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DESIGN AND CONSTRUCTION OF A PROTOTYPE
VAPORIZATION CALORIMETER FOR THE ASSAY
OF RADIOISOTOPIC SAMPLES

T. V. Tormey

Sandia Laboratories

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T. V. Tormey
Thermophysical Properties
Division 5842

Abstract

A prototype vaporization calorimeter has been designed and constructed for use in the assay of low power output radioisotopic samples. The prototype calorimeter design was based on that of a previous experimental instrument used by H. P. Stephens, 4538, to establish the feasibility of the vaporization calorimetry technique for this type of power measurement. The calorimeter is composed of a mechanical calorimeter assembly together with a data acquisition and control system. Detailed drawings of the calorimeter assembly are included and additional drawings are referenced. The data acquisition system is based on an HP 9825A programmable calculator. A description of the hardware is provided together with a listing of all system software programs. The operating procedure is outlined, including initial setup and operation of all related equipment. Preliminary system performance was evaluated by making a series of four measurements on two nominal 1.5W samples and on a nominal 0.75W sample. Data for these measurements indicate that the absolute accuracy (one standard deviation) is $\pm 0.0035W$ in this power range, resulting in an estimated relative one standard deviation accuracy of 0.24% at 1.5W and 0.48% at 0.75W.

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I. Introduction

Vaporization calorimetry may be used as a technique for nondestructive assay of radioisotopes which emit easily absorbed radiation (α , β). The method is based on sensing the thermal power produced by absorption of the radiation, and the quantity of radioisotope in a sample can be calculated from the measured thermal power and the known sample specific power (watts/gram).¹

The vaporization calorimeter operates by allowing the thermal power from a sample to vaporize a volatile liquid in which the sample is immersed. The rate of gas vaporization is determined by using flow and pressure measurement instruments. The data are fed into a data acquisition system for storage and processing, and used to provide output data on the average power produced by the radioisotopic sample.

Two previous reports have been written dealing with the vaporization calorimeter development program. The first report¹ discussed the principles of design for a vaporization calorimeter and the second² described the construction and testing of an experimental vaporization calorimeter. This report describes the design, construction and testing of a prototype vaporization calorimeter which resulted from the previous studies and tests performed with the experimental calorimeter. Several improvements to the experimental calorimeter have been incorporated into the prototype version. These improvements along with a complete description of the design and operating procedure will be described in this report.

II. Description

A complete diagram of the basic design layout of the calorimeter system is shown in Figure 1. The vaporization calorimeter consists of two major parts: (1) the calorimeter assembly and (2) the data acquisition and control system. These two systems are described in the following sections.

Calorimeter Assembly

The calorimeter assembly (or calorimeter stand) shown in Drawing 1 consists of the following items: A front instrument panel, a gas measuring system, an air thermostat, a calorimeter vessel, lifting mechanism and a thermostated water bath. These items will be described in the following paragraphs.

Front Instrument Panel. The front instrument panel of the assembly (shown in Drawing 1) contains all the necessary instruments, meters, controls and switches to operate the equipment associated with the calorimeter assembly.

The items shown in Drawing 1, which make up the front panel of the calorimeter stand, are described as follows. Item 1 is a switch and light panel containing a water bath stirring motor switch with an on/off light, an air thermostat circulating fan switch with an on/off light, a high temperature warning light (for water bath), a low level water warning light and reset button (for water bath), a lifting motor switch, and an on/off switch for the vessel stirring motor.

Items 2 and 6 are Hewlett-Packard platinum resistance thermometers used to measure the water thermostat and the air thermostat temperatures. These instruments provide an analog output signal to the data acquisition system for data processing.

Items 3 and 5 are for temperature controllers. Item 3 was modified to control the water bath temperature while Item 5 is a standard controller and is used to control the air thermostat temperature.

Item 4 is an automatic valve control panel used in connection with Item 17 (three automatic valves for the gas measuring system) located within the air thermostat.

Item 7 is the refrigeration circulating unit control panel. Items 8 and 9 are digital panel meters which display the atmospheric pressure and the flow unit pressure differential during the course of a run.

BLOCK DIAGRAM OF VAPORIZATION CALORIMETER
SYSTEM INCLUDING DATA AQUISION SYSTEM

Figure 1

Gas Measuring System. The gas measuring system is located on the top of the calorimeter stand and is completely enclosed by the air thermostat (Drawing 1, Item 20). The entire gas measuring system must be kept in a temperature controlled environment (approximately 40°C) to avoid temperature variation which would disturb the gas flow measurement during operation of the calorimeter.

The gas measuring system, diagramed in Figure 2, consists of four capillary flow units of different capillary sizes, four manual valves to select the proper flow unit (only one flow unit is used during a determination), one 10 torr pressure differential manometer, one 1000 torr absolute pressure manometer (MKS Instruments, Burlington, ME), three automatic valves, which are operated by the control system during a run, and 1/8 inch copper tubing gas flow lines. For a more detailed explanation of Figure 2, see Appendix F. A simplified view of the gas measuring system showing one flow unit switched into the system is shown in Figure 3.

The three automatic valves located in the gas measuring system are normally operated by the control system, however they may also be manually operated from the front panel if necessary. Three override switches are located on the auto valve control panel (Drawing 1, Item 4) and are normally in the auto position. The pilot lights above the switches indicate the position of the valves at any time during operation. Details of the auto control panel are found in Appendix G, Section B-4.

The gas measuring system operates as follows: the calorimeter vessel is immersed in the water thermostat and allowed to equilibrate. The volatile liquid used in the calorimeter is refrigerant R-11 (CCl_3F). This liquid is vaporized inside the sealed vessel (Drawing 3) either by the calibration heater/resistor or a radioisotopic sample. The R-11 gas then enters the gas measuring system through a 1/8 inch copper line at the gas inlet port (Fig. 2) and is directed

**TOP VIEW OF GAS MEASURING SYSTEM
PART I**

GAS MEASURING SYSTEM

VIEW SHOWS VALVES, FLOW UNITS, MKS METERS AND 1/8 COPPER TUBING CONNECTING THE SYSTEM.
EXPLANATION OF LAYOUT IS IN PART II OF THIS DRAWING

Figure 2

GAS MEASURING SYSTEM

Figure 3

to automatic valve-1, where the valve is either in a vented or closed position. The valve is vented during the initial purge operation to displace any trapped air which might be in the vessel and system. Once the valve is automatically closed by the control system the gas passes through a surge tank to a manual valve C. The surge tank helps to damp out any rapid pressure fluctuations which might occur in the vessel. From this point the gas is directed through a preselected flow unit. The resulting pressure differential is measured across the flow unit by the 10 torr differential manometer. The gas then flows through manual valve D to auto valve 2. During the initial purge of the system, valve 2 is closed. While the valve is closed, there is a slight positive pressure build up in the system. This will prevent air from entering the system when valve 2 is opened. After a short period of time (5 to 10 seconds), valve 2 is opened by a command from the control system and the gas is then vented to the atmosphere. Automatic valve 3 will either allow the 10 torr pressure head to measure the pressure differential across the flow unit or will establish a zero pressure differential across the head. The signals from the 10 torr differential head and 1000 torr absolute head are sent to the data acquisition system for storage and are used in the final processing of the data.

Air Thermostat. The air thermostat is a closed circulating system, consisting of a lucite housing, three circulating fans, a nichrome wire heating element, a temperature controller and a temperature sensor. The fans continuously circulate warm air (approximately 35°C) over the gas measuring system to insure that all parts of the system are at a constant temperature. A temperature controller (Sargent-Welch Thermonitor Model ST) is used to maintain a constant temperature inside the housing to within a few hundredths of a °C. A platinum resistance thermometer sensor is located inside the housing and is connected to a Hewlett-Packard 2802A (Drawing 1, Item 6) which reads out the

temperature directly and also provides an analog output signal to the data acquisition system. The air thermostat temperature is used in the final data calculation by the calculator.

Calorimeter Vessel. The primary functions of the calorimeter vessel are:

(1) to contain the radioisotopic sample in a gas tight container while it is immersed in liquid refrigerant and (2) to keep the sample and refrigerant well insulated from the remainder of the system while immersed in a thermostated water bath during a power determination. The vessel contains a stirring mechanism and a calibration and temperature measuring system located within the vessel. A section view of the calorimeter vessel showing all the major components is shown in Drawing 3. The vessel was built primarily of stainless steel with polyurethane foam (32 kg/m^3) as the insulating material. For descriptive purposes, the vessel is divided into three sections; the upper, center, and lower section. These sections will be described in the following paragraphs and the numbered items refer to items on Drawing 3.

Upper section: The upper section consists of a stirring shaft housing (3), Plates A (15) and B (14), the cover plate (17), support rods (21) between Plate A and the cover plate, the probe (6) and a gas outlet tube (18). Plates A and B are fastened together and form one unit. The probe, fabricated from stainless steel tubing, extends through Plates A and B and is secured in place by two O-ring seal fittings (4). The probe contains two thermistors. One thermistor with a nominal resistance of $100 \text{ k}\Omega$ measures the temperature of the refrigerant and the other is a $15 \text{ k}\Omega$ unit which controls the water thermostat temperature while the vessel is immersed in the water bath. The probe also contains an electrical calibration heater, ($2100 \text{ }\Omega$ resistor), which is soldered to leads extending

from the end of the probe. Fabrication details of the probe are outlined in Appendix E.

Center section: The center section assembly consists of the outer case (5), the inner container (22), the sample stand (10), the stirring bar (11), and the polyurethane foam insulating material. Three center section assemblies, with different internal container sizes, were developed for the calorimeter vessel. The three different center sections should accommodate sample sizes from 4.5 inch diameter down to .5 inch diameter or less. Any one of the three center sections may be interchanged with the upper and lower sections. The intent of having three vessels of different internal sizes, while maintaining the same external dimension, is to add versatility to the overall operation of the calorimeter. The fabrication details of the calorimeter vessel and center sections are found in Appendix H.

Lower section: The lower section consists of the stirring mechanism (2,20), insulation (12) and a coupling magnet (19). The stirring mechanism was designed to be self-contained within the vessel in order to simplify the mechanism handling. The stirring mechanism consists of a slow speed synchronous motor (300 rpm) mounted on the top plate (17), a stirring shaft (2), a set of reduction gears (20), and the coupling magnet (19) imbedded in a polyurethane cylinder which is mounted on the large reduction gear at the center. The magnet couples with the stirring bar of the inner container to create the stirring action of the R-11 (approximately 75 R.P.M.). The primary function of the stirring mechanism is to eliminate gas vaporization fluctuations due to natural convection within the vessel.

Lifting Mechanism: An overhead lifting mechanism was designed to move the vessel in and out of the water bath with relative ease, (shown in Drawing 1). The lifting mechanism consists of the cover plate, to which the vessel is

attached, four support rods bolted to the calorimeter tabletop, the top plate which is supported by the rods, a lifting motor (Drawing 1, Item 11) mounted on the top plate, the lifting cable from the motor to the cover plate, and a switch (S4) located on the front panel to operate the lifting motor. A limit switch (Drawing 1, Item 12) was placed in series with the front panel switch to limit upper travel while the vessel is raised from the water bath. The procedure for operating the lifting mechanism for loading and unloading a sample is outlined in Appendix D.

Water Thermostat. The water thermostat consists of a stainless steel baffled tank (Drawing T-35524), a modified Sargent-Welch temperature controller (Model ST, Thermonitor) (Drawing 1, Item 3), a modified Neslab refrigeration circulation unit (Model RTE-4) (the control panel is shown in Drawing 1, Item 7),* A Hewlett-Packard platinum resistance thermometer (Model 2802A) (Drawing 1, Item 2) and constant speed stirring motor (Drawing 1, Item 13). The Sargent-Welch Thermonitor controls two immersion heaters located in the water tank, and the refrigeration-circulation unit supplies constant cooling to the water through a cooling coil immersed in the water tank. The thermometer measures the temperature of the water and sends data to the control system for monitoring and processing. In this configuration, the water temperature can be controlled at or near room temperature, to within $\pm 0.005^{\circ}\text{C}$, in order to precisely maintain the temperature of the calorimeter vessel.** (The rotary switch located on the front panel of the Thermonitor must be in the auto position in order for the calculator to control the water thermostat system).

The water thermostat temperature is controlled at a temperature slightly higher (approximately 0.2°C) than that of the R-11 temperature in the calorimeter vessel. This will insure that the heat flow between the R-11 and the water will always be into the vessel containing the R-11. During the operation

*See Appendix C for instrument modifications.

**See Appendix B for initial set up procedure.

of the calorimeter, the constant temperature differential between the water and the R-11 is maintained by the control system, which monitors the R-11 temperature, by using a thermistor located in the calorimeter vessel. The control system automatically adjusts the water thermostat temperature controller to track the R-11 temperature during the course of a measurement. The R-11 temperature inside the vessel is pressure dependent, and the vessel pressure will change as the ambient pressure changes because the gas outlet is at ambient pressure.

Two safety switches are located in the water bath system. The first is a water level float switch which will turn off the temperature controller if the water level drops below a safe level to prevent the immersion heaters from burning out. A red warning light on the front panel is simultaneously turned on to indicate to the operator the water level has dropped and the temperature controller has been turned off. The second safety switch is a high temperature cutoff switch which will turn off the temperature controller if the water temperature is abnormally high (above 32°C set point). Again a red high temperature warning light on the front panel indicates an abnormal condition. Refer to the wiring diagram for details of float switch and high temperature switch, Drawing T-55475.

Data Acquisition and Control System

Hardware. A block diagram of the data acquisition system and the peripheral instruments is shown in Figure 1. The data acquisition and control system is used for real time data acquisition, on-line calculation and some aspects of experimental and equipment control. The variables monitored during the calorimeter operation are differential pressure across the flow unit, atmospheric pressure, air and water thermostat temperature and R-11 temperature inside the vessel. In addition to these variables, during an electrical calibration determination the voltage across the calibration heater and across the standard

resistor (to calculate current) are monitored. The equipment under calculator control during calorimeter operation include the water bath thermometer, the current source for the calibration heater (during calibration only) and the three automatic valves.

The data acquisition system consists of the following Hewlett-Packard instruments: A 9825A programmable calculator, a 9866B output printer, a 3490A auto ranging digital voltmeter, a signal scanner, a digital to analog converter, digital clock, and a 6186C dc constant current source. Two MKS Baratron 170-M electronic units are connected directly to the 10 torr and 1000 torr pressure heads. The peripheral measurement instruments necessary to provide the input data to the data acquisition system are the 10 and 1000 torr MKS capacitance-type manometers and the H.P. 2802A thermometers which measure the air and water thermostat temperatures. All of these instruments are rack mounted with the exception of the calculator and printer which are both table models.

A brief description of the data acquisition system sequence of operation is as follows: At precise time intervals the calculator gives a command to the voltmeter to digitize the sequentially scanned analog signals. The data, in digital form, is stored in the calculator until recalled for processing, and is periodically reduced and summarized during the experiment. At the conclusion of the experiment a final summary is printed showing the average data for each ten minute period monitored during the experiment. An example of the printout for a sample determination is shown in Appendix J, Page 73.

Software. The software programs initially written for use with the vaporization calorimeter are recorded on the 9825A calculator master tape cartridge. In all, fourteen files were created for use with the various calorimeter operations. The first twelve are user programs (which are located on track 0), while the

last two are data files (located on track 1). A brief description of the user programs (on track 0) is as follows: File 0 is a power fail program, which will signal to the operator that the power was interrupted and the calorimeter run was terminated. File 1 is an index file which will list out all the file names on the tape. The remainder of the programs on track 0 are: File 2, electrical calibration program; File 3, sample determination program; File 4, least squares fit program; File 5, sample power calculation program; File 6, initial setup and calibration of flow units; File 7, clock reset program; File 8, pressure meter adjustment program key file; File 9, open; File 10, coefficient record and print program and; File 11, program to record vessel heat capacities. Track one contains two data files which include the File 6 calibration coefficients for the flow units and vessels and File 1, the vessel heat capacity data recorded from track 0, File 11.

A brief description of each program is outlined in Appendix I and a complete listing of each program is also shown. Flow diagrams for the electrical calibration program (File 2) and the sample determination program (File 3) are shown in Figures 5 and 6 respectively.

III. Operating Procedure

Initial Setup

Details of the initial setup procedures for the calorimeter assembly and instrument rack are outlined in Appendix A. The setup procedure assumes that the stand has been completely assembled and the instruments have been calibrated and installed in the stand and instrument rack. Appendix A has two parts; the first part deals with the initial start up procedure for all the calorimeter equipment. Part two of Appendix A deals with the initial settings of all switches and instruments located in the stand and rack.

The initial temperature setting for the water thermostat is outlined in Appendix B. The procedure must be followed exactly to insure that the water temperature is slightly above that of the R-11 in the calorimeter vessel.

The four flow units used in the gas measuring system are located within the air thermostat. Any one of these four units may be used in combination with one of the calorimeter vessels (three supplied). The selection of a flow unit must be made prior to a calibration or sample measurement run. At the same time the proper calorimeter vessel must be selected. In general, the sample size will determine which vessel to use while the sample power will determine which flow unit will be used. The approximate power output of the sample should be known prior to a calibration determination since the power input will approximate that value. The flow unit and vessel are then calibrated as one unit. Next, a set of calibration curves must be generated (power vs pressure) for each combination of flow unit and vessel. This is performed by using File 6, "Initial Setup and Calibration of Flow Units." (The calibrating procedure is outlined in paragraph three of the Measurement Procedure Section.) To switch one of the flow units into the gas measuring system the four manual valves located on the top of the air thermostat housing must all be positioned in the same direction. Valve C and D (Figure 2) select the gas inlet and outlet ports while valves A and B (Figure 2) select the pressure differential ports across the flow unit. Since there are four different flow units mounted in the gas measuring system, each position of the five way valves will select a different flow unit.

Measurement Procedure

Initial Operations. The following operating procedure was adopted for each experimental determination and is outlined as follows. The calorimeter

vessel is placed on the loading stand and is filled with R-11. The distance between the R-11 and the top of the container should be approximately 2 to 3 inches. However, this could be changed depending on the test being run. The amount (in cm^3) of R-11 added to the vessel must be recorded for future use as a program input. The amount of R-11 will vary due to the inner container sizes and different sizes of samples placed in the inner container. When initially filling or adding R-11 to the container to bring it up to the proper level, a scribed mark on the inner container or a scale may be used in order to determine the proper level of R-11. After the R-11 has been added, the vessel top plate is lowered onto the center section of the vessel and fastened with six 4-20 nuts, then the vessel assembly is lowered into the water thermostat. Once the vessel is in the water bath the gas outlet tube is connected to the gas measuring system. The vessel should be left in the water bath for several minutes to allow it to equilibrate. (For details of loading the calorimeter vessel see Appendix D).

The pressure meter electronics are then adjusted (both 10 torr and 1000 torr) by following the procedures described in the File 8 Program, "Pressure Meter Adjustment Program." The File 8 Program is located on the calorimeter program tape and is initiated from the 9825A programmable calculator (see Appendix J for calculator operating procedure).

Electrical Calibration. The flow unit/vessel combination is then electronically calibrated at approximately five power settings from 0 watts to the maximum range of the flow unit ($\Delta P = 10$ torr max.) by using File 6 "Initial Setup Program to Calibrate Flow Unit/Vessel Combination." (Runs should be 80 min. long with summary printout every 10 min.) Initially the vessel and gas measuring system are purged at the start of a run, using 5 watts of power for about 20 minutes. This will purge trapped air out of the system. During the electrical calibration

program the following parameters are monitored: the air thermostat temperature (T_A), water thermostat temperature (T_W), heater current (I_H), heater voltage (E_H), barometric pressure (P_A), flow-unit differential (ΔP), and thermistor resistance (R_T). A flow diagram of the "Electrical Calibration Program" File 2 is shown in Figure 6. The data summary printout is shown in Appendix J.

The File 4, "Curve Fit Program" is used to obtain preliminary calibration coefficients of the flow unit/vessel combination. The calibration coefficients are then recorded on Track 1, File ϕ .

At this point the vessel is removed from the water thermostat and R-11 added to bring the refrigerant up to the initial level. The vessel is then returned to the water bath. The "Electrical Calibration Program," File 2, is run next using approximately 8 power settings from 0 watts to full scale of flow unit ($\Delta P = 10$ torr).¹ Once the calibrations are completed the "Curve Fit Program", File 4, is again used to obtain the final set of calibration coefficients. These data are also recorded on Track 1, File ϕ .

The calorimeter vessel is again removed from water thermostat, R-11 is added, then returned to the water bath. At this point the pressure meter electronics are rechecked by using File 8 "Pressure Meter." Adjust the meters if necessary.

An electrical calibration is performed next at a power level which is approximately equal to that of the sample. File 2 "Electrical Calibration Program" is used for this run.

Sample Determination. Following the calibration, the radioisotopic sample is loaded into the vessel as outlined in Appendix D. The sample run is then started by using File 3, "Sample Determination Program." The sample run time is 80 min. with a summary printout every 10 minutes, while the purge time is

approximately 20 minutes (total run time is 100 minutes). During the sample determination program the parameters monitored are: the air thermostat temperature (T_A), water thermostat temperature (T_W), barometric pressure (P_A), flow unit differential pressure (ΔP), and thermistor resistance (R_T). A flow diagram for the sample determination program File 3 is shown in Figure 5.

Following the sample determination another electrical calibration is performed. The bracketing of the electrical calibration about the sample determination is done initially to gain confidence in the performance of the calorimeter. However during routine analytical determination the bracketing technique may be omitted.

The sample power can now be calculated by using File 5, "Sample Power Calculation Program." The sample pressure, as determined in the "Sample Determination Program," is used as part of the input data in the "Sample Power Calculation Program." Calibration data must also be entered in the program. The sample power is then calculated and the result is printed out, along with a summary of the input data. See Appendix J for input information and a printout example of the sample power calculation.

The above operating procedure is intended as a general guide. However, once an operator becomes familiar with the calorimeter equipment the operating procedure may be changed as the need arises.

IV. Preliminary Test Results

The following test results were obtained using Vessel #2 (the intermediate sized vessel) and flow unit #2 (type T-8, Meriam Instruments Model 50 MK 10) for powers up to 1.6 watts.

Four determinations were made at 3 power levels (two nearly the same) from radiometric heat sources produced and calibrated by Mound Laboratories and

loaned to us by Ed Walter, Division 8443, Sandia Laboratories. The determinations were made using the following procedure.

1. A calibration curve was generated for flow unit #2 by making a series of electrical calibrations from 0 to 1.6 W in steps of 0.2 W. The curve consisted of a fourth order fit of flow unit differential pressure ΔP as a function of electrical power W.
2. Calorimetric determination of the radiometric samples was performed during the working day and a series of electrical calibrations of approximately the same power were made at night with the calorimeter under automatic (calculator) control. Thus, each series of sample determinations was bracketed by a series of electrical calibrations. Sample determinations and electrical calibrations had the same equilibration and data acquisition time of 90 min. An additional setup and gas purge time of about 30 min. (15 min. for sample loading and 15 min. for vessel gas purge) was required for each sample determination, for a total sample run time of 2 hours.
3. The sample powers W_s were calculated from the calibration curve slopes $d\Delta P_c/dW_c$ and the bracketing electrical calibrations (W_c) of the same power, via the equation

$$W_s = W_c + \frac{\Delta P_s - \Delta P_c}{\left(\frac{d\Delta P_c}{dW_c}\right)} \quad (1)$$

The average value of W_s determined from the two bracketing electrical calibrations was used.

Table I summarizes the experimental results for the samples measured. The two nominal 1.5 watt as received samples were labeled 1.5 WH and 1.5 WG.

The .25 watt sample was labeled 0.25 WD and the 0.5 watt sample was labeled 0.5 WD. The 0.25 and 0.5 watt samples were combined to form the 0.75 watt third sample.

The entries in Table I are the measured powers for the dates of 2/21/78 - 2/25/78, the average power $\bar{P}$ for each series of measurements, and the experimental standard deviation S for the measurements, as calculated via the relation,

$$S^2 = \frac{1}{N-1} \sum_{i=1}^N (P_i - \bar{P})^2 \quad (2)$$

where N = number of measurements. In each case, $N = 4$.

By applying the "F" test, it was found that there was no significant difference among the variances (S^2) at either the 90% or 95% confidence level. Therefore, the variances were pooled to yield a pooled standard deviation of 0.0036 W. The calculated relative pooled deviations are 0.48% (1S) or 0.96% (2S) at 0.75 W and 0.24% (1S) or 0.48% (2S) at 1.5 W. In addition to the precision calculations, the $\bar{P}$ values were compared with the decay table power values generated by Mound Laboratories. The greatest deviation was found to be -0.67% for one of the 1.5 W samples.

Table I

Vaporization Calorimeter Preliminary Test Data and Statistical Results

<u>Date/Quantity</u>	<u>P(W) (1.5 WH)</u>	<u>P(W) (1.5 WG)</u>	<u>P(W) (0.25 WD + 0.5 WD)</u>
2/21/78	1.4800	1.4890	0.7339
2/22/78	1.4844	1.4867	Line Power Failure
2/23/78	1.4739	1.4865	0.7413
2/24/78	1.4755	1.4924	0.7374
2/25/78			0.7393
$\bar{P}(W)$	1.4785	1.4887	0.7380
$S(W)$	0.0047	0.0027	0.0031
	(0.32%)	(0.18%)	(0.43%)
S-Pooled	(0.24%)	(0.24%)	(0.48%)
Difference From Mound Decayed Values, $P - P_{\text{Mound}}(W)$	-0.0101 -(0.67%)	-0.0011 -(0.074%)	-0.0026 -(0.35%)

Acknowledgement

The author wishes to acknowledge H. P. Stephens for his leadership throughout the course of this project and for his contribution of the computer program development necessary for the successful completion of the project.

V. References

1. H. P. Stephens, "Design of a Vaporization Calorimeter for Assay of Radioisotopic Samples," SAND 76-0635, Sandia Laboratories, Feb. 1977.
2. H. P. Stephens, "Construction and Testing of a Vaporization Calorimeter for Assay of Radioisotopic Samples," SAND 77-0105, Sandia Laboratories, March 1977.

Appendix A

Part 1

Procedure for Initial Startup

1. All power to calorimeter case and instrument rack must be disconnected. Make sure all plug-in strip switches are in the "OFF" position.
2. Fill the water bath to within 5 inches of top and add 15 grams of algae inhibitor to water.
3. Fill the Neslab RTE-4 refrigeration unit's circulating bath with a 50% solution of antifreeze and water (approximately 4 liters of solution). The refrigeration unit is located inside the calorimeter case at the right rear. Set RTE-4 thermoregulator to 5°C.
4. Check the setting of the temperature safety shut-off switches (DeLaval-Barksdale MTLN-RD) for the water and air thermostats. Both safety switches are located on the inside of the calorimeter case. The water thermostat switch is located at the left rear and the air thermostat switch is at the right rear. The water temperature switch should be set to 32°C and the air temperature switch to 45°C.
5. Connect the data acquisition cable between the calorimeter case and instrument rack. Note that the ends of the cable are marked "INSTRUMENT RACK" and "CALORIMETER CASE." The cable is not reversible and must be connected as marked.
6. Connect the MKS pressure measurement heads (located in the air thermostat) to their respective electronic units located in the instrument rack. The 10 torr head must be connected to the electronic unit marked 10 torr, and the 1000 torr head to the 1000 torr unit. After connecting the cables, check the BAKE/REG switch located at the rear of the electronic units. The switch must be in the "REG" position.
7. Connect the three electrical plug-in strips (located at the rear of the calorimeter case) to 115 volts, 20 amp outlets. Turn their switches to "ON" position.

8. Connect the instrument rack, Hewlett-Packard 9825A calculator, and the Hewlett-Packard 9866B printer to 115V outlets (preferably a "clean" instrument power source).
9. Connect the calculator to the data acquisition bus in the instrument rack.
10. Connect the calculator to the printer.
11. Turn calorimeter and instrument rack switches to their normal operating positions (see initial settings for instrument).

Appendix A

Part 2

Initial Settings for Instruments

I. Calorimeter Front Panel*

A. Water Bath (Item 1)

1. Stirring motor switch S1 "ON." Yellow light on.
2. Low water level warning light (red) off. (If light is on, press the reset button - switch S2.)
3. High temperature warning light off. (If light is on, press reset button on DeLaval-Barksdale MTLH-RD located at left rear of case.)

B. Air Bath (Item 1)

1. Air circulating fans switch S3 "ON." Yellow light on.
2. High temperature warning light (red) off. (If light is on, press reset button on DeLaval-Barksdale MTLH-RD located at right rear of case.)

C. Vessel Stirring Motor Switch St "OFF." (Item 1)

D. Lifting Motor Switch S4 Center Position (Item 1)

E. Hewlett-Packard Thermometer (Water Bath Temperature) (Item 2)

1. Power switch "ON."
2. Expand resolution switch "IN."

F. Sargent-Welch Thermonitor (Item 3)

1. Power switch "ON." Yellow light on.
2. Monitor light (red) will vary with control.

*The location of all instruments and switches on front panel may be found on Drawing No. 1 and are referred to by item numbers.

3. Rotary switch set to "AUTO." The small red light indicates that the bath temperature is being controlled relative to the calorimeter vessel temperature. The switch can also be turned to the "IN" and "OUT" positions. The "IN" position allows water bath temperature to be controlled from calorimeter vessel thermistor. The "OU " position allows the water bath to be controlled from the Sargent-Welch thermonitor thermistor settings.
4. Auxiliary heater "OFF".
- G. Digital Panel Meters (2 each) Switches S9 and S10 "ON" (Items 8 and 9)
- H. Auto Valve Control Panel Switch S11 "ON" (Item 4).^{*}
 1. Valve 1 set to "AUTO." White light on. Vent light on.
 2. Valve 2 set to "AUTO." White light on. Closed light on.
 3. Valve 3 set to "AUTO." White light on. "O" head light on.
- I. Neslab RTE-4 Refrigeration Circulation Panel (Item 7)
 1. Power switch "ON." Red light on.
 2. Refrigeration switch "ON." White light on.
 3. Thermoregulator set at 5°C.
- J. Hewlett-Packard Thermometer (Air Bath Temperature) (Item 6)
 1. Power switch "ON."
 2. Expand resolution switch "IN."
- K. Sargent-Welch Thermonitor (Air Bath Temperature Controller) (Item 5)
 1. Power switch "ON." Yellow light on.
 2. Monitor light (red) will vary with control.
 3. Auxiliary power "OFF."
- II. Instrument Rack (Main Power Switch to "ON")
 - A. Timing generator - not in use.
 - B. Digital to analog converter
 1. Power "ON."
 2. Black output mode switch set to 0V to 9.99V.
 - C. Digital Clock
 1. Switches set to "INTERNAL," "365 days," and "RUN."
 - D. Hewlett-Packard 3490A Multimeter
 1. Power "ON."
 2. Input set to "REAR."
 3. Guard strap to "INPUT LOW."

^{*}The valves can also be manually operated by setting the switches to the appropriate positions.

E. Scanner, Power "ON"

F. MKS Baratron 170-M Electronic Unit

1. 10 torr, power "ON." White light on.
2. Switch in "OPERATE" position.
3. 1000 torr, power "ON." White light on.
4. Switch in "OPERATE" position.

G. Hewlett-Packard DC Current Source

1. Power switch "ON." Yellow light on.
2. Voltage limit knob set to full clockwise, limit light off. If limit light is on, reset limit knob or check switch S7 for closure.
3. Range set to 100 MA.
4. Current setting dial not used.

Appendix B

Initial Adjustments for Water Bath Thermostat Temperature Setting

When initially setting up the calorimeter or when installing a new probe in the vessel, the following procedure for setting the water bath temperature must be followed.

1. Fill water tank with distilled water or with tap water and add algae inhibitor.
2. Start water bath stirring motor.
3. Let water in bath equilibrate to room temperature. Read temperature using the platinum resistance thermometer.
4. Start the RTE-4 Neslab refrigeration circulation unit.
5. Set the Sargent-Welch thermomonitor (Item 3, Drawing 1) rotary switch to the "OUT" position. Turn on thermomonitor and set temperature dials to room temperature.
6. Lower the vessel top (upper section) into the water bath so that the tip of the probe is approximately 5 to 6 inches under water. Leave in this position for approximately 10 minutes to equilibrate.
7. Set the controller rotary switch to the "IN" position. This will allow the vessel probe thermistor to act as the thermometric element.

8. Turn the fine adjust knob (10 turn potentiometer) so that the red monitor light is just dim (light will vary from off to bright). Do this several times to obtain an accurate setting.
9. Then add approximately 50 minor divisions of the fine adjust knob to the setting found in Step 6 (each minor division is equal to $.005^{\circ}\text{C}$). The increased temperature setting of the water bath will be slightly higher than that of the refrigerant in the vessel. This creates a slight heat leak into the vessel thereby stabilizing the direction of heat flow.
10. Switch back to auto position. This will allow the control system to regulate bath temperature.

Appendix C

Instrument Modifications

- I. Modifications to Sargent-Welch Model ST Thermonitor temperature controller for water bath thermostat (#3, Drawing 1) are listed below.

The purpose of the modification is to allow the controller system to automatically adjust the temperature of the water when a change in the temperature of the Refrigerant R-11 is noted. Thus the water bath temperature and the R-11 temperature will be maintained at a constant ΔT .

Note: The temperature of the R-11 will change when an atmospheric pressure change occurs.

A. Modifications include:

1. Mounting a rotary switch (single section open, nonshorting contacts, three-pole, Sandia #626-064) on front panel.
2. Mounting indicating light next to switch on front panel.
3. Mounting relay internally (Hi-G Inc., 2 WBC-2717, con't 2A, 42 VDC, 12,000 ohm).
4. Mounting connector on rear panel (Amphenol #80-PC2F).
5. Mounting a 44K ohm and a 6.4 ohm resistor and associated internal wiring.

B. All modifications can be found on:

1. Drawing No. WD-T55475 (general wiring diagram).
2. CK-T55374 (modification diagram), Drawing 4.

II. Modifications to Neslab RTE-4 refrigeration circulation unit.

A. The following modifications were made to the Neslab RTE-4:

1. The control box was removed from the original location on top of the unit and relocated on the front instrument panel of the calorimeter so the operator would have access to the controls of the unit.
2. A connecting block was mounted on top of the unit to connect all the necessary wires to the control box. Drawing WD-T53468 shows all wiring connections (Drawing 5).
3. The mounting plate for the thermoregulator, stirring motor, quartz heater and coolant tubes was rotated 180°. This was done to position the coolant inlet-outlet tubes toward the water bath. A lip on the plate was machined off to give it a flat surface when rotated.
4. One-quarter inch copper tubing lines were connected to the inlet-outlet connection of the RTE-4 and then to the water bath. Located inside the water bath is the cooling coil. The cooling fluid, which is a 50/50 mixture of antifreeze-water, is cooled in the refrigeration unit and then circulated to the water bath through the cooling coil and back to the refrigeration unit. The temperature of the cooling fluid is kept at 5°C by setting the thermoregulator to that temperature. The RTE-4 is located inside the calorimeter stand at the right rear and the control panel is located at the upper right on the front instrument panel of the calorimeter stand (Item 7, Drawing 1).

III. Modification of Hewlett-Packard thermometer Mod. 2802A with a 34740 display

- A. The input connector was changed from the front panel to the rear of the instrument.
- B. An aluminum cover plate was made to place over the front opening after the connector was removed.

IV. Modification for mounting of Sargent-Welch temperature controllers:

Mount left and right hand (Item 4, T-35523C) brackets to sides of instrument by match drilling holes for #10 clearance sheet metal screws. Align tapered side of bracket flush, to match instrument. Mount to front panel by match drilling brackets into front panel and fasten with #10 sheet metal screws.

Appendix D

I. Procedure for Loading Calorimeter for Power Measurement

1. Raise calorimeter cover plate assembly¹ to its maximum height using lifting motor (Switch S4).
2. Place temporary water bath cover plate in position.
3. Close Lucite air thermostat door.
4. Position calorimeter vessel stand in place.
5. Place calorimeter vessel on stand so that it is approximately lined up with top plate assembly (Plates A and B) of the calorimeter vessel.
6. Place magnetic stirring bar at bottom of vessel.
7. Place sample stand in vessel, turn stirring shaft by hand to insure magnet will turn freely.
8. Place sample on stand in vessel.
9. Fill vessel with proper amount of R-11. Note volume of R-11 added.
10. Lower top plate of vessel into position, making sure the top plate and vessel are aligned properly.
11. Bolt top plate and vessel together using six 1/4-20 SS nuts. Tighten, using 1/4 inch ratchet and socket, so that the plates fit snugly together.
12. Raise vessel to maximum height, open the Lucite door and remove temporary water bath cover.
13. Lower vessel into water bath.
14. Connect the 1/8 inch copper outlet tube to gas measuring system.
15. Close Lucite air thermostat door.
16. Start vessel stirring motor (Switch S5).
17. Load appropriate data acquisition program (either for sample determination or electrical calibration).

¹Ref. Drawing No. 49399, or Drawing 1, Assembly consists of: (a) cover plate, (b) Plates A and B, (c) support rods.

18. Vessel is now ready for gas purge and sample determination (or electrical calibration).

The procedure for an electrical calibration is the same as for a sample determination, with the exception that Step 8 is omitted.

II. Periodic Maintenance

The following items require periodic maintenance to insure that the calorimeter is performing properly.

1. The level of fluid in the RTE-4 refrigeration reservoir should be checked on a bi-weekly basis. A solution of 50/50 water-alcohol should be added when necessary.
2. The water level in the water thermostat should be checked weekly. Add tap water if necessary. An algae inhibitor is used in the water tank to prevent any corrosive buildups and to maintain the clarity of the water. Add the inhibitor when necessary.
3. Periodic Calibration of Instruments

The following instruments require periodic calibration to maintain the accuracy of the calorimeter: 1) the 10 torr differential pressure head, 2) the 1000 torr absolute pressure head, 3) the water thermostat thermometer, 4) the air thermostat thermometer, 5) the auto-ranging DVM (Hewlett-Packard 3490A), 6) the 100Ω standard resistor (Leeds & Northrup) and 7) the flow units. The calibration correction value of some of these instruments are used in the computer programs. The following describes the instrument used, the program in which the correction value is used and the line where the value is inserted.

The air thermostat temperature correction value for the air thermometer.

- 1) The "Calorimeter Electrical Calibration Program," line 155.
- 2) "Sample Determination Program," line 143.
- 3) "Initial Setup and Calibration of Flow Units, line 106.

The water thermostat temperature correction value for the water thermometer.

- 1) The "Calorimeter Electrical Calibration Program," line 156.
- 2) "Sample Determination Program," line 145.
- 3) "Initial Setup and Calibration of Flow Units," line 108.

The 1000 torr absolute pressure head correction value for the atmospheric pressure.

- 1) The "Calorimeter Electrical Calibration Program," line 158.
- 2) "Sample Determination Program," line 147.
- 3) "Initial Setup and Calibration of Flow Units," line 110.

The 10 torr differential pressure head correction value for the measurement across the flow units.

- 1) The "Calorimeter Electrical Calibration Program," line 159.
- 2) "Sample Determination Program," line 148.
- 3) "Initial Setup and Calibration of Flow Units," line 111.

Note: The various calibration techniques used to calibrate the different instruments are not presented in this report. However, some information may be found in the manufactures literature concerning the calibration of this equipment.

Appendix E.

Fabrication of Probe

The purpose of the probe is to provide a water tight and gas tight feed-through into the inner container of the calorimeter vessel. The probe, as shown in drawing 3, item 6, contains two thermistors (one a 15 K ohm and the other a 100 K ohm) and a plug in for the calibration/purge resistor (2100 ohm). The two thermistors measure the temperature of the R-11 directly and the resistor is used for purging the vessel and calibrating the system.

The probe is fabricated from 1/4 inch O.D. by .010 wall stainless steel tubing and the length is determined by the sample size and shape. The following steps should be followed to make up a complete probe.

- 1) Make up of thermistors
 - a) cut thermistor leads 1/4 to 1/2 inch long
 - b) spot weld leads to #28 wire (check wire for proper length)
 - c) use shrink tubing to insulate bare wires as shown in diagram 1A, page 33
- 2) Fabricate plug for mounting calibration heater resistor
 - a) fabricate molding fixture from teflon as shown in diagram 2A, page 35
 - b) place two pins (Everett/Charles, Pomona California, Part #SPR-1W) in fixture as shown in diagram 2B, page 35, and fill the cavity with either "Torr-Seal" (Varian Products) or "Hysol" (The Dexter Corp.) epoxy
 - c) let cure and remove from mold

Thermistor Makeup Diagram

DIAGRAM 1A

LOW END OF PROBE

DIAGRAM 1B

Diagram 2A

Teflon Molding Fixture

Diagram 2B

Enlarged View Of SPR-1W Pins
and Epoxy Assembly

- 3) Position the thermistor in lower end of probe so that the 15 K ohm is about 1/2 inch from the end and the 100 K ohm is about 1 1/4 inch from the end. Feed the resistor lead wires through the tube and fill lower end of probe with epoxy (Torr-Seal or Hysol) and position plug in place. See diagram 1B, page 34.
- 4) Pot wire leads at upper end with 5-min. epoxy. Let the epoxy flow one inch or more down the tube. This will secure the wires in place.
- 5) Position and solder resistor in place after probe has been inserted through top of vessel.

Appendix F

Gas Measuring System and Air Thermostat

Top View of Gas Measuring System (Reference to Figure 2)

The four flow units (labeled L.F.U.) are shown in position in Figure 2. The T-5, T-6 and T-8 units are Merian laminar flow units (LFU) (Merian Instruments, Cleveland, Ohio), and the .025 flow unit was fabricated by using precision glass bore tubing inserted into a housing similar to that of a Merian unit.

Valves A and B are 5-way Whitey ball valves (Whitey Co., Part No. SS-43ZF2) and valves C and D are 5-way Hoke valves (Hoke Inc., Part No. 7831G4Y). Automatic valves 1 and 2 are Hoke 3-way ball valves (Part No. 716SF4B) which are actuated by an electrically operated motor (Hoke, Part No. 0121A2C). Automatic valve 3 is a 4-way Whitey valve (Part No. SS-43YF2) also operated by a Hoke electric motor (Part No. 0121A2C). See wiring diagram (Sandia Dwg. No. WD-T55475) for details of electric motor connections.

The surge tank, which is located between valves 1 and C, is a brass cylinder (1/8 in. wall by 3.5 in. O.D. by 5.5 in. high), with the gas inlet port located at the top and the gas outlet port at the bottom. The purpose of the surge tank is to damp out gas pressure fluctuation which occurs in the calorimeter vessel. All copper tubing shown in Figure 2 is 1/8 O.D. tubing.

Air Thermostat

The air thermostat is made up of the following items:

- 1) Lucite Cover Box, Sandia Dwg. No. T-35522A and T-35522B,
- 2) Three Circulating Fans, Parmotor Mod. 8506 (3 each),
- 3) Wire Heater and Supports.

Details of Wire Heater

The wire heater is located in the upper section of the Lucite cover box between Items 17 and 23 (in dwg. 1). The heater is made of four heater supports, (see Fig. F-1), page 38, one attached to each side of the box and two equally spaced in between. Number 28 Nichrome is laced through the holes in the support to form the heating element. The center line of the support holes is set at 30° to provide a large heated area for the air to pass through. The supports were made of 1/8 in. phenolic, with ceramic liners pressed into the holes to insulate the heater wire from the phenolic.

Appendix G

Fabrication of Calorimeter Stand

- A. The following Sandia drawings are used in the fabrication of the calorimeter stand.

1. Drawing No. T-35523A	Stand
2. Drawing No. T-35523B	Front panel detail
3. Drawing No. T-35523C	Instrument mounting hardware for front panel
4. Drawing No. T-35525	Top plate for stand

The following Sandia drawings show assembled details of calorimeter stand and instrument locations

5. Drawing No. T-35523D or Drawing #1	Front view of calorimeter stand
6. Drawing No. T-35523E	Top view of calorimeter stand
7. Drawing No. T-35523F	Switch and light panel

- B. Information for mounting hardware and equipment into calorimeter stand and purpose of each.

1. Mount three each plug-in strips at rear of stand. Attach to underside of upper channel support. Plug-in strips should have an on/off switch, an indicating light and a fuse.
2. Instruments (2) and (6) drawing T-35523D are mounted in place with the rack mounting kit supplied with the instrument (H.P. Part No. HP11457A). Number 10 clearance holes are match drilled in stand frame to secure rack mounting kit. The rack mounting kit must align with cutout for instrument. All necessary information pertaining to the instrument may be found in the operating and service manual for the Model 2802A thermometer system (H.P. Part No. 02802-90003).

Fig F-1

HEATER WIRE SUPPORT

3. Instruments (3) and (5) Drawing No. 1 are Sargent-Welch thermonitors. The panel mounting procedure is as follows: mount Item (5) Drawing T-35523C thermonitor stand support to back side of front panel by positioning stand support so as to be flush with bottom of cutout and centered. Match drill clearance holes for a #10-32 screw from support into front panel. Slide thermonitor into cutout and match drill bracket holes into front panel for #10 sheet metal screws. Details of instrument may be found in the instruction manual for Sargent thermonitor-Model ST.
4. Auto valve control panel, Item (4) Drawing No. 1. The auto valve control panel assembly is made up of parts (1), (2), and (3) Drawing T-35523C. To mount to the front instrument panel, first assemble the three parts and position over cutout. Mark the mounting holes from bracket and drill and tap four places for 10-32 screws. Disassemble and mount brackets and bottom plate in place. Mount nine indicating lights (Eldema, E-Lite ER-B-N117, Neon-100K) in place. Locate three white lights at auto position and the remaining six lights are amber. Then mount three rotary switches (single section open, nonshorting contacts, three pole, Sandia number 626-064) onto panel. Mount three relays (Sigma Instruments, Inc., 4F-10,000-SIL) and one power supply (Acodian Model D15-05) on a phenolic board 1/8 in. thick, locate in back of the panel and fasten to stand frame. Mount the phenolic board at a convenient location during assembly. All wiring for lights and switches is shown in wiring diagram WD-T55475.
5. Mount Neslab RTE-4, Item (7) Drawing T-35523D switch and light panel to back side of front panel. Position RTE-4 panel in center of cutout and transfer mounting holes to front panel. Drill clearance holes for No. 10 screw four places in front panel for mounting.
6. Three LFE digital panel meters (0-20V), Item (8), (9), (10) on Drawing T-35523D are mounted to front panel by screw clamps supplied with the instruments. Remove the front window for access to screws. Meters (8) and (9) are wired into the system and are used to display pressure reading when operating, while meter (10) is used as a spare. However, the spare could be used in the system if needed. All necessary information for meter operation, adjustments and wiring may be found in LFE Corporation Instruction Manual (Part No. 955-163 Rev. A).
7. The switch and light panel for the water bath, air bath, stirring motors and lifting motor is shown as Item 1 Drawing T-35523D. The details of

the panel are shown in Drawing T-35523F and wiring information is shown in Drawing WD T-55475.

The panel is attached to the stand frame by transferring the four mounting holes in the panel to the frame, drill and tap for #10 screw in frame and mount panel. The water bath stirring motor switch (S1) is a SPDT full-sized, positive action, sealed toggle switch. The pilot light to the left of Switch S1 will indicate if the switch is "ON" or "OFF."

The low level warning light for the water bath will indicate if the water level has fallen below a preset level. A Delaval-Gems float level switch (item 15) was used to preset the lower limit of the water level. If the warning light is turned on by the switch, the thermomonitor for the water bath will also be turned off. Add water to bath and push reset switch (S2) to restart water bath thermostat. Switch S2 is a push-type switch, SPDT Honeywell IPB11.

If the high temperature warning light for the water bath is on, the water temperature has exceeded a preset safe operating temperature. The thermomonitor will be shut down and the water bath temperature should drop. Check system for possible causes of overheating. To reset water bath system, push reset button on Delaval-Barksdale MTIH-RD box located at left rear of stand.

The air bath air circulating fans switch (S3) is a DPDT, sealed toggle switch which operates the three fans inside the lucite cover box. The pilot light to the left will indicate if the fans are "ON" or "OFF." The high temperature warning light for the air bath will be on if the temperature in the air bath thermostat exceeds the preset temperature setting of the Delaval-Barksdale MTIH-RD temperature switch. The temperature controller will also be turned off by the same switch. To restart the air thermostat, push the reset button on the MTIH-RD box located at the left rear of the calorimeter stand. The system should be checked for possible causes of the overheating.

The lifting motor switch (S4) is a four-pole Mom. ON-OFF-Mom. ON, sealed toggle switch. The use of this type of switch should reduce the possibility of damage to either the motor or vessel. An upper travel limit

switch (S8) Item (8) Drawing T-35523D was placed in series with the lifting switch to avoid any over travel in the upward direction. The vessel stirring motor switch (S5) is a SPDT sealed toggle switch which operates the stirring motor which in turn drives the stirring mechanism in the calorimeter vessel. The switch must be in the "ON" position during a calorimeter run.

Appendix H

Fabrication Information for Calorimeter Vessel for Center Sections

The following information describes the fabrication procedure for the entire calorimeter vessel, Assembly No. 1, and center section, Assemblies No. 2 and No. 3. The Sandia drawing numbers and the number of parts needed for each assembly are listed in Table A, page 42.

A. Fabrication instructions for Assembly No. 1

1. Weld bottom plate to cylinder, Drawing T-50106
2. Weld cylinder to Place C, Drawing T-49399
3. Pressure check at this point with 15 psig using He gas and He leak detector
4. Weld outer case (T-50108) to Plate C (T-49399)
5. Align center lines of Plates C and D, then weld Plate D in place
6. Pour polyurethane foam (2 lb/ft^3) into assembly and cure
7. Machine polyurethane insulation to clear spur gear and magnet holder. Drill 0.281 dia. hole for shaft (T-49399) from Plate C.
8. Assemble remaining as shown using stainless steel screws.

B. Fabrication Instructions for Assembly No. 2

1. Weld bottom plate to lower cylinder No. 1: 3.313 O.D. (T-50112)
2. Weld lower cylinder No. 1 to connecting Ring A (T-50111)
3. Weld connecting Ring A to top cylinder Ring No. 1 (T-50111)
4. Weld top cylinder ring No. 1 to Plate C (T-50113)
5. Pressure check at this point with 15 psig using He gas and He leak detector
6. Weld outer case (T-50108) to Place C (T-50113)
7. Align center lines of Plates C and D, then weld Plate D (T-50102) to outer case (T-50113)
8. Pour polyurethane foam (2 lb/ft^3) into assembly and let cure
9. Machine polyurethane foam insulation to clear spur gear and magnet holder. Drill 0.281 hole for stirring shaft (T-50113) from Plate C.

Table A

Table A.

Drawing No.	Assembly No. 1		Assembly No. 2		Assembly No. 3	
T-49399		1 EA				
T-50100	Plate E	1 EA				
	Plate F	1 EA				
T-50101	Plate A	1 EA				
	Plate B	1 EA				
	Part 1A	2 EA				
	Part 2A	2 EA				
T-50102	Plate C	1 EA	Plate C	1 EA	Plate C	1 EA
	Plate D	1 EA	Plate D	1 EA	Plate D	1 EA
	Studs	8 EA				
T-50103	Support spacer	4 EA				
	Insulator	1 EA				
	Rubber gasket	1 EA				
	(Rubber gasket spares)	8 EA				
T-50104	Spur gear	1 EA				
	Magnet holder	1 EA				
	Bushing	1 EA				
T-50106	Freon container straight wall	1 EA				
T-50107	Cover plate	1 EA				
T-50108	Outer case	1 EA	Outer case	1 EA	Outer case	1 EA
T-50109	Gasket	1 EA				
	(Gasket spare)	4 EA				
	Drive shaft	1 EA				
T-50111			Connecting ring A	1 EA	Connecting ring B	1 EA
			Top cylinder ring 1	1 EA	Top cylinder ring 2	1 EA
T-50112			Lower cylinder 1	1 EA	Lower cylinder 2	1 EA
T-50113			Center section view		Center section view	

C. Fabrication Instruction for Assembly No. 3

1. Weld bottom plate to lower cylinder No. 2, 2.125 O.D. (T-50112)
2. Weld lower cylinder No. 2 to connecting Ring B (T-50111)
3. Weld connecting Ring B to top cylinder Ring No. 2 (T-50111)
4. Weld top cylinder Ring No. 2 to Plate C (T-50113)
5. Pressure check at 15 psig with He gas and He leak detector.

Appendix I

Software Listings

Software Description

The 9825A calculator tape cartridge for the calorimeter contains the programs and data files necessary to operate the calorimeter. The following is a brief description of the files on the calorimeter tape. Tape track ϕ contains program files and track 1 contains data files.

Track ϕ

File ϕ - POWER FAIL PROGRAM. Upon return of electrical power (after a power failure) this program resets calorimeter valves, initializes instruments, and sounds an alarm to alert the operator.

File 1 - TAPE FILE AND PROGRAM INDEX. This file contains a program which prints an index for the tape and allows the operator to select and run a program. Execute ldpl to run this program.

File 2 - CALORIMETER ELECTRICAL CALIBRATION PROGRAM. This program operates the calorimeter and takes data for electrical calibrations.

File 3 - SAMPLE DETERMINATION PROGRAM. This program is similar to the File 2 electrical calibration program, except that it operates the calorimeter and takes data for a sample power or calibrated heat source.

File 4 - LEAST SQUARES POLYNOMIAL FIT. A program used to perform a least squares polynomial fit of ΔP versus power for a series of calibrations. The program yields a calibration curve for a particular vessel and flow unit.

File 5 - SAMPLE POWER CALCULATION PROGRAM. This program is used to calculate the power of a sample from calibration and sample determination data.

File 6 - INITIAL SETUP AND CALIBRATION OF FLOW UNITS. A program similar to the File 2 electrical calibration program, which is used to initially calibrate the flow units and vessels.

File 7 - CLOCK RESET PROGRAM. This program is used to set the correct date and time into the digital clock.

File 8 - PRESSURE METER ADJUSTMENT PROGRAM. This program is used to zero the 10 torr MKS pressure meter and to set the null and full scale voltage on both the 10 and 1000 torr electronics units.

File 9 - KEY FILE. This is a special function key file (f ϕ) which is used in the File 8 program.

File 10 - COEFFICIENT RECORD AND PRINT PROGRAM. This program allows the calibration curve coefficients (generated by the File 4 program) to be examined or changed.

File 11 - PROGRAM TO RECORD VESSEL HEAT CAPACITIES. This program is used to record the heat capacities of the various calorimeter vessels. The heat capacities are used in the electrical calibration and sample determination programs to make corrections for atmospheric pressure drift.

Track 1

File ϕ - This is a data file which contains the calibration coefficients for the flow units and vessels. Data may be recorded into this file from the calibration curve fit program (Track ϕ , File 4) or the coefficient record and print program (Track ϕ , File 10).

File 1 - This data file contains the vessel heat capacity data recorded from the Track ϕ , File 11 program.

Track ϕ - File ϕ

```
0: "***** FILE #0 *****":  
1: "***** POWER FAIL PROGRAM--12/00/77 *****":  
2: dsp "beep",709,"c1k",716,"dod1",728,"door",729  
3: mnt "beep",0,1,ert "door",H0,ert "dod1",0,00  
4: bnd 0,ert "Power failure,"isnd 1,ert "Press reset to"  
5: bnd 1,ert alert,"Reset clock with","clock program,"isnd 2  
6: dsp "POWER FAILURE--CHECK PRINTER+++"#beep#wait 050#dsp ""#beep#wait 050  
7: jmp -1  
8: end  
+6924
```

Track 4 - File 1

```

0: "*****FILE # 1 *****":
1: "***** TAPE FILE AND PROGRAM INDEX. 1/3/78. *****":
2: trk 0
3: prt "*****INDEX*****" ;sec 2 ;prt "TRACK 0:" ;"PROGRAM FILES." ;sec
4: prt " 0: Power"," failure.," " 1: Index."
5: prt " 2: Electrical"," calibration.," " 3: Sample"," determin-"
6: prt " ation.," " 4: Calibration"," curve fit"," routine."
7: prt " 5: Calculation"," of sample"," power."
8: prt " 6: Initial"," setup and"," calibration."
9: prt " 7: Clock"," reset.," " 8: Pressure"," meter"," adjustment."
10: prt " 9: Key file.," "10: Routine to"," record"," calibration"
11: prt " coefficients"
12: prt "11: Routine to"," record"," vessel heat"
13: prt " capacities."
14: sec 4 ;prt "TRACK1:" ;"DATA FILES." ;sec
15: prt " 0: Calibration"," coefficients"
16: prt " 1: Vessel heat"," capacities."
17: sec 1 ;prt "*****" ;sec 4
18: prt "To run program"," type file no.," "then press the"
19: prt "CONTINUE key." ;sec 1 ;prt "Otherwise press"," the STOP key." ;sec 4
20: prt "Type number or press STOP key.," A
21: ldk A
22: end
*8997

```

Track 6 - File 2

```

0: ***** FILE 2 *****:
1: ***** CALORIMETER ELECTRICAL CALIBRATION PROGRAM 2/17/78 *****:
2: trl 0
3: dcl W05.4,4,0,C040
4: dsp "scan",F09,"clk",F16,"pace",F20,"dow",F22,"daci",F28,"daci",F29
5: wrt "scan",C01wrt "daci",A01wrt "daci",A00
6: llo F16d 2:0+Y1trk 1:1df 0,W05.41df 1,C011trk 0
7: wrt 1:Fz2.0,"E",z1fwt 2:"R",fz1.0,"F0M3T1E",z1fwt 3:Fz2.2
8: fwt 4:"R",fz1.0,"F1M3T1E",z
9: dsp "START VESSEL STIRRING MOTOR"iste
10: dsp "HOW MANY CALIBRATIONS ?"ient ""A
11: dsp "ENTER CALIBRATION TIME (MIN) ?"ient ""r0
12: dsp "ENTER DATA UPDATE TIME (MIN) ?"ient ""r1
13: ent(r1*60/12)+C01int(r0*60/12C)+B
14: if B)=4:sto 21
15: dsp "***** ERFOR *****"iwait 1000
16: dsp "READ ERROR MESSAGE ON PRINTER"iwait 3000wrt 5
17: wrt 6:"THE NUMBER OF DATA BLOCKS MUST BE GREATER OR EQUAL TO 4."
18: wrt 6:"INCREASE THE TOTAL RUN TIME OR DECREASE THE DATA UPDATE TIME"
19: wrt 6:"TO COMPENSATE FOR THIS ERROR. PLEASE ENTER THE TIMES AGAIN"
20: wrt 9:6:1wrt 6.9:sto 11
21: dcl A01C01,C04,15,0,C03,15,0,C02,30,AC011,B0B,8,PC01
22: ent "ENTER VOLUME OF REFRIG-11 (CC)",V
23: ent "ENTER VESSEL NUMBER.",N
24: wrt "clk",C011
25: "COOLING 000 SECONDS"+E011:"WAITING 000 SECONDS"+E012
26: for P=1 to A
27: for Q:0:asp "ENTER POWER FOR CALIB. #",P:ient "",PEP
28: next P
29: wrt "scan","10"
30: if not(PC+1)=0:"YES"+A:sto +4
31: wrt 6:"Want to select a flow unit?",Type 'yes',"or 'no',"i:sto 0
32: ent "WANT TO SELECT A FLOW UNIT",A#
33: if not(A#)="NO"i:sto 38
34: if not(A#)="YES"ient "TYPE IN FLOW UNIT NUMBER",U:sto +2
35: dsp "BAD ENTRY,TRY AGAIN"iwait 2000:sto 31
36: for Q:0:asp "SET VALVES TO FLOW UNIT #",U:iste
37: sto 44
38: add(PC+1)+r0
39: if r0>1.6:isdsp "SELECT FLOW UNIT #1":1+U:sto +4
40: if r0>.85:isdsp "SELECT FLOW UNIT #2":2+U:sto +3
41: if r0>.14:isdsp "SELECT FLOW UNIT #3":3+U:sto +2
42: dsp "SELECT FLOW UNIT #4":4+U
43: sto
44: sto "A-out"
45: "W05.4"
46: ent "DO YOU WANT TO PURGE (YES OR NO)",A#
47: if not(A#)="NO"i:sto 63
48: if not(A#)="YES"i:sto "scan","12"iwait 5000:sto +2
49: dsp "TRY AGAIN"iwait 2000:sto -3
50: 100:0data(4,4)+r0ir0+corea*-598.6+P:wrw "scan","C,10"
*833

```


Track 6 - File 2

```

51: wrt "dac1.3",10r(20/21.5)
52: 100'data*(1.5)+r0;r0+'corta'(r0,17.92)+273.15+r1
53: 250.37+P*(4.4611e-2-2.304e-5+P)+r2
54: fnd 2;dsp "CALORIMETER HEATING:",char(8),"T=",r2-r1
55: if r1-r2;15+M;0;S;sto +2
56: sto 53
57: fnd 3;dsp "PURGE TIME LEFT",M,"MIN",S,"SEC"
58: if M=0;if S=0;wrt "dac1","0.00";sto 63
59: if M=5;if S=0;wrt "scan","11,12,E";wrt "dac1.3",10r(max(P1+1)-21.5)
60: 'data*(1.5)+r0
61: if S=0;N-1+M;59+S;sto +4
62: S-1+S;sto -5
63: wrt "scan","11,12,13,E"
64: for L=1 to 20
65: 'data*(5.4)+r0
66: fnd 2;dsp "NUMBER",L," ",char(8),"PRESSURE",r0
67: if r0;5;cll 'delay'(60,0,1);sto -3
68: next L
69: cll 'delay'(0,60,0)
70: for N=1 to A
71: rad "clk",0#[4]
72: cll 'check';if r0 0;sto "cool"
73: if r0 0;cll 'heating'(0,r0,P[N];N);cll 'check';jnp 0
74: wrt "dac1.3",10r(P[N]/21.5)
75: cll 'check';if r0+r1>10.5;cll 'delay'(0,10,0);jnp 0
76: sto "start"
77: "cool":wrt "dac1","0.00"
78: if r0;1.5;cll 'delay'(300,0,1);cll 'delay'(60,30,0);cll 'check';sto -1
79: if r0;1;cll 'delay'(60,0,1);cll 'delay'(60,30,0);cll 'check';sto "cool"
80: if r0;1;cll 'delay'(30,20,0);cll 'check';sto "cool"
81: "start":
82: rad "clk",0#[13]
83: wrt "dac1.3",10r(P[N]/21.5)
84: for Y=1 to B
85: for I=1 to 11;0+AC1]
86: next I
87: rad "clk",0#[11],F
88: for Z=1 to C
89: 100'data*(0.5)+r0;r0+'corta'(r0,17.91)+r0;r0+273.15+T;r0+AC1]+AC1]
90: sto +1;if r0<40;if r0>30;sto +2
91: wrt 9.5/25x,"AIR TEMPERATURE IS",f6.2,2/;wrt 6.9,r0;sto "ABORT"
92: dsp "AIR TEMPERATURE",r0
93: 100'data*(1.5)+r0;r0+'corta'(r0,17.92)+r0;r0+AC2]+AC2]
94: sto +1;if r0<28;if r0>20;sto +2
95: wrt 9.5/25x,"WATER TEMPERATURE IS",f6.2,2/;wrt 6.9,r0;sto "ABORT"
96: dsp "WATER TEMPERATURE",r0
97: 'data*(2.4)/100+r0;dsp "CURRENT&VOLTAGE BEING CONVERTED"
98: -'data*(3.3)+r0+r0;r0+AC3]+AC3];r0+2+AC6]+AC6]
99: sto +1;if r0<P[X]+.1;if r0>P[X]-.1;sto +2
100: wrt 9.5/25x,"POWER IS",f6.2,2/;wrt 6.9,r0;sto "ABORT"
*21353

```

Track 6 - File 2

```

101: 000 "POWER" "WATTS",r0
102: 100 "data"(4,4)+r0/r0+"corra"+r0/r0+P/r0+AC41+AC41
103: 000 "ATM PRESSURE",r0
104: for L=1 to 6
105: "data"(5,4)+r0/"contin"+r0,T,P+r0/r0+AC51+AC51+r0+r0+AC71+AC71
106: "a0"=-111/r0/1111/r0+-.11/r0+.2
107: 000 "FLOW UNIT PRESSURE IS",+7.3,2 "unit 6.9/r0/r0 "REPORT"
108: 000 "FLOW UNIT PRESSURE",r0
109: next L
110: 1000 "data"(6,3)+r0/r0+AC81+AC81+AC91+144+D+2+AC91/122+AC101+AC101
111: 122+r0+AC111+AC111;dsp "THERMISTOR R ="r0
112: next L
113: 000 "C11"+C101
114: 000 "C12"+C102
115: 000 "C13"+C103
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555: 000 "C453"+C543
556: 000 "C454"+C544
557: 000 "C455"+C545
558: 000 "C456"+C546
559: 000 "C457"+C547
560: 000 "C458"+C548
561: 000 "C459"+C549
562: 000 "C460"+C550
563: 000 "C461"+C551
564: 000 "C462"+C552
565: 000 "C463"+C553
566: 000 "C464"+C554
567: 000 "C465"+C555
568: 000 "C466"+C556
569: 000 "C467"+C557
570: 000 "C468"+C558
571: 000 "C469"+C559
572: 000 "C470"+C560
573: 000 "C471"+C561
574: 000 "C472"+C562
575: 000 "C473"+C563
576: 000 "C474"+C564
577: 000 "C475"+C565
578: 000 "C476"+C566
579: 000 "C477"+C567
580: 000 "C478"+C568
581: 000 "C479"+C569
582: 000 "C480"+C570
583: 000 "C481"+C571
584: 000 "C482"+C572
585: 000 "C483"+C573
586: 000 "C484"+C574
587: 000 "C485"+C575
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591: 000 "C489"+C579
592: 000 "C490"+C580
593: 000 "C491"+C581
594: 000 "C492"+C582
595: 000 "C493"+C583
596: 000 "C494"+C584
597: 000 "C495"+C585
598: 000 "C496"+C586
599: 000 "C497"+C587
600: 000 "C498"+C588
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608: 000 "C506"+C596
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614: 000 "C512"+C602
615: 000 "C513"+C603
616: 000 "C514"+C604
617: 000 "C515"+C605
618: 000 "C516"+C606
619: 000 "C517"+C607
620: 000 "C518"+C608
621: 000 "C519"+C609
622: 000 "C520"+C610
623: 000 "C521"+C611
624: 000 "C522"+C612
625: 000 "C523"+C613
626: 000 "C524"+C614
627: 000 "C525"+C615
628: 000 "C526"+C616
629: 000 "C527"+C617
630: 000 "C528"+C618
631: 000 "C529"+C619
632: 000 "C530"+C620
633: 000 "C531"+C621
634: 000 "C532"+C622
635: 000 "C533"+C623
636: 000 "C534"+C624
637: 000 "C535"+C625
638: 000 "C536"+C626
639: 000 "C537"+C627
640: 000 "C538"+C628
641: 000 "C539"+C629
642: 000 "C540"+C630
643: 000 "C541"+C631
644: 000 "C542"+C632
645: 000 "C543"+C633
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669: 000 "C567"+C657
670: 000 "C568"+C658
671: 000 "C569"+C659
672: 000 "C570"+C660
673: 000 "C571"+C661
674: 000 "C572"+C662
675: 000 "C573"+C663
676: 000 "C574"+C664
677: 000 "C575"+C665
678: 000 "C576"+C666
679: 000 "C577"+C667
680: 000 "C578"+C668
681: 000 "C579"+C669
682: 000 "C580"+C670
683: 000 "C581"+C671
684: 000 "C582"+C672
685: 000 "C583"+C673
686: 000 "C584"+C674
687: 000 "C585"+C675
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700: 000 "C598"+C688
701: 000 "C599"+C689
702: 000 "C600"+C690
703: 000 "C601"+C691
704: 000 "C602"+C692
705: 000 "C603"+C693
706: 000 "C604"+C694
707: 000 "C605"+C695
708: 000 "C606"+C696
709: 000 "C607"+C697
710: 000 "C608"+C698
711: 000 "C609"+C699
712: 000 "C610"+C700
713: 000 "C611"+C701
714: 000 "C612"+C702
715: 000 "C613"+C703
716: 000 "C614"+C704
717: 000 "C615"+C705
718: 000 "C616"+C706
719: 000 "C617"+C707
720: 000 "C618"+C708
721: 000 "C619"+C709
722: 000 "C620"+C710
723: 000 "C621"+C711
724: 000 "C622"+C712
725: 000 "C623"+C713
726: 000 "C624"+C714
727: 000 "C625"+C715
728: 000 "C626"+C716
729: 000 "C627"+C717
730: 000 "C628"+C718
731: 000 "C629"+C719
732: 000 "C630"+C720
733: 000 "C631"+C721
734: 000 "C632"+C722
735: 000 "C633"+C723
736: 000 "C634"+C724
737: 000 "C635"+C725
738: 000 "C636"+C726
739: 000 "C637"+C727
740: 000 "C638"+C728
741: 000 "C639"+C729
742: 000 "C640"+C730
743: 000 "C641"+C731
744: 000 "C642"+C732
745: 000 "C643"+C733
746: 000 "C644"+C734
747: 000 "C645"+C735
748: 000 "C6
```

Track 6 - File 2

```

151:  mov char(8),"P MERS. ",char(8),"P CRC. ",r2
152:  r2 = L
153:  r0 = r0!ret
154:  mov r0,"p1-p2+p3
155:  r1 = 1.2564e-2+p3+(-8.1983e-5+p3+(-9.7634e-5+2.1503e-5+p3))*p4!ret r4
156:  mov r0,"p1-p2+p3
157:  r1 = 1.2549e-2+p3+(-3.6403e-3+p3+(-3.6755e-5+2.4764e-5+p3))*p4!ret r4
158:  mov r0,"1-1.34-p1!ret r1
159:  mov r0,"p1-p1-3.19e-4+1.098e-3+p1+p4
160:  r0 = 5e4+p5
161:  r4 = 1.88922+2.5064*(p2/p5+(-36906)))+p6
162:  r0 = 598.6+p7!p6+1.013+p7+(-9.8375e-5+p7+4.34e-8))*p6
163:  r0 = 190.37+p7+4.46185e-2+2.30401e-5+p7)+p8
164:  p0!p4+p62!p2+(-3.1419e-3+p7+5.10613e-6)*p6!ret p6
165:  data:
166:  org "G1:G1if F=6!jmp 0
167:  G:F
168:  org "scan.1",p1
169:  (r2 = 6!org "dwn.4",p2!ato +2
170:  org "dwn.2",p2
171:  org "dwn",p3!ret p3
172:  "TIME":org 6,"DATE ",C#(1,3,4)," ",C#(1,5,6),"-(1978"if Y=0!ret
173:  ato +2!if Y=8!ato +1
174:  org 6,"CAL STARTING TIME--- ",C#(4,7,8)," ",C#(4,9,10)," ",C#(4,11,12)
175:  org 6,"DATA STARTING TIME--- ",C#(1,7,8)," ",C#(1,9,10)," ",C#(1,11,12)
176:  org 6,"DATA STOPPING TIME--- ",C#(2,7,8)," ",C#(2,9,10)," ",C#(2,11,12)
177:  ret
178:  "heating":p02
179:  if p1=1!4+p7!ato +4
180:  if p1=2!1+p7!ato +3
181:  if p1=3!1+p7!ato +2
182:  if p1=4!1+p7
183:  if p2=-3.542-p5!ato +3
184:  if p2=-1!1+p5!ato +2
185:  if p2=-.21,5+p5
186:  r4 = 3e5+p7!p6
187:  org "dwn.3",10*(p6+(p3+.05)/21.5)
188:  dsp "HEATING",p6,"TIMES POWER"!wait 1000
189:  ret
190:  "del":if p1=0!ato 200
191:  if p2=1!org "scan","C,10,12,13,E"!ato +2
192:  org "scan","C,10,11,13,E"
193:  for L=p1 to 0 by -1
194:  str(L)+E#(1,8,11)
195:  dsp E#(1)
196:  wait 1070
197:  next L
198:  org "scan","11,13,E"
199:  if p2=0!ret
200:  for L=p2 to 0 by -1
+29625

```

Track 4 - File 2

```

203:   let L:=E4C2+111
204:   let E4C3
205:   let L:=1000
206:   let L
207:   let
208:   report:use "+PROGAM ABOFT-CHECK PRINTER+"
209:   let "Tuncit"=10.00/2art "2can"=10
210:   let 2."THE CALIBRATION RUN WAS ABORTED. THE NAME PARAMETER WAS EXCEEDED"
211:   let 2."AND THE VALUE SHOWN IS RESPONSIBLE FOR THE FAILURE."
212:   let 2."PUSH RESET TO STOP ALERT AND RESET THE PROGRAM."1art 2.5 1art 6.9
213:   1art1art 1001art 0
214:   let 2art 2art 9.4.12+ "CALIBRATION SUMMARY"2 1art 6.91art "TIME"
215:   let 2+ "FLOW UNIT #"+2.0+ " CHOSEN"2 1art 6.91art 0
216:   let 2+ "VESSEL #"+2.0+ " USED"2 1art 6.91art 0
217:   let 2+ "NUMBER OF CALIBRATIONS CHOSEN WERE"+2.0+ 1art 6.91art
218:   let 2art 2art 0
219:   let 2+ "PQUER FOR CALIBRATION #"+2.0+ " IS"+2.0+ " WATTS"
220:   let 6.9+PCCPJ1art 2
221:   let 2+ "NUMBER OF DATA SUMMARIES CHOSEN WERE"+2.0+ 1art 6.91art
222:   let 2+ "NUMBER OF POINTS CHOSEN WERE"+4.0+ 1art 6.91art
223:   let 2+ "CALCULATED DATA UPDATE TIME "+5.2+ "MINUTES"2
224:   let 6.91art 0
225:   let 2+ "TIME REQUIRED FOR EACH CALIBRATION IS "+5.2+ "MINUTES"2
226:   let 6.91art 0
227:   let 2+ "TIME REQUIRED FOR COMPLETE RUN IS "+7.2+ "MINUTES"2
228:   let 6.91art 0
229:   1art1art
230:   let 2+ "RUN"+2.0+2 "OF"+2.0+10+ "EL001"+2.0+2 " OF"+2.0+
231:   let 6.91art 2art 0
232:   1art "TIME"
233:   let 2+6.2
234:   let 6.9+ "AVERAGE AIR TEMPERATURE-----" "+BCV+71
235:   let 6.9+ "AVERAGE WATER TEMPERATURE-----" "+BCV+80
236:   let 2+8.5+ "+"2art 6.91art
237:   let 6.9+ "AVERAGE POWER(WATTS)-----" "+BCV+216L+03
238:   let 2+8.3
239:   let 6.9+ "AVERAGE ATMOSPHERE PRESSURE(TOPR)---" "+BCV+61
240:   let 2+6.3+ "+"2art 6.91art
241:   let 6.9+ "AVERAGE LFU PRESSURE(TOPR)-----" "+BCV+41+BCV+53
242:   let 2+8.21art 6.9+ "AVERAGE THERMISTOR RESISTANCE-----" "+AC010
243:   let 2+19.31art 6.9+ "AT/01"2art 6.91art
244:   let 2+ "PRESSURE VARIATION CORRECTION-----" "+610.3+ 1art 6.91art
245:   let
246:   1art "0-out"1
247:   let 2+6.123+ "VAPORIZATION CALORIMETER RECORD"2 1art 6.9
248:   let 2+ "CALIBRATION #"+2.0+2 " OF A SERIES OF"+2.0+ 1art 6.91art 0
249:   let 2+ "FLOW UNIT #"+2.0+ 1art 6.91art
250:   let 2+ "VESSEL #"+2.0+ 1art 6.91art
251:   1art 0

```

Track 6 - File 2

```

251: fnt 9,"POWER (WATTS)",f9.5,3x,"+-",e10.3,/iurt 6.9,AC11/4,AC51
252: fnt 9,"PRESSURE (TORR)",f8.3,3x,"+-",e10.3,/iurt 6.9,AC31/4,AC51
253: fnt 9,2/,x,"ELAPSED",10x,"POWER",12x,"CORR. LFU",z,iurt 6.9
254: fnt 9,6x,"BAROM.",6x,"AIR",6x,"WATER",iurt 6.9
255: fnt 9,"TIME(MIN)",8x,"(WATTS)",9x,"PRESSURE(TORR)",z,iurt 6.9
256: fnt 9,2x,"PRESSURE",3x,"TEMP(C)",3x,"TEMP(C)",/iurt 6.9
257: fnt 9,x,f6.2,3x,f8.5,"/",e9.3,3x,f6.3,"/",e9.3,3x,f6.2,5x,f5.2,5x,i5.2
258: for I=1 to 8
259: wrt 6.9,B[I,1],B[I,2],B[I,3],B[I,4],B[I,5],B[I,6],B[I,7],B[I,8]
260: next I
261: fnt 9,6/,iurt 6.9
262: ret
*28443

```

Track 0 - File 3

```

0: "***** FILE 3 *****":
1: "***** SAMPLE DETERMINATION PROGRAM 2/18/77 *****":
2: r0=0
3: dsp "C5+4+J+C4J"
4: dsp "scan",789,"clk",715,"pnce",729,"dwn",732,"daci",738,"docr",739
5: wrt "scan",0"iwr "docr",0"iwr "daci",0,00"
6: l10 715:ld 310:"i;trk 1;ldf 0,W[0];ldf 1,C[0];trk 0
7: wrt 1:"z1,0,"E",zifst 2,"R",fz1,0,"F0M3T1E",zifst 3,fz4,2
8: wrt 4:"R",fz1,0,"F1M3T1E",z
9: dsp "START VESSEL STIRRING MOTOR":sto
10: dsp "SC0700:dsp "TYPE SAMPLE DESIGNATION,"i;ent "",s#
11: sto "HOW MANY DETERMINATIONS?"i;ent "",A
12: dsp "ENTER DETERMINATION TIME (MIN) ?"i;ent "",r0
13: dsp "ENTER DATA UPDATE TIME (MIN) ?"i;ent "",r1
14: r0=r0+60/120+C;i;ent(r0+60/120)+B
15: r1=r1+41+r0/22
16: dsp "***** ERROR *****":wait 1000
17: dsp "READ ERROR MESSAGE ON PRINTER":wait 3000;wrt 6
18: wrt 6:"THE NUMBER OF DATA BLOCKS MUST BE GREATER OR EQUAL TO 4."
19: wrt 6:"INCREASE THE TOTAL RUN TIME OR DECREASE THE DATA UPDATE TIME"
20: wrt 6:"TO COMPENSATE FOR THIS ERROR. PLEASE ENTER THE TIMES AGAIN"
21: r0=r0+6;i;wrt 6.9;sto 12
22: dsp "H#163,C#[4,15],D#[2,15],E#[2,30],A[11],B[8,8]
23: ent "ENTER VOLUME OF REFRIG-11 (CC)",V
24: wrt "ENTER SAMPLE WEIGHT (g)",D;439D+E
25: ent "ENTER VESSEL NUMBER",N
26: rcd "clk",C#[11]
27: "COOLING 000 SECONDS"+E#[11];"WAITING 000 SECONDS"+E#[21]
28: dsp "ENTER APPROX. SAMPLE POWER (W)"i;ent "",W
29: wrt "scan",10"
30: wrt "Want to select?","a flow unit?","Type 'yes',"or 'no'.";sdc 3
31: ent "WANT TO SELECT A FLOW UNIT?",A#
32: if cdc(A#)="NO"i;sto 37
33: if cdc(A#)="YES"i;ent "TYPE IN FLOW UNIT NUMBER",U;i;sto +2
34: dsp "BAD ENTRY,TRY AGAIN":wait 2000;sto 30
35: rcd 0;dsp "SET VALVES TO FLOW UNIT #",U;i;sto
36: sto 43
37: W=r0
38: if r0>1.6;dsp "SELECT FLOW UNIT #1";1+U;i;sto +4
39: if r0>.85;dsp "SELECT FLOW UNIT #2";2+U;i;sto +3
40: if r0>.14;dsp "SELECT FLOW UNIT #3";3+U;i;sto +2
41: dsp "SELECT FLOW UNIT #4";4+U
42: sto
43: rcd "A-out"
44: "XXX"+A#
45: wrt "DO YOU WANT TO PURGE (YES OR NO)",A#
46: if cdc(A#)="NO"i;sto 62
47: if cdc(A#)="YES"i;wrt "scan",12"i;wait 5000;sto +2
48: dsp "TRY AGAIN":wait 2000;sto -3
49: 100"data/(4,4)+r0;r0+corpa"-598.6+P;i;wrt "scan",0,10"
50: wrt "daci,3",10r((20-W)/21.5)
+21624

```

```

51: 100'data'(1.5)+r0;r0+'contw'(r0,17.92)+273.15+r1
52: 350,37+P*(4.4611e-2+2.304e-5*P)+r2
53: fwt 2;dsp "CALORIMETER HEATING:",char(8),"T= ",r2-r1
54: if r1>r2;15*N;0+S;eto +2
55: eto 51
56: rwd 0;dsp "PURGE TIME LEFT",M,"MIN",S,"SEC"
57: if M=0;if S=0;wrt "dac1","0.00";eto 62
58: if M=5;if S=0;wrt "scan","11;12,E";wrt "dac1","0.00"
59: 'data'(1.5)+r0
60: if S=0;M-1+M;59+S;eto -4
61: S-1+S;eto -5
62: wrt "scan","11;12;13,E"
63: for L=1 to 20
64: 'data'(5.4)+r0
65: rwd 3;dsp "NUMBER",L," ",char(8),"PRESSURE",r0
66: if r0>10.5;cll 'delay'(60,0,1);eto -3
67: next L
68: cll 'delay'(0,60,0)
69: for X=1 to A
70: rwd "clk",C#[4]
71: cll 'check';if r0>0;eto "cool"
72: if r0<0;cll 'heating'(U,r0,W,N);cll 'check';jwp 0
73: wrt "dac1","0.00"
74: cll 'check';if r0+r1>10.5;cll 'delay'(0,10,0);jwp 0
75: eto "start"
76: "cool";wrt "dac1","0.00"
77: if r0>1.5;cll 'delay'(300,0,1);cll 'delay'(60,30,0);cll 'check';eto -1
78: if r0<1;cll 'delay'(60,0,1);cll 'delay'(60,30,0);cll 'check';eto "cool"
79: if r0>.1;cll 'delay'(30,20,0);cll 'check';eto "cool"
80: "start":
81: rwd "clk",C#[3]
82: for Y=1 to B
83: for I=1 to 11;0+AC[I]
84: next I
85: rwd "clk",C#[1],F
86: for Z=1 to C
87: 100'data'(0.5)+r0;r0+'conta'(r0,17.91)+r0;r0+273.15+T;r0+AC[I]+AC[I]
88: eto +1;if r0<40;if r0>30;eto +2
89: fwt 9.5/25x,"AIR TEMPERATURE IS",f6.2,2/;wrt 6.9,r0;eto "ABORT"
90: dsp "AIR TEMPERATURE",r0
91: 100'data'(1.5)+r0;r0+'contw'(r0,17.92)+r0;r0+AC[2]+AC[2]
92: eto +1;if r0<20;if r0>20;eto +2
93: fwt 9.5/25x,"WATER TEMPERATURE IS",f6.2,2/;wrt 6.9,r0;eto "ABORT"
94: dsp "WATER TEMPERATURE",r0
95: 100'data'(4.4)+r0;r0+'corra'+r0;r0+P;r0+AC[4]+AC[4]
96: dsp "ATM PRESSURE",r0
97: for L=1 to 8
98: 'data'(5.4)+r0;'corlfu'(r0,T,P)+r0;r0+AC[5]+AC[5];r0+r0+AC[7]+AC[7]
99: eto +1;if r0<11;if r0>-.1;eto +2
100: fwt 9.5/22x,"FLOW UNIT PRESSURE IS",f7.3,2/;wrt 6.9,r0;eto "ABORT"
+27503

```

Track 0 - File 3

```

101: dsp "FLOW UNIT PRESSURE",r0
102: r1=-1
103: 1000'data'(6,3)+r0;r0+AC(8)+AC(9)+144+2+2+AC(9);122+AC(10)+AC(10)
104: 122+r0+AC(11)+AC(11);dsp "THERMISTOR R =",r0
105: next 2
106: r0="C1K",C#[2]
107: val1=C#[3,11,12]+val1/C#[2,9,10]+60+val1/C#[3,7,8]+3600+r1
108: val1=C#[3,11,12]+val1/C#[3,9,10]+60+val1/C#[3,7,8]+3600+r0
109: r1=r0/r1+r1+86400+r1
110: C1=r0/60+BCY,1]
111: r0=r0-AC+AC(7)-AC(5)+2)/r0-(80-1)/r0)+BCY,5]
112: r01=C+BCY,7];AC(2)/C+BCY,8];AC(4)/C+BCY,9];AC(5)/80+BCY,4]
113: AC(3)/N]+N*(2WC(3,U)+N*(3WC(4,U)+N*(4WC(5,U,N)))>+r3
114: BCY,8]+273.1+r2
115: -AC(8)+AC(10)/C-AC(11))/C+AC(10)+AC(10)/C-AC(9))+r1
116: BCY,6]+BCY,4]+598.6+P
117: r1=N+120/(1.49*(182.59+P+(-1.629e-2+7.816e-6+P)))>+V
118: r2=r2/(3632+AC(8)/C)*r1+r4;(1.29V+C[N]+E)*r3+r4+r5;r5=BCY,2]
119: r5+BCY,4]+BCY,4];r4+BCY,3]
120: r0="S-out"
121: next Y
122: r0=AC(1)-AC(2)+AC(3)+AC(4)
123: for I=B-3 to B;AC(3)+BCI,4]+AC(3);AC(4)+BCI,4]+2+AC(4)
124: next I
125: r0=(4+AC(4)-AC(3)+2)/12)+AC(6)
126: r0="C-out"
127: next X
128: wrt "dcd1",10.00";wrt "scan","C"
129: dsp "SAMPLE DETERMINATION COMPLETED."
130: for I=1 to 10;beep;wait 750
131: next I
132: end
133: "check":
134: WC(1,U)+N]+N*(WC(2,U)+N*(WC(3,U)+N*(WC(4,U)+N*(4WC(5,U,N)))>+r1
135: r0+r0;rd 4
136: 100'data'(8,5)+r4;r4+'corla'(r4,17.91)+273.15+T
137: 100'data'(4,4)+r4;r4+'corpa'+P
138: for L=1 to 5
139: r0'data'(5,4)+r3;'corifu'(r3,T,P)-r1+r2;r2+r0+r0
140: dsp char(8),"P MEAS. -","char(8),"P CALC. =",r2
141: next L
142: r0/5+r0;ret
143: "corla"i p1-p2+p3
144: 4.3564e-2+p3*(-8.1983e-5+p3*(-9.7634e-5+2.1503e-5+p3))+p4;ret p4
145: "corlu"i p1-p2+p3
146: 5.12549e-2+p3*(-3.6403e-3+p3*(-3.6755e-5+2.4764e-5+p3))+p4;ret p4
147: "corp1"i-1.34+p1;ret p1
148: "corifu"i p1-3.19e-4+1.098e-3*p1+p4
149: p3+.5p4+p5
150: p4/(.38922+2.5064*(p2/p5-.36906))+p6
+12>?E

```


Track 6 - File 3

```

151: p3=p4-598.6+p7;p6*(1.013+p7*(-9.0375e-5+p7*4.34e-8))+p5
152: 290.37+p7*(4.46105e-2-2.30401e-5*p7)-p8
153: p5+p4*(p8,p2)*(3.1415e-3+p7*5.10613e-6)+p6;ret p5
154: "data":
155: read clik";Gif F=6;jmp 0
156: G=F
157: wrt "scan.1",p1
158: if p1=8;wrt "don.4",p2;sto +2
159: wrt "don.2",p2
160: read "don",p3;ret p3
161: "TIME":wrt 6,"DATE ",C#[1,3,4], "-",C#[1,5,6], "-1978";if Y=0;ret
162: sto +2;if Y>B;sto +1
163: wrt 6,"CAL STARTING TIME---- ",C#[4,7,8], ":",C#[4,9,10], ":",C#[4,11,12]
164: wrt 6,"DATA STARTING TIME--- ",C#[1,7,8], ":",C#[1,9,10], ":",C#[1,11,12]
165: wrt 6,"DATA STOPPING TIME--- ",C#[2,7,8], ":",C#[2,9,10], ":",C#[2,11,12]
166: ret
167: "heating":ifd 2
168: if p1=1;4+p7;sto +4
169: if p1=2;1+p7;sto +3
170: if p1=3;1+p7;sto +2
171: if p1=4;1+p7
172: if p2<-2.5;2+p5;sto +3
173: if p2<-1;1+p5;sto +2
174: if p2<-2;5+p5
175: p4=5*p5+p7+1+p6
176: wrt "daci.3",10*(p6*(p3+.05)-p3)/21.5)
177: dsp "HEATING",p6,"TIMES POWER";wait 1000
178: ret
179: "delay":if p1=0;sto 189
180: if p3=1;wrt "scan","0,10,12,13,E";sto +2
181: wrt "scan","C,10,11,12,E"
182: for L=p1 to 0 by -1
183: str(L)+E#[1,8,11]
184: dsp E#[1]
185: wait 1070
186: next L
187: wrt "scan","11,13,E"
188: if p2=0;ret
189: for L=p2 to 0 by -1
190: str(L)+E#[2,8,11]
191: dsp E#[2]
192: wait 1070
193: next L
194: ret
195: "ABORT":dsp "**PROGRAM ABORT-CHECK PRINTER**"
196: wrt "daci","0.00";wrt "scan","C"
197: wrt 6,"THE CALIBRATION RUN WAS ABORTED. THE ABOVE PARAMETER WAS EXCEEDED"
198: wrt 6,"AND THE VALUE SHOWN IS RESPONSIBLE FOR THE FAILURE."
199: wrt 6,"PUSH RESET TO STOP ALERT AND RESET THE PROGRAM.";ifnt 9,5;wrt 6,9
200: beep;wait 100;jmp 0
*32457

```

Track 4 - File 3

```

101: "A-out":f1nt 9.4x22x:"SAMPLE DETERMINATION SUMMARY":2:f1nt 6.9:f1sb "TIME"
102: f1nt 9.4:f1nt 6.9:f1nt 6.9
103: f1nt 9.4:"FLOW UNIT #":f2.0x:" CHOSEN":f1nt 6.9:U
104: f1nt 9.4:"VESSEL #":f2.0x:" USED":f1nt 6.9:H
105: f1nt 9.4:"NUMBER OF DETERMINATIONS CHOSEN WERE":f3.0:f1nt 6.9:A
106: f1nt 9.4:"NUMBER OF DATA SUMMARIES CHOSEN WERE":f3.0:f1nt 6.9:B
107: f1nt 9.4:"NUMBER OF POINTS CHOSEN WERE":f4.0:f1nt 6.9:C
108: f1nt 9.4:"CALCULATED DATA UPDATE TIME":f5.2x:"MINUTES":f
109: f1nt 6.9.2C
110: f1nt 9.4:"TIME REQUIRED FOR EACH DETERMINATION IS":f7.2x:"MINUTES":f
111: f1nt 6.9.2BC
112: f1nt 9.4:"TIME REQUIRED FOR COMPLETE RUN IS":f7.2x:"MINUTES":f4
113: f1nt 6.9.2ABC
114: f1nt
115: "B-out":
116: f1nt 9.4:"RUN":f3.0.2x:"OF":f3.0.10x:"BLOCK":f3.0.2x:"OF":f3.0.4
117: f1nt 6.9.2.A.Y.B
118: f1sb "TIME"
119: f1nt 9.4:6.2
120: f1nt 6.9:"AVERAGE AIR TEMPERATURE-----":f6.Y:7]
121: f1nt 6.9:"AVERAGE WATER TEMPERATURE-----":f6.Y:8]
122: f1nt 9.4:8.3
123: f1nt 6.9:"AVERAGE ATMOSPHERE PRESSURE(TORR)--":f6.Y:6]
124: f1nt 9.4:6.3:"+-":f6.9.3
125: f1nt 6.9:"AVERAGE LFU PRESSURE(TORR)-----":f6.Y:4]:f6.Y:5]
126: f1nt 9.4:9.2:f1nt 6.9:"AVERAGE THERMISTOR RESISTANCE-----":f6:1 C
127: f1nt 9.4:10.3:f1nt 6.9:"dT/dt-----":f4
128: f1nt 9.4:"PRESSURE VARIATION CORRECTION-----":f10.3x:f1nt 6.9:r5
129: f1nt
130: "C-out":
131: f1nt 9.4x22x:"VAPORIZATION CALORIMETER RECORD":2:f1nt 6.9:f1nt 6.9
132: f1nt 9.4:"DETERMINATION #":f3.0.2x:"OF A SERIES OF":f3.0:f1nt 6.9.2x:A
133: C:f131+C:f111:f1sb "TIME"
134: f1nt 9.4:"FLOW UNIT #":f2.0x:f1nt 6.9:U
135: f1nt 9.4:"VESSEL #":f2.0x:f1nt 6.9:H
136: f1nt 9.4:"PRESSURE (TORR)":f8.3.3x:"+-":f10.3x:f1nt 6.9:AC3]:f4:AC6]
137: f1nt 9.4:2x:"ELAPSED":f12x:"DRIFT":f6x:"CORR. LFU":f1nt 6.9
138: f1nt 9.4x:"BAROM.":f6x:"AIR":f6x:"WATER":f1nt 6.9
139: f1nt 9.4:"TIME(MIN)":f3x:"dT/dt":f4x:"CORR.":f4x:"PRESSURE(TORR)":f1nt 6.9
140: f1nt 9.4x:"PRESSURE":f3x:"TEMP(C)":f3x:"TEMP(C)":f1nt 6.9
141: f1nt 9.4x:6.2x:10.3x:f6.3x:f6.3x:"/":f9.3x4x:f6.2x5x:f5.2x:f5.2
142: f1nt 1 to 8
143: f1nt 6.9:6C1:1]:6C1:3]:6C1:2]:6C1:4]:6C1:5]:6C1:6]:6C1:7]:6C1:8]
144: f1nt 1
145: f1nt 9.4:f1nt 6.9
146: f1nt
147: -7872

```

Track 4 - File 4

```

0: "****- FILE #4 *****":
1: "LEAST SQUARES POLYNOMIAL FIT--12/16/77":
2: "MAXIMUM ORDER = 9.  MAXIMUM NUMBER OF POINTS = 100.":
3: tsk 0
4: dim WC(100),PC(100),QC(9,9),RC(9),SC(150),TC(150),A$(3),C(5,4,4)
5: "again":
6: spc 5:ert "Least squares","polynomial fit","for calibration","data."
7: spc 1:ert "Maximum order = 4 and maximum # of points = 100."
8: spc 1:ert "Type order (0 = stop) and number of points,"isc 4
9: ent "ORDER:(0=STOP)",0;if 0=0:ato "stop"
10: ent " # POINTS =",N
11: "Is the order less?":
12: min(9,N)+D
13: if 0<D:ato "data"
14: ert "Order must be less than",E:spc 1:ert "Try again."isc 1
15: ato "again"
16: "data":
17: ert "Want new data set? Type 'yes' or 'no'."isc 3
18: ent "'yes' or 'no'? ",A$:if cap(A$)="NO":ato "start"
19: spc 1:ert "Type value of","power (watts) and delta P for each point."
20: spc 3
21: fxd 0:for J=1 to N
22: dsp "FOR N=",J,"; ENTER WATTS :":ent "",WC[J]
23: dsp "FOR H=",J,"; ENTER",char(8),"P:":ent "",PC[J]
24: next J
25: "start":
26: i=0+0
27: for i=1 to 9
28: 0=RC[i]
29: for J=1 to 9
30: 0=QC[i,J]
31: next J
32: next i
33: for K=1 to N
34: i=0
35: for i=1 to 9
36: RC[i]+PC[K]+0=RC[i]:i+=V
37: for J=1 to 9
38: QC[i,J]+0=V+QC[i,J]:V=WK[K]+V
39: next J
40: 0=WK[K]+0
41: next i
42: next K
43: cli 'SMILE'(0,F,9):if F#0:ato "solution"
44: "no solution":
45: dsp "NO SOLUTION"isc 3:ert "No solution"isc 3
46: 0+0:ato "again"
47: "solution":
48: 0+E
49: for K=1 to N
50: P[K]=POLCB'(WK[K],0)+Y+E*Y+E
*2751

```

Track 4 - File 4

```

51: next K
52: "coefficients":
53: spc 3:ert "Check line":printer for":coefficients."ispc 3
54: fnt 9.5/:"COEFFICIENTS:"//ert 6.9
55: for I=1 to 0
56: 1-1:ifnt 9:"N1",f1.0," ***** "e14.7:ert 6.9,J,RD11
57: next I
58: fnt 9.4:"RMS ERROR = "e14.7:ert 6.9,r(E/(N-1)):"XXX"+A$:fnt 9.2/
59: ert 6.9:ert "Want data tabu- lation? Type 'yes' or 'no'."ispc 3
60: spc "yes" or "no"?":A$:if cap(A#)="NO":eto "record"
61: spc 3:ert "Check line":ert "printer for":ert "tabulation."ispc 3
62: fnt 9.2/:" X Y YCALC YCBS-YCALC dy/dx",/
63: ert 6.9
64: for I=1 to N
65: 'POLCB'(WC11,0)+C:fnt 9,e11.4,x,e11.4,x,e11.4,x,e11.4,x,e11.4
66: ert 6.9,WC11,PC11,C,PC11-C,'PRIME'(WC11,0)
67: next I
68: fnt 9.3/:" X Y dy/dx",/
69: ert 6.9:fnt 9.5X,e11.4,x,e11.4,x,e11.4
70: no:(WC11)+W
71: for I=0 to W by W/50
72: ert 6.9,1,'POLCB',1,0,'PRIME'(1,0)
73: next I
74: fnt 9.6/ert 6.9
75: "record":
76: "XXX"+A$
77: ert "Want to record":these coeff-,"ients on the","calorimeter data"
78: ert 'file. Type","yes' or 'no'."ispc 3:ert "Type 'yes' or 'no'."A$
79: if cap(A#)="YES":cll 'COPY':cll 'INPUT':cll 'RECORD':eto +2
80: if cap(A#)#"NO":cll 'ERROR':eto -4
81: eto "adin"
82: "ator":dsp "STOP"
83: end
84: "POLCB":
85: p1=p4:R11=p3
86: for J=2 to p2
87: p3+R[J]*p4+p3
88: p1+p4-p4
89: next J
90: ret p3
91: "PRIME":
92: p1=p4:R11=p3:if 0<3:ret p3
93: for J=3 to p2
94: p3+(J-1)*R[J]*p4+p3
95: p1+p4-p4
96: next J
97: ret p3
98: "SMILE":
99: "equis elimination with full pivotine":
100: 1-p2:p1-1-p5
+32247

```

Track 4 - File 4

```

101: for L=1 to p5
102: L+1+p6:0+p7
103: for I=L to p1
104: for J=L to p1
105: if p7>abs(Q[I,J]):to "one"
106: abs(Q[I,J])>p7:I+p8:J+p9
107: "one":
108: next J
109: next I
110: if p7#0:to "two"
111: "back":
112: 0+p2:ret
113: "two":
114: if p8=L:to "three"
115: for J=L to p1
116: Q[L,J]+p10:Q[p8,J]+Q[L,J]:p10+Q[p8,J]
117: next J
118: R[L]+p10:R[p8]+R[L]:p10+R[p8]
119: "three":
120: if p9=L:to "four"
121: for I=L to p1
122: Q[I,L]+p10:Q[I,p9]+Q[I,L]:p10+Q[I,p9]
123: next I
124: "four":
125: Q[L,L]+p11:p9-L+Q[L,L]
126: for J=p6 to p1
127: Q[L,J]/p11+Q[L,J]
128: next J
129: R[L]/p11+R[L]
130: for I=p6 to p1
131: for J=p6 to p1
132: Q[I,J]-Q[I,L]*Q[L,J]+Q[I,J]
133: next J
134: next I
135: for I=p6 to p1
136: R[I]-Q[I,L]*R[L]+R[I]
137: next I
138: next L
139: if Q[p1,p1]=0:to "back"
140: R[p1]/Q[p1,p1]+R[p1]
141: for K=1 to p5
142: p1-K+I:I+1+p12:R[I]+p7
143: for J=p12 to p1
144: p7-Q[I,J]*R[J]+p7
145: next J
146: Q[I,I]+J:J+I+J:R[J]+R[I]:p7+R[J]
147: next K
148: ret
149: "COPY":trk 1:ldf 0,C[*]:trk 0:ret
150: "RECORD":
*200:15

```

Track 4 - File 4

```

151: prt "Slide tab on","tape to the","RECORD position.,";"Press CONTINUE"
152: prt "when ready to","record.";isp 3
153: dsp "Press CONTINUE when ready.";istp
154: trk 1;ref 0;C1#1;trk 0
155: prt "Slide tab on","tape to the","PROTECT pos-","ition. Press"
156: prt "CONTINUE when","ready.";isp 3
157: dsp "Press CONTINUE when ready.";istp
158: ret
159: "INPUT":ent "Type flow unit number.,";A;if A>4;c11 'ERROR';jmp 0
160: ent "Type vessel number.,";B;if B>4;c11 'ERROR';jmp 0
161: for I=1 to 5
162: A+C11;A,B1
163: next I
164: for I=1 to 0
165: R11+C11;A,B1
166: next I
167: ret
168: "ERROR":
169: for I=1 to 5
170: dsp "INPUT ERROR. TRY AGAIN!!";beep;wait 750;dsp "";wait 250
171: next I
172: ret
*20632

```

Track 4 - File 5

```

0: "***** FILE #5 *****":
1: "***** SAMPLE POWER CALCULATION PROGRAM. 1/20/78. *****":
2: trk 0:dim A$(3),D$(16),C(5,4,4),S$(16),L(10),Q(10),R(5),T(10)
3: "START":isc 3
4: prt "To calculate","sample power","type the number","for one of the"
5: prt "following oper-","tions and","press the","CONTINUE key,"isc
6: prt "0: Stop program.", "1: Calculate", " power from", " calibration"
7: prt " curve only.", "2: Calculate", " power from", " electrical"
8: prt " calibrations", " nearly equal", " to sample", " power,"isc 3
9: ent "Type operation number.",r0
10: if r0=0:eto "STOP"
11: if r0=1:eto "ONE"
12: if r0=2:eto "TWO"
13: cll 'ERROR':eto -4
14: "ONE":c11 'INPUT'
15: dsp "Type",char(8),"P (torr) for sample"ient "",P;'INVERT'<P>+N
16: c11 'RESULTS'(W,1):eto "START"
17: "TWO":c11 'INPUT'ient "Type number of calibrations.",N:ifxd 0
18: dsp "Type",char(8),"P (torr) for sample"ient "",P
19: for I=1 to N
20: dsp "For calib. #",I," enter watts:"ient "",Q(I)
21: dsp "For calib. #",I," enter",char(9),"P:"ient "",L(I)
22: next I
23: 'INVERT'<P>+N;'PRIME'(W,5)+Z:0+T
24: for I=1 to N
25: if abs((Q(I)-W)/W)<.2:if abs(Q(I)-W)<.5:eto +4
26: and 0:prt "The difference","between the","sample and","calibration"
27: prt "power #",I,"is too great.", "Either delete", "this calibration"
28: prt "or calculate the","power using", "method #1,"isc 3:eto "START"
29: Q(I)+(P-L(I))/('PRIME'(Q(I),5)+Z)/2)+T(I):T(I)+T+T
30: next I
31: T/W+M:c11 'RESULTS'(W,2):eto "START"
32: "STOP":dsp "STOP"
33: end
34: "POLCB":
35: p1=p4+R(1)+p3
36: for J=2 to p2
37: p3+R(J)+p4+p3
38: p1+p4+p4
39: next J
40: ret p3
41: "PRIME":
42: p1=p4+R(2)+p3:if p2<3:ret p3
43: for J=3 to p2
44: p3+(J-1)+R(J)+p4+p3
45: p1+p4+p4
46: next J
47: ret p3
48: "COPY":trk 1:ldt 0:Q(1):trk 0:ret
49: "INPUT":c11 'COPY'
50: ent "Type date (<16 char.> for sample",D$
+3216

```

Track 4 - File 5

```

51: ent "Type sample label(<16 char.)",S$
52: ent "Type flow unit number.",A;if A>4:cll 'ERROR':jmp 0
53: ent "Type vessel number.",B;if B>4:cll 'ERROR':jmp 0
54: for i=1 to 5
55: C[i]=A*B+R[i]
56: next i
57: ret
58: "ERROR":
59: for i=1 to 5
60: dsp "INPUT ERROR. TRY AGAIN!!":beep:wait 750:dsr "" :wait 250
61: next i
62: ret
63: "INVERT":1=X+p2
64: for i=1 to 100
65: P[i]=X+(R[i]*X+(R[i]*X*(R[i]*X+R[i])))-p1-F
66: R[i]=X+(2R[i]*X*(R[i]*X+R[i]))+G
67: p2=F/G+p2;if abs((p2-X)/p2)<1e-6:ret p2
68: p2=X
69: next i
70: for i=1 to 5:dsr "NO CONVERGENCE!!":beep:wait 750:dsr "" :wait 250
71: next i
72: ent "No convergence","in subroutine","INVERT","!":spc 3:ato "STOP"
73: "RESULTS":!spc 5:prt "*****":!spc
74: ent "SAMPLE:",S$:!spc :prt "DATE RUN:",D$:!spc :!fxd 0
75: ent "FLOW UNIT: #",A$:!spc :prt "VESSEL: #",B$:!spc 3
76: p2 0:prt "PRESSURE=",P,":(tonn)":!fxd 5:spc
77: prt "POWER=",p1,":(watts)":!spc
78: if p2=1:prt "Based only on","the calibration","curve":!ato +6
79: if p2=2:spc :prt "Based on the","following","calibrations":!spc
80: for i=1 to N
81: fnd 0:prt "calibration #",i:!fxd 3
82: ent "watts   =",C[i],":pressure=",L[i]:!spc
83: next i
84: prt "*****":!spc 5:ret
+15790

```



```

*****FILE #5*****:
1: ***** INITIAL SETUP AND CALIBRATION OF FLOW UNITS. 1/3/78. *****:
2: dsp "scan",709,"clk",716,"pace",720,"dum",722,"dac1",728,"dacr",729
3: wrt "scan",0;wrt "dacr","A0";wrt "dac1","0.00"
4: lls 7;xd 2;0+Y
5: fnt 1;fz2.0,"E",zifmt 2,"R",fz1.0,"F0M3TIE",zifmt 3,fz4.2
6: fnt 4,"R",fz1.0,"F1M3TIE",z
7: dsp "START VESSEL STIRRING MOTOR";stp
8: dsp "HOW MANY CALIBRATIONS ?";ient "",A
9: dsp "ENTER CALIBRATION TIME (MIN) ?";ient "",r0
10: dsp "ENTER DATA UPDATE TIME (MIN) ?";ient "",r1
11: (nch1+60/12)+C;int (r0+60/12C)+B
12: if B=4;sto 19
13: dsp "***** ERROR *****";wait 1000
14: dsp "READ ERROR MESSAGE ON PRINTER";wait 3000;wrt 6
15: wrt 6,"THE NUMBER OF DATA BLOCKS MUST BE GREATER OR EQUAL TO 4."
16: wrt 6,"INCREASE THE TOTAL RUN TIME OR DECREASE THE DATA UPDATE TIME"
17: wrt 6,"TO COMPENSATE FOR THIS ERROR. PLEASE ENTER THE TIMES AGAIN"
18: fnt 9.6;wrt 6.9;sto 9
19: dlm A;C61;C4[3,15],D4[2,15],AC111,B[C,B,9],PCA1
20: rcd "clk",C011
21: for 5=1 to A
22: xnd 0;dsp "ENTER POWER FOR CALIBRATION #";P;ient "",P[P]
23: dsp P
24: wrt "scan","10"
25: dsp "CHOOSE APPROPRIATE LFU UNIT";stp
26: dsp "TYPE IN FLOW UNIT #.",U
27: dsp "A-out"
28: wrt "100;DO YOU WANT TO PURGE (YES OR NO)";A#
29: if A#="A";= NO";sto 46
30: if A#="YES";sto 42
31: dsp "TRY AGAIN";wait 2000;sto -3
32: wrt "scan","12,E";wait 5000
33: (nch1+4.4)+0;r0;corpa=-598.6+P;wrt "scan","C,10"
34: wrt "dac1","10r(20/21.5)
35: 100*cora[1,5]+r0;r0;corw*(r0,17.92)+273.15+r1
36: C99,37+P+ 4.4611e-2-2.304e-5*P)+r2
37: r/d 2;dsp "CALORIMETER HEATING:";char(8),"T= ",r2-r1
38: if r1+2;15*M;0+8;sto +3
39: sto 35
40: dsp "PURGE TIME LEFT",M,"MIN",S,"SEC"
41: if M=0;if S=0;wrt "dac1","0.00";sto 46
42: if M=5;if S=0;wrt "scan","11,12,E";wrt "dac1.3",10r(max(P1+),21.5)
43: 100*data[1,5)+r0
44: if S=0;M-1-M;59+8;sto -4
45: S-1+8;sto -5
46: fnd 5;wrt "scan","11,12,13,E"
47: for L=1 to 20
48: 'data[(5,4)+r0;fnd 2;dsp "NUMBER",L,"LFU PRESSURE",r0
49: if r0;10;wrt "scan","C,10,11,12,E";wait 30000;sto -3
50: halt L
50798

```

Track 6 - File 6

```

51: for I=1 to A
52: red "clk",C#C31
53: wrt "oscl.3",10*(P(X)-21.5)
54: for J=1 to B
55: for L=1 to 11*(B+AC11)
56: next L
57: red "clk",C#C11,F
58: for L=1 to C
59: 100*data*(C.5)+r0:r0+*corda*(r0,17.91)+r0:r0+273.15+T:r0+AC11+AC11
60: sto +1;if r0<40;if r0>30:sto +2
61: wrt 9.5/25*,"AIR TEMPERATURE IS",f6.2/2:wrnt 6.9,r0:sto "ABORT"
62: dsp "AIR TEMPERATURE",r0
63: 100*data*(C1.5)+r0:r0+*cordw*(r0,17.93)+r0:r0+AC21+AC21
64: sto +1;if r0<28;if r0>20:sto +2
65: wrt 9.5/25*,"WATER TEMPERATURE IS",f6.2/2:wrnt 6.9,r0:sto "ABORT"
66: dsp "WATER TEMPERATURE",r0
67: *data*(C2.4)/100+r0:dsp "CURRENT&VOLTAGE BEING CONVERTED"
68: +*data*(C3.3)+r0+r0:r0+AC31+AC31:r0+r0+AC51+AC51
69: sto +1;if r0<P(X)+.1;if r0>P(X)-.1:sto +2
70: wrt 9.5/25*,"POWER IS",f6.2/2:wrnt 6.9,r0:sto "ABORT"
71: dsp "POWER (WATTS)",r0
72: 100*data*(C4.4)+r0:r0+*cordp+r0:r0+P:r0+AC41+AC41
73: dsp "ATM PRESSURE",r0
74: for L=1 to 6
75: *data*(C5.4)+r0:*cordfu*(r0,T,P)+r0:r0+AC51+AC51:r012+AC71+AC71
76: sto +1;if r0<11;if r0>-.1:sto +2
77: wrt 9.5/25*,"LFU PRESSURE IS",f7.3/2:wrnt 6.9,r0:sto "ABORT"
78: dsp "LFU PRESSURE",r0
79: next L
80: 1000*data*(C6.3)+r0:r0+AC81+AC81:AC91+144*Z+Z-AC91:122+AC101+AC101
81: 122*r0+AC111+AC111:dsp "THERMISTOR R =",r0
82: next Z
83: red "clk",C#C21
84: val(C#C2,11,121)+val(C#C2,9,101)*60+val(C#C2,7,81)*3600+r1
85: val(C#C3,11,121)+val(C#C3,9,101)*60+val(C#C3,7,81)*3600+r0
86: if r0>r1:r1+86400+r1
87: C1-r0)/60+BCY,11
88: C0=C+AC61-AC3112)/(C+(C-1)))+BCY,31
89: C0=C+(6C+AC71-AC5112)/(6C+(6C-1)))+BCY,51
90: AC11/C+BCY,71;AC21/C+BCY,81;AC31/C+BCY,21;AC41/C+BCY,61;AC51,61+AC11,41
91: BCY,81+273.1+r21(AC81+AC101/C-AC111))/(AC101+AC101/C+AC91)+r1
92: -r2r2/(3574*AC81/C)+r1+r4:r4+BCY,91
93: wrt "B-out"
94: next Y
95: -r+AC11-AC21+AC31+AC41
96: for I=6-3 to B:AC11+BC1,21+AC11;AC21+BC1,2112+AC21
97: next I
98: C0=C+(4+AC21-AC1112)/12)+AC51
99: for I=B-3 to B:AC31+BC1,41+AC31;AC41+BC1,4112+AC41
100: next I
*8626

```

Track 4 - File 6

```

101: fabs((4*AC41-AC31*2)/12)*AC61
102: srb "C-out"
103: next X
104: wrt "dac1","0.00"iwr "scan","C"
105: end
106: "corto":p1-p2+p3
107: 4.3564e-2+p3*(-8.1983e-5+p3*(-9.7634e-5+2.1503e-5*p3))+p4;ret p4
108: "cortu":p1-p2+p3
109: 3.2549e-2+p3*(-3.6403e-3+p3*(-3.6755e-5+2.4764e-5*p3))+p4;ret p4
110: "corpo":1.34+p1;ret p1
111: "corlfu":p1-3.19e-4+1.098e-3*p1+p4
112: p3+.5e4+p5
113: p4/(.88922+2.5064*(p2/p5-.36906))+p6
114: p3+p4-598.6+p7;p6*(1.013+p7*(-9.0375e-5+p7*4.34e-8))+p6
115: 290.37+p7*(4.46105e-2-2.30401e-5*p7)+p8
116: p6+p4*(p8/p2)*(3.1419e-3+p7*5.10613e-6)+p6;ret p6
117: "data":
118: red "clk".G;if F=G;jmp 0
119: G=F
120: wrt "scan.1",p1
121: if p1=6;wr "dvn.4",p2;sto +2
122: wrt "dvn.2",p2
123: red "dvn",p3;ret p3
124: "TIME":wr 6,"DATE",C#[1,3,4],"-",C#[1,5,6],"-1978";if Y=0;ret
125: sto +2;if Y>0;sto +1
126: wrt 6,"STARTING TIME---",C#[1,7,8],":",C#[1,9,10],":",C#[1,11,12]
127: wrt 6,"STOPPING TIME---",C#[2,7,8],":",C#[2,9,10],":",C#[2,11,12]
128: ret
129: "ABORT":dsp "***PROGRAM ABORT-CHECK PRINTER**"
130: wrt "dac1","0.00"iwr "scan","C"
131: wrt 6,"THE CALIBRATION RUN WAS ABORTED. THE ABOVE PARAMETER WAS EXCEEDED"
132: wrt 6,"AND THE VALUE SHOWN IS RESPONSIBLE FOR THE FAILURE."
133: wrt 6,"PUSH RESET TO STOP ALERT AND RESET THE PROGRAM."ifnt 9;5;wr 6.9
134: beep;wait 100;jmp 0
135: "A-out":fat 9,4,.26x,"CALIBRATION SUMMARY",2;wr 6.9;srb "TIME"
136: fat 9,/, "FLOW UNIT #",f2.0, " CHOSEN",/,;wr 6.9,U
137: fat 9,"NUMBER OF CALIBRATIONS CHOSEN WERE",f3.0,;wr 6.9,A
138: for P=1 to A
139: fat 9,"POWER FOR CALIBRATION #",f2.0,x," IS",f8.4,x,"WATTS"
140: wrt 6.9,P;P;P;next P
141: fat 9,/, "NUMBER OF DATA SUMMARIES CHOSEN WERE",f3.0,;wr 6.9,B
142: fat 9,"NUMBER OF POINTS CHOSEN WERE",f4.0,;wr 6.9,C
143: fat 9,"CALCULATED DATA UPDATE TIME",f5.2,x,"MINUTES",/
144: wrt 6.9,.2C
145: fat 9,"TIME REQUIRED FOR EACH CALIBRATION IS",f7.2,x,"MINUTES",/
146: wrt 6.9,.2BC
147: fat 9,"TIME REQUIRED FOR COMPLETE RUN IS",f7.2,x,"MINUTES",4/
148: wrt 6.9,.2ABC
149: ret
150: "B-out":
*7761

```

Track ϕ - File 6

```

151: fmt 9,"FUN",f3.0/2x,"OF",f3.0/10x,"BLOCK",f3.0/2x,"OF",f3.0/
152: wrt 6.9,x,A,Y,B
153: sep "TIME"
154: fmt 9,f8.2
155: wrt 6.9,"AVERAGE AIR TEMPERATURE-----",BCY,71
156: wrt 6.9,"AVERAGE WATER TEMPERATURE-----",BCY,81
157: fmt 3,f5.5,"+-",x,e9.3
158: wrt 6.9,"AVERAGE POWER(WATTS)-----",BCY,21,BCY,31
159: fmt 9,f8.3
160: wrt 6.9,"AVERAGE ATMOSPHERE PRESSURE(TORR)---",BCY,61
161: fmt 9,f8.3,"+-",x,e9.3
162: wrt 6.9,"AVERAGE LFU PRESSURE(TORR)-----",BCY,41,BCY,51
163: fmt 9,f9.2,fwrt 6.9,"AVERAGE THERMISTOR RESISTANCE-----",AC81,C
164: fmt 9,e10.3/3/fwrt 6.9,"dT/dt-----",f4
165: set
166: "C-out":
167: fmt 9,6/25x,"FREON CALORIMETER RECORD",2/fwrt 6.9
168: fmt 9,"CALIBRATION #",f3.0/2x,"OF A SERIES OF",f3.0/4fwrt 6.9,x,A
169: C4031-C4011$ab "TIME"
170: fmt 9/,"FLOW UNIT #",f2.0/4fwrt 6.9/0
171: fmt 9,"POWER(WATTS)",f9.5/3x,"+-",e10.3/4fwrt 6.9,AC11/4,AC51
172: fmt 9,"LFU PRESSURE",f8.3/3x,"+-",e10.3/4fwrt 6.9,AC31/4,AC61
173: fmt 9,2/x,"ELAPSED",3x,"POWER",10x,"CORR. LFU",zfwrt 6.9
174: fmt 9,6x,"BARON.",4x,"AIR",4x,"WATER",fwrt 6.9
175: wrt 9,"TIME(MIN)",6x,"(WATTS)",7x,"PRESSURE(TORR)",zfwrt 6.9
176: wrt 9,2x,"PRESSURE",1x,"TEMP(C)",1x,"TEMP(C) dT/dt",zfwrt 6.9
177: wrt 9,x,f6.2/1x,f8.3/4,e9.3/1x,f6.3/4,e9.3/3x,f6.2/3,f5.2/7.2,e10.2
178: for I=1 to B
179: wrt 6.9,BCI,11,BCI,21,BCI,31,BCI,41,BCI,51,BCI,61,BCI,71,BCI,81,BCI,91
180: next I
181: fmt 9,6/4fwrt 6.9
182: set
+33892

```

Track 6 - File 7

```

01: "---- FILE # 7 -----":
02: "---- CLOCK RESET PROGRAM 1/3/78 -----":
03: prt "-----" :spc
04: prt " INSTRUCTIONS " :spc prt "WHEN EACH INPUT," "FOR DATE & TIME"
05: prt " IS REQUESTED,KEY", "MAXIMUM OF TWO", "DIGITS , THEN", "PRESS"
06: prt " CONTINUE"
07: dia A#[5,10] :spc 2
08: " MONTHS" :A#[1] :ent "Input this Month", A#[1,1,2]
09: val(A#[1]) :M
10: pos(A#[1]) : " " :X :if X>0 :dsp "BAD INPUT,No Decimal pts." :wait 2000 :jmp -2
11: if M=0 or M>12 :dsp "Incorrect Input!" :wait 2000 :jmp -3
12: " DAYS" :A#[2] :ent "Input Today's Date", A#[2,1,2]
13: pos(A#[2]) : " " :X :if X>0 :dsp "BAD INPUT,No Decimal pts." :wait 2000 :jmp -1
14: val(A#[2]) :A :if M=4 or M=6 or M=9 or M=11 :sto 16
15: if M=2 :sto 17
16: sto +3 :if A=0 or A>31 :dsp "Incorrect Input!" :wait 2000 :sto 11
17: sto +2 :if A=0 or A>30 :dsp "Incorrect Input!" :wait 2000 :sto 11
18: sto +1 :if A=0 or A>28 :dsp "Incorrect Input!" :wait 2000 :sto 11
19: " HOURS" :A#[3] :ent "Input this Hour", A#[3,1,2]
20: val(A#[3]) :A
21: pos(A#[3]) : " " :X :if X>0 :dsp "BAD INPUT,No Decimal pts." :wait 2000 :jmp -2
22: if A=0 or A>23 :dsp "Incorrect Input!" :wait 2000 :jmp -3
23: " MINUTES" :A#[4] :ent "Input Desired Minute", A#[4,1,2]
24: pos(A#[4]) : " " :X :if X>0 :dsp "BAD INPUT,No Decimal pts." :wait 2000 :jmp -1
25: val(A#[4]) :A
26: if A=0 or A>60 :dsp "Incorrect Input!" :wait 2000 :jmp -3
27: " SECONDS" :A#[5] :ent "Input Desired Seconds", A#[5,1,2]
28: pos(A#[5]) : " " :X :if X>0 :dsp "BAD INPUT,No Decimal pts." :wait 2000 :jmp -1
29: val(A#[5]) :A :if A=0 or A>60 :dsp "Incorrect Input!" :wait 2000 :jmp -2
30: dep "CLOCK", 716
31: prt "Clock will begin", "updating tot" :spc
32: for I=1 to 5 :prt A#[I] :next I :spc 2
33: dia B#[12,3] :val(A#[1]) :A :A(-1) :+13 :A
34: "30" :B#[1] :B#[3] :B#[8] :B#[6] :B#[11]
35: "31" :B#[2] :B#[4] :B#[5] :B#[7] :B#[9]
36: "32" :B#[10] :A#[2,1,3] :B#[12]
37: for I=A to 12 :val(B#[1]) :B :B+C :C :next I
38: if M=1 :C-1 :C
39: prt c2 :prt "CLOCK", "RP" :wait 500
40: prt #4.8 :for I=1 to C :prt "CLOCK", "D" :next I
41: for I=3 to 5 :for J=1 to val(A#[1]) :prt c1 :
42: prt "CLOCK", A#[1,4,4] :next J :next I
43: prt "PRESS CONTINUE" :prt "TO START CLOCK" :spc 2 :sto
44: prt c1 :prt "CLOCK", "T"
45: "END" :dsp "***CLOCK SETTING COMPLETED***" :ent
*17199

```

Track 6 - File 8

```

0:  +---+ FILE #8 +---+:
1:  +---+ PRESSURE METER ADJUSTMENT PROGRAM. 1-9-78. +---+:
2:  ldx 10000:ldcn 1700:dmv 1123
3:  rnt 1,fz23.0"E":zifnt 2,"R":fz1.0,"F0M3T15":z
4:  sec 3:rtt "PRESSURE METER"," ADJUSTMENT","*****":sec 3
5:  prt "After completion,"of each oper-,"ation, press","the -f0- key to"
6:  prt "continue." :sec 3:prt "10 TORR HEAD": :sec 1
7:  cll 'ADJUSTMENT'(10,5):fxd 4:sec 3:rtt "1000 TORR HEAD": :sec
8:  cll 'ADJUSTMENT'(1000,4):sec 3
9:  prt "PRESSURE METER"," ADJUSTMENT"," COMPLETED","*****":
10: sec 3:dsr "METER ADJUSTMENT COMPLETED"
11: for i=1 to 5:beep:wait 200
12: next i
13: wrt "scan","C":and
14: "ADJUSTMENT":fxd 0
15: prt "Adjust full","scale setting","to 10 V +- 1mV","dmv reading." :sec 3
16: fsc pi:"torr head--full scale adj." :cll 'READ'(p2,4)
17: prt "Adjust null","setting to","0 V +- 1mV." :sec 3
18: dsr pi:"torr head--null adjustment" :cll 'READ'(p2,6)
19: prt "Recheck full","scale adjust-","ment." :sec 3
20: dsr "Recheck full scale adjustment." :cll 'READ'(p2,4)
21: prt "Recheck null","setting." :sec 3
22: dsr "Recheck null setting." :cll 'READ'(p2,6)
23: rnt +2:if p1=1000:prt "Reset knob","to 'operate'." :sec 3:sto +1
24: dsr "Reset knob to 'operate' position" :cll 'READ'(p2,4):rtt
25: prt "Set knob to","'operate' pos-","ition and","adjust 'head'"
26: prt "zero" pot to","0 V +- 1mV." :sec 3
27: dsr "Adjust 'head zero' pot." :cll 'READ'(p2,6):rtt
28: "READ":fsc 2
29: wrt "scan.1":p1:prt "dmv.2":p2:rd "dmv":p4
30: if f1e2:rtt
31: rnt -2
+33404

```

Track 0 - File 10

```

0: "***** FILE # 10 *****";
1: "PROGRAM TO RECORD AND PRINT OUT CALIBRATION COEFFICIENTS STORED ON";
2: "TRACK 1, FILE 0.";
3: trk 0
4: dim A$(31),M$(5,4,4)
5: "START":
6: prt "To record","or check"
7: prt "calibration","coefficients","type the number"
8: prt "for one of the","following oper-","ations and","press the"
9: prt "CONTINUE key.";spc 2;prt "0: Stop program","1: Record"
10: prt "coefficients"," for all"," vessels and"," flow units."
11: prt "2: Record"," one set of"," coefficients"," for a"
12: prt "certain flow"," unit or"," vessel."
13: prt "3: Record"," one coeff-"," icient of"," a set."
14: prt "4: Print"," currently"," recorded"," coefficients";spc 3
15: "AGAIN":
16: ent "Type operation number.",r0
17: if r0=0;eto "STOP"
18: if r0=1;eto "ONE"
19: if r0=2;eto "TWO"
20: if r0=3;eto "THREE"
21: if r0=4;eto "FOUR"
22: cll 'ERROR';eto "AGAIN"
23: "ONE":fxd 0;cll 'COPY'
24: for V=1 to 4
25: for U=1 to 4
26: for C=1 to 5
27: dsp "For Vess.",V,"; unit#",U,"; C",C,"=?";ent "",M$(C,U,V)
28: next C
29: next U
30: next V
31: cll 'CHECK'(1,4,1,4,0)
32: cll 'RECORD';eto "AGAIN"
33: "TWO":cll 'COPY'
34: prt "Type flow unit","and vessel","number.";spc 3
35: ent "Flow unit number?";U;if U>4;cll 'ERROR';jmp 0
36: ent "Vessel number?";V;if V>4;cll 'ERROR';jmp 0
37: for C=1 to 5
38: dsp "C",C,"=?";ent "",M$(C,U,V)
39: next C
40: cll 'CHECK'(U,U,V,V,2)
41: cll 'RECORD';eto "AGAIN"
42: "THREE":cll 'COPY'
43: prt "Type coeff. ","flow unit, and","vessel nos.";spc 3
44: ent "Coeff. # =? (1.= 8th power.)";C;if C>5;cll 'ERROR';jmp 0
45: ent "Flow unit number?";U;if U>4;cll 'ERROR';jmp 0
46: ent "Vessel number?";V;if V>4;cll 'ERROR';jmp 0
47: ent "Value of coefficient?";M$(C,U,V)
48: dsp "Check value of coefficient++"
49: flt 5;prt "Coefficient =",M$(C,U,V);spc 3;fxd 0;wait 5000
50: ent "Want to change? 'yes' or 'no?";A$;if cap(A$)="NO";eto +2
+15182

```

Track 0 - File 10

```

51: ert "Type value for change.",WC0,U,V)goto -3
52: call 'RECORD'goto "AGAIN"
53: 'PGR':call 'COPY':call 'PRINTOUT'(1,4,1,4)goto "AGAIN"
54: "STOP":trk 0:asp "STOP"
55: and
56: "RECORD":
57: ert "Slide tab on","tape to the","RECORD position.,";"Press CONTINUE"
58: ert "when ready to","record."!asp 3
59: asp "Press CONTINUE when ready."!asp
60: ert 1:trf 0:WC+1:trk 0
61: ert "Slide tab on","tape to the","PROTECT pos-,";"ition, Press"
62: ert "CONTINUE when","ready."!asp 3
63: asp "Press CONTINUE when ready."!asp
64: ret
65: "COPY":trf 1:trf 0:WC+1:trk 0:ret
66: "PRINTOUT":fxd 0
67: for p=3 to p4
68: for Y=p1 to p2
69: asp 3:ert "FLOW UNIT NO.",Y,"VESSEL NUMBER",X!asp !flt 5
70: ert "C1=",WC1,Y,XJ,"C2=",WC2,Y,XJ,"C3=",WC3,Y,XJ
71: ert "C4=",WC4,Y,XJ,"C5=",WC5,Y,XJ!fxd 0
72: asp 2
73: next Y
74: next X
75: asp 3
76: ret
77: "CHECK":asp "Check coefficients+++"!call 'PRINTOUT'(p1,p2,p3,p4)
78: ert "Any changes? 'yes' or 'no'?",A!if cap(A)=0!ret
79: ert "Coeff. # to be changed?",C!if C>5!call 'ERROR':jmp 0
80: if p5=2!goto +2
81: ert "Flow unit number?",U!ert "Vessel number?",V
82: ert "Value of coeff. to be changed?",WC,U,V)
83: sto -6
84: "ERROR":
85: for I=1 to 5
86: asp "INPUT ERROR. TRY AGAIN!!":beep!wait 1000!asp ""!wait 250
87: next I
88: ret
+32:100

```



```

0: ***** FILE #1 *****:
1: "***** PROGRAM TO RECORD VESSEL HEAT CAPACITIES. 1/20/78. *****":
2: dln CC(4),R(3)
3: "START":sec 3
4: prt "Program to","check or record","vessel heat","capacities."
5: prt "Type the number","for the","following","operation:"
6: sec (prt "1: Record":sec (prt "2: Check":sec 3
7: ent "Type number for operation.":r0
8: if r0=1:sto "RECORD"
9: if r0=2:sto "CHECK"
10: sto "START"
11: "RECORD":
12: for l=1 to 4
13: dsp "ENTER Cp (J/gm) FOR VESSEL #",l:ent "",CC(l)
14: next l
15: prt "Slide tab on","tape to the","RECORD position.":"Press CONTINUE"
16: prt "when ready.":"to record.":sec 3
17: dsp "Press CONTINUE when ready.":stp
18: r0:=l:for l=1:CC(l):trk 0:dsp "DATA RECORDED.":wait 1000
19: prt "Slide tab on","tape to the","PROTECT pos-","ition. Press"
20: prt "CONTINUE when","ready.":sec 3
21: dsp "Press CONTINUE when ready.":stp:sto "STOP"
22: "CHECK":trk 1:l:df 1:CC(l):trk 0:sec 3
23: prt "VESSEL Cp's":sec 2
24: for l=1 to 4
25: r0:=0:prt "FOR VESSEL #",l:"Cp = ",CC(l):sec
26: next l
27: sec 5
28: "STOP":dsp "STOP"
29: end
#15009

```

Appendix J
Software Printout

Calculator Terminal Start-up and Program Illustration

The following is an example of starting a program from the 9825A calculator terminal and the follow-up operation performed by the operator.

- 1) To load a program file into the 9825A:

Insert tape cartridge

Press ,

The yellow pilot will be on while tape is loading. The program on tape is now available to the calculator. The file loaded is the "File Index Program."

- 2) To list out the programs:

Press ,

A listing of the program names are printed out on the paper tape listing printer. To select the program you wish to run, follow the message printed out on the paper tape. (Example: "Electrical Calibration")

Press , then

The "Electrical Calibration" program is now ready to run.

- 3) A sequence of messages is displayed on the 9825A screen. An example of the "Electrical Calibration" program sequence is as follows:

Message "Start Vessel Stirring Motor"

This is done manually by the operator. Switch is located on the front of calorimeter stand.

Press

Message "How Many Calibrations"

Enter the total number of calibration you wish to do for this series. (Example 5)

Press , then

Message "Enter Calibration Time"

Enter the total time you want each calibration to be, usually 80 min.

Press , then

Message "Enter Update Time"

If you wish to have a record of the data during the run, enter a time interval, usually 10 min. To suppress printout enter 0.

Press , then

Message "Enter Volume of
Refrig.-11 (C.C.)"

Press , then

Message "Enter Vessel Number"

Press , then

Message "Enter Power For Calib."

Press ,

Press ,

Press ,

Press ,

Press ,

Message "Want to Select A Flow Unit"

Type , Press

Message "Type In Flow Unit Number"

Press ,

Message "Set Values to Flow Unit"

Press

Message "Do You Want to Purge
(Yes or No)"

Type , Press

When filling the vessel, the amount of R-11 must be recorded and entered at this point (Example: 1200 CC were used to fill the vessel).

There are three vessels which may be used 1, 2 or 3. (Example: use vessel 2)

For this example we are doing five calibrations. Five values must be entered. (Example: .5, .6, .7, .8, .9 watts)

One of four flow units may be selected. Answer "yes" or "no".

Flow unit number will be entered next. If answer was "No" the flow unit will be automatically selected.

There are four flow units, numbered 1 through 4. (Example: 4)

On top of the lucite air thermostat cover there are two manual valves which must be set. (Set valve to flow unit 4)

If "Yes" the purge cycle will start (approx. 20 min.). After purge the "Sample Determination" program will begin. If "No" the "Sample Determination" will begin with no purge operation. (Example: Yes)

Message "Calorimeter Heating"

During the purge sequence the calorimeter vessel is stabilized relative to the water bath by adding heat or by not heating (cooling).

Message "Calorimeter Cooling"

Message "Time Left in Purge"

Display will show time left in purging sequence.

- 4) During the course of the determination the data readings are passed to the calculator for storage and processing. Each second on the 9825A, the data readings are displayed. For the calibration sequence the following information is displayed (as an example).

"Air Temperature Is 38C"

"Water Temperature Is 24C"

"Current and Voltage Being Converted"

"Power Is .5 Watts"

"Atm. Pressure Is 630 Torr"

"Flow Unit Pressure Is 2.0 Torr"

"Thermistor R - 103173"

Thermistor is in calorimeter vessel which reads the R-11 temperature directly.

Message "Calibration Completed"

SPECIAL MESSAGES WHICH MAY BE DISPLAYED

"Abort"

The abort message will be printed under the following conditions:

- 1) If water temp. exceeds the set point.
- 2) If water level drops below a fixed level.
- 3) If power level is too high.
- 4) If ΔP across flow unit exceeds 10 torr.
- 5) If air thermostat temp. exceeds the set point.

The following is a "Sample Determination" printout example giving the data input summary, ten minute summary and the final calorimeter data.

SAMPLE DETERMINATION SUMMARY

DATE 07-14-1978

1.5

FLUX UNIT # 2 CHOSEN

VESSEL # 2 USED

NUMBER OF DETERMINATIONS CHOSEN WERE 1

NUMBER OF DATA SUMMARIES CHOSEN WERE 3

NUMBER OF POINTS CHOSEN WERE 50

CALCULATED DATA UPDATE TIME 10.00 MINUTES

TIME REQUIRED FOR EACH DETERMINATION IS 80.00 MINUTES

TIME REQUIRED FOR COMPLETE RUN IS 80.00 MINUTES

RUN 1 OF 1 BLOCK 1 OF 8

DATE 07-14-1978
DATA STARTING TIME--- 23:16:29
DATA STOPPING TIME--- 23:26:29
AVERAGE AIR TEMPERATURE----- 38.40
AVERAGE WATER TEMPERATURE----- 24.61
AVERAGE ATMOSPHERE PRESSURE(TORR)-- 754.798
AVERAGE LFU PRESSURE(TORR)----- 9.838+- 2.876E-01
AVERAGE THERMISTOR RESISTANCE----- 103407.90
dT/dt----- 1.150E-04
PRESSURE VARIATION CORRECTION----- 1.716E 00

RUN 1 OF 1 BLOCK 2 OF 8

DATE 07-14-1978
DATA STARTING TIME--- 23:26:32
DATA STOPPING TIME--- 23:36:32
AVERAGE AIR TEMPERATURE----- 38.42
AVERAGE WATER TEMPERATURE----- 24.65
AVERAGE ATMOSPHERE PRESSURE(TORR)-- 755.017
AVERAGE LFU PRESSURE(TORR)----- 9.213+- 1.041E-01
AVERAGE THERMISTOR RESISTANCE----- 103235.36
dT/dt----- 3.918E-05
PRESSURE VARIATION CORRECTION----- 5.833E-01

RUN 1 OF 1 BLOCK 3 OF 8

DATE 07-14-1978
DATA STARTING TIME--- 23:36:35
DATA STOPPING TIME--- 23:46:35
AVERAGE AIR TEMPERATURE----- 38.43
AVERAGE WATER TEMPERATURE----- 24.66
AVERAGE ATMOSPHERE PRESSURE(TORR)-- 755.041
AVERAGE LFU PRESSURE(TORR)----- 9.128+- 7.737E-02
AVERAGE THERMISTOR RESISTANCE----- 103173.58
dT/dt----- 2.003E-05
PRESSURE VARIATION CORRECTION----- 2.976E-01

RUN 1 OF 1 BLOCK 4 OF 8

DATE 07-14-1978
DATA STARTING TIME--- 23:46:38
DATA STOPPING TIME--- 23:56:38
AVERAGE AIR TEMPERATURE----- 38.44
AVERAGE WATER TEMPERATURE----- 24.67
AVERAGE ATMOSPHERE PRESSURE(TORR)-- 755.035
AVERAGE LFU PRESSURE(TORR)----- 8.956+- 7.131E-02
AVERAGE THERMISTOR RESISTANCE----- 103153.62
dT/dt----- 2.611E-06
PRESSURE VARIATION CORRECTION----- 3.871E-02

SAMPLE DETERMINATION

VAPORIZATION CALORIMETER RECORD

1.5

DETERMINATION # 1 OF A SERIES OF 1

DATE 07-14-1978

CAL STARTING TIME---- 23:13:43

DATA STARTING TIME--- 23:16:29

DATA STOPPING TIME--- 00:36:50

FLOW UNIT # 2

VESSEL # 2

PRESSURE (TORR) 8.928, $\pm 1.061E-01^1$

ELAPSED ² TIME(MIN)	dT/dt ³	DRIFT ⁴ CORR.	CORR. LFU ⁵ PRESSURE(TORR)	BAROM. PRESSURE	AIR ⁶ TEMP(C)	WATER ⁷ TEMP(C)
10.00	1.150E-04	1.716	9.838/2.876E-01	754.80	38.40	24.61
20.05	3.918E-05	0.583	9.213/1.091E-01	755.02	38.42	24.65
30.10	2.003E-05	0.298	9.128/7.787E-02	755.04	38.43	24.66
40.15	2.611E-06	0.039	8.956/7.131E-02	755.04	38.44	24.67
50.20	4.923E-06	0.073	9.012/7.010E-02	755.05	38.44	24.67
60.25	9.585E-07	0.014	9.003/7.658E-02	754.97	38.44	24.67
70.30	-1.724E-05	-0.254	8.783/7.390E-02	754.91	38.45	24.66
80.35	-4.683E-06	-0.069	8.914/7.248E-02	754.93	38.45	24.66

1. Average pressure of last four 10 minute intervals. This value is used in File 5 (Sample Power Calculation Program) to determine the sample power.
2. Time at the end of data interval.
3. Rate ($^{\circ}\text{C}/\text{min}$) temperature change.
4. Correction for thermal duft effect due to atmospheric pressure changes.
5. Average LFU pressure during 10 min interval/standard deviation of LFU pressure.
6. Average air thermostat temperature.
7. Average water thermostat temperature.

The following is a "Calibration Determination" printout example. In this example one calibration was performed at a power level of 1.41 watts. The summary gives the input data, ten minute data summary and final data summary.

CALIBRATION SUMMARY

DATE 12-15-1973

FLOW UNIT # 2 CHOSEN

VESSEL # 0 USED

NUMBER OF CALIBRATIONS CHOSEN WERE 1

POWER FOR CALIBRATION # 1 IS 1.4100 WATTS

NUMBER OF DATA SUMMARIES CHOSEN WERE 8

NUMBER OF POINTS CHOSEN WERE 50

CALCULATED DATA UPDATE TIME 10.00 MINUTES

TIME REQUIRED FOR EACH CALIBRATION IS 20.00 MINUTES

TIME REQUIRED FOR COMPLETE RUN IS 30.00 MINUTES

RUN 1 OF 1 BLOCK 1 OF 8

DATE 07-15-1978
DATA STARTING TIME--- 16:53:41
DATA STOPPING TIME--- 17:03:41
AVERAGE AIR TEMPERATURE----- 38.39
AVERAGE WATER TEMPERATURE----- 24.45
AVERAGE POWER(WATTS)----- 1.41004+- 4.041E-06
AVERAGE ATMOSPHERE PRESSURE(TORR)-- 751.764
AVERAGE LFU PRESSURE(TORR)----- 9.286+- 2.431E-01
AVERAGE THERMISTOR RESISTANCE----- 104220.34
dT/dt----- -6.371E-05
PRESSURE VARIATION CORRECTION----- -8.394E-01

RUN 1 OF 1 BLOCK 2 OF 8

DATE 07-15-1978
DATA STARTING TIME--- 17:03:44
DATA STOPPING TIME--- 17:13:44
AVERAGE AIR TEMPERATURE----- 38.40
AVERAGE WATER TEMPERATURE----- 24.41
AVERAGE POWER(WATTS)----- 1.41004+- 8.330E-06
AVERAGE ATMOSPHERE PRESSURE(TORR)-- 751.921
AVERAGE LFU PRESSURE(TORR)----- 8.967+- 1.753E-01
AVERAGE THERMISTOR RESISTANCE----- 104365.98
dT/dt----- -3.007E-05
PRESSURE VARIATION CORRECTION----- -3.955E-01

RUN 1 OF 1 BLOCK 3 OF 8

DATE 07-15-1978
DATA STARTING TIME--- 17:13:47
DATA STOPPING TIME--- 17:23:47
AVERAGE AIR TEMPERATURE----- 38.40
AVERAGE WATER TEMPERATURE----- 24.39
AVERAGE POWER(WATTS)----- 1.41004+- 8.330E-06
AVERAGE ATMOSPHERE PRESSURE(TORR)-- 752.239
AVERAGE LFU PRESSURE(TORR)----- 8.905+- 1.071E-01
AVERAGE THERMISTOR RESISTANCE----- 104397.88
dT/dt----- -8.580E-06
PRESSURE VARIATION CORRECTION----- -1.126E-01

RUN 1 OF 1 BLOCK 4 OF 8

DATE 07-15-1978
DATA STARTING TIME--- 17:23:50
DATA STOPPING TIME--- 17:33:50
AVERAGE AIR TEMPERATURE----- 38.42
AVERAGE WATER TEMPERATURE----- 24.39
AVERAGE POWER(WATTS)----- 1.41004+- 5.345E-06
AVERAGE ATMOSPHERE PRESSURE(TORR)-- 752.445
AVERAGE LFU PRESSURE(TORR)----- 8.895+- 7.945E-02
AVERAGE THERMISTOR RESISTANCE----- 104414.08
dT/dt----- 4.722E-06
PRESSURE VARIATION CORRECTION----- 6.185E-02

CALIBRATION SUMMARY

VAPORIZATION CALIBRATION RECORD

CALIBRATION # 1 OF A SERIES OF 1

DATE: 1978-10-18

STARTING TIME---- 18:45:05

STOPPING TIME---- 18:53:41

STOPPING TIME---- 18:14:02

FLUID # 2

FLUID # 1

POKE (WRIT) 1.41004 +- 2.387E-06

DEPRATE (WRIT) 8.825 +- 8.953E-04

TIME (min)	POKE (WRIT)	CORR. (WRIT) PRESSURE (Torr)	BAROM. PRESSURE	AIR TEMP.	WATER TEMP.
00.00	1.41004 4.041E-06	8.886 2.431E-01	751.76	20.45	24.45
00.01	1.41004 8.360E-06	8.867 1.753E-01	751.72	20.45	24.41
00.02	1.41004 8.320E-06	8.885 1.071E-01	752.34	20.48	24.39
00.03	1.41004 5.345E-06	8.895 7.945E-02	752.45	20.42	24.39
00.04	1.41004 6.369E-06	8.929 7.783E-02	752.71	20.46	24.49
00.05	1.41004 8.360E-06	8.748 8.117E-02	753.35	20.46	24.40
00.06	1.41004 7.068E-06	8.570 7.634E-02	752.27	20.47	24.39
00.07	1.41004 1.143E-05	8.762 7.230E-02	752.00	20.42	24.38

1. Average power of last 4 data intervals and standard deviation.
2. Average pressure of last 4 data intervals and standard deviation.
3. Time at the end of each data interval.
4. Average power during 10 minute interval/standard deviation.
5. Average pressure during 10 minute interval/standard deviation.
6. Average air thermostat temperature.

The following is a printout example of data using File 5, "Sample Power Calculation Program."

SAMPLE:
1.5WG
DATE RUN:
February 23, 1978
FLOW UNIT: # 2
VESSEL: # 2

PRESSURE= 9.562
(torr)
POWER= 1.48647
(watts)

Based on the
following
calibrations:

calibration # 1
watts = 1.495
pressure= 9.639
calibration # 2
watts = 1.495
pressure= 9.618

Input Data for Program

- 1) Sample label
- 2) Date
- 3) LFU Pressure (torr), from File 3
"Sample Determination Program"
- 4) Number of calibrations, power
and pressure for each calibration

Output Data

- 1) Power of sample

LEAST SQUARES CALIBRATION

DATE TIME 06:05:08
 RPT TIME 15:07:45

DATE TIME 06:05:08
 RPT TIME 15:50:51

RAW DATA

1.7684E-01 9.9329E-01
 1.7690E-01 1.7659E 00
 1.7696E-01 2.6870E 00
 1.7702E-01 3.7635E 00
 1.7708E 00 4.6940E 00
 1.7715E 00 5.9068E 00
 1.7720E 00 7.0762E 00
 1.7726E 00 8.7580E 00
 1.7731E 00 1.0136E 01

COEFFICIENTS:

W0 +---+ 1.7774584E-01
 W1 +---+ 4.0291076E 00
 W2 +---+ -3.6470320E-03
 W3 +---+ 6.3450110E-01
 W4 +---+ -7.5740106E-02

FINAL ERROR = 6.9298467E-02

The following printout is an example of the electrical calibration coefficients stored on track 1, file ϕ . The "Coefficient Record and Print Program" (track ϕ , file 10) is initiated and will call in the data stored on track 1, file ϕ . The information printed out will give the raw data and the final calibration coefficients.

The raw data used by the program are:

X - the measured power input
 Y - the measured pressure differential across the flow unit.

The coefficients are generated by a Least Squares Polynomial Curve Fit. The polynomial is defined by

$$Y_{\text{calc}} = \sum_{i=0}^4 W_i X^i, \text{ where } W_i = W_i$$

on the printout.

YOBS - YCALC: The difference between the observed and calculated values for LFU pressure.

dY/dX: Rate of change of LFU pressure with respect to input power as calculated from the fitted polynomial curve,

$$\frac{dY}{dX} = \sum_{i=1}^4 i W_i X^{(i-1)}$$

X	Y	YCALC	YOBS-YCALC	dY/dX
1.7684E-01	9.9329E-01	9.7407E-01	1.9222E-02	4.0854E 00
1.7690E-01	1.7659E 00	1.8032E 00	-4.3387E-02	4.2797E 00
1.7696E-01	2.6870E 00	2.7038E 00	-1.6784E-02	4.6006E 00
1.7702E-01	3.7635E 00	3.6682E 00	9.5348E-02	5.0297E 00
1.7708E 00	4.6940E 00	4.7442E 00	-5.0240E-02	5.5614E 00
1.7715E 00	5.9068E 00	5.8815E 00	2.5338E-02	6.1465E 00
1.7720E 00	7.0762E 00	7.1797E 00	-1.0334E-01	6.8141E 00
1.7726E 00	8.7580E 00	8.6497E 00	1.0834E-01	7.5485E 00
1.7731E 00	1.0136E 01	1.0170E 01	-3.4362E-02	8.2723E 00

X	Y	dY/dX
1.0000E+00	1.7775E-01	4.0281E 00
1.5000E-01	3.3238E-01	4.0388E 00
1.1000E-02	4.6709E-01	4.0483E 00
1.0000E-01	6.1204E-01	4.0425E 00
1.4000E-01	7.5741E-01	4.0564E 00
1.7000E-01	9.0306E-01	4.0749E 00
1.1541E-01	1.0501E 00	4.0978E 00
1.5131E-01	1.1977E 00	4.1252E 00
1.8034E-01	1.3463E 00	4.1569E 00
1.7112E-01	1.4962E 00	4.1929E 00
1.5003E-01	1.6474E 00	4.2328E 00
1.9400E-01	1.8002E 00	4.2769E 00
1.0000E-01	1.9546E 00	4.3250E 00
1.0000E-01	2.1108E 00	4.3770E 00
1.0000E-01	2.2689E 00	4.4329E 00
1.0000E-01	2.4291E 00	4.4924E 00
1.0000E-01	2.5915E 00	4.5550E 00
1.0000E-01	2.7563E 00	4.6223E 00
1.0000E-01	2.9235E 00	4.6926E 00
1.0000E-01	3.0933E 00	4.7662E 00
1.0000E-01	3.2657E 00	4.8431E 00
1.0000E-01	3.4410E 00	4.9233E 00
1.0000E-01	3.6193E 00	5.0066E 00
1.0000E-01	3.8006E 00	5.0929E 00
1.0000E-01	3.9850E 00	5.1822E 00
1.0000E-01	4.1727E 00	5.2744E 00
1.0000E-01	4.3638E 00	5.3695E 00
1.0000E-01	4.5583E 00	5.4672E 00
1.0000E-01	4.7563E 00	5.5676E 00
1.0000E-01	4.9581E 00	5.6705E 00
1.0000E-01	5.1635E 00	5.7759E 00
1.0000E-01	5.3726E 00	5.8836E 00
1.0000E-01	5.5860E 00	5.9937E 00
1.0000E-01	5.8032E 00	6.1060E 00
1.0000E-01	6.0245E 00	6.2204E 00
1.0000E-01	6.2499E 00	6.3369E 00
1.0000E-01	6.4795E 00	6.4553E 00
1.0000E-01	6.7134E 00	6.5756E 00
1.0000E-01	6.9517E 00	6.6977E 00
1.0000E-01	7.1944E 00	6.8215E 00
1.0000E-01	7.4415E 00	6.9470E 00
1.0000E-01	7.6932E 00	7.0740E 00
1.0000E-01	7.9495E 00	7.2024E 00
1.0000E-01	8.2104E 00	7.3322E 00
1.0000E-01	8.4760E 00	7.4633E 00
1.0000E-01	8.7463E 00	7.5956E 00
1.0000E-01	9.0214E 00	7.7291E 00
1.0000E-01	9.3013E 00	7.8635E 00
1.0000E-01	9.5860E 00	7.9989E 00
1.0000E-01	9.8757E 00	8.1352E 00
1.0000E-01	1.0170E 01	8.2723E 00

All points X and Y will generate
a calibration curve for the
given data from 0 watts to 1.7
watts of input power.

- 1) SW
- 2) H.P. JAT
- 3) SAB
- 4) AUT
- 5) SAB
- 6) NE S
- 7) LFE REA
- 8) LFE REA
- 9) LFE REA
- 10) SP
- 11) LIFT
- 12) LIM
- 13) STIE MOD
- 14) STIE VES
- 15) WAT
- 16) AIR MOL
- 17) HOK ACT
- 18) CON AM
- 19) CON AM
- 20) LUC
- 21) CULI FEEL
- 22) VALV FLOW
- 23) VALV MEA
- 24) TOP
- 25) LOV

AGENCY APPROVALS		SHEET	
NO.	DATE	APPROVALS	NAME

Drawing 1

DESIGN APPROVAL	DATE	FILE
ENG	DATE	FILE
PART CLASSIFICATION		
UNCLASSIFIED		
DESIGN CLASSIFICATION LEVEL		
UNCLASSIFIED		
DATE	DESIGN NO.	REV. NO.
1973	1-35523	1
SHEET 13 OF 2		

FRONT VIEW OF
CALORIMETER STAND

3

- 24
- 25
- 26
- 27
- 28
- 29
- 30
- (A) (B) VA
- (C) (D) VA

2

APPROVED		DATE
FOR	DATE	APPROVAL

7

6

5

4

3

REVISION HISTORY		DATE	BY
PART NO. CONTROL NO.

- (1) CALIBRATION HE. SEAL THIS END
- (2) VESSEL STIRRIN
- (3) STIRRING SHAF
- (4) CATON FITTING
- (5) CALORIMETER
- (6) CALIBRATION HE 303 SS TUBIN
- (7) THERMISTOR, F.
- (8) THERMISTOR, F. AND THERMISTOR SEALED INPLACE
- (9) RESISTOR, (CALIB
- (10) SAMPLE STAND
- (11) STIRRING BAR
- (12) FOAM INSULATIO
- (13) REFRIGERANT R OF R21)
- (14) PLATE B (REF. I
- (15) PLATE A (REF. I
- (16) CATON FITTING;
- (17) COVER PLATE (R
- (18) R-11 GAS OUTLE TUBING IS FOAME IS AT THE TOP
- (19) STIRRING MAG
- (20) GEARS
- (21) SUPPORT RODS
- (22) TANK L CONTAIN

AGENCY APPROVALS		DATE	BY
DATE		BY	DATE
PART NO.		UNC	
DATE		UNC	

7

6

5

3

2

- ① CALIBRATION HEATER & THERMISTOR WIRES. SEAL THIS END WITH EPOXY APPROX. 1" DEEP.
- ② VESSEL STIRRING MOTOR SHAFT.
- ③ STIRRING SHAFT HOUSING.
- ④ COTTON FITTING; $\frac{1}{4}$ INCH, 2 EACH.
- ⑤ CALORIMETER VESSEL.
- ⑥ CALIBRATION HEATER & THERMISTOR PROBE. 303 SS. TUBING, .250 O.D. BY OLD WALL.
- ⑦ THERMISTOR, FENWALL 15K.
- ⑧ THERMISTOR, FENWALL 100K. (END OF PROBE AND THERMISTORS INSIDE PROBE ARE SEALED IN PLACE WITH EPOXY.)
- ⑨ RESISTOR, (CALIBRATION HEATER) APPROX. 2K
- ⑩ SAMPLE STAND
- ⑪ STIRRING BAR
- ⑫ FORM INSULATION.
- ⑬ REFRIGERANT R-11, (NOTE APPROXIMATE LEVEL OF R11)
- ⑭ PLATE B (REF. DWG. NO. T49399)
- ⑮ PLATE A (REF. DWG. NO. T49399)
- ⑯ COTTON FITTING; $\frac{1}{8}$ INCH, 2 EACH
- ⑰ COVER PLATE (REF. DWG. NO. T49399)
- ⑱ R-11 GAS OUTLET TUBE. ($\frac{1}{8}$ INCH COPPER TUBING) TUBING IS FORCED INSIDE VESSEL SO THAT INLET IS AT THE TOP OF INNER VOLUME.
- ⑲ STIRRING MAGNET
- ⑳ GEARS
- ㉑ SUPPORT RODS
- ㉒ INNER CONTAINER

Drawing 3

DESIGN APPROVAL		SHEET		TITLE	
DATE	APPROVAL	DATE	APPROVAL	SECTION VIEW OF CALORIMETER VESSEL, PROBE & OUTLET TUBE	
PART CLASSIFICATION				SCALE	
UNCLASSIFIED				SHEET	
OWN CLASSIFICATION LEVEL				DATE	
UNCLASSIFIED				DATE	
SCALE				SHEET	

3

REV	DATE	BY	CHKD
1	11-15-57	W	A

REV	DATE	BY	CHKD
1	11-15-57	W	A

2

7 6 5 4 3

[illegible]

W67834C8

REVIEW APPROVALS		SHEET NO.	TITLE
☒ REV	☐ APPROVE	NO.	TEMPERATURE CONTROLLER LIQUID SYSTEM MODIFICATIONS
		DATE	
		PROJECT CLASSIFICATION	MODEL RTE-6 NEOLAB
		THIS CLASSIFICATION LABEL	REV D
		UNCLASSIFIED	MBS WD-TS3468
		DATE	NO.
		DATE	NO.

93-94

SAMPLE DETERMINATION PROGRAM
FILE #3

DETERMINATION PROGRAM
FILE #3

2

DATE	TIME	APPROVALS	SHEET
			1
			2
			3
			4
			5
			6
			7
			8
			9
			10

ELECTRICAL CALIBRATION PROGRAM FILE #2

LOAD PROGRAM COMMANDS
14F2; RUN

FLOW UNIT CALIBRATION
COEFFICIENTS LOADED
FROM TAPE.

OPERATOR STARTS VESSEL
STIRRING MOTOR.

OPERATOR INPUTS INFORMATION
FOR CALIBRATION; NUMBER OF
CALIBRATIONS, POWER, ECT.

OPERATOR SETS VALVES
TO APPROPRIATE FLOW
UNIT NUMBER.

WANT TO
PURGE CALORIMETER
?

PURGE FOR 10 MINUTES
AT 20 WATTS; PURGE
FOR 5 MINUTES AT
MAX. CALIBRATION POWER
FOR THE SERIES.

HEAT

ΔP ()
 ΔP ()

YES ΔP (CAL)

COOL ()

NO ΔP ()
> 4

WAIT F

COOL FOR

YES 15

ELECTRICAL CALIBRATION PROGRAM FILE #2

DATE	TIME	OPERATOR	REMARKS