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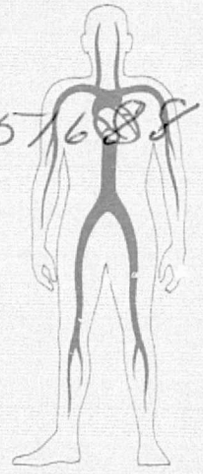

TECHNOLOGY INCORPORATED
LIFE SCIENCES DIVISION

SPECIAL REPORT

Microprocessor-Based Cardiopulmonary Monitoring System

CONTRACT NAS 9-14880

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058

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1.0 INTRODUCTION

The results of physiological investigations during the Gemini and Apollo programs led to certain hypotheses concerning man's physiological adaptation to zero-gravity. Investigation of some of these hypotheses required measurement of pulmonary blood flow (cardiac output) during exercise and parameters describing compartmental volumes of the lung obtained by standard pulmonary function tests. These investigations were conducted pre- and post-flight during the Skylab program. The results of these investigations indicated a need for monitoring the time course of observed changes after insertion to zero-gravity.

In the previous Spacelab simulations, experiments demonstrating potential Shuttle experiments investigating pulmonary blood flow and pulmonary function were proposed, implemented, and conducted. Valuable knowledge about procedures, time-lines, requirements documentation, and other facets of implementing a Spacelab experiment was gained, in addition to demonstrating the scientific value of the experiment.

2.0 EXPERIMENT DESIGN

After the previous simulation, the crew members offered several suggestions for improving operations of the experiment hardware. In the experiment system, data were acquired and analyzed by a dedicated, general purpose minicomputer, and the flow of the computer software was controlled through a standard computer terminal. As a result, it was necessary for the crew members to learn to operate the

computer in addition to learning to perform the experiment. This increased the training required and potential sources of experiment problems.

In addition, the system, as implemented in the previous simulation, was not representative of hardware that will be flown on Shuttle. First, the monitor system was large (1 1/3 racks) and required substantial power (1000 watts). Second, all data were stored on mass storage devices in the experiment system; no interface to an onboard data system was included.

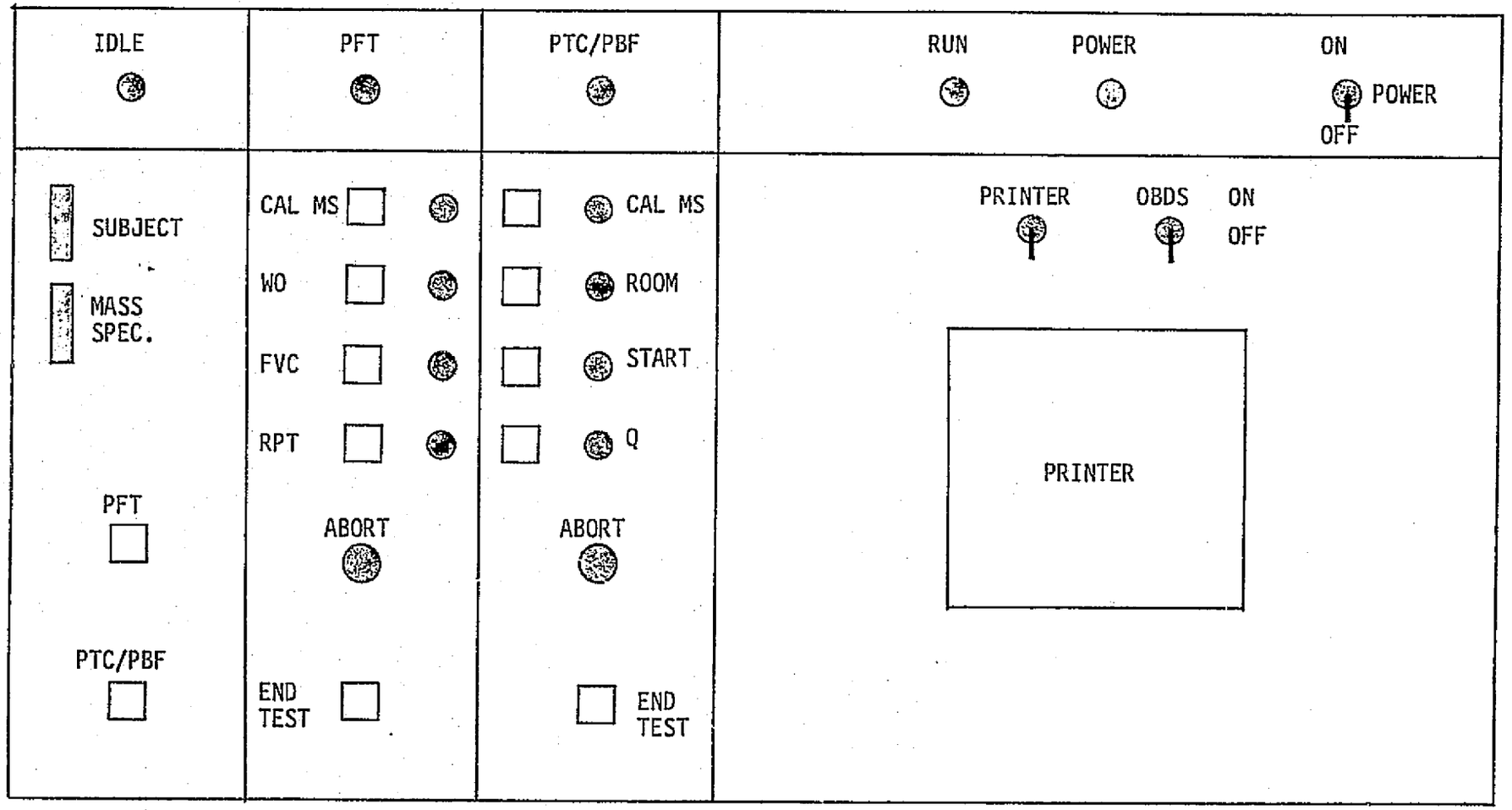
The experiment system has been totally redesigned. Instead of using a general purpose minicomputer for transducer control and data acquisition, analysis and storage, the system uses a dedicated microprocessor for transducer control and data acquisition and analysis. No data will be stored in this system, but the data will be transmitted to the on-board data system. In comparison, the data system will require approximately 12 inches of rack space versus 1 1/3 racks, and will consume only 100 watts versus 1000 watts of power. The computer console and terminal have been replaced by an experiment specific control panel. This control panel, through a series of lighted buttons, will guide the operator through the test series providing a smaller margin of error.

It was the purpose of this OTR to evaluate different aspects of this new system. The experimental validity of the system was verified, and the reproducibility of data and reliability of the system checked. In addition, improvements in ease of training, ease of operator interaction, and crew acceptance were evaluated in actual flight conditions.

To minimize subject interaction with the hardware and thus minimize both time expended and possible operator error, an experiment-specific control panel has replaced the standard computer console.

The experiment control panel (Figure-1) uses a series of step-monitor lamps and lighted pushbuttons to guide the subject through the test. The panel is separated into four modules (from left to right, front view): Module 1-Initialization, Module 2-Pulmonary Function Test (PFT), Module 3-Physiological Time Constants/ Pulmonary Blood Flow (PTC/PBF) and Module 4-Output. The Initialization Module provides subject and mass spectrometer identification and test selection (PFT or PTC/PBF). The PFT module guides the subject through Nitrogen Washout and Forced Vital Capacity Maneuvers. The PTC/PBF module controls an exercise protocol which includes cardiac output maneuvers (also cued by panel lights). The output module includes the controls for selection of the output devices (printer, video, and/or on-board data system). Computer controlled software illuminates the pushbuttons to cue the next step and then after the button is depressed, lights the corresponding green light to indicate the process currently taking place.

Program execution starts with the initialization of all signals on the I/O Bus and the lighting of the IDLE light and the two buttons within Module 1 on the control panel. The subject selects the desired output device(s) in Module 4, and then returns to Module 1 to enter the subject number, mass spectrometer type and the desired test



MICROPROCESSOR CONTROL PANEL
FIGURE 1

(depress either PFT or PTC/PBF). The appropriate test light at the top of Module 2 or Module 3 is lit. From this point on, pushbuttons are lit as cues to the next step and the green monitor lamps are lit to indicate the current process taking place.

The Pulmonary Function Test is started by calibrating the mass spectrometer (CALMS). If the calibration is successful, the WO button is lit; otherwise, the CALMS button is relit. After hoses have been attached between the mouthpiece/valve assembly, the oxygen supply, and the spirometer, the subject depresses the WO button. He then inspires room air and inserts the mouthpiece into his mouth. Next, he exhales slowly to residual volume (RV), inspires a vital capacity (VC) of oxygen, and again exhales slowly to RV. This initial maneuver should take 10-15 seconds. The subject continues to breathe normally with the mouthpiece retained in his mouth until the washout is complete. During the entire washout maneuver, the tidal volume and the FN_2 for each breath is displayed on the video monitor and/or the panel printer. The end point is signaled when the green WO light goes off and the yellow FVC button is lit. This end point is also indicated by watching for two consecutive $FN_2 < 3\%$ on the video monitor or the printer. Next, the washout hoses are stowed and the FVC hose is attached to the spirometer exhalation port. A cardboard tube is inserted in the hose. The FVC maneuver proceeds as follows: Depress the FVC pushbutton (its light turns off and the green monitor lamp is lit), don the noseclamp, inspire maximally to total lung capacity, place the mouthpiece in mouth, and exhale as rapidly as possible to RV. At

this point, the RPT button is lit indicating completion of the FVC maneuver. The subject now depresses the RPT button to display the PFT results on the printer and/or video monitor. The test is complete when the printout is finished and the END TEST button is lit. If the subject wishes to repeat any of the maneuvers, he pushes the desired button and proceeds from that point (this also holds true at any other point during the test when a button is lit). Depressing the END TEST button returns control to Module 1 and the system awaits further subject action (depressing PFT or PTC/PBF button).

The Pulmonary Blood Flow Test also starts out by calibrating the mass spectrometer (CALMS). If the calibration is successful, the ROOM button is lit; otherwise, the light is relit requesting a re-cal. The subject then attached a flexible hose between the spirometer and the mouthpiece. The mass spectrometer capillary is exposed to ambient air while the ROOM button is depressed. Successful sampling of room air is indicated when the START button becomes lit; otherwise, repeat the ROOM air sampling procedure. Next, insert the capillary into the mouthpiece. Verify that the subject has donned the ECG electrodes and the blood pressure cuff. Insert mouthpiece assembly into mouth, don noseclamp and depress the START pushbutton. Breathe normally until the computer requests a cardiac output maneuver (that is, when the Q pushbutton is lit). When the Q pushbutton is lit, the computer expects to see a single breath maneuver within the subsequent minute. To perform a cardiac output maneuver, the subject inspires a slightly larger than normal breath of air, depresses the Q pushbutton, then exhales fully but slowly at a constant flow rate.

If the initial maneuver is thought to be unsatisfactory, the subject may repeat the procedure anytime within that minute after depressing the Q pushbutton again. The test is terminated when the END TEST pushbutton is lit upon completion of the five-minute protocol. During the test, data are output to the video monitor and/or printer every minute.

3.0 PHYSIOLOGICAL PROCEDURES

Initial investigations concerning man's response to weightlessness required the measurements of pulmonary blood flow during exercise and parameters describing compartmental volumes of the lung obtained by standard pulmonary function tests. These investigations were conducted pre- and post-flight during the last three Apollo flights, and during the Skylab program.

The three experiments (pulmonary function, pulmonary blood flow, and physiological time constants) supported by this data system, have been conducted in a laboratory environment, previous SMS tests, or both. A similar complement of transducers is used to monitor totally different parameters. This common use of equipment allowed all three experiments to share the data system, transducers, and software device handlers, with only the control and analysis software being unique for each experiment. The only resulting restriction is that certain experiments are not able to function concurrently. The two experiments that can function concurrently, pulmonary blood flow and physiological time constants, monitor the same parameters, but differ in normalization times and reporting time intervals.

3.1 Pulmonary Function Test

This particular pulmonary function test represents a logical extension of knowledge gained during Skylab investigations which included: in-flight vital capacity measurements, and measurement of maximum sustained minute ventilation (maximum exercise testing) together with the evaluation of ventilatory equivalents ($\dot{V}_E/\dot{V}_{O_2}$) during rest and exercise.

Although these measurements permitted only gross evaluation of pulmonary function, they were sufficient to show that man can endure 3 months exposure to zero-g without serious pulmonary impairment. However, this exposure included a daily regimen of strenuous physical exercise. An approximate 10% decrease in vital capacity was observed although the crewmen were able to sustain exceptionally high maximum ventilatory rates. These high ventilatory rates were possible because of the 3.47×10^3 N/m^2 (5 psia) ambient pressure. (Life Sciences SMS II, 1977).

The integrity and proper function of the body require adequate oxygen delivery to and carbon dioxide removal from the body tissues. Thus, the primary function of the pulmonary system is to arterialize mixed venous blood through elimination of carbon dioxide and addition of oxygen. This is achieved by ventilation which, in turn, is a function of tidal volume, respiratory frequency, and intrapulmonary distribution of the respired air. Superimposed upon these gaseous factors are the quantity and distribution of pulmonary blood flow. It is believed that the measurements proposed herein comprise the minimum number necessary to quantitate pulmonary function in zero-g, thereby providing data to support the contention that man could be qualified for space flights of long duration.

A simple, useful test of pulmonary function is the measurement of a single forced expiration. The subject inspires maximally and then exhales as hard and completely as he can. The volume exhaled in the first second is called the forced expiratory volume or $FEV_{1.0}$, and the total volume exhaled is the forced vital capacity or FVC. The mean

flow rate occurring between 0.2 and 1.2 L of the expired gas volume is the maximum expiratory flow rate or MEFR. The rate of air flow during forced expiration in a healthy young man is initially very rapid, though there is considerable slowing at the end-expiration. A marked reduction in flow rates indicates that a mechanical problem exists which may be present during expiration or inspiration, or both. The maximal flow is limited by the rate at which the muscles are able to transform chemical energy into mechanical energy and also by a rising flow resistance. Thus, the flow rates are reduced in persons who have any airway obstructions (Comroe, 1970).

In the curve generated by the FVC data (volume vs. time), the initial and terminal portions are relatively variable due to non-broncho-pulmonary factors present during these phases of expiratory effort. The terminal phase involves neuromuscular factors, such as maintenance and coordination of effort. The initial phase not only involves neuromuscular factors, but also mechanical equipment factors as well, such as inertial distortion. The measurement of maximum midexpiratory flow rate or MMFR, avoids both initial and terminal phases of the expiratory effort. Although MMFR is slightly less reproducible than other commonly used measurements of ventilatory capacity, its sensitivity more than makes up for this disadvantage.

The forced vital capacity, forced expired volume, and expiratory flow rates are relatively easy to measure using simple spirometry methods. Since there is always a residual volume in the lungs that cannot be expelled by maximal expiration, this volume must be measured

Measurement	Definition
Forced Vital Capacity (FVC)	The maximum volume of air that can be exhaled in the smallest possible time.
Forced Expired Volume - 1 sec. (FEV1)	The maximum volume of air that can be exhaled in 1 second.
Maximum Expiratory Flow Rate (MEFR)	The mean flow rate between 0.2 liters and 1.2 liters of the forced vital capacity maneuver.
Maximum Midexpiratory Flow Rate (MMFR)	The mean flow rate for the middle half (0.25*FVC to 0.75*FVC) of the forced vital capacity maneuver.

PARAMETERS DERIVED FROM FORCED VITAL CAPACITY (FVC) MANEUVER

TABLE I

Measurement	Definition
Residual Volume (RV)	The volume of air remaining in the lungs after a complete exhalation.
N_2 Delta	The change in nitrogen concentration (%) between 0.35*VC liters and 0.65*VC BTPS liters of the first exhalation after the first inhalation of 100% oxygen. This is the slope of the alveolar plateau of the so-called single-breath washout test.
Closing Volume (CV)	The volume of air displaced from the apices following airway collapse at bases near the end of a full exhalation to RV.
VA/RV	The amount of alveolar oxygen ventilation required to washout one liter of residual volume from the lungs.
Vital Capacity (VC)	The maximum volume of air than can be exhaled starting from full inspiration.

PARAMETERS DERIVED FROM NITROGEN WASHOUT MANEUVER

TABLE II

indirectly.

Traditionally, the single breath maneuver for measuring vital capacity (VC) and the nitrogen washout maneuver for measuring residual volume are performed as two separate maneuvers. To minimize subject interaction with the hardware and thus minimize both time expended and possible operator error, these measurements were integrated so that only two subject activities were required during the maneuver. The first required the subject to don a noseclip, place the mouthpiece of a respiratory valve assembly in his mouth, and exhale completely to a residual volume (RV). The subject then took a full inspiration of oxygen (inspiratory vital capacity) and following that he again exhaled (at a low flow rate) completely to RV. After this initial activity, the subject continued to breathe normally through the mouthpiece until his end-tidal nitrogen level was below 3% on two consecutive breaths (approximately 3 minutes).

The second activity requires the subject to perform a maximum flow/volume inhalation and exhalation. Total test time was reduced by combining both procedures.

The open-circuit or nitrogen washout method involves the inspiration of pure oxygen and expiration into a spirometer. If the subject has been breathing air, the gas remaining in his lungs is 78% nitrogen. As he begins to breath the pure oxygen, it will mix with the gas still in his lungs and a certain amount of nitrogen will "washout" with each breath. By measuring the amount of nitrogen in each expired breath, a washout curve is obtained from which the volume of air in the lungs

initially can readily be calculated. The initial alveolar nitrogen concentration is the maximum nitrogen fraction (FN_{2_I}) recorded during the first expiration (before inspiring pure oxygen). The alveolar nitrogen concentration after washout is the maximum FN_{2_F} recorded during the final expiration. Using these alveolar concentrations and the total volume of nitrogen exhaled, the functional residual capacity (FRC) can be determined using the equation:

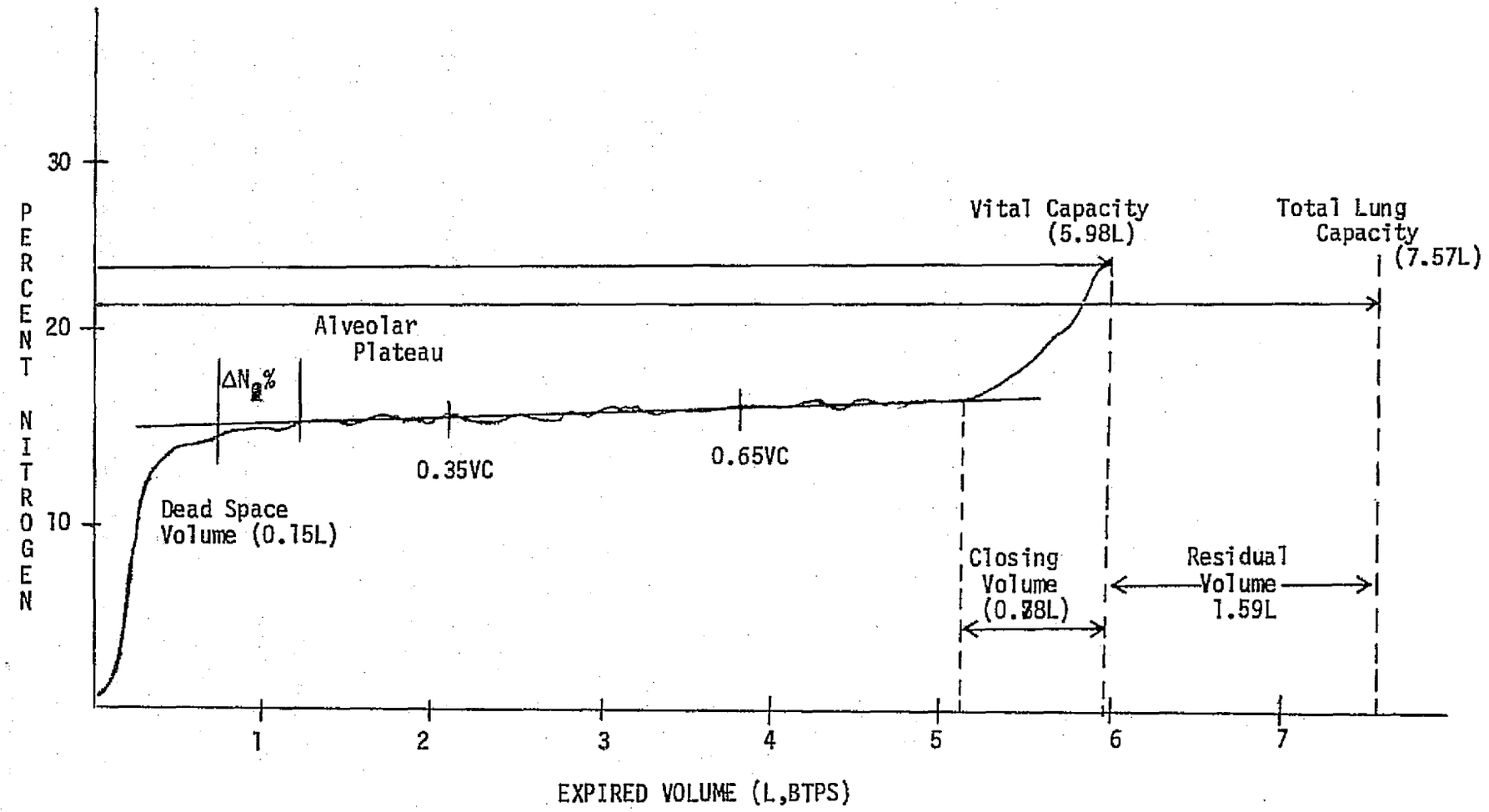
$$FRC = \frac{N_2 \text{ Volume Exhaled} - 0.0312T}{\text{Max. } FN_{2I} - \text{Max. } FN_{2F}}$$

The 0.0312T, a traditional correction factor based on subject body surface area and the time of washout, represents the amount of nitrogen washed out of the blood and tissues. Since the FRC is the volume of gas remaining in the lungs at the end expiratory level, the difference between the the FRC and the amount of anatomical dead space in the lungs (approximately 0.02 liters) is the residual volume. The residual volume represents the air that cannot be removed from the lungs even by forceful expiration. This is important because it provides air in the alveoli to aerate the blood even between breaths.

After the residual volume is computed, the VA/RV ratio is computed by dividing the total volume of gas exhaled by the residual volume. This ratio represents the amount of alveolar oxygen ventilation required to washout one liter of residual volume from the lungs.

Using the single-breath portion of the data,(Figure 2), the maximum volume recorded during the exhalation is stored as the vital capacity (VC),

NITROGEN WASHOUT, SINGLE BREATH MANEUVER
FIGURE 2



that is, the maximum volume of air (in liters, BTPS) that can be exhaled starting from full inspiration.

Following a single inspiration of 100% O_2 , the N_2 concentration rises as the dead space gas is increasingly washed out by alveolar gas (Figure 2). Finally, an almost uniform gas concentration is seen representing pure alveolar gas. This phase is often called the alveolar plateau. The slope of the alveolar plateau can be computed using the volume/nitrogen concentration pairs from the single breath maneuver. The data pairs (volume, FN_2) corresponding to 0.35*VC and 0.65*VC are used in a linear regression routine to compute the best straight line expressing nitrogen fraction as a function of volume within the 0.35VC to 0.65VC interval. The slope of this line multiplied by 100 is the slope of the alveolar plateau in %/L.

Using the linear regression line from above, the closing volume can be found by searching backwards from the maximum volume through the volume/nitrogen concentration pairs until the first FN_2 less than the predicted FN_2 is found (Figure 2). The volume at this point is subtracted from the VC and stored as the volume of air displaced from the apices of the lung following airway closure at the base of the lung near the end of a full exhalation.to RV, or Closing Volume (CV).

Looking at Figure 2, the abrupt deflection of N_2 towards the end of the expiration defines the closing volume (CV). This pattern has been interpreted by the following sequence of events. When starting the maneuver from maximal expiration, a larger fraction of the RV is contained in the upper parts of the lung than in the dependent regions. During

the succeeding inspiration of O_2, the N_2 in the lower lobes becomes more diluted than in the upper ones. During the following slow expiration the upper and lower regions both contribute to the alveolar plateau but toward the end of expiration, some of the airways in the dependent zone collapse due to compression and reduce the contribution with low N_2 to the expirate. At this point the contribution from the upper regions with high N_2 predominates, producing the upward deflection of N_2. The closing volume increases when the elastic recoil of the lungs and/or the caliber of the smaller airways are reduced. So far, knowledge of the CV seems to be particularly helpful for detecting early pathologic conditions in the airways. It might also be useful in the evaluation of more advanced stages of pulmonary disease with respect to progression or regression of the disorder or the effects of therapeutic measures. To date, there are relatively few reports concerning the CV phenomenon and its relation to other tests of pulmonary function. (Lovelace, 1975).

Once the forced vital capacity maneuver and the nitrogen washout maneuver have been completed, the resulting data are combined to produce a set of secondary pulmonary function data (Table III).

The total lung capacity (TLC) is the total volume of the lungs at full inspiration and can be computed as the sum of the residual volume (RV) and the vital capacity (VC).

Four ratios are then determined from the combined data. The first is the percent of forced vital capacity (FVC) that can be expired in one second ($FEV_{1.0}$/FVC). In restrictive diseases (ex. pulmonary fibrosis), both FEV and FVC are reduced but characteristically the $FEV_{1.0}$/FVC % is

Measurements	Description
Total Lung Capacity (TLC) (TLC=RV+VC)	The total volume of the lungs at full inspiration.
FEV1/FVC%	The percent of forced vital capacity that can be exhaled in one second.
FVC/VC%	The ratio of forced vital capacity to vital capacity expressed as a percentage.
CV/VC%	The ratio of closing volume to vital capacity expressed as a percentage.
CC/TLC%	The ratio of the sum of residual volume and closing volume to total lung capacity expressed as a percentage.

PARAMETERS DERIVED FROM COMBINED FORCED VITAL CAPACITY AND NITROGEN WASHOUT MANEUVERS

TABLE III

normal or increased. In obstructive diseases (ex. bronchial asthma), the $FEV_{1.0}$ is reduced more than the FVC giving a low $FEV_{1.0}$/FVC %. (West, 1974).

The third ratio is the ratio of the closing volume to vital capacity expressed as a percentage. Normal CV in young normal adults is about 10% of the VC. The CV increases with age and, usually by the age of 65 years, it is equal to 40% of the VC (West, 1974).

The final ratio is the sum of the residual volume and the closing volume, divided by the total lung capacity.

The data system for this experiment (PFT) interfaces with the on-board-data-system and transmits certain data to it. These data include the parameters in Tables I, II, and III. In addition, the sampled data for the single-breath portion of the washout and the sampled data for the FVC maneuver is transmitted to "ground" and recorded for "ground" processing ("ground" is referring to the earth, as in transmission from the spacecraft to the "ground").

3.2 Physiological Time Constants/Pulmonary Blood Flow (PTC/PBF)

Significant changes in the astronauts' cardiovascular and cardiopulmonary systems as a result of exposure to the zero-g environment of space have been observed during the Apollo and Skylab programs. Tests on Skylab astronauts revealed significant reductions in blood flow and stroke volume in the immediate post-flight period. Steady state heart rates obtained during exercise stress tests were elevated. Systolic time intervals were significantly altered. These parameters returned to

preflight values within two weeks after the flight.(Buderer, 1976). All of these parameters were obtained during steady state conditions. It was hypothesized that these changes were associated with the replenishment of blood volume lost during the period of weightless exposure. This blood loss is presumed to occur as a result of a cephalad shift in blood volume accompanying entry in to the zero-g environment. (Life Sciences SMS II, 1977). Thus, in zero-g, blood tends to be shifted from the lower extremities and abdomen toward the thorax and the head.

It has been postulated that the increased thoracic or "central" blood volume encountered in zero-g will produce at least transient increases in pulmonary blood flow (cardiac output) and more uniform pulmonary perfusion. The lead times required for the Skylab medical experiments did not allow for the inclusion of the in-flight measurements of pulmonary blood flow, and thus the presence of these flow transients could not be verified. It has also been demonstrated that the time course of various cardiopulmonary parameters during exercise stress testing is related to the physical condition of the subject. The transient responses of cardiovascular parameters have never been observed on astronauts before, during, or after space flight. However, the Physiological Time Constants experiment was included in SMSII. (Life Sciences SMSII Report, 1977).

The purpose of the Pulmonary Blood Flow experiment (PBF) was to develop an experiment which would measure the time course and magnitude of changes in central blood flow and volume relationships in zero-g,as determined by measurements of pulmonary blood flow (cardiac output), as

well as to provide information on the initial effects of zero-g on peripheral circulatory function. The parameters of interest are heart rate (HR), $\dot{V}_{O_2}$, $\dot{V}_{CO_2}$, minute volume ($\dot{V}_e$), respiratory rate (RR), cardiac output ($\dot{Q}$), systolic and diastolic blood pressures (SBP and DBP).

Similarly, the purpose of the PTC experiment was to develop a method of evaluating the dynamic response of the cardiopulmonary system during exercise stress tests. The parameters of interest are heart rate (HR), oxygen consumption ($\dot{V}_{O_2}$), carbon dioxide production ($\dot{V}_{CO_2}$), and minute ventilation ($\dot{V}_e$).

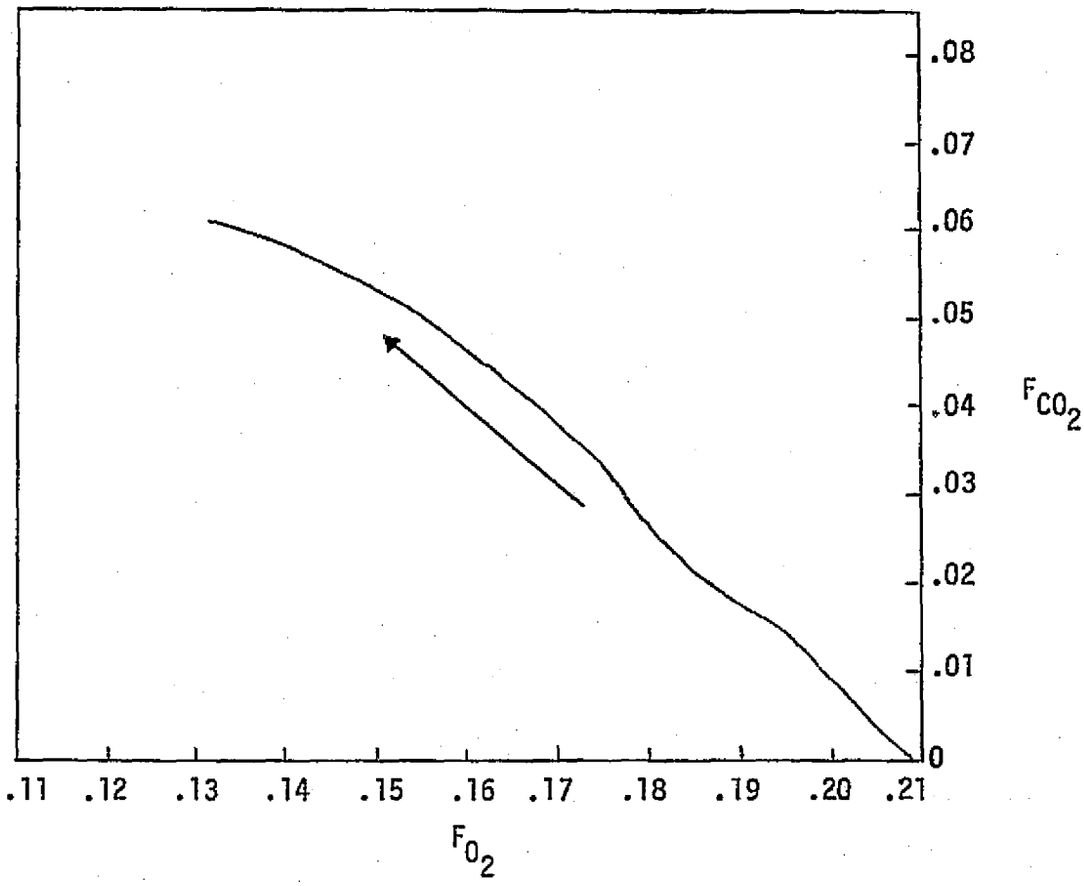
Because of the similarity of measurements, protocols, and transducers involved, these two experiments are conducted at the same time. The data requirements for both will be documented as a single set of requirements.

It is the functional objective of these two experiments to quantitate HR, workload, oxygen consumption, carbon dioxide production, minute volume, respiration rate, cardiac output, systolic blood pressure and diastolic blood pressure. Heart rate is measured by using an ECG preamplifier to identify each QRS complex of an electrocardiogram, then counting the beats over the specified interval. For PBF, this interval is for one minute; for PTC, five seconds. Workload is sampled every 5 seconds. For PBF, each minute, the corresponding twelve samples are averaged to represent the workload for that minute. For PTC, the sampled workloads are saved. Oxygen consumption, carbon dioxide production, and minute volume are calculated on a breath-by-breath basis as described later in the gas exchange calculations. For PBF, these values are summed

over the reporting interval (1 minute). For PTC, the values for each breath, and the elapsed time from the start of the test until that breath is saved. Systolic and diastolic blood pressures are determined for PBF by sampling the output of an automated blood pressure system at the end of each reporting interval.

The procedure for determining pulmonary blood flow (cardiac output) analyzes the gas concentration at the mouth during a single, prolonged exhalation. During any exhalation, the gas concentration at the mouth changes, with oxygen concentration decreasing and the carbon dioxide concentration increasing. These changes in concentrations are not linear, as shown in Figure 3.

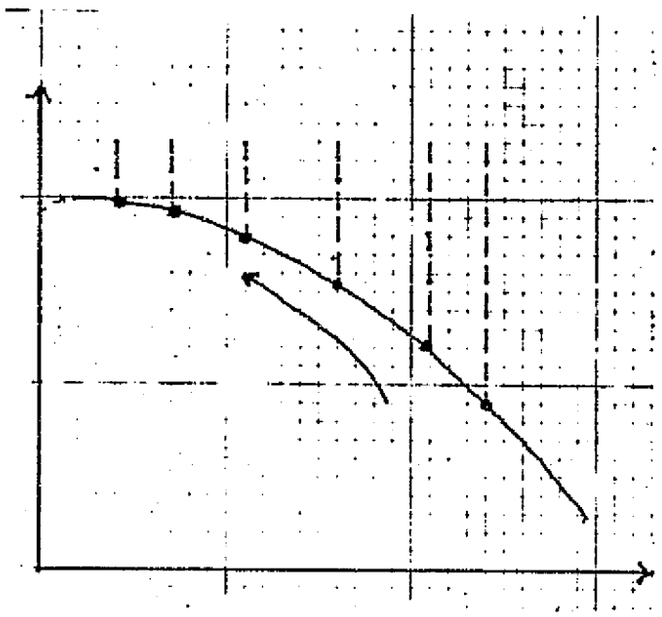
The cardiac output maneuver requires the subject to take a slightly longer than normal exhalation, depress the Q pushbutton whether mounted on the ergometer or the test control panel, and then exhale slowly at a constant flow rate. During the maneuver (next exhalation), data pairs of O_2 fraction (FO_2) and CO_2 fraction (FCO_2) representing the curve in Figure 4 are stored for further analysis. This storing of gas concentrations does not interfere with the computation of gas exchange values, but occurs in addition to these computations. Because the sampled data are used to describe the curve of FCO_2 vs. FO_2, not each of these versus time, the sampling procedure does not simply sample at a fixed frequency. Gas pairs are sampled and checked from the beginning of the exhalation to the end of the exhalation, If the FO_2, FCO_2 data pair does not meet the following restrictions, it is not stored for



Example of a single prolonged expiration plotted on the O_2 - CO_2 diagram.
(Lovelace, 1975).

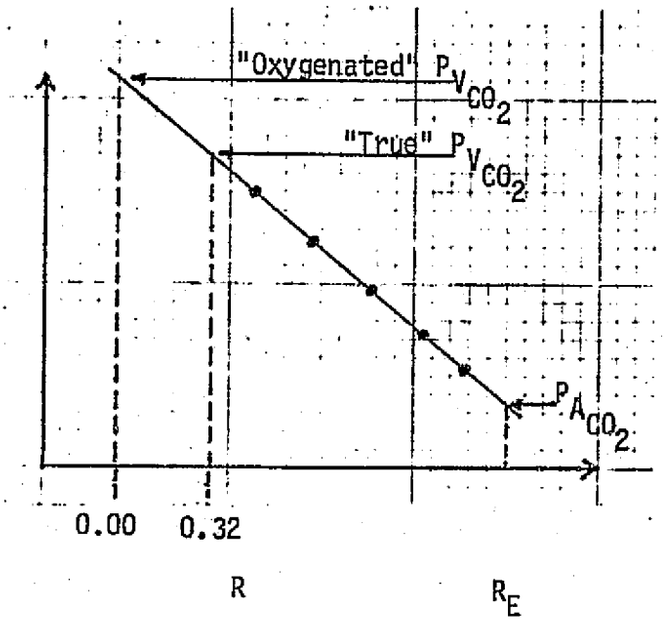
F_{O_2} vs. F_{CO_2} DURING SINGLE BREATHMMANEUVER
FOR CARDIAC OUTPUT DETERMINATION

FIGURE 3



Selection of points on the Single Breath curve to determine slope and R values.

(Lovelace, 1975)



P_{CO_2} versus R values obtained from above.

(Lovelace, 1975)

FIGURE 3 (cont'd)

use in the analysis routine:

1) The CO_2 fraction must be greater than 0.02 (2%) Data below this level is not consistent with method assumptions;

2) The O_2 fraction must be less than the previous stored O_2 fraction by at least 0.0025 (.25%).

The later criterion guarantees that the FO_2 values are monotonic, a necessary assumption for many derivative methods.

After the end of the breath, the FCO_2, FO_2 data pairs are analyzed by first finding the derivative of FCO_2 with respect to FO_2 for each pair. The analysis which has given the best results to date has been the cubic spline, described in Appendix C (Lovelace, 1973). For each point (except the end points), the instaneous inspiratory respiratory exchange quotient (R at each data pair), R_{inst}, is determined from the following formula:

$$R_{inst} = \frac{s - (s*FO_2) - FCO_2}{1 - (s*FO_2) - FCO_2}$$

where s is the negative (or absolute value) of the derivative at the sampled data pair. These R_{inst} values are then used with FCO_2 to compute a least squares linear regression of FCO_2 as a function of R_{inst}. The absolute value of the slope of this regression is stored for output and is used at the end of the reporting interval to calculate cardiac output ($\dot{Q}$) using the formula:

$$\dot{Q} = \frac{\dot{V}_{O_2} \times 1000}{4.7 \times \text{slope}} ,$$

where: $\dot{V}_{O_2}$ = oxygen consumption (liters, STPD)

slope = -1 x slope of the R_{inst} - FCO_2 regression line

4.7 = slope of the standard carbon dioxide dissociation curve (ml/liter/torr PCO_2)

$\dot{Q}$ = cardiac output (liters/minute) .

The data from the PBF experiment is printed on the panel printer and is transmitted to the on-board-data-system each minute. The data from the PTC experiment is transmitted to the on-board-data-system each minute.

3.3 Gas Exchange Calculations

The functional objective of the gas exchange calculations in this experiment is to measure the difference in the volumes of a particular gas or gases, inhaled or exhaled. The volume of a particular gas (x) inhaled or exhaled during a given time interval, is equal to the total volume inhaled or exhaled during that time interval multiplied by the fraction Fx of the gas contained in that volume.

1). $V_{IX} = F_{IX} * V_I$ (Volume inhaled)

2). $V_{EX} = F_{EX} * V_E$ (Volume exhaled).

The volume of that gas consumed by the body can be expressed as:

3). $V_X = F_{IX} * V_I - F_{EX} * V_E = V_{IX} - V_{EX}$.

The volume of that gas (x) produced by the body can be expressed as:

4). $V_X = F_{EX} * V_E - F_{IX} * V_I = V_{EX} - V_{IX}$.

Since nitrogen does not readily dissolve in the blood and referring to the steady state, it can be assumed that the volume of nitrogen inhaled equals the volume of nitrogen exhaled. Therefore, equations

1) and 2) combine to form:

$$5). \quad V_I F_{IN_2} = V_E F_{EN_2} ,$$

rearranging terms, equation 5) becomes:

$$6). \quad V_I = \frac{V_E F_{EN_2}}{F_{IN_2}} .$$

Substituting equation 6) into equation 3) and letting x represent O_2. the equation for oxygen consumption ($\dot{V}_{O_2}$) becomes:

$$\dot{V}_{O_2} = \frac{F_{IO_2} * V_E F_{EN_2}}{F_{IN_2}} - F_{EO_2} * V_E .$$

Collecting terms, the final equation for oxygen consumption becomes:

$$7). \quad \dot{V}_{O_2} = V_E * \left[\frac{F_{IO_2}}{F_{IN_2}} * F_{EN_2} - F_{EO_2} \right] ,$$

where: $\frac{F_{IO_2}}{F_{IN_2}}$ = oxygen/nitrogen ratio of inspired air obtained from ambient air measurements

V_E = volume of expired air per unit time

F_{EO_2} = oxygen fraction of expired air

F_{EN_2} = nitrogen fraction of expired air.

Substituting equation 6) into equation 4), and collecting terms, the final equation for carbon dioxide production becomes :

$$8).\ \dot{V}_{co_2} = V_E * \left[F_{ECO_2} - \frac{F_{ICO_2}}{F_{IN_2}} * F_{EN_2} \right] ,$$

where: F_{ECO_2} = expired fraction of carbon dioxide,

V_E = volume of expired air,

$\frac{F_{ICO_2}}{F_{IN_2}}$ = carbon dioxide/nitrogen ration of inspired air obtained from ambient air measurements,

F_{EN_2} = nitrogen fraction of expired air.

$\dot{V}_{O_2}$ increases linearly with the magnitude of work. As an exercising subject approaches the point of exhaustion or fatigue, his $\dot{V}_{O_2}$ will reach a maximum above which it will not increase even with furthur increases in work. This peak value is referred to as the individual's maximal oxygen uptake ($\dot{V}_{O_2}$ max,); this variable appears to be a fundamental physiological limitation for an individual.

Carbon dioxide production ($\dot{V}_{CO_2}$) is roughly the mirror image of oxygen consumption. As oxygen is burned by the active tissues, carbon dioxide is produced; as oxygen is withdrawn from the lung gases, carbon dioxide is released. The amount of carbon dioxide produced divided by the oxygen consumed is the respiratory exchange ratio, $R = \dot{V}_{CO_2}/\dot{V}_{O_2}$. Values for R vary from lows of 0.65 to about 1.0 at rest, to more than 1.5 during recovery following short-term exhaustive exercise. Elevated R values indicate that more CO_2 is being produced than O_2 is

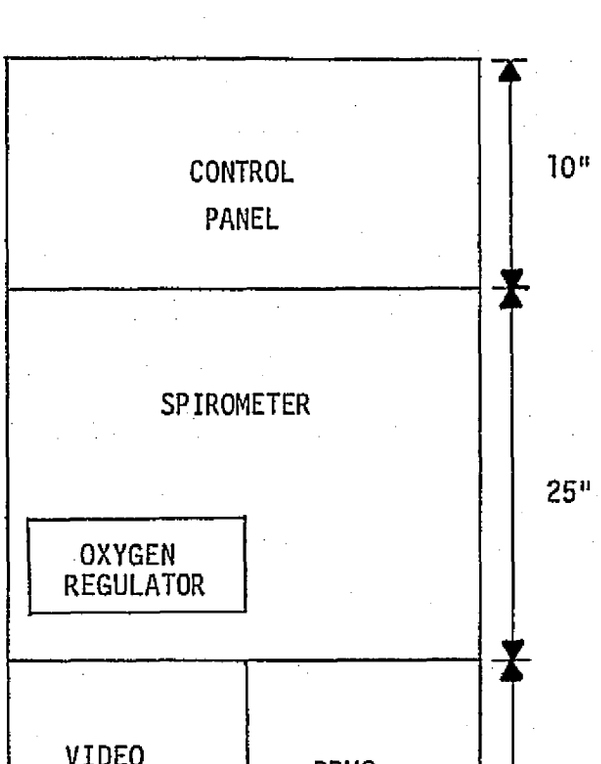
available to support metabolism. Under these conditions, an "oxygen debt" accumulates and metabolism begins to rely on anaerobic processes.

4.0 HARDWARE

The cardiopulmonary monitoring system hardware requires 36 vertical inches of rack space (Figure 4). This system includes an exhalation spirometer, oxygen demand regulator (mounted on the spirometer panel), the experiment control panel, the CPU, the blood pressure measuring system (BPMS) and the video monitor. The microprocessor (mounted behind the control panel) contains the control hardware for the equipment (A/D, printer, control panel and video monitor), and the acquisition/control hardware for the transducers (spirometer, ergometer, BPMS, MS, and ECG). The mass spectrometer (MS) (Perkin-Elmer fixed-collector, magnetic sector) is mounted in the rack adjacent to the spirometer as part of Experiment 58 (X58, West, U. C. at San Diego) and the ECG preamplifier is part of Experiment 50 (X50, Sandler, ARC).

4.1 Microprocessor

The DEC LSI-11 microcomputer is the center of this microprocessor-based system. The CPU, parallel interfaces, serial interface, A/D system, bootstrap, terminator and memory modules are mounted in a DDV11-B Backplane and H0341 card cage assembly. This mounting has room for 1 CPU board and up to 16 option modules including a terminator module. The assembly also has 18 user-defined slots for custom applications. The positioning within the rack for the OTR1 modules is in Table E1, Appendix E.



OTRI

RACK MOUNT CONFIGURATION

FIGURE 4

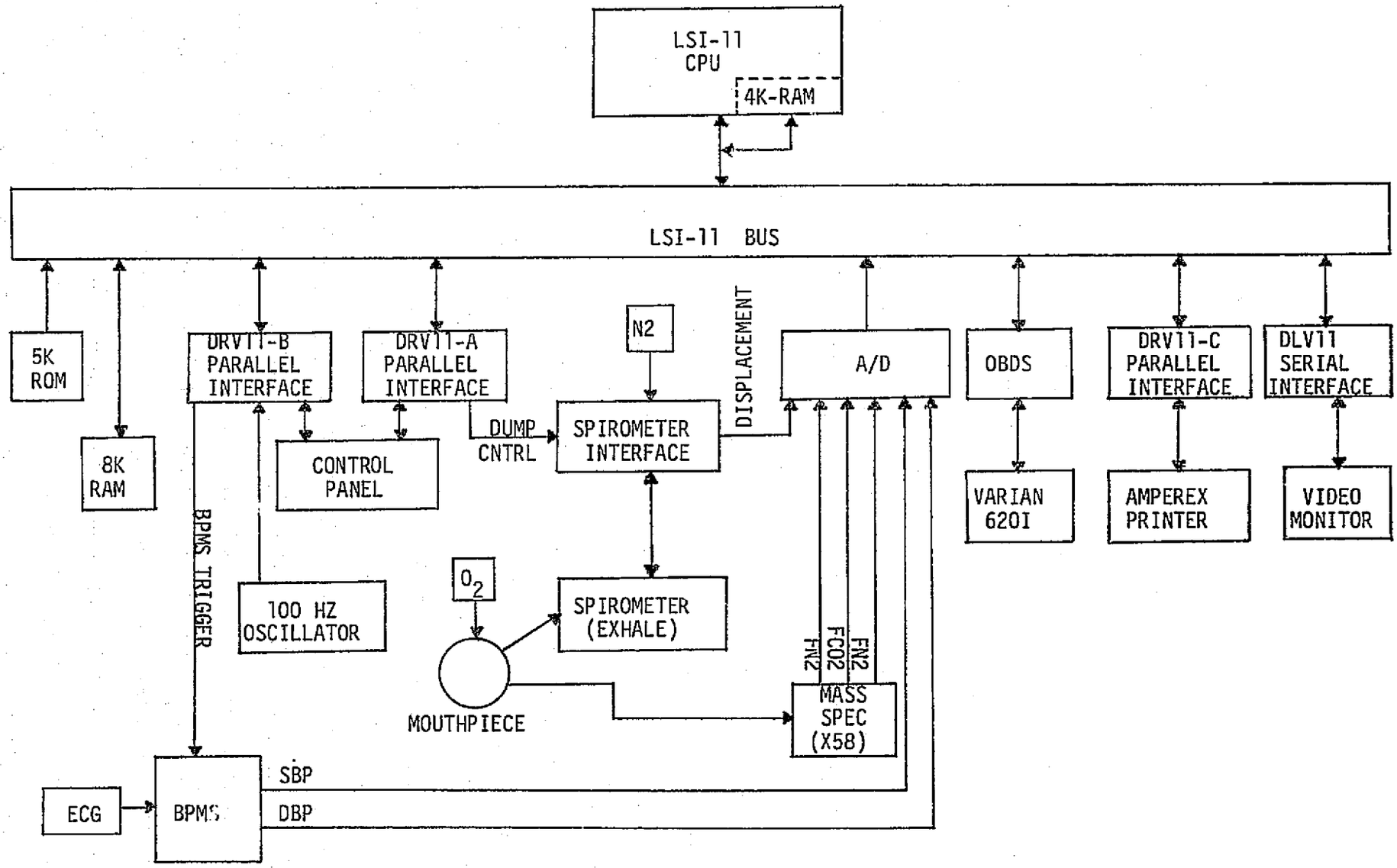


FIGURE 4a

OTRI - MICROPROCESSOR-BASED CARDIOPULMONARY MONITOR SYSTEM

4.1.1 Microprocessor Module

The LSI-11 system includes a KD11-F microcomputer (Figure D1, Appendix D). The 16-bit central processor (CPU) functions are contained in four silicon gate N-channel metal oxide semiconductor (NMOS), large-scale integration (LSI), integrated circuit chips. These chips provide all instruction, decoding, bus control, and arithmetic/logic unit (ALU) functions of the processor. The central processor contains eight general registers which can serve as accumulators, index registers, autoincrement/autodecrement registers, stack pointers, or program counters (PC=Register 7).

The KD11-F module normally requires 1.8A (+5V) and 0.8A (+12V) and operates at 400 ns based on a 10 MHZ oscillator signal. A power fail/auto restart feature provides jumper-selectable restart through a power-up vector, a defined location, or an octal debugging technique (ODT) microcode. The LSI-11 bus has a high-speed, 38-line parallel bus. Sixteen lines are used for time multiplexing of data and addresses. All data and control lines are bidirectional, asynchronous, open-collector lines capable of providing a maximum parallel data transfer rate of 833K words per second under direct memory access operation.

The KD11-F also contains a 4096-by-16 bit read/write MOS semiconductor memory. CPU resident memory can reside in either

the first or second 4K address bank. One of two jumpers can be installed on the module to select the desired bank (bank 0 or 1).

User-selectable options on the KD11-F (by the removal and insertion of jumpers) include the power-up mode, resident memory 4K address selection and memory refresh (from CPU or another device).

The power-up mode selected for the Cardiopulmonary Monitoring System, mode 0, places the processor in a microcode sequence that fetches the contents of memory locations 24 and 26 and loads their contents into the Program Counter (PC) and the Program Status Word (PS), respectively, after application of power. The program then begins execution at the address contained in location 24. This option is selected by removing jumpers W6 and W5 from the KD11-F module.

The resident memory 4K address is selected using jumpers W1 and W2. W1 installed selects Bank 1 (addre-ses 20000-37776) while W2 installed selects Bank 0 (addresses 0 - 17776). If neither jumper is installed, the 4K resident memory will not respond to any address. For OTR1, the resident memory is selected as Bank 1. This allows the use of PROM in Bank 0 to hold the vectored interrupt pairs in locations 0-376 and program code from 400-17776.

Dynamic RAM requires a memory refresh cycle. It can be controlled by the CPU (jumper W4 removed) or another device (jumper W4 installed). Refresh by the CPU is initiated once every 1.6 ms. It is the highest priority processor interrupt, and cannot be disabled

by software using the Processor Status Word (PS) bit 7. The process takes approximately 130 μs during which external interrupts are ignored. This large time requirement for memory refresh prompted a choice of the REV11-C Bootstrap, Refresh module to refresh the 2 RAM modules utilized in OTR1. The REV11-C refreshes memory using a cycle stealing process which does not disable external interrupts thereby allowing normal data interrupts to occur at user-set intervals.

4.1.2 Microprocessor-Parallel Line Unit (PLU)

The DRV11 parallel line unit (PLU) is a general-purpose device interface module that connects parallel I/O devices to the LSI-11 bus. This unit features: 16 diode-clamped data input lines, 16 latched output lines, 16-bit word or 8-bit byte program-controlled data transfer rate of 90K words per second (max.), user-assigned device address decoding and LSI-11 bus interface and control logic for interrupt processing generation.

The control/status register (CSR) and the data registers of the PLU are compatible with PDP-11 routines. Addresses for the DRV11 can range from 16000 through $17777X_8$. The least significant three bits address the desired DRV11 register as follows:

Address	Device Register
167760	DRCSR
167762	DROUTBUF
167764	DRINBUF

Addresses 177560-177566 are reserved for the console device and should not be used for DRV11 addressing.

Two interrupt vectors are jumper selectable in the range of 0 through $37X_8$. The least significant three bits identify the interrupting function:

000300	Interrupt A
000304	Interrupt B

A complete list of devices in this system and their corresponding mnemonics and addresses can be found in Table E2, Appendix E.

4.1.3 Microprocessor - Serial Line Unit (SLU)

The DLV11 serial line unit (SLU) is a general-purpose device interface module that connects asynchronous serial I/O devices to the LSI-11 bus. This unit features: either an optically isolated 20 mA current loop or an EIA interface selected by using the appropriate interface cable option, selectable crystal-controlled baud rates (50-9600 baud), and LSI-11 bus interface and control logic for interrupt processing and vector generation.

The control/status register and data registers are compatible with PDP-11 software routines and can be directly accessed via processor instructions. The least significant three bits address the desired DLV11 register as follows:

Address	Device Register
177760	RCSR address
177762	Receive data register address

177764	XCSR address
177766	Transmit data register address

Appendix E contains a complete list of devices in this system and their corresponding mnemonics and addresses. The diagram in Figure 3 shows the peripheral connections with the various DRV11's and DLV11's.

4.1.4 Microprocessor - Read-Only-Memory Module (ROM)

The MRV11-AA is a read-only memory (ROM) module that allows the use of user-supplied, preprogrammable read-only memory (PROM) and masked ROM chips in a compact, nonvolatile memory subsystem. Depending on chip type, the module's capacity is either 4096 16-bit words or 2048 16-bit words, using 512 by 4-bit or 256 by 4-bit chips, respectively. The 4K bank address is set using jumpers on the board.

The cardiopulmonary monitoring system (OTR1) required 6K of ROM. The data was programmed on 48 Signetics 82S131 bipolar fusible-link (512 by 4-bit) PROMs with the first 32 chips forming 0-4K and the next 16 forming 8-10K. The QJV11 Prom Formatter Program, from DEC, was used to punch the binary paper tapes; which were then used as input to a DATA I/O Model V ROM programmer, to burn the data into the chips.

4.1.5 Microprocessor - A/D Converter

The ADAC Model 600-LSI-11 Data Acquisition and Control System, manufactured by the ADAC Corporation in Hicksville, N.Y, fits directly into the backplane of the DEC LSI-11 minicomputer. The

module is built on an 8 1/2"x10" printed circuit board and contains:

- a 32 channel analog input multiplexor;
- a programmable gain amplifier with automatic zeroing;
- a differential input and amplifier;
- a high speed sample and hold amplifier;
- a high speed 12-bit analog to digital converter;
- 2 digital to analog converters, with the bus interface.

The ADAC 600 uses the +5 volts from the backplane to power its logic as well as to power a self-contained DC to DC converter which supplies +15 volts and -15 volts to the analog circuitry mounted on the board. This unit requires +5V, ±5% @ 2.5 amps for normal operation.

A flat shielded ribbon cable assembly is attached to the end of the board opposite the I/O bus connector to bring the analog signals into and out of the computer. The cable is attached to a terminal strip mounted along side the LSI-11 chassis (Table D2, Appendix D).

4.1.6 Microprocessor - Power-up and Oscillator Circuit (Appendix D)

The power-status signal BPOK H on the LSI-11 backplane must be asserted or negated in a particular sequence as dc operating power is applied or removed. Initially BPOK H is passive (low). As dc voltages rise to operating levels BINIT L is asserted by the processor module. Approximately 3 ms (minimum) after +5V and +12V power are normal, an external signal source produces an active BDCOK H signal; the processor responds by negating BINIT L, and waits for BPOK H. The BPOK H signal, produced by the external circuit in (Figure D3, Appendix D), goes true (high) 70 ms (min.) after BDCOK H goes high. The processor responds by executing the user-selected power-up routine.

The center of the power up circuit is a 555 timer which is a highly stable device for generating accurate time delays or oscillations. At 0.11 seconds (RC constant = 0.005μFd * 22MΩ = .11 secs) after power is turned on, BPOK H is pulled low for 2.2 secs. (RC constant = 0.1μFd * 22MΩ = 2.2 secs) after which it goes high causing processor power up.

The timer circuit (Figure D4, Appendix D) provides the 100 Hz signal which is used as the general interrupt frequency for data collection during actual program execution. The 10 KHZ crystal is set up as a dead short at 10KHZ and an open circuit at any other frequency. It serves to stabilize the oscillator output (555 timer) at pin 3, eliminating a 5% (max.) drift. The 10KHZ output of the timer is then divided by 100 (using 2 SN7490's in a divide-by-10 configuration) and passes through a SN7404 inverter (to remove the notch) to provide a clean 100 HZ signal.

4.1.7 Microprocessor - Interrupt Acknowledge

The interrupt acknowledge board is a DRV11 that has been modified to acknowledge any unanswered interrupt. A recurring problem was the generation of unanswered interrupts by an undebounced pushbutton interrupt. The LSI-11 bus latched onto the interrupt, but by the time the processor went to acknowledge it, the request disappeared.

This malady had its source within the DEC circuit in the DRV11 Select and Acknowledge section (Figure D5, Appendix D). The request line is also input to the interrupt acknowledge

flip-flop; thereby causing the interrupt acknowledge signal to go passive (low) upon removal of the interrupt request (caused by the pushbutton bouncing).

The solution was to modify a DRV11 by removing the acknowledge flip-flop and tying the interrupt acknowledge signal high. The board was then mounted as the last device on the LSI-11 bus, above the terminator (TEV11). Any unanswered interrupt would be answered by this board, preventing the processor from entering the halt mode.

4.2 Control Panel

The control panel was designed specifically for this set of experiments. The series of 12 lighted pushbuttons, 13 green LED indicators, 2 BCD Thumbwheel switches, and 3 two-position toggle switches are connected to the LSI-11 and OTR1 software via 2 parallel interface modules (DRV11A and DRV11B). The data bit assignments for the two modules are in Tables E6 and E7 in Appendix E. The wiring lists and a labeled diagram that shows the control panel with each light and button labeled to correspond to the wiring diagram are in Tables D6, D7, and D8, Appendix D.

The panel itself is made from 3/8" thick aluminum alloy and measures 10 ½" by 19". All buttons, indicators, and switches are connected to a connector on the back of the panel. The 4 cables from the DRV11's are joined in a connector that plugs directly into the back of the panel. This allows for quick disconnect of the panel from the rack and the data system.

The lights and switches are controlled by the DRV11's and the user software. To turn a light on, either indicator or pushbutton, the corresponding bit is cleared ('0'); to turn it off, the corresponding bit is set ('1'). The reverse is true for the pushbuttons, a '1' indicates depression of the button and a '0' indicates no depression of the button. Further discussion of the subject is treated in the software section of this document.

4.3 Panel Printer

The Amperex mosaic printer, type 60SA, is capable of printing all characters that can be formed within a 7x5 dot matrix; i.e., 5 vertical columns of 7 dots. The type 60SA prints directly onto a self-acting paper and uses a paper-roll of standard width (60 mm). A character module (CM64), containing the character generation circuit and printer head drive, controls the printer and has a total capacity of 64 alpha-numeric characters. The character module selects and drives the proper solenoids required to print the character presented by the 6 bit ASCII code at the input. Data input selection and character printing is performed serially; the character is immediately printed after the input selection is completed. The logic voltages used in the module for input and output are compatible to DTL and TTL integrated circuit levels.

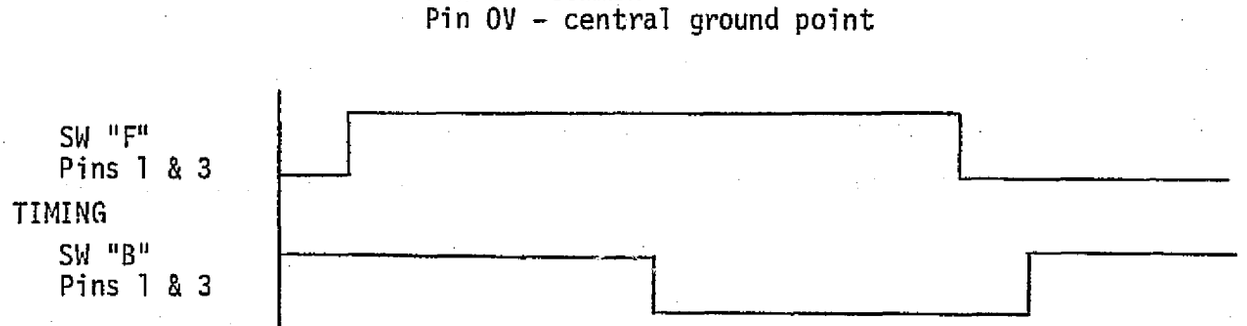
There are four connectors on a printer circuit (P.C.) board on the rear of the printer. The functions of these connectors are as follows:

Connector A - Pin 1 and 2 - 24 VAC 60HZ input
Pin 3 and 4 - paper feed control

Connector B - Switch B (Figure D11, Appendix D)
Pin 1 - normally open
Pin 2 - normally closed
Pin 3 - common

Connector C - Pin 3 and 4 - start printer signal contact input

Connector F - Start printer signal (Figure D11, Appendix D)
Pin 1 - normally open
Pin 2 - normally closed
Pin 3 - common
Pin OV - central ground point



Panel Printer Timing
Figure 5

The CM64 requires the information for the characters to be supplied in serial form. The data interface (Figures D11 and D12, Appendix D) was designed by Jim Brakefield, a Technology, Inc. engineer, to insure data integrity between the LSI-11 parallel interface and the Amperex printer. One output line from the interface to a solenoid starts the printer carriage moving. Since the printer only handles ASCII characters, all control characters and other unprintable characters are handled by hardware.

The printer is designed to interrupt the controlling hardware (LSI-11) in three cases:

1) The printer needs a new character;

2) After the carriage starts moving and has reached the correct speed;

3) The carriage has returned to the beginning of the line.

Seven output lines (OUT6-OUT0) are used in the parallel interface (DRV11) - From the LSI-11) for transmission of the ASCII character. Digital line OUT5 is used for the signal to start the carriage moving. The input line, IN15 is used as a NEW LINE READY signal to distinguish between cases 1) and 3) above.

4.4 Physiological Instrumentation

The gas analyzers used for this experiment are magnetic sector, fixed collector mass spectrometers with four outputs. Of these four, three are to be used in this experiment (nitrogen, oxygen and carbon dioxide). The Space Physiology Branch at NASA/JSC has three different mass spectrometers, each of which operates on the same principles, with the same general characteristics and software requirements, but with different output ranges and slightly different considerations. The control panel has a thumbwheel switch to select which mass spectrometer is to be used and shall automatically choose appropriate constants, ranges and scale factors to accommodate any one of the three.

4.4.1 Mass Spectrometer

In all of the mass spectrometers, the output voltage for a particular channel (gas x) is proportional to the partial pressure (Px) of the gas admitted to the capillary. In addition, for these experiments, the effects of other gases in the atmosphere are ignored. Since the sum of the partial pressures of the components

of a gas mixture is the pressure of the mixture for these analyses, this total pressure is barometric pressure (PB) and the following equation holds:

$$PB = PCO_2 + PN_2 + PO_2$$

Since the output voltages for each channel are proportional to the partial pressure of a gas (x), partial pressure can be computed from:

$$Px = GxVx$$

where Gx is a gain factor. Both the barometric pressure and the pressure drop across the mass spectrometer capillary change, so partial pressures are not used in gas exchange calculations. The fraction of a gas in a mixture can be determined by dividing the partial pressure of that gas by the total pressure:

$$Fx = \frac{Px}{PO_2+PN_2+PCO_2}$$

To determine the gas composition at any one time, all three gases should be sampled, and the partial pressures computed. These partial pressures should then be used to determine the gas fractions. Because a change in inlet pressure will affect each gas partial pressure proportionately, it will not affect the gas fractions.

4.4.2 Spirometer

The rolling-seal exhalation spirometer (7 liter capacity), used for measuring the volume of gas exhaled during a single breath, is the same type used in Skylab Experiment M171 (Metabolic Activity). As the piston is displaced, it turns a potentiometer excited by a constant DC Voltage (10V$\pm$.05V),and produces an output voltage

proportional to piston displacement and hence the volume of gas contained in the spirometer. An electrically controlled, gas-actuated valve opens the piston chambers to ambient, and allows the spring loaded piston to dump its contents whenever the valve is opened (Figure D9, Appendix D).

Because the spirometer is an extremely stable transducer, no provision for calibrating the spirometer need be made in the system software. Known volumes can be pumped into the spirometer, and the output voltage measured. A single conversion factor (liters/A-D converter count) can then be calculated and included in the software (Appendix B). For any volume greater than approximately 0.09 liters, multiplication of the A-D converter output by this floating point conversion factor will yield the volume of gas contained in the spirometer in liters ATP. Because of dead space within the spirometer, approximately 80 cc. of air must be introduced into the piston chamber before the piston will move. As a result, any sample of the spirometer signal which indicates a volume of less than 0.100 - 0.110 liters should be assumed to indicate no piston displacement, or zero volume contained in the spirometer.

4.4.3 ECG Preamplifier

The ECG preamplifier sends out a pulse each time a QRS complex is detected. This pulse is passed through a buffer circuit (Figure D10, Appendix D) in the Blood Pressure Measuring System

which in turn passes the pulse through the REQB interrupt signal on the DRV11-B on the control panel. The number of interrupts generated each minute is counted to yield heart rate in beats per minute.

5.0 SOFTWARE

The computer program for system control, data acquisition, and data analysis consists of 3 major modules (IDLE, PFT, PTC/PBF), each containing 2-4 minor modules (Figure 6). On program initiation (panel power - ON), the IDLE monitor clears the Random Access Memory (RAM), sets various pointers, initializes the control panel, opens the spirometer valve, and enters an idle state, waiting for another test module to be activated following depression of the desired test-select pushbutton (pb). This module is also entered after completion of the other modules.

5.1 PULMONARY FUNCTION MODULE (Flowchart F2, Appendix F)

The PFT (Pulmonary Function Test) module is entered by depressing the lighted PFT pb within the Idle module on the control panel. Four minor modules comprise the PFT module: mass spectrometer calibration (CAL MS), nitrogen washout (WO), forced vital capacity (FVC), and report generation (RPT). Each module can be selected by depression of the corresponding pb, whether or not it is lit (provided at least one pb in the module is lit). The lighted pushbuttons indicate the desired order of operation. The only restriction on order is that the CAL MS module must be enacted before the FVC, WO, and RPT modules. Then the FVC, WO and RPT modules can be selected in any order, any number of times.

5.1.1 Mass Spectrometer Calibration (CAL MS) (Flowchart F9, Appendix F)

The calibration routine samples the mass spectrometer every 10 msec. The sampled datum is converted to a percent and stored. Rapid

FIGURE 6 PROGRAM ORGANIZATION

calibration of the mass spectrometer is possible by sampling gas of known nitrogen content. The values for the cal gas routine are stored in Read-Only-Memory (ROM) as three floating point numbers. Completion of this routine is indicated by "CAL COMPLETE" on the video and the printer. If there was an error during calibration (CO_2 level too high, cal gas not turned on, torn capillary boot,...) the message "BAD MS CAL-REDO" is displayed and the CALMS pb is relit. Once the calibration routine has finished, the green CALMS light is turned off and the WO pb is lit, requesting activation of the nitrogen washout module.

5.1.2 Nitrogen Washout Module (WO) (Figure F6, Appendix F)

The nitrogen washout module incorporates two separate procedures into one subject activity. The subject places the mouthpiece in his mouth, exhales completely to residual volume (RV); inhales oxygen to full inspiratory capacity from an oxygen demand regulator, and again exhales completely (single breath maneuver). The subject then breaths normally, inhaling oxygen and exhaling into the spirometer until the procedure is completed. Throughout the procedure, the tidal volume and nitrogen fraction are displayed on the video monitor and/or the panel printer.

Both procedures (FVC and WO) involve operations on data pairs of nitrogen concentration and spirometer volume. The delay time required for the gas sample to pass through the sample catheter through the analysis chamber to the outputs, poses a potential problem when using instantaneous gas concentration and volume data pairs. Because of this delay, analog data at the mass spectrometer output

represent gas concentrations which were sampled in the past. The time delay varies for different mass spectrometers, but is relatively constant for a particular mass spectrometer. It is dependent on considerations such as catheter length, sample flow rate, inlet rate, and electrometer rise time. To avoid this problem in the program, both the volume and gases are sampled at 10 msec intervals in the FVC module; 20 msec intervals in the single-breath portion of the WO module; and 40 msec intervals in the remaining portion of the WO module. The spirometer control routine (SPIRO) uses the current volume, which is also placed in a First In-First Out Queue. At the same time, a volume sample is taken from the other end of the queue. This process matching the volume and gases is called phasing. The length of this queue is determined by the delay (phasing) time required by each mass spectrometer:

$$\text{Queue length} = \frac{\text{Mass spectrometer delay time}}{\text{Sampling interval}}$$

The mass spectrometer used in this experiment had a delay time of approximately 640 msec, so a queue of length 64 was used ir FVC (128/256 for WO).

Upon entry, the module begins monitoring nitrogen/volume data pairs. No computations are started until after the first end-of-breath is sensed by monitoring the spirometer position. Because the subject breathes ambient air before the first test maneuver, the nitrogen concentration at the mouth following the end of his first exhalation can be used as the nitrogen in his lungs. This nitrogen concentration is stored for later use in calculating residual volume. After this

initial inhalation of ambient air, no calculations are performed until the next exhalation which is the first one following oxygen inspiration from RV to TLC. All volume/nitrogen concentration data pairs for this exhalation are stored for later analysis.

After the subject begins inhaling 100% oxygen, it is necessary to compute the total amount of nitrogen exhaled. For a 20 msec time period, the volume exhaled during the period is simply the difference in a volume sample and the previous value. A negative difference occurs at the end of breath, when the spirometer begins returning values of 0 liters,and is treated as a zero volume difference. The volume of nitrogen exhaled during a 40 msec period is then computed by multiplying that volume difference by the properly phased nitrogen concentration. These 40 msec nitrogen volumes are accumulated from the initiation until the end of the washout. The criterion for ending the washout is the occurrence of two successive breaths with a maximum nitrogen fraction less than 0.03 (3%).

After the criteria for washout termination has been met, the collected data is used to quantitate the parameters defined in Table I. Data analysis begins with the single breath maneuver (the first inhalation and exhalation of 100% oxygen). The maximum volume, located during the maneuver, is converted to BTPS liters and stored as Vital Capacity (VC). Then, volume/nitrogen concentration pairs corresponding to 0.35*VC and 0.65*VC are found. A least-squares linear regression routine computes the best straight line expressing nitrogen concentration as a function of volume within the 0.35VC to 0.65VC interval. The slope of this line is multiplied by 100

and stored as N_2 DELTA (slope of the alveolar plateau in %/L). Next, the nitrogen fraction as the maximum volume (MAXVL) is predicted using the linear regression data from above. The data is searched backwards from MAXVL to find the first nitrogen fraction less than the nitrogen fraction predicted by the linear regression. The volume at this point is subtracted from the VC and stored as the Closing Volume (CV). The Residual Volume (RV) is then computed using a nitrogen dilution technique implemented with the following formula:

$$RV = \frac{NSUM - 0.0312T}{MAXFNI - MAXFNF} - 0.02$$

where:

T = Time of washout (units)

NSUM = Total volume of nitrogen exhaled during the washout.

0.0312T = Amount of nitrogen washed out of blood and tissues.

MAXFNI = Initial alveolar nitrogen concentration (maximum FN2 during first exhalation, i.e., before O_2 inhalation).

MAXFNF = Alveolar nitrogen concentration after washout (maximum FN2 during final exhalation).

The factor 0.0312T is traditionally a correction factor based on subject body surface area and the time of washout. A mean body surface for the expected subject group is used with actual time of washout to determine the volume of nitrogen washout out of the tissues. The constant, 0.02 liters, is an approximation of anatomical dead space. After RV is computed, VA/RV is computed by dividing NSUM by RV.

Once the washout calculations are completed, the WO green light is turned off and the FVC is lit, indicating the next step in the protocol.

5.1.3 Forced Vital Capacity Module (FVC) (Flowcharts F4 and F5, Appendix F)

The forced vital capacity module monitors a single breath, from a point of maximal inhalation to maximal exhalation. On inhalation, the spirometer valve is closed and the spirometer displacement (volume) is sampled every 10 msec. Data are not saved until a sample above a threshold (120 mv) is detected, indicating the beginning of a breath. Each sample is then saved sequentially until six samples differing by less than a threshold (20 mv) is detected, signifying the end of the maneuver. At this time, the spirometer valve is opened and analysis begun to derive the parameters in Table II. First, the volume sample occurring one second after the start of the maneuver is extracted, converted to liters BTPS, and stored in the buffer as FEV1. Next. the maximum spirometer displacement (VLAST), collected during the exhalation, is converted to liters BTPS and stored in the data buffer as FVC. Then, elapsed time values for one-quarter and three-quarters FVC are found. The time between the two points is determined by the number of samples between them and the fixed sampling rate of 10 msec/sample. MMFR is calculated by subtracting the volume at 0.25*FVC from the volume at 0.75*FVC and dividing it by the elapsed time. This same procedure is then repeated for 0.2 liters and 1.2 liters of the FVC to permit calculation of MEFR. The routine then turns off the FVC green light, turns on the RPT pb light, and exists to the PFT monitor idle loop.

5.1.4 Report Module (RPT) (Flowchart F8, Appendix F)

The RPT module combines the data from the FVC maneuver and the WO maneuver to produce a set of secondary pulmonary function data (Table III). The results are then printed on the panel printer and/or

the video monitor (Figure 7). The green RPT light is then turned off, the End-Test pb is lit, and the control passes to the PFT monitor idle loop.

5.2 PHYSIOLOGICAL TIME CONSTANTS/PULMONARY BLOOD FLOW MODULE (Flowchart F3 App.F)

The PTC/PBF module is an integration of two experiments from SMSII: Pulmonary Blood Flow (PBF) and Physiological Time Constants (PTC)(Life Sciences: SMSII, 1977). This combination is possible in the data collection phase since both experiments monitor the same parameters (heart rate, VO_2, VCO_2, V_E, and blood pressure) and differ only in the reporting interval length over which the data is analyzed. Heart rate is is reported in beats/minute for PBF and in beats/15 seconds for PTC. VO_2, VCO_2, and V_F are summed over a one minute reporting interval in PBF, while in the PTC, the values for each breath and the elapsed start time for each breath are computed.

The differences lie in the functional objectives of the PTC and PBF experiments. PBF is concerned with measuring the time course and magnitude of changes in central blood flow and volume relationships in zero-g. On the other hand, the PTC is concerned with the dynamic response of the cardiopulmonary system during exercise stress testing.

The PTC/PBF module is entered by depressing the lighted PTC/PBF pb within the Idle Module on the control panel. Four minor modules comprise the PTC/PBF module: mass spectrometer calibration (CALMS), room air calibration (ROOM), start protocol (START) and the

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$DX
RT-11SJ     V02C-02


.RUN DX1:OTR1


PULMONARY FUNCTION REPORT
SUBJECT 1
CAL COMPLETE

  3.22     0.7969
  5.22     0.2092
  2.45     0.0657
  1.84     0.0513
  1.78     0.0443
  1.66     0.0362
  1.51     0.0277
  1.72     0.0272
  1.76     0.0241
  1.62     0.0203
  1.44     0.0173
  1.55     0.0158




PULMONARY FUNCTION REPORT
SUBJECT 1

FEV1                3.40
FVC                 4.81
MMFR                2.05
MEFR                8.34
VC                  5.22
N2 DELTA            1.07
CV                  2.11
RV                  1.55
VA/RV              12.98
FEV1/FVC%          70.60
FVC/VC%            92.27
CV/VC%             40.51
TLC                 6.77
CC/TLC             54.17
```

FIGURE 7

PTC/PBF

TIME	1.0
HEART RATE	56
WORK LOAD	-
O2 CONSUMPTIO	0.344
CO2 PRODUCTIO	0.335
MINUTE VOLUME	10.0
RES RATE	8
F PCO2 SLOPE	0.0
S B P	112
D B P	73

TIME	2.0
HEART RATE	56
WORK LOAD	-
O2 CONSUMPTIO	0.447
CO2 PRODUCTIO	0.445
MINUTE VOLUME	13.2
RES RATE	12
F PCO2 SLOPE	0.0
CARDIAC OUTPU	0.0
S B P	*.*
D B P	*.*

TIME	3.0
HEART RATE	58
WORK LOAD	-
O2 CONSUMPTIO	0.403
CO2 PRODUCTIO	0.394
MINUTE VOLUME	11.2
RES RATE	7
F PCO2 SLOPE	13.6
CARDIAC OUTPU	6.1
S B P	*.*
D B P	0.0

FIGURE 7 (CONT'D)

TIME	4.0
HEART RATE	59
WORK LOAD	-
O2 CONSUMPTIO	0.393
CO2 PRODUCTIO	0.388
MINUTE VOLUME	11.5
RES RATE	6
F PCO2 SLOPE	0.0
CARDIAC OUTPU	0.0
S B P	*.*
D B P	*.*

TIME	5.0
HEART RATE	62
WORK LOAD	-
O2 CONSUMPTIO	0.404
CO2 PRODUCTIO	0.446
MINUTE VOLUME	13.6
RES RATE	5
F PCO2 SLOPE	10.8
CARDIAC OUTPU	7.9
S B P	*.*
D B P	*.*

*

FIGURE 7 (CONT'D)

cardiac output maneuver (Q). Each module can be selected by depression of the corresponding pb. The lighted pushbuttons (pb) indicate the desired order of operation.

5.2.1 Mass Spectrometer Calibration (CALMS) (Flowchart F9, Appendix F)

The calibration routine samples the mass spectrometer every 10 msec. The sampled data is converted to a percent and stored. Rapid calibration of the mass spectrometer is possible by sampling a gas of known nitrogen content. The values for the cal gas percentages are stored in ROM as three floating-point numbers (one each for N_2, CO_2, O_2). Completion of this routine is indicated by "CAL COMPLETE" on the video and/or the printer. If an error occurs during calibration (CO_2 level too high, cal gas not turned on, torn capillary boot, blocked capillary, ...) the message "BAD MS CAL-REDO" is displayed and the CALMS pb is relit. Once the calibration routine has finished, the green CALMS light is turned off and the ROOM pb is lit, requesting activation of the room air calibration module.

5.2.2 Room Air Calibration Module (ROOM) (Flowchart F13, Appendix F)

The room air module samples the ambient air to obtain the FN_2 (Nitrogen Fraction), FO_2 (Oxygen Fraction), and FCO_2 (Carbon Dioxide Fraction) used in later calculations as gas-inspired concentrations (in CO_2 production and O_2 consumption). Certain checks are performed on the data to verify proper values. The FO_2 value must be greater than 0.19 (19%) and the FCO_2 value must be greater than 0.02 (2%). If this criteria is not met,

the message "BAD ROOM AIR" is displayed, the ROOM green light is turned off and the ROOM pb is relit. If the criteria is met, the three gas fractions are stored in memory (as RAFCO2, RAFN2, RAFO2) along with the FO2/FN2 ratio (ORAT) and the FCO2/FN2 ratio (CRAT) used in later nitrogen ratio computations. Once the ROOM air routine is finished, the ROOM light is turned off and the START pb is lit requesting activation of the protocol module.

5.2.3 Start Module (START) (Flowchart F14-F17, Appendix F)

This module was originally intended for an exercise protocol using a prototype personal exercise system. However, due to circumstances beyond our control, this device was not ready in time for inclusion into the system. The protocol period is currently set up for five minutes with a cardiac output maneuver requested during the third and fifth minute. This protocol can be easily modified by adjusting the protocol code in the constants section in ROM. Module activation takes place when the START pb is depressed. The START green light is lit and the Q pb is lit at the beginning of the third and fifth minutes requesting a cardiac output maneuver.

The software for this module starts at STRTP1 (location 6246_8) by initializing the user stack, the spirometer delay, the mass spectrometer delay (for volume-gas phasing), a number of flags and counters, and the PTC and PBF data buffers. The interrupt counter (PINTCT) is set to allow interrupts every 40 msec., the blood pressure delay is set, and the green START light is lit. A watch loop (EXLOOP) takes control and cycles execution through the various

routines.

The PTC/PBF watch loop serves as a scheduler for the different tasks that take place during execution. These tasks include: gas analysis on volume-gas data, gas exchange end-of-breath processing, cubic spline fit for cardiac output data, R(INST) calculations, initiation of printer and/or video output, transmission of PTC and PBF data to the On-Board-Data-System (OBDS) and end-of-test processing.

The gas analysis routine (Flowchart F16, Appendix F) matches the phased volume with the corresponding gas fractions. Once a cardiac output maneuver is in progress, the FCO_2 and FO_2 values are saved for the cubic spline fit, provided that the CO_2 value is greater than 20 Torr, and the O_2 decreases by more than 0.002. If the phased volume is zero, then, an end-of-breath is signaled, the PTC breath volume is scaled from A/D counts to 0-8L BTPS, the PTC FCO_2 and FO_2 values are scaled from A/D counts to 0-1L STPD, the end-of-breath flag is set, and control passes back to EXLOOP. If the phased volume is not equal tc zero, then the delta volume, oxygen consumption, and carbon dioxide production are computed for the current phased volume-gas pair using the equations described in Section 3.3. Control then passes back to EXLOOP routine.

Since the computations for cardiac output require a considerable amount of computer processing time, they are spaced out over the course of the maneuver. Using the FO2-FCO2 pairs saved in the gas analysis routine, a cubic spline fit is used to compute the derivatives of the curve. The derivatives are evaluated at each of the original data

points using a cubic spline fit (Appendix C), and the value of R (respiratory exchange ratio) is calculated from the derivative at each point. For each point, the calculated R and FCO_2 coordinates are paired, and linear regression analysis is applied to the array of points represented by the R-FCO_2 pairs. Cardiac output ($\dot{Q}$) is computed from the slope of this regression line and from an independently determined oxygen consumption valve using the equation:

$$\dot{Q} = \frac{\dot{V}O_2 * 1000}{4.7 * \text{slope}}$$

where: $\dot{V}O_2$ = O_2 consumption rate (STPD ml/min.)

4.7 = slope of the standard carbon dioxide dissociation curve (ml/liter/torr PCO_2) (Buderer,1973).

$\dot{Q}$ = cardiac output (l/min).

Certain constraints are imposed on the FO_2-FCO_2 data. Since the CO_2 - dissociation curve below FCO_2 = 30 torr is alinear, any point from the FO_2 - FCO_2 curve with a FCO_2 value less than 30 torr is rejected. Also, if the FO_2 value does not decrease by more than 0.002 the point is rejected. If this selection criterion results in a data array of less than 13 points, the entire measurement is rejected. This last criterion eliminates data curves lacking a sufficient space of R values to allow meaningful linear regression analysis of the R-FCO_2 pairs. (Buderer, 1973).

Since the on-board-data-system was not implemented in time for SMD III, the code for PTC and PBF data transmission clears the transmission flags and returns control to EXLOOP.

Output is transmitted to the video monitor and/or printer (depending on which is selected) every minute. Output data includes time (minutes), heart rate, ergometer workload, oxygen consumption carbon dioxide production, respiration, minute volume and systolic and diastolic blood pressure.

Once EXLOOP detects end-of-breath, the cardiac output interrupt is disabled, a delay-loop awaits completion of video and/or printer output, and control passes back to the PTC/PBF monitor awaiting depression of a pb on the control panel.

5.3 SPECIFIC DEVICE HANDLERS

5.3.1 Control Panel Software (Flowcharts F1-F3, Appendix F)

For SMD III, the experiment-specific control panel replaces the standard computer console. Proper design of this panel allows ease of use, flexibility, and requires less training. The control panel, through a series of lights and lighted pushbuttons, guides the operator through the test, thereby providing a smaller margin of error.

The control panel is connected to the LSI-11 via 2 DRV11 Parallel Line Interfaces. The DRV11 output lines control the green LED indicators and the amber pushbutton LED's (one output line per LED), while the DRV11 input lines are connected to the pushbuttons (one input line per pushbutton). One of the interrupt lines is used for the ABORT buttons, and another interrupt is connected to the cardiac output pushbutton. The individual output and input lines can be cleared ('0'), set ('1') and/or read using the respective

LSI-11 assembly commands: BIC (bit clear), BIS (bit set), and BIT (bit test). The LED's are set up so that a BIC ('0') turns the light on, while a BIS ('1') turns the light off. Testing the status of the individual pushbuttons is done with the BIT command. If the result is true ('1') then the button was depressed; if the result is false ('0') then the button was not depressed. Interrupts for the DRV11 are handled using LSI-11 standard vector pairs.

The control panel software monitor (PMON, location 652_8) also serves as the executive controller for the entire system. By turning on lights as cues and sensing the depression of the appropriate pushbuttons, the monitor guides the subject through both tests (PFT and PTC/PBF).

The control panel is physically divided into four modules: 1-Initialization-Idle, 2-PFT, 3-PTC/PBF, 4-Output. After system power-up, the monitor turns on the idle light, the PFT pb light and the PTC/PBF pb light, (all within Module 1), and enters an idle mode awaiting user response. At this point, any button on the panel outside of Module 1 can be depressed, but no action will take place. This feature was included to further eliminate possible sources of human error. Once the user selects the subject code, mass spectrometer type, output devices and then depresses one of the test-select pushbuttons, the monitor moves control to the appropriate module. The light at the top of the selected module is lit, along with the CALMS pb, and the monitor goes into an idle state awaiting further user action.

As in the idle module, the only pushbuttons monitored are those within the selected module. The lighted pushbuttons indicate the desired order of operation, but any order may be used. This flexibility allows the user to repeat maneuvers (FVC, WO, START-exercise) that might have been performed improperly (example: hiccup during FVC maneuver) or experienced some type of failure (clogged mass spectrometer capillary, stuck spirometer valve,...). However, certain maneuvers must be performed prior to other maneuvers. That is, the mass spectrometer must be calibrated (CALMS) before any gas analyses can take place (FVC, WO, ROOM, START) and ROOM air must be sampled before gas exchange analysis can take place within the PTC/PBF module.

To leave the PFT or the PTC/PBF mdoule, the user need only depress the appropriate END TEST pushbutton and control goes back to Module 1 placing the system in an idle mode.

Module 4-output contains the toggle switches allowing user selection of the output devices. Currently there are 2 toggle switches: OBDS and PRINTER. The printer switch turns on the 24 VAC power supply for the printer and signals the control panel monitor through one of the DRV11 input lines. The OBDS switch was intended to do the same thing for the on-board-data-system. However, since the OBDS was not implemented,the switch was used to perform the same function for the video monitor. If an OBDS is ever implemented, another toggle switch can be added to the control panel and connected to an unused input line on one of the control panel DRV11's.

5.3.2 Panel Printer Software

The main portion of the panel printer software exists as an interrupt service routine (PRINT, location 500_8) with the interrupt vector pair located in addresses 320_8 and 322_8.

The printer hardware generates an interrupt every 10 ms. to request a character. If there is any data in the print buffer, the characters are sent to the printer one per interrupt. A null byte is sent to the printer as a new line signal. The interrupt service routine waits until the signal is returned indicating carriage return to the left margin before outputting any more data. A minus one (-1) is used as a print termination character. At this time, the interrupt is disabled and the print buffer is cleared.

5.3.3 Mass Spectrometer Handler

The mass spectrometer software consists of 3 subroutines: SAMGAS, GETGAS, and CALMS.

CALMS is the mass spectrometer calibration routine and must be executed before any gas analysis can take place. CALMS initializes the mass spectrometer constants dependent on the mass spectrometer type selected on the control panel thumbwheel switch. Then, it samples each gas (CO_2, O_2, N_2) from a bottle of Cal Gas (individual gas concentrations are known), averages the 25 samples, adjusts the cal gas percentages for BTPS, and computes the calibration factor for each gas using the equation:

$$CF = \frac{\text{Average of 25 samples}}{\text{Cal Gas \% * BTPS}}$$

The cal factors are then stored as RAM constants (O2CF, N2CF, CO2CF) for later use by the GETGAS routine.

SAMGAS uses the gain set in CALMS and triggers the A/D to sample the three gas channels: O2, N2, and CO2. The values are stored in three registers: R0, R1, and R2 respectively.

GETGAS uses SAMGAS to sample the three gases and then, converts each sample to partial pressure BTPS using the cal factors computed in CALMS. The partial pressure (Px) of each gas x is then converted to gas fraction (Fx) using the equation:

$$Fx = \frac{Px}{P_{CO2} + P_{N2} + P_{O2}}$$

This data is then passed back to the calling program in locations FN2, FO2 and FCO2.

5.3.4 Spirometer Handler (Flowchart F10, Appendix F)

The SPIRO subroutine (location 14154_8) monitors the spirometer status, controls the spirometer dump valve, and determines the breath status. The subroutine is entered with the sampled spirometer volume in register 2 (R2).

If the sample volume exceeds 120 mv, a breath is in progress. The volume is then compared against the previous sample. If the difference is greater than 20 mv (i.e., current sample is greather than the previous sample by at least 20 mv), the volume is saved, and the EOB (end of breath) indicator is cleared since a breath is in progress. If the difference is not greater than 20 mv, then the VWATCH indicator is increased by 1. If the resultant VWATCH is less than zero, then the sample is saved. If VWATCH equals zero, the EOB indicator

is set and the spirometer valve is opened. Initially VWATCH is set to a negative number WAITT. WAITT remains constant throughout a maneuver, but varies from maneuver to maneuver (FVC, WO, PTC/PBF). VWATCH is used as a counter to indicate when WAITT consecutive spirometer values occur, differing by less than 19 mv. This indicates that the spirometer valve has not displaced significantly during the last WAITT samples and therefore signals an end-of-breath.

5.3.5 Conversion Routines

The Integer to Real conversion subroutine (IR) and the Real to Integer conversion subroutines (RI) are taken from the Floating Point Package (FPMP - 11) from Digital Equipment Corporation (DEC) for the PDP-11 computer series.

The Floating Point to ASCII Conversion Routine (FORMAT) was written by Donald G. Mauldin of Technology, Inc. to provide limited format capabilities. FORMAT provides the capability of outputting floating point numbers in the format FX.Y; where X is the number of digits to the left of the decimal point and Y is the number of digits to the right of the decimal point. The total number of spaces (bytes) required for output is: X+Y+2 if Y is greater than zero, and X+Y+1 if Y equals zero. Input to the subroutine includes: the starting address of data output area, Y of FX.Y, X of FX.Y, the least significant word (LSW) of the floating point number and the most significant word (MSW) of the floating point number.

As a note of interest, this routine requires 540_8 words compared to 1630_8 in DEC's floating point package.

APPENDIX A

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

A/D	=	Abbreviation for analog/digital converter
ARC	-	NASA/Ames Research Center, Mountain View, California
bit	-	A single digit in a binary number and can have one of only two values, 0 or 1.
BPMS	-	Blood Pressure Measuring System
BTPS	-	Body Temperature and ambient pressure for gas saturated with water vapor.
CAL MS	-	Mass spectrometer calibration routine
CPU	-	Central Processing Unit
CV	-	Closing Volume
DEC	-	Digital Equipment Corporation
DMA	-	Direct Memory Access
ECG	-	Electrocardiogram
EEG	-	Electroencephlogram
FCO2	-	Carbon dioxide fraction (of mass spectrometer sample)
FEV	-	Forced Expired Volume
FN2	-	Nitrogen Fraction (of mass spectrometer sample)
FO2	-	Oxygen Fraction (of mass spectrometer sample)
FRC	-	Functional Reserve Capacity
FVC	-	Forced Vital Capacity
ICU	-	Intensive Care Unit
JSC	-	Johnson Space Center, Houston, Texas
LED	-	Light Emitting Diode
MIT	-	Massachusetts Institute of Technology, Cambridge, Massachusetts
MEFR	-	Maximum Expiratory Flow Rate

MMFR	-	Maximum Mid-Expiratory Flow Rate
MPU	-	Microprocessing Unit
MS	-	Abbreviation for Mission Specialist
NASA	-	National Aeronautics and Space Administration
OBDS	-	On-Board-Data-System
OTR	-	Operational Test Requirements
pb	-	lighted pushbutton on the control panel
PC	-	Program Counter
PLU	-	Parallel Line Unit
PS	-	Processor Status Word
PFT	-	Pulmonary Function Test
PS2	-	Program Specialist 2
PTC/PBF	-	Physiological Time Constants/Pulmonary Blood Flow
$\dot{Q}$	-	Cardiac Output (L/Min.)
RAM	-	Random Access Memory
ROM	-	Read Only Memory
RV	-	Residual Volume
SLU	-	Serial Line Unit
SMD	-	Spacelab Mission Demonstration
SMS	-	Spacelab Mission Simulation
STPD	-	Standard Temperature and pressure for dry gas
TLC	-	Total Lung Capacity
VA	-	Amount of alveolar oxygen ventilated
$\dot{V}_{CO_2}$	-	Carbon Dioxide Production (L/Min.)

GLOSSARY OF ACRONYMS AND ABBREVIATIONS (cont'd)

$\dot{V}_{O_2}$ - Oxygen Consumption (L/min)

WO - Nitrogen Washout Maneuver

APPENDIX B

Spirometer Calibration

SPIROMETER CALIBRATION

PURPOSE: To obtain a value (in A/D counts) corresponding to spirometer liters/count.

PROCEDURE:

1. Take piston of known volume with valve closed spirometer dumped.
2. Push piston full stroke.
3. Read volts with a voltmeter.
4. Dump piston.
5. Repeat steps 2-4 to verify reproducibility.
6. Do at 3 different volumes and pick middle value (this will give you liters/volt).

RESULTS:

Piston Volume	Output Voltage	Liters/Volt
1.375 L	1.708 V	1.375/1.708 = 0.8050 L/V
2.371 L	2.804 V	2.371/2.804 = 0.8458 L/V
3.341 L	3.916 V	3.341/3.916 = 0.8457 L/V

0.8457 L/V

For the ADAC-600-LSI-11 Analog-to-Digital Converter using a gain of 1,

.488 mv/bit = .488 mv/count

Therefore:

$$0.8457 \frac{\text{Liters}}{\text{Volt}} * .00488 \frac{\text{Volts}}{\text{Count}} = \boxed{0.004127 \frac{\text{liters}}{\text{count}}}$$

APPENDIX C

Pseudo-Cubic Spline Fit

The pseudo cubic spline implemented in OTRI was derived from the spline presented by Ahlberg, et.al. (Ahlberg, 1967). They present an efficient algorithm for solving the system of equations defining the spline.

The basic formula for the matrix is:

$$h_j = z_j - z_{j-1} \quad = j \text{ th sample interval}$$

$$j=1 \qquad m_1 = s_1$$

$$j=2 \qquad 2m_2 + c_2 m_3 = \frac{3a_2}{h_2}(y_2 - y_1) + \frac{3c_2}{h_3}(y_3 - y_2) - a_2 m_1 = d_2$$

$$j=3,n-2 \qquad a_j m_{j-1} + 2m_j + c_j m_{j+1} = \frac{3a_j}{h_j}(y_j - y_{j-1}) + \frac{3c_j}{h_{j+1}}(y_{j+1} - y_j) = d_j$$

$$j=n-1 \qquad a_j m_{j-1} + 2m_j = \frac{3a_j}{h_j}(y_j - y_{j-1}) + \frac{3c_j}{h_{j+1}}(y_{j+1} - y_j) - c_j m_n = d_{n-1}$$

$$j=n \qquad m_n = s_n \quad \text{(given)}$$

The two-step solution is:

1). Forward (k=2,3,...,n-1)

$$p_k = a_k q_{k-1} + 2 \quad (q_1 = 0)$$

$$q_k = -c_k / p_k$$

$$u_k = (d_k - a_k u_{k-1})/p_k \quad (u_1 = 0)$$

where:

$$h_k = z_k - z_{k-1}$$

$$a_k = \frac{h_{k+1}}{h_k + h_{k+1}}$$

$$c_k = 1 - a_k$$

2). Backwards (k = n-1, n-2, ..., 2)

$$m_k = q_k m_{k+1} + u_k$$

The following page contains a "pseudo-code" representation of the algorithm actually implemented. Initially, z_i (i=1,2,...,n) contains the sampled oxygen (FO_2) values and y_i (i=1,2,3,...,n) contains the sampled carbon dioxide (FCO_2) values.

PSEUDO-CODE FOR THE CUBIC SPLINE

Initially: array Z contains FO_2

array Y contains FCO_2

S1 = 0.85 if the last FO_2 = 0

= FCO_2/FO_2 otherwise (FCO_2 and FO_2 are the last values in the array)

SN = 0.0

n = the number of FO_2 - FCO_2 data pairs

$h_n = h_n - h_{n-1}$

; compute differences

DO 3 k = n-1, 2

$h_k = h_k - h_{k-1}$

$$a_k = \frac{h_{k+1}}{h_k + h_{k+1}}$$

$c_k = 1 - a_k$

3 $$d_k = \frac{3*a_k}{h_k}$$

; step 1 - Forward

$u_{n-1} = u_{n-1} + (1.0 - a_{n-1})$

$$u_2 = \frac{d_2 - a_2 * S1}{2}$$

$$q(2) = \frac{a_2 - 1.0}{2.0}$$

PSEUDO-CODE FOR THE CUBIC SPLINE (CONT'D)

DO 5 k = 3, n-1

$p_k = a_k * p_{k-1} + 2.0$

$$u_k = \frac{d_k - (1.0 - a_k) * d_{k-1}}{p_k}$$

5 $q_k = a_k / p_k$

; step 2 - Backwards, compute slopes.

U_n = SN

DO 6 k = n-1, 2

6 $m_k = q_k * m_{k+1} + u_k$

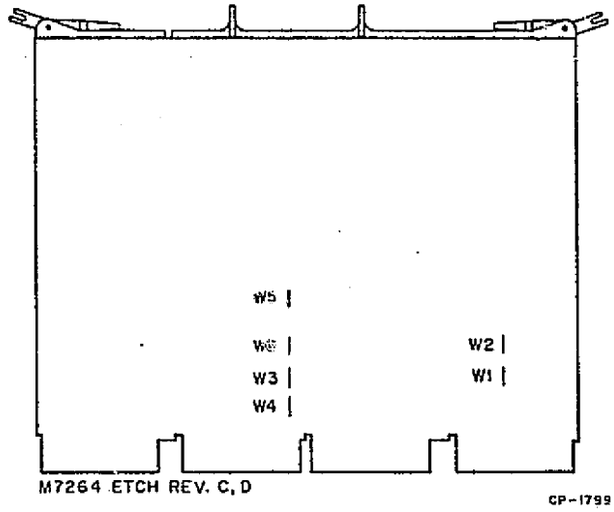
m_1 = S1

APPENDIX D

Schmetics & Wiring Lists

KD11 Factory Jumper Configuration

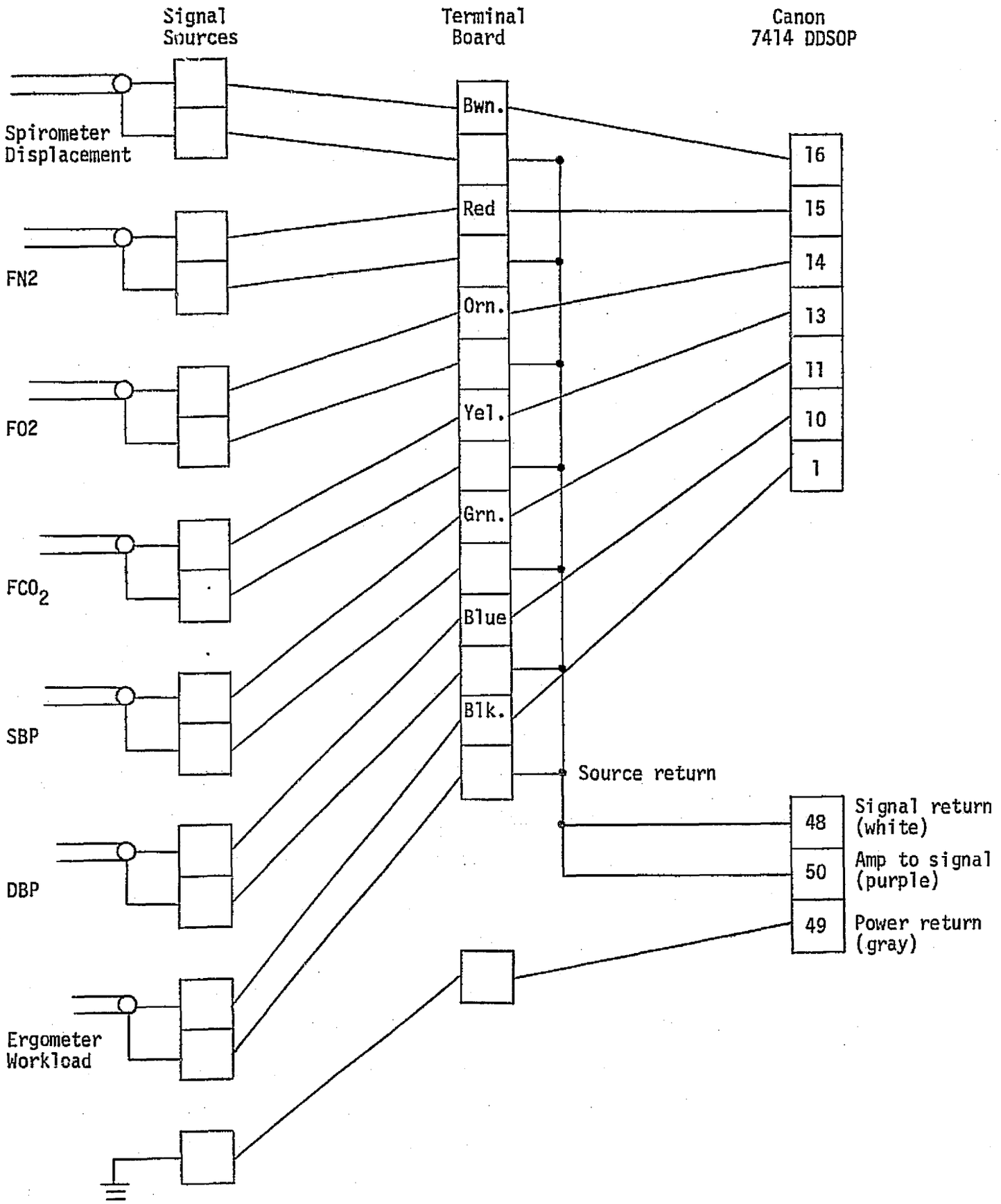
Jumper	Installed	Removed	Function
W1		X	BANK 1 Disabled
W2	X (KD11-F)	X (KD11-J)	BANK 0 Enabled (KD11-F only)
W3		X	Line Time Clock Enable
W4	X (KD11-J)	X (KD11-F)	Memory Refresh Enable (KD11-F only)
W5		X	Power-Up
W6		X	Mode 0



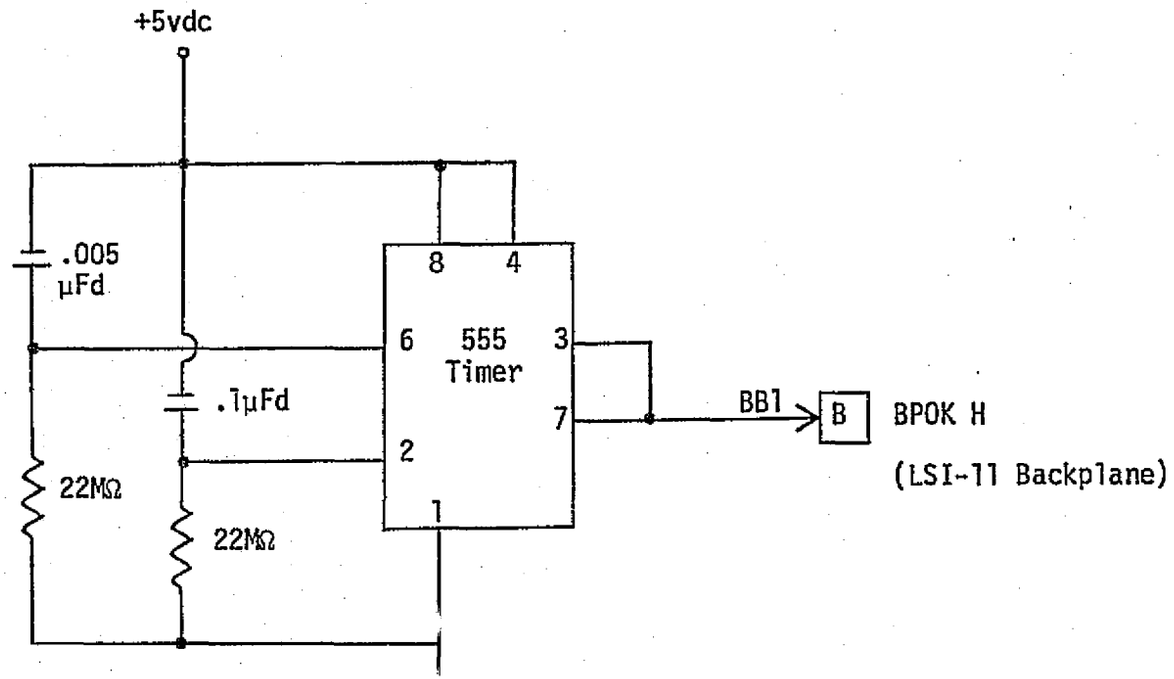
NOTE

W1 through W6 are wire-wrap jumpers

Jumper Locations

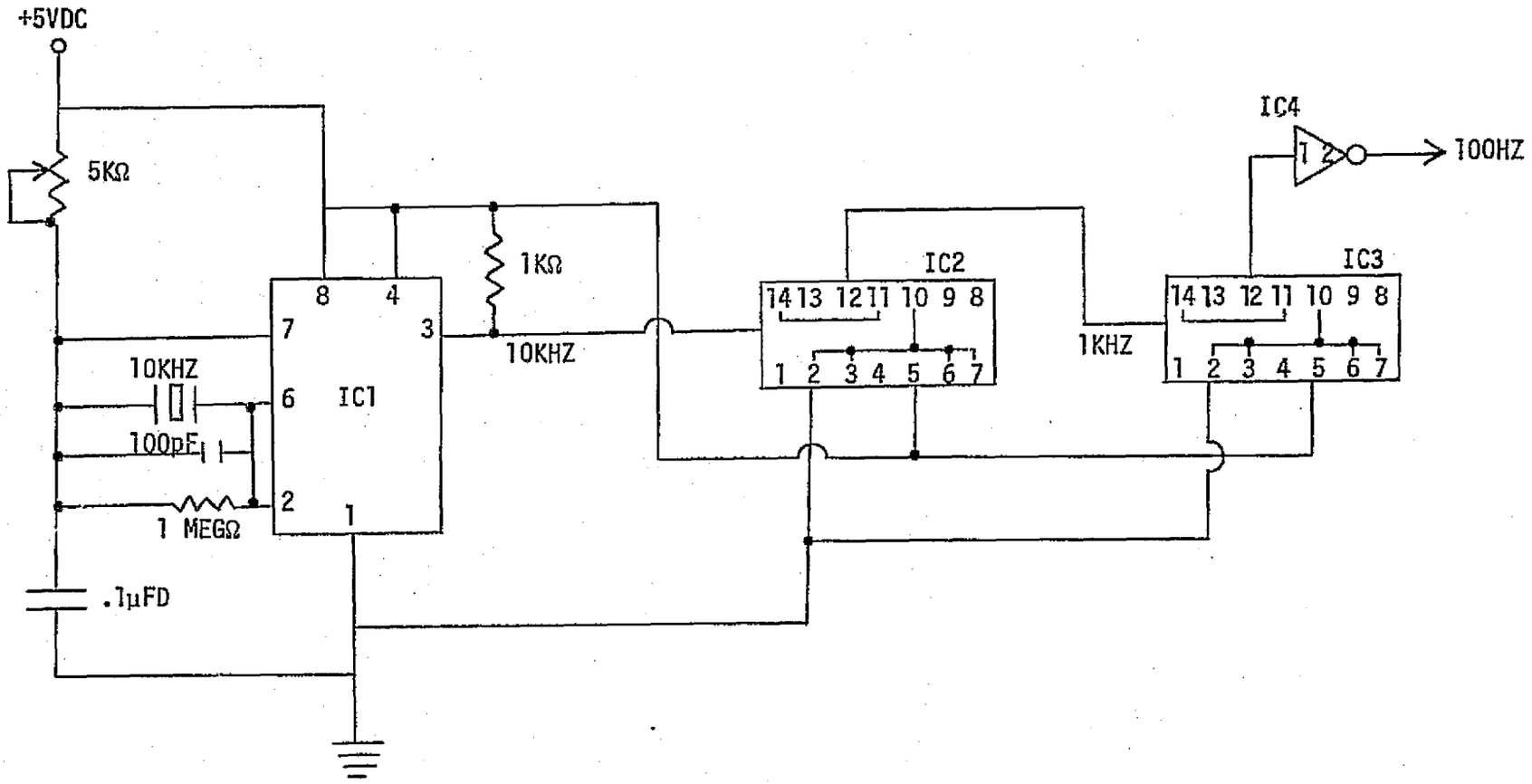


A/D SIGNAL CONNECTION



LSI-11 POWER UP CIRCUIT

D3

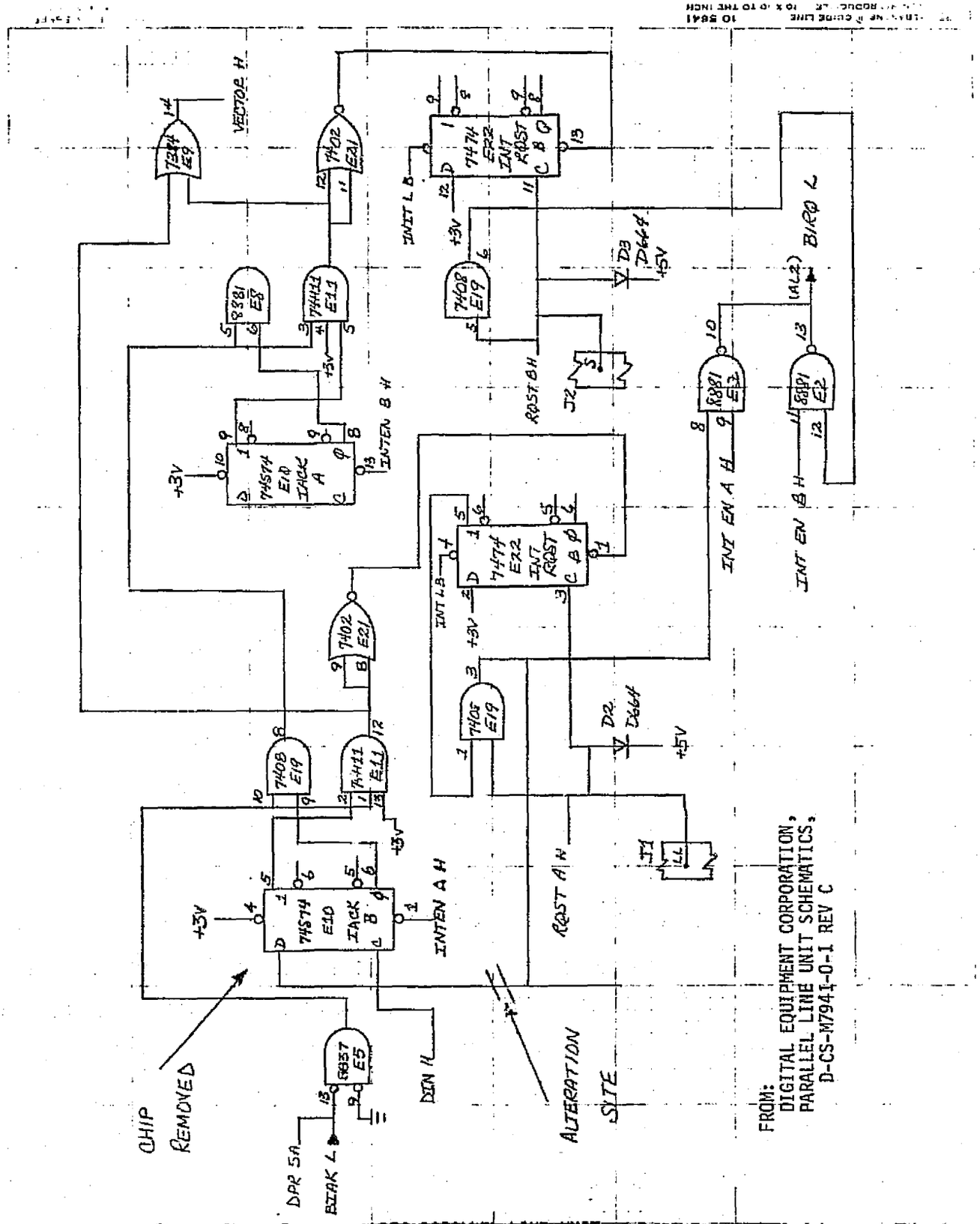


NOTES:

1. IC1 is a 555 timer
2. IC2 and IC3 are SN7490 in divide-by-10 configuration
3. IC4 is a SN7404 used to remove the notch in the output of IC3

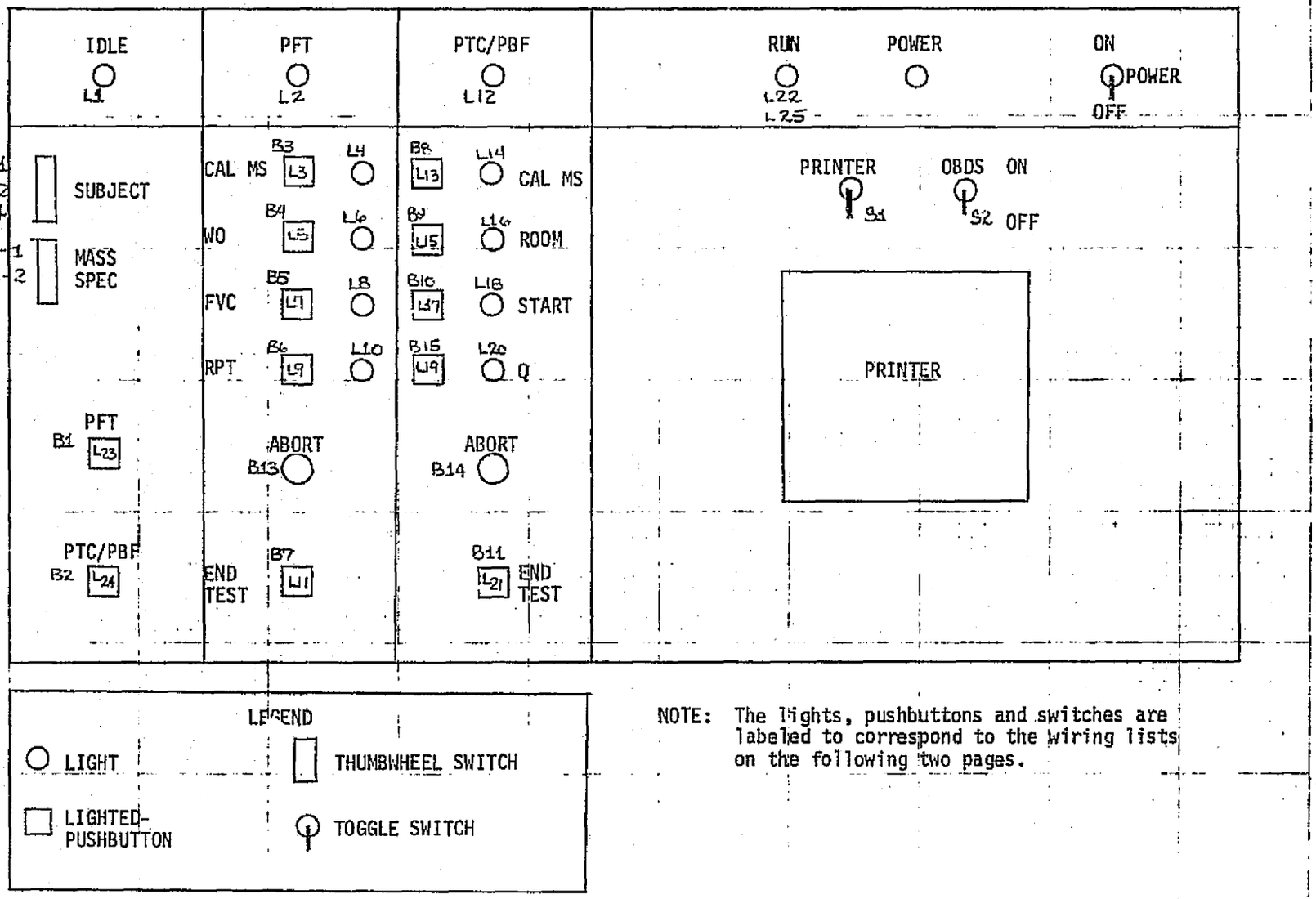
LSI-11 TIMER CIRCUIT

D4



DEC PARALLEL LINE UNIT
SELECT AND INTERRUPT LOGIC SECTION

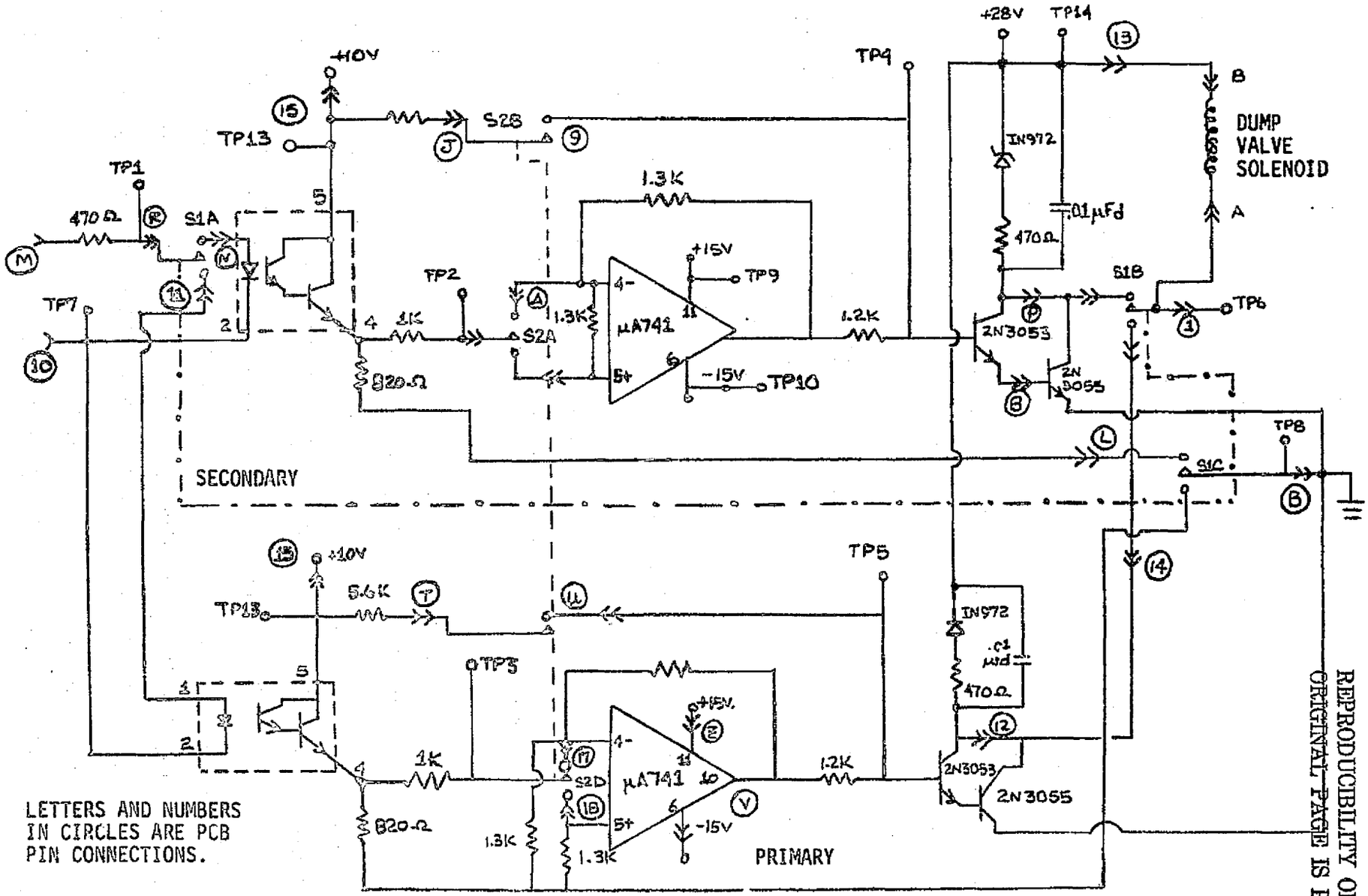
MICROPROCESSOR CONTROL PANEL

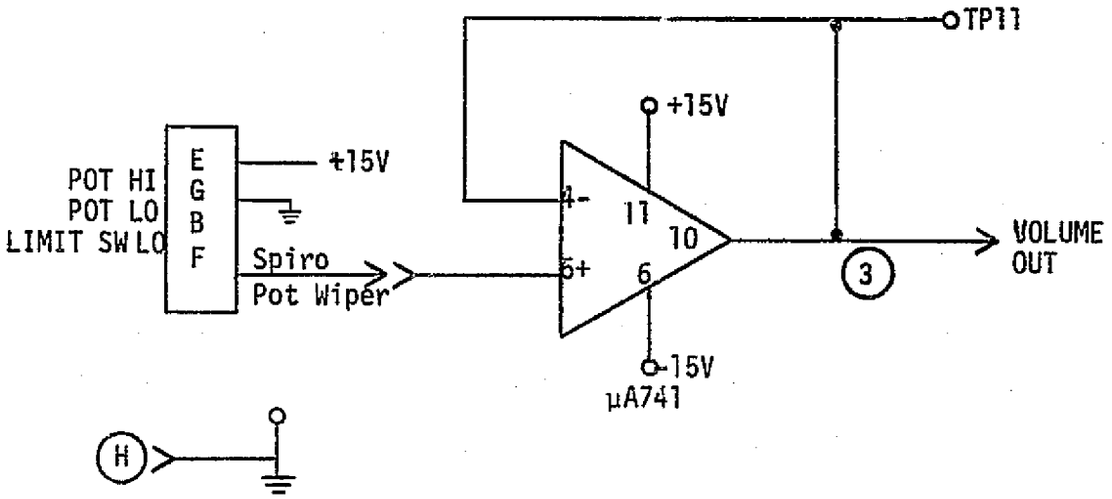


NOTE: The lights, pushbuttons and switches are labeled to correspond to the wiring lists on the following two pages.

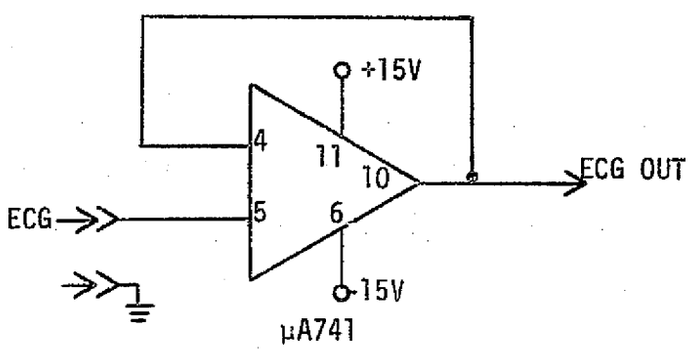
DRV11 - BOARD A			EXTERNAL PANEL CONNECTOR		INTERNAL PANEL CONNECTOR		CONTROL PANEL LED'S & BUTTONS
SIGNAL	CONNECTOR, PIN		CONNECTOR, PIN		CONNECTOR, PIN		SIGNAL (ON PANEL)
IN00	J2A	TT	C1	1	C2	1	T1 - Bit 1
IN01	J2A	LL	C1	2	C2	2	T1 - Bit 2
IN02	J2A	H, E	C1	16	C2	16	T1 - Bit 4
IN03	J2A	BB	C1	7	C2	7	T2 - Bit 1
IN04	J2A	KK	C1	3	C2	3	T2 - Bit 2
IN05	J2A	HH	C1	4	C2	4	B1
IN06	J2A	EE	C1	5	C2	5	B2
IN07	J2A	CC	C1	6	C2	6	B3
IN08	J2A	Z	C1	8	C2	8	B4
IN09	J2A	Y	C1	9	C2	9	B5
IN10	J2A	W	C1	10	C2	10	B6
IN11	J2A	V	C1	11	C2	11	B7
IN12	J2A	U	C1	12	C2	12	B8
IN13	J2A	P	C1	13	C2	13	B9
IN14	J2A	N	C1	14	C2	14	B10
IN15	J2A	M	C1	15	C2	15	B11
OUT00	J1A	C	C1	25	C2	25	L1
OUT01	J1A	K	C1	24	C2	24	L2
OUT02	J1A	NN	C1	26	C2	26	L3
OUT03	J1A	U	C1	19	C2	19	L4
OUT04	J1A	L	C1	23	C2	23	L5
OUT05	J1A	N	C1	22	C2	22	L6
OUT06	J1A	R	C1	21	C2	21	L7
OUT07	J1A	T	C1	20	C2	20	L8
OUT08	J1A	W	C1	18	C2	18	L9
OUT09	J1A	X	C1	17	C2	17	L10
OUT10	J1A	Z	C1	37	C2	37	L11
OUT15	J1A	JJ	C1	28	C2	28	L22
REQA	J1A	LL	C1	27	C2	27	B13, B14
REQB	J2A	S	C1	38	C2	38	B15
CSR0	J2A	K					SPIRO DUMP CIRCUIT
CSR1	J1A	DD					BPMS TRIGGER

DRV11-BOARD B			EXTERNAL PANEL CONNECTOR		INTERNAL PANEL CONNECTOR		CONTROL PANEL LED'S & BUTTONS
SIGNAL	CONNECTOR, PIN		CONNECTOR, PIN		CONNECTOR, PIN		SIGNAL (ON PANEL)
OUT00	J1B	C	C1	50	C2	50	L12
OUT01	J1B	K	C1	49	C2	49	L13
OUT02	J1B	NN	C1	29	C2	29	L14
OUT03	J1B	U	C1	44	C2	44	L15
OUT04	J1B	L	C1	48	C2	48	L16
OUT05	J1B	N	C1	47	C2	47	L17
OUT06	J1B	R	C1	46	C2	46	L18
OUT07	J1B	T	C1	45	C2	45	L19
OUT08	J1B	W	C1	43	C2	43	L20
OUT09	J1B	X	C1	42	C2	42	L21
OUT10	J1B	Z	C1	41	C2	41	L23
OUT11	J1B	AA	C1	40	C2	40	L24
OUT15	J1B	JJ	C1	34	C2	34	L25
IN00	J2B	TT	C1	35	C2	35	S1
IN01	J2B	LL	C1	36	C2	36	S2
REQA	J1B	LL					ECG COUNT INTERRUPT
REQB	J2B	S					100 MSEC CLOCK INTERRUPT
			AC on 1 & 2 +5V on 3 Return on 4				





SPIROMETER VOLUME BUFFER CIRCUIT

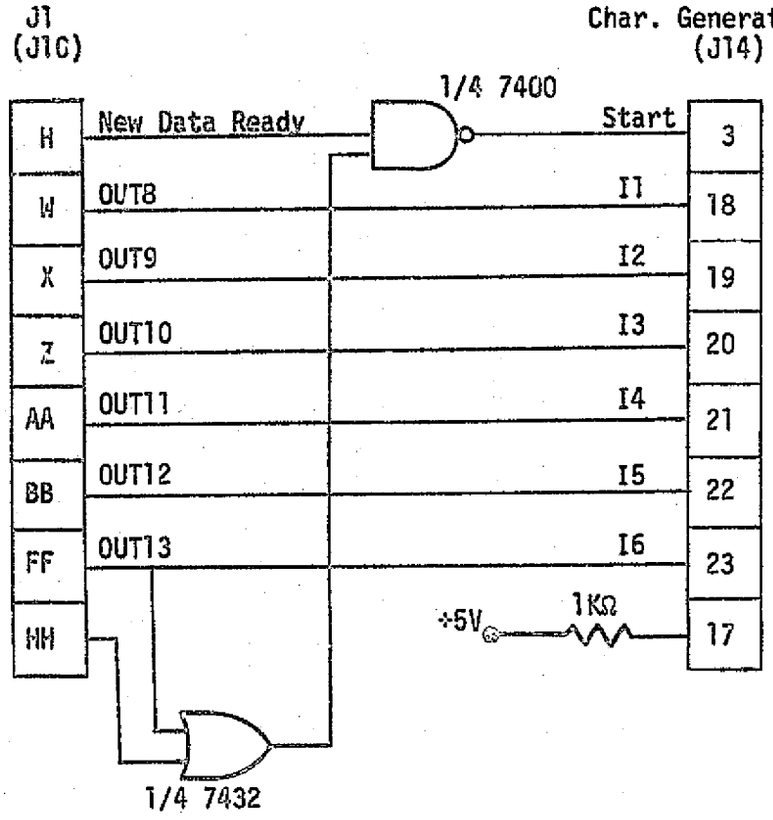


NOTE:
LETTERS AND NUMBERS
IN CIRCLES ARE PCB
PIN CONNECTIONS.

ECG OUT CIRCUIT

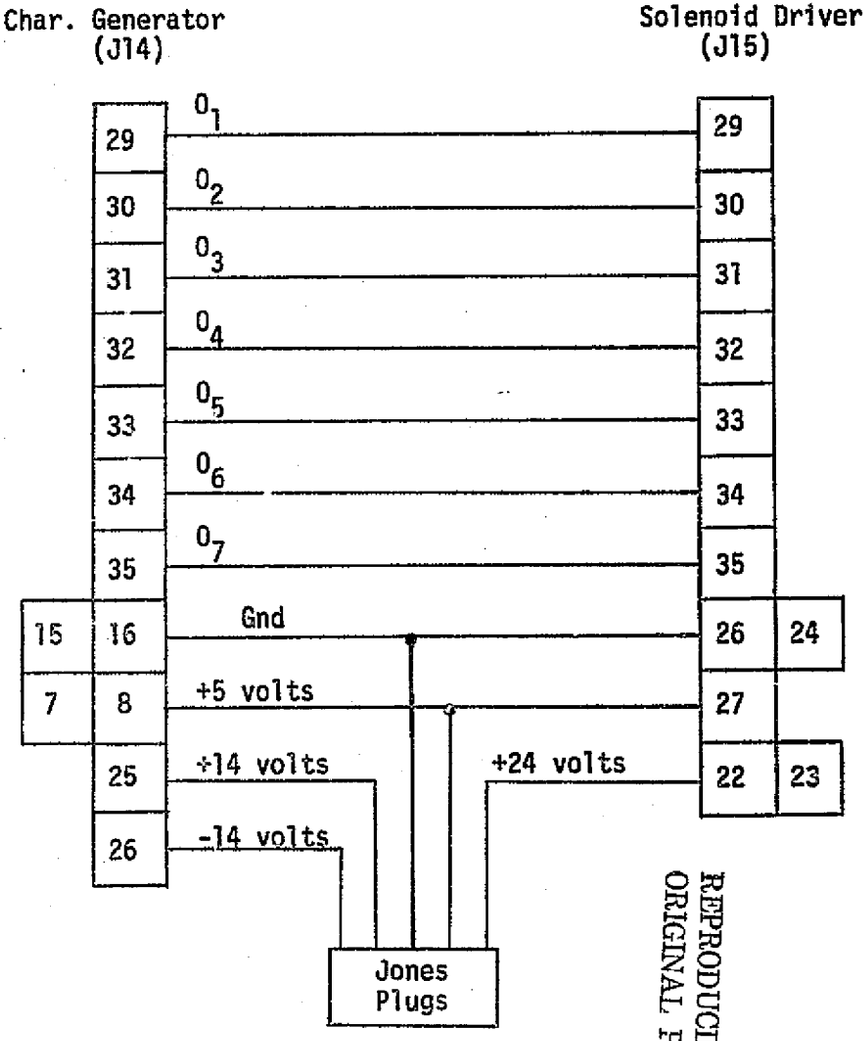
PANEL PRINTER

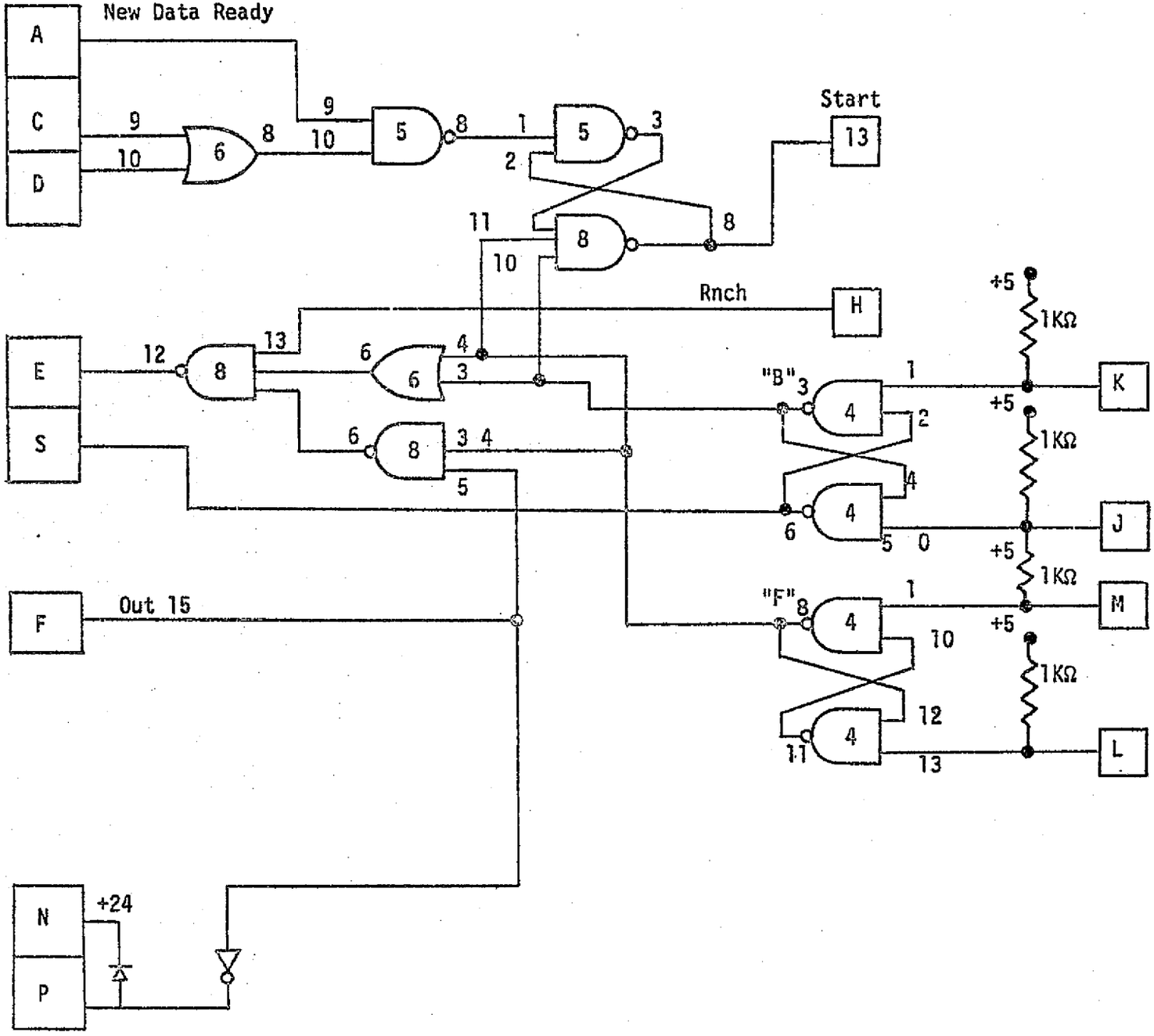
LSI-11 to Character Generator



PANEL PRINTER

Character Generator to Solenoid Driver





4	
6	
7	8
3	5
2	
1	

IC #'s
(Backside)

#1 7490
#2 7490
#3 7490
#4 7400
#5 7400
#6 7432
#7 7406
#8 7410

PANEL PRINTER INTERFACE

D12

APPENDIX E

Device and Register Assignments

A	B	C	D	E	F
CPU & MEMORY (4-8K) - RAM				PROTOTYPE BOARD	Timer Start-UP
ADAC 800 A/D					
MEMORY (0-4K) - ROM		MEMORY (12-16K - RAM			
CP1 - DRV11 A	Parallel	MEMORY (8-12K) - ROM		Printer Hardware	
CP2 - DRV11B	Parallel	REV11-C	Bootstrap Refresh		
VIDEO - DLV11A	Serial	PRINTER - DRV11C	Parallel		
Power-Up & Oscillator Circuit		DRV11 - Interrupt Acknowledge			
		TEV11 - 120Ω Terminator			

Memory Bank - User Selectable Jumpers

BANK 0 - PROM

W8	I
W9	I
W10	I
W15	I
W16	I
W17	I

BANK 2 - PROM

W8	I
W9	I
W10	I
W15	I
W16	I
W17	I
W1	R
↓	
W7	R

BANK 1 - CPU RAM

W1	I
W2	R
W3	R
W4	I
W5	R
W6	R
W9	R
W10	I
W11	I

BANK 3 - RAM

W1	I
W2	R
W3	R

NOTE:
I = Installed jumper
R = Removed jumper

I. CPU-KD11F

POWER UP MODE: MODE 0
MEMORY BANK: 1 (20000-37776)
INTERRUPTS: ENABLED
CPU MEMORY REFRESH: DISABLED

II. RAM - MSV11B

BOARD 3: (60000-77776)

III. ROM-MRV11A (512 x 4 bit ROM)

BOARD 0: (00000-17776)
BOARD 2: (40000-57776)

IV. TELETYPE - SERIAL INTERFACE - DLV11

BAUD: 300
DEVICE: 177760 RCSR
177762 RBUF
177764 XCSR
177766 XBUF
INTERRUPTS: 60 RECEIVER
64 XMITTER

V. CONTROL PANEL - PARALLEL INTERFACE - DRV11A

DEVICE: 167770 DRCSR (DRAS)
167772 DROUTBUF (DRAO)
167774 DRINBUF (DRAI)
INTERRUPTS: 300 PANEL-ABORT
304 Q MANEUVER

VI. CONTROL PANEL - PARALLEL INTERFACE - DRV11B

DEVICE: 167760 DRCSR (DRBS)
167762 DROUTBUF (DRBO)
167764 DRINBUF (DRBI)
INTERRUPTS: 310 ECG COUNT
314 100 MSEC CLOCK

LSI-II BOARD
CONFIGURATION

VII. PANEL PRINTER - PARALLEL INTERFACE - DRV11C

DEVICE:	167750	DRCSR	(LPTSR)
	167752	DROUTBUF	(LPT)
	167754	DRINBUF	(LPTIN)
INTERRUPTS:	320		
	324		

VIII. A/D - ADAC 600 LSI-11

DEVICE:	176770	A/D STATUS	(ADSR)
	176772	A/D DATA	(ADIN)
	176760	DAC1	(DAC1)
	176762	DAC2	(DAC2)
VECTOR:	130 ERROR OR DONE		

IX. INTERRUPT ACKNOWLEDGE

DEVICE:	167740	DRCSR
	167742	DROUTBUF
	167744	DRINBUF

	DEVICE	+5 VOLTS	+12 VOLTS
1.	CPU (4K RAM)	1.8A→2.4A (max.)	0.8A→1.1A (max.)
2.	ADAC A/D	2.5A	
3.	Control Panel (2 DRV11's) Buttons (@0.25A) LED'S (@0.030A) LED Indicator (@0.035A)	0.85A→1.3A 0.85A→1.3A 3.0A 0.36A 0.455A	
4.	Panel Printer (DRV11)	0.85A→1.3A	
5.	Video Monitor (DLV11)	1.0A→1.6A	0.18A→0.25A
6.	Bootstrap (REV11-A)	1.64A→2.24A	
7.	8K RAM (2 MRV11)	0.56A→1.12A 0.56A→1.12A	
8.	ROM (BANK 0)	2.8A→4.1A	
9.	ROM (BANK 2)	1.0A→2.3A	
10.	TERMINATOR (TEV11)	0.54A→0.70A	
		18.765A→25.795A (max.)	

LSI-II POWER REQUIREMENTS

STATUS REGISTER (1677X0 = DRCSR)

Bit	Signal	Description
15	REQ B	REQUEST B - under control of user's device and may be used to initiate an interrupt sequence or generate a flag that may be tested by the program. When used as an interrupt request; it is asserted by the external device and initiates an interrupt provided the INT ENB B bit (bit 05) is also set.
14-08		Not used. Read as 0.
07	REQ A	REQUEST A - same function as REQB except that interrupt is generated only if INT ENB A (bit 06) is also set.
06	INTA	INT ENB A - Interrupt enable bit. When set, allows an interrupt request to be generated, provided REQUEST A (bit 07) becomes set.
05	INTB	INT ENB B - Interrupt enable bit. When set, allows an interrupt request to be generated, provided REQUEST B (bit 15) becomes set.
04-02		Not used. Read as 0.
01	CSR1	CSR1 - This bit can be loaded or read under program control and can be used for a user - defined command to the device.
00	CSR0	CSR0 - Performs same function as CSR1.

STATUS REGISTER

PARALLEL LINE INTERFACE - DRV11*

* from: Digital Microcomputer Handbook, Digital Equipment Corp., 1976.

STATUS REGISTER (INPUT)

Bit	Signal	Description
15		Dataset Status - Done (or Ready) flag
14-08		Not used. Read as 0.
07		Receiver done - Set when an entire character has been received and is ready for input to the processor.
06		Interrupt Enable - Set under program control when it is desired to generate a receiver interrupt request when bit 07 is set.
05-01		Not used. Read as 0.
00		Reader enable - Set by program control to advance the input device to input a new character.

STATUS REGISTER (OUTPUT)

15-08		Not used. Read as 0.
07		Transmit ready - Set when buffer is empty and can accept another character for transmission.
06		Interrupt Enable - Set under program control when it is desired to generate a transmitter interrupt request when the DLV11 is ready to accept a character for transmission.
05-01		Not used. Read as 0.
00		Break - Set or reset under program control. When set, a continuous space level is transmitted.

STATUS REGISTERS

SERIAL LINE INTERFACE - DLV11*

* from: Digital Microcomputer Handbook, Digital Equipment Corp., 1976.

INPUT SIGNALS

DRV11-SIGNAL	PANEL-SIGNAL
IN00	SUBJECT-TW-BIT1
IN01	SUBJECT-TW-BIT2
IN02	SUBJECT-TW-BIT4
IN03	MASS SPEC-TW-BIT1
IN04	MASS SPEC-TW-BIT2
IN05	PFT SELECT - PB
IN06	PTC/PBF SELECT-PB
IN07	PFT CALMS-PB
IN08	PFT WO-PB
IN09	PFT FVC-PB
IN10	PFT RPT-PB
IN11	PFT END-PB
IN12	PTC/PBF CALMS-PB
IN13	PTC/PBF ROOM-PB
IN14	PTC/PBF START-PB
IN15	

OUTPUT SIGNALS

DRV11-SIGNAL	PANEL-SIGNAL
OUT00	IDLE-LT
OUT01	PFT-LT
OUT02	PFT CALMS REQ-LT
OUT03	PFT CALMS RUN-LT
OUT04	PFT WO REQ-LT
OUT05	PFT WO RUN-LT
OUT06	PFT FVC REQ-LT
OUT07	PFT FVC RUN-LT
OUT08	PFT RPT REQ-LT
OUT09	PFT RPT RUN-LT
OUT10	PFT END REQ-LT
OUT11	
OUT12	
OUT13	
OUT14	
OUT15	RUN-LT

INTERRUPT SIGNALS

REQA	PFT ABORT - PB & PTC/PBF ABORT-PB
REQB	PTC/PBF Q MANEUVER-PB

DEVICE ADDRESSES

167770	DRCSR	(DRAS)
167772	DROUTBUF	(DRAO)
167774	DRINBUF	(DRAI)

STATUS SIGNALS

CSR0	SPIROMETER DUMP CONTROL
CSR1	BPMS TRIGGER

INTERRUPT VECTORS

300	INTA - PFT ABORT & PTC/PBF ABORT
304	INTB - PTC/PBF Q REQ-PB

LEGEND

TW - THUMBWHEEL
PB - PUSHBUTTON
LT - LIGHT
SW - SWITCH

CONTROL PANEL
DRV11-BOARD A

INPUT SIGNALS		OUTPUT SIGNALS	
DRV11-SIGNAL	PANEL-SIGNAL	DRV11-SIGNAL	PANEL-SIGNAL
IN00	PRINTER SELECT-SW	OUT00	PTC/PBF RUN-LT
IN01	OBDS SELECT-SW	OUT01	PTC CALMS REQ-LT
IN02		OUT02	PTC CALMS RUN-LT
IN03		OUT03	PTC ROOM REQ-LT
IN04		OUT04	PTC ROOM RUN-LT
IN05		OUT05	PTC START REQ-LT
IN06		OUT06	PTC START RUN-LT
IN07		OUT07	PTC Q REQ-LT
IN08		OUT08	PTC Q RUN-LT
IN09		OUT09	PTC END REQ-LT
IN10		OUT10	PFT SELECT-LT
IN11		OUT11	PTC/PBF SELECT-LT
IN12		OUT12	
IN13		OUT13	
IN14		OUT14	
IN15		OUT15	RUN-LT

INTERRUPT SIGNALS

REQA	ECG HR COUNT INTERRUPT
REQB	100 MSEC CLOCK INTERRUPT

DEVICE ADDRESSES

167760	DRCSR	(DRBS)
167762	DROUTBUF	(DRBO)
167764	DRINBUF	(DRBI)

INTERRUPT VECTORS

310	INTA - HR COUNT INTERRUPT
314	INTB - 100 MSEC CLOCK INTERRUPT

LEGEND

PB - PUSHBUTTON
LT - LIGHT
SW - SWITCH

CONTROL PANEL
DRV11-BOARD B

INPUT SIGNALS		OUTPUT SIGNALS	
DRV11 SIGNAL	PRINTER SIGNAL	DRV11 SIGNAL	PRINTER SIGNAL
IN00		OUT00	BIT 0 - ASCII char.
IN01		OUT01	BIT 1 - ASCII char.
IN02		OUT02	BIT 2 - ASCII char.
IN03		OUT03	BIT 3 - ASCII char.
IN04		OUT04	BIT 4 - ASCII char.
IN05		OUT05	BIT 5 - ASCII char.
IN06		OUT06	BIT 6 - ASCII char.
IN07		OUT07	
IN08		OUT08	
IN09		OUT09	
IN10		OUT10	
IN11		OUT11	
IN12		OUT12	
IN13		OUT13	
IN14		OUT14	
IN15	NEW LINE READY	OUT15	Start Carriage Signal

INTERRUPT SIGNALS

REQA	PRINT character request
REQB	not used

DEVICE ADDRESSES

167750	LPTSR
167752	LPT
167754	LPTIN

INTERRUPT VECTORS

320	PRINT
324	not used

PANEL PRINTER

DRV11-BOARD C

STATUS REGISTER (ADSR = 176770)

Bit	Signal	Description
D15	ERROR	Set if ADC trigger occurs and previous conversion is not complete.
D14	MAINTENANCE	
D13	2^5	
D12	2^4	
D11	2^3	Loads multiplexor address to select one of 64 channels and initiates a conversion (If D01=0)
D10	2^2	
D09	2^1	
D08	2^0	
D07	DONE	Set by completion of conversion, reset upon reading data register or initialize.
D06	INT ENABLE	Program selectable interrupt mode. Interrupt produced by ADC done (D07) or error (D15) when selected.
D05	RESERVED	
D04	GAIN 2^1	Sets gain of programmable gain amplifier option. 11 sets lowest gain and 00 sets highest gain.
D03	GAIN 2^0	
D02	SEQ/RAND	Zero selects random mode for multiplexer. One selects sequential mode for multiplexer.
D01	EXT.ENABLE	Enables clock source to trigger ADC.
D00	START	Triggers ADC, if ext. enable, D1, is a zero.

Perkin-Elmer Mass Spectrometer - Serial Number 9

	Sensitivity Range		
O_2	0 - +5V D.C.	0 to 220 torr	44 torr/volt
N_2	0 - +5V D.C.	0 to 660 torr	132 torr/volt
CO_2, H_2O	0 - 5V D.C.	0 to 66 torr	13.2 torr/volt

ADAC MODEL 600 ANALOG-TO-DIGITAL CONVERTER

I. SPECIFICATIONS

A. 32 Channels A/D

B. Input Voltage Range ←—: -10v to +10v (max. of ± 15v)

C. Input Impedance: Greater than 100 megohms

D. Resolution: 12 bits

E. Maximum Throughput Rate (12 bits): 50,000 channels/second.

F. Sample and Hold Aperture Uncertainty: 20 nanoseconds

G. Jumper-Selectable Modes of Operation

1. Single-ended

2. Pseudo differential

3. Fully differential

H. Programmable Gain Amplifier (PGA)

1. Four gain settings: 1,2,5,10

I. Conversion Times

1. No PGA

a. 5 microseconds for multiplexer and sampling and hold setting

b. 15 microseconds for the A/D conversion

2. With PGA

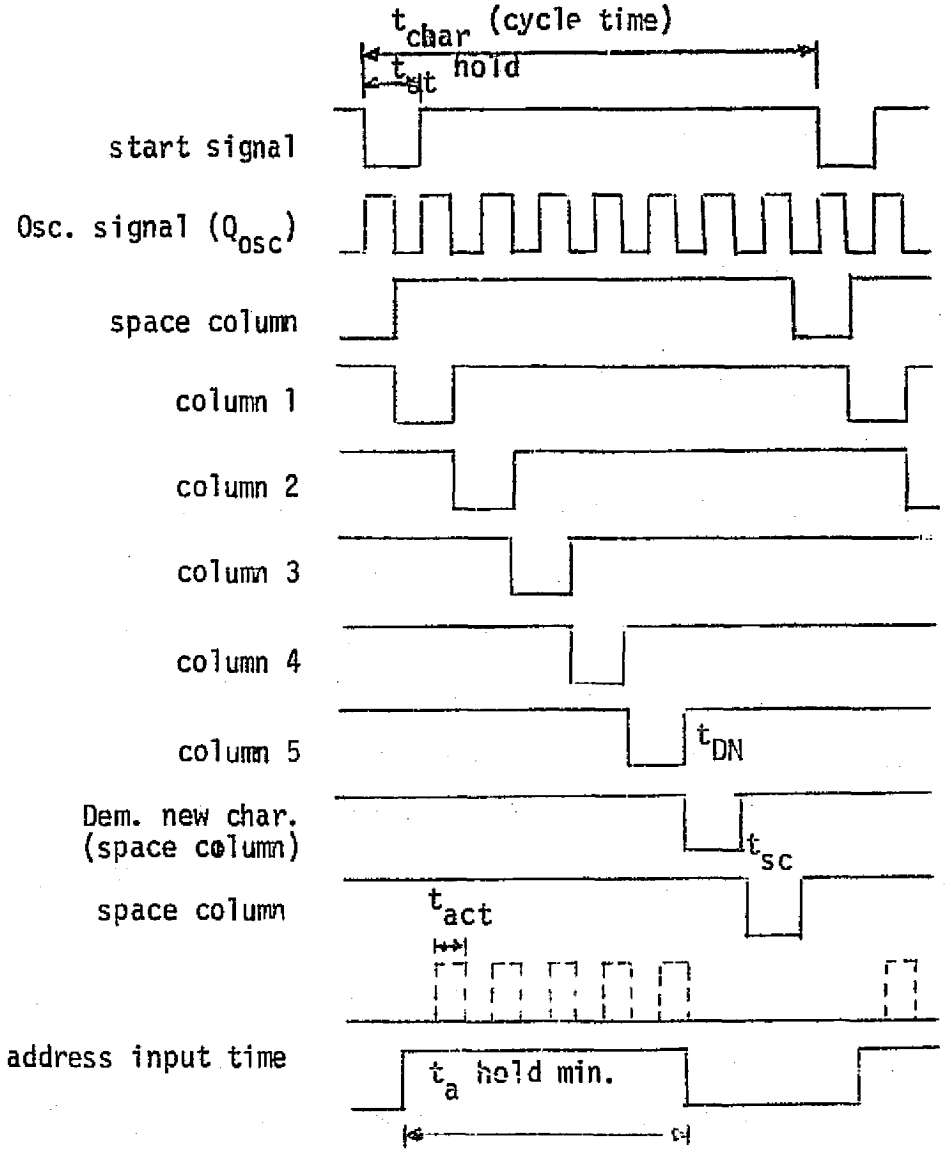
a. 5 microseconds for multiplexor, sampling and hold, and PGA setting

b. 15 microseconds for the A/D conversion

c. 10 microseconds for zeroing operation of the PGA

ANALOG-TO-DIGITAL CONVERTER SPECIFICATIONS
ADAC CORPORATION MODEL 600-LSI-11

Time diagram of a cycle time for one character



NOTE: See following page for symbol legend.

Legend for timing diagram of one character:

t_{sc}	1.8 to 3.4 ms	See note 1	Scanning time of one column
t_{char}	8 x t_{sc}		Cycle time of one character
t_{act}	1.2 ms		Output activation time during one scanning time
t_a hold min	5 x t_{sc}	See note 2	Hold time of input information
t_{st} hold	1 x t_{sc}		Hold time of start signal
t_{DN}	1 x t_{sc}		Time duration of "Demand New Character" signal

The foregoing dynamic data are plotted in "time diagram of a cycle time for one character." (See Below)

NOTE: 1) The scanning time t_{sc} may be adjusted by means of potentiometer P1 for several printing speeds.

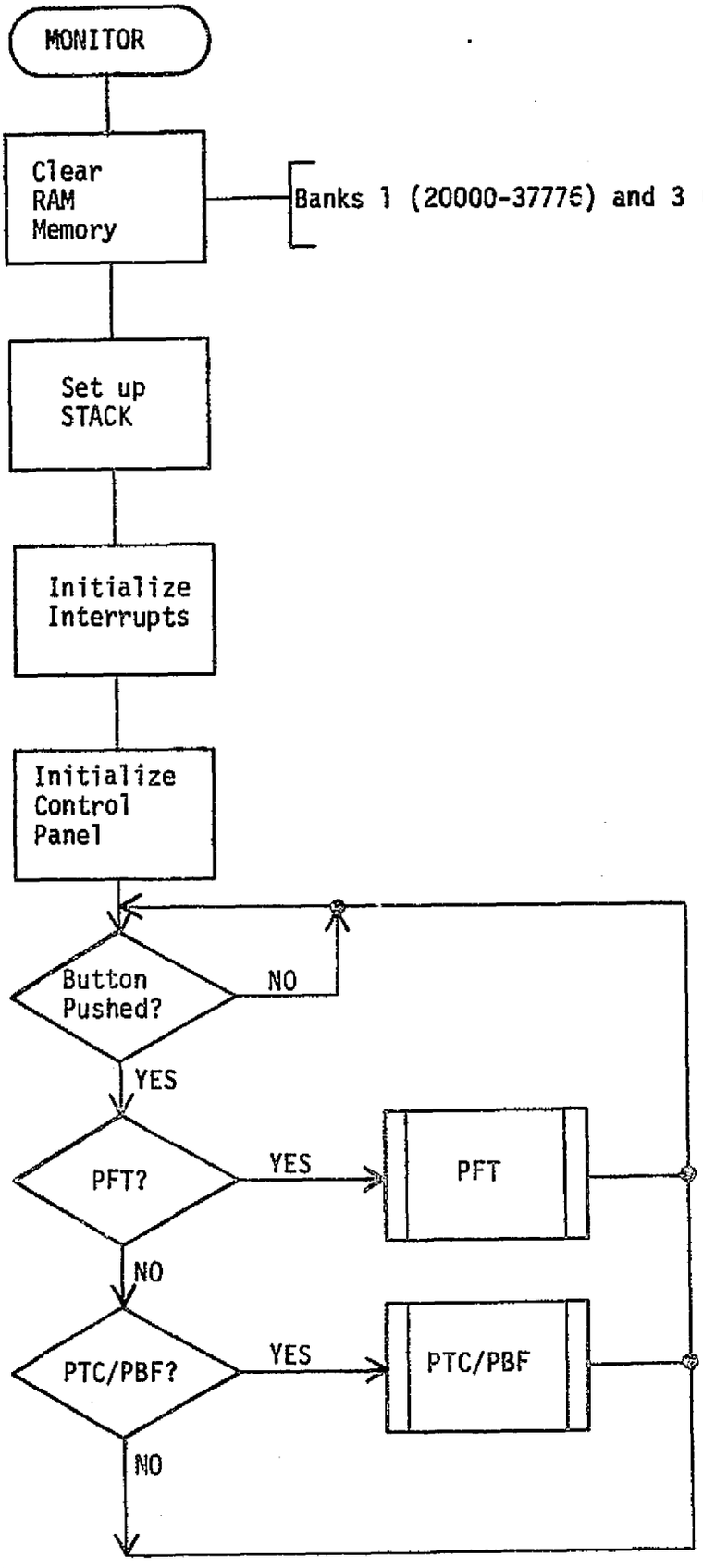
2) The input information must be present during the posttions 1 to 5 of the 8-position counter.

AMPEREX MATRIX PRINTER (cont'd)

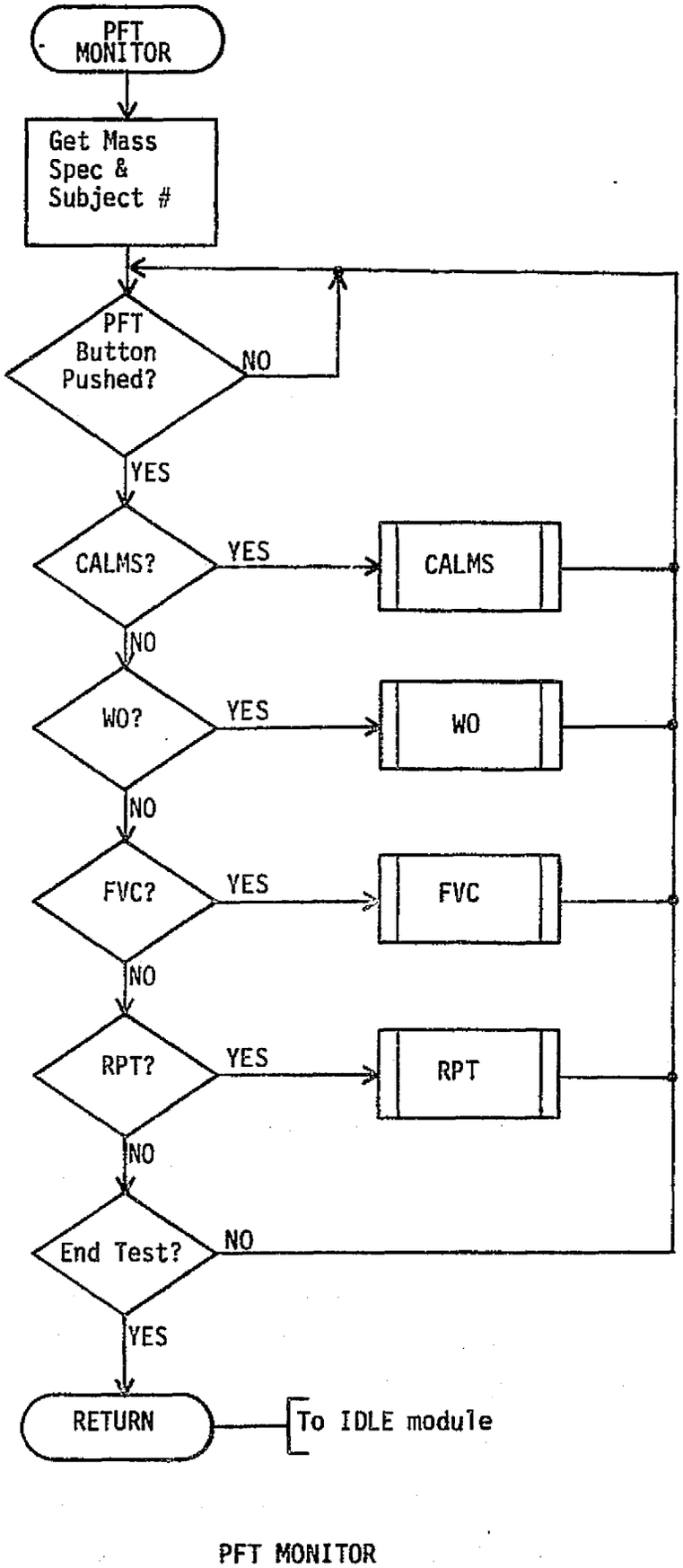
Timing Diagram for One Character

APPENDIX F

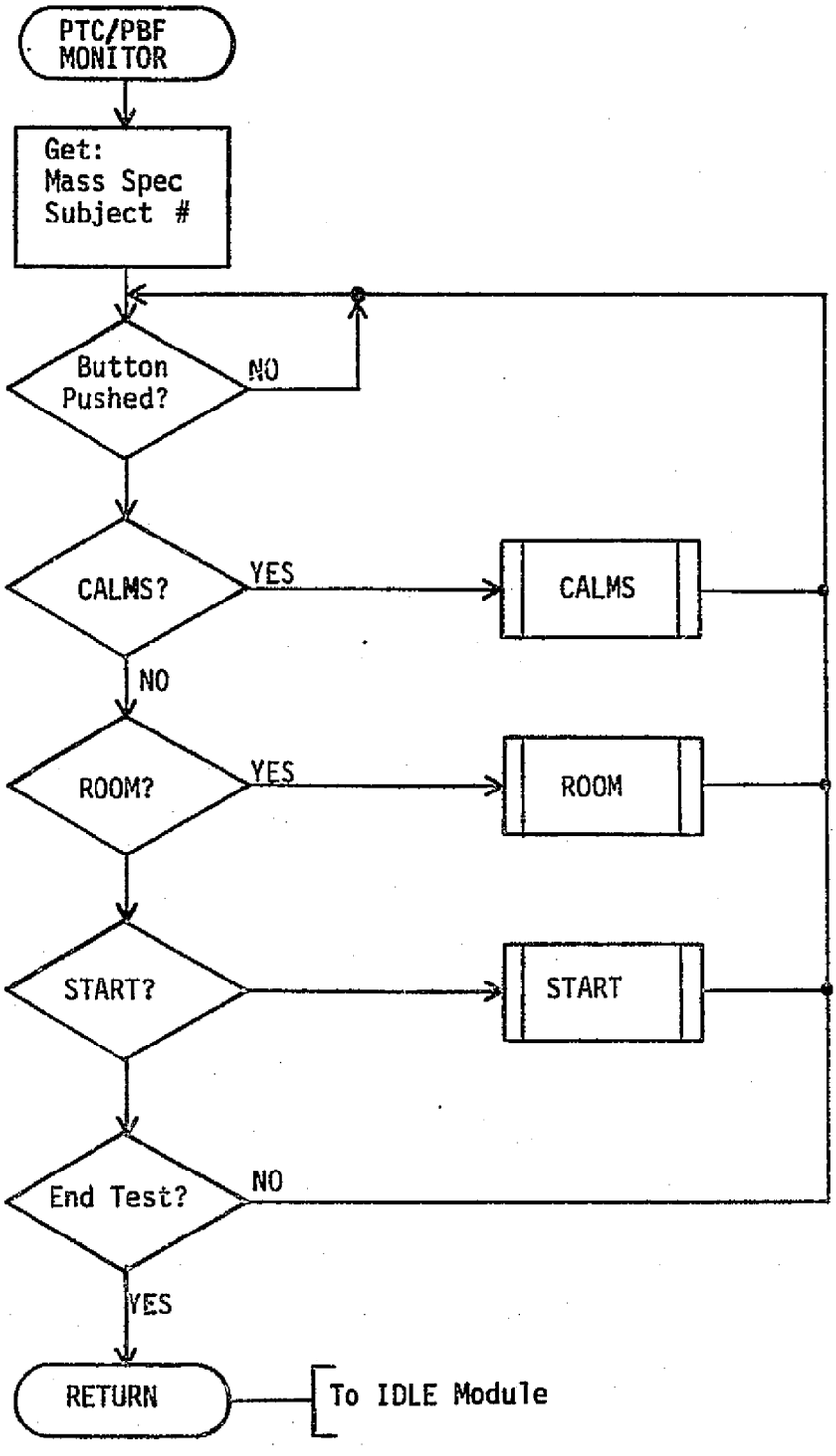
Program Flow Charts



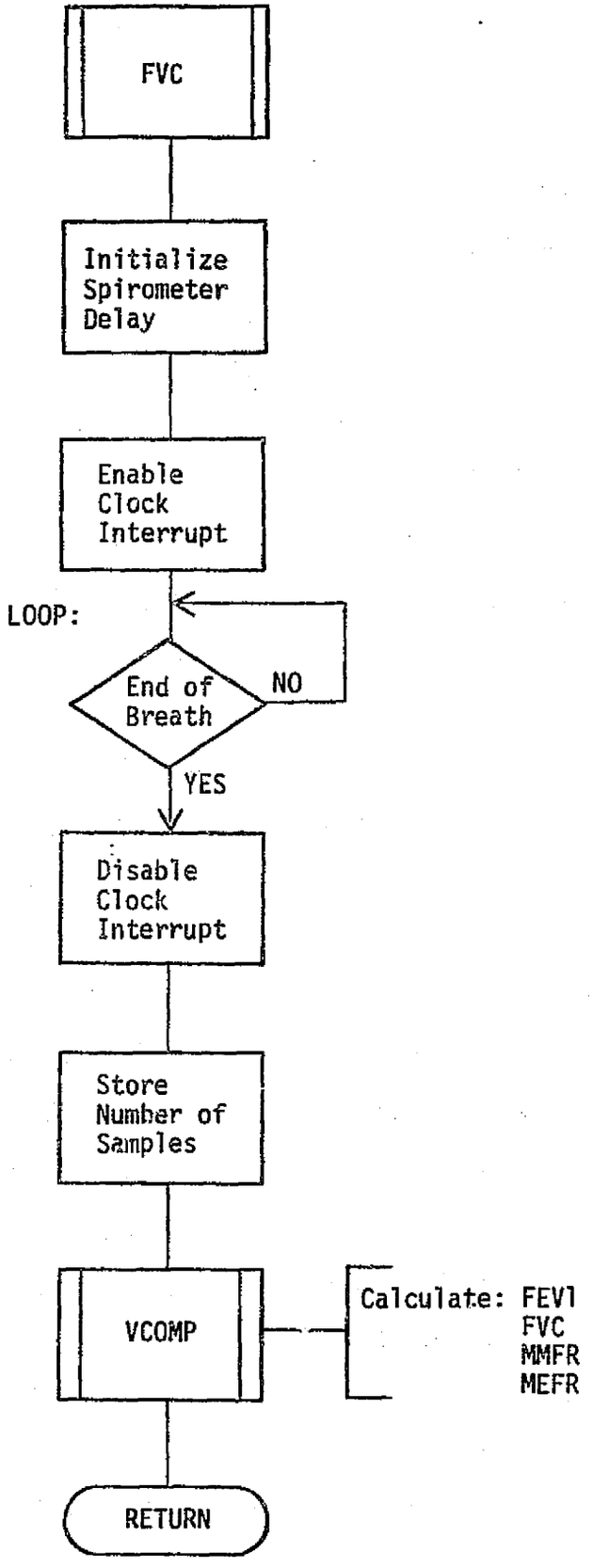
OTR1 PANEL MONITOR


PFT MONITOR
Get Mass Spec & Subject #
PFT Button Pushed?
NO
YES
CALMS?
YES
CALMS
NO
WO?
YES
WO
NO
FVC?
YES
FVC
NO
RPT?
YES
RPT
NO
End Test?
NO
YES
RETURN
To IDLE module

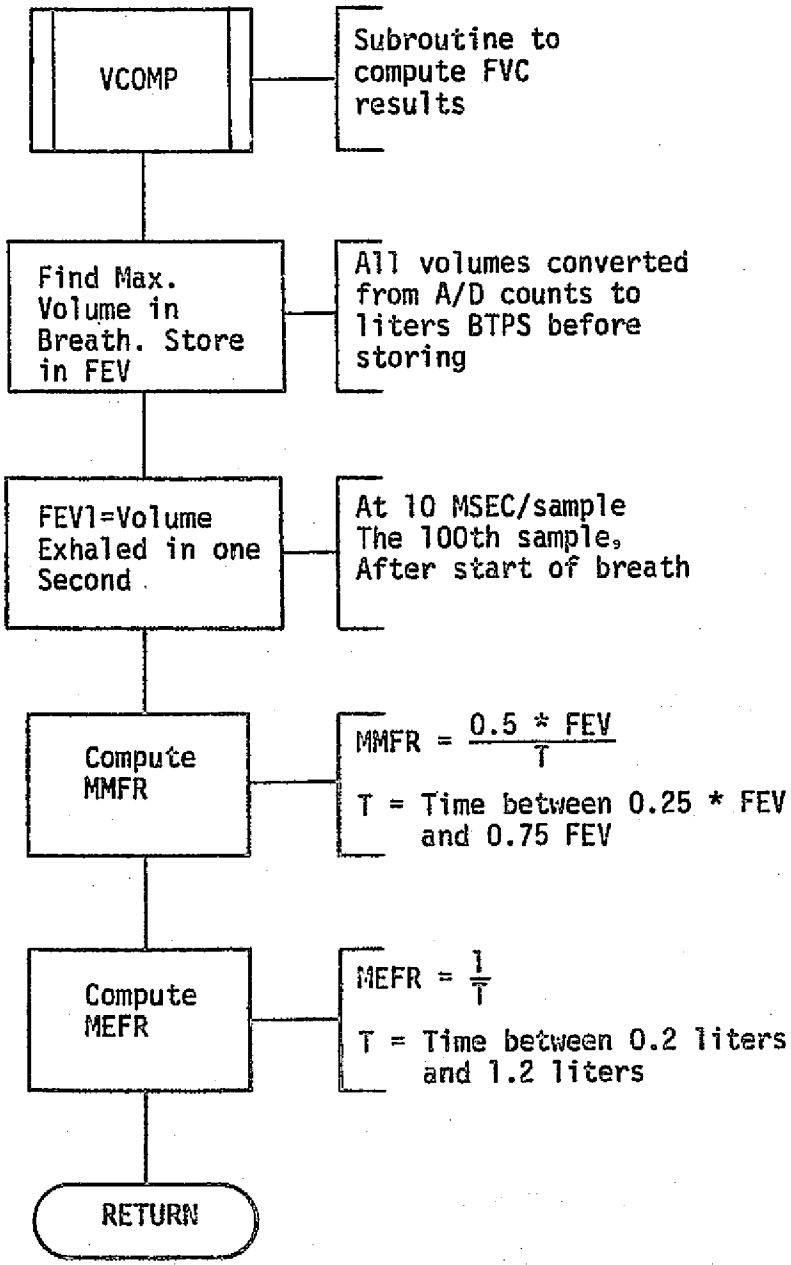
PFT MONITOR



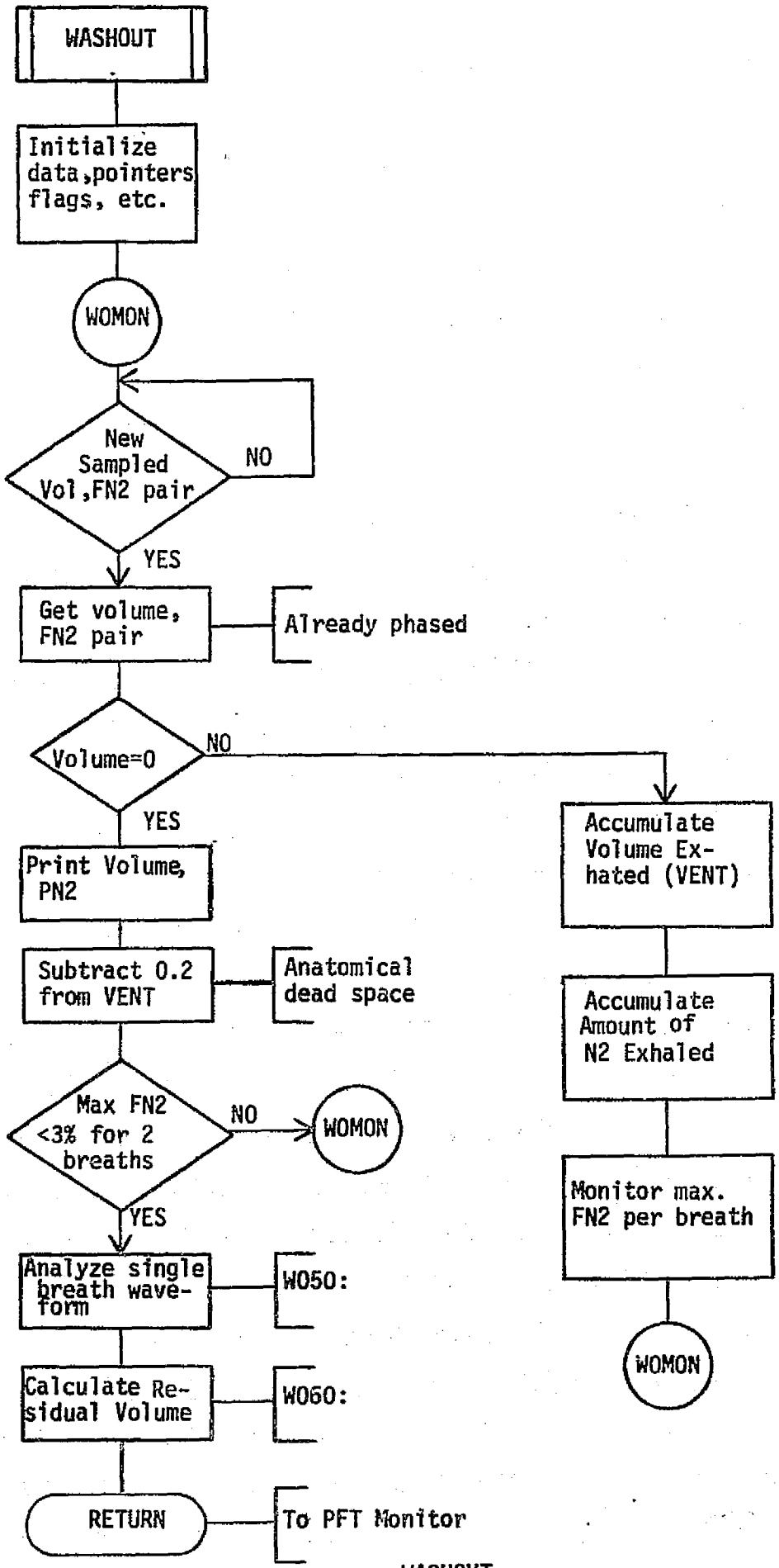
PTC/PBF MONITOR



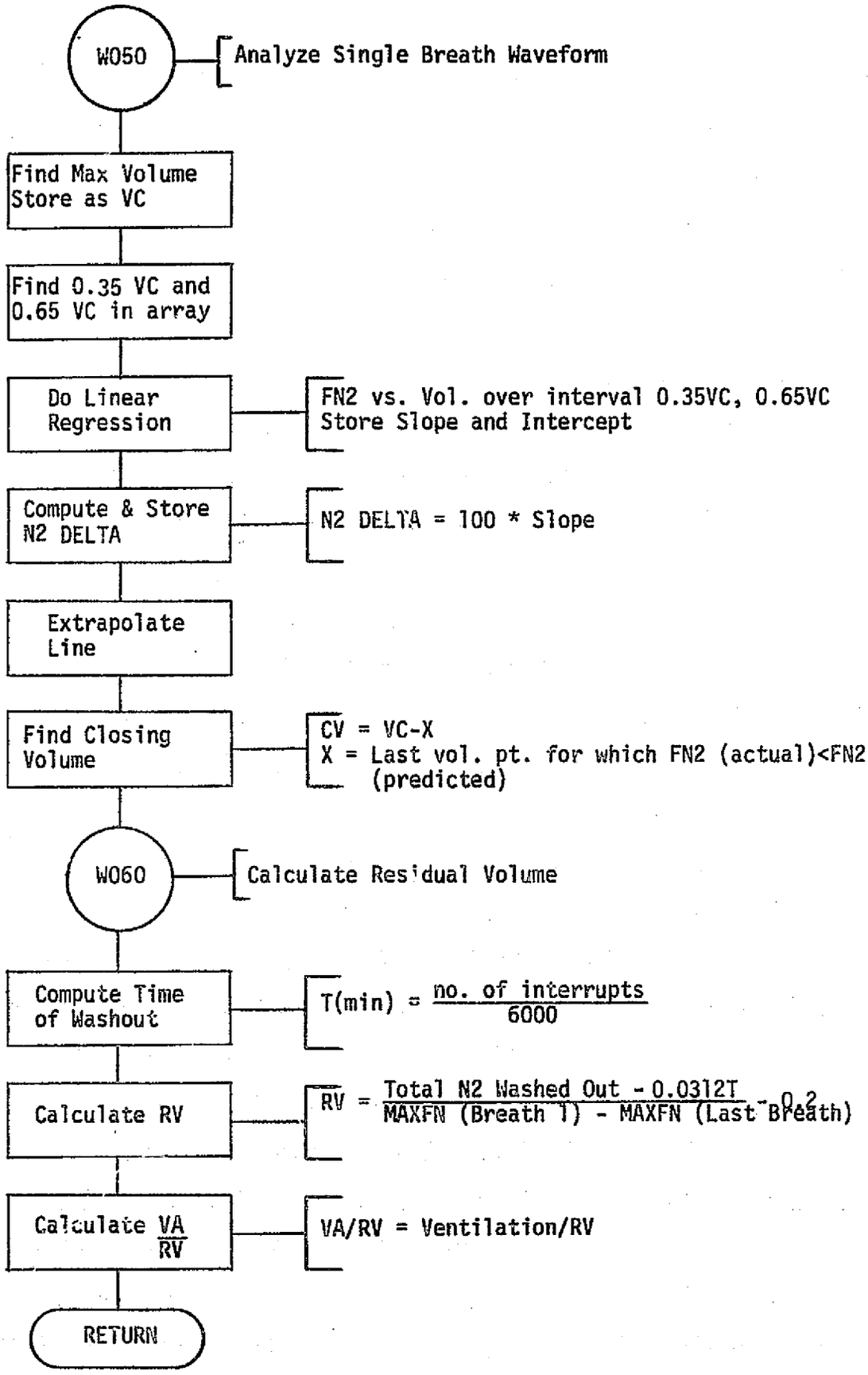
FORCED VITAL CAPACITY



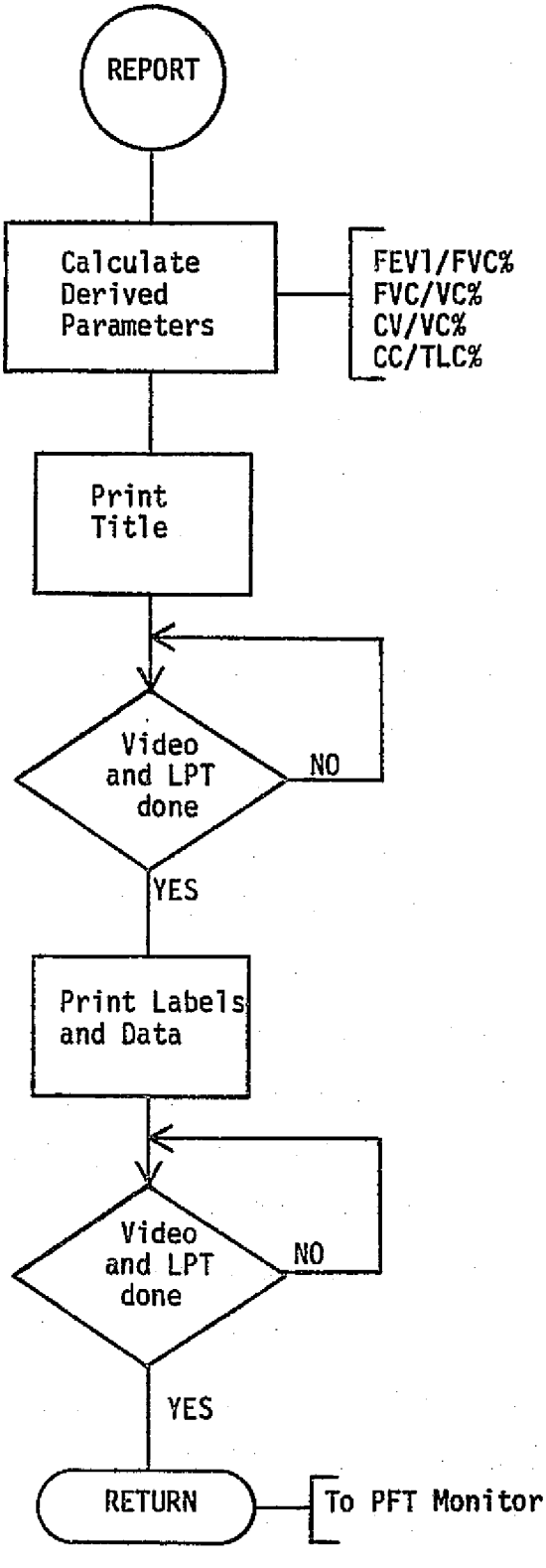
FORCED VITAL CAPACITY (cont'd)

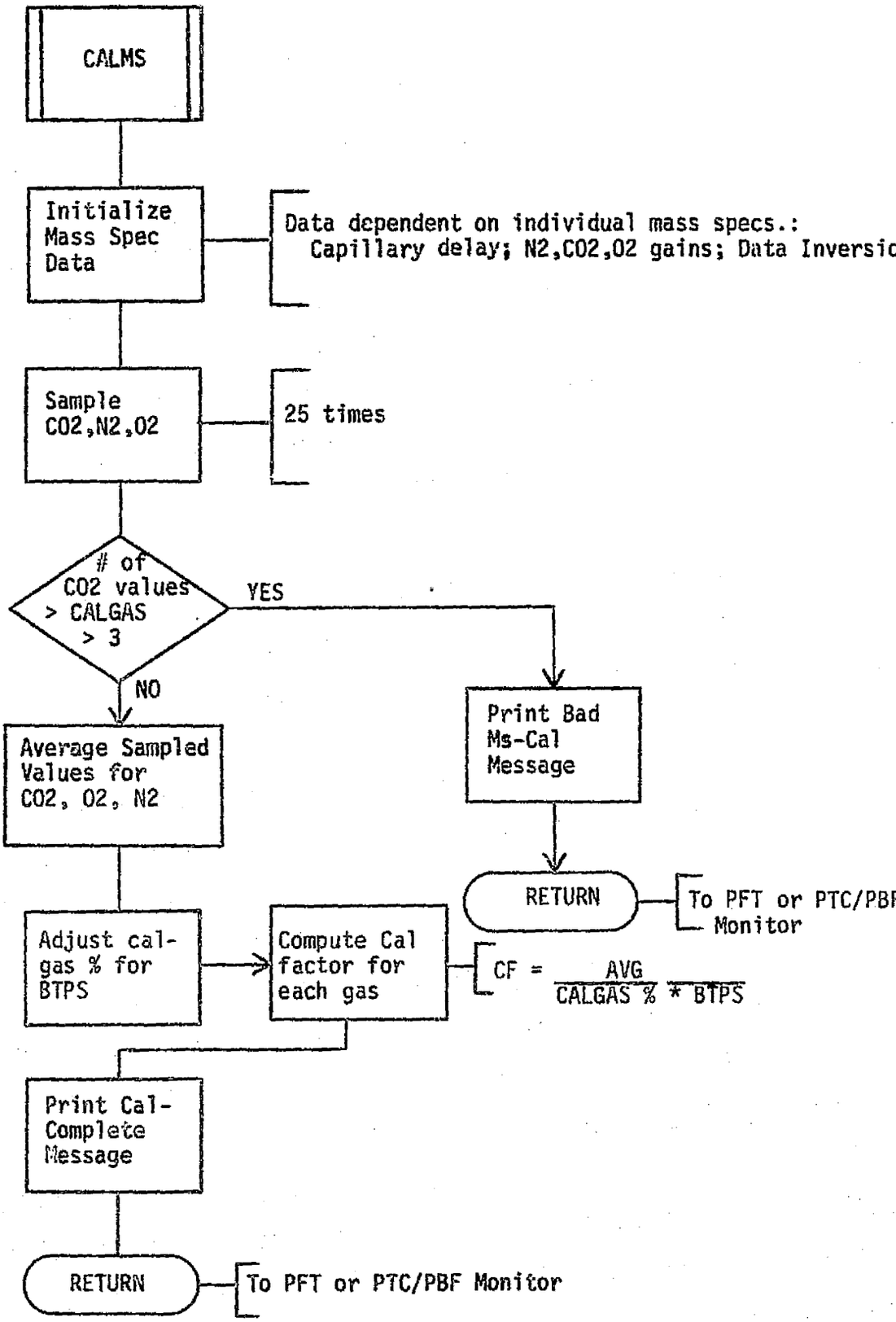

WASHOUT
Initialize data,pointers flags, etc.
WOMON
New Sampled Vol,FN2 pair
NO
YES
Get volume, FN2 pair
Already phased
Volume=0
NO
YES
Print Volume, PN2
Subtract 0.2 from VENT
Anatomical dead space
Max FN2 <3% for 2 breaths
NO
WOMON
YES
Analyze single breath waveform
W050:
Calculate Residual Volume
W060:
RETURN
To PFT Monitor
Accumulate Volume Exhated (VENT)
Accumulate Amount of N2 Exhaled
Monitor max. FN2 per breath
WOMON

WASHOUT

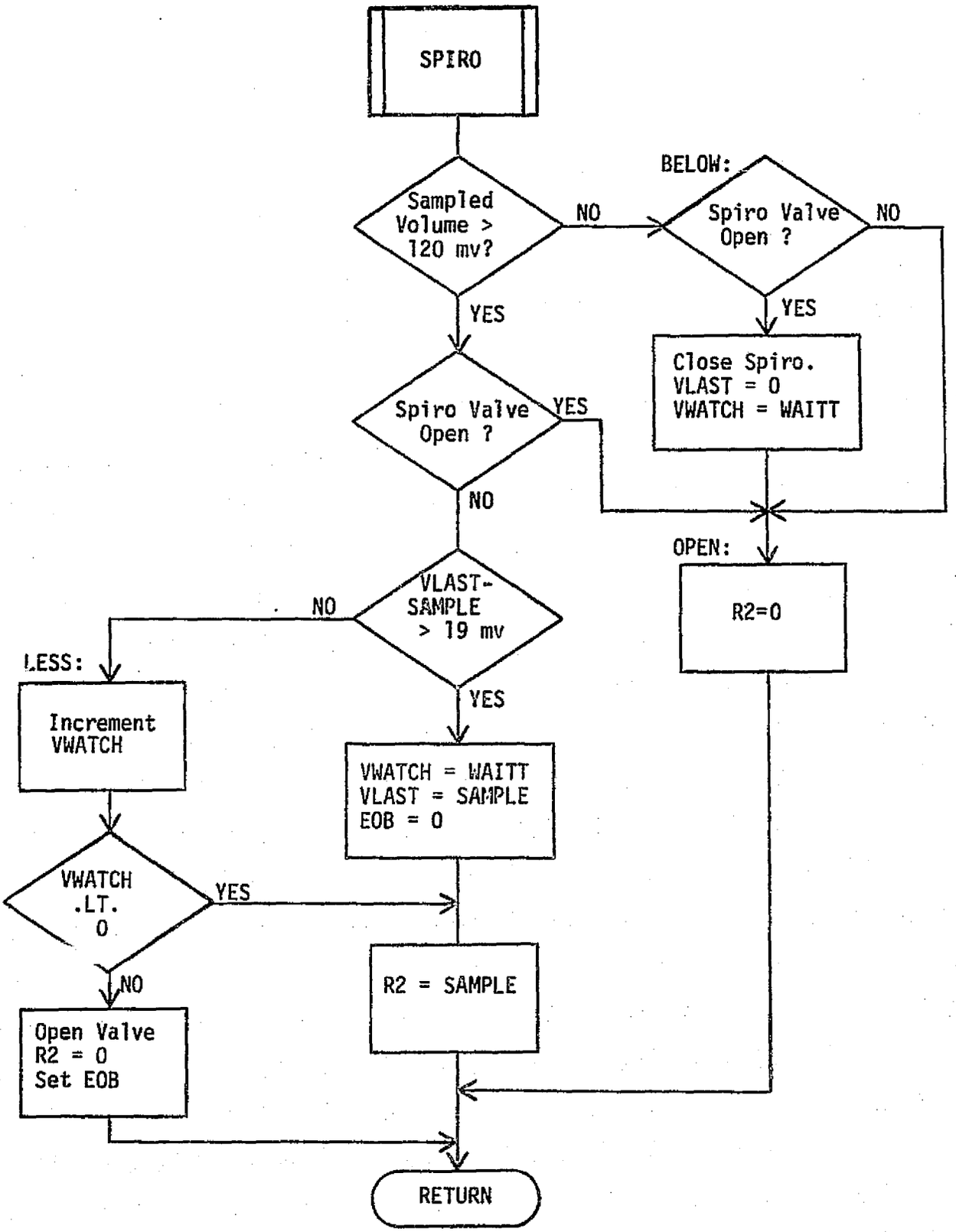


WASHOUT (cont'd)

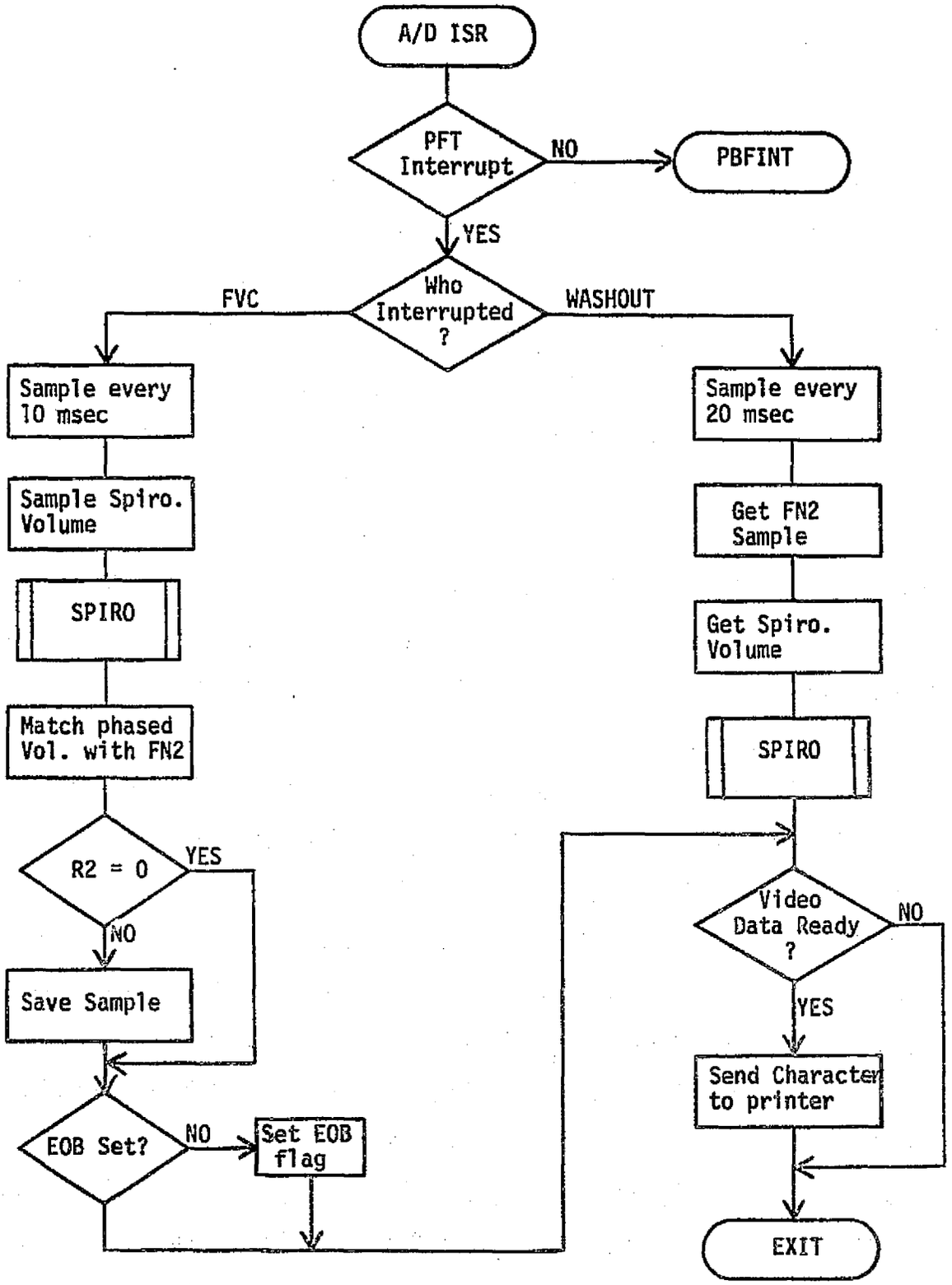

REPORT
Calculate Derived Parameters
FEV1/FVC%
FVC/VC%
CV/VC%
CC/TLC%
Print Title
Video and LPT done
NO
YES
Print Labels and Data
Video and LPT done
NO
YES
RETURN
To PFT Monitor



MASS SPECTROMETER CALIBRATION MODULE

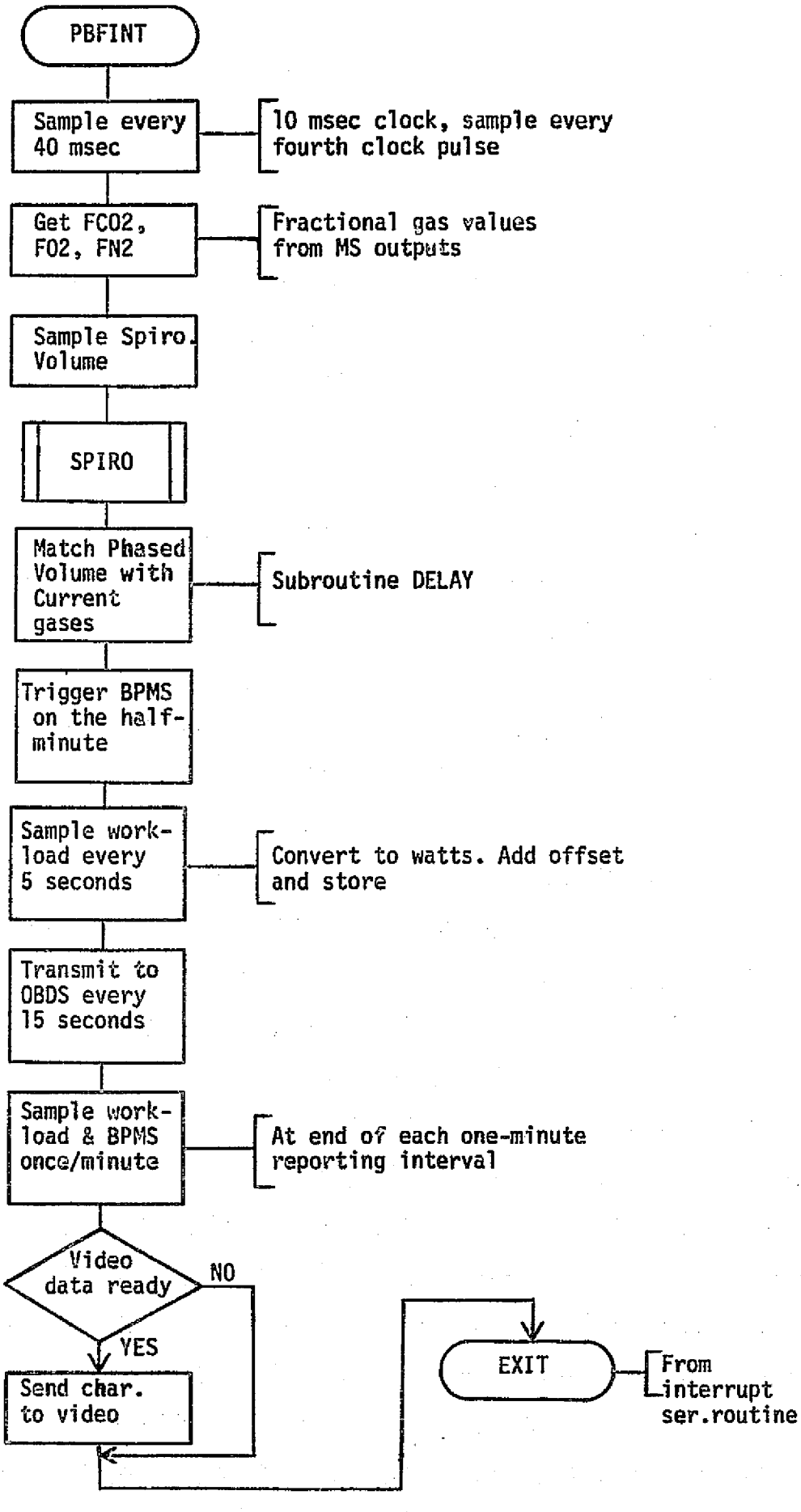


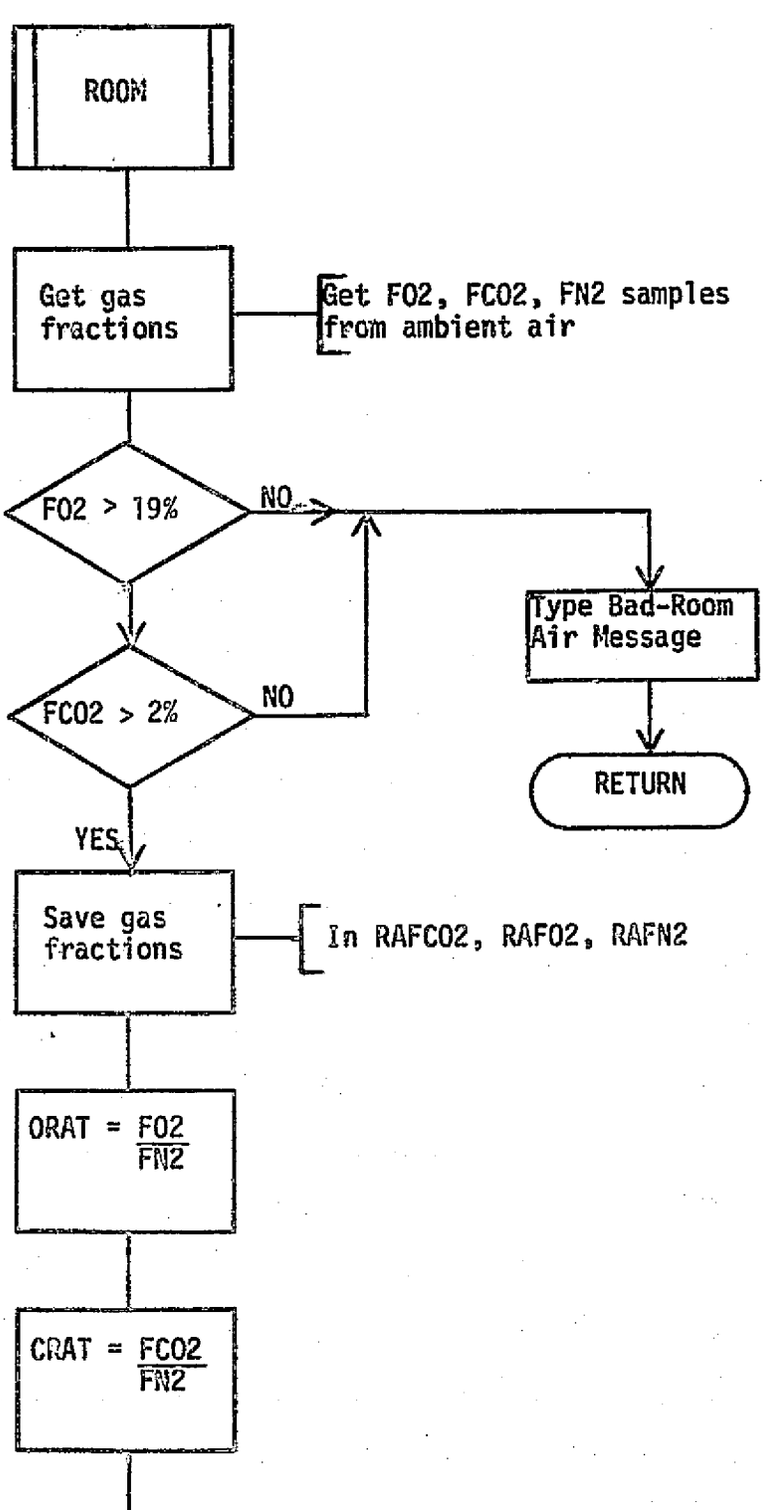
SPIROMETER HANDLER



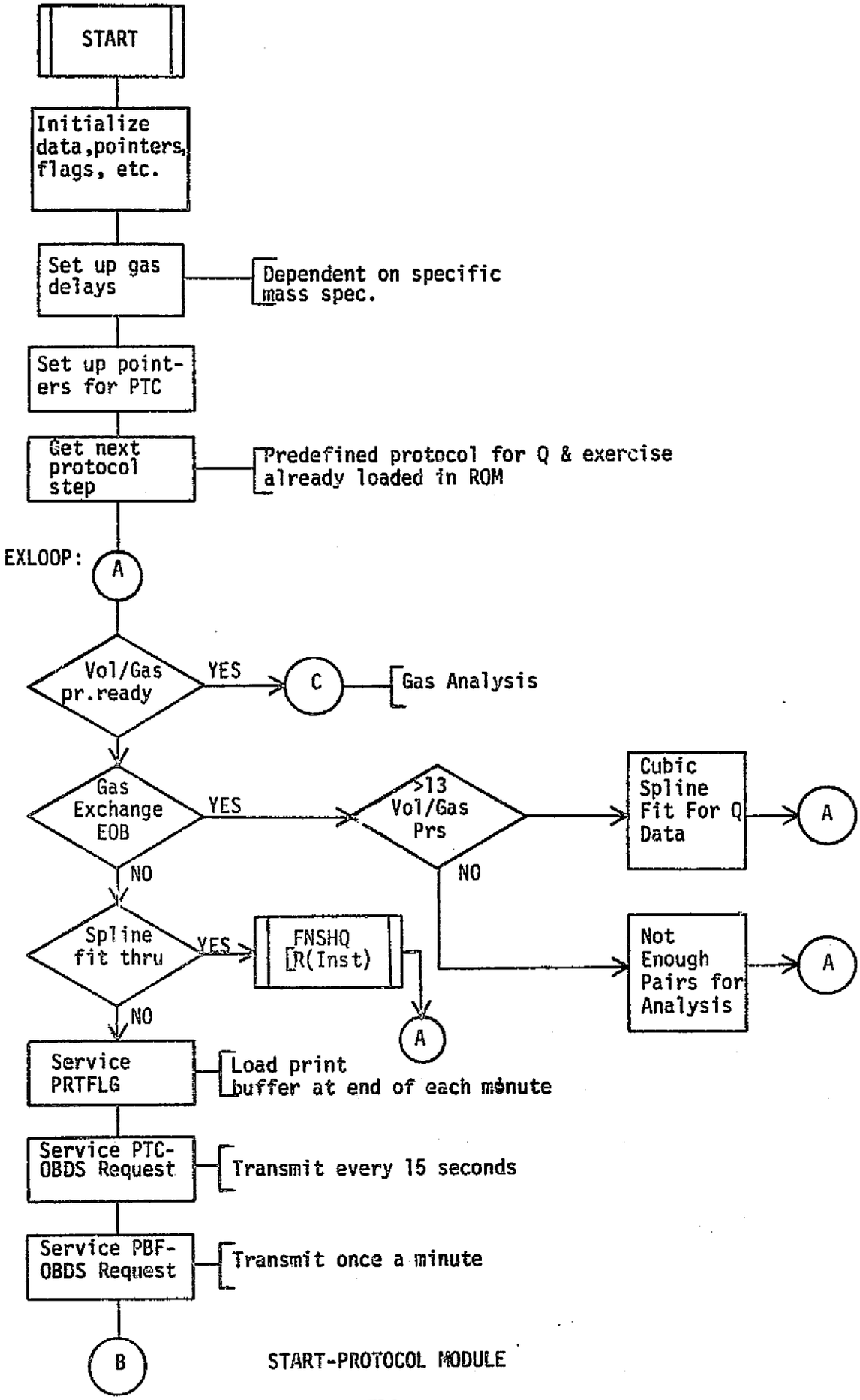
PFT INTERRUPT HANDLER

PTC/PBF INTERRUPT
SERVICE ROUTINE

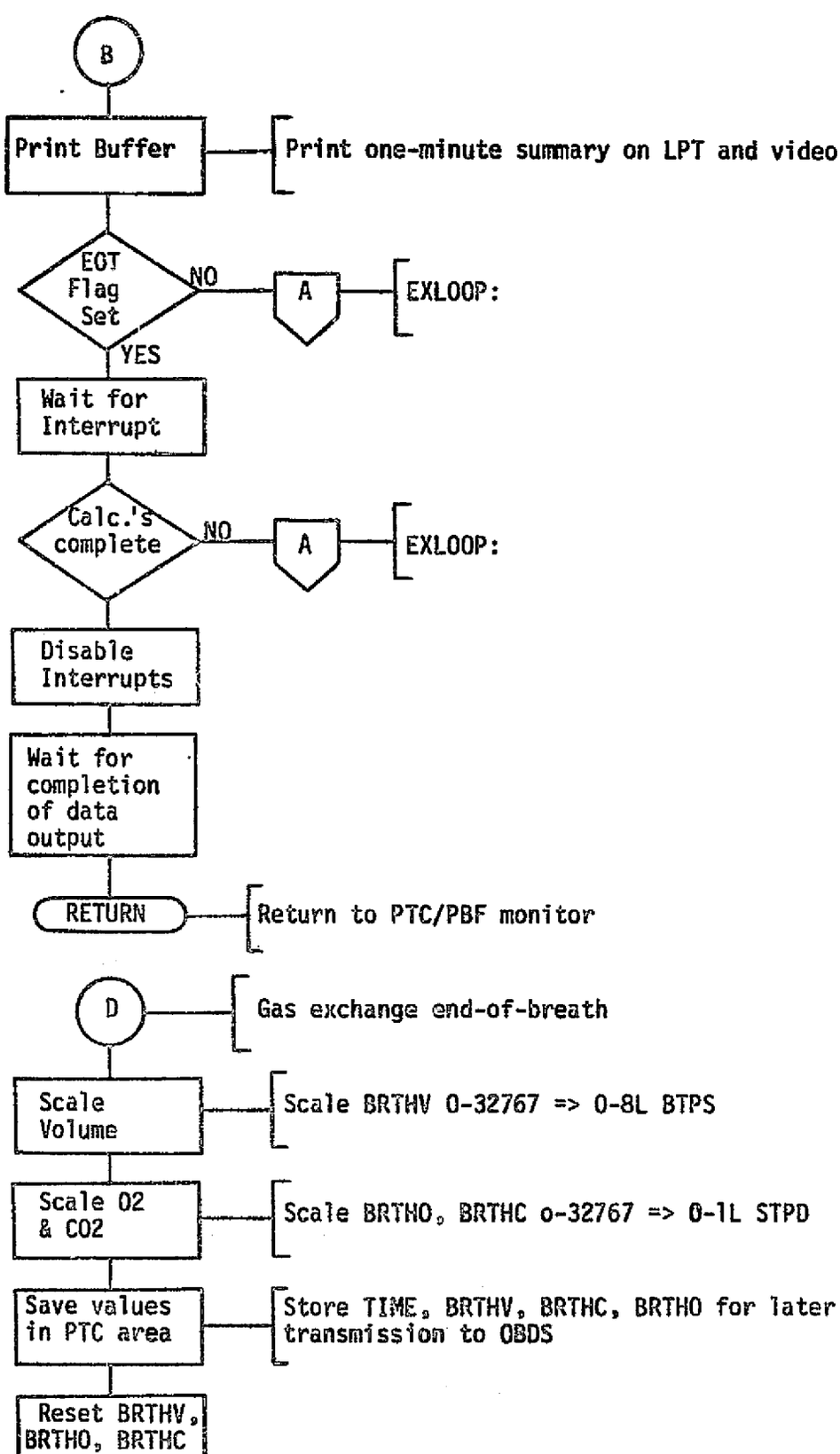




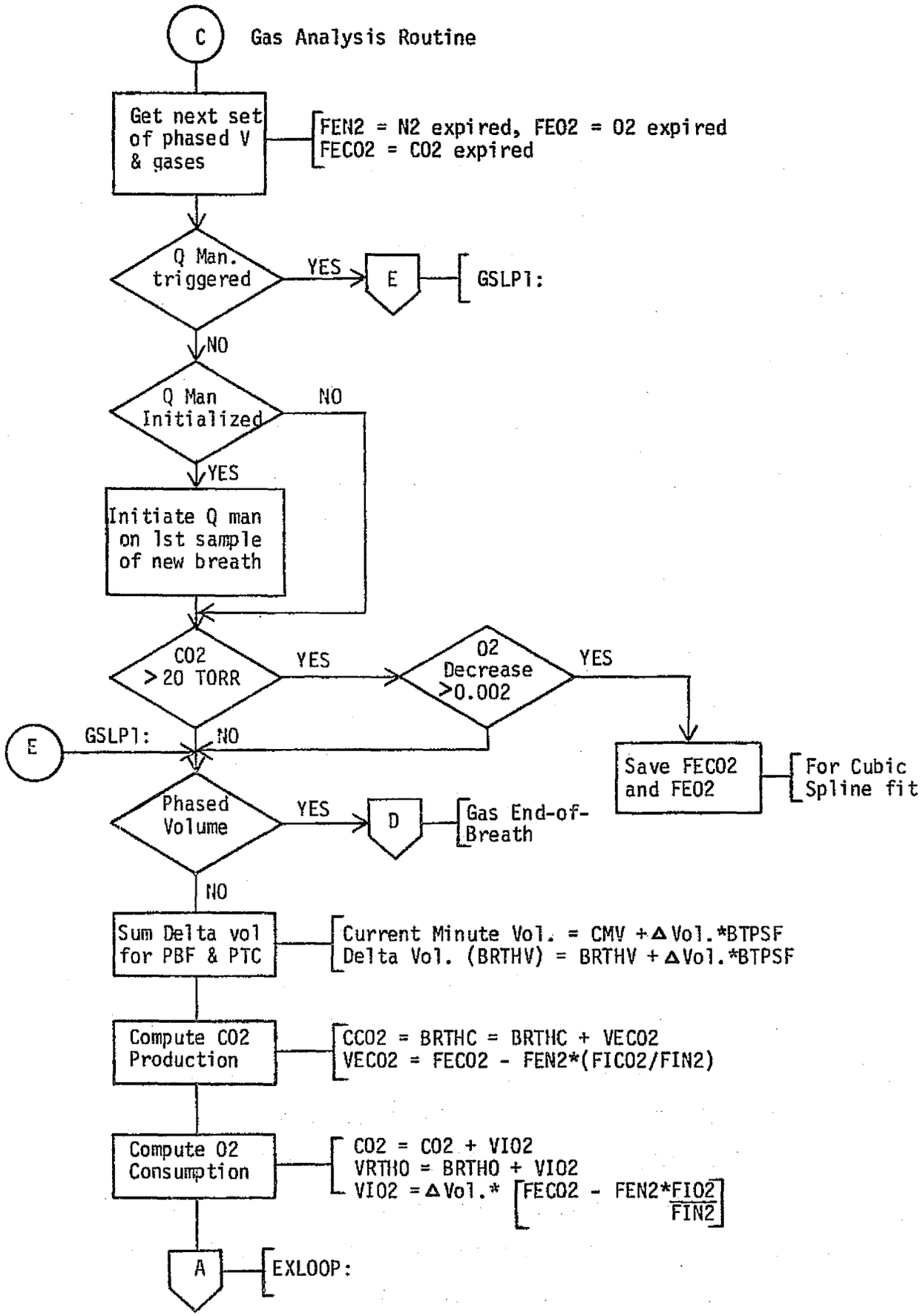
ROOM AIR MODULE



START-PROTOCOL MODULE

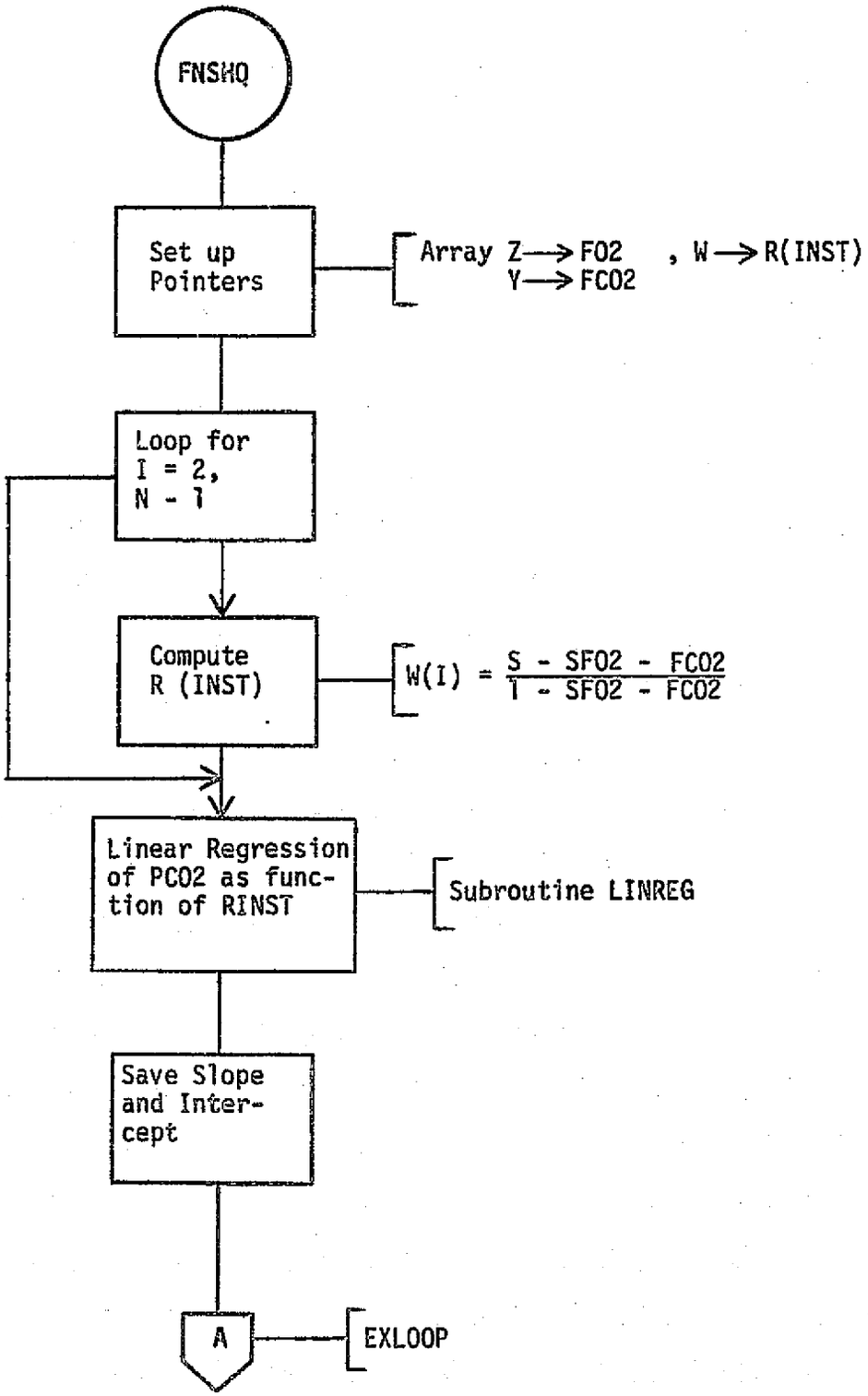


START-PROTOCOL MODULE



START PROTOCOL MODULE (cont'd)

R (INSTANTANEOUS)



APPENDIX G

Operating Procedures

FINAL
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OTR 1: Inflight Exercise

TRAINING NOTES

A. Preparation

1. Verify a data patch panel installed.

   NOTE: Any patch panel may be used as long as one is installed.

2. Remove flexible hoses, blood pressure cuff, respiratory valve assembly, noseclamp, and mass spectrometer (MS) capillary tube from stowage in OH-11.

3. Attach one blue hose (with blue end) to blue quick disconnect port labeled OXYGEN SUPPLY. Rotate latch clockwise to lock.

4. Attach other end of hose to blue port on respiratory valve assembly with arrow pointing toward mouthpiece of assembly.

5. Attach one end of second blue hose (with red end) to red quick disconnect port.

6. Attach other end of hose to red port on respiratory valve assembly.

> **CAUTION**
>
> Steps 7 & 8 must be done in sequence.

7. Spirometer panel:

   VIDEO SEL sel - OTR 1

   NOTE: The mid-position on this 3-way switch is not used and not indicated.

8. Activate computer:

   PRINTER sw - ON
   OBDS sw - ON
   MASS SPEC tw - 1
   SUBJECT tw - set to proper subject
   (0 = MS, 1 = PS-1,
   2 = PS-2)

POWER sw - ON (POWER lt - ON,
IDLE lt - ON, PFT pb - LIT,
PTC/PBF pb - LIT)

9. CRT on rack 13:

POWER pb - verify depressed (POWER lt - ON)

B. MS start-up From "Pumped Down" State

1. Verify that all lts on MS panel are off (see NOTE below step 2).

2. MS Panel:

MS POWER sw - OFF
SYS POWER sw - ON
ION PUMP sw - ON
PRESSURE sw (NORMAL/OVERRIDE) - NORMAL
MODE sw - CLOSED
FIL sw - NORMAL
CAPILLARY SELECT sel - OFF
DVM SELECT sel - I_{IP} (ion pump current)
(Reading on DVM should be approximately -001. All I_{IP} readings are negative, regardless of sign.)
VACUUM PUMP SHUTOFF vlv - full CW (closed)

CAUTION

If ELEC INHIBIT lt or HIGH PRESS lt come on or I_{IP} (on DVM) is much greater than -010, vacuum problem exists within system which must be corrected. Refer to MS activation procedures in flight data file.

C. Verification of MS Vacuum

1. Verify that white filter is in CAL INLET port on MS panel. Cotton packed side of filter should face outward.

2. Place one end of MS capillary tube on CAL INLET port. Stow other end as appropriate.

3. Monitor (on pump current (I_{Ip}) on DVM).

   NOTE: I_{Ip} should range from -001 to -030. Values of I_{Ip} between -030 and -600 indicate probable vacuum problem.

4. MS panel:

   VACUUM PUMP SHUTOFF vlv - full CCW

   NOTE: I_{Ip} should remain same or decrease. If I_{Ip} increases to more than -030, quickly close VACUUM PUMP SHUTOFF vlv and have external vacuum restored.

5. MS panel:

   CAPILLARY SELECT sel - CAL

   NOTE: I_{Ip} should increase to value between -005 and -030. If increase is greater than -030, quickly return CAPILLARY SELECT sel to OFF. Problem probably torn boot or capillary tube out of place. Less likely possibility is absence of external vacuum that was undetected in step 4 above.

D. MS Power-up

1. Verify absence of lts on MS panel.

2. MS panel:

   MS POWER sw - ON (OPEN LOOP lt - ON)

   NOTE: OPEN LOOP lt will remain on for approximately 20 seconds. If lt does not go off, capillary tube may be blocked. If this is case, turn CAPILLARY SELECT sel to OFF, change to new capillary tube, and return CAPILLARY SELECT sel to CAL.

3. Wait 1 minute and then verify absence of lts on MS panel.

4. Verify air values on MS DVM by placing DVM SELECT sel in positions CO_2, O_2, then N_2, and confirming respective gas values. Breathe through MS probe tube and confirm increase in CO_2. Following verification, return DVM SELECT sel to I_{IP} position.

E. Flow/Volume Electronics Power-up

1. Verify on flow/volume electronics panel:

   TEST GAS SEL sel - OFF
   MODE SELECT sel - OPERATE
   All recessed sws (behind glass panel) in AUTO position (UP)

2. Flow/volume electronics panel:

   115 V PWR sw - ON (115 V PWR lt - ON)
   TEST GAS SEL sel - O_2

F. Calibration

1. Transfer loose end of MS capillary tube to CAL GAS tube on flow control unit of X75.

2. Open needle valve on CAL GAS port (flow of 10-15 cc/min).

3. Verify CO_2 value greater than 4.4 on MS DVM by placing DVM SELECT sel in CO_2 position. Following verification, return DVM SELECT sel to I_{IP} position.

   NOTE: If CO_2 value is less than 4.4, go to malfunction procedure _____.

4. Verify printer paper tape feeds properly.

5. OTR 1 panel:

   PFT pb - depress

6. OTR 1 panel:

   CAL MS pb - depress

7. Verify that CAL MS lt blinks on once.

   NOTE: Calibration of mass spectrometer is concluded when message CAL COMPLETE appears on printer.

8. Close needle vlv on CAL GAS port.

9. Verify that WO pb is lit.

   NOTE: Green lts adjacent to PBS indicate tests are in progress. Amber lights in pushbuttons indicate system is ready for next test.

G. Washout Test

1. Transfer MS capillary tube from CAL GAS tube on flow control unit of X75 to mouthpiece assembly, making sure that Teflon tip of capillary extends into valve through aperture in stainless steel inlet.

2. Verify that white sw on oxygen regulator is in 100% OXYGEN position, green sw is in ON position, and meter reading is approximately 200 psi.

3. Flush hose and valve assembly with 100% oxygen using TEST.MASK switch position on oxygen regulator.

4. OTR 1 panel:

   WO pb - depress (WO lt - ON)

5. Don noseclamp.

6. Inspire room air, hold breath, then place mouthpiece in mouth and seal lips over assembly.

   NOTE: Maintain subject dependant to respiratory valve assembly.

7. Exhale slowly to residual volume (RV), inspire vital capacity of oxygen, and again exhale slowly to RV.

8. With mouthpiece still in mouth following initial maneuver, relax and breathe normally until washout is complete. Washout is complete when green WO lt goes off and FVC pb lights up.

9. Remove mouthpiece and noseclamp.

10. Carefully remove MS capillary tube from respiratory valve assembly.

11. Disconnect hoses from quick disconnect ports and from valve assembly. Remove blue inlet hose (with blue end) from assembly and return to stowage.

H. Forced Vital Capacity Test

1. Remove standard cardboard mouthpiece and FVC hose from stowage. Attach one end of white hose (with red end) to red quick disconnect port and other end to cardboard mouthpiece.

2. OTR 1 panel:

   FVC pb - depress (FVC lt - ON)

3. Don noseclamp.

4. Inspire maximally to total lung capacity. Place mouthpiece in mouth, seal lips around mouthpiece, and exhale as rapidly as possible to RV.

5. OTR 1 panel:

   RPT pb - depress

   NOTE: Test is complete when printout is finished.

6. OTR 1 panel:

   END TEST pb - depress

7. Detach white hose from quick disconnect port. Remove cardboard mouthpiece from hose. Return white hose to stowage.

I. Pulmonary Blood Flow Test

1. Verify ECG sensors are attached to subject.

NOTE: If sensors have not been attached, do the following:

a. Attach ECG electrode harness to ECG electrode cable.

b. Attach cable to ECG input connection on HP cardiotach on X50 systems panel.

c. Attach harness leads to ECG electrodes on chest (white lead to upper electrode, black to lower, green to reference).

d. Verify readout on BEATS/MIN panel of HP cardiotach.

e. Verify that ECG lt on BPMS blinks on and off as CAL pb on cardiotach is depressed. (ECG lt will come on in response to sensing of QRS wave during experiment.)

2. Obtain BPMS cuff from OTR 1 stowage.

3. BPMS cuff gas/electrical umb.:

   Attach gas connection to UMB GAS on BPMS.

   Attach BPMS electrical connection to MICROPHONE on BPMS.

4. Place cuff on subject.

5. Activate BPMS:

   POWER sw - ON
   MODE sel - MAN

6. BPMS:

   CUFF/INFLATE sw - START

7. Verify proper cuff inflation/deflation cycle, with Korotkoff sounds being sensed (yellow light on BPMS flashing).

8. BPMS:

   CUFF/INFLATE sw - STOP/RESET

9. Attach one end of blue flexible hose (with red end) (used in washout test) to red quick disconnect port. Attach other end to exhalation port of respiratory valve assembly.

10. Transfer MS capillary tube from loose stowage to CAL GAS tube on flow control unit of X75.

11. Open needle vlv on CAL GAS port (flow 10-15 cc/min).

12. Verify CO_2 value greater than 4.4 on MS DVM by placing DVM SELECT sel in CO_2 position. Following verification, return DVM select sel to I_{IP} position.

13. IDLE panel:

    PTC/PBF pb - depress

14. OTR 1 panel:

    CAL MS pb - depress

15. Verify that green CAL MS lt blinks once.

    NOTE: Calibration of mass spectrometer is concluded when message CAL COMPLETE appears on printer.

16. Close needle vlv on CAL GAS port.

17. Place capillary in position to sample ambient air.

18. OTR 1 panel:

    ROOM AIR pb - depress

19. Conclusion of sampling period indicated when START pb is lit. If ambient air data is invalid, printer will print message BAD ROOM AIR VALUE.

20. Transfer MS capillary tube to valve assembly, making sure that Teflon tip of capillary extends into valve through aperture in stainless steel inlet.

21. BPMS:

    MODE sel - 200
    CUFF/INFLATE sw - START

22. Insert mouthpiece of valve assembly in mouth and don noseclamp. Breathe normally until computer requests cardiac output maneuver (step 24).

23. OTR 1 panel:

    START pb - depress

24. Cardiac output maneuver:

    Take slightly longer than normal inhalation, depress Q pb, then exhale slowly at constant flow rate.

    NOTE: Within minute that maneuver is requested, if initial maneuver is thought to be unsatisfactory, subject may repeat procedure by depressing Q pb again.

25. During 3rd and 5th minutes Q lt will come on, requesting maneuver.

    NOTE: Test is terminated when time 5.0 appears on printer and/or END TEST pb is lit.

26. Remove mouthpiece from mouth.

27. BPMS:

    CUFF/INFLATE sw - STOP/RESET
    POWER sw - OFF

J. Flow/Volume Electronics Shutdown

1. Flow/volume electronics panel:

    TEST GAS SEL sel - OFF
    MODE SELECT sel - OPERATE
    115 V PWR sw - OFF (115 V PWR lt - OFF)

TRAINING NOTES

K. MS Shutdown

1. MS panel:

   DVM SELECT sel - I_{IP}
   MS POWER sw - OFF
   CAPILLARY SELECT sel - OFF

   NOTE: I_{IP} should decrease toward -001.

2. Remove MS capillary tube from CAL INLET port and valve assembly. Clean and return to stowage. Replace capillary plug on CAL INLET port.

3. Wait 1 minute before continuing with shutdown.

4. MS panel:

   VACUUM PUMP SHUTOFF cont - full CW (closed)

5. Verify on MS panel:

   Absence of lts
   I_{IP} less than -004

L. Final Shutdown

1. Remove mouthpiece, noseclamp, blood pressure cuff, and ECG sensors.

4. OTR 1 panel:

   END TEST pb - depress

5. Remove printer tape, label with date/time and stow.

6. Inactivate computer:

   POWER sw - OFF

7. Disconnect hose from quick disconnect port and from valve assembly. Return hose to stowage OH-11.

8. Clean valve assembly and return to stowage OH-11.

9. Return remaining, loose equipment to stowage.

OTR 1

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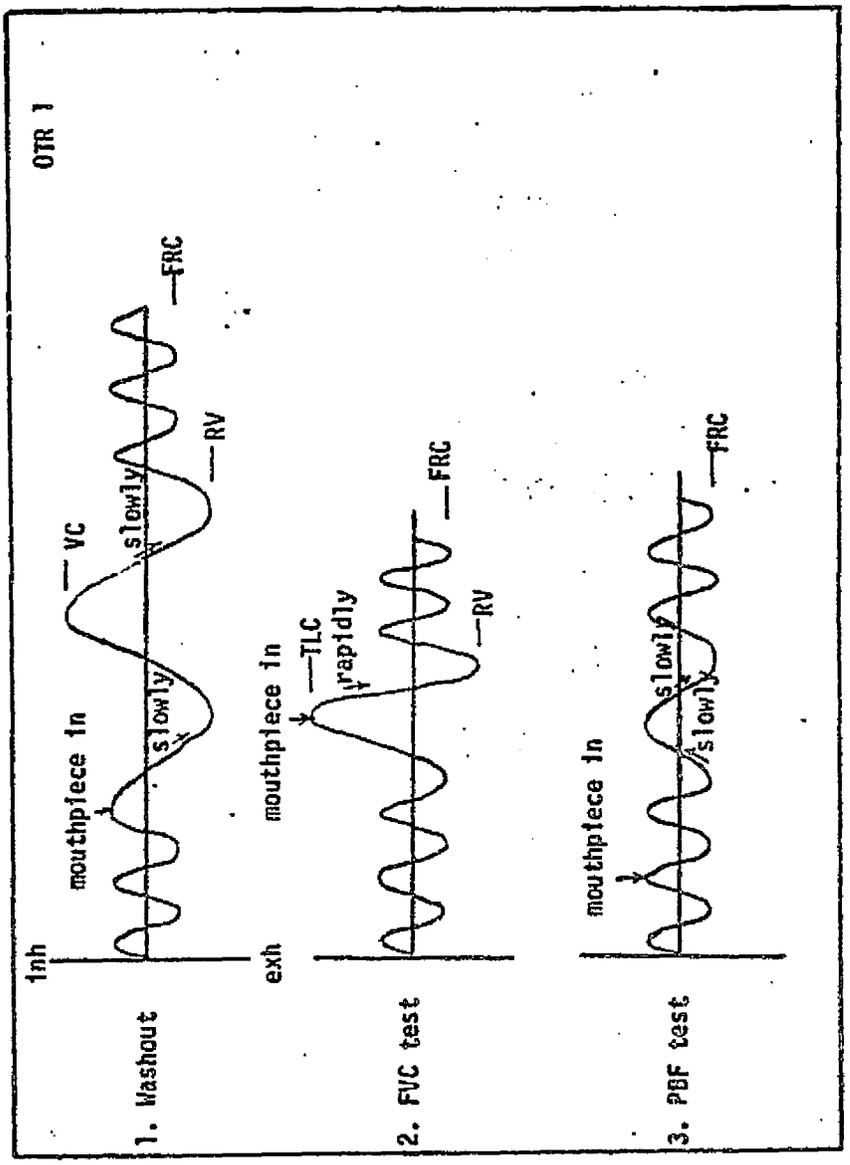
TRAINING NOTES



OTR1 CUE CARD

REAL TIME CREW PROCEDURE CHANGE REQUEST

ALREADY IMPLEMENTED	TIME CHANGE REQUIRED	LATEST DISPOSITION TIME	CONTROL NUMBER
YES ☐ NO ☐	: : GMT	: : GMT	

ORIGINATED BY		INITIATORS MOCR OPERATOR SIGNATURE	DATE SUBMITTED
KATHERINE M. TAMER			19 MAY 77

DOCUMENT AFFECTED

TITLE	BASIC CHG DATE	PAGE NUMBER	MISSION
INFLIGHT PROCEDURES EXP. AND OTR			SMD III

DETAIL CHANGE IN EXACT WORDING:

PROCEDURAL CHANGE:

OTR1-10; STEP 21 - DELETE

OTR1-11; INSERT AFTER STEP 23:

NOTE! STEP 23.1 MUST BE INITIATED WITHIN 25 SEC. AFTER STEP 23 OR BP DATA WILL BE OUT OF SYNC.

23.1 BPMS:

MODE SEL - 200

CUFF/INFLATE sw - START

REAL TIME

TECHNICAL RATIONALE:

SEE ATTACHMENT

OTHER DATA AFFECTED: NONE

MCC DISPOSITION

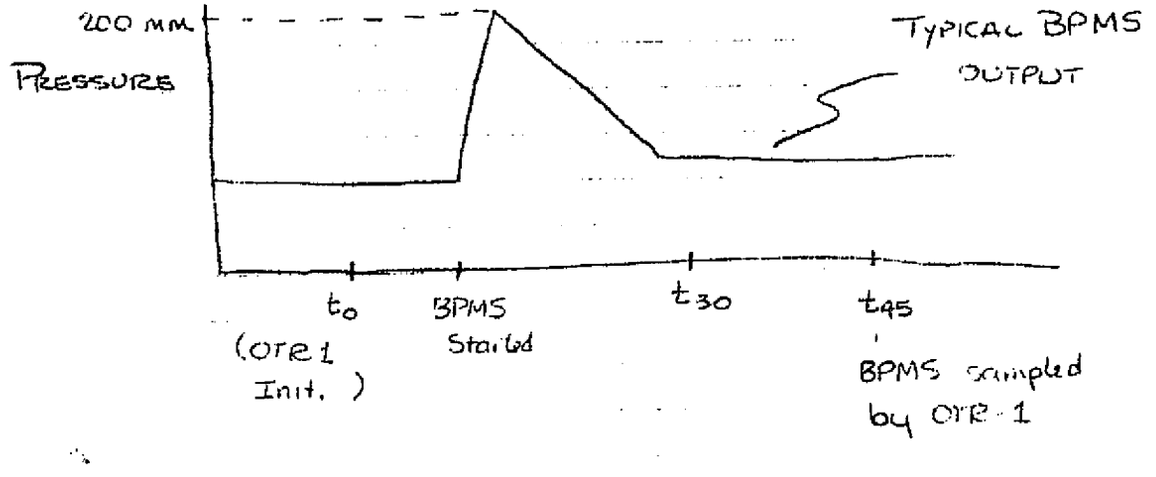
APPROVALS (AS REQUIRED)	APPROVALS (AS REQUIRED)	FAO	FLIGHT DIRECTOR
FUNCTION / NAME / DATE	FUNCTION / NAME / DATE	APPROVAL ☐ DISAPPROVAL ☐	APPROVAL ☐ DISAPPROVAL ☐
APCOM		SIGNATURE	SIGNATURE
		DATE	DATE
		IMPLEMENTATION: APPLICATION USED NO ☐ YES ☐ COMPLETE ☐	
	CKLIST	MCPS ☐ CPDS ☐ PDF ☐ OTHER ____	

MSC FORM 412 D

803E8

TECHNICAL RATIONALE:

BPMS SAMPLES BLOOD PRESSURE ONCE PER MINUTE. DURING THE FIRST ≅ 30 SECONDS THE ANALOG OUTPUTS (SYSTOLIC & DIASTOLIC) TRACK THE PRESSURE RAMP. AFTER DIASTOLE IS DETECTED, THE OUTPUTS ARE HELD UNTIL THE NEXT SAMPLING PERIOD AND THE OTR1 COMPUTER MUST SAMPLE DURING THIS STABLE PERIOD. THE COMPUTER IS PROGRAMMED TO SAMPLE BPMS ≅ 45 SECONDS AFTER INITIALIZATION (STEP 23 IN PROCEDURES). THUS THE PROCEDURE CHANGE WILL ASSURE SAMPLING DURING THE PROPER INTERVAL.



APPENDIX H

Program Listing

```
MONITR  RT-11 MACRO V/M02-12    00:10:02 PAGE 1

 1                      .TITLE  MONITR
 2
 3        000005        TP=%5
 4        000000        IM1=%0
 5        000001        I=%1
 6        000002        IP1=%2
 7
 8                      .MCALL  ..V2...REGDEF,.PRINT,.EXIT
 9 000000               .REGDEF
         000000 R0=%0
         000001 R1=%1
         000002 R2=%2
         000003 R3=%3
         000004 R4=%4
         000005 R5=%5
         000006 SP=%6
         000007 PC=%7
10
11
12              ;ADDRESSES FOR LINE PRINTER - BOARD C
13              ; AND ON BOARD DATA SYSTEM
14
15        167750        LPTSR=167750
16        167752        OBDS=LPTSR+2
17        167753        LPT=OBDS+1
18        167754        LPTIN=OBDS+2
19
20              ;ADDRESSES FOR TELETYPE
21        177560        RCSR=177560
22        177562        RBUF=RCSR+2
23        177564        XCSR=RBUF+2
24        177566        XBUF=XCSR+2
25
26              ;CONTROL PANEL - BOARD A
27        167770        DRAS=167770
28        167772        DRAO=DRAS+2
29        167774        DRAI=DRAO+2
30
31              ;CONTROL PANEL - BOARD B
32        167760        DRBS=167760
33        167762        DRBO=DRBS+2
34        167764        DRBI=DRBO+2
35
36              ;A/D CONVERTER
37        176770        ADSR=176770
38        176772        ADIN=ADSR+2
39        176760        DAC1=176760
40        176762        DAC2=DAC1+2
41
42              ;KW11-P PROGRAMMABLE REAL TIME CLOCK
43              ;       PCSR=172540     ;KW11P CONTROL STATUS REGISTER
44              ;       PCSB=PCSR+2     ;KW11P COUNT SET BUFFER
45              ;       PCR=PCSB+2      ;KW11P COUNT REGISTER
46
47
```

```
                        .TITLE  VECTOR ADDRESSES

                ;SET UP VECTOR ADDRESSES
        000000          .ASECT
                ;START ADDRESS
        000024          .=24
000024  040774          .WORD   BEGIN,0
000026  000000
                ;RT-11 START ADDRESS
        000040          .=40
00040   040774          .WORD   BEGIN,0
00042   000000
                ;FLOATING POINT TRAP
        000240          .=240
00240   000250          .WORD   250,0
00242   000000
        000244          .=244
00244   000250          .WORD   250
        000250          .=250
00250   000002          RTI


                ;A/D ISR ADDRESS (CLOCK VAD)
        000314          .=314
00314   004674          .WORD   ADISR,0
00316   000000
                ;LPT VECTOR ADDRESS
        000320          .=320
00320   000500          .WORD   PRINT,200
00322   000200
                ;ABORT VECTOR ADDRESS
        000300          .=300
00300   000416          .WORD   ABORT,0
00302   000000
                ; CARDIAC OUTPUT TRIGGER
        000304          .=304
00304   000434          .WORD   QMAN,200
00306   000200
                ; ECG COUNTER
        000310          .=310
00310   000466          .WORD   ECG,0
00312   000000


        000100          LPEN=100        ;PANEL PRINTER INT ENB
        000002          TTYBM=2 ;BIT MASK FOR OBDS SWITCH
        000001          PRTBM=1         ;BIT MASK FOR PRINTER SWITCH
```

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```
                        .TITLE  MACRO DEFINITIONS
                ;
                ;MACRO TO RESTORE REGISTERS
                        .MACRO  RESTORE
                        JSR     PC,RESREG
                        .ENDM
                ;
                ;MACRO TO SAVE REGISTERS
                        .MACRO  SAVE
                        JSR     PC,SAVREG
                        .ENDM
                ;
                ;MACRO TO START PRINTER
                        .MACRO  PRTBUF,M2,M3
                        JSR     R5,BUFLOD
                        M2
                        M3
                        MOV     #BUFFER,R0
                        JSR     PC,LPTGO
                        .ENDM
                ;
                ;
                ;MACRO TO PRINT LINE OF TEXT
                        .MACRO  TYPE,M4
                        MOV     #M4,R0
                        JSR     PC,LPTGO
                        .ENDM
                ;
                ;
```

```
                        ;PROGRAM START ADDRESS
        000400                  .=400
                        
                        
                        
000400 032767 DOPEY:    BIT     #1,DRBI         ;LOOK FOR LOOP SWITCH
       000001
       167356
000406 001774           BEQ     DOPEY
000410 000207           RTS     PC
                        
                        ;
                        ;  RPT - REPORT SUBROUTINE
                        
00412 000207 ENDT1:     RTS     PC
                        
00414 000207 ENDT2:     RTS     PC
                        
                        
                        ;INTERRUPT ROUTINE -TEMPORARY
00416 012600 ABORT:     MOV     (SP)+,R0
                        ;CLEAR PC AND PS FROM STACK INTO THE BIT BUCKET
                        ;START ALL OVER AGAIN
00420 012600            MOV     (SP)+,R0
00422                   TYPE    IMSG
   00422 012700         MOV     #IMSG,R0
       017576
   00426 004767         JSR     PC,LPTGO
       014406
                        
                        ;EVENTUALLY THIS MUST BE CHANGED TO **** BR   BEGIN **********************
00432 000456            BR      START
                        
                        
                        ;Q MANEUVER -ISR
00434 012767 QMAN:      MOV     #-1,QFLAG
       177777
       060314
00442 052767            BIS     #200,DRBO
       000200
       167312
00450 042767            BIC     #100040,DRAS
       100040
       167312
00456 042767            BIC     #400,DRBO
       000400
       167276
00464 000002            RTI
                        ;ECG COUNTER ISR
00466 005267 ECG:       INC     PTHRCT
       060246
00472 005267            INC     CHR
       057334
00476 000002            RTI
                        
```

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```
                        .TITLE  PRINTER ISR
                ;PRINTER INTERRUPT SERVICE ROUTINE
                ;1-5 MS RESPONSE TIME
                ;
000500 105777 PRINT:  TSTB    @PRTGO
       037144
000504 003406         BLE     PRTEOL
000506 117767         MOVB    @PRTGO,LPT
       037136
       167237
000514 005267 PRTL:   INC     PRTGO
       037130
00520  000002         RTI
00522  002413 PRTEOL: BLT     PRTERM
00524  112767         MOVB    #40,LPT          ;PUT SPACE TO LPT
       000040
       167221
00532  032767         BIT     #100000,LPTIN            ;NO OUTPUT UNTIL NEW LINE READY SIGNAL
       100000
       167214
00540  001412         BEQ     PRTX
00542  112767         MOVB    #200,LPT         ;START
       000200
       167203
00550  000761         BR      PRTL
00552  142767 PRTERM: BICB    #LPEN,LPTSR
       000100
       167170
00560  112767         MOVB    #40,LPT
       000040
       167165
00566  000002 PRTX:   RTI


                        .TITLE  CLEAR
```

```
1
2                       ;CLEAR RAM BANKS 1 AND 3
3               040570          .=40570
4 040570 012700 CLEAR:  MOV     #20000,R0
         020000
5 040574 005020 CLR1:   CLR     (R0)+
6 040576 032700         BIT     #40000,R0
         040000
7 040602 001774         BEQ     CLR1
8
9 040604 012700         MOV     #60000,R0
         060000
10 40610 005020 CLR2:   CLR     (R0)+
11 40612 032700         BIT     #100000,R0
         100000
12 40616 001774         BEQ     CLR2
13
14 40620 000167         JMP     START
         137744
15
16
17                      .TITLE  SPACR
18
19              040770          .=40770
20 40770 000167 SPACR:  JMP     SPAC1
         177704
21
22              040700          .=40700
23 40700 012701 SPAC1:  MOV     #WOPBFR,R1
         061024
24 40704 012701         MOV     #40,R1
         000040
25 40710 012702         MOV     #20,R2          ;WOPBFR THRU WONBFR
         000020
26
27 40714 110120 SPAC2:  MOVB    R1,(R0)+
28 40716 077202         SOB     R2,SPAC2
29 40720 112767         MOVB    #14,XBUF        ;CLEAR VIDEO SCREEN
         000014
         136640
30 40726 000167         JMP     CLEAR
         177636
31
32
33                      .TITLE  BEGIN
```

```
                        .=40774
040774 012700 BEGIN:    MOV     #20000.R0
       020000
041000 005020 CLR3:     CLR     (R0)+
041002 032700           BIT     #40000.R0
       040000
041006 001774           BEQ     CLR3
041010 012700           MOV     #60000.R0
       060000
041014 005020 CLR4:     CLR     (R0)+
041016 032700           BIT     #100000.R0
       100000
041022 001774           BEQ     CLR4

041024 012700 SPAC3:    MOV     #WOPBFR.R0
       061024
041030 012701           MOV     #40.R1
       000040
041034 012702           MOV     #20.R2
       000020
041040 110120 SPAC4:    MOVB    R1.(R0)+
041042 077202           SOB     R2.SPAC4
041044 112767           MOVB    #14.XBUF
       000014
       136514
041052 000167           JMP     START
       137512


                        .TITLE  MONITOR
```

```
                        ;  START OF MONITOR
                        ;    STORE PROCESSOR STATUS WORDS
                        ;    ENABLE CONTROL PANEL INTERRUPTS
                        ;    ENABLE EXTERNAL DEVICE INTERRUPTS
                000570          .=570
000570 012706 000712 START: MOV     #STACK,SP
000574 000005               RESET
000576 012767 016726        MOV     #MIN1,TTYGO
       036364
000604 106700               MFPS    R0
000606 042700 000200        BIC     #200,R0
000612 005037 167760        CLR     @#DRBS
000616 012705 037112        MOV     #TSTK,TP
000622 106400               MTPS    R0
000624 005037 167770        CLR     @#DRAS
000630 012737 000012        MOV     #12,@#C12
       070716
                        ;
000636 052767 000040        BIS     #40,DRBS
       167114
                        ;
000644 012767 000005        MOV     #5,TTYCNT
       036320
000652 012767 171777 PMON:  MOV     #171777,DRBO    ;CLEAR BOARD B LIGHTS
       167102
000660 012767 177776        MOV     #177776,DRAO    ;TURN ON IDLE, PFT,PTC LIGHTS
       167104
                        ;ENABLE ABORT BUTTONS
000666 052767 000100        BIS     #100,DRAS
       167074
000674 005067 036274        CLR     DUM2
000700 016700 167070 PMON1: MOV     DRAI,R0
                        ;
                        ;WHICH OF THE TWO BUTTONS WAS PUSHED??
000704 032700 000040        BIT     #40,R0
000710 001005               BNE     PFT             ;PFT WAS PUSHED
                        ;
000712 032700 000100        BIT     #100,R0
000716 001137               BNE     PTCBF           ;PTC/PBF WAS PUSHED
                        ;
```

780

```
35                      ;  ERROR CONDITION
36 00720 000167                 JMP     PMON1
         177754
37
38                              .EVEN
```

```
                        .TITLE  PFT MONITOR
                ;  PULMONARY FUNCTION TEST MONITOR
000724 012767   PFT:    MOV     #100,DRAS       ;ENABLE ABORT, DISABLE ALL
000100 167036
000732 012767           MOV     #40,DRBS        ;   OTHERS FROM CP BOARDS
000040 167020

                ;R0 CONTAINS SUBJECT NO. AND MASS SPEC. TYPE

000740 012767           MOV     #177777,DRBO    ;TURN OFF ALL LED'S ON DRV11B
177777 167014
00746 012767    PFT2:   MOV     #077771,DRAO    ;TURN ON IDLE, PFT PB, AND PTC/PBF PB
077771 167016
00754 016700    PFT1:   MOV     DRAI,R0
167014
00760 030027            BIT     R0,#007600
007600
00764 001773            BEQ     PFT1
00766 030027            BIT     R0,#200
000200
00772 001417            BEQ     PFTWO
00774 012767            MOV     #037765,DRAO    ;CALMS PB DEPRESSED
037765 166770
01002 005067            CLR     DUM2
036166
01006 004767            JSR     PC,CALMS
012534
01012 005767            TST     DUM2
036156
01016 001353            BNE     PFT2
                ;BUTON WAS PUSHED
01020 012767            MOV     #077755,DRAO    ;TURN ON PFT-WO-RQP
077755 166744
01026 000167            JMP     PFT1
177722

01032 030027 PFTWO:     BIT     R0,#400
000400
01036 001412            BEQ     PFTFV
01040 012767            MOV     #037735,DRAO    ;WO PB DEPRESSED
037735 166724
01046 004767            JSR     PC,WO
001304
01052 012767            MOV     #077675,DRAO    ;TURN ON PFT-FVC-RQP
077675 166712
01060 000167            JMP     PFT1
177670

```

```
32 01064 030027 PFTFV:  BIT     R0,#1000
         001000
33 01070 001412         BEQ     PFTRT
34 01072 012767         MOV     #037575,DRAO
         037575
         166672
35 01100 004767         JSR     PC,FVC
         000354
36 01104 012767         MOV     #077375,DRAO    ;TURN ON PFT-RPT-RQP
         077375
         166660
37 01112 000167         JMP     PFT1
         177636
38
39 01116 030027 PFTRT:  BIT     R0,#2000
         002000
40 01122 001412         BEQ     PFTE1
41 01124 012767         MOV     #036775,DRAO
         036775
         166640
42 01132 004767         JSR     PC,RPT
         013436
43 01136 012767         MOV     #075775,DRAO    ;TURN ON PFT-END-RQP
         075775
         166626
44 01144 000167         JMP     PFT1
         177604
45 01150 030027 PFTE1:  BIT     R0,#4000
         004000
46 01154 001412         BEQ     PFTER
47 01156 012767         MOV     #035777,DRAO
         035777
         166606
48 01164 004767         JSR     PC,ENDT1
         177222
49 01170 012767         MOV     #177777,DRAO            ;TURN OFF LIGHTS
         177777
         166574
50 01176 000167         JMP     PMON
         177450
51
52 01202        PFTER:  TYPE    MSG1
   01202 012700         MOV     #MSG1,R0
         017546
   01206 004767         JSR     PC,LPTGO
         013626
53 01212 000167         JMP     PFT1
         177536
```

```
                        .TITLE  PTC/PBF MONITOR
                        
                        
001216 012767 PTCBF:    MOV     #100340,DRAS    ;INTEN -> ABORT,Q
       100340
       166544
001224 012767           MOV     #100340,DRBS    ;INTEN -> ECG
       100340
       166526
001232 012767 GPTCST:   MOV     #077774,DRBO
       077774
       166522
001240 016700 PTC1:     MOV     DRAI,R0         ;READ SWITCHES
       166530
001244 030027           BIT     R0,#170000
       170000
001250 001773           BEQ     PTC1
                ;BUTTON WAS PUSHED
01252 030027            BIT     R0,#10000
       010000
01256 001417            BEQ     PTCRM
01260 012767            MOV     #037772,DRBO    ;TURN ON PBF-CALMS-RUN
       037772
       166474
01266 005067            CLR     DUM2
       035702
01272 004767            JSR     PC,CALMS
       012250
01276 005767            TST     DUM2
       035672
01302 001353            BNE     GPTCST
01304 012767 PTC2:      MOV     #077766,DRBO    ;TURN ON PBF-ROOM-RQP
       077766
       166450
01312 000167            JMP     PTC1
       177722

01316 030027 PTCRM:     BIT     R0,#20000
       020000
01322 001417            BEQ     PTCST
01324 012767            MOV     #037756,DRBO    ;TURN ON PBF-ROOM-RUN
       037756
       166430
01332 005067            CLR     DUM2
       035636
01336 004767            JSR     PC,ROOM
       004430
01342 005767            TST     DUM2
       035626
01346 001356            BNE     PTC2
01350 012767            MOV     #077736,DRBO    ;TURN ON PBF-STRT-RQP
       077736
       166404
01356 000167            JMP     PTC1
       177656

01362 030027 PTCST:     BIT     R0,#40000
```

7 8 4

```
          040000
32 01366  001412          BEQ     PTCE2
33 01370  012767          MOV     #037676,DRBO    ;TURN ON PBF-STRT-RUN
          037676
          166364
34 01376  004767          JSR     PC,STRTP1
          004644
35 01402  012767          MOV     #176776,DRBO    ;TURN ON PBF-END-RQP
          176776
          166352
36 01410  000167          JMP     PTC1
          177624
37
38 01414  030027 PTCE2:   BIT     R0,#100000
          100000
39 01420  001412          BEQ     PTCER
40 01422  012767          MOV     #037777,DRBO
          037777
          166332
41 01430  004767          JSR     PC,ENDT2
          176760
42 01434  012767          MOV     #177777,DRBO    ;CLEAR DRBO LIGHTS
          177777
          166320
43 01442  000167          JMP     PMON
          177204
44
45 01446          PTCER:  .PRINT  #MSG1
   01446  012700 .IIF NB <#MSG1>,                  MOV     #MSG1,%0
          017546
   01452  104351                                  EMT     ^O351
46 01454  000167          JMP     PTC1
          177560
47
48
49
```

```
                        .TITLE  FORCE VITAL CAPACITY
                ;
                ;FORCE VITAL CAPACITY MANEUVER
                ;
001460 052767   FVC:    BIS     #1,DRAS
       000001
       166302
001466 012767           MOV     #-50,WAITT
       177730
       036232
                ;       MOV     #100.,PCSR      ;SET CLOCK COUNT TO 100
01474 005000            CLR     R0
01476 005002            CLR     R2
01500 005003            CLR     R3
01502 005067            CLR     VLAST
       032320
01506 012701            MOV     #FVCNT,R1       ;SET UP BUFFER ALLOCATION FOR DATA
       020004
01512 005021            CLR     (R1)+   ;FVCNT=0
                ;R1 NOW EQUALS ADDRESS OF DATA AREA
                ;       MOV     #113,PCSR       ;KICK CLOCK
01514 052767            BIS     #1,DUM1
       000001
       036176
01522 005067            CLR     EOB
       016252

01526 000240 LOOP:      NOP
01530 032767            BIT     #1,EOB  ;END OF BREATH?
       000001
       016242
01536 001773            BEQ     LOOP    ;NO
                ;       CLR     PCSR            ;TURN OFF CLOCK
01540 042767            BIC     #1,DUM1
       000001
       036152
01546 010067            MOV     R0,FVCNT        ;YES,STORE NO. OF SAMPLES
       016232
01552 042703            BIC     #1,R3
       000001

01556 004767            JSR     PC,VCOMP        ;CALCULATE RESULTS
       000002

01562 000207            RTS     PC              ;RETURN TO PFTFV IN PMON
```

7.8.6

```
1
2                       ;
3                       ;SUBROUTINE VCOMP
4                       ;
5  001564 012705 VCOMP:  MOV     #TSTK,TP
          037112
6  001570 012704         MOV     #OUTAR,R4
          054076
7  001574 012700         MOV     #WKAR,R0
          037114
8
9  001600 016745         MOV     FVDAT+200.,-(TP)        ;GET RAW FEV1
          016512
10 01604  004767         JSR     PC,IR
          014042
11 01610  016720         MOV     SLV,(R0)+
          015050
12 01614  016720         MOV     SLV+2,(R0)+
          015046
13 01620  012520         MOV     (TP)+,(R0)+
14 01622  012520         MOV     (TP)+,(R0)+
15 01624  012700         MOV     #WKAR,R0
          037114
16 01630  075020         FMUL    R0
17
18 01632  012024         MOV     (R0)+,(R4)+     ;STORE FEV1 IN FLOAT WORD 1
19 01634  012024         MOV     (R0)+,(R4)+     ;OF OUTAR
20
21                      ;COMPUTE FVC
22 01636  016745         MOV     VLAST,-(TP)
          032164
23 01642  004767         JSR     PC,IR
          014004
24
25 01646  016540         MOV     2(TP),-(R0)
          000002
26 01652  011540         MOV     (TP),-(R0)
27 01654  012700         MOV     #WKAR,R0
          037114
28 01660  075020         FMUL    R0
29
30 01662  012024         MOV     (R0)+,(R4)+     ;STORE FVC IN FLOAT
31 01664  012024         MOV     (R0)+,(R4)+     ;WORD 2 OF OUTAR
32
33                      ;COMPUTE MMFR
34 01666  012700         MOV     #WKAR,R0
          037114
35 01672  005060         CLR     2(R0)
          000002
36 01676  012710         MOV     #40600,(R0)     ;FLOAT 4
          040600
37 01702  075030         FDIV    R0              ;0(R0),2(R0)=FVC*0.25
38
39 01704  016740         MOV     SLV+2,-(R0)
          014756
40 01710  016740         MOV     SLV,-(R0)
          014750
```

```
41 01714 075030          FDIV    R0              ;0(R0),2(R0)=UNCAL FVC*0.25
42
43 01716 016045          MOV     2(R0),-(TP)
         000002
44 01722 011045          MOV     (R0),-(TP)
45 01724 004767          JSR     PC,RI
         014016
46
47 01730 011501          MOV     (TP),R1
48                 ;     MUL     #3,R1           ;0.75*FVC (UNCAL)
49 01732 061501          ADD     (TP),R1
50 01734 061501          ADD     (TP),R1
51 01736 012502          MOV     (TP)+,R2        ;0.25*FVC (UNCAL)
52
53 01740 012700          MOV     #FVDAT,R0
         020006
54 01744 005004          CLR     R4
55
56 01746 022002          CMP     (R0)+,R2
57 01750 100776          BMI     .-2
58 01752 010067          MOV     R0,WKAR
         035136
59
60 01756 005204          INC     R4
61 01760 020120          CMP     R1,(R0)+
62 01762 100375          BPL     .-4
63 01764 010067          MOV     R0,WKAR+2
         035126
64
65                 ;R4 = NUMBER OF TICKS
66                 ;FINISH COMPUTATION OF MMFR
67 01770 004767          JSR     PC,FLOW
         000242
68
69 01774 012704          MOV     #OUTAR+10,R4    ;STORE MMFR
         034106
70 02000 012024          MOV     (R0)+,(R4)+
71 02002 012024          MOV     (R0)+,(R4)+
72
73                 ;COMPUTE MEFR
74                 ;COMPUTE L0.2 AND L1.2 IN SPIRO A/D COUNTS
75 02004 012700          MOV     #WKAR,R0
         037114
76 02010 010001          MOV     R0,R1
77 02012 016721          MOV     SLV,(R1)+
         014646
78 02016 016721          MOV     SLV+2,(R1)+
         014644
79 02022 016721          MOV     D0.2,(R1)+
         014646
80 02026 016721          MOV     D0.2+2,(R1)+
         014644
81 02032 075030          FDIV    R0
82 02034 016045          MOV     2(R0),-(TP)
         000002
83 02040 011045          MOV     (R0),-(TP)
84 02042 004767          JSR     PC,RI
```

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```
                013700
85  02046 012567        MOV     (TP)+,L0.2
                031772
86
87  02052 012700        MOV     #WKAR,R0
                037114
88  02056 016741        MOV     D1.2+2,-(R1)
                014610
89  02062 016741        MOV     D1.2,-(R1)
                014602
90  02066 075030        FDIV    R0
91  02070 016045        MOV     2(R0),-(TP)
                000002
92  02074 011045        MOV     (R0),-(TP)
93  02076 004767        JSR     PC,RI
                013644
94  02102 012567        MOV     (TP)+,L1.2
                031740
95
96  02106 012700        MOV     #FVDAT,R0
                020006
97  02112 016701        MOV     L0.2,R1
                031726
98  02116 010702        MOV     L1.2,R2
                031724
99  02122 005004        CLR     R4
100
101 2124  022001        CMP     (R0)+,R1
102 2126  100776        BMI     .-2
103 2130  010067        MOV     R0,WKAR
                034760
104
105 2134  005204        INC     R4
106 2136  020220        CMP     R2,(R0)+
107 2140  100375        BPL     .-4
108 2142  010067        MOV     R0,WKAR+2
                034750
109
110 2146  004767        JSR     PC,FLOW
                000064
111 2152  012704        MOV     #OUTAR+14,R4
                034112
112 2156  012024        MOV     (R0)+,(R4)+
113 2160  012024        MOV     (R0)+,(R4)+
114
115 2162  016703 MOV     BTPSF,R3
                014602
116 2166  016704        MOV     BTPSF+2,R4
                014600
117 2172  012700        MOV     #OUTAR,R0
                034076
118 2176  012701        MOV     #OUTAR,R1
                034076
119 2202  012702        MOV     #4,R2
                000004
120
121 2206  016045 BTLOOP: MOV     2(R0),-(TP)
```

```
                000002
122 2212 011045         MOV     (R0),-(TP)
123 2214 062700         ADD     #4,R0
         000004
124 2220 010445         MOV     R4,-(TP)
125 2222 010345         MOV     R3,-(TP)
126 2224 075025         FMUL    TP
127 2226 012521         MOV     (TP)+,(R1)+
128 2230 012521         MOV     (TP)+,(R1)+
129 2232 077213         SOB     R2,BTLOOP
130 2234 000207         RTS     PC
131
132                 ;SUBROUTINE FLOW
133                 ;    ENTER WITH:
134                 ;       WKAR=ADDRESS+2 OF LOW VALUE
135                 ;       WKAR+2=ADDRESS+2 OF HIGH VALUE
136                 ;       R4=T
137                 ;    RETURN WITH:
138                 ;       R0 POINTING TO DESIRED FLOW VALUE
139 2236 016700 FLOW:   MOV     WKAR,R0
         034652
140 2242 162700         SUB     #2,R0
         000002
141 2246 011002         MOV     (R0),R2         ;LOW VALUE
142 2250 016700         MOV     WKAR+2,R0
         034642
143 2254 162700         SUB     #2,R0           ;HIGH VALUE
         000002
144 2260 011001         MOV     (R0),R1
145 2262 160201         SUB     R2,R1
146
147 2264 010145         MOV     R1,-(TP)
148 2266 004767         JSR     PC,IR           ;FLOAT(R0)
         013360
149
150 2272 012700         MOV     #WKAR,R0
         037114
151 2276 012520         MOV     (TP)+,(R0)+
152 2300 012520         MOV     (TP)+,(R0)+
153 2302 016720         MOV     SLV,(R0)+
         014356
154 2306 016720         MOV     SLV+2,(R0)+
         014354
155 2312 012700         MOV     #WKAR,R0
         037114
156 2316 075020         FMUL    R0              ;CALIBRATED DIFFERENCE
157
158 2320 010445         MOV     R4,-(TP)        ;FLOAT (T)
159 2322 004767         JSR     PC,IR
         013324
160
161 2326 012700         MOV     #WKAR,R0
         037114
162 2332 010001         MOV     R0,R1
163 2334 012521         MOV     (TP)+,(R1)+
164 2336 012521         MOV     (TP)+,(R1)+
165 2340 075030         FDIV    R0              ;DIFFERENCE/T
```

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```
166
167 2342 016740          MOV     ONEH+2,-(R0)    ;AT 100 S/S, T=TICKS*0.01
         051504
168 2346 016740          MOV     ONEH,-(R0)
         051476
169 2352 075020          FMUL    R0
170
171 2354 000207          RTS     PC
172
173
```

```
                        .TITLE  NITROGEN WASHOUT
002356 012700 WO:       MOV     #TSTK,R0
       037112
002362 012767           MOV     #-17,WAITT
       177761
       035336
002370 016767           MOV     MSDLY,VDEL
       031622
       031616
002376 066767           ADD     MSDLY,VDEL      ;TWICE BECAUSE OF WORDS TO DELAY, NOT BYTES
       031614
       031610
002404 004767           JSR     PC,VDELSU
       011706

               ;XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
               ;NEED SOME MSSPECIFIC SHIT HERE
               ;XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX


02410 052767            BIS     #1,DRAS
       000001
       165352
02416 005067            CLR     TCNT
       031410
02422 012767            MOV     #FVDAT,FVADR
       020006
       015352
02430 005067            CLR     VPREV
       031422
02434 005067            CLR     VLAST
       031366
02440 005067            CLR     MAXFN
       031416
02444 005067            CLR     BRCNT
       031404
02450 005067            CLR     MAXFN
       031406
02454 005067            CLR     MAXFN+2
       031404
02460 005067            CLR     MAXVL
       031374

02464 012767            MOV     #-1,SBFLAG              ;-1 NOT YET   0    NOW                  1PAST
       177777
       034304
02472 012767            MOV     #-1,SBCLR
       177777
       034274
02500 005067            CLR     ALTFLG
       034274
02504 052767            BIS     #1,DUM1
       000001
       035206
```

```
1                       ;BACKGROUND IDLE ROUTINE
2  002512 026767 WOMON:  CMP     QUADO,QUAD1     ; SAME=>NO NEW DATA IN O BUFFER
          001504
          031500
3  002520 001774         BEQ     WOMON
4  002522 016700         MOV     QUADO,R0
          031474
5  002526 020027         CMP     R0,#QUADS1      ;PNTR OUTSIDE OF CIRCULAR BUFFER
          036732
6  002532 002402         BLT     ARN33
7  002534 012700         MOV     #QUADST,R0
          034224
8  002540 012067 ARN33:  MOV     (R0)+,WWV
          034212
9  002544 012067         MOV     (R0)+,WWN
          034210
10 02550  012067         MOV     (R0)+,WWN+2
          034206
11 02554  062700         ADD     #10,R0          ;SKIP O2 AND CO2
          000010
12 02560  010067         MOV     R0,QUADO
          031436
13 02564  005767         TST     WWV
          034166
14 02570  001557         BEQ     EOB1
15 02572  005767         TST     SBFLAG          ;-1=> BEFORE SBM, 0=> SBM, 1=> AFTER SBM
          034200
16 02576  001041         BNE     NOSB
17 02600  005767 SB:     TST     SBCLR
          034170
18 02604  001410         BEQ     NOCLR
19 02606  012767         MOV     #0,TCNT
          000000
          031216
20 02614  012767         MOV     #FVDAT,FVADR
          020006
          015160
21 02622  005067         CLR     SBCLR
          034146
22
23
24
25
26
27 02626  005267 NOCLR:  INC     FVCNT
          015152
28 02632  016700         MOV     FVADR,R0
          015144
29 02636  016720         MOV     WWV,(R0)+
          034114
30 02642  016720         MOV     WWN,(R0)+
          034112
31 02646  016720         MOV     WWN+2,(R0)+
          034110
32 02652  026767         CMP     MAXVL,WWV
          031202
          034076
```

```
33 02660 100006          BPL     SB1
34 02662 016767          MOV     WWV,MAXVL
         034070
         031170
35 02670 016767          MOV     FVADR,LOCMXV
         015106
         031122
36
37
38
39
40 02676 010067 SB1:     MOV     R0,FVADR
         015100
41 02702 005767 NOSB:    TST     ALTFLG
         034072
42 02706 001004          BNE     NOSBD
43 02710 012767          MOV     #-1,ALTFLG
         177777
         034062
44 02716 000675          BR      WOMON
45
46 02720 005067 NOSBD:   CLR     ALTFLG
         034054
47
48 02724 016700          MOV     WWV,R0
         034026
49 02730 166700          SUB     VPREV,R0
         031122
50 02734 016767          MOV     WWV,VPREV
         034016
         031114
51 02742 010045          MOV     R0,-(TP)
52 02744 004767          JSR     PC,IR
         012702
53 02750 016745          MOV     SLV+2,-(TP)
         013712
54 02754 016745          MOV     SLV,-(TP)
         013704
55 02760 075025          FMUL    TP
56 02762 012700          MOV     #WKAR,R0
         037114
57 02766 012520          MOV     (TP)+,(R0)+
58 02770 012520          MOV     (TP)+,(R0)+
59 02772 016720          MOV     VSUM,(R0)+
         031070
60 02776 016720          MOV     VSUM+2,(R0)+
         031066
61 03002 012700          MOV     #WKAR,R0
         037114
62 03006 075000          FADD    R0
63
64                ;VSUM = SUM OF CALIBRATED (WWV-VPREV)
65 03010 012067          MOV     (R0)+,VSUM
         031052
66 03014 012067          MOV     (R0)+,VSUM+2
         031050
67 03020 016740          MOV     WWN+2,-(R0)
```

```
                033736
68  03024 016740        MOV     WWN,-(R0)
          033730
69  03030 162700        SUB     #4,R0
          000004
70  03034 075020        FMUL    R0
71
72                ; NSUM = WWN*SLV(WWV-VPREV) + NSUM
73
74  03036 016740        MOV     NSUM+2,-(R0)
          031032
75  03042 016740        MOV     NSUM,-(R0)
          031024
76  03046 075000        FADD    R0
77  03050 012067        MOV     (R0)+,NSUM
          031016
78  03054 011067        MOV     (R0),NSUM+2
          031014
79  03060 012700        MOV     #WKAR,R0
          037114
80  03064 016720        MOV     WWN,(R0)+
          033670
81  03070 016720        MOV     WWN+2,(R0)+
          033666
82  03074 016720        MOV     MAXFN,(R0)+
          030762
83  03100 016720        MOV     MAXFN+2,(R0)+
          030760
84  03104 012700        MOV     #WKAR,R0
          037114
85  03110 075010        FSUB    R0
86  03112 100004        BPL     WARN
87  03114 014067        MOV     -(R0),MAXFN+2
          030744
88  03120 014067        MOV     -(R0),MAXFN
          030736
89  03124 000167 WARN:  JMP     WOMON
          177362
90
91
92
93
94
95
```

```
 1 003130 016745 EOB1:   MOV     VPREV,-(TP)
          030722
 2 003134 004767         JSR     PC,BTPS
          012762
 3 003140 012746         MOV     #WOPBFR,-(SP)
          061024
 4 003144 012746         MOV     #2,-(SP)
          000002
 5 003150 012746         MOV     #2,-(SP)
          000002
 6 003154 012502         MOV     (TP)+,R2
 7 003156 012546         MOV     (TP)+,-(SP)
 8 003160 010246         MOV     R2,-(SP)
 9 003162 004767         JSR     PC,FFMT
          012004
10 03166 012746          MOV     #WONBFR,-(SP)
          061035
11 03172 012746          MOV     #4,-(SP)
          000004
12 03176 012746          MOV     #1,-(SP)
          000001
13 03202 016746          MOV     MAXFN+2,-(SP)
          030656
14 03206 016746          MOV     MAXFN,-(SP)
          030650
15 03212 004767          JSR     PC,FFMT
          011754
16 03216                 PRTBUF  WOPBFR,1
   03216 004567          JSR     R5,BUFLOD
          013334
   03222 061024          WOPBFR
   03224 000001          1
   03226 012700          MOV     #BUFFER,R0
          037200
   03232 004767          JSR     PC,LPTGO
          011602
17 03236 005067          CLR     VPREV
          030614
18 03242 005767          TST     SBFLAG
          033530
19 03246 100455          BMI     WFIRST
20 03250 001002          BNE     NOREOB
21 03252 005267          INC     SBFLAG
          033520
22
23                  ;NORMAL END OF BREATH
24
25 03256 012700 NOREOB: MOV     #WKAR,R0
          037114
26 03262 012720          MOV     #37514,(R0)+
          037514
27 03266 012720          MOV     #146315,(R0)+
          146315
28 03272 016720          MOV     VSUM,(R0)+
          030570
29 03276 016720          MOV     VSUM+2,(R0)+
          030566
```

```
30 03302 012700 037114          MOV     #WKAR,R0
31 03306 075010                 FSUB    R0
32 03310 012067 030552          MOV     (R0)+,VSUM
33 03314 012067 030550          MOV     (R0)+,VSUM+2
34 03320 016040 030540          MOV     MAXFN+2,-(R0)
35 03324 016740 030532          MOV     MAXFN,-(R0)
36                      ;3% NITROGEN LEVEL FOR WEST'S MASS SPEC
37 03330 016740 013432          MOV     D.03+2,-(R0)
38 03334 016740 013424          MOV     D.03,-(R0)
39 03340 075010                 FSUB    R0
40 03342 100007                 BPL     WABOVE
41 03344 005767 033424          TST     SBCLR           ;BELOW 3%
```

```
                      ;XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      ;MINUS 0.2
003350 001401                 BEQ     NOTYET  ;BOTTOM
003352 000443                 BR      EOT
003354 005267         NOTYET: INC     SBCLR
       033414
003360 000402                 BR      LVEW


003362 005067         WABOVE: CLR     SBCLR
       033406
 03366 005067         LVEW:   CLR     MAXFN
       030470
 03372 005067                 CLR     MAXFN+2
       030466
 03376 000167                 JMP     WOMON
       177110








 03402 005067         WFIRST: CLR     VSUM
       030460
 03406 005067                 CLR     VSUM+2
       030456
 03412 005067                 CLR     FVCNT
       014366
 03416 005067                 CLR     NSUM
       030450
 03422 005067                 CLR     NSUM+2
       030446
 03426 005267                 INC     SBFLAG
       033344
 03432 016767                 MOV     MAXFN,OUTAR+20
       030424
       030456
 03440 016767                 MOV     MAXFN+2,OUTAR+22
       030420
       030452
 03446 005067                 CLR     MAXFN
       030410
 03452 005067                 CLR     MAXFN+2
       030406
 03456 000167                 JMP     WOMON
       177030
 03462 042767         EOT:    BIC     #1,DUM1
       000001
       034230
```

```
                        ;ANALYZE SINGLE BREATH WAVEFORM
003470 012705 WORK:     MOV     #TSTK,TP        ;REINIT USER STACK
       037112
003474 010745            MOV     MAXVL,-(TP)
       :030360
003500 004767            JSR     PC,IR
       012146
                        ;
003504 012704            MOV     #OUTAR+24,R4
       034122
003510 012700            MOV     #WKAR,R0
       037114
003514 010001            MOV     R0,R1
003516 012520            MOV     (TP),(R0)+
003520 016520            MOV     2(TP),(R0)+
       000002
003524 016720            MOV     SLP,(R0)+
       037134
003530 016720            MOV     SLP+2,(R0)+
       013132
003534 075021            FMUL    R1
003536 016720            MOV     BTPSI,(R0)+
       013226
003542 016720            MOV     BTPSF+2,(R0)+
       013224
003546 075021            FMUL    R1
003550 012124            MOV     (R1)+,(R4)+
003552 012104            MOV     (R1)+,(R4)+     ;VITAL CAPACITY
                        ;LOCATE VOL/FN2 PAIRS CORRESPONDING TO .35 * VC AND
                        ;0.65 * VC. STORE AS N2 DELTA OR SLOPE OF ALVEOLAR PLATEAU.
003554 012700            MOV     #WKAR,R0
       037114
003560 010001            MOV     R0,R1
003562 012520            MOV     (TP)+,(R0)+
003564 012520            MOV     (TP)+,(R0)+
003566 016720            MOV     D.35,(R0)+
       013100
003572 016720            MOV     D.35+2,(R0)+
       013104
003576 075021            FMUL R1
003600 012104            MOV     (R1)+,R4
003602 012145            MOV     (R1)+,-(TP)
003604 010445            MOV     R4,-(TP)
003606 004767            JSR     PC,RI
       012154
003612 012504            MOV     (TP)+,R4
                        ;
003614 012700            MOV     #WKAR,R0
       037114
003620 016741            MOV     D.65+2,-(R1)
       013072
003626 016741            MOV     D.65,-(R1)
       013074
003632 075020            FMUL    R0
003634 012003            MOV     (R0)+,R3
003636 012045            MOV     (R0)+,-(TP)
003640 010345            MOV     R3,-(TP)
```

```
41 03640 004767          JSR     PC,R1
         012102
42 03644 012503          MOV     (TP)+,R3
43
44                       ;R3 AND R4 NOW CONTAIN THE INTEGER EQUIV. OF UNCAL
45                       ;0.35*V/C AND 0.65*V/C
46 03646 016700          MOV     FVCNT,R0
         014132
47 03652 012701          MOV     #FVDAT,R1
         020006
48
49 03656 022104 WO12:    CMP     (R1)+,R4
50 03660 100004          BPL     WO13            ;POINT >=0.35*V/C
51
52 03662 062701          ADD     #4,R1           ;SKIP FN2 PAIR
         000004
53 03666 077005          SOB     R0,WO12
54                       ;ERROR CONDITION
55 03670 000000          HALT
56                       ;FOUND PAIR CORRESPONDING TO 0.35*V/C
57 03672 010167 WO13:    MOV     R1,PRLO
         033254
58 03676 062701          ADD     #4,R1
         000004
59                       ;NOW GO FIND VALUE CORRESPONDING TO 0.65*V/C
60 03702 022103 WO14:    CMP     (R1)+,R3
61 03704 100004          BPL     WO15            ;R3>=(R1)
62
63 03706 062701          ADD     #4,R1
         000004
64 03712 077005          SOB     R0,WO14
65                       ;ERROR
66 03714 000000          HALT
67
68 03716 162701 WO15:    SUB     #2,R1
         000002
69 03722 010167          MOV     R1,PRHI
         033226
70 03726 162767          SUB     #2,PRLO
         000002
         033216
```

```
                        ;COMPUTE DELTA VOLUME
003734 004767           JSR     PC,CLRSUM
       012134
003740 016703           MOV     PRLO,R3
       033206
003744 012345 MOSUM:    MOV     (R3)+,-(TP)     ;VOL=X, FN2=Y
003746 004767           JSR     PC,BTPS
       012150
003752 012304           MOV     (R3)+,R4
003754 012345           MOV     (R3)+,-(TP)
003756 010445           MOV     R4,-(TP)
03760  004767           JSR     PC,SUMM
       012404
03764  020367           CMP     R3,PRHI
       033164
03770  002765           BLT     MOSUM
03772  004767           JSR     PC,LSQ
       012156
03776  010500           MOV     TP,R0
04000  012703           MOV     #OUTAR+30,R3
       034126
04004  012023           MOV     (R0)+,(R3)+
04006  012023           MOV     (R0)+,(R3)+
04010  012023           MOV     (R0)+,(R3)+
04012  012023           MOV     (R0)+,(R3)+

04014  016745           MOV     ONEH+2,-(TP)
       050032
04020  016745           MOV     ONEH,-(TP)
       050024
04024  075025           FMUL    TP

04026  012523           MOV     (TP)+,(R3)+     ;STORE N2 DELTA
04030  012023           MOV     (TP)+,(R3)+
                        ;COMPUTE CLOSING VOLUME
04032  012703           MOV     #OUTAR+30,R3
       034126
04036  016704           MOV     LOCMXV,R4       ;ADDR+2 WITHIN FVDAT OF MAXVL
       027756
04042  162704           SUB     #4,R4
       000004

04046  014445 WO21:     MOV     -(R4),-(TP)
04050  004767           JSR     PC,BTPS
       012046
04054  012700           MOV     #WKAR,R0
       037114
04060  010001           MOV     R0,R1
04062  012520           MOV     (TP)+,(R0)+
04064  012520           MOV     (TP)+,(R0)+

04066  012320           MOV     (R3)+,(R0)+
04070  012320           MOV     (R3)+,(R0)+     ;PULL IN SLOPE
04072  075021           FMUL    R1
04074  012320           MOV     (R3)+,(R0)+
04076  012320           MOV     (R3)+,(R0)+     ;PULL IN Y-INT
```

```
 44 04100 075001          FADD    R1              ;0(R1),2(R1)=FN2C
 45 04102 062704          ADD     #2,R4
          000002
 46 04106 012420          MOV     (R4)+,(R0)+     ;NEXT FN2
 47 04110 012420          MOV     (R4)+,(R0)+
 48 04112 012703          MOV     #OUTAR+30,R3
          034126
 49 04116 075011          FSUB    R1              ;0(R1),2(R1)=FN2A-FN2C
 50 04120 100403          BMI     WO22
 51                ;CORRECT (R4) TO POINT TO NEXT VOLUME
 52 04122 162704          SUB     #12,R4
          000012
 53 04126 000747          BR      WO21
 54                ;FOUND FN2A<FN2C, GET CLOSING VOLUME
 55                ;THIS VOLUME SHOULD STILL BE IN WKAR+4
 56 04130 012700 WO22:    MOV     #WKAR,R0
          037114
 57 04134 014360          MOV     -(R3),6(R0)
          000006
 58 04140 014360          MOV     -(R3),4(R0)     ;GET VITAL CAPACITY
          000004
 59 04144 075010          FSUB    R0              ;VC-VOLUME
 60 04146 012067          MOV     (R0)+,OUTAR+44
          027770
 61 04152 012067          MOV     (R0)+,OUTAR+46
          027766
 62                ;CALCULATE RESIDUAL VOLUME
 63 04156 012700 WO60:    MOV     #WKAR,R0
          037114
 64 04162 012704          MOV     #OUTAR+50,R4
          034146
 65 04166 010001          MOV     R0,R1
 66                ;COMPUTE TIME IN MINUTES
 67 04170 016745          MOV     TCNT,-(TP)
          027636
 68 04174 004767          JSR     PC,IR
          011452
 69 04200 016720          MOV     D6000,(R0)+
          012510
 70 04204 016720          MOV     D6000+2,(R0)+
          012506
 71 04210 012520          MOV     (TP)+,(R0)+
 72 04212 012520          MOV     (TP)+,(R0)+
 73 04214 075031          FDIV    R1              ;T=NO. OF INTERRUPTS/6000
 74 04216 016720          MOV     NWOBLD,(R0)+
          012476
 75 04222 016720          MOV     NWOBLD+2,(R0)+  ;CONSTANT 0.0312
          012474
 76 04226 075021          FMUL    R1              ;0(R1),2(R1)=T(IN MIN.)*0.0312
 77 04230 016720          MOV     NSUM,(R0)+
          027636
 78 04234 016720          MOV     NSUM+2,(R0)+
          027634
 79 04240 075011          FSUB    R1
 80 04242 062701          ADD     #4,R1           ;COMPUTE RV DENOM
          000004
 81 04246 016720          MOV     MAXFN,(R0)+     ;GET FN2(FINAL)
```

```
                027610
82  04252 016720        MOV     MAXFN+2,(R0)+
                027806
83  04256 016720        MOV     OUTAR+20.(R0)+
                027634
84  04262 016720        MOV     OUTAR+22,(R0)+
                027632
85  04266 075011        FSUB    F1                      ;FN2(INIT) - FN2(FINAL)
86  04270 012704        MOV     #OUTAR+50,R4
                034146
87  04274 012700        MOV     #WKAR+10,R0
                037124
88  04300 010002        MOV     R0,R2
89  04302 012112        MOV     (R1)+,(R2)
90  04304 012162        MOV     (R1)+,2(R2)
                000002
91  04310 075030        FDIV    R0                      ;RESIDUAL VOLUME
92  04312 016740        MOV     BTPSF+2,-(R0)
                012454
93  04316 016740        MOV     BTPSF,-(R0)
                012446
94  04322 075020        FMUL    R0
95  04324 016740        MOV     D0.2+2,-(R0)    ;ESTIMATE FOR ANATOM. DEAD SPACE
                012346
96  04330 016740        MOV     D0.2,-(R0)
                012340
97  04334 075010        FSUB    R0
98  04336 010002        MOV     R0,R2
99  04340 012024        MOV     (R0)+,(R4)+
100 4342  012024        MOV     (R0)+,(R4)+
101 4344  016720        MOV     VSUM,(R0)+
                027516
102 4350  016720        MOV     VSUM+2,(R0)+
                027514
103 4354  075032        FDIV    R2                      ;COMPUTE VA/RV
104 4356  016742        MOV     BTPSF+2,-(R2)
                012410
105 4362  016742        MOV     BTPSF,-(R2)
                012402
106 4366  075022        FMUL    R2
107 4370  012224        MOV     (R2)+,(R4)+
108 4372  012224        MOV     (R2)+,(R4)+
109 4374  000207        RTS     PC
```

```
1                       ;CALLED FROM RPT.
2                       ;COMPUTE PERCENTAGES, ASSUMES FVC AND WO HAVE BEEN PERFORMED
3  004376 012702 WO35:  MOV     #OUTAR+50,R2
          034146
4  004402 012703        MOV     #OUTAR+60,R3
          034156
5  004406 012704        MOV     #OUTAR,R4
          034076
6  004412 012700        MOV     #WKAR,R0
          037114
7  004416 010001        MOV     R0,R1
8  004420 012460        MOV     (R4)+,4(R0)     ;FEV1
          000004
9  004424 012460        MOV     (R4)+,6(R0)
          000006
10 04430  012410        MOV     (R4)+,(R0)      ;FVC
11 04432  012460        MOV     (R4)+,2(R0)
          000002
12 04436  075030        FDIV    R0              ;FEV1/FVC
13 04440  012023        MOV     (R0)+,(R3)+
14 04442  012023        MOV     (R0)+,(R3)+
15 04444  016140        MOV     2(R1),-(R0)     ;MOVE FVC INTO DENOMINATOR
          000002
16 04450  016140        MOV     0(R1),-(R0)
          000000
17 04454  012704        MOV     #OUTAR,R4
          034076
18 04460  016440        MOV     26(R4),-(R0)    ;VC
          000026
19 04464  016440        MOV     24(R4),-(R0)
          000024
20 04470  075030        FDIV    R0
21 04472  012023        MOV     (R0)+,(R3)+     ;STORE FVC/VC
22 04474  012023        MOV     (R0)+,(R3)+
23 04476  014240        MOV     -(R2),-(R0)     ;CV
24 04500  014240        MOV     -(R2),-(R0)
25 04502  075031        FDIV    R1              ;CV/VC
26 04504  012123        MOV     (R1)+,(R3)+
27 04506  012123        MOV     (R1)+,(R3)+
28
29 04510  012700        MOV     #WKAR+4,R0
          037120
30 04514  010001        MOV     R0,R1
31 04516  012220        MOV     (R2)+,(R0)+
32 04520  012220        MOV     (R2)+,(R0)+
33 04522  012220        MOV     (R2)+,(R0)+
34 04524  012220        MOV     (R2)+,(R0)+
35 04526  075001        FADD    R1              ;CV+RV
36
37 04530  012700        MOV     #WKAR,R0
          037114
38 04534  016720        MOV     OUTAR+24,(R0)+  ;VC
          027362
39 04540  016720        MOV     OUTAR+26,(R0)+
          027360
40 04544  014260        MOV     -(R2),2(R0)
          000002
```

```
 41 04550 011210          MOV     -(R2),(R0)      ;RV
 42 04552 012700          MOV     #WKAR,R0
          037114
 43 04556 075060          FADD    R0
 44 04560 011023          MOV     (R0),(R3)+
 45 04562 016023          MOV     2(R0),(R3)+     ;TLC=RV+VC
          000002
 46 04566 075031          FDIV    R0              ;(RV+CV)/TLC
 47 04570 012023          MOV     (R0)+,(R3)+
 48 04572 012023          MOV     (R0)+,(R3)+
 49                 ;GO BACK AND MULTIPLY BY 100
 50 04574 012703          MOV     #OUTAR+60,R3
          034156
 51 04600 012704          MOV     #3,R4
          000003
 52
 53 04604 012700          MOV     #WKAR,R0
          037114
 54 04610 010001          MOV     R0,R1
 55 04612 016720          MOV     ONEH,(R0)+
          047232
 56 04616 016720          MOV     ONEH+2,(R0)+
          047230
 57 04622 011320  WO36:   MOV     (R3),(R0)+      ;LOOP 3 TIMES AND COMPUTE:
 58 04624 016320          MOV     2(R3),(R0)+     ;FRV1/FVC%
          000002
 59 04630 075021          FMUL    R1              ;   FVC/VC %
 60 04632 012123          MOV     (R1)+,(R3)+     ;   CV/VC %
 61 04634 012123          MOV     (R1)+,(R3)+
 62 04636 012701          MOV     #WKAR,R1
          037114
 63 04642 010100          MOV     R1,R0
 64 04644 062700          ADD     #4,R0
          000004
 65 04650 077414          SOB     R4,WO36
 66                 ;SKIP ONE FLOAT WORD IN OUTAR
 67 04652 062703          ADD     #4,R3
          000004
 68 04656 011320          MOV     (R3),(R0)+
 69 04660 016320          MOV     2(R3),(R0)+
          000002
 70 04664 075021          FMUL    R1
 71 04666 012123          MOV     (R1)+,(R3)+
 72 04670 012123          MOV     (R1)+,(R3)+
 73
 74                 ;DONE - YEAH !!!!!!!
 75
 76                 ;
 77                 ;
 78                 ;
 79                 ; TO BE CONTINUED ********
 80                 ;
 81 04672 000207          RTS     PC
 82
```

```
                        .TITLE  A/D ISR
                ;
004674 010246 ADISR:    MOV     R2,-(SP)
004676 032767           BIT     #1,DUM1
       000001
       033014
004704 001476           BEQ     LVR
004706 016702           MOV     DRAO,R2         ;SEE WHAT WE ARE DOING
       163060
004712 032702           BIT     #200,R2
       000200
004716 001444           BEQ     FVCINT
004720 032702           BIT     #40,R2  ;WASHOUT??
       000040
04724 001405            BEQ     WOINT   ;YEP
04726 032767            BIT     #100,DRBO       ;PBF,PTC
       000100
       163026
04734 001540            BEQ     PBFINT          ;YEP
04736 000461            BR      INTRTN  ;NO  SOMETHING FOULED UP
                ;
04740 005767 WOINT:     TST     CLKFLG
       027236
04744 001403            BEQ     GOGOGO
04746 005067            CLR     CLKFLG
       027230
04752 000453            BR      INTRTN
                ;
04754 005167 GOGOGO:    COM     CLKFLG
       027222
04760 032702            BIT     #40,R2
       000040
04764 004767            JSR     PC,GETGAS
       006214
04770 016767            MOV     TRGR,ADSR
       033272
       171772
04776 032767 GSIN:      BIT     #200,ADSR
       000200
       171764
05004 001774            BEQ     GSIN
05006 016702            MOV     ADIN,R2
       171760
05012 004767            JSR     PC,SPIRO
       007136
05016 004767            JSR     PC,DELAY
       007374
05022 005267            INC     TCNT
       027004
05026 000425            BR      INTRTN
```

```
                        
05030 016767 F/CINT: MOV     TRGR,ADSR
      053232
      171732
                        
05036 032767 F/CIN1: BIT     #200,ADSR
      000200
      171724
05044 001774         BEQ     F/CIN1
05046 016700         MOV     ADIN,R2
      171720
05052 004767         JSR     PC,SPIKC
      007076
05056 005702         TST     R2
05060 001402         BEQ     F/CIN2
05062 010221         MOV     R2,(R1)+
05064 005200         INC     R0
05066 032767 F/CIN2: BIT     #1,EOS
      000001
      012704
05074 001402         BEQ     INTRTN
05076 052703         BIS     #1,R3
      000001
                        
                        
05102          L/R:
05102 005367 INTRTN: DEC     TTYCNT
      032064
05106 005767         TST     TTYCNT
      032060
05112 001044         BNE     L/R1
                        
05114 012767         MOV     #16.,TTYCNT      ;TIME TO OUTPUT A CHARACTER
      000016
      032050
05122 032767         BIT     #200,XCSR
      000200
      172434
05130 001435         BEQ     L/R1
05132 105777         TSTB    @TTYGO
      032032
05136 003406         BLE     TTYEOL
05140 117767         MOVB    @TTYGO,XBUF
      032024
      172420
05146 005267 TTL:    INC     TTYGO
      032016
05152 000424         BR      L/R1
05154 002423 TTYEOL: BLT     L/R1     ;MINUS 1
05156 122767         CMPB    #12,XBUF1
      000012
      000530
05164 001407         BEQ     L/R2
05166 112767         MOVB    #12,XBUF
      000012
      172372
05174 012767         MOV     #12,XBUF1
```

```
          000012
          063512
72 05202 000410          BR      LVR1
73 05204 112767 LVR2:    MOVB    #15,XBUF
          000015
          172354
74 05212 012767          MOV     #15,XBUF1
          000015
          063474
75 05220 005267          INC     TTYGO
          031744
76 05224 042767 LVR1:    BIC     #100000,DRBS
          100000
          162526
77 05232 012602          MOV     (SP)+,R2
78 05234 000002          RTI
79
```

```
                        .TITLE  CLOCK PBF SERVICE
                ;
005236 005367 PBFINT:   DEC     PINTCT
       032530
005242 001317           BNE     INTRTN
005244 012767           MOV     #4,PINTCT       ;ONLY FALLS THROUGH EVERY FOURTH TIME
       000004
       032520
005252 005267           INC     TIM1
       052550
005256 001002           BNE     ARNCTM
005260 005267           INC     TIM2            ;A DOUBLE WORD FOR NUMBER OF 40 MSEC INTERRUPTS
       052544
                ;
05264 004767 ARNCTM:    JSR     PC,GETGAS       ;SAMPLE GSES
       005714
05270 016767            MOV     TRGR,ADSR       ;SAMPLE VOLUME
       032772
       171472
                ;
05276 032767 PBV:       BIT     #200,ADSR       ;DONE?
       000200
       171464
05304 001774            BEQ     PBV
05306 016702            MOV     ADIN,R2
       171460
05312 004767            JSR     PC,SPIRO
       006636
05316 004767            JSR     PC,DELAY        ;ADD PHASED VOLUME TO QUEUE
       007074
                ;
05322 005367            DEC     BPCNT           ;TIME TO TRIGGER IT?
       032410
05326 001006            BNE     NOBP
05330 052767            BIS     #2,DRAS         ;YES
       000002
       162432
05336 012767            MOV     #1500.,BPCNT    ;RESET COUNTER TO 1 MINUTE
       002734
       032372
                ;
05344 005367 NOBP:      DEC     SEC5CT          ;5 SECONDS ELAPSED?
       052440
05350 001064            BNE     NOS
05352 042767            BIC     #2,DRAS
       000002
       162410
05360 012767            MOV,    #125.,SEC5CT
       000175
       052422
05366 016777            MOV     PTHRCT,@PSWHR
       053346
       052420
05374 062767            ADD     #2,PSWHR
       000002
       052412
05402 005067            CLR     PTHRCT
```

```
                053332
31 05406 012767 MOV     #4035,ADSR      ;INITIATE WOL SAM
         004035
         171354
32 05414 032767 WLCK:   BIT     #200,ADSR       ;SAMPLE WORK LOAD EVERY 5 SECS.
         000200
         171346
33 05422 001774         BEQ     WLCK
34 05424 016702         MOV     ADIN,R2
         171342
35 054?  ?10277         MOV     R2,@PSVWL
         052362
36 0543. 062767         ADD     #2,PSVWL
         000002
         052354
37 05442 010245         MOV     R2,-(TP)
38 05444 004767         JSR     PC,IR
         010202
39 05450 016745         MOV     WLFAC+2,-(TP)   ;CONVERT TO WATTS
         012316
40 05454 016745         MOV     WLFAC,-(TP)
         012310
41 05460 075?25         FMUL    TP
42 05462 016?45         MOV     WLOFF+2,-(TP)   ;OFFSET
         012316
43 05466 016745         MOV     WLOFF,-(TP)
         012302
44 05472 075005         FADD    TP
45 05474 016745         MOV     CWL+2,-(TP)     ;ADD TO LAST VALUE
         052340
46 05500 016745         MOV     CWL,-(TP)
         052332
47 05504 075005         FADD    TP
48 05506 012567         MOV     (TP)+,CWL
         052324
49 05512 012567         MOV     (TP)+,CWL+2
         052322
50 05516 005267         INC     SWL             ;NUMBER OF WORK LOAD SAMPLES
         052312
51
52                ;THE WAY 15 SEC IS SET UP WASTES MEMORY
53 05522 005367 NO5:    DEC     SEC15C          ;PTC SPEWS DATA IN 15 SEC. CHUNKC
         052264
54 05526 001040         BNE     NO15
55 05530 012767         MOV     #375.,SEC15C
         000567
         052254
56 05536 010046         MOV     R0,-(SP)
57 05540 010146         MOV     R1,-(SP)
58 05542 010346         MOV     R3,-(SP)
59
60 05544 012702         MOV     #86.,R2
         000126
61 05550 012700         MOV     #PTHS,R0
         060162
62 05554 012701         MOV     #BPTHS,R1
         060462
```

```
                                
                        PTCMVR: MOV     (R0),(R1)+      ;XFER FROM WORKING TO TEMP
                                CLR     (R0)+
                                SOB     R2,PTCMVR
                                MOV     #1,DSCOUT
                                
                                MOV     TIM1,R1
                                MOV     TIM2,R0
                                MOV     #-1,R3
                                ASHC    R3,R0
                                MOV     R1,BPTCT
                                JSR     PC,PTCSV
                                MOV     (SP)+,R3
                                MOV     (SP)+,R1
                                MOV     (SP)+,R0
                                
                                
                        NO15:   DEC     PRDNCT
                                BNE     INTRTX
                                MOV     R0,-(SP)
                                MOV     R1,-(SP)
                                MOV     #2425,ADSR      ;END OF PERION  SAM BP
                                
                                ;GET BLOOD PRESSURE
                        SPWT:   BIT     #200,ADSR
                                BEQ     SPWT
                                MOV     ADIN,CSBP
                                
                                MOV     #3025,ADSR
                                
                        DPWT:   BIT     #200,ADSR
                                BEQ     DPWT
                                MOV     ADIN,CDBP
                                
                                
                                
                                MOV     #CHR,R0         ;CURRENT HEART RATE
                                MOV     #PRHR,R1        ;PREVIOUS HEART RATE
```

```
            060106
 99 05722 012703          MOV     #20.,R3
            000024
100
101 5726 011021 ENPRMV:   MOV     (R0),(R1)+
102 5730 005020           CLR     (R0)+
103 5732 077303           SOB     R3,ENPRMV
104 5734 016767           MOV     TIM1,PRTIM1
            052066
            052140
105 5742 016767           MOV     TIM2,PRTIM2
            052062
            052134
106 5750 004767           JSR     PC,PROFTC
            002172
107 5754 012767           MOV     #77,PRTFLG
            000077
            032006
108 5762 012601           MOV     (SP)+,R1
109 5764 012600           MOV     (SP)+,R0
110 5766 000167 INTRTX:   JMP     INTRTN
            177110
```

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```
                        .TITLE ROOM AIR
                        ;
                        ; SUBROUTINE ROOM - SAMPLE ROOM AIR
                        ;
005772 010046 ROOM:     MOV     R0,-(SP)
005774 010146           MOV     R1,-(SP)
005776 010246           MOV     R2,-(SP)
006000 010346           MOV     R3,-(SP)
006002 010446           MOV     R4,-(SP)

006004 004767           JSR     PC,GETGAS
       005174

                        ;CHECK FO2 AND FCO2
006010 012700           MOV     #WKAR,R0
       037114
006014 012702           MOV     #FO2,R2
       037666
006020 010001           MOV     R0,R1
006022 016721           MOV     D.19,(R1)+      ;GET D1.9
       010726
006026 016721           MOV     D.19,(R1)+
       010722
006032 012221           MOV     (R2)+,(R1)+
006034 012221           MOV     (R2)+,(R1)+
006036 075010           FSUB    R0              ;0(R0),2(R0)=FO2-0.19
006040 100461           BMI     RABAD

006042 012700           MOV     #WKAR,R0
       037114
006046 012702           MOV     #FCO2,R2
       037676
006052 010001           MOV     R0,R1
006054 012221           MOV     (R2)+,(R1)+
006056 012221           MOV     (R2)+,(R1)+
006060 016721           MOV     D.02,(R1)+
       010674
006064 016721           MOV     D.02+2,(R1)+
       010672
006070 075010           FSUB    R0
006072 100444           BMI     RABAD
                        ;
                        ;GOOD DATA
006074 012700           MOV     #FO2,R0
       037666
006100 012701           MOV     #RAFO2,R1
       037704
006104 012702           MOV     #6,R2
       000006

006110 012021 RM1:      MOV     (R0)+,(R1)+
006112 077202           SOB     R2,RM1
006114 916745           MOV     RAFO2+2,-(TP)
       031566
006120 016745           MOV     RAFO2,-(TP)
```

```
            031560
45 06124 016745         MOV     RAFN2+2,-(TP)
         031562
46 06130 016745         MOV     RAFN2,-(TP)
         031554
47 06134 075035         FDIV    TP
48 06136 012567         MOV     (TP)+,ORAT      ;ORAT=RAFO2/RAFN2
         031602
49 06142 012567         MOV     (TP)+,ORAT+2
         031600
57 06146 016745         MOV     RAFCO2+2,-(TP)
         031544
51 06152 016745         MOV     RAFCO2,-(TP)
         031536
52 06156 016745         MOV     RAFN2,-(TP)
         031526
53 06162 016745         MOV     RAFN2,-(TP)
         031522
54 06166 075035         FDIV    TP
55 06170 012567         MOV     (TP)+,CRAT      ;CRAT=RAFCO2/RAFN2
         031544
56 06174 012567         MOV     (TP)+,CRAT+2
         031542
57 06200 000167         JMP     RM2
         000026
58
59 06204        RABAD:  PRTBUF  BADAIR,3
   06204 004567         JSR     R5,BUFLOD
         010346
   06210 016774         BADAIR
   06212 000003         3
   06214 012700         MOV     #BUFFER,R0
         037200
   06220 004767         JSR     PC,LPTGO
         006614
60 06224 012767         MOV     #-1,DUM2
         177777
         030742
61
62 06232 012604 RM2:    MOV     (SP)+,R4
63 06234 012603         MOV     (SP)+,R3
64 06236 012602         MOV     (SP)+,R2
65 06240 012601         MOV     (SP)+,R1
66 06242 012600         MOV     (SP)+,R0
67
68 06244 000207         RTS     PC
```

```
                       .TITLE PTC,PBF SETUP


  006246 012705 STRTP1: MOV     #TSTK,TP
         037112
  006252 012767         MOV     #-10,WAITT
         177770
         031446
  006260 016767         MOV     MSDLY,VDEL      ;MSDLY IS NUMBER OF 20 MSEC CHUNKS TO DELAY, 20 MSEC CANCELS WITH 2BYTES / WORD
         025732
         025726


                       ;MOVE CHARACTERS TO BUFFER ONCE AND FOR ALL
  06266 004567          JSR     R5,BUFLOD
        010264
  06272 017232          TEXTIM
  06274 000013          13

                       ;XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX


  06276 005067          CLR     TIM1
        051524
  06302 005067          CLR     TIM2
        051522
  06306 004767          JSR     PC,VDELSU       ;SET UP GAS DELAYS
        006004
  06312 012767          MOV     #125.,SEC5CT
        000175
        051470
  06320 012767          MOV     #375.,SEC15C
        000567
        051464
  06326 005067          CLR     SPLRQS          ;CLEAR A FLAG FOR SPLINE FIT
        051454
  06332 005067          CLR     QCOMPU          ;AND FOR SECONDARY CARDIAC OUTPUT CALC
        031414
  06336 012767          MOV     #PROTO,PROGET   ;INITIALIZE THE PROTOCOL POINTER
        040020
        031416
  06344 005067          CLR     EOTPFG
        031404
  06350 005067          CLR     EOTCT
        031402
  06354 005067          CLR     DSFOUT  ;OBDS RQST FLAGS
        031404
  06360 005067          CLR     DSCOUT
        031402
  06364 005067          CLR     OUTWFG
        031344
  06370 005067          CLR     PRTFLG          ;REPORT FLAG
        031374
  06374 012767          MOV     #500.,BPCNT     ;TRIGGER FIRST BPMS AFTER 500*.04SEC
        000764
        031334
  06402 005067          CLR     VPREV
```

```
          025450
33 06406 012767          MOV     #4,PINTCT       ;ADISR ONLY GETS INTERRUPTES FOR THIS EVERY 40 MSEC
          000004
          031356
34 06414 012700          MOV     #PTCT1,R0
          060160
35 06420 012701          MOV     #PTEND,R1
          060736
36 06424 005020 PCBFCL:  CLR     (R0)+   ;CLEAR PTC BUFFERS
37 06426 020001          CMP     R0,R1
38 06430 001375          BNE     PCBFCL
39 06432 012700          MOV     #CHR,R0
          060032
40 06436 012701          MOV     #PBFND,R1
          060156
41 06442 005020 PFBFCL:  CLR     (R0)+   ;BUFFERS
42 06444 020001          CMP     R0,R1
43 06446 001375          BNE     PFBFCL
44 06450 042737          BIC     #100,@#DRBO
          000100
          167762
45 06456 052737          BIS     #40,@#DRBO
          000040
          167762
46                                                ;DIDDLE LIGHTS
47 06464 005067          CLR     QFLAG
          052266
48 06470 004767 JSR      PC,PTCSV                ;SET POINTERS FOR PTC DATA
          001426
49
50
51
52
53
54
55
56               ;MORE SETUP???????????????????????????????
57
58
59 06474 004767          JSR     PC,PROFTC       ;GET NEXT PROTOCOL STEP
          001446
60 06500 052767          BIS     #1,DUM1
          000001
          031212
```

```
                        .TITLE  PTC/PBF WATCH LOOP
006500 026767 EXLOOP:   CMP     QUADO,QUADI
       025510
       025504
006514 001071           BNE     GSANAL          ;VOLUME GAS DATA TO BE ANALYZED?????
                ;THIS GETS CHECKED AFTER EVERY TASK BECAUSE IT CAN TIME OUT QUICKLY
006516 005767           TST     SPLRQS
       051264
006522 001412           BEQ     NOSPL
006524 022767           CMP     #13.,NPAIR
       000013
       031242
006532 100404           BMI     EXL1
006534 005067           CLR     SPLRQS
       051246
006540 000167           JMP     ROUT
       004416
006544 000167 EXL1:     JMP     SPLFIT          ;NEED SPLINE FIT FOR Q DATA
       022366
006550 005767 NOSPL:    TST     QCOMPU          ;
       031176
006554 001402           BEQ     NOFIN
006556 000167           JMP     FNSHQ           ;COMPLETE THE Q CALCULATIONS
       004030
006562          NOFIN:
006562 005767           TST     PRTFLG
       031202
006566 001402           BEQ     NOWRIT
006570 000167           JMP     WRITE           ;NEED TO INITIATE PRINTER OUTPUT
       001454
006574 005767 NOWRIT:   TST     DSCOUT
       031166
006600 001402           BEQ     NOCSHV
006602 000167           JMP     SHVTTC          ;PTC DATA TO GO OUT TO OBDS
       002310
006606 005767 NOCSHV:   TST     DSPOUT
       031152
006612 001402           BEQ     NOPSHV
006614 000167           JMP     SHVPBF
       002306
006620 005767 NOPSHV:   TST     OUTWFG
       031110
006624 001402           BEQ     NOWRT
006626 000167           JMP     WRTIT
       002150
006632 005767 NOWRT:    TST     EOTPFG
       031116
006636 001723           BEQ     EXLOOP
006640 000001           WAIT
006642 005367           DEC     EOTCT
```

```
                031110
39 06646 001317         BNE     EXLOOP
40 06650 042767         BIC     #1,DKAS
         000001
         161112
41
42                      ;WAIT FOR PRINTER TO FINISH
43 06656 132767 KT3:    BITB    #LPEN,LPTSR
         000100
         161064
44 06664 001374         BNE     KT3
45
46                      ;WAIT FOR TTY TO FINISH
47 06666 122777         CMPB    #377,@TTYGO
         000377
         030274
48 06674 001374         BNE     .-6
49
50
51 06676 000207         RTS     PC      ;END OF TEST
```

```
                        .TITLE  PTC/PBF GAS ANALYSIS
                        
006700 016700 025316 GSANAL: MOV     QUADO,R0
006704 020027 036732         CMP     R0,#QUADS1
006710 002402                BLT     ARN34
006712 012700 034224         MOV     #QUADST,R0
                        
006716 012701 036756 ARN34:  MOV     #WW,R1
006722 012702 000007         MOV     #7,R2
                        
06726 012021 GSLP:   MOV     (R0)+,(R1)+     ;GET NEXT SET OF PHASED V AND GASES
06730 077202         SOB     R2,GSLP
06732 010067 025264          MOV     R0,QUADO
```

```
!                ;THIS IS THE SB DATA STORAGE PART OF GAS ANALYSIS
2 006736 005767          TST     QFLAG
         052014
3 006742 001506          BEQ     GSLP1   ;NONE IN PROGRESS
4 006744 100401          BMI     FRST1           ;FIRST DATA POINT YET TO BE STORED
5 006746 000421          BR      SAVEQ   ;SAVE SOME MORE//////////??????
6
7
8
9 006750 005767 FRST1:   TST     VPREV           ;WANT TO INITIALIZE ON FIRST SAMPLE OF NEW BREATH
         025102
10 06754 001101          BNE     GSLP1
11 06756 012767          MOV     #1,QFLAG        ;SO WE KNOW WE HAVE INITIALIZED
         000001
         051772
12
13               ;XXXXXXXXXXXXXXXXXXXXXXXX
14               ;LIGHTS??????????????????????
15 06764 012767          MOV     #FVDAT,FVADR
         020006
         011010
16 06772 016767          MOV     D0.2,LSTO
         007676
         051000
17 07000 016767          MOV     D0.2+2,LSTO+2
         007672
         050774
18 07006 005067          CLR     NPAIR
         030762
19 07012 016745 SAVEQ:   MOV     QCTRS+2,-(TP)
         010744
20 07016 016745          MOV     QCTRS,-(TP)
         010736
21 07022 016745          MOV     WWC+2,-(TP)
         027744
22 07026 016745          MOV     WWC,-(TP)
         027736
23 07032 075015          FSUB    TP
24 07034 100403          BMI     QMAYBY          ;CO2 GREATER THAN SOME
25                                               ;THRESHHOLD, ABOUT 20 TORR ?????
26 07036 062705 NOWAY:   ADD     #4,TP           ;TO KEEP IT HONEST
         000004
27 07042 000446          BR      GSLP1           ;AND GET THE HELL OUT OF THIS PART
28 07044 016765 QMAYBY:  MOV     LSTO+2,2(TP)    ;WE DONT USE THE RESULTS OF THE FSUB
         050732
         000002
29 07052 016715          MOV     LSTO,(TP)
         050722
30 07056 016745          MOV     WWO+2,-(TP)
         027704
31 07062 016745          MOV     WWO,-(TP)
         027676
32 07066 075015          FSUB    TP                      ;HAS FO2 DECREASED BY MORE THAN .002
33 07070 016745          MOV     D0.002+2,-(TP)
         010656
34 07074 016745          MOV     D0.002,-(TP)
         010650
```

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```
35 07100 075015          FSUB    TP
36 07102 100755          BMI     NOWAY           ;NOPE
37
38 07104 062705          ADD     #4,TP
         000004
39
40                                               ;KEEP IT STRAIGHT
41 07110 016767          MOV     WWO,LSTO        ;SAVE THIS DATA POINT
         027650
         050662
42 07116 016767          MOV     WWO+2,LSTO+2    ;SHOVE THEM FOR NEXT CHECK
         027644
         050656
43 07124 016700          MOV     FVADR,R0
         010652
44 07130 016720          MOV     WWO,(R0)+
         027630
45 07134 016720          MOV     WWO+2,(R0)+
         027626
46 07140 016720          MOV     WWC,(R0)+
         027624
47 07144 016720          MOV     WWC+2,(R0)+
         027622
48 07150 010067          MOV     R0,FVADR
         010626
49 07154 005267          INC     NPAIR
         030614
50
51
52                                       ;AND THEY WERE STORED
53                                         ;AD
54 07160 016704 GSLP1:   MOV     WWV,R4
         027572
55 07164 001002          BNE     NOTEOB
56 07166 000167          JMP     GSEOB
         000470
57 07172 166704 NOTEOB:  SUB     VPREV,R4        ;DELTA V
         024660
58 07176 016767          MOV     WWV,VPREV
         027554
         024652
59 07204 010445          MOV     R4,-(TP)
60 07206 004767          JSR     PC,IR           ;FLOAT DELAT
         006440
61 07212 016745          MOV     SLV+2,-(TP)
         007460
62 07216 016745          MOV     SLV,-(TP)
         007442
63 07222 075025          FMUL TP                 ;AMBIENT LITERS ON STACK
64 07224 011503          MOV     (TP),R3
65 07226 016504          MOV     2(TP),R4
         000002
66 07232 016745          MOV     STPDF+2,-(TP)
         010510
67 07236 016745          MOV     STPDF,-(TP)
         010502
68 07242 075025          FMUL    TP              ;STPD DELTA VOLUME ON STACK
```

```
69 07244 010500          MOV     TP,R0
70 07246 016045          MOV     2(R0),-(TP)
         000002
71 07252 011045          MOV     (R0),-(TP)      ;DUPLICATE TPO ENTRY
72                ;BOTTOM OF STACK NOV CONTAINS STPD DELTA VOLUME TWICE
73
74 07254 010445          MOV     R4,-(TP)
75 07256 010345          MOV     R3,-(TP)
76 07260 016745          MOV     BTPSF+2,-(TP)
         007506
77 07264 016745          MOV     BTPSF,-(TP)
         007500
78 07270 075025          FMUL    TP                      ;DELTA V BTPS
79 07272 010500          MOV     TP,R0
80 07274 016045          MOV     2(R0),-(TP)
         000002
81 07300 011045          MOV     (R0),-(TP)
82 07302 004767          JSR     PC,IOF                  ;TURN OFF INTERRUPTS IN CASE EOP TIMOUT WHILE DATA OUT OF HOLES
         000336
83                                                       ;BEING UPDATED AND THEN WOULD BE STUFFED OFER ZEROED HOLE
84 07306 016745          MOV     BRTHV+2,-(TP)
         051442
85 07312 016745          MOV     BRTHV,-(TP)
         051434
86 07316 075005          FADD    TP
87 07320 012567          MOV     (TP)+,BRTHV
         051426
88 07324 012567          MOV     (TP)+,BRTHV+2
         051424
89 07330 016745          MOV     CMV+2,-(TP)
         050520
90 07334 016745          MOV     CMV,-(TP)
         050512
91 07340 075005          FADD    TP
92 07342 012567          MOV     (TP)+,CMV
         050504
93 07346 012567          MOV     (TP)+,CMV+2
         050502
94 07352 004767          JSR     PC,ION          ;GIVE THE INTERRUPTS A CHANCE
         000250
95
```

822

```
1                ;STACK SHOULD HAVE STPD DELAT VOLUME TWICE
2
3  007356 016745 MOV     WWC+2,-(TP)
          027410
4  007362 016745         MOV     WWC,-(TP)
          027402
5                                                    ;FECO2 TO STACK
6  007366 016745         MOV     WWN+2,-(TP)
          027370
7  007372 016745         MOV     WWN,-(TP)
          027362
8  007376 016745         MOV     CRAT+2,-(TP)      ;FROM ROOM AIR
          030340
9  007402 016745         MOV     CRAT,-(TP)
          030332
10 07406  075025         FMUL    TP
11 07410  075015         FSUB    TP                ;FEN2*(FICO2/FIN2)SUBTRACTED FROM FECO2
12 07412  075025         FMUL    TP                ;TIMES DELAT VOL -VCO2
13 07414  010500         MOV     TP,R0
14 07416  016345         MOV     2(R3),-(TP)
          000002
15 07422  011045         MOV     (R0),-(TP)
16
17 07424  004767         JSR     PC,IOF
          000214
18 07430  016745         MOV     CCO2+2,-(TP)
          050414
19 07434  016745         MOV     CCO2,-(TP)
          050406
20 07440  075005         FADD    TP
21 07442  012567         MOV     (TP)+,CCO2
          050400
22 07446  012567         MOV     (TP)+,CCO2+2
          050376
23 07452  016745         MOV     BRTHC+2,-(TP)
          051272
24 07456  016745         MOV     BRTHC,-(TP)
          051264
25 07462  075005         FADD    TP
26 07464  012567         MOV     (TP)+,BRTHC
          051256
27 07470  012567         MOV     (TP)+,BRTHC+2
          051254
28
29 07474  004767 JSR     PC,ION
          000126
30
31 07500  016745         MOV     WWN+2,-(TP)
          027250
32 07504  016745         MOV     WWN,-(TP)
          027250
33 07510  016745         MOV     ORAT+2,-(TP)
          030232
34 07514  016745         MOV     ORAT,-(TP)
          030224
35 07520  075025         FMUL    TP
36 07522  016745         MOV     WWO+2,-(TP)
```

```
                027240
37 07526 016745         MOV     WWO,-(TP)
                027232
38 07532 075015         FSUB    TP
39 07534 075025         FMUL    TP              ;VO2 THIS DELTA AS IN CO2
40 07536 010500 MOV     TP,R0
41 07540 016045         MOV     2(R0),-(TP)
                000002
42 07544 011045         MOV     (R0),-(TP)
43
44 07546 004767 JSR     PC,IOF
                000072
45 07552 016745         MOV     BRTHO+2,-(TP)
                051166
46 07556 016745         MOV     BRTHO,-(TP)
                051160
47 07562 075005         FADD    TP
48 07564 012567         MOV     (TP)+,BRTHO
                051152
49 07570 012567         MOV     (TP)+,BRTHO+2
                051150
50 07574 016745         MOV     CO2+2,-(TP)
                050244
51 07600 016745         MOV     CO2,-(TP)
                050236
52 07604 075005         FADD    TP
53 07606 012567         MOV     (TP)+,CO2       ;THIS LABEL IS CONFUSING
                050230
54 07612 012567         MOV     (TP)+,CO2+2     ;IT IS REALLY CURRENT OXYGEN, NOT CARBON DIOXIDE
                050226
55 07616 004767 JSR     PC,ION
                000004
56 07622 000167         JMP     EXLOOP
                176660
57
58
59              ;END OF GAS EXCHANGE CALC
```

```
                        ;THESE ROUTINES WERE ADVANTAGEOUS BECAUSE CANNOT USE MTPS #X FROM ROM
007626 010446 ION:      MOV     R4,-(SP)
007630 106704           MFPS    R4
007632 042704           BIC     #200,R4
       000200
007636 106404           MTPS    R4
007640 012604           MOV     (SP)+,R4
007642 000207           RTS     PC

007644 010446 IOF:      MOV     R4,-(SP)
07646 106704            MFPS    R4
07650 052704            BIS     #200,R4
       000200
07654 106404            MTPS    R4
07656 012604            MOV     (SP)+,R4
07660 000207            RTS     PC
```

```
1                       .TITLE GASEXC END OF BREATH
2 007662 005067 GSEOB:  CLR     VPREV
         024170
3 007666 005267         INC     CRR
         050164
4 007672 016700         MOV     TIM2,R0
         050132
5 007676 016701         MOV     TIM1,R1
         050124
6 007702 012703         MOV     #-1,R3
         177777
7 007706 073003         ASHC    R3,R0
8 007710 016745         MOV     BRTHV+2,-(TP)
         051040
9 007714 016745         MOV     BRTHV,-(TP)
         051032
10 07720 016745         MOV     D8.+2,-(TP)
         010012
11 07724 016745         MOV     D8.,-(TP)
         010004
12 07730 075035         FDIV    TP
13 07732 016745         MOV     D32767+2,-(TP)
         010004
14 07736 016745         MOV     D32767,-(TP)
         007776
15 07742 075025         FMUL    TP
16 07744 004767         JSR     PC,RI           ;FIX TV 0-32767=0-8LBTPS
         005776
17
18 07750 016745         MOV     BRTHC+2,-(TP)
         050774
19 07754 016745         MOV     BRTHC,-(TP)
         050766
20
21 07760 016745         MOV     D32767+2,-(TP)
         007756
22 07764 016745         MOV     D32767,-(TP)
         007750
23 07770 075025         FMUL    TP              ;O2,CO2 0-32767=0-1L STPD
24 07772 004767         JSR     PC,RI
         005750
25 07776 016745         MOV     BRTHO+2,-(TP)
         050742
26 10002 016745         MOV     BRTHO,-(TP)
         050734
27 10006 016745         MOV     D32767+2,-(TP)
         007730
28 10012 016745         MOV     D32767,-(TP)
         007722
29 10016 075025         FMUL    TP
30 10020 004767         JSR     PC,RI
         005722
31 10024 004767         JSR     PC,IOF
         177614
32
33                      ;HERE,R1 HAS TIM IN NO OF 80 MSEC HACKS
34                      ;ON STACK  O2,CO2,TV  SCALED AND INTEGERIXZED
```

```
35
36
37
38
39 10030 010700          MOV     PTSTUF,R0
         047750
40 10034 010120          MOV     R1,(R0)+
41 10036 012520          MOV     (TP)+,(R0)+
42 10040 012520          MOV     (TP)+,(R0)+
43 10042 012520          MOV     (TP)+,(R0)+
44 10044 010067          MOV     R0,PTSTUF
         047734
45 10050 004767          JSR     PC,ION
         177552
46
47 10054 012700          MOV     #BRTHO,R0
         000742
48 10060 012701          MOV     #6,R1
         000006
49
50 10064 005020 CLRBRT:  CLR     (R0)+
51 10066 077102          SOB     R1,CLRBRT
52 10070 005767          TST     QFLAG
         050662
53 10074 003410          BLE     GSLVLV
54
55 10076 005067          CLR     QFLAG
         050654
56 10102 052767          BIS     #400,DRBO
         000400
         157652
57 10110 012767          MOV     #1,SPLROS
         000001
         047670
58 10116 000167 GSLVLV:  JMP     EXLOOP
         176364
```

```
                        .TITLE SLOP SUBROUTINES
                        ;ROUTINE TO RESET PTC BUFFERS
010122 012767 PTCSV:    MOV     #PTH5,PSVHR
       060162
       047664
010130 012767           MOV     #PTW5,PSVWL
       060170
       047660
010136 012767           MOV     #PTGAS,PTSTUF
       060176
       047640
010144 000207           RTS     PC


                        ;ROUTINE TO GET NEXT PROTOCOL STEP

10146 010146 PROFTC:    MOV     R1,-(SP)
10150 010246            MOV     R2,-(SP)
10152 016702            MOV     PROGET,R2
       027604
10156 012267            MOV     (R2)+,PRDNCT
       047640
10162 001416            BEQ     PROND
10164 012201            MOV     (R2)+,R1
10166 100005            BPL     NOPRQ           ;NO CARDIAC OUTPUT REQUEST
10170 005467            NEG     PROND           ;MINUS SAYS CARDIACOUTPUT
       000024

10174 042767            BIC     #200,DRBO       ;Q LIGHT
       000200
       157560
10202 010267 NOPRQ:     MOV     R2,PROGET
       027554
10206 010167            MOV     R1,DAC1         ;CONTROL WORK LOAD THE EASY WAY
       166546
10212 012602            MOV     (SP)+,R2
10214 012601            MOV     (SP)+,R1
10216 000207            RTS     PC


10220 012767 PROND:     MOV     #1,EOTPFG
       000001
       027526
10226 012767            MOV     #400,EOTCT
       000400
       027522
10234 042767            BIC     #1,DUM1
       000001
       027456
```

```
                        ;THIS ROUTINE IS ENTERED WITH THE ADDRESS OF A FLOATING VARIABLE
                        ;IN R2 AND A TIME(DELTA T) IN R3,R4
                        ;FETCHEDC THE DATA FROM @R2,R2+2 DIVIDES BY THE TIME IN MINUTES, AND PUTS IT BACK

010756 016245 NORM:     MOV     2(R2),-(TP)
       000002
010762 011245           MOV     (R2),-(TP)
010764 010345           MOV     R3,-(TP)
010766 010445           MOV     R4,-(TP)
10770 075035            FDIV    TP
10772 012512            MOV     (TP)+,(R2)
10774 012562            MOV     (TP)+,2(R2)
       000002
11000 000207            RTS     PC
```

```
1 011002 016701 WRTIT:  MOV     FRSTPT,R1       ;THE ADDRESS OF THE LABEL
         047760
2 011006 010146         MOV     R1,-(SP)        ;WHERE TO STICK THE FORMATTED LETTERS
3 011010 017746         MOV     @FMTPT,-(SP)    ;GET THE Y PART OF THE PACKED FORMAT
         047750
4 011014 062767         ADD     #2,FMTPT
         000002
         047742
5 011022 017746         MOV     @FMTPT,-(SP)    ;SHOVE THE X PART
         047736
6 011026 062767         ADD     #2,FMTPT
         000002
         047730
7 011034 016700         MOV     ADD2PT,R0
         047722
8 011040 010046         MOV     2(R0),-(SP)
         000002
9 011044 011046         MOV     (R0),-(SP)
10 11046 062700         ADD     #4,R0
         000004
11 11052 010067         MOV     R0,ADD2PT
         047704
12 11056 004767         JSR     PC,FFMT
         004110
13 11062 062767         ADD     #24,FRSTPT
         000024
         047676
14
15 11070 005367         DEC     NUMLFT
         047664
16 11074 001006         BNE     WLVWLV
17 11076                TYPE    BUFFER
   11076 012700         MOV     #BUFFER,R0
         037200
   11102 004767         JSR     PC,LPTGO
         003732
18 11106 005067         CLR     OUTWFG
         026622
19 11112 000167 WLVWLV: JMP     EXLOOP
         175370
20              ;THIS ROUTINE IA A CLUDGE WITH A CAPITAL K
21              ;MUST BE GONE THROUGH ONCE PER LINE
22              ;BUT DONT HAVE TIME TO WAIT ALL DAY OR WILL LOSE GAS DATA
23              ;MY O MY WHAT TO DO WHEN WE GET A PRINTER!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
                          ;LXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                          ;YOU FORGOT TO DO ANYTHING TO WORK LOAD
10572 016745 DOBP:  MOV    PRSBP,-(TP)
      047350
10576 004767        JSR    PC,IR
      005050
10602 016745        MOV    SBPFAC+2,-(TP)
      027174
10606 016745        MOV    SBPFAC,-(TP)
      027166
10612 075025        FMUL   TP                  ;CONVERTING SBP AD CONVERTER UNITS TO MMHG
10614 016745        MOV    SBPOFF+2,-(TP)
      027160
10620 016745        MOV    SBPOFF,-(TP)
      027160
10624 075005        FADD   TP
10626 012567        MOV    (TP)+,PRSBP
      047314
10632 012567        MOV    (TP)+,PRSBP+2
      047312
10636 016745        MOV    PRDBP,-(TP)
      047310
10642 004767        JSR    PC,IR
      005004
10646 016745        MOV    DBPFAC+2,-(TP)
      027140
10652 016745        MOV    DBPFAC,-(TP)
      027132
10656 075025        FMUL   TP
10660 016745        MOV    DBPOFF+2,-(TP)
      027132
10664 016745        MOV    DBPOFF,-(TP)
      027124
10670 075005        FADD   TP
10672 012567        MOV    (TP)+,PRDBP
      047254
10676 012567        MOV    (TP)+,PRDBP+2
      047252
10702 012767        MOV    #1,DSFOUT
      000001
      027054
10710 012767        MOV    #1,OUTWFG
      000001
      027016
10716 012767        MOV    #13,NUMLPT
      000013
      050034
10724 012767        MOV    #PRTIM1,ADD2PT
      060102
      050030
```

```
34 10732 012767          MOV     #XXX1,PMTPT
         017660
         050024
35 10740 012767          MOV     #BUFFER+12.,FRSTPT              ;THIS IS SETTING POINTERS
         037214
         050020
36                                                               ;FOR THE PRINT ROUTINE
37                                                               ;WHICH PRINTS ONE LINE AT A TIMNE
38 10746 005067          CLR     PRTFLG
         027016
39 10752 000167          JMP     EXLOOP
         175530
```

```
                000346
 36 10410 012702        MOV     #PRCO2,R2
          060122
 37 10414 004767        JSR     PC,NORM
          000336
 38 10420 012702        MOV     #PRMV,R2
          060126
 39 10424 004767        JSR     PC,NORM
          000326
 40 10430 012702        MOV     #PRO2,R2
          060116
 41 10434 004767        JSR     PC,NORM
          000316
 42
 43                ;THE ABOVE WERE TO NORMASLICE ALL THE TIME DEPENDET CRAP  IE X/MIN
 44 10440 016745        MOV     PRRR,-(TP)
          047466
 45 10444 004767        JSR     PC,IR
          005202
 46 10450 012567        MOV     (TP)+,PRRR
          047456
 47 10454 012567        MOV     (TP)+,PRRR+2
          047454
 48 10460 012702        MOV     #PRRR,R2
          060132
 49 10464 004767        JSR     PC,NORM
          000266
 50
 51
 52
 53
 54
 55 10470 016745        MOV     PRWL+2,-(TP)
          047420
 56 10474 016745        MOV     PRWL,-(TP)
          047412
 57 10500 010045        MOV     R0,-(TP)
 58 10502 004767        JSR     PC,IR
          005144
 59 10506 075035        FDIV    TP
 60 10510 012567        MOV     (TP)+,PRWL
          047376
 61 10514 012567        MOV     (TP)+,PRWL+2
          047374
 62
 63 10520 005767        TST     PRSLOP          ;WAS A CARDIAC OUTPUT MANEUVER DONE
          047412
 64 10524 001422        BEQ     DOBP
 65 10526 016745        MOV     PRO2+2,-(TP)
          047366
 66 10532 016745        MOV     PRO2,-(TP)
          047360
 67 10536 016745        MOV     D.0047+2,-(TP)
          007214
 68 10542 016745        MOV     D.0047,-(TP)
          007206
 69 10546 016745        MOV     PRSLOP+2,-(TP)
```

```
                047366
70  10552 016745          MOV     PRSLOP,-(TP)
                047360
71  10556 075025          FMUL    TP              ;Q=VO2/0.0047SLOPE
72  10560 075035          FDIV    TP
73  10562 012567          MOV     (TP)+,PRQDOT
                047354
74  10566 012567          MOV     (TP)+,PRQDOT+2
                047352
75
76
77
78
79
```

```
39 10242 012602          MOV     (SP)+,R2
40 10244 012601          MOV     (SP)+,R1
41 10246 000207          RTS     PC
```

```
                        .TITLE  NORMALIZATION OF PBF


                ;ROUTINE TO NORMALIZE OUTPUTS AND SET UP FOR PRINT ROUTINE

010250 016700 WRITE:  MOV     PRTIM2,R0
       047630
010254 016701         MOV     PRTIM1,R1
       047622
010260 012703         MOV     #-1,R3
       177777
010264 073003         ASHC    R3,R0
010266 010145         MOV     R1,-(TP)
010270 004767         JSR     PC,IR           ;FLOAT THE NUMBER OF 80 MSEC
       005356
                                      ;HACKS SINCE BOT
010274 016745         MOV     TIMFAC+2,-(TP)
       007466
010300 016745         MOV     TIMFAC,-(TP)
       007460
010304 075025         FMUL    TP
010306 016745         MOV     LSTTIM+2,-(TP)
       027420
010312 016745         MOV     LSTTIM,-(TP)
       027412
010316 016567         MOV     6(TP),LSTTIM+2
       000006
       027406
010324 016567         MOV     4(TP),LSTTIM
       000004
       027376
010332 016567         MOV     6(TP),PRTIM2
       000006
       047544
010340 016567         MOV     4(TP),PRTIM1
       000004
       047534
010346 075015         FSUB    TP      ;THIS IS DELTA TIME SINCE LAST PERIOD
                                      ;USED FOR NORMALIZING GAS VALUES
                                      ;THE ABOVE BS WAS TO TAKE DIFFERENCE IN
                                      ;CURRENT TIME AND LAST TIME, THEN SAVE CURRENT
                                      ;TIME FOR USE NEXT TIME AS LAST TIME
010350 012504         MOV     (TP)+,R4
010352 012503         MOV     (TP)+,R3
010354 016700         MOV     PRHR+2,R0       ;JUST REMEMBERED TO SAVE # OF WORK LOAD SAMPLES
       047530
010360 016745         MOV     PRHR,-(TP)
       047522
010364 004767         JSR     PC,IR   ;FLOAT NUMBER OF BEATS SINCE LAST REPORT
       005262
010370 012567         MOV     (TP)+,PRHR
       047512
010374 012567         MOV     (TP)+,PRHR+2
       047510
010400 012702         MOV     #PRHR,R2
       060106
010404 004767         JSR     PC,NORM
```

```
                        ;THESE ROUTINES MUST BE FILLED IN LATER
                        
                        
                        
011116 005067 SHVPTC:   CLR     DSCOUT
       026644
011122 000167           JMP     EXLOOP
       175360
                        
                        
                        
                        
11126  005067 SHVPBF:   CLR     DSFOUT
       026632
11132  000167           JMP     EXLOOP
       175350
```

```
                        .TITLE  CUBIC SPLINE FIT
                ;ARRAY Z => O2
                ;ARRAY Y => CO2
011136 005067 SPLFIT: CLR     SPLRQS
       046644
011142 012767         MOV     #1,@COMPU
       000001
       026602
011150 012705 CUBIC:  MOV     #TSTK,TP
       037112
11154  010567         MOV     TP,SAVSTK
       023026

                ;SEPARATE PAIRS FOR LATER USE

11160  012700 C0:     MOV     #FVDAT,R0
       020006
11164  012701         MOV     #Z,R1
       030466
11170  012702         MOV     #Y,R2
       051306
11174  016703         MOV     NPAIR,R3
       026574

11200  012021 C1:     MOV     (R0)+,(R1)+
11202  012021         MOV     (R0)+,(R1)+
11204  012022         MOV     (R0)+,(R2)+
11206  012022         MOV     (R0)+,(R2)+
11210  077305         SOB     R3,C1
```

```
                        ;COMPUTE S1
                        
011212 012700           MOV     #WKAR,R0
       037114
011216 010001           MOV     R0,R1
                        
011220 016702           MOV     PRO2,R2
       046672
011224 001007           BNE     C3
                        ;PRO2=0
011226 016767 C2:       MOV     DM.85,S1
       005502
       026466
11234  016767           MOV     DM.85+2,S1+2
       005476
       026462
11242  000420           BR      C4
                        
11244  012702 C3:       MOV     #PRO2,R2
       060116
11250  012220           MOV     (R2)+,(R0)+
11252  012220           MOV     (R2)+,(R0)+
11254  012220           MOV     (R2)+,(R0)+
11256  012220           MOV     (R2)+,(R0)+
11260  075031           FDIV    R1              ;R1-> PRCO2/PRO2
                        
11262  016741           MOV     DM1+2,-(R1)
       005444
11266  016741           MOV     DM1,-(R1)
       005436
11272  075021           FMUL    R1              ;MULTIPLY BY -1
                        
11274  012167           MOV     (R1)+,S1
       026422
11300  012167           MOV     (R1)+,S1+2
       026420
                        
11304  016701 C4:       MOV     NPAIR,I         ;I=N
       026464
11310  010103           MOV     I,R3
11312  162703           SUB     #2,R3           ; NO OF TIMES TO GO THROUGH LOOP
       000002
11316  162701           SUB     #2,I
       000002
11322  006301           ASL     I
11324  006301           ASL     I               ;I=I*4
11326  010100           MOV     I,IM1
11330  162700           SUB     #4,IM1          ;IM1=I-4
       000004
                        
11334  010004           MOV     IM1,R4
11336  062704           ADD     #Z,R4
       030466
11342  075014           FSUB    R4              ;Z(N)=Z(N)-Z(N-1)
                        
11344  010102 C5:       MOV     I,IP1
11346  010001           MOV     IM1,I
```

```
42 11350 162700          SUB     #4,IM1
         000004
43
44 11354 010004          MOV     IM1,R4
45 11356 062704          ADD     #Z,R4
         030466
46 11362 075014          FSUB    R4              ;Z(I)=Z(I)-Z(I-1)
47
48 11364 012704          MOV     #WKAR,R4
         037114
49 11370 010405          MOV     R4,R5
50 11372 016224          MOV     Z(IP1),(R4)+
         030466
51 11376 016224          MOV     Z+2(IP1),(R4)+
         030470
52 11402 016124          MOV     Z(I),(R4)+
         030466
53 11406 016124          MOV     Z+2(I),(R4)+
         030470
54 11412 075005          FADD    R5
55 11414 016224          MOV     Z(IP1),(R4)+
         030466
56 11420 016224          MOV     Z+2(IP1),(R4)+
         030470
57 11424 075035          FDIV    R5              ;R5 -> G
58                                               ; R5 = WKAR+10
59
60                ;COMPUTE X(I)
61 11426 012704          MOV     #WKAR,R4
         037114
62 11432 010405          MOV     R4,R5
63 11434 016024          MOV     Y(IM1),(R4)+
         031306
64 11440 016024          MOV     Y+2(IM1),(R4)+
         031310
65 11444 016124          MOV     Y(I),(R4)+
         031306
66 11450 016124          MOV     Y+2(I),(R4)+
         031310
67 11454 075015          FSUB    R5              ;R5 -> Y(I) - Y(I-1)
68 11456 016445          MOV     2(R4),-(R5)     ;GET G
         000002
69 11462 016445          MOV     0(R4),-(R5)
         000000
70 11466 075025          FMUL    R5              ;R5 -> R5*G
71 11470 016745          MOV     D3.0+2,-(R5)
         005246
72 11474 016745          MOV     D3.0,-(R5)
         005240
73 11500 075025          FMUL    R5              ;R5 -> 3.0 * R5
74 11502 016145          MOV     Z+2(I),-(R5)
         030470
75 11506 016145          MOV     Z(I),-(R5)
         030466
76 11512 075035          FDIV    R5              ;WKAR+4 = [3.0*G*[Y(I)-Y(I-1]]/Z(I)
77
78 11514 012704          MOV     #WKAR+14,R4
```

```
            037130
 79 11520 010405          MOV     R4,R5
 80 11522 016124          MOV     Y(I),(R4)+
            031306
 81 11526 016124          MOV     Y+2(I),(R4)+
            031310
 82 11532 016224          MOV     Y(IP1),(R4)+
            031306
 83 11536 016224          MOV     Y+2(IP1),(R4)+
            031310
 84 11542 075015          FSUB    R5              ;R5 -> Y(I+1) - Y(I)
 85
 86 11544 016745          MOV     D1.0+2,-(R5)
            005202
 87 11550 016745          MOV     D1.0,-(R5)
            005174
 88 11554 162705          SUB     #4,R5
            000004
 89 11560 075015          FSUB    R5              ;R5 -> 1.0 - G
 90 11562 016745          MOV     D3.0+2,-(R5)
            005154
 91 11566 016745          MOV     D3.0,-(R5)
            005146
 92 11572 075025          FMUL    R5              ;R5 -> 3*(1.0-G)
 93 11574 075025          FMUL    R5              ;R5 -> 3(1.0-G)*[Y(I+1)-Y(I)]
 94 11576 016245          MOV     Z+2(IP1),-(R5)
            030470
 95 11602 016245          MOV     Z(IP1),-(R5)
            030466
 96 11606 075035          FDIV    R5              ;R5=R5/Z(IP1)
 97
 98 11610 012704          MOV     #WKAR+4,R4
            037120
 99 11614 016544          MOV     2(R5),-(R4)
            000002
100 1620 011544           MOV     (R5),-(R4)
101 1622 075004           FADD    R4
102
103 1624 012461           MOV     (R4)+,X(I)
            032126
104 1630 012461           MOV     (R4)+,X+2(I)
            032130
105
106 1634 000402           BR      .+6
107 1636 000167 C5A:      JMP     C5
            177502
108 1642 077303           SOB     R3,C5A
109                 ;END OF DO LOOP 3
110
111                 ;DO LOOP 4
112 1644 012701 C6:       MOV     #4,I
            000004
113 1650 012702           MOV     #10,IP1
            000010
114 1654 016703           MOV     NPAIR,R3
            026114
115 1660 162703           SUB     #2,R3
```

```
                000002
116 1664 012704 C7:     MOV     #WKAR,R4
         037114
117 1670 010405         MOV     R4,R5
118 1672 016124         MOV     Z(I),(R4)+
         030466
119 1676 016124         MOV     Z+2(I),(R4)+
         030470
120 1702 016224         MOV     Z(IP1),(R4)+
         030466
121 1706 016224         MOV     Z+2(IP1),(R4)+
         030470
122 1712 075005         FADD    R5
123 1714 016224         MOV     Z(IP1),(R4)+
         030466
124 1720 016224         MOV     Z+2(IP1),(R4)+
         030470
125 1724 075035         FDIV    R5
126 1726 012561         MOV     (R5)+,Z(I)
         030466
127 1732 012561         MOV     (R5)+,Z+2(I)
         030470
128 1736 010201         MOV     IP1,I
129 1740 062702         ADD     #4,IP1
         000004
130 1744 077331         SOB     R3,C7
131             ;END OF DO LOOP 4
132
```

842

```
1                       ; GET READY FOR DO LOOP 5
2  011746 012704        MOV     #WKAR,R4
          037114
3  011752 010405        MOV     R4,R5
4  011754 012701        MOV     #4,I
          000004
5
6  011760 016124        MOV     Z(I),(R4)+
          030466
7  011764 016124        MOV     Z+2(I),(R4)+
          030470
8  011770 016724        MOV     S1,(R4)+
          025726
9  011774 016724        MOV     S1+2,(R4)+
          025724
10 12000  075025        FMUL    R5
11 12002  016124        MOV     X(I),(R4)+
          032126
12 12006  016124        MOV     X+2(I),(R4)+
          032130
13 12012  075015        FSUB    R5
14 12014  012561        MOV     (R5)+,X(I)
          032126
15 12020  012561        MOV     (R5)+,X+2(I)            ;X(2)=X(2)-Z(2)*S1
          032130
16
17 12024  012701        MOV     #W,I
          032746
18 12030  016721        MOV     Y,(I)+          ;W(1)=Y(1)
          017252
19 12034  016721        MOV     Y+2,(I)+
          017250
20 12040  016721        MOV     D2.0,(I)+
          004700
21 12044  016721        MOV     D2.0+2,(I)+     ;W(2)=2.0
          004676
22 12050  012701        MOV     #4,I
          000004
23 12054  012704        MOV     #WKAR,R4
          037114
24 12060  010405        MOV     R4,R5
25 12062  016124        MOV     W(I),(R4)+
          032746
26 12066  016124        MOV     W+2(I),(R4)+
          032750
27 12072  016124        MOV     X(I),(R4)+
          032126
28 12076  016124        MOV     X+2(I),(R4)+
          032130
29 12102  075035        FDIV    R5
30 12104  012561        MOV     (R5)+,X(I)
          032126
31 12110  012561        MOV     (R5)+,X+2(I)    ;X(2)=X(2)/Y(2)
          032130
32
33 12114  012704        MOV     #WKAR,R4
          037114
```

```
34 12120 010405          MOV     R4,R5
35 12122 016124          MOV     Z(I),(R4)+
         030466
36 12126 016124          MOV     Z+2(I),(R4)+
         030470
37 12132 016724          MOV     D1.0,(R4)+
         004612
38 12136 016724          MOV     D1.0+2,(R4)+
         004610
39 12142 075015          FSUB    R5
40 12144 016745          MOV     DM1+2,-(R5)
         004562
41 12150 016745          MOV     DM1,-(R5)
         004554
42 12154 075025          FMUL    R5              ;R5 -> -1.0(1.0-Z(2))
43 12156 016145          MOV     W+2(I),-(R5)
         032750
44 12162 016145          MOV     W(I),-(R5)
         032746
45 12166 075035          FDIV    R5
46 12170 012561          MOV     (R5)+,W(I)      ;Y(2)=-(1.0-Z(2))/Y(2)
         032746
47 12174 012561          MOV     (R5)+,W+2(I)
         032750
48
49
```

```
1                       ;DO LOOP 5
2 012200 016703         MOV     NPAIR,R3
         025570
3 012204 162703         SUB     #3,R3           ;COUNTER
         000003
4
5 012210 012701         MOV     #10,I
         000010
6 012214 012700         MOV     #4,IM1
         000004
7
8 012220 012704 C8:     MOV     #WKAR,R4
         037114
9 012224 010405         MOV     R4,R5
10 12226 016024         MOV     W(IM1),(R4)+
         032746
11 12232 016024         MOV     W+2(IM1),(R4)+
         032750
12 12236 016124         MOV     Z(I),(R4)+
         030466
13 12242 016124         MOV     Z+2(I),(R4)+
         030470
14 12246 075025         FMUL    R5
15 12250 016745         MOV     D2.0+2,-(R5)
         004472
16 12254 016745         MOV     D2.0,-(R5)
         004464
17 12260 075005         FADD    R5
18 12262 012561         MOV     (R5)+,W(I)
         032746
19 12266 012561         MOV     (R5)+,W+2(I)    ;Y(I)=[Z(I)*Y(I-1)]+2.0
         032750
20
21 12272 016745         MOV     D1.0+2,-(R5)
         004454
22 12276 016745         MOV     D1.0,-(R5)
         004446
23 12302 016145         MOV     Z+2(I),-(R5)
         030470
24 12306 016145         MOV     Z(I),-(R5)
         030466
25 12312 075015         FSUB    R5
26 12314 016045         MOV     X+2(IM1),-(R5)
         032130
27 12320 016045         MOV     X(IM1),-(R5)
         032126
28 12324 075025         FMUL    R5
29 12326 016124         MOV     X(I),(R4)+
         032126
30 12332 016124         MOV     X+2(I),(R4)+
         032130
31 12336 075015         FSUB    R5
32 12340 016145         MOV     W+2(I),-(R5)
         032750
33 12344 016145         MOV     W(I),-(R5)
         032746
34 12350 075035         FDIV    R5
```

```
35 12352 012561          MOV     (R5)+,X(I)
         032126
36 12356 012561          MOV     (R5)+,X+2(I)
         032130
37
38 12362 010405          MOV     R4,R5
39 12364 016124          MOV     W(I),(R4)+
         032746
40 12370 016124          MOV     W+2(I),(R4)+
         032750
41 12374 016124          MOV     Z(I),(R4)+
         030466
42 12400 016124          MOV     Z+2(I),(R4)+
         030470
43 12404 075035          FDIV    R5
44 12406 012561          MOV     (R5)+,W(I)
         032746
45 12412 012561          MOV     (R5)+,W+2(I)
         032750
46
47 12416 010100          MOV     I,IM1
48 12420 062701          ADD     #4,I
         000004
49
50 12424 000402          BR      .+6
51 12426 000167 C8A:     JMP     C8
         177566
52 12432 077303          SOB     R3,C8A
53
54                ;END OF DO LOOP 5
55
56 12434 016703          MOV     NPAIR,R3
         025334
57 12440 006303          ASL     R3
58 12442 006303          ASL     R3
59 12444 005063          CLR     X(R3)
         032126
60 12450 005063          CLR     X+2(R3)          ;X(N)=0
         032130
G1
```

```
1                       ;DO LOOP 6
2
3  012454 016701        MOV     NPAIR,I
          025314
4  012460 010103        MOV     I,R3
5  012462 162703        SUB     #2,R3           ;COUNTER
          000002
6  012466 162701        SUB     #2,I
          000002
7
8  012472 006301        ASL     I
9  012474 006301        ASL     I
10 12476 010102         MOV     I,IP1
11 12500 062702         ADD     #4,IP1
          000004
12                      ;START LOOP
13 12504 012704 C9:     MOV     #WKAR,R4
          037114
14 12510 010405         MOV     R4,R5
15 12512 016124         MOV     W(I),(R4)+
          032746
16 12516 016124         MOV     W+2(I),(R4)+
          032750
17 12522 016224         MOV     X(IP1),(R4)+
          032126
18 12526 016224         MOV     X+2(IP1),(R4)+
          032130
19 12532 075025         FMUL    R5
20 12534 016145         MOV     X+2(I),-(R5)
          032130
21 12540 016145         MOV     X(I),-(R5)
          032126
22 12544 075005         FADD    R5
23 12546 012561         MOV     (R5)+,X(I)
          032126
24 12552 012561         MOV     (R5)+,X+2(I)
          032130
25
26 12556 010102         MOV     I,IP1
27 12560 162701         SUB     #4,I
          000004
28 12564 077331         SOB     R3,C9
29                      ;DONE LOOP 6
30
31 12566 016767         MOV     S1,X
          025130
          017332
32 12574 016767         MOV     S1+2,X+2        ;X(1)=S1
          025124
          017326
```

```
                        :RESTORE STATE OF NATURE
012602 016705 C10:      MOV     SAV/STK,TP
       021400
012606 000167           JMP     EXLOOP
       173674
```

```
                        .TITLE  R (INSTANTANEOUS)

                ;R = RESPIRATORY EXCHANGE RATIO
                ;COMPUTE RINST = (S-SFO2-FCO2)/(1-SFO2-FCO2)
                ;       FOR EACH POINT EXCEPT END PAIR
                ;       S=NEG(ABS) OF DERIVATIVE OF SAMPLED PAIR

012612 005067 RNSHQ:  CLR     QCOMPU
       025134
012616 012700 RINST:  MOV     #FVDAT,R0
       020006
                ;REBUILD Z
 12622 016703         MOV     NPAIR,R3
       025140
 12626 012701         MOV     #Z,R1
       030466

 12632 012021 RINS1:  MOV     (R0)+,(R1)+
 12634 012021         MOV     (R0)+,(R1)+
 12636 062700         ADD     #4,R0
       000004
 12642 077305         SOB     R3,RINS1

 12644 012701         MOV     #4,I
       000004
 12650 016703         MOV     NPAIR,R3
       025120
 12654 162703         SUB     #2,R3
       000002

                ;ABS(SLOPE)
 12660 012700 RIN1:   MOV     #WKAR+4,R0
       037120
 12664 010002         MOV     R0,R2
 12666 016120         MOV     X(I),(R0)+
       032126
 12672 016120         MOV     X+2(I),(R0)+
       032130
 12676 016720         MOV     DM1,(R0)+
       004026
 12702 016720         MOV     DM1+2,(R0)+
       004024
 12706 075022         FMUL    R2              ;R2-> ABS(SLOPE)
 12710 011267         MOV     (R2),WKAR+4
       024204
 12714 016267         MOV     2(R2),WKAR+6
       000002
       024200
 12722 016120         MOV     Z(I),(R0)+
       030466
 12726 016120         MOV     Z+2(I),(R0)+
       030470
 12732 075022         FMUL    R2              ;R2 -> FO2 * S

 12734 016142         MOV     Y+2(I),-(R2)
       031310
 12740 016142         MOV     Y(I),-(R2)
```

```
                031306
39 12744 075012         FSUB    R2              ;R2 -> S*FO2 - FCO2
40 12746 012702         MOV     #WKAR,R2
                037114
41 12752 014062         MOV     -(R0),2(R2)
                000002
42 12756 014012         MOV     -(R0),(R2)      ;PUT SFO2-FCO2 INTO WKAR(1)
43 12760 075012         FSUB    R2
44 12762 016760         MOV     D1.0,4(R0)
                003762
                000004
45 12770 016760         MOV     D1.0+2,6(R0)
                003756
                000006
46 12776 075010         FSUB    R0              ;R0 -> 1-SFO2-FCO2
47
48 13000 016042         MOV     2(R0),-(R2)
                000002
49 13004 011042         MOV     (R0),-(R2)
50 13006 075032         FDIV    R2              ;R2 -> RINST
51 13010 012261         MOV     (R2)+,W(I)
                032746
52 13014 012261         MOV     (R2)+,W+2(I)
                032750
53 13020 062701         ADD     #4,I
                000004
54 13024 077363         SOB     R3,RIN1
55
56
57              ;COMPUTE LINEAR REGRESSION OF PCO2 AS A FUNCTION OF RINST
58              ;       STORE ABS(SLOP) IN CSLOP
59              ;
60              ;       ARRAY:  W -> RINST
61              ;               Z -> FO2
62              ;               Y -> FCO2
63
64 13026 004767 RINLRG: JSR     PC,CLRSUM       ;CLEAR EX,EY,EXY,EX2
                003042
65 13032 012705         MOV     #TSTK,TP
                037112
66              ;IGNORE ENDPOINTS
67 13036 016703         MOV     NPAIR,R3
                024732
68 13042 162703         SUB     #2,R3
                000002
69 13046 012701         MOV     #4,I
                000004
70 13052 016145 RIN5:   MOV     W+2(I),-(TP)    ;RINST
                032750
71 13056 016145         MOV     W(I),-(TP)
                032746
72 13062 016145         MOV     Y+2(I),-(TP)
                031310
73 13066 016145         MOV     Y(I),-(TP)      ;FCO2
                031306
74 13072 004767         JSR     PC,SUMM
                003772
```

```
75 13076 062701          ADD     #4,I
         000004
76 13102 077315          SOB     R3,RTN5
77                ;SUMMATIONS COMPLETED
78 13104 004767          JSR     PC,LSQ          ;GET SLOPE AND INTERCEPT
         003044
79 13110 012700          MOV     #WKAR,R0
         037114
80 13114 010002          MOV     R0,R2
81 13116 012520          MOV     (TP)+,(R0)+
82 13120 012520          MOV     (TP)+,(R0)+
83 13122 016720          MOV     DM1,(R0)+
         003602
84 13126 016720          MOV     DM1+2,(R0)+
         003600
85 13132 075022          FMUL    R2
86 13134 016720          MOV     D713,(R0)+
         004430
87 13140 016720          MOV     D713+2,(R0)+
         004426
88 13144 075022          FMUL    R2
89 13146 012267          MOV     (P2)+,CSLOP
         044710
90 13152 012267          MOV     (R2)+,CSLOP+2
         044706
91 13156 062705          ADD     #4,TP           ;SKIP INTERCEPT
         000004
92
93 13162 047767 ROUT:    BIC     #100000,DRAS    ;CLEAR REQB FOR Q BUTTON
         100000
         154600
94 13170 052767          BIS     #40,DRAS        ;INT ENB REQ B
         000040
         154572
95 13176 000167          JMP     EXLOOP
         173304
96
```

```
                        .TITLE  MASS SPEC HANDLER
                ;SUBROUTINE GETGAS
                ;       CALL            JSR PC,GETGAS
                ;
                ;       WIPES OUT REGISTERS R0,R1,R2,R3,R4
                ;       ASSUMES R5 IS A TEMP STACK POINTER
                ;       RETUENS FRACTIONAL GAS VALUES FOR MS OUTPUTS AT TIME OF CALLING
                ;       STORES
                ;               FO2 IN FO21
12 13202 037670                        FO22
                ;               FN2 IN  FN21
                ;                       FN22
                ;               FCO2 IN FCO21
                ;                       FCO22
22 13204 010046 GETGAS: MOV     R0,-(SP)
23 13206 010146         MOV     R1,-(SP)
24 13210 010246         MOV     R2,-(SP)
25 13212 010346         MOV     R3,-(SP)
26 13214 010446         MOV     R4,-(SP)
27 13216 004767         JSR     PC,SAMGAS
         000212
28 13222 010204         MOV     R2,R4   ;GET N2,CO2 OUT OF FLOATS WAY
29 13224 010103         MOV     R1,R3
30 13226 010045         MOV     R0,-(TP)
31 13230 004767         JSR     PC,IR   ;FLOAT O2 COUNTS
         002416
32 13234 016745         MOV     O2CF2,-(TP)     ;GET CONVERSION FACTORS
         024414
33 13240 016745         MOV     O2CF1,-(TP)
         024406
34 13244 075025         FMUL    TP
35 13246 010345         MOV     R3,-(TP)        ;GET N2 COUNTS
36 13250 004767         JSR     PC,IR   ;FLOAT IT
         002376
37 13254 016745         MOV     N2CF2,-(TP)             ;CAL FACTOR
         024400
38 13260 016745         MOV     N2CF1,-(TP)     ;CAL FACTOR
         024372
39 13264 075025         FMUL    TP              ;MULTIPLY
40 13266 010445         MOV     R4,-(TP)        ;CO2
41 13270 004767         JSR     PC,IR   ;FLOAT IT
         002356
42 13274 016745         MOV     CO2CF2,-(TP)    ;CO2 CAL FACTOR
         024364
43 13300 016745         MOV     CO2CF1,-(TP)    ;DITTO
         024356
44 13304 075025         FMUL    TP
45 13306 010504         MOV     TP,R4   ;GET STACK POINTER
46 13310 016445         MOV     12(R4),-(TP)    ;DUPLICATE STACK
         000012
```

```
47 13314 016445 000010      MOV     10(R4),-(TP)
48 13320 016445 000006      MOV     6(R4),-(TP)
49 13324 016445 000004      MOV     4(R4),-(TP)
50 13330 016445 000002      MOV     2(R1),-(TP)
51 13334 011445             MOV     @R4,-(TP)
52 13336 075005             FADD    TP
53 13340 075005             FADD    TP              ;SUM OF O2,N2,CO2
54 13342 012501             MOV     (TP)+,R1        ;SAVE SUM
55 13344 012502             MOV     (TP)+,R2
56 13346 062705 177774      ADD     #177774,TP              ;RESTORE TP TO WHAT IT WAS
57 13352 075035             FDIV    TP
58 13354 012567 024316      MOV     (TP)+,FCO21     ;SAVE FCO2
59 13360 012567 024314      MOV     (TP)+,FCO22
60 13364 010245             MOV     R2,-(TP)
61 13366 010145             MOV     R1,-(TP)        ;PUT SUM BACK ON STACK
62 13370 075035             FDIV    TP
63 13372 012567 024274      MOV     (TP)+,FN21
64 13376 012567 024272      MOV     (TP)+,FN22              ;SAVE NITROGEN FRAC
65 13402 010245             MOV     R2,-(TP)
66 13404 010145             MOV     R1,-(TP)
67 13406 075035             FDIV    TP
68 13410 012567 024252      MOV     (TP)+,FO21
69 13414 012567 024250      MOV     (TP)+,FO22
70
71 13420 012604             MOV     (SP)+,R4
72 13422 012603             MOV     (SP)+,R3
73 13424 012602             MOV     (SP)+,R2
74 13426 012601             MOV     (SP)+,R1
75 13430 012600             MOV     (SP)+,R0
76
77 13432 000207             RTS     PC
78
```

```
                        ;       SUBROUTINE SAMGAS
                        ;       CALLING SEQUENCE
                        ;               JSR     PC,SAMGAS
                        ;
                        ;       USES FROM RAM
                        ;               O2CTRL
                        ;               N2CTRL
                        ;               C2CTRL
                        ;               MSMVRT  0-DONT INVERT
                        ;                       NEGATIVE-INVERT
                        ;
                        ;       RETURNS
                        ;               R0-ADO2
                        ;               R1-ADN2
                        ;               R2-ADCO2
                        ;
                        ;       ALSO ZAPS R3,R4
                        ;
                        ;
                        ;
                        ;
                        ;
                        ;
                        ;
13434 016737 SAMGAS:    MOV     O2CTRL,@#ADSR           ;SAMPLE O2
      023516
      176770
13442 033727 GCKO:      BIT     @#ADSR,#200
      176770
      000200
13450 001774            BEQ     GCKO
13452 100770            BMI     SAMGAS          ;ERROR
13454 013700            MOV     @#ADIN,R0       ;SAVE O2 SAMPLE
      176772
                        ;
                        ;
13460 016737 GSAMN2:    MOV     N2CTRL,@#ADSR           ;SAMPLE N2
      023474
      176770
13466 033727 GCKN:      BIT     @#ADSR,#10200
      176770
      010200
13474 001774            BEQ     GCKN            ;NOT THROUGH
13476 100770            BMI     GSAMN2
13500 013701            MOV     @#ADIN,R1               ;SAVE SAMPLED N2
      176772
                        ;
                        ;
                        ;
13504 016737 GSAMC:     MOV     C2CTRL,@#ADSR   ;SAMPLE CO2
      023452
      176770
13512 033727 GCKC:      BIT     @#ADSR,#10200
      176770
      010200
13520 001774            BEQ     GCKC
13522 100770            BMI     GSAMC
```

```
44 13524 013702          MOV     @#ADIN,R2       ;SAVE SAMPLED CO2
         176772
45 13530 005767          TST     MSNVRT
         024146
46 13534 002003          BGE     SGLV
47 13536 005100          COM     R0
48 13540 005101          COM     R1              ;FOR MS WITH NEGATIVE OUTPUTS
49 13542 005102          COM     R2
50
51 13544 000207 SGLV:    RTS     PC
52
```

```
                        ;SUBROUTINE CALMS
                        ;
                        ;       ENTER WITH JSR  PC,CALMS
                        ;
                        ;       THIAS ROUTINE READS THE MSTYPE,GETS APPROPRIATE
                        ;       GAINS,FULL SCALES,ETC. AND COMPUTES CALIBRATION
                        ;       FACTORS FOR THE SIGNALS
                        ;       THIS ROUTINE DESTROYS R0,R1,R2,R3,R4
                        ;       IT TAKES CONTROL OF THE CLOCK AND RETURNS WITH
                        ;       THE CLOCK SHUT OFF.
                        ;
                        ;       FOR READING MS TYPE IT LOOKS AT DRAI BITS 3 AND 4
                        ;
                        ;CURRENT ASIGNMENT IS FOR
                        ;       0-SRI MEDSPECT
                        ;       1-WEST PERKIN ELMER
                        ;       2-PE SKYLAB SN 9   CLOSED LOOP
                        ;       3-PE SKYLAB SN 9   OPEN LOOP
                        ;
                        ;ON RETURN
                        ;       R0=0     OK
                        ;       R0=-1    BAD CALIBRATION
                        ;
                        ;       DEFINITIONS
                167774          GDRAI=DRAI
                000001          LINCLK=1
                        ;
13546 010546 CALMS:     MOV     R5,-(SP)        ;SAVE R5
13550 013700            MOV     @#GDRAI,R0
      167774
13554 042700            BIC     #177747,R0      ;STRIP GARBAGE BITS
      177747
                        ;
                        ;       ASH     #76,R0          ;ROTATE THE MOTHER RIGHT
                        ;      (CORRECT FOR ROM COMPATIBILITY)
13560 012703            MOV     #76,R3
      000076
13564 072003            ASH     R3,R0
13566 016067            MOV     OCTMSO(R0),O2CTRL
      017432
      023362
13574 016067            MOV     NCTMSO(R0),N2CTRL
      017442
      023356
13602 016067            MOV     CCTMSO(R0),C2CTRL
      017452
      023352
13610 016067            MOV     INVRT0(R0),MSNVRT
      017462
      024064
13616 016067 MOV        CAPDLY(R0),MSDLY
      017472
      020372
13624 012705            MOV     #31,R5
      000031
```

```
44 13630 016704          MOV     FVDATA,R4
         003662
45 13634 005003          CLR     R3              ;ERROR CK CTR
46
47
48
49
50
51
52
53
54
55
56                       .IF     DF,LINCLK
57 13636 000001 CSRPT:   WAIT
58                       .ENDC
59
60
61
62
63                       .IF     NDF,LINCLK
64
65                       MOV     #620,@#PCSB
66                       MOV     #040033,@#PCSR
67              CSRPT:   BIT     #200,@#PCSR
68                       BEQ     CSRPT
69                       BIC     #200,@#PCSR
70                       .ENDC
71 13640 004767          JSR     PC,SAMGAS
         177570
72 13644 010024          MOV     R0,(R4)+
73 13646 010124          MOV     R1,(R4)+
74 13650 010224          MOV     R2,(R4)+
75 13652 020267          CMP     R2,CO2TRS       ;CO2 ABOVE CAL GAS LEVEL?
         003642
76 13656 003001          BGT     CSRPT1
77 13660 005203          INC R3                  ;ERROR
78
79
80
81 13662 077513 CSRPT1:  SOB     R5,CSRPT
82 13664 020327          CMP     R3,#3
         000003
83 13670 002057          BGE     ERRLV           ;BAD CAL GAS.  NO
84                                               ;CO2.  MS OFFOR ROOM AIR IN
```

```
                        ;ARRIVING HERE, WE HAVE 25 O2,N2,CO2 SAMPLES IN RAM STARTING ABOUT FCVDAT


 013672 012605          MOV     (SP)+,R5        ;GET R5 BACK
 013674 016700          MOV     FVDATA,R0       ;ADDRESS OF FIRST O2 SAMPLE
        003616
 13700 016701           MOV     CGFO2,R1
        003576
 13704 016702           MOV     CGFO2+2,R2      ;GET CAL GAS VALUES
        003574
 13710 004767           JSR     PC,CGAVG
        000140

 13714 010067           MOV     R0,O2CF1
        023732
 13720 010167           MOV     R1,O2CF2
        023730
 13724 016700           MOV     FVDATA,R0
        003566
 13730 062700           ADD     #2,R0
        000002
 13734 016701           MOV     CGFN2,R1
        003546
 13740 016702           MOV     CGFN2+2,R2
        003544
 13744 004767           JSR     PC,CGAVG
        000104
 13750 010067           MOV     R0,N2CF1
        023702
 13754 010167           MOV     R1,N2CF2
        023700
 13760 016700           MOV     FVDATA,R0
        003532
 13764 062700           ADD     #4,R0
        000004
 13770 016701           MOV     CGFCO2,R1
        003516
 13774 016702           MOV     CGFCO2+2,R2
        003514
 14000 004767           JSR     PC,CGAVG
        000050
 14004 010067           MOV     R0,CO2CF1
        023652
 14010 010167           MOV     R1,CO2CF2
        023650
 14014 005000           CLR     R0
 14016                  TYPE    COKM
 14016 012700           MOV     #COKM,R0
        017620
 14022 004767           JSR     PC,LPTGO
        001012
 14026 000207           RTS     PC

```

```
34                                      .IF     DF,LINCLK
35  14030 012700 ERRLV:                 MOV     #-1,R0
          177777
36  14034 010067                        MOV     R0,DUM2
          023134
37  14040 012605                        MOV     (SP)+,R5
38  14042                               TYPE    CBDM
    14042 012700                        MOV     #CBDM,R0
          017636
    14046 004767                        JSR     PC,LPTGO
          000766
39  14052 000207                        RTS     PC
40                                      .ENDC
41
42
43
44                                      .IF     NDF,LINCLK
45                          ERRLV:      CLR     @#PCSR
46                                      MOV     (SP)+,R5
47                                      MOV     #-1,R0
48                                      RTS     PC
49                                      .ENDC
```

```
 1 014054 016704 CGAVG:  MOV     FVDATA,R4
          003436
 2 014060 062704         ADD     #300,R4
          000300
 3 014064 010245         MOV     R2,-(TP)        ;CAL GAS VALUE
 4 014066 010145         MOV     R1,-(TP)
 5 014070 016745         MOV     F760+2,-(TP)
          003330
 6 014074 016745         MOV     F760,-(TP)      ;BTPS
          003322
 7 014100 075025         FMUL    TP
 8 014102 012045         MOV     (R0)+,-(TP)     ;A/D VALUE
 9 014104 004767         JSR     PC,IR           ;FLOAT IT
          001542
10
11
12
13 14110 012704         MOV     #30,R4
          000030
14
15
16
17
18 14114 062700 CGMOR:  ADD     #4,R0
          000004
19 14120 012045         MOV     (R0)+,-(TP)
20 14122 004767         JSR     PC,IR           ;FLOAT NEXT VALUE
          001524
21 14126 075005         FADD    TP
22 14130 077407         SOB     R4,CGMOR        ;AVERAGE THE 25 VALUES
23 14132 016745         MOV     CFL25+2,-(TP)
          003272
24 14136 016745         MOV     CFL25,-(TP)
          003264
25 14142 075035         FDIV    TP              ;DIVIDE SUM BY 25
26 14144 075035         FDIV    TP
27 14146 012500         MOV     (TP)+,R0        ;% = AVG/(CALGAS*BTPS)
28
29 14150 012501         MOV     (TP)+,R1
30 14152 000207         RTS     PC
31
32
```

```
                        .TITLE  SPIROMETER CONTROL
                ;SUBROUTINE SPIRO -     MONITOR SPIRO STATUS
                ;                 -     CONTROL VALVE
                ;                   -   DETERMINE BREATH STATUS
                ;
                ;ENTER WITH:    R2=SAMPLED SPIROMETER VALUE
                ;               R1=DATA BUFFER ADDRESS
                ;               R0=COUNTER FOR FVDAT
                ;               R3=GENERAL INDICATOR
                ;;  SPIROMETER CONTROL - BIT 0 OF DRAS

 14154 010046 SPIRO:  MOV     R0,-(SP)
 14156 020267         CMP     R2,THRSH
       024106
 14162 100422         BMI     BELOW
 14164 032767         BIT     #1,DRAS
       000001
       153576
 14172 001432         BEQ     OPEN
 14174 010200         MOV     R2,R0
 14176 166700         SUB     VLAST,R0
       017624
 14202 020067         CMP     R0,VTHRSH
       003396
 14206 100427         BMI     LESS
 14210 016767         MOV     WAITT,VWATCH
       023512
       017612
 14216 010267         MOV     R2,VLAST
       017604
 14222 005067         CLR     EOB
       003552
 14226 000431         BR      VVRTN

 14230 032767 BELOW:  BIT     #1,DRAS         ;OPEN?
       000001
       153532
 14236 001010         BNE     OPEN            ;LIES   IT IS CLOSED
 14240 052767         BIS     #1,DRAS
       000001
       153522
 14246 005067         CLR     VLAST
       017554
 14252 016767         MOV     WAITT,VWATCH
       023450
       017550
 14260 005002 OPEN:   CLR     R2
 14262 000167         JMP     VVRTN
       000024

 14266 005267 LESS:   INC     VWATCH
       017536
 14272 100407         BMI     VVRTN
 14274 042767         BIC     #1,DRAS
```

```
          000001
          153466
40 14302 005002          CLR     R2
41 14304 052767          BIS     #1,EOB
          000001
          003466
42
43 14312 012600 V%RTN:   MOV     (SP)+,R0
44 14314 000207          RTS     PC
45
46
47
48               ;       SUBROUTINE VDELSU
49
50 14316 010046 VDELSU:  MOV     R0,-(SP)
51 14320 010146          MOV     R1,-(SP)
52 14322 012700          MOV     #VLSTK,R0
          033566
53 14326 010067          MOV     R0,VOLPTO
          017660
54 14332 010067          MOV     R0,VOLPTI
          017652
55 14336 066767          ADD     VDEL,VOLPTI
          017652
          017644
56 14344 012700          MOV     #VLSTK1,R0
          034014
57 14350 162700          SUB     #VLSTK,R0
          033566
58 14354 006200          ASR     R0
59 14356 012701          MOV     #VLSTK,R1
          033566
60 14362 005021 VDVR:    CLR     (R1)+           ;CLEAR PHASED VOL. STACK
61
62 14364 077002          SOB     R0,VDVR
63 14366 012767          MOV     #QUADST,QUADI
          034224
          017624
64 14374 012767          MOV     #QUADST,QUADO
          034224
          017620
65 14402 012767          MOV     #1,LSTCK
          000001
          017574
66 14410 012601          MOV     (SP)+,R1
67 14412 012600          MOV     (SP)+,R0
68 14414 000207          RTS     PC
69
70
71
72
73
74
75
```

```
1
2                       .TITLE  PHASED-DELAY
3
4                ;SUBROUTINE TO SAVE DELAYED VOLUME AND STUFF GAS FRACTIONS ON
5                ;STACK  NOT SYSTEMS STACK
6                ;ENTER WITH OUTPUT OF SPIRO IN R2
7                ;AFTER GETGAS
8                ;EXIT WITH SPIRO,FN2,FO2,FCO2
9                ;PUT IN ALINE ON QUADST
10
11 14416 010046 DELAY:  MOV     R0,-(SP)
12 14420 016700         MOV     VOLPTI,R0
         017564
13 14424 020027         CMP     R0,#VLSTK1
         034014
14 14430 001002         BNE     DELAY1
15 14432 012700         MOV     #VLSTK,R0
         033566
16 14436 010220 DELAY1: MOV     R2,(R0)+
17 14440 010067         MOV     R0,VOLPTI
         017544
18 14444 016700         MOV     VOLPTO,R0
         017542
19 14450 020027         CMP     R0,#VLSTK1
         034014
20 14454 001002         BNE     DELAY2
21 14456 012700         MOV     #VLSTK,R0
         033566
22
23 14462 012002 DELAY2: MOV     (R0)+,R2
24 14464 010067         MOV     R0,VOLPTO
         017522
25 14470 005702         TST     R2
26 14472 001006         BNE     DARN
27 14474 005767         TST     LSTCK
         017504
28 14500 001033         BNE     LVLVLV
29 14502 005267         INC     LSTCK
         017476
30 14506 000402         BR      NEWNEW
31 14510 005067 DARN:   CLR     LSTCK
         017470
32
33 14514 016700 NEWNEW: MOV     QUADI,R0
         017500
34 14520 020027         CMP     R0,#QUADS1
         056732
35 14524 002402         BLT     DELAY3
36 14526 012700         MOV     #QUADST,R0
         034224
37
38 14532 010220 DELAY3: MOV     R2,(R0)+
39 14534 016720         MOV     FN2,(R0)+
         023132
40 14540 016720         MOV     FN2+2,(R0)+
         023130
41 14544 016720         MOV     FO2,(R0)+
```

```
                023116
 42 14550 016720          MOV     FO2+2,(R0)+
                023114
 43 14554 016720          MOV     FCO2,(R0)+
                023116
 44 14560 016720          MOV     FCO2+2,(R0)+
                023114
 45 14564 010067          MOV     R0,QUADI
                017430
 46 14570 012600 LVLVLV:  MOV     (SP)+,R0
 47 14572 000207          RTS     PC
```

```
1                               .TITLE  REPORT
2                       ;
3                       ;SUBROUTINE REPORT - OTR1
4                       ;       ASSUMES COMPLETION OF F/C AND WO
5                       ;       MANEUVERS.
6
7
8
9  014574 012705 RPT:   MOV     #TSTK,TP
           037112
10                      ;REPLACES 2 MOVE INSTRUCTIONS
11                      ;   (ROM CORRECTION AGAIN)
12 14600 000240         NOP
13 14602 000240         NOP
14 14604 000240         NOP
15 14606 000240         NOP
16 14610 000240         NOP
17 14612 000240         NOP
18 14614 004767         JSR     PC,WO35
           167556
19
20                      ;PRINT TITLE
21 14620 016700         MOV     DRA1,R0
           153150
22 14624 042700         BIC     #177770,R0
           177770
23 14630 062700         ADD     #60,R0
           000060
24
25                      ;PRINT TITLE
26                      ;       PRTBUF  TITLE,2
27                      ;   (FAKE MACRO, SO WE CAN GET SUBJECT NUMBER   OUT)
28 14634 004567         JSR     R5,BUFLOD
           001716
29 14640 017052         TITLE
30 14642 000002         2
31 14644 110067         MOVB    R0,BUFFER+40
           022370
32 14650 012700         MOV     #BUFFER,R0
           037200
33 14654 004767         JSR     PC,LPTGO
           000160
34
35
36                      ;MAKE SURE PRINTER IS DONE BEFORE LOADING "BUFFER"
37 14660 132767 KT1:    BITB    #LPEN,LPTSR
           000100
           153062
38 14666 001374         BNE     KT1
39                      ;MAKE SURE TTY IS DONE
40 14670 122777         CMPB    #377,@TTYGO
           000377
           022272
41 14676 001374         BNE     .-6
42
43 14700 004567 RPT1:   JSR     R5,BUFLOD
           001652
```

```
44 14704 017114          MSGS
45 14706 000016          14.
46
47                ;NOW FILL IN NUMBERS
48 14710 012767          MOV     #BUFFER+12.,FLM2        ;FIRST ADDR TO INSERT DIGIT
         037214
         022260
49 14716 012704          MOV     #OUTAR,R4
         034076
50 14722 012700          MOV     #4,R0
         000004
51 14726 004767          JSR     PC,RPTSB
         000064
52
53 14732 062704          ADD     #4,R4
         000004
54 14736 012700          MOV     #1,R0
         000001
55 14742 004767          JSR     PC,RPTSB
         000050
56
57 14746 062704          ADD     #10,R4
         000010
58 14752 012700          MOV     #11,R0
         000011
59 14756 004767          JSR     PC,RPTSB
         000034
60
61
62 14762                 TYPE    BUFFER
   14762 012700          MOV     #BUFFER,R0
         037200
   14766 004767          JSR     PC,LPTGO
         000046
63
64
65 14772 132767 KT2:     BITB    #LPEN,LPTSR
         000100
         152750
66 15000 001374          BNE     KT2
67                ;WAIT FOR TTY TO FINIHS
68 15002 122777          CMPB    #377,@TTYGO
         000377
         022160
69 15010 001374          BNE     .-6
70 15012 000207 RPT2:    RTS     PC
71 15014                 .EXIT
   15014 104350                  EMT     ^O350
72
```

```
                        ;SUBROUTINE RPTSB
                        ;
015016 004767 000066    RPTSB:  JSR     PC,FORMAT
015022 062704 000004            ADD     #4,R4
015026 062767 000024            ADD     #24,FLM2
       022142
015034 077011                   SOB     R0,RPTSB
015036 000207                   RTS     PC
                        ;
                        ;
                        ;PANEL PRINTER START ROUTINE
                        ;
015040 010067 022604    LPTGO:  MOV     R0,PRTGO
015044 032767 000001            BIT     #PRTBM,DRBI     ;LPT SWITCH ON
       152712
015052 001407                   BEQ     LPTGO1
015054 152767 000100            BISB    #LPEN,LPTSR     ;SET INTEN
       152666
015062 000240                   NOP
015064 112767 000200            MOVB    #200,LPT        ;START LPT CARRIAGE MOVING
       152661
                        ;
015072 032767 000002    LPTGO1: BIT     #TTYBM,DRBI
       152664
015100 001402                   BEQ     LPTGO2
015102 010067 022062            MOV     R0,TTYGO
                        ;
015106 000207           LPTGO2: RTS     PC
                        ;
                        ;
                        ;
```

```
                        ;SUBROUTINE FORMAT - INTERFACE BETWEEN REPORT AND
                        ;       FFMT (FLOAT TO ASCII)
                        ;
015110 010046 FORMAT:   MOV     R0,-(SP)
015112 010146           MOV     R1,-(SP)
015114 010246           MOV     R2,-(SP)
015116 010346           MOV     R3,-(SP)
015120 010446           MOV     R4,-(SP)

 15122 016746           MOV     FLM2,-(SP)
       022050
 15126 016746           MOV     FY,-(SP)
       002410
 15132 016746           MOV     FX,-(SP)
       002406
 15136 016446           MOV     2(R4),-(SP)
       000002
 15142 016446           MOV     0(R4),-(SP)
       000000
 15146 004767           JSR     PC,FFMT
       000020

 15152 010367           MOV     R3,LSTAD
       022010
 15156 012604           MOV     (SP)+,R4
 15160 012603           MOV     (SP)+,R3
 15162 012602           MOV     (SP)+,R2
 15164 012601           MOV     (SP)+,R1
 15166 012600           MOV     (SP)+,R0
 15170 000207           RTS     PC

                        .TITLE  FORMAT

                        ;FFMT:ROUTINE TO PROVIDE LIMITED F FORMAT CAPABILITIES.
                        ;WILL PROVIDE FX.Y FORMAT
                        ;       X-NUMBER OF DIGITS TO PRING TO LEFT OF DECIMAL.  ACCEPTABLE RANGE  1-5.
                        ;         MAXIMUM MAGNITUDE OF NUMBER  32767
                        ;       Y-NUMBER OF DIGITS AFTER DECIMAL   RANGE  0-4
                        ;TOTAL NUMBER OF SPACES REQUIRED IS X+Y+1+(1IF Y>0, 0 IF Y=0)


                        ;CALLING SEQUENCE
                        ;       MOV ADD,-(SP)   PUSH STARTING ADDRESS
                        ;       MOV     Y,-(SP)         PUSH Y OF FX.Y
                        ;       MOV     X,-(SP) PUSH X OF FX.Y
                        ;       MOV     FLOW,-(SP)      PUSH LSW OF FLOAT
                        ;       MOV     FHI,-(SP)       PUSH MSW OF FLOAT
                        ;       JSR     PC,FFMT


                        ;CALLS MODIFIED ROUTINE RI WHICH USES R5 AS TP

                        ;ZAPS R0-R4

       000060 CHAR=60
```

```
1  015172 016603 FFMT:   MOV     12(SP),R3       ;GET STORAGE ADDRESS
                000012
2  015176 016304         MOV     6(SP),R4        ;GEYT X OF FX.Y
                000006
3  015202 060403         ADD     R4,R3           ;SUM THEM
4  015204 005203         INC     R3      ;MAKE R3 POINT TO LAST BYTE OF MANTISSA
5  015206 016366         MOV     R3,12(SP)       ;PUT BACK IN STACK
                000012
6  015212 005766         TST     2(SP)           ;NEGATIVE?
                000002
7  015216 003015         BGT     FMPLUS          ;POSITIVE
8  015220 001552         BEQ     FMZRO           ;ZERO
9  015222 016645         MOV     4(SP),-(TP)
                000004
10 15226 016645          MOV     2(SP),-(TP)     ;PUT FLOATING NUMBER ON STACK
                000002
11 15232 016745          MOV     FMFM1+2,-(TP)
                002276
12 15236 016745          MOV     FMFM1,-(TP)     ;GET MINUS 1 ON STACK
                002270
13 15242 075025          FMUL    TP
14 15244 116743          MOVB    FMMINS,-(R3)    ;PUSH MINUS SIGN ON OUTPUT AFTER MAKING THE NUMBER +
                032254
15 15250 000406          BR      FMMANT
16
17
18 15252 116743 FMPLUS:  MOVB    FMSPC,-(R3)
                002247
19 15256 016645          MOV     4(SP),-(TP)     ;GET THE POSITIVE NUMBER
                000004
20 15262 016645          MOV     2(SP),-(TP)
                000002
21 15266 010500 FMMANT:  MOV     TP,R0
22 15270 016045          MOV     2(R0),-(TP)
                000002
23 15274 011045          MOV     (R0),-(TP)
24 15276 016745          MOV     F32768+2,-(TP)
                002226
25 15302 016745          MOV     F32768,-(TP)
                002220
26 15306 075015          FSUB    TP
27 15310 010005          MOV     R0,TP
28 15312 005765          TST     -4(TP)
                177774
29 15316 002403          BLT     FMMAN
30 15320 062705          ADD     #4,TP
                000004
31 15324 000534          BR      FMERRO
32
33 15330 010500 FMMAN:   MOV     TP,R0
34 15332 016045          MOV     2(R0),-(TP)
                000002
35 15336 011045          MOV     (R0),-(TP)
36 15340 004767          JSR     PC,RI
                000404
37 15344 011500          MOV     (TP),R0
39
```

```
39
40 15344 004767 FMOK:   JSR     PC,IR
         000302
41 15350 075015         FSUB    TP              ;TP NOW POINTS TO DIFFERENCE
42
```

```
                        ;AT THIS POINT WE HAVE X IN R4,FIXED MANTISSA IN R0
                        ;ADDRESS OF LSD IN R3
                        ;       SIGN IN (R3)
                        ;(TP),(TP+2) IS FRACTION WE WILL OUTPUT LATER
 015352 010001 FMNDG:   MOV     R0,R1
 015354 005000          CLR     R0
                ;       DIV     #12,R0
 015356 071037          DIV     @#C12,R0
        070716
 15362 062701           ADD     #60,R1          ;MAKE REMAINDER A CHARACTER
       000060
 15366 111302           MOVB    (R3),R2
 15370 110113           MOVB    R1,(R3)
 15372 110243           MOVB    R2,-(R3)
 15374 005700           TST     R0              ;IS IT 0
 15376 001404           BEQ     FMLASP  ;YES
 15400 077414           SOB     R4,FMNDG


                                                ;GETTING HERE IS AN ERROR   NOT ENOUGH X
 15402 062705           ADD     #4,TP           ;CLEAN UP STACK
       000004
 15406 000503           BR      FMERRO
 15410 005704 FMLASP:   TST     R4
 15412 001403           BEQ     FMFRAC

 15414 116743 FMFRA:    MOVB    FMSPC,-(R3)
       002105
 15420 077403           SOB     R4,FMFRA


 15422 016604 FMFRAC:   MOV     10(SP),R4       ;GET Y
       000010
 15426 003003           BGT     FFRCCT
 15430 062705           ADD     #4,TP
       000004
 15434 000437           BR      FTHROU
 15436 016745 FFRCCT:   MOV     FMF10K+2,-(TP)
       002076
 15442 016745           MOV     FMF10K,-(TP)
       002070
 15446 075025           FMUL    TP
 15450 004767           JSR     PC,RI   ;FIX FRAC*10000
       000272
 15454 012500           MOV     (TP)+,R0
 15456 016603           MOV     12(SP),R3       ;GET ADDRESS OF OUT
       000012
 15462 116723           MOVB    FMDOT,(R3)+
       002035
 15466 012702           MOV     #4,R2
       000004
 15472 010001 FMRPTR:   MOV     R0,R1
 15474 005000           CLR     R0
                ;       DIV     #12,R0
 15476 071037           DIV     @#C12,R0
```

```
                070716
 46 15502 062701        ADD     #CHAR,R1
          000060
 47 15506 010145        MOV     R1,-(TP)
 48 15510 077210        SOB     R2,FMRPTR
 49 15512 016600        MOV     10(SP),R0       ;GET Y
          000010
 50 15516 012702        MOV     #4,R2
          000004
 51
 52 15522 012501 FMVRPT: MOV    (TP)+,R1
 53 15524 005300        DEC     R0
 54 15526 002401        BLT     FLPND
 55 15530 110123        MOVB    R1,(R3)+
 56
 57 15532 077205 FLPND:  SOB    R2,FMVRPT
 58 15534 011600 FTHROU: MOV    (SP),R0
 59 15536 062706        ADD     #12,SP
          000012
 60 15542 010016        MOV     R0,(SP)
 61 15544 000207        RTS     PC
 62
 63
 64
 65 15546 016600 FMZRO:  MOV    12(SP),R0
          000012
 66 15552 016601        MOV     6(SP),R1
          000006
 67 15556 112740        MOVB    #CHAR,-(R0)
          000060
 68 15562 116740 ZLP:    MOVB    FMSPC,-(R0)
          001737
 69 15566 077103        SOB     R1,ZLP
 70 15570 016600 FMSZ0:  MOV    12(SP),R0
          000012
 71 15574 016601        MOV     10(SP),R1
          000010
 72 15600 001755        BEQ     FTHROU
 73 15602 116720        MOVB    FMDOT,(R0)+
          001715
 74 15606 112720 FMZOF:  MOVB    #CHAR,(R0)+
          000060
 75 15612 077103        SOB     R1,FMZOF
 76 15614 000747        BR      FTHROU
 77
 78
 79 15616 016600 FMERRO: MOV    12(SP),R0
          000012
 80 15622 016601        MOV     6(SP),R1
          000006
 81 15626 160100        SUB     R1,R0
 82 15630 005300        DEC     R0
 83 15632 066601        ADD     10(SP),R1
          000010
 84 15636 062701        ADD     #2,R1
          000002
 85 15642 116720 FMERRR: MOVB    FMAST,(R0)+
```

```
                M01654
86  15646 077103        SOB     R1,FMERRR
07  15650 000731        BR      FTHROU
```

```
                        .TITLE  INTEGER TO REAL
                ;  INTEGER TO REAL CONVERSION
                ;
                ;  ARGUMENT IS A FULL WORD ON THE TOP OF THE STACK.
                ;  CONVERT IT TO A REAL FORMAT AND RETURN IT AS THE
                ;  TOP TWO WORDS ON THE STACK.P113, FPMP-11 USER'S MANUAL.

015652 010146 IR:       MOV     R1,-(SP)
 15654 010246           MOV     R2,-(SP)
 15656 005045           CLR     -(TP)       ;MAKE ROOM FOR RESULT
 15660 016501           MOV     2(TP),R1            ;GET INTEGER ARGUMENT
        000002
 15664 003002           BGT     POS
 15666 001424           BEQ     ZER
 15670 005401           NEG     R1          ;GET ABSOLUTE VALUE

 15672 006145 POS:      ROL     -(TP)       ;SAVE SIGN
 15674 012702           MOV     #220,R2     ;GET MAX POSSIBLE EXP+1
        #00220
 15700 105065           CLRB    4(TP)       ;CLEAR LOWEST ORDER FRAC.
        000004

 15704 006101 NOM:      ROL     R1          ;LOOK FOR NORMAL BIT
 15706 103402           BCS     NOD         ;JUMP IF FOUND
 15710 005302           DEC     R2          ;DECREASE EXPONENT
 15712 000774           BR      NOM         ;TRY AGAIN

 15714 110165 NOD:      MOVB    R1,5(TP)            ;SAVE LOW ORDER FRAC.
        000005
 15720 105001           CLRB    R1
 15722 150201           BISB    R2,R1       ;COMBINE EXP AND LOW ORDER FRAC.
 15724 000301           SWAB    R1
 15726 006025           ROR     (TP)+       ;GET SIGN
 15730 006001           ROR     R1          ;INSERT SIGN IN RESULT
 15732 106065           RORB    3(TP)
        000003
 15736 010115           MOV     R1,@TP      ;OUTPUT RESULT
 15740 012602 ZER:      MOV     (SP)+,R2
 15742 012601           MOV     (SP)+,R1
 15744 000207           RTS     PC
```

```
                        .TITLE  REAL TO INTEGER
                ;
                ;  REAL TO INTEGER CONVERSION
                ;
                ;  ARGUMENT IS A DOUBLE WORD REAL NUMBER ON THE
                ;  TOP OF THE STACK. TRUNCATE IT AND CONVERT IT
                ;  TO AN INTEGER ON THE TOP OF THE STACK.
                ;
015746 010146 RI:       MOV     R1,-(SP)
15750 010246            MOV     R2,-(SP)
15752 010346            MOV     R3,-(SP)
15754 005002            CLR     R2          ;CLEAR WORK SPACE
15756 005202            INC     R2          ;SET UP NORMAL BIT
15760 012501            MOV     (TP)+,R1            ;GET REAL ARGUMENT
15762 006115            ROL     @TP         ;GET SIGN
15764 006101            ROL     R1          ;AND
15766 006145            ROL     -(TP)       ;SAVE IT
15770 110103            MOVB    R1,R3       ;GET HIGH ORDER FRACTION
15772 105001            CLRB    R1
15774 000301            SWAB    R1          ;GET EXPONENT
15776 162701            SUB     #201,R1
      000201
16002 002432            BLT     ZERRI       ;JUMP IF TOO SMALL
16004 001410            BEQ     ONERI
16006 022701            CMP     #15.,R1
      000017
16012 002422            BLT     OVRRI       ;JUMP IF IT IS TOO BIG
16014 000303            SWAB    R3          ;FORM 16 BITS OF HIGH ORDER FRACTION
16016 105003            CLRB    R3
16020 156503            BISB    3(TP),R3
      000003
16024 073201 SFTRI:     ASHC    R1,R2
16026 005402 ONERI:     NEG     R2          ;MAKE -
16030 102411            BVS     NGMRI       ;JUMP IF POSSIBLE NEGMAX
16032 003012            BGT     OVRRI       ;JUMP IF MORE THAN 15 BITS
16034 006025 SGNRI:     ROR     (TP)+       ;GET SIGN
16036 103401            BCS     OUTRI       ;JUMP IF -
16040 005402            NEG     R2          ;- RESULT
16042 010215 OUTRI:     MOV     R2,@TP      ;STORE INTEGER RESULT
16044 012603            MOV     (SP)+,R3
16046 012602            MOV     (SP)+,R2
16050 012601            MOV     (SP)+,R1
16052 000207            RTS     PC
16054 006025 NGMRI:     ROR     (TP)+
16056 103771            BCS     OUTRI       ;OK IF RESULT TO BE -
16060 005745 OVRRI:     TST     -(TP)       ;FAKE SIGN
16062 000000            HALT
16064 000401            BR      ZERRI
16066    003            .BYTE   3
16067    026            .BYTE   22.
16070 005002 ZERRI:     CLR     R2          ;ANSWER IS ZERO
16072 000760            BR      SGNRI
```

```
1                       .TITLE  LEAST SQUARES ROUTINES
2  016074 010046 CLRSUM: MOV     R0,-(SP)
3  016076 010146         MOV     R1,-(SP)
4  016100 012700         MOV     #EX,R0
          037004
5  016104 012701         MOV     #12,R1
          000012
6
7  016110 005020 CLRSU1: CLR     (R0)+
8  016112 077102         SOB     R1,CLRSU1
9  016114 012601         MOV     (SP)+,R1
10 016116 012600         MOV     (SP)+,R0
11 016120 000207         RTS     PC
12
13
14
15
16
17
18
19 016122 004767 BTPS:   JSR     PC,IR
          177524
20 016126 016745         MOV     SLV+2,-(TP)
          000534
21 016132 016745         MOV     SLV,-(TP)
          000526
22 016136 075025         FMUL    TP
23 016140 016745         MOV     BTPSF+2,-(TP)
          000626
24 016144 016745         MOV     BTPSF,-(TP)
          000620
25 016150 075025         FMUL    TP
26 016152 000207         RTS     PC
27
```

8 7 6

```
1                       ;RETURNS WITH TP,TP+2 SLOPE        TP+4,TP+6     INTERCEPT
2
3 016154 010046 LSQ:MOV R0,-(SP)
4 016156 010146         MOV     R1,-(SP)
5 016160 016745         MOV     NFL,-(TP)
         020640
6 016164 004767         JSR     PC,IR
         177462
7 016170 016745         MOV     EX2+2,-(TP)
         020626
8 016174 016745         MOV     EX2,-(TP)
         020620
9 016200 075025         FMUL    TP
10 16202 016745         MOV     EX+2,-(TP)
         020600
11 16206 016745         MOV     EX,-(TP)
         020572
12 16212 016745         MOV     EX+2,-(TP)
         020570
13 16216 016745         MOV     EX,-(TP)
         020562
14 16222 075025         FMUL    TP
15 16224 075015         FSUB    TP
16 16226 012500         MOV     (TP)+,R0
17 16230 012501         MOV     (TP)+,R1
18 16232 016745         MOV     EX2+2,-(TP)
         020564
19 16236 016745         MOV     EX2,-(TP)
         020556
20 16242 016745         MOV     EY+2,-(TP)
         020544
21 16246 016745         MOV     EY,-(TP)
         020536
22 16252 075025         FMUL    TP
23 16254 016745         MOV     EX+2,-(TP)
         020526
24 16260 016745         MOV     EX,-(TP)
         020520
25 16264 016745         MOV     EXY+2,-(TP)
         020526
26 16270 016745         MOV     EXY,-(TP)
         020520
27 16274 075025         FMUL    TP
28 16276 075015         FSUB    TP
29 16300 010145         MOV     R1,-(TP)
30 16302 010045         MOV     R0,-(TP)
31 16304 075035         FDIV    TP
32 16306 016745         MOV     NFL,-(TP)
         020512
33 16312 004767         JSR     PC,IR
         177334
34 16316 016745         MOV     EXY+2,-(TP)
         020474
35 16322 016745         MOV     EXY,-(TP)
         020466
36 16326 075025         FMUL    TP
37 16330 016745         MOV     EX+2,-(TP)
```

```
                020452
38  16334 016745          MOV     EX,-(TP)
                020444
39  16340 016745          MOV     EY+2,-(TP)
                020446
40  16344 016745          MOV     EY,-(TP)
                020440
41  16350 075025          FMUL    TP
42  16352 075015          FSUB    TP
43  16354 010145          MOV     R1,-(TP)
44  16356 010045          MOV     R0,-(TP)
45  16360 075035          FDIV    TP
46  16362 012601          MOV     (SP)+,R1
47  16364 012600          MOV     (SP)+,R0
48  16366 000207          RTS     PC
```

```
                        ;CALLING ORDER:
                        ;       MOV     X+2,-(TP)
                        ;       MOV     X,-(TP)
                        ;       MOV     Y+2,-(TP)
                        ;       MOV     Y,-(TP)
                        ;RETURNS WITH TP RESTORED TO VALUE PRIOR
                        ;TO PLACING THE X AND Y VALUES ON THE STACK


 16370 010046   SUMM:   MOV     R0,-(SP)
 16372 010500           MOV     TP,R0
 16374 016045           MOV     2(R0),-(TP)
       000002
 16400 011045           MOV     (R0),-(TP)
 16402 016045           MOV     6(R0),-(TP)
       000006
 16406 016045           MOV     4(R0),-(TP)
       000004
 16412 075025           FMUL    TP
 16414 016745           MOV     EXY+2,-(TP)
       020376
 16420 016745           MOV     EXY,-(TP)
       020370
 16424 075005           FADD    TP
 16426 012567           MOV     (TP)+,EXY
       020362
 16432 012567           MOV     (TP)+,EXY+2
       020360
 16436 016045           MOV     6(R0),-(TP)
       000006
 16442 016045           MOV     4(R0),-(TP)
       000004
 16446 016045           MOV     6(R0),-(TP)
       000006
 16452 016045           MOV     4(R0),-(TP)
       000004
 16456 075025           FMUL    TP
 16460 016745           MOV     EX2+2,-(TP)
       020336
 16464 016745           MOV     EX2,-(TP)
       020330
 16470 075005           FADD    TP
 16472 012567           MOV     (TP)+,EX2
       020322
 16476 012567           MOV     (TP)+,EX2+2
       020320
 16502 016745           MOV     EY+2,-(TP)
       020304
 16506 016745           MOV     EY,-(TP)
       020276
 16512 075005           FADD    TP
 16514 012567           MOV     (TP)+,EY
       020270
 16520 012567           MOV     (TP)+,EY+2
       020266
```

```
39 16524 016745          MOV     EX+2,-(TP)
         020256
40 16530 016745          MOV     EX,-(TP)
         020250
41 16534 075005          FADD    TP
42 16536 012567          MOV     (TP)+,EX
         020242
43 16542 012567          MOV     (TP)+,EX+2
         020240
44 16546 005267          INC     NFL
         020252
45 16552 012600          MOV     (SP)+,R0
46 16554 000207          RTS     PC
47
```

```
                        .TITLE  TEXT BUFFER LOAD
                ;
                ;SUBROUTINE BUFLOD
                ;CALLING SEQUENCE
                ;       JSR     R5,BUFLOD
                ;AL     ADDR OF MSG
                ;       NUMBER OF LINES
                
016556 010046 BUFLOD: MOV     R0,-(SP)
016560 010146         MOV     R1,-(SP)
016562 010246         MOV     R2,-(SP)
016564 010346         MOV     R3,-(SP)
016566 010446         MOV     R4,-(SP)

016570 012700         MOV     #BUFFER,R0
       037200
016574 012501         MOV     (R5)+,R1
016576 012702         MOV     #40,R2
       000040
016602 012703         MOV     #19.,R3
       000023
016606 012504         MOV     (R5)+,R4

016610 112120 BUF1:   MOVB    (R1)+,(R0)+
016612 001401         BEQ     BUF2
016614 077303         SOB     R3,BUF1

016616 005300 BUF2:   DEC     R0
016620 000240         NOP
016622 110220         MOVB    R2,(R0)+
016624 077302         SOB     R3,BUF2+4

016626 112720         MOVB    #0,(R0)+
       000000
016632 112703         MOVB    #19.,R3
       000023
016636 077414         SOB     R4,BUF1
016640 112720         MOVB    #-1,(R0)+
       177777

016644 012604         MOV     (SP)+,R4
016646 012603         MOV     (SP)+,R3
016650 012602         MOV     (SP)+,R2
016652 012601         MOV     (SP)+,R1
016654 012600         MOV     (SP)+,R0

016656 000205         RTS     R5
```

```
                        .TITLE  VARIABLE DATA

                ·LOCATE FIRST PART IN RAM
        020000          .=20000

                ;VARIABLE DATA SECTION
                ;TO BE LOCATED SOMEWHERE IN RAM

020000 000000 EOB:      .WORD   0
 20002 000000 FVADR:    .WORD   0
 20004 000000 FVCNT:    .WORD   0       ;COUNTER FOR NUMBER OF POINTS
 20006          FVDAT:  .BLKW   2200.
 30466          Z:      .BLKW   200.
 31306          Y:      .BLKW   200.
 32126          X:      .BLKW   200.
 32746          W:      .BLKW   200.


                ;STACK TO HOLD VOLUMES FOR LATER FN2 PHASING
 33566          VLSTK:  .BLKW   75.
 34014 000000 VLSTK1:   .WORD   0
 34016 000000 RVPTR:    .WORD   0

 34020 000000 LOCMXV:   .WORD   0       ;ADDR+2 OF LOC WITHIN FVDAT OF MAXVL
                ;TWO DUMMY WORDS  FOR PROM COMPATIBILITY
 34022 000000           .WORD   0
 34024 000000           .WORD   0

 34026 000000 VLAST:    .WORD   0       ;MAX SPIRO SAMPLE
 34030 000000 VWATCH:   .WORD   0

 34032 000000 TCNT:     .WORD   0
 34034 000000 TEMP:     .FLT2   0
 34036 000000
 34040 000000 VAL:      .FLT2   0
 34042 000000
 34044 000000           L0.2:   .WORD   0
 34046 000000 L1.2:     .WORD   0
                ;DUMMY TO REPLACE ONEH
 34050 041710           .FLT2   100.
 34052 000000
 34054 000000 BRCNT:    .WORD   0       ;BREATH COUNT IN N2 WO
 34056 000000 VPREV:    .WORD   0
 34060 000000 MAXVL:    .WORD   0
 34062 000000 MAXFN:    .FLT2   0
 34064 000000
 34066 000000 VSUM:     .FLT2   0       ;SUM OF DIFFERENCES BETWEEN VOL SAMPLES (L)
 34070 000000
 34072 000000 NSUM:     .FLT2   0       ;SUM OF ( VOL. DIFFERENCES * NITROGEN GAS FRACTION)
 34074 000000
```

8 3 2

```
 1 034076 000000 OUTAR:  .FLT2   0       ;FEV1
   034100 000000
 2 034102 000000         .FLT2   0       ;FVC
   034104 000000
 3 034106 000000         .FLT2   0       ;MMFR
   034110 000000
 4 034112 000000         .FLT2   0       ;MEFR
   034114 000000
 5                ;WASHOUT VALUES
 6 034116 000000         .FLT2   0       ;MAX FN2 AT END OF FIRST EXHALATION
   034120 000000
 7 034122 000000         .FLT2   0       ;VITAL CAPACITY
   034124 000000
 8 034126 000000         .FLT2   0       ;SLOPE OF LINEAR REGRESSION LINE
   034130 000000
 9 034132 000000         .FLT2   0       ;INTERCEPT OF LIN REG LINE
   034134 000000
10 34136 000000          .FLT2   0       ;SLOPE OF ALVEOLAR PLATEAU IN %L
   34140 000000
11 34142 000000          .FLT2   0       ;CLOSING VOLUME
   34144 000000
12 34146 000000          .FLT2   0       ;RESIDUAL VOLUME
   34150 000000
13 34152 000000          .FLT2   0       ;VA/BV
   34154 000000
14 34156 000000          .FLT2   0       ;FEV1/FVC %
   34160 000000
15 34162 000000          .FLT2   0       ;FVC/VC %
   34164 000000
16 34166 000000          .FLT2   0       ;CV/VC %
   34170 000000
17 34172 000000          .FLT2   0       ;RV+VC
   34174 000000
18 34176 000000          .FLT2   0       ;(RV+CV)/TLC
   34200 000000
19
```

```
 1 034202 000000 CLKFLG: .WORD   0
 2 034204 000000 LSTCK:  .WORD   0
 3 034206 000000 SAVSTK: .WORD   0
 4 034210 000000 VOLPTI: .WORD   0
 5 034212 000000 VOLPTO: .WORD   0
 6 034214 000074 VDEL:   .WORD   60.     ;NO. OF SAMPLES TO DELAY
 7 034216 000000 MSDLY:  .WORD   0
 8 034220 000000 QUADI:  .WORD   0
 9 034222 000000 QUADO:  .WORD   0
10
11               ; CIRCULAR BUFFER WITH VOLUME, FO2, FCO2
12
13 34224         QUADST: .BLKW   675.
14 36732         QUADS1: .BLKW   9.
15 36754 000000 QUADNOD:         .WORD   0
16
17               ;CURRENT PHASED VOLUMES AND GASES
18
19 36756 000000 WWV:    .WORD   0
20 36760 000000 WWN:    .FLT2   0
   36762 000000
21 36764 000000 WWO:    .FLT2   0
   36766 000000
22 36770 000000 WWC:    .FLT2   0
   36772 000000
23 36774 000000 SBCLR:  .WORD   0
24 36776 000000 SBFLAG: .WORD   0
25 37000 000000 ALTFLG: .WORD   0
26 37002 000006 WTHRSH: 6
27 37004 000000 EX:     .FLT2   0.      ;SUM OF X VALUES
   37006 000000
28 37010 000000 EY:     .FLT2   0.      ;SUM OF Y VALUES
   37012 000000
29 37014 000000 EXY:    .FLT2   0.      ;SUM OF (X*Y) VAALUES
   37016 000000
30 37020 000000 EX2:    .FLT2   0.      ;SUM OF (X*X)  VALUES
   37022 000000
31 37024 000000 NFL:    .FLT2   0.
   37026 000000
32               ;STACK USED BY TP
33                       .BLKW   25.
34 37112         TSTK:   .BLKW   1
35
36 37114         WKAR:   .BLKW   15.
37 37152 000000 PRLO:   .WORD   0
38 37154 000000 PRHI:   .WORD   0
39
40
41               ;CALMS DATA
42 37156 000000 O2CTRL: .WORD   0
43 37160 000000 N2CTRL: .WORD   0
44 37162 000000 C2CTRL: .WORD   0
45
46
47 37164 000000 RAD:    .WORD   0
48 37166 000000 LSTAD:  .WORD   0
49 37170 000000 TTYGO:  .WORD   0
```

```
50 37172 000000 TTYCNT: .WORD   0       ;COUNT DOWN FROM 5
51 37174 000000 DUM2:   .WORD   0       ;CALMS AND ROOM ERROR IND.
```

1

```
  037176 000000 FLM2:    .WORD   0
2
3 037200         BUFFER: .BLKB   295.
4 037647     377         .BYTE   -1
5                        .EVEN
6
7 037650 000000 PRTGO:   .WORD   0
8
9 037652 000000 O2CF1:   .WORD   0
10 37654 000000 O2CF2:   .WORD   0
11
12 37656 000000 N2CF1:   .WORD   0
13 37660 000000 N2CF2:   .WORD   0
14
15 37662 000000 CO2CF1:  .WORD   0
16 37664 000000 CO2CF2:  .WORD   0
17
18 37666         FO2:
19 37666 000000 FO21:    .WORD   0
20 37670 000000 FO22:    .WORD   0
21
22 37672         FN2:
23 37672 000000 FN21:    .WORD   0
24 37674 000000 FN22:    .WORD   0
25
26 37676         FCO2:
27 37676 000000 FCO21:   .WORD   0
28 37700 000000 FCO22:   .WORD   0
29
30 37702 000000 MSNVNT:  .WORD   0
31
32                       ;ROOM AIR VALUES
33 37704 000000 RAFO2:   .FLT2   0
   37706 000000
34 37710 000000 RAFN2:   .FLT2   0
   37712 000000
35 37714 000000 RAFCO2:  .FLT2   0
   37716 000000
36
37 37720 000000 DUM1:    .WORD   0
38 37722 000000 S1:      .FLT2   0
   37724 000000
39 37726 000000 WAITT:   .WORD   0
40
41
42
```

```
                        .TITLE  RAM VARIABLES
                        
037730 000000 LSTTIM: .FLT2   0
037732 000000
037734 000000 OUTWFG: .WORD   0
037736 000000 BPCNT:  .WORD   0
037740 000000 CRAT:   .FLT2   0       ;CO2 RATIO = RAFCO2/RAFN2
037742 000000
                        
037744 000000 ORAT:   .FLT2   0       ;O2 RATIO = RAFO2/RAFN2
037746 000000
037750 000000 SPLFLG: .WORD   0
037752 000000 QCOMPUT:        .WORD   0
037754 000000 EOTPFG: .WORD   0
037756 000000 EOTCT:  .WORD   0
037760 000000         .WORD   0       ;0 NO COMPUTATIONS WAITING 1 OW
037762 000000 PROGET: .WORD   0       ;POINTS TO NEXT PROTOCOL STEP
037764 000000 DSFOUT: .WORD   0       ;NONZERO IS DATA SYS OUTPUT REQ FOR PBF
037766 000000 DSCOUT: .WORD   0       ;NONZERO IS PTC ORDS OUTPUT REQUEST
                        
037770 000000 PRTFLG: .WORD   0       ;PRINTER RQST FLAG
037772 000000 PINTCT: .WORD   0       ;COUNTS DOWN FROM 4 TO SAY 40 MSEC ELAPSED
037774 000000 NPAIR:  .WORD   0
                        
                        
                ;LOCATE IN 12-16K
        060000          .=60000
                        
060000 000000 LSTO:   .FLT2   0
060002 000000
060004 000000 PTSTUFF:        .WORD   0       ;WHERE TO STUFF THE PTC GAS DATA
060006 000000 SPLRQS: .WORD   0       ;SPLINE FIT REQUEST
060010 000000 SEC5CT: .WORD   0       ;5 SECOND COUNTER FOR PTC
060012 000000 SEC15C: .WORD   0       ;15 SEC COUNTER FOR PTC
060014 000000 PSVHR:  .WORD   0
060016 000000 PSVWL:  .WORD   0
060020 000000 PSVGS:  .WORD   0
060022 000000 PRDNCT: .WORD   0
060024 000000 PRADD:  .WORD   0
                        
                        
```

```
                        .TITLE  BUFFER AREAS

                ;THESE MUST BE CONTIGUOUS, THEY GET CLEARED IN A GROUP

060026 000000 TIM1:     .WORD   0       ;LSW OF TIME
060030 000000 TIM2:     .WORD   0       ;MSW OF TIME
060032 000000 CHR:      .WORD   0       ;BUMPED BY HR INTERRUPT
060034 000000 SWL:      .WORD   0       ;NO. OF SAMPLES FOR WORKLOAD
060036 000000 CWL:      .WORD   0
 60040 000000           .WORD   0
 60042 000000 CO2:      .FLT2   0       ;CURRENT OXYGEN
 60044 000000
 60046 000000 CCO2:     .FLT2   0       ;CURRENT CO2
 60050 000000
 60052 000000 CMV:      .FLT2   0       ;CURRENT MINUTE VOLUME
 60054 000000
 60056 000000 CRR:      .FLT2   0       ;
 60060 000000

 60062 000000 CSLOP:    .FLT2   0       ;CARDIAC OUTPUT SLOPE
 60064 000000
 60066 000000 CQDOT:    .FLT2   0
 60070 000000
 60072 000000 CSBP:     .FLT2   0
 60074 000000
 60076 000000 CDBP:     .FLT2   0
 60100 000000


                ;STORAGE AREA FOR PREVIOUS MINUTE'S DATA

 60102 000000 PRTIM1:   .WORD   0
 60104 000000 PRTIM2:   .WORD   0
 60106 000000 PRHR:     .FLT2   0
 60110 000000
 60112 000000 PRWL:     .FLT2   0
 60114 000000
 60116 000000 PRO2:     .FLT2   0
 60120 000000
 60122 000000 PRCO2:    .FLT2   0
 60124 000000
 60126 000000 PRMV:     .FLT2   0
 60130 000000
 60132 000000 PRRR:     .FLT2   0
 60134 000000

 60136 000000 PRSLOP:   .FLT2   0
 60140 000000
 60142 000000 PRQDOT:   .FLT2   0
 60144 000000
 60146 000000 PRSBP:    .FLT2   0
 60150 000000
 60152 000000 PRDBP:    .FLT2   0
 60154 000000
 60156 000000 PBFND:    .WORD   0
```

```
                        ;WORKING AREA FOR PTC
                        ;THIS IS A CONTINUOUS BLOCK TO PTEND:
060160 000000 PTCT1:    .WORD   0
060162 000000 PTH5:     .WORD   0
060164 000000 PTH10:    .WORD   0
060166 000000 PTH15:    .WORD   0
060170 000000 PTW5:     .WORD   0
060172 000000 PTW10:    .WORD   0
 60174 000000 PTW15:    .WORD   0
 60176        PTGAS:    .BLKW   80.     ;STORED AS 80 MSEC HACK, INTEGER O2
                                         ;INTEGER CO2, INTEGER MV FOR EACH BREATH
                                         ;REMAINDER OF WORDS 0

 60436        PTCHDR: .BLKW   9.

                        ;BUFFER AREAS FOR PTC FOR TRANSMISSION

 60460 000000 BPTCT:    .WORD   0
 60462 000000 BPTH5:    .WORD   0
 60464 000000 BPTH10:   .WORD   0
 60466 000000 BPTH15:   .WORD   0
 60470 000000 BPTW5:    .WORD   0
 60472 000000 BPTW10:   .WORD   0
 60474 000000 BPTW15:   .WORD   0
 60476        BPTGAS:   .BLKW   80.
 60736 000000 PTEND:    .WORD   0
 60740 000000 PTHRCT:   .WORD   0
 60742 000000 BRTHO:    .FLT2   0
 60744 000000
 60746 000000 BRTHC:    .FLT2   0
 60750 000000
 60752 000000 BRTHV:    .FLT2   0
 60754 000000
 60756 000000 QFLAG:    .WORD   0       ; -1 => Q MANEUVER TRIGGERED BUT NOT YET INIT.
                                        ;  0 => Q MANEUVER DONE OR NOT YET TRIGGERED
                                        ;  1 => TRIGGERED AND INITIALIZED (PB PRESSED)
```

```
1
2  060760 000000 NUMLFT: .WORD   0
3  060762 000000 ADD2PT: .WORD   0
4  060764 000000 FMTPT:  .WORD   0
5  060766 000000 FRSTPT: .WORD   0
6
7  060770        HOLES:  .BLKW   10.
8  061014 000000         .WORD   0
9  061016 000000         .WORD   0
10 61020  000000         .WORD   0
11 61022  000000         .WORD   0
12 61024        WOPBFR: .BLKB   6
13 61032    040         .BYTE   40
14 61033    040         .BYTE   40
15 61034    040         .BYTE   40
16 61035        WONBFR: .BLKB   6
17                      .EVEN
18 61044 000000         .WORD   0
19 61046 000000         .WORD   0
20 61050 000000         .WORD   0
21
22
23                ;STACK
24                      .BLKW   2000.
25 70712        STACK:  .BLKW   1
26 70714 000000 XBUF1:  .WORD   0       ;CR-LF INDICATOR FOR PRINTER
27 70716 000000 C13:    .WORD   0       ;FOR A FORMAT CONSTANT
28
29
30       070760         .=70760
31 70760 000000 NEGDM:  .WORD   0       ;DUMMY NEG DESTINATION
32
```

```
                        .TITLE  CONSTANTS
                ;CONTINUE WHERE PROGRAM ROM LEFT OFF
        016664          .=16664
                ;
                ;CONSTANTS SECTION - TO BE PLACED IN PROM
 16664 036207 SLV:      .FLT2   0.004126        ;SPIROMETER VALVE CORRESP. TO LITERS/VOLTS
 16666 031546
 16670 040231 D1.2:     .FLT2   1.2     ;1.2L BTPS IN SPIROMETER A/D COUNTS
 16672 114632
 16674 037514 D0.2:     .FLT2   0.2     ;0.2L BTPS IN SPIROMETER A/D COUNTS
 16676 146315

 16700 037663 D.35:     .FLT2   0.35
 16702 031463
 16704 040046 D.65:     .FLT2   0.65
 16706 063146
 16710 043273 D6000:    .FLT2   6000.
 16712 100000
 16714 043073 D3000:    .FLT2   3000.
 16716 100000
 16720 036777 NWOBLD:   .FLT2   0.0312
 16722 113444

                ;GENERAL CONSTANTS
 16724 000001 XBUF12:   .WORD   1
 16726 177777 MIN1:     .WORD   -1
 16730 140200 DM1:      .FLT2   -1.0
 16732 000000
 16734 140131 DM.85:    .FLT2   -0.85
 16736 114632
 16740 040500 D3.0:     .FLT2   3.0
 16742 000000
 16744 040400 D2.0:     .FLT2   2.0
 16746 000000
 16750 040200 D1.0:     .FLT2   1.0
 16752 000000

                ;ROOM AIR CONSTANTS
 16754 037502 D.19:     .FLT2   0.19
 16756 107534
 16760 036643 D.02:     .FLT2   0.02
 16762 153412
 16764 036765 D.03:     .FLT2   0.03
 16766 141217

 16770 040213 BTPSF:    .FLT2   1.086
 16772 001014
```

```
1 016774     102 BADAIR: .ASCIZ  /BAD ROOM AIR/
  016775     101
  016776     104
  016777     040
  017000     122
  017001     117
  017002     117
  017003     115
  017004     040
  017005     101
  017006     111
  017007     122
  017010     000
2 017011     103          .ASCIZ  /CORRECT SITUATION/
  017012     117
  017013     122
  017014     122
  017015     105
  017016     103
  017017     124
  017020     040
  017021     123
  017022     111
  017023     124
  017024     125
  017025     101
  017026     124
  017027     111
  017030     117
  017031     116
  017032     000
3 017033     122          .ASCIZ  /RERUN ROOM AIR/
  017034     105
  017035     122
  017036     125
  017037     116
  017040     040
  017041     122
  017042     117
  017043     117
  017044     115
  017045     040
  017046     101
  017047     111
  017050     122
  017051     000
4                         .EVEN
5                         .EVEN
6
7
```

```
                        ;PULMONARY FUNCTION REPORT
017052  120 TITLE:  .ASCIZ  /PULMONARY FUNCTION/
017053  125
017054  114
017055  115
017056  117
017057  116
017060  101
017061  122
017062  131
017063  040
017064  106
017065  125
017066  116
017067  103
017070  124
017071  111
017072  117
017073  116
017074  000
017075  123          .ASCIZ  /SUBJECT       /
017076  125
017077  102
017100  112
017101  105
017102  103
017103  124
017104  040
017105  040
017106  040
017107  040
017110  040
017111  040
017112  040
017113  000
                     .EVEN
017114  106 MSGS:    .ASCIZ  /FEV1/
017115  105
017116  126
017117  061
017120  000
017121  106          .ASCIZ  /FVC/
017122  126
017123  103
017124  000
017125  115          .ASCIZ  /MMFR/
017126  115
017127  106
017130  122
017131  000
17132   115          .ASCIZ  /MEFR/
17133   105
17134   100
17135   122
17136   000
```

```
                                .ASCIZ  /12 DELTA/
                                .ASCIZ  /CV/
                                .ASCIZ  /BV/
                                .ASCIZ  ^VA/BV^
                                .ASCIZ  ^FEV1/VC%^
                                .ASCIZ  ^FVC/VC%^
                                .ASCIZ  ^CV/VC%^
                                .ASCIZ  /TLC/
                                .ASCIZ  ^CC/TLC^
```

```
1                               .TITLE  BLOOD FLOW TEXT
2 017232    124 TEXTIM: .ASCIZ  /TIME/
  017233    111
  017234    115
  017235    105
  017236    000
3 017237    110         .ASCIZ  /HEART RATE/
  017240    105
  017241    101
  017242    122
  017243    124
  017244    040
  017245    122
  017246    101
  017247    124
  017250    105
  017251    000
4 017252    127         .ASCIZ  /WORK LOAD/
  017253    117
  017254    122
  017255    113
  017256    040
  017257    114
  017260    117
  017261    101
  017262    104
  017263    000
5 017264    117         .ASCIZ  /O2 CONSUMPTION/
  017265    062
  017266    040
  017267    103
  017270    117
  017271    116
  017272    123
  017273    125
  017274    115
  017275    120
  017276    124
  017277    111
  017300    117
  017301    116
  017302    000
6 017303    103         .ASCIZ  /CO2 PRODUCTION/
  017304    117
  017305    062
  017306    040
  017307    120
  017310    122
  017311    117
  017312    104
  017313    125
  017314    103
  017315    124
  017316    111
  017317    117
  017320    116
  017321    000
```

```
                                .ASCIZ  /MINUTE VOLUME/
1 017322  115
  017323  111
  017324  116
  017325  125
  017326  124
  017327  105
  017330  040
  017331  126
  017332  117
  017333  114
  017334  125
  017335  115
  017336  105
  017337  000
                                .ASCIZ  /RES RATE/
2 017340  122
  017341  105
  017342  123
  017343  040
  017344  122
  017345  101
  017346  124
  017347  105
  017350  000
                                .ASCIZ  /F PCO2 SLOPE/  *
3 017351  106
  017352  040
  017353  120
  017354  103
  017355  117
  017356  062
  017357  040
  017360  123
  017361  114
  017362  117
  017363  120
  017364  105
  017365  000
                                .ASCIZ  /CARDIAC OUTPUT/
4 017366  103
  017367  101
  017370  122
  017371  104
  017372  111
  017373  101
  017374  103
  017375  040
  017376  117
  017377  125
  017400  124
  017401  120
  017402  125
  017403  124
  017404  000
                                .ASCIZ  /S B P/
5 017405  123
  017406  040
  017407  102
  017410  040
  017411  120
  017412  000
```

```
                        .TITLE  CONSTANTS
                    ;CALMS CONSTANTS
                        .EVEN
017422 042476 F760:     .FLT2   760.
017424 000000
017426 041310 CFL25:    .FLT2   25.
017430 000000
017432 001030 OCTMSO:   .WORD   001030
017434 001020           .WORD   001020
017436 001020           .WORD   001020
017440 001020           .WORD   001020
017442 000430 NCTMSO:   .WORD   000430
017444 000420           .WORD   000420
017446 000420           .WORD   000420
017450 000420           .WORD   000420
017452 001410 CCTMSO:   .WORD   001410
017454 001420           .WORD   001420
017456 001420           .WORD   001420
017460 001420           .WORD   001420
017462 000000 INVRTU:   .WORD   0
017464 000000           .WORD   0
017466 000000           .WORD   0
017470 177770           .WORD   177770
017472 000030 CAPDLY:   .WORD   24.     ;NUMBER OF 20 MSEC HUNKS TO DELAY VOLUME
017474 000040           .WORD   32.
017476 000036           .WORD   30.
017500 000042           .WORD   34.
017502 037425 CGFO2:    .FLT2   0.1464
017504 164742
017506 040116 CGFN2:    .FLT2   0.8056
017510 045715
017512 037104 CGFCO2:   .FLT2   0.048
017514 115646
017516 021006 FVDATA:   .WORD   FVDAT
017520 000400 CO2TRS:   .WORD   400
017522     052 FMAST:   .ASCII  "*"
017523     056 FMDOT:   .ASCII  "."
017524     055 FMMINS:  .ASCII  "-"
017525     040 FMSPC:   .ASCII  " "
                        .EVEN
017526 044000 F32768:   .FLT2   32768.
017530 000000
017532 140200 FMFM1:    .FLT2   -1
017534 000000
017536 043434 FMF10K:   .FLT2   10000.
017540 040000
017542 000002 FV:       2
017544 000003 FX:       3
```

```
 1 017546     127 MSG1:   .ASCIZ  /WHAT BUTTON ???/
   017547     110
   017550     101
   017551     124
   017552     040
   017553     102
   017554     125
   017555     124
   017556     124
   017557     117
   017560     116
   017561     040
   017562     077
   017563     077
   017564     077
   017565     000
 2 017566     377          .BYTE   -1
 3                         .EVEN
 4 017570 042462 D713:    .FLT2   713.
   017572 040000
 5 017574 000006 FTHRSH:  .WORD   6
 6
 7 017576     101 IMSG:   .ASCIZ  /ABORT - RESTART/
   017577     102
   017600     117
   017601     122
   017602     124
   017603     040
   017604     055
   017605     040
   017606     122
   017607     105
   017610     123
   017611     124
   017612     101
   017613     122
   017614     124
   017615     000
 8 017616     377          .BYTE   -1
 9                         .EVEN
10
11
12
```

```
                                .TITLE  ROM CONSTANTS-PBF,PTC

017620  103 COKM:   .ASCIZ  /CAL COMPLETE/,
017621  101
017622  114
017623  040
017624  103
017625  117
017626  115
017627  120
017630  114
017631  105
017632  124
017633  105
017634  000
017635  377          .BYTE   -1
                     .EVEN
017636  102 CBDM:   .ASCIZ  /BAD MS CAL-REDO/
017637  101
017640  104
017641  040
017642  115
017643  123
017644  040
017645  103
017646  101
017647  114
017650  055
017651  122
017652  105
017653  104
017654  117
017655  000
017656  377          .BYTE   -1
                     .EVEN
```

```
1                       ;THESE ARE ROM FORMATS FOR DATA OUTPUT
2  017660 000001 XXX1:  .WORD   1          ;TIMEX
3  017662 000003        .WORD   3          ;X
4  017664 000000        .WORD   0          ;HR Y
5  017666 000005        .WORD   5          ;X
6  017670 000000        .WORD   0          ;ML     Y
7  017672 000005        .WORD   5          ;X
8  017674 000003        .WORD   3          ;O2     Y
9  017676 000001        .WORD   1
10 017700 000003        .WORD   3          ;CO2    Y
11 017702 000001        .WORD   1
12 017704 000001        .WORD   1          ;MV     Y
13 017706 000003        .WORD   3
14 017710 000000        .WORD   0          ;RR
15 017712 000005        .WORD   5
16 017714 000001        .WORD   1          ;SLOPE
17 017716 000003        .WORD   3
18 017720 000001        .WORD   1          ;CARDIAC OUTPUT Y
19 017722 000003        .WORD   3
20 017724 000000        .WORD   0          ;SBP
21 017726 000005        .WORD   5
22 017730 000000        .WORD   0          ;DBP
23 017732 000005        .WORD   5
24                      .EVEN
25 017734 040000 D0.:   .FLT2   0.
   017736 000000
26 017740 043777 D32767: .FLT2  32767.
   017742 177000
27 017744 040150 STPDF: .FLT2   0.91
   017746 172703
28 017750 036003 D0.002: .FLT2  0.002
   017752 011157
29 017754 036232 D.0047: .FLT2  0.0047
   017756 001165
30 017760 036735 QCTRS: .FLT2   0.027   ;Q MANUEVER CO2 THRESHHOLD
   017762 027433
31 017764 035656 TIMFAC: .FLT2  .001335         ;NO OF MIN /80MSEC
   017766 175455
32 017770 037425 MLFAC: .FLT2   .14648
   017772 177337
33 017774 000000 MLOFF: .FLT2   0.
   017776 000000
34
35
36                      ;START 0-12K OF ROM
37              040000          .=.0000
38
39 040000 037307 SBPFAC: .FLT2  .007656         ;50-250  RANGE   MM/CT
   040002 177736
40 040004 041510 SBPOFF: .FLT2  50.
   040006 000000
41 040010 037107 DBPFAC: .FLT2  .048828
   040012 177736
42 040014 041440 DBPOFF: .FLT2  40.
   040016 000000
43
44
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
1                       ;THIS IS THE FUNCTIONAL PROTOCOL
2                       .EVEN
3  040020 002734 PROTO: .WORD   1500.
4  040022 000001        .WORD   1
5  040024 002734        .WORD   1500.    ;REPETITIONS OF TIME IN NUMBER OF 40 MSEC
6  040026 000001        .WORD   1        ;HUNKS, 0-EOT), THEN NUMBER OF D/A
7  040030 002734        .WORD   1500.    ;CONVERTER COUNTS, + NO Q REQUEST
8  040032 177777        .WORD   -1       ;-  REQUESTED Q MANEUVER
9  040034 002734        .WORD   1500.
10 040036 000001        .WORD   1
11 040040 002734        .WORD   1500.
12 040042 177777        .WORD   -1
13 040044 000000        .WORD   0
14                      .BLKW   71.
15
16
17 040264 000000 DDDD:  .WORD   0        ;DUMMY TO KNOW WHERE END OF PROGRAM IS
18
19 040266 000035 TRGR:  .WORD   35       ;A/D CHANNEL 0, GAIN 1
20 040270 000046 THRSH: .WORD   46       ;120 MV THRESHHOLD FOR SPIROMETER
21
22        054050        .=54050
23 54050 041710 ONEH:   .FLT2   100.
   54052 000000
24
25        000570'       .END    START
```

SYMBOL TABLE

```
ABORT   000416    ADD2PT  060762    ADIN   = 176772
ADISR   004674    ADSR   = 176770   ALTFLG  037000
ARNCTM  005264    ARN33   002540    ARN34   006716
BADAIR  016774    BEGIN   040774    BELOW   014230
BPCNT   037736    BPTCT   060460    BPTGAS  060476
BPTH10  060464    BPTH15  060466    BPTH5   060462
BPTN10  060472    BPTN15  060474    BPTN5   060470
BRCNT   034054    BRTHC   060746    BRTHO   060742
BRTMP   060752    BTLOOP  002206    BTPS    016122
BTPSF   016770    BUFFER  037200    BUFLOD  016556
BUF1    016610    BUF2    016616    CALMS   013546
CAPDLY  017472    CBUN    017636    CCO2    060046
CCTMSO  017452    CDBP    060076    CFL25   017426
CGHDG   014054    CGFCO2  017512    CGFN2   017500
CGFO2   017502    CGMOR   014114    CHAR   = 000060
CHR     060032    CLEAR   040570    CLKFLG  034202
CLRBRT  010064    CLRSUM  016074    CLRSU1  016110
CLR1    040574    CLR2    040610    CLR3    041000
CLR4    041014    CMP     000052    COKM    017620
CO2     060042    CO2CF1  037662    CO2CF2  037664
CO2TRS  017520    CODOT   060066    CRAT    037740
CRR     060056    CSDP    060072    CSLOP   060062
CSRPT   013636    CSRPT1  013662    CUBIC   011150
CRL     060036    C0      011160    C1      011200
C10     012602    C12     070716    C2      011226
C2CTRL  037162    C3      011244    C4      011304
C5      011344    C5A     011636    C6      011644
C7      011664    C8      012220    C8A     012426
C9      012504    DAC1   = 176760   DAC2   = 176762
DARN    014510    DBPFAC  040010    DBPOFF  040014
DDDD    040264    DELAY   014416    DELAY1  014436
DELAY2  014462    DELAY3  014532    DM.85   016734
DMI     016730    DOBP    010572    DOPEY   000400
DPMT    005674    DRAI   = 167774   DRAO   = 167772
DRAS   = 167770   DRBI   = 167764   DRBO   = 167762
DRBS   = 167760   DSCOUT  037766    DSFOUT  037764
DUM1    037720    DUM2    037174    D.0047  017754
D.07    016760    D.03    016764    D.19    016754
D.35    016700    D.65    016704    D0.002  017750
D0.2    016674    D1.0    016750    D1.2    016670
D2.0    016744    D3.0    016740    D3000   016714
D32767  017740    D5000   016710    D713    017570
D8.     017734    ECG     000466    ENDT1   000412
ENDT2   000414    ENPRMV  005726    EOB     020000
EOF1    003130    EOT     003462    EOTCT   037756
EOTPFG  037754    ERRLP   014030    EX      037004
EXLOOP  006506    EXL1    006544    EXY     037014
EY2     037020    EY      037010    FCO2    037076
FCOF1   037676    FCO22   037700    FFMT    015172
FFRCCT  015456    FLM2    037176    FLOW    002236
FLPHD   015532    FMAST   017522    FMDOT   017523
FMERRO  015616    FMERRR  015642    FMFM1   017532
FMFRH   015414    FMFRAC  015422    FMF10K  017536
FMLASP  015410    FMMAN   015326    FMMANT  015266
FMMINS  017524    FMMDG   015352    FMOK    015344
FMPLUS  015252    FMRPTR  015472    FMSPC   017525
FMSZU   015570    FMTPT   060764    FMVRPT  015522
```

SYMBOL TABLE

```
FMZOF   006606    FMZRO   015546    FNSHQ   012612
FN2     037672    FN21    037672    FN22    037674
FORMAT  015110    FO2     037666    FO21    037666
FO22    037670    FRSTPT  060766    FRST1   006750
FTHROU  015534    FVHDR   020002    FVC     001460
FVCINT  005030    FVCIN1  005036    FVCIN2  005066
FVCNT   020004    FVDAT   020006    FVDATA  017516
FX      017544    FY      017542    F32768  017526
FY80    017422    GCKC    013512    GCKN    013466
GCLO    013442    GDRAT = 167774    GETGAS  013204
GOGOGO  004754    GPTCST  001232    GSANC   013504
GSANH2  013460    GSANAL  006700    GSBOB   007662
GSIN    004776    GSLP    006726    GSLP1   007160
GSLPLV  010116    HOLES   060770    I     =%000001
IMSG    017576    INI   =%000000    INTETH  005102
INTETX  005766    INTRTO  017462    IOF     007644
ION     007626    IP1   =%000002    IR      015662
KT1     014660    KT2     014772    KT3     006656
LESS    014266    LINCLK= 000001    LOCMXV  034020
LOOP    001526    LPEN  = 000100    LPT   = 167753
LPTGO   015040    LPTGO1  015072    LPTGO2  015106
LPTIN = 167754    LPTSR = 167750    LSQ     016174
LSTAD   037166    LSTCK   034204    LSTO    0[illegible]0
LSTTIM  037730    LVEM    003366    LVLVLV  014570
LVE     005102    LVRI    005224    LVR2    005204
LO.2    034044    L1.2    034040    MAXFN   034062
MAXVL   034060    MINN    016726    MOSUM   037744
MSDLY   034216    MSGS    017114    MSG1    017546
MSNERT  037702    NCTMSO  017442    NEGDM   070760
NEURIEM 014514    NFL     037024    NGMRI   016054
NOBP    005344    NOCLR   002626    NOCSHV  006606
NOD     015714    NOFIN   006562    NOFSHV  006620
NOH     015704    NOTRQ   010202    NOREOB  003256
NORM    010756    NOSB    002702    NOSBD   002720
NOSPL   006550    NOTEOB  007172    NOTYET  003354
NOWAIT  007036    NOWRIT  006574    NOURT   006662
NO15    005630    NOS     005522    NPAIR   037774
NSUM    034072    NUMLFT  060760    NWORLD  016720
N2CF1   037656    N2CF2   037660    N2CTEL  037160
OBDS  = 167752    OCTMSO  017432    ONEH    054050
ONERI   016026    OPEN    014260    ORAT    037744
OUTAR   034076    OUTRI   016042    OUTWFG  037734
OWERI   016060    O2CF1   037652    O2CF2   037654
O2CTRL  037156    PBFINT  005236    PBFTD   060156
PBV     005276    PC    =%000007    PCBFCL  006424
PFBFCL  006442    PFT     000724    PFTER   001202
PFTEI   001150    PFTFV   001064    PFTRT   001116
PFTNO   001032    PFT1    000754    PFT2    000746
PINTCT  037772    PMON    000652    PMON1   000700
POS     015672    PRADD   060024    PRCO2   060122
PRDBP   060152    PRINCT  060022    PRII    037154
PRHR    060106    PRINT   000500    PRLO    037152
PRMP    060126    PROFTC  010146    PROGET  037762
PROND   010720    PROTO   040020    PRO2    060116
PROUOT  060142    PRSR    060132    PRSBP   060146
PRSLOP  060136    PRTRM = 000001    PRTEOL  000522
PRTERM  000552    PRTTLG  037770    PRTGO   037650
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PRTHR	[illegible]	PRTIM2	060104	PRTL	000514
PRT..	[illegible]	PRWL	060112	PSWGS	060020
PSCTR	060014	PSIWL	060016	PTCBF	001216
PTCER	001446	PTCEP	001414	PTCHDR	060436
PTCHTR	005500	PTCRM	001316	PTCST	001362
PTCSP	010122	PTCT1	060160	PTC1	001240
PTC2	001304	PTEND	060736	PTGAS	060176
PTHRCT	060740	PTH10	060164	PTH15	060166
PTH5	060162	PTSTUF	060004	PTW10	060172
PTW15	060174	PTW5	060170	QCOMPU	037752
QCTPS	017760	QFLAG	060756	QMAN	000434
QMAYBY	007044	QUADI	034220	QUADNO	036754
QUADO	034222	QUADST	034224	QUADS1	036732
[illegible]	[illegible]	[illegible]	[illegible]	RANDO2	037714
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	012746	[illegible]	[illegible]
RINGT	012616	RINS1	012632	RIN1	012660
RINS	013052	RM1	006110	RM2	006232
ROOM	005772	ROUT	013162	RPT	014574
RPTSD	015016	RPT1	014700	RPT2	015012
RVPTR	034016	R0	=%000000	R1	=%000001
R2	=%000002	R3	=%000003	R4	=%000004
R5	=%000005	SAMGAS	013434	SAVEO	007012
SAVSTR	034206	SB	002600	SBCLR	036774
SBFLAG	036776	SBPNOC	040000	SBPOFF	040004
SB1	002676	SEC15C	060012	SEC5CT	060010
SF1RI	016024	SGLV	013544	SGHRI	016034
SHVPBF	011126	SHVPTC	011116	SLV	016664
SP	=%000006	SPACR	040770	SPAC1	040700
SPAC2	040714	SPAC3	041024	SPAC4	041040
SPIRO	014154	SPLFIT	011136	SPLFLG	037750
SPLPOS	060036	SPWT	005650	STACK	070712
START	000510	STPDF	017744	STRTP1	006246
SUMM	016310	SWL	060034	S1	037722
TCNT	034032	TEMP	034034	TEXTIM	017232
THRSH	040210	TIMFAC	017764	TIM1	060026
TIM2	060030	TITLE	017052	TP	=%000005
TRGR	040266	TSTK	037112	TTL	005146
TTVBN	= 000002	TTYCNT	037172	TTYEOL	005154
TTYGO	037170	VAL	034040	VCOMP	001564
VDEL	034214	VDELSU	014316	VDVR	014362
VLAST	034026	VLSTK	033566	VLSTK1	034014
VOLPTI	034210	VOLPTO	034212	VPREV	034056
VSUM	034036	VTHRSH	017574	VVETN	014312
VWATCH	034030	W	032746	WABOVE	003362
WAITT	037726	WARN	003124	WFIRST	003402
WKAR	037114	WLCK	005414	WLFAC	017770
WLOFF	017774	WLVWLV	011112	WO	002356
WOINT	034740	WOMON	002512	WONBFR	061035
WOFBFR	061024	WO12	003656	WO13	003672
WO14	003702	WO15	003716	WO21	004046
WO22	004130	WO35	004376	WO36	004622
WO50	003470	WO60	004156	WRITE	010250
WRT[illegible]	011002	WTHRSH	037002	WWC	036770
WWN	036760	WWO	036764	WWP	036756
X	032126	XBUF	= 177566	XBUF1	070714
XBUF12	016124	XCSR	= 177564	XXX1	017660

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RON CONSTANTS-PBF.PTC   RT-11 MACRO VM02-12     00:10:02 PAGE 81+
SYMBOL TABLE

Y       001308          Z       030466          ZER     0157[illegible]
ZERRI   160700          ZLP     015562
. OPS.  [illegible]     000
        [illegible]     001
ERRORS DETECTED: 0
FREE CORE: 15435. WORDS

DK:QTR1,LP:/L=DX0:MOH,DX0:PFT,DX0:PTC,DX0:PBF,DX0:UT,DX0:COH
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CROSS REFERENCE TABLE (CREF V01-03)

CROSS REFERENCE TABLE (CREF V01-03)

```
C8A       40-51#  40-52
C9        41-13#  41-28
CALNS      9-18   10-15   46-30*
CAFDLY    46-42   77-27#
CBDM      47-38   79-6#
CCO2      27-18   27-19   27-21*  27-22*  69-12#
CCTMSO    46-40   77-18#
CDBP      21-93*  69-19#
CFL25     48-23   48-24   77-6#
CGALG     47-12   47-20   47-27   48-1#
CGFCO2    47-25   47-26   77-34#
CGFN2     47-18   47-19   77-33#
CGFO2     47-10   47-11   77-32#
CGMOR     48-18#  48-22
CHAR      53-48*  55-46   55-67   55-74
CHR        4-37*  21-97   23-39   69-7#
CLEAR      6-4#    6-30
CLRFLG    20-15   20-17*  20-20*  65-1#
CLR1       6-5#    6-7
CLR2       6-10#   6-12
CLR3       7-5#    7-7
CLR4       7-9#    7-11
CLRBRT    29-50#  29-51
CLRSU1    58-7#   58-8
CLRSUM    18-2    43-64   58-2#
CMV       26-89   26-90   26-92*  26-93*  69-13#
CO2       27-50   27-51   27-53*  27-54*  69-11#
CO2CF1    44-43   47-28*  67-15#
CO2CF2    44-42   47-29*  67-16#
CO2TRS    46-75   77-36#
COLM      47-31   79-3#
CODOT     69-17#
CRAT      22-55*  22-56*  27-8    27-9    68-6#
CRR       29-3*   69-14#
CSBP      21-88*  69-18#
CSLOP     43-89*  43-90*  69-16#
CSRPT     46-57#  46-81
CSRPT1    46-76   46-81#
CUBIC     37-9#
CWL       21-45   21-46   21-48*  21-49*  69-9#
D.0047    31-67   31-68   80-29#
D.02      22-31   22-32   72-31#
D.03      15-37   15-38   72-32#
D.19      22-19   22-20   72-30#
D.35      17-25   17-26   72-14#
D.65      17-35   17-36   72-15#
D0.002    26-33   26-34   80-28#
D0.2      12-79   12-80   18-95   18-96   26-16   26-17   72-12#
D1.0      38-86   38-87   39-37   39-38   40-21   40-22   43-44
          43-45   72-27#
D1.2      12-88   12-89   72-11#
D2.0      39-20   39-21   40-15   40-16   72-26#
D3.0      38-71   38-72   38-90   38-91   72-25#
D3000     18-69   18-70   72-17#
D32767    29-13   29-14   29-21   29-22   29-27   29-28   80-26#
D5000     72-16#
D713      43-86   43-87   78-4#
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D8.	29-10	29-11	80-25#				
DAC1	1-39#	1-40	30-26*				
DAC2	1-40#						
DAEN	50-26	50-31#					
DBPFAC	32-22	32-23	80-41#				
DBPOFF	32-25	32-26	80-42#				
DDDD	81-17#						
DELAY	20-28	21-17	50-11#				
DELAY1	50-14	50-16#					
DELAY2	50-20	50-23#					
DELAY3	50-35	50-38#					
DM.85	38-9	38-10	72-24#				
DMI	38-20	38-21	39-40	39-41	43-28	43-29	43-83
	43-84	72-23#					
DOBP	31-64	32-10#					
DOPEY	4-6#	4-7					
DPNT	21-91#	21-92					
DRAI	1-29#	8-26	9-11	10-7	46-27	51-21	
DRAO	1-28#	1-29	8-22*	9-10*	9-16*	9-22*	9-27*
	9-29*	9-34*	9-36*	9-41*	9-43*	9-47*	9-49*
	20-6						
DRAS	1-27#	1-28	4-32*	8-15*	8-24*	9-4*	10-4*
	11-6*	13-13*	21-21*	21-26*	24-40*	43-93*	43-94*
	49-17	49-29	49-31*	49-39*			
DRBI	1-34#	4-6	52-14	52-20			
DRBO	1-33#	1-34	4-31*	4-33*	8-21*	9-9*	10-6*
	10-13*	10-18*	10-23*	10-28*	10-33*	10-35*	10-40*
	10-42*	20-11	23-44*	23-45*	29-56*	30-24*	
DRBS	1-32#	1-33	8-12*	8-18*	9-5*	10-5*	20-76*
DSCOUT	21-67*	23-28*	24-24	36-5*	68-16#		
DSFOUT	23-27*	24-28	32-30*	36-11*	68-15#		
DUM1	11-18*	11-25*	13-27*	16-32*	20-4	23-60*	30-38*
	67-37#						
DUM2	8-25*	9-17*	9-19	10-14*	10-16	10-24*	10-26
	22-60*	47-36*	65-51#				
ECG	2-42	4-36#					
ENDT1	4-13#	9-48					
ENDT2	4-15#	10-41					
ENPRMV	21-101#	21-103					
EOB	11-19*	11-22	20-49	49-25*	49-41*	62-9#	
EOB1	14-14	15-1#					
EOT	16-4	16-32#					
EOTCT	23-26*	24-38*	30-37*	68-12#			
EOTFFG	23-25*	24-35	30-36*	68-11#			
ERRLV	46-83	47-35#					
EX	58-4	59-10	59-11	59-12	59-13	59-23	59-24
	59-37	59-38	60-39	60-40	60-42*	60-43*	65-27#
EX2	59-7	59-8	59-18	59-19	60-29	60-30	60-32*
	60-33*	65-30#					
EXL1	24-10	24-14#					
EXLOOP	24-2#	24-36	24-39	27-56	29-58	32-39	34-19
	36-6	36-12	42-4	43-95			
EXY	59-25	59-26	59-34	59-35	60-19	60-20	60-22*
	60-23*	65-29#					
EY	59-20	59-21	59-39	59-40	60-34	60-35	60-37*
	60-38*	65-28#					
F32768	54-24	54-25	77-44#				

F760[illegible]	48-5	48-6	77-4#				
FC[illegible]	22-27	50-43	50-44	67-26#			
FC021	44-58#	67-27#					
FC022	44-59#	67-28#					
FFMT	15-9	15-15	34-12	53-15	54-1#		
FFRCCT	55-31	55-34#					
FLM2	51-48#	52-6#	53-10	67-1#			
FLOM	12-67	12-110	12-139#				
FLPHD	55-54	55-57#					
FMAST	55-85	77-39#					
FMDOT	55-40	55-73	77-40#				
FMEBRO	54-31	55-21	55-79#				
FMERRR	55-85#	55-86					
FMF10R	55-34	55-35	77-46#				
FMF11	54-11	54-12	77-45#				
FMFEA	55-35#	55-36					
FMFFAC	55-23	55-30#					
FMLASP	55-15	55-22#					
FMMAN	54-29	54-35#					
FMMONT	54-15	54-21#					
FMMINS	54-14	77-41#					
FMMPG	55-6#	55-16					
FMOK	54-40#						
FMPLUS	54-7	54-18#					
FMRPTR	55-42#	55-48					
FMSPC	54-18	55-25	55-68	77-42#			
FMS20	55-70#						
FMTPT	32-34#	34-3	34-4#	34-5	34-6#	71-4#	
FMURPT	55-52#	55-57					
FMZOF	55-74#	55-75					
FMZRO	54-8	55-65#					
FN2	50-39	50-40	67-22#				
FN21	44-63#	67-23#					
FN22	44-64#	67-24#					
FNSHQ	24-18	43-8#					
FO2	22-17	22-37	50-41	50-42	67-18#		
FO21	44-68#	67-19#					
FO22	44-12	44-69#	67-20#				
FORMAT	52-4	53-1#					
FRST1	26-4	26-9#					
FRSTPT	32-35#	34-1	34-13#	71-5#			
FTHROU	55-33	55-58#	55-72	55-76	55-87		
FVADR	13-15#	14-20#	14-28	14-35	14-40#	26-15#	26-43
	26-48#	62-10#					
FVC	9-35	11-6#					
FVCIN1	20-41#	20-42					
FVCIN2	20-46	20-49#					
FVCINT	20-8	20-39#					
FVCNT	11-14	11-26#	14-27#	16-23#	17-46	62-11#	
FVDAT	12-9	12-53	12-96	13-15	14-20	17-47	26-15
	37-14	43-9	62-12#	77-35			
FVDATA	46-44	47-9	47-16	47-23	48-1	77-35#	
FX	53-12	77-49#					
FY	53-11	77-48#					
GCKC	45-41#	45-42					
GCKN	45-33#	45-34					
GCKO	45-26#	45-27					

CROSS REFERENCE TABLE (CREF V01-03)

```
GDRAI   46-27#  46-31
GETGAS  20-22   21-10   22-13   44-22#
GOGOGO  20-16   20-20#
GPTCST  10-6#   10-17
GSAMC   45-40#  45-43
GSAMH2  45-32#  45-35
GSHIAL  24-3    25-3#
GSEOB   26-56   29-2#
GSIII   20-24#  20-25
GSLP    25-11#  25-12
GSLP1   26-3    26-10   26-27   26-54#
GSLIV   29-53   29-58#
HOLES   71-7#
IMSG     4-23   78-7#
INTRTN  20-13   20-18   20-30   20-50   20-55#  21-4    21-110
INTRTV  21-80   21-110#
INVRTO  46-41   77-23#
IOF     26-82   27-17   27-44   28-9#   29-31
ION     26-94   27-29   27-55   28-2#   29-45
IR      12-10   12-23   12-148  12-159  14-52   17-4    18-68
        21-38   26-60   31-11   31-31   31-45   31-58   32-11
        32-21   44-31   44-36   44-41   48-9    48-20   54-40
        56-9#   58-19   59-6    59-33
KT1     51-37#  51-38
KT2     51-65#  51-66
KT3     24-43#  24-44
L0.2    12-85#  12-97   62-35#
L1.2    12-94#  12-90   62-36#
LESS    49-22   49-37#
LINCLK  46-28#  46-56   46-63   47-34   47-44
LOCMXV  14-35#  18-29   62-24#
LOOP    11-21#  11-23
LPEN     2-46#   5-17   24-43   51-37   51-65   52-16
LPT      1-17#   5-8    5-12#   5-15#   5-18#   52-18#
LPTGO    4-23    9-52   15-16   22-59   34-17   47-31   47-38
        51-33   51-62   52-13#
LPTGO1  52-15   52-20#
LPTGO2  52-21   52-24#
LPTIN    1-18#   5-13
LPTSR    1-15#   1-16    5-17#   24-43   51-37   51-65   52-16#
LSO     18-13   43-78   59-3#
LSTAD   53-17#  65-48#
LSTCK   49-65#  50-27   50-29#  50-31#  65-2#
LSTO    26-16#  26-17#  26-28   26-29   26-41#  26-42#  68-26#
LSTTIM  31-16   31-17   31-18#  31-19#  68-3#
LIEN    16-6    16-10#
LILILIV 50-28   50-46#
LIR     20-5    20-54#
LIR1    20-57   20-61   20-66   20-67   20-72   20-76#
LIR2    20-69   20-73#
MACEN   13-18#  13-20#  13-21#  14-82   14-83   14-87#  14-88#
        15-13   15-14   15-34   15-35   16-10#  16-11#  16-27
        16-28   16-29#  16-30#  18-81   18-82   62-42#
MACVAL  13-22#  14-32   14-34#  17-3    62-41#
MIII    8-9     72-22#
MOSUM   18-5#   18-12
MSDLY   13-4    13-5    23-6    46-42#  65-7#
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CROSS REFERENCE TABLE (CREF V01-03)

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MSG1      9-52    10-45   78-1#
MSGS      51-44   74-7#
MSHVRT    45-45   46-41*  67-30#
N2CF1     44-38   47-21*  67-12#
N2CF2     44-37   47-22*  67-13#
N2CTRL    45-32   46-39*  65-43#
NCTMSO    46-39   77-13#
NEGDM     71-31#
NENNEW    50-30   50-33#
NFL       59-5    59-32   60-44*  65-31#
NGMRI     57-33   57-46#
NO15      21-54   21-79#
NOS       21-35   21-53#
NOBP      21-20   21-24#
NOCLR     14-18   14-27#
NOCSHV    24-25   24-28#
NOD       56-22   56-26#
NOFIN     24-17   24-19#
NOFSHV    24-29   24-32#
NON       56-21#  56-24
NOFRQ     30-21   30-25#
NOREOB    15-20   15-25#
NORM      31-35   31-37   31-39   31-41   31-49   33-6#
NOSB      14-16   14-41#
NOSBD     14-42   14-46#
NOSPL     24-7    24-16#
NOTEOB    26-55   26-57#
NOTYET    16-3    16-5#
NOWAY     26-26#  26-36
NOWRIT    24-22   24-24#
NOWRT     24-33   24-35#
NPAIR     24-9    26-18*  26-49*  37-17   38-27   38-114  40-2
          40-56   41-3    43-11   43-20   43-67   68-20#
NSUM      14-74   14-75   14-77*  14-78*  16-24*  16-25*  18-77
          18-78   62-44#
NUMLPT    32-32*  34-15*  71-2#
NWOBLD    18-74   18-75   72-18#
O2CF1     44-33   47-14*  67-9#
O2CF2     44-32   47-15*  67-10#
O2CTRL    45-25   46-38*  65-42#
OBDS      1-16#   1-17    1-18
OCTMSO    46-38   77-8#
ONEW      12-167  12-168  18-21   18-22   19-55   19-56   81-23#
ONERI     57-24   57-32#
OPEN      49-18   49-30   49-34#
ORAT      22-48*  22-49*  27-33   27-34   68-8#
OUTAR     12-6    12-69   12-111  12-117  12-118  16-27*  16-28*
          17-6    18-15   18-28   18-48   18-60*  18-61*  18-64
          18-83   18-84   18-86   19-3    19-4    19-5    19-17
          19-38   19-39   19-50   51-49   63-1#
OUTRI     57-37   57-40#  57-47
OUTWFG    23-29*  24-32   32-31*  34-18*  68-4#
OVERI     57-26   57-34   57-48#
PBFINT    20-12   21-3#
PBFND     23-40   69-37#
PBV       21-13#  21-14
PCBFCL    23-36#  23-38
```

PFBFCL	23-41#	23-43					
PFT	8-30	9-4#					
PFT1	9-11#	9-13	9-23	9-30	9-37	9-44	9-53
PFT2	9-10#	9-20					
PFTE1	9-40	9-45#					
PFTER	9-46	9-52#					
PFTPV	9-26	9-32#					
PFTRT	9-33	9-39#					
PFTWD	9-15	9-25#					
PIHTCT	21-31	21-54	23-33*	68-19#			
PMON	8-21#	9-50	10-43				
PMON1	8-26#	8-36					
POS	56-13	56-17#					
PRHDD	68-35#						
PRO02	31-36	69-29#					
PRDBP	32-20	32-28*	32-29*	69-36#			
PRDHCT	21-79*	30-18*	68-34#				
PRHI	17-69*	18-11	65-38#				
PRHR	21-98	31-29	31-30	31-32*	31-33*	31-34	69-26#
PRINT	2-30	5-6#					
PRLO	17-57*	17-70#	18-3	65-37#			
PRMV	31-38	69-30#					
PRO2	31-40	31-65	31-66	38-6	38-13	69-28#	
PROFTC	21-106	23-59	30-15#				
PROSET	23-24*	30-17	30-25*	68-14#			
PROWD	30-19	30-22*	30-36#				
PROTO	23-24	81-3#					
PRODOT	31-73*	31-74*	69-34#				
PRRR	31-44	31-46*	31-47*	31-48	69-31#		
PRSBP	32-10	32-18*	32-19*	69-35#			
PRSLOP	31-63	31-69	31-70	69-33#			
PRTBM	2-48#	52-14					
PRTEOL	5-7	5-11#					
PRTERM	5-11	5-17#					
PRTFLG	21-107*	23-30*	24-21	32-38*	68-18#		
PRTGO	5-6	5-8	5-9*	52-13*	67-7#		
PRTIM1	21-104*	31-7	31-21*	32-33	69-24#		
PRTIM2	21-105*	31-6	31-20*	69-25#			
PRTL	5-9#	5-16					
PRTX	5-14	5-19#					
PRUL	31-55	31-56	31-60*	31-61*	69-27#		
PSIGS	68-33#						
PSMHR	21-28*	21-29*	30-3*	68-31#			
PSMNL	21-35*	21-36*	30-4*	68-32#			
PTC1	10-7#	10-9	10-19	10-29	10-36	10-46	
PTC2	10-18#	10-27					
PTCBF	8-33	10-4#					
PTCE2	10-32	10-38#					
PTCER	10-39	10-45#					
PTCHDR	70-15#						
PTCMBR	21-64#	21-66					
PTCRM	10-12	10-21#					
PTCST	10-22	10-31#					
PTCSW	21-73	23-48	30-3#				
PTCT1	23-34	70-4#					
PTEND	23-35	70-27#					
PTGAS	30-5	70-11#					

CROSS REFERENCE TABLE (CREF V01-03)

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PTH10   70-6#
PTH15   70-7#
PTH5    21-61   30-3    70-5#
PTHRCT   4-36*  21-28    21-30*  70-28#
PTSTUF  29-39   29-44*   30-5*   68-27#
PTW10   70-9#
PTW15   70-10#
PTW5    30-4    70-8#
QCOMPU  23-23*  24-16    37-8*   43-8*   68-10#
QCTES   26-19   26-20    80-30#
QFLAG    4-30*  23-47*   26-2    26-11*  29-52   29-55*  70-32#
QMAIN    2-38    4-30#
QMAYBY  26-24   26-28#
QUAD1   14-2    24-2     49-63*  50-33   50-45*  65-8#
QUADNO  65-15#
QUADO   14-2    14-4     14-12*  24-2    25-3    25-13*  49-64*
        65-9#
QUADS1  14-5    25-4     50-34   65-14#
QUADST  14-7    25-6     49-63   49-64   50-36   65-13#
RABAD   22-24   22-34    22-59#
RAD     65-47#
RAFCO2  22-50   22-51    67-35#
RAFH2   22-45   22-46    22-52   22-53   67-34#
RAFO2   22-38   22-43    22-44   67-33#
RBUF     1-22#   1-23
RCSR     1-21#   1-22
R1      12-45   12-84    12-93   17-31   17-41   29-16   29-24
        29-30   54-36    55-37   57-9#
RIN1    43-24#  43-54
RIN5    43-70#  43-76
RINLRG  43-64#
RINS1   43-14#  43-17
RINST   43-9#
RM1     22-41#  22-42
RM2     22-57   22-62#
ROOM    10-25   22-7#
ROUT    24-12   43-93#
RPT     9-42    51-9#
RPT1    51-43#
RPT2    51-70#
RPTSB   51-51   51-55    51-59   52-4#   52-7
RVPTR   62-22#
S1      38-9*   38-10*   38-24*  38-25*  39-8    39-9    41-31
        41-32   67-38#
SAMGAS  44-27   45-25#   45-28   46-71
SAVEQ   26-5    26-19#
SAVSTK  37-10*  42-3     65-3#
SB      14-17#
SB1     14-33   14-40#
SBCLR   13-25*  14-17    14-21*  15-41   16-5*   16-9*   65-23#
SBFLAG  13-24*  14-15    15-18   15-21*  16-26*  65-24#
SBFFAC  32-12   32-13    80-39#
SBPOFF  32-15   32-16    80-40#
SEC15C  21-53*  21-55*   23-21*  68-30#
SECSCT  21-24*  21-27*   23-20*  68-29#
SFTRI   57-31#
SGLV    45-46   45-51#
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CROSS REFERENCE TABLE (CREF V01-03)

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SGNRI   57-36#  57-54
SHVPBF  24-30   36-11#
SHVPTC  24-26   36-5#
SLV     12-11   12-12   12-39   12-40   12-77   12-78   12-153
        12-154  14-53   14-54   17-11   17-12   26-61   26-62
        58-20   58-21   72-10#
SPAC1    6-20    6-23#
SPAC2    6-27#   6-28
SPAC3    7-13#
SPAC4    7-16#   7-17
SPACR    6-20#
SPIRO   20-27   20-44   21-16   49-14#
SPLFIT  24-14   37-7#
SPLFLG  68-9#
SPLRGS  23-22*  24-6    24-11*  29-57*  37-7*   68-28*
SPLIT   21-86#  21-87
STACK    8-7    71-25#
START    4-26    6-14    7-19    8-7#   81-25
STPDF   26-66   26-67   80-27#
STRTP1  10-34   23-4#
SUMM    18-10   43-74   60-12#
SVL     21-50*  69-8#
TCNT    13-14*  14-19*  18-67   20-29*  62-32#
TEMP    62-33#
TEXTIM  23-11   75-2#
THRSH   49-15   81-20#
TIM1    21-64*  21-68   21-104  23-17*  29-5    69-5#
TIM2    21-84*  21-69   21-105  23-18*  29-4    69-6#
TIMFAC  31-13   31-14   80-31#
TITLE   51-29   74-3#
TRGR    20-23   20-39   21-11   81-19#
TSTK     8-13   12-5    13-2    17-2    23-4    37-9    43-65
        51-9    65-34#
TTL     20-65#
TTYBM    2-47#  52-20
TTYCNT   8-20*  20-55*  20-56   20-59*  65-50#
TTYEOL  20-63   20-67#
TTYGO    8-9*   20-62   20-64   20-65*  20-75*  24-47   51-40
        51-68   52-32*  65-49#
VAL     62-34#
VCOMP   11-29   12-5#
VDEL    13-4*   13-5*   23-6*   49-55   65-6#
VDELSU  13-6    23-19   49-50#
VDVR    49-60#  49-62
VLAST   11-13*  12-22   13-17*  49-20   49-24*  49-32*  62-29*
VLSTK   49-52   49-57   49-59   50-15   50-21   62-20#
VLSTK1  49-56   50-13   50-19   62-21#
VOLPT1  49-54*  49-55*  50-12   50-17*  65-4#
VOLPTO  49-53*  50-18   50-24*  65-5#
VPREV   13-16*  14-49   14-50*  15-1    15-17*  23-32*  26-9
        26-57   26-58*  29-2*   62-40#
VSUM    14-59   14-60   14-65*  14-66*  15-28   15-29   15-32*
        15-33*  16-21*  16-22*  18-101  18-102  62-43#
VTHRSH  49-21   78-5#
VVRTN   49-26   49-35   49-38   49-43#
VWATCH  49-23*  49-33*  49-37*  62-30#
W       39-17   39-25   39-26   39-43   39-44   39-46*  39-47*
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	40-10	40-11	40-18*	40-19*	40-32	40-33	40-39
	40-40	40-44*	40-45*	41-15	41-16	43-51*	43-52*
	43-70	43-71	62-16*				
WABOVE	15-40	16-9*					
WAITT	11-7*	13-3*	23-5*	49-23	49-33	67-39*	
WARN	14-86	14-89*					
WFIRST	15-19	16-21*					
WKAR	12-7	12-15	12-27	12-34	12-58*	12-63*	12-75
	12-87	12-103*	12-108*	12-139	12-142	12-150	12-155
	12-161	14-56	14-61	14-79	14-84	15-25	15-30
	17-7	17-21	17-34	18-34	18-56	18-63	18-87
	19-6	19-29	19-37	19-42	19-53	19-62	22-16
	22-26	38-3	38-48	38-61	38-78	38-98	38-116
	39-2	39-23	39-33	40-8	41-13	43-24	43-31*
	43-32*	43-40	43-79	65-36*			
WLCK	21-32*	21-33					
WLFAC	21-39	21-40	80-32*				
WLOFF	21-42	21-43	80-33*				
WLVWLV	34-16	34-19*					
WO	9-28	13-2*					
WO12	17-49*	17-53					
WO13	17-50	17-57*					
WO14	17-60*	17-64					
WO15	17-61	17-69*					
WO21	18-32*	18-53					
WO22	18-50	18-56*					
WO35	19-3*	51-1[illegible]					
WO36	19-57*	19-65					
WO50	17-2*						
WO60	18-63*						
WOINT	20-10	20-15*					
WOMON	14-2*	14-3	14-44	14-89	16-12	16-31	
WONBFR	15-10	71-16*					
WOPBFR	6-23	7-13	15-3	15-16	71-12*		
WRITE	24-23	31-6*					
WRTIT	24-34	34-1*					
WTHRSH	65-26*						
WWC	[illegible]-21	26-22	26-46	26-47	27-3	27-4	65-22*
WWH	14-9*	14-10*	14-30	14-31	14-67	14-68	14-80
	14-81	27-6	27-7	27-31	27-32	65-20*	
WWO	26-30	26-31	26-41	26-42	26-44	26-45	27-36
	27-37	65-21*					
WWV	14-8*	14-13	14-29	14-32	14-34	14-48	14-50
	25-8	26-54	26-58	65-19*			
X	38-103*	38-104*	39-11	39-12	39-14*	39-15*	39-27
	39-28	39-30*	39-31*	40-26	40-27	40-29	40-30
	40-35*	40-36*	40-59*	40-60*	41-17	41-18	41-20
	41-21	41-23*	41-24*	41-31*	41-32*	43-26	43-27
	62-15*						
XBUF	1-24*	6-29*	7-18*	20-64*	20-70*	20-73*	
XBUF1	20-68	20-71*	20-74*	71-26*			
XBUF12	72-21*						
XCSR	1-23*	1-24	20-60				
XXX1	32-34	80-2*					
Y	37-16	38-63	38-64	38-65	38-66	38-80	38-81
	38-82	38-83	39-18	39-19	43-37	43-38	43-72
	43-73	62-14*					

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CROSS REFERENCE TABLE (CREF V01-03)

Z	37-15	39-37	38-45	38-50	38-51	38-52	38-53
	38-55	38-56	38-74	38-75	38-94	38-95	38-118
	38-119	38-120	38-121	38-123	38-124	38-126*	38-127*
	39-6	39-7	39-35	39-36	40-12	40-13	40-23
	40-24	40-41	40-42	43-12	43-33	43-34	62-13*
ZER	56-14	56-34*					
ZERRI	57-23	57-50	57-53*				
ZLP	55-68*	55-69					

CROSS REFERENCE TABLE (CREF V01-03)

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..V2..    1-8#
.EXIT     1-8#     51-71
.PRINT    1-8#     10-45
.REGDE    1-8#      1-9
PRTBUF    3-14#    15-16     22-59
RESTOR    3-4#
SAVE      3-9#
TYPE      3-24#     4-23      9-52     34-17     47-31     47-38     51-62
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