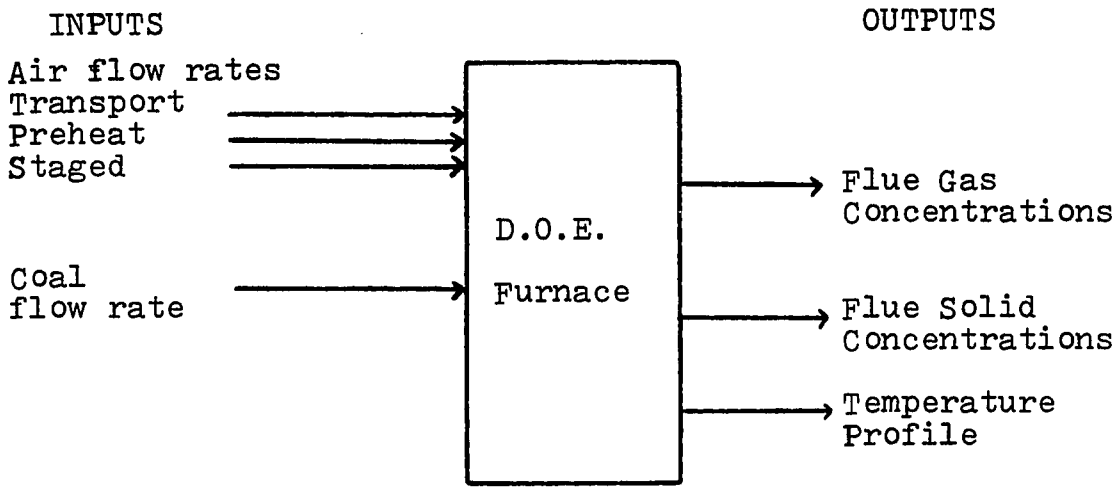

Fig. 1. The laboratory combustor

element. The system uses three pressure transducers which translate the pressure drops into voltage signals. The voltage signals allow the data aquisition system to calculate the air flow rate values.

The outputs monitored by this system are flue gas concentrations. These concentrations are monitored through 5 devices. Oxygen, Carbon Monoxide, Carbon Dioxide, and Nitric Oxide all have specific analyzers monitoring the respective dry flue gas percentages or PPMV. Also, an on-line chromatograph detects all the above mentioned gases except Nitric Oxide, but adds two gases, Hydrogen and Methane, to the on-line monitored flue gas outputs. Information regarding the installation of the the system monitors and the type of chromatograph and gas analyzers used, is described by Glass (1981).

Figure 2 will be used in the discussion of the details of the data acquisition system. The system consists of four main device types. The center of the network is the Cromemco single card microcomputer. The microcomputer interacts with the minicomputer, a General Automation SPC 16/65, the operator interface, a KSR-43 teletype, and all the afore mentioned system monitors. The outputs of the gas analyzers, thermocouples, and pressure

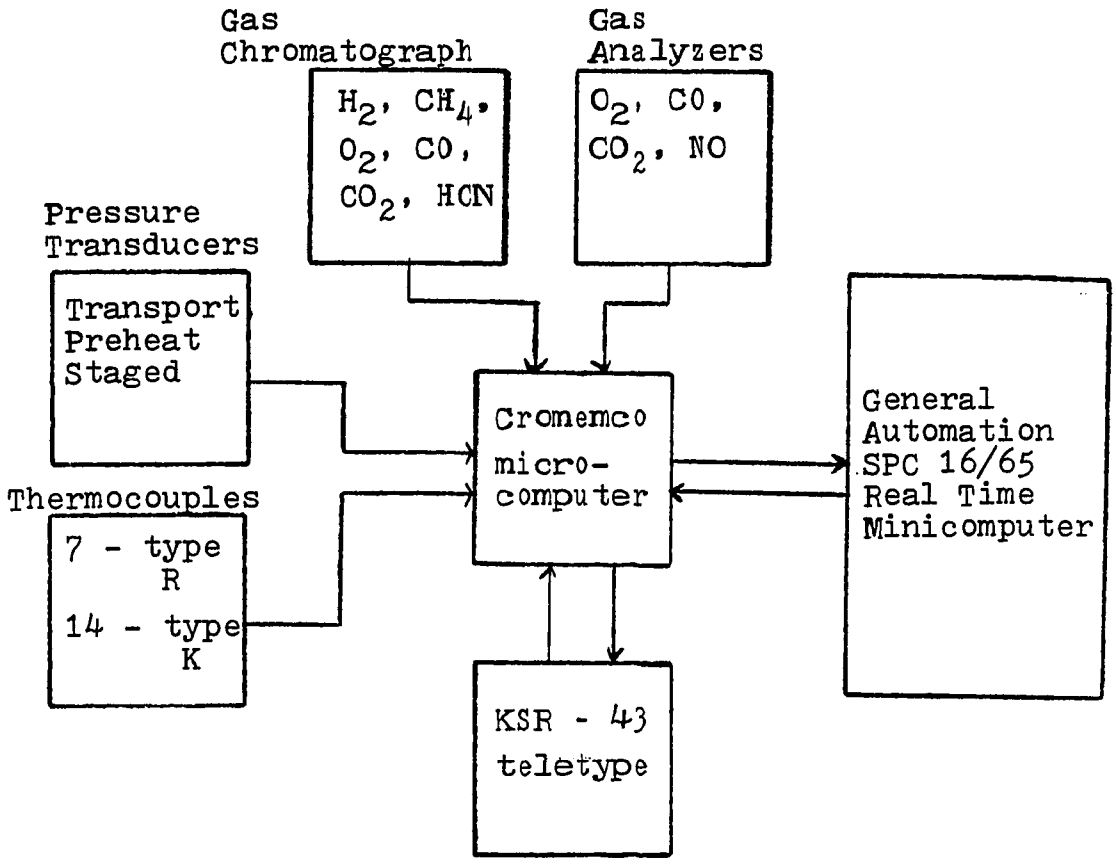

Fig. 2. Real time data acquisition system

transducers are sampled every 4 seconds and stored as 1 minute averages for 15 minutes. If chromatograph data is available, it is read and stored in the memory of the microcomputer.

The minicomputer performs the real time computing. The real time computing includes number conversions, mass balances, and consistency checks. The minicomputer software also executes all the operator interactions.

There are two main objectives of the data acquisition system. The system should be able to collect real time data and at the convenience of the furnace operator, execute a mass balance. Also at the end of a particular run, all pertainent information relating to the run should be printed. A run is defined as an experiment with constant input conditions. In addition to the main objectives, the data acquisition system must be able to accept a variety of experimental inputs being imposed on the furnace. This flexibility is required in order to further analyze the effects of these experimental conditions. The objective of the current research was to complete the entire system, as conceptualized, and make it operable.

The work which was completed before this

thesis project began on the data acquisition system is summerized below. The microcomputer software was completely written and debugged. The circuit which converts the analog signals from the system monitors to digital values had been designed and fabricated. A major portion of the minicomputer software was also completed. This software was capable of entering and acquiring data, performing a mass balance on the data, and checking data for consistency. A description of the above work is detailed by Montgomery (1982).

The work described in this thesis involved three main areas. The first area entailed connecting the gas analyzers, thermocouples, and pressure transducers to the analog to digital circuit. Once these system monitors were connected, the analog to digital circuit was tested and corrected for any electronic problems. The digital values from the analog to digital circuit were then calibrated to obtain useful decimal numbers. During attempts to calibrate the system monitors, a major problem was encountered in that the digital values from the analog to digital circuit drifted with ambient temperature. The system monitors could not be calibrated with this temperature drift problem.

The temperature drift problem could not be corrected electronically. It was ultimately solved by tracking the temperature drift by using ground values input to the analog to digital circuit. A basic circuit diagram of the analog to digital circuit is Figure 3. The ground value inputs can be found on every eighth input channel. This insures that the temperature drift for each primary amplifier is traceable. Once the temperature drift is traceable through the ground values, the other values from the system monitors can be adjusted to a desired calibration point. These adjusted values can be used in conjunction with calibration equations to produce meaningful numbers, such as temperatures.

The second area of work of this thesis was concerned with interfacing the gas chromatograph to the data acquisition system. The chromatograph had to be set-up and calibrated. After the chromatograph was operating properly, a BASIC program was developed to send data to the Cromemco microcomputer. The chromatograph console has no other way of sending the results of a gas analysis to the Cromemco other than through specific BASIC statements. The results of an analysis are sent in an ASCII format. Additional minicomputer software was developed to decode the data

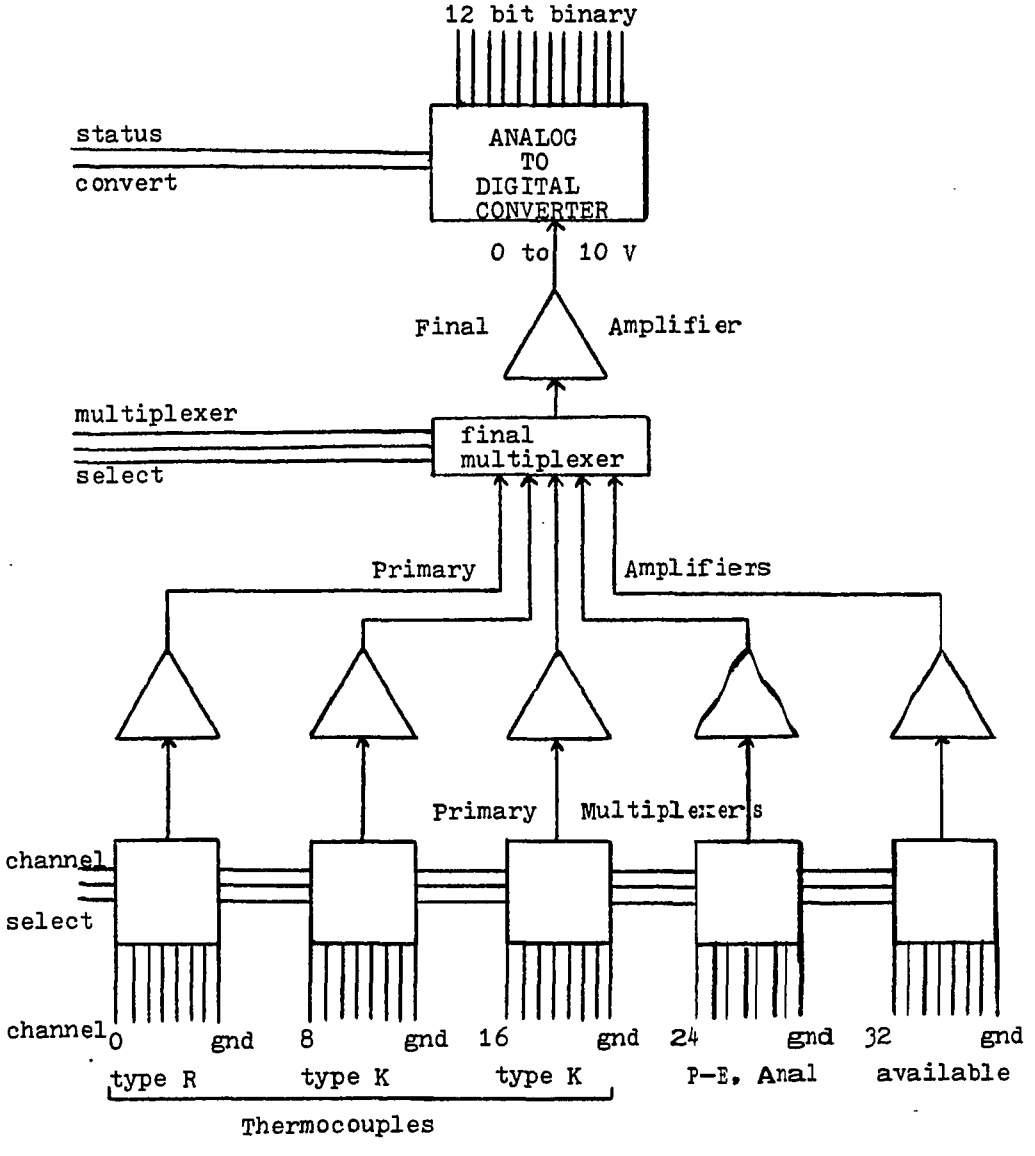

Fig. 3. The analog to digital circuit

into decimal numbers. This minicomputer program decodes each line in the chromatograph report and prints the results to the KSR 43 teletype.

The third and last area of work involved creating a data management system. Minicomputer software was needed that was able to record data associated with a particular run. The program which accomplishes this can associate up to 16 data records with each of 10 run records. The program also stores the constant input conditions and run name (which define the run) for each run record.

Another minicomputer program was developed which prints the results of an entire run. This program prints data in a fashion that is condusive to the study of various profiles in the furnace. Two needed numbers for each data point are calculated by the program, residence time to sample port and stoichiometric species. These numbers are used to model and compare different furnace conditions.

CHAPTER 2

THE INTERFACE BETWEEN THE ON-LINE MONITORS AND THE REAL-TIME DATA ACQUISITION SYSTEM

2.1 The analog to digital circuit

The analog to digital circuit is responsible for converting a voltage signal from one of 32 channels to a number between 0 and 4095. This number range is derived from using a 12 bit analog to digital converter. The lowest number obtainable is all bits set low (which equals zero), and the highest number available is all bits set high (which equals 4095). The numbers can be used with any type of calibration equation and be manipulated to obtain usable values such as, a flow rate in SCFM. The acceptable voltage values to the analog to digital converter are +10 volts to -10 volts. A voltage value of 0 would give a digital value of 2048 and a voltage value of +10 volts gives a digital value of 4095. If an analog signal from a system monitor is 0 volts to either some positive or negative voltage value, the resolution for a value from this monitor will be the full scale value of the monitor divided by 2048. This corresponds to

plus or minus .05% of the monitors full scale value. This assumes that analog signals are amplified or attenuated to give 0 volts to either plus or minus 10 volts to the analog to digital converter.

The capabilities of the analog to digital converter have been discused; an explanation of the analog to digital circuit will follow. The microcomputer program selects the channel (0-31) which a digital value is desired. The analog signal is first appropriately amplified or attenuated, secondly, this signal is delivered to the analog to digital converter, the analog to digital converter changes the voltage signal to a digital value, and finally, the digital values are read and stored by the microcomputer program. Because there is only one analog to digital converter, the 32 channels to be monitored must be multiplexed. The correct signals given to the multiplexers will select one channel only. A basic circuit diagram of the analog to digital circuit is Figure 3. As mentioned before, this process of reading all the channels is done every 4 seconds by the data acquisition system.

The channel assignments can be found in Appendix A. Channels 0-7 are type R thermocouples, channels 8-23 are type K thermocouples, and channels 24-31 are gas analyzers and pressure transducers.

There are eight additional channels for future expansion which are not implemented. The necessary circuit wiring has been done, but an additional amplifier and multiplexer are needed to make these channels operable. Only 7 of these eight channels can be used for additional furnace monitors. One channel in eight is reserved for ground values. The reason for having these ground values will be explained later under the calibration section in this Chapter.

2.2 On-line analyzers - data acquisition system link

Four analyzers, three pressure transducers and 21 thermocouples were connected to the analog to digital circuit. Each analyzer has certain Characteristics which are important with regard to this system. The first analyzers which will be discussed are the Carbon Monoxide and Carbon Dioxide analyers. These analyzers are exactly alike except for a few minor differences allowing them to detect the different gases. Originally, these analyzers had outputs for a chart recorder and a 0 to -10 volt output. The 0-10 volt output was changed to 0 to -5 volts by installing a resistor network. An important fact is the range switch on both analyzers does affect the output to the analog to digital circuit. If the furnace operator changes the range switch from the calibrated position, erroneous values will be reported by the data acquisition system. When the system is operating, the range switch should remain in the calibrated position. The currently calibrated range positions for both analyzers is position 1.

The next two analyzers which will be discussed are the Oxygen analyzer and the Nitric Oxide

analyzer. Unlike the CO and CO_2 analyzers, the Oxygen analyzer and the Nitric Oxide analyzer are not affected by changing the range switches. The operator can use a very precise range setting and the data acquisition system will still report correct values. The Oxygen analyzer produces analog values of 0 to 3.5 volts, and a concentration accuracy of plus or minus .02% is obtainable. The Nitric Oxide analyzer gives a signal of 0-5 volts on a range for 0 to 10000 PPMV. This corresponds to an accuracy of plus or minus 2.5 PPMV. For the Nitrous Oxide analyzer to work properly, one of two conditions must be true. The microcomputer power must be on or the cable connecting the analyzers to microcomputer must be disconnected. The reason is the microcomputer has a low impedance when the power is off.

The three pressure transducers which measure pressure drops across three different laminar flow elements will be explained. The laminar flow elements were chosen to give the same relative maginitude of pressure drops at the expected flows into the furnace. Since the desired pressure drops were less than 10 inches of water, all three pressure transducers have an input pressure differential of 0 to 10 inches of water. These pressure transducers give a linear

voltage value of 0 to +5 volts directly proportional to the pressure drop. The accuracy obtainable is plus or minus .005 inches of water. A warning that a condition which there is more than 10 inches of water pressure differential across any of the pressure tranducers will damage these devices both mechanically and electronically.

The last system monitor type left to discuss is the thermocouples. The system is able to acquire 7 type R thermocouple temperatures and 14 type K thermocouple temperatures. When these thermocouples are in use, they should not be grounded. If a thermocouple is grounded, the digital temperature meter will give a bad temperature value and the data acquisition system will collect these bad values. Information regarding what thermocouple channel is related to what channel on the digital temperature meter can be found in Appendix B. Appendix B also contains all wiring layouts for the data acquisition system.

2.3 Calibration of system monitors

The purpose of calibration is to convert the number given from the analog to digital converter to a known percentage, temperature, or PPMV. For example, if a pressure transducer gave a digital value of 0 (from the A to D) for 0 inches of water pressure and gave a value of 500 (from the A to D) for 3 inches of water pressure, a linear calibration equation can be derived to give pressure drops for other A to D values. In calibrating thermocouples, a known fact that voltage generated by the thermocouple is directly proportional to temperature. Only two constants are needed to calibrate the thermocouples. The analyzers and pressure transducers outputs can be calibrated with up to third order equations.

A specific procedure must be followed to calibrate this system. A few facts regarding accurate calibration will be discussed. Only the Carbon Dioxide analyzer and the Carbon Monoxide analyzer need quadratic equations to fit their responses. These analyzers operate on Beer's Law principles, and the output of the analyzers is not linerized. All the other analyzers have linear

responses. A majority of the analyzers need only a linear least-square-fit through the number of data points to obtain a good calibration equation. At least 4 data points must be collected to obtain an accurate calibration equation.

The first major problem incountered with the data acquisition system is the digital values from the A to D drift with ambient temperature. To cancel the effect of this problem, five input channels on the analog to digital circuit are grounded. These ground values will drift with ambient temperature giving the system a way to calculate the relative drift. The relative drift is calculated by using a number called basepoint. This number is picked by selecting an arbitrary ground value when calibrating. To explain

ber, the BASIC program used to calibrate the system monitors will be described.

This paragraph explains how to enter the BASIC program and how to run this program. Disconnect the cable from the teletype to the microcomputer (marked tty). Secondly, disconnect the cable from the minicomputer (marked SPC 16) to the microcomputer. Next, plug the teletype cable where the minicomputer cable was. Turn on the teletype , turn on the microcomputer, and press the 'term ready' button on

the teletype. Now, press the return key on the teletype quickly three times. "OK" will be printed followed by a "½" prompt. This enters the Cromemco into the BASIC language mode. Enter the program from Appendix C. If a line is mistyped, retype the line. To check what has been typed, enter the command "LIST". This command will print all lines which have been entered. The print-out should be exactly as the the Appendix program. If an erroneous line number has been entered, enter that line number and then press the return key. When the program has been entered correctly, type the command "RUN".

The program collects data 8 times a minute, averages the values, and prints them as illustrated in Table 1. These values are raw A to D values (0-4095). The last column contains the present ground value. Table 1 represents the results of running the BASIC program for three minutes.

Table 1

Calibration Print-out

							GRND
2500	3000	1000	2400	1265	2343	1324	1950
2540	3002	1005	2395	1250	2400	1350	1953
2525	2999	1010	2450	1275	2405	1330	1965

On the print-out, there will be no column labeled "GRND" as in Table 1. This label is for illustrative purposes only. The numbers in the column underneath this label have drifted up. The basepoint number is used to correct the drift. If the basepoint number was chosen to be 1950 (using Table 1 as an example), the values in the second and third rows would have to be adjusted so that their values correspond to a basepoint of 1950. The equation which does this is;

1) Adjusted value = reported value + (basepoint -reported ground value).

In Table 1 the reported values in row 2 would be diminished by 3 and the values of row 3 would be dimished by 15. A constant basepoint should be chosen for calibration of all channels. The present common basepoint value is 1950.

Appendix C tells which numbers to use for variables in the BASIC program depending what is being calibrated. Appendix C does not give any information about what system monitor belongs to what column of values printed by the BASIC program (as in Tabel 1). The FOR - NEXT loop varaibles are actually selecting the channels to be calibrated.

To obtain what column of numbers in the print-out correspond to what system monitor, Appendix A is used in conjuction with the FOR - NEXT loop varibles assigned in Appendix C. If the gas analyzers and pressure transducers are being calibrated, channels 24 to 31 will be printed begining with channel 24 as the leftmost column of numbers.

The remaining steps of calibration follows below.

1) Set a known value to the analyzer, thermocouple, or pressure transducer. (ie. Run calibration gas through the analyzer to be calibrated. **Make sure analyzers are calibrated.)
2) Run the BASIC program for approximately 6 to 10 minutes with a known calibration value to the monitor.
3) Inconsistent values should be discarded at this time. At least 4 values should remain.
4) Correct these values for temperature drift with Equation 1.
5) Average these values and save this number.
6) Repeat steps 1 through 5 at least 4 times with different known calibration inputs to the monitor.
7) Enter a control C to stop the BASIC program.

8) Return cables to their original positions.

Steps 1 through 5 give an A to D value which corresponds to a known input to a monitor. After completing steps 1 through 7, information such as Table 2 will be available.

Table 2

Calibration Information

% O2	A to D value
0	2000
3.1	2460
10.5	2800
15.0	3000
21.0	4000

Basepoint = 1950

The calibration information such as Table 2 is used to derive constants for the calibration equations for each system monitor. These constants are entered through the calibration option described in Chapter 5 section 8.

CHAPTER 3

THE CHROMATOGRAPH INTERFACE TO THE DATA ACQUISITION SYSTEM

3.1 Chromatograph Configuration.

This data acquisition system uses a Perkin-Elmer Sigma 1B chromatograph. In conjunction with the actual chromatograph, a microcomputer console is used to control the chromatograph. This computer console is a necessity for this particular chromatograph to operate properly. The chromatograph is equipped with two columns, a Molsieve and a Poropak, and two detectors, a Hot-Wire detector and a Nitrogen-Phosphorous detector. With this equipment, it is possible to detect CO, CO_2, O_2, N_2, H_2, CH_4, and HCN. A sample network is connected to a 10 port sampling valve, which allows gaseous samples to be taken directly from the furnace flue gas.

For the data acquisition system to work properly with the chromatograph, two conditions must be met. First, the chromatograph console is configured correctly. The configuration procedure takes place when the console power is turned on. The correct

responses to the console questions must be supplied by the furnace operator. The first question asked is how many terminals exist in the system. There are two, the console and the Cromemco microcomputer. This answer allows the the chromatograph console to send results of a gas analysis to the Cromemco microcomputer. Next, the console asks how many analyzers are used with the chromatograph. There is only one. The final question asked is how many instruments are used with the chromatograph. There are zero. After the system is properly configured, the system time is set. The configuration of the chromatograph is also explained in the Sigma 1B Owners Manual(1979).

The second condition for the chromatograph to work with the data acquisition system is a BASIC program must be controlling the chromatograph console. If a BASIC program is not controlling the chromatograph console, the data acquisition system is unable to acquire the results of a gas analysis. The only way for the chromatograph to report results to the microcomputer is by using the PKPRINT command while a BASIC program is executing. The BASIC program now used can be found in Appendix E. This program uses both the Hot-Wire detector and the Nitrogen-Phosphorous detector and assumes the carrier gas used is Helium.

3.2 The Method

A data file in the console memory called a Method is a group of numbers in a specific order which when accessed by a "SET-UP SEQUENCE" or by a BASIC "SETUP" command, controls the chromatograph's analyzers, describes how to process data acquired by the analyzers, and controls events such as when the sample valve is actuated. The Method used to analyze a gas sample is very important. The currently used Methods are in Appendix D.

The more important facts about the Method will follow. Under the 'ANALYZER CONTROL' section, the setpoint temperatures for various locations within the chromatograph are found. The last line in the 'ANALYZER CONTROL' section indicates the oven initial temperature and how long the oven is held at this temperature. If there is nothing below the 'INT OVEN TEMP TIME' line, the sample is isothermally analyzed.

The next section is the data processing section, labeled 'DATA PROC'. An important line is the 'TIMES' line. The first number denotes how long the data will be processed (It must be the same as the sample run time.) , and the next number is the time in

minutes from when the ready button was pressed to the beginning of the sample run. The numbers following are forced base point times. The 'REF PK' line has the information regarding the reference peak. The first number is a factor used in calculating Relative Response Times. The next three numbers explain some important facts about the reference peak. The three numbers are the time in minutes when the peak could be first detected, the latest the peak could come out, and exactly when the peak is expected, respectively. The important information in the Methods are the concentrations along with the gas names in the next few lines. These concentrations are obtained from the calibration gas bottle tag. If a bottle of calibration gas is emptied, the new calibration gas used will not contain exactly the same composition of gases. Every time a new tank of calibration gas is installed, the concentration values found in the Method must also be changed. If the concentrations are not changed, the Relative Response Factors calculated when using the 'CALIB' console command or BASIC 'CALIB' command will not calculate correct Relative Response Factors.

The last section in the METHOD is the 'EVENT CONTROL'. This controls the sample valve, the chart speed and attenuation, and the detector which the

method is associated. A detailed explanation of each line of the 'EVENT 'CONTROL' section and the other sections of the Method can be found in the Perkin-Elmer Console Manual(1979). If a Method is to be changed, a section contained in the console manual describes how to edit the Methods.

3.3 The BASIC program

The BASIC program discussed in this section can be found in Appendix E. To start a BASIC program, the operator issues the command '/BR PROGRAMNAME.1'. The program expects the first chromatograph run to be a calibration run. The operator should have calibration gas running through the sample valve for a length of time before pressing the start button. This built in feature allows automatic calibration at the begining of a furnace run. The lines which print to RS a "$" or "?" do belong in the program. These characters tell the Cromemco microcomputer to initialize the chromatograph buffer or send a message to the furnace operator, respectively. The message sent to the furnace operator indicates the chromatograph console reported the results of an analysis.

This program will halt execution when calibrating, if any of the calculated relative response factors are out of the accepted range. If the program halts, there is a major problem with the calibration run. Once an acceptable calibration run has been completed, the program continues to run and gather data. After the program completes a run, the start of

a new run is initiated. When the program is to be stopped, the command '/BH PROGRAMNAME.1' is given. This command suspends execution of the basic program. All facts relating to BASIC directives and BASIC programming can be found in the Perkin-Elmer Programability Option Manual (1979).

3.4 The Chromatograph Link

Installed on the chromatograph console is a RS-232 communications card. This circuit allows the results of a chromatograph run to be transferred to the microcomputer. As mentioned previously, the console must be configured with 2 terminals in order for this data transfer. When the appropriate BASIC program is controlling the chromatograph, the command 'PKPRINT ON ("RS")' prints the run results to the microcomputer. These results are printed and stored in a ASCII format. The contents of the stored chromatograph run data are the same as the print-out on the console after a run is finished. This ASCII data is useless unless it is converted to numbers and names.

The BASIC program first prints a "$" to the Cromemco microcomputer. This character initializes the microcomputer chromatograph buffer. After the chromatograph buffer is is initialized, the BASIC program prints the ASCII results to the Cromemco microcomputer, and the microcomputer stores this data in the memory buffer. The BASIC program prints a "?" to the Cromemco microcomputer. This character directs the microcomputer to print to the teletype "Ship data

to the SPC-16 !". At the end of this message, the bell rings several times to get the attention of the furnace operator. The operator must choose the Aquire option within one minute to make certain the chromatograph results correspond when the sample was taken. At the present time, the chromatograph results are printed 11 minutes after the sample is taken.

The minicomputer obtains 11 minute old data from the other on-line system monitors, reads the chromatograph data and decodes it, and stores this information with the correct sample time. How the minicomputer decodes the chromatograph results is explained below.

The minicomputer scans each line in the ASCII chromatograph buffer until the word "RUN" is found. Immediately following this section is a actual chromatograph buffer (Table 3) as stored by the Cromemco microcomputer. In the present system, the records which follow contain the information about run results. The minicomputer reads each line after the 'RUN' line with a FORTRAN Format statement. If the first number read, the Retention Time of an eluted peak, is zero, the minicomputer jumps to the next line. Otherwise, the minicomputer searches on the first three leters of the component name except in

the case of Carbon Monoxide and Carbon Dioxide (The first three letters of the last name are used.) If a match is found, the concentration is stored. If more than one peak is labled as the same component, the sum of the concentrations of these peaks will be reported by the minicomputer. After all the chromatograph records are read, the results of decoding the chromatograph data are printed on the teletype. The user has the option of accepting or rejecting these results.

Table 3

Chromatograph buffer

```
ANAL  1  DET    1  METH    2  FILE  293

RUN      2  RUN 43 12 :  5.6   5 / 25 / 82

   0.44     2.8708 V     0.830   0.336      5.3743 OXYGEN:
   0.53    46.6048 T     1.000   0.300     77.8964 NITROGEN:
   0.80     0.0158 TS    1.509   0.368      0.0326 METHANE:
   0.95     2.0624       1.792   0.300      3.4473 CARBON MONOXIDE:
   4.74    19.8176 V     8.943   0.120     13.2495 CARBON DIOXIDE:
```

CHAPTER 4

DATA MANAGEMENT SYSTEM

4.1 The run set-up

This section of Chapter 4 deals with the portion of the data acquisition system which gathers pertinent information regarding a run. This set-up section of the data acquisition system is needed for a number of reasons. All the data records for a run must be associated with the run if all the data is to be reported in a single print-out. A run is defined as data gathered with constant input conditions. These constant input conditions must be retrieved and stored. The constant input conditions which are stored are input air flow rates, input fuel rate, and input air temperature. In addition to the above data, a temperature profile of the furnace must be stored in order to calculate the residence times of the gases in the furnace.

The program which stores all of the above information has some limitations. The first limitation is how many data points can be stored for each run. Each run can only have 16 data records associated with

it. Data points could be taken at each sample port and leave 7 data points available for repeated data points at any sample port. The next limitation is how many runs can be stored at one time. Ten runs are the maximum number that can be stored. The run numbers can only be labeled with numbers 1 through 10. The two limitations mentioned above can be circumvented by printing a run after all the necessary data is collected and by labeling runs with the same run number with different names. This statement will be explained in Chapter 5 section 10.

A flow chart of the run set-up is Figure 4 Using the flow chart as a guide, the following sequence of events occur. The first question asked is what run number is being set-up. If a valid run number is selected (1-10), the program checks for any data in the run record. If data exists in the run record, the user has the option to delete or change it. If there is no run data or if the data is deleted, the program asks if there is staging. If there is staging, it is possible to obtain a coal flowrate from another run record. This option is used if several runs are to occur at the same time. If the coal flow rate is not obtained from another run record, the program asks if the furnace is at fuel-lean conditions.

When the furnace is at steady-state fuel-lean conditions, an automatic data Acquire is done, followed by an automatic Analyze option. If the reported coal flow rate is acceptable, the remaining pertinent information regarding the the run is obtained. An actual example with system print-outs will be discussed further in Chapter 5 section 10.

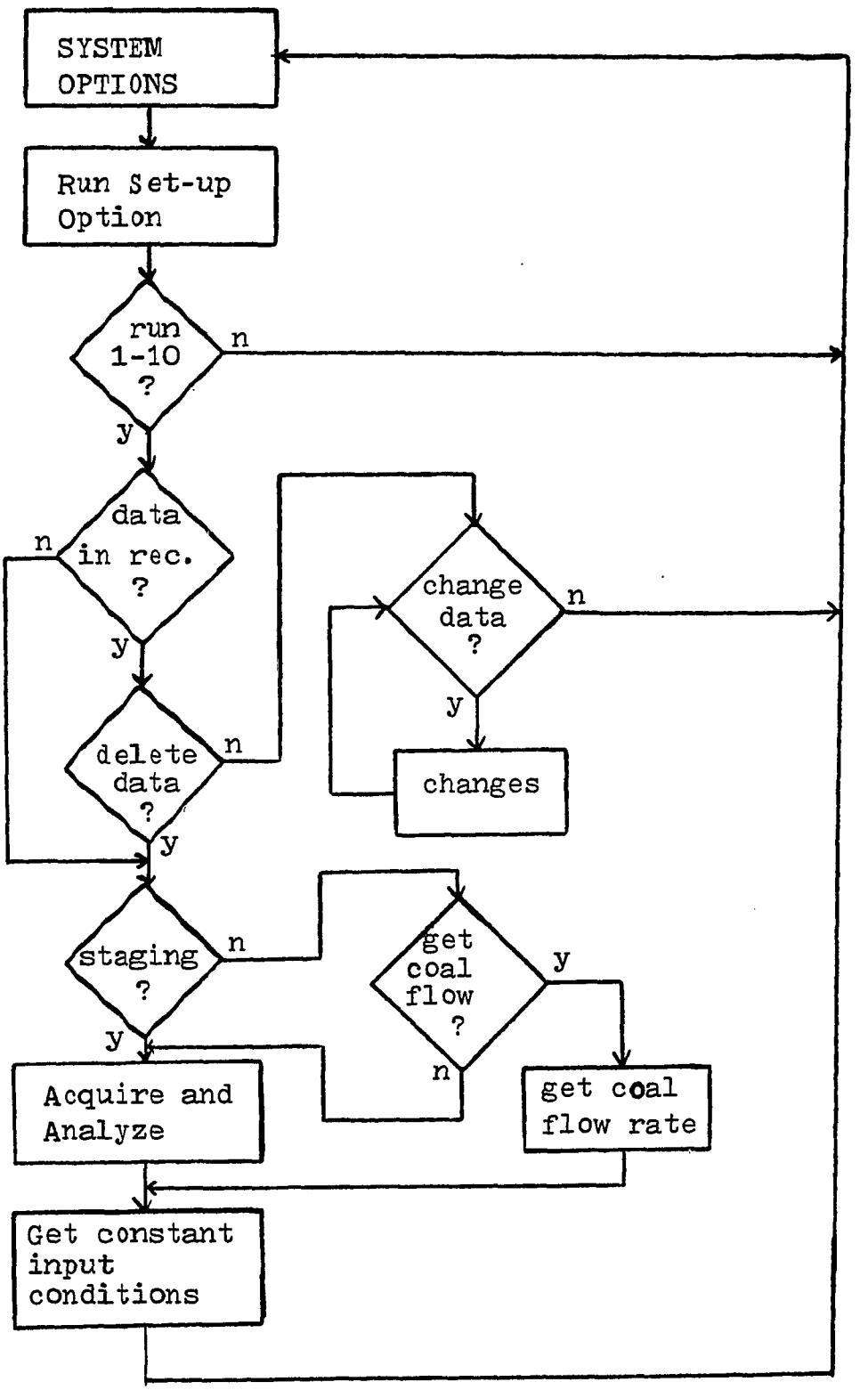

Fig. 4. Run set-up

4.2 The run print-out

The run print-out program does what its name implies. It prints all data pertaining to a run. This program was needed because previous work on the data acquisition system did not distinguish what data record belonged to what run. Since the run set-up program does this, a program was needed to print in tabular form the results of a run. This tabulation of run data allows the experimental results to be compared side by side. The program also calculates two additional pieces of information needed as an aid in analyzing experimental results, stoichiometric species and residence times.

The format of the run print-out must have certain requirements. First, a set of data pertaining to one sample must be printed in a column and nine sets of data should be in each segment of the print-out. Nine columns of data will give a print-out for a run that has samples taken at every sample port. The program must print the data by the position of the sample probe. The sequencing of the data by sample ports is that data be printed from left to right increasing in port number. A port number will not be

repeated on the same 9 column print-out. For example, if there is 8 data records with record numbers 1 through 8, and each had sample probe positions of 2, 2A, 1, 4A, 5, 2, 3, and 3, respectively, the print-out program would print records 3, 1, 2, 7, 4, and 5 in columns 1 through 6. The remaining 3 columns would be padded with zeros and blanks. After the above 6 data records were printed, then records 6 and 8 would be printed in columns 1 and 2 on a new 9 column print-out with 7 columns filled with zeros and blanks. This is fully illustrated in Chapter 5 section 11.

When the run data is printed, the residence time to the sample port is calculated. This number is calculated by using the run temperature profile, the flue gas output flow rate at the sample probe, and the estimated volume of the furnace between ports. These estimated volumes can be seen in Table 4 (as reported by Botsford (1982)). These numbers are hard coded in a DATA statement in the subroutine DOEPOR. The program calculates average temperature between ports. This calculation is shown by Equation 2.

$$2)\quad T_{i\ avg} = (T_i - T_{i+1})/2 + T_{i+1};$$

Where i ranges from inlet to port 7.

Table 4. Esitmated volumes between sample ports.

Between Ports	Volume (CF)
Top and port 1	0.0806
Port 1 and port 2	0.0982
Port 2 and port 2A	0.0491
Port 2A and port 3	0.0491
Port 3 and port 4	0.0982
Port 4 and port 4A	0.0982
Port 4A and port 5	0.0850
Port 5 and port 6	0.171
Port 6 and port 7	0.171

Once the average temperature between ports is calculated, the residence time can be calculated. Equation 3 shows this calculation.

$$3)\ \text{Residence time(sec)} = \frac{\text{Volume}_i}{\text{SCFM}} \cdot \frac{\text{Tstand} \times 60}{T_{i\ avg}};$$

Where i ranges from 1 to sample probe position number (1-9).

The actual flow rate between each port at the time of sample can only be calculated if simultaneous samples were taken in every port above the desired sample port. Since there is only 1 sample probe, there are only two known flow rates which pertain to the above calculation. The input flow rate and the output flow rate at the sample port are these known values. The output flow rate was chosen for use in the calculation. Chapter 5 section 11 will show examples and illustrations of the print-out information just described.

Since the furnace can run under a number of constant input conditions, the data must be adjusted to a standard so that the effects of changing the input conditions can be studied. The standard used in this research is stoichiometric input air flow rate. Stoichiometric input air flow rate is the amount of

input air required to completely combust the coal. This assumes all Carbon, Hydrogen, and Sulfur in the coal form Carbon Dioxide, Water, and Sufur Dioxide, respectively, and that no other reactions take place. Stoichiometric species are calculated by using Equation 4.

$$4)\ \text{Factor} = \frac{\frac{Q}{O\ \%\ OX} \times SR + (1-1.5n)\ (-)\ \frac{H}{2}\ /(1-0.005X_{CO})}{\frac{Q}{21.0} - 0.25\ H}$$

The equation takes into account that an in-flame sample still has combustion reactions taking place. This equation was developed by Joannes Wann Nan Lee (1979), and his thesis describes in detail all assumptions made in calculating this factor. The factor calculated is multiplied times the calculated flue gas concentrations which are adjusted for flue gas moisture. The resulting numbers are stoichiometric concentrations; concentrations adjusted to stoichmetric input air flow rate. When all data sets are adjusted in this manner, comparisons between different furnace input conditions can be made.

CHAPTER 5

AN OWNERS MANUAL TO THE REAL-TIME DATA ACQUISITION SYSTEM

5.1 Introduction

A few general facts about the system will be mentioned before discussing all the options that are available. The first will be how to start the system. The procedure is as follows. Turn on the KSR-43 teletype, turn on the Cromemco microcomputer, and then push the term ready button on the teletype. In less than 30 seconds the teletype will print the following message;

```
CROMEMCO SCCMON

 RTOS-16. Rev.7:  D.O.E. Furnace

 *** Options:
     1 = Data Entry   6 = Analyze
     2 = Search       7 = Calibrate
     3 = Delete       8 = Reload
     4 = Examine      9 = Run set-up
     5 = Acquire     10 = Run print-out

 * Enter option
```

if the above print-out is not typed, one of two things

are wrong. The General Automation SPC 16/65 minicomputer (SPC-16) is not on-line or the SPC-16 program is at a different place than down-loading the Cromemco microcomputer program. If the program is at different place than a down-load, either the SPC-16 should be rebooted or the following procedure should be executed. (The SPC-16 should not be rebooted unless other users of the SPC-16 are notified.) The following procedure should not be used unless each step is thoroughly understood.

1., Open the back of the second cabinet of the SPC-16 minicomputer. If the correct cabinet was opened, there should be a row of cables connected midway up from the floor.
2. Disconnect the third cable from the left. This cable is the line to the Cromemco microcomputer downstairs.
3. Disconnect the first cable on the left and connect it to the third from left socket just uncovered. This connects the LA-120 printer in front of the SPC-16 to the furnace data acquisition line.
4. Set the parity on the LA-120 to 3. Press the return key. The system option list should be printed. If it doesn't see the note below.*

5. Press 8 and then return key.** Set parity on the LA-120 to 5. The LA-120 should periodically print nonsense characters.
6. Set parity back to 1 on the LA-120. Return cables back to their original positions.

Notes:

* This means the system did not down load the Cromemco program for some reason. It is ready to download, proceed to step 6.

** The '8' will not print on the LA-120.

Turning on the Cromemco signals the SPC-16 to down-load the machine language program which resides in and controls the Cromemco. For this reason, the last command given to the Cromemco before turning it off is option 8, Reload. Otherwise, the SPC-16 program is at the system options question.

Once the system is running, the user will notice a definite pattern of prompts. These prompts have been standardized for ease of operator use. Table 5 shows what each of these prompts mean.

TABLE 5

System prompts

* = Enter the option number desired.
> = Enter a number or a name.
>> = Enter a 'y' or 'n'.
<< = A system message.

The data acquisition system supports some control characters as commands. Table 6 explains what each control character does when entered at the KSR-43 teletype. A control character is not followed by a carriage return.

TABLE 6

System control characters

CONTROL	FUNCTION
C	Stop whatever the program is doing and restart from systems option list.
B	Delete chromatograph buffer.
D	Dump chromatograph buffer to KSR-43.
F	Print-out 'Ship data to SPC-16!'.
S	Stop print-out.
Q	Start print-out again.
U	Delete what has been entered and start over.
T	Print out system time.

With these few facts, the system options will be discussed.

5.2 Data entry option

This routine allows the user to modify a data record or enter manually a complete set of data. After the system option list is printed;

```
*** Options:
    1 = Data Entry   6 = Analyze
    2 = Search       7 = Calibrate
    3 = Delete       8 = Reload
    4 = Examine      9 = Run set-up
    5 = Acquire     10 = Run print-out

 * Enter option
.1
```

enter a 1 as shown, and then press carriage return. (All resposes to system questions are always to be followed by a cariage return.) Immediately following this action, the teletype will print another question asking what data record is to be modified. Enter the data record number, 1-80, then press carriage return. If the user had entered a data record number not between 1 and 80 or if a carriage return only had been entered, the program would return to the system option list as above and would only type a '* Enter option'.

If a valid record number has been entered, the following will be printed.

```
> Modify which data record?
.1

*** Data Entry Options:
1 = Coal Feed Rate              7 = Air Input Rates
2 = Proximate Analysis          8 = Flue Gas Analysis
3 = Ultimate Analysis           9 = Flue Gas Temperature
4 = Flue Solids Analysis       10 = Probe Positions
5 = Air Temperature and Pressures
6 = Coal Sample Name

* Enter the data option:
```

These are the data options under the Data Entry system option.

5.2.1 Coal Feed Rate

The options are explanatory as to what can be changed in a data record. Beginning with option 1, the option is selected by entering the option number and then a carriage return. After selecting option 1, the system types the following.

```
.1
 > Coal Feed Rate = ?    [=] lbs/hour
.6.0            6.000
```

In the above example, a 6.0 was entered. The 6.000 is an echo of what information has been entered. This option has the effect of changing the default coal feed rate for any data record to be Analyzed which will be fuel-rich. The coal feed rate for a fuel-lean case is always calculated and stored. The

last fuel-lean calculated coal feed rate by an Analyze system option or a coal feed rate entered as above, which ever occurs last, will be the default coal feed rate, for an Analyzed fuel-rich data record.

5.2.2 Proximate Analysis

To change the proximate coal analysis, choose option 2. The print-out will be as follows.

```
 * Enter the data option:
.2
 << Proximate Analysis:  (As-Received Basis)
 > Percent F.C. = ?
.40              40.00
 > Percent V.M. = ?
.40              40.00
 > Percent  ASH = ?
.9.5              9.500
 > Percent  H2O = ?
.11.86           11.86
```

F.C. means Fixed Carbon and V.M is Volatile Material. These 4 numbers that are entered should add to 100 percent. The most important percentages are the Ash and H_2O. The first two percentages are not used in any calculations, but are printed in the Run print-out. This option changes the default proximate analysis for any data record Analyzed after the option has been executed.

5.2.3 Ultimate Analysis

The next option, 3, changes the ultimate

analysis. After choosing this option the following will be printed.

```
 * Enter the data option:
.3
 << Ultimate Analysis:  (Dry, Ash-included Basis)
 > Percent  C   = ?
.62.25          62.25
 > Percent  H   = ?
.4.83           4.830
 > Percent  O   = ?
.17.9           17.90
 > Percent  S   = ?
.3.40           3.400
 > Percent  N   = ?
..82           0.8200
```

The ultimate analysis is on a dry, ash included basis. Normally, the above entered percentages plus the ash percentage (on a dry basis) will equal 100 percent. This option also has the effect of changing the default proximate analysis for any data record to be Analyzed. All percentages in the proximate analysis are used in calculations.

5.2.4 Flue Solids Analysis

Flue solids analysis changes are entered through choosing option 4. The print-out follows.

```
 * Enter the data option:
.4
 << Flue Solids Analysis:  (Ash-Free Basis)
 > Percent  C   = ?
.0            0.0000
 > Percent  H   = ?
.0            0.0000
 > Percent  N   = ?
.0            0.0000
 > Percent  S   = ?
.0            0.0000
```

These numbers should add to 100 percent on an ash included basis. Usually, all flue solids are due to ash in a fuel-lean case. If a fuel-rich situation arises, the mass balance calculates the amount of carbon in the solids. The effect of changing these numbers, changes the default solids percentages for Analyzed data records thereafter.

5.2.5 Air Temperature and Pressure

Option 5 changes the default ambient air temperature and pressures with respect to the laminar flow elements. The changes are made as illustrated below.

```
 * Enter the data option:
.5
 > Air Temperature:  [=] Fahrenheit
.80            80.00
 > TRNS Pressure:  [=] psig
.7.9           7.900
 > PRHT Pressure:  [=] psig
.12            12.00
 > STGD Pressure:  [=] psig
.11.5          11.50
```

If these above numbers stay constant for a run, the furnace operator, while executing an Aquire data

option, need only enter carriage returns when asked for the above information. If these numbers are entered during an Acquire, the new numbers entered become the default values.

5.2.6 Coal Sample Name

Option 6 changes the sample name. This name may be up to 80 characters in length. An example of this option follows.

```
 * Enter the data option:
.6
 > Input Sample Name
.BEULAH LIGNITE
 BEULAH LIGNITE
```

This option also changes the default sample names written to data record if an Aquire option is executed.

5.2.7 Air Input Rates

Option 7, the changing of input air flow rates is illustrated below.

```
 * Enter the data option:
.7
 > TRNS Air = ?  [=] SCFM
..89          0.8900
 > PRHT Air = ?  [=] SCFM
.4.5           4.500
 > STGD Air = ?  [=] SCFM
.0             0.0000
```

This option enters the flow rates only in the data record chosen to be modified.

5.2.8 Flue Gas Analysis

Option 8 allows the user to modify flue gas analysis for a data record. A print-out of this data option follows.

```
 * Enter the data option:
.8
 << Flue Gas Analysis:
 > Percent  CO2 = ?
.12.1          12.10
 > Percent  CO  = ?
.2.923         2.923
 > Percent  O2  = ?
.3.4           3.400
 > Percent  CH4 = ?
.              0.0000
 > Percent  H2  = ?
.4.5           4.500
 > Percent  N2  = ?
.0             0.0000
 > PPMV  NO  = ?
.1000          1000.
 > PPMV  HCN = ?
.100           100.0
 > PPMV  H2S = ?
.              0.0000
 > PPMV  NH3 = ?
.55            55.00
```

If the user is manually entering a data record, the percentage of N_2 is always calculated when an Analyze option is executed. A zero value entered will suffice. Values should always be entered as measured, and not corrected for H_2O.

5.2.9 Flue Gas Temperature

Option 9 can change the flue gas temperature at the sample probe.

```
 * Enter the data option:
.9
 > Flue Gas Temperature:  [=] Celsius
.1000          1000.
```

This number is used only during the consistency test of a data record with the water-gas-shift reaction included. If this option is executed, the number entered is the default value for the previously mentioned reaction from then on.

5.2.10 Probe Positions

Option 10 enters the probe positions. The option print-out is as follows.

```
 * Enter the data option:
.10

 0 - No position  5 - Port 4
 1 - Port 1       6 - Port 4A
 2 - Port 2       7 - Port 5
 3 - Port 2A      8 - Port 6
 4 - Port 3       9 - Port 7
 > Probe Position of Sample   probe ?
.1
 > Probe Position of Cooling  probe ?
.0
 > Probe Position of Staging  probe ?
.
```

The sample probe position entered must be at ports 1-7, or the program will not go beyond the first question. The other two probes need not have a position. If the cooling probe and staging probes are not used, a 0 or a carriage return should be entered.

To return to the main system options, repeated pressing of the return key will always bring the program to the main option list.

5.3 Search option

The Search option allows the user to find a record or records on a specified date. After the Search option is specified, the first question printed is as follows.

```
 * Enter option
.2

 >>Search on today's date?
.Y

 << Searching for records on:  5/25/82

 Record:  2          Probe:  0          Time: 12:59:34

 << End search
```

In the example above, a 'Y' was entered when the first question was asked. If only a carriage return had been entered, the program would return to the main system option list and print '* Enter option'. Since a carriage return was not entered above, this option types what date it is searching for records. In the above search, one data record, 2, was found. In addition to printing the record number, the sample probe position and time of sample are printed.

If a 'N' is entered in response to the first question, the option print-out would be this.

```
 * Enter option
.2

 >>Search on today's date?
.N
 <<Input date record was obtained:  MM,DD,YY
.5,25,82

 << Searching for records on:  5/25/82

 Record:  2          Probe:  2          Time: 12:12: 9

 << End search
```

After the no response, the search option requires a date which the desired data record was Acquired or Entered. The program does not check for a valid date when the date is entered. The above search was successful and the same information as the first example in this section is printed. The Search option always prints 'End search' to inform the user that it is finished searching.

5.4 Delete option

The Delete option is used to delete a record or delete all the records. After selecting this option, the option questions are as follows.

```
 * Enter option
.3
 >> Delete all data?
.Y
 >> Delete every record?
.Y
```

In this example the option is instructed to delete all 80 data records. To do this, a 'Y' answer to the above two questions is entered. If anything but a yes response is given to the above two questions, the Delete option will continue as the example below.

```
 * Enter option
.3
 >> Delete all data?
.Y
 >> Delete every record?
.N
 > Input record number to be Deleted
.2
 > Input record number to be Deleted
.
```

The option asks for a valid data record number (1-80). If a carriage return or an invalid record number is entered, the program returns to the main system option list.

5.5 Examine option

The Examine option permits the user to inspect the contents of a particular data record. After selecting this option, the print-out which follows is:

```
> Examine which record?
.1
RECORD  1     PROBE  1      5/25/82     12:20:48     BEULAH LIGNITE
COAL FEED              :  5.030324E+00
P-E TRANSDUCERS        :  8.900000E-01  4.500000E+00  0.000000E-01
FLUE SOLIDS ANALYSIS:     0.000000E-01  0.000000E-01  0.000000E-01  0.000000E-01
PROXIMATE ANALYSIS     :  4.000000E+01  4.000000E+01  9.500000E+00  1.186000E+01
ULTIMATE ANALYSIS      :  6.225000E+01  4.830000E+00  1.790000E+01  3.400000E+00  8.200000E-01
CHROMATOGRAPH          :  1.210000E+01  0.000000E-01  3.500000E+00  1.000000E+03  0.000000E-01  0.000000E-01
CHROMATOGRAPH          :  0.000000E-01  0.000000E-01  0.000000E-01  0.000000E-01  0.000000E-01  0.000000E-01
FLUE GAS TEMPERATURE:        0.0
```

The record to be examined must be a valid record number or the program returns to the main options list. No units or specific labels are on the print-out.

The COAL FEED is LB/Hr and the P-E TRANSDUCER line reports transport, preheat, and staged flow rates in SCFM. The FLUE SOLIDS ANALYSIS, PROXIMATE ANALYSIS, and ULTIMATE ANALYSIS are reported as percentages exactly and in the same order as the previouly explained Enter options, sections 4, 2, and 3, respectively, asks for them. The CHROMATOGRAPH

lines report as measured flue gas analysis, if the record was not Analyzed, or adjusted flue gas analysis, if the record was Analyzed. The order of gases is %CO_2, %CO, %O_2, PPMV NO, PPMV HCN, %CH_4, PPMV H_2S, PPMV SO_2, PPMV NH_2, %H_2, %H_2O, AND %N_2.

5.6 Acquire option

This option is used solely to gather real-time data from the furnace. Upon choosing this option, the program first obtains necessary information about the oxidizer inputs, then acquires chromatograph data if available, and finally, stores all obtained information. The option print-out begins as the following example.

```
 * Enter option
.5

 > What is the run number (1-10) ?
.7
```

The first question after choosing this option, is which run number is the data to be associated . If a run number is entered here, the program checks if the run record is 'set-up'. If the run record is not set-up, then the error message below will be printed.

```
<< Run record not set-up
```

If the run record is set-up, the program checks the stored data records in the run record to ascertain whether the data record was already stored previously.

If the data record had been stored in the run record, the system error message printed is:

```
<< Data record already stored
```

If the data record has not been stored in the run record and the run record is set-up, the probe ports are entered as follows.

```
 > What is the run number (1-10) ?
.1

 Option  Port   Option  Port
   1  -  1       6  -  4A
   2  -  2       7  -  5
   3  -  2A      8  -  6
   4  -  3       9  -  7
   5  -  4       0  -  No port

 > Enter sample port option number
.2

 > Enter cooling port option number
.0

 > Enter staging port option number
.0
```

As in the Enter option section 5.2.10, the sample probe must have a port number, otherwise the program is halted at this question. A carriage return only entered for the port option number for the cooling probe or the staging probe position will give a no position default.

If a carriage return is entered for the run number, the program would bypass all the above questions and

tests and then resume at this point. The program continues as in the following example.

```
*** RESULTS OF CHROMATOGRAPH DATA ***

<<  0.00 %  H2
<<  5.37 %  02
<< 77.90 %  N2
<<  0.03 %  CH4
<<  3.45 %  CO
<< 13.25 %  CO2
```

This will only be printed if there is chromatograph data available. The questions now asked are:

```
 > Enter the air temperature:  [=] Fahrenheit
.80

 > Enter TRNS pressure:  [=] psig
.8.0

 > Enter PRHT pressure:  [=] psig
.12.2

 > Enter STGD pressure:  [=] psig
.11
```

Immediately after answering the last of the above questions, the data acquisition information is printed as below.

```
*** RECORD  1     TIME 13:17:49     DATE  5/25/82

*** ANALYZER AND TRANSDUCER OUTPUTS:

          CO2   14.67 %          TRNS    1.77 SCFM        3.10 inches H20
          CO     4.79 %          PRHT    3.93 SCFM        0.92 inches H20
          02     0.25 %          STGD    0.00 SCFM        0.00 inches H20
          NO   582.02 PPMV
```

If this is a run data record, a print-out will follow as below.

```
*** RECORD  1     PROBE  1      5/25/82     13:17:49     BEULAH LIGNITE

                          [=]  LB/HR             KG/S

***       COAL INPUT RATE =  5.030E+00         6.344E-04
***    FLUE SOLIDS OUTPUT =  1.165E+00         1.469E-04

                          [=]  SCFM              M**3/S

***       FLUE GAS OUTPUT =  6.546E+00         3.090E-03
***        AIR INPUT RATE =  5.701E+00         2.691E-03

            TRANSPORT AIR =  1.773E+00         8.369E-04
            SECONDARY AIR =  3.928E+00         1.854E-03
               STAGED AIR =  0.000E-01         0.000E-01

***    STOICHIOMETRIC AIR =  7.979E+00         3.766E-03

     STOICHIOMETRIC RATIO =  0.71

    COAL           FLUE SOLIDS        FLUE GAS         FLUE GAS
 PERCENTAGES       PERCENTAGES      PERCENTAGES       TRACE PPMV

   54.09 C          58.98 C         12.59 CO2        499.50 NO
    4.20 H           0.00 H          4.11 CO           0.00 HCN
   15.55 O           0.00 N          0.22 O2           0.00 H2S
    2.95 S           0.00 S          0.00 CH4       4577.14 SO2
    0.71 N          41.02 ASH        0.00 H2           0.00 NH3
   11.86 H2O                        13.67 H2O
    9.50 ASH                        68.90 N2

PERCENTAGE N IN COAL CONVERTED TO NO  =  23.07
PERCENTAGE N IN COAL CONVERTED TO HCN =   0.00
PERCENTAGE N IN COAL CONVERTED TO NH3 =   0.00
```

This print-out is the result of a mass-balance. The program automatically selected the Analyze option without a consistency check.

5.7 Analyze option

This option analyzes a data record by performing a mass-balance and if specified, a consistency check on the data acquired by the system. The results of a consistency check will not be given. The portion of the data acquisition system which performs the consistency checks was developed and implemented by Montgomery (1982). Montgomery goes into detail of how to interpret the results of this option. It should be mentioned that if a consistency check is is performed, the data acquisition system requires 30 minutes for a reasonable set of data.

After selecting this option, the program will ask the following questions.

```
 * Enter option
.6

 > Analyze which data record?
.1
 >> Include a consistency analysis?
.N
```

If an invalid record number had been entered, the program would immediately return to the main system options list. The next question asks if a consistency check is to be performed. Since this part

of the option will not be discussed, a negative response to the consistency question has been entered. If a positive response had been entered to the consistency check question, the next question would ascertain if the water-gas-shift reaction is to be included. When the questions are answered as above, the results of the mass balance are printed as below.

```
*** RECORD  1     PROBE  1      5/25/82     14:36:33     BEULAH LIGNITE

                          [=]  LB/HR              KG/S

***       COAL INPUT RATE =  2.100E+00         2.648E-04
***     FLUE SOLIDS OUTPUT =  1.995E-01         2.515E-05

                          [=]  SCFM              M**3/S

***       FLUE GAS OUTPUT =  5.437E+00         2.566E-03
***        AIR INPUT RATE =  5.390E+00         2.544E-03

            TRANSPORT AIR =  8.900E-01         4.201E-04
            SECONDARY AIR =  4.500E+00         2.124E-03
               STAGED AIR =  0.000E-01         0.000E-01

***    STOICHIOMETRIC AIR =  3.330E+00         1.572E-03

     STOICHIOMETRIC RATIO =  1.62

    COAL           FLUE SOLIDS        FLUE GAS          FLUE GAS
 PERCENTAGES       PERCENTAGES      PERCENTAGES       TRACE PPMV

   54.09 C          0.00 C          11.23 CO2        928.08 NO
    4.20 H          0.00 H           0.00 CO           0.00 HCN
   15.55 O          0.00 N           3.25 O2           0.00 H2S
    2.95 S          0.00 S           0.00 CH4       2300.07 SO2
    0.71 N        100.00 ASH         2.97 H2           0.00 NH3
   11.86 H2O                        3.90 H2O
    9.50 ASH                       78.33 N2

PERCENTAGE N IN COAL CONVERTED TO NO  =  78.87
PERCENTAGE N IN COAL CONVERTED TO HCN =   0.00
PERCENTAGE N IN COAL CONVERTED TO NH3 =   0.00
```

The print-out gives all pertinent information about the data record which was analyzed. After a data record has been anaylzed, the numbers reported in the print-out are stored in a specific data record. This option takes the numbers stored in a data record as measured values, therefore, a data record should never be analyzed more than once. If a data record is analyzed more than once, the reported mass-balance percentages will change.

In the Acquire option, an automatic Analyze was performed if the data record was to be stored as part of a run. This is done primarly for the user's benifit. If an Acquired data record has some obvious errors in it, the following procedure should be followed to correct the information in the data record.

1) Record the acquired data as it should be.
2) Select the Delete option and delete the record which has the obvious errors.
3) Select the Enter option (using data record just deleted) and enter information for suboptions 7, 8, and 10.
4) Select the Analyze option and analyze the the above record.

In using this procedure, the run record will not be affected. The above record will still be associated

with the desired run number except the data record just changed will have correct values stored. The alternate method to the above procedure is to use the Run set-up option and delete the data record associated with the run record. This method will be explained in the Run set-up option, section 5.10.

5.8 Calibration option

The calibration option is used to enter calculated calibration constants for the data acquisition monitors. After selecting this option the program asks if the calibration assignments should be printed out. Normally, this would not be done as it takes considerable time to execute. The example below shows these constants which are the present constants stored in the system.

```
 * Enter option
.7
 >> List the calibration assignments?
.Y

CHANNEL                SLOPE                INTERCEPT
   0        TC.R =  2.118E-22 * TC.R +  0.000E-01
   1        TC.R =  0.000E-01 * TC.R +  0.000E-01
   2        TC.R =  0.000E-01 * TC.R +  0.000E-01
   3        TC.R =  0.000E-01 * TC.R +  0.000E-01
   4        TC.R =  0.000E-01 * TC.R +  0.000E-01
   5        TC.R =  0.000E-01 * TC.R +  0.000E-01
   6        TC.R =  0.000E-01 * TC.R +  0.000E-01
   7        TC.R =  0.000E-01 * TC.R +  0.000E-01
   8        TC.K =  5.000E+00 * TC.K +  1.000E+00
   9        TC.K =  0.000E-01 * TC.K +  0.000E-01
  10        TC.K =  3.000E+00 * TC.K +  1.000E+00
  11        TC.K =  3.000E+00 * TC.K +  1.000E+00
  12        TC.K =  0.000E-01 * TC.K +  0.000E-01
  13        TC.K =  3.000E+00 * TC.K +  2.000E+00
  14        TC.K =  0.000E-01 * TC.K +  0.000E-01
  15        TC.K =  0.000E-01 * TC.K +  0.000E-01
  16        TC.K =  0.000E-01 * TC.K +  0.000E-01
  17        TC.K =  0.000E-01 * TC.K +  0.000E-01
  18        TC.K =  9.000E+00 * TC.K +  7.000E+00
  19        TC.K =  0.000E-01 * TC.K +  0.000E-01
```

(Calibration constants -- Continued)

```
 20        TC.K =  0.000E-01 * TC.K +  0.000E-01
 21        TC.K =  0.000E-01 * TC.K +  0.000E-01
 22        TC.K =  0.000E-01 * TC.K +  0.000E-01
 23        TC.K =  0.000E-01 * TC.K +  0.000E-01

CHANNEL = A0 + A1*ADC + A2*ADC**2 + A3*ADC**3
          A0          A1          A2          A3
TRNS  9.940E+00  -4.780E-03   0.000E-01   0.000E-01
PRHT  9.170E+00  -4.709E-03   0.000E-01   0.000E-01
STGD  1.005E+01  -5.253E-03   0.000E-01   0.000E-01
 CO2 -5.009E-03  -4.341E-03   2.170E-06   0.000E-01
 CO   1.119E-03  -1.974E-03   1.038E-06   0.000E-01
 O2   3.374E+01  -1.730E-02   0.000E-01   0.000E-01
 NO  -4.800E+03   2.455E+00   0.000E-01   0.000E-01


*** Calibration options:
    1 = P/E Transducers
    2 = Analyzers
    3 = Pt/PT-Rhodium Thermocouples
    4 = Chromel/Alumel Thermocouples CH(8-15)
    5 = Chromel/Alumel Thermocouples CH(16-23)
```

This system option has 5 suboptions. They all deal with changing the above listed calibration constants. The P/E Transducers and the Analyzer suboptions will be similar, as all the Thermocouple options will be. Starting with the P/E Tranducer suboption, the questions asked will be:

```
 * Enter the calibration option:
.1
 >> Do you wish to change base point? 1950
.N

 CHANNEL = A0 + A1*ADC + A2*ADC**2 + A3*ADC**3

 > Enter the constants:  A0.A1.A2.A3 for:  TRNS
 >> Change calibrations? (CR=NO)
.
```

```
> Enter the constants:  A0,A1,A2,A3 for:  PRHT
>> Change calibrations? (CR=NO)
.

> Enter the constants:  A0,A1,A2,A3 for:  STGD
>> Change calibrations? (CR=NO)
.
```

The base point was not changed and as mentioned before it should always be a predetermined constant for all channels. Changing the base point for the Analyzers, also changes the base point for the P/E Transducers. These two groups of monitors must be calibrated to the same base point.

This option inquires if the constants for a particular system monitor are to be changed. In parentheses the characters CR=NO are seen. Entering a carraige return means no. Only if a 'Y' character is entered will the calibration constants be allowed to change. In case of the Analyzers and the P/E Transducers, four numbers must be entered correctly, seperated by commas (number, number, number, number carraige return). Any numbers entered as carriage returns will be interpreted as zeros and the program will expect all calibration constants to be entered. It is important to enter all four numbers on one line, otherwise the constants can be stored wrong.

An example of changing the thermocouple

constants will follow.

```
 * Enter the calibration option:
.4
 >> Do you wish to change base point? 1950
.N

 > Enter the intercept and slope for:  TC.K  8
 >> Change calibrations? (CR=NO)
.

 > Enter the intercept and slope for:  TC.K  9
 >> Change calibrations? (CR=NO)
.

 > Enter the intercept and slope for:  TC.K 10
 >> Change calibrations? (CR=NO)
.

 > Enter the intercept and slope for:  TC.K 11
 >> Change calibrations? (CR=NO)
.

 > Enter the intercept and slope for:  TC.K 12
 >> Change calibrations? (CR=NO)
.

 > Enter the intercept and slope for:  TC.K 13
 >> Change calibrations? (CR=NO)
.

 > Enter the intercept and slope for:  TC.K 14
 >> Change calibrations? (CR=NO)
.

 > Enter the intercept and slope for:  TC.K 15
 >> Change calibrations? (CR=NO)
.
```

Changing thermocouple calibration constants is exactly like changing Analyzer or P/E Transducer calibration constants except that only two numbers are entered, the slope and intercept.

5.9 Reload option

This option has only one purpose and has no print-outs or error messages. The option is executed in the example below.

```
* Enter option
.8
```

After this option is performed, the data acquisition program residing in the SPC-16 goes into a down-load state. The program is waiting to down-load the Cromemco program. The signal to down-load the Cromemco program is given to the SPC-16 program every time the Cromemco is turned on. When the Cromemco is turned on, the resident monitor controlling the Cromemco issues an 'OK'. This prompt is sensed by the SPC-16 program which then down-loads the Cromemco program. It can be seen that an undesirable situation arises if the SPC-16 program is not in a down-load state and the Cromemco is without its program. This situation will arise if the Cromemco is turned off before a Reload option is executed. The SPC-16 program will be executing commands other than the down load. Two methods in section 5.1 were discussed on how to

correct this situation. This option should always be executed before turning the power off to the Cromemco.

5.10 Run set-up option

This option is used to set-up an end-of-run print-out. This option would normally be executed first at beginning of a run. After selecting this option the following print-out will result.

```
 * Enter option
.9

 > What is the run # (1-10) ?
.1
```

5.10.1 Intial set-up

At this point the program checks the run record for data. If there has been data entered, the user is given the option to delete all of the data as follows.

```
 << Run record contains data
 Do you wish to delete it ?
.Y
```

In this example, all the run data was deleted. The program proceeds as follows.

```
 >> Is there staging ?
.N
```

If there were staging the coal flowrate could be obtained from another run record. This will be demonstrated shortly. The program prints the

following message and question.

```
>> Furnace must be running at fuel lean conditions
Is this condition now true ?
.Y
```

The program will halt and not go beyond this point until a positive answer is given. After a positive answer is given, the program does an automatic Acquire and Analyze option. The user is required to enter the ambient air temperature and pressures on the laminar flow elements as below.

```
> Enter the air temperature:  [=] Fahrenheit
.

> Enter TRNS pressure:  [=] psig
.

> Enter PRHT pressure:  [=] psig
.

> Enter STGD pressure:  [=] psig
.
```

(Print-out -- Continued)

*** RECORD 1 PROBE 1 5/25/82 16:18:18 BEULAH LIGNITE

	[=] LB/HR	KG/S
*** COAL INPUT RATE =	5.060E+00	6.381E-04
*** FLUE SOLIDS OUTPUT =	5.451E-01	6.874E-05
	[=] SCFM	M**3/S
*** FLUE GAS OUTPUT =	6.635E+00	3.132E-03
*** AIR INPUT RATE =	5.390E+00	2.544E-03
TRANSPORT AIR =	8.900E-01	4.201E-04
SECONDARY AIR =	4.500E+00	2.124E-03
STAGED AIR =	0.000E-01	0.000E-01
*** STOICHIOMETRIC AIR =	8.026E+00	3.789E-03

STOICHIOMETRIC RATIO = 0.67

COAL PERCENTAGES	FLUE SOLIDS PERCENTAGES	FLUE GAS PERCENTAGES	FLUE GAS TRACE PPMV
54.09 C	11.82 C	10.83 CO2	386.73 NO
4.20 H	0.00 H	10.83 CO	0.00 HCN
15.55 O	0.00 N	0.00 O2	0.00 H2S
2.95 S	0.00 S	0.00 CH4	4542.64 SO2
0.71 N	88.18 ASH	3.01 H2	0.00 NH3
11.86 H2O		10.56 H2O	
9.50 ASH		64.28 N2	

PERCENTAGE N IN COAL CONVERTED TO NO = 17.97
PERCENTAGE N IN COAL CONVERTED TO HCN = 0.00
PERCENTAGE N IN COAL CONVERTED TO NH3 = 0.00

Again, a positive response must supplied to this last question before the program proceeds. If a positive response is not entered, the program restarts at the question about the furnace being at fuel-lean conditions. If an unacceptable coal flow rate is not acquired within two trys, a positive answer should be given to the coal flow rate question. The user is allowed to change the coal flow rate manually. Changing the coal flow rate manually is explained in section 5.10.3. The program now asks for the constant conditions expected for this run. An example follows.

```
 >> Is the coal flowrate acceptable ?
.Y

 > What is the Trns flowrate (SCFM) ?
..89

 > What is the Prht flowrate (SCFM) ?
.4.5

 > What is the Stgd flowrate (SCFM) ?
.0

 > What is the temperature (C) at port  1
.1100

 > What is the temperature (C) at port  2
.1190

 > What is the temperature (C) at port 2A
.1250

 > What is the temperature (C) at port  3
.1220

 > What is the temperature (C) at port  4
.1195
```

(run set-up questions -- Continued)

```
 > What is the temperature (C) at port 4A
.1135

 > What is the temperature (C) at port  5
.1065

 > What is the temperature (C) at port  6
.1025

 > What is the temperature (C) at port  7
.980

 > Enter stoichiometric ratio above(or w/o) staging
..8

 > Enter stoichiometric ratio below(or CR) staging
.
```

This concludes setting-up a run record for final print-out as per the Run print-out option.

5.10.2 Staging

The program conversation dealing with the coal flow rate and staging will be explained. If a positive answer had been given to the staging question the program would proceed as follows.

```
 >> Is there staging ?
.Y

 >> Do you wish to get coal flowrate from another
 run record ?
.Y

 > What run record ?
.1
```

If an invalid run record is entered, or if the run record entered is not set-up, or the run record entered is the same as the run record presently being set-

up, the program proceeds to the furnace at fuel-lean question.

5.10.3 Changing run conditions

If a run record has been successfully set-up, changing constant input conditions is possible. After selecting the run set-up option and selecting the run record to be changed, the message:

```
 > What is the run # (1-10) ?
.1

 << Run record contains data
 Do you wish to delete it ?
.N
```

will be printed. A negative response should be entered to the last question. This will cause the following change suboptions to be printed out.

```
CHANGE:
1 Temperature profile    5 Staged air flowrate
2 Sample name            6 Coal flow rate
3 Trans air flowrate     7 Delete or Add data records
4 Preheat air flowrate
```

These suboptions allow the user to change everything stored in the run record. The change print-out questions will be exactly as in the example where the run record data was entered, section 5.2. The only new print-out is the 'Delete or Add data records' suboption. An example follows

```
 * Enter run option
.7

 << Presentlv stored records are   0  0  0  0  0  0  0  0  0  0  0  0
```

The stored data records are printed. The 16 possible data records are printed with zeros indicating available room for additional data records. Examples of adding and deleting data records are given below.

```
 > 1 - Delete or 2 - Add a record ?
.2

 > Record to be Added ?
.4

 << Presentlv stored records are   1  3  4  0  0  0  0  0  0  0  0  0

 > 1 - Delete or 2 - Add a record ?
.1

 > Record number to be Deleted ?
.3

 << Presentlv stored records are   1  4  0  0  0  0  0  0  0  0  0  0
```

A record is not allowed to be stored twice, and if an invalid record is entered various system messages will inform the user of his mistake. To exit this subop-tion enter a carriage return to return to the suboptions entry point (Another carriage return will return the user to the main system options.) The next section will discuss the print-out of run data now made posible by executing the system option.

5.11 Run print-out option

The sole purpose of this option is to print the results of a run. It also calculates stoichiometric species and residence time to sample port. After selecting this option the following questions will be asked.

```
 > What is the run number ?
.1
 PORT 1  TEMPERATURE =  1100.0 C
 PORT 2  TEMPERATURE =  1190.0 C
 PORT 2A TEMPERATURE =  1250.0 C
 PORT 3  TEMPERATURE =  1220.0 C
 PORT 4  TEMPERATURE =  1195.0 C
 PORT 4A TEMPERATURE =  1135.0 C
 PORT 5  TEMPERATURE =  1065.0 C
 PORT 6  TEMPERATURE =  1025.0 C
 PORT 7  TEMPERATURE =   980.0 C

 >> Is this profile okay ?
.Y

 << The inlet air temperature is   500.0 C
 >> Is this acceptable ?
.Y
 TRNS FLOWRATE =    0.89
 PRHT FLOWRATE =    4.50
 STGD FLOWRATE =    0.00
 >> Are these flows acceptable ?
.Y
```

The run number entered must be set-up. If the temperature profile, or the oxidizer flowrates are unacceptable, the program returns the user to the main

system option list. The user then must choose the Run set-up option and change the unacceptable conditions as required. The inlet air temperture (after the preheater) however, can be changed. An Example follows.

```
 << The inlet air temperature is   500.0 C
 >> Is this acceptable ?
.N

 > What is the inlet air temperature (C) ?
.750

 << The inlet air temperature is   750.0 C
 >> Is this acceptable ?
.Y
```

After a yes response is given to the flow rate question, a print-out will follow. If a run record has no data records associated with it, the print-out will stop after the inlet air temperature is reported. The following is a print-out of a run.

RUN NUMBER 3 DATE 5/11/82 RUN 20 BEULAH LIGNITE SR=.6 3/19/82

TEMPERATURE PROFILE

PORT	TEMPERATURE(C)
1	1208.0
2	1176.0
2A	1150.0
3	1115.0
4	1080.0
4A	1050.0
5	1021.0
6	1005.0
7	994.0

FLOWRATES

FLOW	SCFM
TRNS	1.0
PRHT	3.8
STGD	0.0
	LB/HR
COAL	5.0

INLET AIR TEMPERATURE = 750.0 C

(run print-out -- Continued)

COAL COMPOSITION

PROXIMATE ANALYSIS PERCENTAGES		ULTIMATE ANALYSIS PERCENTAGES	
F.C. =	40.00	C =	62.25
V.M. =	40.00	H =	4.83
ASH =	9.50	O =	17.90
H2O =	11.86	S =	3.40
		N =	0.82

FLUE SOLIDS PERCENTAGES

C =	0.0
H =	0.0
N =	0.0
S =	0.0
ASH =	100.0

DATA INFORMATION

TIME	12: 9	12: 6	11:34	11:23	11:17	11:12	11: 7	0: 0	0: 0
RECORD	21	20	19	18	17	16	15	0	0
AIR INPUT (SCFM)									
TOTAL	4.8	4.8	4.8	4.8	4.8	4.8	4.8	0.0	0.0
TRNS	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0
PRHT	3.8	3.8	3.8	3.8	3.8	3.8	3.8	0.0	0.0
STGD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FLUE OUTPUT (SCFM)	5.7	5.8	5.8	5.8	5.9	5.9	5.9	0.0	0.0
PORT FOR : SAMPLE STAGED COOLING	1	2	3	4	5	6	7		
STOICHIOMETRIC RATIO	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.00	0.00
STOICHIOMETRIC AIR (SCFM)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	0.0	0.0

(run print-out -- Continued)

FLUE GAS PERCENTAGES									
CO2	10.7	9.3	9.2	9.3	9.6	10.0	10.1	0.0	0.0
CO	6.4	9.7	9.6	9.5	9.4	9.9	9.9	0.0	0.0
O2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H2	2.1	4.1	3.5	3.4	3.5	3.8	4.2	0.0	0.0
H2O	13.5	11.1	11.8	11.9	11.7	11.3	10.8	0.0	0.0
N2	66.7	65.3	65.3	65.4	65.2	64.4	64.4	0.0	0.0
FLUE GAS TRACE PPMV									
NO	481.7	132.2	252.4	210.3	151.5	63.3	50.6	0.0	0.0
HCN	77.9	105.2	61.4	61.4	74.1	87.8	92.0	0.0	0.0
H2S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO2	5238.7	5125.2	5131.9	5134.7	5121.2	5061.8	5057.9	0.0	0.0
NH3	82.1	314.9	218.8	213.7	257.6	370.4	370.5	0.0	0.0
STOICHIOMETRIC TRACE PPMV									
NO	293.5	83.9	158.3	131.5	95.1	39.9	32.2	0.0	0.0
HCN	47.5	66.8	38.5	38.4	46.5	55.4	58.6	0.0	0.0
H2S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO2	3191.8	3253.4	3218.7	3209.7	3212.7	3195.0	3220.1	0.0	0.0
NH3	50.0	199.9	137.2	133.6	161.6	233.8	235.9	0.0	0.0
PERCENTAGE OF N IN COAL CONVERTED TO									
NO	19.9	5.6	10.6	8.8	6.4	2.7	2.2	0.0	0.0
HCN	3.2	4.4	2.6	2.6	3.1	3.7	3.9	0.0	0.0
NH3	3.4	13.2	9.2	9.0	10.8	15.7	15.7	0.0	0.0
RESIDENCE TIME TO SAMPLE PORT (SEC)	0.1986	0.3967	0.6061	0.8231	1.2383	1.6203	2.0194	0.0000	0.000
ACTUAL FLUE SOLIDS (LB/HR)									
INPUT	5.03	5.03	5.03	5.03	5.03	5.03	5.03	0.00	0.00
OUTPUT	1.3797	1.1359	1.1559	1.1617	1.1321	1.0024	0.9938	0.0000	0.0000

If another run is to be printed after the first print-out, the run number is entered in response to the last question. A carriage return will return the program to the main system options list.

5.12 Additional information

The minicomputer program is divided into three jobs, 27, 6, and 3 on the SPC-16. Appendix G contains the new listings of the source code for jobs 27 and 6. All other source code is unchanged and contained in Montgomery's Thesis. The microcomputer program and all associated programs have not been listed as they have not been changed.

Appendix F contains the disk storage layout for all data records and run records. If the program is changed in the future, this information is invaluable.

NOMENCLATURE

Variable	Description
H	Weight fraction of hydrogen in coal.
Q/O % OX	Theoretical amount of oxidizer needed for completed combustion of coal (moles of oxidizer/lb coal).
Q/21.0	Theoretical amount of air needed for completed coal combustion. (moles air/lb coal)
n	Fraction of hydrogen in coal converted to H_2O.
SCFM	Flue gas output at sample port. (scfm)
SR	Stoichiometric ratio.
T_i	Temperature at port i. (K)
T_{stand}	70 F.
$Volume_i$	Volume between port i-1 and port i of the furnace. (cu.ft)
X_{CO}	Mole percent of CO in dry gas sample.

APPENDIX A

Channel Assignments

CHANNEL	DEVICE ON CHANNEL
0	PT/PT-RD THERMOCOUPLE
1	"
2	"
3	"
4	"
5	"
6	"
7	GROUND
8	CR/CR-AL THERMOCOUPLE
9	"
10	"
11	"
12	"
13	"
14	"
15	GROUND
16	CR/CR-AL THERMOCOUPLE
17	"
18	"
19	"
20	"
21	"

CHANNEL	DEVICE ON CHANNEL (continued)
22	"
23	GROUND
24	TRANSPORT PRESSURE TRANSDUCER
25	PREHEAT PRESSURE TRANSDUCER
26	STAGED PRESSURE TRANSDUCER
27	CO2 ANALYZER
28	CO ANALYZER
29	O2 ANALYZER
30	NO ANALYZER
31	GROUND
32	FREE FOR EXPANSION
33	"
34	"
35	"
36	"
37	"
38	"
39	GROUND

APPENDIX B

System Wiring

Cromemco Connector - Interface Board

Pin Assignments

Connector I					CONNECTOR II				
COLOR	#	#	COLOR	A TO D CHANNEL	COLOR	#	#	COLOR	A TO D CHANNEL
R	1	17	BN	0	GY	1	17	P	16
Y	2	18	O	1	BK	2	18	W	17
B	3	19	G	2	R	3	19	BN	18
GY	4	20	P	3	Y	4	20	O	19
BK	5	21	W	4	B	5	21	G	20
R	6	22	BN	5	GY	6	22	P	21
Y	7	23	O	6	BK	7	23	W	22
B	8	24	G	7	R	8	24	BN	23
GY	9	25	P	8	Y	9	25	O	24
B	10	26	W	9	B	10	26	G	25
R	11	27	BN	10	R	11	27	BN	26
Y	12	28	O	11	Y	12	28	O	27
B	13	29	G	12	B	13	29	G	28
R	14	30	BN	13	GY	14	30	P	29
Y	15	31	O	14	BK	15	31	W	30
B	16	32	G	15	R	16	32	BN	31
			GRND					GRND	

Junction Box - Cromemco Connector

Pin Assignments

Connector I

PIN	WIRE COLORS		PIN
1	----------		17
2	ORANGE	GREEN	18
3	BLUE	GREEN	19
4	BLACK	GREEN	20
5	RED	YELLOW	21
6	BLACK	YELLOW	22
7	GREEN	YELLOW	23
8	BLUE	YELLOW	24
9	BROWN	YELLOW	25
10	GREEN	WHITE	26
11	BLACK	WHITE	27
12	ORANGE	WHITE	28
13	BROWN	WHITE	29
14	YELLOW	WHITE	30
15	RED	WHITE	31
16	BLUE	WHITE	32
		GROUND	

Connector II

PIN	WIRE COLORS		PIN
1	RED	GREEN	17
2	ORANGE	GREEN	18
3	BLUE	GREEN	19
4	BLACK	GREEN	20
5	RED	YELLOW	21
6	BLACK	YELLOW	22
7	GREEN	YELLOW	23
8	BLUE	YELLOW	24
9	BROWN	YELLOW	25
10	GREEN	WHITE	26
11	BLACK	WHITE	27
12	ORANGE	WHITE	28
13	BROWN	WHITE	29
14	YELLOW	WHITE	30
15	RED	WHITE	31
16	BLUE	WHITE	32
		GROUND	

Field - Junction Box Pin Assignments

CHANNELS										
0-4	1	2	3	4	5	6	7	8	9	10
	1	2	3	4	5	6	7	8	8	10
	R	G	O	G	B	G	BK	G	R	Y
5-9	11	12	13	14	15	16	17	18	19	20
	11	12	13	14	15	16	17	18	19	20
	BK	Y	G	Y	B	Y	BN	Y	G	W
10-14	21	22	23	24	25	26	27	28	29	30
	21	22	23	24	25	26	27	28	29	30
	BK	W	O	W	BN	W	Y	W	R	W
15-19	31	32	33	34	35	36	37	38	39	40
	31	32	33	34	35	36	37	38	39	40
	B	W	R	G	O	G	B	G	BK	G
20-24	41	42	43	44	45	46	47	48	49	50
	41	42	43	44	45	46	47	48	49	50
	R	Y	BK	Y	G	Y	B	Y	BN	Y
25-29	51	52	53	54	55	56	57	58	59	60
	51	52	53	54	55	56	57	58	59	60
	G	W	BK	W	O	W	BN	W	Y	W
30-32					61	62	63	64	65	66
					61	62	63	64	65	66
					R	W	B	W		

Cromemco Channel - Digital Thermometer Channel Assignments

CHANNEL #	COLORS	DIGITAL CHANNEL #
0	Y/BK	NOT USED
1	Y/R	5
2	Y/W	6
3	Y/BN	7
4	W/O	8
5	W/P	4
6	W/BL	3
7	THIS IS GROUNDED TRACE CHANNEL	
8	W/GY	9
9	W/BK	11
10	W/BN	12
11	W/R	13
12	BK/G	14
13	BK/BL	15
14	BK/O	16
15	THIS IS A GROUNDED TRACE CHANNEL	
16	BK/R	18
17	BK/BN	19
18	BK/GY	20
19	BN/R	21
20	BN/O	22
21	BN/P	1

(continued)

22	BN/BK	2
23	THIS IS A GROUNDED TRACE CHANNEL	

APPENDIX C

Calibration Program

This is the BASIC program used in calibrating the system monitors.

```
 10 A=0
 15 B=64
 20 R=*
 25 S=**        See note at bottom for proper values.
 30 T=***
 35 FOR U=1 TO 1000
 40 FOR I=1 TO 8
 45 ,(I)=0
 50 NEXT I
 60 FOR K=R TO S
 70 X=K-T
 80 OUT(10)=A
 90 OUT(10)=K
100 OUT(10)=K+B
110 OUT(10)=A
120 F=IN(10)
130 E=IN(11)
140 G=AND(E,%0F)
150 H=256*G+F
160 @(X)=@(X)+H
170 NEXT K
180 FOR L=1 TO 1800
190 Z=L
200 NEXT L
210 NEXT J
220 FOR M=1 TO 8
230 @(M)=@(M)/8
240 NEXT M
250 FOR N=1 TO 8
260 PRINT @(N),
270 NEXT N
280 PRINT
290 NEXT U
```

Note:
R=0,S=7,T=-1 for calibration of PT/PT-RD Thermocouples.

R=8,S=15,T=7 for calibration of CR/CR-AL Thermocouples (CH 8-15)

R=16,S=23,T=15 " " (CH 16-23)

R=24,S=31,T=23 for calibration of P to Es and analyzers.

Appendix D

Chromatograph Methods

METHOD 2 = Hot Wire Detectors

METHOD 3 = Nitrogen-Phosphorous Detector

LST2

METHOD 2

ANALYZER CONTROL

INJ TEMP 250
DET ZONE 1,2 250 200
AUX TEMP 125
FLOW A,B 60 60
INIT OVEN TEMP,TIME 140 11

DATA PROC

STD WT,SMP WT 0.0000 1.0000 0
FACTOR,SCALE 1 0
TIMES 11.00 0.18 0.18 0.40 4.59 327.67
SENS-DET RANGE 50 2 0.05 2 0 0
UNK,AIR 0.000 0.00
TOL 0.0200 0.100 3.0
REF PK 1.000 0.49 0.55 0.52
STD NAME NITROGEN

RT	RF	CONC	NAME
0.31	18.784	6.3600	HYDROGEN
0.44	0.336	0.0000	OXYGEN
0.52	0.300	72.0480	NITROGEN
0.80	0.368	1.9400	METHANE
0.88	0.300	4.5000	CARBON MONOXIDE
4.84	0.120	15.1496	CARBON DIOXIDE

EVENT CONTROL

ATTN-CHART-DELAY 5 100 1.00

TIME	DEVICE		FUNCTION	NAME
0.00	EXT	X	7	MAKE PLUS POL
0.00	NO INT	NI	1	DO NOT INTEGRATE
0.01	EXT	X	6	ACTIVATE 10 PORT
0.06	EXT	X	-6	DEACTIVATE 10 PORT
0.07	ATTN	A	2	CHART ATTN 2
0.20	ZERO	Z	1	ZERO DETECTOR
0.26	NO INT	NI	0	START INTEGRATING
0.48	ATTN	A	3	CHART ATTN 3
1.42	NO INT	NI	1	STOP INTEGRATING
1.44	CHART	C	5	TURN SPEED DOWN
3.75	EXT	X	-7	MAKE MINUS POL
4.00	EXT	X	5	ACTIVATE 10 PORT
4.06	EXT	X	-5	DEACTIVATE 10 PORT
4.20	CHART	C	100	TURN SPEED BACK UP
4.22	ZERO	Z	1	ZERO FOR CO2
4.60	NO INT	NI	0	START INTEGRATING
5.00	NO INT	NI	1	STOP INTEGRATING
5.05	CHART	C	5	TURN SPEED DOWN

```
LST3

METHOD   3


ANALYZER CONTROL

INJ TEMP     250
DET ZONE 1,2    250    200
AUX TEMP     125
FLOW A,B     60    60
INIT OVEN TEMP,TIME     140    11

DATA PROC

STD WT,SMP WT      0.0000     1.0000   0
FACTOR,SCALE        1    0
TIMES     11.00     9.00   327.67   327.67   327.67   327.67
SENS-DET RANGE      50     5    25.00     2    0    0
UNK,AIR     0.000     0.00
TOL        0.0000   10.000      3.0
REF PK      1.000     9.80    10.60    10.30
STD NAME   HCN

  RT      RF       CONC      NAME
   8.20   1.000   157.9968 HCN

EVENT CONTROL

ATTN-CHART-DELAY       0     5     0.01

  TIME  DEVICE     FUNCTION NAME
   0.00 NO INT NI   1        DONT INTEGRATE
   8.90 ATTN   A     0       TURN ATTN TO 0
   9.00 ZERO   Z    2        ZERO DETECTOR
   9.10 CHART  C   100      TURN SPEED UP
   9.20 NO INT NI   0        START INTEGRATING
  11.00 NO INT NI   1        STOP INTEGRATING
  11.02 CHART  C     5      SLOW CHART DOWN
```

APPENDIX E

Chromatograph Program

Program name:	Means:
HWDHEM2	Hot-Wire-Detector using pure Helium carrier gas and METHOD 2.

```
/BL HWDHEM2
1  REM THIS PROGRAM SETS UP THE HWD WITH METHOD 2
2  REM AND SETS UP THE NPD WITH METHOD 3
3  REM IT DOE NOT REPORT NPD RESULTS TO CROMEMCO
4  REM THIS PROGRAM IS SET UP TO SHIP HWD RESULTS
5  REM TO THE CROMEMCO
6  LET X = 1
7  OPEN "PP"
10  PRINT ON ("PP") "GAS ANALYSIS METHOD"
20  PRINT ON ("PP") "ENTER RUN IDENTIFICATION"
30  INPUT ON ("PP") A$
40  CLOSE "PP"
50  REM LOOP POINT
110  SETUP A$,X,1,1,2,2,3
120  RUN A$,X
130  FILE A$,X,1,F1,F2
140  FILE A$,X,2,F3,F4
143  IF X<>1 THEN GOTO 150
144  CALIB F1,2,1,E
145  IF E<>0 THEN GOTO 400
150  OPEN "PP"
151  OPEN "RS"
152  PRINT ON("RS") "$"
160  PRINT ON ("PP") "RESULTS OF GAS ANALYSIS"
170  PRINT ON ("PP")
200  PRINT ON ("PP")
210  PRINT ON ("PP")"****** PERMANENT GASES - HWD *****"
220  PRINT ON ("PP")
230  PKREP "A",F1,2
```

```
240  PKPRINT ON ("PP") "A"
245  PKPRINT ON("RS") "A"
255  PRINT ON("RS") "?"
256  CLOSE "RS"
260  PRINT ON ("PP") "*** RESULTS OF NPD ***"
270  PKREP "A",F3,3
280  PKPRINT ON ("PP") "A"
320  CLOSE "PP"
340  ERASE F1,E
350  ERASE F3,E
370  SETUP A$
380  LET X = X + 1
390  GOTO 50
400  CLOSE "PP"
410  END
OK
```

APPENDIX F

Disk Storage Layout

NUMBER OF DISK RECORDS = 100

NUMBER OF INTEGER ELEMENTS IN EACH RECORD = 102

NUMBER OF INTEGER ELEMENTS AVAILABLE FOR USE = 100

Element 1 of every record contains the number of bytes to process.

Element 2 of every record contains the record number.

RECORD 1-80 = DATA RECORDS.

ELEMENT	TYPE	DESCRIPTION		
3	I	SAMPLE PROBE POSITION		
4	I	MONTH		
5	I	DAY		
6	I	YEAR		
7	I	HOUR		
8	I	MINUTE		
9	I	SECOND		
10	R	TEMPERATURE OF SAMPLE		
12	R	FLOWRATES SCFM	TRNS	
14	R		PRHT	
16	R		STGD	
18	R	FLUE GAS ANALYSIS	%	CO2
20	R			CO
22	R			O2
24	R		PPMV	NO
26	R			HCN
28	R		%	CH4
30	R		PPMV	H2S
32	R			SO2
34	R			NH3
36	R		%	H2
38	R			H20
40	R			N2
42	R	PROXIMATE ANALYSIS	%	FIXED CARBON
44	R			VOLITILE MATTER
46	R			ASH
48	R			H2O
50	R	ULTIMATE ANALYSIS	%	C
52	R			H

DATA RECORD -- Continued

ELEMENT	TYPE	DESCRIPTION
54	R	O
56	R	S
58	R	N
60	R	SOLIDS ANALYSIS % C
62	R	H
64	R	N
66	R	S
68	R	COAL FLOW RATE LB/HR
70-89	I	80 ASCII CHARACTERS REP. SAMPLE NAME
90	I	COOLING PORT
91	I	STAGING PORT
92	R	RESIDENCE TIME TO SAMPLE PORT SEC.
94	R	STOICHIOMETRIC RATIO
96	R	% N IN COAL CONVERTED TO NO
98	R	FLUE GAS FLOWRATE OUT SCFM
100	R	FLUE SOLIDS OUTPUT RATE LB/HR

RECORD 81 is coal analysis default RECORD. If coal analysis is changed, this RECORD will also be changed. It contains exactly the same information as the above RECORDS but the analysis section contains the last record analyzed data.

RECORD 82 contains a0, a1, a2, a3, and a4 Calibration Constants for the TRNS, PRHT, STGD, CO2, CO, O2, NO, and So2 system monitors. Starting with element 3, each monitors constants take up 8 elements r+spectively.

RECORD 83 contains the calibration constants for all the thermocouples. First is stored, starting with the third element, are the slope constants for 0-23 channels. then comes the intercepts for 0-23 channels. Each constant takes up two elements.

RECORDS 84-90 are used in saving labeled common. This is necessary when swapping jobs on the SPC/16.

RECORDS 91-100 are the run records. The layout follows.

ELEMENT	TYPE	DESCRIPTION
3	R	TRNS FLOWRATE SCFM
5	R	PRHT FLOWRATE SCFM
7	R	STGD FLOWRATE SCFM
9	R	COAL FLOWRATE LB/HR
11-26	I	INTEGER NUMBERS REPRESENTING RECORD #S ASSOCIATED WITH THE RUN RECORD
17-44	R	TEMPERATURE AT PORTS 1, 2, 2A, 3, 4, 4A, 5, 6, AND 7.
69	I	AN INTEGER FLAG: -1 IF RECORD IS SETUP, 0 IF NOT SETUP.
70-89	I	80 ASCII CHARACTERS REPRESENTING RUN NAME
90	I	MONTH
91	I	DAY
92	I	YEAR

APPENDIX G

Source Code

JOB 6

MASS BALANCE PROGRAM

```
C
C=====================================================================
C
C     D.O.E. COAL FURNACE COMMON ALLOCATION FOR SHARED DSECT
C
      BLOCK DATA
C
C=====================================================================
C
      INTEGER RDATA(102),DISK,TTY
      INTEGER IBASPT(5),IBUF(40)
C
      LOGICAL O2RICH,COGGIN,CHROMO,DEBUG,RESET,SHIFT,SSQMIN
      LOGICAL SETUP
C
      REAL CNAME(2),GNAME(4)
      REAL XNAME(6),YNAME(12),SNAME(4),PNAME(4)
C
      DOUBLE PRECISION SR,AIRSR
      DOUBLE PRECISION Q,W,X,Y,S,P,T,
     + QDATA,WDATA,XDATA,YDATA,SDATA,PDATA,TDATA
      DOUBLE PRECISION LASTZ(22),DELZ(22)
C
      COMMON /DATA  / RDATA
      COMMON /INDEX / INDEX(30)
      COMMON /TEMPER/ TAXIS(24)
      COMMON /WEIGHT/ WEIGHT(30)
      COMMON /GAMMA / SR,AIRSR
      COMMON /LUN   / TTY,DISK,MAXREC,IREC
      COMMON /DEBUG / DEBUG,RESET,SHIFT,SSQMIN
      COMMON /BURN  / O2RICH,COGGIN,CHROMO
      COMMON /NAME  / XNAME,YNAME,SNAME,PNAME,CNAME,GNAME
      COMMON /SYSTEM/ Q(4),W(2),X(6),Y(12),S(4),P,T
      COMMON /SEARCH/ QDATA(4),WDATA(2),XDATA(6),YDATA(12),
     +                SDATA(4),PDATA,TDATA
      COMMON /VECTOR/ LASTZ,DELZ,NSERCH
      COMMON /MAXPIV/ UNITS(96),NSIZE
      COMMON /CHRBUF/ IBUF
      COMMON /SETURN/ SETUP
      COMMON /BASE  / IBASPT
C
      DATA TTY,DISK,MAXREC,IREC/20,53,80,0/
C
      DATA RDATA/200,1,100*0/
      DATA IBASPT/5*1950/
      DATA IBUF/40*0/
      DATA SETUP/.FALSE./
C
      DATA CNAME/'COAL','FLUE'/
      DATA XNAME/' C  ',' H  ',' O  ',
     +           ' S  ',' N  ',' H2O'/
      DATA YNAME/' CO2',' CO ',' O2 ',
     +           ' NO ',' HCN',' CH4',
     +           ' H2S',' SO2',' NH3',
     +           ' H2 ',' H2O',' N2 '/
      DATA SNAME/' C  ',' H  ',' N  ',' S  '/
      DATA PNAME/'F.C.','V.M.',' ASH',' H2O'/
      DATA GNAME/'TRNS','PRHT','STGD','FLUE'/
C
      DATA INDEX/1,2,3,8,9,10,11,12,13,15,16,5,24,27,28,30,17,18,19,21/
      DATA WEIGHT/29*1.0,10.0/
C
     END
C
C=====================================================================
C
C     D.O.E. FURNACE REPORT GENERATING MAIN-LINE
C
C=====================================================================
C
      INTEGER NOW(2)
      INTEGER RECORD,ANS,TTY,DISK
      INTEGER RDATA(102),RANGET,RANPUT
      INTEGER PUSH,PULL
C
      LOGICAL DEBUG,RESET,SHIFT,SSQMIN
C
      COMMON /DATA  / RDATA
```

```
      COMMON /LUN   / TTY,DISK,MAXREC,RECORD
      COMMON /DEBUG / DEBUG,RESET,SHIFT,SSQMIN
C
      DATA JOB,JOB27,JOB3/0,27,3/
      DATA MODE,IOPT/2*0/, NOW/0,4/
      DATA PUSH,PULL/0,1/, NO/1HN/
C
      DATA M,ANS/0,0/, A/0.0/
      DATA RANGET/Z105F/, RANPUT/Z109F/
C
      CALL FREMAT
C
10    CONTINUE
C
C     RETRIEVE LABELED COMMON
C
      CALL DOESTK(PULL)
C
C     SEE IF A DATA PRINT OUT IS REQUESTED
C
      IF(RECORD.EQ.99) CALL DOEPOR
      IF(RECORD.EQ.99) JOB=27
      IF(RECORD.EQ.99) GOTO 40
C
C     GET THE OPTION FROM THE STATUS RECORD
C
      RDATA(2)=MAXREC+1
      CALL F$OPN(DISK)
      CALL F$IOS(RANGET,RDATA,DISK,M)
      CALL F$CLS(DISK)
      IOPT=RDATA(4)
C
      IF(IOPT.LT.1.OR.IOPT.GT.3) GO TO 10
C
C     CHECK FOR MASS BALANCE
C
      IF(IOPT.NE.1) GO TO 20
      JOB=JOB3
20    CONTINUE
C
C     CHECK FOR A COGGIN SEARCH
C
      IF(IOPT.NE.2) GO TO 30
      JOB=JOB3
      CALL DOEOUT
      IF(.NOT.SSQMIN) JOB=JOB27
30    CONTINUE
C
C     CHECK FOR A RETURN TO THE MAIN-LINE
C
      IF(IOPT.NE.3) GO TO 40
      JOB=JOB27
      CALL DOERPT
40    CONTINUE
C
C     SWAP TASKS TO EXECUTE THE OPTION
C
      CALL DOESTK(PUSH)
      CALL TPN$1(JOB,NOW,MODE)
      CALL R$FOF
      IF(.TRUE.) GO TO 10
C
      A=ALOG(A)
C
     END
C
C=====================================================================
C
      SUBROUTINE DOERPT
C
C     THIS ROUTINE OUTPUTS THE RESULTS OF THE COGGIN SEARCH.
C
C=====================================================================
C
      EXTERNAL DOEBTA
C
      INTEGER TTY,DISK
      INTEGER IY(10),ITEMP(40),INDEX(25)
C
```

```
      LOGICAL D2RICH,COGGIN,CHROMO
      LOGICAL DELETE(30),REJECT(30)
      LOGICAL VERIFY,DEBUG,RESET,SHIFT,SSQMIN
      LOGICAL TRUE,FALSE,CONSIS
C
      COMMON /LUN   / TTY,DISK,MAXREC,IREC
      COMMON /BURN  / D2RICH,COGGIN,CHROMO
      COMMON /NAME  / XNAME(6),YNAME(12),SNAME(4),
     +                PNAME(4),CNAME(2),GNAME(4)
      COMMON /SYSTEM/ Q(4),W(2),X(6),Y(12),S(4),P,T
      COMMON /SEARCH/ QDATA(4),WDATA(2),XDATA(6),YDATA(12),
     +                SDATA(4),PDATA,TDATA
      COMMON /VECTOR/ DELZ(44),NSERCH
      COMMON /MAXPIV/ UNITS(96),K
      COMMON /DEBUG / DEBUG,RESET,SHIFT,SSQMIN
C
      DOUBLE PRECISION DMEAN,DSIGMA
      DOUBLE PRECISION DELZ,DZERO
      DOUBLE PRECISION Z(1),ZDATA(1)
      DOUBLE PRECISION Q,W,X,Y,S,P,T,TEMP1,TEMP2
      DOUBLE PRECISION SCFM,DECISN,ACCPT,REJCT,
     + QDATA,WDATA,XDATA,YDATA,SDATA,PDATA,TDATA
C
      REAL TVALUE(30),CHANGE(30)
C
      EQUIVALENCE (BETA,UNITS(2)), (N,UNITS(3))
      EQUIVALENCE (Z(1),Q(1)), (ZDATA(1),QDATA(1))
      EQUIVALENCE (RMEAN,DMEAN), (SIGMA,DSIGMA)
      EQUIVALENCE (TVALUE(1),UNITS(37)), (CHANGE(1),UNITS(67))
      EQUIVALENCE (DELETE(1),UNITS(22)), (REJECT(1),UNITS(7))
      EQUIVALENCE (DMEAN,DELZ(31)), (DSIGMA,DELZ(32))
      EQUIVALENCE (TEMP1,DELZ(33)), (TEMP2,DELZ(34))
      EQUIVALENCE (ITEMP(1),DELZ(35)), (J,ITEMP(1))
      EQUIVALENCE (I,ITEMP(2)), (NU,ITEMP(3))
      EQUIVALENCE (BSAVE,ITEMP(5)), (DEGREE,ITEMP(7))
      EQUIVALENCE (F,ITEMP(9)), (DF,ITEMP(11))
      EQUIVALENCE (GAMMA,UNITS(4)), (C,UNITS(5))
      EQUIVALENCE (DECISN,ITEMP(13))
C
      DATA TRUE,FALSE/.TRUE.,.FALSE./, VERIFY/.TRUE./
      DATA FILTER/0.0005/, A,B,COEF/0.0,0.5,0.0/
      DATA ACCPT,REJCT/'     ','  YES  '/
      DATA DZERO/0.000/, ZERO,ONE,TWO/0.0,1.0,2.0/
      DATA ALPHA,TOLER,PI/0.95,0.001,3.14159/
      DATA NYDATA /10/, IFORM /Z0C00/, SCFM /0.1705D0/
      DATA IY/1,2,3,4,5,7,9,6,10,12/, BLANK/'    '/
      DATA INDEX/1,2,3,7,8,9,10,11,12,13,14,15,16,
     +           25,26,27,28,5,30,17,18,19,21,22,24/
C
      WRITE(TTY,116) IFORM
C
C     DETERMINE THE NUMBER OF POSSIBLE DATA POINTS
C
      NSERCH=13
      IF(D2RICH) GO TO 1
      NSERCH=19
      IF(.NOT.CHROMO) GO TO 1
      NSERCH=25
1     CONTINUE
C
C     INTIALIZE THE LOGICAL VECTORS
C
      DO 2 I=1,NSERCH
         J=INDEX(I)
         REJECT(J)=FALSE
         DELETE(J)=TRUE
         TVALUE(J)=ZERO
         IF(ZDATA(J).EQ.DZERO) GO TO 2
         DELETE(J)=FALSE
2        CONTINUE
      IF(RESET.OR..NOT.SHIFT) DELETE(30)=TRUE
C
C     COMPUTE THE MEAN DATA ADJUSTMENT
C
4     CONTINUE
      N=0
      DMEAN=DZERO
      DEGREE=ZERO
      DO 6 I=1,NSERCH
```

```
            J=INDEX(I)
            IF(DELETE(J).OR.REJECT(J)) GO TO 6
            N=N+1
            DELZ(N)=DABS((ZDATA(J)-Z(J))/ZDATA(J))
            CHANGE(J)=SNGL(DELZ(N))
            IF(CHANGE(J).GT.DEGREE) DEGREE=CHANGE(J)
            DMEAN=DMEAN+DELZ(N)
6           CONTINUE
         CONSIS=DEGREE.LT.FILTER
         DMEAN=DMEAN/N
         NU=N-1
C
CC       COMPUTE THE STANDARD DEVIATION OF DATA ADJUSTMENTS
C
         DSIGMA=DZERO
         DO 10 I=1,N
            DSIGMA=DSIGMA+(DELZ(I)-DMEAN)**2
10          CONTINUE
         DSIGMA=DSQRT(DSIGMA/NU)
C
CC       COMPUTE THE STUDENT-T VALUES FOR EACH DATA ADJUSTMENT
C
         DO 15 I=1,NSERCH
            J=INDEX(I)
            IF(DELETE(J).OR.REJECT(J)) GO TO 15
C
CC          FORM THE NORMALIZED STUDENT-T VARIABLE
C
            TVALUE(J)=ABS(CHANGE(J)-RMEAN)/SIGMA
15          CONTINUE
C
CC       DETERMINE THE REJECTION CONSTANT FOR A GIVEN CONFIDENCE:
C           ALPHA/2, WITH A NEWTON RAPHSON ALGORITHM
C
         BETA=ONE-4.0*FLOAT(N)/NU**2
C
CC       EVALUATE THE COEFFICIENT OF THE BETA FUNCTION
C
         A=(FLOAT(NU)-ONE)/TWO
         DEGREE=A
         CALL DOEGMA(DEGREE,GAMMA)
         COEF=GAMMA
         DEGREE=B
         CALL DOEGMA(DEGREE,GAMMA)
         COEF=COEF*GAMMA
         DEGREE=A+B
         CALL DOEGMA(DEGREE,GAMMA)
         COEF=GAMMA/COEF
20       CONTINUE
C
CC       EVALUATE THE DERIVATIVE
C
         BSAVE=BETA
         DEGREE=(NU+ONE)/TWO
         DF=COEF*(BETA**(A-ONE))/SQRT(ONE-BETA)
C
CC       EVALUATE THE FUNCTION
C
         F=DOEGAU( DOEBTA )-(ONE-ALPHA)/TWO
         BETA=BETA-F/DF
         BSAVE=ABS((BETA-BSAVE)/BETA)
         IF(BSAVE.GT.TOLER) GO TO 20
C
CC       CONVERGENCE ACHEIVED
C
28       CONTINUE
C
CC       COMPUTE THE ANSCOMBE CONSTANT FOR OUTLYING T-VALUES.
C
         C=SQRT((ONE-BETA)/FLOAT(N))*NU
C
CC       CHECK FOR OUTLYING T-VALUES
C
         IF(CONSIS) GO TO 60
         DO 35 I=1,NSERCH
            J=INDEX(I)
            IF(DELETE(J).OR.REJECT(J)) GO TO 35
            CHANGE(J)=ABS(CHANGE(J))*100.0
            IF(TVALUE(J).LE.C) GO TO 35
```

```
            REJECT(J)=TRUE
35          CONTINUE
60      CONTINUE
        IF(VERIFY) WRITE(TTY,112) NU,RMEAN,SIGMA,ALPHA,C
C
CCC     REPORT THE RESULTS OF THE COGGIN SEARCH
C
        WRITE(TTY,100)
C
CCC     COAL MASS FRACTIONS
C
        WRITE(TTY,101)
        DO 70 I=1,6
           J=I+6
           IF(DELETE(J)) GO TO 70
           DECISN=ACCPT
           IF(REJECT(J)) DECISN=REJCT
           WRITE(TTY,114)  ZDATA(J),XNAME(I),
     +     Z(J),CHANGE(J),TVALUE(J),DECISN
70         CONTINUE
C
CCC     FLUE GAS MOLE FACTIONS
C
        WRITE(TTY,102)
        WRITE(TTY,101)
        NYDATA=10
        IF(O2RICH.OR..NOT.CHROMO) NYDATA=4
        DO 80 I=1,NYDATA
           J=IY(I)+12
           IF(DELETE(J)) GO TO 80
           DECISN=ACCPT
           IF(REJECT(J)) DECISN=REJCT
           WRITE(TTY,114) ZDATA(J),YNAME(IY(I)),
     +     Z(J),CHANGE(J),TVALUE(J),DECISN
80         CONTINUE
        IF(O2RICH) GO TO 50
C
CCC     FLUE SOLIDS MASS FRACTIONS
C
        WRITE(TTY,104)
        WRITE(TTY,101)
        DO 90 I=1,4
           J=I+24
           IF(DELETE(J)) GO TO 90
           DECISN=ACCPT
           IF(REJECT(J)) DECISN=REJCT
           WRITE(TTY,114) ZDATA(J),SNAME(I),
     +     Z(J),CHANGE(J),TVALUE(J),DECISN
90         CONTINUE
C
CCC     TEMPERATURE
C
        IF(RESET.OR..NOT.SHIFT) GO TO 95
        WRITE(TTY,106)
        WRITE(TTY,101)
        J=30
        IF(DELETE(J)) GO TO 95
        DECISN=ACCPT
        IF(REJECT(J)) DECISN=REJCT
        WRITE(TTY,114) ZDATA(J),BLANK,
     + Z(J),CHANGE(J),TVALUE(J),DECISN
95      CONTINUE
C
CCC     COAL INPUT RATE
C
        WRITE(TTY,108)
        WRITE(TTY,101)
        J=5
        IF(DELETE(J)) GO TO 50
        DECISN=ACCPT
        IF(REJECT(J)) DECISN=REJCT
        WRITE(TTY,114) ZDATA(J),CNAME(1),
     + Z(J),CHANGE(J),TVALUE(J),DECISN
50      CONTINUE
C
CCC     AIR INPUT RATES
C
        WRITE(TTY,110)
        WRITE(TTY,101)
```

```
      DO 40 I=1,3
         J=I
         TEMP1=ZDATA(J)/SCFM
         TEMP2=Z(J)/SCFM
         IF(DELETE(J)) GO TO 40
         DECISN=ACCPT
         IF(REJECT(J)) DECISN=REJCT
         WRITE(TTY,114) TEMP1,GNAME(I),
     +   TEMP2,CHANGE(J),TVALUE(J),DECISN
40       CONTINUE
C
      WRITE(TTY,116)
      CALL DOEOUT
C
      RETURN
C
100   FORMAT(///'MASS FRACTIONS OF COAL:'/)
101   FORMAT(' RAW DATA',13X,'ADJUSTED DATA',4X,'% ADJUSTMENT',
     + 5X,'T VALUE',5X,'OUTLIER?')
102   FORMAT(///'MOLE FRACTIONS OF FLUE GAS:'/)
104   FORMAT(///'MASS FRACTIONS OF FLUE SOLIDS:'/)
106   FORMAT(///'TEMPERATURE AT PROBE:  [=] KELVIN'/)
108   FORMAT(///'SOLIDS FLOW RATES:  [=] LB/HR'/)
110   FORMAT(///'GAS FLOW RATES:  [=] SCFM'/)
112   FORMAT('D.O.F. ',I3,5X,'MEAN: ',1PE10.3,5X,'SDEV: ',1PE10.3,
     + 5X,'CONFIDENCE:',0PF7.3,5X,'T,REJECT:',0PF7.3)
114   FORMAT(1PE11.5,4X,A4,4X,1PE11.5,6X,
     + 0PF8.1,7X,0PF8.3,6X,A8)
116   FORMAT(//A2)
C
      END
C
C=======================================================================
C
      SUBROUTINE DOEGMA(Y,GAMMA)
C
C     THIS ROUTINE COMPUTES THE GAMMA FUNCTION OF Y.
C
C=======================================================================
C
      EXTERNAL DOEGFN
C
      COMMON /MAXPIV/ UNITS(96),I
C
      EQUIVALENCE (X,UNITS(1))
C
      DATA ONE/1.0/, NLOOPS/0/
C
C     INITIALIZE THE FACTORIAL
C
      X=Y
      GAMMA=ONE
C
C     COMPUTE THE NUMBER OF FACTORIAL LOOPS
C
      NLOOPS=INT(X-ONE)
      IF(NLOOPS.LE.0) GO TO 10
C
C     COMPUTE THE FACTORIAL PORTION
C
      DO 20 I=1,NLOOPS
         X=X-ONE
         GAMMA=GAMMA*X
20       CONTINUE
C
C     COMPUTE THE INTEGRAL PORTION
C
10    CONTINUE
      GAMMA=GAMMA*DOEGAU( DOEGFN )
C
      RETURN
      END
C
C=======================================================================
C
      FUNCTION DOEGFN(Z)
C
C     THIS ROUTINE COMPUTES THE INTEGRAND
C             FOR THE GAMMA FUNCTION.
```

```
C
C=======================================================================
C
      COMMON /MAXPIV/ UNITS(96),I
C
      EQUIVALENCE (DEGREE,UNITS(1))
      EQUIVALENCE (DOEGFN,GAMMA)
C
      DATA ONE/1.0/,X,DX/2*0.0/
C
      X=(Z+ONE)/(ONE-Z)
      DX=2.0/(ONE-Z)**2
      GAMMA=X**(DEGREE-ONE)*EXP(-X)*DX
C
      RETURN
      END
C
C=======================================================================
C
      FUNCTION DOEGAU( FOFX )
C
C     THIS FUNCTION COMPUTES THE INTEGRAL OF THE EXTERNAL
C     FUNCTION FOFX WITH A 14 POINT POINT GAUSSIAN QUADRATURE.
C
C=======================================================================
C
C
      EQUIVALENCE (DOEGAU,SUM)
C
      REAL X(7),W(7)
C
      DATA ZERO,ONE/0.0,1.0/, I/0/
C
C     CONSTANTS  FOR GAUSSIAN QUADRATURE
C
      DATA X
     +          /.20119409,.39415135,.57097217,
     +           .72441773,.84820658,.93727339,.98799252/
      DATA W
     +          /.19843149,.18616100,.16626921,
     +           .13957068,.10715922,.07036605,.03075324/
      DATA W0/.20257824/
C
C     COMPUTE THE INTEGRAL
C
      SUM=FOFX(ZERO)*W0
      DO 10 I=1,7
         SUM=SUM+FOFX(X(I))*W(I)
         SUM=SUM+FOFX(-X(I))*W(I)
10       CONTINUE
C
      RETURN
      END
C
C=======================================================================
C
      SUBROUTINE DOESTK(IOPT)
C
C     THIS ROUTINE STORES/RETRIEVES LABELED COMMON
C     DATA TO/FROM THE DISK DURING TASK SWAPPING.
C
C=======================================================================
C
      INTEGER RDATA(102),DISK,TTY
      INTEGER BUFFER(1),PULL,PUSH,NULL(3)
C
      LOGICAL O2RICH,COGGIN,CHROMO,DEBUG,RESET,SHIFT,SSOMIN
C
      REAL CNAME(2),GNAME(4)
      REAL XNAME(6),YNAME(12),SNAME(4),PNAME(4)
C
      DOUBLE PRECISION SR,AIRSR
      DOUBLE PRECISION Q,W,X,Y,S,P,T,
     + QDATA,WDATA,XDATA,YDATA,SDATA,PDATA,TDATA
      DOUBLE PRECISION LASTZ(22),DELZ(22)
C
      EQUIVALENCE (RDATA(3),BUFFER(1))
C
      COMMON /DATA  / RDATA
```

```
      COMMON /INDEX / INDEX(30)
      COMMON /TEMPER/ TAXIS(24)
      COMMON /WEIGHT/ WEIGHT(30)
      COMMON /GAMMA / SR,AIRSR
      COMMON /VECTOR/ LASTZ,DELZ,NSERCH
      COMMON /LUN   / TTY,DISK,MAXREC,IREC
      COMMON /DEBUG / DEBUG,RESET,SHIFT,SSQMIN
      COMMON /BURN  / O2RICH,COGGIN,CHROMO
      COMMON /NAME  / XNAME,YNAME,SNAME,PNAME,CNAME,GNAME
      COMMON /SYSTEM/ Q(4),W(2),X(6),Y(12),S(4),P,T
      COMMON /SEARCH/ QDATA(4),WDATA(2),XDATA(6),YDATA(12),
     +                SDATA(4),PDATA,TDATA
      COMMON /MAXPIV/ UNITS(96),NSIZE
C
      DATA IOSPUT,IOSGET/Z109F,Z105F/
      DATA PUSH,PULL/0,1/, I,J,M/3*0/
      DATA NWORDS/0/, NRECRD/7/, NULL/1,0,0/
C
      NWORDS=(RDATA(1)+1)/2
C
      CALL F$OPN(DISK)
      IF(IOPT.EQ.PULL) GO TO 25
C
C     SAVE LABELED COMMON ON THE DISK
C
      DO 10 I=1,NRECRD
         DO 20 J=1,NWORDS
              RDATA(J+2)=BUFFER(J+(I-1)*NWORDS)
20            CONTINUE
         RDATA(2)=MAXREC+I+3
         CALL F$IOS(IOSPUT,RDATA,DISK,M)
10       CONTINUE
      CALL F$CLS(DISK)
C
C     DISABLE ^C WHILE SWAPPING TASKS
C
      CALL U$INTR(TTY,.FALSE.)
C
      RETURN
25    CONTINUE
C
C     ENABLE ^C AFTER THE JOB NUMBER IS IN THE DCB
C
      CALL F$IOS(IOSPUT,NULL,TTY,M)
      CALL U$INTR(TTY,.TRUE.)
C
      CALL F$OPN(DISK)
C
C     RETRIEVE DATA FROM THE DISK
C
      DO 30 I=1,NRECRD
         RDATA(2)=MAXREC+4+NRECRD-I
         CALL F$IOS(IOSGET,RDATA,DISK,M)
         DO 40 J=1,NWORDS
              BUFFER(J+(NRECRD-I)*NWORDS)=RDATA(J+2)
40            CONTINUE
30       CONTINUE
      CALL F$CLS(DISK)
C
      RETURN
     END
C
C=====================================================================
C
      SUBROUTINE DOEOUT
C
C     OUTPUT SUBROUTINE FOR FURNACE
C
C     THIS SUBROUTINE OUTPUTS THE RESULTS
C     OF THE MASS BALANCE ANALYSIS.
C
C=====================================================================
C
      COMMON /SYSTEM/ Q,W,X,Y,S,L,T
      COMMON /NAME  / XNAME,YNAME,SNAME,PNAME,CNAME,GNAME
      COMMON /LUN   / TTY,DISK,MAXREC,REC
      COMMON /TEMPER/ TEMP(24)
      COMMON /DATA  / RDATA
      COMMON /GAMMA / SR,AIRSR
```

```
      COMMON /MAXPIV/ UNITS(96),ITEMP
      COMMON /BURN  / O2RICH,COGGIN,CHROMO
C
C     LOGICAL O2RICH,COGGIN,CHROMO
C
      DOUBLE PRECISION Q(4),W(2),X(6),Y(12),S(4),L,T
      DOUBLE PRECISION AIRSR,SR,YSUM,ONE
C
      REAL XNAME(6),YNAME(12),SNAME(4),PNAME(4),CNAME(2),GNAME(4)
      REAL AIR(3),PROX(4),ULTIM(5),FLUE(12),SMOKE(4),PRESSR(3)
      REAL KPROX(4),KULTIM(5),KSMOKE(4),KCOAL
C
      INTEGER TTY,DISK,REC,RANGET,RANPUT,IQ(4),IF(12)
C
      INTEGER RECORD,LPROBE,DATE(3),TIME(3),RDATA(102)
      INTEGER KDATA(102)
      INTEGER KNAME(20),NAME(20)
      INTEGER COOL,STAGE
C
C
      EQUIVALENCE     (RECORD,RDATA(2)),
     +                (LPROBE,RDATA(3)),
     +                (DATE(1),RDATA(4)),
     +                (TIME(1),RDATA(7)),
     +                (TSAMPL,RDATA(10)),
     +                (AIR(1),RDATA(12)),
     +                (FLUE(1),RDATA(18)),
     +                (PROX(1),RDATA(42)),
     +                (ULTIM(1),RDATA(50)),
     +                (SMOKE(1),RDATA(60)),
     +                (COAL,RDATA(68)),
     +                (NAME(1),RDATA(70)),
     +                (COOL,RDATA(90)),
     +                (STAGE,RDATA(91)),
     +                (SSR,RDATA(94)),
     +                (CONVNO,RDATA(96)),
     +                (FLGSOT,RDATA(98)),
     +                (SOLOUT,RDATA(100))
      EQUIVALENCE     (KDATA(1),UNITS(40)),
     +                (PRESSR(1),KDATA(34)),
     +                (AIRTMP,KDATA(40)),
     +                (KPROX(1),KDATA(42)),
     +                (KULTIM(1),KDATA(50)),
     +                (KSMOKE(1),KDATA(60)),
     +                (KCOAL,KDATA(68)),
     +                (KNAME(1),KDATA(70))
C
      DATA IFORM/Z0C00/
      DATA ASH/' ASH'/
C
      DATA IQ/5,7,9,1/, IF/1,2,3,6,10,11,12,4,5,7,8,9/
C
      DATA PRCNCN,PRNH3C/2*0.0/
      DATA RANGET /Z105F/, RANPUT /Z109F/
      DATA M,I/0,0/, YSUM,ONE/0.0D0,1.0D0/
      DATA SRAIR,SASH/2*0.0/
C
CC    RETRIEVE RECORD FROM DISK
C
      RECORD=REC
      KDATA(1)=RDATA(1)
      KDATA(2)=MAXREC+1
      CALL F$OPN(DISK)
      CALL F$IOS(RANGET,RDATA,DISK,M)
      CALL F$IOS(RANGET,KDATA,DISK,M)
C
CC    CONVERT COAL AND FLUE SOLIDS TO ASH INCLUDED BASIS
C
      UNITS(1)=SNGL(W(1))*100./(100.-PROX(3))
      UNITS(2)=UNITS(1)*0.454/3600.
      UNITS(3)=UNITS(1)*PROX(3)/100.+SNGL(W(2))
      UNITS(4)=UNITS(3)*0.454/3600.
      SASH=UNITS(1)*PROX(3)/100./UNITS(3)
C
CC    UPDATE THE COAL MASS FLOW RATE IF FUEL LEAN CONDITIONS
C
      IF(O2RICH) COAL=UNITS(1)
      KCOAL=COAL
      SOLOUT=UNITS(3)
```

```
      CONVNO=SNGL((Q(4)*Y(4)*1400)/(W(1)*X(5)))
      PRCNCN=CONVNO*SNGL(Y(5)/Y(4))
      PRNH3C=CONVNO*SNGL(Y(9)/Y(4))
      SSR=SNGL(SR)
C
      WRITE(TTY,100) IFORM,RECORD,LPROBE,DATE,TIME,NAME
      WRITE(TTY,105) (UNITS(I),I=1,4)
C
C     CONVERT VOLUMETRIC FLOWS FROM*E/HR TO SCFM
C
      DO 5 I=1,4
         UNITS(IQ(I))=SNGL(Q(I))/0.1550
         UNITS(IQ(I)+1)=UNITS(IQ(I))/60./35.31
5        CONTINUE
      UNITS(3)=UNITS(5)+UNITS(7)+UNITS(9)
      UNITS(4)=UNITS(3)/60./35.31
      SRAIR=AIRSR/60./35.31
      FLGSOT=UNITS(1)
C
C     UPDATE
C             1. COAL MASS FLOW RATE LB/HR
C             2. SOLIDS OUTPUT RATE LB/HR
C             3. FLUE GAS OUTPUT RATE SCFM
C             4. STOICHIOMETRIC RATIO TO PORT
C             5. CONVERTED N TO NO
C
      CALL F$IOS(RANPUT,RDATA,DISK,M)
      CALL F$IOS(RANPUT,KDATA,DISK,M)
      WRITE(TTY,110) (UNITS(I),I=1,10),AIRSR,SRAIR,SR
C
      IF(COGGIN) GO TO 55
      YSUM=Y(12)
      DO 10 I=1,10
         YSUM=YSUM+Y(I)
10       CONTINUE
      Y(12)=Y(12)*(ONE-Y(11))/YSUM
      DO 15 I=1,10
         Y(I)=Y(I)*(ONE-Y(11))/YSUM
15       CONTINUE
C
C     CONVERT MASS/MOLE FRACTIONS TO PERCENTAGES AND PPMVS
C
55    CONTINUE
      DO 20 I=1,6
         Y(IF(I))=Y(IF(I))*100.
         X(I)=X(I)*(100.-PROX(3))
20       CONTINUE
      Y(IF(7))=Y(IF(7))*100.
C
      DO 30 I=8,12
         Y(IF(I))=Y(IF(I))*1000000.
30       CONTINUE
C
      DO 45 I=1,4
         S(I)=S(I)*(1.0-SASH)*100.
45       CONTINUE
C
C     SAVE TRUE SPECIES % AND PPMV
C
      DO 60 I=1,12
      FLUE(I)=SNGL(Y(I))
60    CONTINUE
      CALL F$IOS(RANPUT,RDATA,DISK,M)
      CALL F$CLS(DISK)
      SASH=SASH*100.
C
      WRITE(TTY,115)
      WRITE(TTY,120) X(1),XNAME(1),S(1),SNAME(1),Y(1),YNAME(1),Y(4)
     + ,YNAME(4)
      WRITE(TTY,120) X(2),XNAME(2),S(2),SNAME(2),Y(2),YNAME(2),Y(5)
     + ,YNAME(5)
      WRITE(TTY,120) X(3),XNAME(3),S(3),SNAME(3),Y(3),YNAME(3),Y(7)
     + ,YNAME(7)
      WRITE(TTY,120) X(4),XNAME(4),S(4),SNAME(4),Y(6),YNAME(6),Y(8)
     + ,YNAME(8)
      WRITE(TTY,120) X(5),XNAME(5),SASH,ASH,Y(10),YNAME(10),Y(9)
     + ,YNAME(9)
      WRITE(TTY,122) X(6),XNAME(6),Y(11),YNAME(11)
      WRITE(TTY,122) PROX(3),ASH,Y(12),YNAME(12)
```

```
      WRITE(TTY,130)CONVNO,PRCNCN,PRNH3C
C
C     RESTORE FLUE FRACTIONS FROM PERCENTAGES AND PPMV
C
      DO 25 I=1,6
         Y(IF(I))=Y(IF(I))/100.
         X(I)=X(I)/(100.-PROX(3))
25       CONTINUE
      Y(IF(7))=Y(IF(7))/100.
C
      DO 35 I=8,12
         Y(IF(I))=Y(IF(I))/1000000.
35       CONTINUE
C
      DO 40 I=1,4
         S(I)=S(I)/(100.-SASH)
40       CONTINUE
C
C     WRITE(TTY,124)
C
      RETURN
C
100   FORMAT(//A2,'*** RECORD',I3,5X,'PROBE',I3,5X,
     + I2,'/',I2,'/',I2,5X,I2,':',I2,':',I2,5X,40A2)
105   FORMAT(//24X,' [=]',2X,'LB/HR',13X,'KG/S'//
     + '***',6X,' COAL INPUT RATE = ',1PE10.3,7X,1PE10.3/
     + '***',3X,' FLUE SOLIDS OUTPUT = ',1PE10.3,7X,1PE10.3)
110   FORMAT(/24X,' [=]',2X,'SCFM',13X,'M**3/S'//
     + '***',6X,' FLUE GAS OUTPUT = ',1PE10.3,7X,1PE10.3/
     + '***',7X,' AIR INPUT RATE = ',1PE10.3,7X,1PE10.3//,12X
     + 'TRANSPORT AIR = ',1PE10.3,7X,1PE10.3/,12X
     + 'SECONDARY AIR = ',1PE10.3,7X,1PE10.3/,12X
     + '    STAGED AIR = ',1PE10.3,7X,1PE10.3//
     + '***',3X,' STOICHIOMETRIC AIR = ',1PE10.3,7X,1PE10.3//
     + '      STOICHIOMETRIC RATIO = ',0PF5.2)
115   FORMAT(/4X,'COAL',11X,'FLUE SOLIDS',8X,'FLUE GAS',9X,'FLUE GAS'/
     + ' PERCENTAGES ',5X,' PERCENTAGES ',5X,' PERCENTAGES ',5X,
     + 'TRACE PPMV'/)
120   FORMAT(4(F8.2,A4,5X))
122   FORMAT(F8.2,A4,5X,17X,2(F8.2,A4,5X))
124   FORMAT(11(/))
130   FORMAT(/'PERCENTAGE N IN COAL CONVERTED TO NO  = ',F6.2/
     +'PERCENTAGE N IN COAL CONVERTED TO HCN = ',F6.2/
     +'PERCENTAGE N IN COAL CONVERTED TO NH3 = ',F6.2)
C
      END
C
C=======================================================================
C
      FUNCTION DOEBTA(T)
C
C     THIS FUNCTION RETURNS THE VALUE OF THE
C     INCOMPLETE BETA DENSITY INTEGRAND.
C
C=======================================================================
C
      COMMON /MAXPIV/ UNITS(96),I
C
      EQUIVALENCE (UNITS(2),XLIMIT)
      EQUIVALENCE (UNITS(3),N)
      EQUIVALENCE (DOEBTA,BETA)
C
      DATA TWO/2.0/, ONE/1.0/
C
      DATA X,DX,DEGREE/3*0.0/, NU/0/
C
C     TRANSFORM THE INDEPENDENT VARIABLE FOR GAUSSIAN QUADRATURE.
C
      NU=N-1
      DEGREE=(NU-ONE)/TWO
C
      X=XLIMIT*(T+ONE)/TWO
      DX=XLIMIT/TWO
      BETA=X**(DEGREE-ONE)/SQRT(ONE-X)*DX
C
      RETURN
      END
C
C=======================================================================
```

```
C
      SUBROUTINE DOEINP(ANS,BLANK,LUN)
C
C     FREE FORMAT INPUT ROUTINE FOR THE D.O.E. FURNACE
C
C=====================================================================
C
      LOGICAL BLANK
C
      INTEGER BUFFER(5),KBUFF(7)
C
      EQUIVALENCE (BUFFER(1),KBUFF(3))
C
      DATA KBUFF/10,0,5*0/, IOSGET/Z205F/
      DATA M,ICNT,IVAR/3*0/
C
      ANS=1H
      ICNT=10
      BLANK=.TRUE.
C
      CALL F$IOS(IOSGET,KBUFF,LUN,M)
      IF(BUFFER(1).EQ.2H  )RETURN
C
      BLANK=.FALSE.
      DECODE(ICNT,102,BUFFER,IVAR)ANS
      RETURN
C
102   FORMAT(V)
      END
```

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INPUT/OUTPUT PROGRAM

```
C       DISPLAY SUBROUTINE FOR FURNACE
C
C=======================================================================
C
        INTEGER RECORD,LPROBE,DATE(3),TIME(3),RDATA(102)
        INTEGER KDATA(102),KNAME(20),NAME(20)
C
        REAL AIR(3),PROX(4),ULTIM(5),FLUE(12),SMOKE(4),PRESSR(3)
        REAL KPROX(4),KULTIM(5),KSMOKE(4),KCOAL
C
        COMMON /LUN    / TTY,DISK,MAXREC,IREC
        COMMON /DATA   / RDATA
        COMMON /MAXPIV/ UNITS(96),M
C
        EQUIVALENCE     (RECORD,RDATA(2)),
     +                  (LPROBE,RDATA(3)),
     +                  (DATE(1),RDATA(4)),
     +                  (TIME(1),RDATA(7)),
     +                  (TSAMPL,RDATA(10)),
     +                  (AIR(1),RDATA(12)),
     +                  (FLUE(1),RDATA(18)),
     +                  (PROX(1),RDATA(42)),
     +                  (ULTIM(1),RDATA(50)),
     +                  (SMOKE(1),RDATA(60)),
     +                  (COAL,RDATA(68)),
     +                  (NAME(1),RDATA(70))
        EQUIVALENCE     (KDATA(1),UNITS(40)),
     +                  (PRESSR(1),KDATA(34)),
     +                  (AIRTMP,KDATA(40)),
     +                  (KPROX(1),KDATA(42)),
     +                  (KULTIM(1),KDATA(50)),
     +                  (KSMOKE(1),KDATA(60)),
     +                  (KCOAL,KDATA(68)),
     +                  (KNAME(1),KDATA(70))
C
        INTEGER RANGET,DISK,TTY
C
        DATA RANGET /Z105F/
        DATA I/0/
        DATA IANS /0/
C
C       SHOW WHICH RECORD?
C
        WRITE(TTY,100)
        READ(TTY,102) IANS
        IF(IANS.LT.1.OR.IANS.GT.MAXREC) RETURN
C
C       RETRIEVE RECORD FROM DISK
C
        RECORD=IANS
        KDATA(1)=RDATA(1)
        KDATA(2)=MAXREC+1
        CALL F$OPN(DISK)
        CALL F$IOS(RANGET,RDATA,DISK,M)
        CALL F$IOS(RANGET,KDATA,DISK,M)
        CALL F$CLS(DISK)
C
        WRITE(TTY,104) RECORD,LPROBE,DATE,TIME,NAME
        WRITE(TTY,118) COAL
        WRITE(TTY,108) AIR
        WRITE(TTY,120) SMOKE
        WRITE(TTY,112) PROX
        WRITE(TTY,114) ULTIM
        WRITE(TTY,116) FLUE
        WRITE(TTY,106) TSAMPL
        RETURN
C
100     FORMAT(/'> Examine which record?')
102     FORMAT(V)
104     FORMAT('RECORD',I3,5X,'PROBE',I3,5X,
     + I2,'/',I2,'/',I2,5X,I2,':',I2,':',I2,5X,40A2)
106     FORMAT('FLUE GAS TEMPERATURE:',F10.1)
108     FORMAT('P-E TRANSDUCERS',5X,':',3(1PE15.6))
112     FORMAT('PROXIMATE ANALYSIS',2X,':',4(1PE15.6))
114     FORMAT('ULTIMATE ANALYSIS',3X,':',5(1PE15.6))
116     FORMAT(('CHROMATOGRAPH',7X,':',6(1PE15.6)))
118     FORMAT('COAL FEED'.11X,':',1PE15.6)
120     FORMAT('FLUE SOLIDS ANALYSIS:',5(1PE15.6))
C
```

```
            READ(TTY,100) (A(I,J),J=1,4)
52          CONTINUE
        GO TO 15
C
C       ENTER THE ANALYZER CONSTANTS
C
60      CONTINUE
        WRITE(TTY,120)
        DO 62 I=1,NANALZ
            K=NAIR+I
            WRITE(TTY,108) YNAME(IY(I))
        WRITE(TTY,130)
        READ(TTY,102) IANS2
        IF(IANS2.NE.YES) GOTO 62
            READ(TTY,100) (A(K,J),J=1,4)
62          CONTINUE
        GO TO 15
C
C       ENTER THE PT/PT-RHODIUM THERMOCOUPLE CONSTANTS
C
70      CONTINUE
        K=0
        DO 72 I=1,8
            WRITE(TTY,106) TNAME1,K
        WRITE(TTY,130)
        READ(TTY,102) IANS2
        IF(IANS2.NE.YES) GOTO 71
            READ(TTY,100) TBASE(I),TSLOPE(I)
71      CONTINUE
            K=K+1
72          CONTINUE
        GO TO 15
C
C       ENTER THE CHROMEL/ALUMEL THERMOCOUPLE CONSTANTS
C
80      CONTINUE
        K=8
        M=9
        N=16
        IF(IANS.EQ.5) K=16
        IF(IANS.EQ.5) M=17
        IF(IANS.EQ.5) N=24
        DO 74 I=K,N
            WRITE(TTY,106) TNAME2,K
        WRITE(TTY,130)
        READ(TTY,102) IANS2
        IF(IANS2.NE.YES) GOTO 73
            READ(TTY,100) TBASE(I),TSLOPE(I)
73      CONTINUE
            K=K+1
74          CONTINUE
        GO TO 15
C
100     FORMAT(V)
102     FORMAT(A1)
104     FORMAT('>> List the calibration assignments? ')
106     FORMAT(/'> Enter the intercept and slope for:  ',A4,I3)
108     FORMAT(/'> Enter the constants:  A0,A1,A2,A3 for:  ',A4)
112     FORMAT(/'CHANNEL',13X,'SLOPE',13X,'INTERCEPT')
114     FORMAT(14,8X,A4,' = ',1PE10.3,' # ',A4,' + ',1PE10.3)
116     FORMAT(/'* Enter the calibration option:')
118     FORMAT(//'*** Calibration options:'/
    +  4X,'1 = P/E Transducers'/
    +  4X,'2 = Analyzers'/
    +  4X,'3 = Pt/PT-Rhodium Thermocouples'/
    +  4X,'4 = Chromel/Alumel Thermocouples CH(8-15)'/
    +  4X,'5 = Chromel/Alumel Thermocouples CH(16-23)')
120     FORMAT(/'CHANNEL = A0 + A1*ADC + A2*ADC**2 + A3*ADC**3')
122     FORMAT(10X,'A0',10X,'A1',10X,'A2',10X,'A3')
124     FORMAT(A4,1X,4(1PE10.3,2X))
126     FORMAT('>> Do you wish to change base point?',I5)
128     FORMAT('> What is the base point ?(1600-2300)')
130     FORMAT('>> Change calibrations? (CR=NO)')
        END
C
C=======================================================================
C
        SUBROUTINE DOEDIS
C
```

```
      READ(TTY,102) IANS
      IF(IANS.NE.YES) GO TO 10
      WRITE(TTY,112)
C
CC    OUTPUT THE THERMOCOUPLE CONSTANTS
C
      K=0
      DO 20 I=1,8
         WRITE(TTY,114) K,TNAME1,TSLOPE(I),
     +   TNAME1,TBASE(I)
         K=K+1
20       CONTINUE
      DO 21 I=9,NTC
         WRITE(TTY,114) K,TNAME2,TSLOPE(I),
     +   TNAME2,TBASE(I)
         K=K+1
21       CONTINUE
C
C     OUTPUT THE P/E TRANSDUCER CONSTANTS
C
      WRITE(TTY,120)
      WRITE(TTY,122)
      DO 22 I=1,NAIR
         WRITE(TTY,124) GNAME(I),(A(I,J),J=1,4)
22       CONTINUE
C
C     OUTPUT THE ANALYZER CONSTANTS
C
      DO 24 I=1,NANALZ
         K=NAIR+I
         WRITE(TTY,124) YNAME(IY(I)),(A(K,J),J=1,4)
24       CONTINUE
C
C     OBTAIN THE CALIBRATION OPTION
C
10    CONTINUE
      WRITE(TTY,118)
15    CONTINUE
      WRITE(TTY,116)
      CALL DOEINP(ANS,BLANK,TTY)
      IF(BLANK) GO TO 5
      IANS=INT(ANS+0.5)
      IF(IANS.LT.1.OR.IANS.GT.5) GO TO 10
7     CONTINUE
      K=IANS-2
      IF(IANS.EQ.1.OR.IANS.EQ.2) K=4
      WRITE(TTY,126)IBASPT(K)
      READ(TTY,102)IANS2
      IF(IANS2.NE.YES) GOTO 6
      WRITE(TTY,128)
      CALL DOEINP(ANS,BLANK,TTY)
      IANS2=INT(ANS+0.5)
      IF(IANS2.LT.1600.OR.IANS2.GT.2300) GOTO 7
      IF(IANS.EQ.1) IBASPT(4)=IANS2
      IF(IANS.EQ.2) IBASPT(4)=IANS2
      IF(IANS.EQ.3) IBASPT(1)=IANS2
      IF(IANS.EQ.4) IBASPT(2)=IANS2
      IF(IANS.EQ.5) IBASPT(3)=IANS2
6     CONTINUE
      GO TO (50,60,70,80,80),IANS
C
CC    SAVE THE CHANGES ON DISK
C
5     CONTINUE
      CALL F$OPN(DISK)
      CALL F$IOS(RANPUT,IDATA,DISK,M)
      CALL F$IOS(RANPUT,JDATA,DISK,M)
      CALL F$CLS(DISK)
      RETURN
C
CC    ENTER THE P/E TRANSDUCER CONSTANTS
C
50    CONTINUE
      WRITE(TTY,120)
      DO 52 I=1,NAIR
         WRITE(TTY,108) GNAME(I)
      WRITE(TTY,130)
      READ(TTY,102) IANS2
      IF(IANS2.NE.YES) GOTO 52
```

```
      RETURN
25    CONTINUE
C
C     ENABLE ^C AFTER THE JOB NUMBER IS IN THE DCB
C
      CALL F$IOS(IOSPUT,NULL,TTY,M)
      CALL U$INTR(TTY,.TRUE.)
C
      CALL F$OPN(DISK)
C
C     RETRIEVE DATA FROM THE DISK
C
      DO 30 I=1,NRECRD
         RDATA(2)=MAXREC+4+NRECRD-I
         CALL F$IOS(IOSGET,RDATA,DISK,M)
         DO 40 J=1,NWORDS
              BUFFER(J+(NRECRD-I)*NWORDS)=RDATA(J+2)
40            CONTINUE
30       CONTINUE
      CALL F$CLS(DISK)
C
      RETURN
     END
C
C=====================================================================
C
      SUBROUTINE DOECAL
C
C     THIS ROUTINE ALLOWS THE USER TO ENTER THE CALIBRATION
C     CONSTANTS FOR THE RAW MULTIPLEXED CROMEMCO DATA.
C
C=====================================================================
C
      COMMON /DATA  / RDATA
      COMMON /LUN   / TTY,DISK,MAXREC,IREC
      COMMON /NAME  / XNAME,YNAME,SNAME,PNAME,CNAME,GNAME
      COMMON /SYSTEM/ IDATA1(X'78')
      COMMON /SEARCH/ JDATA1(X'78')
      COMMON /BASE/ IBASPT
C
      LOGICAL BLANK
C
      INTEGER RDATA(102),IDATA(102),JDATA(102)
      INTEGER TTY,DISK,RANGET,RANPUT,IBASPT(5)
      INTEGER YES,IY(5)
C
      REAL A(8,4),TSLOPE(1),TBASE(1)
      REAL XNAME(6),YNAME(12),SNAME(4),PNAME(4)
      REAL CNAME(2),GNAME(4)
C
      EQUIVALENCE     (IDATA(1),IDATA1(1)),
     +                (JDATA(1),JDATA1(1)),
     +                (A(1,1),IDATA(3)),
     +                (TSLOPE(1),JDATA(3)),
     +                (TBASE(1),JDATA(51))
C
      DATA RANGET,RANPUT/Z105F,Z109F/
      DATA NA1R,NANALZ,NTC/3,4,24/
      DATA IY/1,2,3,4,8/, TNAME1,TNAME2/'TC,R','TC,K'/
C
      DATA IANS2/0/
      DATA YES/'Y'/, ANS/0.0/, I,K,M,IANS/4*0/, BLANK/.FALSE./
C
C     RETRIEVE THE CALIBRATION CONSTANTS FROM DISK
C
      IDATA(1)=RDATA(1)
      JDATA(1)=RDATA(1)
      IDATA(2)=MAXREC+2
      JDATA(2)=MAXREC+3
C
      CALL F$OPN(DISK)
      CALL F$IOS(RANGET,IDATA,DISK,M)
      CALL F$IOS(RANGET,JDATA,DISK,M)
      CALL F$CLS(DISK)
C
C     OUTPUT THE CALIBRATION CONSTANTS
C
1     CONTINUE
      WRITE(TTY,104)
```

```
C
          WRITE(TTY,108) RECORD,RDATA(3),(RDATA(I),I=7,9)
20        CONTINUE
          WRITE(TTY,110)
          RETURN
C
100       FORMAT(/25H>>Search on today's date?)
102       FORMAT(A1)
103       FORMAT('<<Input date record was obtained:  MM,DD,YY')
104       FORMAT(/'<< Searching for records on:',I3,'/',I2,'/',I2/)
106       FORMAT(3V)
108       FORMAT('Record:',I3,10X,'Probe:',I3,10X,'Time:',I3,':',I2,':',I2)
110       FORMAT(/'<< End search')
C
          END
C
C=====================================================================
C
          SUBROUTINE DOESTK(IOPT)
C
C         THIS ROUTINE STORES/RETRIEVES LABELED COMMON
C         DATA TO/FROM THE DISK DURING TASK SWAPPING.
C
C=====================================================================
C
          INTEGER RDATA(102),DISK,TTY
          INTEGER BUFFER(1),PULL,PUSH,NULL(3)
C
          LOGICAL D2RICH,COGGIN,CHROMO,DEBUG,RESET,SHIFT,SSQMIN
C
          REAL CNAME(2),GNAME(4)
          REAL XNAME(6),YNAME(12),SNAME(4),PNAME(4)
C
          DOUBLE PRECISION SR,AIRSR
          DOUBLE PRECISION Q,W,X,Y,S,P,T,
         + QDATA,WDATA,XDATA,YDATA,SDATA,PDATA,TDATA
          DOUBLE PRECISION LASTZ(22),DELZ(22)
C
          EQUIVALENCE (RDATA(3),BUFFER(1))
C
          COMMON /DATA  / RDATA
          COMMON /INDEX / INDEX(30)
          COMMON /TEMPER/ TAXIS(24)
          COMMON /WEIGHT/ WEIGHT(30)
          COMMON /GAMMA / SR,AIRSR
          COMMON /VECTOR/ LASTZ,DELZ,NSERCH
          COMMON /LUN   / TTY,DISK,MAXREC,IREC
          COMMON /DEBUG / DEBUG,RESET,SHIFT,SSQMIN
          COMMON /BURN  / D2RICH,COGGIN,CHROMO
          COMMON /NAME  / XNAME,YNAME,SNAME,PNAME,CNAME,GNAME
          COMMON /SYSTEM/ Q(4),W(2),X(6),Y(12),S(4),P,T
          COMMON /SEARCH/ QDATA(4),WDATA(2),XDATA(6),YDATA(12),
         +                SDATA(4),PDATA,TDATA
          COMMON /MAXPIV/ UNITS(96),NSIZE
C
          DATA IOSPUT,IOSGET/Z109F,Z105F/
          DATA PUSH,PULL/0,1/, I,J,M/3*0/
          DATA NWORDS/0/, NRECRD/7/, NULL/1,0,0/
C
          NWORDS=(RDATA(1)+1)/2
C
          CALL F$OPN(DISK)
          IF(IOPT.EQ.PULL) GO TO 25
C
C         SAVE LABELED COMMON ON THE DISK
C
          DO 10 I=1,NRECRD
             DO 20 J=1,NWORDS
                RDATA(J+2)=BUFFER(J+(I-1)*NWORDS)
20           CONTINUE
             RDATA(2)=MAXREC+I+3
             CALL F$IOS(IOSPUT,RDATA,DISK,M)
10        CONTINUE
          CALL F$CLS(DISK)
C
C         DISABLE ^C WHILE SWAPPING TASKS
C
          CALL U$INTR(TTY,.FALSE.)
C
```

```
30        CONTINUE
      RETURN
10    CONTINUE
C
C     CHECK FOR SINGLE RECORD DELETION
C
      WRITE(TTY,106)
      READ(TTY,108) IANS
      IF(IANS.GT.MAXREC.OR.IANS.LT.1) RETURN
      RECORD=IANS
      SETUP=.FALSE.
35    CONTINUE
      IF(SETUP) RECORD=IREC
      CALL F$OPN(DISK)
      CALL F$IOS(RANGET,RDATA,DISK,M)
      DO 40 I=3,102
         RDATA(I)=0
40       CONTINUE
      RDATA(4)=-1
      CALL F$IOS(RANPUT,RDATA,DISK,M)
      CALL F$CLS(DISK)
      IF(SETUP) GOTO 30
      GO TO 10
C
100   FORMAT('?? Delete all data? ')
102   FORMAT('?? Delete every record? ')
104   FORMAT(A1)
106   FORMAT('? Input record number to be Deleted')
108   FORMAT(V)
      END
C
C=====================================================================
C
      SUBROUTINE DOESEA
C
C     THIS SUBROUTINE SEARCHES FOR RECORDS
C     OBTAINED ON A GIVEN DATE.
C
C=====================================================================
C
      INTEGER D,Y,ANS,TTY,DISK,RANGET,RECORD,RDATA
C
      COMMON /DATA/ RDATA(102)
      COMMON /LUN/ TTY,DISK,MAXREC,IREC
C
      EQUIVALENCE (RDATA(2),RECORD)
C
      DATA RANGET/Z105F/
      DATA M,D,Y,I,MD,J,ANS/7*0/
C
C     GET RECORD DATE:
C
C     CHECK FOR DEFAULT
C
      WRITE(TTY,100)
      READ(TTY,102) ANS
      IF(ANS.EQ.1H ) RETURN
      CALL DATE$B(Y,M,D)
      IF(ANS.EQ.1HY) GO TO 10
C
C     INPUT DATE
C
      WRITE(TTY,103)
      READ(TTY,106) M,D,Y
10    CONTINUE
      WRITE(TTY,104) M,D,Y
C
C     MATCH RECORD DATE WITH SEARCH DATE
C
      DO 20 I=1,MAXREC
         RECORD=I
         CALL F$OPN(DISK)
         CALL F$IOS(RANGET,RDATA,DISK,MD)
         CALL F$CLS(DISK)
         IF(RDATA(4).NE.M) GO TO 20
         IF(RDATA(5).NE.D) GO TO 20
         IF(RDATA(6).NE.Y) GO TO 20
C
C        MATCH FOUND
```

```
C
C       ***ENABLE <LF> ON INPUT
C
        ISTATS(11)=ISTATS(11).AND.X'FEFF'
C
C       ***COMMUNICATIONS SHOULD NOW BE ESTABLISHED
C
        MODE=1
        RETURN
100     FORMAT(A2/A2)
        END
C
C=======================================================================
C
        INTEGER FUNCTION Z80FUN(K)
C
C       THIS ROUTINE CONVERTS ASCII HEX TO BINARY
C
C=======================================================================
C
        DATA ITEMP1,ITEMP2/2*0/
C
        ITEMP1=(K.AND.X'7F00')/X'100'-X'30'
        ITEMP2=(K.AND.X'007F')-X'30'
        IF(ITEMP1.GT.9)ITEMP1=ITEMP1-7
        IF(ITEMP2.GT.9)ITEMP2=ITEMP2-7
        Z80FUN=ITEMP1*X'10'.OR.ITEMP2
        RETURN
        END
C
C=======================================================================
C
        SUBROUTINE DOEDEL
C
C       THIS ROUTINE ALLOWS THE OPERATOR TO DELETE SELECTED DATA
C            RECORDS OR INITIALIZE THE ENTIRE DATA BASE.
C
C=======================================================================
C
        COMMON /LUN/ TTY,DISK,MAXREC,IREC
        COMMON /DATA/ RDATA
        COMMON/SETURN/SETUP
C
        INTEGER RANGET,RANPUT,RECORD
        INTEGER TTY,DISK
C
        INTEGER RDATA(102)
C
        LOGICAL SETUP
C
        EQUIVALENCE (RECORD,RDATA(2))
C
        DATA RANGET/Z105F/, RANPUT/Z109F/
C
        DATA I,J,M/3*0/
        DATA IANS/0/
C
C       CHECK TO SEE IF THIS IS DELETE AFTER SETUP
C
        IF(SETUP) GOTO 35
C
C       CHECK FOR FILE INITIALIZATION
C
        WRITE(TTY,100)
        READ(TTY,104)IANS
        IF(IANS.NE.1HY) GO TO 10
        WRITE(TTY,102)
        READ(TTY,104)IANS
        IF(IANS.NE.1HY) GO TO 10
        DO 30 I=1,MAXREC
           RECORD=I
           CALL F$OPN(DISK)
           CALL F$IOS(RANGET,RDATA,DISK,M)
           DO 20 J=3,102
                RDATA(J)=0
20              CONTINUE
           RDATA(4)=-1
           CALL F$IOS(RANPUT,RDATA,DISK,M)
           CALL F$CLS(DISK)
```

```
      CALL F$IOS(IOSPUT,BASIC,LINE,MODE)
      CALL DEL$1(WAIT)
40    CONTINUE
C
C     START PROGRAM
C
      NREC=NREC*32
      WRITE(LINE,520) ISTART,NREC,CHKSUM,ISTART
      WRITE(LINE,522)
14    CONTINUE
      M=M$FBF(DOEDAT)
      M=M$CFA(DISK,DATFIL)
      RETURN
C
500   FORMAT('NEW')
502   FORMAT('LOCK Z40')
512   FORMAT(40A2)
516   FORMAT('QUIT')
518   FORMAT('R',Z4,4H S20)
520   FORMAT('1 A=',I5,'#N=',I5,'#S=',I3,'#CALLX',Z4,'(S,N,A)')
522   FORMAT('RUN')
524   FORMAT(32Z4)
C
      END
C
C=====================================================================
C
      SUBROUTINE Z80SHK(LINE,MODE)
C
C     ***ROUTINE TO INITIALIZE COMMUNICATIONS WITH CROMEMCO
C
C=====================================================================
C
      INTEGER IWORD(2),IDEL(2)
C
      COMMON ISTATS(16)
C
C     ***GLOBAL SHOULD BE BOUNDED AT THE DCB'S LO
C
      DATA IWORD/2*0/
      DATA ITIME/Z8004/,IDEL/0,1/
      DATA I/0/
C
C     ***CHECK CALLING PARAMETERS***
C
      MODE=0
      IF(LINE.LT.0.OR.LINE.GT.63) RETURN
C
C     ***INHIBIT NULL OUTPUT ON WRITE
C
      ISTATS(10)=ISTATS(10).AND.X'FDFF'
C
C     ***INHIBIT <LF> ON INPUT
C
      ISTATS(11)=ISTATS(11).OR.X'100'
C
C     ***ENABLE USER PROMPT
C
      ISTATS(2)=ISTATS(2).OR.X'200'
C
C     ***SET BAUD RATE TO 2400
C
      ISTATS(9)=X'127'
      CALL F$OPN(LINE)
C
C     ***ENABLE INPUT WITH TIME-OUT
C
10    CONTINUE
      CALL I$CLCK(LINE,ITIME,MODE)
C
C     ***WAIT FOR CROMEMCO TO BE TURNED ON
C
      READ(LINE,100) IWORD
      CALL DEL$1(IDEL)
      IF(IWORD(2).NE.'OK') GO TO 10
C
C     ***DISABLE USER PROMPT
C
      ISTATS(2)=ISTATS(2).AND.X'FDFF'
```

```
C
C     MICRO-C PROGRAM PROGRAM FOUND, DOWN-LOAD SOURCE
C
      READ(DISK,512) (ASCII(I),I=1,40)
      DO 20 I=1,40
         J=41-I
         IF(ASCII(J).NE.2H  ) GO TO 22
20       CONTINUE
C
C     BLANK RECORD
C
      GO TO 16
22    CONTINUE
C
C     NON-BLANK RECORD
C
      NCHAR=J
      IF(ASCII(1).EQ.2H*=) GO TO 30
      IF(ASCII(4).EQ.2HEN.AND.ASCII(5).EQ.2HD )GO TO 40
C
C     OUTPUT A LINE OF CONTROL BASIC
C
      WRITE(LINE,512) (ASCII(I),I=1,NCHAR)
      CALL DEL$1(WAIT)
      GO TO 16
C
C     Z80 MACHINE LANGUAGE FOUND, I.E. '*=HHLL'
C
30    CONTINUE
C
C     GO TO SCC MONITOR, SUBSTITUTE MEMORY AT 'HHLL'
C
      WRITE(LINE,516)
      CALL DEL$1(WAIT)
C
C     GET MACHINE LANGUAGE SOURCE
C
      LTEMP=Z80FUN(ASCII(2))
     * LDA LTEMP
     * SRC A,8
     * STA LTEMP
      ADDR=LTEMP.OR.Z80FUN(ASCII(3))
      ISTART=ADDR
      CHKSUM=0
      NREC=0
34    CONTINUE
C
C     DOWNLOAD BINARY RECORDS
C
      READ(DISK,512) (ASCII(I),I=1,32)
      IF(ASCII(4).EQ.2HEN.AND.ASCII(5).EQ.2HD )GO TO 42
      ENCODE(9,518,BUFF,MODE) ADDR
      ADDRS(7)=(ADDRS(7).AND.X'FF00').OR.X'000D'
C
C     OUTPUT A LINE OF SOURCE
C
      NREC=NREC+1
      J=0
      DO 36 I=1,32,2
         J=J+1
         LTEMP=Z80FUN(ASCII(I))
         CHKSUM=CHKSUM+LTEMP
         CHKSUM=CHKSUM.AND.X'FF'
     *   LDA LTEMP
     *   SRC A,8
     *   STA LTEMP
         BINARY(2+J)=Z80FUN(ASCII(I+1))
         CHKSUM=CHKSUM+BINARY(2+J)
         CHKSUM=CHKSUM.AND.X'FF'
         BINARY(2+J)=BINARY(2+J).OR.LTEMP
36       CONTINUE
      CALL F$IOS(IOSPUT,ADDRS,LINE,MODE)
      CALL F$IOS(IOSPUT,BINARY,LINE,MODE)
      ADDR=ADDR+32
      GO TO 34
42    CONTINUE
C
C     GO TO CONTROL BASIC MONITOR
C
```

```
      CALL R$FOF
      CALL DOESTK(PULL)
C
      GO TO 10
C
100   FORMAT(///'RTOS-16, Rev.7:  D.O.E. Furnace')
101   FORMAT(//'*** Options:'/
     + 4X,'1 = Data Entry   6 = Analyze'/
     + 4X,'2 = Search       7 = Calibrate'/
     + 4X,'3 = Delete       8 = Reload'/
     + 4X,'4 = Examine      9 = Run set-up'/
     + 4X,'5 = Acquire     10 = Run print-out')
102   FORMAT(/'* Enter option')
104   FORMAT(V)
106   FORMAT(/'> Analyze which data record?')
108   FORMAT('>> Include a consistency analysis? ')
110   FORMAT('>> Include the gas-shift reaction? ')
112   FORMAT(A1)
      END
C
C=====================================================================
C
      SUBROUTINE Z80LOD
C
C     THIS ROUTINE IS USED TO DOWN-LOAD THE CROMEMCO.
C
C=====================================================================
C
      COMMON /LUN/ LINE,DISK,MAXREC,IREC
C
      INTEGER BINARY(18),WAIT(2),Z80FIL,DATFIL,Z80FUN
      INTEGER Z80PGM(4),DISK,ASCII(40),DOEDAT(4)
      INTEGER ADDR,BASIC(3)
      INTEGER BUFF(5),ADDRS(7)
      INTEGER CHKSUM,TIME(4),HR,MN,SC
C
      EQUIVALENCE (ADDRS(3),BUFF(1))
      EQUIVALENCE (Z80FIL,Z80PGM(1))
      EQUIVALENCE (DATFIL,DOEDAT(1))
C
      DATA BINARY/32,0,16*0/
      DATA Z80PGM/'UJ','Z8','0P','GM'/
      DATA DOEDAT/'UJ','DO','ED','AT'/
      DATA WAIT/0,1/
      DATA ASCII/40*2H  /
      DATA IOSGET/Z0C5F/, IOSPUT/Z009F/
      DATA TIME/4,0,Z2E00,0/
      DATA NCHAR,M,I,J/4*0/
      DATA NREC,CHKSUM /0,0/
      DATA BASIC/2,0,2HBA/
      DATA ADDRS/10,0,5*0/
      DATA MODE,ADDR,LTEMP,ISTART/4*0/
      DATA HR,MN,SC/0,0,0/
C
C
10    CONTINUE
C
C     ESTABLISH COMMUNICATIONS WITH CROMEMCO
C
      CALL Z80SHK(LINE,MODE)
      CALL DEL$1(WAIT)
C
C     INITIALIZE MICRO
C
      WRITE(LINE,500)
      CALL DEL$1(WAIT)
C
      WRITE(LINE,502)
      CALL DEL$1(WAIT)
C
C     GET MICRO-C PROGRAM FROM USER FILE
C
      M=M$ERF(Z80PGM)
      M=M$CFA(DISK,Z80FIL)
C
C     MAKE LOGICAL TO PHYSICAL UNIT ASSIGNMENT
C
      REWIND DISK
16    CONTINUE
```

```
      COMMON /LUN   / TTY,DISK,MAXREC,IREC
      COMMON /DEBUG / DEBUG,RESET,SHIFT,SSQMIN
C
      DATA JOB3,JOB6,IOPT/3,6,0/
      DATA RANGET,RANPUT/Z105F,Z109F/
      DATA NOW/0,4/, MODE/0/
      DATA PUSH,PULL/0,1/
      DATA MASSBL/17, RELOAD/.TRUE./
C
      CALL FREMAT
C
      RDATA(1)=200
1     CONTINUE
      IF(RELOAD) CALL ZBOLOD
      CALL DEL$1(NOW)
      RELOAD=.FALSE.
C
      WRITE(TTY,100)
5     CONTINUE
      WRITE(TTY,101)
10    CONTINUE
      IREC=0
      WRITE(TTY,102)
      READ(TTY,104) IOPT
      IF(IOPT.LT.1.OR.IOPT.GT.10) GO TO 5
      IF(IOPT.EQ.1) CALL DOENTR
      IF(IOPT.EQ.2) CALL DOESEA
      IF(IOPT.EQ.3) CALL DOEDEL
      IF(IOPT.EQ.4) CALL DOEDIS
      IF(IOPT.EQ.5) CALL DOEGET
      IF(IOPT.EQ.6) GO TO 15
      IF(IOPT.EQ.7) CALL DOECAL
      IF(IOPT.EQ.9) CALL DOERSU
      IF(IOPT.EQ.10) GOTO 12
      IF(IOPT.NE.8) GO TO 10
      RELOAD=.TRUE.
      GO TO 1
C
C     RUN PRINT OUT
C
12    CONTINUE
      IREC=99
      GOTO 20
15    CONTINUE
C
C     SAVE THE OPTION ON DISK
C
      RDATA(2)=MAXREC+1
      CALL F$OPN(DISK)
      CALL F$IOS(RANGET,RDATA,DISK,MODE)
      RDATA(4)=MASSBL
      CALL F$IOS(RANPUT,RDATA,DISK,MODE)
      CALL F$CLS(DISK)
C
C     FIND OUT WHICH RECORD TO ANALYZE
C
      WRITE(TTY,106)
      READ(TTY,104) IOPT
      IF(IOPT.LE.0.OR.IOPT.GT.MAXREC) GO TO 10
      IREC=IOPT
C
C     CHECK FOR A CONSISTENCY ANALYSIS
C
      WRITE(TTY,108)
      READ(TTY,112) IOPT
      SSQMIN=IOPT.EQ.'Y'
      IF(.NOT.SSQMIN) GO TO 20
C
C     CHECK FOR THE INCLUSION OF THE GAS-SHIFT REACTION
C
      WRITE(TTY,110)
      READ(TTY,112) IOPT
      SHIFT=IOPT.NE.'N'
20    CONTINUE
C
C     SAVE LABELED COMMON ON DISK
C
      CALL DOESTK(PUSH)
      CALL TPN$1(JOB6,NOW,MODE)
```

```
C
C=======================================================================
C
C       D.O.E. COAL FURNACE COMMON ALLOCATION FOR SHARED DSECT
C
        BLOCK DATA
C
C=======================================================================
C
        INTEGER RDATA(102),DISK,TTY
        INTEGER IBASPT(5),IBUF(40)
C
        LOGICAL O2RICH,COGGIN,CHROMO,DEBUG,RESET,SHIFT,SSQMIN
        LOGICAL SETUP
C
        REAL CNAME(2),GNAME(4)
        REAL XNAME(6),YNAME(12),SNAME(4),PNAME(4)
C
        DOUBLE PRECISION SR,AIRSR
        DOUBLE PRECISION Q,W,X,Y,S,P,T,
     + QDATA,WDATA,XDATA,YDATA,SDATA,PDATA,TDATA
        DOUBLE PRECISION LASTZ(22),DELZ(22)
C
        COMMON /DATA  / RDATA
        COMMON /INDEX / INDEX(30)
        COMMON /TEMPER/ TAXIS(24)
        COMMON /WEIGHT/ WEIGHT(30)
        COMMON /GAMMA / SR,AIRSR
        COMMON /LUN   / TTY,DISK,MAXREC,IREC
        COMMON /DEBUG / DEBUG,RESET,SHIFT,SSQMIN
        COMMON /BURN  / O2RICH,COGGIN,CHROMO
        COMMON /NAME  / XNAME,YNAME,SNAME,PNAME,CNAME,GNAME
        COMMON /SYSTEM/ Q(4),W(2),X(6),Y(12),S(4),P,T
        COMMON /SEARCH/ QDATA(4),WDATA(2),XDATA(6),YDATA(12),
     +                  SDATA(4),PDATA,TDATA
        COMMON /VECTOR/ LASTZ,DELZ,NSERCH
        COMMON /MAXFIV/ UNITS(96),NSIZE
        COMMON /CHRBUF/ IBUF
        COMMON /SETURN/ SETUP
        COMMON /BASE  / IBASFT
C
        DATA TTY,DISK,MAXREC,IREC/20,53,80,0/
C
        DATA RDATA/200,1,100*0/
        DATA IBASPT/5*1930/
        DATA IBUF/40*0/
        DATA SETUP/.FALSE./
C
        DATA CNAME/'COAL','FLUE'/
        DATA XNAME/' C  ',' H  ',' O  ',
     +             ' S  ',' N  ',' H2O'/
        DATA YNAME/' CO2',' CO ',' O2 ',
     +             ' NO ',' HCN',' CH4',
     +             ' H2S',' SO2',' NH3',
     +             ' H2 ',' H2O',' N2 '/
        DATA SNAME/' C  ',' H  ',' N  ',' S  '/
        DATA PNAME/'F.C.','V.M.',' ASH',' H2O'/
        DATA GNAME/'TRNS','PRHT','STGD','FLUE'/
C
        DATA INDEX/1,2,3,8,9,10,11,12,13,15,16,5,26,27,28,30,17,18,19,21/
        DATA WEIGHT/29*1.0,10.0/
C
      END
C
C=======================================================================
C
C       D.O.E. COAL FURNACE MAIN-LINE
C
C=======================================================================
C
        INTEGER RDATA(102),TTY,DISK,NOW(2)
        INTEGER RANGET,RANPUT
        INTEGER PUSH,PULL
C
        LOGICAL DEBUG,RESET,SHIFT,SSQMIN
        LOGICAL RELOAD
C
        COMMON /DATA  / RDATA
```

```
      END
C
C=====================================================================
C
      SUBROUTINE DOEGET
C
C     ROUTINE TO RETRIEVE DATA FROM THE CROMEMCO
C
C=====================================================================
C
      INTEGER RECORD,LPROBE,DATE(3),TIME(3)
      INTEGER RDATA(102),IDATA(102),JDATA(102)
      INTEGER KNAME(20),NAME(20)
      INTEGER ZBODAT(96),CNTRLD(3),CNTRLA(3)
      INTEGER KDATA(102),IBASPT(5),IERROR(4)
      INTEGER IBUF(40)
      INTEGER PUSH,PULL,NOW(2)
      INTEGER COOL,STAGE
      INTEGER DEBUG,STOP(2)
      INTEGER IQ(6)
C
      REAL AIR(3),PROX(4),ULTIM(5),FLUE(12),SMOKE(4),PRESSR(3)
      REAL KPROX(4),KULTIM(5),KSMOKE(4),KCOAL
      REAL LFE(3),A(8,4),TSLOPE(1),TBASE(1)
      REAL XNAME(6),YNAME(12),SNAME(4),PNAME(4),CNAME(2),GNAME(4)
      REAL CHRDAT(6)
C
      LOGICAL BLANK,SETUP,SHIFT,DEBUG,RESET,DATAFT
      LOGICAL SSQMIN
C
      COMMON /IDATA  / RDATA
      COMMON /TEMPER/ T(24)
      COMMON /BASE/IBASPT
      COMMON /LUN    / TTY,DISK,MAXREC,IREC
      COMMON /NAME   / XNAME,YNAME,SNAME,PNAME,CNAME,GNAME
      COMMON /MAXPTS/ UNITS(96),P
      COMMON /SYSTEM/ IDATA1(X'78')
      COMMON /SEARCH/ JDATA1(X'78')
      COMMON /VECTOR/ KDATA1(X'81')
      COMMON /CHRBUF/ IBUF
      COMMON /SETUPN/ SETUP
      COMMON  /DEBUG / DEBUG,RESET,SHIFT,SSQMIN
C
      EQUIVALENCE      (RECORD,RDATA(2)),
     +                 (LPROBE,RDATA(3)),
     +                 (DATE(1),RDATA(4)),
     +                 (TIME(1),RDATA(7)),
     +                 (TSAMPL,RDATA(10)),
     +                 (AIR(1),RDATA(12)),
     +                 (FLUE(1),RDATA(18)),
     +                 (PROX(1),RDATA(42)),
     +                 (ULTIM(1),RDATA(50)),
     +                 (SMOKE(1),RDATA(60)),
     +                 (COAL,RDATA(68)),
     +                 (NAME(1),RDATA(70)),
     +                 (COOL,RDATA(90)),
     +                 (STAGE,RDATA(91)),
     +                 (RESTIM,RDATA(92)),
     +                 (SR,RDATA(94)),
     +                 (CONVNO,RDATA(96)),
     +                 (FLGSOT,RDATA(98)),
     +                 (SOLOUT,RDATA(100))
      EQUIVALENCE      (KDATA(1),UNITS(40)),
     +                 (PRESSR(1),KDATA(34)),
     +                 (AIRTMP,KDATA(40)),
     +                 (KPROX(1),KDATA(42)),
     +                 (KULTIM(1),KDATA(50)),
     +                 (KSMOKE(1),KDATA(60)),
     +                 (KCOAL,KDATA(68)),
     +                 (KNAME(1),KDATA(70))
C
      EQUIVALENCE      (IDATA(1),IDATA1(1)),
     +                 (JDATA(1),JDATA1(1)),
     +                 (A(1,1),IDATA(3)),
     +                 (TSLOPE(1),JDATA(3)),
     +                 (TBASE(1),JDATA(51))
      EQUIVALENCE      (ZBODAT(1),KDATA1(1))
C
      INTEGER RANGET,RANPUT,DISK,TTY
```

```
C
      DATA ICOUNT/0/,IERROR/480/
      DATA RANGET /Z105F/, RANPUT /Z109F/
      DATA IOSPUT/Z009F/
      DATA ANS/0.0/,IANS,IOPT/280/
C
      DATA J,NREC/280/, BLANK/.TRUE./
      DATA I,K/280/, ZERO/0.0/
      DATA SCFM,PCNT,PPMV/'SCFM','%   ','PPMV'/
      DATA CNVDAT/460.0/
      DATA DATAPT/.FALSE./
      DATA PUSH,PULL,JOB6,NOW,MODE/0,1,6,0,4,0/
      DATA STOP/0,5/,CEDUD/1/
      DATA IQ/10,3,12,6,2,1/
C
CCC   LAMINAR FLOW ELEMENT SPECIFICATIONS
CCC
CCC   SPECIFICATIONS UNITS ARE [=] SCFM/INCH H2O
C
      DATA LFE/.4,2.5,2.2/
      DATA RANKIN,STAND,HG1ATM,TUCSON,GAUGE/460.,70.,760.,692.,14.7/
C
      DATA CNTRLA/1,0,Z0100/, CNTRLD/1,0,Z0400/
C
CCC   SEARCH FOR AN EMPTY RECORD
CCC
      CALL FSOPN(DISK)
      DO 10 RECORD=1,MAXREC
         CALL FSIOS(RANGET,RDATA,DISK,M)
         IF(DATE(1).EQ.-1) GO TO 20
10       CONTINUE
CCC
CCC   ALL RECORDS FILLED
CCC
      CALL FSCLS(DISK)
      WRITE(TTY,100)
      RETURN
C
CCC   EMPTY RECORD FOUND
CCC
20    CONTINUE
      CALL TIMESP(TIME(1),TIME(2),TIME(3))
      CALL DATESR(DATE(3),DATE(1),DATE(2))
C
CCC   SAVE TIME AND DATE ON DISK
CCC
      IREC=RECORD
      NREC=RECORD
      CALL FSIOS(RANPUT,RDATA,DISK,M)
C
CCC   SAVE RECORD NUMBER IN CONSTANTS RECORD
CCC
      KDATA(1)=RDATA(1)
      KDATA(2)=MAXREC+1
      CALL FSIOS(RANGET,KDATA,DISK,M)
      KDATA(3)=NREC
C
CCC   USE DEFAULT COAL AND FLUE SOLIDS ANALYSIS
C
      DO 22 I=42,102
         KDATA(I)=KDATA(I)
22       CONTINUE
CCC
CCC   SEE IF THIS IS A RUN SETUP
C
      DATAPT=.FALSE.
      IF(SETUP) GOTO 21
C
CCC   THIS ACTUAL DATA POINT OR ORDINARY AQUIRE
C     IF NO RUN 0, THEN ORDINARY AQUIRE
C
15    CONTINUE
      WRITE(TTY,160)
      CALL DOEINP(ANS,BLANK,TTY)
      IF(BLANK) GOTO 21
      IANS=IFIX(ANS+0.5)
      IF(IANS.LT.1.OR.IANS.GT.10) GOTO 15
      JDATA(1)=RDATA(1)
      JDATA(2)=MAXREC+10*IANS
```

```
      CALL F$IOS(RANGET,JDATA,DISK,M)
      IF(JDATA(50).NE.-1) GOTO 17
      DO 16 I=11,26
      IF(JDATA(I).EQ.NREC) GOTO 18
      IF(ICOUNT.NE.0) GOTO 16
      IF(JDATA(I).EQ.0) ICOUNT=I
16    CONTINUE
      IF(ICOUNT.EQ.0) GOTO 19
      JDATA(ICOUNT)=NREC
      DATAPT=.TRUE.
      CALL F$IOS(RANPUT,JDATA,DISK,M)
      GOTO 199
17    CONTINUE
      WRITE(TTY,165)
      CALL F$CLS(DISK)
      GOTO 55
18    CONTINUE
      WRITE(TTY,170)
      CALL F$CLS(DISK)
      GOTO 55
19    CONTINUE
      WRITE(TTY,175)
      CALL F$CLS(DISK)
      GOTO 55
C
C     GET PORT NUMBERS FOR PROBE, COOLING,AND STAGING
C
199   CONTINUE
      WRITE(TTY,180)
200   CONTINUE
      WRITE(TTY,185)
      CALL DOEINP(ANS,BLANK,TTY)
      IF(BLANK) GOTO 200
      IANS=IFIX(ANS+0.5)
      IF(IANS.LT.1.OR.IANS.GT.9) GOTO 200
      RDATA(3)=IANS
205   CONTINUE
      WRITE(TTY,190)
      CALL DOEINP(ANS,BLANK,TTY)
      IF(BLANK) GOTO 205
      IANS=IFIX(ANS+0.5)
      IF(IANS.LT.0.OR.IANS.GT.9) GOTO 205
      RDATA(90)=IANS
210   CONTINUE
      WRITE(TTY,195)
      CALL DOEINP(ANS,BLANK,TTY)
      IF(BLANK) GOTO 210
      IANS=IFIX(ANS+0.5)
      IF(IANS.LT.0.OR.IANS.GT.9) GOTO 210
      RDATA(91)=IANS
21    CONTINUE
C
C     RETRIEVE THE CALIBRATION CONSTANTS FROM DISK
C
      IDATA(1)=RDATA(1)
      JDATA(1)=RDATA(1)
      IDATA(2)=MAXREC+2
      JDATA(2)=MAXREC+3
C
      CALL F$IOS(RANGET,IDATA,DISK,M)
      CALL F$IOS(RANGET,JDATA,DISK,M)
C
C     RETRIEVE MULTIPLEXED DATA FROM THE CROMEMCO
C
C     T-1 MINUTE IS IN Z80DAT( 1 - 40 )
C     T-11 MINUTES IS IN Z80DAT( 41 - 80 )
C     T-15 MINUTES IS IN Z80DAT( 81 - 120 )
C
      CALL F$IOS(IOSPUT,CNTRLA,TTY,M)
      READ(TTY,104) Z80DAT
      CALL DEL$1(STOP)
C
C  RETRIEVE # OF RECORDS TO BE SENT FROM CHROMATOGRAPH
C
      CALL F$IOS(IOSPUT,CNTRLD,TTY,M)
C     CALL DEL$1(STOP)
      READ(TTY,106)NREC
      IF(NREC.LE.0) GOTO 25
C
```

```
C  READ IN CHROMATOGRAPH RECORDS
C
      DO 24 I=1,NREC
      READ(TTY,108) IBUF
      CALL DOEDCD(NREC,I,CHRDAT)
24    CONTINUE
C
C     REPORT RESULTS
C
      CALL DEL$1(STOP)
      WRITE(TTY,124)
      WRITE(TTY,122)
      DO 88 I=1,6
      WRITE(TTY,120) CHRDAT(I),YNAME(IO(I))
88    CONTINUE
C
C    EXCHANGE 1 MINUTE OLD DATA FOR 11 MINUTE OLD DATA
C
      DO 25 I=1,32
      Z80DAT(I)=Z80DAT(I+32)
25    CONTINUE
C
C  FIND THE DRIFT BY COMPARING GROUND VALUES
C
      DO 26 I=1,4
      J=I*6
      IERROR(I)=IBASPT(I)-Z80DAT(J)
26    CONTINUE
C
C  CONDITION RAW DATA FOR TEMPERATURE DRIFT
C
      DO 27 I=1,4
      DO 28 J=1,7
      K=J+(I-1)*6
      Z80DAT(K)=Z80DAT(K)+IERROR(I)
28    CONTINUE
27    CONTINUE
C
C     RETRIEVE THE UPDATED STATIC PRESSURES AND AIR TEMPERATURE
C
      WRITE(TTY,114)
      CALL DOEINP(ANS,BLANK,TTY)
      IF(.NOT.BLANK) AIRTMP=ANS
      DO 30 I=1,3
        WRITE(TTY,116) GNAME(I)
        CALL DOEINP(ANS,BLANK,TTY)
        IF(.NOT.BLANK) PRESSR(I)=ANS
30      CONTINUE
C
C     CONVERT PT/PT-RHODIUM T.C. DATA
C
      DO 32 I=1,8
         T(I)=TSLOPE(I)*Z80DAT(I)+TBASE(I)
32       CONTINUE
C
C     CONVERT CHROMEL/ALUMEL T.C. DATA
C
      DO 33 I=9,24
         T(I)=TSLOPE(I)*Z80DAT(I)+TBASE(I)
33       CONTINUE
C
C     SAVE THE FLUE GAS TEMPERATURE
C
      TSAMPL=T(2)
C
C     CONVERT THE P/E TRANSDUCER DATA
C
      DO 36 I=1,3
C
C        CONVERT ADC VALUES TO INCHES H2O
C
         BASEPT=Z80DAT(24+I)
         UNITS(I)=A(I,1)+A(I,2)*BASEPT+A(I,3)*BASEPT**2+
     +A(I,4)*BASEPT**3
         IF(UNITS(I).LT.ZERO) UNITS(I)=ZERO
C
C        CONVERT INCHES H2O TO SCFM
C
         AIR(I)=UNITS(I)*LFE(I)
```

```
C
C         CONVERT CUBIC FEET PER MINUTE TO STANDARD CONDITIONS
C
          AIR(I)=AIR(I)*(TUCSON+HG1ATM*PRESSR(I)/GAUGE)/HG1ATM
          AIR(I)=AIR(I)*(RANKIN+TSTAND)/(RANKIN+AIRTMP)
36        CONTINUE
C
C       CONVERT THE ANALYZER DATA
C
          DO 38 I=1,4
             K=I+3
             BASEPT=ZBODAT(27+I)
             FLUE(I)=A(K,1)+A(K,2)*BASEPT+A(K,3)*BASEPT**2+A(K,4)*BASEPT**3
             IF(FLUE(I).LT.ZERO) FLUE(I)=ZERO
38        CONTINUE
C
C       IF CHROMATOGRAPH BUFFER AVAILABLE AND ACCEPTABLE
C       THEN CHANGE TIME AND DECODE BUFFER AND STORE USEABLE DATA
C
          IF(NREC.LE.0.OR.NREC.GT.50) GOTO 45
C
C         ASK IF CHROMATOGRAPH IS GOOD
C
          WRITE(TTY,220)
          READ(TTY,230)IOPT
          IF(IOPT.EQ.'N') GOTO 45
          CALL DOETCH(TIME)
          FLUE(6)=CHRDAT(4)
          FLUE(1)=CHRDAT(6)
          FLUE(2)=CHRDAT(5)
          FLUE(3)=CHRDAT(2)
          FLUE(12)=CHRDAT(3)
          FLUE(10)=CHR%
45        CONTINUE
C
C         CLEAN CHROMATOGRAPH BUFFER
C
          DO 46 I=1,6
          CHRDAT(I)=0.0
46        CONTINUE
C
C         OUTPUT THE T-1 MINUTE ANALYZER AND TRANSDUCER VALUES
C         IF CHROMATOGRAPH BUFFER IS AVAILABLE, OUTPUT T-6 VALUES
C
          WRITE(TTY,102) RECORD,TIME,DATE
          WRITE(TTY,112)
          DO 50 I=1,3
             WRITE(TTY,110) YNAME(I),FLUE(I),PCNT,
     +       GNAME(I),AIR(I),SCFM,UNITS(I)
50        CONTINUE
          WRITE(TTY,110) YNAME(4),FLUE(4),PPMV
C
C         SAVE DATA ON DISK
C
          CALL F$OPN(DISK)
          CALL F$IOS(RANPUT,RDATA,DISK,M)
          CALL F$IOS(RANPUT,RDATA,DISK,M)
          CALL F$CLS(DISK)
C
C         IF JUST A PLAIN AQUIRE, RETURN,
C         OTHERWISE DO A MASS BALANCE
C
          IF(.NOT.SETUP) GOTO 47
          GOTO 49
47        CONTINUE
          IF(.NOT.DATAPT) GOTO 55
49        CONTINUE
C
C         SAVE MASS BALANCE ON DISK
C
          RDATA(2)=MAXREC+1
          CALL F$OPN(DISK)
          CALL F$IOS(RANGET,RDATA,DISK,MODE)
          RDATA(4)=1
          CALL F$IOS(RANPUT,RDATA,DISK,MODE)
          CALL F$CLS(DISK)
          SSOMIN=.FALSE.
          SHIFT=.FALSE.
```

```
C
C       SAVE LABELED COMMON ON DISK
C
        CALL DOESTK(PUSH)
        CALL TPN$1(JOB6,NOW,MODE)
        CALL R$FOF
        CALL DOESTK(PULL)
        IF(SETUP) GOTO 52
51      CONTINUE
        GOTO 55
52      CONTINUE
        CALL DOEDEL
55      CONTINUE
        RETURN
C
100     FORMAT(//'<< All records filled, Delete required !')
102     FORMAT(//'*** RECORD ',I3,5X,'TIME',I3,':',I2,':',I2,
     +         5X,'DATE',I3,'/',I2,'/',I2)
104     FORMAT(16Z4)
106     FORMAT(I2)
108     FORMAT(40A2)
110     FORMAT(10X,A4,F8.2,1X,A4,6X,A4,F8.2,1X,A4,
     + 4X,F8.2,' inches H20')
112     FORMAT(//'*** ANALYZER AND TRANSDUCER OUTPUTS:'/)
114     FORMAT(//'> Enter the air temperature:  [=] Fahrenheit')
116     FORMAT(//'> Enter ',A4,' pressure:  [=] psig')
120     FORMAT('<< ',F5.2,' % ',A4)
122     FORMAT(//'*** RESULTS OF CHROMATOGRAPH DATA ***'/)
124     FORMAT('  .  ')
160     FORMAT(//'> What is the run number (1-10) ?')
165     FORMAT(//'<< Run record not set-up ')
170     FORMAT(//'<< Data record already stored ')
175     FORMAT(//'<< Run record full - Delete data record requires')
180     FORMAT(//'Option  Port   Option  Port',
     +/'  1   -  1        6   -  4A',
     +/'  2   -  2        7   -  5',
     +/'  3   -  2A       8   -  6',
     +/'  4   -  3        9   -  7',
     +/'  5   -  4        0   -  No port')
185     FORMAT(//'> Enter sample port option number')
190     FORMAT(//'> Enter cooling port option number')
195     FORMAT(//'> Enter staging port option number')
220     FORMAT(//'>> Is chromatograph data okay ?')
230     FORMAT(A1)
C
        END
C
C=======================================================================
C
        SUBROUTINE DOENTR
C
C       THIS SUBROUTINE ALLOWS THE OPERATOR
C       TO FILL A DATA RECORD FROM THE TELETYPE.
C
C=======================================================================
C
        LOGICAL BLANK
C
        INTEGER RECORD,LPROBE,DATE(3),TIME(3),RDATA(102)
        INTEGER H,S,D,Y,RANPUT,RANGET
        INTEGER DISK,TTY,KDATA(102)
        INTEGER KNAME(20),NAME(20)
        INTEGER ICOMP(12)
        INTEGER COOL,STAGE,IPORT(3)
C
        REAL FORTNM(6)
        REAL AIR(3),PROX(4),ULTIM(5),FLUE(12),SMOKE(4),PRESSR(3)
        REAL KPROX(4),KULTIM(5),KSMOKE(4),KCOAL
        REAL XNAME(6),YNAME(12),SNAME(4),PNAME(4)
        REAL CNAME(2),GNAME(4)
C
        COMMON /LUN   / TTY,DISK,MAXREC,IREC
        COMMON /DATA  / RDATA
        COMMON /MAXPIV/ UNITS(96),M
        COMMON /NAME  / XNAME,YNAME,SNAME,FNAME,CNAME,GNAME
C
        EQUIVALENCE     (RECORD,RDATA(2)),
     +                  (LPROBE,RDATA(3)),
     +                  (DATE(1),RDATA(4)),
```

```
     +                (TIME(1),RDATA(7)),
     +                (TSAMPL,RDATA(10)),
     +                (AIR(1),RDATA(12)),
     +                (FLUE(1),RDATA(18)),
     +                (PROX(1),RDATA(42)),
     +                (ULTIM(1),RDATA(50)),
     +                (SMOKE(1),RDATA(60)),
     +                (COAL,RDATA(68)),
     +                (NAME(1),RDATA(70)),
     +                (COOL,RDATA(90)),
     +                (STAGE,RDATA(91))
       EQUIVALENCE   (KDATA(1),UNITS(40)),
     +                (PRESSR(1),KDATA(34)),
     +                (AIRTMP,KDATA(40)),
     +                (KPROX(1),KDATA(42)),
     +                (KULTIM(1),KDATA(50)),
     +                (KSMOKE(1),KDATA(60)),
     +                (KCOAL,KDATA(68)),
     +                (KNAME(1),KDATA(70))
C
CC
      DATA ICOMP/1,2,3,6,10,12,11,4,5,7,9/
C
      DATA RANPUT /Z109F/, RANGET /Z105F/
      DATA NOPT/10/, I,H,S,D,Y/5*0/
      DATA BLANK/.TRUE./, IANS,VALUE,ANS/0,2*0.0/
      DATA IPORT/3*0/,PORTNM/'Samp','le  ','Cool','ins ','Stas','ins '/
C
CC    FIND OUT WHICH RECORD
CC
      WRITE(TTY,100)
      CALL DOEINP(ANS,BLANK,TTY)
      IANS=INT(ANS+.5)
      IF(BLANK) RETURN
      IF(IANS.LE.0.OR.IANS.GT.MAXREC) RETURN
C
CC    RETRIEVE RECORD FROM DISK
CC
      CALL F$OPN(DISK)
      KDATA(1)=RDATA(1)
      KDATA(2)=MAXREC+1
      CALL F$IOS(RANGET,KDATA,DISK,M)
      KDATA(3)=IANS
      RECORD=IANS
      CALL F$IOS(RANGET,RDATA,DISK,M)
      CALL F$CLS(DISK)
      IF(DATE(1).NE.-1) GO TO 15
C
CC    USE DEFAULT CONSTANT ASSIGNMENTS
CC
      DO 12 I=42,102
         RDATA(I)=KDATA(I)
12       CONTINUE
15    CONTINUE
CC
CC    MODIFY TIME AND DATE
CC
      CALL TIME$B(H,M,S)
      TIME(1)=H
      TIME(2)=M
      TIME(3)=S
      CALL DATE$B(Y,M,D)
      DATE(1)=M
      DATE(2)=D
      DATE(3)=Y
C
CCC   FIND OUT WHICH ENTRY TO MODIFY
CCC
2     WRITE(TTY,104)
1     CONTINUE
      WRITE(TTY,105)
      CALL DOEINP(ANS,BLANK,TTY)
      IF(BLANK) GO TO 5
      IANS=INT(ANS+.5)
      IF(IANS.LE.0.OR.IANS.GT.NOPT) GO TO 2
      GO TO(45,30,35,50,25,60,20,40,10,55),IANS
C
CCC   PUT CHANGES ON DISK
C
```

```
5       CONTINUE
        CALL F$OPN(DISK)
        CALL F$IOS(RANPUT,RDATA,DISK,M)
        CALL F$IOS(RANPUT,KDATA,DISK,M)
        CALL F$CLS(DISK)
        RETURN
C
C       OBTAIN FLUE GAS TEMPERATURE
C
10      CONTINUE
        WRITE(TTY,110)
        CALL DOEINP(ANS,BLANK,TTY)
        IF(.NOT.BLANK) TSAMPL=ANS
        CALL DOECHO(TSAMPL)
        GO TO 1
C
C
C       OBTAIN AIR FLOWS
C
20      CONTINUE
        DO 22 I=1,3
           WRITE(TTY,112) GNAME(I)
           CALL DOEINP(ANS,BLANK,TTY)
           IF(.NOT.BLANK) AIR(I)=ANS
           VALUE=AIR(I)
           CALL DOECHO(VALUE)
22         CONTINUE
        GO TO 1
C
C       OBTAIN THE AIR TEMPERATURE AND GAUGE PRESSURES
C
25      CONTINUE
        WRITE(TTY,106)
        CALL DOEINP(ANS,BLANK,TTY)
        IF(.NOT.BLANK) AIRTMP=ANS
        CALL DOECHO(AIRTMP)
C
        DO 27 I=1,3
           WRITE(TTY,117) GNAME(I)
           CALL DOEINP(ANS,BLANK,TTY)
           IF(.NOT.BLANK) PRESSR(I)=ANS
           CALL DOECHO(PRESSR(I))
27         CONTINUE
        GO TO 1
C
C       OBTAIN PROXIMATE ANALYSIS
C
30      CONTINUE
        WRITE(TTY,120)
        DO 32 I=1,4
           WRITE(TTY,118) PNAME(I)
           CALL DOEINP(ANS,BLANK,TTY)
           IF(.NOT.BLANK) PROX(I)=ANS
           KPROX(I)=PROX(I)
           CALL DOECHO(PROX(I))
32         CONTINUE
        GO TO 1
C
C       OBTAIN ULTIMATE ANALYSIS
C
35      CONTINUE
        WRITE(TTY,122)
        DO 37 I=1,5
           WRITE(TTY,118) XNAME(I)
           CALL DOEINP(ANS,BLANK,TTY)
           IF(.NOT.BLANK) ULTIM(I)=ANS
           CALL DOECHO(ULTIM(I))
           KULTIM(I)=ULTIM(I)
37         CONTINUE
        GO TO 1
C
C       OBTAIN FLUE GAS ANALYSIS
C
40      CONTINUE
        WRITE(TTY,124)
        DO 42 I=1,6
           WRITE(TTY,118) YNAME(ICOMP(I))
           CALL DOEINP(ANS,BLANK,TTY)
           IF(.NOT.BLANK) FLUE(ICOMP(I))=ANS
```

```
            CALL DOECHO(FLUE(ICOMP(I)))
 42         CONTINUE
            DO 43 I=8,11
               WRITE(TTY,119) YNAME(ICOMP(I))
               CALL DOEINP(ANS,BLANK,TTY)
               IF(.NOT.BLANK) FLUE(ICOMP(I))=ANS
               CALL DOECHO(FLUE(ICOMP(I)))
 43            CONTINUE
            GO TO 1
C
C           OBTAIN COAL INPUT RATE
C
 45         CONTINUE
            WRITE(TTY,126)
            CALL DOEINP(ANS,BLANK,TTY)
            IF(.NOT.BLANK) COAL=ANS
            CALL DOECHO(COAL)
            KCOAL=COAL
            GO TO 1
C
C           OBTAIN SMOKE ANALYSIS
C
 50         CONTINUE
            WRITE(TTY,128)
            DO 52 I=1,4
               WRITE(TTY,118) SNAME(I)
               CALL DOEINP(ANS,BLANK,TTY)
               IF(.NOT.BLANK) SMOKE(I)=ANS
               CALL DOECHO(SMOKE(I))
               KSMOKE(I)=SMOKE(I)
 52            CONTINUE
            GO TO 1
C
C           OBTAIN PROBE POSITION
C
 55         CONTINUE
            WRITE(TTY,135)
 56         CONTINUE
            DO 59 I=1,3
            ICOUNT=I*2-1
 57         CONTINUE
            WRITE(TTY,130) PORTNM(ICOUNT),PORTNM(ICOUNT+1)
            CALL DOEINP(ANS,BLANK,TTY)
            IANS=INT(ANS+.5)
            IF(BLANK) IANS=0
            IF(BLANK) GOTO 58
            IF(IANS.LT.0.OR.IANS.GT.9) GOTO 57
 58         CONTINUE
            IPORT(I)=IANS
            IF(IPORT(1).EQ.0) GOTO 57
 59         CONTINUE
            LPROBE=IPORT(1)
            COOL=IPORT(2)
            STAGE=IPORT(3)
            GO TO 1
C
C           OBTAIN SAMPLE NAME
C
 60         CONTINUE
            WRITE(TTY,132)
            READ(TTY,103) NAME
            WRITE(TTY,103) NAME
            DO 65 I=1,20
               KNAME(I)=NAME(I)
 65            CONTINUE
            GO TO 1
C
C
100         FORMAT(///'> Modify which data record?')
103         FORMAT(40A2)
104         FORMAT(//'*** Data Entry Options:'/
     +  '1 = Coal Feed Rate',10X,'7 = Air Input Rates'/
     +  '2 = Proximate Analysis',6X,'8 = Flue Gas Analysis'/
     +  '3 = Ultimate Analysis',7X,'9 = Flue Gas Temperature'/
     +  '4 = Flue Solids Analysis',3X,'10 = Probe Positions'/
     +  '5 = Air Temperature and Pressures'/
     +  '6 = Coal Sample Name')
105         FORMAT(/'* Enter the data option:')
106         FORMAT('> Air Temperature:  [=] Fahrenheit')
```

```
110     FORMAT('> Flue Gas Temperature:  [=] Celsius')
112     FORMAT('> ',A4,' Air = ?  [=] SCFM')
117     FORMAT('> ',A4,' Pressure:  [=] psig')
118     FORMAT('> Percent ',A4,' = ?')
119     FORMAT('> PPMV ',A4,' = ?')
120     FORMAT('<< Proximate Analysis:  (As-Received Basis)')
122     FORMAT('<< Ultimate Analysis:  (Dry, Ash-included Basis)')
124     FORMAT('<< Flue Gas Analysis:')
126     FORMAT('> Coal Feed Rate = ?   [=] lbs/hour')
128     FORMAT('<< Flue Solids Analysis:  (Ash-Free Basis)')
130     FORMAT('> Probe Position of ',2A4,' probe ?')
135     FORMAT(/'0 - No position  5 - Port 4'/
     + '1 - Port 1       6 - Port 4A'/
     + '2 - Port 2       7 - Port 5'/
     + '3 - Port 2A      8 - Port 6'/
     + '4 - Port 3       9 - Port 7')
132     FORMAT('> Input Sample Name')
C
      END
C
C=====================================================================
C
      SUBROUTINE DOEINP(ANS,BLANK,LUN)
C
C     FREE FORMAT INPUT ROUTINE FOR THE D.O.E. FURNACE
C
C=====================================================================
C
      LOGICAL BLANK
C
      INTEGER BUFFER(5),KBUFF(7)
C
      EQUIVALENCE (BUFFER(1),KBUFF(3))
C
      DATA KBUFF/10,0,5*0/, IOSGET/Z205F/
      DATA M,ICNT,IVAR/3*0/
C
      ANS=1H
      ICNT=10
      BLANK=.TRUE.
C
      CALL F$IOS(IOSGET,KBUFF,LUN,M)
      IF(BUFFER(1).EQ.2H  )RETURN
C
      BLANK=.FALSE.
      DECODE(ICNT,102,BUFFER,IVAR)ANS
      RETURN
C
102   FORMAT(V)
      END
C
C=====================================================================
C
      SUBROUTINE DOECHO(VALUE)
C
C     THIS ROUTINE ECHOES OPERATOR INPUT WITHOUT A LINEFEED.
C
C=====================================================================
C
      INTEGER DISK,TTY,IOSTEM(8),IOSBUF(20)
C
      EQUIVALENCE (IOSBUF(10),IOSTEM(1))
C
      COMMON /LUN/ TTY,DISK,MAXREC,IREC
C
      DATA IOSPUT/Z009F/
      DATA I,NOUT,M,IOSBUF/23*0/
C
      IOSBUF(1)=25
      IOSBUF(2)=0
      DO 10 I=3,20
         IOSBUF(I)=2H
10       CONTINUE
C
      ENCODE(10,100,IOSTEM,NOUT) VALUE
C
      IOSBUF(15)=X'0D0D'
C
      CALL F$IOS(IOSPUT,IOSBUF,TTY,M)
```

```
C
      RETURN
100   FORMAT(G10.4)
      END

C
C=============================================================
      SUBROUTINE DOERSU
C
C     THIS SUBROUTINE SETS UP THE RUN RECORD OR
C     CHANGES THE INFORMATION CONTAINED IN IT.
C=============================================================
C
      INTEGER RDATA(102),KDATA(102),TTY,DISK
      INTEGER DATE(3),RANGET,RANPUT,RECORD(16)
      INTEGER NAME(9),SPNAME(20),ARNAME(6)
      INTEGER STUPNM
C
      LOGICAL BLANK,SETUP,GETCOL
C
      DOUBLE PRECISION Q,W,X,Y,S,P,T
C
      REAL AIR(3),SR(2),TEMP(9)
      REAL KCOAL
C
      COMMON /DATA  / RDATA
      COMMON /LUN   / TTY,DISK,MAXREC,IREC
      COMMON /SYSTEM/ Q(4),W(2),X(6),Y(12),S(4),P,T
      COMMON /SETURN/ SETUP
C
      EQUIVALENCE (TEMP(1),RDATA(27))
      EQUIVALENCE (SPNAME(1),RDATA(70))
      EQUIVALENCE (AIR(1),RDATA(3))
      EQUIVALENCE (COAL,RDATA(9))
      EQUIVALENCE (RECORD(1),RDATA(11))
      EQUIVALENCE (DATE(1),RDATA(90))
      EQUIVALENCE (SR(1),RDATA(65))
      EQUIVALENCE (KCOAL,KDATA(9))
      EQUIVALENCE (ISET,RDATA(50))
      EQUIVALENCE (NSET,KDATA(50))
C
C
      DATA IRN,IANS,ICOUNT,ICNTP/4*0/
      DATA ANS,TEMP/10*0.0/,KDATA/102*0/
      DATA KCOAL/0.0/,IRUN/0/
      DATA BLANK/.TRUE./,SETUP/.FALSE./,GETCOL/.TRUE./
      DATA RANPUT/Z109F/,RANGET/Z105F/
      DATA NAME/' 1',' 2','2A',' 3',' 4','4A',' 5',' 6',' 7'/
      DATA M,I,IOPT,ICNP1/4*0/
      DATA ARNAME/'Tr','ns','Pr','ht','St','sd'/
      DATA STUPNM/0/
C
C     GET RUN NUMBER
C
      SETUP=.FALSE.
10    CONTINUE
      WRITE(TTY,1100)
      CALL DOEINP(ANS,BLANK,TTY)
      IANS=INT(ANS+0.5)
      IF(BLANK) GOTO 1111
      IF(IANS.LT.1.OR.IANS.GT.10) GOTO 10
C
C     CHECK TO SEE IF RUN ALREADY TAKEN
C
      RDATA(2)=MAXREC+10+IANS
      STUPNM=RDATA(2)
      CALL F$OPN(DISK)
      CALL F$IOS(RANGET,RDATA,DISK,M)
      CALL F$CLS(DISK)
      IRUN=ISET
      IF(IRUN.NE.-1) GOTO 160
C
C     RUN RECORD HAS DATA
C
      WRITE(TTY,1105)
      READ(TTY,1110) IOPT
      IF(IOPT.EQ.'Y') GOTO 160
C
C     IF RUN EXISTS, CHANGE TEMPERATURE PROFILE
```

```
C       COAL NAME OR FLOWRATES.
C
30      CONTINUE
        WRITE(TTY,1115)
35      CONTINUE
        WRITE(TTY,1120)
        CALL DOEINP(ANS,BLANK,TTY)
        IF(BLANK) GOTO 999
        IANS=INT(ANS+0.5)
        IF(IANS.LT.1.OR.IANS.GT.7) GOTO 30
        GOTO (40,60,70,70,70,80,90), IANS
C
C       TEMPERATURE PROFILE
C
40      CONTINUE
        DO 50 I=1,9
        WRITE(TTY,1125)NAME(I)
        CALL DOEINP(ANS,BLANK,TTY)
        IF(.NOT.BLANK) TEMP(I)=ANS
        IF(BLANK) TEMP(I)=0.0
50      CONTINUE
        IF(SETUP) GOTO 230
        GOTO 35
C
C       SAMPLE NAME
C
60      CONTINUE
        WRITE(TTY,1130)
        READ(TTY,1135)SPNAME
        IF(SETUP) GOTO 240
        GOTO 35
C
C       FINAL FLOWRATES
C
70      CONTINUE
        ICOUNT=(IANS-2)*2-1
        ICNTP1=ICOUNT+1
        WRITE(TTY,1140) ARNAME(ICOUNT),ARNAME(ICNTP1)
        CALL DOEINP(ANS,BLANK,TTY)
        IF(.NOT.BLANK) AIR(IANS-2)=ANS
*   *   IF(BLANK)GOTO 200
        GOTO 35
C
C       COAL FEED RATE
C
80      CONTINUE
        WRITE(TTY,1145)
        CALL DOEINP(ANS,BLANK,TTY)
        IF(.NOT.BLANK) COAL=ANS
        GOTO 35
C
C       ASSOCIATED RECORD NUMBERS WITH RUN RECORD
C
90      CONTINUE
        WRITE(TTY,1150)(RECORD(I),I=1,16)
100     CONTINUE
        WRITE(TTY,1155)
        CALL DOEINP(ANS,BLANK,TTY)
        IF(BLANK) GOTO 35
        IANS=IFIX(ANS+0.5)
        IF(IANS.LT.1.OR.IANS.GT.2) GOTO 100
        IF(IANS.EQ.2) GOTO 135
C
C       DELETE A RECORD
C
        WRITE(TTY,1160)
        CALL DOEINP(ANS,BLANK,TTY)
        IF(BLANK) GOTO 90
        IANS=IFIX(ANS+0.5)
        IF(IANS.LT.1.OR.IANS.GT.MAXREC) GOTO 110
C
C       SEE IF ANSWER EXISTS
C
        DO 110 I=1,16
        ICOUNT=I
        IF(RECORD(I).EQ.IANS) GOTO 120
110     CONTINUE
        WRITE(TTY,1165)
        GOTO 90
```

```
C
C       RECORD NUMBER FOUND, DELETE, AND RESTACK
C
120     CONTINUE
        DO 130  I=ICOUNT,15
        RECORD(I)=RECORD(I+1)
130     CONTINUE
        RECORD(16)=0
        GOTO 90
C
C       ADD A RECORD
C
135     CONTINUE
        WRITE(TTY,1170)
        CALL DOEINP(ANS,BLANK,TTY)
        IF(BLANK) GOTO 90
        IANS=IFIX(ANS+0.5)
        IF(IANS.LT.1.OR.IANS.GT.MAXREC) GOTO 110
C
C       SEE IF RECORD NUMBER ALREADY STORED
C
        ICOUNT =0
        DO 140 I=1,16
        IF(RECORD(I).EQ.IANS) GOTO 150
        IF(ICOUNT.NE.0) GOTO 140
        IF(RECORD(I).EQ.0) ICOUNT =I
140     CONTINUE
        IF(ICOUNT.EQ.0) WRITE(TTY,1172)
        RECORD(ICOUNT)=IANS
        GOTO 90
C
C       RECORD NUMBER ALREADY STORED
C
150     CONTINUE
        WRITE(TTY,1177)
        GOTO 90
C
C       ZERO EVERYTHING BUT FIRST TWO IN ARRAY RECORD
C
160     CONTINUE
        DO 170 I=3,102
        RDATA(I)=0
170     CONTINUE
C
C       THIS SECTION DEALS ONLY WITH INTIAL SETUP
C       OF RUN RECORD.
C
180     CONTINUE
        GETCOL=.TRUE.
        SETUP=.TRUE.
185     CONTINUE
        WRITE(TTY,1180)
        READ(TTY,1110)IOPT
        IF(IOPT.EQ.'Y') GOTO 250
C
C       GET COAL FLOW RATE
C
190     CONTINUE
        WRITE(TTY,1185)
        READ(TTY,1110)IOPT
        IF(IOPT.NE.'Y') GOTO 190
200     CONTINUE
        CALL DOEGET
        WRITE(TTY,1190)
        READ(TTY,1110)IOPT
        IF(IOPT.EQ.'N') GOTO 190
        COAL=SNGL(W(1))
C
C       GET FINAL FLOWRATES
C
205     CONTINUE
        DO 220 I=3,5
        IANS=I
        GOTO 70
210     CONTINUE
220     CONTINUE
C
C       GET TEMPERATURE PROFILE
C
```

```
      GOTO 40
230   CONTINUE
C
C     GET DATE FOR RUN
C
      CALL DATE$B(DATE(3),DATE(1),DATE(2))
C
C     GET OPERATOR CALCULATED STIOCHOMETRIC RATIOS
C
      WRITE(TTY,1195)
      CALL DOEINP(ANS,BLANK,TTY)
      IF(BLANK) SR(1)=0.0
      IF(.NOT.BLANK) SR(1)=ANS
      WRITE(TTY,1200)
      CALL DOEINP(ANS,BLANK,TTY)
      IF(BLANK) SR(2)=0.0
      IF(.NOT.BLANK) SR(2)=ANS
C
C     SET RUN # WITH IN USE FLAG
C
      ISET=-1
C
C     GET SAMPLE NAME
C
      GOTO 60
240   CONTINUE
C
C     STORE ALL INFORMATION AND RETURN
C
      GOTO 999
C
C     IF STAGING, USE ANOTHER RUNS COAL FLOWRATE
C
250   CONTINUE
      WRITE(TTY,1205)
      READ(TTY,1110)IOPT
      IF(IOPT.NE.'Y') GOTO 190
      WRITE(TTY,1210)
      CALL DOEINP(ANS,BLANK,TTY)
      IF(BLANK) GOTO 190
      IANS=IFIX(ANS+0.5)
      IF(IANS.LT.1.OR.IANS.GT.10) GOTO 190
      IOPT=RDATA(2)-90
      IF(IOPT.EQ.IANS) GOTO 190
C
C     PULL INFORMATION OFF OF DISK
C
      KDATA(1)=RDATA(1)
      KDATA(2)=90+IANS
      CALL F$OPN(DISK)
      CALL F$IOS(RANGET,KDATA,DISK,M)
      CALL F$CLS(DISK)
      COAL=KCOAL
      IF(KSET.EQ.-1) GOTO 260
      WRITE(TTY,1215)
      COAL=0.0
      GETCOL=.TRUE.
      GOTO 190
260   CONTINUE
      GETCOL=.FALSE.
      GOTO 205
C
C     SAVE DATA AND RETURN
C
999   CONTINUE
      RDATA(2)=STUPNM
      CALL F$OPN(DISK)
      CALL F$IOS(RANPUT,RDATA,DISK,M)
      CALL F$CLS(DISK)
      SETUP=.FALSE.
1111  CONTINUE
      RETURN
C
C
1100  FORMAT(/'> What is the run # (1-10) ?')
1105  FORMAT(/'<< Run record contains data'/
     + 'Do you wish to delete it ?')
1110  FORMAT(A1)
1115  FORMAT(/'CHANGE: '/
```

```
     +'1 Temperature profile   5 Staged air flowrate'/
     +'2 Sample name           6 Coal flow rate'/
     +'3 Trans air flowrate    7 Delete or Add data records'/
     +'4 Preheat air flowrate')
1120   FORMAT(/'$ Enter run option')
1125   FORMAT(/'> What is the temperature (C) at port ',A2)
1130   FORMAT(/'> What is the sample name ?')
1135   FORMAT(40A2)
1140   FORMAT(/'> What is the ',2A2,' flowrate (SCFM) ?')
1145   FORMAT(/'> What is the coal flowrate lb/hr ?')
1150   FORMAT(/'<< Presently stored records are ',16(1X,I2))
1155   FORMAT(/'> 1 - Delete or 2 - Add a record ?')
1160   FORMAT(/'> Record number to be Deleted ?')
1165   FORMAT(/'<< Record number not stored !')
1170   FORMAT(/'> Record to be Added ?')
1172   FORMAT(/'<< No room left in run record for data record')
1175   FORMAT(/'<< Record number already exists')
1177   FORMAT(/'<< Record number already stored')
1180   FORMAT(/'>> Is there staging ?')
1185   FORMAT(/'>> Furnace must be running at fuel lean conditions'/
     + 'Is this condition now true ?')
1190   FORMAT(/'>> Is the coal flowrate acceptable ?')
1195   FORMAT(/'> Enter stoichiometric ratio above(or w/o) staging')
1200   FORMAT(/'> Enter stoichiometric ratio below(or CR) staging')
1205   FORMAT(/'>> Do you wish to get coal flowrate from another'/
     + 'run record ?')
1210   FORMAT(/'> What run record ?')
1215   FORMAT(/'<< Record unused !')
       END
C
C=======================================================================
C
       SUBROUTINE DOETCH(TIME)
C
C      ROUTINE TO CHANGE TIME IF CHROMATOGRAPH RECORD IS BEING STORED
C
C=======================================================================
C
       INTEGER TIME(3),CHANGE
C
C
       DATA CHANGE/11/
C
C
       IF(TIME(2).LT.11) GOTO 10
       TIME(2)=TIME(2)-CHANGE
       GOTO 30
C
C
10     CONTINUE
       IF(TIME(1).LT.1) GOTO 20
       TIME(1)=TIME(1)-1
       TIME(2)=TIME(2)+60-CHANGE
       GOTO 30
C
C
20     CONTINUE
       TIME(1)=23
       TIME(2)=TIME(2)+60-CHANGE
C
C
30     CONTINUE
       RETURN
C
       END
C
C=====================================
C
       SUBROUTINE DOEDCD(NREC,REC,CHRDAT)
C
C      ROUTINE WHICH DECODES CHROMATOGRAPH BUFFER, ANALYZES DATA,
C      AND PRINTS OUT RESULTS OF DECODE.
C
C=====================================
C
       INTEGER IBUF(40),REC
       INTEGER TTY,DISK,MAXREC,IREC
       INTEGER GARBAG(18)
C
```

```
      REAL CNAME(2),GNAME(4),XNAME(6)
      REAL CHRDAT(6)
      REAL YNAME(12),SNAME(4),PNAME(4)
C
      COMMON /CHRBUF/ IBUF
      COMMON /LUN   /TTY,DISK,MAXREC,IREC
      COMMON /NAME  / XNAME,YNAME,SNAME,PNAME,CNAME,GNAME
C
      LOGICAL KEY
C
      DATA RESTIM,AREA,RRT,RF,CONC/5*0.0/
      DATA GARBAG/1B*0/,I,J,K,M,N/5*0/
      DATA KEY/.FALSE./
C
C       CHECK TO SEE IF KEY RECORD PREVIOUSLY FOUND
C
      IF(KEY) GOTO 20
C
C     SEARCH FOR KEY RECORD
C
      IF(IBUF(1).EQ.'RU'.AND.IBUF(2).EQ.'N '.AND.
     +IBUF(3).EQ.'  ') KEY=.TRUE.
      IF(NREC.EQ.REC) WRITE(TTY,180)
      GOTO 70
C
C     KEY RECORD FOUND
C
20    CONTINUE
      M=80
      DECODE(M,100,IBUF,N) RESTIM,AREA,J,RRT,RF,CONC,GARBAG
      IF(RESTIM.EQ.0.0) GOTO 30
C
C     FIND CONCENTRATIONS AND SUM
C
      IF(GARBAG(1).EQ.' H'.AND.GARBAG(2).EQ.'YD')
     + CHRDAT(1)=CHRDAT(1)+CONC
      IF(GARBAG(1).EQ.' D'.AND.GARBAG(2).EQ.'XY')
     + CHRDAT(2)=CHRDAT(2)+CONC
      IF(GARBAG(1).EQ.' N'.AND.GARBAG(2).EQ.'IT')
     + CHRDAT(3)=CHRDAT(3)+CONC
      IF(GARBAG(1).EQ.' M'.AND.GARBAG(2).EQ.'ET')
     + CHRDAT(4)=CHRDAT(4)+CONC
      IF(GARBAG(5).EQ.'MO'.AND.GARBAG(6).EQ.'NO')
     + CHRDAT(5)=CHRDAT(5)+CONC
      IF(GARBAG(5).EQ.'DI'.AND.GARBAG(6).EQ.'OX')
     + CHRDAT(6)=CHRDAT(6)+CONC
30    CONTINUE
      IF(NREC.NE.REC) GOTO 70
      KEY=.FALSE.
70    CONTINUE
      RETURN
C
100   FORMAT(F7.2,F11.4,A2,F9.3,F8.3,F12.4,18A2)
180   FORMAT('<< Key record never found ')
      END
```

LIST OF REFERENCES

1. Botsford, C. W. , Private Conversation, Dept. of Chemical Engineering, University of Arizona, 1982.

2. Glass, J. W., "Fuel Nitrogen Conversion During Fuel Rich Combustion of Pulverized Coal and Char", Ph. D. Dissertation, University of Arizona, 1981.

3. Lee, J. W. N., "Formation of NO_X in Staged Combustion of Pulverized Coal", M. S. Thesis, University of Arizona, 1979

4. Montgomery, R. L., "Real-Time Reconciliation of Coal Combustor Data", M. S. Thesis, University of Arizona, 1982.

5. Perkin-Elmer Model Sigma 1 Gas Chromatograph Manuel, Perkin-Elmer Corporation, Rev., August 1979.

6. Perkin-Elmer Sigma Series Console Instructions Manuel, Perkin-Elmer Corporation, Rev., June 1979.

7. Perkin-Elmer Sigma Programmability Option Manuel, Perkin-Elmer Corporation, Rev., February 1979.