NBSIR 84-3008

A CALORIMETER FOR MEASURING HIGH-ENERGY OPTICAL PULSES

National Bureau of Standards
U.S. Department of Commerce
Boulder, Colorado 80303

October 1984

NBSIR 84-3008

A CALORIMETER FOR MEASURING HIGH-ENERGY OPTICAL PULSES

P.A. Simpson
E.G. Johnson, Jr.
S.M. Etzel

Electromagnetic Technology Division
National Engineering Laboratory
National Bureau of Standards
U.S. Department of Commerce
Boulder, Colorado 80303

October 1984

Sponsored by
Newark Air Force Base, Ohio

U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, Secretary

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

CONTENTS

List of Figures

A Calorimeter for Measuring High-Energy Optical Pulses

P. A. Simpson, E. G. Johnson, Jr., and S. M. Etzel

National Bureau of Standards
Electromagnetic Technology Division
Boulder, Colorado 80303

Two similar calorimeters for measuring laser pulses in the range 1 kJ to 15 kJ are described. The calorimeters, which are electrically calibrated, can be operated anywhere from the ultraviolet to infrared by selecting the proper materials for the volume absorber and deflecting mirror. Operation of each calorimeter is controlled by a dedicated desk-top computer. The theoretical basis for the calorimeters is given as are the constructional and operational details. The computer programs that are used are included in the appendices.

Key words: calorimeter; electrically calibrated calorimeter; high energy calorimeter; laser pulse; volume absorbing calorimeter.

1. Description and Operational Procedures

1.1 Introduction

This publication describes two reference standard calorimeters for laser optical pulses (CLOP). The instruments are designed to measure pulses having energies from 1 to 15 kJ at wavelengths from ultraviolet to infrared. Beam size can be as big as 30 cm by 15 cm. They are presently set up for measurements at 340 nm and 10.6 µm but can be rather simply adapted for other wavelengths by merely selecting the appropriate materials for a new volume absorber and mirror. The two entire units can be electrically calibrated and hence may be referred back to the basic SI measurement system. The two calorimeter systems have been built to be quite similar, but do possess minor differences because they are controlled by computers from different manufacturers.

1.2 Description of CLOP

CLOP consists of five modules designed to trap the laser radiation and convert it to heat. The normal configuration of CLOP, from input to beam termination, is (1) extension tube, (2) overspill monitor, (3) backscatter monitor, (4) separation tube, (5) deflecting mirror, and (6) main calorimeters, hence five modules contain six energy-measuring units. The overspill monitor and backscatter monitor share the same module. CLOP is so designed that the order of the modules may be rearranged or any of the modules may be omitted if so desired. The major portion of the radiation is absorbed in the main calorimeter which is housed in a thermally isolated enclosure. The other four modules are designed to reduce ambient effects on the main calorimeter, steer the beam into the main calorimeter, and estimate the radiation reflected back out of the main calorimeter. All of the modules are instrumented to measure their temperature rise and have provision for individual electrical calibration.

A blast shield is provided to be placed around the entrance aperture of CLOP to protect it from damage caused by errant laser shots. This unit is not instrumented. It is so designed to direct the reflected laser beam downward at a shallow angle.

Operation of one of the calorimeters is controlled by an HP 85* computer (System H) contained in a data acquisition rack. The other calorimeter is controlled by a Tektronix 4052A (System T) located outside the data acquisition rack. The data acquisition rack contains the necessary equipment to record the output of the various sensors and contains the power supplies required to operate the electronics associated with CLOP and perform the electrical calibrations. Finally, a gas supply system consisting of a high-pressure manifold for connecting nitrogen gas cylinders to CLOP, a pressure reducing valve (PRV), an electrically operated off-on valve on a low-pressure manifold, and a gas preheater is also supplied. The high-pressure manifold is mounted on a stand which also serves as a base for sturdy mounting of the gas cylinders. This manifold has been tested for safe operation and leak-free integrity at pressures of 15168472 Pa (2200 psi). Pictures of the two versions of CLOP are shown in figures 1-1 and 1-2.

1.3 Operational Principle

1.3.1 Main Calorimeter Principles

CLOP uses a volume-absorbing material to capture the laser radiation, thus avoiding the damage effects possible with surface absorbers. For 340 nm, the material used is common soda glass since this material has an absorption coefficient compatible with present-day, high-energy uv lasers (~1 kJ) [1]. If, in the future, higher energy lasers are to be measured, a more transparent material will have to be used and small chunks (~1 cm size) substituted for the glass plates to avoid fracturing due to thermal stress. For 10.6 μm radiation, calcium fluoride pieces are used as the absorber [2].

Even though the bulk of the laser radiation is absorbed in the volume absorber and the resultant temperature rise is associated with this material, the temperature sensors cannot be located in the absorber. The radiation might damage or destroy the sensors. Consequently, dry nitrogen gas is blown through the porously stacked absorber and the temperature rise of the gas measured. Thus, the calorimeter is instrumented with expediently located thermistors to measure the mass and temperature of the gas entering and leaving the main calorimeter. A copper resistance thermometer is also included to measure the gas temperature just before it flows through the volume absorber. The PRV maintains the gas flow sufficiently constant for the measurements and a feedback circuit from the temperature in thermistor to the preheater maintains the gas input temperature constant, offsetting the cooling of the gas due to expansion.

Since the gas is the vehicle for transferring the temperature rise information, none must be allowed to escape through leaks. It must all flow past the temperature out thermistor. Thus, the main calorimeter is a sealed unit with just a single gas exit area. Just before the laser pulse is to be shot into the main calorimeter the gas is turned off and a trapdoor that seals the main calorimeter entrance aperture is opened. After the laser shot the trapdoor is closed again and the gas flow resumed. In System H this time window is 14 s; in System T it is 33 s.

*Certain commercial equipment, instruments, or materials are identified in this paper in order to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

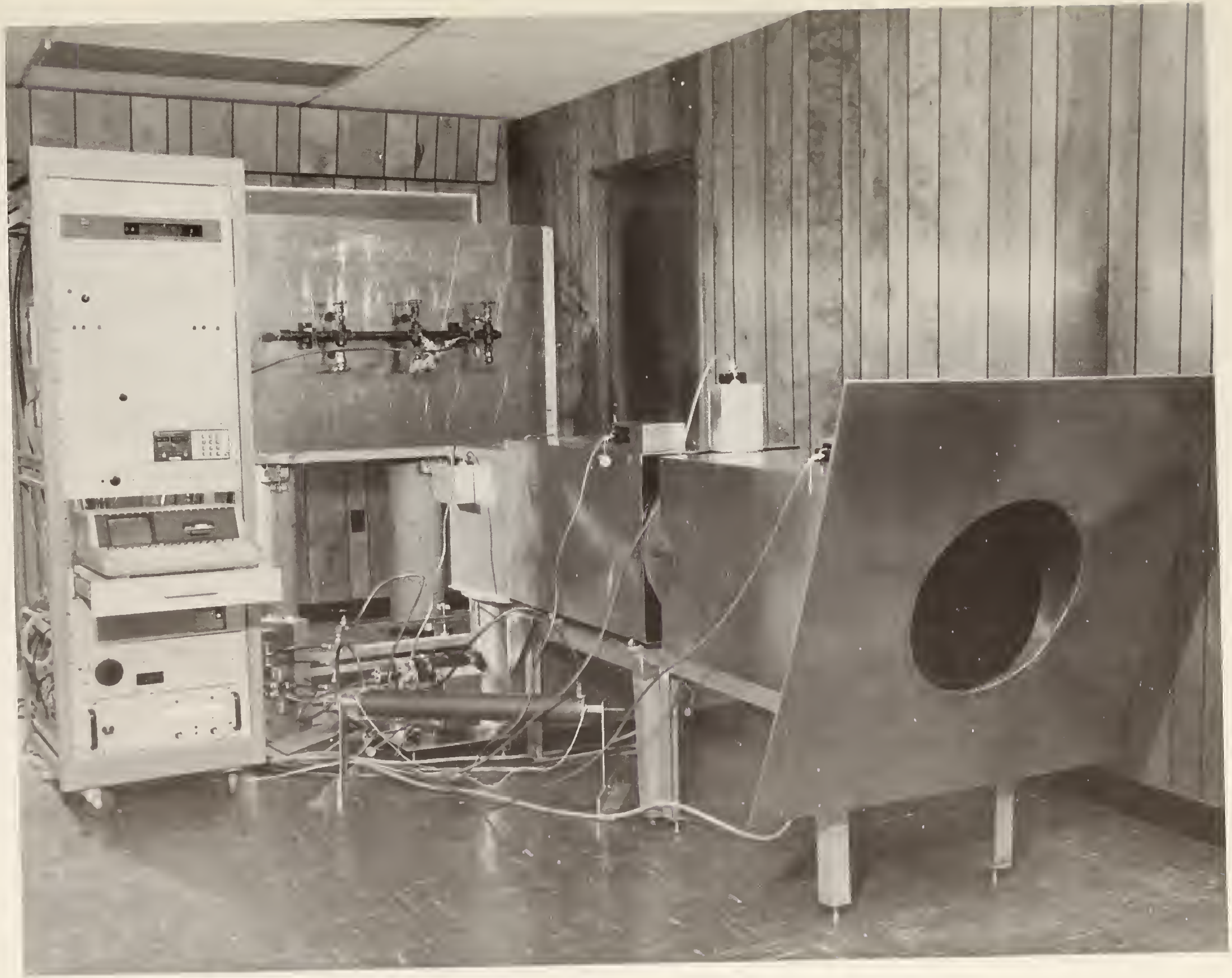


Figure 1-1. Photograph of CLOP system controlled by System H computer.

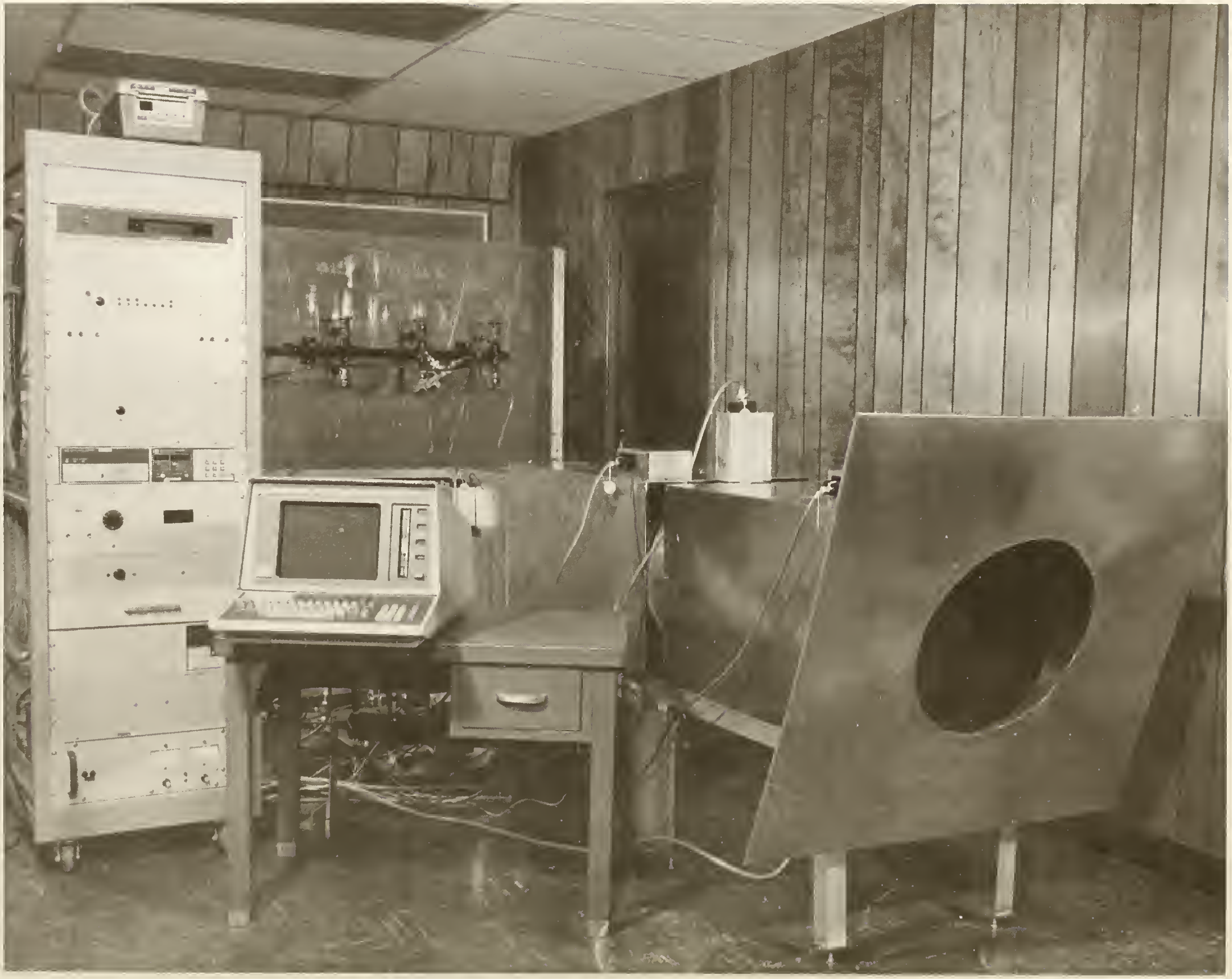


Figure 1-2. Photograph of CLOP system controlled by System T computer.

1.3.2 Gas Flow Procedures

Gas flow is furnished from cylinders of dry nitrogen gas. At the flow conditions enumerated in the computer program, one cylinder at 15168472 Pa (2200 psi) will be just insufficient for a single run. Thus, provisions are made for two different methods of uninterrupted gas flow during a run.

The first method, although inferior to the second, can be used if conditions preclude the preferred method. This first method uses two to four cylinders, each with its own PRV connected to the separate electrically operated valves on the low-pressure manifold. During the setup procedure for the run, each PRV is adjusted one at a time to produce the prescribed reading from the mass flow in thermistor. In practice, this is quite difficult and a slight discontinuity results whenever gas cylinders are changed.

The second and preferred method uses three or more cylinders connected to the high-pressure gas manifold. One PRV outputs gas from the manifold at low pressure to a single electrically operated valve on the low-pressure manifold. Two gas cylinders are used to charge the high-pressure manifold and the rest is held in reserve. When the first two cylinders are nearly empty (at ~6894.76×10^3 Pa [100 psi]), one cylinder is shut off from the manifold and a reserve cylinder opened up to the manifold. During this manual switching process the second of the two original cylinders has sufficient capacity to maintain the required flow conditions. This second method produces a much more constant gas flow than the first, and is the preferred method.

1.3.3 Functional Description of Modules Preceding the Main Calorimeter

As mentioned in section 1.2, the four modules preceding the main calorimeter have three functions. These are: steering the beam, isolation of the main calorimeter from the ambient conditions, and measurement of energy reflected back out of the main calorimeter.

The main calorimeter, because of the fact the volume absorber does not lend itself to vertical stacking, must have its entrance aperture facing upward. Thus, directly above the main calorimeter is a module with a mirror-like surface used to deflect a horizontal beam downward into the main calorimeter. This surface need not be an optically flat, aberration-free surface but it must be shiny and free from any blemishes or other imperfections that could possibly cause plasma ignition or high absorption with its associated burning.

Two different kinds of surfaces have been furnished. The first uses highly polished copper surfaces to which a thin plate containing the electrical instrumentation sensors is attached on the backside. These mirrors were originally acquired for use at CO_2 wavelengths and should not be used in the uv because of their low reflectivity.

The preferred deflecting surface consists of a foil reflector stretched over an instrumented back piece. The foil is stretched tight and a slight negative pressure applied to maintain the shape. When the foil is eventually damaged it is merely thrown away and a new piece used. Highly polished thin aluminum sheets may be used in place of the foil but the material should be rolled since this method of manufacturing greatly reduces the occurrence of possible damage center sites in the metal.

Preceding the mirror module is the separation tube module. This unit is a tube 91.5 cm long with an i.d. of 43 cm. The inside is black anodized aluminum to absorb scattered laser radiation. The length of the unit helps reduce the solid angle of the ambient seen by the main calorimeter.

In front of the separation tube is a disc-shaped module containing a backscatter monitor (BSM) and an overspill monitor (OSM). The BSM is used to measure the reflected energy from the main calorimeter, while the purpose of the OSM is to indicate poorly directed laser shots in which only part or none of the energy enters the main calorimeter. In the center of the module is a 15 cm by 30 cm aperture similar in shape to the aperture of the main calorimeter. A dual shutter closes this aperture to block out ambient effects except for a short time window when the main calorimeter trap door is also opened for the laser shot.

In front of the BSM/OSM module is the extension tube module. The module is a duplicate of the separation tube and is used to further reduce the effects of the external environment.

1.4 Description of Measurement and Data Handling Procedures

Operation of CLOP is controlled completely by the desktop computer. The operator inputs the run conditions and the computer takes over. When the run is completed the operator indicates what he wants done to the data. All computer programs are discussed in detail in section 4 and listed in appendices B and C. This section will give just a general outline of the steps.

There are two classes of cassette tapes furnished with each CLOP system. These are program tapes and data tapes. All of the programs necessary for operating each CLOP system is on the one program tape for that system. A duplicate copy of each of the two different program tapes (System T and System H) is also furnished. As good practice, the program tapes are kept in the write-protected condition.

The first program used is the data-taking program. This is accessed somewhat differently in the two systems because of the different type computers. In System T it is most easily accessed by using the AUTO LOAD button, that loads the tape index from which the desired program can be called up. In the System H the computer memory space requires that the program be split into two parts and chained together for operation. The first part is labeled "Autost". This program name will automatically load and run, if the tape is fully inserted before System H is first turned on. Of course, these programs can be loaded and run using the ordinary commands from the keyboard as described in the computer instruction manuals.

The data-taking program first initializes the equipment and then goes through a pre-run checklist including a 45 min warm-up period if that is required. Next, the run parameters are input. Table 1.1 lists the various parameters and the format to be used. In addition to acquiring these parameters, the program also leads the operator through the various steps to set up the gas flow if the main calorimeter is to receive energy (laser or electrical). When all this is accomplished a final check list is presented in anticipation of starting the data-taking. It is at this point that the System H performs the previously mentioned CHAINing operation.

Figure 1-3 shows the time progression of events during a run. During the 2 min adjustment period and the 8 min monitor period, the output from all 10 sensors is measured at 3 s intervals and displayed on the computer screen. The 2 min adjustment period allows the operator to set the zero reading (i.e., the baseline reading before laser or electrical energy injection) of any sensors he so desires; the 8 min monitor period allows him to verify that all relevant sensor outputs are stable to within acceptable limits. The operator can abort the run any time during these two periods with a user-defined key on the computer. An abort in the 2 min adjustment period stops the program which can

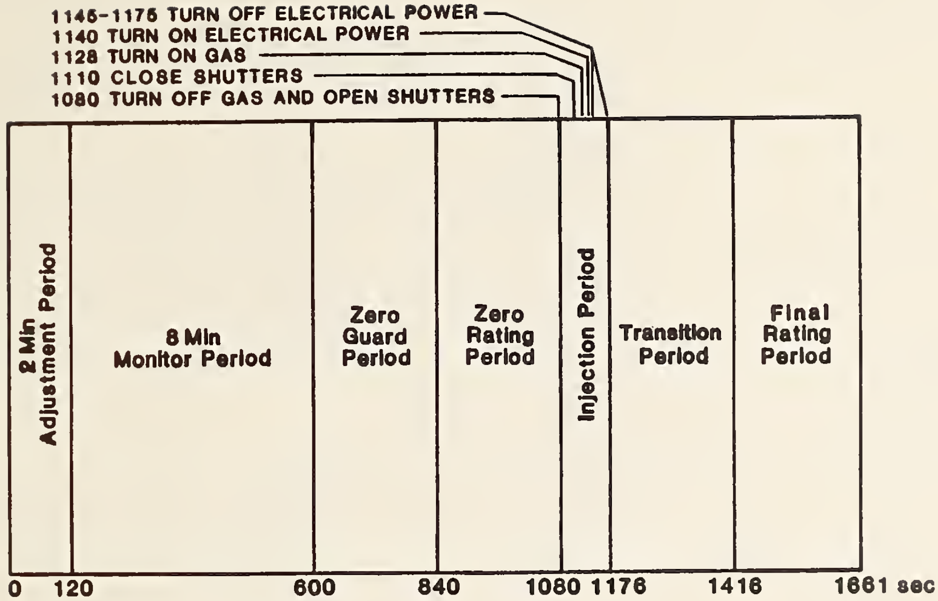


Figure 1-3. Time progression of events during one measurement run with CLOP.

be restarted at the beginning of the 2 min adjustment by pressing the CONT key. An abort during the 8 min monitor period restarts the program at the beginning of the 2 min adjustment period.

When the 8 min monitor period is completed the run enters the data-taking stage.

WARNING

During the data-taking period of laser (L) and combination (C) runs, all personnel should leave the area for a place safe from the laser. After the laser shot when the CLOP area is again safe they may return. For electrical (E) runs the personnel can remain with CLOP.

Here the output of all the sensors is measured every second. Every 6 s the values are summed and stored in the appropriate location of a 10 column by 176 row matrix (VØ). The first 8 min of the data-taking period are to record the zero readings of the sensors. For mathematical purposes this 8 min interval as well as a final one are divided into two 4-min intervals each. These four periods are referred to as the Zero Guard Period, the Zero Rating Period, the Transition Period, and the Final Rating Period.

Interposed between the two 8-min periods is a 96-s Injection Period. During this time the gas flow is stopped and shutters opened. The laser shot is now made into CLOP (unless the run is an electrical calibration). Next, the shutters are closed and gas flow resumed. Finally, electrical energy is injected if the run is an E or C type (see table 1.1).

When the run is completed, all appropriate functions of CLOP are shut down and a run-end checklist presented. When the checklist is completed, some preliminary mathematical manipulations are performed and the run data is stored in a temporary data file selected by the operator. Finally, the mathematical processing program is called up.

Table 1.1. Run parameters entered for CLOP runs.

Parameters	Format
1. Run number	1. YYMMDD.RR Y = year; M = month; D = day; R = run no. for that day; e.g., 830217.03 is the third run on February 17, 1983
2. Run type	2. L = Laser E = Electrical C = Combination (laser and electrical energy injected into the main calorimeter)
3. Calorimeter configuration	3. DDDDDD D = digit; 1 = extension tube; 2 = OSM; 3 = BSM; 4 = separation tube; 5 = deflector or foil reflector; 6 = main calorimeter; ∅ = no module
4. Mirror device	4. D D = digit; 1 = deflector; 2 = foil reflector
5. Room temperature	5. Degrees centigrade
6. Barometric pressure	6. Millimeters of mercury
7. Electrical energy	7. Joules (E and C runs only)

1.5 Data Reduction and Storage

The data reduction are performed by program "CALC" on System H and by file 5 on System T. These programs calculate the zeroth, first, and second moments for each sensor's voltage output curve in the zero rating period, the transition period, and the final rating period. For a detailed description of the mathematics involved see section 2.2.

For laser and combination runs, the moments for all the sensors along with other pertinent information are stored in data files. No provisions for further mathematic manipulations of this type data have been developed at this time as no experience with laser shots has yet been acquired. As this experience is gained it is expected that the routines will be developed. Section 2.3 offers some thoughts for consideration for a first approach to this development. In System H the data storage files are on tape LASER RUNS 1; for System T they are files 24 through 33 on each data tape.

For electrical calibration runs, calibration factors are calculated for the Temperature Out sensor and the main calorimeter resistance thermometer detector (RTD) as also for the RTD of each of the ancillary modules. A stability factor is calculated for the Mass Flow In, Mass Flow Out, and Temperature In sensors. The moments, calibration factors, stability factors, and other pertinent data are stored in the appropriate electrical summary file. There is one summary file for each sensor. For the System H these files are on the tape labeled ELECTRICAL SUMMARY. In System T these are files 12 through 22 on the data tapes.

Finally, one more operation is performed on the results of the electrical runs. A "best" estimate of the calibration factor for each temperature sensor is derived. This is done by still another program ("FACTOR" on System H, file 7 on System T). These programs calculate the mean and standard deviation for the RTD of each ancillary module. For the main calorimeter RTD and Temperature Out sensor, the program performs a linear least squares fit of calibration factor as a function of the first moment (drift) during the zero rating period. The reason for this is discussed in section 2.

The results are stored in the form of an 8 x 4 matrix in data file "CALFAX" on System H and file 23 on the System T along with an operator-input descriptive information note for each sensor. Table 1.2 shows the storage scheme used for the data.

Table 1.2. Array FØ for storing CLOP calibration factors.

	1	2	3	4
1	KO main cal. RTD	% std. dev. of KO main cal. RTD	No. of points main cal. RTD	A1 main cal. RTD
2	KO temp. out	% std. dev. of KO temp. out	No. of points temp. out	A1 temp. out
3	KO foil refl.	% std. dev. of KO foil refl.	No. of points foil refl.	% std. dev. of A1 for main cal. RTD
4	KO mirror deflector	% std. dev. of KO mirror deflector	No. of points mirror deflector	% std. dev. of A1 for temp. out
5	KO separation tube	% std. dev. of KO separation tube	No. of points separation tube	0 (not used)
6	KO BSM	% std. dev. of KO BSM	No. of points BSM	0 (not used)
7	KO OSM	% std.dev. of KO OSM	No. of points OSM	0 (not used)
8	KO extension tube	% std. dev. of KO extension tube	No. of points extension tube	0 (not used)

No "best" values are calculated for the Mass Flow In, Mass Flow Out, and Temperature In sensors, since these readings may vary from run to run and the constancy of the value during the run is the important factor.

2. Theoretical Basis of CLOP

2.1 Basic Principles

Ordinarily, laser calorimetry involves the injection of energy into the calorimeter and after a suitable time period to allow high-order heat modes to decay, fitting a single-mode exponential curve to the data to determine the magnitude of injected energy [3]. CLOP, however, is a dynamic, gas-flowing system and as such does not lend itself readily to the above method. That method is based on isoperibol conditions; CLOP is a non-isoperibol system.

A method of moments has been developed to reduce the sensor voltage output data and establish a procedure for summarizing the results. As mentioned in section 1.4 and shown in figure 1-3, there are four 4-min periods of rapid data taking: the zero guard period, the zero rating period, the transition period, and the final rating period. Interposed between the zero rating period and the transition period is a 96 s injection period. For the latter three 4-min periods the zeroth, first, and second moments are calculated as described in section 2.2. These moments correspond to the dc value, the drift, and the curvature of the sensor output voltage curve. They are calculated in such a manner that they are orthogonal to each other.

This is the primary data reduction method. The zero guard and the zero rating periods provide the baseline information to confirm that the system is operating in a reproducible way, namely that the drift is constant. Once this is so, energy is injected into that calorimeter to create a differential change from the nominal baseline conditions. This change is a measure of the amount of injected energy and is determined by subtracting the zeroth and first moments of the zero rating period from the zeroth and first moments of the transition period. This method assumes that while the shutters are open heat flow into and out of the calorimeter is negligible. Maximum accuracy is achieved by making the mass flow in and temperature in of the nitrogen gas the same for laser shot runs and electrical calibration runs. Also, the shutters are opened and closed in like manner for both type runs.

In section 2.2 we shall define the calculation of the moments and then define how the temperature differential is computed based on these moments. We have found that there is a drift term present in temperature out sensor signal and, while it may not be the same value from one run to the next, it can be made constant for any one run. Thus, for each run the drift can be subtracted out of the data to determine quite precisely the differential change from the baseline conditions. We believe the drift terms arise from the fact that the absorber material is at a cooler temperature than the flowing gas and is absorbing heat from the gas as it is being raised toward the temperature of the gas.

The second moment is used basically as an indicator that the drift is constant. When this is so the second moment is insignificant.

Thus, the calibration procedure for the main calorimeter requires the determination of two constants. The first is a fundamental energy constant and the second is a linear correction factor based on the drift (e.g., the first moment in the zero rating period). This determination is accomplished by performing a linear least squares fit of calibration factor versus first moment as measured from a number of different runs [4]. The Y intercept is the fundamental constant and the slope of the line is the drift coefficient or linear correction factor.

For the ancillary modules we determine just the fundamental energy constant. Here we assume that the drift term is insignificant which is quite valid since these modules will be absorbing only a small portion of the total energy of a laser shot and the drift term will be a second-order correction. For these calibration factors only an average and standard deviation need be calculated.

For the mass flow in, mass flow out, and temperature in data a stability factor is calculated based on the zeroth and first moments of the zero rating period and the transition period. No further mathematical operations are performed on these data but the data are saved if needed for future use.

2.2 Derivation of Basic Equation

In deriving the basic equations we shall endeavor to use the same designation for each particular quantity as is used in the computer programs for performing calculations. First, we must consider how the data are taken. Voltage readings of a sensor output are taken at 1 s intervals for 1056 s (four 4-min periods and a 96 s injection period). During the data-taking process these are averaged on a

Table 2.1. Numerical indicator for CLOP sensors.

Numbers System H	Numbers System T	Sensor
0	1	Main calorimeter RTD
1	2	Main calorimeter mass flow out
2	3	Main calorimeter temperature out
3	4	Main calorimeter mass flow in
4	5	Main calorimeter temperature in
5	6	Foil reflector or deflector
6	7	Separation tube
7	8	Backscatter monitor
8	9	Overspill monitor
9	10	Extension tube

6 s basis to reduce noise in the readings and because of computer memory space limitations. Thus, we have for each sensor 176 values representing its output over the time period t = 0 to t = 1055 s. These are stored in the array V(I,J), where $0 \geqslant I \geqslant 175$ and $0 \leqslant J \leqslant 9$, (J = sensor index, see table 2.1). Note that for System T the index limits are increased by 1 since that computer does not allow an array index of 0.

In terms of the actual time expressed in seconds, we can say,

X1 = 237 starting time of the zero rating period,

X2 = 477 ending time of the zero rating period,

X3 = 573 starting time of the transition period,

X4 = 813 ending time of the transition period and the starting time of the final rating period, and

X5 = 1053 ending time of the final rating period.

Also,

X7 = (X1 + X2)/2 midpoint of the zero rating period,

X8 = (X4 + X5)/2 midpoint of the final rating period, and

X9 = (X3 + X4)/2 midpoint of the transition period.

Now we set N = 20, which represents the half width of the stored values in array V(I,J) for any one sensor during any of the three periods of interest. Also XØ = (X2 - X1), the duration in seconds of each of the time periods of interest, so that we derive ZØ, the number of measurements represented by each value in V(I,J), as

$$Z\emptyset = X\emptyset/2N. \qquad (2\text{-}1)$$

Because we will be using a finite number of terms in the integrals that will calculate the moments, we need to introduce a first-order correction factor to get true orthogonality. This term, AØ, is

$$A\emptyset = 1 - 1/4N^2. \qquad (2\text{-}2)$$

Normalization constants for the moments are

$$C\emptyset = 1/\sqrt{X\emptyset} \qquad \text{(zeroth moment)}, \qquad (2\text{-}3)$$

$$C1 = \sqrt{12/A\emptyset}/(X\emptyset)^{3/2} \qquad \text{(first moment)}, \qquad (2\text{-}4)$$

$$C2 = \sqrt{180}/(X\emptyset)^{5/2} \qquad \text{(second moment)}. \qquad (2\text{-}5)$$

Using the above terms we can now calculate the moments for the output from any sensors as

$$Y\emptyset(n,J) = \sum_{I=-N}^{N-1} P\emptyset \cdot V((K1 + Z1)/Z\emptyset,J), \qquad (2\text{-}6)$$

where

- $Y\emptyset(n,J)$ = an array containing the zeroth moments of the various sensors for the periods of interest,
- n = ∅ for zero rating period, 1 for final rating period, and 2 for transition period in System H (add 1 for System T),
- J = an index representing the sensor (see table 1.2),
- $P\emptyset$ = zeroth moment function and equal to $C\emptyset$,
- K1 = X7 for the zero rating period, X8 for final rating period, and X9 for the transition period,
- Z1 = $Z\emptyset(I + 0.5)$
- V(x,J) = an array containing the averaged values of output voltage from all the sensors, and
- N & $Z\emptyset$ as defined above;

$$Y1(n,J) = \sum_{I=-N}^{N-1} P1 \cdot V((K1 + Z1)/Z\emptyset,J), \qquad (2\text{-}7)$$

where

- Y1(n,J) = an array containing the first moments of the various sensors for the periods of interest,
- P1 = the first moment function and equal to $C1 \cdot Z1$, and n, J, V(x,J), N, K1, Z1, $Z\emptyset$, and C1 are as previously defined; and

$$Y2(n,J) = \sum_{I=-N}^{N-1} P2 \cdot V((K1 + Z1)/Z\emptyset,J), \qquad (2\text{-}8)$$

where

- Y2(n,J) = an array containing the second moments of the various sensors for the periods of interest,
- P2 = the second moment function and equal to $C2(Z1^2 - (A\emptyset \cdot X\emptyset^2)/12)$, and n, J, V(x,J), N, K1, Z1, $Z\emptyset$, $X\emptyset$, $A\emptyset$, and C2 are previously defined.

We can now define a calibration factor, $K\emptyset$, as

$$K\emptyset(J) = \frac{Y\emptyset(2,J) - Y\emptyset(\emptyset,J) - \sqrt{12} \cdot T2 \cdot Y1(\emptyset,J)}{J\emptyset}, \qquad (2\text{-}9)$$

where

$K\emptyset(J)$ = calibration constant for the particular sensor,

J = index of the sensor as given in table 1.2,

$Y\emptyset(x,J)$ = the zeroth moment as defined above,

$Y1(x,J)$ = the first moment as defined above,

T2 = the ratio of the sensor output voltage after the shutter closes to that before the shutter opens (assume T2 = 1), and

$J\emptyset$ = injected electrical energy in joules.

For the mass flow in, mass flow out, and temperature out, we wish to calculate a stability factor which will give us a measure of how constant the input conditions are for a particular run. This we define as

$$K\emptyset(J) = Y\emptyset(2,J) - Y\emptyset(\emptyset,J) - \sqrt{12} \cdot T2 \cdot Y1(\emptyset,1), \qquad (2\text{-}10)$$

where

$K\emptyset$ = the stability factor, and all the rest of the terms are as defined above for the calibration factor.

Now there remains the task of determining a "best" value of calibration factor. As mentioned in section 2.1, we found that the calibration factor is a linear function of temperature. Thus, we perform a series of electrical calibrations on the main calorimeter which have various drift rates and for the temperature out and main calorimeter RTD we perform a least squares fit on the following equation

$$\frac{Y\emptyset(2,J) - Y\emptyset(\emptyset,1) - \sqrt{12} \cdot T2 \cdot Y1(\emptyset,J)}{J\emptyset} = K\emptyset(n) + A1 \cdot Y1(\emptyset,J), \qquad (2\text{-}11)$$

where

A1 = drift coefficient, and all the rest of the terms are as previously defined.

For all the modules other than the main calorimeter, we assume A1 = 0 and simply calculate an average calibration factor ($K\emptyset$) and its standard deviation. These "best" values are stored in an 8 x 4 array, $F\emptyset$, in a data file. Table 2.1 shows the organization of $F\emptyset$. Note no "best" values are determined for the mass flow in, mass flow out, and temperature in.

2.3 Laser Runs

Since no experience using lasers on CLOP has been acquired as yet, this section will only offer various points as a guide to developing future procedures and computer programs for processing the data from laser and combination runs. As experience is acquired, first procedures (and the related computer programs) should be refined.

In order to calculate the injected energy for a laser run, we need to transpose the terms in eq (2-11) for the temperature out sensor in the main calorimeter and eq (2-9) for the sensors in the ancillary modules. Thus, for the temperature out we get from eq (2-11)

$$E = \frac{Y\emptyset(i + 2,J) - Y\emptyset(i,J) - \sqrt{12} \cdot T2 \cdot Y1(i,J)}{K\emptyset + A1 \cdot Y1(i,J)}, \qquad (2\text{-}12)$$

where

- E = laser energy absorbed in the main calorimeter in joules,
- i = 0 for System H and 1 for System T,
- J = index of the temperature sensor as given in table 1.2,
- $K\emptyset$ = $F\emptyset(2,1)$ in the file of "best" values,
- $A1$ = $F\emptyset(2,4)$ in the same file,
- $Y\emptyset(i,J)$ = zeroth moment as stored in a laser run results file,
- $Y1(i,J)$ = first moment as stored in the laser run results file, and
- $T2$ as defined in eq (2-11).

For the ancillary modules eq (2-9) transposes to become

$$E = \frac{Y\emptyset(i+2,J) - Y\emptyset(i,J) - \sqrt{12} \cdot T2 \cdot Y1(i,J)}{K\emptyset}, \tag{2-13}$$

where

- E = the energy in joules absorbed by the module,
- $K\emptyset$ = $F\emptyset(1,a)$ with a being determined for the particular module from table 2.1, and the rest of the terms are as in eq (2-12).

It should be noted that the OSM has a high reflectance and the value of E in eq (2-13) is actually E_A in eq (3-1). The actual laser energy incident upon the OSM should be modified accordingly.

Now the total laser energy is the sum of the energies measured by the various units of CLOP. However, there are two more important factors to be considered, backscatter and inequivalence. Considering the index of refraction for the glass and calcium fluoride ($n = 1.5$ or less), the reflection should be of the order of 4 percent or less. Also, the orientation of the surfaces of the absorbing material is such that the reflected light must experience additional reflections (with some associated absorption) before escaping through the calorimeter trapdoor opening. The light will then experience more reflections off of the surfaces of the deflecting unit and the separation tube before arriving at the BSM. The surface of the separation tube is quite black. At the BSM some of the energy will be absorbed by its black surface but some will escape through the open aperture where more will be absorbed by the extension tube. This untrapped (and unmeasured) backscatter should be quite small but it would be prudent to confirm this analysis.

The inequivalence arises from differences in the way the laser energy is injected as compared to the way the electrical energy is injected. The laser energy is absorbed (and converted to heat) throughout the entire volume of the absorber. The electrical energy heats the moving nitrogen gas by conduction and convection which must then transfer the heat to the surface of the absorbing materials. Some of the electrical energy also heats the walls of the calorimeter by radiation. With the large ratio of surface area to volume for the glass plates there should be very little difference when extracting the heat from that absorber, whether it was deposited by optical or electrical energy. The same should hold true for the calcium fluoride for pieces up to 1 cm on a side. Larger pieces may have to be broken down. Thus, the major contributor to inequivalence in the main calorimeter will probably be the less efficient way of transferring the electrical energy to the volume absorbing material.

The deflector unit receives the full energy of the laser beam but should absorb only 1 or 2 percent of it. Thus, inequivalence here should not be as serious as in the main calorimeter. The foil reflector with its air space between the foil and the plate on which the sensor and heater are mounted should have a greater inequivalence than the mirror deflecting unit. However, an inequivalence of 50 percent should only introduce a 0.5 to 1.0 percent error in the total energy measurement.

The same holds true for the other ancillary modules. Here we are talking about measuring only 4 percent of the total energy so we can tolerate inequivalences of 50 percent. This would yield an additional error of 2 percent in the total energy measurement. The close, intimate contact of the electrical heaters and sensors for these units plus the black surfaces and thin walls should result in a much greater equivalence than 50 percent.

3. Description of Components

3.1 Blast Shield

The blast shield is a piece of aluminum 99 cm by 99 cm and 1.6 mm thick. This shield leans forward at an angle of approximately 20 degrees from the vertical so that any radiation reflected from it is directed downward and absorbed at some remote place. In the center is a 42 cm diameter tube which mates with the inside of the next section, the extension tube. The blast shield is held in place by two aluminum straps which connect to supports on the mounting stand for the extension tube.

No electrical instrumentation is associated with the blast shield; its sole function is to provide some measure of protection for CLOP in the event there is a gross misalignment of the laser beam.

3.2 Extension Tube

The extension tube is made from black anodized aluminum. It is 92 cm long by 43 cm in diameter and 1.6 mm thick. It is enclosed in an insulating jacket made from aluminum which is lined on the inside with 2.54 cm foamed polystyrene to isolate the unit from ambient effects. The outer dimensions of the insulating jacket are 90 cm long by 50 cm square. The extension tube protrudes 1 cm beyond each end of the insulating jacket to permit connecting to adjacent sections.

Instrumentation is provided to measure the temperature change of the unit and thus the amount of absorbed backscattered energy from the laser shot. The instrumentation consists of two insulated, bifilar windings of #40 copper wire which are wrapped in a coincident spiral around the outside of the extension tube. Pitch of the spiral is 2 cm per turn. Nominal resistance of each winding is 440 Ω and the two are equal to within 0.5 Ω. The two windings are designated RT1 and RT2 and form opposite arms of a bridge circuit.

This bridge circuit is shown in figure 3-1. It is mounted on a printed circuit board which is housed in an aluminum circuit box located on the outside of the insulating jacket. Zeroing of the bridge output is accomplished with the 10 turn wirewound pot, R16, that is mounted on the side of the circuit box. All power and signal connections to the bridge circuit are via a 10-pin connector mounted on the circuit box.

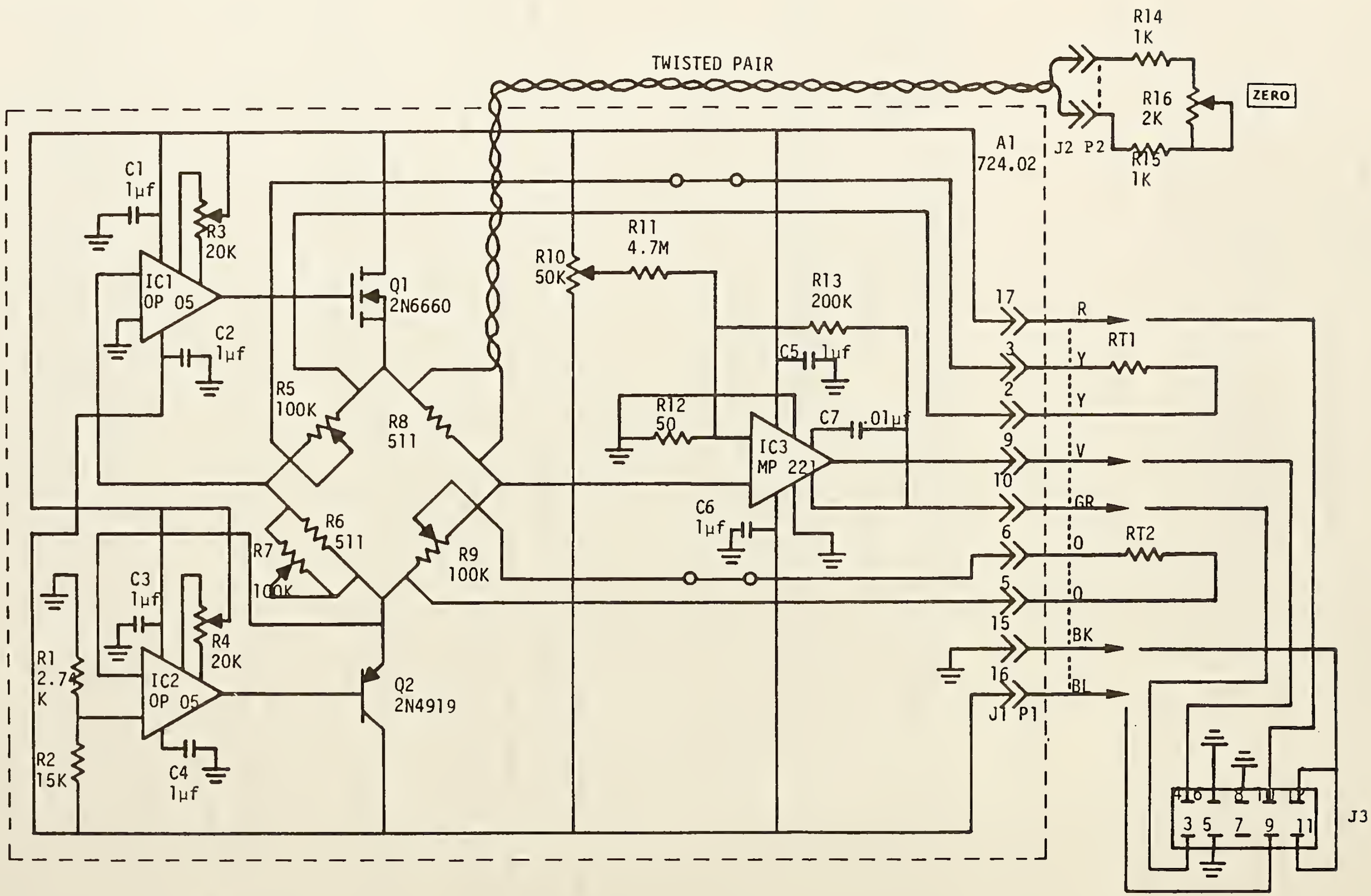


Figure 3-1. Extension tube bridge circuit schematic diagram.

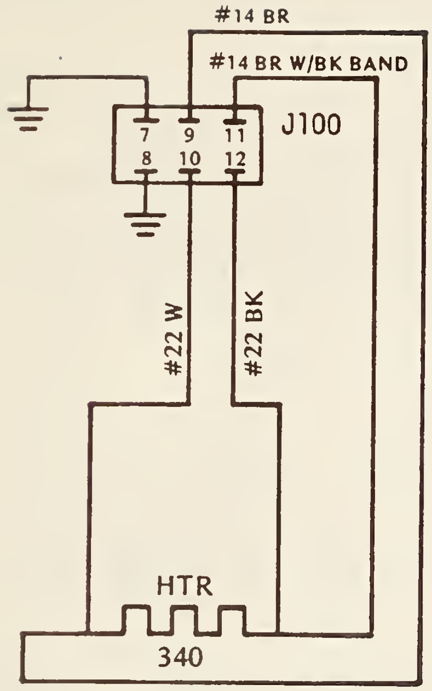


Figure 3-2. Schematic diagram of the heater circuit for the extension tube.

Electrical calibration is performed using a heater wire of bare #24 nickel chromium wire. The wire is insulated from the metal tube by a layer of 76 μm Teflon tape. Both the heater wire and resistance thermometers are covered with a layer of polystyrene coil dope which serves to anchor the wires in place and maintain good thermal contact with the metal tube.

The heater wire is also wound on a 2 cm pitch spiral and is centered between the turns of the resistance thermometers. Thus, the heater is separated from the temperature sensor by 1 cm on each side. The resistance of the heater is approximately 340 Ω at room temperature.

The ends of the nickel chromium heater wire are secured on ceramic standoff insulators from which leads are brought out to a six-pin connector on the same circuit box that contains the bridge printed circuit board. The voltage across the heater is measured via a twisted pair of black and white #22 wires connected to lugs on the ceramic insulators. The two leads are brought out to the same connector as the power leads. A schematic diagram of the heater circuit is shown in figure 3-2.

3.3 Overspill Monitor/Backscatter Monitor

3.3.1 General Features

The overspill monitor (OSM) and backscatter monitor (BSM) share the same section of CLOP. The dimensions of this section are 50 cm in diameter by 9.5 cm long. The outer skin is made of 1.6 mm thick aluminum and is lined on the inside with foamed polystyrene 3.5 cm thick for environmental insulation. Inside the insulation is another aluminum wall, 1.6 mm thick, which forms a compartment for certain electrical circuits.

Along the centerline of the OSM/BSM section is a 30 cm by 15 cm aperture through which the laser beam is directed. A motor-driven shutter blocks this aperture for all measurement phases except laser energy injection, thereby helping to isolate the inner parts of CLOP from external ambient temperature effects and also inhibiting thermal radiation losses to the outside during the post-injection measuring period. Provision has been made to orient the aperture with the long dimension either horizontal or vertical.

3.3.2 Overspill Monitor

The function of the OSM is to measure how much energy misses going into the calorimeter. The absorbing surface is a piece of aluminum 43 cm in diameter and 3.2 mm thick. Since aluminum is quite reflective at most wavelengths, the reflectance must be considered when determining the amount of energy incident upon the OSM. Thus, the incident energy should be calculated by eq (3-1),

$$E_I = \frac{E_A}{1 - R}, \tag{3-1}$$

where

E_I = the energy, in joules, incident upon the OSM,

E_A = the energy, in joules, absorbed by the OSM, and

R = the reflectance of the OSM which is equal to the ratio of the reflected energy to the incident energy.

Table 3.1 gives the reflectance of aluminum at certain selected wavelengths. The values given are from Bennett et al. [5] and are for "aged evaporated" films.

OSM temperature changes are sensed with two windings of #40 copper wire, each of 50 Ω resistance. They are wound in a hexagonal shape around the inside of the periphery of the back side of the OSM and are separated from the metallic surface by a layer of 89 μm mylar tape. This tape, which has an adhesive on both sides, serves to hold the windings in place. A second layer of mylar tape covers the windings and in turn is covered by 89 μm copper foil tape.

The sensors form the opposite arms of the bridge circuit shown in figure 3-3 for System H and figure 3-4 for System T system. Except for the sensors (RT1 and RT2) and R16 the zero adjustment, these circuits are contained on printed circuit boards located in a circuit box on the outside of the section. R16 is mounted on the circuit box for convenient access. All connections from the PC board to the data acquisition rack are via pins 1 through 12 of a 24-pin connector. This connector is shared with the output from the BSM PC board.

Two commercially available heaters are used to electrically calibrate the OSM. The heaters are 7.62 cm by 10.16 cm and are located next to the center portion along the 30 cm edge of the entrance aperture. The two heaters are each 3.93 Ω and are connected in series. Total power dissipation is limited to 336 W by the computer program to prevent possible damage to the heaters. Leads to the heater are brought out to a six-pin connector on the circuit box. This connector is wired the same as the connector on the extension tube (see fig. 3-2).

3.3.3 Backscatter Monitor

The BSM is used to measure the energy that enters the calorimeter and is not absorbed but instead is reflected back out and hence not measured by the main calorimeter. It is made of black anodized aluminum 43 cm in diameter and 1.6 mm thick. In the center is a 15 cm by 30 cm aperture through which the laser beam passes.

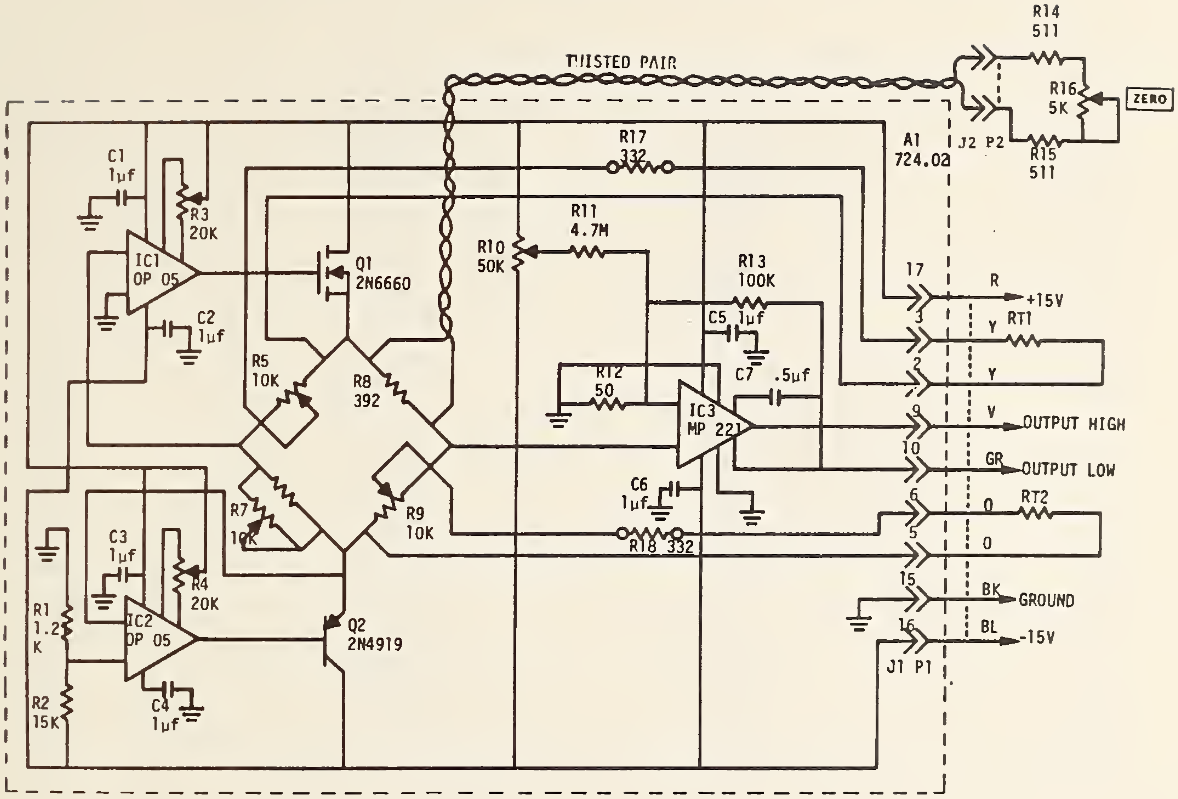


Figure 3-3. OSM bridge circuit schematic diagram (System H).

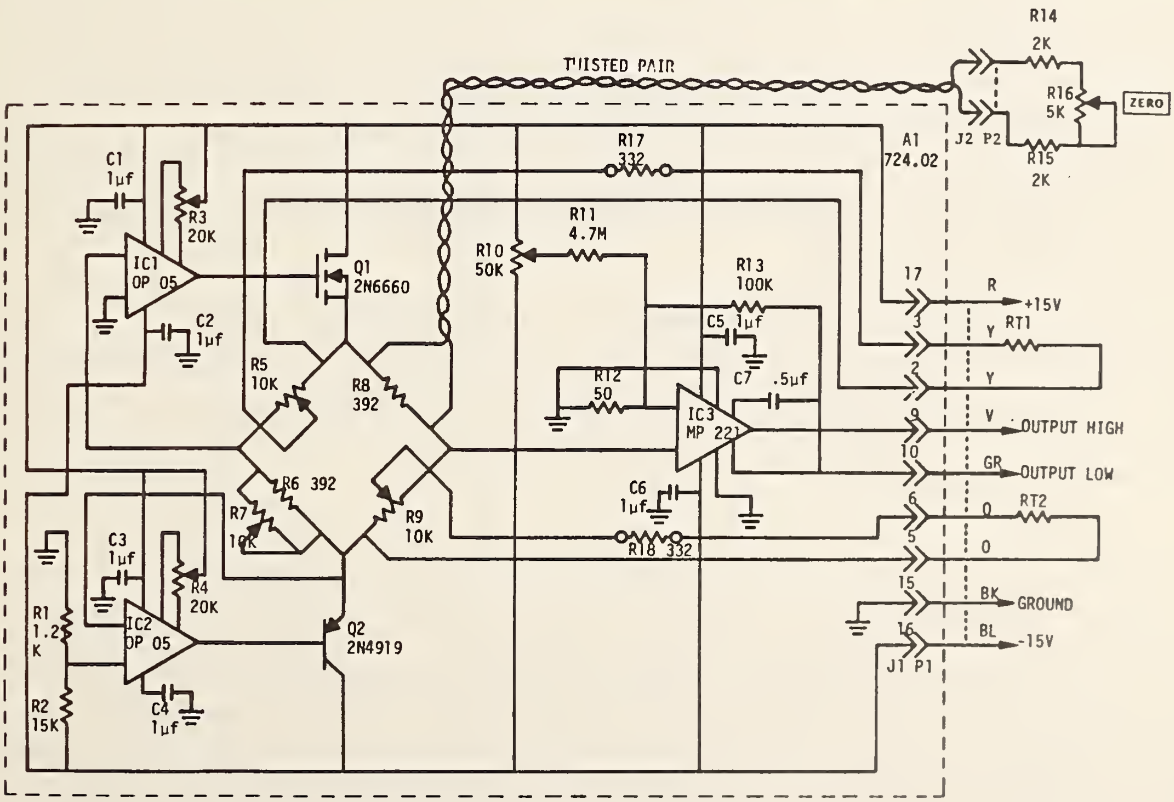


Figure 3-4. OSM bridge circuit schematic diagram (System T).

Table 3.1. Reflectance of aged, evaporated aluminum films.

λ, μm	R	λ, μm	R
0.400	0.9076	4.000	0.9758
0.450	0.9061	5.000	0.9772
0.500	0.9034	6.000	0.9784
0.550	0.9032	7.000	0.9794
0.600	0.9027	8.000	0.9801
0.650	0.8976	9.000	0.9807
0.700	0.8886	10.000	0.9812
0.750	0.8761	11.000	0.9816
0.775	0.8678	12.000	0.9821
0.800	0.8596	13.000	0.9826
0.825	0.8556	14.000	0.9830
0.850	0.8596	16.000	0.9838
0.875	0.8730	18.000	0.9845
0.900	0.8894	20.000	0.9852
0.925	0.9030	22.000	0.9856
0.950	0.9154	24.000	0.9861
1.000	0.9324	26.000	0.9864
1.200	0.9585	28.000	0.9867
1.500	0.9658	30.000	0.9870
2.000	0.9699	32.000	0.9872
3.000	0.9736		

Two 56 Ω RTDs made of #40 copper wire are used to measure the temperature rise of the BSM. They are wound in a rectangular shape around the central aperture leaving two spaces 2.54 cm wide along each 30 cm edge of the aperture. These two spaces are for the calibrating heaters (see below). The RTDs form the opposite arms of the bridge circuit in figure 3-5 for System H and figure 3-6 for System T. This circuit is on a PC board in the same circuit box with the OSM PC board. As with the OSM circuit, the zero adjust pot, R16, for the BSM is located on the circuit box. Leads from the PC board to the data acquisition rack are via pins 13 through 24 of the 24-pin connector. A diagram of the 24-pin connector is shown in figure 3-7.

The two calibrating heaters are commercially available. They are each 30.5 cm long and 2.54 cm wide. Each has a resistance of 11.1 Ω and they are connected in series. Maximum power dissipation for the total series combination is limited to 336 W to prevent possible damage. Connections to these heaters is via a six-pin connector on the circuit box. The connector in figure 3-2 also serves for this circuit.

3.3.4 OSM/BSM Shutter

As mentioned in section 3.3.1, a shutter is used to block the aperture in the OSM/BSM section. Normally, this shutter is closed for all phases of electrical and laser runs except for those time periods corresponding to laser energy injection. The shutter is made from two pieces of electropolished stainless steel that are opened and closed by individual motors which drive them through rack and gear arrangements. The "open" and "closed" positions of each shutter section are sensed by miniature roller-action switches. Each shutter section is powered independently of the other and thus a

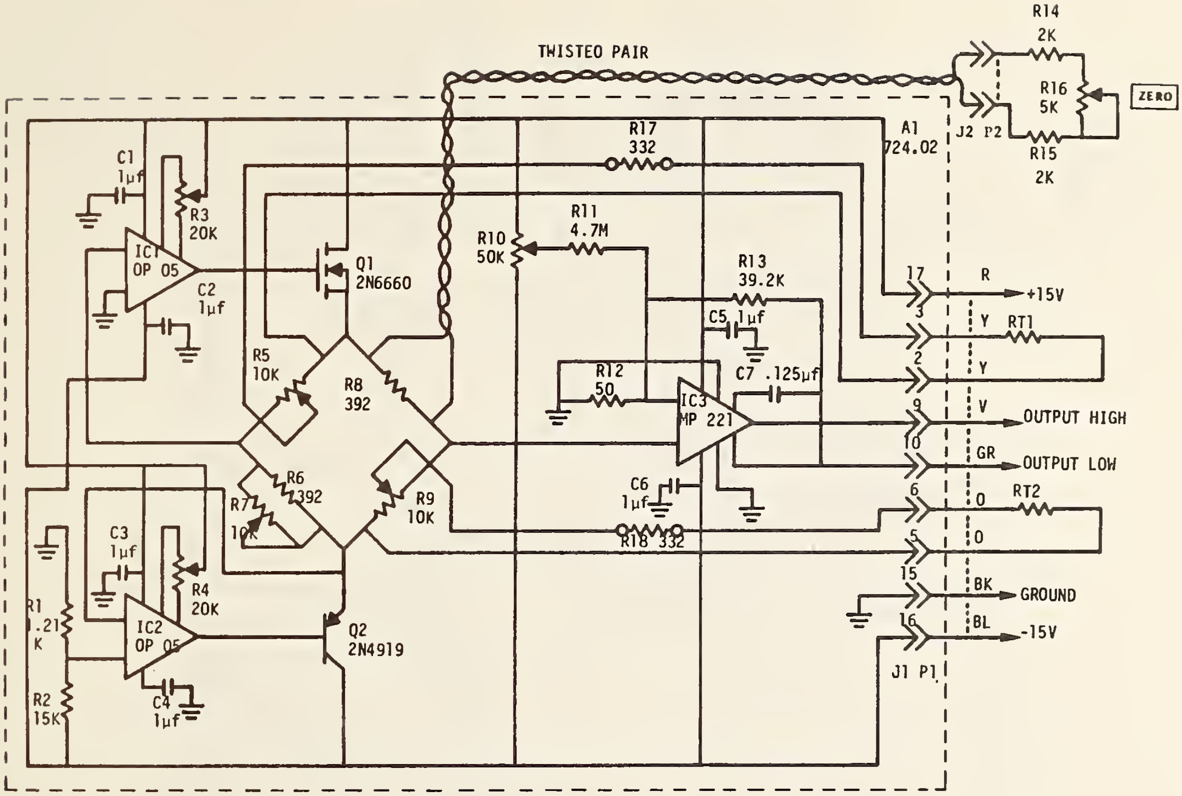


Figure 3-5. BSM bridge circuit schematic diagram (System H).

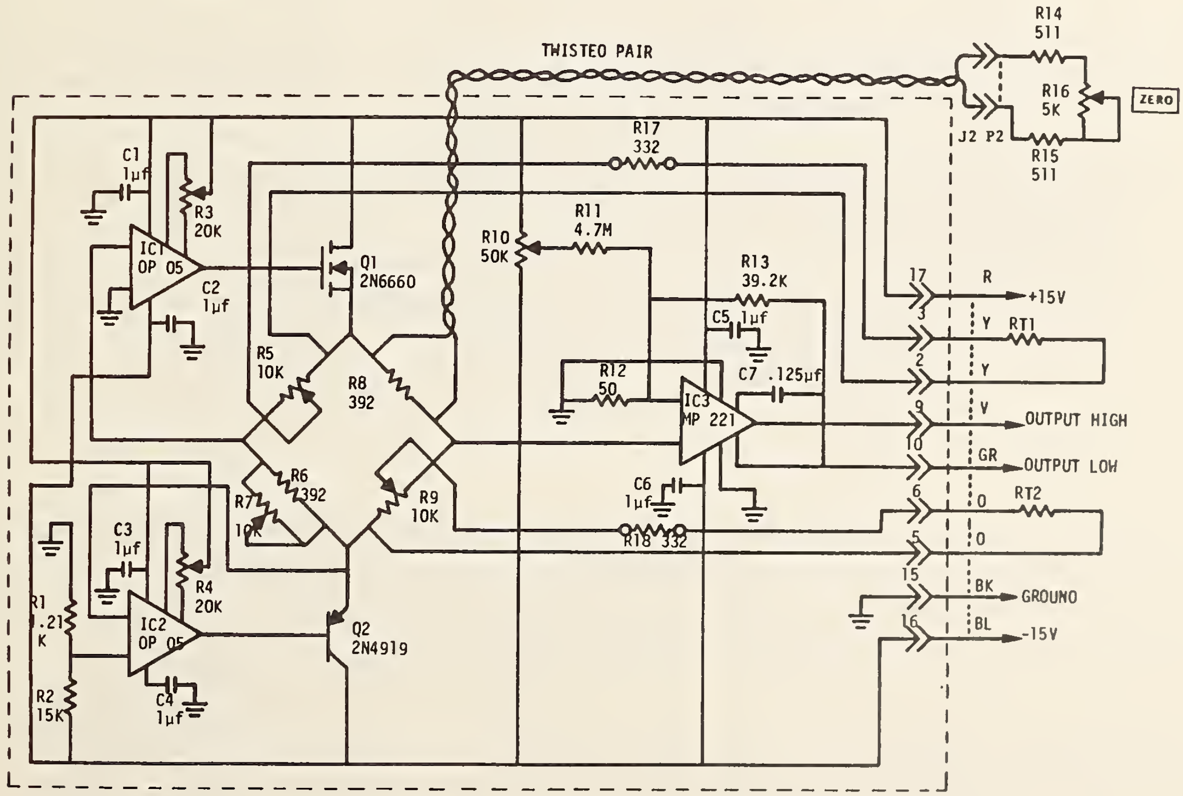
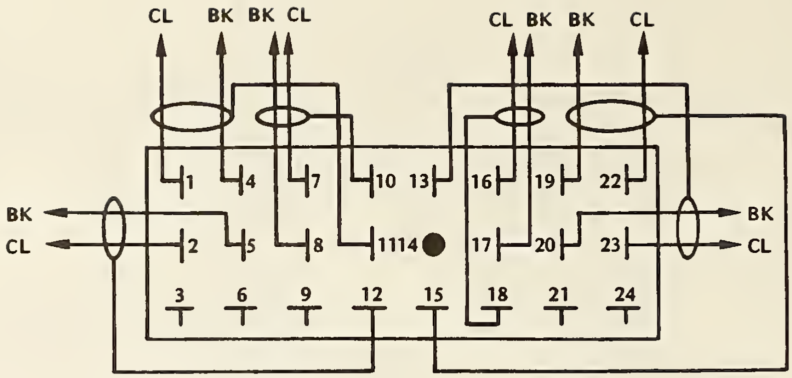


Figure 3-6. BSM bridge circuit schematic diagram (System T).



PIN	ACQUISITION RACK CONNECTION	PIN	ACQUISITION RACK CONNECTION
1	+15V DC POWER SUPPLY DECK	13	-15V SHIELD
2	-15V DC POWER SUPPLY DECK	14	NC
3	NC	15	+15V SHIELD
4	GROUND POWER SUPPLY DECK	16	SCANNER CONTACT 07 H
5	GROUND POWER SUPPLY DECK	17	SCANNER CONTACT 07 L
6	NC	18	SCANNER CONTACT 07 SHIELD
7	SCANNER CONTACT 08 H	19	GROUND POWER SUPPLY DECK
8	SCANNER CONTACT 08 L	20	GROUND POWER SUPPLY DECK
9	NC	21	NC
10	SCANNER CONTACT 08 SHIELD	22	+15V DC POWER SUPPLY DECK
11	+15V SHIELD	23	-15V DC POWER SUPPLY DECK
12	-15V SHIELD	24	NC

Figure 3-7. Wiring diagram of the 24-pin connector on the OSM/BSM circuits box.

slower moving one will complete its operation even after the other has terminated its movement. Position of the shutter is indicated by a red or green LED on the status light panel on the data acquisition rack. Red indicates "closed" and green "open."

Operation of the shutter is controlled by relays K1 through K9 in the circuit shown in figure 3-8. Commands to open or close the shutter may be initiated manually or by computer control. The manual pushbuttons OPEN, CLOSE, and STOP can be used during a computer controlled run to override computer commands if so desired. The computer uses scanner contacts 32 to open and 33 to close the shutter. Connection for operating the shutter is made via a 14-pin connector mounted on a 10.16 cm by 5.08 cm by 5.08 cm aluminum circuit box.

3.4 Separation Tube

The separation tube is similar to the extension tube (see section 3.2) except for values of components in the bridge circuit. Figure 3-9 is a schematic diagram of the bridge circuit for System H and figure 3-10 is for System T. All constructional details of the two tubes were made as close as possible to be alike, including sensor resistance and heater resistance.

3.5 Mirror Reflector Surface

3.5.1 Description of Module Supporting Frame

The mirror reflecting surface module is used to direct the incoming horizontal laser beam downward at a 90° angle into the volume absorbing material in the main calorimeter. This beam steering is

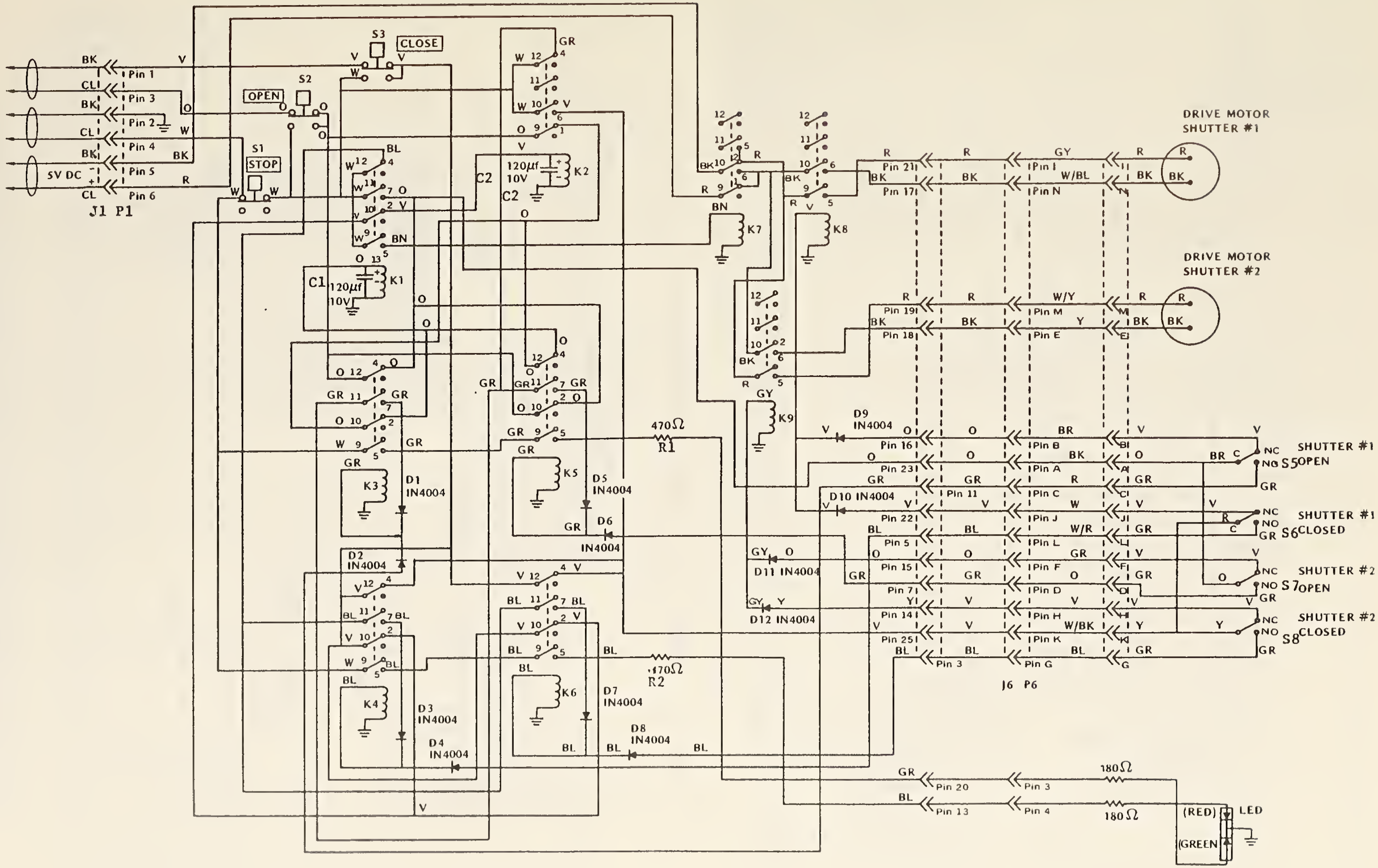


Figure 3-8. OSM/BSM shutter circuit schematic diagram.

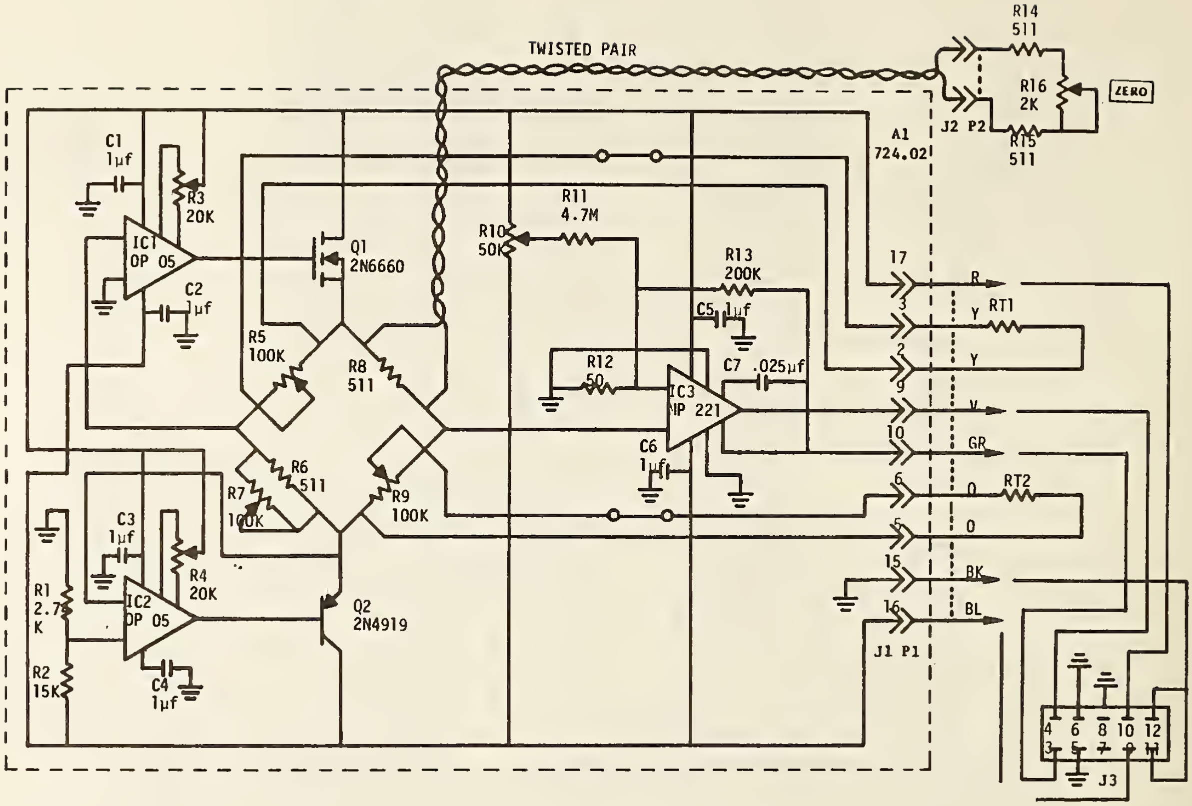


Figure 3-9. Separation tube bridge circuit schematic diagram (System H).

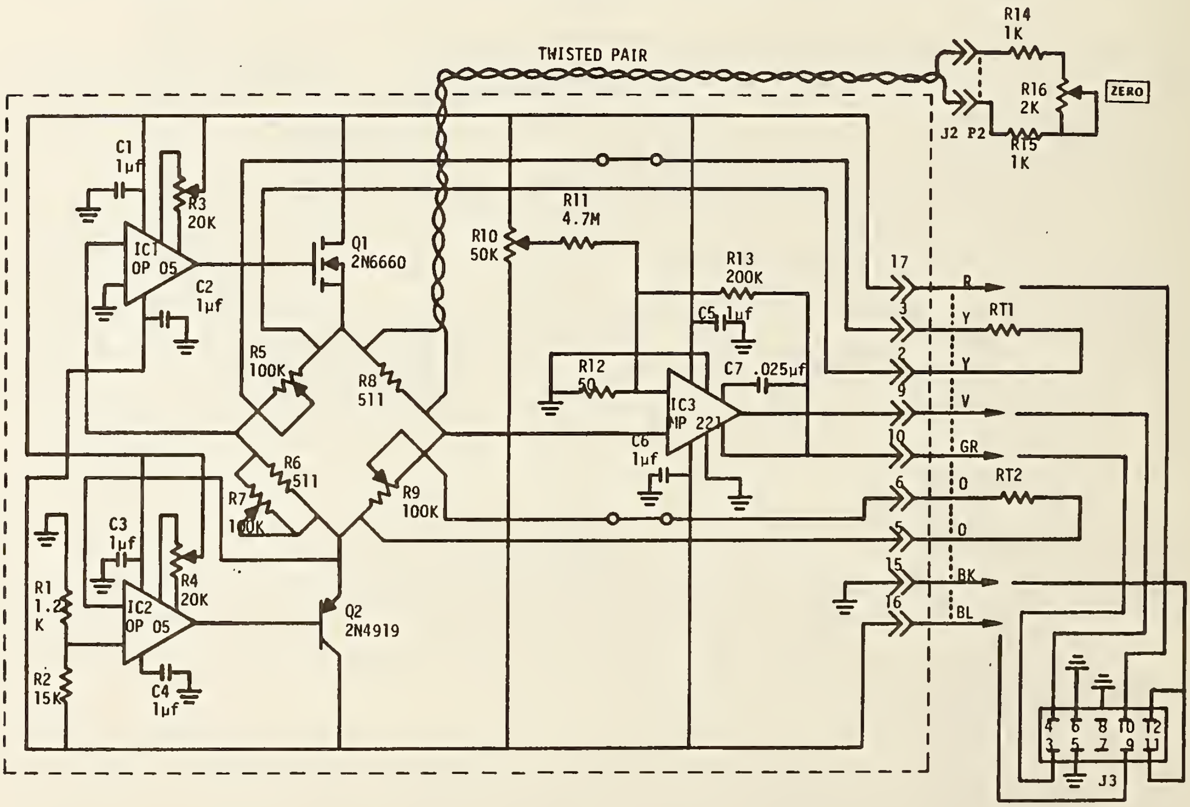


Figure 3-10. Separation tube bridge circuit schematic diagram (System T).

necessitated by the fact that the volume absorber is often in a form that does not lend itself to a vertical orientation; e.g., small pellets, glass plates, etc.

The deflector unit consists of a frame of 1.6 mm aluminum which holds a reflecting surface at a 45° angle to the incoming beam. The dimensions of the reflecting surface should be approximately 53 cm by 38 cm to best fit the frame. The front face of the frame, through which the laser beam enters, has a 43 cm diameter ring for connecting to the separation tube. The bottom surface of the frame, through which the laser beam exits, has a 43 cm diameter tube 19.5 cm long which projects down to the top surface of the main calorimeter. This tube plus the two triangular sides of the frame and the back of the reflecting surface are all instrumented for performing electrical calibrations and measuring temperature rise. The entire frame is enclosed in an aluminum box, lined on the inside with 2.54 cm foamed polystyrene, for isolation from the outside environment.

Each triangular side of the frame has a 10.16 cm diameter, 677 Ω heater at its center. The 43 cm diameter tube has two 63.5 cm by 10 cm heaters, each 145 Ω, wrapped around the outside. These four heaters plus the one on the backplate are connected in parallel at a 10 contact terminal block from which leads are brought out to a six-pin connector on a circuit box (connections are as in fig. 3-2). Figure 3-11 is a schematic wiring diagram of the heaters. The resistance values of the various heaters are chosen to approximate relative heat distributions expected from laser shots.

The resistance thermometers (RTDs) are made from #40 copper wire. All windings are placed on 89 μm thick mylar tape with adhesive on both sides. This tape serves to insulate the windings from

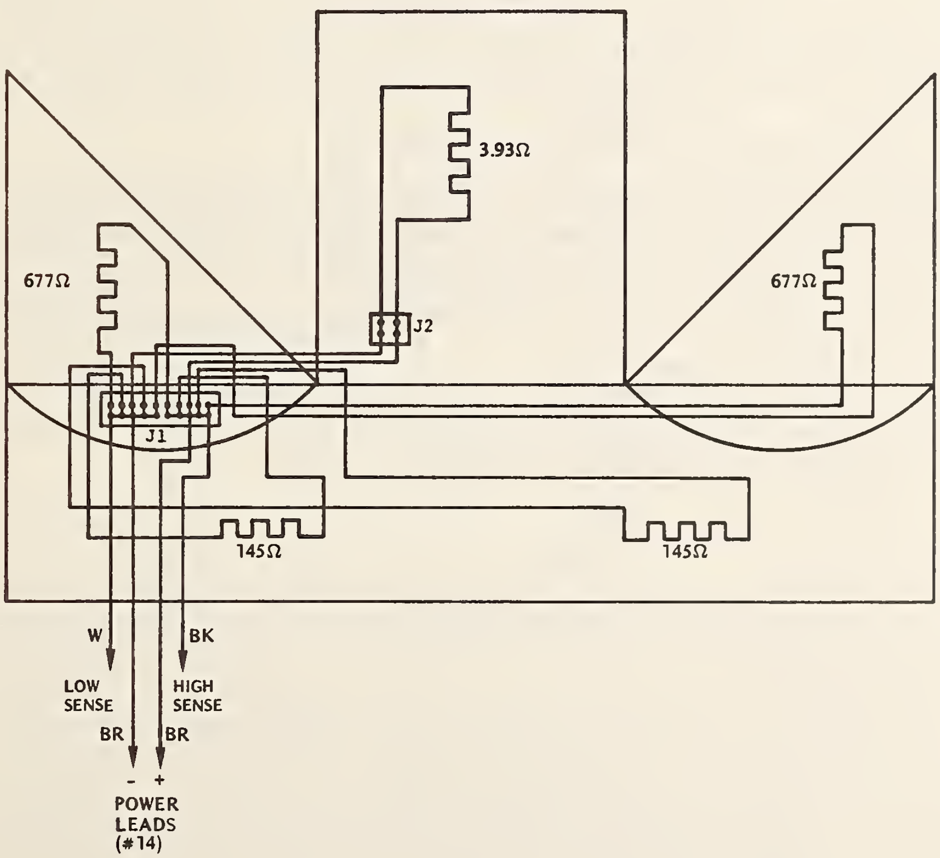


Figure 3-11. Schematic wiring diagram of deflector heater circuit.

the metal and to hold them in place. They are covered with another piece of mylar and finally with 89 μm copper foil tape.

On the frame the two triangular sides and the tubular bottom were wound with two bifilar windings. Both RTDs cover the three sections with continuous strands of the #40 copper wire. These are brought out to an eight-contact terminal block which is attached to the frame with epoxy. Leads from the RTD on the mirror reflector are connected in series at the terminal block as shown in figure 3-12 and twisted pair leads brought out to the PC board in the circuit box on the outside of the unit.

On the triangular sides of the frame the pattern of the RTDs is a right isosceles triangle with 25.4 cm legs. Each side has 3.8 turns. The tubular bottom has 5 turns. Resistance of the total thermometer is 300 Ω (including the 200 Ω of the mirror backplate).

The bridge circuit is shown in figure 3-13. Leads are brought out from the PC board to a 10-pin connector on the circuit box.

3.5.2 Deflecting Plate

The deflecting plate is a rectangular mirror approximately 2 cm thick. The mirror has a copper surface and therefore should not be used at uv wavelengths because of its reduced reflectivity. This surface will be useful in ir wavelengths and at longer visible ones.

The mirror itself does not contain the temperature sensors and electrical calibration heaters; these are mounted on a 1.6 mm thick aluminium backplate which is maintained in close thermal contact with the mirror by means of clamps and a layer of silicone grease. The central region of the backplate which holds the calibration heater is thermally isolated from the outer region by slots which are designed to force the electrical heat to flow into the mirror and back out again before reaching the sensors.

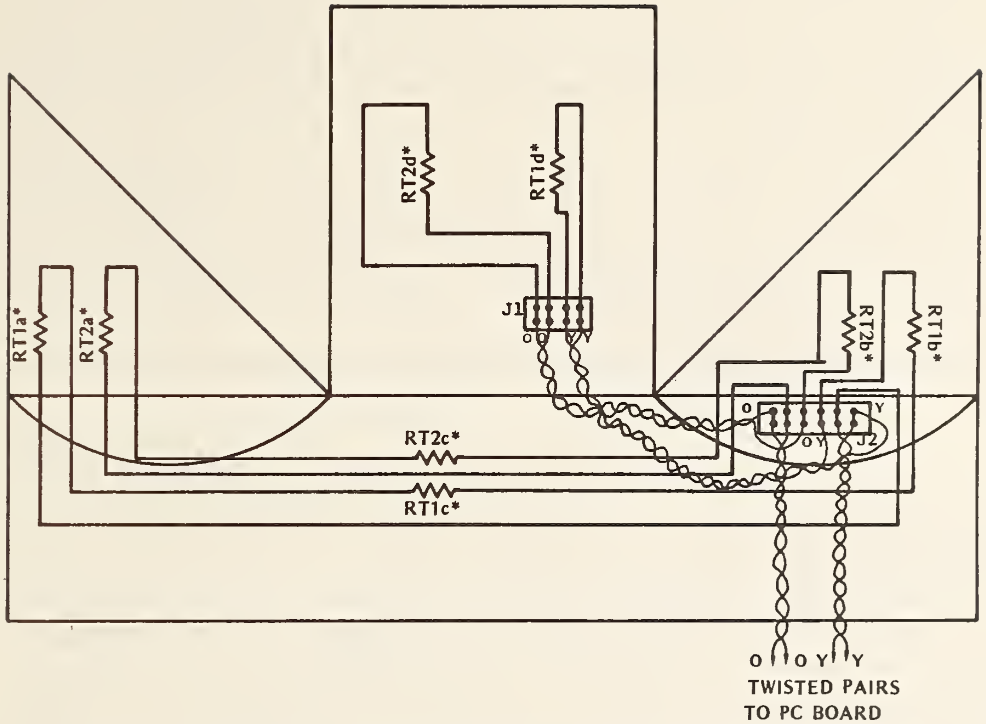
The sensor is two pairs of bifilar windings in the shape of a rectangular spiral. Thirty turns of #40 copper wire are used, giving a resistance of 200 Ω. Leads to the RTD are connected via lugs to a four-contact terminal block attached to the backplate with epoxy. The RTD is mounted using mylar tape with adhesive on both faces to hold the #40 wire in place and covered with copper foil tape.

The heater is a commercially available model and has a resistance of 3.93 Ω. It is mounted in the central, isolated section of the backplate. Its leads go to a two-contact terminal block on the backplate before being connected in parallel with the other heaters.

3.5.3 Foil Reflector

The foil reflector was designed to furnish a "throw away" mirror surface. This was deemed prudent because of the high probability of damage from the intense laser pulses.

The support for the foil is an aluminum plate with a depression machined in the front side. A rectangular ring is attached with screws around the perimeter to hold the foil reflecting surface in place. The reflecting surface can be made from thin aluminum foil or from thin sheets of the metal. The critical elements are that it have a shiny surface and be made by a rolling process since this will reduce the number of potential damage sites. Also, the surface must be free of grease and fingerprints.



*RT1a, b, & c and RT2a, b, & c are shown as series-connected lumped elements but are actually one continuous length of #40 copper wire for each thermometer (RT1 & RT2). The "d" elements are separate lengths of #40 copper wire connected as shown with twisted pairs of #20 copper wire.

Figure 3-12. Schematic wiring diagram of deflector RTD circuit.

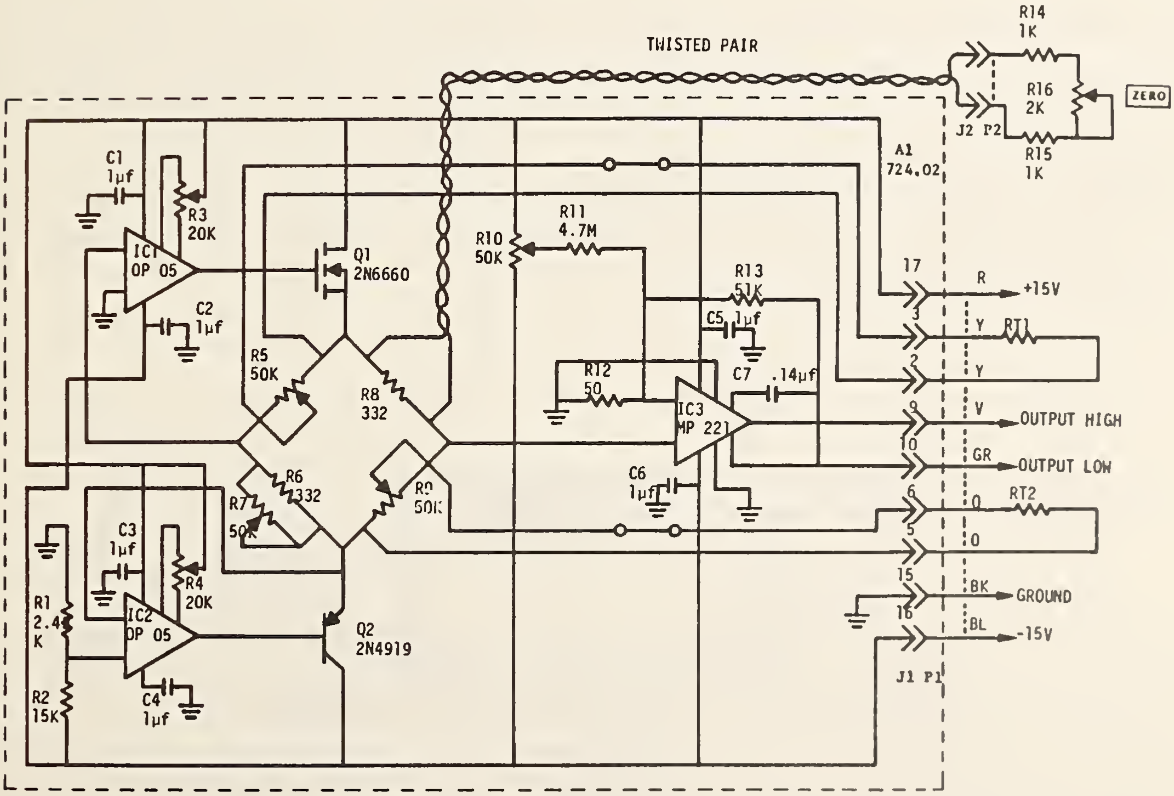


Figure 3-13. Schematic wiring diagram of deflector bridge circuit.

While the surface does not have to be of high optical quality it should be reasonably smooth so that little or none of the laser radiation will miss the main calorimeter. Thin sheets will probably have enough rigidity to maintain the proper shape. Thin foil will more likely need careful stretching and a slight negative pressure applied through a fitting on the backside of the support place to achieve a satisfactory surface.

The electrical heater is mounted to one side of the fitting on the back. It is 12.5 cm by 17.5 cm and has a resistance of 44.5 Ω. The temperature sensor is two pair of bifilar windings of #40 copper wire, each pair having a resistance of 200 Ω. These are wound in a "C" shape around three sides of the heater. Leads to the heater and the RTDs are connected to terminal blocks on the back side of the support plate so that the plate can be easily disconnected from the frame when it needs to be removed.

3.6 Main Calorimeter

3.6.1 General Features

The main calorimeter is a copper vessel, 43 cm in diameter and 24 cm tall. It consists of a top section which hangs down into a lower section. Located centrally on the top piece is a 15 cm by 30 cm aperture through which the laser beam enters. A motor driven shutter seals this aperture for all phases of electrical and laser runs except for the time corresponding to laser energy injection. Below the aperture is a gold plated compartment for holding the volume absorbing material. The holder can be of various designs; e.g., basket for pellets, rack for stacked plates, etc. The lower section of the calorimeter contains a heater for performing electrical calibrations plus a copper RTD.

As discussed in section 1, dry nitrogen gas is used as a vehicle for transferring the heat of the absorbed energy from the volume absorber to a heat sensing thermistor. The gas flows in through a pipe on the side of the bottom section, up through the porous volume absorber, into the upper section, and out a pipe on the side of the upper section. Figure 3-14 is a cross sectional diagram of the calorimeter showing gas flow paths in the calorimeter and various sensor locations.

The whole calorimeter fits into an insulated box for isolation from ambient changes. The box sits on a shelf just behind the legs for the separation tube. The box with the calorimeter can rotate 90° if it is desired to change the orientation of the input aperture. Also on the shelf are two circuit boxes for the associated electronics.

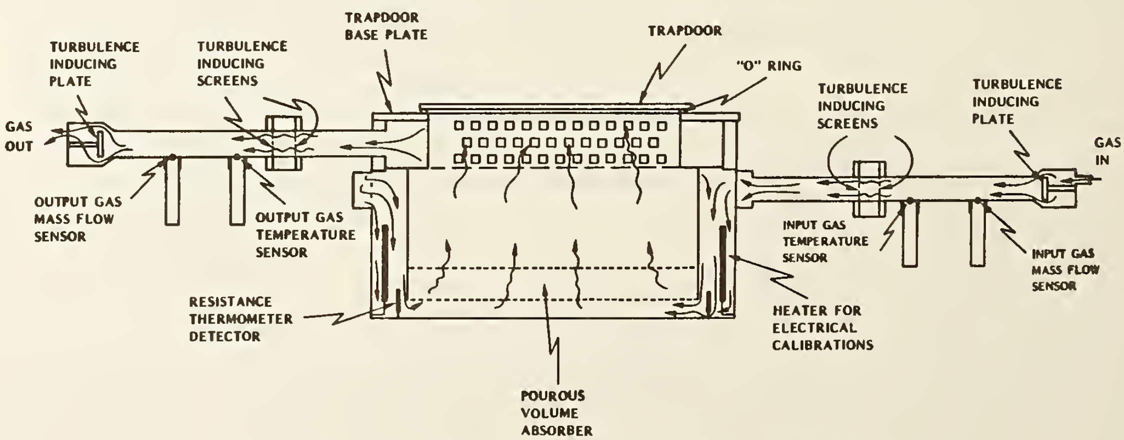


Figure 3-14. Cross sectional view of calorimeter unit.

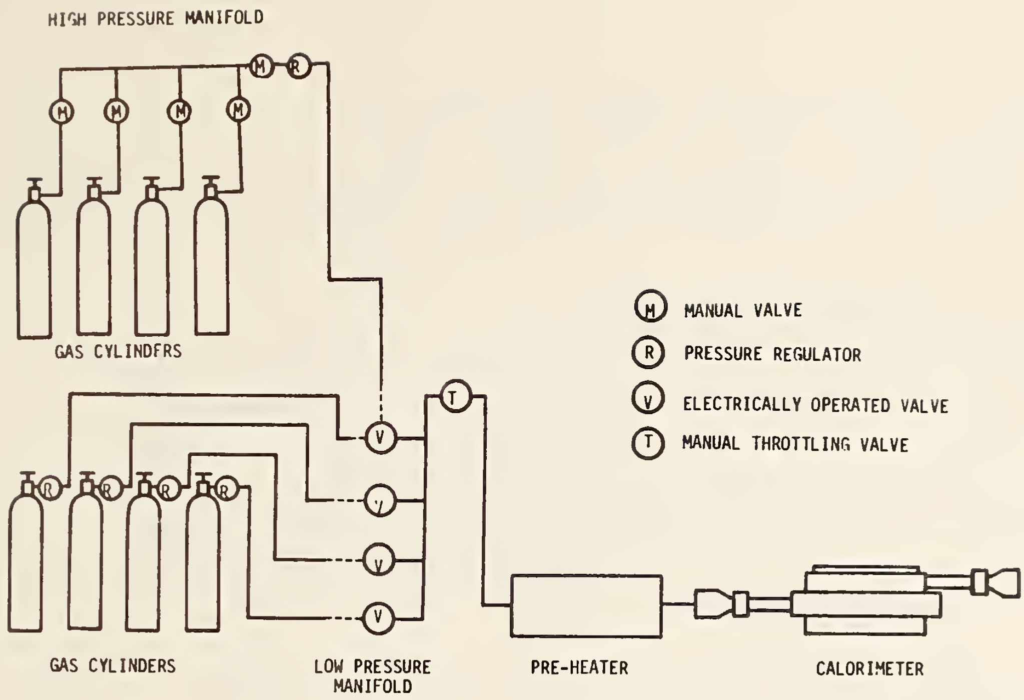


Figure 3-15. Total gas flow system for CLOP. Either the output from the high pressure manifold may be connected to an electrically operated valve on the low pressure manifold or individual cylinders with PRV's may be connected to the low pressure manifold.

3.6.2 Gas Flow

Figure 3-15 shows the total gas flow system. Gas flow is turned on and off with electrically controlled valves. Scanner contacts 34 through 37 actuate the four valves. Flow rate is controlled with PRVs and a throttling valve on the output of the low-pressure manifold. Dry nitrogen gas is supplied to the calorimeter by one of two methods. The preferred method uses three or more cylinders connected to a high-pressure manifold which has a PRV on its output, supplying gas at a constant reduced pressure to electrical valve #1 on the low-pressure manifold. All manifold valves to the cylinder are opened and two cylinders are opened up to the manifold while the rest are held in reserve. When the two cylinders begin to empty and the manifold pressure gets to the last graduation on the gauge, the manifold valve to one cylinder is shut off and the cylinder valve to the reserve cylinder opened. The empty cylinder can now be replaced with a full one. The operator should plan ahead of time to make this switch if the gas supply is in danger of running out during the data taking part of a run. When using this method of gas supply, manual valves on the output of unused electrical valves on the low-pressure manifold must be shut off to prevent back leakage through the electrical valves.

The second method uses two to four cylinders each with its own PRV and connected to separate electrical valves on the low-pressure manifold. This method is less desirable than the first because of the difficulty in setting two PRVs to the same pressure. The computer program (see section 4) leads the operator through the steps to adjust each regulator one at a time to get the same mass flow in reading for each PRV during the pre-run set up procedure. The operator presses a user-defined key during a run to turn off the empty cylinder and turn on the reserve cylinder. The empty cylinder can then be replaced. Thus there can be as low as one reserve cylinder or as many as three. The computer program is designed to handle any situation within this number. As with the preferred method, the operator should plan ahead to avoid running out of gas while he is out of the room during laser shots.

A preheater unit is installed after the low-pressure manifold to reduce temperature background drift caused by cooling due to adiabatic expansion of the gas. This preheater is rated at 680 W and with a resistance of 145 Ω can supply up to a nominal 100 W when operated with a 120 V ac adjustable autotransformer.

As shown in figure 3-14, when the gas enters the input arm of the main calorimeter, it strikes a flat plate which induces turbulent flow. Turbulence is required to ensure good mixing of the gas and maximum flow past the sensors located near the wall of the pipe. The gas then passes through a section in the input arm with a pair of screens which are used to break up laminar flow for cases where gas flow might be reversed. The gas then continues through the main chamber of the calorimeter and into the output arm. There it encounters another pair of screens which breaks up the laminar flow and induces turbulence. It then passes over the output sensors, comes to a final plate which (under reverse flow) corresponds to the initial plate, and flows out of the calorimeter.

In this section reference has been made to "reverse flow conditions." For some tests it may be advantageous to run the gas through the calorimeter opposite to what is normally done; e.g., in the top section, down through the volume absorber, and out the bottom section. Note that the calorimeter is designed symetrically with respect to input and output sensors and turbulence-inducing elements. Thus, the gas dynamics are roughly the same under both forward and reverse gas flow. However, no provision has been allowed for this in the computer program and the sensors will be labelled incorrectly. Also, input to the preheater control circuits will have to be changed.

3.6.3 Electrical Instrumentation

3.6.3.1 Thermistor Sensors

Thermistor sensors are used to measure the following gas parameters:

1. The mass of the gas flowing into the calorimeter,
2. The temperature of the gas flowing into the calorimeter,
3. The mass of the gas flowing out of the calorimeter, and
4. The temperature of the gas flowing out of the calorimeter.

The locations of these sensors are shown in figure 3-14.

Each sensor is actually a pair of thermistors in the opposite arms of the appropriate bridge circuits in figures 3-16 through 3-19. Figure 3-20 is a typical I-V curve for a thermistor. As explained in the figure, point A indicates the I-V point of the thermistor at 50°C while point B is for 300°C. The temperature sensors are operated in the linear portion of the curve well below point A as shown in the figure for greatest sensitivity to temperature changes of the gas. Conversely, the mass flow sensors are operated at some high temperature as shown in the figure in order to minimize the effect of temperature changes in the gas. The exact point of operation is set by the bias current and is chosen to make the thermistor operate where the slope is maximum and slow changing. For the mass flow thermistors the bias current is approximately 10 ma.

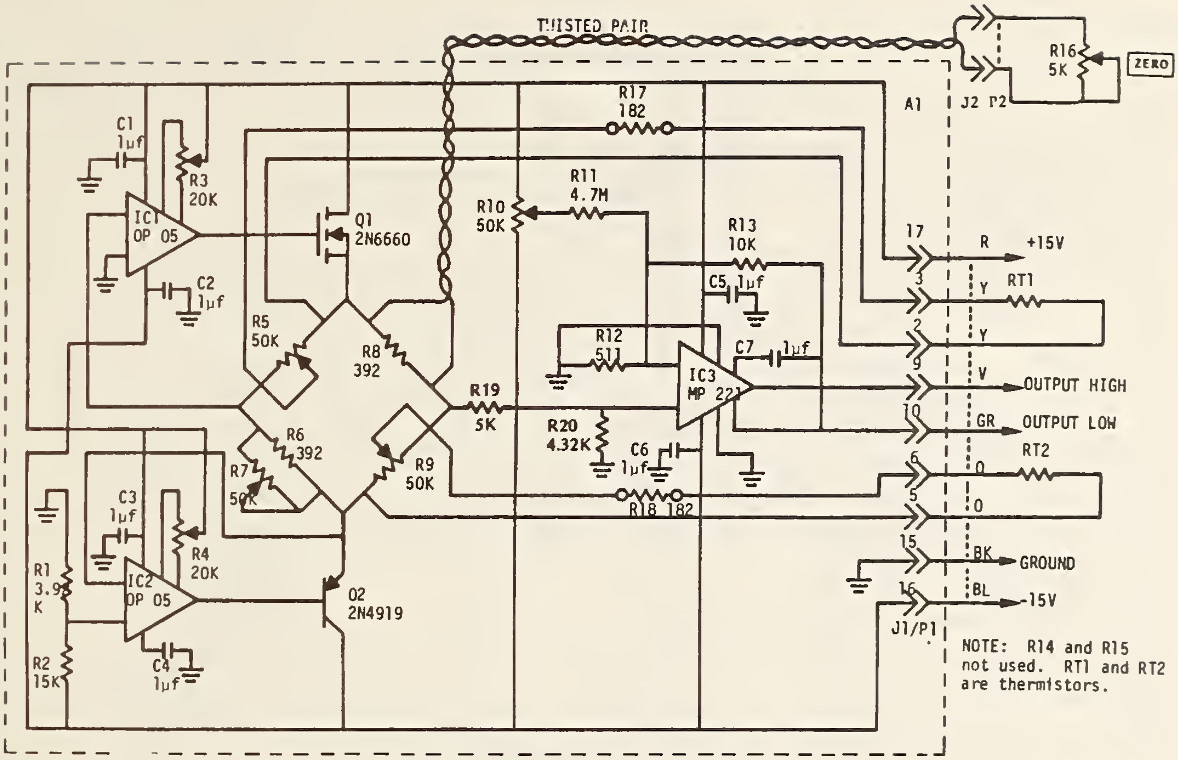


Figure 3-16. Schematic diagram of Mass Flow In bridge circuit.

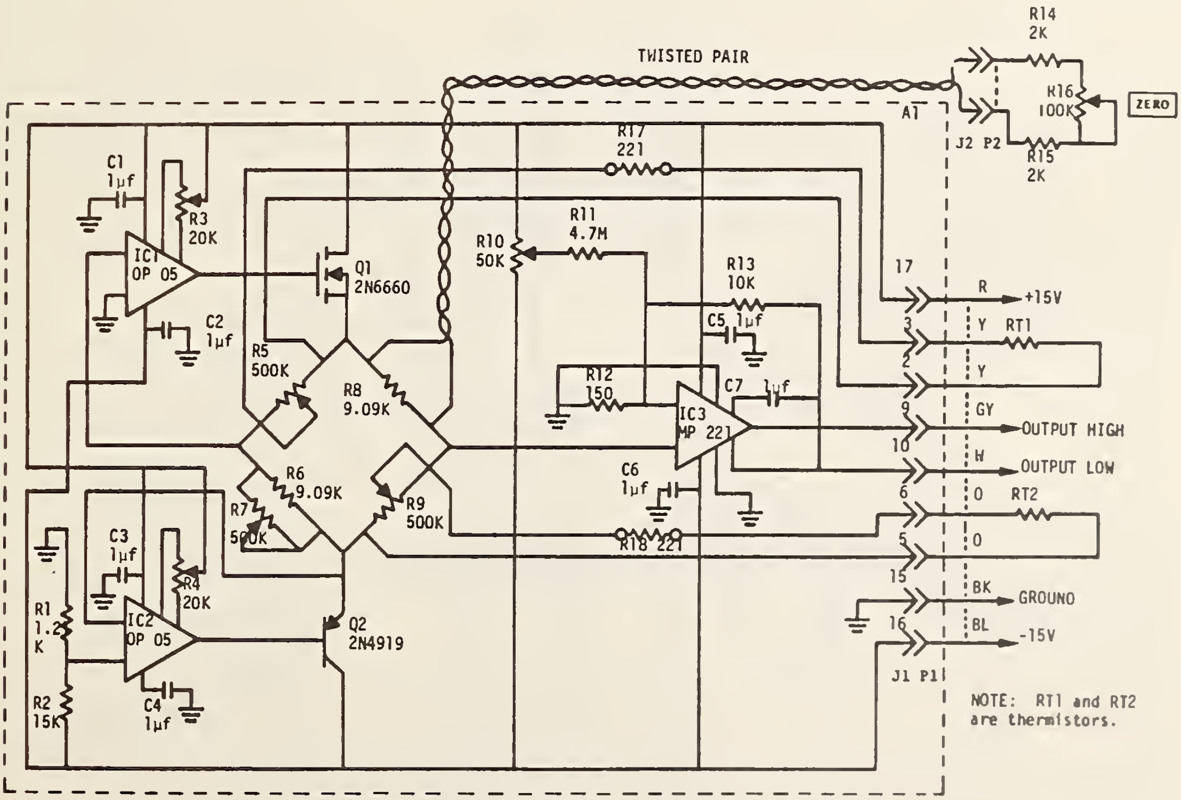


Figure 3-17. Schematic diagram of Temperature In bridge circuit.

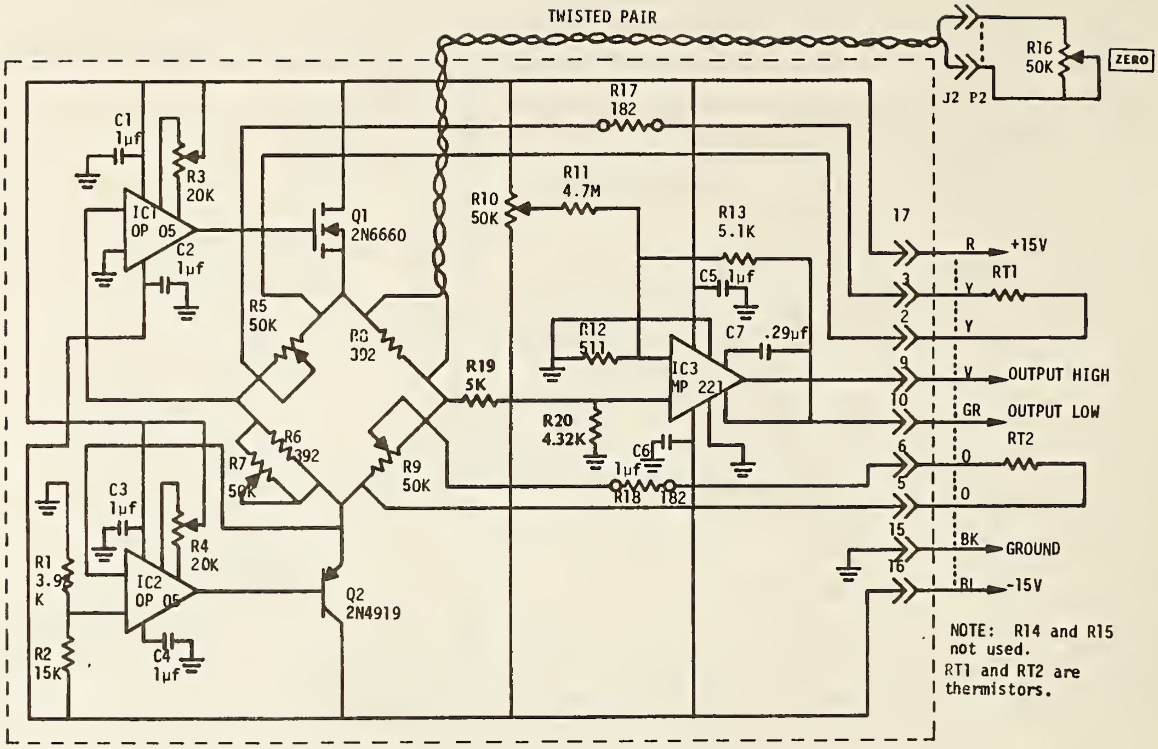


Figure 3-18. Schematic diagram of Mass Flow Out bridge circuit.

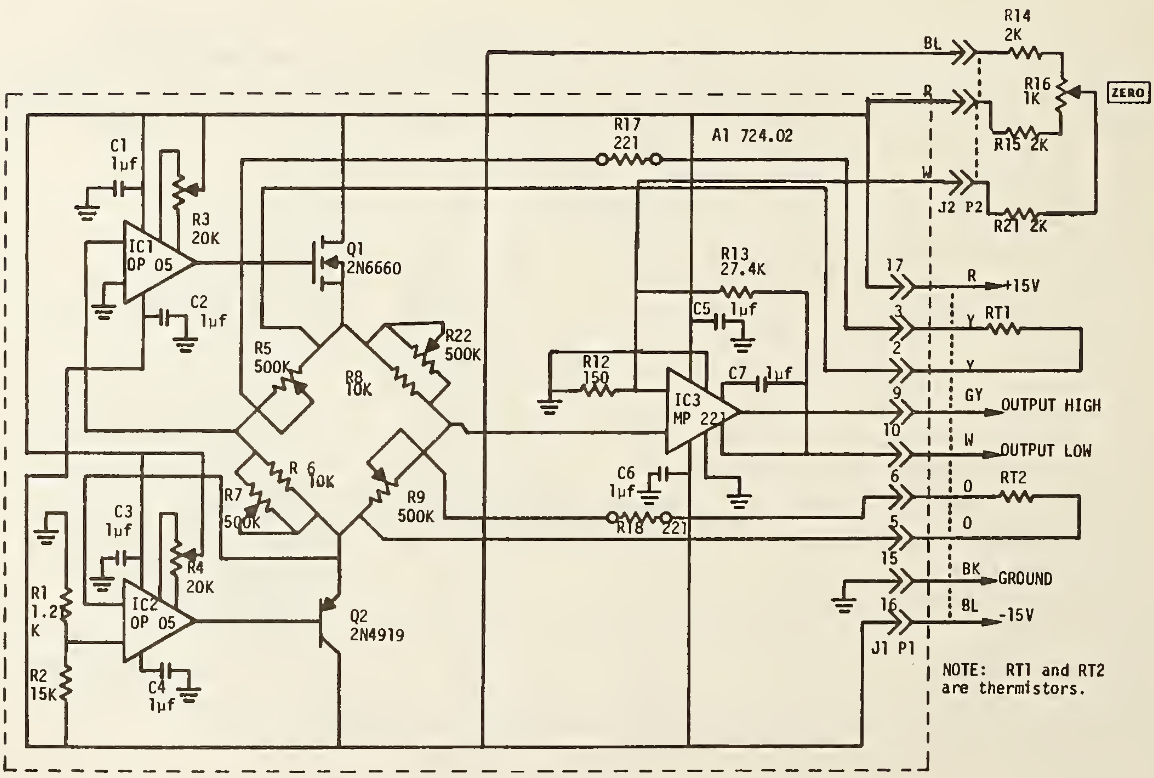


Figure 3-19. Schematic diagram of Temperature Out bridge circuit.

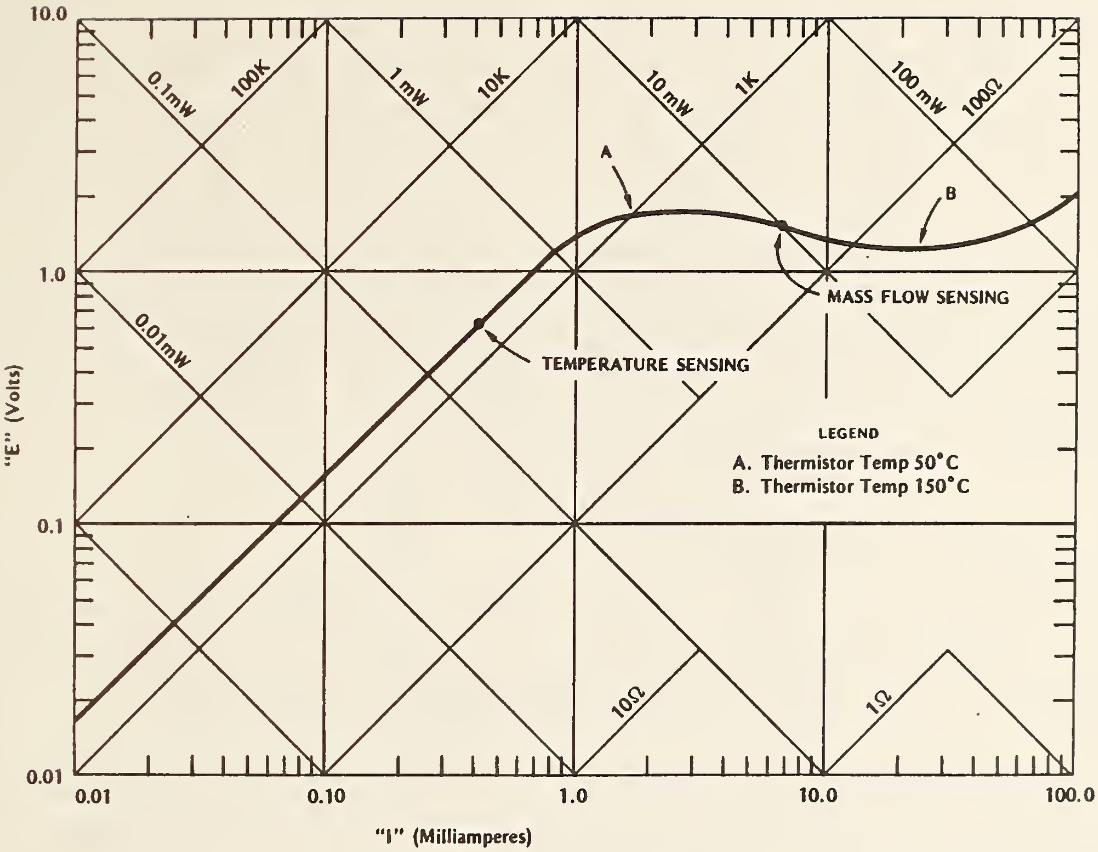


Figure 3-20. Typical I-V curve for thermistor sensors.

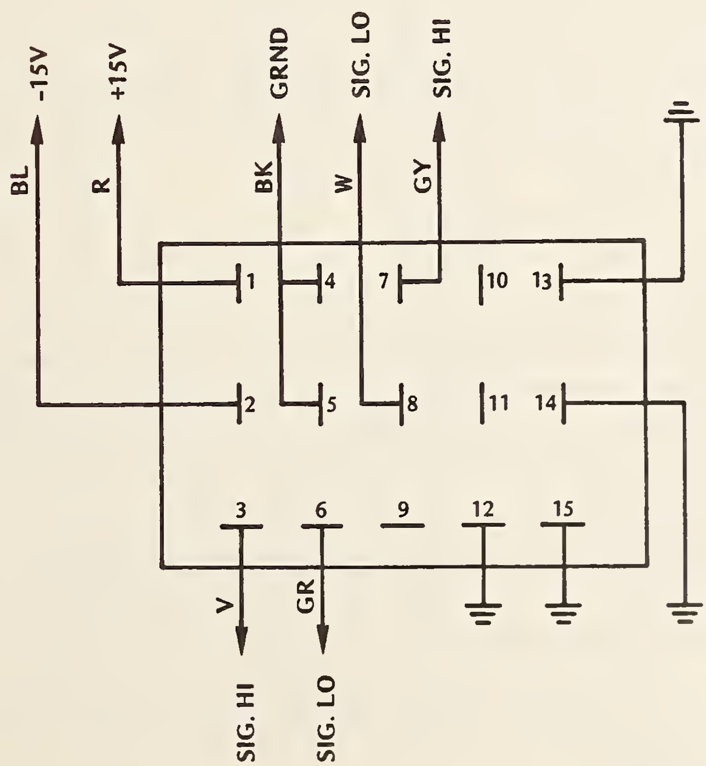


Figure 3-21. Wiring diagram for 15-pin connector on gas input circuits box.

The electronic circuitry for measuring the input gas parameters is housed in a circuit box mounted on a bracket on the left side (as the observer faces the input of the extension tube) of the shelf on which the calorimeter rests. The two zero-adjustment pots are mounted on the box. Connections to the bridge circuits are made via a 15-pin connector. Figure 3-21 shows the diagram for this connector.

A circuit box for housing the electronics for the output temperature and mass flow circuits is mounted on the opposite side of the shelf. This box also contains the circuit board for the main calorimeter RTD (see section 3.6.3.2, below). All circuit zero adjustments are mounted on the box. This box can be moved to the back of the shelf if the calorimeter is rotated 90°. Connections for the output gas mass flow and temperature measuring circuits plus the RTD are via a 24-pin connector whose wiring diagram is given in figure 3-22.

3.6.3.2 Resistance Thermometer Detector

A resistance thermometer detector (RTD) is installed in the lower section of the main calorimeter. It is located at the bottom just outside of the region where the lower part of the top section is suspended. The RTD is wound on a form of 16 equispaced posts made from 2.54 cm 4-40 screws. These are arranged in a circular pattern having a 36.8 cm diameter.

The RTD is made from 2 bifilar windings of 48 turns of #40 copper wire. The exact length was individually adjusted to equalize the two resistances to 219.5 ± 0.1 Ω at room temperature. The copper wires are enclosed between two pieces of 76 μm thick Teflon tape which are in turn covered with 89 μm thick copper tape which serves as a radiation shield. Leads to the RTD are brought through the wall via hermetic seals. Pins 1 and 3 are for one pair of wires and pins 2 and 4 for the other pair. The leads then continue to the same circuit box that contains the mass flow out and temperature out circuit boards (see section 3.6.3.1).

Figure 3-23 shows the bridge circuit for the RTD. As mentioned in section 3.6.3.1, the zero adjustment is located on the outside of the circuit box. Power and signal connections are via pins 16 through 24 of the 24-pin connector shown in figure 3-22.

3.6.3.3 Calibration Heater

A heater for performing electrical calibration is located in the lower section of the calorimeter. This heater is made of #18 nickel chromium wire and is wound on a cylindrical wire frame. Its resistance is 15 Ω. The turns are insulated from the wire frame by a layer of glass fiber insulating tape. The ends of the heater are anchored to ceramic standoff insulators. Power leads to the heater are copper braid. Voltage sensing leads are bare stranded copper wire. The two current leads and the two voltage sensing leads are fed through the calorimeter wall via individual ceramic hermetic seals. The leads continue on to the circuit box containing the gas output bridge circuits and go through a six-pin connector to the data acquisition rack. Pin connections for this connector are as shown in figure 3.2.

3.6.4 Main Calorimeter Shutter

As mentioned in section 3.6.1, a shutter is used to seal the input aperture of the main calorimeter for all phases of a run except for that time corresponding to laser energy injection. It is

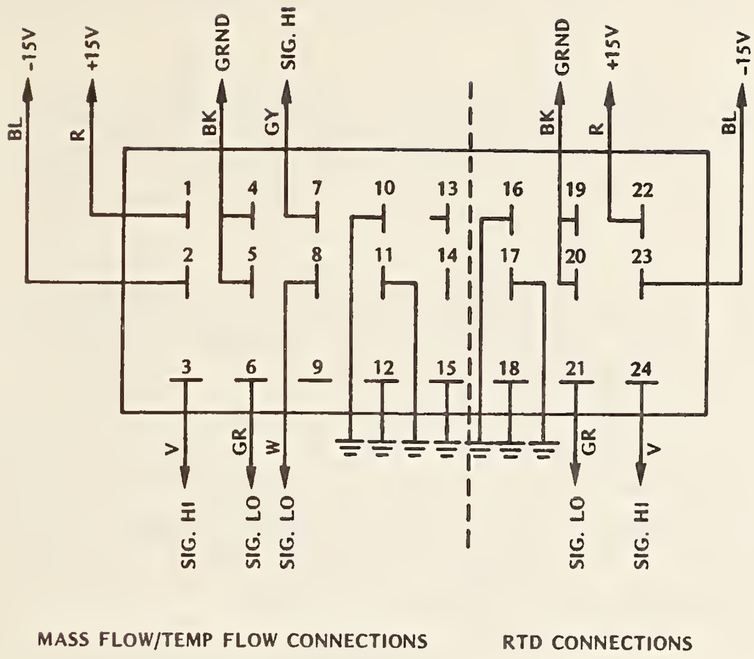


Figure 3-22. Wiring diagram for 24-pin connector on gas output circuits box.

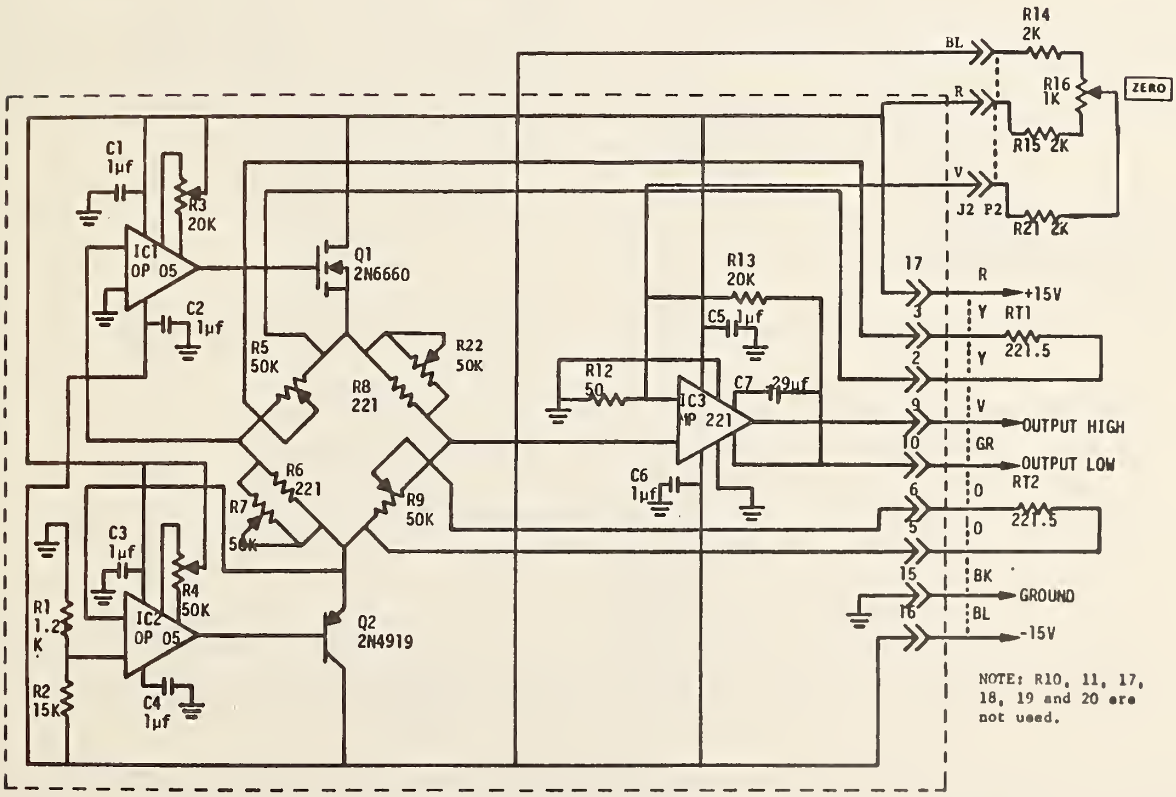


Figure 3-23. Schematic diagram for the bridge circuit for the main calorimeter RTD.

essential that the seal be free from gas leaks as any loss of gas will ultimately result in an error in the measurement of injected energy. This is true for both electrical calibrations and laser measurements.

The shutter is in the form of a motor-driven trap door used in conjunction with a motor-driven latch for sealing purposes. The trap door is made of 6.25 mm aluminum and seals against a 6.25 mm aluminum baseplate. An O-ring is used to effect a gas tight seal. The O-ring should be frequently checked for laser damage.

The latch consists of a rotating shaft with two arms which press down on the two corners opposite the hinged side of the trap door. A screw adjustment is provided on each arm to precisely set the amount of pressure needed for a gas-tight seal.

When closing, the trap door moves first and when its operation is completed the latch begins operation. This sequence is reversed when the shutter is opening. Miniature roller action switches sense when the trap door and latch reach the limits of their movement. Leads from the four switches and two motors all come out to a 25-pin connector which connects to a cable from the data acquisition rack where the controlling circuitry is located.

The shutter may be operated manually using pushbuttons labelled "OPEN," "CLOSE," and "STOP" or it may be operated under computer control through scanner contacts. Momentary closure of scanner contact 30 opens the shutter while momentary closure of contact 31 closes the shutter.

Figure 3-24 is a schematic diagram of the control circuit for the calorimeter shutter. A six-pin connector, J1, on the chassis brings in +10 V dc to operate the relays and a floating 5 V dc for powering the two motors. The polarity of this 5 V dc is reversible through the action of relay K5 to control motor direction. The six-pin connector also brings in the OPEN and CLOSE signals from the scanner.

3.7 Data Acquisition Rack

3.7.1 General Description

The data acquisition rack contains equipment for performing the following tasks:

1. Controlling the sequence of events during electrical calibrations.
2. Controlling the sequence of events during laser energy measurements.
3. Accumulating, storing, and processing data from the various sensors in CLOP.
4. Measuring, recording, and processing the dc calibration voltage and current values.
5. Furnishing electrical power to all modules of CLOP.
6. Controlling electromechanical operations.
7. Maintaining the temperature of the input gas to the main calorimeter at a constant value.
8. Visually indicating the status of various critical elements of CLOP during runs.

The rack is 1.71 m (67.25 in) high by 0.61 m (24 in) deep. It has a front and rear opening, each 1.556 m (61.25 in) high in which may be mounted standard 48.2 cm (19 in) width panels. The rack is mounted on casters to permit easy movement.

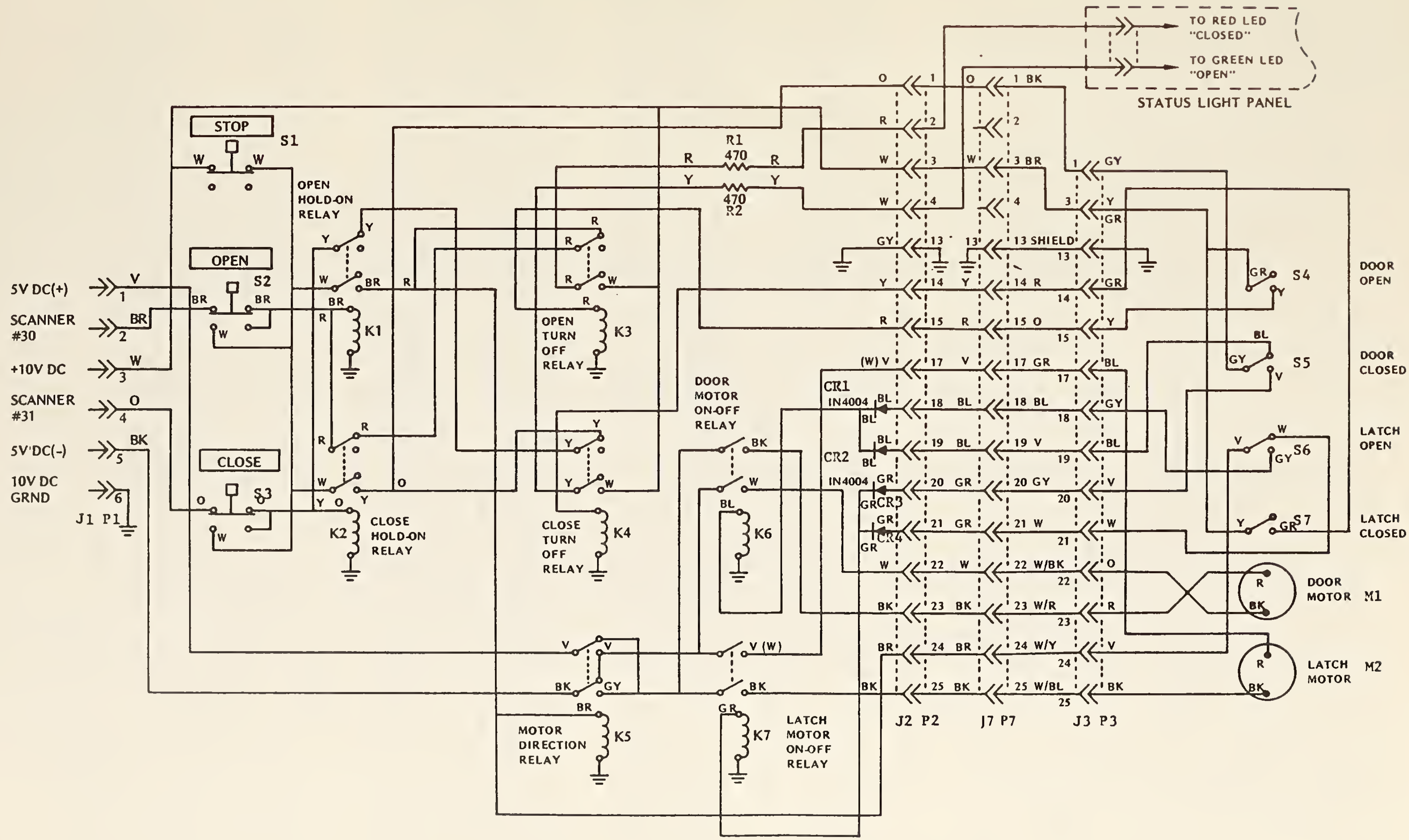


Figure 3-24. Schematic diagram of calorimeter shutter circuit.

Figure 3-25 is a front view drawing of the rack for System H showing the positions of various pieces of equipment. The rack for System T, shown in figure 3-26, is quite similar except as noted below. Figure 3-27 is a rear view drawing showing the location of the outputs for the cables to CLOP and the ac power outlet locations. This section (3.7) will describe the various pieces of equipment in the data acquisition rack in the order of location in the rack, first the front from top to bottom and then the rear from top to bottom. There are two major differences in the computers which affect the data acquisition rack for each system. These are the large size of the System T computer which prevents it from fitting into the rack and the fact that the System H computer possesses an internal clock system for timing events while the System T computer does not. The first difference means that System T is located separately from the data acquisition rack. Its space is advantageously filled with the preheater control circuit which, in System H, is crowded onto the panel with the calibration power supply status circuit (see sections 3.7.10 and 3.7.13). The second difference requires a separate pacer (timing unit) for System T. This is a half-rack width instrument and is located next to the DVM, also a half-rack width instrument (see section 3.7.8).

3.7.2 Main Power Switch Panel

The main power switch panel is used to turn on and off the 115 V ac to the various units in the data acquisition rack. This is done with the white rocker switch on the front of the panel. Also mounted on the front of the panel is a neon pilot light and the RESET button of a 15 A circuit breaker. Figure 3-28 is a wiring diagram of the panel.

The panel uses a two wire (high and neutral) plus case ground system. Its input cord plugs into an outlet on the ac input panel (see section 3.7.11) and its output is a duplex outlet mounted on the back side of the panel. A seven-plug outlet strip which is mounted on the back of the rack is plugged into this duplex outlet. The various pieces of equipment in the rack plug into the outlet strip.

3.7.3 Scanner

The scanner is used to connect the output of the various sensors to the digital voltmeter (DVM) and to furnish signals for controlling various operations. This instrument has two plug-in units to perform these functions. A 20-contact duodecade unit is used to switch the sensor outputs. A 10-contact actuator unit is used to control the operations. Full information on the contact arrangement of these plug ins is given the manufacturer's instruction book. Table 3.2 is a list of the instruments connected to the scanner channels. The sensors are connected to channels 00 through 14 and the operations are controlled by channels 30 through 37 as described in table 3.2.

The scanner is operated with the IEEE 488 bus. Its address is 9. Since for the System H computer the general address of the bus is 700, an example of the command to the scanner to turn on channels 7 and 32 and turn off all others is OUTPUT 7Ø9 USING "K"; "3,Ø7,32" for System H. For System T this command is PRINT@9: "3,07,32".

The expression USING "K" is required in the System H command to have the duodecade function correctly. The "3" in the command opens all contacts in the 30 decade. The "Ø7" closes contacts 7 in the duodecade and by the nature of this plug-in all others are opened. Finally, the "32" closes these contacts. If contacts 32 had been already closed they would have remained closed continuously even though the "3" command was given.

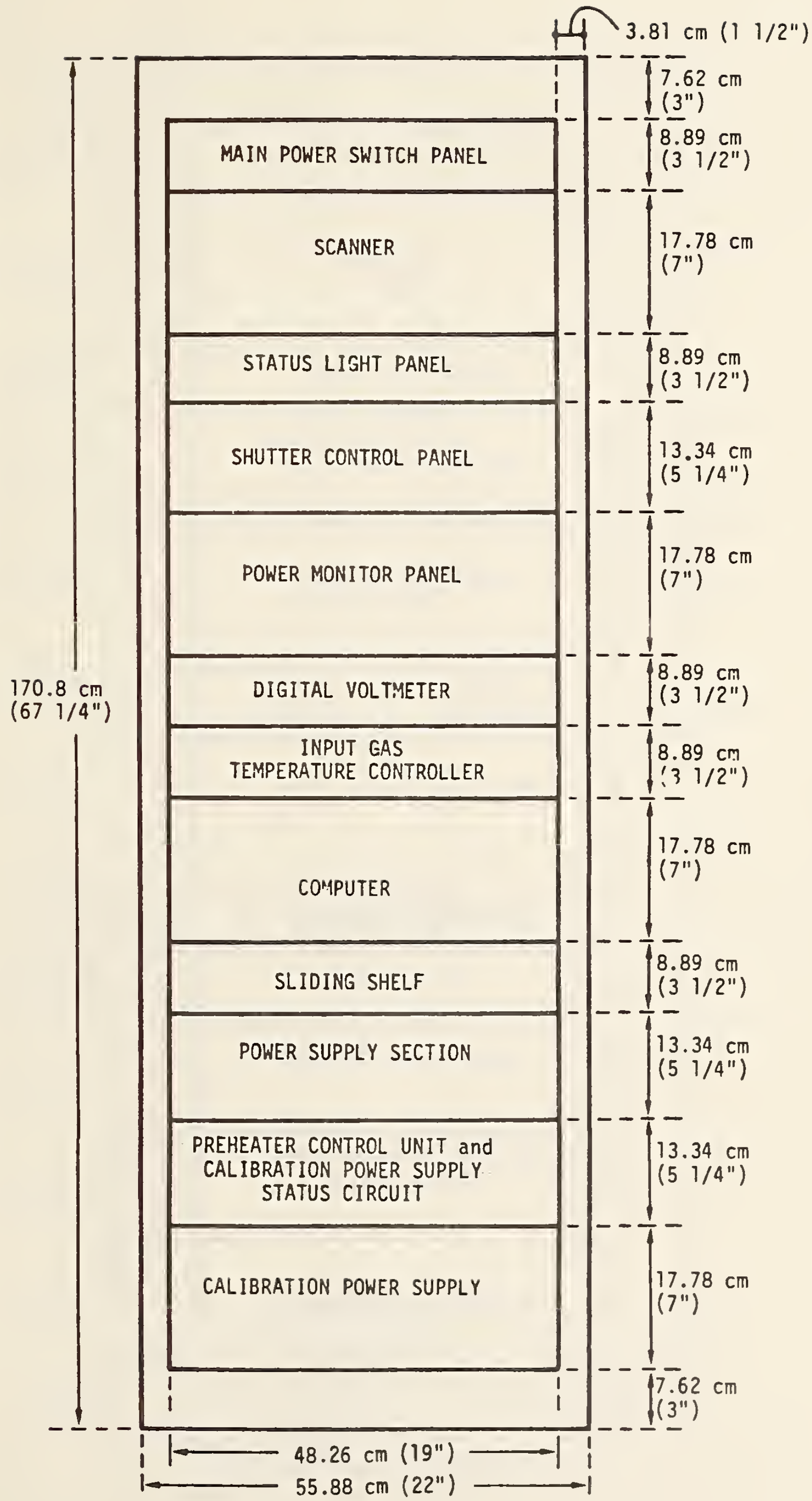


Figure 3-25. Front view of the data acquisition rack for System H.

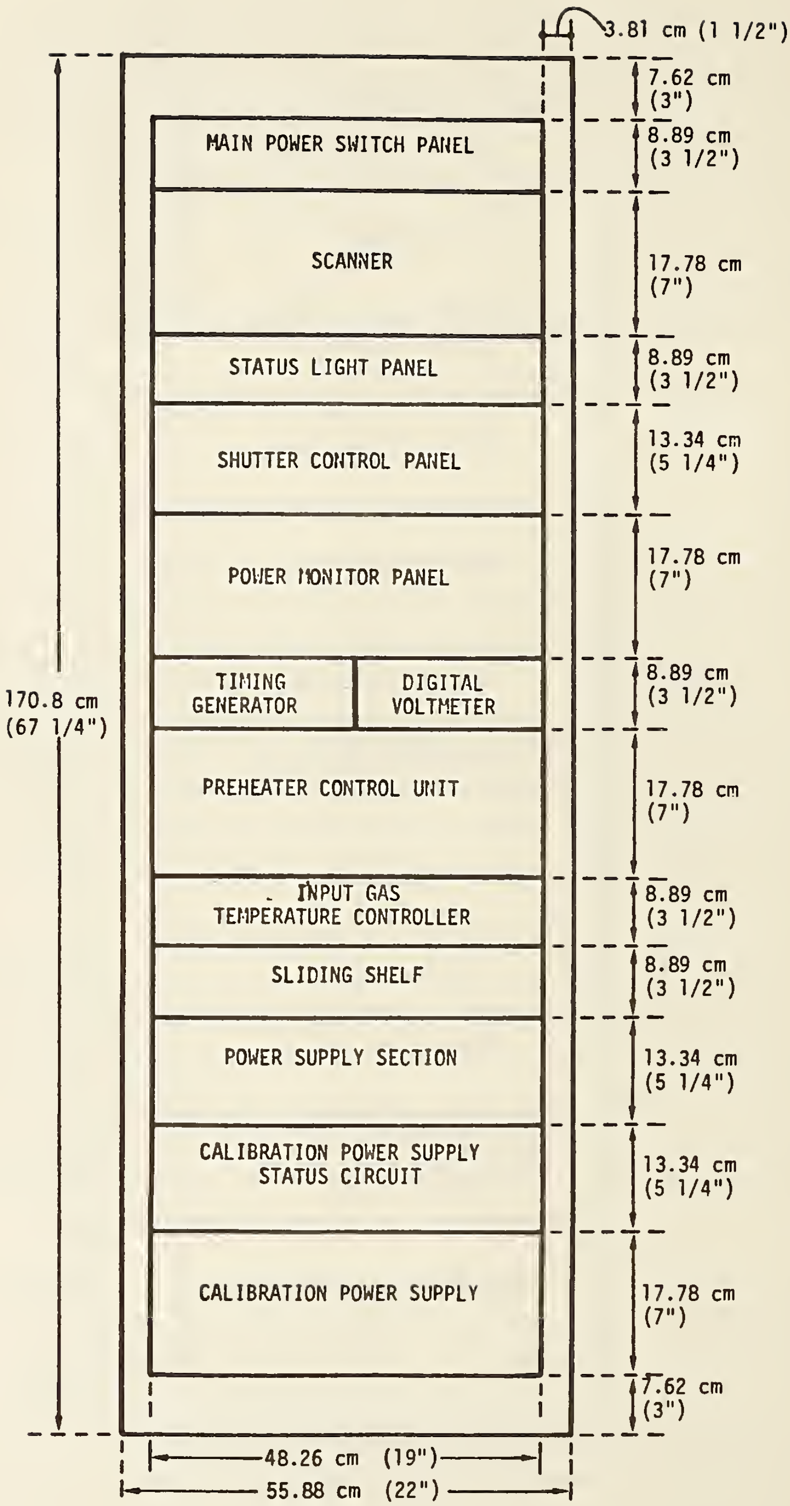


Figure 3-26. Front view of the data acquisition rack for System T.

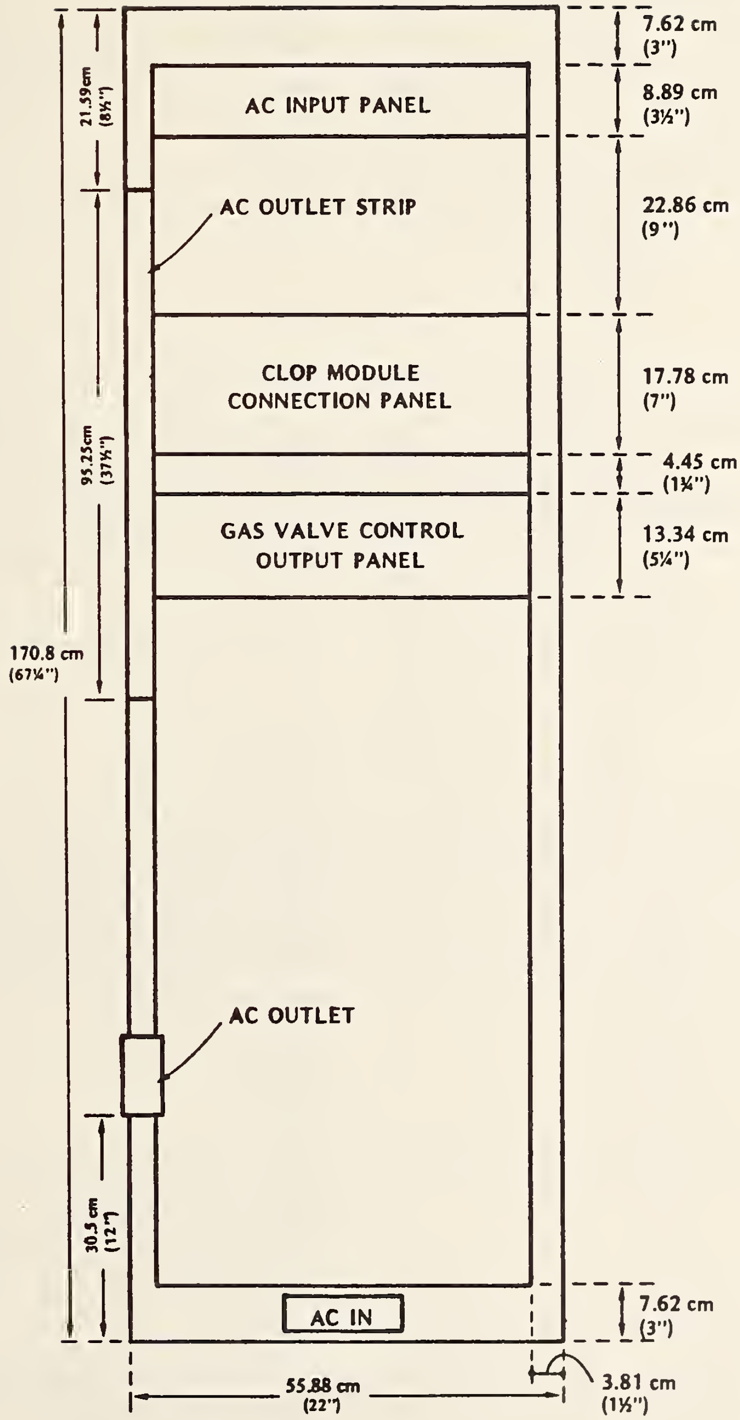


Figure 3-27. Rear view of the data acquisition racks for both systems.

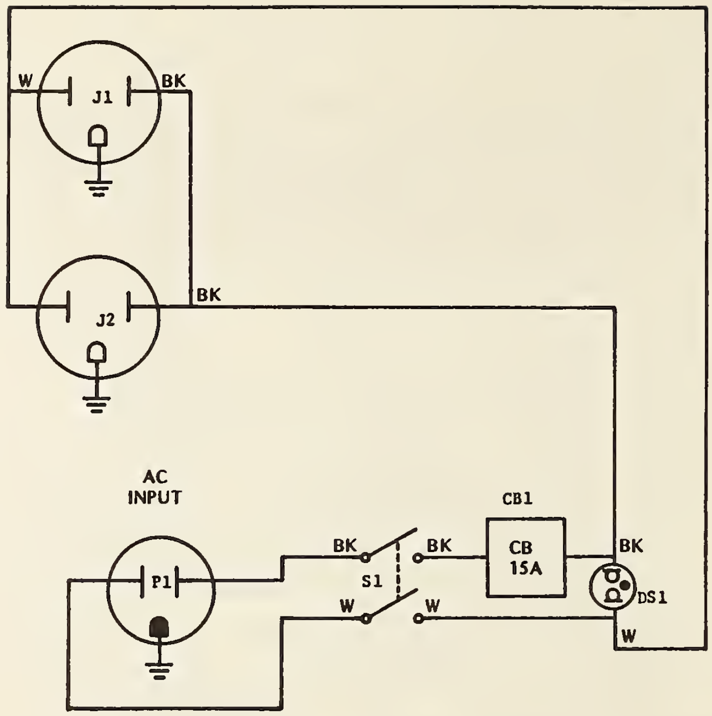


Figure 3-28. Wiring diagram of the main power switch panel.

Table 3.2. Scanner channel connection.

Channel	Sensor or Operation
00	Main calorimeter RTD
01	Main calorimeter output mass flow
02	Main calorimeter output temperature
03	Main calorimeter input mass flow
04	Main calorimeter input temperature
05	Mirror reflector
06	Separation tube RTD
07	BSM RTD
08	OSM RTD
09	Extension tube RTD
10	Electrical calibration current
11	Electrical calibration voltage
12	Electrical calibration voltage ÷ 10
13	Electrical calibration voltage ÷ 20
14	Low voltage dc supplies
15-19	Not used
30	Main calorimeter shutter OPEN
31	Main calorimeter shutter CLOSE
32	OSM/BSM shutter OPEN
33	OSM/BSM shutter CLOSE
34	Gas valve #1 OPEN
35	Gas valve #2 OPEN
36	Gas valve #3 OPEN
37	Gas valve #4 OPEN
38-39	Not used

Table 3.3. Status light color indications.

Light	Red	Green
Incandescents	no-go for laser shot	go for laser shot
Calorimeter	shutter closed	shutter open
BSM	shutter closed	shutter open
Calib. power supply units	ac off to one or both	ac on to both
Gas flow	gas not flowing	gas flowing
+15 V	off	on
-15 V	off	on
(spare)	not connected	not connected

3.7.4 Status Light Panel

The status light panel is an 8.89 cm (3 1/2 in) high panel containing six dual-color LEDs plus one spare in System H and seven red-green pairs in System T that give a visual indication of the status of certain CLOP elements. Also on the front of the panel are red and green incandescent indicator lights that give the overall status of the run and a switch to set the proper logic for either a laser run or combination run. When the green incandescent light is on CLOP is ready for a laser shot. Figure 3-29 is a schematic wiring diagram of this panel for System H; figure 3-30 is for System T.

The LEDs emit red and green colors. Table 3.3 explains what the colors indicate for the different CLOP elements.

3.7.5 Shutter Control Panel

This panel is 13.3 cm (5.25 in) high and contains two chassis--one for the OSM/BSM shutter control circuit and the other for the main calorimeter shutter-control circuit. The front of the panel contains push buttons to OPEN, CLOSE, and STOP each shutter. A description of the OSM/BSM shutter circuit and operation is given in section 3.3.4. The description for the main calorimeter shutter circuit and operation is in section 3.6.4.

3.7.6 Power Monitor Panel

The power monitor panel is 17.8 cm (7 in) high. It serves two functions, which are (1) provide a means of measuring the low voltage dc supply voltages and (2) provide a means of measuring the dc voltage and current used in electrical calibrations.

On the front of the panel is the shaft of a five-position, double-pole rotary switch. The various low-voltage dc supply voltages are input to this switch via a nine-pin connector. The voltage selected is output through pins 1 and 2 of a four-pin connector, goes to contacts 14 on the scanner and is eventually measured by the digital voltmeter (DVM). Figure 3-31 is a schematic wiring diagram of the switching circuit. The position marked -5 V measures the floating output supply that furnishes the reversible polarity power for the shutter motors. The other voltages are all referenced to ground potential.

The second module on this panel measures the dc voltage and current supplied during an electrical calibration. Figure 3-32 is a schematic diagram of the circuit. Input power from the calibration power supply (described in section 3.7.14) is furnished through pins 12 (+) and 10 (ground) of

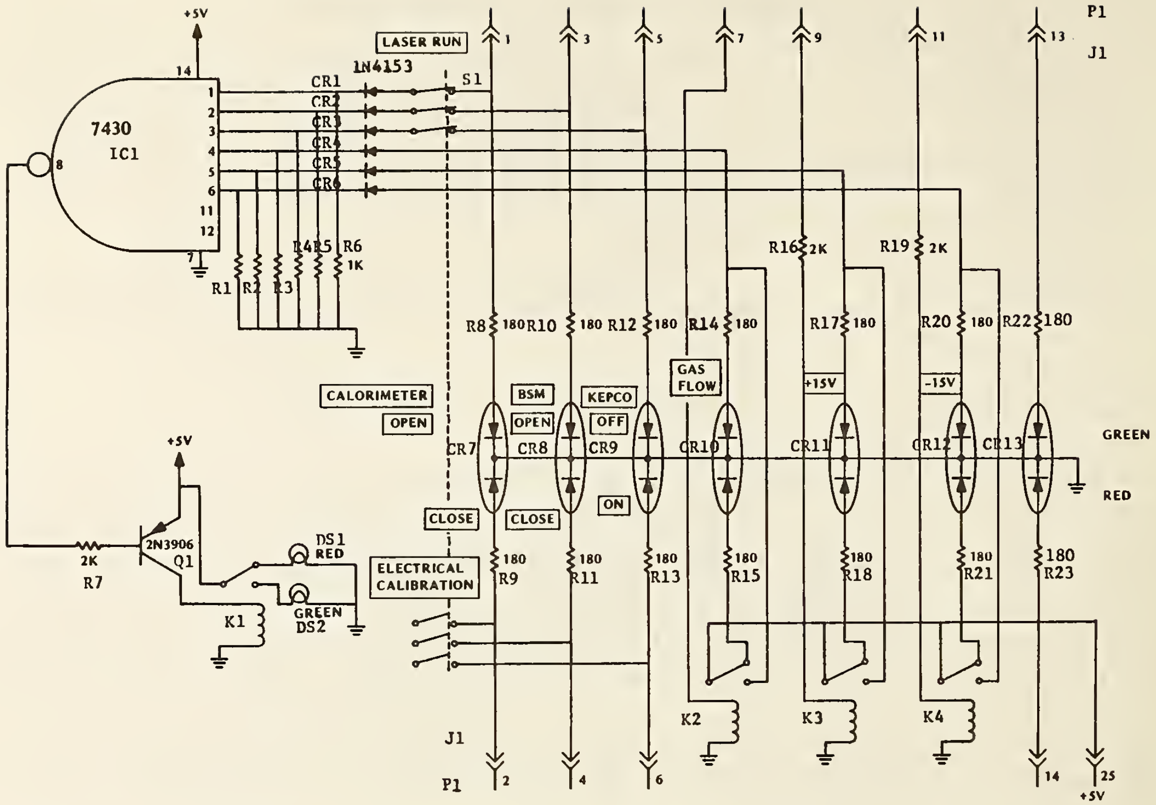


Figure 3-29. Schematic wiring diagram of the status light panel (System H).

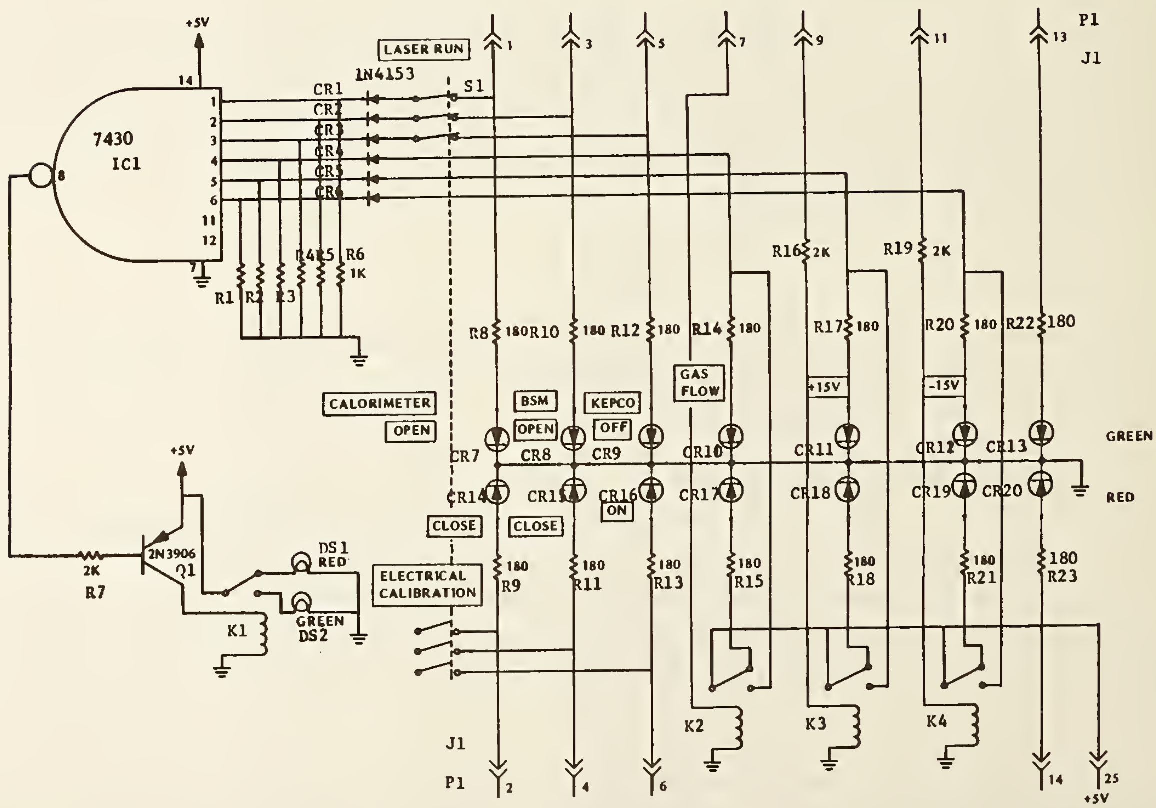


Figure 3-30. Schematic wiring diagram of the status light panel (System T).

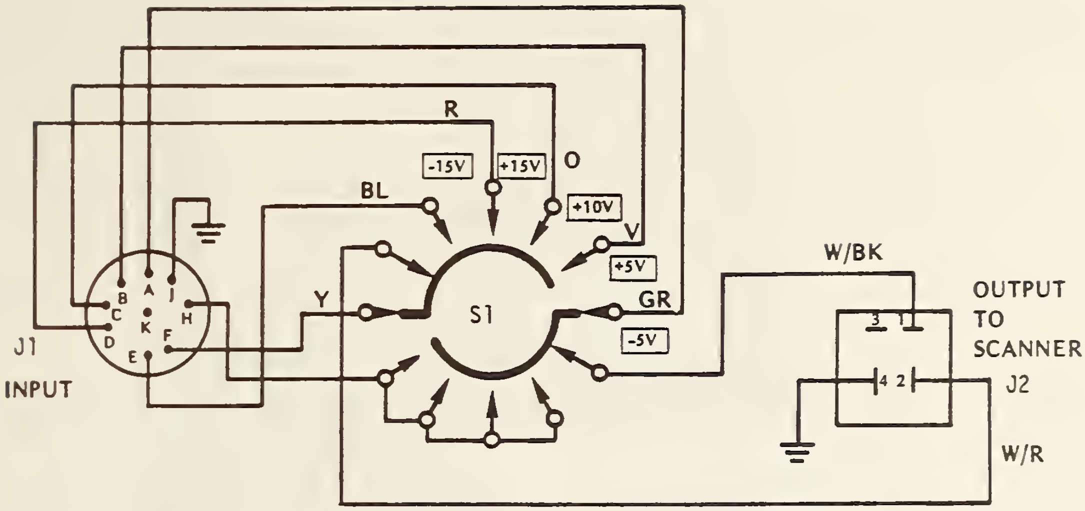


Figure 3-31. Schematic wiring diagram of the switching circuit for measuring low dc voltage.

connector P 406 DB. Voltage sensing leads from the power supply come in through pins 9 and 11. Power output is through pins 12 (+) and 10 (low) of connector S 406 DB. Voltage across the load is brought in through pins 9 (+) and 11 (-) to the divider chain formed by R4 and R5.

The voltage across the total divider formed by R4 and R5 is equal to the voltage across the calibration heater. The wiper on R4 is set to 0.1 times the voltage; the wiper on R5 is set to 0.05 times the voltage. Output to the scanner (see table 3.2) and DVM is through the 25-pin connector.

If an adjustable precision voltage source is not available, the following can be used to set the divider chain, R4-R5.

1. Set the calibration power supply so the DVM reads approximately +1.99 V on the 10 V range of the DVM when the scanner is on channel 11.
2. Switch the scanner to channel 12 and the DVM to the 1 V range.
3. Adjust R4 so the DVM reads the same as the previous reading; e.g., +1.990. Tighten the locking nut on the shaft of R4.
4. Switch the scanner to channel 13 and adjust R5 to read one half of the previous reading; e.g., +0.995. Tighten the locking nut on the shaft of R5.

Generally speaking, no measurements need be done on channel 13 as the calibration power supply does not ordinarily put out more than 100 V.

3.7.7 Digital Voltmeter

The digital voltmeter (DVM) is described in the manufacturer's instruction book. It has five functions which are programmable through front panel pushbuttons and the IEEE 488 bus. These are:

1. Voltage range,
2. Trigger mode,
3. Trigger delay,
4. Number of readings taken per input trigger, and
5. SRQ enable/disable.

The operation of CLOP utilizes only the first three functions. The burst mode of operation and the SRQ are not used.

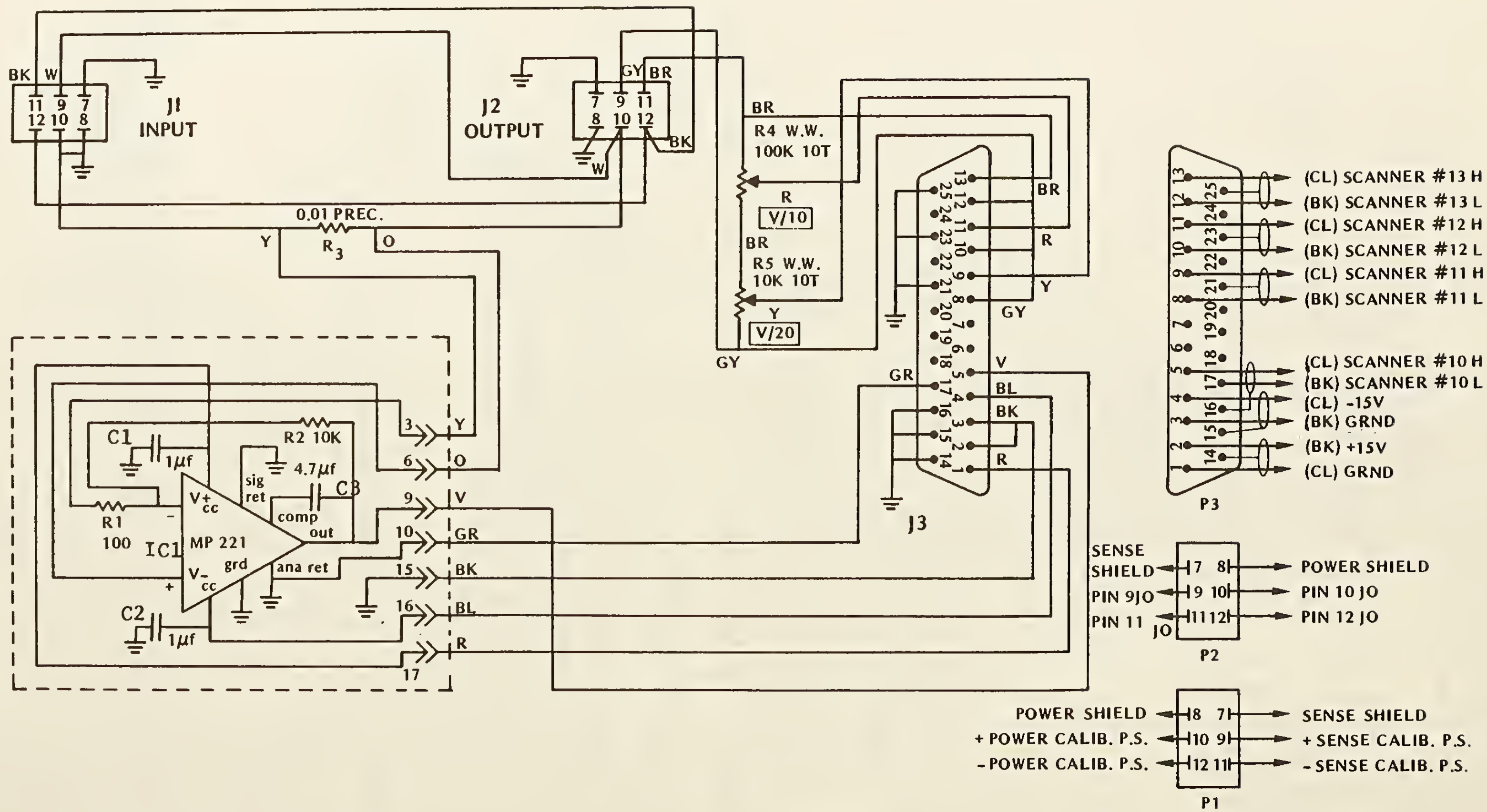


Figure 3-32. Schematic diagram of the circuit for measuring the dc electrical voltage and current.

When using the pushbuttons, the voltage range and the trigger mode are set by merely pushing the desired button; e.g., 0.1 V, 1.0 V, 10 V, INT, EXT, HOLD/MAN. To set a trigger delay; e.g., 50 ms, the following sequence of buttons are pushed:

1. DELAY
2. . (decimal point)
3. 0
4. 5
5. SET

Note the decimal point is the first piece of data entered. This is required by the instrument to recognize the "DELAY" function. When the DVM is running in the internal trigger mode, the trigger delay function can be used to slow down the number of readings being taken. In the above case there would be 20 readings per second (50 ms period). In the external trigger and manual trigger modes, the trigger delay regulates the time lapse between the trigger command and when the reading is taken.

When using the IEEE 488 bus the DVM is addressed as device 24. Table 3.4 is a list of the commands that the CLOP programs use.

Thus, a command on System H to tell the DVM to take a reading on the 1 V scale 5 ms after an external trigger signal is received is OUTPUT 724; "R2T2D.ØØ5S". On the System T it is PRINT@24:"R2T2D.ØØ5S".

Two methods may be used to take readings under computer control. The first method is used when readings are not to be taken very rapidly. The HOLD/MANUAL command, T3, is simply sent to the DVM each time a reading is to be taken. For taking 10 or 12 readings in less than 1 s, the external trigger mode, T2, is used with a 5 ms delay. The external trigger is furnished by the scanner everytime it switches channels over a BNC cable from the scanner sync jack to the DVM external trigger input jack. The 5 ms delay is required to allow time for the scanner contacts to close and voltage transients to decay before making the DVM measurement.

Table 3.4.* IEEE 488 commands used by the DVM.

ASCII Character	Description
D	Delay
S	Store
R	Range
1	0.1 V
2	1 V
3	10 V
T	Trigger
1	Internal
2	External
3	Hold/Man

*Condensed from table 3.4, page 3-6, of manufacturer's operating manual.

The rear-input, triaxial jack on the DVM is used since the instrument is mounted in a rack. This jack is connected via a triaxial cable to the common contacts of the duodecade plug-in of the scanner. The command to transfer the DVM reading to the memory in the System H computer is ENTER 724; V1. For System T the command is INPUT @24:V1. In this example the reading is stored as the variable V1.

3.7.8 Pacer Unit (System T Only)

The pacer unit is located to the left of the DVM in System T. It is used to furnish a train of pulses at precisely equal time intervals to form a time base for CLOP to operate by. This unit tells the System T computer when to order certain operations be done. On the System H computer there are three internal programmable timers which obviate the need for a pacer in that system.

The pacer is programmable over the IEEE 488 bus and sends pulses to the 4052A which counts them to keep track of the time that has elapsed since the run began. The pulses are first at 3 s intervals during the monitor period but change to a 1 s interval when data acquisition begins. The computer takes this into account when computing the time.

A typical command to the pacer is

```
PRINT @19:"P1ØØE4SR"
```

where the P signifies the pacer mode of operation (as opposed to the timer mode), 100E4 is the period in microseconds (1×10^6 or 1 s), S enables the SRQ on the unit, and R either starts the pulse train or resets the internal pulse counter in the unit.

3.7.9 Input Gas Temperature Controller

The Input Gas Temperature Controller is used to supply a proportional signal that will maintain the temperature of the input gas to the main calorimeter at a constant value and cancel out the tendency of the gas to cool because of its expansion from the pressurized condition in the cylinder. The proportional correction signal is in the form of a variable duration pulse having a 1 pps repetition rate. This correction signal is furnished to the Preheater Control Unit (see section 3.7.13) to switch on and off the ac power to the preheater and thus control the temperature of the gas entering CLOP.

The correction signal is derived from the output voltage of the temperature bridge circuit. This voltage, after entering the data acquisition rack through jack 5B of the CLOP Module Connection Panel (see section 3.7.16) is routed to the input gas temperature controller chassis. A schematic diagram of the circuitry in this unit is shown in figure 3-33.

In this unit the signal voltage is first sent to an isolation amplifier board with two outputs. One output leaves this chassis and goes to scanner contacts Ø4 for measurement by the DVM. The other output goes to another PC board containing the proportional signal generator. On this board the temperature in voltage is connected to the inverting input of a differential amplifier. The non-inverting input of the differential amplifier is connected to an adjustable reference voltage. This reference voltage first is set so that the controller is just turned off while the gas is not flowing; i.e., the controller is not pulsing as indicated by the extinguished LED. When the gas starts flowing (and cooling) the balance is upset and the controller starts generating a correction signal. The

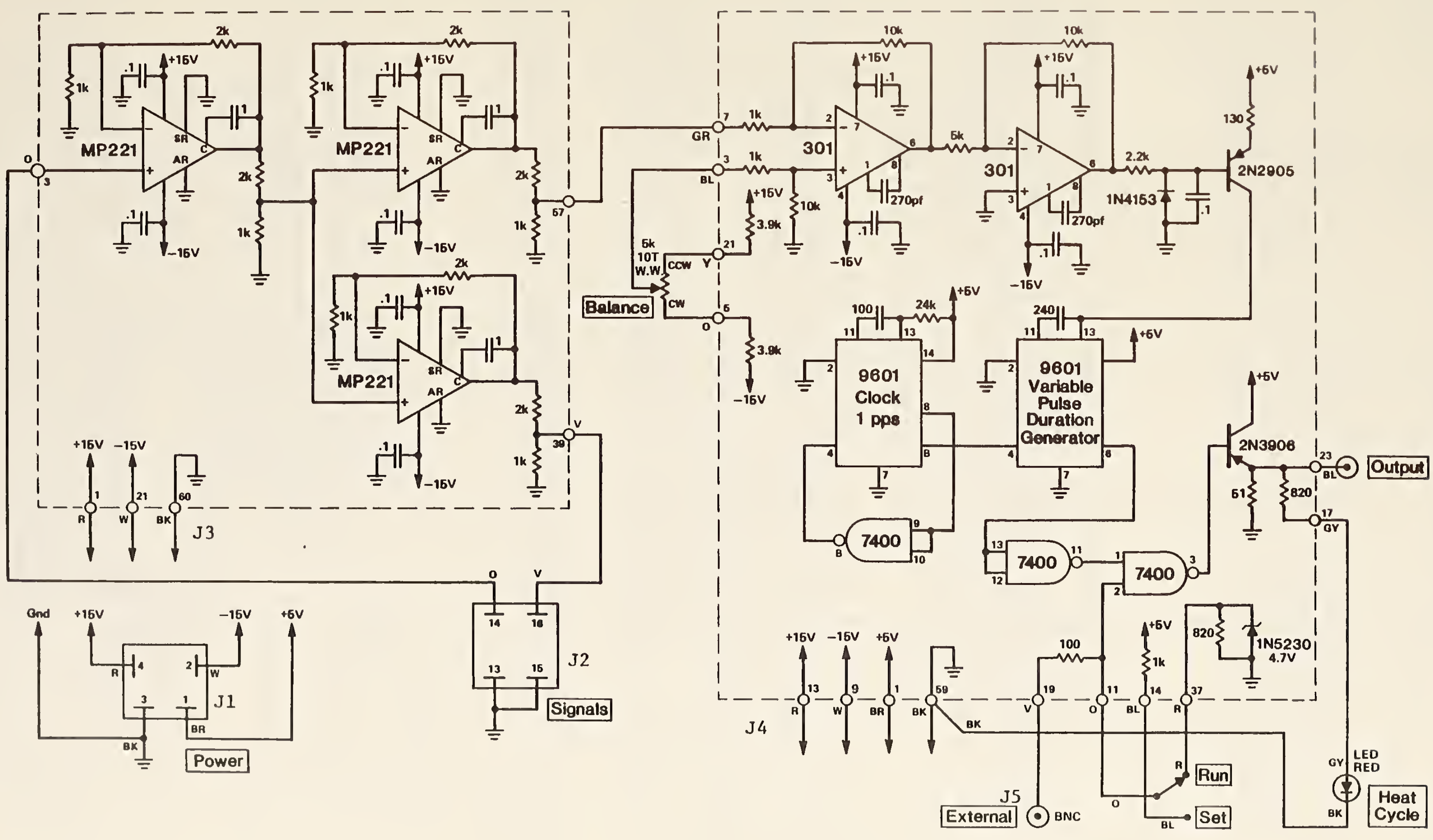


Figure 3-33. Schematic diagram of input gas temperature controller.

reference voltage is now reset to produce a temperature in reading called for in the program. If the gas becomes too warm the correction signal disappears until the natural cooling of the gas returns conditions to the balanced state.

When setting the balance conditions a RUN-SET switch is put in the SET position which turns on a gate and allows the correction signal to appear on the output. During a run the switch is put in the RUN position so that a gating signal from the Gas Valve Control Output panel (see section 3.7.17) turns on the correction signal only while gas is flowing. This gating signal enters via the BNC connector labelled EXTERNAL.

3.7.10 Computer Section

The next 26.5 cm (10.5 in) below the Input Gas Temperature Controller in System H only is used to hold the computer. The instrument is attached to a sliding shelf in the rack and may be pulled out for convenient use and pushed inside the rack for safe storage. The computer is described as to its specifications and programming in the manufacturer's instruction manual. No attempt will be made to go into great detail about its operation but certain useful facts are given below.

The computer is furnished with an IEEE 488 bus output and an RS232 output.

The computer has 32 kbytes of memory of which space for 30288 bytes is available. Programs requiring more space than this are split into smaller programs and stored on tape as separate files. When run, they are chained in the proper sequence to perform the complete program.

The programs are described in section 4 of this manual.

The System T computer is too large to fit into the data acquisition rack. Hence, it is located externally to the rack and its space in the rack is filled by the preheater control circuit (see section 3.7.13).

This computer has available 54624 bytes of memory eliminating the need for chaining any of the programs described in section 4. It, too, has IEEE 488 and RS 232 interfaces and a four-slot ROM pack for external ROMs.

3.7.11 Power Supply Section

The power supply section is contained on a shelf behind a 13.3 cm (5.25 in) panel just below the computer. This section contains the power supplies that furnish the low voltage dc for powering the various sensor circuits and the shutter motors. It also contains an interfacing unit between the IEEE 488 bus and the calibration power supply (see section 3.7.13). These two parts are described in the following subsections.

3.7.11.1 Low Voltage dc Supplies

One ±15 V dc dual output power supply and three 5 V dc supplies are used to fill all the low-voltage dc requirements of CLOP. Two of the 5 V supplies are connected in series to furnish 10 V dc as well as 5 V dc. Table 3.5 gives useful information about the power supply voltages. Figure 3-34 is a schematic wiring diagram of the low-voltage dc power supply section.

Table 3.5. Low voltage dc supply summary.

Designation*	Voltage	Current	Remarks
A1	+5 V	3 A	
A2	+10 V	3 A	A second 5 V, 3 A power supply connected in series with A1
A3	+ or -5 V	3 A	Output floating; polarity reversible
A4	± 15 V	3 A	

*Refer to figure 3-34.

3.7.11.2 Calibration Power Supply Interface Unit

The calibration power supply interface unit is a commercially available unit made by the manufacturer of the calibration power supply. It is merely a D to A converter which receives a digital command on the IEEE 488 bus and puts out dc voltages specified by the command which are used to program the calibration power supply to the desired output voltage and current. Full particulars of the interface unit are given in the manufacturer's instruction book. Certain useful information is given in this section.

The unit has two output channels. Channel 1 is used to set the voltage limit and channel 2 sets the current limit. Only one channel need be set if the other needs no changing. For example, if the calibration power supply is running in the voltage limiting mode at 100 V and 6A and the interface unit is set to 100 V limit and a 6 A limit, only a new voltage limit need be set on the interface unit to reduce the power supply output to a lower value, e.g., 50 V.

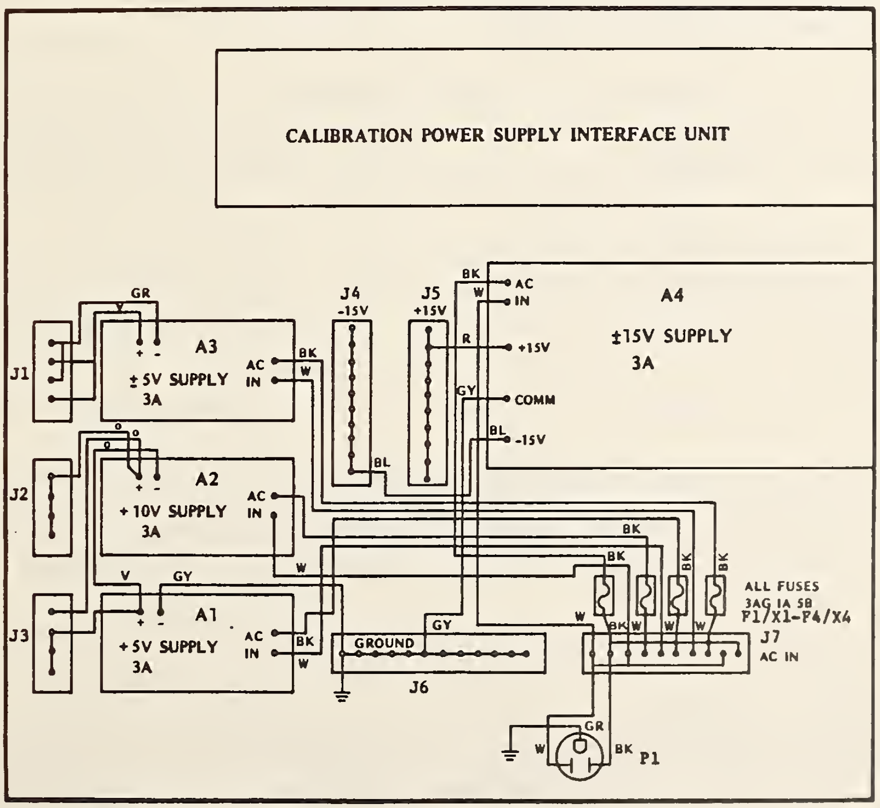


Figure 3-34. Wiring diagram of low voltage dc power supply section.

Each channel has two output ranges, 0 to +1 V and 0 to +10 V which correspond to power supply output limits of 0 V to 10 V (0 A to +10 A) and 0 V to +100 V, respectively. In addition, the interface unit can set low and high negative voltage and current limits but these are not used with CLOP since the calibration power supply has a unipolar output with the negative side grounded.

The desired voltage and current limit are set with three-character hexadecimal words, ØØØ through FFF. Thus, the incremental steps of voltage and current are 1 part in 4096, or approximately 0.024 percent. In terms of calibration power supply output, this is 2.4 mV resolution up to 10 V and 24 mV from 10 V to 100 V. Appendix A is included for convenience as a review of the methods for converting back and forth between the decimal and hexadecimal based number systems.

The address of the interface unit on the IEEE 488 bus is device 6. A five-character command is used to set the desired limit on the calibration power supply. The command is of the form (reading from top to bottom):

Channel 1 = voltage, 2 = current

Range 0 = high positive, 2 = low positive

Magnitude ØØØ through FFF

Thus the command to set a 50 V, 4 A limit on the power supply is OUTPUT 7Ø6; "1Ø7FF"; "22666" on the System H and PRINT@6:"1Ø7FF";"22666" for the System T.

The unit has been modified to permit sampling of the ac input power as shown in figure 4-5 of the manufacturer's instruction book. This sampled ac goes to the calibration power supply status circuit (see section 3.7.12) to sense whether the instrument is on or off.

3.7.12 Calibration Power Supply Status Circuit

This circuit is used to sense if both the calibration power supply and the calibration power supply interface unit are turned on or if either one is turned off. It then applies 5 V dc to either pin 5 or 6 of the status light panel which lights the color indicating the existing condition.

Figure 3-35 is a schematic wiring diagram of circuit. The two relays, K1 and K2, are activated by the 115 V ac from the interface unit and the power supply, respectively. These voltages are fed into the chassis through two recessed male receptacles. In the interface unit the ac is monitored on the input voltage selector board (see fig. 5-4 in the instruction book). In the calibration power supply the ac is sampled on terminals 1 and 5 of T201 (see fig. 6-3 in instruction book).

The 5 V dc for the status light panel comes in through pin A of a five-pin connector and out on either pin D or E depending on the condition of K1 and K2. The contacts of K1 and K2 are wired such that they perform a logical AND function for the "ON" condition of the power supply and interface unit and a logical OR for the "OFF" condition.

3.7.13 Preheater Control Circuit

The preheater control circuit is contained on the same panel as the calibration power supply status circuit for System H and is located separately for System T. It is used to apply ac power to

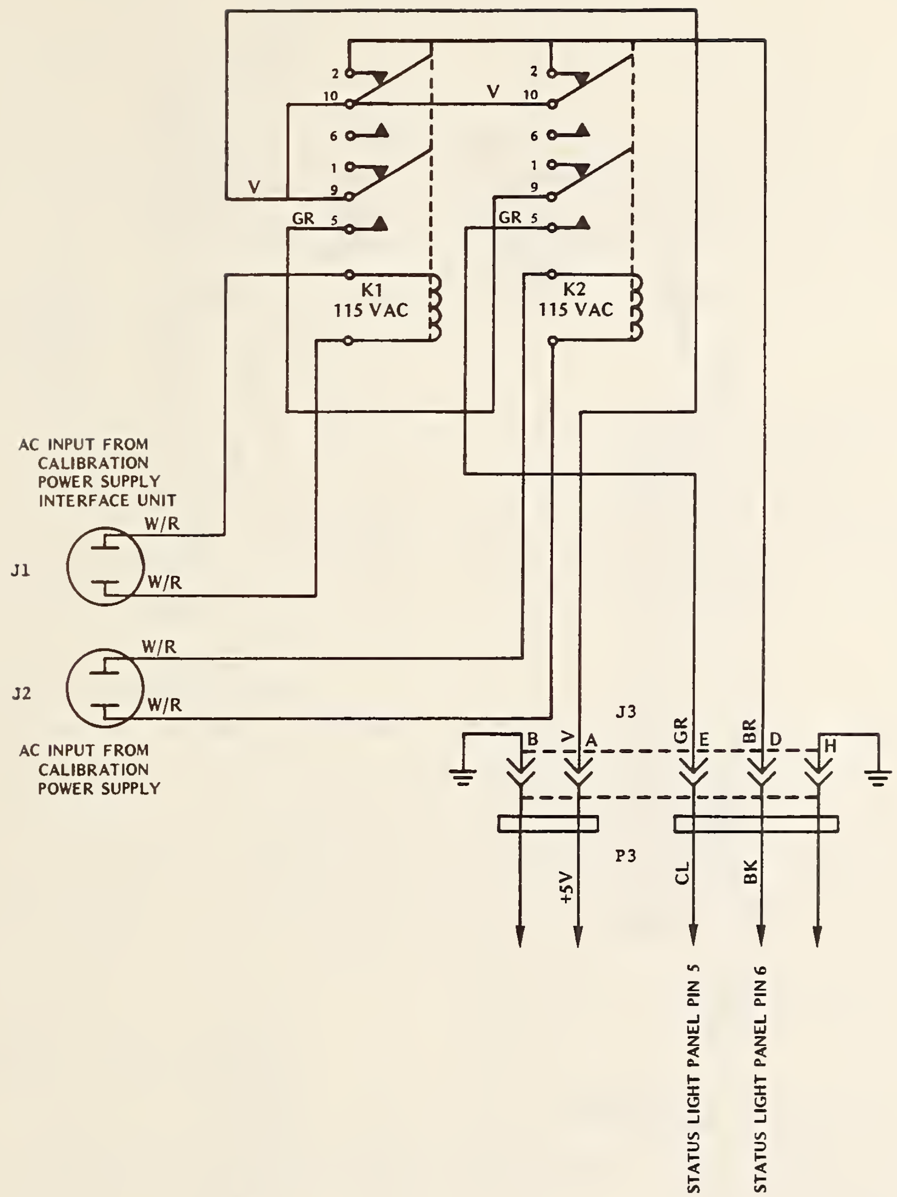


Figure 3-35. Schematic diagram of calibration power supply status circuit.

the preheater unit to heat the gas flowing into the calorimeter. The level of the ac power is adjustable by means of a variable auto transformer in the circuit. The output voltge of the autotransformer is converted to a proportional dc voltage and displayed on a front panel DVM.

The unit may be operated either manually or under automatic control. When operated automatically, the output from the Input Gas Temperature Controller is fed into this chassis through the BNC connector labelled EXTERNAL. The signal goes to the control terminal on a solid state relay and turns on and off the ac power. If for some reason the Input Gas Temperature Controller is not used, the output from the gas valve control panel should go to this connector to turn off the ac power when the gas flow is off.

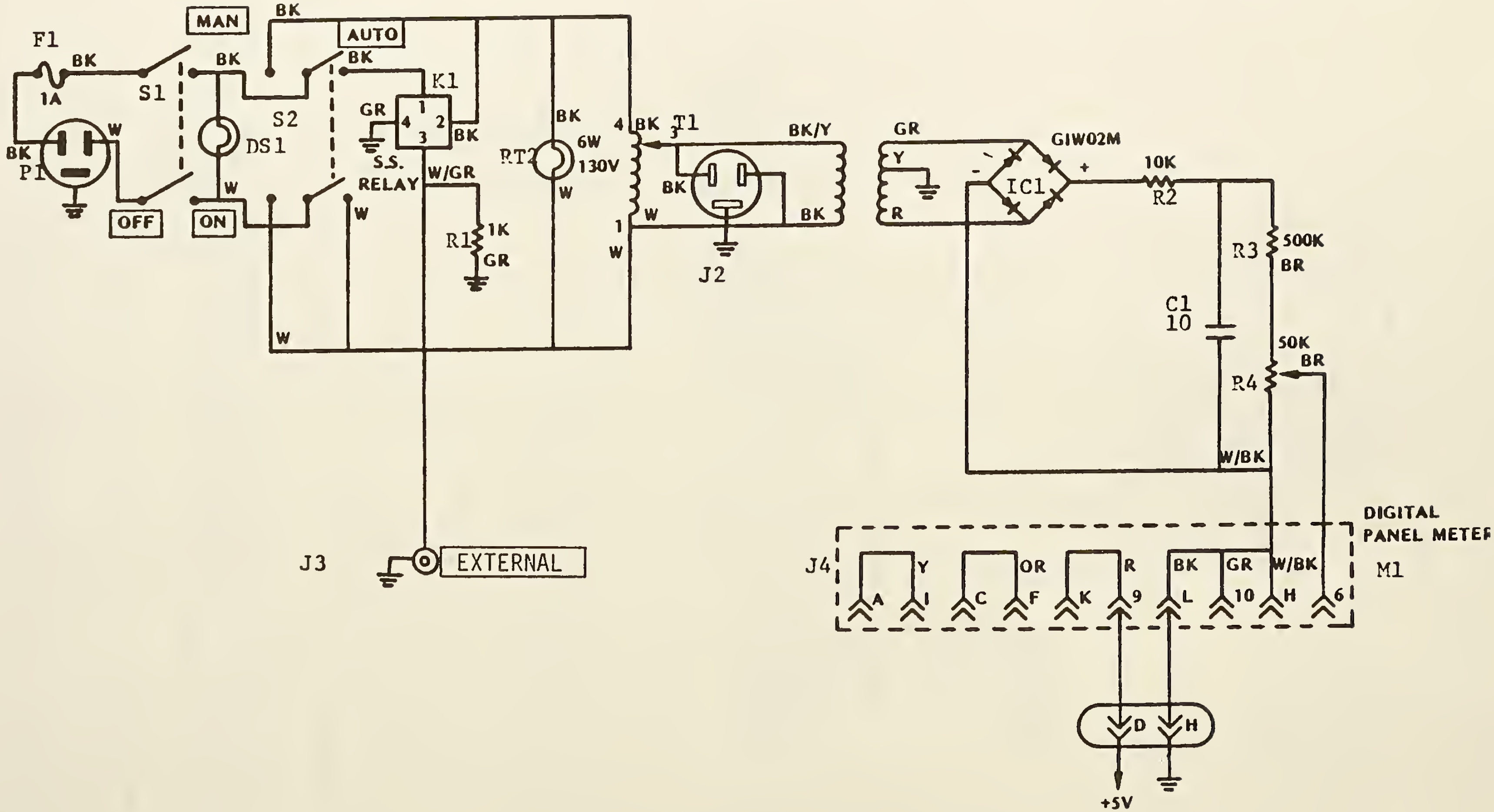


Figure 3-36. Schematic diagram of preheater control circuit.

Figure 3-36 is a schematic diagram of the preheater control circuit. The output of this unit goes to a duplex outlet on the lower left side of the rear of the data acquisition rack. The preheater plugs into this outlet.

3.7.14 Calibration Power Supply

The calibration power supply is located at the bottom of the front of the rack. Chassis supports are mounted in the rack to facilitate installing and removing the power supply. Alternating current power is supplied to this unit through a single special receptacle for 20 A which is mounted on the rack below the bottom of the rear opening. The receptacle has a 3.66 m (12 ft) power cord for connection to an ac power main. This power line should be connected to a separate ac main from the cord from the ac input panel to avoid overloading the mains.

The calibration power supply is rated at 100 V dc and 10 A output. Operation of the unit is as described in the manufacturer's instruction manual. Factory wiring has been modified as shown in figure 3-16 on page 3-17 of the instruction manual to permit remote programming by the interface unit (see section 3.7.11.2) and remote voltage sensing in the power monitor module (see section 3.7.6). Also, connections have been added to position 1 and 5 on T201 in figure 6-3 of the instruction manual for monitoring the ac input power as discussed in section 3.7.12.

3.7.15 Alternating Current Input Panel

The ac input panel is located at the top of rear opening of the rack. It is 8.89 cm (3.5 in) high and contains one duplex receptacle unit. This receptacle has a 3.66 m (12 ft) power cord for connection to an ac power main. The duplex receptacle is powered whenever the power cord is connected to an ac source. The main power switch panel (see section 3.7.2) plugs into one outlet of the duplex receptacle; the other outlet is available for general utility. The power cord from this panel should be connected to a separate ac main from the cord from the calibration power supply to avoid overloading the main.

3.7.16 CLOP Module Connection Panel

This panel contains jacks into which plug all the cables coming into the data acquisition rack from the various components of CLOP. From the terminals on the jacks other cables go to the different units in the data acquisition rack such as the scanner, the low voltage dc power supplies, and the shutter control circuits. Table 3.6 lists the jacks on this panel and the CLOP module to which they connect.

Figures 3-37 through 3-47 are wiring diagrams of the nine output connectors on this panel in the two systems. The cables that go from these jacks to the CLOP modules are straight pin for pin connections; e.g., they have similar male and female connectors and pin 1 on the male connector is connected to pin 1 on the female connector, pin 2 to pin 2, etc.

3.7.17 Gas Valve Control Output Panel

The gas valve control panel has four output jacks into which plug power cables for the valves on the low pressure gas flow manifold (see section 3.6.2). These four jacks are labelled CHANNEL 34, CHANNEL 35, CHANNEL 36, and CHANNEL 37 which correspond to the scanner channel which controls their output. Cable 1, which comes from valve 1, plugs into channel 34, cable 2 into channel 35, etc.

Table 3.6. Jack panel connections to CLOP.

Designator	No. of pins	Destination
J0	6	Heater circuit on all modules (one at a time)
J1	10	Extension tube bridge circuit
J2	24	OSM/BSM bridge circuits
J3	10	Separation tube bridge circuit
J4	10	Mirror reflector bridge circuit
J5A	24	Main cal. temp and mass flow out and RTD bridge circuits
J5B	15	Main cal. temp and mass flow in bridge circuits
J6	14	OSM/BSM shutter motors
J7	25	Main cal. shutter motors

Figure 3-48 is a wiring diagram of the gas valve control output panel and the connecting cable plugs. The wiring of the cable plugs is included to show the interlock formed through pins 13 and 14 which allows the status light panel to give a more valid indication of the gas flow condition. Alternating current input to this unit is through a four-prong connector on the chassis. Direct current control signals from the scanner and connections to the status light panel and input gas temperature controller chassis are through a 25-pin connector.

4. Computer Programs and Data Storage Files

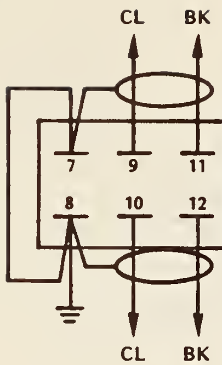
4.1 Introduction

This section gives a description of each program used with CLOP. There are two subgroups in the section, the first for System T and the second for System H. A description of each program specifying what it is, what it does, etc. is given and the similar program in the other system is noted. Computer programs and variable maps for the System T are given in appendix B and for System H in appendix C.

Data tape catalogs (indexes) are listed to show the schemes for data storage. These are somewhat different for the two systems since System T has an external tape drive for the data tape cartridges while System H, with only the internal tape drive available, requires the plugging in and taking out of tape cartridges.

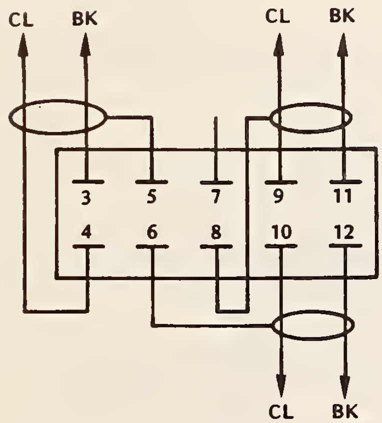
There are quite a few differences in the operation and basic languages of the two computers that require different methods to accomplish the same results in similar programs. Some of these are:

1. System H screen scrolls while System T pages.
2. System H has a printer; System T copies the screen.
3. System T can FIND and OLD the next program under program control; System H cannot perform a LOAD this way.
4. System H has a programmable PAUSE which CONT will terminate while System T requires a software indefinite wait that is terminated by a user-defined key (UDK).
5. System H allows array index 0; System T does not.



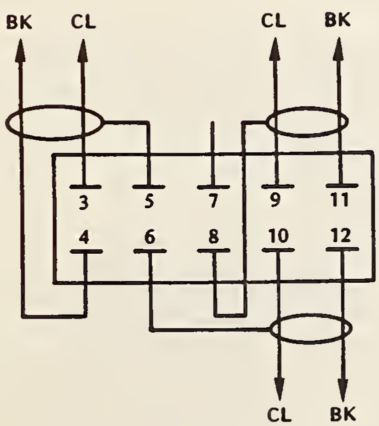
PIN	ACQUISITION RACK CONNECTION
7	PIN 7 V-I BOX OUTPUT
8	PIN 8 V-I BOX OUTPUT
9	PIN 9 V-I BOX OUTPUT
10	PIN 10 V-I BOX OUTPUT
11	PIN 11 V-I BOX OUTPUT
12	PIN 12 V-I BOX OUTPUT

Figure 3-37. Wiring diagram of connector J0 to heater circuits.



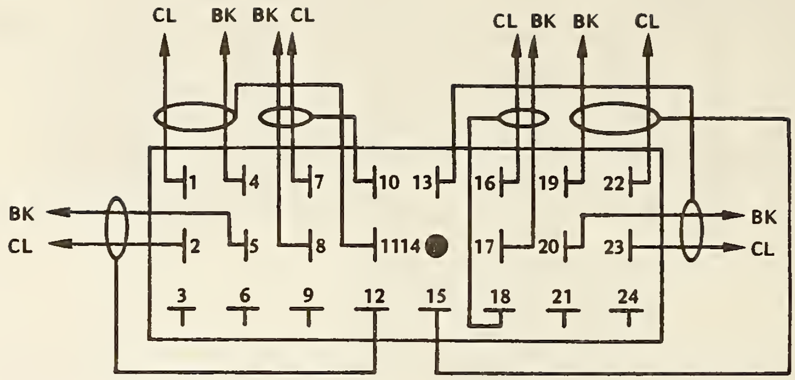
PIN	ACQUISITION RACK CONNECTION
3	SCANNER CONTACT 09 H
4	SCANNER CONTACT 09 L
5	SIGNAL SHIELD
6	+15V SHIELD
7	NC
8	-15V SHIELD
9	-15V DC POWER SUPPLY DECK
10	+15V DC POWER SUPPLY DECK
11	GROUND POWER SUPPLY DECK
12	GROUND POWER SUPPLY DECK

Figure 3-38. Wiring diagram of connector J1 to extension tube bridge circuit (System H).



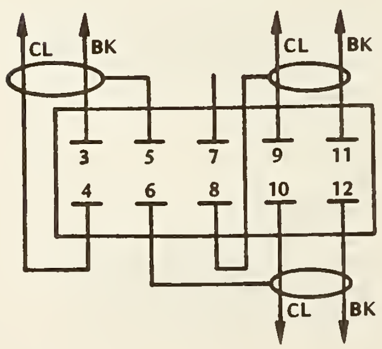
PIN	ACQUISITION RACK CONNECTION
3	SCANNER CONTACT 09 L
4	SCANNER CONTACT 09 H
5	SIGNAL SHIELD
6	+15V SHIELD
7	NC
8	-15V SHIELD
9	-15V DC POWER SUPPLY DECK
10	+15V DC POWER SUPPLY DECK
11	GROUND POWER SUPPLY DECK
12	GROUND POWER SUPPLY DECK

Figure 3-39. Wiring diagram of connector J1 to extension tube bridge circuit (System T).



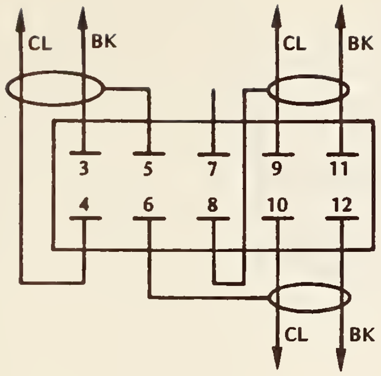
PIN	ACQUISITION RACK CONNECTION	PIN	ACQUISITION RACK CONNECTION
1	+15V DC POWER SUPPLY DECK	13	-15V SHIELD
2	-15V DC POWER SUPPLY DECK	14	NC
3	NC	15	+15V SHIELD
4	GROUND POWER SUPPLY DECK	16	SCANNER CONTACT 07 H
5	GROUND POWER SUPPLY DECK	17	SCANNER CONTACT 07 L
6	NC	18	SCANNER CONTACT 07 SHIELD
7	SCANNER CONTACT 08 H	19	GROUND POWER SUPPLY DECK
8	SCANNER CONTACT 08 L	20	GROUND POWER SUPPLY DECK
9	NC	21	NC
10	SCANNER CONTACT 08 SHIELD	22	+15V DC POWER SUPPLY DECK
11	+15V SHIELD	23	-15V DC POWER SUPPLY DECK
12	-15V SHIELD	24	NC

Figure 3-40. Wiring diagram of connector J2 to OSM/BSM bridge circuits.



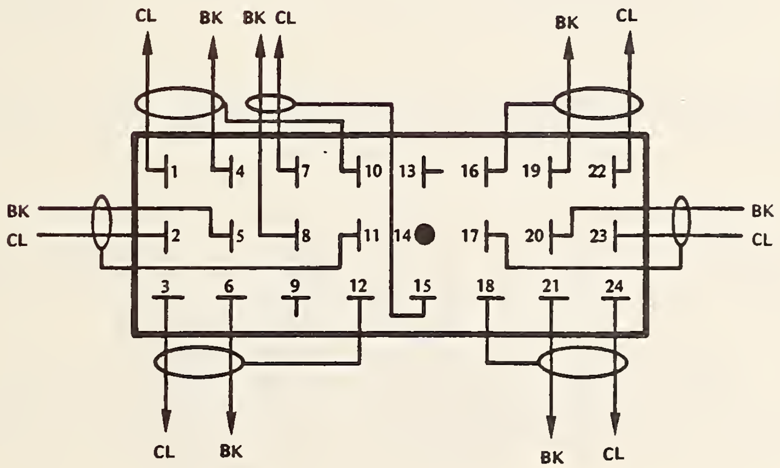
PIN	ACQUISITION RACK CONNECTION
3	SCANNER CONTACT 06 L
4	SCANNER CONTACT 06 H
5	SIGNAL SHIELD
6	+15V SHIELD
7	NC
8	-15V SHIELD
9	-15V DC POWER SUPPLY DECK
10	+15V DC POWER SUPPLY DECK
11	GROUND POWER SUPPLY DECK
12	GROUND POWER SUPPLY DECK

Figure 3-41. Wiring diagram of connector J3 to separation tube bridge circuits.



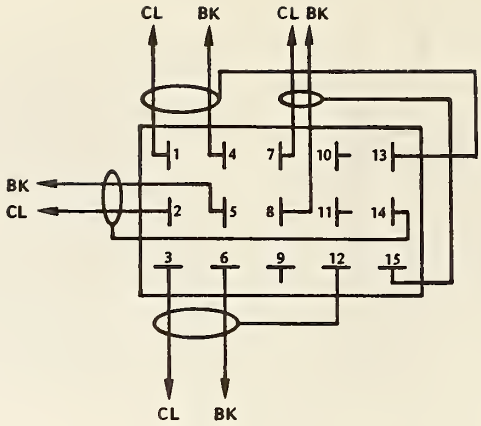
PIN	ACQUISITION RACK CONNECTION
3	SCANNER CONTACT 05 L
4	SCANNER CONTACT 05 H
5	SIGNAL SHIELD
6	+15V SHIELD
7	NC
8	-15V SHIELD
9	-15V DC POWER SUPPLY DECK
10	+15V DC POWER SUPPLY DECK
11	GROUND POWER SUPPLY DECK
12	GROUND POWER SUPPLY DECK

Figure 3-42. Wiring diagram of connector J4 to deflector bridge circuit.



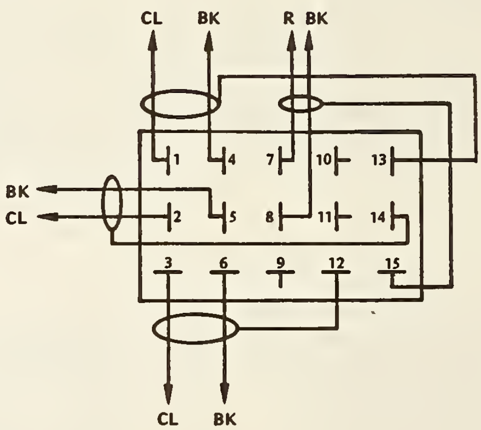
PIN	ACQUISITION RACK CONNECTION	PIN	ACQUISITION RACK CONNECTION
1	+15V DC POWER SUPPLY DECK	13	NC
2	-15V DC POWER SUPPLY DECK	14	NC
3	SCANNER CONTACT 01 H	15	SCANNER CONTACT 02 SHIELD
4	GROUND POWER SUPPLY DECK	16	+15V DC SHIELD
5	GROUND POWER SUPPLY DECK	17	-15V DC SHIELD
6	SCANNER CONTACT 01 L	18	SCANNER CONTACT 00 SHIELD
7	SCANNER CONTACT 02 H	19	GROUND POWER SUPPLY DECK
8	SCANNER CONTACT 02 L	20	GROUND POWER SUPPLY DECK
9	NC	21	SCANNER CONTACT 00 L
10	+15V DC SHIELD	22	+15V DC POWER SUPPLY DECK
11	-15V DC SHIELD	23	-15V DC POWER SUPPLY DECK
12	SCANNER CONTACT 01 SHIELD	24	SCANNER CONTACT 00 H

Figure 3-43. Wiring diagram of connector J5A to main calorimeter gas output circuits box.



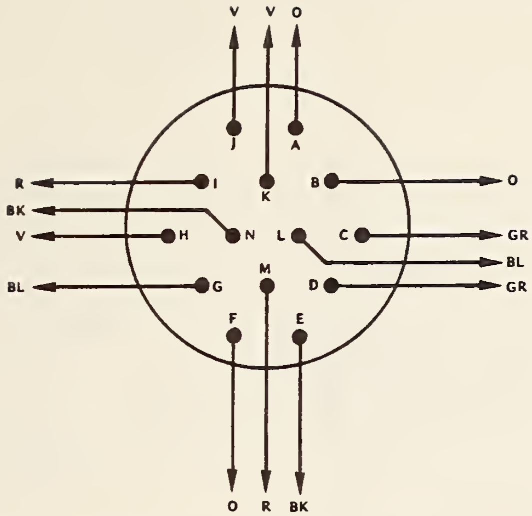
PIN	ACQUISITION RACK CONNECTION	PIN	ACQUISITION RACK CONNECTION
1	+15V DC POWER SUPPLY DECK	9	NC
2	-15V DC POWER SUPPLY DECK	10	NC
3	SCANNER CONTACT 03 H	11	NC
4	GROUND POWER SUPPLY DECK	12	SCANNER CONTACT 03 SHIELD
5	GROUND POWER SUPPLY DECK	13	+15V DC SHIELD
6	SCANNER CONTACT 03 L	14	-15V DC SHIELD
7	SCANNER CONTACT 04 H	15	SCANNER CONTACT 04 SHIELD
8	SCANNER CONTACT 04 L		

Figure 3-44. Wiring diagram of connector J5B to main calorimeter gas input circuits box (System H).



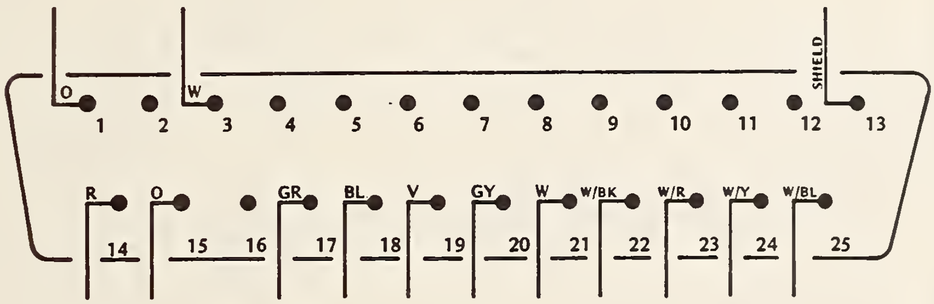
PIN	ACQUISITION RACK CONNECTION	PIN	ACQUISITION RACK CONNECTION
1	+15V DC POWER SUPPLY DECK	9	NC
2	-15V DC POWER SUPPLY DECK	10	NC
3	SCANNER CONTACT 03 H	11	NC
4	GROUND POWER SUPPLY DECK	12	SCANNER CONTACT 03 SHIELD
5	GROUND POWER SUPPLY DECK	13	+15V DC SHIELD
6	SCANNER CONTACT 03 L	14	-15V DC SHIELD
7	SCANNER CONTACT 04 H	15	SCANNER CONTACT 04 SHIELD
8	SCANNER CONTACT 04 L		

Figure 3-45. Wiring diagram of connector J5B to main calorimeter gas input circuits box (System T).



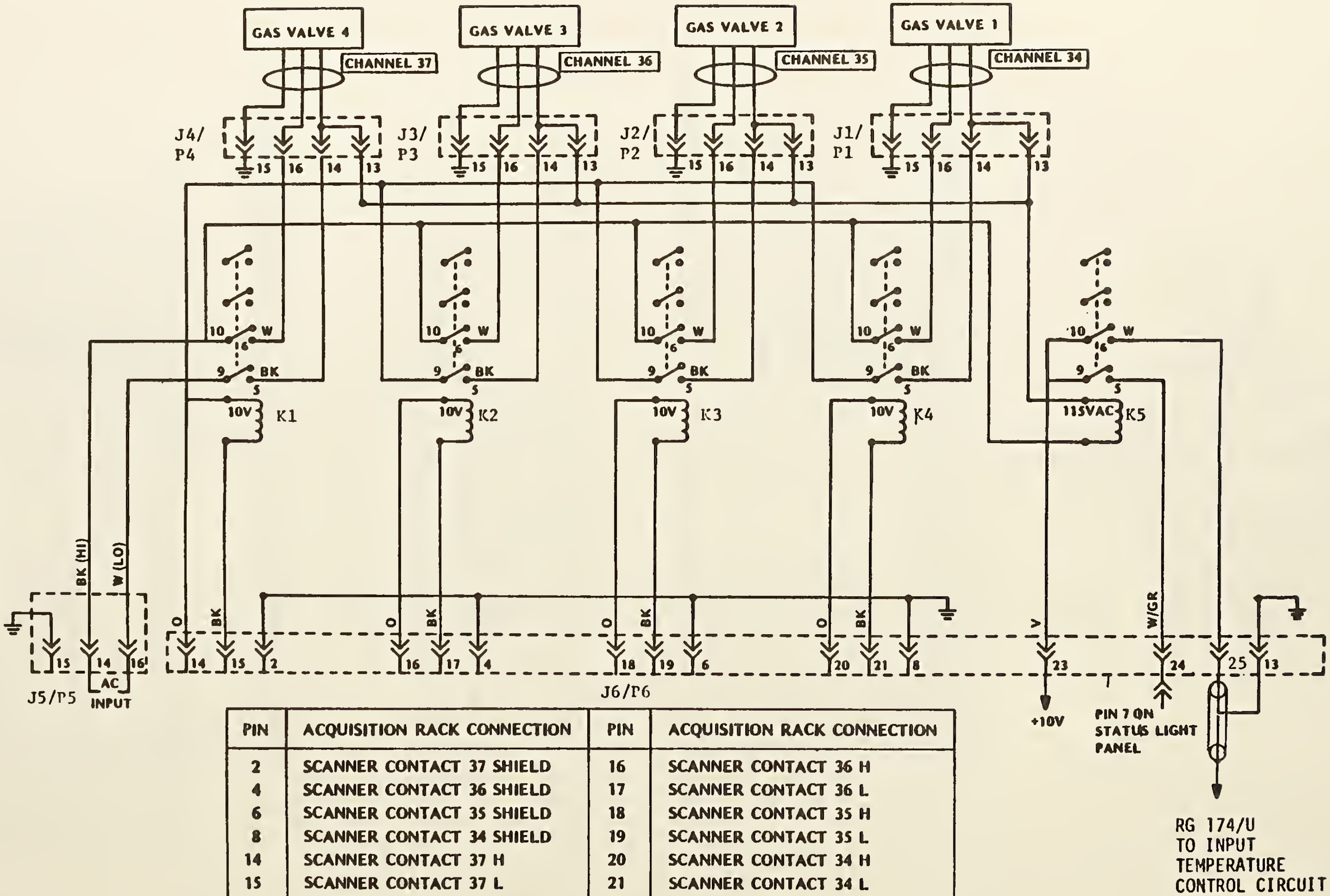
PIN	CONTROL CHASSIS CONNECTION	PIN	CONTROL CHASSIS CONNECTION
A	PIN 23	H	PIN 14
B	PIN 16	I	PIN 21
C	PIN 11	J	PIN 22
D	PIN 7	K	PIN 25
E	PIN 18	L	PIN 5
F	PIN 15	M	PIN 19
G	PIN 3	N	PIN 17

Figure 3-46. Wiring diagram of connector J6 to OSM/BSM shutter motors.



PIN	CONTROL CHASSIS CONNECTION	PIN	CONTROL CHASSIS CONNECTION
1	PIN 1	14	PIN 14
2	NC	15	PIN 15
3	PIN 3	16	NC
4	NC	17	PIN 17
5	NC	18	PIN 18
6	NC	19	PIN 19
7	NC	20	PIN 20
8	NC	21	PIN 21
9	NC	22	PIN 22
10	NC	23	PIN 23
11	NC	24	PIN 24
13	PIN 13	25	PIN 25

Figure 3-47. Wiring diagram of connector J7 to main calorimeter shutter motors.



PIN	ACQUISITION RACK CONNECTION	PIN	ACQUISITION RACK CONNECTION
2	SCANNER CONTACT 37 SHIELD	16	SCANNER CONTACT 36 H
4	SCANNER CONTACT 36 SHIELD	17	SCANNER CONTACT 36 L
6	SCANNER CONTACT 35 SHIELD	18	SCANNER CONTACT 35 H
8	SCANNER CONTACT 34 SHIELD	19	SCANNER CONTACT 35 L
14	SCANNER CONTACT 37 H	20	SCANNER CONTACT 34 H
15	SCANNER CONTACT 37 L	21	SCANNER CONTACT 34 L

Figure 3-48. Wiring diagram of gas valve control output panel.

There are also some subtle differences in similar statements in the two basic languages. For instance, in the following sequence on System T

```
J = 1
J$ = STR(J).
```

J$ is a string two terms long having preserved the space for the implied plus sign. This space needs to be removed for concatenation and certain other operations. On System H the space is dropped. Also, on System H in computed GOTO statements, arguments outside the range of accepted values (zero included) cause a fatal error. On System T the computer goes to the next line, which allows software handling of mistakes such as wrong answers from keyboard input from the operator. Other differences will become apparent as the operator becomes better acquainted with the two systems.

4.2 System T Programs and Data Files

4.2.1 Index (FILE 1)

This index can most easily be run by pressing the AUTO LOAD button. The program lists the file number and name of each program on the tape and automatically loads and runs the program selected by the operator.

At the beginning of the program is a routine that tells the operator the other programs on the tape will not run if he is not using an "A" series 4050. See appendix B, section B.1, for a variable map and listing of this program.

The nearest thing on System H is the command CAT which lists the programs only.

4.2.2 CLOP (FILE 2)

CLOP is the data acquisition program. It accepts run parameters input by the operator and then starts operating the calorimeter, performing such functions as reading and storing the output of all the sensors, operating shutters, turning on and off the electrical calibration power supply, and shutting off and turning on the gas flow. It also performs simple mathematical operations such as averaging data packets by dividing by 6 and scaling calibration voltages by multiplying by 10.

After the run is completed results can be printed to the screen and copied, and then stored on the data tape in a temporary storage file. See appendix B, section B.2, for a variable map and listing of this program.

This program performs the same functions as "Autost" and "CLOP2" which are chained on System H.

4.2.3 CHANNEL MONITOR (FILE 3)

CHANNEL MONITOR is a general utility program. It is used to switch in various channels on the scanner to read the output from the sensor, or to perform certain operations such as switching open and closed gas valves and CLOP shutters. This program is extremely useful when setting up CLOP or repairing sensor and shutter circuits. See appendix B, section B.3, for a listing of this program. There is no variable map, since the program uses no variables.

This program is used for the same function as "CHMON" on System H but is more elaborate because of the greater number of UDKs.

4.2.4 READ RUN DATA FILES (FILE 4)

This program is used to read and list the contents of the temporary data storage files. If the operator has data stored that he does not wish to overwrite and lose, he can use this program to ascertain which file contains that data. This program also contains a graphing routine so the operator can use this program after he stores the data from CLOP to graph the sensor outputs. See appendix B, section B.4, for a variable map and listing of this program.

The equivalent program on System H is "FILEXM". That program does not contain a graphing routine.

4.2.5 CALCULATE RESULTS (FILE 5)

This program retrieves the raw data from the temporary storage file and calculates the zeroth, first, and second moments for the zero rating, transition, and final rating periods. For electrical runs a calibration factor or stability factor, whichever is appropriate, is also calculated. Results from electrical runs are stored in electrical summary files. Results of laser and combination runs are stored in data files labelled LASER OR COMBINATION RUN RESULTS FILE #1 through #10. See appendix B, section B.5, for a variable map and listing of this program.

The corresponding program in System H is "CALC".

4.2.6 READ ELECTRICAL SUMMARY FILE (FILE 6)

This program displays and lists the contents of the electrical summary file for any sensor of CLOP. For each electrical calibration run, the run parameters; zeroth, first, and second moments for the zero rating, transition period, and final rating period; and calibration factor (or stability factor) are printed. This program is useful when the operator wishes to obtain an over-all picture of how well CLOP is operating, environmental effects, etc. See appendix B, section B.6, for a variable map and listing of this program.

The corresponding program in System H is "ELSCAN".

4.2.7 CALCULATE CAL FACTORS (FILE 7)

This program calculates the "best" values of calibration factor and drift as described in section 2. For the ancillary modules it calculates an average value; standard deviation; and 90 percent, 95 percent, and 99 percent confidence intervals. For the main calorimeter RTD and temperature out sensor, a least squares fit is performed. Standard deviations and confidence intervals are calculated for the Y-intercept and the slope.

An editing routine is included in the program to allow removal of bad or irrelevant runs. Also, provision is made to add a descriptive information note in which the operator can record comments pertinent to the data. The only character not permitted in the comments is an asterisk (*) since this character is used as a delimiter between the individual information notes. Results are stored in file 23 in the form of an 8 x 4 array (see table 2.1) and a single alpha string containing the information notes for all sensors. See appendix B, section B.7, for a variable map and listing of this program.

The equivalent program in System H is "FACTOR."

4.2.8 RUN KEPCO (FILE 8)

This program is a general utility program. It allows the operator to set the electrical calibration power supply to run at any desired voltage limit and current limit to the limits of the instrument (100 V and 10 A). This is especially useful when one desires to set the divider ratios in the dc calibration voltage and current measuring circuits (see section 3.7.6). See appendix B, section B.8, for a variable map and listing of this program. In System H, program "KEPCO" performs the same functions.

4.2.9 System T Data Tapes

All data tapes for System T are formatted the same. Since this system has an external tape deck, this should require less changing of tape cartridges. The data tape index is given in table 4.1.

File 1 is written in ASCII; all the rest are in binary. Since binary data takes less space than ASCII, this permits storing greater amounts of data. The binary data can also be accessed faster.

File 1 is marked to hold 5120 bytes. Files 2 through 11 hold 20224 bytes each. The electrical summary files, 12 through 22 hold 9216 bytes each. File 23, the electrical calibration summary file

Table 4.1. Index of System T data tapes.

CLOP Data Tape #1 Index
FILE 1 : INDEX
FILE 2 : RUN DATA FILE #1
FILE 3 : RUN DATA FILE #2
FILE 4 : RUN DATA FILE #3
FILE 5 : RUN DATE FILE #4
FILE 6 : RUN DATA FILE #5
FILE 7 : RUN DATA FILE #6
FILE 8 : RUN DATA FILE #7
FILE 9 : RUN DATA FILE #8
FILE 10 : RUN DATA FILE #9
FILE 11 : RUN DATA FILE #10
FILE 12 : MAIN CALORIMETER RTD ELECTRICAL SUMMARY
FILE 13 : MASS FLOW OUT ELECTRICAL SUMMARY
FILE 14 : TEMPERATURE OUT ELECTRICAL SUMMARY
FILE 15 : MASS FLOW IN ELECTRICAL SUMMARY
FILE 16 : TEMPERATURE IN ELECTRICAL SUMMARY
FILE 17 : FOIL REFLECTOR ELECTRICAL SUMMARY
FILE 18 : DEFLECTOR ELECTRICAL SUMMARY
FILE 19 : SEPARATION TUBE ELECTRICAL SUMMARY
FILE 20 : BACKSCATTER MONITOR ELECTRICAL SUMMARY
FILE 21 : OVERSPILL MONITOR ELECTRICAL SUMMARY
FILE 22 : EXTENSION TUBE ELECTRICAL SUMMARY
FILE 23 : ELECTRICAL CALIBRATION FACTOR SUMMARY FILE
FILE 24 : LASER OR COMBINATION RUN RESULTS FILE #1
FILE 25 : LASER OR COMBINATION RUN RESULTS FILE #2
FILE 26 : LASER OR COMBINATION RUN RESULTS FILE #3
FILE 27 : LASER OR COMBINATION RUN RESULTS FILE #4
FILE 28 : LASER OR COMBINATION RUN RESULTS FILE #5
FILE 29 : LASER OR COMBINATION RUN RESULTS FILE #6
FILE 30 : LASER OR COMBINATION RUN RESULTS FILE #7
FILE 31 : LASER OR COMBINATION RUN RESULTS FILE #8
FILE 32 : LASER OR COMBINATION RUN RESULTS FILE #9
FILE 33 : LASER OR COMBINATION RUN RESULTS FILE #10

is 1536 bytes. The last 10 files, 24 through 33, are 14848 bytes each. Thus, there is space in the electrical summary files for the results of 55 electrical calibrations. Files 24 through 33 can each hold the results of 13 laser runs.

The total space on the tape used is 458 kbytes. The tape deck has trouble marking this much space so it is recommended that marking of new data tapes be done with the internal drive of the System T computer. When making a new file 23 (or after a KILL 23:), a dummy array and information note must be put in the new file. The following program will perform this operation.

```
100  INIT
110  DIM FØ(8,4),IØ$(584)
120  FØ=Ø
130  IØ$ = "null*null*null*null*null*null*null*null*"
140  FIND 23
150  WRITE FØ,IØ$
160  PRINT @33,2:
170  END
```

4.3 System H Programs and Data Files

4.3.1 "Autost"

This program, along with CLOP2 (see section 4.3.2) which is chained to it, performs the same function as CLOP on System T (see section 4.2.2). Autost performs all the operations up to the start of the data-taking process. This program is named Autost so that it will load and run automatically when System H is first turned on. It may also be loaded the normal way by typing LOAD "Autost" followed by RUN. See section 4.2.2 for a more complete description of the operations performed by this program.

This program, since it is chained with CLOP2, requires that some variables be stored in COMMON. Those variables so stored are preserved for use in CLOP2; all others are discarded during the chaining operation. In the program map variables in COMMON are marked (C). See appendix C, section C.1, for a variable map and listing of this program.

4.3.2 "CLOP2"

This is the second half of the main data-acquisition program and is chained to Autost. Together these two programs perform the same function as CLOP does for System T (see section 4.2.2). This program begins with the data-taking routines and completes all phases of the run thereafter. This program cannot be run alone as many of the variables need to be defined in Autost.

Variables stored in COMMON are marked (C) in the variable map. See appendix C, section C.2, for a variable map and listing of this program.

4.3.3 "CALC"

This program performs the same functions as program CALCULATE RESULTS (FILE5) in System T (see 4.2.5). The program retrieves the raw run data from a temporary storage file on tape RUN DATAØ or RUN

DATA1 and does the required mathematical calculations. For electrical calibration runs the results are stored in the appropriate electrical summary file on the tape marked ELEC. SUMMARY. Results of laser and combination runs are stored in files on the tape marked LASER RUNS 1. See appendix C, section C.3, for a variable map and listing of this program.

4.3.4 "ELSCAN"

"ELSCAN" is similar to the program READ ELECTRICAL SUMMARY FILES (FILE6) on System T (see section 4.2.6). See appendix C, section C.4 for a variable map and listing of this program.

4.3.5 "FACTOR"

This program is the System H equivalent of CALCULATE CAL FACTORS (FILE 7) on System T (see section 4.2.7). The same statistical methods are used for the various sensors and editing of the electrical summary file data is possible.

The information note utilizes certain infrequently used characters unique to the System H computer as delimiters. These characters are listed below with their associated keystrokes.

Table 4.2 Delimiter characters used with the HP85 information notes.

¿	CONTROL A
@	CONTROL @
Æ	CONTROL [
œ	CONTROL \
£	CONTROL ^
↑	CONTROL J
▒	CONTROL _
⊢	SHIFT +
÷	SHIFT -

These delimiters are listed in the order they appear in the long alpha string, except for the control A. This character is not in the alpha string and hence, when its position is searched for, a zero is returned indicating the beginning of the alpha string. Thus, on System H the asterisk is permitted in the information notes.

A variable map and listing for this program are given in appendix C, section C.5.

4.3.6 "FILEXM"

"FILEXM" is the System H equivalent of READ RUN DATA FILES (FILE 4) on System T (see section 4.2.4). This program performs the same functions as its System T counterpart except there is no routine included for graphing sensor output. See appendix C, section C.6, for the variable map and a listing of this program.

4.3.7 "CHMON"

This program is similar to program CHANNEL MONITOR (FILE 3) on System T (see section 4.2.3). Since there are only eight UDKs on System H, only six of the sensor outputs are available with a single keystroke. However, UDK#7 allows the operator to input via the keyboard any channel command he desires. UDK#8 terminates the program. A variable map and listing for this program are given in appendix C, section C.7.

4.3.8 "KEPCO"

This program performs the same function as its System T equivalent RUN KEPCO (FILE 8) (see section 4.2.8). Appendix C, section C.8, has the variable map and program listing.

4.3.9 System H Data Files

Data files are maintained on separate tape cartridges according to the type of data stored. Since the internal tape drive of System H is the only drive available for tape use, the data and program tapes must be plugged in and removed at various times during program operation. Usually this will be done according to prompting messages displayed on the screen.

Temporary files for storing the raw data acquired by "Autost" and "CLOP2" are available on tapes RUN DATA Ø and RUN DATA 1. Each of these two tapes has 10 files, RUN DATA Ø through RUN DATA 9 and RUN DATA 1Ø through RUN DATA 19, respectively. Each file holds data from one run.

The data tape marked ELEC. SUMMARY contains the electrical summary files for all the sensors. Each file can hold the results of 69 electrical calibrations. Also on this tape is the file "CALFAX" which contains the statistical summary for each of the temperature sensors.

The tape labelled LASER RUNS 1 is used to store the results of L- and C-type runs. The tape has 9 files, each capable of holding the results of 28 runs. Tables 4.3 through 4.6 list catalogs of the four data tapes for System H.

Table 4.3. Catalog for data tape RUN DATA Ø.

Name	Type	Bytes	Recs	File
DATAØ	DATA	256	70	1
DATA1	DATA	256	70	2
DATA2	DATA	256	70	3
DATA3	DATA	256	70	4
DATA4	DATA	256	70	5
DATA5	DATA	256	70	6
DATA6	DATA	256	70	7
DATA7	DATA	256	70	8
DATA8	DATA	256	70	9
DATA9	DATA	256	70	10

Table 4.4. Catalog for data tape RUN DATA 1Ø.

Name	Type	Bytes	Recs	File
DATA1Ø	DATA	256	70	1
DATA11	DATA	256	70	2
DATA12	DATA	256	70	3
DATA13	DATA	256	70	4
DATA14	DATA	256	70	5
DATA15	DATA	256	70	6
DATA16	DATA	256	70	7
DATA17	DATA	256	70	8
DATA18	DATA	256	70	9
DATA19	DATA	256	70	10

Table 4.5. Catalog for data tape ELEC. SUMMARY.

Name	Type	Bytes	Recs	File
MCRTD*	DATA	150	69	1
MAOUT*	DATA	150	69	2
TEOUT*	DATA	150	69	3
MASIN*	DATA	150	69	4
TEMIN*	DATA	150	69	5
DEFLC*	DATA	150	69	6
FOREF*	DATA	150	69	7
SPTUB*	DATA	150	69	8
BSMON*	DATA	150	69	9
OSMON*	DATA	150	69	10
EXTUB*	DATA	150	69	11
CALFAX	DATA	256	4	12

Table 4.6. Catalog for data tape LASER RUNS 1.

Name	Type	Bytes	Recs	File
LAS1ØØ	DATA	822	28	1
LAS1Ø1	DATA	822	28	2
LAS1Ø2	DATA	822	28	3
LAS1Ø3	DATA	822	28	4
LAS1Ø4	DATA	822	28	5
LAS1Ø5	DATA	822	28	6
LAS1Ø6	DATA	822	28	7
LAS1Ø7	DATA	822	28	8
LAS1Ø8	DATA	822	28	9

5. References

[1] Hoya Glass Works Std., Hoya color filter glass, p. 6, Catalog No. 7109E.

[2] Laser Focus, Buyers' Guide, p. 444 (1983).

[3] Johnson, Jr., E. G. Evaluating the inequivalence and a computational simplification for the NBS laser energy standards. App. Opt. 16: 2315-2331; 1977 August.

[4] Natrella, M. Experimental statistics, Nat. Bur. Stand. (U.S.) Handb. 91; 1963 August. pp.5-10.

[5] Bennett, H. E., et. al. Infrared reflectance of aluminum evaporated films in high vacuum. J. Opt. Soc. of Am. 53(9): 1089-1095; 1963 September.

Appendix A. Conversion Routines Between Decimal and Hexadecimal Based Number Systems

The electrical calibration power supply utilizes commands containing hexadecimal numbers to set voltage and current limits. The routines used in the CLOP computer programs employ the conventional hexadecimal digits 0 through 9 and continuing A through F, where $F_{16} = 15_{10}$ and $10_{16} = 16_{10}$. The algorithm used to convert from the decimal to hexadecimal base involves dividing the decimal number by 16 and recording the remainder, R, of each step as illustrated in the following.

Convert $(1240)_{10} \rightarrow (?)_{16}$.

$$16\,\overset{77}{\overline{)1240}} \qquad R = 8$$

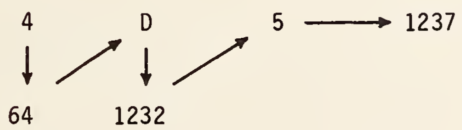
$$16\,\overset{4}{\overline{)77}} \qquad r = 13_{10} = D$$

$$16\,\overset{0}{\overline{)4}} \qquad R = 4$$

Therefore, $1240_{10} \rightarrow 4D8_{16}$.

The inverse operation involves multiplying each hexadecimal digit, starting with the most significant, by 16 and adding in the next digit before again multiplying by 16. An example is given below.

Convert $(4D5)_{16} \rightarrow (?)_{10}$.



Therefore, $4D5_{16} = 1237_{10}$.

B1. Index (FILE 1)

Program Listing

```
100 REM ************* PROGRAM INDEX ********** DATA-TIME: 830331 @ 16:16
110 REM
120 REM ********* TAPE CLOP ***************** FILE 1 ********************
130 INIT
140 X=RND(0)
150 FUZZ 2
170 IF X=0.79 OR X=0.89 OR X=0.59 THEN 210
180 PRINT "LGTAPE CLOP HAS PROGRAMS WHICH WILL RUN ONLY ON THE `A´ SER";
190 PRINT "IES 4050´s.^JJTHEY WILL NOT RUN ON THIS COMPUTER."
200 GO TO 9998
210 PRINT "LGTAPE CLOP                                    DATE: 840111"
220 PRINT
230 PRINT "FILE  1 : Index"
240 PRINT "FILE  2 : Perform CLOP Runs"
250 PRINT "FILE  3 : Read Scanner Channels"
260 PRINT "FILE  4 : Read Run Data Files"
270 PRINT "FILE  5 : Calculate Run Results"
280 PRINT "FILE  6 : Read Electrical Summary Files"
290 PRINT "FILE  7 : Calculate Cal Factor and Stats For Each Module."
300 PRINT "FILE  8 : Run KEPCO Power Supply."
500 PRINT "JJWhat file no.? (Enter 0 for no file)  ";
510 INPUT F
520 IF F=0 THEN 9998
530 FIND F
540 OLD
9998 PRINT "JDONE"
9999 END
```

Variable Map
F-file number of program to run
X-number indicating type of System T computer being used

```
1 INIT
2 SET KEY
3 GO TO 100
4 REM READ MASS IN
5 IF F3<>1 AND F3<>2 THEN 7
6 GOSUB 9800
7 RETURN
8 REM READ TEMP IN
9 IF F3<>1 AND F3<>2 THEN 11
10 GOSUB 9900
11 RETURN
16 REM PAUSE ROUTINE
17 F8=1
18 RETURN
44 REM GAS ON
45 IF F3<>1 AND F3<>2 THEN 47
46 GOSUB 9600
47 RETURN
48 REM GAS OFF
49 IF F3<>1 AND F3<>2 THEN 51
50 GOSUB 9700
51 RETURN
52 REM CHANGE GAS CYLINDER
53 IF F3<>1 THEN 55
54 GOSUB 10100
55 RETURN
80 REM ABORT RUN ROUTINE
81 IF F2=0 THEN 96
82 PRINT @19:"D"
83 F3=0
84 F2=0
85 IF J>120 THEN 92
86 GOSUB 9700
87 PRINT "JJGProgram aborted!G CLOP is on HOLD before 2 min adj period."
88 WBYTE @56,4,1:
89 CALL "IFC"
90 GOSUB 10000
91 GO TO 3740
92 PRINT "JJGGJGAbort activated! We are retreating to the 2 min adjus";
93 PRINT "tment period."
94 CALL "WAIT",2
95 GO TO 3740
96 RETURN
100 REM *********** PROGRAM CLOP ************** DATE-TIME 840210 @ 09:21
110 REM
120 REM *****************TAPE CLOP ********** FILE 2 *****************
130 REM INIT EQUIP.
140 ON SRQ THEN 10300
150 PRINT @6:"12000";"2200F"
160 WBYTE @56,4,1:
```

```
170 PRINT @9:"C,31,33"
180 PRINT @9:"3"
190 PRINT @19:"T100E1DR"
200 CALL "RENOFF"
210 CALL "RENON"
220 DIM IO$(5),L$(1),N$(9),O1$(6),R$(1),U1$(19),V(10),V4(176,10),H1(10)
230 DIM G0$(3),G1$(2),G2$(2),G3$(2),G4$(2),G5$(2),V1(55),I1(55)
240 DIM V1$(5),V2(176,3),U2$(1),M5$(17),U$(1)
250 REM SET CRITICAL FLAGS
260 F3=0
270 F2=0
280 PRINT "LPRE-RUN CHECKLIST"
290 PRINT "JPRE-HEATER CONTROLS SHOULD BE--"
300 PRINT "J    OFF-ON SWITCH--------------OFF"
310 PRINT "    MANUAL-AUTO SWITCH---------MANUAL"
320 PRINT "    VOLTAGE KNOB---------------0 VOLTS (FULL CCW)"
330 GOSUB 10000
340 PRINT "LGSTATUS LIGHT CHECK"
350 PRINT "JARE SHUTTER STATUS LIGHTS RED? (Y OR N)  ";
360 INPUT R$
370 GO TO (R$="Y")+2*(R$="N") OF 410,390
380 GO TO 340
390 PRINT "JUSE MANUAL PUSHBUTTONS TO CLOSE SHUTTERS."
400 GOSUB 10000
410 PRINT "JJKEPCO STATUS LIGHT SHOULD BE RED."
420 PRINT "JKepco OFF and Interface Unit ON"
430 GOSUB 10000
440 PRINT "JJGAS FLOW status light should be RED"
450 PRINT "J+15V & -15V status lights should be GREEN"
460 PRINT "JDVM should be on 10V RANGE. INT. TRIG., ASCII FORMAT, ZER";
470 PRINT "O DELAY"
480 PRINT "JSCANNER should be BLANK"
490 GOSUB 10000
500 G1$=""
510 G9=0
520 PRINT "LGIS EQUIPMENT WARMED UP? (Y OR N)  ";
530 INPUT R$
540 GO TO (R$="Y")+2*(R$="N") OF 760,560
550 GO TO 520
560 PRINT @9:"14"
570 PRINT "LG45 MINUTE WARM-UP PERIOD STARTED.J"
580 PRINT "JCHECK POWER SUPPLY VOLTAGES."
590 J=0
600 PRINT @19:"P100E4SR"
610 WAIT
620 J=J+1
630 IF J<>600 THEN 650
640 PRINT "G10 MIN ELAPSED"
650 IF J<>1200 THEN 670
660 PRINT "G20 MIN ELAPSED"
```

```
670 IF J<>1800 THEN 690
680 PRINT "G30 MIN ELAPSED"
690 IF J<>2400 THEN 710
700 PRINT "G40 MIN ELAPSED"
710 IF J<>2700 THEN 610
720 PRINT @19:"P100E4D"
730 PRINT "JG45 MIN WARM-UP COMPLETED"
740 GOSUB 12000
750 GO TO 800
760 REM PWR CHK-NO WARM UP
770 PRINT @9:"14"
780 PRINT "LCHECK POWER SUPPLY VOLTAGES"
790 GOSUB 10000
800 REM INPUT RUN PARAMETERS
810 PRINT "LGWHAT IS THE RUN NO.?  ";
820 INPUT N$
830 PRI "JIS THIS A LASER(L), ELECTRICAL(E), OR COMBINATION(C) RUN?  ";
840 INPUT L$
850 U1$=""
860 GO TO (L$="L")+2*(L$="E")+3*(L$="C") OF 1050,900,880
870 GO TO 830
880 U1=6
890 GO TO 1030
900 PRINT "LWHAT UNIT IS TO BE CALIBRATED?"
910 PRINT "J  1. EXTENSION TUBE"
920 PRINT "  2. OVERSPILL MONITOR"
930 PRINT "  3. BACKSCATTER MONITOR"
940 PRINT "  4. SEPARATION TUBE"
950 PRINT "  5. DEFLECTOR or FOIL REFLECTOR"
960 PRINT "  6. MAIN CALORIMETER"
970 PRINT "JENTER LINE NO.  ";
980 INPUT U1
990 U1=INT(U1)
1000 IF U1<=6 AND U1=>1 THEN 1030
1010 PRINT "G"
1020 GO TO 970
1030 REM GET CALOR CONFIGURATION
1040 GO TO 1080
1050 U1=6
1060 U1$="MAIN CALORIMETER"
1070 T0=0
1080 O1$=""
1090 M5$="DEFLECTOR=        "
1100 IF L$="L" THEN 1130
1110 PRINT "LSet LASER RUN - COMBINATION switch to COMBINATION"
1120 GO TO 1140
1130 PRINT "LSet LASER RUN - COMBINATION switch to LASER RUN"
1140 GOSUB 10000
1150 F=0
1160 FOR I=1 TO 6
```

```
1170 U$=""
1180 PRINT "LRECORD CALORIMETER CONFIGURATION"
1190 PRINT "J  0. NO MODULE"
1200 PRINT "  1. EXTENSION TUBE"
1210 PRINT "  2. OVERSPILL MONITOR"
1220 PRINT "  3. BACKSCATTER MONITOR"
1230 PRINT "  4. SEPARATION TUBE"
1240 PRINT "  5. DEFLECTOR or FOIL REFLECTOR"
1250 PRINT "  6. MAIN CALORIMETER"
1260 PRINT "JFROM THE INPUT END, WHAT MODULE IS NUMBER ";I
1270 INPUT U$
1280 IF U$<>"5" THEN 1370
1290 PRINT "LWHICH DEVICE IS BEING USED?"
1300 PRINT "J   1. DEFLECTOR"
1310 PRINT "   2. FOIL REFLECTOR"
1320 PRINT "JENTER LINE NO.  ";
1330 INPUT R
1340 GO TO R OF 1370,1360
1350 GO TO 1290
1360 M5$="FOIL REFL=        "
1370 IF VAL(U$)<>U1 THEN 1390
1380 F=1
1390 O1$=O1$&U$
1400 NEXT I
1410 D$=SEG(M5$,1,1)
1420 IF F=1 THEN 1480
1430 PRINT "JGNUMBER ";U1;" IS TO RECEIVE ELECTRICAL ENERGY BUT IS NOT";
1440 PRINT " IN THE CALORIMETER_CONFIGURATION. RESOLVE THIS PROBLEM ";
1450 PRINT "BEFORE CONTINUING."
1460 GOSUB 10000
1470 GO TO 1040
1480 IF L$="L" THEN 1520
1490 GOSUB U1 OF 8000,8100,8200,8300,8400,8600  ! GET ELEC PARAM
1500 V1=0
1510 I1=0
1520 REM GET AMBIENT CONDITIONS
1530 PRINT "LWHAT IS THE AMBIENT TEMPERATURE IN DEGREES C?  ";
1540 INPUT T9
1550 PRINT "JWHAT IS THE BAROMETRIC PRESSURE IN mm OF Hg?  ";
1560 INPUT B9
1570 PAGE
1580 IF U1<>6 THEN 1920
1590 REM SET RTD & TEMP OUT DIALS
1600 PRINT @9:"00"
1610 PRINT "LSet RTD dial for convenient reading on DVM."
1620 PRINT "Enter dial reading  ";
1630 INPUT Z5
1640 PRINT @9:"02"
1650 PRINT "JSet TEMP OUT dial for convenient reading on DVM."
1660 PRINT "Enter dial reading  ";
```

```
1670 INPUT Z6
1680 REM GET MAIN CAL ZERO READINGS
1690 PRINT @24:"R3T2D.010S"
1700 PRINT @9:"03"
1710 INPUT @24:Z1
1720 PRINT @9:"01"
1730 INPUT @24:Z2
1740 PRINT @9:"04"
1750 INPUT @24:Z3
1760 PRINT @9:"02"
1770 INPUT @24:Z4
1780 PRINT @9:"00"
1790 INPUT @24:Z9
1800 PRINT @24:"T1D.1S"
1810 WBYTE @56,1:
1820 IMAGE "MASS FLOW IN ZERO RDG: ",30T,+2D.2D
1830 IMAGE "TEMP IN ZERO RDG: ",30T,+2D.2D
1840 IMAGE "MASS FLOW OUT ZERO RDG: ",30T,+2D.2D
1850 IMAGE "TEMP OUT ZERO RDG: ",30T,+2D.2D
1860 PRINT USING 1820:Z1
1870 PRINT USING 1840:Z2
1880 PRINT
1890 PRINT USING 1830:Z3
1900 PRINT USING 1850:Z4
1910 CALL "WAIT",2
1920 REM PRINT RUN PARAM
1930 PRINT "LRUN NO:   ";N$
1940 PRINT "JRUN TYPE: ";L$
1950 IF L$="L" THEN 1980
1960 PRINT "JUNIT RECEIVING ELECTRICAL ENERGY:  ";U1$
1970 PRINT "JNOMINAL ELECTRICAL ENERGY:  ";E1;" J"
1980 PRINT "JCALORIMETER CONFIGURATION:  ";O1$
1990 PRINT "AMBIENT TEMP:  ";T9;" DEG C"
2000 PRINT "BAROM. PRESS:  ";B9;" mm Hg"
2010 IF U1<>6 THEN 2100
2020 PRINT
2030 PRINT USING 1820:Z1
2040 PRINT USING 1840:Z2
2050 PRINT
2060 PRINT USING 1830:Z3
2070 PRINT USING 1850:Z4
2080 PRINT USING """JRTD dial setting:"",30T,4D":Z5
2090 PRINT USING """TEMP OUT dial setting:"",30T,4D":Z6
2100 CALL "WAIT",2
2110 COPY
2120 IF U1<>6 THEN 3340
2130 PRINT "LWE ARE READY TO SET THE GAS FLOW."
2140 PRINT "JGAS FLOW WILL BE FROM--"
2150 PRINT "J   1. DIRECT FROM INDIVIDUAL CYLINDERS ONE AT A TIME"
2160 PRINT "    2. SEVERAL CYLINDERS ON A HIGH PRESSURE MANIFOLD"
```

```
2170 PRINT "JENTER LINE NO.  ";
2180 INPUT G9
2190 IF G9=1 OR G9=2 THEN 2220
2200 PRINT "GJANSWER MUST BE 1 OR 2"
2210 GO TO 2170
2220 IF G9=2 THEN 2620
2230 REM INDIVIDUAL BOTTLE ROUTINE
2240 PRINT "LOPEN MANUAL VALVES ON INPUT TO ALL ELECTRICAL VALVES TO BE"
2250 PRINT "USED. MAKE SURE MANUAL VALVES ON NON-CONNECTED ELECTRICAL"
2260 PRINT "VALVES ARE CLOSED TO PREVENT BACK LEAKAGE."
2270 GOSUB 10000
2280 PRINT "JOPEN ALL CYLINDER VALVES. CHECK CYLINDER PRESSURE >100#."
2290 PRINT "JSET REGULATORS TO APPROXIMATELY 85 PSI."
2300 GOSUB 10000
2310 M9$="GJERROR! ANSWER MUST BE 1, 2, 3, OR 4"
2320 PRINT "LTO WHAT VALVE IS THE PRIMARY CYLINDER CONNECTED?  ";
2330 INPUT R
2340 IF R=1 OR R=2 OR R=3 OR R=4 THEN 2370
2350 PRINT M9$
2360 GO TO 2320
2370 G0$=STR(33+R)
2380 G1$=TRIM(G0$)
2390 PRINT "JTO WHAT VALVE IS THE #1 BACK-UP CYLINDER CONNECTED?  ";
2400 INPUT R
2410 IF R=1 OR R=2 OR R=3 OR R=4 AND R<>VAL(G1$)-33 THEN 2440
2420 PRINT M9$;" AND ";VAL(G1$)-33;" IS THE PRIMARY CYLINDER VALVE"
2430 GO TO 2390
2440 G0$=STR(33+R)
2450 G2$=TRIM(G0$)
2460 PRINT "JTO WHAT VALVE IS THE #2 BACK-UP CYLINDER CONNECTED?  ";
2470 INPUT R
2480 IF R=1 OR R=2 OR R=3 OR R=4 AND R<>VAL(G2$)-33 THEN 2510
2490 PRINT M9$;" AND ";VAL(G2$)-33;" IS THE #1 BACK-UP CYLINDER VALVE"
2500 GO TO 2460
2510 G0$=STR(33+R)
2520 G3$=TRIM(G0$)
2530 PRINT "JTO WHAT VALVE IS THE #3 BACK-UP CYLINDER CONNECTED?  ";
2540 INPUT R
2550 IF R=1 OR R=2 OR R=3 OR R=4 AND R<>VAL(G3$)-33 THEN 2580
2560 PRINT M9$;" AND ";VAL(G3$)-33;" IS THE #2 BACK-UP CYLINDER"
2570 GO TO 2530
2580 G0$=STR(33+R)
2590 G4$=TRIM(G0$)
2600 F3=1
2610 GO TO 2950
2620 REM GAS SUPPLY FROM MANIFOLD ROUTINE
2630 PRI "LMAKE SURE ALL VALVES ON MANIFOLD AND CYLINDERS ARE SHUT OFF."
2640 PRINT "JCONNECT 3 OR MORE GAS CYLINDERS TO THE MANIFOLD WITH THE"
2650 PRINT "COPPER TUBING PIG-TAILS."
2660 PRINT "JOPEN ALL MANIFOLD VALVES TO CYLINDERS."
```

```
2670 PRINT "JOPEN VALVES ON 2 CYLINDERS."
2680 GOSUB 10000
2690 PRINT "LFOR YOUR INFORMATION--"
2700 PRINT "JJCHANGE GAS CYLINDERS IF PRESSURE DROPS TO 100#."
2710 PRINT "JPROCEDURE IS AS FOLLOWS:"
2720 PRINT "J   1. SHUT OFF MANIFOLD VALVE TO ONE CYLINDER."
2730 PRINT "    2. TURN ON CYLINDER VALVE TO A NEW CYLINDER."
2740 PRINT "    3. CLOSE THE CYLINDER VALVE ON THE CYLINDER IN STEP 1."
2750 PRINT "    4. REPLACE CYLINDER IN STEP 1 WITH A NEW CYLINDER."
2760 PRINT "    5. OPEN THE MANIFOLD VALVE ON REPLACEMENT CYLINDER."
2770 GOSUB 10000
2780 PRINT "LCONTINUING WITH SETTING UP THE GAS MANIFOLD--"
2790 PRINT "JOPEN MANIFOLD VALVE TO PRESSURE REGULATOR."
2800 PRINT "JSET REGULATOR TO APPROXIMATELY 85 PSI."
2810 GOSUB 10000
2820 PRINT "LTO WHAT ELECTRICAL VALVE IS THE PRESSURE REGULATOR CONNEC";
2830 PRINT "TED?  ";
2840 INPUT R
2850 IF R=1 OR R=2 OR R=3 OR R=4 THEN 2890
2860 PRINT M9$
2870 CALL "WAIT",2
2880 GO TO 2820
2890 G0$=STR(33+R)
2900 G1$=TRIM(G0$)
2910 F3=2
2920 PRINT "GJMAKE SURE MANUAL VALVES ON UNUSED ELECTRICAL VALVES ARE ";
2930 PRINT "CLOSED."
2940 GOSUB 10000
2950 PRINT "LWe are now setting up the gas flow."
2960 PRINT "JOn the INPUT GAS CONTROLLER--"
2970 PRINT "J   1. Put the RUN-SET switch to SET"
2980 PRI "   2. Adjust the BALANCE knob so the HEAT CYCLE LED just does"
2990 PRINT "       remain extinguished."
3000 PRINT "    3. Put the RUN-SET switch to RUN."
3010 GOSUB 10000
3020 PRINT "JOn the PREHEATER CONTROL CIRCUIT--"
3030 PRINT "J   1. Put the MANUAL-AUTO switch to AUTO."
3040 PRINT "    2. Rotate VOLTAGE knob to 80 on the front dial."
3050 PRINT "    3. Put the OFF-ON switch to ON."
3060 GOSUB 10000
3070 Z0=7.8  ! THIS VALUE DETERMINED EMPIRICALLY AT DESIRED FLOW RATE
3080 T1=0.61  ! THIS VALUE DETERMINED AS WELL ABOVE LAB TEMP 23 DEG C
3090 PRINT @9:"03"
3100 PRINT "LGUDK 1, 2, 11, 12, 13 (if approp) and 20 are available fo";
3110 PRINT "r use if needed_in succeeding procedures."
3120 PRINT "JMASS FLOW readings on DVM."  ! _=CONTROL RUBOUT
3130 PRINT "JMake sure REGULATORS are set to approximately 85 PSI."
3140 PRI "JOpen FLOW VALVE approximately 7 turns. Leave it alone if yo";
3150 PRINT "u know it is_already set from a previous run."
3160 GOSUB 10000
```

```
3170 GOSUB 9600
3180 PRINT "GJHEAT CYCLE LED should start BLINKING."
3190 PRI "JAdjust FLOW VALVE to get the below MASS IN reading and the ";
3200 PRINT "BALANCE knob_to get the below TEMP IN reading."
3210 PRINT "JIMASS IN = ";Z1+Z0
3220 PRINT "ITEMP IN = ";T1
3230 IF G9=2 THEN 3270
3240 PRINT "JSwitch to each gas cylinder and set its regulator to get ";
3250 PRINT "the MASS IN _reading."
3260 PRINT "JBe sure to end up with the primary cylinder."
3270 PRINT "JMASS IN and TEMP IN readings are coupled. Use UDK´s to sw";
3280 PRINT "itch back and"
3290 PRINT "forth while setting MASS FLOW and TEMPERATURE."
3300 GOSUB 10000
3310 PRINT @9:"3"
3320 F3=0
3330 GO TO 3400
3340 C$=STR(10-U1)
3350 C$=TRIM(C$)
3360 C$="0"&C$
3370 PRINT @9:C$
3380 PRINT "LG";U1$;" output readings ON DVM."
3390 CALL "WAIT",2
3400 PRINT "LSHUTTERS BEING TESTED"
3410 PRINT @9:"3,30,32"
3420 PRINT @9:"3"
3430 CALL "WAIT",9
3440 PRINT "JGShutter STATUS LIGHTS should be GREEN."
3450 CALL "WAIT",4
3460 PRINT "GJTEST CONTINUING."
3470 PRINT @9:"3,31,33"
3480 PRINT @9:"3"
3490 CALL "WAIT",9
3500 PRINT "JGShutter STATUS LIGHTS should be RED."
3510 PRINT "JDID SHUTTERS TEST OKAY? (Y OR N)  ";
3520 INPUT R$
3530 GO TO (R$="Y")+2*(R$="N") OF 3600,3560
3540 PRINT "JGWHAT?"
3550 GO TO 3510
3560 PRINT "JExercise balky shutter with pushbuttons. It must operate ";
3570 PRINT "in 9 seconds."
3580 GOSUB 10000
3590 GO TO 3400
3600 IF L$<>"L" THEN 3630
3610 U1$="MAIN CALORIMETER"
3620 U1=0
3630 U2$=SEG(U1$,1,1)
3640 PRINT "LGFINAL PRE-RUN CHECKLIST"
3650 PRINT "JVerify CABLE 0 is connected to ";U1$
3660 IF L$="L" THEN 3690
```

```
3670 PRINT "JTurn on KEPCO power supply."
3680 GO TO 3700
3690 PRINT "JVerify KEPCO power supply is OFF."
3700 IF U1=6 OR U1=0 THEN 3720
3710 PRINT "JGAS CYLINDERS should be turned OFF at cylinder valves."
3720 PRINT "JMake SAFETY CHECK of area."
3730 GOSUB 10000
3740 H1=0
3750 IF L$="E" AND U2$<>"M" THEN 3770
3760 F3=G9  !ACTIVATE UDK´S
3770 F2=1
3780 PRINT "LBegin 2 min adjustment periodJ"
3790 PRINT @24:"R3T2D.010S"
3800 IF L$="E" AND U2$<>"M" THEN 3820
3810 PRINT @9:"3.";G1$
3820 J=0
3830 N9=20+T0
3840 PRINT @19:"P300E4SR"
3850 WAIT
3860 FOR I=0 TO 9
3870 C$=STR(I)
3880 C$=TRIM(C$)
3890 PRINT @9:"0";C$
3900 INPUT @24:V(I+1)
3910 NEXT I
3920 PRINT "LMASS IN=          ";V(4)
3930 PRINT "MASS OUT=         ";V(2)
3940 PRINT "TEMP IN=          ";V(5)
3950 PRINT "TEMP OUT=         ";V(3)
3960 PRINT "CAL RTD=          ";V(1)
3970 PRINT M5$;V(6)
3980 PRINT "SEP TUBE=         ";V(7)
3990 PRINT "BSM RTD=          ";V(8)
4000 PRINT "OSM RTD=          ";V(9)
4010 PRINT "EXT TUBE=         ";V(10)
4020 J=J+3
4030 PRINT "JTIME: ";J;" SEC"
4040 IF J<120 THEN 3850
4050 IF J<>120 THEN 4070
4060 PRINT "JGStart 8 min monitor periodG"
4070 IF J<600 THEN 3850
4080 PRINT "LGRun is in data taking stage"
4090 PRINT @19:"P100E4R"
4100 WAIT
4110 GO TO 4810  ! 1 COUNT ONLY & THEN OPERATE FROM 2 LINES DOWN
4120 REM DATA TAKING ROUTINE
4130 WAIT
4140 PRINT @9:"00"
4150 INPUT @24:H0
4160 H1(1)=H1(1)+H0
```

```
4170 PRINT @9:"01"
4180 INPUT @24:H0
4190 H1(2)=H1(2)+H0
4200 PRINT @9:"02"
4210 INPUT @24:H0
4220 H1(3)=H1(3)+H0
4230 PRINT @9:"03"
4240 INPUT @24:H0
4250 H1(4)=H1(4)+H0
4260 PRINT @9:"04"
4270 INPUT @24:H0
4280 H1(5)=H1(5)+H0
4290 PRINT @9:"05"
4300 INPUT @24:H0
4310 H1(6)=H1(6)+H0
4320 PRINT @9:"06"
4330 INPUT @24:H0
4340 H1(7)=H1(7)+H0
4350 PRINT @9:"07"
4360 INPUT @24:H0
4370 H1(8)=H1(8)+H0
4380 PRINT @9:"08"
4390 INPUT @24:H0
4400 H1(9)=H1(9)+H0
4410 PRINT @9:"09"
4420 INPUT @24:H0
4430 H1(10)=H1(10)+H0
4440 IF J MOD 6<>0 THEN 4560
4450 V4((J-600)/6,1)=H1(1)
4460 V4((J-600)/6,2)=H1(2)
4470 V4((J-600)/6,3)=H1(3)
4480 V4((J-600)/6,4)=H1(4)
4490 V4((J-600)/6,5)=H1(5)
4500 V4((J-600)/6,6)=H1(6)
4510 V4((J-600)/6,7)=H1(7)
4520 V4((J-600)/6,8)=H1(8)
4530 V4((J-600)/6,9)=H1(9)
4540 V4((J-600)/6,10)=H1(10)
4550 H1=0
4560 IF J<1081 OR J>1150+T0 THEN 4800
4570 IF J>1130 THEN 4690
4580 IF J<>1081 THEN 4620
4590 PRINT @9:"3,30,32"
4600 PRINT @9:"3"
4610 GO TO 4810
4620 IF J<>1120 THEN 4660
4630 PRINT @9:"3,31,33"
4640 PRINT @9:"3"
4650 GO TO 4810
4660 IF J<>1129 THEN 4810
```

```
4670 PRINT @9:"3.";G1$
4680 GO TO 4810
4690 IF L$="L" THEN 4310
4700 PRINT @9:"10"
4710 INPUT @24:I1(J-1130)
4720 PRINT @9:"12"
4730 INPUT @24:V1(J-1130)
4740 IF J<>1140+TO THEN 4770
4750 PRINT @6:"12000","2200F"
4760 GO TO 4810
4770 IF J<>1140 THEN 4810
4780 PRINT @6:V1$,I0$
4790 GO TO 4810
4800 IF J>1656 THEN 4830
4810 J=J+1
4820 GO TO 4130
4830 PRINT @19:"T100E1DR"
4840 PRINT @9:"3"
4850 PRINT @24:"R3T1D.1S"
4860 WBYTE @56,1:
4870 CALL "IFC"
4880 PRINT @9:"14"
4890 PRINT "LGRUN END CHECKLIST"
4900 PRINT "JCHECK CALORIMETER AND ENVIRONS FOR DAMAGE."
4910 PRINT "JPREHEATER SHOULD BE TURNED OFF."
4920 PRINT "JTURN OFF VALVES ON GAS CYLINDERS."
4930 PRINT "JCHECK POWER SUPPLY VOLTAGES ARE NOMINAL."
4940 IF L$="L" THEN 4960
4950 PRINT "JTURN OFF KEPCO POWER SUPPLY."
4960 GOSUB 12000
4970 PRINT "LDATA-SUM PACKETS BEING AVERAGED"
4980 V4=V4/6
4990 IF L$="L" THEN 5050
5000 PRINT "JCALIBRATION VOLTAGES BEING SCALED"
5010 REM MULTIPLY V1 BY 10 BECAUSE OF DIVIDER IN V-I BOX
5020 FOR I=1 TO N9
5030 V1(I)=10*V1(I)
5040 NEXT I
5050 REM OUTPUT RESULTS
5060 M=1
5070 Y1=32
5080 REM FOR PRINTER CHANGE THIS LINE TO "GO TO <2 lines down>
5090 REM MAKE THIS LINE Y1=<printer's add.> & FIX UDK TO "GO TO <here>"
5100 PAGE
5110 PRINT @Y1:"Run No:     ";N$
5120 PRINT @Y1:"JRun Type:  ";L$
5130 PRINT @Y1:"JJCalorimeter Configuration:  ";O1$
5140 PRINT @Y1:"Room Temperature:             ";T9;" deg C"
5150 PRINT @Y1:"Barometric Pressure:          ";B9;" mm Hg"
5160 IF L$="L" THEN 5800
```

```
5170 PRINT @Y1:"JELEC. DATAJ"
5180 Y1$="NO   VOLTS     AMPS"
5190 PRINT @Y1: USING "3(24A)":Y1$,Y1$,Y1$
5200 IMAGE 3(2D.2X,+2D.3D.2X,+2D.3D.4X)
5210 IMAGE 2(2D.2X,+2D.3D.2X,+2D.3D.4X)
5220 IMAGE 2D.2X,+2D.3D.2X,+2D.3D.4X
5230 PRINT
5240 N8=INT(N9/3)
5250 IF N9 MOD 3=0 THEN 5270
5260 N8=N8+1
5270 FOR I=1 TO N8
5280 N=I+N8
5290 P=I+2*N8
5300 IF N9 MOD 3<>0 THEN 5330
5310 PRINT @Y1: USING 5200:I,V1(I),I1(I),N,V1(N),I1(N),P,V1(P),I1(P)
5320 GO TO 5430
5330 IF N9 MOD 3=2 THEN 5390
5340 IF I=N8 THEN 5370
5350 PRI @Y1: USI 5200:I,V1(I),I1(I),N,V1(N),I1(N),P-1,V1(P-1),I1(P-1)
5360 GO TO 5430
5370 PRINT @Y1: USING 5220:I,V1(I),I1(I)
5380 GO TO 5430
5390 IF I=N8 THEN 5420
5400 PRINT @Y1: USING 5200:I,V1(I),I1(I),N;V1(N),I1(N),P,V1(P),I1(P)
5410 GO TO 5430
5420 PRINT @Y1: USING 5210:I,V1(I),I1(I),N,V1(N),I1(N)
5430 NEXT I
5440 CALL "WAIT",2
5450 IF M=1 THEN 5470
5460 COPY
5470 PRINT @Y1:"JJ"
5480 IF L$="C" THEN 5800
5490 PAGE
5500 PRINT @Y1:U1$;" OUTPUT"
5510 IMAGE 3D.2X,4(+2D.4D.7X)
5520 IF U1=6 THEN 5570
5530 PRINT
5540 J1=11-U1
5550 GOSUB 10500
5560 GO TO 6190
5570 PRINT @Y1:"JMASS FLOW INJ"
5580 J1=4
5590 GOSUB 10500
5600 PRINT @Y1:"JMASS FLOW OUTJ"
5610 J1=2
5620 GOSUB 10500
5630 PRINT @Y1:"JTEMPERATURE INJ"
5640 J1=5
5650 GOSUB 10500
5660 PRINT @Y1:"JTEMPERATURE OUTJ"
```

```
5670 PRINT @Y1:
5680 PRINT @Y1:"JTEMP OUT dial setting=";Z6
5690 PRINT @Y1:"TEMP OUT zero reading=";Z4
5700 GO TO 5710
5710 J1=3
5720 GOSUB 10500
5730 PRINT @Y1:"JCALORIMETER RTD"
5740 PRINT @Y1:"JRTD dial setting=";Z5
5750 PRINT @Y1:"RTD zero reading=";Z9
5760 PRINT @Y1:
5770 J1=1
5780 GOSUB 10500
5790 GO TO 6190
5800 REM OUTPUT L&C RUN RESULTS
5810 FOR J1=1 TO 10
5820 GO TO J1 OF 5830,5890,5910,5960,5980,6000,6050,6070,6090,6110
5830 PRINT @Y1:"JMAIN CALORIMETER RTDJ"
5840 PRINT @Y1:"JRTD dial setting:  ";Z5
5850 PRINT @Y1:"RTD zero reading: ";Z9
5860 PRINT @Y1:
5870 J2=6
5880 GO TO 6130
5890 PRINT @Y1:"JMASS FLOW OUTJ"
5900 GO TO 6130
5910 PRINT @Y1:"JTEMPERATURE OUTJ"
5920 PRINT @Y1:"TEMP OUT dial setting:  ";Z6
5930 PRINT @Y1:"TEMP OUT zero reading: ";Z4
5940 PRINT @Y1:
5950 GO TO 6130
5960 PRINT @Y1:"JMASS FLOW INJ"
5970 GO TO 6130
5980 PRINT @Y1:"JTEMPERATURE INJ"
5990 GO TO 6130
6000 IF D$="F" THEN 6030
6010 PRINT @Y1:"JDEFLECTORJ"
6020 GO TO 6120
6030 PRINT @Y1:"JFOIL REFLECTORJ"
6040 GO TO 6120
6050 PRINT @Y1:"JSEPARATION TUBEJ"
6060 GO TO 6120
6070 PRINT @Y1:"JBACKSCATTER MONITORJ"
6080 GO TO 6120
6090 PRINT @Y1:"JOVERSPILL MONITORJ"
6100 GO TO 6120
6110 PRINT @Y1:"JEXTENSION TUBEJ"
6120 J2=11-J1
6130 GOSUB 11000
6140 IF F=1 THEN 6170
6150 PRINT @Y1:"NULL DATA"
6160 GO TO 6180
```

```
6170 GOSUB 10500
6180 NEXT J1
6190 IF M=2 THEN 6270
6200 PRINT "GDO YOU WANT A COPY OF THE RESULTS? (Y OR N)  ";
6210 INPUT R$
6220 GO TO (R$="Y")+2*(R$="N") OF 6240,6310
6230 GO TO 6200
6240 PRINT @32,26:3
6250 M=2
6260 GO TO 5100
6270 CALL "WAIT",3
6280 COPY
6290 M=1
6300 PRINT @32,26:0
6310 PRINT "LGDO YOU WANT TO STORE DATA ON TAPE? (Y OR N)  "
6320 INPUT R$
6330 GO TO (R$="Y")+2*(R$="N") OF 6350,6510
6340 GO TO 6310
6350 PRINT "JWHAT FILE?"
6360 PRINT "JChoices are files 2 through 11"
6370 INPUT L1
6380 FIND @4:L1
6390 WRITE @4:N$,L$,O1$,D$
6400 WRITE @4:T9,B9,U1
6410 IF U1<>6 AND U1<>0 THEN 6430
6420 WRITE @4:Z5,Z6
6430 WRITE @4:V4
6440 IF L$="L" THEN 6480
6450 WRITE @4:U1$
6460 WRITE @4:T0,E1,N9
6470 WRITE @4:V1,I1
6480 PRINT @4,2:
6490 PRINT "JGData stored in file ";L1;" of CLOP DATA tape."
6500 CALL "WAIT",2
6510 PRINT "LRUN NO: ";N$;" COMPLETED."
6520 PRINT "JINDICATE CHOICE"
6530 PRINT "J    1. END RUNS"
6540 PRINT "     2. START NEW RUN"
6550 PRINT "     3. READ RUN DATA FILE"
6560 PRINT "     4. PERFORM DATA REDUCTION CALCULATIONS"
6570 PRINT "     5. TRANSFER DATA VIA RS232 INTERFACE"
6580 PRINT "     6. DISPLAY CURRENT DATA"
6590 PRINT "     7. COPY CURRENT DATA TO FILE"
6600 PRINT "JENTER LINE NUMBER  ";
6610 INPUT R
6620 IF R=>1 AND R<=7 AND R MOD 1=0 THEN 6650
6630 PRINT "JGWHAT?"
6640 GO TO 6610
6650 GO TO R OF 6880,6660,6670,6750,6770,5100,6350
6660 RUN
```

```
6670 PRI "CAUTION--This will wipe out program and all data from memory."
6680 PRINT "Do you wish to continue? (Y or N)  ";
6690 INPUT R$
6700 GO TO (R$="Y")+2*(R$="N") OF 6730,6510
6710 PRINT "JGWHAT?"
6720 GO TO 6690
6730 FIND 4  ! READ FILE
6740 OLD
6750 FIND 5  ! PERFORM CALC.
6760 OLD
6770 PRINT "LGROUTINE NEEDS TO BE DEVELOPED TO SUIT PARTICULAR SERIAL ";
6780 PRINT "TRANSFER_SYSTEM"
6790 GO TO 6500
6800 REM = = = = = = = = = = = = =
6810 REM SPACE
6820 REM         FOR
6830 REM                  FUTURE
6840 REM        RS232
6850 REM ROUTINE
6860 REM                     HERE
6870 REM = = = = = = = = = = = = =
6880 REM END RUNS
6890 WBYTE @56,4,1:
6900 PRINT "JGDONE"
6910 END
8000 REM MAX PARAM FOR EXT TUBE
8010 E0=1000
8020 V0=100
8030 R0=340
8040 I0$="2207A"
8050 U1$="EXTENSION TUBE"
8060 GO TO 8900
8100 REM MAX PARAM FOR OSM
8110 E0=1000
8120 V0=51.2
8130 R0=7.9
8140 I0$="22A7F"
8150 U1$="OVERSPILL MONITOR"
8160 GO TO 8900
8200 REM MAX PARAM FOR BSM
8210 E0=1000
8220 V0=86.4
8230 R0=22.2
8240 I0$="22639"
8250 U1$="BACKSCATTER MONITOR"
8260 GO TO 8900
8300 REM MAX PARAM FOR SEP TUBE
8310 E0=1000
8320 V0=100
8330 R0=340
```

```
8340 I0$="2207A"
8350 U1$="SEPARATION TUBE"
8360 GO TO 8900
8400 REM MAX PARAM FOR DEFLECTOR
8410 IF D$="F" THEN 8480
8420 E0=1000
8430 V0=26
8440 R0=3.56
8450 I0$="22BAE"
8460 U1$="DEFLECTOR"
8470 GO TO 8900
8480 E0=1000
8490 V0=78.9
8500 R0=25.5
8510 I0$="224F2"
8520 U1$="FOIL REFLECTOR"
8530 GO TO 8900
8600 REM MAX PARAM FOR MAIN CAL
8610 E0=15000
8620 V0=100
8630 R0=12.7
8640 I0$="22C98"
8650 U1$="MAIN CALORIMETER"
8900 PRINT "LHOW MANY JOULES ARE TO BE INJECTED?  ";
8910 INPUT E1
8920 IF E1<=E0 THEN 8960
8930 PRINT "JGTOO MUCH ENERGY! TRY ";E0;" JOULES OR LESS."
8940 CALL "WAIT",2
8950 GO TO 8900
8960 T0=5
8970 V3=SQR(E1*R0/T0)
8980 IF V3<=V0 THEN 9030
8990 T0=1+INT(E1*R0/V0^2)
9000 V3=SQR(E1*R0/T0)
9010 PRINT "JJGINJECTION TIME LENGTHENED TO ";T0;" SECONDS."
9020 CALL "WAIT",2
9030 REM GET KEPCO COMMAND
9040 IF V3>10 THEN 9080
9050 K1=409.6
9060 D2=2
9070 GO TO 9100
9080 K1=40.96
9090 D2=0
9100 D2$=STR(D2)
9110 D2$=TRIM(D2$)
9120 K9=INT(K1*V3)
9130 REM CONVERT K9 TO RADIX 16
9140 V9=INT(K9/16)
9150 D5=K9 MOD 16
9160 D3=INT(V9/16)
```

```
9170 D4=V9 MOD 16
9180 D0$=STR(D5)
9190 IF D5<10 THEN 9210
9200 GOSUB 9400
9210 D5$=TRIM(D0$)
9220 D0$=STR(D4)
9230 IF D4<10 THEN 9250
9240 GOSUB 9400
9250 D4$=TRIM(D0$)
9260 D0$=STR(D3)
9270 IF D3<10 THEN 9290
9280 GOSUB 9400
9290 D3$=TRIM(D0$)
9300 V1$="1"&D2$&D3$&D4$&D5$
9310 RETURN
9400 REM CONVERT LARGE HEX DIGITS
9410 GO TO VAL(D0$)-9 OF 9420,9440,9460,9480,9500,9520
9420 D0$="A"
9430 RETURN
9440 D0$="B"
9450 RETURN
9460 D0$="C"
9470 RETURN
9480 D0$="D"
9490 RETURN
9500 D0$="E"
9510 RETURN
9520 D0$="F"
9530 RETURN
9600 REM TURN ON GAS
9610 PRINT @9:G1$
9620 RETURN
9700 REM TURN OFF GAS
9710 PRINT @9:"3"
9720 RETURN
9800 REM MASS IN VOLTS
9810 PRINT @9:"03"
9820 RETURN
9900 REM TEMP IN VOLTS
9910 PRINT @9:"04"
9920 RETURN
10000 REM PAUSE ROUTINE
10010 PRINT "GJPush UDK#4 to continue"
10020 F8=0
10030 REM IDLING LOOP
10040 IF F8=1 THEN 10060
10050 GO TO 10030
10060 F8=0
10070 RETURN
10100 REM CHG GAS CYLINDER ROUTINE
```

```
10110 G5$=G1$
10120 G1$=G2$
10130 PRINT @9:"3,";G1$
10140 G2$=G3$
10150 G3$=G4$
10160 G4$=G5$
10170 RETURN
10300 POLL C,D;19
10310 GO TO C OF 10320
10320 RETURN
10500 REM PRINT OUT SENSOR DATA
10510 IMAGE 3D,2X,4(+2D.4D,7X)
10520 FOR K=1 TO 176 STEP 4
10530 PRINT @Y1: USING 10510:K,V4(K,J1),V4(K+1,J1),V4(K+2,J1),V4(K+3,J1)
10540 NEXT K
10550 RETURN
11000 REM MISSING MODULE DETECTION ROUTINE
11010 F=0
11020 J2$=STR(J2)
11030 J2$=TRIM(J2$)
11040 FOR L=1 TO 6
11050 O2$=SEG(O1$,L,1)
11060 IF O2$<>J2$ THEN 11080
11070 F=1
11080 NEXT L
11090 RETURN
12000 REM ROUTINE TO KEEP SCREEN FROM ERASING
12010 PRINT "JPush UDK#4 to continue."
12020 F8=0
12030 K=0
12040 DO
12050 K=K+1
12060 CALL "WAIT",1
12070 IF K MOD 1500<>0 THEN 12090
12080 PRINT "^"
12090 EXIT IF F8=1
12100 LOOP
12110 F8=0
12120 RETURN
```

Variable Map

Program: CLOP Date: 840210

B9 - barometric pressure in mm of Hg

C - polling variable indicating unit activating SRQ
C$ - scanner channel command for switching sensor channels

D - polling variable indicating SRQ message
D2 - number indicating power supply voltage range
D3 - first hexadec. digit (MSD) of voltage part of power supply command
D4 - second hexadec. digit of voltage part of power supply command
D5 - third hexadec. digit (LSD) of voltage part of power supply command
D$ - deflector-type descriptor (F = foil reflector, D = mirror deflector)
D2$ - second digit in power supply command (string version of D2)
D3$ - third digit in power supply command (string version of D3)
D4$ - fourth digit in power supply command (string version of D4)
D5$ - fifth digit in power supply command (string version of D5)
DØ$ - temporary string variable for converting hexadec. digits to string variables

E1 - nominal electrical energy input
E0 - maximum allowable electrical energy

F - flag to look for unit missing from calorimeter configuration
F2 - flag to lock out UDK #20
F3 - flag to lock out UDKs #1, #2, #11, #12, and #13
F8 - flag to leave indefinite wait subroutine

G9 - method of gas supply (1 = low press. manifold, 2 = high press. manifold)
G1$ - electrical valve channel for primary gas cylinder (LP and HP supply)
G2$ - electrical valve channel for #1 back-up gas cylinder (LP supply)
G3$ - electrical valve channel for #2 back-up gas cylinder (LP supply)
G4$ - electrical valve channel for #3 back-up gas cylinder (LP supply)
G5$ - temporary string variable for changing order of gas cylinders in LP supply
GØ$ - temporary string variable for setting up gas flow valve priorities

H1 - array for acquiring by summing sensor output data packets
HØ - measured sensor output voltage to be summed to H1

I - counter
I1 - array containing electrical calibration current readings
IØ$ - current limit command to calibration power supply

J - counter
J1 - index indicating sensor data being handled
J2 - index indicating unit being searched for missing module routine
J2$ - string version of J2

K - counter
K1 - sealing constant for calculating power supply command
K9 - decimal equivalent of hexadecimal voltage part of power supply command

L - counter
L1 - no. of file in which data is to be stored
L$ - run type (L = laser, C = combination, E = electrical)

M - results output-type descriptor (1 = display, 2 = hardcopy)
M5$ - deflector-type name display message during monitor period
M9$ - error message in gas set-up routine

N - line number of second column of V1 - I1 data
N8 - number of lines of V1 and I1 readings to be displayed
N9 - number of V1 (and I1) readings
N$ - run number

O1$ - calorimeter configuration description

P - index of third column of V1 - I1 data being displayed

R - numeric answer to questions
RØ - resistance of calibration heater
R$ - alpha answer to questions

T1 - temperature in reading desired while gas is flowing
T9 - ambient temperature in degrees C
TØ - electrical energy injection period duration in seconds

U1 - numeric indicator of unit receiving electrical energy
U$ - temporary string variable for building U1$
U1$ - name of unit to be calibrated
U2$ - one letter descriptor of unit receiving energy (laser or electrical)

V - array for storing sensor output readings during monitor period
V1 - array containing electrical calibration voltage readings
V3 - required voltage setting of electrical calibration power supply
V4 - matrix for storing all data pockets acquired through H1
V9 - quotient derived during hexadecimal conversion
VØ - maximum allowable electrical calibration voltage
V1$ - voltage command to calibration power supply

Y1 - address of device outputting results
Y1$ - column heading title for printing out V1 - I1 data

Z1 - mass flow in zero reading
Z2 - mass flow out zero reading
Z3 - temperature in zero reading
Z4 - temperature out zero reading
Z5 - main calorimeter RTD dial setting
Z6 - temperature out dial setting
Z9 - main calorimeter zero reading
ZØ - change in mass flow in reading when gas is turned on

B3. CHANNEL MONITOR (FILE 3)

Program Listing

```
1 INIT
2 SET KEY
3 GO TO 100
4 REM READ MAIN CAL RTD
5 PRINT @9:"00"
6 PRINT "LJJJJMAIN CAL RTD READINGS ON DVM"
7 RETURN
8 REM READ MASS FLOW OUT
9 PRINT @9:"01"
10 PRINT "LJJJJMASS FLOW OUT READINGS ON DVM"
11 RETURN
12 REM READ TEMP OUT
13 PRINT @9:"02"
14 PRINT "LJJJJTEMPERATURE OUT READINGS ON DVM"
15 RETURN
16 REM READ MASS FLOW IN
17 PRINT @9:"03"
18 PRINT "LJJJJMASS FLOW IN READINGS ON DVM"
19 RETURN
20 REM READ TEMP IN
21 PRINT @9:"04"
22 PRINT "LJJJJTEMPERATURE IN READINGS ON DVM"
23 RETURN
24 REM READ DEFLECTOR
25 PRINT @9:"05"
26 PRINT "LJJJJDEFLECTOR READINGS ON DVM"
27 RETURN
28 REM READ SEP TUBE
29 PRINT @9:"06"
30 PRINT "LJJJJSEPARATION TUBE READINGS ON DVM"
31 RETURN
32 REM READ BSM
33 PRINT @9:"07"
34 PRINT "LJJJJBACKSCATTER MONITOR READINGS ON DVM"
35 RETURN
36 REM READ OSM
37 PRINT @9:"08"
38 PRINT "LJJJJOVERSPILL MONITOR READINGS ON DVM"
39 RETURN
40 REM READ EXT TUBE
41 PRINT @9:"09"
42 PRINT "LJJJJEXTENSION TUBE READINGS ON DVM"
43 RETURN
44 REM GAS VALVE #1
45 PRINT @9:"34"
46 RETURN
48 REM GAS VALVE #2
49 PRINT @9:"35"
50 RETURN
52 REM GAS VALVE #3
```

```
53 PRINT @9:"36"
54 RETURN
56 REM GAS VALVE #4
57 PRINT @9:"37"
58 RETURN
60 REM GASS OFF
61 PRINT @9:"3"
62 RETURN
64 REM OPEN MAIN CAL SHUTTER
65 PRINT @9:"30"
66 PRINT @9:"3"
67 RETURN
68 REM CLOSE MAIN CAL SHUTTER
69 PRINT @9:"31"
70 PRINT @9:"3"
71 RETURN
72 REM OPEN BSM/OSM SHUTTER
73 PRINT @9:"32"
74 PRINT @9:"3"
75 RETURN
76 REM CLOSE BSM/OSM SHUTTER
77 PRINT @9:"33"
78 PRINT @9:"3"
79 RETURN
80 REM READ POWER SUPPLY VOLTAGES
81 PRINT @9:"14"
82 PRINT "LJJJPOWER SUPPLY VOLTAGE READINGS ON DVM. USE PANEL SWITCH."
83 RETURN
100 REM **** PROGRAM CHANNEL MONITOR ********** DATE-TIME 830207 @ 13:40
110 REM
120 REM ********** TAPE CLOP ************** FILE 3 ********************
130 PRINT "LPUSH APPROPRIATE UDK TO GET DESIRED CHANNEL."
140 REM
150 PRINT "^"
160 GO TO 140
170 END
```

Variable Map, no variables used

```
100 REM ******* PROG READ RUN DATA FILES ****** DATE-TIME 840209 @ 08:15
110 REM
120 REM *************** TAPE CLOP **************** FILE 4 **************
130 INIT
140 ON SRQ THEN 3000
150 DIM D$(1),L$(1),N$(9),O1$(6),O2$(1),R$(1),U1$(19),U2$(1)
160 DIM V0(176,10),V1(55),I1(55)
170 PRINT "LGWHAT FILE DO YOU WISH TO ACCESS?"
180 PRINT "JChoices are files 2 through 11J"
190 INPUT L1
200 L1=INT(L1)
210 IF L1<2 OR L1>11 THEN 170
220 FIND @4:L1
230 PRINT "JFile contents being loaded into memory."
240 READ @4:N$,L$,O1$,D$,T9,B9,U1
250 IF U1<>0 AND U1<>6 THEN 270
260 READ @4:Z5,Z6
270 READ @4:V0
280 IF L$="L" THEN 300
290 READ @4:U1$,T0,E1,N9,V1,I1
300 N=1
310 PRINT "LFile ";L1
320 PRINT "JRun No:   ";N$
330 PRINT "JRun Type: ";L$
340 PRINT "JCalorimeter Configuration:  ";O1$
350 PRINT "Room Temperature:            ";T9;" deg C"
360 PRINT "Barometric Pressure:         ";B9;" mm Hg"
370 IF L$="L" THEN 950
380 PRINT "Nominal Energy:              ";E1;" J"
390 Y1$="NO   VOLTS     AMPS"
400 PRINT "JELEC DATAJ"
410 PRINT USING "3(24A)":Y1$,Y1$,Y1$
420 IMAGE 3(2D,2X,+2D.3D,2X,+2D.3D,4X)
430 IMAGE 2(2D,2X,+2D.3D,2X,+2D.3D,4X)
440 IMAGE 2D,2X,+2D.3D,2X,+2D.3D
450 PRINT
460 N8=INT(N9/3)
470 IF N9 MOD 3=0 THEN 490
480 N8=N8+1
490 FOR I=1 TO N8
500 N=I+N8
510 P=I+2*N8
520 IF N9 MOD 3<>0 THEN 550
530 PRINT USING 420:I,V1(I),I1(I),N,V1(N),I1(N),P,V1(P),I1(P)
540 GO TO 650
550 IF N9 MOD 3=2 THEN 610
560 IF I=N8 THEN 590
570 PRINT USING 420:I,V1(I),I1(I),N,V1(N),I1(N),P-1,V1(P-1),I1(P-1)
580 GO TO 650
590 PRINT USING 440:I,V1(I),I1(I)
```

```
600 GO TO 650
610 IF I=N3 THEN 640
620 PRINT USING 420:I,V1(I),I1(I),N,V1(N),I1(N),P,V1(P),I1(P)
630 GO TO 650
640 PRINT USING 430:I,V1(I),I1(I),N,V1(N),I1(N)
650 NEXT I
660 GIN X,Y
670 MOVE 0,0
680 PRINT
690 IF L$="C" THEN 990
700 PRINT U1$;" OUTPUT"
710 IMAGE 3D,2X,4(+2D.4D,7X)
720 U2$=SEG(U1$,1,1)
730 IMAGE /,20A,40T,"Dial Setting: ",4D,/
740 IF U2$="M" THEN 790
750 J1=(U2$=D$)+2*(U2$="S")+3*(U2$="B")+4*(U2$="O")+5*(U2$="E")+5
760 PRINT
770 GOSUB 2500
780 GO TO 1310
790 PRINT "JMASS FLOW INJ"
800 J1=4
810 GOSUB 2500
820 PRINT "JMASS FLOW OUTJ"
830 J1=2
840 GOSUB 2500
850 PRINT "JTEMPERATURE INJ"
860 J1=5
870 GOSUB 2500
880 PRINT USING 730:"TEMPERATURE OUT",Z6
890 J1=3
900 GOSUB 2500
910 PRINT USING 730:"CALORIMETER RTD",Z5
920 J1=1
930 GOSUB 2500
940 GO TO 1310
950 REM OUTPUT L&C RUNS
960 IF M=1 THEN 980
970 COPY
980 PAGE
990 FOR J1=1 TO 10
1000 GO TO J1 OF 1010,1040,1060,1080,1100,1120,1170,1190,1210,1230
1010 PRINT USING 730:"MAIN CALORIMETER RTD",Z5
1020 J2=6
1030 GO TO 1250
1040 PRINT "JMASS FLOW OUTJ"
1050 GO TO 1250
1060 PRINT USING 730:"TEMPERATURE OUT",Z6
1070 GO TO 1250
1080 PRINT "JMASS FLOW INJ"
1090 GO TO 1250
```

```
1100 PRINT "JTEMPERATURE INJ"
1110 GO TO 1250
1120 IF D$="F" THEN 1150
1130 PRINT "JDEFLECTORJ"
1140 GO TO 1240
1150 PRINT "JFOIL REFLECTORJ"
1160 GO TO 1240
1170 PRINT "JSEPARATION TUBEJ"
1180 GO TO 1240
1190 PRINT "JBACKSCATTER MONITORJ"
1200 GO TO 1240
1210 PRINT "JOVERSPILL MONITORJ"
1220 GO TO 1240
1230 PRINT "JEXTENSION TUBEJ"
1240 J2=11-J1
1250 GOSUB 2000  ! MISSING MODULE DETECT
1260 IF F=1 THEN 1290
1270 PRINT "NULL DATA"
1280 GO TO 1300
1290 GOSUB 2500
1300 NEXT J1
1310 IF M=2 THEN 1390
1320 PRINT "JGDO YOU WANT A COPY OF THE DATA? (Y or N)  ";
1330 INPUT R$
1340 GO TO (R$="Y")+2*(R$="N") OF 1360,1430
1350 GO TO 1320
1360 PRINT @32,26:3
1370 M=2
1380 GO TO 310
1390 CALL "WAIT",3
1400 COPY
1410 M=1
1420 PRINT @32,26:0
1430 REM GRAPH OF SENSOR OUTPUT
1440 PRINT "DO YOU WISH TO PRINT A GRAPH OF ANY SENSOR´S OUTPUT?"
1450 PRINT "Y OR N"
1460 INPUT B$
1470 IF B$="N" THEN 1500
1480 IF B$="Y" THEN 1490
1490 GOSUB 4000
1500 PRINT "JGPROGRAM FINISHED. RE-RUN TO ACCESS MORE FILES."
1510 END
2000 REM MISSING MODULE DETECTION ROUTINE
2010 F=0
2020 J2$=STR(J2)
2030 J2$=TRIM(J2$)
2040 FOR L=1 TO 6
2050 O2$=SEG(O1$,L,1)
2060 IF O2$<>J2$ THEN 2080
2070 F=1
```

```
2080 NEXT L
2090 RETURN
2500 REM PRINT OUT SENSOR DATA
2510 IMAGE 3D,2X,4(+2D.4D,7X)
2520 FOR K=1 TO 176 STEP 4
2530 PRINT USING 2510:K,VO(K,J1),VO(K+1,J1),VO(K+2,J1),VO(K+3,J1)
2540 NEXT K
2550 RETURN
3000 POLL X,Y;4
3010 INPUT @4,30:Z
3020 IF Z<>7 THEN 3070
3030 PRINT "JGNO CARTRIDGE INSERTED IN 4924."
3040 PRINT "JPRESS <return> WHEN READY"
3050 INPUT Z$
3060 RUN
3070 PRINT "JGERROR MESSAGE ";Z;" FROM 4924. SEE PAGE 2-26 OF INSTRUCT";
3080 PRINT "ION BOOK."
3090 STOP
3100 RETURN
4000 REM GRAPH OF SENSOR OUTPUT
4005 PAGE
4010 PRINT " 1","MAIN CALORIMETER RTD"
4020 PRINT " 2","MASS FLOW OUT THERMISTOR"
4030 PRINT " 3","TEMPERATURE OUT THERMISTOR"
4040 PRINT " 4","MASS FLOW IN THERMISTOR"
4050 PRINT " 5","TEMPERATURE IN THERMISTOR"
4060 PRINT " 6","DEFLECTOR RTD"
4070 PRINT " 7","SEPARATION TUBE RTD"
4080 PRINT " 8","BACKSCATTER MONITOR RTD"
4090 PRINT " 9","OVERSPILL MONITOR RTD"
4100 PRINT "10","EXTENSION TUBE RTD"
4110 PRINT
4120 PRINT
4130 PRINT "TYPE IN THE INDEX OF THE SENSOR´S OUTPUT THAT YOU"
4140 PRINT "WISH TO GRAPH AND PRESS RETURN."
4150 INPUT J1
4160 DIM A(176)
4170 FOR K=1 TO 176
4180 A(K)=VO(K,J1)
4190 NEXT K
4200 REM GRAPH OF SENSOR OUTPUT
4210 PAGE
4220 VIEWPORT 10,125,10,88
4230 WINDOW 0,175,-14,14
4240 AXIS 10,1
4242 AXIS 0,0,175,14
4244 AXIS 10,0,0,-14
4250 MOVE 0,A(1)
4260 FOR I=0 TO 175
4270 DRAW I,A(I+1)
```

```
4280 NEXT I
4290 MOVE 58,-14
4300 PRINT "JJHHHHHHHH";"READINGS, MINUTES"
4320 FOR I=-14 TO 14
4330 MOVE -10,I
4340 PRINT I
4350 NEXT I
4360 FOR I=1 TO 17
4370 MOVE 10*I,-14
4380 PRINT "J";I
4390 NEXT I
4400 V$="VOLTS"
4410 MOVE -15,0
4420 FOR I=1 TO LEN(V$)/2
4430 PRINT "K";
4440 NEXT I
4450 FOR I=1 TO LEN(V$)
4460 W$=SEG(V$,I,1)
4470 PRINT W$;"JH";
4480 NEXT I
5000 IF J1<>1 THEN 5030
5010 A$="MAIN CALORIMETER RTD"
5020 GO TO 6000
5030 IF J1<>2 THEN 5060
5040 A$="MASS FLOW OUT"
5050 GO TO 6000
5060 IF J1<>3 THEN 5090
5070 A$="TEMPERATURE OUT"
5080 GO TO 6000
5090 IF J1<>4 THEN 5120
5100 A$="MASS FLOW IN"
5110 GO TO 6000
5120 IF J1<>5 THEN 5150
5130 A$="TEMPERATURE IN"
5140 GO TO 6000
5150 IF J1<>6 THEN 5180
5160 A$="DEFLECTOR"
5170 GO TO 6000
5180 IF J1<>7 THEN 5210
5190 A$="SEPARATION TUBE"
5200 GO TO 6000
5210 IF J1<>8 THEN 5240
5220 A$="BACKSCATTER MONITOR"
5230 GO TO 6000
5240 IF J1<>9 THEN 5270
5250 A$="OVERSPILL MONITOR"
5260 GO TO 6000
5270 IF J1<>10 THEN 5300
5280 A$="EXTENSION TUBE"
5290 GO TO 6000
```

```
5300 MOVE 88,14
5310 PRINT "KHHHHH";N$
5315 FOR I=1 TO 32
5320 PRINT
5321 NEXT I
5325 PAGE
5330 PRINT "JDO YOU WANT TO MAKE A GRAPH OF ANY OTHER SENSOR? Y OR N"
5340 INPUT C$
5350 IF C$="Y" THEN 4000
5360 IF C$="N" THEN 5390
5370 PRINT "JGWHAT?"
5380 GO TO 5340
5390 RETURN
6000 MOVE 88,14
6010 FOR I=1 TO LEN(A$)/2
6020 PRINT "H";
6025 NEXT I
6030 PRINT "KK";A$
6040 GO TO 5300
```

Variable Map

Program: READ RUN DATA FILES Date: 840209

A - array containing sensor output values to be graphed
A$ - name of sensor output being graphed-graph label

B9 - barometric pressure in mm of Hg
B$ - answer to graphing question

C$ - answer to "graph again" question

D$ - deflector-type descriptor (D = mirror deflector, F = foil reflector)

E1 - nominal electrical energy injected

F - flag in missing module routine (0 = missing, 1 = present)

I - counter
I1 - array containing electrical calibration current readings

J1 - column index in VØ indicating particular sensor
J2 - numeric indicator of module
J2$ - string equivalent of J2 for comparing in missing module routine

K - counter

L - counter
L1 - number of data storage file to be read
L$ - run type (L = laser, C = combination, E = electrical)

M - results output-type descriptor (1 = display, 2 = hardcopy)

N - line number of second column of V1 - I1 data
N8 - number of lines of V1 and I1 readings to be displayed
N9 - number of V1 (and I1) data points
N$ - run numbers

O1$ - calorimeter configuration description
O2$ - segment of O1$ in missing module routine

P - index of third column of V1 - I1 data being displayed

R$ - alpha answer to questions

T9 - ambient temperature in degrees C
TØ - duration of injection period in seconds

U1 - number of module receiving energy (laser or electrical)
U1$ - name of module receiving electrical energy
U2$ - one letter descriptor of unit receiving electrical energy

V1 - array containing electrical calibration voltage readings
VØ - matrix (176 x 10) containing output values for all sensors
V$ - graph ordinate label

W$ - segment of V$ for printing ordinate label vertically

X - GIN variable in routine to create PAGE FULL

Y - GIN variable in routine to create PAGE FULL
Y1$ - column heading title for printing out V1 - I1 data, also POLLing variable

Z - error message number from tape deck
Z5 - main calorimeter RTD dial setting
Z6 - temperature out dial setting

```
1 INIT
2 SET KEY
3 GO TO 100
16 REM CONTINUE AFTER INDEFINTE PAUSE
17 F8=1
18 RETURN
100 REM ***** PROGRAM CALCULATE RESULTS ******* DATE-TIME 840216 @ 13:30
110 REM
120 REM ***** TAPE CLOP PROGRAMS ***** FILE 5 *************************
130 ON SRQ THEN 5000
140 DIM D$(1),G$(19),L$(1),M$(19),N$(9).O1$(6),R$(1),U1$(19),U2$(1)
150 DIM F1(10),I1(55),K0(10),V(176,10),V1(55),Y0(3,10),Y1(3,10),Y2(3,10)
160 PRINT "LWHAT FILE DO YOU WISH TO ACCESS?"
170 PRINT "JChoices are files 2 through 11."
180 INPUT L1
190 IF L1<2 OR L1>11 THEN 160
200 L1=INT(L1)
210 FIND @4:L1
220 READ @4:N$,L$,O1$,D$,T9,B9,U1
230 IF U1<>0 AND U1<>6 THEN 250
240 READ @4:Z5,Z6
250 READ @4:V
260 IF L$="L" THEN 280
270 READ @4:U1$,T0,E1,N5,V1,I1
280 PRINT "LGContents of file ";L1;" are in memory."
290 PRINT "JRun No:   ";N$
300 PRINT "JRun Type: ";L$
310 PRINT "JCalor. Config: ";O1$
320 IF L$="C" OR L$="L" THEN 1920
330 U2$=SEG(U1$,1,1)
340 IF U2$<>"M" THEN 370
350 N1=1
360 N2=5
370 IF U2$<>"E" THEN 410
380 N1=10
390 N2=10
400 L2=22
410 IF U2$<>"O" THEN 450
420 N1=9
430 N2=9
440 L2=21
450 IF U2$<>"B" THEN 490
460 N1=8
470 N2=8
480 L2=20
490 IF U2$<>"S" THEN 530
500 N1=7
510 N2=7
520 L2=19
530 IF U2$<>"D" THEN 570
```

```
540 N1=6
550 N2=6
560 L2=18
570 IF U2$<>"F" THEN 610
580 N1=6
590 N2=6
600 L2=17
610 M$=U1$
620 GOSUB 4000
630 GOSUB 4500
640 REM GET CAL FACTOR
650 ON SIZE THEN 6000
660 T2=1  ! ASSUME TEMP BEFORE SHUTTER OPENS=TEMP AFTER SHUTTER CLOSES
670 FOR I=N1 TO N2
680 K0(I)=(Y0(3,I)-Y0(1,I)-Y1(1,I)*T2*SQR(12))/J0
690 NEXT I
700 REM OUTPUT RESULTS
710 M=1
720 Y9=32
730 PAGE
740 PRINT @Y9:"Run No:                              ";N$
750 PRINT @Y9:"JRun Type:                                    ";L$
760 PRINT @Y9:"Unit Calib:                                   ";
770 U1$=TRIM(U1$)
780 FOR I=1 TO LEN(U1$)
790 PRINT @Y9:"H";
800 NEXT I
810 PRINT @Y9:U1$
820 PRINT @Y9: USING "30A,6A":"Calor. Config:",O1$
830 PRINT @Y9: USING "31A,-2D.D,6A":"Room Temp:",T9," deg C"
840 PRINT @Y9: USING "31A,3D.D,6A":"Barom. Press:",B9," mm Hg"
850 PRINT @Y9: USING "31A,5D,2A":"Elec. Energy",J0," J"
860 PRINT @Y9: USING "34A,2D,5A":"Inject. Time:",T0," secJ"
870 IF U2$<>"M" THEN 900
880 PRINT @Y9: USING "32A,4D":"RTD dial setting:",Z5
890 PRINT @Y9: USING "32A,4D":"TEMP OUT dial setting:",Z6
900 IF M=2 THEN 930
910 GOSUB 6500
920 GO TO 940
930 COPY
940 IMAGE 20A,24T,+4E
950 FOR I=N1 TO N2
960 IF I<>1 THEN 990
970 M$="RTD"
980 GO TO 1100
990 IF I<>2 THEN 1020
1000 M$="MASS FLOW OUT"
1010 GO TO 1100
1020 IF I<>3 THEN 1050
1030 M$="TEMPERATURE OUT"
```

```
1040 GO TO 1100
1050 IF I<>4 THEN 1080
1060 M$="MASS FLOW IN"
1070 GO TO 1100
1080 IF I<>5 THEN 1100
1090 M$="TEMPERATURE IN"
1100 PAGE
1110 PRINT @Y9:"Run No:    ";N$
1120 PRINT @Y9:"J";M$
1130 PRINT @Y9:
1140 PRINT @Y9:"JZERO RATING PERIODJ"
1150 PRINT @Y9: USING 940:"0th MOMENT:",Y0(1,I)
1160 PRINT @Y9: USING 940:"1st MOMENT:",Y1(1,I)
1170 PRINT @Y9: USING 940:"2nd MOMENT:",Y2(1,I)
1180 PRINT @Y9:"JTRANSITION PERIODJ"
1190 PRINT @Y9: USING 940:"0th MOMENT:",Y0(3,I)
1200 PRINT @Y9: USING 940:"1st MOMENTS",Y1(3,I)
1210 PRINT @Y9: USING 940:"2nd MOMENTS:",Y2(3,I)
1220 IF I=2 OR I=4 OR I=5 THEN 1250
1230 PRINT @Y9: USING 940:"JCALIBRATION FACTOR:",K0(I)
1240 GO TO 1260
1250 PRINT @Y9: USING 940:"JSTABILITY FACTOR:",K0(I)*J0
1260 PRINT @Y9:"JFINAL RATING PERIODJ"
1270 PRINT @Y9: USING 940:"0th MOMENT:",Y0(2,I)
1280 PRINT @Y9: USING 940:"1st MOMENT:",Y1(2,I)
1290 PRINT @Y9: USING 940:"2nd MOMENT:",Y2(2,I)
1300 IF M=2 THEN 1330
1310 GOSUB 6500
1320 GO TO 1350
1330 CALL "WAIT",2
1340 COPY
1350 NEXT I
1360 IF M=2 THEN 1430
1370 PRINT "GDO YOU WANT A COPY OF THE RESULTS? (Y OR N)  ";
1380 INPUT R$
1390 GO TO (R$="Y")+2*(R$="N") OF 1410,1440
1400 GO TO 1370
1410 M=2
1420 GO TO 720
1430 M=1
1440 PRINT "LGDO YOU WANT TO STORE IN SUMMARY FILE? (Y OR N)  ";
1450 INPUT R$
1460 GO TO (R$="Y")+2*(R$="N") OF 1480,3100
1470 GO TO 1440
1480 FOR I=N1 TO N2
1490 IF I<>1 THEN 1520
1500 L2=12
1510 GO TO 1630
1520 IF I<>2 THEN 1550
1530 L2=13
```

```
1540 GO TO 1630
1550 IF I<>3 THEN 1580
1560 L2=14
1570 GO TO 1630
1580 IF I<>4 THEN 1610
1590 L2=15
1600 GO TO 1630
1610 IF I<>5 THEN 1630
1620 L2=16
1630 J=0
1640 FIND @4:L2
1650 INPUT @4,6:Q1,Q2
1660 GO TO Q1 OF 1770,1690,1720,1740
1670 PRINT "GJNEW FILE"
1680 GO TO 1810
1690 PRINT "GJASCII file! It should be binary. File no. is ";L2
1700 PRINT "Fix problem. Then type RUN 1430"  !FIX LINE# AFTER RENUMBER
1710 STOP
1720 READ @4:G
1730 GO TO 1650
1740 READ @4:G$
1750 J=J+0.5
1760 GO TO 1650
1770 IF J<55 THEN 1810
1780 PRINT "GJFile is full. Take appropriate action."
1790 GOSUB 6500
1800 GO TO 1440
1810 WRITE @4:N$,01$,T9,B9
1820 IF I<>1 THEN 1840
1830 WRITE @4:Z5
1840 IF I<>3 THEN 1860
1850 WRITE @4:Z6
1860 WRITE @4:J0,K0(I),Y0(1,I),Y0(2,I),Y0(3,I),Y1(1,I),Y1(2,I),Y1(3,I)
1870 WRITE @4:Y2(1,I),Y2(2,I),Y2(3,I)
1880 PRINT @4,2:
1890 PRINT "GJ";J+1;" lines stored in file ";L2
1900 NEXT I
1910 GO TO 3100
1920 REM DO L&C RUNS
1930 FOR J1=1 TO 10
1940 J2=11-J1
1950 IF J2<5 THEN 1970
1960 J2=6
1970 GOSUB 5500
1980 IF F1(J1)=0 THEN 2030  ! MISSING MODULE TEST
1990 N1=J1
2000 N2=J1
2010 GOSUB 4000
2020 GO TO 2040
2030 GOSUB 5700
```

```
2040 NEXT J1
2050 REM CALC. ELEC ENERGY OF C RUNS
2060 E2=0
2070 IF L$<>"C" THEN 2100
2080 GOSUB 4500
2090 E2=J0
2100 REM OUTPUT RESULTS
2110 M=1
2120 Y9=32
2130 PAGE
2140 PRINT @Y9:"Run No:    ";N$
2150 PRINT @Y9:"JRun Type: ";L$
2160 PRINT @Y9:"JCalorimeter Configuration:  ";O1$
2170 PRINT @Y9:"Room Temperature:            ";T9;"deg C"
2180 PRINT @Y9:"Barometric Pressure:           ";B9;" mm HgJ"
2190 PRINT @Y9:"JRTD dial setting:                ";Z5
2200 PRINT @Y9:"TEMP OUT dial setting:         ";Z6
2210 IF L$="L" THEN 2240
2220 PRINT @Y9: USING "28A,5D,2A":"JInjected Elect. Energy: ";E2;" J"
2230 PRINT @Y9:
2240 FOR I=1 TO 10
2250 GO TO I OF 2260,2280,2300,2320,2340,2360,2410,2430,2450,2470
2260 PRINT @Y9:"IMAIN CALORIMETER RTD"
2270 GO TO 2480
2280 PRINT @Y9:"IMASS FLOW OUT"
2290 GO TO 2480
2300 PRINT @Y9:"ITEMPERATURE OUT"
2310 GO TO 2480
2320 PRINT @Y9:"IMASS FLOW IN"
2330 GO TO 2480
2340 PRINT @Y9:"ITEMPERATURE IN"
2350 GO TO 2480
2360 IF D$="F" THEN 2390
2370 PRINT @Y9:"IDEFLECTOR"
2380 GO TO 2480
2390 PRINT @Y9:"IFOIL REFLECTOR"
2400 GO TO 2480
2410 PRINT @Y9:"ISEPARATION TUBE"
2420 GO TO 2480
2430 PRINT @Y9:"IBACKSCATTER MONITOR"
2440 GO TO 2480
2450 PRINT @Y9:"IOVERSPILL MONITOR"
2460 GO TO 2480
2470 PRINT @Y9:"IEXTENSION TUBE"
2480 IF F1(I)=1 THEN 2510
2490 PRINT @Y9:"JNULL DATAJ"
2500 GO TO 2710
2510 PRINT @Y9:"JZERO RATING PERIOD"
2520 PRINT @Y9: USING 940:"0th MOMENT:",Y0(1,I)
2530 PRINT @Y9: USING 940:"1st MOMENT:",Y1(1,I)
```

```
2540 PRINT @Y9: USING 940:"2nd MOMENT:",Y2(1,I)
2550 PRINT @Y9:"JTRANSITION PERIOD"
2560 PRINT @Y9: USING 940:"0th MOMENT:",Y0(3,I)
2570 PRINT @Y9: USING 940:"1st MOMENT:",Y1(3,I)
2580 PRINT @Y9: USING 940:"2nd MOMENT:",Y2(3,I)
2590 PRINT @Y9:"JFINAL RATING PERIOD"
2600 PRINT @Y9: USING 940:"0th MOMENT:",Y0(2,I)
2610 PRINT @Y9: USING 940:"1st MOMENT:",Y1(2,I)
2620 PRINT @Y9: USING 940:"2nd MOMENT:",Y2(2,I)
2630 PRINT @Y9:
2640 IF I=10 THEN 2660
2650 IF I-1 MOD 2<>0 THEN 2710
2660 GIN X,Y
2670 MOVE 0,0
2680 PRINT
2690 IF M=1 THEN 2710
2700 CALL "WAIT",3
2710 NEXT I
2720 IF M=2 THEN 2800
2730 PRINT "JDO YOU WANT A COPY OF THE RESULTS? (Y OR N)  ";
2740 INPUT R$
2750 GO TO (R$="Y")+2*(R$="N") OF 2770,2840
2760 GO TO 2730
2770 M=2
2780 PRINT @32,26:3
2790 GO TO 2120
2800 IF SUM(F1) MOD 2=0 THEN 2820
2810 COPY
2820 M=1
2830 PRINT @32,26:0
2840 PRINT "GJDO YOU WANT TO SAVE RESULTS ON TAPE? (Y OR N)  ";
2850 INPUT R$
2860 GO TO (R$="Y")+2*(R$="N") OF 2880,3100
2870 GO TO 2840
2880 PRINT "JWHAT FILE NUMBER? (Choices are 24 through 33)  ";
2890 PRINT "NOTE--each file can hold results of 13 runs"
2900 INPUT L2
2910 IF L2<23 OR L2>32 THEN 2880
2920 L2=INT(L2)
2930 FIND @4:L2
2940 INPUT @4,6:Q1,Q2
2950 GO TO Q1 OF 3040,2980,3000,3020
2960 PRINT "JG New File"
2970 GO TO 3040
2980 PRINT "JGASCII FILE! It should be binary. File number is ";L2
2990 STOP
3000 READ @4:G
3010 GO TO 2940
3020 READ @4:G$
3030 GO TO 2940
```

```
3040 WRITE @4:N$,L$,O1$,D$,T9,B9,Z5,Z6
3050 IF L$="L" THEN 3070
3060 WRITE @4:U1$,TO
3070 WRITE @4:E2,Y0,Y1,Y2
3080 PRINT @4,2:
3090 PRINT "JGRESULTS STORED IN FILE ";L2
3100 PRINT "JDONE"
3110 END
4000 REM GET 0th, 1st & 2nd MOMENTS
4010 N=20
4020 X1=237
4030 X2=477
4040 X3=573
4050 X4=813
4060 X5=1053
4070 X0=X2-X1
4080 X7=(X2+X1)/2
4090 X8=(X4+X5)/2
4100 X9=(X3+X4)/2
4110 A0=1-1/(4*N^2)
4120 C0=X0^-0.5
4130 C1=SQR(12/A0)/X0^1.5
4140 C2=SQR(180)/X0^2.5
4150 Z0=(X2-X1)/(2*N)
4160 P0=C0
4170 FOR J=N1 TO N2
4180 K1=X7
4190 GOSUB 7000
4200 Y0(1,J)=S0
4210 Y1(1,J)=S1
4220 Y2(1,J)=S2
4230 K1=X8
4240 GOSUB 7000
4250 Y0(2,J)=S0
4260 Y1(2,J)=S1
4270 Y2(2,J)=S2
4280 K1=X9
4290 GOSUB 7000
4300 Y0(3,J)=S0
4310 Y1(3,J)=S1
4320 Y2(3,J)=S2
4330 NEXT J
4340 RETURN
4500 REM CALCULATE ELECTRICAL ENERGY
4510 V2=0
4520 V3=0
4530 I2=0
4540 I3=0
4550 REM GET AVERAGE OF PRE- & POST INJECTION READING
4560 FOR I=1 TO 10
```

```
4570 V2=V2+V1(I)
4580 V3=V3+V1(I+T0+10)
4590 I2=I2+I1(I)
4600 I3=I3+I1(I+T0+10)
4610 NEXT I
4620 V2=V2/10
4630 I2=I2/10
4640 V3=V3/10
4650 I3=I3/10
4660 REM REMOVE LINEAR DRIFT & CALCULATE ENERGY
4670 J0=0
4680 FOR I=1 TO N5
4690 V4=V1(I)-V2-I*(V3-V2)/N5
4700 I4=I1(I)-I2-I*(I3-I2)/N5
4710 J0=J0+V4*I4
4720 NEXT I
4730 RETURN
5000 POLL C,D;4
5010 REM SPACE FOR COMPUTED "GO TO"
5020 INPUT @4,30:F0
5030 IF F0=12 THEN 5590
5040 IF F0<>2 THEN 5070
5050 PRINT "GJFILE NOT FOUND! RUN PROGRAM AGAIN."
5060 STOP
5070 IF F0<>7 THEN 5500
5080 PRINT "GJNO CARTRIDGE INSERTED IN TAPE DECK. INSERT CARTRIDGE."
5090 GOSUB 6500
5100 GO TO 2840
5110 IF F0<>9 THEN 5150
5120 PRINT "GJCARTRIDGE IS WRITE PROTECTED"
5130 GOSUB 6500
5140 GO TO 2840
5150 IF F0<>4 THEN 5220
5160 PRINT "JGEMPTY FILE! DO YOU WISH TO START A NEW FILE? (Y OR N)  ";
5170 INPUT R$
5180 GO TO (R$="Y")+2*(R$="N") OF 5250,5210
5190 PRINT "GJWHAT?"
5200 GO TO 5170
5210 GO TO 2840
5220 PRINT "JGERROR MESSAGE ";F0;" FROM TAPE DECK"
5230 PRINT "JPRESS <return> WHEN READY TO CONTINUE"
5240 INPUT Z$
5250 RETURN
5500 REM MISSING MODULE DETECTION SUBROUTINE
5510 F1(J1)=0
5520 J2$=STR(J2)
5530 J2$=TRIM(J2$)
5540 FOR L=1 TO 6
5550 O2$=SEG(O1$,L,1)
5560 IF O2$<>J2$ THEN 5570
```

```
5570 F1(J1)=1
5580 NEXT L
5590 RETURN
5700 REM FILL NULL DATA ARRAY SLOTS
5710 FOR J=1 TO 3
5720 Y0(J,J1)=-99999
5730 Y1(J,J1)=-99999
5740 Y2(J,J1)=-99999
5750 NEXT J
5760 RETURN
6000 REM SIZE ERROR SUBROUTINE
6010 RETURN
6500 REM INDEFINITE PAUSE
6510 PRINT "JGPush UDK#4 to continue"
6520 F8=0
6530 REM
6540 IF F8=1 THEN 6560
6550 GO TO 6530
6560 F8=0
6570 RETURN
7000 REM MOMENT SUMMING ROUTINE
7010 S0=0
7020 S1=0
7030 S2=0
7040 FOR I=-N TO N-1
7050 Z1=Z0*(I+0.5)
7060 P1=C1*Z1
7070 P2=C2*(Z1^2-A0*X0*X0/12)
7080 S0=S0+V(1+(K1+Z1)/Z0,J)*P0
7090 S1=S1+V(1+(K1+Z1)/Z0,J)*P1
7100 S2=S2+V(1+(K1+Z1)/Z0,J)*P2
7110 NEXT I
7120 RETURN
```

Variable Map

Program: CALCULATE RUN RESULTS Date: 840216

AØ - first-order correction factor to get orthogonality between moments

B9 - barometric pressure in mm of Hg

C - PULL variable
C1 - normalization factor for first moment
C2 - normalization factor for second moment
CØ - normalization factor for zeroth moment

D - PULL variable
D$ - deflector-type descriptor (D = mirror deflector, F = foil reflector)

E1 - nominal electrical energy injected
E2 - energy injected during C run

F1 - array containing flags indicating missing modules
F8 - flag in indefinite wait routine
FØ - error message number from tape deck

G - throwaway variable while finding EOF
G$ - throwaway string variable while finding EOF

I - counter
I1 - array containing electrical calibration current readings
I2 - average zero reading of I1 before injection
I3 - average zero reading of I1 after injection
I4 - I1 readings corrected for drift

J - counter
J1 - counter while calculating moments of L and C runs
J2 - number indicating unit being searched for in missing mod test
JØ - electrical energy injected during calibration run
J2$ - string equivalent of J2 used in missing module routine

K1 - midpoint of period being calculated
KØ - calibration factor

L - counter
L1 - number of file containing data to be processed
L2 - number of file in which results are to be stored
L$ - run type (L = laser, C = combination, E = electrical)

M - results output-type descriptor (1 = display, 2 = hardcopy)
M$ - temporary label for printing name of unit

N - number of data packets in half duration of any time period
N1 - lower sensor index of data to be processed
N2 - upper sensor index of data to be processed
N5 - number of V1 (and I1) readings
N$ - run number

O1$ - calorimeter configuration description
O2$ - segment of O1$ being searched for in missing module routine

P1 - first moment function
P2 - second moment function
PØ - zeroth moment function

Q1 - TYP(Ø) command variable indicating type of data read
Q2 - TYP(Ø) command variable indicating length of data read

R$ - alpha answer to questions

S1 - first moment summing variable
S2 - second moment summing variable

S∅ - zeroth moment summing variable

T2 - factor representing ratio of temp. after shutter closes to temp. before shutter opens
T9 - ambient temperature in degrees C
T∅ - duration in seconds of electrical energy injection period

U1 - numeric indicator of unit receiving energy (laser or electrical)
U1$ - name of module receiving electrical energy
U2$ - single letter descriptor of unit receiving electrical energy

V - array (176 x 10) containing voltage output readings for the 10 sensors
V1 - array containing electrical calibration voltage readings
V2 - average zero reading of V1 before injection
V3 - average zero reading of V1 after injection
V4 - V1 readings corrected for drift

X - GIN variable used in creating PAGE FULL
X1 - time in seconds of starting point of zero rating period
X2 - time in seconds of ending point of zero rating period
X3 - time in seconds of starting point of transition period
X4 - time in seconds of ending point of transition period
X5 - time in seconds of ending point of final rating period
X7 - midpoint of zero rating period in seconds
X8 - midpoint of transition period in seconds
X9 - midpoint of final rating period in seconds
X∅ - period duration in seconds

Y - GIN variable used in creating PAGE FULL
Y1 - array containing first moments of three time periods for all sensors
Y2 - array containing second moments of three time periods for all sensors
Y9 - address of device outputting results
Y∅ - array containing zeroth moments of three time periods for all sensors

Z1 - time coordinate of the point under question
Z5 - main calorimeter RTD dial setting
Z6 - temperature out dial setting
Z∅ - number of readings averaged to get one data packet
Z$ - throwaway answer to wait routine

B6. READ ELECTRICAL SUMMARY FILES (FILE 6)

Program Listing

```
100 REM ******* PROG READ ELECT SUMMARY FILE ** DATE-TIME 840130 @ 09:50
110 REM
120 REM ********** TAPE CLOP PROGRAMS ********** FILE 6 ****************
130 INIT
140 ON SRQ THEN 2000
150 DIM R$(1),Y0(3),Y1(3),Y2(3)
160 PAGE
170 C1$="MAIN CALORIMETER RTD"
180 C2$="MASS FLOW OUT"
190 C3$="TEMPERATURE OUT"
200 C4$="MASS FLOW IN"
210 C5$="TEMPERATURE IN"
220 D1$="FOIL REFLECTOR"
230 D2$="DEFLECTOR"
240 S1$="SEPARATION TUBE"
250 B1$="BACKSCATTER MONITOR"
260 O2$="OVERSPILL MONITOR"
270 E1$="EXTENSION TUBE"
280 PRINT "Electrical Summary File for which sensor is to be accessed?J"
290 PRINT "    1. ";C1$
300 PRINT "    2. ";C2$
310 PRINT "    3. ";C3$
320 PRINT "    4. ";C4$
330 PRINT "    5. ";C5$
340 PRINT "    6. ";D1$
350 PRINT "    7. ";D2$
360 PRINT "    8. ";S1$
370 PRINT "    9. ";B1$
380 PRINT "   10. ";O2$
390 PRINT "   11. ";E1$
400 PRINT "JJEnter line number  ";
410 INPUT R
420 GO TO INT(R) OF 450,470,490,510,530,550,570,590,610,630,650
430 PRINT "JGWHAT?"
440 GO TO 410
450 T$=C1$
460 GO TO 660
470 T$=C2$
480 GO TO 660
490 T$=C3$
500 GO TO 660
510 T$=C4$
520 GO TO 660
530 T$=C5$
540 GO TO 660
550 T$=D1$
560 GO TO 660
570 T$=D2$
580 GO TO 660
590 T$=S1$
```

```
600 GO TO 660
610 T$=B1$
620 GO TO 660
630 T$=O2$
640 GO TO 660
650 T$=E1$
660 L1=R+11
670 F1=0
680 FIND @4:L1
690 IF F1=1 THEN 670
700 IF R<>2 AND R<>4 AND R<>5 THEN 730
710 F1$="Stability Factor:"
720 GO TO 800
730 F1$="Calibration Factor:"
740 IMAGE P,"Electrical Summary file: ",20A,66T,"Page"3D,/
750 IMAGE /,5T,"Room Temperature:",30T,2D.D,45T,"deg C"
760 IMAGE 5T,21A,6D,45T,5A
770 IMAGE 5T,19A,30T,+4E
780 IMAGE /,2T,18A,27T,17A,51T,"FINAL RATING PERIOD",/
790 IMAGE 3T,9A,4E,26T,9A,4E,50T,9A,4E
800 J1=0
810 INPUT @4,6:H1
820 IF H1=1 THEN 1500
830 READ @4:N$,O1$,T9,B9
840 IF R<>1 AND R<>3 THEN 860
850 READ @4:Z0
860 READ @4:J0,K0,Y0(1),Y0(2),Y0(3),Y1(1),Y1(2),Y1(3),Y2(1),Y2(2),Y2(3)
870 J1=J1+0.5
880 IF J1=INT(J1) THEN 900
890 PRINT USING 740:T$,INT(J1+1)
900 PRINT "Run No: ";N$
910 PRINT USING 750:T9
920 PRINT USING 760:"Barometric Press:",B9,"mm Hg"
930 PRINT USING 760:"Calor. Config:",VAL(O1$)," "
940 PRINT
950 PRINT USING 760:"Injected Energy:",J0,"J"
960 PRINT USING 770:F1$,K0
970 IF R<>1 AND R<>3 THEN 1000
980 PRINT USING 760:"Dial Setting:",Z0,""
990 GO TO 1010
1000 PRINT
1010 PRINT USING 780:"ZERO RATING PERIOD","TRANSITION PERIOD"
1020 PRINT USING 790:"0th MOM:",Y0(1),"0th MOM:",Y0(3),"0th MOM:",Y0(2)
1030 PRINT USING 790:"1st MOM:",Y1(1),"1st MOM:",Y1(3),"1st MOM:",Y1(2)
1040 PRINT USING 790:"2nd MOM:",Y2(1),"2nd MOM:",Y2(3),"2nd MOM:",Y2(2)
1050 PRINT "J"
1060 GO TO 810
1500 IF J1<>0 THEN 1530
1510 PRINT "JGEmpty file"
1520 GO TO 1540
```

```
1530 PRINT "JRead out of file ";L1;" for ";T$;" completed"
1540 PRINT "JGRe-run program to access other files"
1550 END
2000 POLL Q1,02;4
2010 INPUT @4,30:H
2020 GO TO H OF 2040,2060,2080,2100,2020,2180,2200,2250,2270,2320
2030 GO TO H-10 OF 2340,2360
2040 PRINT "JGDomain error or invalid argument--Error message 1"
2050 STOP
2060 PRINT "JGFile not found--Error message 2"
2070 STOP
2080 PRINT "JGMag tape format error--Error message 3"
2090 STOP
2100 PRINT "JGIllegal access--Error message 4"
2110 FIND @4:L1
2120 PRINT "JHeaderJ"
2130 INPUT @4,9:H0$
2140 PRINT H0$
2150 STOP
2160 F1=1
2170 RETURN
2180 PRINT "JGRead error (10 re-reads)--Error message 6"
2190 STOP
2200 PRINT "JGNo cartridge inserted--Error message7"
2210 PRINT "JPush <ret> when ready to continue"
2220 INPUT Z$
2230 F1=1
2240 RETURN
2250 PRINT "JGOver-read (illegal tape record length)--Error message 8"
2260 STOP
2270 PRINT "JGCartridge write-protected--Error message 9"
2280 PRINT "JPush <ret> when ready to continue"
2290 INPUT Z$
2300 FIND L1
2310 RETURN
2320 PRINT "JGRead after write error--Error message 10"
2330 STOP
2340 PRINT "JGEnd of medium--Error message 11"
2350 STOP
2360 PRINT "JGEnd of file--Error message 12"
2370 PRINT "JHit BREAK twice to abort run"
2380 PRINT "JPush <ret> to continue"
2390 INPUT Z$
2400 RETURN
```

Variable Map

Program: READ ELECTRICAL SUMMARY FILE Date: 840210

B9 - barometric pressure in mm of Hg
B1$ - title "BACKSCATTER MONITOR"

C1$ - title "MAIN CALORIMETER RTD"
C2$ - title "MASS FLOW OUT"
C3$ - title "TEMPERATURE OUT"
C4$ - title "MASS FLOW IN"
C5$ - title "TEMPERATURE IN"

D1$ - title "FOIL REFLECTOR"
D2$ - title "DEFLECTOR"

E1$ - title "EXTENSION TUBE"

F1 - flag indicating tape deck has issued error message (0 = no error, 1 = error)
F1$ - title "STABILITY FACTOR:" or "CALIBRATION FACTOR:"

H - tape deck error message
H1 - TYP(Ø) integer indicate tape type of character read
HØ$ - header of data tape file

J1 - page counter (two runs per page)
JØ - injected electrical energy in joules

KØ - calibration or stability factor as appropriate

L1 - number of summary file to be accessed

N$ - run number

O1$ - calorimeter configuration descriptor
O2$ - title "OVERSPILL MONITOR"

Q1 - POLLing variable
Q2 - PULLing variable

R - numeric answer to questions
R$ - alpha answer to questions

S1$ - title "SEPARATION TUBE"

T9 - ambient temperature in degrees C
T$ - transfer string variable for titles

Y1 - array containing first moments for zero rating, transition, and final rating periods
Y2 - array containing second moments for zero rating, transition, and final rating periods
YØ - array containing zeroth moments for zero rating, transition, and final rating periods

ZØ - dial setting for either main calorimeter RTD or temp. out sensor
Z$ - throwaway string variable for creating a wait

```
100 REM **** PROG CALCULATE CAL FACTORS ******* DATE-TIME 840128 / 16:00
110 REM
120 REM ********** TAPE CLOP PROGRAMS ****** FILE 7 ********************
130 REM
140 REM APPLIES CORECTION FOR DRIFT TO TEMP OUT AND MAIN CALOR. FOR
150 REM OTHER MODULES PROGRAM AVERAGES RESULTS.  NO PROVISION FOR MASS
160 REM FLOW IN AND OUT AND TEMP IN.
170 INIT
180 ON SRQ THEN 8000
190 DIM M$(20),N$(9),O1$(6),N0(38),K1(38),R$(1),V1(38),F0(8,4),IO$(504)
200 DIM V2(38),K2(38),V3(38)
210 PRINT "LEnter line number of sensor desiredJ"
220 PRINT "  1. Main Calorimeter RTD"
230 PRINT "  2. Temperature Out"
240 PRINT "  3. Foil Reflector"
250 PRINT "  4. Mirror reflector"
260 PRINT "  5. Separation Tube"
270 PRINT "  6. Backscatter Monitor"
280 PRINT "  7. Overspill Monitor"
290 PRINT "  8. Extension Tube"
300 PRINT "JJEnter line number  ";
310 INPUT R
320 R=INT(R)
330 GO TO R OF 360,390,420,450,480,510,540,570
340 PRINT "JGWHAT?"
350 GO TO 310
360 L1=12
370 M$="MAIN CALORIMETER RTD"
380 GO TO 590
390 L1=14
400 M$="TEMPERATURE OUT"
410 GO TO 590
420 L1=17
430 M$="FOIL REFLECTOR"
440 GO TO 590
450 L1=18
460 M$="MIRROR DEFLECTOR"
470 GO TO 590
480 L1=19
490 M$="SEPARATION TUBE"
500 GO TO 590
510 L1=20
520 M$="BACKSCATTER MONITOR"
530 GO TO 590
540 L1=21
550 M$="OVERSPILL MONITOR"
560 GO TO 590
570 L1=22
580 M$="EXTENSION TUBE"
590 FIND @4:L1
```

```
600 N1=1
610 DO
620 INPUT @4,6:H1
630 EXIT IF H1=1
640 READ @4:N$,01$,T9,B9
650 NO(N1)=VAL(N$)
660 IF R<>1 AND R<>2 THEN 680
670 READ @4:ZO
680 READ @4:J0,K1(N1),G,G,G,V1(N1),G,G,G,G,G
690 N1=N1+1
700 LOOP
710 N1=N1-1
720 IF N1<37 THEN 730
725 PRINT "JGFile ";L1;" for ";M$;" is full."
730 IF N1<>0 THEN 760
740 PRINT "JGFile ";L1;" for ";M$;" is empty"
750 GO TO 2500
760 IF N1<3 AND (R=1 OR R=2) THEN 2200
770 GOSUB 7000
780 REM SELECT APPROPRIATE RUNS
790 IMAGE 6D.2D,19T,+4E,37T,+4E
800 PRINT "L";M$
810 PRINT "JRUN NO.           CAL FACTOR        DRIFT TERMJ"
820 FOR I=1 TO N1
830 PRINT USING 790:NO(I),K1(I),V1(I)
840 NEXT I
850 PRINT "JINFORMATION NOTE:_";I1$
860 PRINT "JDelete any run? (Y or N)  ";
870 INPUT R$
880 GO TO (R$="Y")+2*(R$="N") OF 910,1170
890 PRINT "JGWHAT?"
900 GO TO 870
910 PRINT "JWhat run number?  ";
920 INPUT N9
930 PRINT "JIs ";N9;" the correct number? (Y or N)  ";
940 INPUT R$
950 GO TO (R$="Y")+2*(R$="N") OF 980,910
960 PRINT "JGWHAT?"
970 GO TO 940
980 N2=-1
990 FOR I=1 TO N1  ! FIND INDEX OF RUN
1000 IF NO(I)<>N9 THEN 1020
1010 N2=I
1020 NEXT I
1030 IF N2<>-1 THEN 1070
1040 PRINT "JRun no. ";N9;" not found. GTry again."
1050 CALL "WAIT",2
1060 GO TO 800
1070 FOR I=N2 TO N1-1
1080 IF N2=N1 THEN 1120
```

```
1090 NO(I)=NO(I+1)
1100 K1(I)=K1(I+1)
1110 V1(I)=V1(I+1)
1120 NEXT I
1130 N1=N1-1
1140 IF N1>0 THEN 800
1150 PRINT "LGNo values left to be considered!"
1160 GO TO 2500
1170 IF N1<3 AND (R=1 OR R=2) THEN 2200  ! NOT ENOUGH DATA FOR LST SQRS
1180 IF N1>1 OR R=1 OR R=2 THEN 1210
1190 GOSUB 6000
1200 GO TO 1640
1210 IF R<>1 AND R<>2 THEN 1230
1220 GOSUB 3000
1230 IF R=1 OR R=2 THEN 1250
1240 GOSUB 4000
1250 GOSUB 5000
1260 IF R<>1 AND R<>2 THEN 1640
1270 REM OUTPUT TEMP OUT OR RTD RESULTS
1280 IMAGE 15A,19T,+4E
1290 IMAGE 15A,19T,4A,4E,39T,3A
1300 M=1
1310 PRINT "L";M$,"J"
1320 PRINT USING 1280:"Calib Factor:",K
1330 PRINT USING 1280:"JStd Deviation:",K8
1340 PRINT USING 1290:"%Std Dev:";"+H H",ABS(100*K8/K),"%"
1350 PRINT USING 1290:"J90% Conf. int:","+H H",ABS(100*T0*K8/K),"%"
1360 PRINT USING 1290:"95% Conf. int:","+H H",ABS(100*T5*K8/K),"%"
1370 PRINT USING 1290:"99% Conf. int:","+H H",ABS(100*T9*K8/K),"%"
1380 PRINT USING 1280:"JDrift Coef:",A1
1390 PRINT USING 1280:"JStd Deviation:",A8
1400 PRINT USING 1290:"%Std Dev:","+H H",ABS(100*A8/A1),"%"
1410 PRINT USING 1290:"J90% Conf. int:","+H H",ABS(100*T0*A8/A1),"%"
1420 PRINT USING 1290:"95% Conf. int:","+H H",ABS(100*T5*A8/A1),"%"
1430 PRINT USING 1290:"99% Conf. int:","+H H",ABS(100*T9*A8/A1),"%"
1440 PRINT "JNo. of points:",N1
1450 PRINT "J";I1$
1460 IF M=2 THEN 1610
1470 PRINT "JDo you want to change information note? (Y or N)  ";
1480 INPUT R$
1490 GO TO (R$="Y")+2*(R$="N") OF 1520,1540
1500 PRINT "JGWHAT?"
1510 GO TO 1480
1520 GOSUB 7500
1530 GO TO 1300
1540 PRINT "JDo you want a copy of the results? (Y or N)  ";
1550 INPUT R$
1560 GO TO (R$="Y")+2*(R$="N") OF 1590,2000
1570 PRINT "JGWHAT?"
1580 GO TO 1550
```

```
1590 M=2
1600 GO TO 1310
1610 COPY
1620 M=1
1630 GO TO 2000
1640 REM OUTPUT ANCILLARY MODULE RESULTS
1650 M=1
1660 PRINT "L";M$;"J"
1670 PRINT USING 1280:"Calib Factor:",K
1680 PRINT USING 1280:"JStd Deviation:",K8
1690 PRINT USING 1290:"% Std Dev:","+H H",ABS(100*K8/K),"%"
1700 PRINT USING 1290:"J90% Conf int:","+H H",ABS(100*T0*K8/K),"%"
1710 PRINT USING 1290:"95% Conf int:","+H H",ABS(100*T5*K8/K),"%"
1720 PRINT USING 1290:"99% Conf int:","+H H",ABS(100*T9*K8/K),"%"
1730 PRINT "JNo. of points:",N1
1740 PRINT "J";I1$
1750 IF M=2 THEN 1900
1760 PRINT "JDo you want to change information note? (Y or N)  ";
1770 INPUT R$
1780 GO TO (R$="Y")+2*(R$="N") OF 1810,1830
1790 PRINT "JGWHAT?"
1800 GO TO 1770
1810 GOSUB 7500
1820 GO TO 1650
1830 PRINT "JDo you want a copy of the results? (Y or N)  ";
1840 INPUT R$
1850 GO TO (R$="Y")+2*(R$="N") OF 1880,2000
1860 PRINT "JGWHAT?"
1870 GO TO 1840
1880 M=2
1890 GO TO 1660
1900 COPY
1910 M=1
1920 GO TO 2000
2000 REM SAV RESULTS ON TAPE
2010 PRINT "JDo you want to save results on tape? (Y or N)  ";
2020 INPUT R$
2030 GO TO (R$="Y")+2*(R$="N") OF 2060,2500
2040 PRINT "JGWHAT?"
2050 GO TO 2020
2060 F0(R,1)=K
2070 F0(R,2)=100*K8/K
2080 F0(R,3)=N1
2090 IF R<>1 THEN 2120
2100 F0(1,4)=A1
2110 F0(3,4)=A8
2120 IF R<>2 THEN 2150
2130 F0(2,4)=A1
2140 F0(4,4)=A8
2150 FIND @4:23
```

```
2160 WRITE @4:F0,I0$
2170 PRINT @4,2:
2180 PRINT "JGDATA STORED IN FILE 23"
2190 GO TO 2500
2200 PRINT "JGNot enough runs for least squares fit. Only ";N1;" runs."
2210 GO TO 2500
2500 PRINT "JGDONE!"
2510 END
3000 REM LINEAR LEAST SQUARE FIT (NATRELLA)
3010 S1=0
3020 S2=0
3030 S3=0
3040 S4=0
3050 S5=0
3060 FOR I=1 TO N1
3070 V2(I)=V1(I)^2
3080 V3(I)=V1(I)*K1(I)
3090 K2(I)=K1(I)^2
3100 S1=S1+V1(I)  ! SUM X´s
3110 S2=S2+K1(I)  ! SUM Y´s
3120 S3=S3+V3(I)  ! SUM XY´s
3130 S4=S4+V2(I)  ! SUM X^2´s
3140 S5=S5+K2(I)  ! SUM Y^2´s
3150 NEXT I
3160 REM W1=Sxx;W2=Syy;W3=Sxy;V0=X-bar;K0=Y=bar
3170 W3=S3-S1*S2/N1
3180 W1=S4-S1^2/N1
3190 W2=S5-S2^2/N1
3200 V0=S1/N1
3210 K0=S2/N1
3220 REM A1=SLOPE;K=Y-INT
3230 A1=W3/W1
3240 K=K0-A1*V0
3250 REM W4=S(Y)^2;W5=S(Y)
3260 W4=(W2-W3^2/W1)/(N1-2)
3270 W5=SQR(W4)
3280 REM A9=VAR OF SLOPE;K9=VAR OF Y-INT;A8=S.D OF SLOPE;K8=S.D OF Y-INT
3290 A9=W4/W1
3300 K9=W4*(1/N1+V0^2/W1)
3310 A8=SQR(A9)
3320 K8=SQR(K9)
3330 RETURN
4000 REM AVERAGE AND STD DEV
4010 S1=0
4020 S2=0
4030 S4=0
4040 S5=0
4050 FOR I=1 TO N1
4060 V2(I)=V1(I)^2
4070 K2(I)=K1(I)^2
```

```
4080 S1=S1+V1(I)
4090 S2=S2+K1(I)
4100 S4=S4+V2(I)
4110 S5=S5+K2(I)
4120 NEXT I
4130 V0=S1/N1
4140 K=S2/N1
4150 V9=(N1*S4-S1^2)/(N1*(N1-1))
4160 V8=SQR(V9)
4170 K9=(N1*S5-S2^2)/(N1*(N1-1))
4180 K8=SQR(K9)
4190 RETURN
5000 REM t-STATISTIC--T0=90%,T5=95%,T9=99%
5010 IF R<>1 AND R<>2 THEN 5030
5020 N3=N1-2
5025 GO TO 5040
5030 N3=N1-1
5040 IF N3>4 THEN 5080
5050 T0=15.016+N3*(-12.1829+N3*(3.8945-0.4135*N3))
5060 T5=34.958+N3*(-31.3655+N3*(10.208-1.0945*N3))
5070 GO TO 5100
5080 T0=N3/(-0.559925368278+0.60784409253*N3)+6.0E-4
5090 T5=N3/(-0.6115593191+0.5101102332*N3)+6.0E-4
5100 IF N3>1 THEN 5130
5110 T9=63.657
5120 GO TO 5170
5130 IF N3>5 THEN 5160
5140 T9=35.362+N3*(-20.6568+N3*(4.6965-0.36367*N3))
5150 GO TO 5170
5160 T9=N3/(-0.715572170161+0.387490270184*N3)+6.0E-4
5170 RETURN
6000 REM ROUTINE FOR 1 DATA POINT
6010 K=K1(I)
6020 K8=0
6030 A8=0
6040 A1=V1(I)
6050 V8=0
6060 T0=1
6070 T5=1
6080 T9=1
6090 RETURN
7000 REM CAL FACTOR MATRIX AND INFO NOTES
7010 FIND @4:23
7020 READ @4:F0,I0$
7030 REM GET INFO NOTE
7040 J1=1
7050 P=0
7060 DO
7070 P1=P+1
7080 P=POS(I0$,"*",P1)
7090 IF J1<>R THEN 7120
7100 I1$=SEG(I0$,P1,P-P1)
7110 EXIT IF J1=R
7120 J1=J1+1
7130 LOOP
7140 RETURN
7500 REM MAKE NEW INFO NOTE
7510 PRINT "JType new info note [max length=72 char.(1 line)]J"
7520 INPUT I$
7530 P2=LEN(I1$)
7540 I0$=REP(I$,P1,P2)
7550 I1$=I$
7560 RETURN
8000 POLL Q1,Q2;4
8010 INPUT @4,30:H
8020 PRINT "JGError message ";H;" from TAPE DECK"
8030 STOP
```

Variable Map

Program: CALCULATE CAL FACTORS Date: 840126

A1 - drift coefficient (slope from least squares fit)
A8 - standard deviation of A1
A9 - variance of the slope

B9 - barometric pressure in mm of Hg

FØ - 8 x 4 array containing "best" values of temperature sensors

G - throwaway variable

H - error message from tape deck
H1 - TYP(Ø) integer

I - counter
I$ - new information note to replace I1$
I1$ - information note for data being considered
IØ$ - alpha string containing info note and delimiters for all eight sensors

J1 - stepping index to find info note of sensor
JØ - electrical energy injected

K - "best" value of calibration factor
K1 - array containing cal factors read from elec. summary file
K8 - standard deviation of K
K9 - variance of K
KØ - average value of K1

L1 - file number of electrical summary file to be accessed

M - results output type descriptor (1 = display, 2 = copy)
M$ - name of sensor for electrical summary file

N1 - counter of lines of data
N2 - index of run data to be edited out
N3 - degrees of freedom in t-statistic subroutine
N9 - run number for data to be edited out
NØ - array containing numeric equivalents of N$
N$ - run number

O1$ - calorimeter configuration descriptor

P - position of next delimiter in IØ$
P1 - starting point in IØ$ to look for next delimiter

Q1 - POLLing variable
Q2 - POLLing variable

R - numeric answer to questions
R$ - alpha answer to questions

S1 - summation of V1 terms
S2 - summation of K1 terms
S3 - summation of V1 x K1 terms
S4 - summation of $V1^2$ terms
S5 - summation of $K1^2$ terms

T5 - 95 percent t-stat
T9 - ambient temperature in degrees C; after line 250, 99 percent t-stat
TØ - 90 percent t-stat

V1 - array containing first moments for zero rating from elec. sum. file
VØ - ave value of V1

W1 - sum of the squares of the V1 residuals
W2 - sum of the squares of the K1 residuals

W3 - sum of the squares of the V1 x K1 residuals

W4 - $(W3^2/W2) * (N1 - 2)$

W5 - square root of W4

Z∅ - dial setting for either main calorimeter RTD or temp. out (as appropriate)

B8. RUN KEPCO (FILE 8)
Program Listing

```
1 INIT
2 SET KEY
3 GO TO 100
4 REM TURN OFF KEPCO
5 PRINT @6:"12000","22000"
6 PRINT "JGKEPCO TURNED OFF."
24 REM READ KEPCO VOLTAGE
25 PRINT @9:"12"
26 RETURN
28 REM READ KEPCO CURRENT
29 PRINT @6:"10"
30 RETURN
100 REM *********** PROG RUN KEPCO *********** DATE-TIME: 830303 @ 12:30
110 REM
120 REM ************** TAPE CLOP PROGRAMS ******* FILE 8 **************
130 PRINT "LWHAT VOLTAGE LIMIT?  ";
140 INPUT V1
150 IF V1>10 THEN 180
160 K1=409.6
170 GO TO 190
180 K1=40.96
190 VO=INT(K1*V1)
200 D1$="1"
210 IF V1>10 THEN 250
220 D2$="2"
230 GOSUB 1000
240 GO TO 270
250 D2$="0"
260 GOSUB 1000
270 A$=X$
280 REM SET CURRENT LIMIT
290 PRINT "JWHAT CURRENT LIMIT?  ";
300 INPUT V2
310 D1$="2"
320 D2$="2"
330 VO=INT(409.6*V2)
340 GOSUB 1000
350 B$=X$
360 PRINT @6:A$;B$
370 PRINT "LGKEPCO SET TO ";V1;"VOLTS AND ";V2;" AMPS."
380 PRINT "JJJPRESS UDK #1 TO TURN OFF KEPCO."
390 PRINT "JPRESS UDK #6 TO READ VOLTAGE."
400 PRINT "PRESS UDK #7 TO READ CURRENT."
410 END
1000 REM CONVERT VO TO RADIX 16
1010 E1=INT(VO/16)
1020 D5=VO-16*E1
1030 E2=INT(E1/16)
1040 D4=E1-16*E2
1050 D3=E2
```

```
1060 DO$=STR(D5)
1070 DO$=TRIM(DO$)
1080 IF D5<10 THEN 1100
1090 GOSUB 2000
1100 D5$=DO$
1110 DO$=STR(D4)
1120 DO$=TRIM(DO$)
1130 IF D4<10 THEN 1150
1140 GOSUB 2000
1150 D4$=DO$
1160 DO$=STR(D3)
1170 DO$=TRIM(DO$)
1180 IF D3<10 THEN 1200
1190 GOSUB 2000
1200 D3$=DO$
1210 X$=D1$&D2$&D3$&D4$&D5$
1220 RETURN
2000 REM CONVERT LARGER HEXADECIMALS TO ALPHAS
2010 D6=VAL(DO$)-9
2020 GO TO D6 OF 2030,2050,2070,2090,2110,2130
2030 DO$="A"
2040 RETURN
2050 DO$="B"
2060 RETURN
2070 DO$="C"
2080 RETURN
2090 DO$="D"
2100 RETURN
2110 DO$="E"
2120 RETURN
2130 DO$="F"
2140 RETURN
```

Variable Map

Program: RUN KEPCO Date: 840303

A$ - voltage command to power supply

B$ - current command to power supply

D3 - first hexadec. digit (MSD) of voltage part of power supply command
D4 - second hexadec. digit of voltage part of power supply command
D5 - third hexadec. digit (LSD) of voltage part of power supply command
D6 - amount hexadec. number exceeds 9
D1$ - first character in power supply command (channel)
D2$ - second character in power supply command (range)
D3$ - third character in power supply command (MSD)
D4$ - fourth character in power supply command (second hexadec. digit)
D5$ - fifth character in power supply command (LSD)
DØ$ - temporary string variable for converting hexadec. digits to string variables

E1 - quotient derived during hexadecimal conversion
E2 - quotient derived during hexadecimal conversion

K1 - scaling constant for calculating power supply command

V1 - voltage limit
V2 - current limit
VØ - decimal equivalent of hexadecimal number part of power supply command

X$ - transfer string variable for calculating power supply commands

C1. "AUTOST"

Program Listing

```
10 REM PROGRAM "CLOP1" STORED A
   s  Autost". DATE-TIME 840214
    @ 12:20
20 OUTPUT 706 ;"12000";"2200F"
30 OUTPUT 724 ;"R3,T1,N1S,E0S,F
   1,D.0S"
40 LOCAL 724
50 OUTPUT 709 USING "K" ; "C,31
   ,33" @ OUTPUT 709 USING "K"
   ; "3"
60 CLEAR @ DISP "PREHEATER CONT
   ROLS SHOULD BE"
70 DISP "    OFF-ON SWITCH----OF
   F" @ DISP "    MAN-AUTO SWITC
   H--MAN"
80 DISP "    VOLTAGE KNOB-----0
   VOLTS"
90 DISP @ DISP "Push CONT when
   ready"
100 PAUSE
110 CLEAR @ DISP "STATUS LIGHT
    CHECK" @ DISP @ BEEP
120 DISP "ARE SHUTTER STATUS LIG
    HTS RED? (Y OR N)"
130 INPUT R$
140 IF R$="Y" THEN 220
150 IF R$="N" THEN 180
160 BEEP @ DISP "WHAT?"
170 GOTO 120
180 CLEAR @ DISP "USE MANUAL PUS
    HBUTTONS TO CLOSE SHUTTERS"
190 DISP @ DISP "Push CONT when
    status lights are red"
200 PAUSE
210 GOTO 110
220 DISP "KEPCO STATUS LIGHT SHO
    ULD BE RED"
230 DISP "(Kepco OFF and Interfa
    ce Unit ON)"
240 DISP "Push CONT when ready"
250 PAUSE
260 CLEAR @ OPTION BASE 0
270 CLEAR @ DISP "GAS FLOW statu
    s light should be RED"
280 DISP "+15V & -15V status lig
    hts should be GREEN"
290 DISP "DVM should be on 10V R
    ANGE, INT. TRIG., ASCII FORM
    AT, ZERO DELAY"
300 DISP "SCANNER should be BLAN
    K"
310 DISP @ DISP "Push CONT when
    ready"
320 PAUSE
330 COM G1$[2],G2$[2],G3$[2],G4$
    [2],I0$[5],L$[1],M5$[17],N$[
    9],O1$[6],U1$[19],V1$[5]
340 COM SHORT B9,E1,T9,Z1,Z2,Z3,
    Z4,Z5,Z6 ,INTEGER G9,T0,U1
350 DIM G5$[2],M9$[35]
360 INTEGER F,I,J,R
370 OUTPUT 709 USING "K" ; "14"
380 CLEAR
390 G1$="" @ G9=0
400 DISP "IS EQUIPMENT WARMED UP
    ? (Y OR N)"
410 INPUT R$
420 IF R$="Y" THEN 680
430 IF R$="N" THEN 460
440 DISP @ BEEP
450 DISP "WHAT?" @ GOTO 400
460 REM WARM UP PERIOD
470 CLEAR @ DISP "45 MIN WARM UP
     PERIOD STARTED" @ DISP
480 DISP "CHECK POWER SUPPLY VOL
    TAGES" @ BEEP
490 J=0
500 ON TIMER# 1,1000 GOTO 520
510 GOTO 510
520 J=J+1
530 IF J<>600 THEN 560
540 BEEP @ DISP "10 MIN ELAPSED"
550 GOTO 510
560 IF J<>1200 THEN 590
570 BEEP @ DISP "20 MIN ELAPSED"
580 GOTO 510
590 IF J<>1800 THEN 620
600 BEEP @ DISP "30 MIN ELAPSED"
610 GOTO 510
620 IF J<>2400 THEN 650
630 BEEP @ DISP "40 MIN ELAPSED"
640 GOTO 510
650 IF J<>2700 THEN 510
660 OFF TIMER# 1 @ BEEP @ DISP "
    WARM UP PERIOD COMPLETED" @
    WAIT 2000
670 GOTO 730
680 REM PWR CHK-NO WARM UP
690 CLEAR @ BEEP
700 DISP "CHECK POWER SUPPLY VOL
    TAGES" @ DISP
710 DISP "Push CONT when check i
    s complete"
720 PAUSE
730 REM INPUT RUN PARAMETERS
740 CLEAR
750 DISP "WHAT IS THE RUN NO.";
760 INPUT N$
770 DISP @ DISP "IS THIS A LASER
     (L), ELECTRICAL (E) OR COMB
    INATION (C) RUN";
780 INPUT L$@ U1$=""
790 IF L$="L" THEN 1000
800 IF L$="C" THEN 840
810 IF L$="E" THEN 850
820 BEEP @ DISP @ DISP "WHAT?"
830 GOTO 770
840 U1=6 @ GOTO 950
850 CLEAR
860 DISP "WHAT UNIT IS TO BE CAL
    IBRATED?" @ DISP
```

```
870 DISP "  1. EXTENSION TUBE"
880 DISP "  2. OVERSPILL MONITOR
     "
890 DISP "  3. BACKSCATTER MONIT
     OR"
900 DISP "  4. SEPARATION TUBE"
910 DISP "  5. DEFLECTOR/FOIL RE
     FLECTOR"
920 DISP "  6. MAIN CALORIMETER"
930 DISP @ DISP "ENTER LINE NO."
940 INPUT U1
950 IF U1<=6 AND U1>=1 AND FP(U1
     )=0 THEN 980
960 BEEP @ DISP @ DISP "WHAT?"
970 WAIT 1000 @ GOTO 850
980 REM GET CALOR. CONFIGURATION
990 GOTO 1010
1000 U1=6 @ U1$="MAIN CALORIMETE
     R" @ T0=0
1010 O1$="" @ F=0 @ CLEAR @ M5$=
     "DEFLECTOR=        "
1020 IF L$="L" THEN 1040
1030 DISP "Set LASER RUN - COMBI
     NATION switch to COMBINATIO
     N" @ GOTO 1050
1040 DISP "Set LASER RUN - COMBI
     NATION switch to LASER"
1050 DISP @ DISP "Push CONT when
      ready" @ PAUSE
1060 FOR I=1 TO 6
1070 CLEAR @ DISP "RECORD CALORI
     METER CONFIGURATION" @ DISP
1080 DISP "  0. NO MODULE"
1090 DISP "  1. EXTENSION TUBE"
1100 DISP "  2. OVERSPILL MONITO
     R"
1110 DISP "  3. BACKSCATTER MONI
     TOR"
1120 DISP "  4. SEPARATION TUBE"
1130 DISP "  5. DEFLECTOR/FOIL R
     EFLECTOR"
1140 DISP "  6. MAIN CALORIMETER
     "
1150 DISP "FROM THE INPUT END, W
     HAT MODULE IS NUMBER ";I
1160 INPUT R$
1170 IF R$<>"5" THEN 1250
1180 CLEAR @ DISP "WHICH DEVICE
     IS BEING USED?"
1190 DISP @ DISP "  1. DEFLECTOR
     " @ DISP "  2. FOIL REFLECT
     OR"
1200 DISP @ DISP "ENTER LINE NO.
     ";
1210 INPUT R
1220 IF R=1 OR R=2 THEN 1230 ELS
     E 1200
1230 ON R GOTO 1250,1240
1240 M5$="FOIL REFLECTOR=  "
1250 IF VAL(R$)<>U1 THEN 1270
1260 F=1
1270 O1$=O1$&R$
1280 NEXT I
1290 IF F=1 THEN 1340
1300 BEEP @ CLEAR
1310 DISP USING "K" ; U1$;" IS T
     O RECEIVE ENERGY BUT IS NOT
      IN CALOR. CONFIGURATION"
1320 DISP @ DISP "Push CONT when
      problem is resolved" @ PAU
     SE
1330 GOTO 990
1340 IF L$="L" THEN 1370
1350 REM GET ELECTRICAL PARAMETE
     RS
1360 ON U1 GOSUB 4000,4100,4200,
     4300,4400,4600
1370 REM GET AMBIENT CONDITIONS
1380 CLEAR @ DISP "WHAT IS THE A
     MBIENT TEMPERATURE IN DEG.
     C?"
1390 INPUT T9
1400 CLEAR @ DISP "WHAT IS THE B
     AROMETRIC PRESSURE IN mm?"
1410 INPUT B9@ CLEAR
1420 IF U1<>6 THEN 1710
1430 REM SET RTD & TEMP OUT DIAL
1440 OUTPUT 709 USING "K" ; "00"
1450 CLEAR @ DISP "Set RTD dial
     for convenient reading on D
     VM"
1460 DISP @ DISP "Input dial rea
     ding  ";
1470 INPUT Z5
1480 OUTPUT 709 USING "K" ; "02"
1490 CLEAR @ DISP "Set TEMP OUT
     dial for convenient reading
      on DVM"
1500 DISP @ DISP "Input dial rea
     ding  ";
1510 INPUT Z6
1520 REM GET MAIN CAL ZERO RDGS
1530 OUTPUT 724 ;"R3T2D.005S"
1540 OUTPUT 709 USING "K" ; "03"
1550 ENTER 724 ; Z1
1560 OUTPUT 709 USING "K" ; "01"
1570 ENTER 724 ; Z2
1580 OUTPUT 709 USING "K" ; "04"
1590 ENTER 724 ; Z3
1600 OUTPUT 709 USING "K" ; "02"
1610 ENTER 724 ; Z4
1620 OUTPUT 724 ;"T1D.1S" @ LOCA
     L 724
1630 IMAGE "MASS FLOW IN ZERO RD
     G: ",2X,SDZ.2D
1640 IMAGE "TEMP IN ZERO RDG ",2
     X,SDZ.2D
1650 IMAGE "MASS FLOW OUT ZERO R
     DG:",2X,SDZ.2D
1660 IMAGE "TEMP OUT ZERO RDG ",
     2X,SDZ.2D
```

```
1670 DISP USING 1630 ; Z1
1680 DISP USING 1650 ; Z2
1690 DISP @ DISP USING 1640 ; Z3
1700 DISP USING 1660 ; Z4
1710 REM PRINT RUN PARAM
1720 PRINT "RUN NO:    ";N$
1730 PRINT @ PRINT "RUN TYPE: ";
     L$
1740 IF L$="L" THEN 1780
1750 PRINT @ PRINT "UNIT RECEIVI
     NG ELECTRICAL ENERGY"
1760 PRINT U1$ @ PRINT
1770 PRINT "NOMINAL ELEC. ENERGY
     : ";E1;" J"
1780 PRINT @ PRINT "CALOR. CONFI
     G: ";O1$
1790 PRINT "AMBIENT TEMP: ";T9;"
      DEG C"
1800 PRINT "BAROM  PRESS: ";B9;"
      mm Hg"
1810 WAIT 2000
1820 IF U1<>6 THEN 2940
1830 PRINT "RTD DIAL SETTING:
        ";Z5 @ PRINT "TEMP OUT D
     IAL SETTING:  ";Z6 @ PRINT
1840 PRINT @ PRINT USING 1630 ;
     Z1
1850 PRINT USING 1650 ; Z2
1860 PRINT @ PRINT USING 1640 ;
     Z3
1870 PRINT USING 1660 ; Z4
1880 REM STABILIZE GAS ZERO TEMP
1890 OUTPUT 709 USING "K" ; "04"
1900 CLEAR
1910 DISP "WE ARE READY TO SET T
     HE GAS FLOW" @ DISP
1920 DISP "GAS FLOW WILL BE FROM
     --" @ DISP
1930 DISP "   1. DIRECT FROM IND
     IVIDUAL" @ DISP "       CYLI
     NDERS ONE AT A TIME"
1940 DISP "   2. SEVERAL CYLINDE
     RS ON A" @ DISP "       HIGH
      PRESSURE MANIFOLD"
1950 DISP @ DISP "ENTER LINE NO.
     ";
1960 INPUT G9
1970 IF G9=1 OR G9=2 THEN 1990
1980 BEEP @ DISP "ANSWER MUST BE
      1 OR 2" @ GOTO 1950
1990 IF G9=2 THEN 2270
2000 REM IND. CYLINDER ROUTINE
2010 CLEAR @ DISP "OPEN MANUAL V
     ALVES ON INPUT TO ALL ELECT
     RICAL VALVES USED."
2020 DISP "MAKE SURE MANUAL VALV
     ES ON NON-CONNECTED ELECTRI
     CAL VALVES ARE CLOSED TO PR
     EVENT";
2030 DISP " BACK LEAKAGE."
2040 GOSUB 5810
2050 M9$="ERROR! ANSWER MUST BE
     1, 2, 3 OR 4"
2060 CLEAR @ DISP "TO WHAT VALVE
      IS THE PRIMARY CYLINDER CO
     NNECTED?"
2070 INPUT R
2080 IF R=1 OR R=2 OR R=3 OR R=4
      THEN 2100
2090 DISP M9$ @ GOTO 2060
2100 G1$=VAL$(33+R)
2110 DISP @ DISP "TO WHAT VALVE
     IS THE #1 BACK-UP CYLINDER
     CONNECTED?"
2120 INPUT R
2130 IF R=1 OR R=2 OR R=3 OR R=4
      AND R<>VAL(G1$)-33 THEN 21
     50
2140 DISP M9$;" AND  ";R;" IS TH
     E PRIMARY CYLINDER VALVE" @
      BEEP @ GOTO 2110
2150 G2$=VAL$(33+R)
2160 DISP @ DISP "TO WHAT VALVE
     IS THE #2 BACK-UP CYLINDER
     CONNECTED?"
2170 INPUT R
2180 IF R=1 OR R=2 OR R=3 OR R=4
      AND R<>VAL(G2$)-33 THEN 22
     00
2190 DISP M9$;" AND ";R;" IS THE
      #1 BACK-UP CYLINDER VALVE"
      @ BEEP @ GOTO 2160
2200 G3$=VAL$(33+R)
2210 DISP @ DISP "TO WHAT VALVE
     IS THE #3 BACK-UP CYLINDER
     CONNECTED?"
2220 INPUT R
2230 IF R=1 OR R=2 OR R=3 OR R=4
      AND R<>VAL(G3$)-33 THEN 22
     50
2240 DISP M9$;" AND ";R;" IS THE
      #2 BACK-UP CYLINDER VALVE"
      @ BEEP @ GOTO 2210
2250 G4$=VAL$(33+R)
2260 GOTO 2520
2270 REM GAS FROM MANIFOLD
2280 CLEAR @ DISP "MAKE SURE ALL
      VALVES ON MANIFOLD AND CYL
     INDERS ARE SHUT OFF." @ DIS
     P
2290 DISP "CONNECT 3 OR MORE GAS
      CYLINDERS TO MANIFOLD WITH
      THE COPPER TUBING PIGTAILS
     "
2300 DISP @ DISP "OPEN ALL MANIF
     OLD VALVES TO CYLINDERS" @
     DISP
2310 DISP "OPEN VALVES TO 2 CYLI
     NDERS."
2320 GOSUB 5810
```

```
2330 CLEAR @ DISP "FOR YOUR INFO
     RMATION--" @ DISP
2340 DISP "CHANGE CYLINDERS IF P
     RESSURE DROPS TO 100#"
2350 DISP "PROCEDURE TO FOLLOW I
     S:" @ DISP "   1. SHUT OFF
     MANIFOLD VALVE TO       ONE
     CYLINDER"
2360 DISP "   2. TURN ON CYLINDE
     R VALVE TO        A NEW CYLI
     NDER."
2370 DISP "   3. CLOSE THE CYLIN
     DER VALVE         ON THE CYL
     INDER IN STEP 1"
2380 DISP "   4. REPLACE CYLINDE
     R IN STEP 1       WITH A NEW
      CYLINDER."
2390 DISP "   5. OPEN MANIFOLD V
     ALVE ON THE       REPLACEMEN
     T CYLINDER."
2400 GOSUB 5810
2410 CLEAR @ DISP "CONTINUING WI
     TH SETTING UP THE GAS MANIF
     OLD--" @ DISP
2420 DISP "OPEN MANIFOLD VALVE T
     O PRESURE REGULATOR." @ DIS
     P
2430 DISP "SET REGULATOR TO 40 P
     SI "
2440 GOSUB 5810
2450 CLEAR @ DISP "TO WHAT ELECT
     RICAL VALVE IS THE REGULATO
     R CONNECTED?"
2460 INPUT R
2470 IF R=1 OR R=2 OR R=3 OR R=4
      THEN 2490
2480 DISP @ DISP M9$ @ BEEP @ WA
     IT 2000 @ GOTO 2450
2490 G1$=VAL$(33+R) @ BEEP
2500 DISP @ DISP "MAKE SURE MANU
     AL VALVE ON UNUSED ELECTRIC
     AL VALVES ARE CLOSED."
2510 GOSUB 5810
2520 CLEAR @ DISP "We are now se
     tting up the gas flow." @ D
     ISP
2530 DISP "On the INPUT GAS TEMP
     . CONT--" @ DISP
2540 DISP "   1. Put the RUN-SET
      switch to        SET."
2550 DISP "   2. Adjust the BALA
     NCE knob so       the HEAT C
     YCLE LED just"
2560 DISP "      does remain ext
     inguished."
2570 DISP "   3  Put the RUN-SET
      switch to        RUN."
2580 GOSUB 5810
2590 DISP @ DISP "On the PREHEAT
     ER CONTROL UNIT" @ DISP
2600 DISP "   1. Put the MANUAL-
     AUTO switch       to AUTO."
2610 DISP "   2. Rotate the VOLT
     AGE knob to       FULL CLOCK
     WISE "
2620 DISP "   3. Put the OFF-ON
     switch to         ON "
2630 GOSUB 5810
2640 Z0=9 ! THIS VALUE DETERMINE
     D EMPIRICALLY.
2645 T4=.95 ! ABITRARY VALUE ABO
     VE ROOM TEMP
2650 ON KEY# 1,"GAS ON" GOSUB 53
     00
2660 ON KEY# 2,"GAS OFF" GOSUB 5
     400
2670 IF G9=2 THEN 2690
2680 ON KEY# 3,"CHG CYL" GOSUB 5
     700
2690 ON KEY# 5,"MASS IN" GOSUB 5
     500
2700 ON KEY# 6,"TEMP IN" GOSUB 5
     600
2710 ON KEY# 8,"CONT" GOTO 2910
2720 OUTPUT 709 USING "K" ; "03"
2730 CLEAR @ KEY LABEL
2740 DISP "MASS FLOW IN readings
      on DVM"
2750 DISP "Make sure REGULATORS
     are set to    40 PSI."
2760 DISP "Open FLOW VALVE 2 tur
     ns."
2770 GOSUB 5810
2780 GOSUB 5300
2790 BEEP @ CLEAR @ KEY LABEL
2800 DISP "Check HEAT CYCLE LED
     is BLINKING"
2810 DISP "Use FLOW VALVE and BA
     LANCE knob respectively to
     get below MASS  "
2820 DISP "IN and TEMP IN readin
     gs."
2830 DISP "     MASS IN=";Z1+Z0
2840 DISP "     TEMP IN=";T4
2850 IF G9=2 THEN 2880
2860 DISP "Switch to each REGULA
     TOR and setit to get these
     readings. At end"
2870 DISP "switch to primary cyl
     inder."
2880 DISP "MASS IN and TEMP IN a
     re coupled.Switch back and
     forth to monitorboth readin
     gs."
2890 DISP "Push k8 to continue."
2900 GOTO 2900
2910 OUTPUT 709 USING "K" ; "3"
2920 OFF KEY# 1 @ OFF KEY# 2 @ O
     FF KEY# 3 @ OFF KEY# 6 @ OF
     F KEY# 8 @ CLEAR
```

```
2930 GOTO 2970
2940 OUTPUT 709 USING "K" ; "0"&
     VAL$(10-U1)
2950 CLEAR @ BEEP @ DISP USING "
     K" ; U1$;" OUTPUT READINGS
     ON DVM"
2960 WAIT 2000 @ CLEAR
2970 DISP "SHUTTERS BEING TESTED
     "
2980 OUTPUT 709 USING "K" ; "3,3
     0,32"
2990 OUTPUT 709 USING "K" ; "3"
3000 WAIT 18000
3010 BEEP @ DISP "SHUTTER LED's
     SHOULD BE GREEN" @ WAIT 200
     0
3020 OUTPUT 709 USING "K" ; "3,3
     1,33"
3030 OUTPUT 709 USING "K" ; "3"
3040 WAIT 18000 @ DISP @ BEEP
3050 DISP "SHUTTER LED's SHOULD
     BE RED" @ DISP
3060 DISP "DID SHUTTERS TEST OK?
      (Y OR N)"
3070 INPUT R$
3080 IF R$="Y" THEN 3170
3090 IF R$="N" THEN 3120
3100 BEEP @ DISP "WHAT?"
3110 GOTO 3060
3120 CLEAR
3130 DISP "EXERCISE BALKY SHUTTE
     R WITH PUSHBUTTONS. IT MUST
      OPERATE IN 18 SEC" @ DISP
3140 DISP "Push CONT when ready"
3150 PAUSE
3160 CLEAR @ GOTO 2970
3170 CLEAR
3180 IF L$<>"L" THEN 3220
3190 U1$="MAIN CALORIMETER"
3200 U1=0
3210 DISP "FINAL PRE-RUN CHECK L
     IST" @ DISP
3220 DISP USING "K" ; "VERIFY  C
     ABLE 0  IS CONNECTED TO ";U
     1$ @ DISP
3230 IF L$="L" THEN 3250
3240 DISP "TURN ON KEPCO POWER S
     UPPLY" @ GOTO 3260
3250 DISP "VERIFY KEPCO POWER SU
     PPLY IS OFF"
3260 IF U1=6 OR U1=0 THEN 3280
3270 DISP @ DISP "GAS BOTTLES SH
     OULD BE TURNED OFF AT CYLIN
     DERS"
3280 DISP @ DISP "MAKE SAFETY CH
     ECK OF AREA"
3290 DISP @ DISP "Push CONT when
      ready"
3300 PAUSE
3310 CHAIN "CLOP2"
```

```
4000 REM MAX PARAM FOR EXT TUBE
4010 E0=1000
4020 V0=100
4030 R0=340
4040 I0$="2207A"
4050 U1$="EXTENSION TUBE"
4060 GOTO 4700
4100 REM MAX PARAM FOR OSM
4110 E0=1000
4120 V0=51.2
4130 R0=7.8
4140 I0$="22A7F"
4150 U1$="OVERSPILL MONITOR"
4160 GOTO 4700
4200 REM MAX PARAM FOR BSM
4210 E0=1000
4220 V0=86.4
4230 R0=22.2
4240 I0$="22639"
4250 U1$="BACKSCATTER MONITOR"
4260 GOTO 4700
4300 REM MAX PARAM FOR SEP TUBE
4310 E0=1000
4320 V0=100
4330 R0=340
4340 I0$="2207A"
4350 U1$="SEPARATION TUBE"
4360 GOTO 4700
4400 REM MAX PARAM FOR DEFLECTOR
4410 IF M5$[1,1]="F" THEN 4480
4420 E0=1000
4430 V0=26
4440 R0=3.56
4450 I0$="22BAE"
4460 U1$="DEFLECTOR"
4470 GOTO 4700
4480 E0=1000
4490 V0=78.9
4500 R0=25.5
4510 I0$="224F2"
4520 U1$="FOIL REFLECTOR"
4530 GOTO 4700
4600 REM MAX PARAM FOR MAIN CAL
4610 E0=15000
4620 V0=100
4630 R0=15.05
4640 I0$="22AA0"
4650 U1$="MAIN CALORIMETER"
4700 CLEAR @ DISP "HOW MANY JOUL
     ES ARE TO BE INJECTED?"
4710 INPUT E1
4720 IF E1<=E0 THEN 4750
4730 BEEP @ DISP USING "K" ; "TO
     O MUCH ENERGY. TRY ";E0;" J
     OULES OR LESS." @ WAIT 1000
4740 GOTO 4700
4750 T0=5
4760 V1=SQR(E1*R0/T0)
4770 IF V1<=V0 THEN 4810
4780 T0=CEIL(E1*R0/V0^2)
```

```
4790 V1=SQR(E1*R0/T0)
4800 BEEP @ DISP "INJECTION TIME
      LENGTHENED TO ";T0;" SECON
     DS" @ WAIT 2000
4810 REM GET KEPCO COMMAND
4820 IF V1>10 THEN 4860
4830 K1=409.5
4840 D2=2
4850 GOTO 4880
4860 K1=40.95
4870 D2=0
4880 K9=INT(K1*V1)
4890 REM CONVERT K9 TO RADIX 16
4900 V9=INT(K9/16)
4910 D5=K9-16*V9
4920 D3=INT(V9/16)
4930 D4=V9-16*D3
4940 D0$=VAL$(D5)
4950 IF D5>9 THEN GOSUB 5100
4960 D5$=D0$
4970 D0$=VAL$(D4)
4980 IF D4>9 THEN GOSUB 5100
4990 D4$=D0$
5000 D0$=VAL$(D3)
5010 IF D3>9 THEN GOSUB 5100
5020 D3$=D0$
5030 V1$="1"&VAL$(D2)&D3$&D4$&D5
     $
5040 RETURN
5100 REM CONVERT LARGE HEX DIG.
5110 D6=VAL(D0$)-9
5120 ON D6 GOTO 5130,5150,5170,5
     190,5210,5230
5130 D0$="A"
5140 RETURN
5150 D0$="B"
5160 RETURN
5170 D0$="C"
5180 RETURN
5190 D0$="D"
5200 RETURN
5210 D0$="E"
5220 RETURN
5230 D0$="F"
5240 RETURN
5300 REM TURN ON GAS
5310 OUTPUT 709 USING "K" ; G1$
5320 RETURN
5400 REM TURN OFF GAS
5410 OUTPUT 709 USING "K" ; "3"
5420 RETURN
5500 REM MASS IN VOLTS
5510 OUTPUT 709 USING "K" ; "03"
5520 RETURN
5600 REM TEMP IN VOLTS
5610 OUTPUT 709 USING "K" ; "04"
5620 RETURN
5700 REM CHG GAS BOTTLE ROUTINE
5710 REM
5720 G5$=G1$
5730 G1$=G2$
5740 OUTPUT 709 USING "K" ; "3,"
     &G1$
5750 G2$=G3$
5760 G3$=G4$
5770 G4$=G5$
5780 RETURN
5800 REM PAUSE SUBROUTINE
5810 BEEP @ DISP
5820 DISP "Push CONT when ready"
5830 PAUSE
5840 RETURN
```

Variable Map

Program: AUTOST Date: 840214

B9	-	barometric pressure in mm of Hg	(c)
D2	-	number indicating power supply voltage range	
D3	-	first hexadec. digit (MSD) of voltage part of power supply command	
D4	-	second hexadec. digit of voltage part of power supply command	
D5	-	third hexadec. digit (LSD) of voltage part of power supply command	
D6	-	amount hexadec. number exceeds 9	
D3$	-	third character in power supply command (string version of D3)	
D4$	-	fourth character in power supply command (string version of D4)	
D5$	-	fifth character in power supply command (string version of D5)	
DØ$	-	temporary string variable for converting hexadec. digits to string variables	
E1	-	nominal electrical energy input	(c)
EØ	-	maximum allowable electrical energy	
F	-	flag to look for unit missing from calorimeter configuration descriptor	
G9	-	method of gas supply (1=low pressure manifold, 2=high pressure manifold)	(c)
G1$	-	electrical valve channel for primary gas cylinder (L.P. and H.P. supply)	(c)
G2$	-	electrical valve channel for #1 back up gas cylinder (L.P. supply)	(c)
G3$	-	electrical valve channel for #2 back up gas cylinder (L.P. supply)	(c)
G4$	-	electrical valve channel for #3 back up gas cylinder (L.P. supply)	(c)
G5$	-	temporary string variable for changing order of gas cylinders in L.P. supply	(c)
IØ$	-	current limit command to calibration power supply	(c)
J	-	counter	(c)
K1	-	scaling constant for calculation power supply command	
K9	-	decimal equivalent of hexadecimal voltage part of power supply command	
L$	-	run type (L=laser, C=combination, E=electrical)	(c)
M5$	-	deflector type name display message during monitor period	(c)
M9$	-	error message in gas set-up routine	
N$	-	run number	(c)
O1$	-	calorimeter configuration descriptor	(c)
R	-	numeric answer to questions	
RØ	-	resistance of calibration heater	(c)
R$	-	alpha answer to questions	
T4	-	temperature in reading desired while gas is flowing	
T9	-	ambient temperature in degrees C	(c)
TØ	-	electrical energy injection period duration in seconds	(c)
U1	-	numeric indicator of unit receiving electrical	

		energy	(c)
U1$	-	name of unit to be calibrated	(c)
V1	-	required voltage setting of electrical calibration power supply	
V9	-	quotient derived during hexadecimal conversion	
VØ	-	maximum allowable electrical calibration voltage	
V1$	-	voltage command to calibration power supply	(c)
Z1	-	mass flow in zero reading	(c)
Z2	-	mass flow out zero reading	(c)
Z3	-	temperature in zero reading	(c)
Z4	-	temperature out zero reading	(c)
Z5	-	main calorimeter RTD dial setting	(c)
Z6	-	temperature out dial setting	(c)
ZØ	-	change in mass flow in reading when gas is turned on	(c)

C2. "CLOP2"
Program Listing

```
 10 REM "CLOP2" DATE-TIME 831118
     @ 09:30
 20 OPTION BASE 0
 30 DIM R$[1]
 40 OUTPUT 709 USING "K" ; "1200
    0";"2200F" @ CLEAR
 50 COM G1$[2],G2$[2],G3$[2],G4$
    [2],I0$[5],L$[1],M5$[17],N$[
    9],O1$[6],U1$[19],V1$[5]
 60 COM SHORT B9,E1,T9,Z1,Z2,Z3,
    Z4,Z5,Z6 ,INTEGER G9,T0,U1
 70 SHORT V(10),V0(176,10),H0,H1
    (10),V1(55),I1(55)
 80 INTEGER I,J,J1,J2,K,L,N9,R
 90 FOR I=0 TO 9
100 H1(I)=0
110 NEXT I
120 BEEP @ DISP "Begin 2 min adj
    ustment period"
130 IF L$="E" AND U1$[1,1]<>"M"
    THEN 180
140 ON G9+1 GOTO 180,150,160
150 ON KEY# 1,"CHG BTL" GOSUB 30
    00
160 ON KEY# 2,"GAS ON" GOSUB 350
    0
170 ON KEY# 3,"GAS OFF" GOSUB 36
    00
180 ON KEY# 8,"ABORT" GOTO 3700
190 OUTPUT 724 ;"R3T2D.001S"
200 IF L$="E" AND U1$[1,1]<>"M"
    THEN 220
210 OUTPUT 709 USING "K" ; "3,"&
    G1$
220 J=0 @ N9=20+T0
230 ON TIMER# 1,3000 GOTO 260
240 GOTO 240
250 REM PERIOD B
260 CLEAR @ KEY LABEL
270 FOR I=0 TO 9
280 C$="0"&VAL$(I)
290 OUTPUT 709 USING "K" ; C$
300 ENTER 724 ; V(I)
310 NEXT I
320 DISP "MASS IN=           ";V(3
    )
330 DISP "MASS OUT=          ";V(1
    )
340 DISP "TEMP IN=           ";V(4
    )
350 DISP "TEMP OUT=          ";V(2
    )
360 DISP "MAIN CAL RTD=      ";V(0
    )
370 DISP M5$;V(5)
380 DISP "SEP TUBE=          ";V(6
    )
390 DISP "BSM RTD=           ";V(7
    )
400 DISP "OSM RTD=           ";V(8
    )
410 DISP "EXT TUBE=          ";V(9
    )
420 J=J+3
430 DISP "TIME: ";J;" SEC"
440 IF J<120 THEN 240
450 IF J<>120 THEN 480
460 ON KEY# 8,"ABORT" GOTO 4000
470 BEEP @ DISP "Start 8 min adj
    ustment period"
480 IF J<600 THEN 240
490 REM PERIOD D
500 CLEAR @ KEY LABEL @ DISP "Ru
    n is in data taking stage."
510 ON TIMER# 1,1000 GOTO 530
520 GOTO 520
530 OUTPUT 709 USING "K" ; "00"
    @ ENTER 724 ; H0@ H1(0)=H1(0
    )+H0
540 OUTPUT 709 USING "K" ; "01"
    @ ENTER 724 ; H0@ H1(1)=H1(1
    )+H0
550 OUTPUT 709 USING "K" ; "02"
    @ ENTER 724 ; H0@ H1(2)=H1(2
    )+H0
560 OUTPUT 709 USING "K" ; "03"
    @ ENTER 724 ; H0@ H1(3)=H1(3
    )+H0
570 OUTPUT 709 USING "K" ; "04"
    @ ENTER 724 ; H0@ H1(4)=H1(4
    )+H0
580 OUTPUT 709 USING "K" ; "05"
    @ ENTER 724 ; H0@ H1(5)=H1(5
    )+H0
590 OUTPUT 709 USING "K" ; "06"
    @ ENTER 724 ; H0@ H1(6)=H1(6
    )+H0
600 OUTPUT 709 USING "K" ; "07"
    @ ENTER 724 ; H0@ H1(7)=H1(7
    )+H0
610 OUTPUT 709 USING "K" ; "08"
    @ ENTER 724 ; H0@ H1(8)=H1(8
    )+H0
620 OUTPUT 709 USING "K" ; "09"
    @ ENTER 724 ; H0@ H1(9)=H1(9
    )+H0
630 IF FP((J-5)/6)<>0 THEN 700
640 V0((J-605)/6,0)=H1(0) @ V0((
    J-605)/6,1)=H1(1) @ V0((J-60
    5)/6,2)=H1(2)
650 V0((J-605)/6,3)=H1(3)
660 V0((J-605)/6,4)=H1(4) @ V0((
    J-605)/6,5)=H1(5) @ V0((J-60
    5)/6,6)=H1(6)
670 V0((J-605)/6,7)=H1(7) @ V0((
    J-605)/6,8)=H1(8) @ V0((J-60
    5)/6,9)=H1(9)
680 H1(0)=0 @ H1(1)=0 @ H1(2)=0
    @ H1(3)=0 @ H1(4)=0 @ H1(5)=
    0 @ H1(6)=0
690 H1(7)=0 @ H1(8)=0 @ H1(9)=0
```

```
700 IF J<1080 OR J>1150+T0 THEN
    940
710 IF J>1130 THEN 830
720 IF J<>1080 THEN 760
730 OUTPUT 709 USING "K" ; "3,30
    ,32"
740 OUTPUT 709 USING "K" ; "3"
750 GOTO 950
760 IF J<>1110 THEN 800
770 OUTPUT 709 USING "K" ; "3,31
    ,33"
780 OUTPUT 709 USING "K" ; "3"
790 GOTO 950
800 IF J<>1128 THEN 950
810 OUTPUT 709 USING "K" ; "3,"&
    G1$
820 GOTO 950
830 IF L$="L" THEN 950
840 OUTPUT 709 USING "K" ; "10"
850 ENTER 724 ; I1(J-1131)
860 OUTPUT 709 USING "K" ; "12"
870 ENTER 724 ; V1(J-1131)
880 IF J<>1140+T0 THEN 910
890 OUTPUT 706 ;"12000","2200F"
900 GOTO 950
910 IF J<>1140 THEN 950
920 OUTPUT 706 ;V1$,I0$
930 GOTO 950
940 IF J>1661 THEN 970
950 J=J+1
960 GOTO 520
970 OFF TIMER# 1 @ OUTPUT 709 US
    ING "K" ; "3"
980 OUTPUT 724 ;"R3T1D.1S" @ LOC
    AL 724
990 OUTPUT 709 USING "K" ; "14"
1000 BEEP @ CLEAR @ DISP "RUN EN
     D CHECK LIST" @ DISP
1010 DISP "CHECK CALORIMETER AND
      ENVIRONS FOR DAMAGE" @ DIS
     P
1020 DISP "PREHEATER SHOULD BE T
     URNED OFF" @ DISP
1030 DISP "TURN OFF VALVES ON GA
     S CYLINDERS" @ DISP
1040 DISP "CHECK POWER SUPPLY VO
     LTAGES ARE NOMINAL"
1050 IF L$="L" THEN 1070
1060 DISP "TURN OFF KEPCO POWER
     SUPPLY"
1070 DISP @ DISP "Push CONT when
      ready"
1080 PAUSE
1090 CLEAR @ DISP "DATA-SUM PACK
     ETS BEING AVERAGED"
1100 FOR K=0 TO 9
1110 FOR I=0 TO 175
1120 V0(I,K)=V0(I,K)/6
1130 NEXT I
1140 NEXT K
1150 IF L$="L" THEN 1200
1160 DISP "Calibration voltages
     being scaled"
1170 FOR I=0 TO N9-1 ! MULT V1 B
     Y 10 BECAUSE OF DIVIDER IN
     V-I BOX
1180 V1(I)=10*V1(I)
1190 NEXT I
1200 CLEAR @ DISP "DO YOU WANT A
      PRINT OUT OF THE RESULTS?
     (Y OR N)"
1210 INPUT R$
1220 IF R$="Y" THEN 1260
1230 IF R$="N" THEN 1900
1240 BEEP @ DISP @ DISP "WHAT?"
1250 WAIT 1000 @ GOTO 1200
1260 IF L$="L" THEN 1570
1270 PRINT @ PRINT "ELEC DATA" @
      PRINT
1280 PRINT "NO.  VOLTS   AMPS"
1290 IMAGE 3D,3X,SDZ.2D,2X,SDZ.2
     D
1300 FOR I=0 TO N9-1
1310 PRINT USING 1290 ; I+1,V1(I
     ),I1(I)
1320 NEXT I
1330 IF L$="C" THEN 1570
1340 PRINT @ PRINT U1$;" OUTPUT"
      @ PRINT
1350 IMAGE 3D,3X,SDZ.4D
1360 IF U1=6 THEN 1410
1370 PRINT
1380 J1=10-U1
1390 GOSUB 4500
1400 GOTO 1900
1410 PRINT @ PRINT "MASS FLOW IN
     "
1420 J1=3 @ PRINT
1430 GOSUB 4500
1440 PRINT @ PRINT "MASS FLOW OU
     T"
1450 PRINT @ J1=1
1460 GOSUB 4500
1470 PRINT @ PRINT "TEMP IN"
1480 PRINT @ J1=4
1490 GOSUB 4500
1500 PRINT @ PRINT "TEMP OUT"
1510 PRINT @ J1=2
1520 GOSUB 4500
1530 PRINT @ PRINT "CAL RTD"
1540 PRINT @ J1=0
1550 GOSUB 4500
1560 GOTO 1900
1570 FOR I=0 TO 9
1580 ON I+1 GOTO 1590,1620,1640,
     1660,1680,1700,1730,1750,17
     70,1790
1590 PRINT "MAIN CAL RTD"
1600 J2=6
1610 GOTO 1810
```

```
1620 PRINT "MASS FLOW OUT"
1630 GOTO 1810
1640 PRINT "TEMP OUT"
1650 GOTO 1810
1660 PRINT "MASS FLOW IN"
1670 GOTO 1810
1680 PRINT "TEMP IN"
1690 GOTO 1810
1700 IF M5$[1,1]="D" THEN PRINT
     "DEFLECTOR"
1710 IF M5$[1,1]="F" THEN PRINT
     "FOIL REFLECTOR"
1720 GOTO 1800
1730 PRINT "SEP TUBE"
1740 GOTO 1800
1750 PRINT "BSM"
1760 GOTO 1800
1770 PRINT "OSM"
1780 GOTO 1800
1790 PRINT "EXT TUBE"
1800 J2=10-I
1810 GOSUB 5000
1820 IF F=1 THEN 1850
1830 PRINT "NULL DATA"
1840 GOTO 1880
1850 FOR K=0 TO 175
1860 PRINT USING "3D,3X,SDZ.4D"
     ; K+1,V0(K,I)
1870 NEXT K
1880 NEXT I
1890 CLEAR @ BEEP
1900 DISP "DO YOU WANT TO STORE
     DATA ON TAPE? (Y OR N)"
1910 INPUT R$
1920 IF R$="Y" THEN 1960
1930 IF R$="N" THEN 2140
1940 BEEP @ DISP @ DISP "WHAT?"
1950 WAIT 1000 @ GOTO 1890
1960 DISP "Insert tape  RUN DATA
      x  in tapedrive"
1970 DISP @ DISP "Push CONT when
      ready" @ PAUSE
1980 CLEAR @ DISP "What file?"
1990 DISP "Choices are DATA0 thr
     ough DATA19"
2000 INPUT F$
2010 ASSIGN# 1 TO F$
2020 PRINT# 1 ; N$,L$,O1$,M5$[1,
     1]
2030 PRINT# 1 ; T9,B9,U1
2040 IF U1<>6 THEN 2060
2050 PRINT# 1 ; Z5,Z6
2060 PRINT# 1 ; V0(,)
2070 IF L$="L" THEN 2110
2080 PRINT# 1 ; U1$
2090 PRINT# 1 ; T0,E1,N9
2100 PRINT# 1 ; V1(),I1()
2110 ASSIGN# 1 TO *
2120 BEEP @ DISP @ DISP "Data st
     ored in file ";F$
2130 PRINT @ PRINT "Data stored
     in file ";F$ @ PRINT
2140 WAIT 1000 @ CLEAR
2150 DISP "RUN NO: ";N$;" COMPLE
     TED" @ DISP
2160 DISP "INDICATE CHOICE"
2170 DISP "  1  END RUNS"
2180 DISP "  2. NEW RUN"
2190 DISP "  3. READ DATA FILE"
2200 DISP "  4. PERFORM CALCULAT
     IONS"
2210 DISP "  5. TRANSFER DATA ON
      RS232"
2220 DISP "  6. PRINT OUT CURREN
     T RUN DATA"
2230 DISP "  7. COPY CURRENT DAT
     A TO FILE"
2240 DISP @ DISP "ENTER LINE NO.
     "
2250 INPUT R
2260 IF R>=1 AND R<=7 AND FP(R)=
     0 THEN 2290
2270 BEEP @ DISP @ DISP "WHAT?"
2280 GOTO 2140
2290 ON R GOTO 2530,2300,2310,23
     40,2400,1260,1960
2300 OUTPUT 724 ;"R3T1D.0S" @ LO
     CAL 724 @ ABORTIO 7 @ CHAIN
      "Autost"
2310 DISP "Enter LOAD ";CHR$(34)
     ;"FILEXM";CHR$(34);". Then
     push END LINE."
2320 DISP "CAUTION--This will wi
     pe out current program and
     data from memory" @ BEEP
2330 GOTO 2370
2340 CLEAR @ DISP "Make sure tap
     e CLOP is in tape drive."
2345 BEEP @ DISP "Push CONT when
      ready" @ PAUSE
2350 DISP USING "K" ; "Type LOAD
      ";CHR$(34);"CALC";CHR$(34)
     ;" and push END LINE key."
2360 DISP "When loading is compl
     ete, push RUN."
2370 PAUSE
2380 BEEP @ DISP "ERROR!--Do not
      push CONT!"
2390 GOTO 2370
2400 DISP "PROGRAM NEEDS TO BE D
     EVELOPED TO SUIT PARTICULAR
      SERIAL TRANSFER SYSTEM."
2410 WAIT 2000 @ GOTO 2140
2420 REM = = = = = = = = = = =
2430 REM SPACE
2440 REM
2450 REM         FOR
2460 REM
2470 REM                FUTURE
2480 REM
```

```
2490 REM        RS232
2500 REM
2510 REM ROUTINE          HERE
2520 REM = = = = = = = = = = = =
2530 REM END RUN
2540 OUTPUT 724 ;"R3T1D 0S"
2550 LOCAL 724 @ ABORTIO 7
2560 BEEP @ DISP @ DISP "DONE"
2570 END
3000 REM CHG GAS BOTTLE ROUTINE
3010 G5$=G1$
3020 G1$=G2$
3030 OUTPUT 709 USING "K" ; "3,"
     &G1$
3040 G2$=G3$
3050 G3$=G4$
3060 G4$=G5$
3070 RETURN
3500 REM GAS ON ROUTINE
3510 OUTPUT 709 USING "K" ; "3,"
     &G1$
3520 RETURN
3600 REM GAS OFF ROUTINE
3610 OUTPUT 709 USING "K" ; "3"
3620 RETURN
3700 REM ABORT #1 ROUTINE
3710 OFF TIMER# 1
3720 OFF KEY# 1 @ OFF KEY# 2 @ O
     FF KEY# 3 @ OFF KEY# 8
3730 GOSUB 3600
3740 BEEP 40,300 @ BEEP 50,500
3750 CLEAR
3760 DISP "Program aborted. Push
      CONT to start over!" @ DIS
     P
3770 OUTPUT 724 ;"R3,T1,D.1S"
3780 LOCAL 724 @ ABORTIO 7
3790 PAUSE
3800 GOTO 120
4000 REM ABORT #2 ROUTINE
4010 OFF TIMER# 1
4020 BEEP 40,300 @ BEEP 50,500
4030 BEEP 40,300 @ BEEP 50,500
4040 DISP "ABORT ACTIVATED! WE A
     RE RETREATING TO 2 MIN ADJU
     STMENT PERIOD"
4050 WAIT 2000 @ GOTO 120
4500 REM ELECT. SENSOR PRINT OUT
4510 FOR I=0 TO 175
4520 PRINT USING "3D,3X,SDZ.4D"
     ; I,V0(I,J1)
4530 NEXT I
4540 RETURN
5000 REM MISSING MODULE ROUTINE
5010 F=0
5020 FOR L=1 TO 6
5030 IF O1$[L,L]<>VAL$(J2) THEN
     5050
5040 F=1
5050 NEXT L
5060 RETURN
```

Variable Map

Program: CLOP2 Date: 831118

B9	-	barometric pressure in mm of Hg	(c)
C$	-	scanner channel command for switching sensor channels	
E1	-	nominal electrical energy input	(c)
F	-	flag to look for unit missing from calorimeter configuration	
F$	-	name of file in which run data is to be stored	
G9	-	method of gas supply (1 = low press. manifold, 2 = high press. manifold)	(c)
G1$	-	electrical valve channel for primary gas cylinder (LP and HP supply)	(c)
G2$	-	electrical valve channel for #1 back-up gas cylinder (LP supply)	(c)
G3$	-	electrical valve channel for #2 back-up gas cylinder (LP supply)	(c)
G4$	-	electrical valve channel for #3 back-up gas cylinder (LP supply)	(c)
G5$	-	temporary string variable for changing order of gas cylinders in LP supply	
H1	-	array for acquiring by summing sensor output data packets	
HØ	-	measured sensor output voltage to be summed to H1	
I	-	counter	
I1	-	array containing electrical calibration current readings	
IØ$	-	current limit command to calibration power supply	(c)
J	-	counter	
J1	-	index indicating sensor data being handled	
J2	-	index indicating unit being searched for missing module routine	
K	-	counter	
L	-	counter	
L$	-	run type (L = laser, C = combination, E = electrical)	(c)
M5$	-	deflector-type name display message during monitor period	(c)
N9	-	number of V1 (and I1) readings	
N$	-	run number	(c)
O1$	-	calorimeter configuration descriptor	(c)
R	-	numeric answer to questions	
R$	-	alpha answer to questions	
T9	-	ambient temperature in degrees C	
TØ	-	electrical energy injection period duration in seconds	(c)
U1	-	numeric indicator of unit receiving electrical energy	(c)
U1$	-	name of unit being calibrated	(c)
V	-	array for storing sensor output readings during monitor period	
V1	-	array containing electrical calibration voltage readings	
VØ	-	matrix for storing all data packets acquired through H1	
V1$	-	voltage command to calibration power supply	(c)

Z1 - mass flow in zero reading (c)
Z2 - mass flow out zero reading (c)
Z3 - temperature in zero reading (c)
Z4 - temperature out zero reading (c)
Z5 - main calorimeter RTD dial setting (c)
Z6 - temperature out dial setting (c)

```
10 REM PROG "CALC" DATE-TIME 84
   0227 @ 15:45
20 OPTION BASE 0
30 SHORT V(176,10),V1(55),I1(55
   ),T9,B9,F1(10),Z5,Z6
40 DIM D$[1],F$[6],F1$[6],L$[1]
   ,M$[19],M1$[20],N$[9],O1$[6]
   ,R$[1],U1$[19]
50 DIM Y0(3,10),Y1(3,10),Y2(3,1
   0),K0(10)
60 INTEGER I,J,J1,J2,K,L,N1,N2,
   N3,N4,N5,T0
70 M1$="Push CONT when ready"
80 CLEAR @ BEEP
90 DISP "Insert tape RUN DATA x
    in drive",M1$
100 PAUSE
110 CLEAR
120 DISP "WHAT FILE DO YOU WISH
    TO ACCESS?"
130 INPUT F$
140 ASSIGN# 1 TO F$
150 READ# 1 ; N$,L$,O1$,D$
160 READ# 1 ; T9,B9,U1
170 IF U1<>6 THEN 190
180 READ# 1 ; Z5,Z6
190 READ# 1 ; V(,)
200 IF L$="L" THEN 240
210 READ# 1 ; U1$
220 READ# 1 ; T0,E1,N5
230 READ# 1 ; V1(),I1()
240 ASSIGN# 1 TO *
250 CLEAR @ BEEP
260 DISP "Contents of file ";F$;
    " are in memory"
270 DISP "Run No: ";N$ @ DISP
280 DISP "Re-insert tape CLOP in
     drive",M1$
290 PAUSE
300 CLEAR
310 DISP "Run No:    ";N$ @ DISP
320 DISP "Run Type: ";L$ @ DISP
330 DISP "Calor Config: ";O1$
340 IF L$="L" THEN 2000
350 DISP @ DISP "Unit receiving
    elec. energy"
360 DISP U1$ @ DISP
370 DISP "Nominal Energy: ";E1,"
     J"
380 IF L$="C" THEN 2000
390 IF U1$[1,1]<>"M" THEN 400 EL
    SE N1=0 @ N2=4
400 IF U1$[1,1]<>"E" THEN 410 EL
    SE N1=9 @ N2=9 @ M$=U1$ @ F1
    $="EXTUB*" @ J1=9
410 IF U1$[1,1]<>"O" THEN 420 EL
    SE N1=8 @ N2=8 @ M$=U1$ @ F1
    $="OSMON*" @ J1=8
420 IF U1$[1,1]<>"B" THEN 430 EL
    SE N1=7 @ N2=7 @ M$=U1$ @ F1
    $="BSMON*" @ J1=7
430 IF U1$[1,1]<>"S" THEN 440 EL
    SE N1=6 @ N2=6 @ M$=U1$ @ F1
    $="SPTUB*" @ J1=6
440 IF U1$[1,1]<>"F" THEN 450 EL
    SE N1=5 @ N2=5 @ M$=U1$ @ F1
    $="FOREF*" @ J1=5
450 IF U1$[1,1]<>"D" THEN 460 EL
    SE N1=5 @ N2=5 @ M$=U1$ @ F1
    $="DEFLC*" @ J1=5
460 GOSUB 3000
470 GOSUB 3500
480 REM GET CAL FACTOR
485 T2=1 ! NO HEAT FLOW WHILE SH
    UTTER IS OPEN
490 FOR I=N1 TO N2
500 K0(I)=(Y0(2,I)-Y0(0,I)-Y1(0,
    I)*T2*SQR(12))/J0
510 NEXT I
520 REM OUTPUT ELEC RESULTS
530 M=1
540 CRT IS M
550 CLEAR @ BEEP
560 DISP "RUN NO:    ";N$ @ DISP
570 DISP "RUN TYPE: ";L$
580 DISP "UNIT CALIB: ";U1$
590 DISP "CALOR CONFIG: ";O1$
600 DISP @ DISP USING "13A,3X,SD
    .4DE,2A" ; "ELECT ENERGY:",J
    0," J"
610 DISP USING "12A,4X,2D,4A" ;
    "INJECT TIME",T0," SEC"
620 DISP
630 IF U1$[1,1]<>"M" THEN 660
640 DISP "RTD dial setting:
     ";Z5
650 DISP "TEMP OUT dial setting:
     ";Z6
660 DISP @ IF M=2 THEN 690
670 DISP M1$ @ BEEP @ PAUSE
680 IMAGE 12A,1X,SD.3DE
690 FOR I=N1 TO N2
700 IF I=0 THEN M$="RTD"
710 IF I=1 THEN M$="MASS FLOW OU
    T"
720 IF I=2 THEN M$="TEMP OUT"
730 IF I=3 THEN M$="MASS FLOW IN
    "
740 IF I=4 THEN M$="TEMP IN"
750 DISP @ DISP M$ @ DISP
760 DISP "ZERO RATING PERIOD" @
    DISP "=================="
770 DISP USING 680 ; "0th MOMENT
    :",Y0(0,I)
780 DISP USING 680 ; "1st MOMENT
    :",Y1(0,I)
790 DISP USING 680 ; "2nd MOMENT
    :",Y2(0,I)
800 DISP
810 IF M=2 THEN 840
820 DISP M1$ @ BEEP @ PAUSE
```

```
830 DISP
840 DISP "TRANSITION PERIOD" @ D
    ISP "=================="
850 DISP USING 680 ; "0th MOMENT
    :",Y0(2,I)
860 DISP USING 680 ; "1st MOMENT
    :",Y1(2,I)
870 DISP USING 680 ; "2nd MOMENT
    :",Y2(2,I) @ DISP
880 IF I=1 OR I=3 OR I=4 THEN 91
    0
890 DISP USING 680 ; "CAL FACTOR
    =";K0(I)
900 GOTO 920
910 DISP USING 680 ; "STABIL FAC
    T=";K0(I)*J0
920 DISP
930 IF M=2 THEN 960
940 DISP M1$ @ BEEP @ PAUSE
950 DISP
960 DISP "FINAL RATING PERIOD" @
     DISP "==================="
970 DISP USING 680 ; "0th MOMENT
    :",Y0(1,I)
980 DISP USING 680 ; "1st MOMENT
    :",Y1(1,I)
990 DISP USING 680 ; "2nd MOMENT
    :",Y2(1,I)
1000 DISP
1010 IF M=2 THEN 1040
1020 DISP M1$ @ BEEP @ PAUSE
1030 DISP
1040 NEXT I
1050 IF M=2 THEN 1120
1060 DISP "DO YOU WANT A PRINT-O
     UT OF THE RESULTS? (Y OR N)
     "
1070 INPUT R$
1080 ON 1+(R$="Y")+2*(R$="N") GO
     TO 1090,1100,1120
1090 BEEP @ GOTO 1060
1100 M=2
1110 GOTO 540
1120 M=1 @ CRT IS M @ CLEAR
1130 DISP "DO YOU WANT TO STORE
     IN SUMMARY? (Y OR N)"
1140 INPUT R$
1150 ON 1+(R$="Y")+2*(R$="N") GO
     TO 1160,1170,2920
1160 BEEP @ GOTO 1120
1170 DISP "Insert tape ELEC SUMM
     ARY in tape drive"
1180 DISP M1$
1190 PAUSE
1200 FOR I=N1 TO N2
1210 N6=12
1220 IF I=0 OR I=2 THEN N6=13
1230 IF I=0 THEN F1$="MCRTD*"
1240 IF I=1 THEN F1$="MAOUT*"
1250 IF I=2 THEN F1$="TEOUT*"
1260 IF I=3 THEN F1$="MASIN*"
1270 IF I=4 THEN F1$="TEMIN*"
1280 ASSIGN# 1 TO F1$
1290 FOR J=0 TO 58
1300 ON ERROR GOTO 1410
1310 READ# 1 ; G$
1320 READ# 1 ; G$
1330 FOR K=0 TO N6
1340 READ# 1 ; G
1350 NEXT K
1360 NEXT J
1370 ASSIGN# 1 TO *
1380 BEEP @ DISP USING "K" ; "Fi
     le ";F1$;" is full! No room
      for new data."
1390 DISP @ BEEP @ DISP "PAUSE a
     t line 1390"
1400 PAUSE
1410 OFF ERROR
1420 IF ERRN=71 THEN 1460
1430 BEEP @ DISP "ERRN=",ERRN," 
     ERRL=";ERRL
1440 ASSIGN# 1 TO *
1450 PAUSE
1460 REM ADD NEW DATA
1470 PRINT# 1 ; N$,O1$
1480 PRINT# 1 ; T9,B9
1490 IF I<>0 THEN 1510
1500 PRINT# 1 ; Z5
1510 IF I<>2 THEN 1530
1520 PRINT# 1 ; Z6
1530 PRINT# 1 ; J0,K0(I),Y0(0,I)
     ,Y0(1,I),Y0(2,I),Y1(0,I),Y1
     (1,I),Y1(2,I),Y2(0,I),Y2(1,
     I),Y2(2,I)
1540 ASSIGN# 1 TO *
1550 BEEP
1560 DISP J+1;" lines stored in
     ";F1$
1570 NEXT I
1580 WAIT 2000
1590 CLEAR @ DISP "Re-insert tap
     e CLOP in tape drive"
1600 DISP M1$
1610 PAUSE
1620 GOTO 2920
2000 REM DO L & C RUNS
2002 IF L$="C" THEN 2010
2005 U1$="N/A"
2007 T0=0
2010 FOR J1=0 TO 9
2020 J2=10-J1
2030 IF J2>6 THEN J2=6
2040 GOSUB 4000 ! MISSING MOD
2050 IF F1(J1)=0 THEN 2080
2060 N1=J1 @ N2=J1
2070 GOSUB 3000
2075 GOTO 2085
2080 GOSUB 5200
2085 NEXT J1
```

```
2090 REM CALC EL ENER OF C RUNS
2100 E2=0
2110 IF L$<>"C" THEN 2140
2120 GOSUB 3500
2130 E2=J0
2140 REM OUTPUT RESULTS
2150 PRINT "RUN NO:    ";N$ @ PRI
     NT
2160 PRINT "RUN TYPE: ";L$ @ PRI
     NT
2170 PRINT "CALOR CONFIG: ";O1$
2180 PRINT "ROOM TEMP:     ";B9
2190 PRINT "BAROM PRESS:   ";T9
2200 PRINT @ PRINT "RTD dial set
     ting:        ";Z5
2210 PRINT @ PRINT "TEMP OUT dia
     l setting: ";Z6
2220 PRINT
2230 IF L$="L" THEN 2260
2240 PRINT USING "17A,5D,2A" ; "
     INJ ELEC ENERGY: ";E2;" J"
2250 PRINT
2260 FOR I=0 TO 9
2270 IF I=0 THEN PRINT "MAIN CAL
      RTD"
2280 IF I=1 THEN PRINT "MASS FLO
     W OUT"
2290 IF I=2 THEN PRINT "TEMP OUT
     "
2300 IF I=3 THEN PRINT "MASS FLO
     W IN"
2310 IF I=4 THEN PRINT "TEMP IN"
2320 IF I=5 AND D$="D" THEN PRIN
     T "DEFLECTOR"
2330 IF I=5 AND D$="F" THEN PRIN
     T "FOIL REFLECTOR"
2340 IF I=6 THEN PRINT "SEP TUBE
     "
2350 IF I=7 THEN PRINT "BACKSCAT
     TER MONITOR"
2360 IF I=8 THEN PRINT "OVERSPIL
     L MONITOR"
2370 IF I=9 THEN PRINT "EXT TUBE
     "
2380 PRINT
2390 IF F1(I)=1 THEN 2430
2400 PRINT "NULL DATA" @ PRINT
2410 GOSUB 4500
2420 GOTO 2550
2430 PRINT "ZERO RATING PERIOD"
     @ PRINT "==================
     "
2440 PRINT USING 680 ; "0th MOME
     NT:",Y0(0,I)
2450 PRINT USING 680 ; "1st MOME
     NT:",Y1(0,I)
2460 PRINT USING 680 ; "2nd MOME
     NT:",Y2(0,I) @ PRINT
2470 PRINT "TRANSITION PERIOD" @
      PRINT "================="
2480 PRINT USING 680 ; "0th MOME
     NT:",Y0(2,I)
2490 PRINT USING 680 ; "1st MOME
     NT:",Y1(2,I)
2500 PRINT USING 680 ; "2nd MOME
     NT:",Y2(2,I) @ PRINT
2510 PRINT "FINAL RATING PERIOD"
      @ PRINT "=================
     =="
2520 PRINT USING 680 ; "0th MOME
     NT:",Y0(1,I)
2530 PRINT USING 680 ; "1st MOME
     NT:",Y1(1,I)
2540 PRINT USING 680 ; "2nd MOME
     NT:",Y2(1,I)
2550 PRINT
2560 CLEAR @ BEEP
2570 DISP "DO YOU WANT TO SAVE R
     ESULTS ON TAPE? (Y OR N)"
2580 INPUT R$
2590 ON 1+(R$="Y")+2*(R$="N") GO
     TO 2600,2610,2920
2600 BEEP @ GOTO 2560
2610 DISP @ DISP "Insert tape LA
     SER RUN x in tape drive" @
     PRINT M1$ @ PAUSE
2620 DISP @ DISP "What file do y
     ou wish to access?"
2630 INPUT F1$
2640 ASSIGN# 1 TO F1$ ! LOOK FOR
      EOF
2650 FOR I=0 TO 27
2660 ON ERROR GOTO 2790
2670 READ# 1 ; G$,G$,G$,G$
2680 READ# 1 ; G,G,G,G
2690 READ# 1 ; G$
2700 FOR J=0 TO 91
2710 READ# 1 ; G
2720 NEXT J
2730 NEXT I
2740 BEEP @ DISP "File ";F1$;" i
     s full. Input another file
     name  ";
2750 INPUT F1$
2760 DISP "PAUSE to create ";F1$
     ;" if necessary. Push CONT
     when ready."
2770 PAUSE
2780 GOTO 2640
2790 OFF ERROR
2800 IF ERRN=71 THEN 2840
2810 BEEP @ DISP "ERRN=";ERRN;"E
     RRL=";ERRL
2820 ASSIGN# 1 TO *
2830 PAUSE
2840 PRINT# 1 ; N$,L$,O1$,D$
2850 PRINT# 1 ; T9,B9,Z5,Z6
2860 PRINT# 1 ; U1$
2870 PRINT# 1 ; T0,E2,Y0(,),Y1(,
     ),Y2(,)
```

```
2880 ASSIGN# 1 TO *
2890 DISP I+1;" lines stored in
     ";F1$ @ BEEP
2900 WAIT 2000
2910 CLEAR @ DISP "Re-insert tap
     e CLOP in tape drive"
2920 DISP "DONE"
2930 END
3000 REM CALCULATE MOMENTS
3010 N=20 @ X1=237 @ X2=477 @ X3
     =573 @ X4=813 @ X5=1053
3020 X0=X2-X1 @ X7=(X1+X2)/2 @ X
     8=(X4+X5)/2 @ X9=(X3+X4)/2
     @ A0=1-1/(4*N^2)
3030 C0=X0^-.5 @ C1=SQR(12/A0)/X
     0^1.5 @ C2=SQR(180)/X0^2.5
     @ Z0=(X2-X1)/(2*N) @ P0=C0
3040 FOR J=N1 TO N2
3050 K1=X7
3060 GOSUB 5000
3070 Y0(0,J)=S0 @ Y1(0,J)=S1 @ Y
     2(0,J)=S2
3080 K1=X8
3090 GOSUB 5000
3100 Y0(1,J)=S0 @ Y1(1,J)=S1 @ Y
     2(1,J)=S2
3110 K1=X9
3120 GOSUB 5000
3130 Y0(2,J)=S0 @ Y1(2,J)=S1 @ Y
     2(2,J)=S2
3140 NEXT J
3150 RETURN
3500 REM ELEC ENERGY INJ
3510 V2=0
3520 V3=0
3530 I2=0
3540 I3=0
3550 FOR I=0 TO 9
3560 V2=V2+V1(I)
3570 V3=V3+V1(I+T0+10)
3580 I2=I2+I1(I)
3590 I3=I3+I1(I+T0+10)
3600 NEXT I
3610 V2=V2/10
3620 V3=V3/10
3630 I2=I2/10
3640 I3=I3/10
3650 J0=0
3660 FOR I=0 TO N5-1
3670 V4=V1(I)-V2-I*(V3-V2)/N5
3680 I4=I1(I)-I2-I*(I3-I2)/N5
3690 J0=J0+V4*I4
3700 NEXT I
3710 RETURN
4000 REM MISSING MOD DETECT
4010 F1(J1)=0
4020 FOR L=1 TO 6
4030 IF O1$[L,L]<>VAL$(J2) THEN
     4050
4040 F1(J1)=1
4050 NEXT L
4060 RETURN
4500 REM FILL NULL DATA SLOTS
4510 FOR J=0 TO 2
4520 Y0(J,I)=-INF
4530 Y1(J,I)=-INF
4540 Y2(J,I)=-INF
4550 NEXT J
4560 RETURN
5000 REM MOMENT CALC ROUTINE
5010 S0=0 @ S1=0 @ S2=0
5020 FOR I=-N TO N-1
5030 Z1=Z0*(I+.5)
5040 P1=C1*Z1
5050 P2=C2*(Z1^2-A0*X0*X0/12)
5060 S0=S0+V((K1+Z1)/Z0,J)*P0
5070 S1=S1+V((K1+Z1)/Z0,J)*P1
5080 S2=S2+V((K1+Z1)/Z0,J)*P2
5090 NEXT I
5100 RETURN
5200 REM FILL NULL DATA FOR L RU
     NS
5210 T0=-INF
5220 E1=-INF
5230 E2=-INF
5240 U1$="N/A"
5250 RETURN
```

Variable Map

Program: CALC Date: 840227

AØ	-	first order correction factor to get orthogonality between moments
B9	-	barometric pressure in mm of Hg
C1	-	normalization factor for 1st moment
C2	-	normalization factor for 2nd moment
CØ	-	normalization factor for 0th moment
D$	-	deflector type descriptor (D=mirror deflector, F=foil reflector)
E1	-	nominal electrical energy injected
E2	-	energy injected during C run
F1	-	array containing flags indicating missing modules
F$	-	name of file containing raw run data
F1$	-	name of file in which results are to be stored
G	-	throw away numeric variable
G$	-	throw away string variable
I	-	counter
I1	-	array containing electrical calibration current readings
I2	-	average zero reading of I1 before injection
I3	-	average zero reading of I1 after injection
I4	-	I1 readings corrected for drift
J	-	counter
J1	-	index of sensor data in V being processed
J2	-	number indicating unit being searched for in missing mod test
JØ	-	electrical energy injected during calibration run
K1	-	midpoint of period being calculated
KØ	-	calibration factor
L	-	counter
L$	-	run type (L=laser, C=combination, E=electrical)
M	-	results output type descriptor (1=display, 2=print)
M$	-	temporary label for printing name of unit
M1$	-	-message- "Push CONT when ready"
N	-	number of data packets in half duration of any time period
N1	-	lower sensor index of data to be processed
N2	-	upper sensor index of data to be processed
N5	-	number of V1 (and I1) readings
N6	-	number of throw away numerical variables per line in electrical summary file
N$	-	run number
O1$	-	calorimeter configuration descriptor
P1	-	1st moment function
P2	-	2nd moment function
PØ	-	0th moment function
R$	-	alpha answer to questions
S1	-	1st moment summing variable
S2	-	2nd moment summing variable
SØ	-	0th moment summing variable

T2 - factor representing ratio of temp after shutter closes to temp before shutter opens
T9 - ambient temperature in degrees C
TØ - duration in seconds of electrical energy injection period

U1 - numeric indicator of unit receiving energy (electrical or laser)
U1$ - name of unit receiving electrical energy

V - array (176 x 10) containing voltage output readings for 10 sensors
V1 - array containing electrical calibration voltage readings
V2 - average zero readings of V1 before injection
V3 - average zero reading of V1 after injection
V4 - V1 readings corrected for drift

X1 - time in seconds of starting point of zero rating period
X2 - time in seconds of ending point of zero rating period
X3 - time in seconds of starting point of transition period
X4 - time in seconds of ending point of transition period
X5 - time in seconds of ending point of final rating period
X7 - midpoint of zero rating period in seconds
X8 - midpoint of transition period in seconds
X9 - midpoint of final rating period in seconds
XØ - period duration in seconds

Y1 - array containing 1st moments of 3 time periods for all sensors
Y2 array containing 2nd moments of 3 time periods for all sensors
YØ - array containing 0th moments of 3 time periods for all sensors

Z1 - time coordinate of the point under question
Z5 - main calorimeter RTD dial setting
Z6 - temperature out dial setting
ZØ number of readings averaged to get one data packet

```
10 REM PROG "ELSCAN" DATE-TIME
   840228 @ 09:25
20 OPTION BASE 0
30 DIM F$[6],M$[20],M1$[20],R$[
   1],Y0(3),Y1(3),Y2(3)
40 SHORT B9,T9,Z5,Z6
50 INTEGER I,M,R
60 M1$="Push CONT when ready"
70 CLEAR @ DISP "Insert tape EL
   EC. SUMMARY in drive"
80 DISP @ DISP M1$ @ PAUSE
90 CLEAR
100 DISP "DATA FILE FOR WHICH SE
    NSOR IS TOBE ACCESSED?"
110 DISP "  1. MAIN CAL. RTD"
120 DISP "  2. MASS FLOW OUT"
130 DISP "  3. TEMPERATURE OUT"
140 DISP "  4. MASS FLOW IN"
150 DISP "  5. TEMPERATURE IN"
160 DISP "  6. DEFLECTOR"
170 DISP "  7. FOIL REFLECTOR"
180 DISP "  8. SEPARATION TUBE"
190 DISP "  9. BACKSCATTER MONIT
    OR"
200 DISP " 10. OVERSPILL MONITOR
    "
210 DISP " 11. EXTENSION TUBE"
220 DISP @ DISP "ENTER LINE NO.
     ";
230 INPUT R
240 IF R>=1 AND R<=11 THEN 270
250 BEEP @ DISP @ DISP "WHAT?"
260 WAIT 2000 @ GOTO 90
270 ON R GOTO 280,290,300,310,32
    0,330,340,350,360,370,380
280 F$="MCRTD*" @ M$="MAIN CALOR
    IMETER RTD" @ GOTO 390
290 F$="MAOUT*" @ M$="MASS OUT"
    @ GOTO 390
300 F$="TEOUT*" @ M$="TEMPERATUR
    E OUT" @ GOTO 390
310 F$="MASIN*" @ M$="MASS IN" @
     GOTO 390
320 F$="TEMIN*" @ M$="TEMPERATUR
    E IN" @ GOTO 390
330 F$="DEFLC*" @ M$="MIRROR DEF
    LECTOR" @ GOTO 390
340 F$="FOREF*" @ M$="FOIL REFLE
    CTOR" @ GOTO 390
350 F$="SPTUB*" @ M$="SEPARATION
     TUBE" @ GOTO 390
360 F$="BSMON*" @ M$="BACKSCATTE
    R MONITOR" @ GOTO 390
370 F$="OSMON*" @ M$="OVERSPILL
    MONITOR" @ GOTO 390
380 F$="EXTUB*" @ M$="EXTENSION
    TUBE"
390 M=1
400 O1$="?"
410 CRT IS M
420 CLEAR @ DISP M$
430 IMAGE 12A,1X,SD.3DE
440 ASSIGN# 1 TO F$
450 FOR I=0 TO 68
460 ON ERROR GOTO 960
470 READ# 1 ; N$,O1$
480 READ# 1 ; T9,B9
490 IF R<>1 AND R<>3 THEN 510
500 READ# 1 ; Z0
510 READ# 1 ; J0,K0,Y0(0),Y0(1),
    Y0(2),Y1(0),Y1(1),Y1(2),Y2(0
    ),Y2(1),Y2(2)
520 DISP "LINE ";I+1 @ DISP
530 DISP "RUN NO: ";N$ @ DISP
540 DISP "ELEC. ENERGY: ",J0;" J
    " @ DISP
550 DISP "CAL. CONFIG  ";O1$
560 DISP "ROOM TEMP: ";T9;" DEG
    C"
570 DISP "BAROM PRESS: ";B9;" mm
     Hg" @ DISP
580 IF R<>1 THEN 600
590 DISP "RTD DIAL SETTING: ";Z0
     @ DISP
600 IF R<>3 THEN 620
610 DISP "TEMP OUT DIAL SETTING:
     ";Z0 @ DISP
620 IF M=2 THEN 650
630 BEEP @ DISP M1$ @ PAUSE
640 DISP
650 DISP "ZERO RATING PERIOD" @
    DISP "=================="
660 DISP USING 430 ; "0th MOMENT
    :",Y0(0)
670 DISP USING 430 ; "1st MOMENT
    :",Y1(0)
680 DISP USING 430 ; "2nd MOMENT
    :",Y2(0)
690 DISP
700 IF M=2 THEN 730
710 BEEP @ DISP M1$ @ PAUSE
720 DISP
730 DISP "TRANSITION PERIOD" @ D
    ISP "================="
740 DISP USING 430 ; "0th MOMENT
    :",Y0(2)
750 DISP USING 430 ; "1st MOMENT
    :",Y1(2)
760 DISP USING 430 ; "2nd MOMENT
    :",Y2(2) @ DISP
770 IF R=2 OR R=4 OR R=5 THEN 80
    0
780 DISP USING 430 ; "CAL FACTOR
    :",K0
790 GOTO 810
800 DISP USING 430 ; "STABIL FAC
    T:",K0*J0
810 DISP
820 IF M=2 THEN 850
830 BEEP @ DISP M1$ @ PAUSE
```

```
840 DISP
850 DISP "FINAL RATING PERIOD" @
     DISP "==================="
860 DISP USING 430 ; "0th MOMENT
    :",Y0(1)
870 DISP USING 430 ; "1st MOMENT
    :",Y1(1)
880 DISP USING 430 ; "2nd MOMENT
    :",Y2(1)
890 DISP
900 IF M=2 THEN 930
910 BEEP @ DISP M1$ @ PAUSE
920 DISP
930 NEXT I
940 IF M=2 THEN 960
950 BEEP @ DISP "File ";F$;" is
    full" @ OFF ERROR @ GOTO 104
    0
960 OFF ERROR
970 IF ERRN=71 THEN 1010
980 BEEP @ DISP "ERRN=";ERRN;"ER
    RL=";ERRL
990 ASSIGN# 1 TO *
1000 PAUSE
1010 IF O1$<>"7" THEN 1050
1020 BEEP @ DISP "FILE IS EMPTY!
     "
1030 GOTO 1130
1040 IF M=2 THEN 1120
1050 DISP "DO YOU WANT A PRINT-O
     UT OF THE FILE? (Y OR N)  "
     ;
1060 INPUT R$
1070 ON 1+(R$="Y")+2*(R$="N") GO
     TO 1080,1100,1130
1080 BEEP @ DISP "WHAT?"
1090 GOTO 1060
1100 M=2
1110 GOTO 410
1120 M=1 @ CRT IS M
1130 BEEP @ DISP "DONE!"
1140 DISP @ DISP "TO ACCESS MORE
      FILES RE-RUN PROGRAM."
1150 END
```

Variable Map

Program: ELSCAN Date: 840228

B9 - barometric pressure in mm of Hg

F$ - name of summary file to be accessed

I - counter

JØ - injected electrical energy in joules

KØ - calibration or stability factor as appropriate

M - data output method descriptor (1=display, 2=print)
M$ - name of unit in F$
M1$ - -message- "Push CONT when ready"

N$ - run number

O1$ - calorimeter configuration descriptor

R - numeric answer to questions
R$ - alpha answer to questions

T9 - ambient temperature in degrees C

Y1 - array containing 1st moments for zero rating, transition, and final rating periods
Y2 - array containing 2nd moments for zero rating, transition, and final rating periods
YØ - array containing 0th moments for zero rating, transition, and final rating periods

ZØ - dial setting for either main calorimeter RTD or temp out sensor

```
  10 REM PROG "FACTOR" DATE-TIME
     840224 @ 16:25
  20 REM APPLIES CORR FOR DRIFT F
     ROM OUTSIDE AMBIENT TO RTD A
     ND TEMP OUT. FOR OTHER MODUL
     ES
  30 REM AVERAGES ELECTRICAL RESU
     LTS. NO PROVISIONS FOR MASS
     IN OR OUT OR TEMP IN
  40 OPTION BASE 0
  50 CLEAR
  60 DIM N0(69),K1(69),K2(69),V1(
     69),V2(69),N$[9],O1$[6],I1$[
     35],I0$[288]
  70 DIM F$[6],R$[1],M$[19],F0(8,
     4),V3(69)
  80 DISP "Insert tape ELEC. SUMM
     ARY in drive"
  90 BEEP @ DISP "Push CONT when
     ready"
 100 PAUSE
 110 CLEAR @ DISP "Enter line no
     of sensor desired"
 120 DISP "  1. Main Cal RTD"
 130 DISP "  2. Temp Out"
 140 DISP "  3. Foil Reflector"
 150 DISP "  4. Mirror Deflector"
 160 DISP "  5. Separation Tube"
 170 DISP "  6. Backscatter Monit
     or"
 180 DISP "  7. Overspill Monitor
     "
 190 DISP "  8. Extension Tube"
 200 DISP @ DISP "Enter line no.
     ";
 210 INPUT R@ R=INT(R)
 220 IF R>=1 OR R<=8 THEN 240
 230 DISP @ BEEP @ DISP "WHAT?" @
      GOTO 210
 240 ON R GOTO 250,260,270,280,29
     0,300,310,320
 250 F$="MCRTD*" @ M$="MAIN CAL R
     TD" @ GOTO 330
 260 F$="TEOUT*" @ M$="TEMP OUT"
     @ GOTO 330
 270 F$="FOREF*" @ M$="FOIL REFLE
     CTOR" @ GOTO 330
 280 F$="DEFLC*" @ M$="MIRROR DEF
     LECTOR" @ GOTO 330
 290 F$="SPTUB*" @ M$="SEPARATION
      TUBE" @ GOTO 330
 300 F$="BSMON*" @ M$="BACKSCATTE
     R MONITOR" @ GOTO 330
 310 F$="OSMON*" @ M$="OVERSPILL
     MONITOR" @ GOTO 330
 320 F$="EXTUB*" @ M$="EXTENSION
     TUBE"
 330 ASSIGN# 1 TO F$
 335 N1=0
 340 FOR I=0 TO 68
 350 ON ERROR GOTO 470
 360 READ# 1 , N$,O1$
 370 N0(I)=VAL(N$)
 380 READ# 1 ; T9,B9
 390 IF R<>1 AND R<>2 THEN 410
 400 READ# 1 ; Z0
 410 READ# 1 ; J0,K1(I),G,G,G,V1(
     I),G,G,G,G,G
 420 N1=N1+1
 430 NEXT I
 440 BEEP @ DISP "File ";F$;" is
     full"
 450 OFF ERROR
 460 WAIT 2000 @ GOTO 540
 470 OFF ERROR
 480 IF ERRN=71 THEN 510
 490 BEEP @ DISP "ERRN=";ERRN;"ER
     RL=";ERRL
 500 PAUSE
 510 IF N1>0 THEN 540
 520 CLEAR @ DISP "File ";F$;" is
      empty"
 530 DISP @ GOTO 2500
 540 ASSIGN# 1 TO *
 550 IF N1<3 AND (R=1 OR R=2) THE
     N 2200
 555 GOSUB 7000
 560 REM SELECT APROPRIATE RUNS
 570 IMAGE 6D.2D,X,SD.2DE,2X,SD.2
     DE
 580 CLEAR @ DISP M$
 590 FOR I=0 TO N1-1
 600 DISP USING 570 : N0(I),K1(I)
     ,V1(I)
 610 NEXT I
 620 DISP "Delete any run? (Y or
     N)  ",
 630 INPUT R$
 640 ON 1+(R$="Y")+2*(R$="N") GOT
     O 650,660,890
 650 BEEP @ DISP "WHAT?" @ GOTO 6
     30
 660 DISP @ DISP "What run no?  "
     ;
 670 INPUT N9
 680 DISP USING "K" ; "Is ",N9;"
     the correct no? (Y or N)  "
 690 INPUT R$
 700 ON 1+(R$="Y")+2*(R$="N") GOT
     O 710,720,660
 710 BEEP @ DISP "WHAT?" @ GOTO 6
     90
 720 N2=-1
 730 FOR I=0 TO N1-1 ! FIND INDEX
 740 IF N0(I)<>N9 THEN 760
 750 N2=I
 760 NEXT I
 770 IF N2<>-1 THEN 800
 780 BEEP @ DISP USING "K" ; "Run
      no. ",N9," not found  Try a
     gain!"
```

```
790 WAIT 2000 @ GOTO 580
800 FOR I=N2 TO N1-2
810 IF N2=N1-1 THEN 850
820 N0(I)=N0(I+1)
830 K1(I)=K1(I+1)
840 V1(I)=V1(I+1)
850 NEXT I
860 N1=N1-1
870 IF N1>0 THEN 580
875 CLEAR @ BEEP @ DISP "No valu
    es left to be considered"
880 GOTO 2500
890 IF N1<3 AND (R=1 OR R=2) THE
    N 2200
900 IF N1>1 OR R=1 OR R=2 THEN 9
    30
910 GOSUB 6000
920 GOTO 1600
930 IF R<>1 AND R<>2 THEN 950
940 GOSUB 3000
950 IF R=1 OR R=2 THEN 970
960 GOSUB 4000
970 GOSUB 5000
980 IF R<>1 AND R<>2 THEN 1400
990 REM OUTPUT RTD & TEMP OUT RE
    SULTS
1000 IMAGE 15A,X,SD.3DE
1010 IMAGE 15A,2X,D.3DE,2X,A
1020 M=1 @ CLEAR
1030 CRT IS M @ DISP M$ @ DISP
1040 DISP USING 1000 ; "Calib Fa
     ctor:",K
1050 DISP @ DISP USING 1000 ; "S
     td Deviation:",K8
1060 DISP USING 1010 ; "% Std De
     v:",ABS(100*K8/K),"%"
1070 DISP @ DISP USING 1010 ; "9
     0% Conf int:",ABS(100*T0*K8
     /K),"%"
1080 DISP USING 1010 ; "95% Conf
      int:",ABS(100*T5*K8/K),"%"
1090 DISP USING 1010 ; "99% Conf
      int:",ABS(100*T9*K8/K),"%"
1100 IF M=2 THEN 1130
1110 BEEP @ DISP "Push CONT when
      ready"
1120 PAUSE
1130 DISP @ DISP USING 1000 ; "D
     rift Coef:",A1
1140 DISP @ DISP USING 1000 ; "S
     td. Dev:",A8
1150 DISP USING 1010 ; "% Std De
     v:",100*A8/A1
1160 DISP @ DISP USING 1010 ; "9
     0% Conf int:",ABS(100*T0*A8
     /A1),"%"
1170 DISP USING 1010 . "95% Conf
      int:",ABS(100*T5*A8/A1),"%
     "
1180 DISP USING 1010 ; "99% Conf
      int:",ABS(100*T9*A8/A1)
1190 DISP @ DISP "No. of Points:
     ",N1
1200 DISP @ DISP I1$
1210 IF M=2 THEN 1330
1220 DISP "Do you want to change
      into note? (Y or N)    ";
1230 INPUT R$
1240 ON 1+(R$="Y")+2*(R$="N") GO
     TO 1250,1260,1280
1250 BEEP @ DISP "WHAT?" @ GOTO
     1220
1260 GOSUB 7500
1270 GOTO 1020
1280 DISP "Do you want a copy of
      the results? (Y or N)   ";
1290 INPUT R$
1300 ON 1+(R$="Y")+2*(R$="N") GO
     TO 1310,1320,1330
1310 BEEP @ DISP "WHAT?" @ GOTO
     1290
1320 M=2 @ GOTO 1030
1330 M=1 @ CRT IS M
1340 GOTO 2000
1400 REM OUTPUT ANCILLARY MODULE
     S
1410 M=1 @ CLEAR
1420 CRT IS M @ DISP M$ @ DISP
1430 DISP USING 1000 ; "Calib Fa
     ct:",K
1440 DISP @ DISP USING 1000 ; "S
     td Deviation:",K8
1450 DISP USING 1010 ; "% Std De
     v:",ABS(100*K8/K),"%"
1460 DISP @ DISP USING 1010 ; "9
     0% Conf int:",ABS(100*T0*K8
     /K),"%"
1470 DISP USING 1010 ; "95% Conf
      int:",ABS(100*T5*K8/K),"%"
1480 DISP USING 1010 ; "99% Conf
      int:",ABS(100*T9*K8/K),"%"
1490 DISP @ DISP "No. of Points:
     ",N1
1500 DISP @ DISP I1$
1510 IF M=2 THEN 1630
1520 DISP "Do you want to change
      into note? (Y or N)   ";
1530 INPUT R$
1540 ON 1+(R$="Y")+2*(R$="N") GO
     TO 1550,1560,1580
1550 BEEP @ DISP "WHAT?" @ GOTO
     1520
1560 GOSUB 7500
1570 GOTO 1420
1580 DISP "Do you want a copy of
      the results? (Y or N)   ";
1590 INPUT R$
1600 ON 1+(R$="Y")+2*(R$="N") GO
     TO 1610,1620,1630
1610 BEEP @ DISP "WHAT?" @ GOTO
     1590
```

```
1620 M=2 @ GOTO 1420
1630 M=1 @ CRT IS M
1640 GOTO 2000
2000 REM SAVE RESULTS ON TAPE
2010 CLEAR @ DISP "Do you want t
     o save results on tape? (Y
     or N)   ";
2020 INPUT R$
2030 ON 1+(R$="Y")+2*(R$="N") GO
     TO 2040,2050,2500
2040 BEEP @ DISP "WHAT?" @ GOTO
     2020
2050 F0(R,1)=K
2060 F0(R,2)=100*K8/K
2070 F0(R,3)=N1
2080 IF R<>1 THEN 2110
2090 F0(1,4)=A1
2100 F0(3,4)=100*A8/A1
2110 IF R<>2 THEN 2140
2120 F0(2,4)=A1
2130 F0(4,4)=100*A8/A1
2140 ASSIGN# 2 TO "CALFAX"
2150 PRINT# 2 ; F0(,)
2160 PRINT# 2 ; I0$
2170 ASSIGN# 2 TO *
2180 BEEP @ DISP "Data stored in
      file CALFAX"
2190 GOTO 2500
2200 BEEP @ DISP @ DISP "NOT ENO
     UGH RUNS FOR LEAST SQUARES
     FIT"
2210 GOTO 2500
2500 BEEP @ DISP "DONE"
2510 END
3000 REM LIN LST SQR FIT (NATREL
     LA)
3010 S1=0 @ S2=0 @ S3=0 @ S4=0 @
      S5=0
3020 FOR I=0 TO N1-1
3030 V2(I)=V1(I)^2
3040 V3(I)=V1(I)*K1(I)
3050 K2(I)=K1(I)^2
3060 S1=S1+V1(I)
3070 S2=S2+K1(I)
3080 S3=S3+V3(I)
3090 S4=S4+V2(I)
3100 S5=S5+K2(I)
3110 NEXT I
3120 REM W1=Sxx;W2=Syy;W3=Sxy;V0
     =Xbar;K0=Y-bar
3130 W3=S3-S1*S2/N1
3140 W1=S4-S1^2/N1
3150 W2=S5-S2^2/N1
3160 V0=S1/N1
3170 K0=S2/N1
3180 REM A1=SLOPE;K=Y-int
3190 A1=W3/W1
3200 K=K0-A1*V0
3210 REM W4=S(Y)^2;W5=S(Y)
3220 W4=(W2-W3^2/W1)/(N1-2)
3230 W5=SQR(W4)
3240 REM A9=VAR OF SLOPE;K9=VAR
     OF Y-int
3250 A9=W4/W1
3260 A8=SQR(A9)
3270 K9=W4*(1/N1+V0^2/W1)
3280 K8=SQR(K9)
3290 RETURN
4000 REM AVE & S.D
4010 S1=0 @ S2=0 @ S4=0 @ S5=0
4020 FOR I=0 TO N1-1
4030 V2(I)=V1(I)^2
4040 K2(I)=K1(I)^2
4050 S1=S1+V1(I)
4060 S2=S2+K1(I)
4070 S4=S4+V2(I)
4080 S5=S5+K2(I)
4090 NEXT I
4100 V0=S1/N1
4110 K=S2/N1
4120 V9=(N1*S4-S1^2)/(N1*(N1-1))
4130 V8=SQR(V9)
4140 K9=(N1*S5-S2^2)/(N1*(N1-1))
4150 K8=SQR(K9)
4160 RETURN
5000 REM t -STAT--T0=90%;T5=95%;
     T9=99%
5010 IF R<>1 AND R<>2 THEN 5030
5020 N3=N1-2
5025 GOTO 5040
5030 N3=N1-1
5040 IF N3>4 THEN 5080
5050 T0=15.016+N3*(-12.1829+N3*(
     3.8945-.4135*N3))
5060 T5=34.958+N3*(-31.3655+N3*(
     10.208-1.0945*N3))
5070 GOTO 5100
5080 T0=N3/(-.559925368278+.6078
     4409253*N3)+.0006
5090 T5=N3/(-.6115593191+.510110
     2332*N3)+.0006
5100 IF N3>1 THEN 5130
5110 T9=63.657
5120 GOTO 5170
5130 IF N3>5 THEN 5160
5140 T9=35.362+N3*(-20.6568+N3*(
     4.6965-.36367*N3))
5150 GOTO 5170
5160 T9=N3/(-.715572170161+.3874
     90270184*N3)+.0006
5170 RETURN
6000 REM ROUTINE FOR 1 DATA PT
6010 K=K1(0)
6020 K8=0
6030 A8=0
6040 A0=V1(0)
6050 T0=1
6060 T5=1
6070 T9=1
6080 V8=0
```

```
6090 RETURN
7000 REM IDEN INFO
7010 IF R=1 THEN P1$="¿" @ P2$="
     ◀"
7020 IF R=2 THEN P1$="◀" @ P2$="
     Æ"
7030 IF R=3 THEN P1$="Æ" @ P2$="
     æ"
7040 IF R=4 THEN P1$="æ" @ P2$="
     £"
7050 IF R=5 THEN P1$="£" @ P2$="
     ↑"
7060 IF R=6 THEN P1$="↑" @ P2$="
     ▒"
7070 IF R=7 THEN P1$="▒" @ P2$="
     ├"
7080 IF R=8 THEN P1$="├" @ P2$="
     →"
7090 ASSIGN# 3 TO "CALFAX"
7100 READ# 3 ; F0(,)
7110 READ# 3 ; I0$
7120 P1=POS(I0$,P1$)
7130 P2=POS(I0$,P2$)
7140 I1$=I0$[P1+1,P2-1]
7150 RETURN
7500 REM MAKE NEW INFO NOTE
7510 DISP @ DISP "Type in new in
     fo note [max=35 char]"
7520 INPUT I1$
7530 P3=POS(I0$,"→")
7540 IF R<>1 THEN 7570
7550 I0$=I1$&I0$[P2,P3]
7560 GOTO 7580
7570 I0$=I0$[1,P1]&I1$&I0$[P2,P3
     ]
7580 RETURN
```

Variable Map

Program: FACTOR   Date: 840224

A1 -	drift coefficient (slope from least squares fit)
A8 -	standard deviation of A1
A9 -	variance of A1
FØ -	8 x 4 array containing "best" values of temperature sensors
F$ -	name of electrical summary file to be accessed
G -	throw away variable
I -	counter
IØ$ -	alpha string containing info notes and delimiters for all 8 sensors
I1$ -	information note for data being considered
JØ -	electrical energy injected
K -	"best" value of calibration factor
K1 -	array containing cal factor read from elec. summary file
K2 -	array containing $K1^2$ terms
K8 -	standard deviation of K
K9 -	variance of K
KØ -	average value of K1
M -	results output type descriptor (1=display, 2=printer)
M$ -	name of sensor represented by F$
N1 -	counter of lines of data
N2 -	index of run data to be edited out
N3 -	degrees of freedom in t-statistic eoutine
N9 -	run number for data to be edited out
NØ -	array containing numeric equivalents of N$
N$ -	run number
O1$ -	calorimeter configuration descriptor
P1 -	position of P1$ in IØ$
P2 -	position of P2$ in IØ$
P3 -	position of last delimiter in IØ$
P1$ -	leading delimiter for info note
P2$ -	trailing delimiter for info note
R -	numeric answer to question
R$ -	alpha answer to question
S1 -	summation of V1 terms
S2 -	summation of K1 terms
S3 -	summation of V1 x k1 terms
S4 -	summation of $V1^2$ terms
S5 -	summation of $K1^2$ terms
T5 -	95 percent t-stat
T9 -	ambient temperature in degrees C, also after line 970, 99 percent t-stat
TØ -	90 percent t-stat
V1 -	array containing 1st moments of zero rating period from elec. summary files
V2 -	array containing squares of V1
V3 -	array containing V1 x K1 terms
VØ -	average value of V1
W1 -	sum of squares of the V1 residuals
W2 -	sum of squares of the K1 residuals

W3 - sum of squares of the V1 x K1 residuals

W4 - $(W3^2/W2) \times (N1-2)$

W5 - square root of W4

ZØ - dial setting of main calorimeter RTD or temperature out (as appropriate)

```
 10 REM PROG "FILEXM" DATE-TIME
    840220 @ 12:35
 20 OPTION BASE 0
 30 SHORT V(176,10),V1(55),I1(55
    )
 40 DIM D$[1],F$[6],L$[1],O1$[6]
    ,N$[9],R$[1],U1$[19],M$[20]
 50 INTEGER I,N5,U1,J1
 60 M$="Push CONT when ready"
 70 CLEAR @ BEEP
 80 DISP "Insert tape RUN DATA x
     in drive"
 90 DISP M$ @ PAUSE
100 CLEAR
110 DISP "What file do you wish
    to access?"
120 INPUT F$
130 ASSIGN# 1 TO F$
140 READ# 1 ; N$,L$,O1$,D$
150 READ# 1 ; T9,B9,U1
160 IF U1<>6 THEN 180
170 READ# 1 ; Z5,Z6
180 READ# 1 ; V(,)
190 IF L$="L" THEN 230
200 READ# 1 ; U1$
210 READ# 1 ; T0,E1,N5
220 READ# 1 ; V1(),I1()
230 ASSIGN# 1 TO *
240 CLEAR @ DISP USING "K" ; "Co
    ntents of file ";F$;" are in
     memory"
250 WAIT 2000
260 M=1
270 CLEAR @ CRT IS M
280 DISP "Run No:      ";N$
290 DISP @ DISP "Run Type:
       ";L$
300 DISP @ DISP "Calor Config:  "
    ;O1$
310 DISP "Room Temp:          ";T9;
    " DEG c"
320 DISP "Barom Press:        ";B9;
    " mm Hg"
330 IF L$="L" THEN 800
340 DISP @ DISP USING "15A,5D,2A
    " ; "Nom Energy:",E1," J"
350 IF M=2 THEN 380
360 DISP @ DISP M$
370 PAUSE
380 DISP @ DISP "Elec Data" @ DI
    SP
390 DISP "Line   Volts    Amps"
400 FOR I=0 TO N5-1
410 DISP USING "3D,3X,M2D.2D,2X,
    M2D.2D" ; I+1,V1(I),I1(I)
420 NEXT I
430 IF M=2 THEN 460
440 DISP @ DISP M$ @ DISP
450 PAUSE
460 IF L$="C" THEN 810
470 DISP @ DISP U1$;" OUTPUT" @
    DISP
480 IMAGE /,"DIAL SETTING",/ M3D
    .2/
490 IF U1$[1,1]="M" THEN 540
500 U$=U1$[1,1]
510 J1=(U$=D$)+2*(U$="S")+3*(U$=
    "B")+4*(U$="O")+5*(U$="E")+4
520 GOSUB 2500
530 GOTO 1140
540 DISP "MASS FLOW IN" @ DISP
550 J1=3
560 GOSUB 2500
570 DISP @ DISP "MASS FLOW OUT"
    @ DISP
580 J1=1
590 GOSUB 2500
600 DISP @ DISP "TEMPERATURE IN"
     @ DISP
610 J1=4
620 GOSUB 2500
630 DISP @ DISP "TEMPERATURE OUT
    "
640 DISP USING 480 ; Z6 @ J1=2
650 GOSUB 2500
660 DISP @ DISP "CALORIMETER RTD
    "
670 DISP USING 480 ; Z5 @ J1=0
680 GOSUB 2500
690 GOTO 1140
800 REM OUTPUT L & C RUNS
810 FOR J1=0 TO 9
820 ON J1+1 GOTO 830,860,880,910
    ,930,950,1000,1020,1040,1060
830 DISP @ DISP "CALORIMETER RTD
    "
840 DISP USING 480 ; Z5 @ J2=6
850 GOTO 1080
860 DISP @ DISP "MASS FLOW OUT"
    @ DISP
870 GOTO 1080
880 DISP @ DISP "TEMPERATURE OUT
    "
890 DISP USING 480 ; Z6
900 GOTO 1080
910 DISP @ DISP "MASS FLLOW IN"
    @ DISP
920 GOTO 1080
930 DISP @ DISP "TEMPERATURE IN"
     @ DISP
940 GOTO 1080
950 IF D$="F" THEN 980
960 DISP @ DISP "DEFLECTOR" @ DI
    SP
970 GOTO 1070
980 DISP @ DISP "FOIL REFLECTOR"
     @ DISP
990 GOTO 1070
1000 DISP @ DISP "SEPARATION TUB
     E" @ DISP
```

```
1010 GOTO 1070
1020 DISP @ DISP "BACKSCATTER MO
     NITOR" @ DISP
1030 GOTO 1070
1040 DISP @ DISP "OVERSPILL MONI
     TOR" @ DISP
1050 GOTO 1070
1060 DISP @ DISP "EXTENSION TUBE
     " @ DISP
1070 J2=10-J1
1080 GOSUB 2000
1090 IF F=1 THEN 1120
1100 DISP "NULL DATA"
1110 GOTO 1130
1120 GOSUB 2500
1130 NEXT J1
1140 IF M=2 THEN 1230
1150 DISP @ BEEP @ DISP "DO YOU
     WANT A COPY OF THE DATA?"
1160 INPUT R$
1170 ON 1+(R$="Y")+2*(R$="N") GO
     TO 1180,1200,1230
1180 BEEP @ DISP @ DISP "WHAT?"
1190 GOTO 1160
1200 M=2
1210 CRT IS M
1220 GOTO 280
1230 M=1
1240 CRT IS M
1250 BEEP @ DISP @ DISP "DONE"
1260 DISP @ DISP "RE-RUN PROG TO
      READ MORE FILES"
1270 END
2000 REM MISSING MODULE DETECT
2010 F=0
2020 J2$=VAL$(J2)
2030 FOR L=1 TO 6
2040 IF O1$[L,L]<>J2$ THEN 2060
2050 F=1
2060 NEXT L
2070 RETURN
2500 REM PRINT OUT SENSOR DATA
2510 IMAGE 3D,2X,M2D.4D,4X,3D,2X
     ,M2D.4D
2520 FOR K=0 TO 87
2530 DISP USING 2510 ; K+1,V(K,J
     1),K+89,V(K+88,J1)
2540 NEXT K
2550 RETURN
```

Variable Map

Program: FILEXM Date: 840220

B9	-	barometric pressure in mm of Hg
D$	-	deflector type descriptor (D=mirror deflector, F=foil reflector)
E1	-	nominal electrical energy injected
F	-	flag in missing module routine (0=missing, 1=present)
F$	-	name of temporary data file to be accessed
I	-	counter
I1	-	array containing electrical calibration current readings
J1	-	column index in V indicating particular sensor
J2	-	numeric indicator of module
J2$	-	string equivalent of J2 for comparing in missing module routine
K	-	counter
L	-	counter
L$	-	run type (L=laser, C=combination, E=electrical)
M	-	results output type descriptor (1=display, 2=printer)
M$	-	-message- "Push CONT when ready"
N5	-	number of V1 (and I1) data points
N$	-	run number
O1$	-	calorimeter configuration descriptor
R$	-	alpha answer to questions
T9	-	ambient temperature in degrees C
TØ	-	duration of injection period in seconds
U1	-	number of module receiving energy (laser or electrical)
U$	-	one letter descriptor of unit receiving electrical energy
U1$	-	name of module receiving electrical energy
V	-	matrix (176 x 10) containing output values for all sensors
V1	-	array containing electrical calibration voltage readings
Z5	-	main calorimeter RTD dial setting
Z6	-	temperature out dial setting

C7. "CHMON"
Program Listing

```
    5 REM PROG "CHMON" DATE-TIME 8
      40222 @ 09:55
   10 CLEAR
   30 ON KEY# 1,"09" GOTO 300
   40 ON KEY# 2,"08" GOTO 500
   50 ON KEY# 3,"07" GOTO 700
   60 ON KEY# 4,"06" GOTO 900
   70 ON KEY# 5,"05" GOTO 1100
   80 ON KEY# 6,"00" GOTO 1300
   85 ON KEY# 7,"SELECT" GOTO 1500
   90 ON KEY# 8,"STOP" GOTO 140
   91 CLEAR
   92 DISP "Push UDK to connect ap
      propriate scanner channel to
       DVM." @ DISP
   93 DISP "Pushing  SELECT  lets
      you chooseany channel"
  100 KEY LABEL
  110 REM IDLING LOOP
  120 REM
  130 GOTO 110
  140 DISP "PROGRAM TERMINATED"
  150 BEEP
  160 END
  300 OUTPUT 709 USING "K" ; "09"
  310 GOTO 91
  500 OUTPUT 709 USING "K" ; "08"
  510 GOTO 91
  700 OUTPUT 709 USING "K" ; "07"
  710 GOTO 91
  900 OUTPUT 709 USING "K" , "06"
  910 GOTO 91
  1100 OUTPUT 709 USING "K" ; "05"
  1110 GOTO 91
  1300 OUTPUT 709 USING "K" ; "00"
  1310 GOTO 91
  1500 CLEAR @ DISP "WHAT CHANNEL"
       ,
  1510 INPUT C$
  1520 OUTPUT 709 USING "K" ; C$
  1530 GOTO 91
```

Variable Map

C$ - channel command to scanner

```
   5 REM PROG "KEPCO" DATE-TIME 6
     40222 @ 10:10
  10 CLEAR
  20 DISP "WHAT VOLTAGE LIMIT";
  30 INPUT V1
  40 IF ABS(V1)>10 THEN 70
  50 K1=409.5
  60 GOTO 80
  70 K1=40.95
  80 V0=INT(ABS(K1*V1))
  90 D1=1
 100 IF V1<0 THEN 180
 110 IF V1>10 THEN 150
 120 D2=2
 130 GOSUB 1000
 140 GOTO 240
 150 D2=0
 160 GOSUB 1000
 170 GOTO 240
 180 IF V1<-10 THEN 220
 190 D2=3
 200 GOSUB 1000
 210 GOTO 240
 220 D2=1
 230 GOSUB 1000
 240 A$=X$
 250 REM SET CURRENT LIMIT
 260 DISP
 270 DISP "WHAT CURRENT LIMIT";
 280 INPUT V2
 290 D1=2
 300 D2=2
 310 V0=INT(ABS(409.5*V2))
 320 GOSUB 1000
 330 B$=X$
 335 GOSUB 500
 340 OUTPUT 706 ;A$;B$
 350 DISP
 360 BEEP
 370 DISP "KEPCO SET TO ";V1;" VO
     LTS AND ";V2;" AMPS!"
 380 END
 500 REM --ROUTINE TO SET DVM & S
     CANNER
 510 IF ABS(V1)>15 THEN 540
 520 OUTPUT 709 USING "K" ; "11"
 530 GOTO 550
 540 OUTPUT 709 USING "K" ; "12"
 550 OUTPUT 724 ;"R3"
 560 LOCAL 724
 570 ABORTIO 7
 580 RETURN
1000 REM CONVERT V0 TO RADIX 16
1010 LET E1=FLOOR(V0/16)
1020 D5=V0-16*E1
1030 LET E2=FLOOR(E1/16)
1040 D4=E1-16*E2
1050 D3=E2
1060 D0$=VAL$(D5)
1070 IF D5>9 THEN GOSUB 2000
1080 D5$=D0$
1090 D0$=VAL$(D4)
1100 IF D4>9 THEN GOSUB 2000
1110 D4$=D0$
1120 D0$=VAL$(D3)
1130 IF D3>9 THEN GOSUB 2000
1140 D3$=D0$
1150 X$=VAL$(D1)&VAL$(D2)&D3$&D4
     $&D5$
1160 RETURN
2000 REM CONVERT LARGER HEXADECI
     MALS TO ALPHANUMERICS
2010 D6=VAL(D0$)-9
2020 ON D6 GOTO 2030,2050,2070,2
     090,2110,2130
2030 D0$="A"
2040 GOTO 2140
2050 D0$="B"
2060 GOTO 2140
2070 D0$="C"
2080 GOTO 2140
2090 D0$="D"
2100 GOTO 2140
2110 D0$="E"
2120 GOTO 2140
2130 D0$="F"
2140 RETURN
```

Variable Map

Program: KEPCO Date: 840222

A$ - voltage command to power supply

B$ - current command to power supply

D1 - number indicating SN488 channel (1=voltage, 2=current)
D2 - number indicating SN488 range
D3 - 1st hexadecimal digit (MSD) of power supply command
D4 - 2nd hexadecimal digit of power supply command
D5 - 3rd hexadecimal digit (LSD) of power supply command
D6 - amount hexadecimal number exceeds 9
D3$ - 3rd character in power supply command (MSD)
D4$ - 4th character in power supply command (2nd hexadecimal digit)
D5$ - 5th character in power supply command (LSD)
DØ$ - temporary string variable for converting hexadec digits to string variables

E1 - quotient derived during hexadecimal conversion

K1 - scaling constant for calculating power supply command

V1 - voltage limit
V2 - current limit
VØ - decimal equivalent of hexadecimal number part of power supply command

X$ - transfer string variable for calculating power supply commands

NBS-114A (REV. 2-80)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)	1. PUBLICATION OR REPORT NO. NBSIR 84-3008	2. Performing Organ. Report No.	3. Publication Date October 1984

4. TITLE AND SUBTITLE

A Calorimeter for Measuring High-Energy Optical Pulses

5. AUTHOR(S)

P. A. Simpson, E. G. Johnson, Jr., S. M. Etzel

6. PERFORMING ORGANIZATION *(If joint or other than NBS, see instructions)*

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

Newark AFB
Newark, Ohio

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)*

Two similar calorimeters for measuring laser pulses in the range 1 kJ to 15 kJ are described. The calorimeters, which are electrically calibrated, can be operated anywhere from the ultraviolet to infrared by selecting the proper materials for the volume absorber and deflecting mirror. Operation of each calorimeter is controlled by a dedicated desk-top computer. The theoretical basis for the calorimeters is given as are the constructional and operational details. The computer programs that are used are included in the appendices.

12. KEY WORDS *(Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)*

calorimeter; computer-controlled calorimeter; electrically calibrated calorimeter; high energy calorimeter; laser pulse; volume absorbing calorimeter.

13. AVAILABILITY

☒ Unlimited
☐ For Official Distribution. Do Not Release to NTIS
☐ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

14. NO. OF PRINTED PAGES

170

15. Price

$16.00