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SPECIAL REPORT

Microrowessor-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

<table>
<thead>
<tr>
<th>IDLE</th>
<th>PFT</th>
<th>PTC/PBF</th>
<th>RUN</th>
<th>POWER</th>
<th>ON</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

### Subjects
- CAL MS
- WO
- FVC
- RPT
- PFT
- PTC/PBF

### Buttons
- ABORT
- END TEST

### Legend
- LIGHT
- THUMBWHEEL
- LIGHTED-PUSHBUTTON
- TOGGLE SWITCH

### Other
- Printer
- OBDs
(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 push-button (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 de-pressing 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: inflight vital capacity measurements, and measurement of maximum sustained minute ventilation (maximum exercise testing) together with the evaluation of ventilatory equivalents (\( V_E/V_O2 \)) 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 $3.47 \times 10^3 \text{ N/m}^2$ (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 $\text{FEV}_{1.0}$, 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-bronchopulmonary 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
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forced Vital Capacity (FVC)</td>
<td>The maximum volume of air that can be exhaled in the smallest possible time.</td>
</tr>
<tr>
<td>Forced Expired Volume – 1 sec. (FEV1)</td>
<td>The maximum volume of air that can be exhaled in 1 second.</td>
</tr>
<tr>
<td>Maximum Expiratory Flow Rate (MEFR)</td>
<td>The mean flow rate between 0.2 liters and 1.2 liters of the forced vital capacity maneuver.</td>
</tr>
<tr>
<td>Maximum Midexpiratory Flow Rate (MMFR)</td>
<td>The mean flow rate for the middle half (0.25<em>FVC to 0.75</em>FVC) of the forced vital capacity maneuver.</td>
</tr>
</tbody>
</table>

PARAMETERS DERIVED FROM FORCED VITAL CAPACITY (FVC) MANEUVER

TABLE I
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual Volume (RV)</td>
<td>The volume of air remaining in the lungs after a complete exhalation.</td>
</tr>
<tr>
<td>$\text{N}_2$ Delta</td>
<td>The change in nitrogen concentration (%) between 0.35<em>VC liters and 0.65</em>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.</td>
</tr>
<tr>
<td>Closing Volume (CV)</td>
<td>The volume of air displaced from the apices following airway collapse at bases near the end of a full exhalation to RV.</td>
</tr>
<tr>
<td>VA/RV</td>
<td>The amount of alveolar oxygen ventilation required to washout one liter of residual volume from the lungs.</td>
</tr>
<tr>
<td>Vital Capacity (VC)</td>
<td>The maximum volume of air than can be exhaled starting from full inspiration.</td>
</tr>
</tbody>
</table>
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 \(\text{FN}_2^i\) recorded during the first expiration (before inspiring pure oxygen). The alveolar nitrogen concentration after washout is the maximum \(\text{FN}_2^f\) 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:

\[
\text{FRC} = \frac{\text{N}_2 \text{ Volume Exhaled} - 0.0312T}{\text{Max. } \text{FN}_2^i - \text{Max. } \text{FN}_2^f}
\]

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),
Vital Capacity (5.98L)

Total Lung Capacity (7.57L)

Closing Volume (0.28L)

Residual Volume 1.59L

Dead Space Volume (0.15L)

0.35VC
0.65VC

Alveolar Plateau

ΔN₂ %

Nitrogen Washout, Single Breath Maneuver

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

Following a single inspiration of 100% O₂, the N₂ concentration rises as the dead space gas is increasingly washed out by alveolar gas (Figure 2). Finally, an almost uniform N₂ 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 \((\text{volume}, \text{FN}_2)\) 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 FN₂ less than the predicted FN₂ 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 N₂ 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 O₂, the N₂ 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 N₂ to the expirate. At this point the contribution from the upper regions with high N₂ predominates, producing the upward deflection of N₂. 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 (FEV₁₀/FVC). In restrictive diseases (ex. pulmonary fibrosis), both FEV and FVC are reduced but characteristically the FEV₁₀/FVC % is
<table>
<thead>
<tr>
<th>Measurements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Lung Capacity (TLC)</td>
<td>The total volume of the lungs at full inspiration.</td>
</tr>
<tr>
<td>(TLC=RV+VC)</td>
<td></td>
</tr>
<tr>
<td>FEV1/FVC%</td>
<td>The percent of forced vital capacity that can be exhaled in one second.</td>
</tr>
<tr>
<td>FVC/VC%</td>
<td>The ratio of forced vital capacity to vital capacity expressed as a percentage.</td>
</tr>
<tr>
<td>CV/VC%</td>
<td>The ratio of closing volume to vital capacity expressed as a percentage.</td>
</tr>
<tr>
<td>CC/TLC%</td>
<td>The ratio of the sum of residual volume and closing volume to total lung capacity expressed as a percentage.</td>
</tr>
</tbody>
</table>
normal or increased. In obstructive diseases (e.g., bronchial asthma),
the FEV\textsubscript{1.0} is reduced more than the FVC giving a low FEV\textsubscript{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 sam-
pled 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 trans-
mission from the spacecraft to the "ground").

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

Significant changes in the astronauts' cardiovascular and cardio-
pulmonary 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 into 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 SMS II. (Life Sciences SMS II 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), $\dot{V}_0$, $\dot{V}_{CO_2}$, minute volume ($\dot{V}_e$), respiratory rate (RR), cardiac output ($Q$), 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 ($\dot{V}_O$), 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 O₂ fraction (F₀₂) and CO₂ fraction (F₇C₀₂) 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 F₇C₀₂ vs. F₀₂, 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 F₀₂, F₇C₀₂ 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 BREATH MANEUVER FOR CARDIAC OUTPUT DETERMINATION

FIGURE 3
Selection of points on the Single Breath curve to determine slope and R values.

(Lovelace, 1975)
use in the analysis routine:

1) The CO\textsubscript{2} fraction must be greater than 0.02 (2%) 
   Data below this level is not consistent with method 
   assumptions;

2) The O\textsubscript{2} fraction must be less than the previous stored 
   O\textsubscript{2} fraction by at least 0.0025 (.25%).

The later criterion guarantees that the F\textsubscript{O\textsubscript{2}} values are monotonic, a 
necessary assumption for many derivative methods.

After the end of the breath, the F\textsubscript{CO\textsubscript{2}}, F\textsubscript{O\textsubscript{2}} data pairs are 
analyzed by first finding the derivative of F\textsubscript{CO\textsubscript{2}} with respect to 
F\textsubscript{O\textsubscript{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 instantaneous in-
spiratory respiratory exchange quotient (R at each data pair), R\textsubscript{inst}, 
is determined from the following formula:

$$R_{\text{inst}} = \frac{s - (s\cdot F_{O_2}) - F_{CO_2}}{1 - (s\cdot F_{O_2}) - F_{CO_2}}$$

where \(s\) is the negative (or absolute value) of the derivative at the 
sampled data pair. These R\textsubscript{inst} values are then used with F\textsubscript{CO\textsubscript{2}} to 
compute a least squares linear regression of F\textsubscript{CO\textsubscript{2}} as a function of R\textsubscript{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 (Q) using the formula:

$$Q = \frac{\dot{V}_O \times 1000}{\frac{2}{4.7 \times \text{slope}}}$$
where: 

\[ V_{O_2} = \text{oxygen consumption (liters, STPD)} \]

\[ \text{slope} = -1 \times \text{slope of the } R_{\text{inst}} - FCO_2 \text{ regression line} \]

\[ 4.7 = \text{slope of the standard carbon dioxide dissociation curve (ml/liter/torr PCO}_2) \]

\[ Q = \text{cardiac output (liters/minute)} \]

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 \(F_x\) of the gas contained in that volume.

1. \[ V_{IX} = F_{IX} \times V_I \quad \text{(Volume inhaled)} \]
2. \[ V_{EX} = F_{EX} \times V_E \quad \text{(Volume exhaled)} \]

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

3. \[ V_x = F_{IX} \times V_I - F_{EX} \times V_E = V_{IX} - V_{EX} \]

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

4. \[ V_x = F_{EX} \times V_E - F_{IX} \times V_I = V_{EX} - V_{IX} \]

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:

\[ V_F I N_2 = V_E F E N_2, \]

rearranging terms, equation 5) becomes:

\[ V_I = \frac{V_E F E N_2}{F I N_2}. \]

Substituting equation 6) into equation 3) and letting \( x \) represent \( O_2 \), the equation for oxygen consumption (\( V_{O_2} \)) becomes:

\[ V_{O_2} = \frac{F I O_2 * V_E F E N_2}{F I N_2} - F E O_2 * V_E. \]

Collecting terms, the final equation for oxygen consumption becomes:

\[ V_{O_2} = V_E * \left[ \frac{F I O_2 * F E N_2}{F I N_2} - F E O_2 \right], \]

where:

\[ \frac{F I O_2}{F I N_2} = \text{oxygen/nitrogen ratio of inspired air obtained from ambient air measurements} \]

\( V_E = \text{volume of expired air per unit time} \)

\( F E O_2 = \text{oxygen fraction of expired air} \)

\( F E N_2 = \text{nitrogen fraction of expired air.} \)

Substituting equation 6) into equation 4), and collecting terms, the final equation for carbon dioxide production becomes:
where: $F_{ECO_2}$ = expired fraction of carbon dioxide,

$V_E$ = volume of expired air,

$F_{ICO_2}$ = carbon dioxide/nitrogen ratio of inspired air obtained from ambient air measurements,

$F_{IN_2}$

$F_{EN_2}$ = 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 further increases in work. This peak value is referred to as the individual's maximal oxygen uptake ($\dot{V}_{O_2} \text{ max}$); 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,

$R = \frac{\dot{V}_{CO_2}}{\dot{V}_{O_2}}$. 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
OTRI - MICROPROCESSOR-BASED CARDIOPULMONARY MONITOR SYSTEM

FIGURE 4a

LSI-11 BUS

LSI-11 CPU

4K-RAM

5K ROM

8K RAM

BPM'S

DBP

ECG

100 HZ OSCILLATOR

CONTROL PANEL

DUMP CNTRL

SPIROMETER INTERFACE

N2

DISPLACEMENT

A/D

OBDS

DRV11-C PARALLEL INTERFACE

VARIAN 620I

AMPEREX PRINTER

DLV11 SERIAL INTERFACE

VIDEO MONITOR

SPIROMETER (EXHALE)

MOUTHPIECE

O2

FIO2

FO2

PA2

MASS SPEC (X58)
4.1.1 Microprocessor Module

The LSI-11 system includes a KDII-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, auto-increment/autodecrement registers, stack pointers, or program counters (PC=Register 7).

The KDII-F module normally requires 1.8A (+5V) and 0.8A (+12V) and operates at 400 ms 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 KDII-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 (addresses 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 17777H. The least significant three bits address the desired DRV11 register as follows:

<table>
<thead>
<tr>
<th>Address</th>
<th>Device Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>167760</td>
<td>DRCSR</td>
</tr>
<tr>
<td>167762</td>
<td>DROUTBUF</td>
</tr>
<tr>
<td>167764</td>
<td>DRINBUF</td>
</tr>
</tbody>
</table>
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 37X8. The least significant three bits identify the interrupting function:

<table>
<thead>
<tr>
<th>Address</th>
<th>Device Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>000300</td>
<td>Interrupt A</td>
</tr>
<tr>
<td>000304</td>
<td>Interrupt B</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Address</th>
<th>Device Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>177760</td>
<td>RCSR address</td>
</tr>
<tr>
<td>177762</td>
<td>Receive data register address</td>
</tr>
</tbody>
</table>
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 (OTRI) 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 QJVV11 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 = 0.11 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 D6, 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 ¾" 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 push-buttons, 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 0V - central ground point

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. When the carriage starts moving and has reached the correct speed.

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

Seven output lines (CUT50-CUT56) are used in the parallel interface (SP110 - from the LSI-11) for transmission of the ASCII character. Digital line CUT5 is used for the signal to start the carriage moving. The input line, CUT16 is used as a NEW LINE READY signal to distinguish between cases 1) and 3) above.

4.6 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 (P_x) 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:

\[ P_x = G_x V_x \]

where \( G_x \) 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:

\[ F_x = \frac{P_x}{P_2 + PN_2 + PCO_2} \]

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 ± 0.5V), 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
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 (CO₂ 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
current time delay is 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 in 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:

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

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 \( FN_2 \) during first exhalation, i.e., before \( O_2 \) inhalation).
- \( MAXFNF \) = Alveolar nitrogen concentration after washout (maximum \( FN_2 \) 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 W0 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 FEVI. 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 exits 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, \( V_O^2 \), \( V_CO^2 \), \( V_E \), and blood pressure) and differ only in the reporting interval length over which the data is analyzed. Heart rate is reported in beats/minute for PBF and in beats/15 seconds for PTC. \( V_O^2 \), \( V_CO^2 \), and \( V_E \) 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
$DX
RT-118J       V02C-02

.RUN DX:O1TR1

PULMONARY FUNCTION REPORT
SUBJECT 1
CAL COMPLETE

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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
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*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 per-
centages are stored in ROM as three floating-point numbers (one
each for N₂, CO₂, O₂). Completion of this routine is indicated
by "CAL COMPLETE" on the video and/or the printer. If an error
occurs during calibration (CO₂ 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
FN₂ (Nitrogen Fraction), FO₂ (Oxygen Fraction), and FCO₂ (Carbon
Dioxide Fraction) used in later calculations as gas-inspired
concentrations (in CO₂ production and O₂ consumption). Certain
checks are performed on the data to verify proper values. The
FO₂ value must be greater than 0.19 (19%) and the FCO₂ 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, RAF02) along with the F02/FN2 ratio (ORAT) and the FC02/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 STRTPI (location 62468) 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
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 FCO₂ and FO₂ values are saved for the cubic spline fit, provided that the CO₂ value is greater than 20 Torr, and the O₂ 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 FCO₂ and FO₂ 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 to 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 repre-
sentated by the \( R-FCO_2 \) pairs. Cardiac output (\( Q \)) is computed from
the slope of this regression line and from an independently determined
oxygen consumption value using the equation:

\[
Q = \frac{V_{O_2} \times 1000}{4.7 \times \text{slope}}
\]

where:

- \( V_{O_2} \) = \( O_2 \) consumption rate (STPD ml/min.)
- 4.7 = slope of the standard carbon dioxide
dissociation curve (ml/liter/torr
\( PCO_2 \)) (Buderer, 1973).
- \( Q \) = cardiac output (l/min).

Certain constraints are imposed on the \( F_2-FCO_2 \) data. Since the
\( CO_2 \) - dissociation curve below \( FCO_2 \) = 30 torr is alinear, any point
from the \( F_2-FCO_2 \) curve with a \( FCO_2 \) value less than 30 torr is
rejected. Also, if the \( F_2 \) 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 \texttt{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 DRVII are handled using LSI-11 standard vector pairs.

The control panel software monitor (PMON, location 6528) 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 module, 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) with the interrupt vector pair located in addresses 320 and 322.

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 (CO₂, O₂, N₂) 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:

\[ CF = \frac{\text{Average of 25 samples}}{\text{Cal Gas %} \times \text{BTPS}} \]
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 ($P_x$) of each gas $x$ is then converted to gas fraction ($F_x$) using the equation:

$$F_x = \frac{P_x}{P_{CO2} + P_{N2} + P_{O2}}$$

This data is then passed back to the calling program in locations FN2, F02 and FCO2.

5.3.4 Spirometer Handler (Flowchart F10, Appendix F)

The SPIRO subroutine (location 141540) 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 greater 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 WATCH indicator is increased by 1. If the resultant WATCH is less than zero, then the sample is saved. If WATCH 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 words compared to 1630 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
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMFR</td>
<td>Maximum Mid-Expiratory Flow Rate</td>
</tr>
<tr>
<td>MPU</td>
<td>Microprocessing Unit</td>
</tr>
<tr>
<td>MS</td>
<td>Abbreviation for Mission Specialist</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>OBDS</td>
<td>On-Board-Data-System</td>
</tr>
<tr>
<td>OTR</td>
<td>Operational Test Requirements</td>
</tr>
<tr>
<td>pb</td>
<td>lighted pushbutton on the control panel</td>
</tr>
<tr>
<td>PC</td>
<td>Program Counter</td>
</tr>
<tr>
<td>PLU</td>
<td>Parallel Line Unit</td>
</tr>
<tr>
<td>PS</td>
<td>Processor Status Word</td>
</tr>
<tr>
<td>PFT</td>
<td>Pulmonary Function Test</td>
</tr>
<tr>
<td>PS2</td>
<td>Program Specialist 2</td>
</tr>
<tr>
<td>PTC/PBF</td>
<td>Physiological Time Constants/Pulmonary Blood Flow</td>
</tr>
<tr>
<td>Q</td>
<td>Cardiac Output (L/Min.)</td>
</tr>
<tr>
<td>RAM</td>
<td>Random Access Memory</td>
</tr>
<tr>
<td>ROM</td>
<td>Read Only Memory</td>
</tr>
<tr>
<td>RV</td>
<td>Residual Volume</td>
</tr>
<tr>
<td>SLU</td>
<td>Serial Line Unit</td>
</tr>
<tr>
<td>SMD</td>
<td>Spacelab Mission Demonstration</td>
</tr>
<tr>
<td>SMS</td>
<td>Spacelab Mission Simulation</td>
</tr>
<tr>
<td>STPD</td>
<td>Standard Temperature and pressure for dry gas</td>
</tr>
<tr>
<td>TLC</td>
<td>Total Lung Capacity</td>
</tr>
<tr>
<td>VA</td>
<td>Amount of alveolar oxygen ventilated</td>
</tr>
<tr>
<td>$\dot{V}_{CO_2}$</td>
<td>Carbon Dioxide Production (L/Min.)</td>
</tr>
</tbody>
</table>
GLOSSARY OF ACRONYMS AND ABBREVIATIONS (cont'd)

\( V_{O_2} \) - 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:

<table>
<thead>
<tr>
<th>Piston Volume</th>
<th>Output Voltage</th>
<th>Liters/Volt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.375 L</td>
<td>1.708 V</td>
<td>1.375/1.708 = 0.8056 L/V</td>
</tr>
<tr>
<td>2.371 L</td>
<td>2.804 V</td>
<td>2.371/2.804 = 0.8458 L/V</td>
</tr>
<tr>
<td>3.341 L</td>
<td>3.916 V</td>
<td>3.341/3.916 = 0.8457 L/V</td>
</tr>
</tbody>
</table>

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 Leters/Volt * .00488 Volts/Count = 0.004127 liters/count

B1
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:

\[ h_j = z_j - z_{j-1} = j \text{ th sample interval} \]

\[ j=1 \quad m_1 = s_1 \]

\[ j=2 \quad 2m_2 + c_2m_3 = \frac{3a_2}{h_2} (y_2 - y_1) + \frac{3c_2}{h_3} (y_3 - y_2) - a_2m_1 = d_2 \]

\[ j=3, \ldots, n-2 \quad a_jm_{j-1} + 2m_j + c_jm_{j+1} = \frac{3a_j}{h_j} (y_j - y_{j-1}) + \frac{3c_j}{h_{j+1}} (y_{j+1} - y_j) - c_jm_n = d_{n-1} \]

\[ j=n \quad m_n = s_n \quad \text{(given)} \]

The two-step solution is:

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

\[ p_k = a_kq_{k-1} + 2 \quad (q_1 = 0) \]

\[ q_k = -c_k/p_k \]

\[ u_k = (d_k - a_ku_{k-1})/p_k \quad (u_1 = 0) \]
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 (\( k = n-1, n-2, \ldots, 2 \))

\[ m_k = q_k m_{k+1} + u_k \]

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 FO₂
array Y contains FCO₂
S1 = 0.85 if the last FO₂ = 0
  = FCO₂/FO₂ otherwise (FCO₂ and FO₂ are the last values in the array)
SN = 0.0
n = the number of FO₂ - FCO₂ data pairs

\[ h_n = h_n - h_{n-1} \]
; compute differences
DO 3 k = n-1, 2
  \[ h_k = h_k - h_{k-1} \]
  \[ a_k = \frac{h_{k+1}}{h_k + h_{k+1}} \]
  \[ c_k = 1 - a_k \]
  \[ d_k = 3a_k \]
3 ; step 1 - Forward
  \[ u_{n-1} = u_{n-1} + (1.0 - a_{n-1}) \]
  \[ u_2 = \frac{d_2 - a_2 \cdot S1}{2} \]
  \[ q(2) = \frac{a_2 - 1.0}{2.0} \]
PSEUDO-CODE FOR THE CUBIC SPLINE (CONT'D)

DO 5 k = 3, n-1
   \( p_k = a_k \cdot p_{k-1} + 2.0 \)
   \( u_k = d_k - (1.0 - a_k) \cdot d_{k-1} \)
   \( q_k = a_k / p_k \)

5 ; step 2 - Backwards, compute slopes.
   \( U_n = SN \)
   DO 6 k = n-1, 2
   \( m_k = q_k \cdot m_{k+1} + u_k \)
   \( m_1 = S1 \)
APPENDIX D

Schematics & Wiring Lists
### KD11 Factory Jumper Configuration

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Installed</th>
<th>Removed</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>W1</td>
<td>X</td>
<td></td>
<td>BANK 1 Disabled</td>
</tr>
<tr>
<td>W2</td>
<td>X (KD11-F)</td>
<td>X (KD11-J)</td>
<td>BANK 0 Enabled (KD11-F only)</td>
</tr>
<tr>
<td>W3</td>
<td>X</td>
<td></td>
<td>Line Time Clock Enable</td>
</tr>
<tr>
<td>W4</td>
<td>X (KD11-J)</td>
<td>X (KD11-F)</td>
<td>Memory Refresh Enable (KD11-F only)</td>
</tr>
<tr>
<td>W5</td>
<td>X</td>
<td></td>
<td>} Power-Up</td>
</tr>
<tr>
<td>W6</td>
<td>X</td>
<td></td>
<td>} Mode0</td>
</tr>
</tbody>
</table>

#### NOTE

W1 through W6 are wire-wrap jumpers.

#### Jumper Locations

```
W4 | W2 |
W3 | W1 |
W6 | W1 |
```

KD11-F CPU (DEC, 1977)
A/D SIGNAL CONNECTION

CANON 7414 DDSOP

16 15 14 13 11 10 1

SPIROMETER DISPLACEMENT

FN2

FO2

FCO2

SBP

DBP

ERGOMETER WORKLOAD

Amp to signal (purple)

Signal return (white)

Power return (gray)
LSI-11 POWER UP CIRCUIT

+5vdc

22kΩ

1μF

22kΩ

P:0.5

6 555 Timer

3

4

2

7

8

6

BB1

BPOK H

(LSI-11 Backplane)
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
**MICROPROCESSOR CONTROL PANEL**

<table>
<thead>
<tr>
<th>IDLE</th>
<th>POWER ON</th>
<th>POWER OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SUBJECT**

<table>
<thead>
<tr>
<th>CAL MS</th>
<th>0</th>
<th></th>
<th>TR##</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PTC/PBF**

<table>
<thead>
<tr>
<th>ABORT</th>
<th>ABORT</th>
<th>PT</th>
<th>PFT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**

The lights, pushbuttons, and switches are labeled to correspond to the wiring lists on the following two pages.
<table>
<thead>
<tr>
<th>SIGNAL</th>
<th>CONNECTOR, PIN</th>
<th>CONNECTOR, PIN</th>
<th>CONNECTOR, PIN</th>
<th>SIGNAL (ON PANEL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN00</td>
<td>J2A TT</td>
<td>C1 1</td>
<td>C2 1</td>
<td>T1 - Bit 1</td>
</tr>
<tr>
<td>IN01</td>
<td>J2A LL</td>
<td>C1 2</td>
<td>C2 2</td>
<td>T1 - Bit 2</td>
</tr>
<tr>
<td>INC2</td>
<td>J2A H, E</td>
<td>C1 16</td>
<td>C2 16</td>
<td>T1 - Bit 4</td>
</tr>
<tr>
<td>IN03</td>
<td>J2A BB</td>
<td>C1 7</td>
<td>C2 7</td>
<td>T2 - Bit 1</td>
</tr>
<tr>
<td>IN04</td>
<td>J2A KK</td>
<td>C1 3</td>
<td>C2 3</td>
<td>T2 - Bit 2</td>
</tr>
<tr>
<td>IN05</td>
<td>J2A HH</td>
<td>C1 4</td>
<td>C2 4</td>
<td>B1</td>
</tr>
<tr>
<td>IN06</td>
<td>J2A EE</td>
<td>C1 5</td>
<td>C2 5</td>
<td>B2</td>
</tr>
<tr>
<td>IN07</td>
<td>J2A CC</td>
<td>C1 6</td>
<td>C2 6</td>
<td>B3</td>
</tr>
<tr>
<td>IN08</td>
<td>J2A Z</td>
<td>C1 2</td>
<td>C2 8</td>
<td>B4</td>
</tr>
<tr>
<td>IN09</td>
<td>J2A Y</td>
<td>C1 9</td>
<td>C2 9</td>
<td>B5</td>
</tr>
<tr>
<td>IN10</td>
<td>J2A W</td>
<td>C1 10</td>
<td>C2 10</td>
<td>B6</td>
</tr>
<tr>
<td>IN11</td>
<td>J2A V</td>
<td>C1 11</td>
<td>C2 11</td>
<td>B7</td>
</tr>
<tr>
<td>IN12</td>
<td>J2A U</td>
<td>C1 12</td>
<td>C2 12</td>
<td>B8</td>
</tr>
<tr>
<td>IN13</td>
<td>J2A P</td>
<td>C1 13</td>
<td>C2 13</td>
<td>B9</td>
</tr>
<tr>
<td>IN14</td>
<td>J2A N</td>
<td>C1 14</td>
<td>C2 14</td>
<td>B10</td>
</tr>
<tr>
<td>IN15</td>
<td>J2A M</td>
<td>C1 15</td>
<td>C2 15</td>
<td>B11</td>
</tr>
<tr>
<td>OUT00</td>
<td>J1A C</td>
<td>C1 25</td>
<td>C2 25</td>
<td>L1</td>
</tr>
<tr>
<td>OUT01</td>
<td>J1A K</td>
<td>C1 24</td>
<td>C2 24</td>
<td>L2</td>
</tr>
<tr>
<td>OUT02</td>
<td>J1A NN</td>
<td>C1 26</td>
<td>C2 26</td>
<td>L3</td>
</tr>
<tr>
<td>OUT03</td>
<td>J1A U</td>
<td>C1 19</td>
<td>C2 19</td>
<td>L4</td>
</tr>
<tr>
<td>OUT04</td>
<td>J1A L</td>
<td>C1 23</td>
<td>C2 23</td>
<td>L5</td>
</tr>
<tr>
<td>OUT05</td>
<td>J1A N</td>
<td>C1 22</td>
<td>C2 22</td>
<td>L6</td>
</tr>
<tr>
<td>OUT06</td>
<td>J1A R</td>
<td>C1 21</td>
<td>C2 21</td>
<td>L7</td>
</tr>
<tr>
<td>OUT07</td>
<td>J1A T</td>
<td>C1 20</td>
<td>C2 20</td>
<td>L8</td>
</tr>
<tr>
<td>OUT08</td>
<td>J1A W</td>
<td>C1 18</td>
<td>C2 18</td>
<td>L9</td>
</tr>
<tr>
<td>OUT09</td>
<td>J1A X</td>
<td>C1 17</td>
<td>C2 17</td>
<td>L10</td>
</tr>
<tr>
<td>OUT10</td>
<td>J1A Z</td>
<td>C1 37</td>
<td>C2 37</td>
<td>L11</td>
</tr>
<tr>
<td>OUT15</td>
<td>J1A JJ</td>
<td>C1 28</td>
<td>C2 28</td>
<td>L22</td>
</tr>
<tr>
<td>REQ A</td>
<td>J1A LL</td>
<td>C1 27</td>
<td>C2 27</td>
<td>B13, B14</td>
</tr>
<tr>
<td>REQ B</td>
<td>J2A S</td>
<td>C1 38</td>
<td>C2 38</td>
<td>B15</td>
</tr>
<tr>
<td>CSRO</td>
<td>J2A K</td>
<td></td>
<td></td>
<td>SPIRO DUMP CIRCUIT</td>
</tr>
<tr>
<td>CSR1</td>
<td>J1A DD</td>
<td></td>
<td></td>
<td>BPMS TRIGGER</td>
</tr>
<tr>
<td>SIGNAL</td>
<td>CONNECTOR, PIN</td>
<td>CONNECTOR, PIN</td>
<td>CONNECTOR, PIN</td>
<td>CONTROL PANEL LED'S &amp; BUTTONS</td>
</tr>
<tr>
<td>--------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>OUT00</td>
<td>J1B C</td>
<td>C1 50</td>
<td>C2 50</td>
<td>L12</td>
</tr>
<tr>
<td>OUT01</td>
<td>J1B K</td>
<td>C1 49</td>
<td>C2 49</td>
<td>L13</td>
</tr>
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<td>J1B U</td>
<td>C1 44</td>
<td>C2 44</td>
<td>L15</td>
</tr>
<tr>
<td>OUT04</td>
<td>J1B L</td>
<td>C1 48</td>
<td>C2 48</td>
<td>L16</td>
</tr>
<tr>
<td>OUT05</td>
<td>J1B N</td>
<td>C1 47</td>
<td>C2 47</td>
<td>L17</td>
</tr>
<tr>
<td>OUT06</td>
<td>J1B R</td>
<td>C1 46</td>
<td>C2 46</td>
<td>L18</td>
</tr>
<tr>
<td>OUT07</td>
<td>J1B T</td>
<td>C1 45</td>
<td>C2 45</td>
<td>L19</td>
</tr>
<tr>
<td>OUT08</td>
<td>J1B W</td>
<td>C1 43</td>
<td>C2 43</td>
<td>L20</td>
</tr>
<tr>
<td>OUT09</td>
<td>J1B X</td>
<td>C1 42</td>
<td>C2 42</td>
<td>L21</td>
</tr>
<tr>
<td>OUT10</td>
<td>J1B Z</td>
<td>C1 41</td>
<td>C2 41</td>
<td>L23</td>
</tr>
<tr>
<td>OUT11</td>
<td>J1B AA</td>
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<td>OUT15</td>
<td>J1B JJ</td>
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<td>C2 34</td>
<td>L25</td>
</tr>
<tr>
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<td>C1 35</td>
<td>C2 35</td>
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</tr>
<tr>
<td>IN01</td>
<td>J2B LL</td>
<td>C1 36</td>
<td>C2 36</td>
<td>S2</td>
</tr>
<tr>
<td>REQA</td>
<td>J1B LL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQB</td>
<td>J2B S</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AC on 1 & 2
+5V on 3
Return on 4

ECG COUNT INTERRUPT
100 MSEC CLOCK INTERRUPT
**SPIROMETER VOLUME BUFFER CIRCUIT**

**ECG OUT CIRCUIT**

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

**LSI-11 to Character Generator**

- H: New Data Ready
- W: OUT8
- X: OUT9
- Z: OUT10
- AA: OUT11
- BB: OUT12
- FF: OUT13
- HH: 1/4 7432

**Character Generator (J14)**

- 1/4 7400 Start
- I1 18
- I2 19
- I3 20
- I4 21
- I5 22
- I6 23
- I7 24

**PANEL PRINTER**

**Character Generator to Solenoid Driver**

- Char. Generator (J14)
  - 01 29
  - 02 30
  - 03 31
  - 04 32
  - 05 33
  - 06 34
  - 07 35

- Solenoid Driver (J15)
  - 01 29
  - 02 30
  - 03 31
  - 04 32
  - 05 33
  - 06 34
  - 07 35

- Gnd 26 24
- +5 volts 27
- +14 volts 22 23
- +24 volts

**Jones Plugs**
New Data Ready

Start

Rnch

Panel Printer Interface

Out 15

+24

IC #''s (Backside)

#1 7490
#2 7490
#3 7490
#4 7400
#5 7400
#6 7432
#7 7406
#8 7410
## OTRI - Board Configuration for LSI-11 Chassis

### Memory Bank - User Selectable Jumpers

<table>
<thead>
<tr>
<th>BANK 0 - PROM</th>
<th>BANK 2 - PROM</th>
<th>BANK 1 - CPU RAM</th>
<th>BANK 3 - RAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>W8</td>
<td>W8</td>
<td>W1</td>
<td>W1</td>
</tr>
<tr>
<td>W9</td>
<td>W9</td>
<td>W2</td>
<td>W2</td>
</tr>
<tr>
<td>W10</td>
<td>W10</td>
<td>W3</td>
<td>W3</td>
</tr>
<tr>
<td>W15</td>
<td>W15</td>
<td>W4</td>
<td>W4</td>
</tr>
<tr>
<td>W16</td>
<td>W16</td>
<td>W5</td>
<td>W5</td>
</tr>
<tr>
<td>W17</td>
<td>W17</td>
<td>W9</td>
<td>W9</td>
</tr>
<tr>
<td>W10</td>
<td>W10</td>
<td>W10</td>
<td>W10</td>
</tr>
<tr>
<td>W11</td>
<td>W11</td>
<td>W11</td>
<td>W11</td>
</tr>
<tr>
<td>W7</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOTE:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I = Installed jumper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R = Removed jumper</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 DRCRS (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 DRCRS
        167742 DROUTBUF
        167744 DRINBUF

LSI-II BOARD
CONFIGURATION (cont'd)

E2 (cont'd)
<table>
<thead>
<tr>
<th>DEVICE</th>
<th>+5 VOLTS</th>
<th>+12 VOLTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CPU (4K RAM)</td>
<td>1.8A → 2.4A (max.)</td>
<td>0.8A → 1.1A (max.)</td>
</tr>
<tr>
<td>2. ADAC A/D</td>
<td>2.5A</td>
<td></td>
</tr>
<tr>
<td>3. Control Panel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2 DRV11's)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buttons (@0.25A)</td>
<td>0.85A → 1.3A</td>
<td>0.85A → 1.3A</td>
</tr>
<tr>
<td>LED'S (@0.030A)</td>
<td>0.36A</td>
<td></td>
</tr>
<tr>
<td>LED Indicator (@0.035A)</td>
<td>0.455A</td>
<td></td>
</tr>
<tr>
<td>4. Panel Printer (DRV11)</td>
<td>0.85A → 1.3A</td>
<td></td>
</tr>
<tr>
<td>5. Video Monitor (DLV11)</td>
<td>1.0A → 1.6A</td>
<td>0.18A → 0.25A</td>
</tr>
<tr>
<td>6. Bootstrap (REV11-A)</td>
<td>1.64A → 2.24A</td>
<td></td>
</tr>
<tr>
<td>7. 8K RAM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2 MRV11)</td>
<td>0.56A → 1.12A</td>
<td>0.56A → 1.12A</td>
</tr>
<tr>
<td>8. ROM (BANK 0)</td>
<td>2.8A → 4.1A</td>
<td></td>
</tr>
<tr>
<td>9. ROM (BANK 2)</td>
<td>1.0A → 2.3A</td>
<td></td>
</tr>
<tr>
<td>10. TERMINATOR (TEV11)</td>
<td></td>
<td>0.54A → 0.70A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18.765A → 25.795A (max.)</td>
</tr>
</tbody>
</table>

LSI-II POWER REQUIREMENTS

E3
### STATUS REGISTER (1677x0 = DCSR)

<table>
<thead>
<tr>
<th>Bit</th>
<th>Signal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>REQ B</td>
<td>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.</td>
</tr>
<tr>
<td>14-08</td>
<td></td>
<td>Not used. Read as 0.</td>
</tr>
<tr>
<td>07</td>
<td>REQ A</td>
<td>REQUEST A - same function as REQB except that interrupt is generated only if INT ENB A (bit 06) is also set.</td>
</tr>
<tr>
<td>06</td>
<td>INTA</td>
<td>INT ENB A - Interrupt enable bit. When set, allows an interrupt request to be generated, provided REQUEST A (bit 07) becomes set.</td>
</tr>
<tr>
<td>05</td>
<td>INTB</td>
<td>INT ENB B - Interrupt enable bit. When set, allows an interrupt request to be generated, provided REQUEST B (bit 15) becomes set.</td>
</tr>
<tr>
<td>04-02</td>
<td></td>
<td>Not used. Read as 0.</td>
</tr>
<tr>
<td>01</td>
<td>CSRI</td>
<td>CSRI - This bit can be loaded or read under program control and can be used for a user-defined command to the device.</td>
</tr>
<tr>
<td>00</td>
<td>CSRO</td>
<td>CSRO - Performs same function as CSRI.</td>
</tr>
</tbody>
</table>

### STATUS REGISTER

PARALLEL LINE INTERFACE - DRV11*

### Status Register (Input)

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

### Status Register (Output)

<table>
<thead>
<tr>
<th>Bit</th>
<th>Signal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-08</td>
<td>Not used. Read as 0.</td>
<td></td>
</tr>
<tr>
<td>07</td>
<td>07</td>
<td>Transmit ready - Set when buffer is empty and can accept another character for transmission.</td>
</tr>
<tr>
<td>06</td>
<td>06</td>
<td>Interrupt Enable - Set under program control when it is desired to generate a transmitter interrupt request when the DLVII is ready to accept a character for transmission.</td>
</tr>
<tr>
<td>05-01</td>
<td>Not used. Read as 0.</td>
<td></td>
</tr>
<tr>
<td>00</td>
<td>00</td>
<td>Break - Set or reset under program control. When set, a continuous space level is transmitted.</td>
</tr>
</tbody>
</table>

---

**STATUS REGISTERS**

**SERIAL LINE INTERFACE - DLV11**


E5
### INPUT SIGNALS

<table>
<thead>
<tr>
<th>DRV11-SIGNAL</th>
<th>PANEL-SIGNAL</th>
<th>DRV11-SIGNAL</th>
<th>PANEL-SIGNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN00</td>
<td>SUBJECT-TW-BIT1</td>
<td>OUT00</td>
<td>IDLE-LT</td>
</tr>
<tr>
<td>IN01</td>
<td>SUBJECT-TW-BIT2</td>
<td>OUT01</td>
<td>PFT-LT</td>
</tr>
<tr>
<td>IN02</td>
<td>SUBJECT-TW-BIT4</td>
<td>OUT02</td>
<td>PFT CALMS REQ-LT</td>
</tr>
<tr>
<td>IN03</td>
<td>MASS SPEC-TW-BIT1</td>
<td>OUT03</td>
<td>PFT CALMS RUN-LT</td>
</tr>
<tr>
<td>IN04</td>
<td>MASS SPEC-TW-BIT2</td>
<td>OUT04</td>
<td>PFT WO REQ-LT</td>
</tr>
<tr>
<td>IN05</td>
<td>PFT SELECT - PB</td>
<td>OUT05</td>
<td>PFT WO RUN-LT</td>
</tr>
<tr>
<td>IN06</td>
<td>PTC/PBF SELECT-PB</td>
<td>OUT06</td>
<td>PFT FVC REQ-LT</td>
</tr>
<tr>
<td>IN07</td>
<td>PFT CALMS-PB</td>
<td>OUT07</td>
<td>PFT FVC RUN-LT</td>
</tr>
<tr>
<td>IN08</td>
<td>PFT WO-PB</td>
<td>OUT08</td>
<td>PFT RPT REQ-LT</td>
</tr>
<tr>
<td>IN09</td>
<td>PFT FVC-PB</td>
<td>OUT09</td>
<td>PFT RPT RUN-LT</td>
</tr>
<tr>
<td>IN10</td>
<td>PFT RPT-PB</td>
<td>OUT10</td>
<td>PFT END REQ-LT</td>
</tr>
<tr>
<td>IN11</td>
<td>PFT END-PB</td>
<td>OUT11</td>
<td></td>
</tr>
<tr>
<td>IN12</td>
<td>PTC/PBF CALMS-PB</td>
<td>OUT12</td>
<td></td>
</tr>
<tr>
<td>IN13</td>
<td>PTC/PBF ROOM-PB</td>
<td>OUT13</td>
<td></td>
</tr>
<tr>
<td>IN14</td>
<td>PTC/PBF START-PB</td>
<td>OUT14</td>
<td></td>
</tr>
<tr>
<td>IN15</td>
<td></td>
<td>OUT15</td>
<td>RUN-LT</td>
</tr>
</tbody>
</table>

### INTERRUPT SIGNALS

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

### DEVICE ADDRESSES

<table>
<thead>
<tr>
<th>DEVICE ADDRESS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>167770</td>
<td>DRCSR (DRAS)</td>
</tr>
<tr>
<td>167772</td>
<td>DROUTBUF (DRAO)</td>
</tr>
<tr>
<td>167774</td>
<td>DRINBUF (DRAI)</td>
</tr>
<tr>
<td></td>
<td>CSRO</td>
</tr>
<tr>
<td></td>
<td>CSR1</td>
</tr>
</tbody>
</table>

### 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

E6
INPUT SIGNALS

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

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 - PUSHPBUTTON
LT - LIGHT
SW - SWITCH

CONTROL PANEL
DRV11-BOARD B
E7
<table>
<thead>
<tr>
<th>DRV11 SIGNAL</th>
<th>PRINTER SIGNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN00</td>
<td>OUT00</td>
</tr>
<tr>
<td>IN01</td>
<td>OUT01</td>
</tr>
<tr>
<td>IN02</td>
<td>OUT02</td>
</tr>
<tr>
<td>IN03</td>
<td>OUT03</td>
</tr>
<tr>
<td>IN04</td>
<td>OUT04</td>
</tr>
<tr>
<td>IN05</td>
<td>OUT05</td>
</tr>
<tr>
<td>IN06</td>
<td>OUT06</td>
</tr>
<tr>
<td>IN07</td>
<td>OUT07</td>
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<td>IN08</td>
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<td>IN09</td>
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<tr>
<td>IN12</td>
<td>OUT12</td>
</tr>
<tr>
<td>IN13</td>
<td>OUT13</td>
</tr>
<tr>
<td>IN14</td>
<td>OUT14</td>
</tr>
<tr>
<td>IN15</td>
<td>NEW LINE READY</td>
</tr>
</tbody>
</table>

**INPUT SIGNALS**

**OUTPUT SIGNALS**

<table>
<thead>
<tr>
<th>DRV11 SIGNAL</th>
<th>PRINTER SIGNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIT 0 - ASCII char.</td>
<td>BIT 0 - ASCII char.</td>
</tr>
<tr>
<td>BIT 1 - ASCII char.</td>
<td>BIT 1 - ASCII char.</td>
</tr>
<tr>
<td>BIT 2 - ASCII char.</td>
<td>BIT 2 - ASCII char.</td>
</tr>
<tr>
<td>BIT 3 - ASCII char.</td>
<td>BIT 3 - ASCII char.</td>
</tr>
<tr>
<td>BIT 4 - ASCII char.</td>
<td>BIT 4 - ASCII char.</td>
</tr>
<tr>
<td>BIT 5 - ASCII char.</td>
<td>BIT 5 - ASCII char.</td>
</tr>
<tr>
<td>BIT 6 - ASCII char.</td>
<td>BIT 6 - ASCII char.</td>
</tr>
</tbody>
</table>

**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)

<table>
<thead>
<tr>
<th>Bit</th>
<th>Signal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D15</td>
<td>ERROR</td>
<td>Set if ADC trigger occurs and previous conversion is not complete.</td>
</tr>
<tr>
<td>D14</td>
<td>MAINTENANCE</td>
<td></td>
</tr>
<tr>
<td>D13</td>
<td>$2^5$</td>
<td></td>
</tr>
<tr>
<td>D12</td>
<td>$2^4$</td>
<td></td>
</tr>
<tr>
<td>D11</td>
<td>$2^3$</td>
<td>Loads multiplexor address to select one of 64 channels and initiates a conversion (If D01=0)</td>
</tr>
<tr>
<td>D10</td>
<td>$2^2$</td>
<td></td>
</tr>
<tr>
<td>D09</td>
<td>$2^1$</td>
<td></td>
</tr>
<tr>
<td>D08</td>
<td>$2^0$</td>
<td></td>
</tr>
<tr>
<td>D07</td>
<td>DONE</td>
<td>Set by completion of conversion, reset upon reading data register or initialize.</td>
</tr>
<tr>
<td>D06</td>
<td>INT ENABLE</td>
<td>Program selectable interrupt mode. Interrupt produced by ADC done (D07) or error (D15) when selected.</td>
</tr>
<tr>
<td>D05</td>
<td>RESERVED</td>
<td></td>
</tr>
<tr>
<td>D04</td>
<td>GAIN $2^1$</td>
<td>Sets gain of programmable gain amplifier option. 11 sets lowest gain and 00 sets highest gain.</td>
</tr>
<tr>
<td>D03</td>
<td>GAIN $2^0$</td>
<td></td>
</tr>
<tr>
<td>D02</td>
<td>SEQ/RAND</td>
<td>Zero selects random mode for multiplexer. One selects sequential mode for multiplexer.</td>
</tr>
<tr>
<td>D01</td>
<td>EXT.ENABLE</td>
<td>Enables clock source to trigger ADC.</td>
</tr>
<tr>
<td>D00</td>
<td>START</td>
<td>Triggers ADC, if ext. enable, D1, is a zero.</td>
</tr>
</tbody>
</table>
Perkin-Elmer Mass Spectrometer - Serial Number 9

Sensitivity Range

<table>
<thead>
<tr>
<th>Gas</th>
<th>Range</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$O_2$</td>
<td>0 - +5V D.C.</td>
<td>0 to 220 torr</td>
</tr>
<tr>
<td>$N_2$</td>
<td>0 - +5V D.C.</td>
<td>0 to 660 torr</td>
</tr>
<tr>
<td>$CO_2$</td>
<td>0 - 5V D.C.</td>
<td>0 to 66 torr</td>
</tr>
<tr>
<td>$H_2O$</td>
<td>0 - 5V D.C.</td>
<td>0 to 66 torr</td>
</tr>
</tbody>
</table>

MASS SPECTROMETER SPECIFICATIONS

E10
ADAC MODEL 600 ANALOG-TO-DIGITAL CONVERTER

I. SPECIFICATIONS

A. 32 Channels A/D

B. Input Voltage Range $\rightarrow: -10v$ to $+10v$ (max. of $\pm 15v$)

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 multiplexer, sampling and hold, and PGA setting
      b. 15 microseconds for the A/D conversion
      c. 10 microseconds for zeroing operation of the PGA
Time diagram of a cycle time for one character

\[
\begin{align*}
t_{\text{char}} \quad \text{(cycle time)} \\
t_{\text{hold}} \\
\text{start signal} \\
\text{Osc. signal (}Q_{\text{osc}}) \\
\text{space column} \\
\text{column 1} \\
\text{column 2} \\
\text{column 3} \\
\text{column 4} \\
\text{column 5} \\
\text{Dem. new char. (space column)} \\
\text{space column} \\
\text{t}_{\text{act}} \\
\text{address input time} \\
\text{t}_{\text{a hold min.}}
\end{align*}
\]

NOTE: See following page for symbol legend.

AMPEREX MATRIX PRINTER
Timing Diagram for One Character
E12
Legend for timing diagram of one character:

- $t_{sc}$: 1.8 to 3.4 ms  
  See note 1  
  Scanning time of one column

- $t_{char}$: $8 \times t_{sc}$  
  Cycle time of one character

- $t_{act}$: 1.2 ms  
  Output activation time during one scanning time

- $t_{a\text{ hold}}$: min $5 \times t_{sc}$  
  See note 2  
  Hold time of input information

- $t_{st\text{ hold}}$: $1 \times t_{sc}$  
  Hold time of start signal

- $t_{DN}$: $1 \times t_{sc}$  
  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 positions 1 to 5 of the 8-position counter.
APPENDIX F

Program Flow Charts
MONITOR

Clear RAM Memory

Set up STACK

Initialize Interrupts

Initialize Control Panel

Button Pushed?

YES

PFT?

YES

PFT

NO

PTC/PBF?

YES

PTC/PBF

NO

OTRI PANEL MONITOR
PTC/PBF MONITOR

Get:
Mass Spec
Subject #

Button
Pushed?

CALMS?

ROOM?

START?

End Test?

RETURN

To IDLE Module
FORCED VITAL CAPACITY
Subroutine to compute FVC results

Find Max. Volume in Breath. Store in FEV

All volumes converted from A/D counts to liters BTPS before storing

FEV1=Volume Exhaled in one Second

At 10 MSEC/sample The 100th sample, After start of breath

Compute MMFR

$MMFR = \frac{0.5 \ast FEV}{T}$

$T =$ Time between $0.25 \ast FEV$ and $0.75 \ast FEV$

Compute MEFR

$MEFR = \frac{1}{T}$

$T =$ Time between 0.2 liters and 1.2 liters

RETURN

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

Accumulate Volume Exhaled (VENT)

Subtract 0.2 from VENT

Anatomical dead space

Max FN2 < 3% for 2 breaths

NO

WOMON

YES

Analyze single breath waveform

Calculate Residual Volume

W050:

W060:

RETURN To PFT Monitor

WASHOUT

W050:

W060:

WOMON

Monitor max. FN2 per breath

Accumulate Amount of N2 Exhaled
W050  [Analyze Single Breath Waveform]

Find Max Volume
Store as VC

Find 0.35 VC and 0.65 VC in array

Do Linear Regression

FN2 vs. Vol. over interval 0.35VC, 0.65VC
Store Slope and Intercept

Compute & Store N2 DELTA

N2 DELTA = 100 * Slope

Extrapolate Line

Find Closing Volume

CV = VC - X
X = Last vol. pt. for which FN2 (actual) < FN2 (predicted)

W060  [Calculate Residual Volume]

Calculate Time of Washout

T(min) = no. of interrupts
6000

Calculate RV

RV = Total N2 Washed Out - 0.0312T
MAXFN (Breath 1) - MAXFN (Last Breath)

Calculate VA

VA/RV = Ventilation/RV

RETURN

WASHOUT (cont'd)

F7
REPORT

Calculate Derived Parameters

FEV1/FVC%
FVC/VC%
CV/VC%
CC/TLC%

Print Title

Video and LPT done

Print Labels and Data

Video and LPT done

RETURN To PFT Monitor
CALMS

Initialize Mass Spec Data

Sample CO2,N2,O2 25 times

# of CO2 values > CALGAS > 3

YES

Average Sampled Values for CO2, O2, N2

NO

Print Bad Ms-Cal Message

RETURN To PFT or PTC/PBF Monitor

Adjust cal-gas % for BTPS

Compute Cal factor for each gas

Print Cal-Complete Message

RETURN To PFT or PTC/PBF Monitor

Data dependent on individual mass specs:
Capillary delay; N2,CO2,O2 gains; Data Inversion

MASS SPECTROMETER CALIBRATION MODULE
F9
SPIRO

Sampled Volume > 120 mv?

YES

SPIRO Valve Open?

YES

Spiral Valve Open?

NO

VLAST > SAMPLE > 19 mv

NO

Increment VWATCH

YES

VWATCH < LT. 0

NO

Open Valve R2 = 0
Set EOB

SPIROMETER HANDLER

F10
Sample every 10 msec
Sample Spiro. Volume
Match phased Vol. with FN2
R2 = 0
YES
NO
Save Sample
EOB Set? NO
Set EOB flag
YES
EXIT

Sample every 20 msec
Get FN2 Sample
Get Spiro. Volume
SPIRO
Video Data Ready?
YES
Send Character to printer
NO
EXIT

PFT INTERRUPT HANDLER
Sample every 40 msec
Get FCO2, FO2, FN2
Sample Spiro Volume
Match Phased Volume with Current gases
Subroutine DELAY
Trigger BPMS on the half-minute
Sample workload every 5 seconds
Convert to watts. Add offset and store
Transmit to OBDS every 15 seconds
Sample workload & BPMS once/minute
At end of each one-minute reporting interval
Video data ready
Send char. to video
EXIT
From interrupt ser.routine

PTC/PBF INTERRUPT SERVICE ROUTINE
If $\text{FO}_2 > 19\%$

If $\text{FCO}_2 > 2\%$

Yes

Return

Get gas fractions from ambient air

Save gas fractions in RAFC02, RAF02, RAFN2

$\text{ORAT} = \frac{\text{FO}_2}{\text{FN}_2}$

$\text{CRAT} = \frac{\text{FCO}_2}{\text{FN}_2}$

Type Bad-Room Air Message

Return
START

- Initialize data, pointers, flags, etc.
- Set up gas delays
- Set up pointers for PTC
- Get next protocol step

EXLOOP:

- Vol/Gas pr.ready
  - YES: Gas Analysis
  - NO: Gas Exchange EOB

- Gas Exchange EOB
  - YES: >13 Vol/Gas Prs
  - NO: Spline fit thru

- Spline fit thru
  - YES: FNSHQ [R(Inst)]
  - NO: NOT Enough Pairs for Analysis

- Service PRTFLG
  - Load print buffer at end of each minute
- Service PTC-OBDS Request
  - Transmit every 15 seconds
- Service PBF-OBDS Request
  - Transmit once a minute

START-PROTOCOL MODULE
Print one-minute summary on LPT and video

EXLOOP:

Print Buffer

EOT Flag Set

YES

NO

Wait for Interrupt

Calc.'s complete

NO

A

EXLOOP:

RETURN

Return to PTC/PBF monitor

D

Gas exchange end-of-breath

Scale BRTHV 0-32767 => 0-8L BTPS

Scale BRTHO, BRTHC 0-32767 => 0-1L STPD

Save values in PTC area

Store TIME, BRTHV, BRTHC, BRTHO for later transmission to ODDS

Reset BRTHV, BRTHO, BRTHC

EXLOOP

START-PROTOCOL MODULE
Gas Analysis Routine

Get next set of phased V & gases

Q Man. triggered

Q Man Initialized

Initiate Q man on 1st sample of new breath

CO2 > 20 TORR

O2 Decrease > 0.002

GSLP1:

Phased Volume

Sum Delta vol for PBF & PTC

Compute CO2 Production

Compute O2 Consumption

EXLOOP:

START PROTOCOL MODULE (cont'd)

F16
R (INSTANTANEOUS)

FNSHQ

Set up Pointers

Array \( Z \rightarrow F_{O2} \), \( Y \rightarrow F_{CO2} \), \( W \rightarrow R\text{(INST)} \)

Loop for \( I = 2, N - 1 \)

Compute \( R \text{(INST)} \)

\( W(I) = \frac{s - S_{F02} - F_{CO2}}{1 - S_{F02} - F_{CO2}} \)

Linear Regression of \( PCO2 \) as function of \( R\text{INST} \)

Subroutine LINREG

Save Slope and Intercept

EXLOOP
APPENDIX G

Operating Procedures
OTR 1: Inflight Exercise

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 Its 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 - IIp (ion pump current)
   (Reading on DVM should be approximately -001. All IIp readings are negative, regardless of sign.)
   VACUUM PUMP SHUTOFF vl' - full CW
   (closed)

CAUTION

If ELEC INHIBIT lt or HIGH PRESS lt come on or IIp (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_p) on DVM).

   NOTE: I_p should range from -001 to -030. Values of I_p between -030 and -600 indicate probable vacuum problem.

4. MS panel:
   VACUUM PUMP SHUTOFF vlv - full CCW

   NOTE: I_p should remain same or decrease. If I_p 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_p 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 Its on MS panel.

2. MS panel:

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

   NOTE: OPEN LOOP It will remain on for approximately 20 seconds. If It 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 Its on MS panel.

4. Verify air values on MS DVM by placing DVM SELECT sel in positions CO₂, O₂, then N₂, and confirming respective gas values. Breathe through MS probe tube and confirm increase in CO₂. Following verification, return DVM SELECT sel to 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 It - ON)
   TEST GAS SEL sel - O₂
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 CO₂ value greater than 4.4 on MS DVM by placing DVM SELECT sel in CO₂ position. Following verification, return DVM SELECT sel to Ip position.

   **NOTE:** If CO₂ 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 It 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 Its 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 or 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 It on BPMS blinks on and off as CAL pb on cardiotach is depressed. (ECG It 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 CO2 value greater than 4.4 on MS DVM by placing DVM SELECT sel in CO2 position. Following verification, return DVM select sel to Ip position.
13. IDLE panel:
   PTC/PBF pb - depress

14. OTR 1 panel:
   CAL MS pb - depress

15. Verify that green CAL MS It blinks once.
   NOTE: Calibration of mass spectrometer is concluded when message CAL COMPLETE appears on printer.


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 It 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)
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 I_{ls}
   - 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.
1. Washout

- Inh: Mouthpiece in
- Exh: Mouthpiece in

2. FVC test

- Inh: Mouthpiece in
- Exh: Mouthpiece in

3. POF test

- Inh: Mouthpiece in
- Exh: Mouthpiece in

OTR 1
REAL TIME CREW PROCEDURE CHANGE REQUEST

DETAIL CHANGE IN EXACT WORDING:

PROCEDURE 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 BPME:
Mode Sel. - 200
Cliff/Inflate Sw. - Start

OTHER DATA AFFECTED: None

MCC DISPOSITION

APPROVALS (AS REQUIRED): APPROVAL □ DISAPPROVAL □ APRON
APPROVALS (AS REQUIRED): APPROVAL □ DISAPPROVAL □ APRON
FAO
FLIGHT DIRECTOR

IMPLEMENTATION: □ SIGNATURE □ NO □ OK □ COMPLETE □

DATE
APRON
SIGNATURE

APRON
APRON
TECHNICAL RATIONALE:

BPMS samples blood pressure once per minute. During the first \( \leq 30 \) 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 \( \leq 45 \) seconds after initialization (step 23 in procedures). Thus the procedure change will assure sampling during the proper interval.

[Graph showing typical BPMS output with the following labeled points:
- \( t_0 \): BPMS started
- \( t_{30} \): BPMS sampled by OTR 1
- \( t_{45} \): BPMS sampled by OTR 1]
APPENDIX H

Program Listing
MONTIR Ri-11 MACRO WMO2-12 00:18:02 PAGE 1

.TITLE MONITR

000005 TP=x5
000000 IM1=x0
000001 I=x1
000002 IP1=x2

8 MCALL \;V2...REGDEF..PRINT..EXIT

9 000000 REGDEF
     000000 R0=x0
     000001 R1=x1
     000002 R2=x2
     000003 R3=x3
     000004 R4=x4
     000005 R5=x5
     000006 R6=x6
     000007 R7=x7

10 AADRESSES FOR LINE PRINTER - BOARD C
12 AND ON BOARD DATA SYSTEM
14 : LPTSR=167750
16 OBD=167750
18 LPT=OBD+1
20 LPT=OBD+2

19 AADRESSES FOR TELETYPE
21 XCSR=177560
22 RXBF=RXSR+2
23 XCSR=RXBF+2
24 XBUF=XCSR+2

20 CONTROL PANEL - BOARD A
22 DRAS=167770
24 DRA=DRAS+2
26 DRA=DRA+2

21 CONTROL PANEL - BOARD B
23 DRBS=167780
25 DRBO=DRBS+2
27 DRBS+2

24 A/D CONVERTER
26 ADSR=176770
28 ADIN=ADSR+2
29 DAC=176760
30 DACE=DAC+2

31 KW11-P PROGRAMMABLE REAL TIME CLOCK
32 PCSR=172540
33 PCSB=PCSR+2
34 PCR=PCSB+2
VECTOR ADDRESSES

.Title VECTOR ADDRESSES

.SET UP VECTOR ADDRESSES

.ASect

.START ADDRESS

.000000 000024 .=24

.000024 048774 .WORD BEGIN.0

.RT-11 START ADDRESS

.000040 000250 .=24

.000240 000000 .WORD 250.0

.FLOATING POINT TRAP

.000240 000250 .=24

.000240 000000 .WORD 250

.A/D ISR ADDRESS (CLOCK PAD)

.000314 000250 .=25

.000314 0004674 .WORD ADISR.0

.LPT VECTOR ADDRESS

.000320 000000 .=32

.000320 000500 .WORD PRNT.200

.ABORT VECTOR ADDRESS

.000380 000000 .=380

.000380 000416 .WORD ABORT.0

.CARDIAC OUTPUT TRIGGER

.000304 000434 .=304

.000304 000434 .WORD QMAN.200

.ECG COUNTFE

.000310 000000 .=310

.000310 000466 .WORD ECG.0

.PANEL PRINTER INT ENB

.000100 .LPEN=100

.BIT MASK FOR OBDS SWITCH

.000002 .TT+DM=0

.BIT MASK FOR PRINTER SWITCH

.000001 .PRTBM=1
.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 RS, BIFLOD
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
000801 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
00418 012600 MOV (SP)+,R0
00426 014400 CLEAR PC AND PS FROM STACK INTO THE BIT BUCKET
00420 012600 START ALL OVER AGAIN

00422 012600 MOV (SP)+,R0
00424 012600 MOV (SP)+,R0
00426 014400 JSR PC,LPTGO
00428 014400 EVENTUALLY THIS MUST BE CHANGED TO **** BR BEGIN **************

00432 000456 BR START

: G MANEUVER -ISR

00434 012607 QMAN: MOV #0, QFLAG
00436 017777 000314
00442 052767 000200
00450 042767 167312
00456 042767 100040
00464 000002 RTI

: ECG COUNTER ISR

00466 005267 ECG: INC PTHRCT
00472 005267 060246
00476 005267 057334
00476 000002 RTI
.TITLE PRINTER ISR

:PRINTER INTERRUPT SERVICE ROUTINE

: 1-5 MS RESPONSE TIME

6 008500 105777 PRINT: TSTB @PRTGO
   037144
7 008504 003486 BLE PRTEOL
   037136
8 008506 117767 MOV/B @PRTGO.LPT
   037136
   167237
9 008514 005267 PRTL: INC PRTGO
   037136
10 00520 000082 RTI
11 00522 002413 PRTEOL: BLT PRTERM

12 00524 112767 MOV/B #40.LPT
   060840
   167221
13 00532 032767 BIT #100000.LPTIN :NO OUTPUT UNTIL NEW LINE READY SIGNAL
   100000
   167214
14 00540 001412 BEQ PRTX
15 00542 112767 MOV/B #200.LPT :START
   060840
   167203
16 00550 000761 BR PRTL
17 00552 142767 PRTTERM: BICB #LPEN.LPTSR
   060840
   167174
18 00560 112767 MOV/B #40.LPT
   000440
   167165
19 00566 000082 PRTX: RTI

21 .TITLE CLEAR

22
CLEAR RT-11 MACRO VM02-12

1
2 ; CLEAR RAM BANKS 1 AND 3
3 040570 040570
4 040570 040570 CLEAR: MOV #20000.R0
5 040570 005800 CLR1: CLR (R0) +
6 040570 003270 BIT #40000.R0
7 040602 001774 BEQ CLR1
8 040604 001270 MOV #60000.R0
9 040610 005800 CLR2: CLR (R0) +
10 040612 003270 BIT #100000.R0
11 040616 001774 BEQ CLR2
12 040620 008167 JMP START
13
14 .TITLE SPRCR
15 040770 040770
16 040770 000167 SPACR: JMP SPAC1
17 177704
18
19 040780 040780
20 040780 000167 SPACR: JMP SPAC1
21 1777704
22
23 040790 040790
24 040790 001270 SPAC1: MOV #WOPBFR.R1
25 040794 001270 MOV #40.R1
26 040798 001270 MOV #20.R2
27 04079C 000020 : WOPBFR THRU WOBBFR
28
29 0407A0 010120 SPAC2: MOV R1,(R0) +
30 0407A4 007720 MOV R2,SPAC2
31 0407A8 011270 MOV #14.XBUF
32 0407AC 000014 : CLEAR VIDEO SCREEN
33 0407B0 138648
34 0407B4 000167 JMP CLEAR
35 177636
36
37 .TITLE BEGIN
START OF MONITOR

STORE PROCESSOR STATUS WORDS

ENABLE CONTROL PANEL INTERRUPTS

ENABLE EXTERNAL DEVICE INTERRUPTS

; START:

MOV #STACK, SP

RESET

MOV #MINI.TTYGO

MOV #200, R0

CLR &DBBS

MOV #TSTK, TP

MOV #R0

CLR @DBAS

MOV #77, DRBS

BIS #40, DRBS

MOV #S, TTVCNT

PMON: MOV #171777, DRBO : CLEAR BOARD B LIGHTS

MOV #777776, DRAO : TURN ON IDLE, PFT, PTC LIGHTS

BIS #100, DRAS

CLR DUA12

PMOH1: MOV DRA1, R0

; WHICH OF THE TWO BUTTONS WAS PUSHED??

BIT #40, R0

BNE PFT : PFT WAS PUSHED

BIT #100, R0

BNE PTCBF : PTC/PTF WAS PUSHED
35 ERROR CONDITION
36 00720 000167 JMP PMON1
37 177754
38 EVEN
.TITLE PFT MONITOR

; "MONARY FUNCTION TEST MONITOR

PFT: MOV #100,DRAS ;ENABLE ABORT, DISABLE ALL

MOV #40,DRBS ;OTHERS FROM CP BOARDS

:R0 CONTAINS SUBJECT NO. AND MASS SPEC. TYPE

MOV #177777,DRBO ;TURN OFF ALL LED'S ON DRIV11B

PFT2: MOV #077777,DRBO ;TURN ON IDLE, PFT PB, AND PTC/PBF PB

:BIT R0,4200

:BIT R0,4200

BEQ PFTON

BEQ PFT0

MOV #037765,DRBO ;CALMS PB DEPRESSED

CLR DUM2

JSR PC.CALMS

TST DUM2

BNE PFT2

:BIT R0,4080

BEQ PFTFV

MOV #037735,DRBO ;WO PB DEPRESSED

JSR PC.WO

MOV #077675,DRBO ;TURN ON PFT-FVC-RGF

JMP PFT1

PFT2: ;BIT R0,4400

BEQ PFTFV

MOV #037735,DRBO ;WO PB DEPRESSED

JSR PC.WO

MOV #077675,DRBO ;TURN ON PFT-FVC-RGF

JMP PFT1
PFT MONITOR  RT-11 MACRO M12E-12  00:10:02 PAGE 9+

32 01064 030027 PFTFV: BIT R0, #1000
33 01070 014112 BEQ PFTRT
34 01072 012767 MOV #037575, DRAO
35 01100 004767 JSR PC, F/PC
36 01104 012767 MOV #077575, DRAO :TURN ON PFT-RPT-RQP
37 01112 000167 JMP FFT1
38 39 01116 030027 PFTRT: BIT R0, #2000
40 01122 001412 BEQ PFTE1
41 01124 012767 MOV #037575, DRAO
42 01132 004767 JSR PC, RPT
43 01136 012767 MOV #077575, DRAO :TURN ON PFT-END-RQP
44 01144 000167 JMP FFT1
45 46 01150 030027 PFTE1: BIT R0, #4000
47 01154 001412 BEQ PFTER
48 01156 012767 MOV #035777, DRAO
49 01164 004767 JSR PC, ENDT1
50 01170 012767 MOV #177777, DRAO :TURN OFF LIGHTS
51 52 01176 000167 JMP PMON
53 54 01202 PFTER: TYPE REG1
55 01202 012767 MOV #MSG1, RB
56 01206 004767 JSR PC, LPT60
57 01206 004767 JSR PC, LPT60
58 01212 000167 JMP FFT1
1 001216 012767  PTCBF:  MOV  #100340,DRAS  ;INTEN -> ABORT, G
   100340
   166544

2 001224 012767  MOV  #100340,DRBS  ;INTEN -> ECG
   100340
   166526

3 001232 012767  GPTCST:  MOV  #077774,DRBO
   077774
   166526

4 001240 016700  PTC1:  MOV  DRA1,RO  ;READ SWITCHES
   166530

5 001244 030027  BIT  RO,#170000
   170000

6 001250 001773  BEQ  PTC1

7 01252 030027  BIT  RO,#10000
   01252

8 01256 001417  BEQ  PTCRM

9 01260 012767  MOV  #037772,DRBO  ;TURN ON PBF-CALMS-RUN
   037772
   166474

10 01266 005967  CLR  DUM2
   005967

11 01272 004767  JSR  PC, CALMS
   004767

12 01276 005767  TST  DUM2
   005767

13 01302 001253  BNE  GPTCST

14 01304 012767  PTC2:  MOV  #077766,DRBO  ;TURN ON PBF-ROOM-RQP
   077766
   166450

15 01312 000167  JMP  PTC1
   00167

16 01316 030027  PTCRM:  BIT  RO,#20000
   030027

17 01322 001417  BEQ  PTCST

18 01324 012767  MOV  #037756,DRBO  ;TURN ON PBF-ROOM-RUN
   037756
   166430

19 01332 005967  CLR  DUM2
   005967

20 01336 004767  JSR  PC, ROOM
   004767

21 01342 005767  TST  DUM2
   005767

22 01346 001253  BNE  PTC2

23 01350 012767  MOV  #077736,DRBO  ;TURN ON PBF-STRT-RQP
   077736
   166484

24 01356 000167  JMP  PTC1
   000167

25 01362 030027  PTCST:  BIT  RO,#40000
   030027
; FTC/PBF MONITOR RT-11 MACRO VMO2-12
; 08:10:02 PAGE 10+

040000  BEQ  PTCE2
33 01379 012767  MOV  *037676,DRBO  ;TURN ON PBF-STRT-RUN

34 01376 004767  JSR  PC,STRTP2
35 01402 012767  MOV  *176776,DRBO  ;TURN ON PBF-END-REQ

36 01418 000167  JMP  PTC1

37

38 01414 030027  PTCE2:  BIT  R0,#100000
39 01439 001412  BEQ  PTCER
40 01422 012767  MOV  #037777,DRBO

41 01438 004767  JSR  PC,ENDT2
42 01434 012767  MOV  *177777,DRBO  ;CLEAR DRBO LIGHTS

43 01442 000167  JMP  PMON

44

45 01440  PTCE:  PRINT  #MSG1
01446 012788  IF NB #MSG1,
017356
01452 104351  EMT  #0351
46 01454 000167  JMP  PTC1

47

48

49
.TITLE FORCE VITAL CAPACITY

;FORCE VITAL CAPACITY MANEUVER

6 001460 052767 FVC: BIS *1,DRAS
    000001
    166302

7 001460 012767 MOV *-50,WAIII
    177738
    056232

8  MOV *100..PCSB :SET CLOCK COUNT TO 100

9 01474 005000 CLR R0
10 01476 005002 CLR R2
12 01500 005003 CLR R3
13 01502 005467 CLR VLRST

14 01506 012781 MOV #FVCNT,R1 :SET UP BUFFER ALLOCATION FOR DATA
022004
15 01512 005021 CLR (R1)+ :FVCNT=0
16 01514 012701 MOV 41-.FVCNT,R1 :SET UP BUFFER ALLOCATION FOR DATA

17 01516 005000 CLR R0
18 01518 005003 CLR R3
32 01538 005467 CLR VLRST

19 01520 005067 MOV R0,FVCNT ;YES,STORE NO. OF SAMPLES
016252
20 01522 005001 CLR PCSR ;TURN OFF CLOCK

21 01524 005242 LOOP: NOP
22 01530 032767 BIT *1,EOB :END OF BREATH?
000001

23 01536 001773 BEQ LOOP :NO
24 01540 042767 BIC *1,DRAS :TURN OFF CLOCK
000001

25 01544 036152 MOV R0,FVCNT :YES,STORE NO. OF SAMPLES
016232
26 01546 018067 MOV R0,FVCNT :YES,STORE NO. OF SAMPLES
016232
27 01552 042703 BIC *1,R3
000001
28 01556 004767 JSR PCSR, VCOMP :CALCULATE RESULTS
000001
29 01562 006005 RTS PC
30 01564 006207 RTS PC :RETURN TO PFTFV IN PMON
31
; SUBROUTINE VCOMP

; GET RAW FVC

; STORE FVC IN FLOAT WORD 1

; STORE FVC IN FLOAT WORD 2

; COMPUTE FRFR
FORCE VITAL CAPACITY

RT-11 MACRO VMB2-12

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41 B1714 075030 FDIV R0 :0(R0),2(R0)=UNCAL FVC<0.25
42 B1716 016045 MOV 2(R0),-(TP)
43 B1722 011845 MOV (R0),-(TP)
44 B1724 004767 JSR PC.R1
45 B1730 011501 MOV (TP),R1
46 B1732 061501 MUL *3,R1
47 B1734 061501 ADD (TP),R1
48 B1736 002502 MOV (TP)+,R2
49 B1740 012700 MOV *FVAT.R0
50 B1744 005004 CLR R4
51 B1746 020002 CMP (R0)+,R2
52 B1750 100776 BMI -2
53 B1752 010067 MOV R0,WNAR
54 B1756 005204 INC R4
55 B1760 028102 CMP R1,(R0)+
56 B1762 100375 BPL -4
57 B1764 010067 MOV R0,WNAR+2
58 B1770 004767 JSR PC.PLOW
59 B1774 012704 MOV #OUTAR+10,R4
60 B1800 012024 MOV (R0)+,(R4)+
61 B1802 012024 MOV (R0)+,(R4)+
62 B1808 012024 MOV #WNAR,R0
63 B180A 017114 MOV R0,R1
64 B1812 015721 MOV SV,(R1)+
65 B1816 016721 MOV SV+2,(R1)+
66 B1822 014644 MOV D0.2,(R1)+
67 B1824 014646 MOV D0.2+2,(R1)+
68 B1826 014644
69 B1832 075030 FDIV R0
70 B1834 016045 MOV 2(R0),-(TP)
71 B1840 011845 MOV (R0),-(TP)
72 B1842 004767 JSR PC.R1

:FINISH COMPUTATION OF MMFR

:COMPUTE MEFR

:COMPUTE LDL.2 AND L1.2 IN SPIRO A/D COUNTS

01714 075030 FDIV R0
01716 016045 MOV 2(R0),-(TP)
01722 011845 MOV (R0),-(TP)
01724 004767 JSR PC.R1
01730 011501 MOV (TP),R1
01732 061501 MUL *3,R1
01734 061501 ADD (TP),R1
01736 002502 MOV (TP)+,R2
01740 012700 MOV *FVAT.R0
01744 005004 CLR R4
01746 020002 CMP (R0)+,R2
01750 100776 BMI -2
01752 010067 MOV R0,WNAR
01756 005204 INC R4
01760 028102 CMP R1,(R0)+
01762 100375 BPL -4
01764 010067 MOV R0,WNAR+2
01770 004767 JSR PC.PLOW
01774 012704 MOV #OUTAR+10,R4
01800 012024 MOV (R0)+,(R4)+
01802 012024 MOV (R0)+,(R4)+
01808 012024 MOV #WNAR,R0
01812 015721 MOV R0,R1
01816 016721 MOV SV,(R1)+
01822 014644 MOV SV+2,(R1)+
01824 014646 MOV D0.2,(R1)+
01826 014644 MOV D0.2+2,(R1)+
01832 075030 FDIV R0
01834 016045 MOV 2(R0),-(TP)
01840 011845 MOV (R0),-(TP)
01842 004767 JSR PC.R1

:FINISH COMPUTATION OF MMFR

:COMPUTE MEFR

:COMPUTE LDL.2 AND L1.2 IN SPIRO A/D COUNTS
FORCE VITAL CAPACITY | RT-11 MACRO VM92-12 | 00:10:02 PAGE 12+

```assembly
MOV  (R0), -(TP)
ADD  *4, R0
MOV  R4, -(TP)
MOV  R3, -(TP)
FMUL  TP
MOV  (TP)+, (R1)+
MOV  (TP)+, (R1)+
SOB  R2, BTLOOP
RTS  PC

; SUBROUTINE FLOW
ENTER EDITH:
WKAR=ADDRESS+2 OF LOW VALUE
WKAR+2=ADDRESS+2 OF HIGH VALUE
R4=T
RETURN WITH:
R0 POINTING TO DESIRED FLOW VALUE
FLOW:
MOV  WKAR, R0
SUB  *2, R0
MOV  (R0), R2 ;LOW VALUE
MOV  WKAR+2, R0
SUB  *2, R0 ;HIGH VALUE
MOV  (R0), R1
SUB  R2, R1
MOV  R1, -(TP)
JSR  PC, IR ;FLOAT(R0)

WKAR, R0
MOV  (TP)+, (R0)+
MOV  (TP)+, (R0)+
MOV  SLY, (R0)+
MOV  SLY+2, (R0)+
MOV  WKAR, R0
FMUL  R0 ;CALIBRATED DIFFERENCE
MOV  R4, -(TP) ;FLOAT(T)
JSR  PC, IR
MOV  WKAR, R0
MOV  R0, R1
MOV  (TP)+, (R1)+
MOV  (TP)+, (R1)+
FDIV  R0 ;DIFFERENCE/T
```
TITLE NITROGEN WASHOUT

1 002356 012700 WO:
037112
2 002362 012767
177761
035336
3 002370 016767
031622
031616
031614
031610
4 002376 066767
031614
031610
5 002404 004767
011706
6 002410 052767
165352
7 MOV *TSTK,R0
8 MOV *-17,WAIT
9 MOV MSDLY,VDEL
10 ADD MSDLY,VDEL :TWICE BECAUSE OF WORDS TO DELAY, NOT BYTES
11 JSR PC,VDESTU
12 02410 052767
000001
13 02416 005867
031410
14 02422 012767
020006
015352
15 02430 005067 CLR VPREV
16 02434 005867 CLR VLAST
17 02440 005067 CLR MAXFH
18 02444 005067 CLR BRCHT
19 02448 005067 CLR MAXFH
20 02450 005067 CLR MAXFH
21 02454 005067 CLR MAXFH+2
22 02460 005067 CLR MAXV
23 02464 012767
177777
24 02472 012777
177777
034304
25 02477 012777
177777
034274
26 02500 005067 CLR ALTFLG
27 02504 052767
000001
035206
28
29
30
002512 026767  Womon: CMP #QUADO,QUAD1: SAME=>NO NEW DATA IN O BUFFER
031504
03150A
5 002520 001744  BEO  Womon
4 002522 016700  MOV  #QUADO,RO
031474
6 002526 020027  CMP  #QUADST,RO
036732
7 002532 002407  BLT  ARH33
034224
8 002540 012067  MOV  (RO)+,W+R
034212
9 002544 012067  MOV  (RO)+,W+R
034210
10 002550 012067  MOV  (RO)+,W+R
034206
11 02554 062700  ADD  #10,RO :SKIP 02 AND CO2
000518
12 02560 010067  MOV  RO,QUADO
031436
13 02564 005767  TST  W+R
034166
14 02570 001557  BEO  EOF1
034200
15 02572 005767  TST  SBFLAG
034200
16 02576 001041  BNE  MSBP
034170
18 02584 001410  BEO  NOCLR
034170
19 02606 012767  MOV  #0,TCHT
000000
031216
20 02614 012767  MOV  #FVDR,FVADR
020086
015168
21 02622 005907  CLR  SPCR
034196
22
23
24
25
27 02626 005267  NOCLR:  INC  GVCN
015152
28 02632 016796  MOV  FVADR,RO
015144
29 02636 016796  MOV  W+R,(RO)+
034114
30 02642 016796  MOV  W+R,(RO)+
034117
31 02646 016796  MOV  W+R+2,(RO)+
034118
32 02652 026767  CMP  MFRYR,W+R
031292
034876
NITROGEN 14RSHOUT RT-11 MACRO WM2-12 00:10:02 PAGE 14+

33 02660 100806 BPL SB1
34 02662 016767 MOV WWV, MAXV
35 02670 016767 MOV FWADR, LOCMAX
36
37
38
39
40 02676 010867 SB1: MOV R0, FWADR
41 02678 005767 NOSBD: TST ALTFLG
42 02680 001004 BNE NOSBD
43 02682 012767 MOV #-1, ALTFLG
44 02684 008675 BR WOMON
45
46 02686 005067 NOSBD: CLR ALTFLG
47
48 02688 016700 MOV WWV, R0
49 02690 016700 SUB VPREV, R0
50 02692 016767 MOV WWV, VPREV
51 02694 010845 MOV R0, -(TP)
52 02696 004767 JSR PG, IR
53 02698 016745 MOV SLV+2, -(TP)
54 02700 013712 MOV SLV, -(TP)
55 02702 075025 FMUL TP
56 02704 012700 MOV #WKAR, R0
57 02706 012520 MOV (TP)+, (R0)+
58 02708 013520 MOV (TP)+, (R0)+
59 02710 016730 MOV VSUM, (RO)+
60 02712 016720 MOV VSUM+2, (RO)+
61 02714 012700 MOV #WKAR, R0
62 02716 075000 FADD R0
63
64 VSUM = SUM OF CALIBRATED (WWV-VPREV)
65 03010 012867 MOV (R0)+, VSUM
66 03012 012867 MOV (R0)+, VSUM+2
67 03014 016748 MOV WWN+2, -(R0)

36
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39
40 02676 010867 SB1: MOV R0, FWADR
41 02678 005767 NOSBD: TST ALTFLG
42 02680 001004 BNE NOSBD
43 02682 012767 MOV #-1, ALTFLG
44 02684 008675 BR WOMON
45
46 02686 005067 NOSBD: CLR ALTFLG
47
48 02688 016700 MOV WWV, R0
49 02690 016700 SUB VPREV, R0
50 02692 016767 MOV WWV, VPREV
51 02694 010845 MOV R0, -(TP)
52 02696 004767 JSR PG, IR
53 02698 016745 MOV SLV+2, -(TP)
54 02700 013712 MOV SLV, -(TP)
55 02702 075025 FMUL TP
56 02704 012700 MOV #WKAR, R0
57 02706 012520 MOV (TP)+, (R0)+
58 02708 013520 MOV (TP)+, (R0)+
59 02710 016730 MOV VSUM, (RO)+
60 02712 016720 MOV VSUM+2, (RO)+
61 02714 012700 MOV #WKAR, R0
62 02716 075000 FADD R0
63
64 VSUM = SUM OF CALIBRATED (WWV-VPREV)
65 03010 012867 MOV (R0)+, VSUM
66 03012 012867 MOV (R0)+, VSUM+2
67 03014 016748 MOV WWN+2, -(R0)

36
37
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39
40 02676 010867 SB1: MOV R0, FWADR
41 02678 005767 NOSBD: TST ALTFLG
42 02680 001004 BNE NOSBD
43 02682 012767 MOV #-1, ALTFLG
44 02684 008675 BR WOMON
45
46 02686 005067 NOSBD: CLR ALTFLG
47
48 02688 016700 MOV WWV, R0
49 02690 016700 SUB VPREV, R0
50 02692 016767 MOV WWV, VPREV
51 02694 010845 MOV R0, -(TP)
52 02696 004767 JSR PG, IR
53 02698 016745 MOV SLV+2, -(TP)
54 02700 013712 MOV SLV, -(TP)
55 02702 075025 FMUL TP
56 02704 012700 MOV #WKAR, R0
57 02706 012520 MOV (TP)+, (R0)+
58 02708 013520 MOV (TP)+, (R0)+
59 02710 016730 MOV VSUM, (RO)+
60 02712 016720 MOV VSUM+2, (RO)+
61 02714 012700 MOV #WKAR, R0
62 02716 075000 FADD R0
63
64 VSUM = SUM OF CALIBRATED (WWV-VPREV)
65 03010 012867 MOV (R0)+, VSUM
66 03012 012867 MOV (R0)+, VSUM+2
67 03014 016748 MOV WWN+2, -(R0)
NITROGEN WASHOUT

RT-11 MACRO IMO2-12  00:18:02 PAGE 14+

033736
68 03024 016740
MOV [WWH-(R0)]
035730
69 03130 162700
SUB #4, R0
030006
70 03034 075028
FMUL R0
71
72 03036 016740
MOV NSUM+2-(R0)]
031032
73 03042 016740
MOV NSUM-(R0)
031024
74 03046 075000
FADD R0
031067
75 03050 012067
MOV (R0)+, NSUM
031016
76 03054 011067
MOV (R0), NSUM+2
031014
77 03060 012708
MOV *WKAR, R0
037114
78 03064 016720
MOV WWH-(RO)+
037673
79 03070 016720
MOV WWH+2-(RO)+
033666
80 03074 016720
MOV MAXFN-(RO)+
038662
81 03106 016720
MOV MAXFN+2-(RO)+
038759
82 03104 012700
MOV *WKAR, R0
037114
83 03110 075010
PSUB R0
037501
84 03112 160000
BFL WARN
031067
85 03114 014067
MOV -(R0), MAXFN+2
030744
86 03120 014067
MOV -(R0), MAXFN
030736
87 03124 008167 WARN: JMP WMON
177362
88
89
90
91
92
93
94
95

REPRODUCIBILITY OF THE ORIgINAL PAGE IS POOR.
NITROGEN WASHOUT
RT-11 MACRO P/M92-12
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1 003130 016745 EOB1: MOV VPREV,-(TP)
   030722
2 003134 004767 JSR PC.BTPS
   012762
3 003140 012746 MOV #WOPBFR,-(SP)
   061824
4 003144 012746 MOV #2,-(SP)
   000002
5 003150 012746 MOV #2,-(SP)
   000002
6 003154 012502 MOV (TP)+,R2
   012746
7 003156 012546 MOV (TP)+,-(SP)
   030656
8 003160 012246 MOV R2,-(SP)
   030656
9 003162 004767 JSR PC.FFMT
   012004
10 003166 012746 MOV #WONBFR,-(SP)
    061024
11 003172 012746 MOV #4,-(SP)
    000004
12 003176 012746 MOV #1,-(SP)
    000004
13 03202 016746 MOV MAXFN+2,-(SP)
    030604
14 03206 016746 MOV MAXFN,-(SP)
    030604
15 03212 004767 JSR PC.FFMT
    011754
16 03216 004567 JSR RS.BUFL0D
    000002
17 03222 001024 WOPBFR
    000001
18 03224 000001 MOV #BUFFER,R0
    037200
19 03226 004246 MOV MAXFN,-(SP)
    030604
20 03232 004767 JSR PC.LPTGO
    011602
21 03236 005067 CLR VPREV
    030614
22 03242 005767 TST SBFLAG
    033530
23 03246 004567 BMI WFIRST
    033520
24 03250 001024 BNE MOREOB
    030604
25 03252 000526 INC SBFLAG
    033520
26 03256 012700 MOREOB: MOV #WKAR,R0
    037114
27 03262 012720 MOV #37514,(R0)+
    037514
28 03266 012720 MOV #146315,(R0)+
    146315
29 03272 016720 MOV VSUM,(R0)+
    036576
30 03276 016720 MOV VSUM+2,(R0)+
    036566
1 003350 001481 MINUS 0.2
3 003352 000043 BEQ NOTYET :BOTTOM
4 003354 000043 BR EOT
5 003354 005267 INC SBCLR 033414
6 003360 000402 BR LVEW
7 8 9 003362 005067 WABOVE: CLR SBCLR 033496
10 003366 005067 LVEW: CLR MAXFN 030470
11 003372 005067 .CLR MAXFN+2 030466
12 003376 000167 JMP WOMON 177110
13
14
15
16
17
18
19 20 03402 005067 WFIRST: CLR VSUM 030460
21 03406 005067 OLSUM 030456
22 03412 005067 CLR FVCNT 014366
23 03416 005067 CLR NSUM 030450
24 03422 005067 CLR NSUM+2 030446
25 03426 005267 INC SBFLAG 033344
26 03432 016767 MOV MAXFN, OUTAR+20 030424
27 03440 016767 MOV MAXFN+2, OUTAR+22 030420
28 03446 005067 CLR MAXFN 030420
29 03452 005067 CLR MAXFN+2 030452
30 03452 005067 CLR MAXFN+2 030446
31 03456 000167 JMP WOMON 177030
32 03462 042767 EOT: BIC #1, DUM1 042001
034230
ANALYZE SINGLE BREATH WAVEFORM

REINIT USER STACK

MOVE MAXUL, (TP)

MOVE R0, R1

MOVE (TP) + (R0) +

MOVE (TP) + (R0) +

MOVE D.35, (R0) +

MOVE D.35 + 2, (R0) +

MOVE (R1) + R4

MOVE (R1) + R4

MOVE R4, (TP)

MOVE PC.RI

MOVE (TP) + R4

MOVE #WRXAR.R0

MOVE D.05 + 2, (R1)

MOVE D.65, (R1)

MOVE R8

MOVE (R0) + R3

MOVE (R0) + (TP)

MOVE R3, (TP)
41 03640 004767  JSB  PC.R1
42 03644 012563  MOV  (TP)+, R3
43
44  R3 AND R4 NOW CONTAIN THE INTEGER EQUIV. OF UNCAL
45 0.35%C AND 0.65%C
46 03646 016700  MOV  R1, R013
47 03652 017701  MOV  #FVHAT.R1
48
49 03656 022104  W012:  CMP  (R1)+, R4

50 03660 000004  BPL  W013  ;POINT >= 0.35%C
51
52 03662 002701  ADD  #4.R1  ;SKIP FN2 PAIR
53 03666 077605  SOB  R0, W012
54
55 03670 000000  :ERROR CONDITION
56 03672 019167  W013:  MOV  R1, PRLO
57 03676 033254
58 03678 002701  ADD  #4.R1
59 000004
60
61 03682 022103  W014:  CMP  (R1)+, R3
62 03684 000004  BPL  W015  ;R3 >= (R1)
63 03688 022701  ADD  #4.R1
64 000004
65 03712 077005  SOB  R0, W014
66 03716 000000  :ERROR
67 03718 162701  W015:  SUB  #2.R1
68 000002
69 03722 010107  MOV  R1, PRHI
70 033226
71 03726 162767  SUB  #2.PRLO
NITROGEN WASHOUT

1. COMPUTE DELTA VOLUME:
   003734 004767
   JSR PC.CRSUM
   012154
   MOV ERO.R3

2. MOSUM:
   MOV (R3)+,-(TP) : VOLUME = X, FZ = Y
   JSR PC.BTPS
   012156
   MOV (R3)+,(R3)+
   MOV (R3)+,(R3)+
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   MOV (R3)+
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44 04100 075881  FADD  R1  ;D(R1),2(R1)=FN2C
45 04102 062704  ADD  #2, R4
46 04104 014240  MOV  (R4)+,(R0)+  ;NEXT FN2
47 04106 014240  MOV  (R4)+,(R0)+
48 04110 012420  MOV  +OUTAR+30, R3
49 04112 012703  BMI  NO22
50 04114 075811  FSUB  R1  ;D(R1),2(R1)=FN2A-FN2C
51 04116 080403  ;CORRECT (R4) TO POINT TO NEXT VOLUME
52 04118 162704  SUB  #12, R4
53 0411A 080740  BR  4:31
54 0411C 004767  ;FOUND FN2A-FN2C, LET CLOSING VOLUME
55 0411E 004767  ;THIS VOLUME SHOULD STILL BE IN WKB+.4
56 04120 012700  NO22:  MOV  #WKB+.4
57 04122 014260  MOV  -(R3),6(R0)
58 04124 014360  MOV  -(R3),4(R0)  ;GET VITAL CAPACITY
59 04126 075810  FSUB  R0  ;/C+VOLUME
60 04128 012467  MOV  (R0)+,OUTAR+44
61 0412A 027770  MOV  (R0)+,OUTAR+46
62 0412C 027766  ;CALCULATE RESIDUAL VOLUME
63 0412E 012700  NO2B:  MOV  #WKB+.4
64 04130 012704  MOV  +OUTAR+50, R4
65 04132 010681  MOV  R0, R1
66 04134 016745  ;COMPUTE TIME IN MINUTES
67 04136 027636  MOV  TCNT,-(TP)
68 04138 004767  JSR  PC, IR
69 0413A 014552  MOV  D3000,(R0)+
70 0413C 012510  MOV  D3000+2,(R0)+
71 04140 012520  MOV  (TP)+,(R0)+
72 04142 012520  MOV  (TP)+,(R0)+
73 04144 075831  FDIV  R1  ;T=NO. OF INTERRUPTS/6000
74 04146 016726  MOV  #WOBLD, R0)+
75 04148 016726  MOV  #WOBLD+2,(R0)+  ;CONSTANT 0.0312
76 0414A 012474  MOV  #WOBLD+2,(R0)+
77 0414C 075811  FMUL  R1  ;D(R1),2(R1)=T(IN MIN.)*0.0312
78 0414E 016729  MOV  NSUM,(R0)+
79 04150 027636  MOV  NSUM+2,(R0)+
80 04152 027634  MOV  NSUM+2,(R0)+
81 04154 075811  FSUB  R1  ;COMPUTE RV DENOM
82 04156 004240  ADD  #4, R1
83 04158 000040  ADD  #4, R1
84 0415A 000044  ADD  #4, R1
85 0415C 016720  MOV  #MAXFN,(R0)+  ;GET FN2(FINAL)
CALLED FROM RT.

COMPUTE PERCENTAGES, ASSUMES FVC AND NO HAVE BEEN PERFORMED

3 004376 012702 W035: MOV *OUTAR+50, R2
   MOV 034146
4 004402 012703 MOV *OUTAR+60, R3
   MOV 034156
5 004406 012704 MOV *OUTAR, R4
   MOV 034876
6 004412 012700 MOV *WKAR, R0
   MOV 037114
7 004416 018001 MOV R0, R1
8 004426 012460 MOV (R4)+.4(R0) ; FVC
   MOV 000004
9 004424 012460 MOV (R4)+.6(R0)
   MOV 000006
10 004430 012410 MOV (R4)+.2(R0) ; FVC
11 004432 012460 MOV (R4)+.0(R0)
   MOV 000002
12 004436 075030 F DIV R0
13 004440 012023 MOV (R0)+.(R3)+ ; FEV/FVC
14 004442 012023 MOV (R0)+.(R3)+
15 004444 016140 MOV 2(R1),-(R0) ; MOVE FVC INTO DENOMINATOR
   MOV 000002
16 004450 016140 MOV 0(R1),-(R0)
   MOV 000000
17 004454 012704 MOV *OUTAR, R4
   MOV 034076
18 004460 016440 MOV 26(R4),-(R0) ; FVC
   MOV 000026
19 004464 016440 MOV 24(R4),-(R0)
   MOV 000024
20 004468 075080 F DIV R0
21 004472 012033 MOV (R0)+.(R3)+ ; STORE FVC/FVC
22 004474 012033 MOV (R0)+.(R3)+
23 004476 014240 MOV -(R2),-(R0) ; CV
24 004500 014240 MOV -(R2),-(R0)
25 004502 075031 F DIV R1
26 004504 012123 MOV (R1)+.(R3)+ ; CV/FVC
27 004506 012123 MOV (R1)+.(R3)+
28 004510 012700 MOV *WKAR+4,R0
29 004514 010001 MOV R0, R1
30 004516 012001 MOV (R2)+.(R0)+
31 004518 012220 MOV (R2)+.(R0)+
32 004520 012220 MOV (R2)+.(R0)+
33 004522 012220 MOV (R2)+.(R0)+
34 004524 012220 MOV (R2)+.(R0)+
35 004526 075001 FADD R1 ; CV+RV
36 004528 075001 FADD R1
37 004532 012700 MOV *WKAR+4,R0
38 004534 016720 MOV OUTAR+24,(R0)+ ; FVC
   MOV 037114
39 004540 016720 MOV OUTAR+26,(R0)+
   MOV 027360
40 004544 014260 MOV -(R2),2(R0)
   MOV 000002
NITROGEN WASHOUT

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41 04569 B10210
42 0-3402 810220
43 04569 B10210
44 04569 B12223
45 04569 B10223
46 04569 B10210
47 04569 B10210
48 04569 B10210
49 04569 B10210
50 B4571 010708
51 B4571 010708
52 B4571 010708
53 04569 010708
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82 04569 010708

DONE - YEAH !!!!!!!

TO BE CONTINUED
.TITLE A/D ISR

3 004674 00246 ADISR: MOV R2, -(SP)
4 004676 032767 BIT #1, DUM1
5 004704 081476 BEQ L/R
6 004679 016762 MOV DRAC, R2 ;SEE WHAT WE ARE DOING
7 004712 032767 BIT #200, R2
8 004676 001444 BEQ FVCINT
9 004679 032762 BIT #40, R2 ;WASHOUT??
10 004724 001445 BEQ WONT ;YEP
11 004676 032767 BIT #100, DRBO ;PBF, PTC
12 004734 001446 BEQ PBFINT ;YEP
13 004736 001441 BR INTRTN ;NO SOMETHING FOULED UP
14 15 004740 005767 WONT: TST CLKFLG
16 004744 001442 BEQ GOGOGO
17 00474C 005067 CLR CLKFLG
18 004752 002733 BR INTRTN
19 20 004756 005167 GOGOGO: COM CLKFLG
21 004760 032767 BIT #40, R2
22 004764 005167 JSR PC, GETGAS
23 004768 005272 MOV TRGR, ADSR
24 004772 032767 GSIN: BIT #200, ADSR
25 26 005004 001774 BEQ GSIN
27 005008 016702 MOV ADIN, R2
28 005128 004767 JSR PC, SPIRO
29 005112 004767 JSR PC, DELAY
30 005122 005272 INC TCMT
31 32 005228 008425 BR INTRTH
05050 016727  FNIC1: MOV TRGR, ABDR
41 05036 016727  FNIC1: BIT #300,ABDR
42 05040 016728  BEQ FNIC1
43 05040 016728  MOV ADIN,R2
44 05052 004767  JSR PC, SFHC
45 05056 015769  TST R2
46 05060 001402  BEQ FNIC2
47 05060 018221  MOV R2, (R1)+
48 05064 005200  INC R2
49 05066 032767  FNIC2: BIT #1, EOS
50 05074 001402  BEQ INTPTH
51 05076 027203  BIS #1, EOS
52
53 LVR:
54 05102 005367  INTOTH: DEC TTYCNT
55 05102 053262  TST TTYCNT
56 05126 010069  RNE LVR1
57 05112 001644  MOV #16, TTYCNT ;TIME TO OUTPUT A CHARACTER
58
59 05114 012767  MOV #299, XCSR
60 05122 032767  BIT #299, XCSR
61 05128 001485  BEQ LV1
62 05132 002477  TSTB TTYGO
63 05136 003406  BLE TTYEO1
64 05140 117267  MOVB TTYGO, XBUF
65 05146 005247  TTL: INC TTYGO
66 05152 004234  BR LV1
67 05154 002423  TTYEO1: BLT LV1 ;MINUS 1
68 05156 123767  CMPB #12, XBUF
69 05164 001487  BEQ LV2
70 05166 112767  MOVB #12, XBUF
71 05174 012767  MOV #12, XBUF1
A/D ISR RT-11 MACRO VM02-12

000012
003512
72 05202 000418  BR  LVR1
73 05204 112767  MOV R1  #15.XBUF
       000015
       172354
74 05212 012767  MOV  #15.XBUF1
       000015
       063474
75 05220 005207  INC  TTYGO
       000015
       031744
76 05224 042767  BIC  #100000.DRBS
       100000
       162526
77 05232 012002  MOV  (SP)+,R2
78 05234 000002  RTI
.TITLE CLOCK PBF SERVICE

005236 005656 PBFINT: DEC PINTCT
003433
005242 001517 BNE INTRTM
005404 003220
005244 012767 MOV #.PINTCT : ONLY FALLS THROUGH EVERY FOURTH TIME
003404 003420
005252 005267 INC TIMI
052550
005256 003102 BNE ARNCTM
005256 003254
005260 005267 INC TIME : A DOUBLE WORD FOR NUMBER OF 40 MSEC INTERRUPTS
005254
005264 004167 ARNCTM: JSR PC.GETGHS :SAMPLE GSES
005714
005270 012767 MOV TRGR.ADSR :SAMPLE VOLUME
002772 171472
005276 032767 PBFV: BIT #200.ADSR :DONE?
000690 171464
003014 001774 BEQ PBV
171460
003396 016762 MOV ADIN.R2
171460
005312 004767 JSR PC.SPIRO
006636
005316 004767 JSR PC.DELAY :ADD PHASED VOLUME TO QUEUE
008764
001574 002767 DEC BPCHR :TIME TO TRIGGER IT?
003210
005326 001006 BNE NOBP
000682 062432
005330 052767 BIS #2.DRAS :YES
002734 162432
005336 012767 MOV #1500..BPCHR :RESET COUNTER TO 1 MINUTE
002734 032372
005340 052767 MOV #1500..SEC5CT :5 SECONDS ELAPSED?
002448
005344 005567 NOBP: DEC SECSCT
005240
005348 001064 BNE NO5
000682 0162410
005352 042767 BIC #2.DRAS
162410
005356 012767 MOV #125..SEC5CT
000682 062432
005360 016777 MOV PTHRCT.0PSWHR
053346
055340 052420
055344 052420 ADD #2.PSWHR
062767
000682 052412
003234 005236 CLR PTHRCT
000002 052412
CLOCK PBF SERVICE
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31 05486 012767 MOV #4835,ADSR ;INITIATE WOL SAM
   004635
6 171234
32 05414 032767 WLCK: BIT #200,ADSR ;SAMPLE WORK LOAD EVERY 5 SECS.
   000200
   171346
33 05422 001774 BEQ WLCK
34 05424 016762 MOV ADIN,R2
   171342
35 0541 110277 MOV R2,8PSWL
   .02356
36 0543 062767 ADD #2,PSWL
   000002
   052354
37 05442 010245 MOV R2,-(TP)
38 05444 004767 JSR PC,IR
   012232
39 05450 016745 MOV WLFA,-(TP) ;CONVERT TO WATTS
   012316
40 05454 016,45 MOV WLFA,-(TP)
41 05458 017525 PMUL TP
42 05462 016745 MOV WLFP+2,-(TP) ;OFFSET
   012310
43 05466 016745 MOV WLFP,-(TP)
44 05467 012362 FADD TP
45 05474 016745 MOV CWL+2,-(TP) ;ADD TO LAST VALUE
46 05480 016745 MOV CWL,-(TP)
47 05494 075085 FADD TP
48 05494 012567 MOV (TP)+,CWL
   052348
49 05504 012567 MOV (TP)+,CWL+2
50 05514 065267 INC SHL ;NUMBER OF WORK LOAD SAMPLES
   .052312
51
52 ;THE WAY 15 SEC IS SET UP WASTES MEMORY
53 05522 085367 NOS: DEC SEC15C ;PTC SPEWS DATA IN 15 SEC. CHUNK
   05264
54 05526 01043 BNE NO15
55 05530 012767 MOV #373,SEC15C
   000567
   052654
56 05536 010046 MOV R0,-(SP)
57 05540 010146 MOV R1,-(SP)
58 05542 010346 MOV R3,-(SP)
59 05544 012762 MOV #86,R2
60 05550 012762 MOV #PTH5.R0
   000126
61 05554 012762 MOV #BPTH5.R1
62 05546 012762
CLOCK PBF SERVICE

RT-11 MACRO INW02-12

00:18:02 PAGE 21+

63
64 05560 011021 PTCM/R: MOV (R0),(R1)+ :XFER FROM WORKING TO TEMP
65 05562 005020 CLR (R0)+
66 05564 077263 SOB R, PTCM/R
67 05566 012767 MOV #1, DECUT
000001
032172
68 05574 0116701 MOV 
TIM1.R1
69 05580 0116708 MOV TIM2.R0
70 05584 012783 MOV #1, R3
71 05588 077283 ASHC R3, R0
72 05592 010187 MOV R1, BPTCT
73 05596 004762 JSR PC.PTCS/P
74 05598 012663 MOV (SP)+, R3
75 05602 012601 MOV (SP)+, R1
76 05606 012600 MOV (SP)+, R0
77
78 05610 005367 NO15: DEC PRMHT
052166
80 05614 001054 BNE INTRT:
81 05618 010460 MOV R0, -(SP)
82 05620 010145 MOV R1, -(SP)
83 05624 012767 MOV #2425, ADSR :END OF PERIOD SAM BP
84
85 05628 032767 HP: BIT #200. ADSR
000200
171112
87 05632 001774 BEQ SPWT
88 05636 010767 MOV ADIN.CSBP
171106
052204
89 05640 012767 MOV #3025, ADSR
000325
171074
90
91 05644 032767 DPWT: BIT #200. ADSR
000200
171160
92 05648 001774 BEQ DPWT
93 05652 010767 MOV ADIN.CDBP
171062
052164
94
95
96
97 05712 012700 MOV #CHR.R0 :CURRENT HEART RATE
98 05716 012761 MOV #PRHR.R1 :PREVIOUS HEART RATE
CLOCK PBF SERVICE

BT-11 MACRO vMB2-12  00:10:02 PAGE 21+

00 05722 012783  MOV  #20..R3
000024

100
101 5726 011021  ENPRMV:  MOV  (RD),(RD)+
102 5730 005920  CLR  (RD)+
103 5732 077263  SDB  R3, ENPRMV
104 5734 016767  MOV  TIM1, PRTIM1
052066
052148
105 5743 016767  MOV  TIM2, PRTIM2
052202
052348
106 5750 004767  JSR  PC, PROFTC
107 5754 012757  MOV  #77, PRTFLG
000077
032006
108 5762 012681  MOV  (SP)+, R1
109 5764 012600  MOV  (SP)+, R0
110 5766 006167  INTRX:  JMP  INTRIN
177110
ROOM AIR

RT-11 MACROS 0302-12 08:18:02 PAGE 22

[TITLE ROOM AIR]

; SUBROUTINE ROOM - SAMPLE ROOM AIR

1 8A577D 010046 ROOM: MOV B0, -(SP)
2 065771 010146 MOV B1, -(SP)
3 00577B 010246 MOV B2, -(SP)
4 06800 010346 MOV B3, -(SP)
5 06906 010446 MOV B4, -(SP)
6 06604 004767 JSR PC, GETGAS
7 065174
8
9

; CHECK FO2 AND FC02

0 06010 001270 MOV *FO2, R0
1 06014 012702 MOV #FO2, R2
2 06026 010061 MOV B0, R1
3 06822 010721 MOV D.19, (R1)+
4 06026 010722 MOV D.19, (R1)+
5 06052 012221 MOV (R2)+, (R1)+
6 06034 012221 MOV (R2)+, (R1)+
7 06836 075810 FSUB R0
8 06548 100461 BMI RABAD
9 06842 012708 MOV #FO2, R0
10 06046 010702 MOV #FC02, R2
11 06852 010831 MOV B0, R1
12 06854 012221 MOV (R2)+, (R1)+
13 06856 012221 MOV (R2)+, (R1)+
14 06856 012221 MOV D.02, (R1)+
15 06864 016721 MOV D.02+2, (R1)+
16 06078 075810 FSUB R0
17 06072 100444 BMI RABAD
18
19

; GOOD DATA

20 06074 012708 MOV #FO2, R0
21 06760 012701 MOV #RAFO2, P1
22 06104 013782 MOV #6, R2
23
24

; ROOM AIR

25 06110 012691 BMI: MOV (R0)+, (R1)+
26 06112 077262 SOB R2, BMI
27 06114 016745 MOV RAFO2+2, -(TP)
28 06120 016745 MOV RAFO2, -(TP)
45 06124 016745  MOV  RAFN2+2, - (TP)
46 06130 016745  MOV  RAFN2, - (TP)
47 06134 015935  FDiv  TP  (TP)+, ORAT  ORAT = RAFO2/RAFN2
48 06136 012567  MOV  (TP)+, ORAT+2
49 06142 012567  MOV  RAFCO2+2, - (TP)
50 06152 016745  MOV  RAFN2, - (TP)
51 06156 016745  MOV  RAFN2, - (TP)
52 06162 016745  MOV  RAFN2, - (TP)
53 06166 015935  FDiv  TP  (TP)+, ORAT  ORAT = RAFCO2/RAFN2
54 06170 012567  MOV  (TP)+, ORAT+2
55 06174 012567  MOV  RAFCO2+2, - (TP)
56 06180 000167  JMP  RM2
57 06184 004567  PARAB:  PRTBU4  BADAIR, 3
58 06204 004567  JSR  BS, BUFL0D
59 06214 012760  BADAIR
60 06220 004767  JSR  PC, LPTGO
61 06224 012767  MOV  # R1FFER, R0
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 06244 003287  RTS  PC
33 06400 012767 MOV #4, PINTCT ; ADISR ONLY GETS INTERRUPTES FOR THIS EVERY 40 MSEC
000004
01346
000160
000136
35 06414 012767 MOV *PTCTL.R0
000160
000136
36 06420 012767 MOV *PTEND.R1
000160
000136
37 06424 020001 CMP R0.R1
000160
000136
38 06430 001375 BNE PCBFCL
000160
000136
39 06432 012767 MOV *CHR.R0
000160
000136
40 06436 012767 MOV *PBMD.R1
000160
000136
41 06442 005020 PCBFCL: CLR (RO)+ ; CLEAR PTC BUFFERS
000160
000136
42 06444 020001 CMP R0.R1
000160
000136
43 06446 001375 BNE PCBFCL
000160
000136
44 06448 045001 BIC *100.00DRBO
000160
000136
45 06456 035737 BIS #40, 00DRBO
000160
000136
46 06464 005067 CLEAR GFLAG
000160
000136
47 06470 004767 JSR PC.PTCSW ; SET POINTERS FOR PTC DATA
001436
48 001436
49 001436
50 001436
51 001436
52 001436
53 001436
54 001436
55 001436
56 001436
57 001436
58 001436
59 06474 004767 JSR PC.PROFTC ; GET NEXT PROTOCOL STEP
001446
60 06500 0050757 BIS *1, DUMI
000001
0031212
.TITLE PTC/PBF WATCH LOOP

1 006566 066780 EXLOOP: CMP $1264
2 006567 066781 DEQ $1264
3 006514 061071 BNE GSANAL
4 006515 061072 ;VOLUME, GAS DATA TO BE ANALYZED????
5 006516 061073 ;THIS GETS CHECKED AFTER EVERY TASK BECAUSE IT CAN TIME OUT QUICKLY
6 006517 061074 TST SPLKOS
7 006518 061075 BEO NOSPL
8 006519 061076 CMP #13.NPAIR
9 006520 061077 BMI EXL1
10 006521 061078 CLR SPLKOS
11 006522 061079 JMP ROUT
12 006540 068167 JMP ROUT
13 006541 000187 EXL1: JMP SPLFIT
14 006542 000188 ;NEED SPLINE FIT FOR Q DATA
15 006543 000189 TST OCOMPU
16 006544 00018A BEO NOFIN
17 006545 00018B JMP FINSH
18 006546 00018C ;COMPLETE THE Q CALCULATIONS
19 006547 00018D HOSPL: TST OCOMPU
20 006548 00018E ;NEED TO INITIATE PRINTER OUTPUT
21 006549 00018F TST FRITFLG
22 006550 000190 BEO NOH:IT
23 006551 000191 JMP NRITE
24 006552 000192 NOH:IT: TST DSCOUT
25 006553 000193 BEO NOC:HP
26 006554 000194 JMP SHITTC
27 006555 000195 ;PTC DATA TO GO OUT TO ORBS
28 006556 000196 HOSHP: TST DSCOUT
29 006557 000197 BEO NOC:HP
30 006558 000198 JMP SHFP:HP
31 006559 000199 NOC:HP: TST OUTHP
32 006560 00019A ;OUTHP
33 006561 00019B BEO NOUMP
34 006562 00019C JMP WPIT
35 006563 00019D NOUMP: TST EOTFP:G
36 006564 00019E ;EOTFP:G
37 006565 00019F BEQ EXLOOP
38 006566 000200 WAIT EOTCT
39 006567 000201 DEC EOTCT
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<tr>
<th>Line</th>
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<th>Decimal</th>
<th>Assembly Code</th>
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<td>39</td>
<td>06646</td>
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<td>BNE 001317</td>
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<td>00267</td>
<td>BIC @1.DRAS</td>
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<td>42</td>
<td>06656</td>
<td>122767</td>
<td>:WAIT FOR PRINTER TO FINISH :</td>
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<td>BITB #LPRN.LPTSR :</td>
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<td>44</td>
<td>06666</td>
<td>001374</td>
<td>BNE KT3</td>
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<td>45</td>
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<td>:WAIT FOR TTY TO FINISH :</td>
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<tr>
<td>46</td>
<td>06666</td>
<td>122777</td>
<td>CHFB #377 @TTYGO</td>
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<td>000377</td>
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<td>48</td>
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<td>000274</td>
<td>BNE ,6</td>
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<td>51</td>
<td>06676</td>
<td>000267</td>
<td>RTS PC :END OF TEST</td>
</tr>
</tbody>
</table>
This is the SB data storage part of gas analysis.

None in progress.

First, we want to initialize on first sample of new breath.

So we know we have initialized.

Lights????????????????????????????

Threshold: about 20 Torr? ????

To keep it honest.

And get the hell out of this part.

We don't use the results of the Fsub.

Has F02 decreased by more than .002.
;KEEP IT STRAIGHT
;SAVE THIS DATA POINT
;SHOW THEM FOR NEXT CHECK

;AND THEY WERE STORED

;AD

;FLOAT DELAT

;AMBIENT LITERS ON STACK

;STPD DELTA VOLUME ON STACK
FTC/PBF GAS ANALYSIS - RT-11 MACRO VM02-12 00:10:02 PAGE 26+

69 07244 010500  MOV  TP, R0
70 07246 016845  MOV  2(R0), -(TP)
71 07252 011045  MOV  (R0), -(TP) ; DUPLICATE TPO ENTRY
72 07260 016745  MOV  BTPSF+2, -(TP)
73 07264 016745  MOV  BTPSF, -(TP)
74 07270 010445  MOV  B4, -(TP)
75 07272 010545  MOV  B3, -(TP)
76 07260 016745  MOV  BTPSF+2, -(TP)
77 07264 016745  MOV  BTPSF, -(TP)
78 07270 075025  FMUL  TP
79 07272 010500  MOV  TP, R0
80 07274 016845  MOV  2(R0), -(TP)
81 07300 011045  MOV  (R0), -(TP)
82 07302 004767  JSR  PC, IOF
83 07306 016745  MOV  BTPSF+2, -(TP)
84 07312 016745  MOV  BTPSF, -(TP)
85 07316 079065  FADD  TP
86 07320 012507  MOV  (TP)+, BTPSF
87 07324 012545  MOV  (TP)+, BTPSF+2
88 07330 016745  MOV  CMV+2, -(TP)
89 07334 018745  MOV  CMV, -(TP)
90 07340 079075  FADD  TP
91 07344 012567  MOV  (TP)+, CMV
92 07348 005854  MOV  (TP)+, CMV+2
93 07346 012567  MOV  (TP)+, CMV+2
94 07352 004767  JSR  PC, IOF
95 0000250

: TURN OFF INTERRUPTS IN CASE EOF TIMOUT WHILE DATA OUT OF HOLES
: BEING UPDATED AND THEN WOULD BE STUFFED FROM ZEROED HOLE

: DELTA V' BTPS

: BOTTOM OF STACK MOV CONTAINS STPD DELTA VOLUME TWICE

: GIVE THE INTERRUPTS A CHANCE
:STACK SHOULD HAVE STPD DELAT VOLUME TWICE

:FE CO2 TO STACK

:FROM ROOM AIR

:FE N2*(F E CO2/F I N2) SUBTRACTED FROM FE CO2

:TIMES DELAT V OL -V CO2

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
PTC/PBF GAS ANALYSIS      RT-11 MACRO VM02-12      00:18:02 PAGE 27+

027240
37 07526 016745   MOV    WHO,-(TP)
027232
38 07532 075015   FSUB   TP
39 07534 075023   FMUL   TP
40 07536 016580   MOV   TP,R0
41 07540 016045   MOV   2(R0),-(TP)
000002
42 07544 011945   MOV   (R0),-(TP)
43
44 07546 064767   JSR   PC.IOF
090002
45 07552 016745   MOV   BRTHO+2,-(TP)
051166
46 07556 016745   MOV   BRTHO,-(TP)
051160
47 07562 075000   FADD   TP
48 07564 012567   MOV   (TP)+,BRTHO
051152
49 07570 012567   MOV   (TP)+,BRTHO+2
051150
50 07574 016745   MOV   CO2+2,-(TP)
053044
51 07600 016745   MOV   CO2,-(TP)
050236
52 07604 075005   FADD   TP
53 07606 012567   MOV   (TP)+,CO2
050230
54 07612 012567   MOV   (TP)+,CO2+2
050226
55 07616 004767   JSR   PC.IOH
000004
56 07622 000167   JMP   EXLOOP
176688
57
59
59
:END OF GAS EXCHANGE CALC

:VO2 THIS DELTA AS IN CO2

:THIS LABEL IS CONFUSING

:IT IS REALLY CURRENT OXYGEN, NOT CARBON DIOXIDE
THESE ROUTINES WERE ADVANTAGEOUS BECAUSE CANNOT USE MTPS #X FROM ROM

<table>
<thead>
<tr>
<th>Line</th>
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<td>007626 010446</td>
<td>IN thất: MOV</td>
<td>007630 10C704</td>
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<td>3</td>
<td>007630 10C704</td>
<td>MTPS</td>
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<td>4</td>
<td>007632 042704</td>
<td>BIC</td>
<td>007636 106404</td>
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<td>MTPS</td>
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<td>6</td>
<td>007640 012604</td>
<td>MOV (SP) , R4</td>
<td>007642 60U527</td>
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<td>007642 60U527</td>
<td>RTS</td>
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<td>LOOP</td>
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<td>007656 012604</td>
<td>MOV (SP) , R4</td>
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</table>
TITLE: GASEXC END OF BREATH

1 007662 005007 GSEOB: CLR
024170
2 007666 005267 INC
050184
3 007672 016780 MOV
050153
4 007676 016781 MOV
050124
5 007702 012783 MOV
050164
6 007706 017382 MOV
051040
7 007710 016745 MOV
051032
8 007716 016745 MOV
050124
9 007720 016745 MOV
050132
10 007724 016745 MOV
050164
11 007730 016745 MOV
050196
12 007734 016745 MOV
051032
13 007738 016745 MOV
050124
14 007744 004767 JSR
005776
15 007748 004767 JSR
005766
16 007752 004767 JSR
005750
17 007756 004767 JSR
004767
18 007760 016745 MOV
050774
19 007764 016745 MOV
051032
20 007768 016745 MOV
050124
21 007772 004767 JSR
005776
22 007776 016745 MOV
051032
23 007780 016745 MOV
050124
24 007784 016745 MOV
051032
25 007788 016745 MOV
050124
26 007792 016745 MOV
051032
27 007796 016745 MOV
050124
28 007800 016745 MOV
051032
29 007804 016745 MOV
050124
30 007808 016745 MOV
051032
31 007812 016745 MOV
050124
32 007816 016745 MOV
051032
33 007820 016745 MOV
050124
34 007824 016745 MOV
051032

HERE.R1 HAS TIM IN NO OF 80 MSEC HACKS
ON STACK 02,CO2,TV SCALED AND INTEGERIZED
35
36
37
38
39 16630 015790
   047750
40 16634 016126
   MOV   RL, (DR)+
41 16636 012950
   MOV   (TP)+, (DR)+
42 16640 012520
   MOV   (TP)+, (DR)+
43 16642 012520
   MOV   (TP)+, (DR)+
44 16644 010067
   MOV   RL, PTSTUF
   047734
45 16650 001767
   JSR   PC, ION
   177592
46
47 16654 012700
   MOV   #BRTHO, R0
   001742
48 16656 012991
   MOV   S.G, R1
   000986
49
50 16664 009020
   CLRBRT: CLR   (TP)+
51 16666 007102
   SDB   R1, CLRBRT
52 16670 005767
   TST   OFlag
   000662
53 16674 003410
   BLE   GSLVL.P
54
55 16676 005067
   CLR   OFlag
   050684
56 16802 002767
   RIS   #=400, DRBO
   000486
57 16818 012767
   MOV   #1, R1,ROS
   157662
58 16818 009367
   GSLVL.P: JMT   Z/LOOP
   170364

ORIGINAL PAGE IS PRINT
.TITLE SLOP SUBROUTINES

;ROUTINE TO RESET PTC BUFFERS

010122 012767 PTCSV:
  MOV #PTH5,P9H
010130 012767 MOV OPTW5,PSVWL
010136 012767 MOV 4PTGAS,PTSTUF
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
10156 012267. MC7V(R2)+, PRDNCT
10162 001416 DEQ PROND
10164 012201 MOV (R2)+$R1
10166 100005 	BPL NOPRQ ;NO CARDiac OUTPUT REQUEST
10170 005467 	NEG PROND ;MINUS SAYS CARDIACOUTPUT
10144 042767 	BIC *200,DRBO ;Q LIGHT
10202 010267 NOPRG: MOV R2,PROGET
10206 010167 MOV R1,DAC1 ;CONTROL WORK LOAD THE EASY WAY
10212 012662 MOV (SP)+,R2
10214 012201 MOV (SP)+,R1
10216 000207 RTS PC
36 10220 012767 PROND: MOV *1,EOTPG
37 10226 012767 MOV *400,EOTCT
38 10234 042767 BIC *1,DUM1
THIS routine is entered with the address of a floating variable
in R2 and a time (delta t) in R3, R4
Fetched the data from @R2, R2+2 divides by the time in minutes, and puts it back

6 010756 816245 NORM  MOV  2(R2), -(TP)
7 010762 811245 MOV  (R2), -(TP)
9 010764 810245 MOV  R3, -(TP)
9 010766 810445 MOV  R4, -(TP)
10 010770 875035 FDIV  TP
11 010772 812512 MOV  (TP)+, (R2)
12 010774 812562 MOV  (TP)+,2(R2)
13 11000 000207 RTS  PC
NORMALIZATION OF PDF

RT-11 MACRO M32-12

011002  016781  WRITIT:  MOV  FRSTPT.R1  ;THE ADDRESS OF THE LABEL

011005  016146  MOV  R1,-(SP)  ;WHERE TO STICK THE FORMATTED LETTERS

011010  017746  MOV  @FMTPT,-(SP)  ;GET THE Y PART OF THE PACKED FORMAT

011014  062767  ADD  #2,FMTPT

011022  017746  MOV  @FMTPT,-(SP)  ;MOVE THE X PART

011026  062767  ADD  #2,FMTPT

011034  016799  MOV  ADD2PT.R0

011040  018846  MOV  2,(R0),-(SP)

011044  018846  MOV  (R0),-(SP)

111046  062799  ADD  #4,R0

111052  016067  MOV  R0,ADD2PT

111056  004767  JSR  PC,FFMT

111062  062767  ADD  #24,FRSTPT

111070  005367  DEC  NUMLFT

111074  001886  BNE  WL/WL/WL

111076  012700  TYPE  BUFFER

111076  012700  MOV  #BUFFER.R0

111082  004767  JSR  PC,LPTGO

111086  005967  CLR  OUTWFG

111112  001617  WL/WL/WL:  JMP  EXLOOP

20  :THIS ROUTINE IS A CLUDGE WITH A CAPITAL K
21  :MUST BE RUN THROUGH ONCE PER LINE
22  :BUT DON'T HAVE TIME TO WAIT ALL DAY OR WILL LOSE GAS DATA
23  :MY O MY WHAT TO DO WHEN WE GET A PRINTER!!!!!!!!!!!!!!!!!!!!!!!!!!!
I forgot to do anything to work load.

; Converting SBP ad converter units to MMHG

18 10572 016745 DBBP: MOV PRSBP,-(TP)
19 10576 004736 JSR PC, IR
20 10602 016745 MOV SBPFAC+2,-(TP)
21 10606 002714 MOV SBPFNC,-(TP)
22 10612 0075023 FMUL TP
23 10614 016745 MOV CBPOFF+2,-(TP)
24 10620 002714 MOV SBPOFF, (TP)
25 10624 0075023 FADD TP
26 10626 012567 MOV (TP)+, PRSBP
27 10632 0047314 MOV (TP)+, PRSBP+2
28 10636 002714 MOV PRDBP,-(TP)
29 10642 0047314 JSR PC, IR
30 10646 0047314 MOV DBPFAC+2,-(TP)
31 10652 002714 MOV DBPFNC,-(TP)
32 10658 0075023 FMUL TP
33 10660 016745 MOV DBPOFF+2,-(TP)
34 10664 002714 MOV DBPOFF,-(TP)
35 10668 0075023 FADD TP
36 10672 0047314 MOV (TP)+, PRDBP
37 10676 0047314 MOV (TP)+, PRDBP+2
38 10682 002714 MOV #1, DSFOUT
39 10686 0047314 MOV #1, OUTWIG
40 10692 002714 MOV #13, HURLFT
41 10696 002714 MOV #PRTIM1, ADD2PT
34 10732 012767  
    MOV  #X001, FMTPT

35 10746 012767  
    MOV  #BUFFER+12, FRSTPT : THIS IS SETTING POINTERS

36

37

38 10746 005007  
    CLR  PRTFLG : FOR THE PRINT ROUTINE

39 10752 009107  
    JMP  EXLOOP : WHICH PRINTS ONE LINE AT A TIME
36 10418 012762 MOV *PRC02, R2
068122
37 10414 004767 JSR PC, NORM
068336
38 10426 012762 MOV *PEN/, R2
068126
39 10424 004767 JSR PC, NORM
068326
40 10430 012762 MOV *PR02, R2
068116
41 10434 004767 JSR PC, NORM
068316

THE ABOVE WERE TO NORMASLICE ALL THE TIME DEPENDENT CRAP IE X/MIN

44 10448 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 10468 012782 MOV *PERR, R2
068132
49 10464 004767 JSR PC, NORM
068266

50
51
52
53
54
55 10470 016745 MOV PRWL+2, -(TP)
047426
56 10474 016745 MOV PRWL, -(TP)
047412
57 10500 010045 MOV RO, -(TP)
095144
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 0085767 TST PRSLOP WAS A CARDIAC OUTPUT MANEUVER DONE
047412
64 10524 001422 BEQ DOEP
047366
65 10526 016745 MOV PRO2+2, -(TP)
047366
66 10532 016745 MOV PRO2, -(TP)
047366
67 10536 016745 MOV D, 0.0047+2, -(TP)
067214
68 10542 016745 MOV D, 0.0047, -(TP)
067208
69 10546 016745 MOV PRSLOP+2, -(TP)
NORMALIZATION OF PBF

832
39 10242 012602
40 10244 012601
41 10246 000207

MOV (SP)+, R2
MOV (SP)+, R1
RTS PC
.TITLE NORMALIZATION OF PBF

;ROUTINE TO NORMALIZE OUTPUTS AND SET UP FOR PRINT ROUTINE

6 010250 016760 WRITE: MOV PRTIME, R0
  047630
7 010254 016760 MOV PRTIM1, R1
  047622
8 010260 012703 MOV R1, (TP)
  1?????
9 010264 073003 ASHC R3, R0
10 010266 018145 MOV R1, (TP)
11 010270 004767 JSR PC, IR
   005396

12 10274 016745 MOV TIMAC+2, (TP)
  007466
13 10280 016745 MOV TIMAC, (TP)
  007460
14 10284 073025 FMUL TP
15 10288 016745 MOV LSTTIM+2, (TP)
  027420
16 10294 016745 MOV LSTTIM, (TP)
  027412
17 10298 016567 MOV 6(TP), LSTTIM+2
  000006
18 1029C 016567 MOV 6(TP), LSTTIM
  000006
19 10300 016567 MOV 4(TP), LSTTIM
  002737
20 10304 016567 MOV 6(TP), PRTIM2
  004754
21 10308 016567 MOV 4(TP), PRTIM1
  004754
22 1030C 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
23 10310 012504 MOV (TP)+, R4
24 10312 012503 MOV (TP)+, R3
25 10314 016760 MOV PBHR+2, R0
   047530
26 10318 016745 MOV PBHR, (TP)
   047522
27 1031C 004767 JSR PC, IR
   :FLOAT NUMBER OF BEATS SINCE LAST REPORT
28 10320 004767 MOV (TP)+, PBHR
29 10324 012507 MOV (TP)+, PBHR+2
30 10328 012567 MOV #PBHR, P2
31 1032C 068106 JSR PC, NORM
:THESE ROUTINES MUST BE FILLED IN LATER

5 011116 DD6867 SH/PFC: CLR DSCOUT
   D26644
6 011122 DD6167 JMP EXLOOP
   175356
7
8
9
10
11 11126 DUO667 SH/PBF: CLR DSFOUT
    D26632
12 11132 DUO167 JMP EXLOOP
    175358

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
.TITLE CUBIC SPLINE FIT

:ARRAY Z => O2
:ARRAY Y => CO2

7 011136 005967 SPLFIT: CLR SPLRGS
 046644
8 011142 012767 MOV #1.COMPU
 000061
 026602
9 011150 012705 CUBIC: MOV #TSTK,TP
 037112
10 11154 010557 MOV TP.SAV/STK
 023026

:SEPARATE PAIRS FOR LATER USE

14 11160 012700 C0: MOV #IF/DAT,R0
 026006
15 11164 012301 MOV #Z,R1
 030496
16 11170 012702 MOV #V,R2
 051306
17 11174 016703 MOV MPAIR,R3
 026974
18 19 11200 012021 C1: MOV (R0)+,(R1)+
20 11202 012021 MOV (R0)+,(R1)+
21 11204 012022 MOV (R0)+,(R2)+
22 11206 012022 MOV (R0)+,(R2)+
23 11210 017565 SUB R3,C1
1. COMPUTE S1

2. 011212 012700 MOV #WARM.R0

3. 011216 010000 MOV R0.R1

4. 011220 016702 MOV PRO2.R2

5. 011224 001007 BNE C3

6. 011226 016707 C2: MOV DM.R5.S1

7. 011234 016707 MOV DM.R5+S1+2

8. 011242 000420 BR C4

9. 011244 012702 C3: MOV #PRO2.R2

10. 011250 012220 MOV (R2)+, (R3)+

11. 011252 012220 MOV (R2)+, (R3)+

12. 011254 012220 MOV (R2)+, (R3)+

13. 011256 012220 MOV (R2)+, (R3)+

14. 011260 075031 FDIV R1 :R1 -> PRO2/PRO2

15. 011262 016741 MOV DM+2, -(R1)

16. 011266 016741 MOV DM, -(R1)

17. 011272 075021 FMUL R1 :MULTIPLY BY -1

18. 011274 012167 MOV (R1)+, S1

19. 011300 012167 MOV (R1)+, S1+2

20. 011304 016701 C4: MOV NPAIR.I :I=N

21. 011310 001003 MOV I.R3

22. 011316 016703 SUB #2.R3 :NO OF TIMES TO GO THROUGH LOOP

23. 011316 016703 SUB #2.I

24. 011322 006301 ASL I

25. 011324 006301 ASL I :I*I+4

26. 011326 016100 MOV L,IM1

27. 011326 016100 MOV L, IM1

28. 011330 016200 SUB #4,IM1 :IM1=I-4

29. 011334 016004 MOV IM1.R4

30. 011338 062704 ADD #Z.R4

31. 011342 075014 FSUB R4 :Z(N)=Z(N)-Z(N-1)

32. 011344 010102 C5: MOV I.IP1

33. 011346 010001 MOV IM1.I
CUBIC SPLINE FIT   RT-11 MACRO IMD2-12   00:10:02 PAGE 38+

42 11350 162700  SUB   #4, IM1

44 11351 010004  MOV   IM1, R4
45 11356 062704  ADD   #2, R4

46 11362 075014  FSLUB  R4
47 11364 012704  MOV   #WRAR, R4

49 11370 010005  MOV   R4, R5
50 11371 016224  MOV   Z(IP1), (R4) +
51 11376 016224  MOV   Z+2(IP1), (R4) +

52 11382 016124  MOV   Z(I), (R4) +
53 11406 016124  MOV   Z+2(I), (R4) +

54 11412 075005  FADD  R5
55 11414 016224  MOV   Z(IP1), (R4) +
56 11420 016224  MOV   Z+2(IP1), (R4) +

57 11424 075035  FDIV  R5

: COMPUTE X(I)
60 11426 012704  MOV   #WRAR, R4

62 11432 010005  MOV   R4, R5
63 11434 016024  MOV   Y(IP1), (R4) +
64 11440 016024  MOV   Y+2(IP1), (R4) +
65 11444 016124  MOV   Y(I), (R4) +
66 11450 016124  MOV   Y+2(I), (R4) +
67 11454 075015  FSUB  R5
68 11456 016445  MOV   Z(R4), -(R5)

69 11462 016445  MOV   0(R4), -(R5)
70 11466 075025  FMUL  R5
71 11470 016745  MOV   D3.0+2, -(R5)

72 11474 016745  MOV   D3.0, -(R5)
73 11500 075025  FMUL  R5
74 11502 016145  MOV   Z+2(I), -(R5)
75 11506 016145  MOV   Z(I), -(R5)
76 11512 075035  FDIV  R5
77 11514 012704  MOV   #WRAR+4, R4

: R5 = WRAR + 10
: R5 = WRAR + 10

: GET G

: R5 = R5 * G

: R5 = 3.0 * R5

: WRAR + 4 = [3.0 * G * (Y(I) - Y(I-1)) / Z(I)]
CUBIC SPLINE FIT

037130
73 11529 016485
MOV R4, R5
80 11532 016124
MOV Y(I), R4
81 11526 016124
MOV Y(I+1), R4
82 11542 016224
MOV Y(IP1), R4
83 11536 016224
MOV Y+2(IP1), R4
84 11542 075015
FSUB R5
85
88 11544 016745
MOV D1.0+2, -(R5)
87 11550 016745
MOV D1.0, -(R5)
89 11557 162705
SUB #4, R5
90 11560 075015
FSUB R5
91 11562 016745
MOV D3.0+2, -(R5)
92 11566 016745
MOV D3.0, -(R5)
93 11572 075025
FMUL R5
94 11576 015225
FMUL Z(IP1), -(R5)
95 11582 016245
MOV Z(IP1), -(R5)
96 11606 075065
FDIV R5
97 11610 012704
MOV #4*AR+4, R4
99 11614 016544
MOV 2(R5), -(R4)
100 1620 011544
MOV (R5), -(R4)
101 1622 075004
FADD R4
102
103 1624 012461
MOV (R4)+, X(I)
104 1630 012461
MOV (R4)+, X+2(I)
105
106 1654 000402
BR +6
107 1636 000167
35A: JMP C5
110 1177502
180 1652 077363
SDB R3, C5A
183 :END OF DO LOOP 3
184
185 1112 1644 012701
CC: MOV #4, I
186 126 012702
MOV IP1
187 1654 016703
MOV HPAIR, R3
189 026114
190 117508
191 1642 077363
SUB R3, C5A
194 :DO LOOP 4
195 1112 1644 012701
CC: MOV #4, I
196 126 012702
MOV IP1
197 1654 016703
MOV HPAIR, R3
199 026114
200 117508
201 1642 077363
SUB R3, C5A
204 :DO LOOP 5
205 1112 1644 012701
CC: MOV #4, I
206 126 012702
MOV IP1
207 1654 016703
MOV HPAIR, R3
209 026114
210 117508
211 1642 077363
SUB R3, C5A
214 :DO LOOP 6
MOV #WKRAR, R4
MOV R4, R5
MOV Z(I), (R4)+
MOV Z+2(I), (R4)+
MOV Z(IP1), (R4)+
MOV Z+2(IP1), (R4)+
FADD R5
MOV Z(IP1), (R4)+
MOV Z+2(IP1), (R4)+
FDIV R5
MOV (R5)+, Z(I)
MOV (R5)+, Z+2(I)
MOV IP1, I
ADD #4, IP1
SOB R3, C7
END OF DO LOOP 4
CUBIC SPLINE FIT
RT-11 MACRO /M02-12

1: GET READY FOR DO LOOP 5

2 011746 012764
037114

3 011752 013405
MOV R4, R5

4 011754 012701
MOV #4, I

5

6 011760 016124
MOV Z(I), (R4) +

7 011764 016124
MOV Z+2(I), (R4) +

8 011770 016724
MOV S1, (R4) +

9 011774 016724
MOV S1+2, (R4) +

10 120800 075025
FMUL R5

11 120802 016124
MOV X(I), (R4) +

12 120806 016124
MOV X+2(I), (R4) +

13 120812 075015
FSUB R5

14 120814 012561
MOV (R5) +, X+2(I) :

15 120820 012561
MOV (R5) +, X+2(I) :

16

17 120824 012761
MOV #4, I

18 120830 016721
MOV Y(I) +

19 120834 016721
MOV Y+2(I) +

20 120840 016721
MOV D2, 0, (I) +

21 120844 016721
MOV D2, 0, (I) +

22 120850 012761
MOV #4, I

23 120854 012764
MOV #MKAR, R4

24 120860 016405
MOV R4, R5

25 120862 016124
MOV M(I), (R4) +

26 120866 016124
MOV M+2(I), (R4) +

27 120872 016124
MOV X(I), (R4) +

28 120876 016124
MOV X+2(I), (R4) +

29 121002 075025
PDI R5

30 121004 012561
MOV (R5) +, X(I) :

31 121100 012561
MOV (R5) +, X+2(I) :

32 121112 012764
MOV #MKAR, R4
CUBIC SPLINE FIT

RT-11 MACRO WM02-12

34 12120 016405
    MOV R4, R5
35 12122 016124
    MOV Z(I), (R4)+
36 12126 016124
    MOV Z+2(I), (R4)+
37 12132 016724
    MOV D1.0, (R4)+
38 12136 016724
    MOV D1.0+2, (R4)+
39 12142 075015
    FSUBB R5
40 12144 016745
    MOV DM1+2, -(R5)
41 12150 016745
    MOV DM1, -(R5)
42 12154 075025
    FMUL R5
43 12156 016145
    MOV W+2(I), -(R5)
44 12162 016145
    MOV W(I), -(R5)
45 12166 075035
    FDIV R5
46 12170 012581
    MOV (R5)+, W(I)
47 12174 012581
    MOV (R5)+, W+2(I)

49 49
CUBIC SPLINE FIT Program

DO LOOP 5

012206 016793 MOV NPAIR, R3
012204 162703 SUB #3, R5 : COUNTER
012210 012791 MOV #18, I
012214 012790 MOV #4, IM1
012220 012704 CR: MOV #4, IM1
012224 010405 MOV D4, R5
012226 016024 MOV W(IM1), (R4)+
012232 016024 MOV W+2(IM1), (R4)+
012236 015124 MOV Z(I), (R4)+
012242 016124 MOV Z+2(I), (R4)+
012246 075025 FMUL R5
012250 016745 MOV D2.0+2, (R5)
012254 016745 MOV D2.0, -(R5)
012260 075005 FADD R5
012262 012361 MOV (R5)+, W+1
012266 032746 MOV D1.0+2, -(R5)
012272 016745 MOV D1.0+2, -(R5)
012276 016745 MOV D1.0, -(R5)
012280 016145 MOV Z+2(I), -(R5)
012284 016145 MOV Z(I), -(R5)
012290 075015 FADD R5
012310 016945 MOV W(IM1), -(R5)
012314 016945 MOV X(1M1), -(R5)
012320 016945 MOV X(1M1), -(R5)
012324 075025 FMUL R5
012326 015124 MOV X(I), (R4)+
012330 015124 MOV X+2(I), (R4)+
012336 075015 FADD R5
012340 016145 MOV W+2(I), -(R5)
012344 016145 MOV W(1), -(R5)
012348 075033 FDIV R5
CUBIC SPLINE FIT RT-11 MACRO IMB2-12 00:18:02 PAGE 41

:DO LOOP 6
1 812454 816781
2 MOV NPAIR, I
3 025314
4 812459 816103
5 MOV I, R3
6 812462 162783
7 SUB #2, R3 ; COUNTER
8 000002
9 812466 162781
10 SUB #2, I
11 000002
12 812472 086381
13 ASL 1
14 086381
15 812474 086381
16 NSL I
17 812476 010102
18 MOV L, IP1
19 006301
20 812478 012454
21 ADD #4, IP1
22 006301
23 812500 062702
24 START LOOP
25 12504 012704 C9: MOV R4, R5
26 037114
27 12508 018405
28 MOV W(I), (R4)+
29 032746
30 12510 018124
31 MOV W+2(I), (R4)+
32 032126
33 12512 016224
34 MOV X(IP1), (R4)+
35 032126
36 12516 016124
37 MOV X+2(IP1), (R4)+
38 032130
39 12518 077325
40 FMUL R5
41 032130
42 12522 016561
43 MOV X(I), -(R5)
44 032126
45 12524 016145
46 MOV X(I), -(R5)
47 032126
48 12526 077325
49 FADD R5
50 032126
51 12528 012561
52 MOV (R5)+, X(I)
53 032126
54 12532 012561
55 MOV (R5)+, X+2(I)
56 032130
57 12534 016145
58 MOV X+2(I), -(R5)
59 032130
60 12536 016145
61 MOV X(I), -(R5)
62 032126
63 12538 077325
64 FADD R5
65 032126
66 12540 012561
67 MOV (R5)+, X(I)
68 032126
69 12542 012561
70 MOV (R5)+, X+2(I)
71 032130
72 12544 016145
73 MOV X(I), -(R5)
74 032126
75 12546 077325
76 FADD R5
77 032126
78 12548 012561
79 MOV (R5)+, X(I)
80 032126
81 12550 012561
82 MOV (R5)+, X+2(I)
83 032130
84 12552 016145
85 MOV X(I), -(R5)
86 032126
87 12554 077325
88 FADD R5
89 032126
90 12556 012561
91 MOV (R5)+, X(I)
92 032126
93 12558 012561
94 MOV (R5)+, X+2(I)
95 032130
96 12560 016145
97 MOV X(I), -(R5)
98 032126
99 12562 077325
100 FADD R5
101 032126
102 12564 012561
103 MOV (R5)+, X(I)
104 032126
105 12566 012561
106 MOV (R5)+, X+2(I)
107 032130
108 12568 016145
109 MOV X(I), -(R5)
110 032126
111 12570 077325
112 FADD R5
113 032126
114 12572 012561
115 MOV (R5)+, X(I)
116 032126
117 12574 012561
118 MOV (R5)+, X+2(I)
119 032130
120 12576 016145
121 MOV X(I), -(R5)
122 032126
123 12578 077325
124 FADD R5
125 032126
126 12580 012561
127 MOV (R5)+, X(I)
128 032126
129 12582 012561
130 MOV (R5)+, X+2(I)
131 032130
132 12584 016145
133 MOV X(I), -(R5)
134 032126
135 12586 077325
136 FADD R5
137 032126
138 12588 012561
139 MOV (R5)+, X(I)
140 032126
141 12590 012561
142 MOV (R5)+, X+2(I)
143 032130
144 12592 016145
145 MOV X(I), -(R5)
146 032126
147 12594 077325
148 FADD R5
149 032126
150 12596 012561
151 MOV (R5)+, X(I)
152 032126
153 12598 012561
154 MOV (R5)+, X+2(I)
155 032130
156 12599
**:RESTORE STATE OF NATURE**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>012602 016705</td>
<td>C10: MOV SAVSTK, TP</td>
</tr>
<tr>
<td>4</td>
<td>012606 000167</td>
<td>JMP EMLOOP</td>
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</table>
R (INSTANTANEOUS)  RT-11 MACRO VMD2-12  00:10:02 PAGE 43

.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

8 012617 005067 INSHQ:  CLR  QCOMFU
9 012618 012700 RINST:  MOV  #PVDAT.R0
  020000
10 12622 016783 MOV  HPAIR.R3
12 12626 012781 MOV  #2.R1
13 12632 012921 RINS1:  MOV  (R0)+(R1)+
15 12634 012821 MOV  (R0)+(R1)+
16 12630 082700 ADD  #4.R0
    000004
17 12642 077305 SUB  R2.RINS1
18 19 12644 012781 MOV  #4.I
20 12658 016783 MOV  HPAIR.R3
21 12654 012783 SUB  #2.P3
22 22 12668 012780 RINS1:  MOV  #WKR+4.R0
23 037128
25 12664 010992 MOV  R8.R2
26 12666 016684 MOV  X(I), (R0)+
    032126
27 12672 016190 MOV  X+2(I), (R0)+
    032136
28 12676 016728 MOV  DM1, (R0)+
    004026
29 12702 00172B MOV  DM1+2, (R0)+
    004924
30 12706 075022 FMUL  R2  R2  ;R2 -> ABS(SLOPE)
31 12710 011267 MOV  (R2), WKR+4
    024284
32 12714 016267 MOV  2(R2), WKR+6
    000032
    024230
33 12722 016198 MOV  Z(I), (R0)+
    07F436
34 12726 016120 MOV  Z+2(I), (R0)+
    036478
35 12732 075022 FMUL  R2  R2  ;R2 -> F02 * S
36 12734 016142 MOV  Y+2(I), -(R2)
    031316
37 12740 016142 MOV  Y(I), -(R2)
R (INSTANTANEOUS)  RT-11 MACRO VMB2-12 08:10:02 PAGE 43+

031306

39 12744 075012  FSUB R2  :R2 -> S*FO2 - FC02
40 12746 012702  MOV #WKR1.R2
41 12752 014062  MOV -(R0),2(R2)
42 12756 014012  MOV -(R0),(R2) ;PUT SFO2-FC02 INTO WKR1(1)
43 12760 075012  FSUB R2
44 12762 016740  MOV D1.4(R8)
003762
800004
45 12770 016760  MOV D1.6+2.6(R0)
023756
000006
46 12776 075010  FSUB R0  :R0 -> 1-SFO2-FC02
47 13000 016042  MOV Z(R0),-(R2)
48 13004 016062  MOV -(R0),-(R2)
49 13008 011942  MOV (R0),-(R2)
50 13010 075032  FDIV R2
51 13018 012261  MOV (R2)+.W(1)
032764
52 13014 012261  MOV (R2)+.W+2(1)
032750
53 13020 062701  ADD #4, I
000004
54 13024 077363  SOB R3.RIN1
55
56 ;COMPUTE LINEAR REGRESSION OF FC02 AS A FUNCTION OF RINST
57 STORE ABS(SLOP) IN CSLOP
58 ;
59 ; ARRAY: W -> RINST
60 ; Z -> FO2
61 ; Y -> FC02
62
63 13026 004767  RINLRG: JSR PC.CLRSUM :CLEAR EX.EY.EXY..EX2
64 13030 063802
65 13032 012735  MOV #TSTK,TP
037112
66 ;IGNORE ENDPOINTS
67 13036 016703  MOV NPAIR.R3
024732
68 13042 012703  SUB #2, R3
000002
69 13046 012701  MOV #4, I
000004
70 13052 016145  RIN5: MOV W+2(1),-(TP) ;RINST
032799
71 13056 016145  MOV W(1),-(TP)
032746
72 13062 016145  MOV Y+2(1),-(TP)
031310
73 13066 016145  MOV Y(1),-(TP) ;FC02
031306
74 13072 004767  JSR PC.CLRSUM
75 13076 062701  ADD   #4.1
    000004
76 13102 077315  SUB    R3, RIN5
77 13104 004767  JSR    FC, LCO
                          :GET SLOPE AND INTERCEPT
                          :SUMMATIONS COMPLETED
79 13110 012700  MOV    #HKAR, R0
    037114
80 13114 015002  MOV    R0, R2
81 13116 012520  MOV    (TP)+, (R0)+
82 13120 012520  MOV    (TP)+, (R0)+
83 13122 016720  MOV    DML, (R0)+
    003602
84 13126 016720  MOV    DML+2, (R0)+
    003602
85 13132 075022  FMUL   R2
86 13134 016720  MOV    DF13, (R0)+
    004430
87 13140 016720  MOV    DF13+2, (R0)+
    004426
88 13144 075022  FMUL   R2
89 13146 012267  MOV    (PP)+, CSLOP
    044710
90 13152 012267  MOV    (R2)+, CSLOP+2
    044706
91 13156 062705  ADD    #4, TP
    000004
22
93 13162 097567  BOUT:   BIC    #100000, DRAS
                          :CLEAR REG FOR Q BUTTON
                          100000
                          154600
94 13170 052767  BIS    #40, DRAS
                          :INT ENR REQ B
                          000040
                          154572
95 13176 000187  JNP    EXLOOP
    175334
.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
; RETURNS FRACTIONAL GAS VALUES FOR MS OUTPUTS AT TIME OF CALLING
STORES

F02 IN F021
FN2 IN FN21
FCO2 IN FCO21

13204 010046 GETGAS: MOV R8, -(SP)
13206 010146 MOV R1, -(SP)
13218 010246 MOV R2, -(SP)
13212 010346 MOV R3, -(SP)
13214 010446 MOV R4, -(SP)
13216 004767 JSR PC, SAMSAS
13222 010546 MOV R0, -(SP)
13224 010646 MOV R1, -(SP)
13226 010745 MOV R0, -(IP)
13230 004767 JSR PC, IR
13234 010845 MOV O2CF2, -(TP)
13240 010945 MOV O2CF1, -(TP)
13244 075025 FMUL TP
13246 010A45 MOV R3, -(TP)
13250 004767 JSR PC, IR
13254 010B45 MOV H2CF2, -(TP)
13260 010C45 MOV H2CF1, -(TP)
13264 075025 FMUL TP
13266 010D45 MOV R4, -(TP)
13270 004767 JSR PC, IR
13274 010E45 MOV CO2CF2, -(TP)
13280 010F45 MOV CO2CF1, -(TP)
13284 075025 FMUL TP
13286 011045 MOV TP, R4
13290 011145 MOV IE(R4), -(TP)
13294 075025 FMUL TP
13296 011245 MOV TP, R4
132A0 011345 MOV IE(R4), -(TP)
132A4 075025 FMUL TP
132A6 011445 MOV TP, R4
132B0 011545 MOV IE(R4), -(TP)
MASS SPEC HANDLER
RT-11 MICRO /MIP-12
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47 13314 016445
MOV 10(R4),-(TP)
48 13320 016445
MOV 6(R4),-(TP)
49 13324 016445
MOV 4(R4),-(TP)
50 13330 016445
MOV 2(R4),-(TP)
51 13334 011445
MOV 0(R4),-(TP)
52 13336 075005
FADD TP
53 13340 075005
FADD TP
54 13344 012501
MOV (TP)+,R1
55 13344 012502
MOV (TP)+,R2
56 13346 062785
ADD #177774,TP
57 13352 075035
FDIV TP
58 13354 012567
MOV (TP)+,FCO2
024316
59 13360 012567
MOV (TP)+,FCO2
024314
60 13364 010245
MOV R2,-(TP)
61 13366 010145
MOV R1,-(TP)
62 13370 075035
FDIV TP
63 13372 012567
MOV (TP)+,FN2
024274
64 13376 012567
MOV (TP)+,FN2
024272
65 13382 010245
MOV R2,-(TP)
66 13384 010145
MOV R1,-(TP)
67 13386 075035
FDIV TP
68 13410 012567
MOV (TP)+,FO2
024252
69 13414 012567
MOV (TP)+,FO2
024250
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
SUBROUTINE SAMGAS

CALLING SEQUENCE

JSR PC,SAMGAS

USES FROM RAM

O2CTRL
N2CTRL
C2CTRL

MSM/RT 0-DONT INVERT
NEGATIVE INVERT

RETURNS
R0-AD02
R1-ADN2
R2-ADCO2

ALSO ZAPS R3, R4

13434 016737 SAMGAS: MOV O2CTRL,#ADSR ;SAMPLE O2
023516 026770

13442 033727 GCKO: BIT #ADSR,#200
176770 006260

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 026770

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 026770

13512 033727 GCKC: BIT #ADSR,#10200
176770 010200

13520 001774 BEQ GCKC
13522 100770 BMI GSAMC
44 13524 013762
176772
45 13530 005767
024146
46 13534 006003
47 13536 005100
48 13540 005101
49 13542 005102
51 13544 000207
52

MOV @AD IN.R2 :SAVE SAMPLED CO2
TST MSHRPT
BGE SGL/V
COM R0
COM R1 :FOR MS WITH NEGATIVE OUTPUTS
COM L2
RTS PC
; SUBROUTINE CALMS

; ENTER WITH JSR PC.CALMS

; THIS ROUTINE READS THE MSTYPE, GETS APPROPRIATE
; GAINS, FULL SCALES, ETC. AND COMPUTES CALIBRATION
; FACTORS FOR THE SIGNALS
; THIS ROUTINE DESTROS 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

30 13546 010546 CALMS: MOV R5,-(SP) ; SAVE R5
31 13550 013700 MOV @GDRAI,R0
167774
32 13554 042700 BIC #177747,R0 ; STRIP GARBAGE BITS
177747
33
34 ; ASH #76,R0 ; ROTATE THE MOTHER RIGHT
35 ; (CORRECT FOR ROM COMPATIBILITY)
36 13560 012703 MOV #76,R3
000076
37 13564 072003 ASH R3,R2
38 13566 016067 MOV OCTMSO(R0),O2CTRL
017432
023362
39 13574 016067 MOV OCTMSO(R0),N2CTRL
017442
023356
40 13602 014067 MOV CCTMSO(R0),C2CTRL
017452
023352
41 13610 016067 MOV INVRT0(R0),MSNVRT
017462
024064
42 13616 016067 MOV CAPDLY(R0),MSDLY
017472
024072
43 13624 012705 MOV #31,R5
000031

8 5 6
IBM

ASS SPEC HANDLER RT-11 MACRO VM02-12 08:10:02 PAGE 46+

44 13630 016704 MOV FV'DATA, R4
45 13634 005000 CLR R3 ;ERROR CK CTR
46
47
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83
84

. IF DF, LINC

13636 000001 CSRPT: WAIT

13636 000001 CSRPT: WAIT

. ENDC

. IF HDF, LINC

13640 004767 JSR PC, SANGAS

13636 000001 CSRPT: WAIT

13644 010024 MOV R0, (R4)+

13646 010124 MOV R1, (R4)+

13648 010224 MOV R2, (R4)+

13652 020267 CMP R2, CO2TRS ;CO2 ABOVE CAL GAS LEVEL?

13656 003642 BGT CSRPT1

13660 005203 INC R3 ;ERROR

13662 077513 CSRPT1: SOR R5, CSRPT

13664 020327 CMP R3, #8

13670 002057 BGE ERRLY ;BAD CAL GAS. NO

13674 002057 BGE ERRLY ;CO2. MS OFF OR ROOM AIR IN
ARRIVING HERE, WE HAVE 25 O2, N2, CO2 SAMPLES IN RAM STARTING ABOUT FVDAT.

:GET R5 BACK

ADDRESS OF FIRST O2 SAMPLE

:GET CAL GAS VALUES

MOV (SP)+, R5

MOV FV/DATA, R0

MOV CGF02, R1

MOV CGF02+2, R2

JSR PC, CGAVG

MOV R0, 02CF1

MOV R1, 02CF2

MOV RG02+2, R2

JSR PC, CGAVG

MOV R0, N2CF1

MOV R1, N2CF2

MOV FV/DATA, R0

ADD #2, R0

MOV CGF N2, R1

MOV CGF N2+2, R2

JSR PC, CGAVG

MOV R0, N2CF1

MOV R1, N2CF2

MOV FV/DATA, R0

ADD #4, R0

MOV CGF CO2, R1

MOV CGF CO2+2, R2

JSR PC, CGAVG

MOV R0, CO2CF1

MOV R1, CO2CF2

CLR R0

TYPE COGM

MOV #COGM, R0

JSR PC, LPTGO

RTS PC
            IF DF.LINCLK
   35 14030 012700 ERRLV: MOV #=-1,R0
   36 14034 010067 MOV R0,DUM2
   37 14040 012605 MOV (SP)+,R5
   38 14042 MOV R5
   39 14042 012700 MOV #=.CBDM,R0
   40 14042 017636 JSR PC.LPT60
   41 14046 004767 003766
   42 14052 000207 RTS PC
   43
   44
   45 ERRLV: .IF MDF.LINCLK
   46 CLR @PCS
   47 MOV (SP)+,R5
   48 MOV #=-1,R0
   49 RTS PC
   50 .ENDC
RT-11 MACRO VM02-12

1 014054 016704 CGA/G: MOV FV/DATA,R4
003436
2 014060 002704 ADD #300.R4
000330
3 014066 010245 MOV R2, -(TP) :CAL GAS VALUE
4 014066 010445 MOV R1, -(TP)
5 014070 016745 MOV F760+2, -(TP)
003330
6 014074 016745 MOV F760, -(TP) :BTPS
003330
7 014100 0075025 FMUL TP
000322
8 014102 012045 MOV (R8)+, -(TP) :A/D VALUE
9 014104 004767 JSR PC, IR :FLOAT IT
001542
10
11
12
13 014110 012704 MOV #30, R4
000030
14
15
16
17
18 014114 062704 CMOR: ADD #4, R8
000004
19 014120 012845 MOV (R8)+, -(TP)
20 014122 004767 JSR PC, IR :FLOAT NEXT VALUE
001524
21 014126 0075085 FADD TP
22 014130 007447 SCB R4, CMOR :AVERAGE THE 25 VALUES
23 014132 016745 MOV CFL25+2, -(TP)
003272
24 014136 016745 MOV CFL25, -(TP)
00C664
25 014142 0075035 FDIV TP :DIVIDE SUM BY 25
26 014144 0075035 FDIV TP
27 014146 012300 MOV (TP)+, R8 :% = AVG/(CALGAS*BTPS)
28 014150 012591 MOV (TP)+, R1
29 014152 000207 RTS PC
30
.TITLE SPIROMETER CONTROL

;SUBROUTINE SPIRO -   MONITOR SPIRO STATUS
;             -   CONTROL VALVE
;             -   DETERMINE BREATH STATUS

;ENTER WITH:    R2=SAMPLED SPIROMETER VALUE
;               R1=DATA BUFFER ADDRESS
;               R6=COUNTER FOR F/DAT
;               R3=GENERAL INDICATOR

; SPIROMETER CONTROL - BIT 0 OF DRAS

14 14154 010046 SPIRO: MOV R0, -(SP)
15 14156 020267 CMP R2, THRESH
16 14162 100422 BMI BELOW
17 14164 032767 BIT #1, DRAS
   000001 155576
18 14172 000001 CMP R2, THRESH
19 14174 000001 MOV R2, R0
20 14176 166700 SUB VLAST, R0
   011624
21 14176 020267 CMP RC, VTHRESH
22 14196 000001 BMI LESS
23 14198 016767 MOV WAITT, VWATCH
24 14200 022400 MOV R2, VLAST
25 14222 000001 CLR EOB
26 14226 000431 BR W/RTN
27 14230 032767 BELOW: BIT #1, DRAS ;OPEN?
   000001 155576
30 14236 000001 BNE OPEN ;LIES IT IS CLOSED
31 14240 052767 BIS #1, DRAS
   000001 155576
32 14246 0050007 CLR VLAST
33 14252 016767 MOV WAITT, VWATCH
34 14260 000001 OPEN: CLR R2
35 14262 000167 JMP W/RTN
36 14266 005267 LESS: INC VWATCH
   0117556
37 14272 100407 BMI W/RTN
38 14274 042767 BIC #1, DRAS
; CLEAR PHASED VOL. STACK

2153466
40 14302 005002 CLR R2
41 14304 092767 BIS #I, EOB

42 14312 012600  ; SUBROUTINE VDELSU

43 14316 010046 VDELSU: MOV R0, -(SP)
44 14320 010067 MOV R1, -(SP)
45 14322 001200 MOV #VLSTK, R0
46 14326 010067 MOV R0, VOLPTI
47 14332 017652 MOV R1, VOLPTI
48 14336 0010067 ADD VDELSU, VOLPTI
49 14340 017644 MOV #VLSTK, R0
50 14344 017635 SUB #VLSTK, R0
51 14348 006200 ASR R0
52 14352 017616 MOV WLSTK, R1
53 14356 005021 VDEVR: CLR (R1)+
54 14360 005521  ; CLEAR PHASED VOL. STACK
55 14364 007700 SOB R0, VDEVR
56 14368 012767 MOV #QUADST, QUADI
57 14372 012767 MOV #QUADST, QUADO
58 14376 017624 MOV #1, LSTCK
59 14380 017574 MOV (SP)+, R1
60 14384 012600 MOV (SP)+, R0
61 14388 000207 RTS PC
62 14392 000001
63 14396 017624
64 14400 017624
65 14404 017624
66 14408 000001
67 14412 012600
68 14416 000207
69 14420 000001
70 14424 017624
71 14428 017624
72 14432 017624
73 14436 017624
74 14440 017624
75 14444 017624
76 14448 017624
77 14452 017624
78 14456 017624
79 14460 017624
.TITLE PHASED-DELAY

;SUBROUTINE TO SAVE DELAYED VOLUME AND STUFF GAS FRACTIONS ON STACK NOT SYSTEMS STACK
;ENTER WITH OUTPUT OF SPIRO IN R2
;AFTER GETGAS
;EXIT WITH SPIRO, FN2, FO2, FC02
;PUT IN ALINE ON QUHDST

11 14416 018046 DELAY: MOV R0, -(SP)
12 14420 018700 MOV VOLPTI, R0
13 14424 020027 CMP R0, #VLSTK1
14 14430 081052 BNE DELAY1
15 14432 012700 MOV #VLSTK, R0
16 14436 018220 DELAY1: MOV R2, (R0) +
17 14440 018067 MOV R0, VOLPTI
18 14444 017544 MOV R2, 0
19 14448 011560 MOV VOLPTO, R0
20 14452 017542 CMP R0, #VLSTK1
21 14456 020627 BNE DELAY2
22 14460 010220 DELAY2: MOV (R0) +, R2
23 14464 018067 MOV R0, VOLPTO
24 14468 017542 TST R2
25 14470 005702 TST VOLPTO
26 14472 001036 BNE DARN
27 14474 005707 TST LSTCK
28 14478 017504 CMP R0, #VLSTK1
29 14482 017542 TST LSTCK
30 14486 017467 BNE LSTCK
31 14490 005067 MOV QUADST, R0
32 14494 017470 GOTO NEWKW
33 14498 018600 NEWKW: MOV QUAD1, R0
34 14500 017504 CMP R0, #QUADS1
35 14502 002827 CMP R0, #QUADS2
36 14504 056732 CMP R0, #QUADS3
37 14506 061232 CMP R0, #QUADS4
38 14508 004892 CMP R0, #QUADS5
39 14510 005067 CMP QUAD5, R0
40 14512 017470 BR NEWKW
41 14514 016700 DELAY3: MOV R2, (R0) +
42 14518 016700 MOV FN2, (R0) +
43 14520 025132 MOV FN2+2, (R0) +
44 14522 016700 MOV FO2, (R0) +
023116
42 14550 016720  MOV  FO2+2, (R0)+
023114
43 14554 016720  MOV  FC02, (R0)+
023116
44 14560 016720  MOV  FC02+2, (R0)+
023114
45 14564 010067  MOV  RO, QUAD I
017430
46 14570 012600  MOV  (SP)+, R0
017430
47 14572 000207  RTS  PC
.TITLE REPORT

:SUBROUTINE REPORT - OTR1
:ASSUMES COMPLETION OF FVC AND WO
:MANEUVERS.

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,W035
19 167596

20 :PRINT TITLE
21 14620 016700 MOV DRAI, R0
153150
22 14624 042700 RIC #177770, R0
177778
23 14630 062700 ADD #60, R0
000060

24 :PRINT TITLE
25 :PRTBUF TITLE, 2
26 : (FAKE MACRO, SO WE CAN GET SUBJECT NUMBER OUT)
27 14634 004567 JSR R5, BUFLOD
001716
29 14640 017052 TITLE
30 14642 000062 2
31 14644 110667 MOV/B R0, BUFFER+40
022370
32 14650 012700 MOV #BUFFER, R0
037290
33 14654 004767 JSR PC,LPTGO
001160

34 :MAKE SURE PRINTER IS DONE BEFORE LOADING "BUFFER"
35 14660 132767 KT1: RITB #LPEN.LPTSR
001100
001377
133062
38 14666 001374 BNE KT1
39 :MAKE SURE TTY IS DONE
40 14670 122777 CMPF #TTYGO
000377
002272
41 14676 001374 BNE -.6
42 14700 004567 RPT1: JSR R5, BUFLOD
001652
REPORT BT-11 MACRO VMO2-12  00:10:02 PAGE 51

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
  024076

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 14762 012700  MOV  @BUFFER,R0
  037200

62 14766 004767  JSR  PC,LPTGO
  000046

63
64 14772 132767  KT2:  BITB  @LPEH,LPTSR
  000100
  152750

65 15000 001374  BNE  KT2

66 15002 122777  CMPB  @S77,TTFGO
  000377
  022160

67 15010 001374  BNE  -.6

68 15012 000027  RPT2:  RTS  PC

69 15014 104350  .EXIT  EMT  ^0350
SUBROUTINE RPTSB

015016 004767 RPTSB: JSR PC, FORMAT
000006
015022 062764 ADD #4, R4
000004
015026 062767 ADD #24, FLH2
000024
022142
015034 077014 SUB R0, RPTSB
015036 000087 RTS PC

:PRINTER START ROUTINE

15040 010067 LPTGO: MOV R0, PRTGO
022604
15044 032767 BIT #PR1BM, DRB1 ; LPT SWITCH ON
000001
152712
15052 001407 BEQ LPTGO1 ; LPT SWITCH ON
15054 152767 DISB #LPEN, LPTSR ; SET INTEN
15062 002408 NOP
15064 112767 MOV B #200, LPT ; START LPT CARRIAGE MOVING
002200
152661
15072 032767 LPTG01: BIT #TTYBM, DRB1
003022
152664
15106 001402 BEQ LPTGO2
15108 010067 MOV R0, TTYGO
022062
15106 000027 LPTGO2: RTS PC
20
22
24
26
SUBROUTINE FORMAT - INTERFACE BETWEEN REPORT AND
      FMT (FLOAT TO ASCII)

FORMAT:  
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)
015122 010546 MOV  FLR2,-(SP)
015124 010646 MOV  FY,-(SP)
015126 010746 MOV  FX,-(SP)
015128 010846 MOV  (R4),--(SP)
01512A 010946 MOV  R4,--(SP)
01512C 010A46 MOV  I=LM2,-(SP)
01512E 010B46 MOV  FY,—(SP)
015130 010C46 MOV  FX,—(SP)
015132 010D46 MOV  2(R4),—(SP)
015134 010E46 MOV  0(R4),—(SP)
015136 004746 JSR  PC, FMT
015138 011046 MOV  R3,LSTD
01513A 011146 MOV  (SP)+,R4
01513C 011246 MOV  (SP)+,R3
01513E 011346 MOV  (SP)+,R2
015140 011446 MOV  (SP)+,R1
015142 011546 MOV  (SP)+,R0
015144 004746 JSR  PC, FMT
015146 004746 JSR  PC, FMT
015148 004746 JSR  PC, FMT
01514A 004746 JSR  PC, FMT
01514C 004746 JSR  PC, FMT
01514E 004746 JSR  PC, FMT
015150 004746 JSR  PC, FMT
015152 011646 MOV  (SP)+,R4
015154 011746 MOV  (SP)+,R3
015156 011846 MOV  (SP)+,R2
015158 011946 MOV  (SP)+,R1
01515A 011A46 MOV  (SP)+,R0
01515C 004746 JSR  PC
01515E 004746 JSR  PC
015160 004746 JSR  PC
015162 004746 JSR  PC
015164 004746 JSR  PC
015166 004746 JSR  PC
015168 004746 JSR  PC
01516A 004746 JSR  PC
01516C 004746 JSR  PC
01516E 004746 JSR  PC
015170 000207 RTS  PC

.TITLE FORMAT

;FFMT: ROUTINE TO PROVIDE LIMITED F FORMAT CAPABILITIES.
;WILL PROVIDE FX.Y FORMAT
;X-NUMBER OF DIGITS TO PRINT 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+(1 IF 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, FMT

;CALLS MODIFIED ROUTINE RI WHICH USES R5 AS TP
;ZAPS R0-R4

000060 CHAR=60
`gos text`
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<tr>
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<th>Instruction</th>
<th>Description</th>
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<td>JSR PC, IR</td>
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<td>41</td>
<td>15350075015</td>
<td>FSUB TP</td>
<td>TP now points to difference</td>
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</table>

Reproducibility of the original page is poor.
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

FORMAT RT-11 MACRO WMB-12 08:10:02 PAGE 55

1 015352 016801 FMMDG: MOV R0, R1
2 015354 005800 CLB R0
3 015356 071837 DIV *12, R0
4 070216 10 15562 062791 ADD *60, R1
5 000003 11 15366 111362 MOV/B (R3), R2
6 15370 110113 MOV/B R1, (R3)
7 15372 110243 MOV/B R2, -(R3)
8 15374 005700 TST R0
9 15376 091404 BEQ FMLASP: YES
10 15400 077414 SOB R4, FMMDG
11
12 15402 062795 ADD #4, TP
13 000004 19 15406 061533 BR FMERRO
14 15410 005704 FMLASP: TST R4
15 15412 001403 BEQ FMFRC
16 15414 116743 FMFRA: MOV/B FMFRC, -(R3)
17 002105 16 15420 077403 SOB R4, FMFRA
18
19 15422 016684 FMFRA: MOV 10(SP), R4
20 000018 20 15426 003003 BGT FFRCC
21 15430 062795 ADD *4, TP
22 000004 32 15434 060037 BR FTHROU
23 15438 616745 FFRCC: MOV FMF10K+2, -(TP)
24 002076 34 15442 016684 FFRCC: MOV FMF10K, -(TP)
25 002076 35 15446 062795 ADD *4, TP
26 000004 36 15448 073428 FMUL TP
27 36 15450 001403 JSR PC, R1: FIX FRAC*10000
28 001403 37 15454 001403 JSR PC, R1
29 001403 30 15456 012500 MOV (TP)+, R0
30 002076 31 15458 010003 MOV (SP), R3
31 002076 32 15462 116722 MOV/B FMDOT, (R3)+
33 002076 41 15466 012702 MOV *4, R2
34 001403 42 15472 016001 FMRPTR: MOV R0, R1
35 15474 005000 CLR R0
36 43 15476 071037 DIV *12, R0
37 44 04C12, R0
38 45 04C12, R0

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR.
FORMAT RT-11 MACRO FM22-12  00:10:02 PAGE 55+

078716  ADD  #CHAR.R1
46 15582  062701
47 15506  010145  MOV  R1,-(TP)
48 15510  077210  SOB  R2,FMRPTR
49 15512  016800  MOV  10(SP),R0
50 15516  012702  MOV  #4, R2
51 52 15522  012501  FMRPT: MOV  (TP)+, R1
53 15524  005500  DEC  R0
54 15526  002-481  BLT  FLPND
55 15530  110123  MOV.B R1,(R3)+
56 57 15532  077205  FLPND: SOB  R2,FMRPT
58 15534  011800  FTHROU: MOV  (SP), R0
59 15536  002706  ADD  #12, SP
60 15542  010016  MOV  R0,(SP)
61 15544  000207  RTS  PC
62 63 64 65 15546  016800  FMZRO: MOV  12(SP), R0
66 15552  016801  MOV  6(SP), R1
67 15556  112740  MOV.B #CHAR,-(R0)
68 15562  11740 ZLP: MOV.B FMSPC,-(R0)
69 15566  077103  SOB  R1,ZLP
70 15570  016800  FMZBO: MOV  12(SP), R0
71 15574  016801  MOV  10(SP), R1
72 15600  001755  BEQ  FTHROU
73 15602  116720  MOV.B FMDOT,(R0)+
74 15606  112720  FMZOFO: MOV.B #CHAR,(R0)+
75 15612  077103  SOB  R1,FMZOFO
76 15614  000747  BR  FTHROU
77 78 79 15616  016800  FMERRO: MOV  12(SP), R0
80 15622  016801  MOV  6(SP), R1
81 15626  150100  SUB  R1,R0
82 15630  005300  DEC  R0
83 15632  066601  ADD  10(SP), R1
84 15636  002701  ADD  #2, R1
85 15642  116720  FMERRE: MOV.B FMAST,(R0)+
**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.

**ARGUMENT** IS A FULL WORD ON THE TOP OF THE STACK.

**CONVERSION**

**INTEGER TO REAL**

ARGUMENT IS A FULL WORD ON THE TOP OF THE STACK.

**INTEGER TO REAL**

CONVERT IT TO A REAL FORMAT AND RETURN IT AS THE

**TOP TWO WORDS ON THE STACK.**

PPMP-11 USER'S MANUAL.

**INTEL TO REAL MACRO PME2-12**

00:10:82 PAGE 56

015692 010146 IR: MOV R1, -(SP)
10 15684 010246 MOV R2, -(SP)
11 15696 005045 CLR -(TP); MAKE ROOM FOR RESULT
12 15680 016501 MOV 2(TP), R1; GET INTEGER ARGUMENT
13 000002 000002
14 15660 003002 BGT POS; GET INTEGER ARGUMENT
15 15686 001424 REG ZER
16 15670 005401 NEG R1; GET ABSOLUTE VALUE
17 15664 006145 POS: POL -(TP); SAVE SIGN
18 15674 012702 MOV #220, R2; GET MAX POSSIBLE EXP+1
19 15660 806501 CLR -(TP); MAKE ROOM FOR RESULT
20 15672 006145 MOV R1, -(SP)
21 15676 003402 CLR -(TP); MAKE ROOM FOR RESULT
22 15700 005302 DEC R2; DECREASE EXPONENT
23 15704 007774 BCS NOD; JUMP IF FOUND
24 15706 003402 DEC R2; DECREASE EXPONENT
25 15708 003402 DEC R2; DECREASE EXPONENT
26 15710 005302 DEC R2; DECREASE EXPONENT
27 15712 007774 DEC R2; DECREASE EXPONENT
28 15714 108065 NOD: MOV R1.5(TP); SAVE LOW ORDER FRAC.
29 15720 106001 CLR R1; LOOK FOR NORMAL BIT
30 15724 103402 BCS NOD; JUMP IF FOUND
31 15726 006801 DEC R2; DECREASE EXPONENT
32 15728 006801 DEC R2; DECREASE EXPONENT
33 15730 006801 DEC R2; DECREASE EXPONENT
34 15732 006801 DEC R2; DECREASE EXPONENT
35 15734 001015 MOV R1.0TP; OUTPUT RESULT
36 15736 012602 ZER: MOV (SP)+, R2
37 15740 012602 ZER: MOV (SP)+, R2
38 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 018146 R1: MOV R1, -(SP)
10 15750 018246 MOV R2, -(SP)
11 15752 018346 MOV R3, -(SP)
12 15754 005002 CLR R2 ; CLEAR WORK SPACE
13 15756 005202 INC R2 ; SET UP NORMAL BIT
14 15758 012501 MOV R1,.+(TP); GET REAL ARGUMENT
15 15762 006115 ROL @TP; GET SIGN
16 15764 006101 ROL R1 ; AND
17 15766 006145 ROL -(TP); SAVE IT
18 15770 118103 MOV R1, R3 ; GET HIGH ORDER FRACTION
19 15772 185001 CLR R1
20 15774 020301 SWAB R1 ; GET EXPONENT
21 15776 162701 SUB R2,000001
22 16002 002432 BLT ZERRI ; JUMP IF TOO SMALL
23 16004 001410 BEQ ONERI
24 16006 022701 CMP #15, R1
25 16008 000117 BISB 3(TP), R3
26 16012 002422 BLT OVRRI ; JUMP IF IT IS TOO BIG
27 16014 000303 SWAB R3
28 16016 105003 CLR R3
29 16020 156503 BISE 3(TP), R3
30 16024 073201 SFTRI: ASHC R1, R2
31 16026 005402 ONERI: NEG R2 ; MAKE -
32 16030 102411 BVS NGMR; ; JUMP IF POSSIBLE NEGMAX
33 16032 003612 BGT OVRRI ; JUMP IF MORE THAN 15 BITS
34 16034 006025 SGMRI: ROR (TP)+ ; GET SIGN
35 16036 163401 BCS OUTRI ; JUMP IF -
36 16038 005402 NEG R2 ; - RESULT
37 16040 010215 OUTRI: MOV R2, @TP ; STORE INTEGER RESULT
38 16044 012603 MOV (SP)+, R3
39 16046 012602 MOV (SP)+, R2
40 16048 012601 MOV (SP)+, R1
41 16050 000207 RTS PC
42 16052 000205
43 16054 006025 NGMRI: ROR (TP)+ ; OK IF RESULT TO BE -
44 16056 103771 BCS OUTRI ; FAKE SIGN
45 16058 005745 OVRRI: TST -(TP); SAVE IT
46 16060 000000 HALT
47 16064 004011 BR ZERRI
48 16068 000300 .BYTE 3
49 1606C 820026 .BYTE 22
50 16070 005002 ZERRI: CLR R2 ; ANSWER IS ZERO
51 16072 008708 BR SGMRI
.TITLE  LEAST SQUARES ROUTINES

016074 010046  CLRSUM:  MOVR0,(SP)
016076 010146  MOVR1,(SP)
016100 012700  MOV$EX,R0
016104 012701  MOV#12,R1

016110 005020  CLRSUI:  CLR(R0)+
016112 077102  SOB(R1,CLRSUI)
016114 012601  MOV(SP)+,R1
016116 012600  MOV(SP)+,R0
016120 000207  RTSPC

016122 004767  BTPS:  JSRPC,IR
016126 016745  MOVSLV+2,(TP)
016132 016745  MOVSLV,(TP)
016136 075825  FMULTP
016140 016745  MOVBTPSF+2,(TP)
016144 016745  MOVBTPSF,(TP)
016150 075825  FMULTP
016152 000207  RTSPC
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<tr>
<td>1</td>
<td>:RETURNS WITH TP, TP+2 SLOPE</td>
<td>TP+4, TP+6</td>
<td>INTERCEPT</td>
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<td>2</td>
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<td>3</td>
<td>016154 010946 LSG=MOV RO, -(SP)</td>
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<td>4</td>
<td>016156 010146 MOV R1, -(SP)</td>
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<td>5</td>
<td>016180 016745 MOV NFL, -(TP)</td>
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<td>016154 004767 JSR PC, IR</td>
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<td>016170 016745 MOV EX+2, -(TP)</td>
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<td>016174 016745 MOV EX+2, -(TP)</td>
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<td>016200 075025 FMUL TP</td>
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<td>10</td>
<td>016202 016745 MOV EV+2, -(TP)</td>
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<td>016206 016745 MOV EV, -(TP)</td>
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<td>12</td>
<td>016212 016745 MOV EV+2, -(TP)</td>
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<td>13</td>
<td>016216 016745 MOV EV, -(TP)</td>
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<td>016222 075025 FMUL TP</td>
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<td>15</td>
<td>016224 075015 FSUB TP</td>
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<td>16</td>
<td>016226 012500 MOV (TP)+, RO</td>
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<td>17</td>
<td>016230 012501 MOV (TP)+, R1</td>
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<td>18</td>
<td>016232 016745 MOV EV+2, -(TP)</td>
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<td>016236 016745 MOV EV+2, -(TP)</td>
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<td>016252 075025 FMUL TP</td>
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<td>016254 016745 MOV EV+2, -(TP)</td>
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<td>016260 016745 MOV EV, -(TP)</td>
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<td>016264 016745 MOV EV+2, -(TP)</td>
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<td>016270 016745 MOV EV+2, -(TP)</td>
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<td>016274 075025 FMUL TP</td>
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<td>016276 075015 FSUB TP</td>
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<td>016300 010145 MOV R1, -(TP)</td>
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<td>016302 010045 MOV RB, -(TP)</td>
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<td>016304 075035 FMUL TP</td>
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<td>016306 016745 MOV NFL, -(TP)</td>
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<td>34</td>
<td>016316 016745 MOV EXV+2, -(TP)</td>
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<td>016322 016745 MOV EV, -(TP)</td>
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<td>016326 075025 FMUL TP</td>
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<td>37</td>
<td>016330 016745 MOV EX+2, -(TP)</td>
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LEAST SQUARES Routines RT-11 Macro VM02-12 00:10:02 PAGE 59+

020452
38 16334 016745
020444 MOV EX, -(TP)
39 16340 016745
020444 MOV EV+2, -(TP)
40 16344 016745
020448 MOV EV, -(TP)
41 16350 075025
Fmul TP
42 16352 075015
FSUB TP
43 16354 016145
44 16356 010045
MOV R1, -(TP)
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 TF RESTORED TO VALUE PRIOR
; TO PLACING THE X AND Y VALUES ON THE STACK

: SUM:

MOV RB, -(SP)
MOV TP, RB
MOV 2(RB), -(TP)

MOV (RB), -(TP)
MOV 6(RB), -(TP)
MOV 4(RB), -(TP)

FMUL TP
MOV EY+2, -(TP)
MOV EX+2, -(TP)
MOV EX, -(TP)

FADD TP
MOV (TP)+, EY
FADD TP
MOV (TP)+, EY+2

MOV 6(RB), -(TP)
MOV 4(RB), -(TP)
MOV 4(RB), -(TP)
MOV 4(RB), -(TP)

FADD TP
MOV (TP)+, EY+2
FADD TP
MOV (TP)+, EY+2

FADD TP
MOV (TP)+, EY+2
FADD TP
MOV (TP)+, EY+2

FADD TP
MOV (TP)+, EY+2
FADD TP
MOV (TP)+, EY+2

FADD TP
MOV (TP)+, EY+2
FADD TP
MOV (TP)+, EY+2
LEAST SQUARES ROUTINES  RT-11 MACRO VMB2-12  00:10:02 PAGE 60+

39 16524 016745  MOV  EX+2,-(TP)
39 16525 020256
40 16530 016745  MOV  EX,-(TP)
40 16535 020250
41 16534 079005  FADD  TP
42 16536 012567  MOV  (TP)+, EX
42 16538 020242
43 16542 012567  MOV  (TP)+, EX+2
43 16547 020240
44 16546 005267  INC  NFL
44 16552 020252
45 16552 012600  MOV  (SP)+, R0
46 16554 000020?  RTS  PC
.TITLE TEXT BUFFER LOAD

; SUBROUTINE BUFLOD
; CALLING SEQUENCE
; JSR R5, BUFLOD
; AL ADDR OF MSG
; NUMBER OF LINES

BUFLOD: MOV R0-(5P)
016556 010046
016569 010146
01656E 010246
01656F 010346
016566 010446
016570 01279H
016574 012796
016577 012794
016576 012793
016602 012763
016606 012504
016610 011210
016612 001401
016614 007303
016616 005300
016620 000248
016622 010220
016624 007302
016626 011270
016632 011270
016636 007414
016640 011270
177777
016644 012604
016646 012603
016650 012602
016652 012601
016654 012600
016656 000255
RTS R5

RESIDENT PAGE IS FLOOR
.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
30466 Z: .BLK 200.
31306 Y: .BLK 200.
32126 X: .BLK 200.
32746 W: .BLK 200.

STACK TO HOLD VOLUMES FOR LATER PH2 PHASING
33566 VLSTK: .BLK 75.
34814 000000 VLSTK1: .WORD 0
34816 000000 RVPTR: .WORD 0
: TWO DUMMY WORDS FOR PROM COMPATIBILITY
34020 000000 LOCMYV: .WORD 0
: ADDR+2 OF LOC WITHIN FVDAT OF MAX+1
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 VAL: .FLT2 0
34040 000000 VAL2: .FLT2 0
34044 000000 L0.2: .WORD 0
34046 000000 L1.2: .WORD 0
: DUMMY TO REPLACE OMEH
34050 041710 .FLT2 100.
34052 000000
34054 000000 BRCNT: .WORD 0
: BREATH COUNT IN N2 WO
34056 000000 VPREV: .WORD 0
34060 000000 MAXV+1: .WORD 0
34062 000000 MAXPHN: .FLT2 0
34064 000000
34066 000000 SUM: .FLT2 0
: SUM OF DIFFERENCES BETWEEN VOL SAMPLES (L)
34070 000000
34072 000000 NSUM: .FLT2 0
: SUM OF (VOL. DIFFERENCES * NITROGEN GAS FRACTION)
<table>
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<th>Variable</th>
<th>Description</th>
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<td>FLT2</td>
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<td>INTERCEPT OF LIN REG LINE</td>
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<td>FLT2</td>
<td>SLOPE OF ALVEOLAR PLATEAU IN XEL</td>
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<td>RV+VC%</td>
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VARIABLE DATA

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 QUAQ: .WORD 0

: CIRCULAR BUFFER WITH VOLUME, FO2, FO2

13 36722 QUADST: .BLKW 675.
14 36723 QUADS1: .BLKW 9.
15 36754 QUADNOD: .WORD 0

: CURRENT PHASED VOLUMES AND GASES

19 36726 WWV: .WORD 0
20 36728 WWN: .FLT2 0
21 36734 WWO: .FLT2 0
22 36736 WWW: .FLT2 0
23 36774 SBCLR: .WORD 0
24 36776 SBFLAG: .WORD 0
25 37000 ALTFLG: .WORD 0
26 37002 WWHSCH: 6
27 37004 EX: .FLT2 0. :SUM OF X VALUES
28 37006 EXY: .FLT2 0. :SUM OF Y VALUES
29 37010 EXY: .FLT2 0. :SUM OF (X*Y) VALUES
30 37014 EXY: .FLT2 0. :SUM OF (X**X) VALUES
31 37024 NPL: .FLT2 0.
32 37026 :STACK USED BY TP
33 37112 TSTK: .BLKW 25.
34 37113 TSTK: .BLKW 1
35 37114 WKAR: .BLKW 15.
36 37152 PELO: .WORD 0
37 37154 PRHI: .WORD 0
38 37156 :CALMS DATA
39 37164 000000 Q2CTRL: .WORD 0
40 37166 000000 N2CTRL: .WORD 0
41 37168 000000 C2CTRL: .WORD 0
42 37170 000000 BAD: .WORD 0
43 37176 LSTAD: .WORD 0
44 37178 TTYGO: .WORD 0

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
50 37172 000000 TTYCNT: .WORD 0
51 37174 000000 DUM2: .WORD 0
:COUNT DOWN FROM 5
:CALMS AND ROOM ERROR IND.
.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/RAFM2
037742 000000
037744 000000 ORAT: .FLT2 0 ; O2 RATIO = RAFO2/RAFM2
037746 000000
037750 000000 SPLFLG: .WORD 0
10 37752 000000 QCOMPUT: .WORD 0
11 37754 000000 EOTPFG: .WORD 0
12 37756 000000 EOTCT: .WORD 0
13 37758 000000 SPCNT: .WORD 0 ; CO2 RATIO = RAFCO2/RAFM2
14 37760 000000 PRTFLG: .WORD 0 ; PRINTER BUSY FLAG
18 37770 000000 PRTINTC: .WORD 0 ; COUNTS DOWN FROM 4 TO SAY 40 MSEC ELAPSED
20 37774 000000 NPAIR: .WORD 0
21
22 ; LOCATE IN 12-16K
24 060000 :=60000
25
26 60000 000000 LSTO: .FLT2 0
27 60002 000000
28 60006 000000 PTSTUFF: .WORD 0 ; WHERE TO STUFF THE PTC GAS DATA
29 60008 000000 SPORE: .WORD 0 ; SPLINE FIT REQUEST
30 60010 000000 SCSC: .WORD 0 ; 5 SECOND COUNTER FOR PTC
31 60012 000000 SEC15C: .WORD 0 ; 15 SEC COUNTER FOR PTC
32 60014 000000 PSIP: .WORD 0
33 60016 000000 PSIV: .WORD 0
34 60020 000000 PSVGS: .WORD 0
35 60024 000000 PRADD: .WORD 0
36
37
TITLE BUFFER AREAS

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

060026 000000 TIM1: .WORD 0 ; LSW OF TIME
060020 000000 TIM2: .WORD 0 ; MSW OF TIME
060032 000000 CRR: .WORD 0 ; BUMPED BY HR INTERRUPT.
060034 000000 SWL: .WORD 0 ; NO. OF SAMPLES FOR WORKLOAD
060036 000000 CWL: .WORD 0
060040 000000 CO2: .WORD 0 ; CURRENT CO2
060042 000000 CO2: .FLT2 0
060044 000000 CON: 0
060046 000000 CCO2: .FLT2 0 ; CURRENT OXYGEN
060052 000000 CMP: .FLT2 0 ; CURRENT MINUTE VOLUME
060056 000000 CRR: .FLT2 0
060058 000000 CMV: .FLT2 0 ; CURRENT MINUTE VOLUME
060062 000000 CSLOP: .FLT2 0 ; CARDIAC OUTPUT SLOPE
060064 000000 CODOT: .FLT2 0
060072 000000 CSEP: .FLT2 0
060074 000000 CDBF: .FLT2 0
060076 000000 CDBF: .FLT2 0
060082 000000 PRTIM: .WORD 0
060084 000000 PRTIM2: .WORD 0
060106 000000 PRHR: .FLT2 0
060110 000000 PRNL: .FLT2 0
060114 000000 PRW: .FLT2 0
060116 000000 PRO2: .FLT2 0
060120 000000 PRCO2: .FLT2 0
060124 000000 PRM1: .FLT2 0
060130 000000 PRM2: .FLT2 0
060132 000000 RRR: .FLT2 0
060134 000000 PRSLOP: .FLT2 0
060140 000000 PRSLOP: .FLT2 0
060142 000000 PROGOT: .FLT2 0
060144 000000 PROGOT: .FLT2 0
060146 000000 PRSDP: .FLT2 0
060150 000000 PRSDP: .FLT2 0
060152 000000 PRDBP: .FLT2 0
060154 000000 PRDBP: .FLT2 0
060156 000000 PRFND: .WORD 0

; STORAGE AREA FOR PREVIOUS MINUTE'S DATA

STORAGE AREAS FOR PREVIOUS MINUTE'S DATA
WORKING AREA FOR PTC

; THIS IS A CONTINUOUS BLOCK TO PTEND:

060160 000000 PTCT!: .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
060174 000000 PTW15: .WORD 0
11 60176 PTGAS: .BLKW 80. ; STORED AS 00 MSEC HACK, INTEGER 02
12 ; INTEGER CO2, INTEGER MV FOR EACH BREATH
13 ; REMAINDER OF WORDS 0
14
15 60436 PTCHDR: .BLKW 9.
16 ; BUFFER AREAS FOR PTC FOR TRANSMISSION
17
19 60460 000000 BPTCT: .WORD 0
20 60462 000000 BPTH5: .WORD 0
21 60464 000000 BPTH10: .WORD 0
22 60466 000000 BPTH15: .WORD 0
23 60470 000000 BPW5: .WORD 0
24 60472 000000 BPW10: .WORD 0
25 60474 000000 BPW15: .WORD 0
26 60476 BPWTGAS: .BLKW 80.
27 60736 000000 PTEND: .WORD 0
28 60740 000000 PTHRCT: .WORD 0
29 60742 000000 BRTHO: .FLT2 0
30 60744 000000 BRTHC: .FLT2 0
31 60750 000000 OFLAG: .WORD 0 ; -1 => Q MANEUVER TRIGGERED BUT NOT YET INIT.
32 60756 000000 OFLAG: .WORD 0 ; 0 => Q MANEUVER DONE OR NOT YET TRIGGERED
33 34 35 36 37

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR
600760 000000 NUMFLT: .WORD 0
600762 000000 ADJPT: .WORD 0
600764 000000 FMPT: .WORD 0
600766 000000 FRSTPT: .WORD 0
600770 000000 HOLES: .BLKW 10.
601014 000000 . WORD 0
601016 000000 . WORD 0
601020 000000 . WORD 0
601022 000000 . WORD 0
601024 000000 WOPBFR: .BLKB 6
601032 0400 .BYTE 40
601033 0400 .BYTE 40
601034 0400 .BYTE 40
601035 000000 WONBFR: .BLKB 6
601044 000000 . WORD 0
601046 000000 . WORD 0
601050 000000 . WORD 0
70714 000000 XBUF: .WORD 0
70716 000000 C12: .WORD 0
30 070760 . =TPOF8
31 70760 000000 HEOHIN: .WORD 0
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 VALUE CORRESP. TO LITERS/VOLTS
16666 031546
16670 00231 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 146515
16678 037663 D.35: .FLT2 0.35
16680 031463
16684 040946 D.65: .FLT2 0.65
16686 063146
16690 043273 D6000: .FLT2 6000.
16692 100000
16694 037514 D0.2: .FLT2 0.2 :0.2L BTPS IN SPIROMETER A/D COUNTS
16696 146315
16698 037663 D.35: .FLT2 0.35
16700 031463
16704 040946 D.65: .FLT2 0.65
16706 100000
16708 043273 D6000: .FLT2 6000.
16710 100000
16712 0140500 D3.0: .FLT2 3.0
16714 000000
16716 040200 D1.0: .FLT2 1.0
16718 000000
16720 036777 N0WBLD: .FLT2 0.0312
16722 113444
16724 0000001 XBUF12: .WORD 1
16726 177777 MINI: .WORD -1
16728 140200 DMI: .FLT2 -1.0
16730 000000
16732 140131 DM.85: .FLT2 -0.85
16734 114632
16736 040946 D.65: .FLT2 0.65
16738 000000
16740 040200 D1.0: .FLT2 1.0
16742 000000
16744 040200 D1.0: .FLT2 1.0
16746 000000
16748 140200 DMI: .FLT2 -1.0
16750 000000
16752 000000
16754 137502 D.19: .FLT2 0.19
16756 107554
16758 036643 D.02: .FLT2 0.02
16760 153412
16762 036643 D.02: .FLT2 0.02
16764 153412
16766 036643 D.02: .FLT2 0.02
16768 153412
16770 040213 BTPSF: .FLT2 1.086
16772 001014
1 016774  182  BADAIR: .ASCIZ  /BAD ROOM AIR/
   016775  181
   016776  184
   016777  040
   017009  122
   017001  117
   017002  117
   017003  115
   017004  043
   017005  161
   017006  111
   017007  122
   017010  000

2 017011  183  .ASCIZ  /CORRECT SITUATION/
   017012  117
   017013  122
   017014  122
   017015  103
   017016  103
   017017  124
   017020  048
   017021  122
   017022  111
   017023  124
   017024  123
   017025  161
   017026  124
   017027  111
   017030  117
   017031  116
   017032  000

3 017033  122  .ASCIZ  /PERUN ROOM AIR/
   017034  103
   017035  102
   017036  125
   017047  116
   017040  048
   017041  122
   017042  117
   017043  117
   017044  115
   017045  048
   017046  101
   017047  111
   017049  122
   017051  000

4
5
6
7
PULMONARY FUNCTION REPORT

TITLE: ASCIZ /PULMONARY FUNCTION/

017052  120  ASCIZ /SUBJECT /
017055  125
017054  114
017055  115
017056  117
017057  118
017060  101
017061  122
017062  131
017063  040
017064  106
017065  125
017066  116
017067  103
017068  124
017071  111
017072  117
017073  116
017074  000

017114  106  ASCIZ /FEV1/
017115  105
017116  126
017117  061
017130  000

017121  106  ASCIZ /FVC/
017122  126
017123  103
017124  000

017125  115  ASCIZ /MMFR/
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017132  115  ASCIZ /MEFR/
017133  105
017134  106
017135  122
017136  000
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**CONSTANTS**

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017-42 0-42476 FLT2 760.
017-424 000000
017-426 041510 CFL25: FLT2 25.
017-430 000000
017-432 001030 OCTMSO: WORD 001030
017-434 001030 . WORD 001030
017-436 001030 . WORD 001030
017-438 001030 . WORD 001030
017-440 001030 . WORD 001030
017-442 0004-30 LCHMSO: . WORD 000430
017-444 0004-30 . WORD 000430
017-446 0004-30 . WORD 000430
017-448 0004-30 . WORD 000430
017-450 0004-30 . WORD 000430
017-452 001410 OCTMSO: . WORD 001410
017-454 001410 . WORD 001410
017-456 001410 . WORD 001410
017-458 001410 . WORD 001410
017-460 001410 . WORD 001410
017-462 000000 UNIBTU: . WORD 0
017-464 000000 . WORD 0
017-466 000000 . WORD 0
017-468 000000 . WORD 0
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017-472 0000-10 . WORD 0000-10
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017-498 0000-10 . WORD 0000-10
017-500 0000-10 . WORD 0000-10
017-502 001415 CGFO2: . FLT2 f .1464
017-504 18-17-12
017-506 001116 CGFO2: . FLT2 0.0056
017-508 18-17-12
017-510 11-57-15
017-512 007104 CWF10: . FLT2 0.048
017-514 11-56-46
017-516 008006 FVDATA: . WORD FVDAT
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017-536 4.02000 FHFM1: . FLT2 -1
017-538 14.02000 FHFM1: . FLT2 -1
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017-542 4.41300 FHM1K: . FLT2 10000.
017-544 000000
017-546 4.41300 FHM1K: . FLT2 10000.
017-548 14.02000 FHFM1: . FLT2 -1
017-550 02-134 FHFM1: . FLT2 10000.
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017-556 4.02000 FHFM1: . FLT2 -1
017-558 14.02000 FHFM1: . FLT2 -1
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017-564 000000
017-566 4.41300 FHM1K: . FLT2 10000.
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017-570 02-134 FHFM1: . FLT2 10000.
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1 017506 127 MSG: ASCIZ WHAT BUTTON ???
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017556 101
017511 124
017556 020
017512 125
017558 017
017556 124
017557 117
017560 116
017561 020
017562 017
017543 017
017564 027
017556 000
2 017556 377 .BYTE -1
3 .EVEN
4 017570 042-462 D713: PLT2 713.
017572 040-000
5 017574 000-000 ITHRS: .WORD 6
7 017516 101 MSG: ASCIZ ABORT - RESTART
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017600 117
017601 122
017602 124
017603 040
017604 055
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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

.BYTE -1

.EVEN

.BYTE -1

.EVEN
:THIS IS THE FUNCTIONAL PROTOCOL

REPRODUCIBILITY OF THE ORIGINAL PAGE IS POOR

ROM CONSTANTS-PBF,PTC  RT-11 MACRO VMB2-12  00:10:02 PAGE 81

1 ;THIS IS THE FUNCTIONAL PROTOCOL
2
3 :REPEETIONS OF TIME IN NUMBER OF 40 MSEC
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*Note: The symbols represent ROM constants for the RT-11 MACRO VMG2-12 version.*

**ROM Constants**

- **PC** (Program Counter): Used to store the address of the next instruction to be executed.
- **VOC** (Value of Counter): Stores the current value of the program counter.
- **PVT** (Program Variables): Stores temporary data used by the program during execution.
- **PFI** (Program Flags): Indicates the status of the program.
- **PFD** (Program Data): Stores data used by the program.
- **PM3** (Program Memory): Stores memory addresses used by the program.
- **PCW** (Program Counter Word): Stores the address of the next instruction to be executed.

**Table Values**

- **FMZOF**: 07606
- **FMZRO**: 015546
- **FMZRT**: 037672
- **F021**: 037666
- **F022**: 087658
- **F0STPT**: 097666
- **FPAD**: 107692
- **FPAGR**: 137704
- **FPAGP**: 167716
- **FPAGP2**: 197728
- **F01**: 012345
- **F02**: 037066
- **F021**: 037604
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