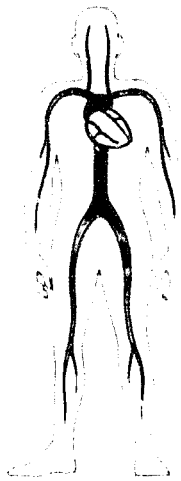


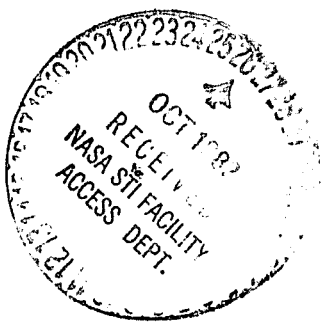
SPECIAL REPORT ON THE DATA COLLECTION PROGRAMS FOR THE GROUND BASED NITROGEN WASHOUT EXPERIMENT

VOLUME ONE: USER'S GUIDE

Prepared for the NASA Johnson Space Center
Life Sciences Medical Directorate
by Penelope A. Bueker

July 30, 1982

Contract NAS9-14880
Project 0185-40



Technology Incorporated
Life Sciences Division

P.O. Box 58827
Houston, Texas 77058

SPECIAL REPORT

ON THE DATA COLLECTION PROGRAMS

FOR THE GROUND BASED NITROGEN WASHOUT EXPERIMENT

VOLUME ONE: USER'S GUIDE

ABSTRACT

The Nitrogen Washout System measures nitrogen elimination on a breath basis from the body tissues of a subject breathing pure oxygen. The system serves as a prototype for a Space Shuttle Life Sciences experiment and in the Environmental Physiology Laboratory. Typically, a subject washes out body nitrogen for three hours while breathing oxygen from a mask enclosed in a positive-pressure oxygen tent. A nitrogen washout requires one test operator and the test subject.

A DEC LSI-11/02 computer is used to (1) control and calibrate the mass spectrometer and Skylab spirometer, (2) gather and store experimental data (3) and provide limited real time analysis and more extensive post-experiment analysis. Five programs are used to gather and store the experimental data and perform all the real time control and analysis.

The Personal Data Input Program collects the data on a subject's physical characteristics and body measurements as entered by the test operator. The body composition and body nitrogen content are calculated by the program for one or more processes: (1) Water Immersion, (2) Skinfold Process I, (3) Skinfold Process II and (4) Nutrition Journal Formula. Body composition and body nitrogen content are also calculated from the subject's known per cent body fat, if available. The program produces a subject characteristics profile on the printing terminal and stores the same information in a data file.

The Decompression Data Program collects data from a decompression experience experiment, then computes the final tissue nitrogen and the decompression ratio at the time of final decompression. The data is written to a data file suitable for analysis. It types a short report on final tissue nitrogen partial pressure and decompression ratio at time of final decompression for tissues of specified saturation half times.

The Nitrogen Washout Program controls the gas valving system for the mass spectrometer, calibrates the mass spectrometer and spirometer, and records all the subject and test data entered by the test operator. It samples the spirometer and the gas channels from the mass spectrometer, calculates inspired/expired air gas concentrations and breath volumes, then writes the data to a floppy disk for storage. It also produces a typed report of the nitrogen washout parameters along with one minute summaries as the washout proceeds.

The Nitrogen Data Program reads the information from the nitrogen washout and produces a typed report of one of four available reports on a printing terminal. The Update Program takes a previously collected, unformatted data file generated by the old nitrogen washout program and rewrites it to a formatted data file for use with N2DATA report writing program or for transfer to the VAX.

APPROVAL SHEET FOR THE
DATA COLLECTION PROGRAMS FOR THE
GROUND BASED NITROGEN WASHOUT EXPERIMENTS

VOLUME ONE: USER'S GUIDE

Approved by:

Edward C. Moseley

Edward C. Moseley, Ph.D.

Medical Sciences Division

NASA/Johnson Space Center

Joseph T. Baker

Joseph T. Baker

Supervisor, Laboratory Research

Support Section

Technology Incorporated

Life Sciences Division

Houston, Texas

Harry F. Walbrecher

Harry F. Walbrecher

Project Manager

Technology Incorporated

Life Sciences Division

Houston, Texas

Prepared by:

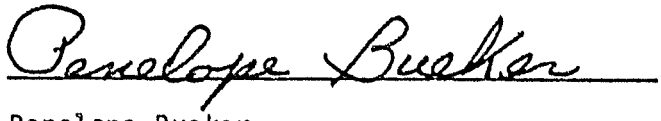
Craig E. Litton

Task Manager, Biomathematics Services

Technology Incorporated

Life Sciences Division

Houston, Texas



Penelope Bueker

Junior Programmer

Biomathematics Services

Technology Incorporated

Life Sciences Division

Houston, Texas

PERSONNEL

Craig E. Litton - Project Design and Development

Penelope Bueker - Programming, Documentaton

Barry Levitan - Engineering, Programming

Linda Weaver - Graphics

Scott Thompson - Technical Assistance

Lita Holt - Typing

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1.0 INTRODUCTION

1.1 PROBLEM DESCRIPTION

Preflight denitrogenation to lower the partial pressure of nitrogen in the body is a long established practice in aerospace medicine to prevent decompression sickness. The protection afforded by this procedure is dependent of the partial pressure of nitrogen remaining in critical tissues at the time of decompression. If oxygen prebreathing is not adequate tissues will become supersaturated during decompression causing nitrogen gas phase separation and bubble formation. This probably starts a series of actions leading to symptoms of decompression sickness.

1.2 BACKGROUND

Preflight denitrogenation was recognized and pioneered by Behnke (4,6), Ferris et. al. (9,10) and Gray (11,12). Behnke, in 1942, was the first to apply the measurement of nitrogen washout rate to the problem of decompression hazards (3,5). The method consisted of measuring the volume of nitrogen accumulated in a closed breathing system while a subject breathed 100% oxygen. Behnke determined the physiologic factors that influenced nitrogen elimination rates such as fat and water content of the body; resting versus exercise and increased cardiac output. Balke (7) and Boothby, et. al. (8) established denitrogenation schedules for high altitude missions using this technique in the early 1950's. About the same time Lundin (13) developed a method to measure nitrogen in a closed rebreathing system down to levels of 2%. Nitrogen washout curves were obtained by maintaining the nitrogen in the rebreathing system at 2% by diluting the system with 100% oxygen. The amount of nitrogen eliminated was calculated from the volume of oxygen added, the CO2 being removed by an absorber. Balldin, et. al. (2) used this method to show that nitrogen washout rates were increased in the supine position , with elevated temperature, and during water immersion. These observations were confirmed at the School of Aerospace Medicine using a method of continuous breath-by-breath analysis of nitrogen in the expired air developed by Adams (1).

These observations are the basis for the design of the programs developed to implement the nitrogen washout study. If sufficient information as to total body nitrogen and rate of washout of a particular human subject is closely estimated and measured, a satisfactory nitrogen elimination prior to a selected hypobaric deompression can be defined quantitatively for that person. A satisfactory nitrogen elimininination would be one that would protect an individual from decompression sickness due to specific atmospheric pressure reductions.

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DATA PATHWAY FOR GROUND BASED NITROGEN WASHOUT EXPERIMENT

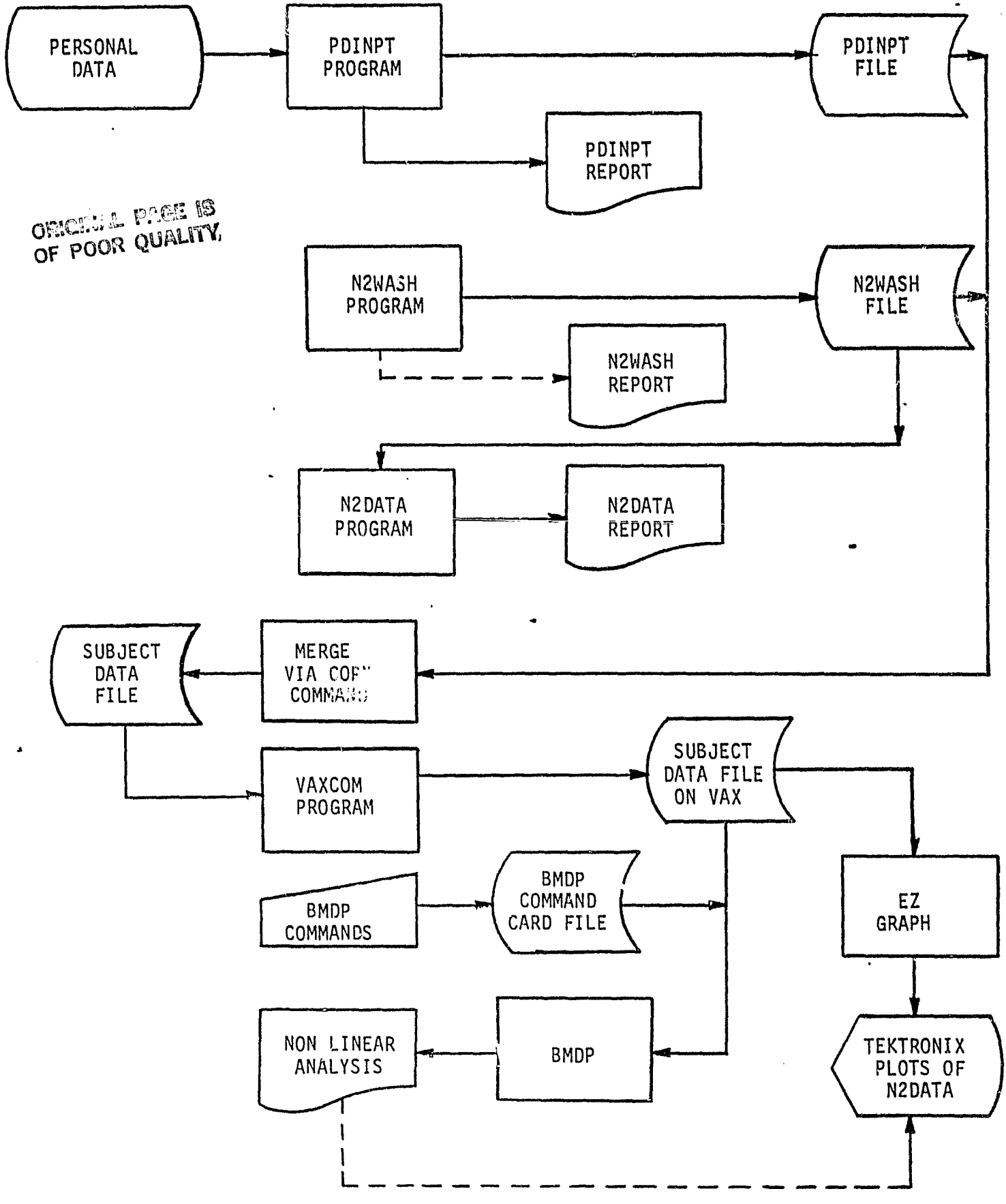


FIGURE 1

DATA PATHWAY FOR DECOMPRESSION EXPERIENCE EXPERIMENT

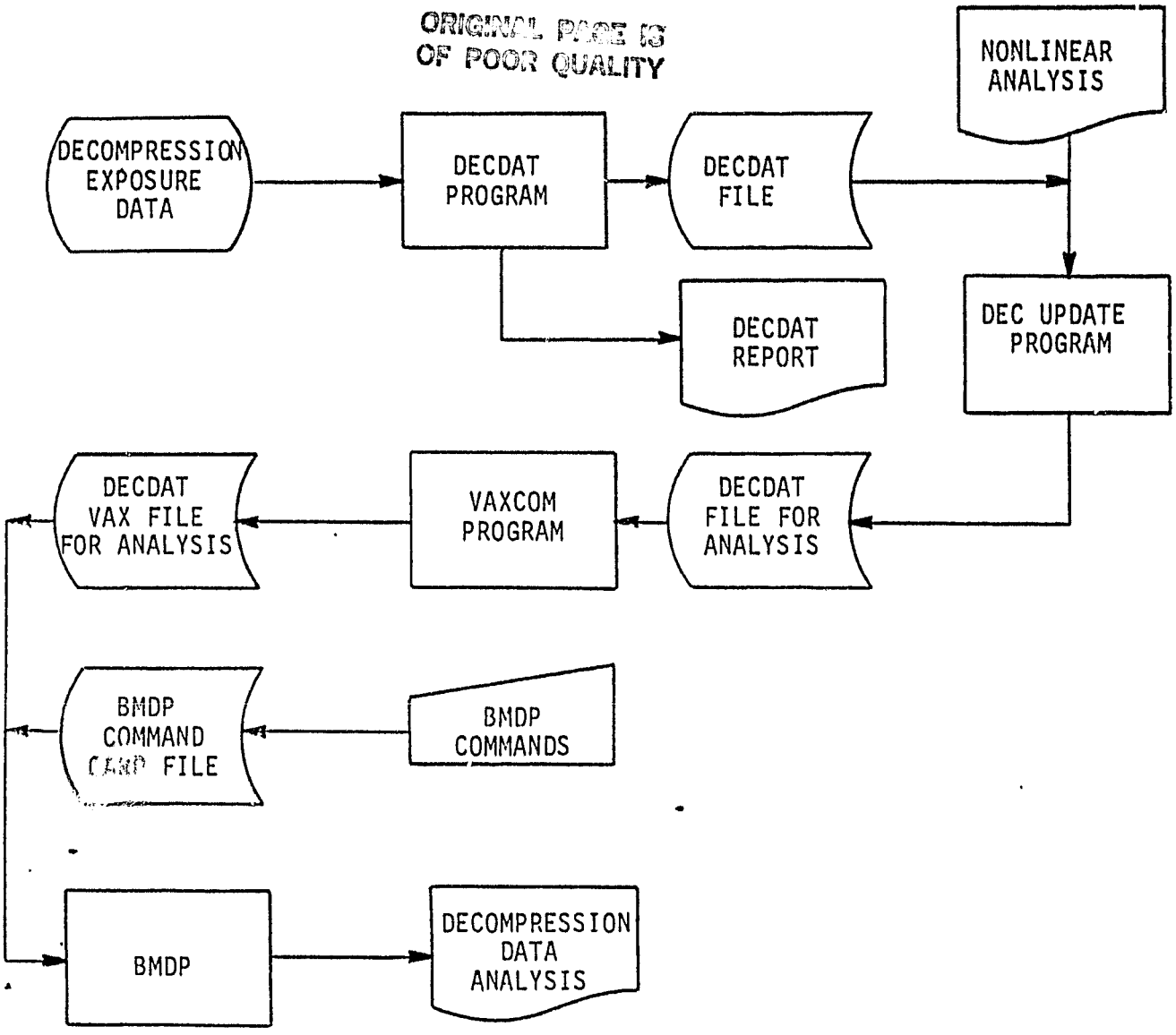


FIGURE 2

2.0 DESIGN CONCEPTS

In order to look at all or pa§rt of these contributing factors it was necessary to develop sofware which could collect a broad range of subject and experimental data at the time of a nitrogen washout or decompression experience and store it for post-experiment analysis and plotting. The data collection programs include a range of parameters necessary for both interactive and post-experimental analysis. Analysis of the nitrogen washout over time is to be performed by the use of BMDP linear regression programs. Since data is collected on LSI micro-computers and the BMDP programs are on the VAX, the VAXCOM program will be used to transfer data files from the LSI to the VAX. Diagrams of the experiment information processing flow are shown in Figures 1 and 2.

2.1 PERSONAL DATA INPUT PROGRAM

The Personal Data Input Program is designed to collect descriptive information on the subject's physical characteristics and data from a water immersion process and/or from one or both of two skinfold measurement processes. This data is used to determine the body composition and to compute estimates of the nitrogen content in the body by each of the water immersion and skinfold processes used, by a nutrition journal formula and by a known % body fat from the personal characteristics data. The data is entered by the test operator in response to computer prompts. The program stores the data in a data file on the floppy disk in device DY1: and produces a typed report on the printing terminal.

2.2 DECOMPRESSION DATA PROGRAM

The Decompression Data Program records identification data, data from a nitrogen washout and the data from a decompression experience in the chamber. The data is used to compute the final tissue partial pressure of nitrogen in psi for each of three types of body tissue and the decompression ratio for each type of tissue at the time of final decompression. Tissues of half saturation time 180 minutes, 240 minutes and 360 minutes are used. The test operator enters the data on the subject's identification, the nitrogen partial pressure and duration of washout for each phase of a nitrogen washout, the experimental conditions during the chamber run, and the subject's symptoms during decompression in the hypobaric chamber. The program produces a summary report on the printing terminal, containing subject identification, the partial pressure of nitrogen in each of the three types of tissue and the decompression ratio for each of the three types of tissue. It also produces a data file on a floppy disk in device DY1: which contains all the data entered by the test operator and the computed information in the summary on partial pressure of nitrogen in the three types of tissue and the decompression ratio for each of the three types of tissue.

2.3 NITROGEN WASHOUT PROGRAM

The Nitrogen Washout Program is the main program for running the nitrogen washout experiment. A read only data file named DATCON.VAL is located on the system floppy in device DY0: and contains the initial calibration values used by the program. The program prints the data constants and allows the test operator to make changes if necessary. The data on the subject's identification and the experimental conditions is entered by the test operator in response to computer prompts. The computer calibrates the spectrometer and spirometer and collects the test data as the experiment runs. During the nitrogen washout, test data and one minute summaries are produced on the printing terminal allowing the test operator to monitor the progress of the experiment. The test data is also being stored in a data file on a floppy disk in device DY1: along with the data that was entered by the test operator. Dummy zeroes mark the end of data input into the storage file. The test data and minute summaries produced on the printing terminal provide a preliminary report on the nitrogen washout. A final report is obtained by using the Nitrogen Data Program.

2.4 NITROGEN DATA PROGRAM

The Nitrogen Data Program uses a data file from the Nitrogen Washout Program to type a formatted report of the Nitrogen Washout Expeirment. The input data is stored in a data file on the floppy disk in device DY1:. There are four types of reports which can be produced by the Nitrogen Data Program. (1) A short report types the data on subject identification and experimental conditons with a summary of the average breath volume, average nitrogen volume per breath, average oxygen concentration per breath, average nitrogen concentration per breath, average carbon dioxide concentration per breath, total nitrogen expired and total number of breaths. (2) A full report types the data on subject identification and experimental conditions with a breath by breath account of breath number, elapsed time in seconds, breath volume, nitrogen volume per breath, oxygen concentration per breath, nitrogen concentration per breath and carbon dioxide concentration per breath. It also types a summary of the average breath volume, average nitrogen volume per breath, average oxygen concentration per breath, average nitrogen concentration per breath, average carbon dioxide concentration per breath, total nitrogen expired and total number of breaths. (3) A One Minute Interval report types the data on subject identification and experimental conditions with elapsed time in minutes and one minute readings of CO2 ml/min, O2 ml/min, N2 ml/min, N2 ml/kg of body-mass/min, N2 Out (Torr)/minute, cummulative N2 washed out, cummulative % of N2 estimate washed out, and the metabolic rate for the minute as CO2 * 1362.4. It also types a summary of the average breath volume, average nitrogen volume per breath, average oxygen concentration per breath, average nitrogen concentration per breath, average carbon dioxide concentration per breath, total nitrogen expired and total number of breaths. (4) A Five Minute Interval report types the data on subject identification and experimental conditions with five minute readings of CO2

ml/five-minute interval, O2 ml/five-minute interval, N2 ml/five-minute interval, N2 ml/kg of body-mass/five minute interval, N2 Out (Torr)/minute, cummulative N2 washed out, cummulative % of N2 estimate washed out, and the metabolic rate for five minutes as CO2 * 1362.4. It also types a summary of the average breath volume, average nitrogen volume per breath, average oxygen concentration per breath, average nitrogen concentration per breath, average carbon dioxide concentration per breath, total nitrogen expired and total number of breaths.

2.5 UPDATE PROGRAM

The Update Program is designed for limited use. It reads the unformatted data stored on a floppy disk file from an earlier version nitrogen washout program and writes it to another file so that it is formatted. It records blanks or zeroes for the header information data which was not included in the early nitrogen washouts. The input for the Update Program is the unformatted data stored on a floppy disk file from an earlier version of the nitrogen washout program. The output is a formatted file identical to the the files being produced by the current version of the Nitrogen Washout Program.

2.6 LSI-11 ENVIRONMENT

2.6.1 Hardware

THE NASA/JSC Life Sciences laboratory LSI configuration consists of a DEC M7270 LSI-11/02 microprocessor, a DEC M8044 with 32,000 words (2 characters/word) of memory, a control terminal (Hazeltine 2000 CRT or ITT 43 printing terminal), three MDB DLV11 serial interfaces, a Data Systems DSD480 floppy disk interface, a Data Systems model 480 dual double-density floppy disk drive, a MDB KW11P programmable clock, a MDB SMU line clock/system monitoring unit and a MDB M2689A power supply 5/12/12. The microprocessor is interfaced to laboratory equipment through an ADAC 1632TTL parallel interface and an ADAC 1030 analog-digital, digital-analog programmable gain converter.

2.6.2 Operating System

All the programs run on a basic LSI-11/02 with 32,000 words of memory on an RT-11/V4.0 operating system. The System Floppy, a floppy disk containing an RT-11/V4.0 operating system, PDINPT.SAV, DECDAT.SAV, N2WASH.SAV, N2DATA.SAV, and DATCON.VAL is placed in device DY0:. The Data Floppy, an initialised double-density floppy disk containing at least 400 free blocks for 3 hours worth of data is placed in device DY1:. Before starting the program, the following must be available and, where approriate, connected correctly: Perkin Elmer Mass Spectrometer MGA 1100, Skylab Exhalation Sprirometer and control electronics, breathing 02 gas, calibration gases (100% 02, 3 gas mixture), mask assembly and hoses to spirometer, and N2 gas with 160 psi to drive the spirometer dump solenoid.

3.0 PROGRAM USAGE

3.1 THE PERSONAL DATA INPUT PROGRAM

PDINPT.SAV is the executable program designed to collect a subject's physical characteristics and body measurements so that the subject's body composition and nitrogen content can be estimated. The test operator enters the data in response to prompting by the computer. After the data has been entered the program will perform the necessary calculations and type a report to the printing terminal and store the data and the results of the calculations on the Data Floppy in device DY1:.

Before beginning the program, be sure that DY1: is assigned as the default device. To do this type:

```
ASSIGN DY1: DK
```

When you are ready to run the program type:

```
R PDINPT
```

The computer will type:

```
NITROGEN WASHOUT PERSONAL DATA INPUT PROGRAM
FILENAME ON WHICH TO STORE DATA
DEVICE: FILENAME.TYPE=
```

Type up to 6 characters for the filename, a dot, and 3 character extension on which data is to be stored. For example, to store personal data for John Smith you could type: SMITH.PDI.

The computer will type:

```
IDENTIFICATION NUMBER OF THE SUBJECT (xxx-xx-xxxx):
```

Type the 11 character social security number of subject.

The computer will type:

```
DATE (MM-DD-YY):
```

Type the 8 character date using 01-12 for MM, 01-31 for DD, and 00-99 for YY.

The computer will type:

```
DATE OF BIRTH (MM-DD-YR):
```

Type the 8 character date using 01-12 for MM, 01-31 for DD, and 00-99 for YY.

The computer will type:

AGE IN YEARS:

Type the 2 character age of subject,

The computer will type:

SEX (M/F):

Type M for male of F for female.

The computer will type:

HEIGHT IN CM:

Type the height of subject.

The compter will type:

NUDE WEIGHT IN KG:

Type the subject's weight.

The computer will type:

IS % BODY FAT EXPLICITLY KNOWN (Y/N)?

Type Y for yes or N for no.

If Y is typed tne computer will type:

ENTER % BODY FAT:

Type % body fat.

The computer will type:

IS BODY COMPSITION TO BE MEASURED BY WATER IMMERSION (Y/N)?

Type Y for yes or N for no.

If Y is typed tne computer will type:

WATER TEMPERATURE IN CENTIGRADE:

Type the water temperature.

The computer will type:

WATER DENSITY IN KG/L:

Type the water density.

The computer will type:

RESIDUAL VOLUME IN L:

Type the residual volume.

The computer will type:

WEIGHT OF UNDERWATER CHAIR IN KG:

Type the weight of underwater chair.

The computer will type:

ENTER THE NUMBER OF TRIALS FOR UNDERWATER WEIGHT:

Type 1-10 for the number of trials for underwater weight.

The computer will type:

TRIAL 1 UNDERWATER WEIGHT IN KG:

Type the underwater weight. This message will repeat from 1 to 10 times for entering each trial for underwater weight.

The computer will type:

DATE OF MEASURMENTS (MM-DD-YY):

Type the 8 character date using 01-12 for MM, 01-31 for DD, and 00-99 for YY.

The computer will type:

IS BODY COMPOSITION TO BE MEASURED BY SKINFOLD PROCESS I (Y/N)?

Type Y for yes and N for no.

If Y is typed the computer will type:

BODY SIDE USED (R/L)?

Type R for right and L for left.

The computer will type:

ENTER THE NUMBER OF MEASUREMENTS RECORDED:

Type 1-3 for number of measurements recorded.

The computer will type:

MEASUREMENT 1 BICEPS IN MM:

Type the biceps measurement. This message will repeat from 1 to 3 times for recording each measurement of biceps.

The computer will type:

MEASUREMENT OF 1 TRICEPS IN MM:

Type the triceps measurement. This message will repeat from 1 to 3 times for recording each measurement of triceps.

The computer will type:

MEASUREMENT 1 SUBSCAPULAR IN MM:

Type the subscapular measurement. This message will repaet from 1 to 3 times for recording each measurement of subscapular.

The computer will type:

MEASUREMENT 1 SUPRAILIAC IN MM:

Type the suprailiac measurement. This message will repeat from 1 to 3 times for recording each measurement of suprailiac.

The computer will type:

DATE OF MEASUREMENTS (MM-DD-YY):

Type the 8 character date with 01-12 for MM, 01-31 for DD, and 00-99 for YY.

The computer will type:

IS BODY COMPOSITION TO BE MEASURED BY SKINFOLD PROCESS II (Y/N)?

Type Y for yes or N for no.

If Y is type the computer will type:

BODY SIDE USED (R/L)?

Type R for right or L for left.

The computer will type:

ENTER THE NUMBER OF MEASUREMENTS RECORDED:

Type 1-3 for the number of measurements recorded.

The computer will type:

MEASUREMENT 1 MIDCLAVICULAR IN MM:

Type the midclavicular measurement. This message will repeat from 1 to 3 times for recording each measurement of midclavicular.

The computer will type:

MEASUREMENT 1 UMBILICUS IN MM:

Type the umbilicus measurement. This message will repeat from 1 to 3 times for recording each measurement of umbilicus.

The computer will type:

MEASUREMENT 1 ANTERIOR MID-THIGH IN MM:

Type the anterior mid-thigh measurement. This message will repeat from 1 to 3 times for recording each measurement of mid-thigh.

The computer will type:

DATE OF MEASUREMENTS (MM-DD-YY):

Type the 8 character date using 01-12 for MM, 01-31 for DD, and 00-99 for YY.

The computer will type:

ALIGN PRINTER TO TOP OF PAGE AND PRESS CARRIAGE RETURN

Align the paper to the top of the page. A personal data output report, 8 1/2 x 11, and suitable for filing will follow after the carriage return is pressed. The information will also be stored on the Data Floppy in device DY1:

3.2 THE DECOMPRESSION DATA PROGRAM

DECDAT.SAV is the executable program for calculating the decompression ratios for different types of tissue based on the partial pressure of nitrogen in the tissue at the end of a washout and for collecting the data on the experimental conditions and the subject's symptoms during a decompression experience. The test operator enters the data in response to prompting by the computer. After the data has been entered the program performs the necessary calculations and types a short summary report on the printing terminal and stores the data and the summary on the Data Floppy in device DY1:.

To run DECDAT.SAV type:

```
R DECDAT
```

The computer will type:

```
DECOMPRESSION EXPERIENCE DATA PROGRAM
FILENAME ON WHICH TO STORE DATA
DEVICE:  FILENAME.TYPE
```

Type a filename of up to 6 characters, a dot, and a 3 character extension naming the file on which you would like the data stored. For example, to store the decompression data for John Smith you could type: SMITH.DEC.

The computer will type:

```
SUBJECT IDENTIFICATION NUMBER (XXX-XX-XXXX):
```

Type the 11 character social security number of the subject.

The computer will type:

```
TEST NUMBER (XX):
```

Type the test number 01-99.

The computer will type:

```
TEST DATE (MM-DD-YY):
```

Type the 8 character date using 01-12 for MM, 01-31 for DD and 00-99 for YY.

The computer will type:

```
HOW MANY PHASES (XX):
```

Type 1-10 for the number of washout phases.

The computer will type:

INITIAL PN2 (PSI):

Type the initial nitrogen pressure.

The computer will type:

PN2 DURING WASHOUT PHASE 1 (PSI):

Type the Phase 1 nitrogen pressure.

The computer will type:

DURATION OF WASHOUT, PHASE 1 (MIN):

Type the duration of Phase 1 in minutes.

The computer will prompt from 1 to 10 times for nitrogen pressure and duration for each washout phase.

The computer will type:

FINAL PRESSURE (PSIA):

Type the final nitogen pressure.

The computer will type:

TEMPERATURE IN CENTIGRADE:

Type the temperature.

The computer wil type:

TIME OF FINAL DECOMPRESSION (HH:MM):

Type the 5 character time of final decompression using 01-24 for HH and 00-59 for MM.

The computer will type:

TIME OF RECOMPRESSION (HH:MM):

Type the 5 character time of recompression using 01-24 for HH and 00-59 for MM.

The computer will type:

EXERCISE LEVEL
LOW 400-800 BTU/HR
MED 800-1600 BTU/HR
HIGH 1600 BTU/HR AND ABOVE
ENTER (L/M/H):

Type L for low or M for medium or H for high.

The computer will type:

WERE BUBBLES MEASURED (Y/N)?

Type Y for yes and N for no.

If Y is typed the computer will type:

WERE BUBBLES PRESENT (Y/N)?

Type Y for yes or N for no.

If Y is typed the computer will type:

GRADE OF BUBBLES: ENTER 0 FOR NOT OBSERVED
TIME OF ONSET GRADE 1 (HH:MM)

Type 0 for not observed or the 5 character time for onset of grade 1 bubbles using 01-24 for HH and 00-59 for MM. This message will repeat for bubbles grade 2, 3 and 4.

The computer will type:

GRADE OF BUBBLES: ENTER 0 FOR NOT OBSERVED
TIME OF REMISSION GRADE 1 (HH:MM):

Type 0 for not observed or the 5 character time for remission of grade 1 bubbles using 01-24 for HH and 00-59 for MM. This message will repet for bubbles grade 2, 3 and 4.

The computer will type:

GRADE OF BUBBLES: ENTER 0 FOR NOT OBSERVED
PRESSURE AT REMISSION GRADE 1 (PSIA):

Type 0 for not observed or the pressure at remission for grade 1 bubbles. This message will repeat for bubbles grade 2, 3 and 4.

The computer will type:

WERE BENDS PRESENT (Y/N)?

Type Y for yes and N for no.

If Y is typed the computer will type:

BENDS LOCATION (TEXT):

Type a line of text.

The computer will type:

GRADE OF BENDS: ENTER 0 FOR NOT OBSERVED
TIME OF ONSET GRADE 1 (HH:MM):

Type 0 for not observed or the 5 character time of onset of bends for grade 1 using 01-24 for HH and 00-59 for MM. This message will repeat for bends grade 2, 3 and 4.

The computer will type:

GRADE OF BENDS: ENTER 0 FOR NOT OBSERVED
TIME OF REMISSION GRAGE 1 (HH:MM):

Type 0 for not observed or the 5 character time of remission of bends for grade 1 using 01-24 for HH and 00-59 for MM. This message will repeat for bends grade 2, 3 and 4.

The computer will type:

GRADE OF BENDS: ENTER 0 FOR NOT OBSERVED
PRESSURE AT REMISSION GRADE 1 (PSIA):

Type 0 for not observed or the pressure at remission for grade 1 bends. This message will repeat for bends grade 2, 3 and 4.

The computer will type:

ALIGN PAPER TO THE TOP OF PAGE AND HIT CARRIAGE RETURN

Align the paper to the top of page. When the carriage return is pressed there will follow a short summary report listing subject ID, date, tissue nitrogen pressures and decompression ratios at the time of final decompression.

3.3 THE N2WASH PROGRAM

N2WASH collects all the header information prior to the washout, prompting the test operator to enter all the information. Next, it controls and calibrates all of the subsystems necessary to the measurement of the washout, determining slopes and intercepts from calibration values. Finally, the program reads all the data during the experiment, performs some real time analysis and loads the data to the floppy disk and prints out the measured parameters on a breath by breath basis. One minute summary reports are also typed out.

This report assumes that the test operator is familiar with the general operation of the DEC LSI-RT11 operating system. If this is not so, refer to the Section 5.0, RT11 COMMANDS.

3.3.1 Setting Up The Equipment

Before starting the program, the following must be available and, where appropriate, connected correctly (see illustrations on pages 21-23):

Perkin-Elmer Mass Spectrometer MGA 1100
Skylab Exhalation Spirometer and control electronics
LSI-11/02 Computer console w/floppy disk drive and printing terminal
Breathing O2 gas
Calibration gases (100% O2, and three gas mixture)
Mask assembly and hoses to spirometer
Floppy disk containing N2WASH.SAV on RT-11 version 4.0 Operating System (System floppy)
An initialized double density single sided floppy disk containing at least 500 free blocks for 3 hours worthnb of data (Data Floppy)
N2 gas with approximately 160 psi (depends on the actuating pressure listed on the air diverter 3-way valve) to drive the spirometer dump solenoid

1. Turn power on the following, (verify with on lights)

   Computer console
   LSI-11/02 computer (Line Time Clock, Run/Halt switches in up position)
   Disk drive (write protect off)
   Spirometer controller
   Mass spectrometer (on switch depressed)
   Printing terminal

2. Open all calibration gas valves (low flow, approximately 5 psi)

3. Instructions

a. Insert the system floppy into the left hand slot DY0: with the label on the top. The exposed portion is inserted first. Push the floppy in all the way and close the door.

b. Insert the data floppy in the right hand slot DY1: in the same manner and close the door. (Note: DY1: is vital to program startup).

c. The disk drive will engage (with a series of audible clicks and the door LED flashing) and the terminal will respond by printing:

```
RT-11 SJ V04.00A

.D 56 = 1012

SET TT:SCOPE

ASS DY1:  DK

TYPE SY:REMIND.TXT

ENTER DATE AND TIME
```

Enter the current date and time by typing:

DATE dd-mmm-yy (where dd=day, 0-31; mmm=month, three letters of the month JAN-DEC; and yy=year, 81,82..., separated by hyphens).

Press Return

Type TIME hh:mm (where hh=hours 01-24 and mm=minutes 00-59,separated by a colon).

Press Return

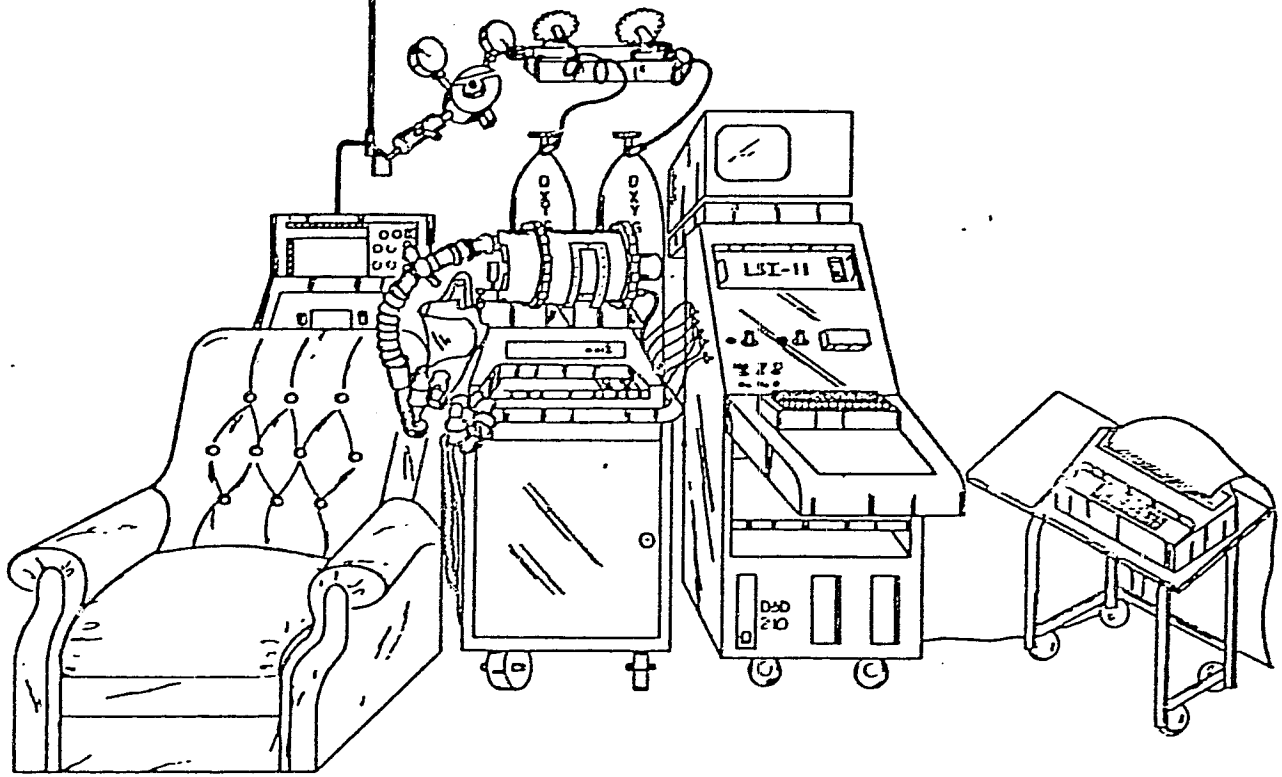
Verify the time by typing TIME and return, and the computer will respond by printing the updated time.

To switch the printing terminal to a CRT terminal, one must type:

R TTY and press return.

The prompt character will then appear on the CRT (if turned on and connected). There will be no hard copy of the test generated unless R TTY is again typed in to return control to the printing terminal. This must be done while under monitor control, not in the N2WASH program.

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



ORIGINAL PAGE IS
OF POOR QUALITY

QTY REQD	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION
			PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ARE
FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±

MATERIAL

FINISH

NEXT ASSY | USED ON

APPLICATION

CONTRACT NO

APPROVALS	DATE
DRAWN LINDA WEAVER	9/15/87
CHECKED	

Technology Incorporated
LIFE SCIENCES DIVISION HOUSTON, TEXAS

NITROGEN WASHOUT SYSTEM

SIZE	CODE IDENT NO	DRAWING NO
C		TH8187-0H01-J000

SCALE N/A | SHEET 1 OF 2

LEGEND

1. 3-Way Rudolf Valve
   1A. One way valve from regulator (4) to face mask inhalation port (open on inspiration)
   1B. One way valve from face mask exhalation port (3) to spirometer (open on exhalation)

2. 3-Way Rudolf Valve
   2A. One way valve from 1 to spirometer (open on exhalation)
   2B. Sample port for mass spectrometer catheter #1
   2C. Adapter to demand regulator (4)

3. Sierra Firefighters Face Mask 651-02-4
   3A. Inhalation port
   3B. Exhalation port

4. 900-002-074-01 Regulator
   4A. High pressure O_2 supply hose to regulator
   4B. High pressure O_2 supply hose to O2 source

5. Mass spectrometer catheter #1 from mass spectrometer inlet #1 to sample port (2B)

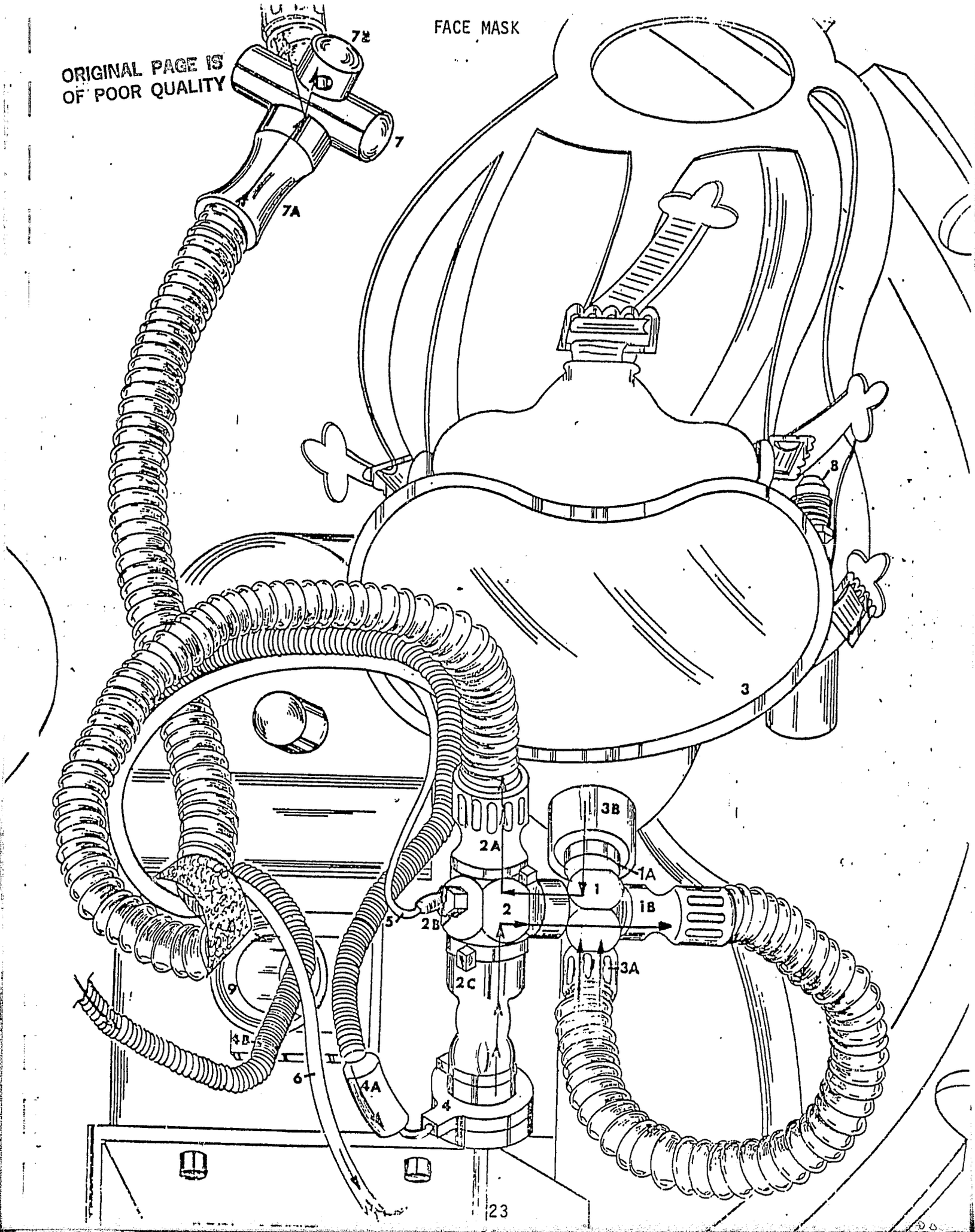
6. Oxygen tent O_2 supply hose (from O_2 source to inside O_2 positive pressure tent)

7. Air Diverter 3-Way Valve
   7A. Opening to face mask
   7B. Opening to ambient air (note: connect only between A+B or A+C)
   7C. Opening to spirometer intake port

8. Nitrogen gas solenoid drive connector (3/8" swagelock stainless fitting)

9. Spirometer dump port

FACE MASK



3.3.2 Preparing The Subject

Being the subject in a nitrogen washout experiment is a passive process which involves sitting quietly in a reclining chair for three or more hours, while wearing a firefighter's mask and breathing 100% oxygen against pressure. A prospective test subject must have passed an Air Force Class III Physical within the last twelve months. It is desirable that the subject have short hair and necessary that the subject be clean shaven in order to ensure a snug seal around the face mask to prevent outside leakage.

Before the test begins the subject is given instruction and information on possible events:

(1) The test operator asks the subject if he is claustrophobic and records his answer. The subject is instructed on the procedure for disconnecting the hose to the spirometer in the event that there is a power outage.

(2) The subject is informed of the possibility of feeling a sense of fullness in the ears on the day after the nitrogen washout. This is due to a negative pressure behind the ear drum and is of no concern.

(3) The subject is instructed not to talk during the test as any expiration will be treated by the computer as a breath or partial breath. Instead, he is instructed to use certain hand signals to communicate with the test operator.

(4) The subject is instructed to remain awake. This is necessary because the subject is breathing against some pressure due to the mechanical setup and purposeful breathing is required.

(5) The subject is instructed to remain seated in a reclined position and to keep movement to a minimum in order to maintain the integrity of the system.

(6) The subject is instructed to urinate before beginning the nitrogen washout process.

3.3.3 Running The N2WASH Program

N2WASH.SAV is the executable program for running the nitrogen washout experiment. It checks the data constants, collects data on subject identification and experimental conditions, calibrates the spectrometer and spirometer, and collects the test data as the experiment runs. It produces a report to the terminal during the experiment and a data file.

When you are ready to run the program type:

R N2WASH and press return

In a few seconds the printer will type:

INSTRUCTIONS

Type Y, return for yes or return for no. If yes, then the computer will print out:

N2 WASHOUT

TESTLOAD N2WASH HAS 6 PHASES:

1. DATA CONSTANTS -- ALLOWS USER MODIFICATION OF CAL-GAS %, OTHERWISE PROGRAM USES DEFAULT VALUES.

2. INITIALIZATION -- ENTER HEADER INFORMATION

3. CALIBRATE MASS SPECTROMETER

4. CALIBRATE SPIROMETER

5. TEST DATA -- SAMPLES TEST DATA CONTINUOUSLY UNTIL USER TERMINATES

6. TERMINATE -- RETURNS CONTROL TO SYSTEM MONITOR

ENTER PHASE # AND RETURN

It is normally a good idea to enter 1 to list the calibration values even if they are not going to be changed. Entering 1 and return starts phase one, reading values from a file named DATCON.VAL And printing:

PHASE 1 DATA CONSTANTS

TO LEAVE VALUE UNCHANGED ENTER:

N AND RETURN(or just return)

TO CHANGE, ENTER Y AND RETURN

Get "NEW VALUE" prompt, enter new value and return.

The computer will print the first of twelve calibration values in the format of CALPCT (I,J).

I=1,3 and J=1,3 where:

J=1 is ambient air
J=2 is pure 02 cal gas
J=3 is 3 gas mixture (approx. 86% 02, 9% N2, 5% C02)

and I=1 nitrogen concentration
I=2 oxygen concentration
I=3 C02 concentration

Thus, CALPCT (1,1) = 79.00 (ambient nitrogen air concentration) is first typed.

Typing N and return (or just return) prompts

CALPCT (2,1) = 21.00 (oxygen concentration ambient air)

And typing N and return (or just return) prompts

CALPCT (3,1) = 0.05 (carbon dioxide in ambient air)

Continuing similarly for the next 3 steps:

CALCPT (1,2) = 0.00 (nitrogen in pure 02)
CALCPT (2,2) = 99.99 (oxygen in pure 02)
CALCPT (3,2) = 0.00 (C02 in pure 02)

The next three values should correspond to the 3 gas mixture values tagged on the calibration gas tank:

CALCPT (1,3) = 9.31
CALCPT (2,3) = 82.69
CALCPT (3,3) = 7.99

The previous concentration values will probably not need changing unless the calibration gas tank was just changed and DATCON.VAL was not correspondingly adjusted (see Section on Calibration Values). The next value printed is:

SAMPLE RATE = 25/SEC

This rate is adequate for most healthy male subjects with no respiratory problems. In the past it has on occasion been necessary to reduce the sample rate to 15/sec for a subject who breathed very shallowly due to allergy/asthma problems. Adjustment of the sample rate should be performed in dry run trials before the actual test. In order to change the rate, you would type Y following the printout, followed by a return. The computer would print:

NEW VALUE =

And you would type in the new value.

The last value is:

BREATH GATE = 15.

This value is appropriate for the spirometer, effectively removing noise from a breath determination without losing any volume data.

Upon pressing return, the computer responds:

END OF PHASE 1

When the computer types:

ENTER PHASE #

Type 2 to enter header information.

The computer will type:

DATE (MM-DD-YY):

Type the 8 character date using 01-12 for MM, 00-31 for DD and 00-99 for YY.

The computer will type:

SUBJECT NAME:

Type the name of the subject.

The computer will type:

SUBJECT IDENTIFICATION (XXX-XX-XXXX):

Type the 11 character social security number of subject.

The computer will type:

SUBJECT AGE (YEARS AS OF THIS DATE):

Type the age of subject.

The computer will type:

EXTERNAL TEMPERATURE IN CENTIGRADE (XX.X):

Type the external temperature.

The computer will type:

EXTERNAL GRAVITY (1,0):

Type 1 or 0.

The computer will type:

IS SUBJECT IMMERSED (Y/N):

Type Y for yes or N for no.

The computer will type:

ENTER CODE FOR BODY POSITION (0 FOR NO DATA OR 1-99):

Type 0 for no data or code 1-99.

The computer will type:

AMBIENT PRESSURE IN MM HG (XXX.X):

Type the ambient pressure.

The computer will type:

ENTER CODE FOR DRUGS (0 FOR NO DATA OR 1-99):

Type 0 for no data or code # 1-99:

The computer will type:

ENTER CODE FOR EXERCISE PROTOCOL (0 FOR NO DATA OR 1-99):

Type 0 for no data or code # 1-99.

The computer will type:

ENTER CODE FOR BREATHING MIXTURE (0 FOR NO DATA OR 1-99):

Type 0 for no data or code # 1-99.

The computer will type:

ENTER CODE FOR BODY HYDRATION (0 FOR NO DATA OR 1-99):

Type 0 for no data or code # 1-99.

ENTER CODE FOR AMBIENT GAS COMPOSITION (0 FOR NO DATA OR 1-99):

Type 0 for no data or code # 1-99.

The computer will type:

STARTING TIME OF DAY (HH:MM):

Type the 5 charcter time using 01-24 for HH and 00-59 for MM.

The computer will type:

ENTER CODE FOR OTHER SPECIAL CONDITIONS (0 FOR NO DATA OR 1-99):

Type 0 for no data or code # 1-99.

The computer will type:

ARE THERE ANY COMMENTS TO RECORD (Y/N)?

Type Y for yes or N for no.

If Y is typed the computer will type:

TO ENTER COMMENTS HIT CARRIAGE RETURN THEN ENTER UP TO 4 LINES OF COMMENT

Press the carriage return.

The computer will prompt for each line of comment with

?

Type the line of comment and press return.
The ? will repeat 4 times for entering comments.

The computer will type:

END OF PHASE 2
ENTER NEW PHASE #

If you type in a 3 and press return, the computer will return with:

PHASE 3 MASS SPEC CALIBRATION
VERIFY CAL GASES ARE OPEN
SET MASS SPEC FUNCTION TO "AUTO", PAUSE, SELECT N-2 0-10%
RETURN.

Setting the mass spectrometer rotary inlet select switch to Auto is optional if a 100% 02 calibration gas is connected to the console. Usually however, the 100% 02 gas will be sampled from inlet 1, via the oxygen tent aviators 02 breathing line. If this is the case, the inlet select switch must be in position 1 to start. Select the nitrogen range switch under the mass spectrometer front control panel cover to 0-10%. Verify that the mass spectrometer reads 0.00% (0.01%) on the nitrogen channel and the display is set for percent % (not mm Hg). Press return and observe the 100% 02 indicator light on the front of the console lighting up. It will stay on for about 10 seconds. You will then hear a click from the switching solenoids and the 83% 02 light will come on. You must switch the mass spectrometer

to inlet select 2 if it is set on inlet 1. The mass spectrometer should, within 2 or 3 seconds, show about the N2 concentration stated on the cal gas tank. (If not, you will have to increase the flow and repeat the calibration.) After another ten seconds the computer will print:

PAUSE -- SELECT N-2 0-100%. Return

Change the N2 rocker switch to 0-100% from 0-10% and press return. The 79% N2 light will come on as the solenoid clicks. Verify that the mass spectrometer display shows about 79% N2 (ambient air). After 10 seconds the computer will switch to 83% 02 again and then start printing out the results of the gas calibration.

The following is a sample calibratin printout with the approximate values expected. The starred items will vary with different three gas mixture calibration tanks.

NITROGEN, HI-RANGE

CTS-1	CTS-2	SLOPE	INTCPT
1614.44	*196.86	0.049	-0.364

NITROGEN, LO RANGE

CTS-1	CTS-2	SLOPE	INTCPT
*1915.14	0.38	0.005	-0.002

OXYGEN

CTS-1	CTS-2	SLOPE	INTCPT
2047.00	1706.24	0.051	-3.934

CARBON DIOXIDE

CTS-1	CTS-2	SLOPE	INTCPT
*1632.37	0.83	0.005	0.004

END OF PHASE 3

ENTER NEW PHASE #

If the mass spectrometer calibration values are within limits, proceed to type in 4 and press return (otherwise, repeat 3).

The computer responds:

PHASE 4 SPIROMETER CALIBRATION
PAUSE -- ZERO SPIROMETER. RETURN

The spirometer is displayed on the LED voltmeter on the console front panel. It should read about 0.09 - 0.15 volts. If it is higher, disconnect the hose going into the spirometer, allowing the spirometer to empty. If it reads zero, verify that all connections are made properly. (See section on Spirometer Hardware). When the voltmeter shows a constant voltage, press return. The computer will then print (with approximate values shown):

```
SPIROMETER

CTS-2  CTS-2      SLOPE      INTCPT
462.86 52.36      0.002      -52.358

END OF PHASE 4
ENTER NEW PHASE #
```

At any point where the computer asks for a new phase number, any phase can be repeated. It is not necessary to follow the phases sequentially. However, the data acquisition phase (5) should not be run before phases 3 or 4 are performed. If all the preceding is correct, you can then type in 5 and return. The computer will type:

```
FILENAME ON WHICH TO STORE DATA
DEVICE:  FILENAME.TYPE:
```

Type the 6 character filename, dot and 3 character extension on which data is to be stored, for example, the nitrogen washout data for John Smith might be stored in ITHNW1.N2W.

The computer will type:

```
SELECT N2 0-100% RANGE
RETURN TO START.
TO STOP AT ANY TIME, ENTER S AND RETURN.
```

At this point, the program is ready to start collecting data, waiting only for a return.

STARTING THE NITROGEN WASHOUT

Catheter 1 from the mass spectrometer must be connected to the plastic Rudolf valve sample port at this point. Set the mass spectrometer select switch to inlet 1.

The subject is now seated to start the washout and the following is performed:

(1) The subject dons the oxygen tent by fitting his/her head through the hole in the rubber dental dam. The plastic is folded down to prevent carbon dioxide buildup.

(2) The modified Sierra Firefighters mask is put on with the air hose removed from the mouthpiece so the subject can continue breathing ambient air.

(3) The spirometer air diverter valve is adjusted so as to isolate the face mask (closing the exhalation pathway).

(4) The subject exhales fully as the manual purge valve on the mask regulator is depressed and the air hose is reconnected.

(5) The subject stops exhaling as the purge continues. The positive pressure leaks out around the mask.

(6) The subject takes a maximum inhalation of oxygen and holds it for the following few seconds.

(7) Release the purge valve - stop purging.

(8) The air diverter valve is opened between the face mask and the spirometer.

(9) The system is activated by pressing the return key on the terminal.

(10) The subject exhales all the gas possible.

(11) The subject breaths normally for the duration of the test.

(12) The oxygen tent is rolled up and clipped closed over the subject's head. The O2 line is turned on so a light flow can be felt leaking out of the tent top.

OPERATION AND TERMINATION OF N2WASH

As the subject exhales into the spirometer, the voltage display will increase and the amber breath indicator lamp will light. When the breath is finished, the lamp will go out and the spirometer will dump the breath. The computer then prints a line indicating:

1. Breath number
2. Consecutive elapsed time to breath (in seconds).
3. Breath volume (in liters).
4. Nitrogen volume (in liters).
5. Average breath O2 concentratoin (fraction of 1).
6. Average breath N2 concentratoin (fraction of 1).
7. Average breath CO2 concentratoin (fraction of 1).

If the breath indicator lamp flickers and the computer prints out faulty data (zero volumes and concentrations) you will have to decrease the sampling rate or encourage the subject not to breath shallowly. Type S and press return and the computer will ask for a new phase . Enter 1, make the sampling rate change and continue by entering phase 5 and restarting the washout.

At the end of every minute the computer prints out a one minute summary consisting of the minute count, nitrogen eliminated for the minute, and total nitrogen eliminated (in liters) as shown in this

example:

4 MIN N2(L) 0.05844 N2TOT 2.47504

Usually after the first or second minute summary, the computer types out:

SELECT N-2 0-10% RANGE

Change the N2 range rocker switch to the 0-10% range. You will not need to readjust this again during the run. If after 3 minutes the computer has not prompted the 0-10% range switch, verify the switch position, the mass spectrometer display (N2 should be less than 10%), and the mass spectrometer catheters.

Occasionally, a breath artifact (belch, yawn, hiccup, etc.) will cause the computer to see a breath of little or no volume or exaggerated N2 volumes. A few of these will have no effect on the test.

After the three hours (or whatever time period used), type in S and press return and the computer will stop its analysis and print:

END OF PHASE 5
ENTER NEW PHASE #

Type in 6 and press return to terminate the program. The computer will type:

STOP -- BYE

If you type in 5, you will make inaccesible all the previously collected data (unless an involved block editing is performed). If the washout needs to be restarted shortly after data collection is initiated for any reason, you may type 5, return and re-enter phase 5.

3.4 THE NITROGEN DATA PROGRAM

N2DATA.SAV is the executable program created to write a report on the printing terminal from the data collected during the nitrogen washout experiment. There are four types of reports available: (1) a full report, (2) a one minute report, (3) a five minute report, or (4) a short report.

To run N2DATA.SAV type:

```
R N2DATA
```

The computer will type:

```
NITROGEN WASHOUT DATA ANALYSIS
ENTER FILENAME ON WHICH DATA IS STORED
(DEVICE:FILENAME.TYPE):
```

Type the 6 character filename, dot and 3 character extention in which data is stored. For example, the nitrogen washout data for John Smith might be stored in a file named ITHNW1.N2W.

The computer will type:

```
A FULL REPORT (F) GIVES BREATH BY BREATH PARAMETERS
A 1 MINUTE REPORT (1) GIVES PARAMETERS FOR 1 MINUTE INTERVALS
A 5 MINUTE REPORT (5) GIVES PARAMETERS FOR 5 MINUTE INTERVALS
A SHORT REPORT (S) GIVES THE OVERALL AVERAGES
DO YOU WANT A FULL REPORT (F), A 1 MINUTE REPORT (1),
A 5 MINUTE REPORT (5), OR A SHORT REPORT (S) ?
TYPE (F/1/5/S):
```

Type F for full, 1 for one minute, 5 for five minute, or S for short report.

The computer will type:

```
PAUSE -- ADVANCE CARRIAGE IF DESIRED RETURN
```

You may advance the carriage to the top of page.

If "F" was typed the computer will type a full report giving subject identification, experimental conditions, a breath by breath account of elapsed time, breath volume, nitrogen volume, O2 concentration, N2 concentration and CO2 concentration, and a summary report of the average breath volume, nitrogen volume, O2 concentration, N2 concentration and of CO2 concentration. It will give the total nitrogen eliminated and the total number of breaths.

If "1" was typed the computer will type:

```
ENTER THE SUBJECT'S BODY WEIGHT IN kg:
```

Type the subject's body weight in kg.

The computer will type:

ENTER THE SUBJECT'S ESTIMATED N2 CONTENT IN LITERS:

Type the subject's estimated N2 content in liters.

The computer will type:

ENTER THE SUBJECT'S ESTIMATED PULMONARY N2 CONTENT IN LITERS:

Type the subject's estimated pulmonary N2 content in liters.

The computer will type: a one minute report giving subject identification, experimental conditions, elapsed time in minutes, the volume of nitrogen, oxygen and carbon dioxide eliminated for the one minute interval, the ratio of nitrogen ml elimianted per kg of body weight for the one minute interval, the average nitrogen concentration during the one minute interval, the cummulative nitrogen eliminated, the per-cent of the body's estimated nitrogen content which has been eliminated so far, the metabolic rate during the one minute interval, and a summary report of the average breath volume, nitrogen volume, O2 concentration, N2 concentration and of CO2 concentration. It will give the total nitrogen eliminated and the total number of breaths.

If "5" was typed the computer will type:

ENTER THE SUBJECT'S BODY WEIGHT IN kg:

Type the subject's body weight in kg.

The computer will type:

ENTER THE SUBJECT'S ESTIMATED N2 CONTENT IN LITERS:

Type the subject's estimated N2 content in liters.

The computer will type:

ENTER THE SUBJECT'S ESTIMATED PULMONARY N2 CONTENT IN LITERS:

Type the subject's estimated pulmonary N2 content in liters.

The computer will type a five minute report giving subject identification, experimental conditions, elapsed time in minutes, the volume of nitrogen, oxygen and carbon dioxide eliminated for the five minute interval, the ratio of nitrogen ml elimianted per kg of body weight for the five minute interval, the average nitrogen concentration during the five minute interval, the cummulative nitrogen eliminated, the per-cent of the body's estimated nitrogen content which has been eliminated so far, the metabolic rate during the five minute interval, and a summary report of the average breath volume, nitrogen volume, O2 concentration, N2 concentration and of CO2 concentration. It will give the total nitrogen eliminated and the

total number of breaths.

If "S" was typed the computer will type a summary report of the average breath volume, nitrogen volume, O2 concentration, N2 concentration and of CO2 concentration. It will give the total nitrogen eliminated and the total number of breaths.

The computer will type:

END OF DATA..READ ANOTHER FILE?

Type Y for yes or N for no.

If Y is typed the computer will return to the beginning of N2DATA.SAV and prompt you for a filename.

3.5 THE UPDATE PROGRAM

UPDATE.SAV is the executable program which takes the previously collected, unformatted, nitrogen washout data from an earlier version of the nitrogen washout program and formats it so that it can be transferred to the VAX or input in the N2DATA program for writing a report. UPDATE.SAV is stored on a floppy disk along with the necessary system files. It will be run in the Neurophysiology computer room. Place the UPDATE system floppy in device DY0:. Boot DY0:. RK0: should be assigned as the default device. Place the old N2wash file in device DY1:.

When you are ready to run the program type:

```
R UPDATE
```

The computer will type:

```
ENTER FILENAME ON WHICH DATA IS STORED
(DEVICE:FILENAME.TYPE):
```

Type the device, colon, 6 character filename, dot and 3 character extension on which data is stored. For example, DY1:ITHNW1.N2W.

The computer will type:

```
ENTER FILENAME ON WHICH DATA IS TO BE PLACED
(DEVICE:FILENAME.TYPE):
```

Type the device, colon, 6 character filename, dot and 3 character extension on which data is to be placed. For example, RK0:ITHNW1.N2W. This would cause the new data file to have the same name but be located on device RK0:. The old data file will be unchanged.

The computer will read the old file, format it, add blanks and zeros for variables which are not part of the old file, and write a new file on RK0:.

Then the computer will type :

```
STOP --
```

Remove the old data file from device DY1: and replace with a double density floppy disk containing at least 400 free blocks.

Type:

```
COPY RK0:ITHNW1.N2W DY1:*.*
```

The computer will copy the new file onto the disk in DY1:. The new floppy disk can be stored in the Environmental laboratory and will be identical with the files being generated by current nitrogen washout program.

4.0 HARDWARE OPERATION

4.1 OVERVIEW

The volume of nitrogen eliminated from a subject is measured on a breath by breath basis by carefully measuring the volume and the gas composition of each expired breath. A Perkin-Elmer Medical Gas Analyzer 1100 Mass Spectrometer is used to measure the concentrations of nitrogen, oxygen, and carbon dioxide (in percent of total gas concentration) in expired breaths and the nitrogen concentration of the inspired air. The volume of nitrogen eliminated is equal to the breath volume times the concentration of nitrogen in the expired air less the volume of nitrogen inspired (this should be zero when breathing pure oxygen). The mass spectrometer has two nitrogen range settings, 0-100% and 0-10% to allow for greater resolution of nitrogen concentration at low levels. The output signal for each channel is 0-10 volts, including the two nitrogen ranges.

Breath volume is determined by a Skylab exhalation spirometer. The spirometer is a dry roller seal type which outputs an increasing voltage (approximately 0-7 volts) as the measured breath volume increases. The maximum measurable volume is five liters. After each breath, a five volt signal from the computer activates a solenoid which dumps the spirometer. The dump solenoid is gas driven and is connected to a high pressure (160 psi) nitrogen source. A return spring empties the spirometer chamber, forcing over four liters of air out in less than 0.25 seconds. The breath is determined to be over when five consecutive samples of the spirometer input have not increased. The accuracy of the spirometer has been measured and is within 2% of the actual volume (1.000 liter reads 1.000 $\pm$ 0.0201).

Calibration of the mass spectrometer is performed by analyzing calibration gases of known purity and concentrations and determining slope and intercept values for each of the three gases analyzed (N_2, CO_2, and O_2). Real time analysis solves the linear equation y (% concentration) = slope x mass spectrometer output + b (intercept). Three N_2 concentrations are used to provide high and low range calibration curves for each N_2 range.

The LSI-11/02 measures the gas concentrations and breath volume by means of an ADAC 1030 analog to digital converter. The ADAC 1030 has 8 channels for differential analog input signals. Sampling of the analog input determines a digital output to the computer of an integer from 0-2047. The gain and channel selection is under computer software control. It is this count which is converted to the appropriate measurement (% or liters) by means of the slope and intercept determined by the calibration procedure.

The spirometer is calibrated by emptying the spirometer and having the computer sample the zero volume output. A one liter volume is simulated by the computer and determines the high calibration volume. Slope and intercept values are then calculated from the zero and one liter values.

Breath volume is continuously updated during a breath; a breath being defined as a spirometer analog output being greater than a minimum noise gate over the zero volume output. Consecutive volume samples are compared to each other to determine if the breath volume is still increasing. If there is no additional volume measured between five samplings, the breath is considered to be over. The computer then loads one ADAC 1030 digital to analog channel with a 5 volt signal to the spirometer controller that dumps the spirometer. The spirometer purges to the ambient air.

The parallel interface board (ADAC 1632TTL) output controls the three 12 volt calibration gas solenoids and valves, and the LED breath indicators. The input buffer reads the mass spectrometer nitrogen range select switch and inlet valve select position.

The MDB KW11P Programmable Clock board regulates the interrupt timings for the subroutine SAMPLE. The two MDB DLV11 serial interface boards allow the use of either the printing terminal or a CRT terminal.

4.2 MASS SPECTROMETER

The Perkin-Elmer MGA 1100 Mass Spectrometer has been found to have a severe baseline drift (approximately + 0.5 %) due to a nitrogen exposure problem. When subjected to more than several minutes of gas samples with a high (ambient) N2 concentration, several hours may be required to read a true 0.00% nitrogen when pure oxygen is being sampled. It is necessary to flush pure oxygen into the mass spectrometer for at least two days prior to and up to the time of a test. With this flushing, a pure oxygen source will read 0.00% N2. The 30 seconds of nitrogen during the calibration does not affect the baseline drift for more than the first fifteen minutes of the washout, during which time the drift is a small (less than 2%) fraction of the expired breath nitrogen concentration. If the mass spectrometer is not adequately flushed out, pure oxygen will show up to 0.5 - 0.6% nitrogen, which is up to twenty times the value that may actually exist after a three hour washout. The software subtracts out low level nitrogen baseline drifts measured in the inspired air, but cannot cancel the effect of large drifts that overwhelm the desired measurement. Following lengthy oxygen flushing and minimizing the mass spectrometer exposure to nitrogen has given repeatable three hour washouts on a subject that are within 50 ml. of nitrogen of each other.

Typically, an easy method to flush the mass spectrometer is to insert the face mask catheter (inlet #1) into the oxygen tent 02 line set at a low flow. The inlet select switch must be switched to inlet #2 during calibration and returned to inlet #1 for the test and no longer than one or two minutes of ambient nitrogen exposure will occur.

4.3 CALIBRATION VALUES

A read only data file named DATCON.VAL is stored on the system floppy (DY0:), and contains all the initial calibration values used by the main program N2WASH.SAV. The three gas mixture calibration gas tank should be 9% N2, 86% 02, and 5% C02 (all + 1 %). Certification must be precise to at least 20 parts per million (0.002%). The first three values in DATCON.VAL represent the concentrations of N2 in ambient air, 100% 02 and the three gas mixture. The next three values in DATCON.VAL represent the concentrations of 02 in ambient air, 100% 02 and the three gas mixture. The next three values in DATCON.VAL represent the concentrations of C02 in ambient air, 100% 02 and the three gas mixture. These nine values, all separated by commas, are followed by the sample rate and the breath gate.

Each time a new tank of three gas calibration mixture gas is received in the Environmental Laboratory it will be necessary to change the gas percentages in DATCON.VAL.

In order to change the values listed in DATCON.VAL (originally 79.0,0.0,9.313,21.0,99.99,82.69,0.05,0.00,7.99,25,15.0),

Type:

R LEDITV

The computer will type:

```
LINE-ORIENTED TEXT EDITOR
VERSION 2.0/A
FILE (DEVICE:FILENAME.TYPE) =
```

Type:

DY0:DATCON.VAL

The computer will type:

NEW FILE (Y/N)?

Type:

N (for no)

The computer will type:

```
FILE:DATCON.VAL                CONTAINS 1 LINES
BEGIN TEXT EDITING
```

Type:

L (to list the line)

The computer will type the line. The N2, O2, and CO2 in the three gas mixture are the 3rd, 6th, and 9th values, respectively.

To replace the current value with a new value type:

RS:/(current value)/,/(new value)/

To check that the new value has been entered correctly type:

L (to list the line)

Repeat the previous 2 steps for each value which needs to be replaced. When you are satisfied that the line is correct with the new values , type:

END

This will make the changes permanent. Typing stop will abort the editing process and leave DATCON.VAL in its original form.

5.0 RT-11 COMMANDS

5.1 SPECIAL FUNCTION KEYS

The special functions of certain terminal keys you need for communication with the keyboard monitor are explained below. A more complete list of special function keys and commands is provided in section 3 of the RT-11 System User's Guide.

Enter CTRL commands by holding the CTRL key down while typing the appropriate letter.

CTRL/C terminates program execution and returns control to the keyboard monitor. CTRL/C echoes C on the terminal. You must type two CTRL/C's to terminate execution unless the program to be terminated is waiting for terminal input or is using the TT handler for input. In these cases, one CTRL/C terminates execution.

CTRL/O causes RT-11 to suppress terminal output while continuing program execution. CTRL/O echoes O on the terminal. RT-11 enables terminal output when one of the following occurs:

1. You type a second CTRL/O.

2. You return the control to the monitor by typing CTRL/C when program terminates.

Note that when you are using CTRL/O the system can print an extraneous character after the monitor echoes the CTRL/O and a carriage return/line feed.

CTRL/Q resumes printing characters on the terminal from the point previously stopped because of a CTRL/S.

CTRL/S temporarily suspends output to the terminal until you type a CTRL/Q. CTRL/S does not echo. You can alternate between CTRL/S and CTRL/Q to temporarily stop and then resume the display of output on a CRT terminal. Type CTRL/S when the screen is almost full, then CTRL/Q to continue when you are ready.

DELETE OR RUBOUT deletes the last character from the current line and echoes a backlash plus the character deleted. Each RUBOUT succeeding DELETE deletes and echoes another character. The system prints an enclosing backlash when you type a key other than DELETE. This erasure is performed from right to left up to the beginning of the current line.

If you are using a video display terminal and you have issued the SET TT SCOPE command, DELETE erases the characters with a backspace, space, backspace sequence. Your corrections appear on the screen; RUBOUT does not enclose them with backlash characters.

5.2 USING THE SYSTEM UTILITIES FOR FILE MAINTENANCE

Keyboard commands let you communicate with the RT-11 monitor to allocate system resources, start programs, and use various services.

The following keyboard commands are the ones most frequently used with our LSI-11 computers.

They should be used regularly to do such things as obtaining listings of the directory information for the data floppies and making backup copies of files. For more detailed information about using these or other commands, refer to the DEC RT-11 System User's Guide.

Some of the more commonly used RT-11 commands for performing file maintenance tasks are listed below. They may be used in any order, whenever the system has typed a "." to let you know it is ready.

All information that you enter is underlined here. Anything which is not underlined is typed by the computer.

A. Initializing a Floppy Disk

This is done either:

1. When you want to use a new floppy disk which has never been used before, or
2. When a floppy has old data on it which is of no value, and you want to remove the old information so that the floppy can be used again.

To initialize the floppy, put it in the right hand disk slot and type:

DIR DY1:

The system will then type: DIR-F-Illegal Directory (if the floppy is new and has never been initialized before), or it will type a list of the files already stored in the floppy. Make sure that there are none that you might want to save.

Next type:

INIT/BAD/VOL DY1:

When the system asks "Are you sure?", check to make sure that you have the correct floppy in DY1 and that you have not erroneously typed DY0 instead of DY1. Then type Y (for Yes) followed by a carriage return. If you are not sure, type N instead, and repeat the INIT command.

The /BAD option with the INIT command will cause the floppy to be checked for any bad blocks that might be present on it. This will take a minute or so. When finished, the system will type ?DUP-I-No bad blocks detected DY1: if the floppy has no bad spots, it will then ask for a volume (or floppy)

identification code, follwed by the owner name. You may type in anything you want for these two entries, but each must be 12 characters or less in length, including spaces, hyphens, etc. Typically, you would use a floppy ID number or code for the Volume ID, and the laboratory name (or your own name) for the owner. For example:

Volume ID? Disk 52A

Owner? G Washington

The INIT command causes the directory on the floppy in DY1 to be zeroed out. This effectively erases the information on it. Although it is sometimes possible to retrieve information from a floppy after it has had its directory zeroed (if nothing on it has been overwritten), it is rather difficult and generally not practical.

B. Getting a Floppy Directory (Contents) Listing

To get a complete, formatted summary of what is stored on a floppy disk, type the following:

DIR/VOL/FULL/BLOCKS DY1: (Carriage Return)

This causes a listing of the file names, their creation dates, and other information concerning such things as their physical locations on the floppy in DY1 to be printed on the terminal. The date printed for each file is the date the file was created or last modified, whichever is later.

To get a simplified directory listing, type:

DIR DY1: (Return).

A listing of each subject data floppy, using the DIR command, should be obtained regularly if data files are being created on it. This should preferably be done at the end of each day in which tests were run. The latest listing for each floppy should be saved in order to help keep track of what information is on each floppy, and also because it can sometimes be useful in retrieving files which have accidentally been deleted or overwritten. Each such listing should be labeled to correspond with the particular floppy it summarizes, and then taped on the special protective enveloped for that floppy. Alternatively, the listings can be kept in a notebook.

If you need to see if a particular file is on a floppy without getting a complete listing, put the floppy in DY1 and type:

DIR DY1:name.suf (Return)

Here name is tne filename that you used when creating the file, and "suf" is the 3-letter suffix (or extension or file type) for that file. If you are not sure what the suffix is, just type DIR.DY1: name with no period following the name. If the file exists on the floppy, the system will print a line containing the directory information for that file, preceeded by the date if it has been entered into the system, and followed by the total number of files listed (not the total number on the floppy) and the number of free (unused) blocks on it. The number of free blocks can be used to estimate how many more subject data files can be stored on the floppy. If the requested filename does not exist on the floppy, then only the date, "0 files", and number of free blocks will be printed. Therefore, this is also an easy way of determining how much unused space is on the floppy. Note that the unused space may not all be in one contiguous area, however, the /FULL option can be used to tell you where the unused blocks are distributed.

C. Deleting Files

To delete a single file which has erroneous or useless information on it, put the floppy in DY1 (the right hand disk slot), and type:

DELETE DY1:name.suf followed by a carriage return,

Where "name" is the filename that you want to delete. This can be repeated for several files, if desired. Be sure that the filename is entered correctly, because a different file could be inadvertantly deleted if the incorrect filename is typed in. The system will type the file name followed by "?".

Respond with Y (Return) if you are sure that you want to delete a file.

D. Renaming a File

If a test has been run and it is later discovered that an incorrect filename was used throughout, then it can be renamed, without changing any of the data stored in it, by inserting the floppy into DY1 and typing:

RENAME DY1:oldname.suf DY1:newname.suf

Where "newname" is the new filename under which you want the data to be stored, and "oldname" is the old filename that was previously used.

For example:

RENAME DY1:T00900.DAT DY1:T01000.DAT

will cause the filename for file T00900.DAT to be changed to T01000.DAT and the old filename will no longer exist.

E. Copying Data Files (Making Disk Backups)

Data files may be copied from one floppy to another very easily. This enables one or more backup copies to be made of all important data.

To copy all files from one floppy disk to another, do the following:

1. Initialize the blank floppy you are going to copy onto as described above in "A. Initializing a Floppy Disk". Note that this will destroy any information stored on it, so be sure you have used a floppy which does not have any data that you want to save.

   This step can be skipped if you are only going to add or replace files on a floppy which already has files on it.

2. Several options are now available depending on what you want to do.

   (a) To copy all files from DY0 to DY1, type:

   COPY/WAIT/SYS DY0:*.* DY1:*.*

   (You do not need to include /SYS unless you are copying system files from a system floppy.)

   The system will then let you take out the system floppy (if it is not the one you are copying from) and replace it with whatever floppy has the files you wish to copy.

   (The /WAIT option is not necessary if you are copying from your system floppy.) This process can take from several seconds to several minutes, depending on how many files are being copied. When the system has finished, it will tell you to replace (mount) the original system floppy back in DY0: (if you used the /WAIT option), and then let you type Y when you are ready. The system will type a period when it is ready for a new command.

   (b) To copy only those files with the current date (which were created or last modified today), include /NEWFILES in the list of options with the copy command.

   COPY/NEWFILES/WAIT DY0:*.* DY1:*.*

The /NEWFILES causes the system to compare the dates of each file in the disk directory with the current date entered previously with the DATE command. Therefore, the current date must have been entered correctly when the computer was powered up in order for this to work properly.

(c) To selectively copy certain files, include /Q (for QUERY) in the list of options. For example:

COPY/SYS/Q DY0:*.* DY1:*.*

The /Q causes the system to individually list each filename on DY0 to see if it is to be copied. To bypass copying a particular file, simply hit the Carriage Return Key after the filename is printed. For files that you do want to copy, type Y(Return) (Y for yes) after their names. For example: if DY0 has files named A.DAT, B.DAT, and C.DAT on it and you want to copy only A.DAT and C.DAT do the following (your responses are underlined as usual):

Type:

COPY/Q DY0:*.* DY1:*.*

A .DAT? Y(Return) (yes, copy it)

B .DAT? (Return) (no, do not copy it)

C .DAT? Y(Return) (yes, copy it)

(d) To copy one or a few files from DY0 to DY1, type:

COPY/SYS/WAIT DY0:name.suf DY1:*.*

Where "name" is the filename. This can be repeated for several files, if desired.

3. A backup system floppy can be created in a similar manner. First, put a blank floppy in DY1 and perform step (1) above. Next, type:

COPY/SYS DY0:*.* DY1:*.* (A list of files copied will follow.)

COPY/BOOT DY1:RT11SJ DY1:

DY1 now contains a floppy which has all of the files that the original system floppy had on it. Note that the copying caused by the first line above may take a minute or so to perform, so wait until it is finished and the system responds with another "." before typing the second line.

4. These procedures can be used regularly to maintain backup copies of all data files. The recommended procedure is:
   (a) First, perform step 1 above.
   (b) Second, perform step 2(a) to copy all the files onto a new backup floppy.
   (c) Third, perform step 2(b) at the end of each day to copy new files onto the backup floppy. As an alternative, the new files from one or more days may be copied using the procedures in steps 2(c) or 2(d).

It is probably best to keep two backup floppies, in addition to the original, for important files, since it takes only a few minutes to perform the copying operation.

If you try to copy a data file from one floppy onto another that already contains a file with the same name, then the file on the floppy being copied into will be deleted and the copy operation will be performed as requested. Normally, this is not really a problem, since files with the same name should generally be identical. However, if an erroneous filename was entered when creating a file, for example, then it is possible that this file might replace one on the backup floppy unintentioanlly. This could happen if the file was copied before correcting the filename by using the Rename command (step D above). Therefore, be particularly careful when entering filenames or copying with possibly erroneous filenames, since valuable data might be deleted. Frequently the /NOREPLACE option with the COPY command will help to avoid this potential problem.

F. Getting Help with System Commands

If you do not remember which command or option to use for a particular function, or the syntax for a particular command, use the HELP command. If you type only HELP followed by a carriage return, information on the help command itself will be typed. For a list of all the possible commands (some are not always available, depending on which system disk you are presently using), type HELP (Return). For more information on one of these commands, including possible options, type HELP (space) command, where "command" is the name of the command (or the first few letters of it). For example, for information on the DIRECTORY (or DIR) command, type:

HELP DIR followed by a carriage return.

If the information typed is not clear or you need more details, refer to the RT-11 System User's Guide. The first half of that manual contains an alphabetized list of all commands, with complete information and examples on most options.

5.3 GLOSSARY

Breath gate - the minimum noise level of the spirometer. Also referred to as minimum noise gate.

DATCON.VAL - a data file on the system disk which contains the default values for calibrating the spirometer and mass spectrometer.

DECDAT - a program on the system disk which accepts information from the test operator on a decompression experience experiment, types a report on the printing terminal, then stores the data in a data file.

DY1: - the disk drive device on the right where a floppy disk can be inserted, e.g., for a data file.

External gravity - the gravity outside of the experimental environment, one if the experimnt is conducted at ground level and zero if conducted in space.

N2DATA - a program on the system disk which reads the nitrogen washout data from a data file and types a report on the printing terminal.

N2WASH - the main program on the system disk which calibrates the spirometer and spectrometer, records the data during a nitrogen washout experiment and stores it in a data file.

PDINPT - a program on the system disk which accepts information from the test operator on the physical characteristics of a subject, types a report on the printing terminal and stores the data in a data file.

UPDATE - a program on a system disk which reads an unformatted nitrogen washout data file, formats the data, then stores it in a data file.