(4)

CR 151298

MAY 29, 1970

TECHNICAL LIBRARY
BUILDING 45
APR 21 1972
Manned Spacecraft Center
Houston, Texas 77058

MICROFICHED
MAY 1 1972

IMBLMS PROGRAMMING DOCUMENTATION

CONTRACT NASW - 1631

MAY 1977
RECEIVED
NASA STI FACILITY
BRANCH

(NASA-CR-151298) IMBLMS PROGRAMMING DOCUMENTATION. VOLUME 3: RESPIRATORY (Lockheed Missiles and Space Co.) 158 p

N77-78371

Unclas
00/12 30268

BEST AVAILABLE COPY

Lockheed

MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

VOLUME III

RESPIRATORY

BEST AVAILABLE COPY

Safety check to be performed before starting the series of Respiratory Test Procedures ATP-1 through 14.

1. No Smoking Permitted in the test room because:
   (a) Hazardous when pure oxygen is being breathed.
   (b) Smoke affects respiration of the subject.

2. Verify that the frame of the Auxiliary Respiratory Rack is grounded via the special braided grounding line to the ground bus of the PBEM Console, and that the PBEM ground bus is itself properly grounded.

3. Verify that the interlock switch opens when the rear door of the Auxiliary Respiratory Rack is opened, thereby shutting off 115V 60 Hz power to the Respiratory equipment.

Step		Remarks

FLOW METER SELECTOR

1. Select desired flowmeter: 1, 2, or 3.

2. Starting with the lower strain gage coupler (Beckman 9801), and proceeding from left to right, make the following settings:

STRAIN GAGE COUPLER (LOWER UNIT)

	Switch or Knob	Setting
2.a	Polarity	+

STRAIN GAGE COUPLER PRE-AMP (FLOW)

2.b	Gain Control for 100L/Min.	2 mv/cm
	for 1000L/Min.	20 mv/cm

RESETTING INTEGRATOR PRE-AMP (VOL.)

2.c	Gain Control	5

POWER AMPLIFIERS (Same Settings for Both) 462

2.d	Filter	Hi. Out
2.e	Gain Control	X1 Preamp
2.f	A560 CONTROL PANEL	On

3. Turn on PBEM and switch to "Normal". Load ADTS Program into Computer and initiate operation. Enter V01, N 62 and depress "Enter" button on Processor Keyboard. For digital display of Flow Signal voltage, set "Test" thumbwheels to 01, set "Test Value" thumbwheels to 08001.

4. With no airflow through the flowmeter which is being set, adjust the "Balance" knob for that particular flowmeter to obtain zero output voltage. This output voltage signal is preferably read on a digital display as explained in the preceding step. If this is not feasible, as during pulmonary measurements, the "Balance" knob should be adjusted so that the Analog Meter for Flow is at zero and the Analog Meter for Volume remains stationary (does not rise, or drop).

NOTE: Each time the Flow Preamp Setting is changed, the Balance knob for the flowmeter in use must be re-set to obtain a zero output for zero flow.

5. Turn recorder function switch to 'Operate'.

6. Position left pen to paper center line with Zero Setting Control. NOTE: With Flow Preamp set at 2 mv/cm, depressing the "CAL" button on the Beckman 9801 will give a signal which represents the following:

Flowmeter 1 = 100 L/M
Flowmeter 2 & 3 = 95 L/M

Step	RESETTING INTEGRATOR (Beckman 9873)	Remarks
7.	Integration Constant --- set to 1.	
8.	Set the Integrator Selector Knob on the Resetting Integrator to "Pulse + and -".	
9.	While depressing the Manual Reset button, adjust the right pen to desired zero position.	
10.	Use the "Offset" knob to simultaneously obtain zero voltage signals for both flow and volume. If digital voltage readouts are not available, use the zero positions on the analog meters for flow and volume as an approximation, or use the oscilloscope with a high vertical magnification and switch the trace alternately between "ground" and "DC".	
11.	NOTE: Each time the Vol. (Integrator) Preamp setting is changed, steps 9 and 10 must be repeated. And as a prerequisite, the Flow output must be adjusted to zero for zero flow.	
12.	If it is desired to record the quantities shown on scope channels 3 and 4 on the two pen recorder, switch the Beckman 462 knobs to 1 v/cm.	

INTEGRATED MANNED SUBSYSTEM CHECKOUT Rev. E	LOCKHEED MISSILES & SPACE COMPANY A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION	INITIALIZATION AND CHECK OF O_2 ANALYZER-1 [illegible] RESP/ATP - 2 SHEET 1 OF 1 SHEETS

Step		Remarks
1.	Verify that Main Power Switch on Auxiliary Respiratory Rack is "ON".	
2.	Depress Oxygen Analyzer Power pushbutton. ALLOW AT LEAST 2 HOUR WARM-UP PERIOD PRIOR TO USE.	
3.	Turn zero adjust knob to its extreme clockwise position; then turn counter-clockwise 4-1/2 turns.	
4.	If it is desired to use the 11% to 21% range, set both the rotary Range control knob and the toggle switch above it to "RANGE 3". For measurements in the 0-100% range, set both of the above controls to "RANGE 1".	
5.	Turn on PBDM and switch to "Normal". Load the ADTS Program into the Computer and initiate operation. Enter (V 01, N 62) and depress "ENTER" button on Processor Keyboard. Insert Test 01 in Test Number thumbwheels and 03002 in test value thumbwheels. Press "Input" switch on Data Entry Panel to display voltage on requested A/D channel. To change channel or switch assignment, depress "Clear" switch, then change channel-switch assignment on test value thumbwheel and then press "Input". Channel No. is 4 on large pen recorder.	
6.	With room air passing through the Oxygen Analyzer, use the Zero Adjust to obtain a digital reading (on Range 1) +1.00 volts. Depress "CLEAR" button at PBDM Numerical Data Entry Panel.	
7.	The O_2 Analyzer is now ready for use.	
8.	If it is desired to display oxygen analysis on Dynograph 2-pen recorder without using a computer program, set the switch on rear of PBDM to "Backup", set one of the Beckman 462 amplifiers at 1 v/cm, press buttons in the following sequence: Verb 53, Noun 02 Enter. If oxygen analysis is to be recorded by the left hand pen, press Verb 66, Noun 04 Enter. If right hand pen is to be used for oxygen: Verb 67, Noun 04 Enter.	

Step	Remarks
1. Verify that Main Power Switch on Auxiliary Respiratory Rack is "ON".	
2. Turn "ON" CO_2 Analyzer Power Switches (2), labeled "MAINS" and "ON"; allow at least two hours warm-up period prior to use.	
3. Turn "ON" CO_2 Analyzer Pump. NOTE: Nitrogen Analyzer Vacuum must be OFF.	
4. Using flow throttle, adjust flow rate to approximately 2 liter per minute.	
5. Switch Meter Selector Knob to "Meter" position.	
6. Turn on PBIM and switch to "Normal". Load the ADTS Program into the Computer and initiate operation. Enter (V 01, N 62) and depress "ENTER" button on Processor Keyboard. Insert Test 01 in Test Number Thumbwheels, and 07001 in Test Value thumbwheels. Press "Input" switch on Data Entry Panel to display voltage on requested A/D channel. To change channel or switch assignment, depress "Clear" switch, then change channel-switch assignment on Test Value thumbwheels and press "Input". Channel No. is 8 on large pen recorder.	
7. Verify Meter Selector Knob in "METER" position. Using ambient air as the sample gas, adjust digital voltage readout with Zero Control on PBIM to "0.00 Volts". (0% on CO_2 Meter).	
8. Turn Meter Selector Knob to red dot (calibrate) position; use "Coarse" and "Fine" controls to adjust PBIM Digital readout to "3.10 Volts" (6% on CO_2 Meter).	
9. Repeat steps #7 and #8 until both "zero" and "red dot" positions do not require further adjustment. Return Meter Selector Switch to "Meter" position. The CO_2 Analyzer is now ready for use.	
10. If CO_2 sample is to be taken when the Respiratory J Valve is being used, the handle of Valve V3 must be horizontal; if the subject is breathing through the four position valve, the handle of V3 must be vertical to obtain the sample there.	
11. To display CO_2 analysis on Dynograph 2 pen recorder without using a computer program, set the switch on rear of PBIM to "Backup", set one of the Beckman 462 amplifiers at 1 v/cm, press buttons in the following sequence: Verb 57, Noun 01 Enter. If CO_2 analysis is to be recorded by the left hand pen, press Verb 66, Noun 10 Enter. To use right hand pen, press Verb 67, Noun 10 Enter.	

INTEGRATED MANNED SUBSYSTEM CHECKOUT

Rev. E

LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

INITIALIZATION AND CALIBRATION OF N_2 ANALYZER-[illegible]

SHEET 1 OF 1 SHEETS

Step		Remarks
1.	Verify that Main Power Switch on Auxiliary Respiratory Rack is "ON". Turn on N_2 Analyzer Vacuum Pump. CAUTION: Be sure pump starts immediately when switched On. If not, switch OFF and rotate pump 1/2 turn by hand. Then close rear door of ARR and try the pump switch again.	
2.	Turn "ON" Nitrogen Analyzer Range switch to "0-100%" Range. ALLOW AT LEAST 2 HOUR WARM-UP PERIOD PRIOR TO USE.	
3.	Rotate the red (inner) concentric Balance knob at lower right-hand side of N_2 Analyzer fully counter-clockwise. Rotate the black (outer) Gain knob fully clockwise.	
4.	Turn on PBDM and switch to "Normal". Load the ADTS Programs into the Computer and initiate operation. Enter (V 01, N 62) and depress "ENTER" button on Processor Keyboard. Insert Test 01 in Test Number Thumbwheels, and 04004 in Test Value thumbwheels. Press "Input" switch on Data Entry Panel to display voltage on requested A/D channel. To change channel or switch assignment, depress "Clear" switch, then change channel-switch assignment on Test Value thumbwheel and then press "Input". Channel No. is 5 on large pen recorder.	
5.	With room air passing through the Nitrogen Analyzer, use the Adjust knob to obtain a digital value of +3.95 volts at PBDM Processor Readout. The Nitrogen Analyzer is now ready for use.	
6.	If it is desired to display N_2 analysis on Dynograph 2 pen recorder without using a computer program, set the switch on rear of PBDM to "Backup", set one of the Beckman 462 amplifiers at 1 v/cm , then depress buttons in the following sequence: Verb 54, Noun 04 Enter. If Nitrogen analysis is to be recorded by the left hand pen, depress Verb 66, Noun 05 Enter. If right hand pen is to be used for Nitrogen analysis: Verb 67, Noun 05 Enter.	

Step		Remarks
1.	Verify that Main Power Switch on Auxiliary Respiratory Rack is "ON".	
2.	Turn "ON" Power Switch on Helium and "Inst" switch on CO Analyzers. ALLOW AT LEAST 2 HOUR WARM-UP PERIOD FOR EACH ANALYZER PRIOR TO USE.	
3.	Turn handle on valve V-10 to Position "1". Turn pump switch of CO Analyzer "ON".	
4.	Adjust pump flow throttle on CO Analyzer to obtain 1.0 liter/minute as indicated by its rotameter.	
5.	Adjust valve knob V-11 He Analyzer Flowmeter (located immediately above the words "Ambient Environmental Monitor") until it indicates a flow of approximately 300 cc per minute.	
6.	Using ambient air, set the He and CO Meters on "zero", using the appropriate Zero knobs. CO range must be at 0-.05%. Note: For the CO Analyzer, any value less than 0.01% is satisfactory. For the Helium Analyzer, turn the Zero Adjust only far enough to obtain a digital reading of 0.00, until P-light is just flashing.	
7.	Switch the Range knob to the "CURRENT ADJUST" position; rotate the Current Adjust knob to give a reading of 9.00; switch back to the "Helium Test" position.	
8.	Supply a calibration gas to gas connector B. Calibration gas should have a helium concentration from 5% to 10% and a CO concentration from 0.15 to 0.20%.	
9.	On the CO Analyzer, set the Coarse and Fine gain control knobs until the meter (with the range switch in the proper position) corresponds to the given gas analysis.	Approximate setting C-15 or B-46.
10.	Replace the calibration gas with room air by disconnecting the inlet sample line from Gas Connector B. If the CO Meter returns to "zero", the Analyzer is ready for use. If not, repeat both the zero and sample gas reading.	

Step	Remarks RESP/ATP
11. On the Helium Analyzer, use a screwdriver in the "Gain" adjustment to make the digital readout agree with the known gas concentration.	
12. Recheck the zero setting of the Helium Analyzer using room air and the electronic calibration of 9.00. If all three values are correct and stabilized, the Helium Analyzer is ready for use.	

INTEGRATED MANNED SUBSYSTEM CHECKOUT

Rev. E

LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

ROUTINE PULMONARY
RESP/ATP-6

SHEET 1 OF 2 SHEETS

Step		Remarks
1.	Unstow personal mouthpiece and nose clip; remove from protective case.	
2.	Attach mouthpiece to four position valve, turn valve to position 4; slide valve must be closed; open valve V-1 to ambient; adjust height of plumbing to suit subject.	
3.	Turn on PBDM. Enter Astronaut Identification ( ), Mission Day ( ), Mission Time ( ), Organ Sys. ( ), Test No. ( ), and Test Value ( ) at Numerical Data Entry Panel.	
4.	Perform preliminary Respiratory Adjustment with Flowmeter Selector Switch set to #1. Verify Pre-Amp Flow Settings are set as shown at right.	
5.	Set toggle switch on rear of PBDM to "Normal" Mode. Load Standard Lung Volume program into Computer: Enter Verb 01, Noun 31 and depress "Enter" button on Processor Keyboard.	
6.	Log subject, date, test and channel identification; turn pen recorders 'On'.	
7.	Turn on Main Power Switch of Aux. Resp. Rack. Turn on Respiratory Panel by rotating function switch to 'On" position. ALLOW 5 MINUTES FOR THERMAL STABILIZATION OF FLOWMETER AND PRESSURE TRANSDUCER.	
8.	Concurrent with thermal stabilization period, attach mouthpiece. Push "Record" on Analog Tape Recorder. Turn Beckman A 560 Control to "Operate".	
9.	Push 'Input' button. Log subject, date, test and channel identification on intercom and tape settings on pen records. Press 'Cal.' button on Beckman 9801. Use 1 L syringe for Vol. cal of pen recorder.	
10.	Proceed with Experiment. Subject assumes normal standing position with mouthpiece and nose clip. Instruct subject to proceed through the following measurement profile:	
11.	Press V 08, N 01 and "Enter". Breathe normally until Computer activity light goes off to obtain tidal volume. Then press "Record" button if acceptable; otherwise, repeat.	
12.	Change gain controls per above table for ERV and V.C. Note: Whenever the Flow preamp setting is changed, the "balance" knob for the Flowmeter in use must be reset to obtain a zero output for zero flow.	Change Flow Preamp from 2 to 20 mv/cm.

	PREAMP MV/cm FLOW	VOL.
TID. VOL.	2	5
E.R.V. & VIT.CAP.	20	5
M.B.C.	20	5

LARGE PEN RECORDER

Flow Rec. Ch. 9
Vol. Rec. Ch. 10

Step		Remarks
12.	(Continued) Subject breathes normally; press V 08, N 02 and "Enter" buttons. Subject proceeds immediately to the normal end-tidal position, pause briefly and then exhale the maximum amount of air. Press V 08, N 04, then inspire maximally; at same time, press 'Enter' button, then subject must exhale the maximum amount of air at the fastest possible rate. Then press 'Record' button; otherwise, repeat.	Note: ERV and VC must be run as a group
13.	Operator verify the MV/cm control set for M.B.C. Set paper speed at 5 mm/sec. Breathe normally, then press V 08, N 03 Enter, and begin a 15 second period of maximum inhalation and exhalation -- the purpose of which is to move as much air as possible during this 15 second period. Then press "Record" button or re-run.	
14.	Repeat steps #11, #12, and #13 as required. Push "Clear" and V 09.	
15.	Turn pen recorders "OFF". Log subject, date, test complete, identification and tape setting on pen records and intercom.	
16.	Push Analog Tape Recorder "OFF" button.	
17.	Remove and stow mouthpiece, nose clip, and flowmeter assembly.	
18.	Turn PBDM and Aux. Resp. Rack "OFF" if no further testing.	

MEASUREMENT REQUIREMENTS DATA SHEET

SUB-SYSTEM : Respiratory

MEASUREMENT GROUP : Respiratory

MEASUREMENT : Lung Volumes and Flow Rates

MEASUREMENT DESCRIPTION : Obtain the following pulmonary measurements: Vital Capacity (VC), Timed Vital Capacity (VC_1, VC_3), Inspiratory Capacity (IC), Expiratory Reserve Volume (ERV), Tidal Volume (TV), Minute Tidal Volume (MTV) Maximum Inspiratory Flow (MIF), Maximum Expiratory Flow (MEF), and Maximum Breathing Capacity (MBC).

1. Input signal characteristics — Biphasic inspired and expired air flow and volume waveforms.

2. Electrodes, transducers — Mouthpiece, Mainland pneumotach head, A-W pressure capsule in Greer micromanometer

3. Signal conditioner(s) — Greer micromanometer (M-6), Volume Integrator (Beckman 9873B)

4. Range of measurement — Flow: 0-12 liters/second
Volume: 0-6 liters

5. Frequency of measurement — Once per week

6. Output signal characteristics

analog/digital	Flow and Volume Analog Waveforms (See #13)
amplitude	0-5 volts
frequency range	N/A
accuracy/sensitivity	± 2% values

7. Calibration

type & technique	Precalibration of pneumotach head; will provide electrical calibration for flow (1.0 and 5.0 liters sec.
frequency	Before each series of measurements

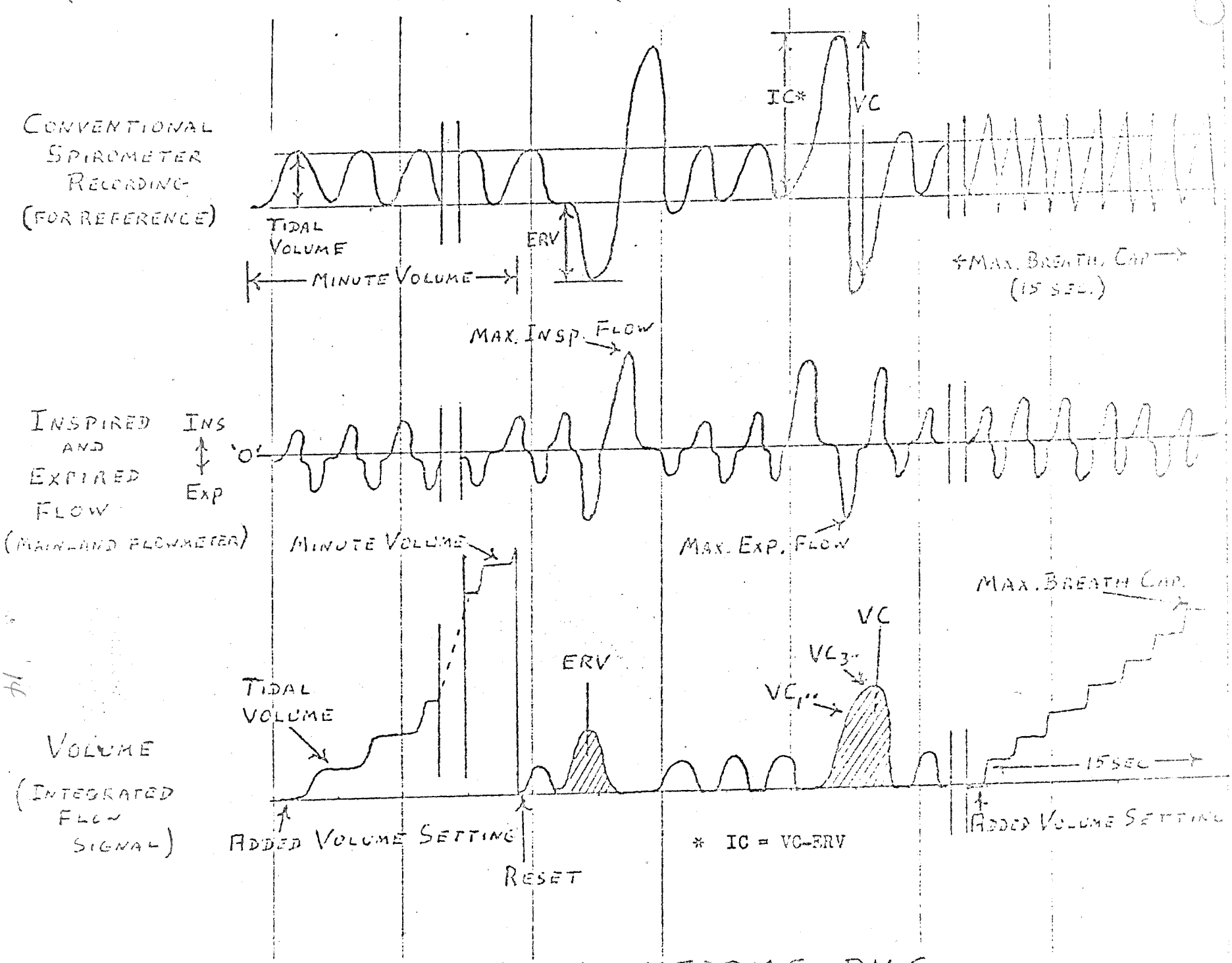
8. Data handling

display analog/digital (raw, processed; local, remote; continuous, intermittent)	Raw, analog, intermittent on respiratory monitor; raw, analog, intermittent on CRT
recording analog/digital (raw, processed; continuous, intermittent)	Raw, digitized, intermittent
manual/programmed A or D switching	Programmed
manual/verbal data entry	Subject identification and measurement number
A/D conversion frequency	200 sps
storage time analog/digital	Digitized until next data dump
recording/storage quantity per subject	3 min./run; approx. 10 mins, total for three runs.

9. Derived quantities

other measurements required simultaneously for calculations	Time base
digital computation	TV, ERV, IC, VC, VC_1, VC_3, MTV, MIF, MEF MBC
display analog/digital; location; updating frequency	All values in digital form on processor readout
recording analog/digital	Digitized & computed values
storage time analog/digital	Until next data dump.

10. Comparison with previous data	Manual in logbooks from printouts
11. Analog/digital display range & resolution/accuracy	Analog waveform ± 4%; total volume 6.0 liters, maximum flow 15 liters per second. Digital ± 2%
12. Printout frequency & other requirements	Once per run



ANALOG WAVEFORMS - DMS

STANDARD LOCATIONS AND MOD

000005	[illegible]	.EQU	.0005
000006	[illegible]	.EQU	.0006
000013	[illegible]	.EQU	.0013
000005	[illegible]	.EQU	.0005
000020	[illegible]	.EQU	.0020
000004	[illegible]	.EQU	.0004
000006	[illegible]	.EQU	.0006
000113	[illegible]	.EQU	.0113
000004	[illegible]	.EQU	.0004
000174	[illegible]	.EQU	.0174
000021	[illegible]	.EQU	.0021
000013	[illegible]	.EQU	.0013
000100	[illegible]	.EQU	.0100
000002	[illegible]	.EQU	.0002
000003	[illegible]	.EQU	.0003
000015	[illegible]	.EQU	.0015
000016	[illegible]	.EQU	.0016
000017	[illegible]	.EQU	.0017
000020	[illegible]	.EQU	.0020
000021	[illegible]	.EQU	.0021
000106	[illegible]	.EQU	.0106
000202	[illegible]	.EQU	.0202
000207	[illegible]	.EQU	.0207
000137	[illegible]	.EQU	.0137
000203	[illegible]	.EQU	.0203
000003	[illegible]	.EQU	.0003
000202	[illegible]	.EQU	.0202
001203	[illegible]	.EQU	.0203
000212	[illegible]	.EQU	.0212
000205	[illegible]	.EQU	.0205
000200	[illegible]	.EQU	.0200
000136	[illegible]	.EQU	.0136
000204	[illegible]	.EQU	.0204
000214	[illegible]	.EQU	.0214
000206	[illegible]	.EQU	.0206
000100	ONE	.EQU	.0100
000101	TWO	.EQU	.0101
000112	M1	.EQU	.0112
000105	SIX	.EQU	.0105
000110	[illegible]	.EQU	.0110
000103	FOUR	.EQU	.0103
000111	TEN	.EQU	.0111
000146	FOV	.EQU	~~.0146~~ 0376
000147	[illegible]	.EQU	.0147
000150	[illegible]	.EQU	~~.0150~~ 0377
000010	[illegible]	.EQU	.0010
000001	[illegible]	.EQU	.0001
000002	[illegible]	.EQU	.0002
000104	[illegible]	.EQU	.0104
000102	[illegible]	.EQU	.0102

```
010020                    .BRA    .SINGR
010021  000000  VER2      .BEGIN  .BETC
010022  017000  I  DLVE   .LDA    .NNN     LOAD START VER2 BRANCH
010023  000000            .STA    .SVCB
010024  010100            .LDA    .FINE
010025  000000            .JMPM*  .ANSW    SET DATA INPUT-OUTPUT
010026  100000
010027  011000  B         .PZE    .SHST
010030  017000  I         .LDA    .DS2     ANALOG RECORDER ON
010031  000000            .JMPM*  .SENC
010032  100212
010033  011000  B         .PZE    .STAR
010034  017000  I         .LDA    .DS1     ANALOG RECORDER OFF
010035  000000            .JMPM*  .SENC
010036  100212
010037  011000  B         .PZE    .EN1
010040  010100            .LDA    .NINE    RECORD SWITCH INPUT
010041  000000            .JMPM*  .SENC
010042  100212
010043  011000  B         .PZE    .ACCP
010044  000000            .JMPM*  .TRIN
010045  100201
010046  000000            .PZE    .ASTR
010047  017000  I         .LDA    .DISP
010050  000000            .STA    .DRAD
010051  017000  I         .LDA    .DISP
010052  000000            .STA    .DRAD
010053  001000            .JMP*   .ENPT
010054  100212
010055  010110    STAR    .LDA    .NINE    TURN OFF STANDBY LIGHT
010056  000000            .JMPM*  .KYLT
010057  100000
010060  017000  I         .LDA    .K2      TURN ON EXP-ACTY LIGHT
010061  000000            .JMPM*  .KYLT
010062  100000
010063  017000  I         .LDA    .PRNT    PRINT OUT PROGRAM NAME
010064  000000            .JMPM*  .PROR
010065  100204
010066  011000  B         .PZE    .PRNT+1
010067  010000            .LDA    .ASTR    ASTRO ID
010070  000000            .LSBA   .3
010071  017000  I         .STA    .DT1
010072  010000            .LDA    .DRDS    MISSION DAY
010073  100177            .ANA    .MSKH
010074  017000  I         .STA    .DR3
010075  000000            .JMPM*  .MSTM    TIME
010076  100000
010077  010000            .LDA    .HTA
010078  017000  I         .STA    .DR5
010079  010100            .LDA    .THDF
010080  000000            .JMPM*  .DCNT
010081  100000
010082  011000  B         .PZE    .DR10
010083  000000            .JMPM*  .SPEL
```

```
010064  [illegible]
010065  [illegible]          ,DATA   ,040002
010066  [illegible] R        ,RZE    ,MS10
010067  [illegible]          ,JMP*   ,ENDT
010070  [illegible]
010071  [illegible] I  MS10  ,LDA    ,GO
010072  [illegible]          ,JAZ    ,*+4
010073  [illegible] R
010074  [illegible]          ,JMP*   ,TPEL
010075  [illegible]
010076  [illegible]          ,LDA    ,TWO          READ A/D CHANNELS
010077  [illegible]          ,JMPM*  ,ARPN
010100  [illegible]
010101  [illegible] R        ,RZE    ,IB00
010102  [illegible] R        ,RZE    ,CN00
010103  [illegible] I        ,LDA    ,IB01
010104  [illegible] I        ,ANA    ,MSKY
010105  [illegible]          ,JAZ    ,*+4
010106  [illegible] R
010107  [illegible]          ,JMP    ,*+4
010110  [illegible] R
010111  [illegible]          ,TVA    ,
010112  [illegible] I        ,STA    ,IB01
010113  017667 I             ,LDA    ,IB01
010114  [illegible]          ,ANA    ,MSKG
010115  [illegible] I        ,STA    ,IB01
010116  [illegible] I        ,LDA    ,RUN
010117  001004               ,JAN    ,INEX
010120  [illegible] R
010121  001010               ,JAZ    ,MBCG
010122  [illegible] R
010123  017666 I             ,LDA    ,DELY
010124  001010               ,JAZ    ,*+8
010125  [illegible] R
010126  047666 I             ,INR    ,DELY         5* DELAY
010127  077666 I             ,LDX    ,DELY
010130  [illegible]          ,JXZ    ,*+4
010131  [illegible] R
010132  [illegible]          ,JMP*   ,TPEL
010133  [illegible]
010134  [illegible] I        ,LDA    ,IB01
010135  [illegible]          ,ANA    ,MSKG
010136  [illegible] I        ,STA    ,IB01
010137  017667 I             ,LDA    ,STTV       FLAG INDICATING COMPUTATION
010140  [illegible]          ,JAN    ,TVPN
010141  [illegible] R
010142  [illegible]          ,JAZ    ,TVA
010143  [illegible] R
010144  [illegible] I        ,LDA    ,IB01
010145  [illegible] I        ,SUB    ,NOIS
010146  [illegible]          ,JAN    ,*+7
010147  [illegible] R
010150  [illegible]          ,JAZ    ,*+7
010151  [illegible] R
```

```
0[illegible]  [illegible] I        .LDA    .IB01
0[illegible]  [illegible]          .JMP*   .TDEL
0[illegible]  [illegible]
0[illegible]  [illegible]          .TXA    .
0[illegible]  [illegible] I        .STA    .STTV
0[illegible]  [illegible] I  TVA   .LDA    .TIM     FLAG INDICATING START TIME
0[illegible]  [illegible]          .JMP    .*+4
0[illegible]  [illegible] P
0[illegible]  [illegible]          .JMP    .*+16
0[illegible]  [illegible] P
0[illegible]  [illegible] I        .LDA    .IB01    Wait until volume zero
0[illegible]  [illegible] I        .SUB    .NOIS
0[illegible]  [illegible]          .JMP*   .TDEL
0[illegible]  [illegible]
0[illegible]  [illegible]          .JAZ*   .TDEL
0[illegible]  [illegible]
0[illegible]  [illegible] I        .LDA    .IB01
0[illegible]  [illegible] I        .STA    .TVUP
0[illegible]  [illegible]          .LDA    .ONE
0[illegible]  [illegible] I        .STA    .TIM
0[illegible]  [illegible]          .JMP*   .TDEL
0[illegible]  [illegible]
0[illegible]  [illegible] I        .INR    .CT01
0[illegible]  [illegible] I        .LDX    .CT01
0[illegible]  [illegible]          .JXZ    .NEXC
0[illegible]  [illegible] P
0[illegible]  [illegible] I        .LDA    .IB01
0[illegible]  [illegible] I        .ADD    .BAND
0[illegible]  [illegible]          .TAX    .
0[illegible]  [illegible] I        .SUB    .TVUP
0[illegible]  [illegible]          .JAN    .*+7
0[illegible]  [illegible] P
0[illegible]  [illegible]          .JAZ*   .TDEL
0[illegible]  [illegible]
0[illegible]  [illegible]          .TXA    .
0[illegible]  [illegible]          .JMP    .*+12
0[illegible]  [illegible] P
0[illegible]  [illegible] I        .INR    .CONT    COUNT BREATHS
0[illegible]  [illegible] I        .LDA    .TVUP
0[illegible]  [illegible] I        .ADD    .TVSM
0[illegible]  [illegible] I        .STA    .TVSM    STORE PEAK
0[illegible]  [illegible] I        .LDA    .NOIS
0[illegible]  [illegible] I        .STA    .TVUP
0[illegible]  [illegible]          .LDA    .M1
0[illegible]  [illegible] I        .STA    .STTV
0[illegible]  [illegible]          .JMP*   .TDEL
0[illegible]  [illegible]
0[illegible]  [illegible] I        .SUB    .BAND
0[illegible]  [illegible] I        .STA    .TVUP
0[illegible]  [illegible]          .JMP*   .TDEL
0[illegible]  [illegible]
0[illegible]  [illegible] I  TVON  .INR    .CT01
0[illegible]  [illegible] I        .LDX    .CT01
0[illegible]  [illegible]          .JXZ    .NEXC
```

```
010248  [illegible]
010249  [illegible] I        .LDA    .D01
010250  [illegible] I        .ADD    .TVUP
010251  [illegible]          .JMP    .**6
010252  [illegible] B
010253  [illegible]          .JAZ    .**4
010254  [illegible] B
010255  [illegible]          .JMP*   .TDEL
010256  [illegible]
010257  [illegible]          .TZA    .
010258  [illegible] I        .STA    .STTV
010259  [illegible]          .JMP*   .TDEL
010260  [illegible]
010261  [illegible]  MEXG    .LDA    .ONE        TIDAL VOLUME CALC.
010262  [illegible] I        .STA    .SD
010263  [illegible] I        .LDA    .K6
010264  [illegible]          .JMPM*  .KYLT
010265  [illegible]
010266  [illegible]          .LDA    .ONE
010267  [illegible]          .JMPM*  .KYLT
010268  [illegible]
010269  [illegible] I        .LDA    .D819
010270  [illegible] I        .STA    .D825
010271  [illegible]          .TZA    .
010272  [illegible] I        .LDA    .TVSM
010273  [illegible] I        .ADD    .CCHT
010274  [illegible] I        .STA    .D801       TIDAL VOLUME SETUP
010275  [illegible] I        .LDA    .TVSM
010276  [illegible] I        .ADD    .TVUP
010277  [illegible] I        .STA    .D833       MINV SETUP
010278  [illegible] I        .LDA    .D41
010279  [illegible] I        .STA    .DXX
010280  [illegible]          .TZA    .
010281  [illegible] I        .LDA    .D801
010282  [illegible] I        .MUL    .D562
010283  [illegible]          .JMPM   .FDV
010284  [illegible] B
010285  [illegible] I        .STA    .D801       TIDAL VOLUME
010286  [illegible] I        .STA    .DBDV
010287  [illegible]          .TZA    .
010288  [illegible] I        .LDA    .D833
010289  [illegible] I        .MUL    .D562
010290  [illegible]          .JMPM   .FDV
010291  [illegible] B
010292  [illegible] I        .STA    .D709
010293  [illegible] I        .STA    .D833       MINV
010294  [illegible] I        .LDA    .TVS        SET FOR DISPLAY
010295  [illegible]          .STA    .DSP1
010296  [illegible] I        .LDA    .MINV
010297  [illegible]          .STA    .DSPV
010298  [illegible]          .LDA    .SJV
010299  [illegible]          .STA    .DSPS
010300  [illegible]          .LDA    .TVS        DIS.DISP.TV+MINV
010301  [illegible]          .JMPM   .DISP
```

```
010326  [illegible]
010327  [illegible]  P          ,PZE    ,DR00
010330  [illegible]             ,LDA    ,IND          POINT TV+MINV
010331  [illegible]             ,JMP*   ,DOUT
010332  [illegible]
010333  [illegible]  P          ,PZE    ,OR06
010334  [illegible]             ,LDA    ,ONE          PP DISPLAY
010335  [illegible]             ,JMP*   ,DOUT
010336  [illegible]
010337  [illegible]  P          ,PZE    ,DR18
010340  [illegible]  I          ,LDA    ,M100
010341  [illegible]  I          ,STA    ,DELY
010342  [illegible]  I          ,LDA    ,MSN
010343  [illegible]  I          ,STA    ,CT01
010344  [illegible]             ,LDA    ,ONE
010345  [illegible]  I          ,STA    ,STTV
010346  [illegible]             ,TZA    ,
010347  [illegible]  I          ,STA    ,TIM
010350  [illegible]  I          ,STA    ,TVUP
010351  [illegible]  I          ,STA    ,TVSK
010352  [illegible]  I          ,STA    ,CONT
010353  [illegible]             ,JMP*   ,TDEL
010354  [illegible]
010355  017715  I   INEX    ,LDA    ,IB00         TEST SIGN OF FLOW
010356  [illegible]  I          ,ANA    ,MSKX
010357  [illegible]             ,JAZ    ,INSP
010360  [illegible]  P
010361  017715  I   EXSP    ,LDA    ,IB00         GET EXPIRED PEAK
010362  150136                ,ANA    ,MSKG
010363  005014                ,TAX    ,
010364  147716  I             ,SUB    ,PEKE
010365  001004                ,JAN    ,SERV
010366  010412  P
010367  001010                ,JAZ    ,SERV
010370  010412  P
010371  005041                ,TXA    ,
010372  057716  I             ,STA    ,PEKE
010373  001000                ,JMP    ,SERV
010374  010412  P
010375  017715  I   INSP    ,LDA    ,IB00         GET INSPIRED PEAK
010376  150136                ,ANA    ,MSKG
010377  057717  I             ,STA    ,TEMP
010400  010136                ,LDA    ,MSKG
010401  147717  I             ,SUB    ,TEMP
010402  005014                ,TAX    ,
010403  147720  I             ,SUB    ,PEKI
010404  001004                ,JAN    ,SERV
010405  010412  P
010406  001010                ,JAZ    ,SERV
010407  010412  P
010410  005041                ,TXA    ,
010411  057720  I             ,STA    ,PEKI
010412  017721  I   SERV    ,LDA    ,ALRT
010413  001010                ,JAZ    ,*+4
```

```
010414  010417 R
010415  001000          ,JMP     ,*+6
010416  010420 R
010417  010100          ,LDA     ,ONE
010420  057721 I        ,STA     ,ALPT
010421  001000          ,JMP*    ,TDEL
010422  100205
010423  017722 I        ,LDA     ,VCOC
010424  001004          ,JAN     ,VCO1
010425  010510 R
010426  001010          ,JAZ     ,VCO2
010427  010504 R
010428  017723 I        ,LDA     ,CKRV
010431  001004          ,JAN     ,PEAK
010432  010451 R
010433  001010          ,JAZ     ,DNRV
010434  010470 R
010435  017663 I        ,LDA     ,IBO1
010436  147724 I        ,SUB     ,THPS          THPS=90 (RISE THRESHOLD
010437  001004          ,JAN*    ,TDEL
010440  100205
010441  001010          ,JAZ*    ,TDEL
010442  100205
010443  017663 I        ,LDA     ,IBO1
010444  057725 I        ,STA     ,PEKA
010445  010110          ,LDA     ,M1            SET FLAG INDICATING PROPER
010446  057723 I        ,STA     ,CKRV
010447  001000          ,JMP*    ,TDEL
010450  100205
010451  017663 I  PEAK  ,LDA     ,IBO1
010452  127726 I        ,ADD     ,BOND
010453  147725 I        ,SUB     ,PEKA
010454  001004          ,JAN     ,*+8
010455  010464 R
010456  001010          ,JAZ*    ,TDEL
010457  100205
010460  017663 I        ,LDA     ,IBO1
010461  057725 I        ,STA     ,PEKA
010462  001000          ,JMP*    ,TDEL
010463  100205
010464  000001          ,XZA     ,
010465  057723 I        ,STA     ,CKRV          SET FLAG, ERV FOUND
010466  001000          ,JMP*    ,TDEL
010467  100205
010470  017663 I  DNRV  ,LDA     ,IBO1
010471  147727 I        ,SUB     ,NOFS
010472  001004          ,JAN     ,*+7
010473  010501 R
010474  001010          ,JAZ     ,*+5
010475  010501 R
010476  017663 I        ,LDA     ,IBO1
010477  001000          ,JMP*    ,TDEL
010500  100205
010501  010110          ,LDA     ,M1
```

```
010503 [illegible]          .STA   .VCDC       SET FLAG*START VC
[illegible — lines struck through by hand, "Oops"]
010507 100000
010510 [illegible]          .JMP*  .TDEL
010511 100000
010512 017663 I  WCD1       .LDA   .IR01       WAIT FOR RISE ABOVE [illegible]
010513 147727 I             .SUB   .NCES
010514 001004               .JAN*  .TDEL
010515 100000
010516 001010               .JAZ*  .TDEL
010517 100000
010520 005001               .TYA   .
010521 057727 I             .STA   .VCDC
010522 001000               .JMP*  .TDEL
010523 100000
010524 017771 I  WCD3       .LDA   .VCD3
010525 001004               .JAN   .VCOM
010526 010512 R
010527 [illegible — struck through by hand]
010530 [illegible — struck through by hand]
010531 047732 I             .INR   .MIN1       1 SEC COUNT
010532 037732 I             .LDX   .MIN1
010533 001040               .JXZ   .*+4
010534 010537 R
010535 001000               .JMP   .*+4
010536 010541 R
010537 017663 I             .LDA   .IR01
010540 057777 I             .STA   .DP09       VC1
010541 047734 I             .INR   .MIN3       3 SEC COUNT
010542 037734 I             .LDX   .MIN3
010543 001040               .JXZ   .*+4
010544 010547 R
010545 001000               .JMP   .*+6
010546 010553 R
010547 017663 I             .LDA   .IR01
010550 057775 I             .STA   .DS11       VC3
010551 010110               .LDA   .M1
010552 057736 I             .STA   .AAA
010553 017663 I             .LDA   .IR01
010554 127726 I             .ADD   .ROND
010555 005014               .TAX   .
010556 147737 I             .SUB   .VCTP
010557 001004               .JAN   .*+2
010560 010570 R
010561 001010               .JAZ*  .TDEL
010562 100000
010563 005001               .TYA   .
010564 117726 I             .SUB   .ROND
010565 057737 I             .STA   .VCTP
010566 001000               .JMP*  .TDEL
010567 100000
```

Q2

```
010570  017774 I          .LDA   .AA1
010571  057771 I          .STA   .VCC3
010572  001000            .JMP*  .TDEL
010573  100225
010574  047774 I   VCOM   .LDA   .MIN3
010575  057774 I          .LDX   .MIN3
010576  001040            .JXZ   .**4
010577  010002 P
010600  001000            .JMP   .**6
010601  010606 P
010602  017760 I          .LDA   .DB01
010603  057770 I          .STA   .DB11
010604  010110            .LDA   .M1
010605  057771 I          .STA   .VCC3
010606  001000            .JMP*  .TDEL
010607  100225
010610  010100     VCOM   .LDA   .ONE          VITAL CAPACITY COMPUTAT
010611  054761            .STA   .GO
010612  017677 I          .LDA   .K6
010613  002000            .JMPM* .KYLT
010614  100220
010615  010100            .LDA   .ONE
010616  002000            .JMPM* .KYLT
010617  100220
010620  017704 I          .LDA   .D1M
010621  057705 I          .STA   .DXX
010622  003001            .TZA   .
010623  027735 I          .LDB   .PEKA
010624  164756            .MUL   .D141
010625  002000            .JMPM  .FDV
010626  011422 P
010627  003014            .TAX   .
010630  003001            .TPA   .
010631  003042            .TXB   .
010632  057742 I          .STA   .DB05        FDV
010633  057741 I          .STA   .DB11
010634  003001            .TZA   .
010635  057777 I          .LDB   .VCTP        VC
010636  164744            .MUL   .D141
010637  002000            .JMPM  .FDV
010640  011422 P
010641  057742 I          .STB   .DB07
010642  057743 I          .STB   .DB13
010643  003001            .TZA   .
010644  027733 I          .LDB   .DB09        VC1
010645  164735            .MUL   .D141
010646  002000            .JMPM  .FDV
010647  011422 P
010650  057773 I          .STB   .DB09
010651  057744 I          .STB   .DB15
010652  003001            .TZA   .
010653  027775 I          .LDB   .DB11        VC3
010654  164736            .MUL   .D141
010655  002000            .JMPM  .FDV
```

Remove

```
010[illegible]  011[illegible]  P
010[illegible]  067[illegible]  I      ,STB    ,DB11
010[illegible]  067[illegible]  I      ,STB    ,DB17
010[illegible]  017[illegible]  I      ,LDA    ,DB07
010[illegible]  1[illegible]  I      ,SUB    ,DB05        VC-EDV=IC
010[illegible]  0[illegible]  I      ,STA    ,DB13
010[illegible]  0[illegible]  I      ,STA    ,DB19
010[illegible]  017[illegible]  I      ,LDA    ,D100
010[illegible]  0[illegible]  I      ,STA    ,DXX
010[illegible]  00[illegible]  I      ,TZA    ,
010[illegible]  0[illegible]  I      ,LDB    ,PEKF        CALC. MEF
010[illegible]  1[illegible]  I      ,MUL    ,CVPT
010[illegible]  00[illegible]  I      ,JMPM   ,EDV
010[illegible]  011[illegible]  P
010[illegible]  067[illegible]  I      ,STB    ,DB17
010[illegible]  067[illegible]  I      ,STB    ,DB23
010[illegible]  00[illegible]  I      ,TZA    ,
010[illegible]  0[illegible]  I      ,LDB    ,PEKI        CALC. MIF
010[illegible]  1[illegible]  I      ,MUL    ,CVPT
010[illegible]  00[illegible]  I      ,JMPM   ,EDV
010[illegible]  011[illegible]  P
010[illegible]  067[illegible]  I      ,STB    ,DB15
010[illegible]  067[illegible]  I      ,STB    ,DB21
010[illegible]  00[illegible]  I      ,TZA    ,
010[illegible]  0[illegible]  I      ,STA    ,PEKF
010[illegible]  0[illegible]  I      ,STA    ,PEKI
010[illegible]  014[illegible]  I      ,LDA    ,EVPD        SET FOR DIG DISPLAY
010[illegible]  0[illegible]  I      ,STA    ,DSP1
010[illegible]  014[illegible]  I      ,LDA    ,VCD
010[illegible]  0[illegible]  I      ,STA    ,DSP2
010[illegible]  014[illegible]  I      ,LDA    ,VC1D
010[illegible]  0[illegible]  I      ,STA    ,DSP3
010[illegible]  014[illegible]  I      ,LDA    ,VCPD
010[illegible]  0[illegible]  I      ,STA    ,DSP4
010[illegible]  014[illegible]  I      ,LDA    ,ICD
010[illegible]  0[illegible]  I      ,STA    ,DSP5
010[illegible]  01[illegible]  I      ,LDA    ,SVN         OUT TO DISPLAY
010[illegible]  00[illegible]  I      ,JMPM*  ,DOUT
010[illegible]  10[illegible]  I
010[illegible]  011[illegible]  R      ,PZE    ,DB04
010[illegible]  01[illegible]  I      ,LDA    ,SVN         OUT TO PRINTER
010[illegible]  00[illegible]  I      ,JMPM*  ,DOUT
010[illegible]  10[illegible]  I
010[illegible]  01[illegible]  P      ,PZE    ,DB10
010[illegible]  01[illegible]  I      ,LDA    ,ONE         RESTORE COUNTERS
010[illegible]  0[illegible]  I      ,STA    ,VCOO
010[illegible]  0[illegible]  I      ,STA    ,CKRV
010[illegible]  0[illegible]  I      ,STA    ,VCO3
010[illegible]  00[illegible]  I      ,TZA    ,
010[illegible]  0[illegible]  I      ,STA    ,AAA
010[illegible]  0[illegible]  I      ,STA    ,VCTP
010[illegible]  0[illegible]  I      ,STA    ,PEKA
010[illegible]  014[illegible]  I      ,LDA    ,M20
010[illegible]  0[illegible]  I      ,STA    ,MIN1
```

```
010744  014647          ,LDA    ,MBC
010745  034647          ,STA    ,MINS
010746  001000          ,JMP*   ,TDEL
010747  100205
010750  014707  MBCC    ,LDA    ,MBCA          MAXIMUM BREATHING
010751  001004          ,JAN    ,MBCN
010752  011047 R
010753  001010          ,JAZ    ,MBCP
010754  011007 R
010755  014727          ,LDA    ,ELLO
010756  001010          ,JAZ    ,*+4
010757  010760 R
010760  001000          ,JMP    ,*+6
010761  010766 R
010762  044637          ,INR    ,MB15
010763  034639          ,LDX    ,MB15
010764  001040          ,JXZ    ,ENB
010765  011072 R
010766  014734          ,LDA    ,IB01
010767  144612          ,SUB    ,THES
010770  001004          ,JAN    ,*+4
010771  010774 R
010772  001000          ,JMP    ,*+5
010773  010777 R
010774  014726          ,LDA    ,IB01
010775  001000          ,JMP*   ,TDEL
010776  100205
010777  005001          ,TZA    ,
011000  034704          ,STA    ,ELLO
011001  014721          ,LDA    ,IB01
011002  034707          ,STA    ,MBCP
011003  005001          ,TZA    ,
011004  034677          ,STA    ,MBCA          SET FLAG TO LOOK FOR PEAK
011005  001000          ,JMP*   ,TDEL
011006  100205
011007  044606  MBCE    ,INR    ,MB15
011010  034605          ,LDX    ,MB15
011011  001040          ,JXZ    ,ENB
011012  011072 R
011013  014707          ,LDA    ,IB01
011014  124565          ,ADD    ,BCND
011015  005014          ,TAX    ,
011016  144667          ,SUB    ,MBCP
011017  001004          ,JAN    ,*+14
011020  011035 R
011021  001010          ,JAZ    ,*+5
011022  011026 R
011023  005041          ,TXA    ,
011024  001000          ,JMP    ,*+5
011025  011031 R
011026  005041          ,TXA    ,
011027  001000          ,JMP*   ,TDEL
011030  100205
011031  144646          ,SUB    ,BCND
```

```
011033  054[illegible]          ,STA    ,MBCP
011035  001[illegible]          ,JMP*   ,TDEL
011036  100[illegible]
011037  014[illegible]          ,LDA    ,MBCP
011038  104[illegible]          ,ADD    ,DB21
011039  054[illegible]          ,STA    ,DB21
011040  014[illegible]          ,LDA    ,NCES
011041  054644                  ,STA    ,MBCP
011042  044[illegible]          ,INR    ,CTPP          PP COUNT
011043  010112                  ,LDA    ,M1            SET FLAG TO FIND LOW POINT
011044  054[illegible]          ,STA    ,MBCA
011045  001[illegible]          ,JMP*   ,TDEL
011046  100[illegible]
011047  044[illegible]  MPCN    ,INR    ,MB15
011050  054[illegible]          ,LDX    ,MB15
011051  001[illegible]          ,JXZ    ,EN5
011052  011[illegible] P
011053  014647                  ,LDA    ,IB31
011054  144[illegible]          ,SUB    ,NCES
011055  001[illegible]          ,JAN    ,*+7
011056  011[illegible] P
011057  001[illegible]          ,JAZ    ,*+5
011060  011[illegible] P
011061  054641                  ,LDX    ,IB31
011062  001[illegible]          ,JMP*   ,TDEL
011063  100[illegible]
011064  005[illegible]          ,TZA    ,
011065  054617                  ,STA    ,ELLC
011066  010[illegible]          ,LDA    ,ONE
011067  054614                  ,STA    ,MBCA
011070  001[illegible]          ,JMP*   ,TDEL
011071  100[illegible]
011072  010[illegible]  EN5     ,LDA    ,ONE
011073  054477                  ,STA    ,GO
011074  014[illegible]          ,LDA    ,K6
011075  002[illegible]          ,JMPM*  ,KYLT
011076  100[illegible]
011077  010[illegible]          ,LDA    ,ONE
011100  002[illegible]          ,JMPM*  ,KYLT
011101  100[illegible]
011102  014[illegible]          ,LDA    ,MBCA
011103  001[illegible]          ,JAN    ,*+9
011104  011[illegible] P
011105  001[illegible]          ,JAZ    ,*+4
011106  011[illegible] P
011107  001[illegible]          ,JMP    ,*+5
011110  011[illegible] P
011111  014[illegible]          ,LDA    ,IB31
011112  104[illegible]          ,ADD    ,DB21
011113  054[illegible]          ,STA    ,DB21
011114  014[illegible]          ,LDA    ,DB21
011115  005[illegible]          ,TZA    ,
011116  100[illegible]          ,MUL    ,ECUR
011117  054[illegible]          ,STA    ,DB21
```

```
011120  [illegible]          ,TZA    ,
011121  [illegible]          ,LDB    ,CTRP
011122  [illegible]          ,MUL    ,ZOUP
011123  [illegible]          ,STB    ,DB19
011124  [illegible]          ,STB    ,OB25
011125  [illegible]          ,LDA    ,DIM
011126  [illegible]          ,STA    ,DXX
011127  [illegible]          ,TZA    ,
011130  [illegible]          ,LDB    ,DB21
011131  [illegible]          ,MUL    ,D256
011132  [illegible]          ,JMPM   ,FDV
011133  [illegible] R
011134  [illegible]          ,STB    ,DB21
011135  [illegible]          ,STB    ,OB27
011136  [illegible]          ,LDA    ,RBD
011137  [illegible]          ,STA    ,DSP1
011140  [illegible]          ,LDA    ,MBCD
011141  [illegible]          ,STA    ,DSP2
011142  [illegible]          ,LDA    ,SIX
011143  [illegible]          ,STA    ,DSP3
011144  [illegible]          ,STA    ,DSP4
011145  [illegible]          ,STA    ,DSP5
011146  [illegible]          ,LDA    ,TXO
011147  [illegible]          ,JMPM*  ,DOUT
011150  [illegible]
011151  [illegible] R        ,PZE    ,DB18
011152  [illegible]          ,LDA    ,TXO
011153  [illegible]          ,JMPM*  ,DOUT
011154  [illegible]
011155  [illegible] R        ,PZE    ,OB24
011156  [illegible]          ,LDA    ,THRF
011157  [illegible]          ,JMPM*  ,DOUT
011160  [illegible]
011161  [illegible] R        ,PZE    ,CB01
011162  [illegible]          ,LDA    ,M300
011163  [illegible]          ,STA    ,MB15
011164  [illegible]          ,TZA    ,
011165  [illegible]          ,STA    ,CTRP
011166  [illegible]          ,STA    ,ZERO
011167  [illegible]          ,LDA    ,ONE
011170  [illegible]          ,STA    ,ELLQ
011171  [illegible]          ,STA    ,MBCA
011172  [illegible]          ,JMP*   ,TDEL
011173  [illegible]
011174  [illegible]  ACCP    ,LDA    ,RUN          ENTER FROM RECORD SW.
011175  [illegible]          ,JAN    ,*+16
011176  [illegible] R
011177  [illegible]          ,JAZ    ,TMBC
011200  [illegible] R
011201  [illegible]          ,LDA    ,DB01
011202  [illegible]          ,ADD    ,ST00
011203  [illegible]          ,STA    ,ST00
011204  [illegible]          ,LDA    ,DB03
011205  [illegible]          ,ADD    ,ST01
```

```
011206  054440          ,STA    ,ST01
011207  044414          ,INR    ,CON1
011210  054417          ,LDX    ,CON1
011211  001[illegible]          ,JYZ    ,**4
011212  011[illegible] R
011213  001[illegible]          ,JMP    ,FIN
011214  011[illegible] R
011215  014544          ,LDA    ,DB05
011216  124[illegible]          ,ADD    ,ST02
011217  054[illegible]          ,STA    ,ST02
011220  014[illegible]          ,LDA    ,DB07
011221  124[illegible]          ,ADD    ,ST03
011222  054[illegible]          ,STA    ,ST03
011223  014[illegible]          ,LDA    ,DB09
011224  124[illegible]          ,ADD    ,ST04
011225  054[illegible]          ,STA    ,ST04
011226  014541          ,LDA    ,DB11
011227  124[illegible]          ,ADD    ,ST05
011230  054[illegible]          ,STA    ,ST05
011231  014[illegible]          ,LDA    ,DB13
011232  124[illegible]          ,ADD    ,ST06
011233  054[illegible]          ,STA    ,ST06
011234  014[illegible]          ,LDA    ,DB15
011235  124422          ,ADD    ,ST07
011236  054421          ,STA    ,ST07
011237  014[illegible]          ,LDA    ,DB17
011240  124[illegible]          ,ADD    ,ST08
011241  054417          ,STA    ,ST08
011242  044362          ,INR    ,CON2
011243  054361          ,LDX    ,CON2
011244  001[illegible]          ,JYZ    ,**4
011245  011[illegible] R
011246  001000          ,JMP    ,FIN
011247  011[illegible] R
011250  014527    TMPC  ,LDA    ,DB19
011251  124410          ,ADD    ,ST09
011252  054407          ,STA    ,ST09
011253  014[illegible]          ,LDA    ,DB21
011254  124[illegible]          ,ADD    ,ST10
011255  054405          ,STA    ,ST10
011256  044347          ,INR    ,CON3
011257  010105    FIN   ,LDA    ,SIX
011260  002000          ,JMPM*  ,KYLT        TURN OFF NEW DATA LIGHT
011261  100220
011262  001000          ,JMP*   ,ENPT
011263  100212
011264  005001    EN1   ,TZA    ,
011265  027[illegible] I        ,LDB*   ,SM00
011266  174[illegible]          ,DIV    ,CON1
011267  067[illegible] I        ,STB*   ,DBXX
011270  067[illegible] I        ,STB*   ,DBXX
011271  014[illegible]          ,LDA    ,SM00
011272  120100          ,ADD    ,ONE
011273  054[illegible]          ,STA    ,SM00
```

```
011274  014310          ,LDA    ,DBXX
011275  120101          ,ADD    ,TWO
011276  054306          ,STA    ,DBXX
011277  014306          ,LDA    ,OBXX
011300  120101          ,ADD    ,TWO
011301  054304          ,STA    ,OBXX
011302  044325          ,JMP    ,CTWO
011303  054325          ,LDX    ,CTWO
011304  001040          ,JXZ    ,*+4
011305  011310 R
011306  001000          ,JMP    ,EN1
011307  011264 R
011310  014317          ,LDA    ,FLAG
011311  001010          ,JAZ    ,*+4
011312  011315 R
011313  001000          ,JMP    ,*+10
011314  011323 R
011315  014307          ,LDA    ,CON2
011316  054305          ,STA    ,CON1
011317  010122          ,LDA    ,M7
011320  054310          ,STA    ,CTWO
011321  010100          ,LDA    ,ONE
011322  054323          ,STA    ,FLAG
011323  001000          ,JMP    ,EN1
011324  011264 R
011325  014301          ,LDA    ,REPT
011326  001010          ,JAZ    ,*+4
011327  011332 R
011330  001000          ,JMP    ,*+10
011331  011342 R
011332  014273          ,LDA    ,CON3
011333  054270          ,STA    ,CON1
011334  010113          ,LDA    ,M2
011335  054273          ,STA    ,CTWO
011336  010100          ,LDA    ,ONE
011337  054267          ,STA    ,REPT
011340  001000          ,JMP    ,EN1
011341  011264 R
011342  014274          ,LDA    ,VCD
011343  050315          ,STA    ,DSP1
011344  014271          ,LDA    ,EVDD
011345  050316          ,STA    ,DSP2
011346  014273          ,LDA    ,ICD
011347  050317          ,STA    ,DSP3
011350  014262          ,LDA    ,TVD
011351  050320          ,STA    ,DSP4
011352  014270          ,LDA    ,MBCD
011353  050321          ,STA    ,DSP5
011354  014405          ,LDA    ,DB05
011355  057446          ,STA*   ,ERV
011356  014403          ,LDA    ,DB07
011357  057430          ,STA*   ,VC
011360  014772          ,LDA    ,D11
011361  002000          ,JMPM*  ,DOUT
```

```
011362  100000
011363  011772 R          ,RZE     ,DR00
011364  010100            ,LDA     ,ONE
011365  002000            ,JMPM*   ,DOUT
011366  100200
011367  012161 R          ,RZE     ,CR00
011370  014700            ,LDA     ,D11
011371  002000            ,JMPM*   ,DOUT
011372  100200
011373  012011 R          ,RZE     ,OR06
011374  014724            ,LDA     ,K9
011375  002000            ,JMPM*   ,KYLT        TURN ON STNDBY LIGHT
011376  100200
011377  010101            ,LDA     ,TWO
011400  002000            ,JMPM*   ,KYLT        TURN OFF EXP-ACT LIGHT
011401  100200
011402  002000            ,JMPM*   ,CDEL
011403  100204
011404  012071 R          ,RZE     ,MS10
011405  014735            ,LDA     ,D30
011406  002000            ,JMPM*   ,CENC
011407  100214
011410  014326            ,LDA     ,D31
011411  002000            ,JMPM*   ,CENC
011412  100214
011413  010110            ,LDA     ,NINE
011414  002000            ,JMPM*   ,CENC
011415  100214
011416  002000            ,JMPM*   ,TERM
011417  100236
011420  001000            ,JMP*    ,ENRT
011421  100212
011422  000000      EDV   ,RZE     ,0
011423  005014            ,TAX     ,
011424  144264            ,SUB     ,DXX
011425  001004            ,JAN     ,*+4
011426  011431 R
011427  001000            ,JMP     ,*+5
011430  011434 R
011431  005041            ,TXA     ,
011432  001000            ,JMP     ,*+10
011433  011444 R
011434  005041            ,TXA     ,
011435  004701            ,LAS?    ,1
011436  044252            ,INR     ,CTZO
011437  074252            ,LDX     ,CTZO
011440  001040            ,JXZ     ,*+4
011441  011442 R
011442  001000            ,JMP     ,EDV+1
011443  011423 R
011444  174244            ,DIV     ,DXX
011445  014244            ,LDA     ,CTZO
011446  005211            ,CPA     ,
011447  005111            ,JAP     ,
```

```
011[illegible]  [illegible]                  .TAX    .ERV
011[illegible]  [illegible] R
011[illegible]  [illegible]                  .STA    .CTZC
011[illegible]  [illegible]                  .TXA    .
011[illegible]  [illegible]                  .LASL   .1              SHIFT BACK [illegible]
011[illegible]  [illegible]                  .TAX    .CTZC
011[illegible]  [illegible]                  .LDX    .CTZC
011[illegible]  [illegible]                  .JYE*   .ERV
011[illegible]  [illegible] R
011[illegible]  [illegible]                  .JMP    .*+5
011[illegible]  [illegible] R
011[illegible]  [illegible]      NEPT        .LDA    .FIVE       TURN OFF OP. ERROR
011[illegible]  [illegible]                  .IMPV*  .FLSH
011[illegible]  [illegible]
011[illegible]  [illegible]                  .LDA    .VNON
011[illegible]  [illegible]                  .ANA    .NSKE
011[illegible]  [illegible]                  .JAZ    .*+4
011471  011474 R
011472  [illegible]                          .JMP    .*+7
011473  [illegible] R
011474  [illegible]      ERR                 .LDA    .KE
011475  [illegible]                          .IMPV*  .FLSH
011476  [illegible]
011477  [illegible]                          .JMP*   .ENRT
011500  [illegible]
011501  [illegible]                          .TAX    .
011502  [illegible]                          .SUB    .TWO
011503  [illegible]                          .JAZ    .XYZB
011504  011507 R
011505  [illegible]                          .JAN    .*+4
011506  011511 R
011507  [illegible]                          .JMP    .*+5
011510  011514 R
011511  [illegible]                          .TXA    .
011512  [illegible]                          .JMP    .XYZA
011513  011517 R
011514  [illegible]                          .TXA    .
011515  [illegible]                          .SUB    .THRE
011516  [illegible]                          .JAN    .XYZC
011517  011546 R
011520  [illegible]                          .JAZ    .XYZC
011521  011546 R
011522  [illegible]                          .TXA    .
011523  [illegible]                          .SUB    .FOUR
011524  [illegible]                          .JAN    .*+6
011525  011532 R
011526  [illegible]                          .JAZ    .*+4
011527  011532 R
011530  [illegible]                          .JMP    .ERR
011531  011474 R
011532  [illegible]                          .LDA    .RUN
011533  [illegible]                          .JAN    .*+4
011534  011537 R
011535  [illegible]                          .JMP    .ERR
```

```
011535  [illegible]                  .ZZA    .
011536  [illegible]                  .STA    .GO
011537  [illegible]                  .STA    .HIN
011540  [illegible]                  .JMP*   .KYLT
011541  [illegible]
011542  [illegible]                  .JMP*   .ENRT
011543  [illegible]
011544  [illegible]     XXZO         .ZZA    .
011545  [illegible]                  .STA    .RUN
011546  [illegible]                  .STA    .GO
011547  [illegible]                  .JMP    .*+10
011550  [illegible]
011551  [illegible]     XXZA         .STA    .RUN
011552  [illegible]                  .ZZA    .
011553  [illegible]                  .JMP    .*+5
011554  [illegible]
011555  [illegible]     XXZP         .LDA    .M1
011556  [illegible]                  .STA    .RUN
011557  [illegible]                  .JMP    .*+5
011560  [illegible]
011561  [illegible]                  .LDA    .SIX        TURN OFF NEW DATA
011562  [illegible]                  .JMP*   .KYLT
011563  [illegible]
011564  [illegible]                  .LDA    .K1         TURN ON COUP+ACTY
011565  [illegible]                  .JMP*   .KYLT
011566  [illegible]
011567  [illegible]                  .JMP*   .ENRT
011570  [illegible]
*
* CONSTANTS AND STORAGE
*
*
011573  000001      GO       .DATA   .1
011574  777774      ONLY     .DATA   .-100
011575  000010      NOIS     .DATA   .10          NOISE BANDS
011576  000010      NOFS     .DATA   .10
011577  000010      BANB     .DATA   .10
011600  000010      BANF     .DATA   .10
011601  000060      TURS     .DATA   .50
011602  000060      TURF     .DATA   .50
011603  [illegible]  DIAG     .DATA   .3671
011604  000010      TEMP     .DATA   .264
011605  011775 R    TOXX     .EQU    .DB01        STORE ADDRESSES
011606  011710 R    COXX     .EQU    .CB07
011607  000001      MLRT     .DATA   .1
011610  777774      MIN      .DATA   .-20         RESTORE MINI
011611  777774      MIN      .DATA   .-60         RESTORE MINS
011612  [illegible]  [illegible] .DATA   .-1200
011613  [illegible]  MIN      .DATA   .-1200
011614  [illegible]  MIN1     .DATA   .-20         1 SEC COUNT
011615  [illegible]  MIN5     .DATA   .-60         5 SEC COUNT
011616  [illegible]  MIN15    .DATA   .-300        15 SEC COUNT
011617  000000      ONTV     .DATA   .0
```

```
011620  000001   STRV   .DATA   .1
011621  000000   RAN    .DATA   .0
011622  000000   TMOD   .DATA   .0
011623  001000   TIM    .DATA   .1000
011624  000000   CRT1   .DATA   .0
011625  000000   CRT2   .DATA   .0
011626  000000   CRT3   .DATA   .0
011627  000000   CRT4   .DATA   .0
011630  000000   TMAS   .DATA   .0
011631  777776   STAS   .DATA   .-2
011632  000000   CHN    .DATA   .0
011633  000037   TVD    .DATA   .037
011634  000002   TPD    .DATA   .2
011635  000111   TEMP   .DATA   .0111
011636  000034   TMSP   .DATA   .034
011637  000037   VSP    .DATA   .037
011640  000040   VSP10  .DATA   .040
011641  000041   VSP20  .DATA   .041
011642  000042   VSP    .DATA   .042
011643  000043   VSP30  .DATA   .043
011644  000036   TMPP   .DATA   .036
011645  000035   TMPC   .DATA   .035
011646  012077 R  TTOP   .BZE    .PRT
011647  012104 R  DIGT   .BZE    .DIG
011650  011671 R  STOP   .BZE    .ST00
011651  000000   ST00   .DATA   .0                    DATA ACCUMULATORS
011652  000000   ST01   .DATA   .0
011653  000000   ST02   .DATA   .0
011654  000000   ST03   .DATA   .0
011655  000000   ST04   .DATA   .0
011656  000000   ST05   .DATA   .0
011657  000000   ST06   .DATA   .0
011660  000000   ST07   .DATA   .0
011661  000000   ST08   .DATA   .0
011662  000000   ST09   .DATA   .0
011663  000000   ST10   .DATA   .0
011664  100005   KF     .DATA   .0100005
011665  777634   M100   .DATA   .-100
011666  000000   CONT   .DATA   .0
011667  000000   TVSM   .DATA   .0
011670  000001   VC00   .DATA   .1
011671  000001   CKPV   .DATA   .1
011672  000000   PEKA   .DATA   .0
011673  000000   PEKE   .DATA   .0
011674  000000   PEKI   .DATA   .0
011675  001750   CURT   .DATA   .1000
011676  176000   MSKZ   .DATA   .0176000
011677  000001   VC03   .DATA   .1
011700  777774   M300   .DATA   .-300
011701  000000   AAA    .DATA   .0
011702  000000   VCTP   .DATA   .0
011703  000000   ZERO   .DATA   .0
011704  000001   VC02   .DATA   .1
011705  000001   ELLO   .DATA   .1
```

```
011702  000000   CTRS   .DATA   .0
011703  000000   CTRS   .DATA   .0
011710  000144   T100   .DATA   .100
011711  000000   DXX    .DATA   .0
011712  000000   DTXX   .DATA   .0
011713  000013   T11    .DATA   .11
011714  000014   T12    .DATA   .12
011715  000000   CTAV   .DATA   .0
011716  100001   K1     .DATA   .0100001
011717  100002   K2     .DATA   .0100002
011720  100006   K6     .DATA   .0100006
011721  100011   K9     .DATA   .0100011
011722  000000   *DOT   .DATA   .0                FLOW A/D
011723  000000   I001   .DATA   .0                VOLUME A/D
011724  000010   CH08   .DATA   .8                F
011725  000011          .DATA   .9                V
011726  002000   MAXX   .DATA   .02000
011727  004401   SWRT   .DATA   .04401
011730  005001          .DATA   .05001
011731  006001          .DATA   .06001
011732  007412          .DATA   .07412
011733  010011          .DATA   .010011
011734  000000   TEMP   .DATA   .0
011735  000400   M256   .DATA   .256
011736  000006   D30    .DATA   .6
011737  000010   D31    .DATA   .8
011740  000013   BPUT   .DATA   .11
011741  145725          .DATA   .'LUNG VOLUME CAPACITY  '
011742  147727
011743  120726
011744  147714
011745  152717
011746  142642
011747  141701
011750  152701
011751  141711
011752  152731
011753  120240
011754  011467 R  WWW    .BZE    .STRT
011755  021033   DB00   .DATA   .021033
011756  000000   DB01   .DATA   .0            TIDAL VOLUME DIGITAL DISPLA
011757  021111   DB02   .DATA   .021111
011760  000000   DB03   .DATA   .0                MINV
011761  021034   DB04   .DATA   .021034
011762  000000   DB05   .DATA   .0                ERV
011763  021037   DB06   .DATA   .021037
011764  000000   DB07   .DATA   .0                VC
011765  021040   DB08   .DATA   .021040
011766  000000   DB09   .DATA   .0                VC1
011767  021041   DB10   .DATA   .021041
011770  000000   DB11   .DATA   .0                VC3
011771  021042   DB12   .DATA   .021042
011772  000000   DB13   .DATA   .0                IC
011773  020435   DB14   .DATA   .020435
```

```
012[illegible]  [illegible]  [illegible]  DATA   =0                 MIF
012[illegible]  [illegible]  [illegible]  DATA   =027435
012[illegible]  [illegible]  [illegible]  DATA   =0                 MEF
012[illegible]  [illegible]  [illegible]  DATA   =000002
012[illegible]  [illegible]  [illegible]  DATA   =0                 PP
012[illegible]  [illegible]  [illegible]  DATA   =021043
012[illegible]  [illegible]  [illegible]  DATA   =0                 MBC
012[illegible]  [illegible]  [illegible]  DATA   =054000     ASTRONAUT ID
012[illegible]  [illegible]  [illegible]  DATA   =0
012[illegible]  [illegible]  [illegible]  DATA   =054000     MISSION ID
012[illegible]  [illegible]  [illegible]  DATA   =0
012[illegible]  [illegible]  [illegible]  DATA   =054000     TIME
012[illegible]  [illegible]  [illegible]  DATA   =0
012[illegible]  [illegible]  [illegible]  DATA   =0115033
012[illegible]  [illegible]  [illegible]  DATA   =0                 TV
012[illegible]  [illegible]  [illegible]  DATA   =0115111
012[illegible]  [illegible]  [illegible]  DATA   =0                 MINV
012[illegible]  [illegible]  [illegible]  DATA   =0115034
012[illegible]  [illegible]  [illegible]  DATA   =0                 EPV
012[illegible]  [illegible]  [illegible]  DATA   =0115037
012[illegible]  [illegible]  [illegible]  DATA   =0                 VC
012[illegible]  [illegible]  [illegible]  DATA   =0115040
012[illegible]  [illegible]  [illegible]  DATA   =0                 VC1
012[illegible]  [illegible]  [illegible]  DATA   =0115041
012[illegible]  [illegible]  [illegible]  DATA   =0                 VC3
012[illegible]  [illegible]  [illegible]  DATA   =0115042
012[illegible]  [illegible]  [illegible]  DATA   =0                 IC
012[illegible]  [illegible]  [illegible]  DATA   =0114435
012[illegible]  [illegible]  [illegible]  DATA   =0                 MIF
012[illegible]  [illegible]  [illegible]  DATA   =0114436
012[illegible]  [illegible]  [illegible]  DATA   =0                 MEF
012[illegible]  [illegible]  [illegible]  DATA   =0114002
012[illegible]  [illegible]  [illegible]  DATA   =0                 PP
012[illegible]  [illegible]  [illegible]  DATA   =0114043
012[illegible]  [illegible]  [illegible]  DATA   =0                 MBC
012[illegible]  [illegible]  PRT          DATA   =2
012[illegible]  [illegible]               DATA   =*PP  *
012[illegible]  [illegible]
012[illegible]  [illegible]               DATA   =033
012[illegible]  [illegible]               DATA   =*TV  *
012[illegible]  [illegible]
012[illegible]  [illegible]               DATA   =034
012[illegible]  [illegible]               DATA   =*EPV *
012[illegible]  [illegible]
012[illegible]  [illegible]               DATA   =040
012[illegible]  [illegible]               DATA   =*VC1 *
012[illegible]  [illegible]
012[illegible]  [illegible]               DATA   =041
012[illegible]  [illegible]               DATA   =*VC3 *
012[illegible]  [illegible]
012[illegible]  [illegible]               DATA   =037
012[illegible]  [illegible]               DATA   =*VC  *
012[illegible]  [illegible]
012[illegible]  [illegible]               DATA   =040
```

```
012002  [illegible]          .DATA   .*IC  *
012003  [illegible]
012004  [illegible]          .DATA   .036
012005  [illegible]          .DATA   .*MSF *
012006  [illegible]
012007  [illegible]          .DATA   .035
012070  [illegible]          .DATA   .*MIF *
012071  [illegible]
012072  [illegible]          .DATA   .043
012073  [illegible]          .DATA   .*MDC *
012074  [illegible]
012075  [illegible]          .DATA   .0111
012076  [illegible]          .DATA   .*MINV*
012077  [illegible]
012100  [illegible]          .DATA   .0100
012101  [illegible]          .DATA   .*AVG *
012102  [illegible]
012103  [illegible]          .DATA   .0
012104  [illegible]  [illegible]  .DATA   .2
012105  [illegible]          .DATA   .01002
012106  [illegible]          .DATA   .017437
012107  [illegible]          .DATA   .037
012110  [illegible]          .DATA   .016
012111  017437               .DATA   .017437
012112  [illegible]          .DATA   .034
012113  007402               .DATA   .07402
012114  [illegible]          .DATA   .07037
012115  [illegible]          .DATA   .040
012116  007011               .DATA   .07011
012117  002437               .DATA   .02437
012120  [illegible]          .DATA   .041
012121  007011               .DATA   .07011
012122  [illegible]          .DATA   .010037
012123  [illegible]          .DATA   .037
012124  007011               .DATA   .07011
012125  017437               .DATA   .017437
012126  [illegible]          .DATA   .042
012127  011411               .DATA   .011411
012130  017437               .DATA   .017437
012131  [illegible]          .DATA   .036
012132  012017               .DATA   .012017
012133  011037               .DATA   .011037
012134  [illegible]          .DATA   .035
012135  [illegible]          .DATA   .012023
012136  [illegible]          .DATA   .011037
012137  [illegible]          .DATA   .043
012140  [illegible]          .DATA   .012025
012141  004437               .DATA   .04437
012142  [illegible]          .DATA   .0111
012143  [illegible]          .DATA   ~~.012026~~   012000
012144  017437               .DATA   .017437   [illegible]
012145  [illegible]          .DATA   ~~.012023~~   0
012146  007037               .DATA   ~~.07037~~   0
012147  [illegible]          .DATA   ~~[illegible]~~   0
```

```
[illegible]  [illegible]          ,DATA   ,017477
[illegible]  [illegible]          ,DATA   ,017477
[illegible]  [illegible]          ,DATA   ,0
[illegible]  [illegible]  0001    ,DATA   ,060006
[illegible]  [illegible]          ,DATA   ,-1
[illegible]  [illegible]          ,DATA   ,060006
[illegible]  [illegible]          ,DATA   ,-1
012157  [illegible]          ,DATA   ,060006
[illegible]  [illegible]          ,DATA   ,-1
012161  [illegible]  0000    ,DATA   ,0114100
[illegible]  [illegible]          ,DATA   ,0
        [illegible]          ,END    ,
```

LITERALS

POINTERS

```
000650  011734
000651  011736
000652  011737
000653  011646
000654  011647
000655  011717
000656  011740
000657  012004
000660  012006
000661  012010
000662  011573
000663  011723
000664  011726
000665  011632
000666  011374
000667  011620
000670  011575
000671  011621
000672  011622
000673  011612
000674  011577
000675  011666
000676  011667
000677  011720
000700  012000
000701  012034
000702  011753
000703  011760
000704  011623
000705  011711
000706  011624
000707  012012
000710  012014
000711  011637
000712  011638
000713  011663
000714  011613
000715  011722
```

[illegible]	[illegible]
000716	[illegible]
000717	[illegible]
000720	[illegible]
000721	[illegible]
000722	[illegible]
000723	011671
000724	[illegible]
000725	011672
000726	[illegible]
000727	011776
000730	[illegible]
000731	[illegible]
000732	[illegible]
000733	011766
000734	011615
000735	011772
000736	011771
000737	[illegible]
000740	[illegible]
000741	[illegible]
000742	[illegible]
000743	[illegible]
000744	[illegible]
000745	[illegible]
000746	[illegible]
000747	012026
000750	011710
000751	011675
000752	011776
000753	[illegible]
000754	011774
000755	[illegible]
000756	[illegible]
000757	111605
000760	111606

SYMBOLS

1	012161	R	[illegible]
1	012153	R	[illegible]
1	012104	R	[illegible]
1	012037	R	[illegible]
1	012036	R	[illegible]
1	[illegible]	R	[illegible]
1	012034	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]

1	012023	R	DP38
1	012022	R	DP37
1	012021	R	DP36
1	012020	R	DP35
1	012017	R	DP34
1	012016	R	DP33
1	012015	R	DP32
1	012014	R	DP31
1	012013	R	DP30
1	012012	R	DP29
1	012011	R	DP28
1	012010	R	DP27
1	012007	R	DP26
1	012006	R	DP25
1	012005	R	DP24
1	012004	R	DP23
1	012003	R	DP22
1	012002	R	DP21
1	012001	R	DP20
1	012000	R	DP19
1	011777	R	DP18
1	011776	R	DP17
1	011775	R	DP16
1	011774	R	DP15
1	011773	R	DP14
1	011772	R	DP13
1	011771	R	DP12
1	011770	R	DP11
1	011767	R	DP10
1	011766	R	DP09
1	011765	R	DP08
1	011764	R	DP07
1	011763	R	DP06
1	011762	R	DP05
1	011761	R	DP04
1	011760	R	DP03
1	011757	R	DP02
1	011756	R	DP01
1	011755	R	DP00
1	011754	R	NUM
1	011745	R	PRNT
1	011737	R	DT1
1	011736	R	DT0
1	011735	R	D276
1	011734	R	TEMP
1	011727	R	DMST
1	011725	R	USMX
1	011724	R	CM10
1	011723	R	ID01
1	011722	R	ID02
1	011721	R	K0
1	011720	R	K6
1	011717	R	K0
1	011715	R	K1

39

1	011717	R	[illegible]
1	011714	R	[illegible]
1	011713	R	[illegible]
1	011712	R	[illegible]
1	011711	R	[illegible]
1	011710	R	[illegible]
1	011707	R	[illegible]
1	011706	R	[illegible]
1	011707	R	[illegible]
1	011704	R	[illegible]
1	011707	R	[illegible]
1	011700	R	[illegible]
1	011701	R	[illegible]
1	011700	R	[illegible]
1	011677	R	[illegible]
1	011676	R	[illegible]
1	011675	R	[illegible]
1	011674	R	[illegible]
1	011673	R	[illegible]
1	011672	R	[illegible]
1	011671	R	[illegible]
1	011670	R	[illegible]
1	011667	R	[illegible]
1	011666	R	[illegible]
1	011663	R	[illegible]
1	011664	R	[illegible]
1	011667	R	[illegible]
1	011662	R	[illegible]
1	011661	R	[illegible]
1	011660	R	[illegible]
1	011657	R	[illegible]
1	011656	R	[illegible]
1	011655	R	[illegible]
1	011654	R	[illegible]
1	011653	R	[illegible]
1	011652	R	[illegible]
1	011651	R	[illegible]
1	011650	R	[illegible]
1	011647	R	[illegible]
1	011646	R	[illegible]
1	011645	R	[illegible]
1	011644	R	[illegible]
1	011643	R	[illegible]
1	011642	R	[illegible]
1	011641	R	[illegible]
1	011640	R	[illegible]
1	011637	R	[illegible]
1	011636	R	[illegible]
1	011635	R	[illegible]
1	011634	R	[illegible]
1	011633	R	[illegible]
1	011632	R	[illegible]
1	011631	R	[illegible]
1	011630	R	[illegible]

1	011[illegible]	R	[illegible]
1	011[illegible]	R	[illegible]
1	011[illegible]	R	[illegible]
1	011[illegible]	R	[illegible]
1	011[illegible]	R	[illegible]
1	011[illegible]	R	[illegible]
1	0116[illegible]	R	[illegible]
1	011[illegible]	R	[illegible]V
1	0115[illegible]	R	[illegible]V
1	0115[illegible]	R	[illegible]
1	0115[illegible]	R	[illegible]
1	0115[illegible]	R	[illegible]
1	0115[illegible]	R	[illegible]
1	011[illegible]	R	[illegible]
1	011511	R	[illegible]
1	01151[illegible]	R	[illegible]
1	011607	R	AL[illegible]T
1	0116[illegible]	R	[illegible]XX
1	0115[illegible]	R	[illegible]Y
1	011604	R	[illegible]
1	0115[illegible]	R	DIAL
1	0115[illegible]	R	[illegible]S
1	0115[illegible]	R	[illegible]S
1	0115[illegible]	R	LOAD
1	011577	R	BAND
1	011576	R	NDES
1	011575	R	[illegible]
1	011574	R	DPLY
1	011573	R	GO
1	011557	R	XYTP
1	011550	R	XYZA
1	011543	R	XYZD
1	011474	R	LTR
1	011463	R	STRT
1	011432	R	FDV
1	011264	R	EN1
1	011257	R	FIN
1	011230	R	TMSD
1	011174	R	ACCP
1	011072	R	ENT
1	011047	R	NCON
1	011007	R	NEDP
1	010753	R	NTOO
1	010516	R	VCOM
1	010574	R	VCO3
1	010[illegible]4	R	VCO2
1	010712	R	VCO1
1	010473	R	[illegible]DV
1	010431	R	PEAK
1	010412	R	[illegible]
1	010375	R	INSP
1	010[illegible]1	R	[illegible]SP
1	0103[illegible]	R	INCR
1	010[illegible]	R	[illegible]AD

1	010[illegible]	[illegible]
1	010[illegible]	[illegible]
1	010071	[illegible]
1	010[illegible]	[illegible]
1	010[illegible]	[illegible]
1	000[illegible]	[illegible]
1	000104	[illegible]
0	000[illegible]	[illegible]
0	000441	[illegible]
0	000440	[illegible]
1	000[illegible]	[illegible]
0	000447	[illegible]
1	000446	[illegible]
0	000111	[illegible]
1	000103	[illegible]
1	000110	[illegible]
1	000105	SIX
1	000112	[illegible]
1	000101	TWO
1	000[illegible]	[illegible]
1	000[illegible]	[illegible]
1	000214	[illegible]
1	000204	[illegible]
1	000[illegible]	[illegible]
1	000209	ADRN
1	000[illegible]	[illegible]
1	000213	[illegible]
1	000203	[illegible]
1	000222	DOUT
1	000[illegible]	[illegible]
1	000223	TRIM
1	000[illegible]	[illegible]
1	000307	OPGS
1	000202	[illegible]
1	000106	SVN
1	000321	[illegible]
1	000320	DSP4
1	000317	[illegible]
1	000315	DSP2
1	000[illegible]	[illegible]
1	000327	DGAB
1	000322	[illegible]
1	000120	M7
1	000313	VNON
1	000221	FLSH
1	000[illegible]	[illegible]
0	000324	[illegible]
1	000113	[illegible]
1	000306	[illegible]
1	000[illegible]	[illegible]
1	000[illegible]	KYLT
0	000[illegible]	[illegible]
1	000[illegible]	[illegible]
1	000[illegible]	[illegible]

Step		Remarks
1.	Perform Initialization and Calibration of CO_2 Analyzer - Procedure C.	
2.	Perform Initialization and Calibration of O_2 Analyzer - Procedure B. Set the rotary range selector switch and the toggle switch to Range 3.	
3.	Set Flowmeter Selector on Respiratory Panel of PBEM to Flowmeter 2.	
4.	Perform preliminary adjustments on respiratory console and on 2-pen recorder according to Preliminary Adj. Procedure for the Lower strain gage coupler and the resetting integrator. Place flow setting at 2 and volume setting at 5.	
5.	Turn PBEM On. Enter Astronaut Identification, Mission Day, Mission Time, Organ System, Test No., and Test Value at Numerical Data Entry Panel.	
6.	Set toggle switch on rear of PBEM Console to "Normal". Load O_2 consumption, CO_2 production program into Computer: Press Verb 01, Noun 49, and "Enter" button on Processor Keyboard. After "Standby" lights, press "Input".	
7.	Beckman 462 settings: "Preamp X1" for Flow or Vol., "1 V/cm" for O_2 or CO_2.	
8.	Log subject, date, test and channel identification; turn pen recorders "On".	
9.	Unstow personal mouthpiece and nose clip; remove from protective case.	
10.	Mount mouthpiece on Respiratory J Valve; turn Valve V2 to ambient; verify that Valve V3 is connected to Respiratory Valve (horizontal).	
11.	Instruct subject to sit on ergometer assembly.	
12.	Check height of mouthpiece with subject seated in an upright position. Adjust plumbing height as required.	
13.	Insert mouthpiece, place nose clip, and breathe normally.	
14.	Push both Analog Tape Recorder "RECORD" buttons. Log subject, date, test and channel identification on intercom and tape settings on pen records. Press "CAL" button on Beckman 9801.	

	Recorder	Scope Ch.
O_2	Ch. 4	3
CO_2	Ch. 8	4
F	Ch. 9	2
V	Ch. 10	
AT	Ch. 12	

Step

Turn Beckman A560 Control to "Operate".

15. Press V-08, N 01 and "Enter", V 08, N-- (Per Table A) and "Enter". Record for approximately 5 minutes at rest.

16. Change flow setting from 2 to 5, 10, or 20 and Verb, Noun digits per Table B, and Volume setting remains at 5. Note on records and intercom. Reset Balance Knob #2 per "Preliminary Adjustment" procedure. Have subject exercise for 5 minutes.

17. Turn pen recorders "OFF". Log subject, date, test complete, identification and tape setting on pen records and intercom.

18. Push Analog Tape Recorder "OFF" button.

19. If additional Respiratory Measurements are not to be done at this time, instruct subject to remove mouthpiece and nose clip; clean and store equipment.

20. Turn PBIM "OFF" if no further testing. Turn O_2 Analyzer, CO_2 Analyzer, and Aux. Resp. Rack Main Power Switch off if no further tests are to be performed.

Remarks

Table A

Verb	Noun	Measure.
08	20	B. by B.
08	21	60 Sec. Av.
08	22	30 Sec. Av.
08	23	No print

Table B

Verb	Noun	Flow Range L/min.	Flow Preamp mv/cm
08	01	to 100	2
08	02	to 250	5
08	03	to 500	10
08	04	to 1000	20

Verify Tracings:

O_2 _____

CO_2 _____

F _____

Vol _____

4/11

```
* O2-CO2 CONSUMPTION-BREATH BY BREATH
* V01-N00 = 100% O2
* V01-N01 = 21% O2
* V03-N01 = 0-100 L/M
* V03-N02 = 0-250
* V03-N03 = 0-500
* V03-N04 = 0-1000
* V03-N10 = 100% O2
* V03-N11 = 21% O2
* V03-N20 = BREATH BY BREATH PRINTOUT
* V03-N21 = 10 AVERAGE
* V03-N22 = 30* AVERAGE
* V03-N23 = NO PRINTOUT
* V09      = STOP CALCULATIONS
* SUBROUTINES-DPA,DST
* VOLUMES CORRECTED TO STPD
*
*
*
*
        000326    EVRR   ,EQU    ,0326
        000325    SVRR   ,EQU    ,0325
        000313    VLON   ,EQU    ,0313
        000134    MSKE   ,EQU    ,0134
        000105    SIX    ,EQU    ,0105
        000225    ANSN   ,EQU    ,0225
        000213    SENC   ,EQU    ,0213
        000107    ATE    ,EQU    ,0107
        000212    ENPT   ,EQU    ,0212
        000110    MINE   ,EQU    ,0110
        000220    KYLT   ,EQU    ,0220
        000101    TWO    ,EQU    ,0101
        000224    PPDR   ,EQU    ,0224
        000306    ASTR   ,EQU    ,0306
        000307    CROS   ,EQU    ,0307
        000137    MSKH   ,EQU    ,0137
        000202    MSTN   ,EQU    ,0202
        000303    MTA    ,EQU    ,0303
        000102    THRE   ,EQU    ,0102
        000222    DCUT   ,EQU    ,0222
        000315    DSP1   ,EQU    ,0315
        000316    DSP2   ,EQU    ,0316
        000317    DSP3   ,EQU    ,0317
        000320    DSP4   ,EQU    ,0320
        000321    DSP5   ,EQU    ,0321
        000322    PRAD   ,EQU    ,0322
        000323    DGAD   ,EQU    ,0323
        000203    SDFL   ,EQU    ,0203
        000104    FIVE   ,EQU    ,0104
        000221    FLSH   ,EQU    ,0221
        000103    FOUR   ,EQU    ,0103
        000100    ONE    ,EQU    ,0100
        000111    TEN    ,EQU    ,0111
        000112    M1     ,EQU    ,0112
```

```
                 002115     R7     .EQU     .0116
                 002113     R7     .EQU     .0114
                 002207     TEEL   .EQU     .0206
                 002200     ATRN   .EQU     .0220
                 002126     RSRB   .EQU     .0176
                 002441     RPB    .EQU     .0410
                 002441     RH20   .EQU     .0441
                 002106     SVN    .EQU     .0106
                 002117     R9     .EQU     .0117
                 002204     OTEL   .EQU     .0204
                 002214     OTNC   .EQU     .0214
                 002236     TCRN   .EQU     .0236
                 002105     SIX    .EQU     .0105
                 002223     TWIN   .EQU     .0223
010000                             .OPG     .010000
                 002700     INOR   .BEGIN   .0700
010000  017700 I  COMS             .LDA     .ETAB
010001  057726                     .STA     .EVRB          INIT. STOP VERB ADDRESS
010002  017701 I                   .LDA     .STAB
010003  057735                     .STA     .SVRB          INIT START VERB ADDRESS
010004  010105                     .LDA     .SIX
010005  002000                     .JMPN*   .ANSR          INIT. ANALOG SWITCHING
010006  100223
010007  011352 R                   .BZE     .SW01
010010  002000                     .JMPN*   .TWIN          THUMBWHEEL INPUT
010011  100223
010012  002306                     .BZE     .ASTR
010013  010105                     .LDA     .SIX
010014  002000                     .JMPN*   .SENC          SET ENCODER ADDRESS TABL
010015  100213
010016  010025 R                   .BZE     .STRT          FOR START VERB
010017  010107                     .LDA     .ATE
010020  002000                     .JMPN*   .SENC          SET ENCODER ADDRESS TABL
010021  100213
010022  011265 R                   .BZE     .STOP          FOR STOP VERB
010023  001000                     .JMP*    .ENRT
010024  100212
* START VERB ENTRY
010025  010110     STRT            .LDA     .NINE
010026  002000                     .JMPN*   .KYLT          TURN OFF STBY LIGHT
010027  100220
010030  010101                     .LDA     .TWO
010031  006130                     .TRAI    .0100000
010032  100001
010033  002000                     .JMPN*   .KYLT          EXPERIMENTAL ACTIVITY LI
010034  100220
010035  017702 I                   .LDA     .PRNT
010036  002000                     .JMPN*   .PRBF          PRINT *O2-CO2 CONSUMPTIO
010037  100224
010040  011340 R                   .BZE     .PRNT+1
010041  010306                     .LDA     .ASTR
010042  057703 I                   .STA     .OR01
010043  010307                     .LDA     .ORCS
010044  152137                     .ANA     .HSKR
```

```
010045  057704 I          ,STA    ,OB03
010046  002000            ,JMPM*  ,MSTM          READ MISSION TIME
010047  100202
010050  010303            ,LDA    ,MTA
010051  057705 I          ,STA    ,OB05
010052  010102            ,LDA    ,THRE
010053  002000            ,JMPM*  ,DOUT
010054  100221
010055  011500 R          ,PZE    ,OB00
010056  017706 I          ,LDA    ,C2D           SET UP DISPLAYS
010057  050315            ,STA    ,DSP1
010060  017707 I          ,LDA    ,O2D
010061  050316            ,STA    ,DSP2
010062  017710 I          ,LDA    ,RQD
010063  050317            ,STA    ,DSP3
010064  017711 I          ,LDA    ,CPD
010065  050320            ,STA    ,DSP4
010066  017712 I          ,LDA    ,OPD
010067  050321            ,STA    ,DSP5
010070  017713 I          ,LDA    ,PPT
010071  050322            ,STA    ,PRAD
010072  017714 I          ,LDA    ,DIG
010073  050323            ,STA    ,DGAD
010074  002000            ,JMPM*  ,SDEL          SET TIME DELAYS
010075  100203
010076  040024            ,DATA   ,040024        20 MILLI-SEC
010077  010337 R          ,PZE    ,MS20
010100  002000            ,JMPM*  ,SDEL
010101  100203
010102  140062            ,DATA   ,0140062       5 MILLI-SEC
010103  011065 R          ,PZE    ,MS5
010104  017715 I          ,LDA    ,TFIX          USE OB04+5 AS BREATH COU
010105  057716 I          ,STA    ,OB04
010106  001000            ,JMP*   ,ENRT
010107  100212
010110  010104     SWIN   ,LDA    ,FIVE          OPERATOR ERROR OFF
010111  002000            ,JMPM*  ,FLSH
010112  100221
010113  010313            ,LDA    ,VNON
010114  150134            ,ANA    ,MSKF
010115  001010            ,JAZ    ,*+4
010116  010121 R
010117  001000            ,JMP    ,*+0
010120  010130 R
010121  010104     ERR    ,LDA    ,FIVE
010122  006130            ,ERAI   ,0100000
010123  100000
010124  002000            ,JMPM*  ,FLSH
010125  100221
010126  001000            ,JMP*   ,ENRT
010127  100212
010130  003014            ,TAX    ,
010131  140101            ,SUB    ,TWO
010132  001004            ,JAN    ,XYZA
```

```
010133  010147 R
010134  001010          .JAZ     .XYZB
010135  010155 R
010136  003041          .TXA     .
010137  147003          .SUB     .EQUP
010140  001004          .JAN     .XYZC
010141  010163 R
010142  001010          .JAZ     .XYZD
010143  010171 R
010144  003041          .TXA     .
010145  001003          .JMP     .OXTP
010146  010227 R
010147  010100    XYZA  .LDA     .ONE
010150  057717 I        .STA     .SFIX
010151  010100          .LDA     .ONE
010152  057720 I        .STA     .SHFT
010153  001000          .JMP     .ROUT
010154  010175 R
010155  017721 I  XYZB  .LDA     .D25
010156  057717 I        .STA     .SFIX
010157  010111          .LDA     .TEN
010160  057720 I        .STA     .SHFT
010161  001000          .JMP     .ROUT
010162  010175 R
010163  010104    XYZC  .LDA     .FIVE
010164  057717 I        .STA     .SFIX
010165  010100          .LDA     .ONE
010166  057720 I        .STA     .SHFT
010167  001000          .JMP     .ROUT
010170  010175 R
010171  010111    XYZD  .LDA     .TEN
010172  057717 I        .STA     .SFIX
010173  010100          .LDA     .ONE
010174  057720 I        .STA     .SHFT
010175  005001    ROUT  .TZA     .                EXIT FROM ERROR ROUTINE
010176  057722 I        .STA     .GO
010177  057723 I        .STA     .JUMP
010200  010100          .LDA     .ONE
010201  006170          .CPAI    .0100000
010202  100300
010203  002000          .JMPM*   .KYLT
010204  100223
010205  001000          .JMP*    .ENRT
010206  100212
010207  147724 I  OXTP  .SUB     .D10
010210  001004          .JAN     .ERR
010211  010121 R
010212  001010          .JAZ     .*+10
010213  010235 R
010214  003041          .TXA     .
010215  147725 I        .SUB     .D11
010216  001004          .JAN     .*+13
010217  010235 R
010220  001010          .JAZ     .*+11
```

```
010221  010233 R
010222  005041                  ,TXA     ,
010223  001000                  ,JMP     ,FOUT
010224  010241 R
010225  017736 I                ,LDA     ,OXG1
010226  057737 I                ,STA     ,OXGT
010227  017730 I                ,LDA     ,OXG3
010230  057731 I                ,STA     ,OXB
010231  001000                  ,JMP*    ,ENRT
010232  100212
010233  017732 I                ,LDA     ,OXG2
010234  057737 I                ,STA     ,OXGT
010235  017733 I                ,LDA     ,OXG4
010236  057731 I                ,STA     ,OXB
010237  001000                  ,JMP*    ,ENRT
010240  100212
010241  147734 I   FOUT         ,SUB     ,D20
010242  001004                  ,JAN     ,ERR
010243  010121 R
010244  001010                  ,JAZ     ,*+10
010245  010256 R
010246  005041                  ,TXA     ,
010247  147735 I                ,SUB     ,D22
010250  001004                  ,JAN     ,*+10
010251  010262 R
010252  001010                  ,JAZ     ,*+12
010253  010266 R
010254  001000                  ,JMP     ,CESE
010255  011160 R
010256  005001                  ,TZA     ,
010257  057736 I                ,STA     ,SOUT
010260  001000                  ,JMP*    ,ENRT
010261  100212
010262  010100                  ,LDA     ,ONE
010263  057736 I                ,STA     ,SOUT
010264  001000                  ,JMP*    ,ENRT
010265  100212
010266  010112                  ,LDA     ,M1
010267  057736 I                ,STA     ,SOUT
010270  001000                  ,JMP*    ,ENRT
010271  100212
010272  000000     SCHG         ,PZE     ,0                FLOW SCALING SUB.
010273  017720 I                ,LDA     ,SHFT
010274  057737 I                ,STA     ,SHFF
010275  005001                  ,TZA     ,
010276  167717 I                ,MUL     ,SFIX
010277  177737 I                ,DIV     ,SHFF
010300  001000                  ,JMP*    ,SCHG
010301  110272 R
010302  000000     FDV          ,PZE     ,0                DIVISION SUB.
010303  005014                  ,TAX     ,
010304  147740 I                ,SUB     ,DXX
010305  001004                  ,JAN     ,*+11
010306  010320 R
```

```
010307  005041          ,TXA    ,
010310  004001          ,LASR   ,1
010311  047741 I        ,INR    ,CTZO
010312  017741 I        ,LDA    ,CTZO
010313  001010          ,JAZ    ,*+4
010314  010317 R
010315  001000          ,JMP*   ,FDV
010316  110302 R
010317  005041          ,TXA    ,
010320  177740 I        ,DIV    ,DXX
010321  017741 I        ,LDA    ,CTZO
010322  005211          ,SPA    ,
010323  005111          ,IAP    ,
010324  001010          ,JAZ*   ,FDV
010325  110302 R
010326  057741 I        ,STA    ,CTZO
010327  005001          ,TZA    ,
010330  004401          ,LASL   ,1
010331  047741 I        ,INP    ,CTZO
010332  037741 I        ,LDX    ,CTZO
010333  001040          ,JXZ*   ,FDV
010334  110302 R
010335  001000          ,JMP    ,*-5
010336  010330 R
* 20 MILLI- SEC INTERRUPT ENTRY
010337  017722 I  MS20  ,LDA    ,GC          START A/D INPUT
010340  001010          ,JAZ    ,*+4         YES
010341  010344 R
010342  001000          ,JMP*   ,TDEL        NO-TIME DELAY RETURN
010343  100205
* LOOK FOR FLOW RISE AND STORE FLOW VALUES UNTIL FLOW STOPS
* STORE O2 AND CO2 VALUES, TAKING INTO ACCOUNT DELAY TIMES
*  CALCULATE AND DISPLAY VALUES FOR EACH BREATH
010344  010102          ,LDA    ,THRE
010345  002000          ,JMPM*  ,ADRN        A/D INPUT
010346  100200
010347  011406 R        ,PZE    ,IB00
010350  011412 R        ,PZE    ,CN00
010351  017742 I        ,LDA    ,IB00
010352  157743 I        ,ANA    ,MSKX
010353  001010          ,JAZ    ,*+4
010354  010357 R
010355  001000          ,JMP    ,*+3
010356  010360 R
010357  057742 I        ,STA    ,IB00
010360  017742 I        ,LDA    ,IB00
010361  150136          ,ANA    ,MSKG
010362  057742 I        ,STA    ,IB00
010363  017744 I        ,LDA    ,IB01
010364  150136          ,ANA    ,MSKG
010365  124746          ,ADD    ,OXR
010366  057744 I        ,STA    ,IB01
010367  014742          ,LDA    ,OXCT
010370  147744 I        ,SUB    ,IB01
```

```
010371  057744 I        ,STA    ,IB01
010372  014741          ,LDA    ,OXB
010373  001010          ,JAZ    ,*+6
010374  010401 R
010375  005001          ,TZA    ,
010376  057744 I        ,LDB    ,IB01
010377  172111          ,DIV    ,TEN
010400  057744 I        ,STB    ,IB01
010401  017743 I        ,LDA    ,IB02
010402  157743 I        ,ANA    ,MSKX
010403  001010          ,JAZ    ,*+4
010404  010407 R
010405  001000          ,JMP    ,*+4
010406  010411 R
010407  005001          ,TZA    ,
010410  054777          ,STA    ,IB02
010411  014776          ,LDA    ,IB02
010412  150136          ,ANA    ,MSKG
010413  144778          ,SUB    ,DO3
010414  001002          ,JAP    ,*+3
010415  010417 R
010416  005001          ,TZA    ,
010417  005012          ,TAB    ,
010420  005001          ,TZA    ,
010421  172111          ,DIV    ,TEN
010422  054765          ,STB    ,IB02
010423  014772          ,LDA    ,FLG0
010424  001010          ,JAZ    ,*+4
010425  010430 R
010426  001000          ,JMP    ,*+14
010427  010444 R
010430  014755          ,LDA    ,IB00
010431  144766          ,SUB    ,THSF
010432  001004          ,JAN    ,*+6
010433  010440 R
010434  001010          ,JAZ    ,*+4
010435  010440 R
010436  001000          ,JMP*   ,TDEL
010437  100205
010440  010100          ,LDA    ,ONE
010441  054754          ,STA    ,FLG0
010442  001000          ,JMP*   ,TDEL
010443  100205
010444  014752          ,LDA    ,FLG1
010445  001004          ,JAN    ,CCTM
010446  010531 R
010447  001010          ,JAZ    ,OCTM
010450  010502 R
010451  014734          ,LDA    ,IB00
010452  144745          ,SUB    ,THSF
010453  001010          ,JAZ*   ,TDEL
010454  100205
010455  001004          ,JAN*   ,TDEL
010456  100205
```

```
010457  024776          ,LDB    ,IB00
010460  005001          ,TZA    ,
010461  002000          ,JMPM   ,SCHG
010462  010272 R
010463  067746 I        ,STB*   ,TM00
010464  044734          ,INR    ,CONT
010465  044734          ,INR    ,ODLY          02 DELAY COUNTER
010466  034733          ,LDX    ,ODLY
010467  001040          ,JXZ    ,*+4
010470  010473 R
010471  001000          ,JMP*   ,TDEL
010472  100205
010473  014713          ,LDA    ,IB01
010474  057747 I        ,STA*   ,TM01
010475  044757          ,INR    ,TM01
010476  005001          ,TZA    ,
010477  054717          ,STA    ,FLG1
010500  001000          ,JMP*   ,TDEL
010501  100205
010502  024703    CCTM  ,LDB    ,IB00
010503  005001          ,TZA    ,
010504  002000          ,JMPM   ,SCHG
010505  010272 R
010506  067746 I        ,STB*   ,TM00
010507  044711          ,INR    ,CONT
010510  044741          ,INR    ,TM00
010511  014675          ,LDA    ,IB01
010512  057747 I        ,STA*   ,TM01
010513  044741          ,INR    ,TM01
010514  044706          ,INR    ,ODLY
010515  034705          ,LDX    ,ODLY
010516  001040          ,JXZ    ,*+4
010517  010522 R
010520  001000          ,JMP*   ,TDEL
010521  100205
010522  014665          ,LDA    ,IB02
010523  057750 I        ,STA*   ,TM02
010524  044733          ,INR    ,TM02
010525  010112          ,LDA    ,H1
010526  054670          ,STA    ,FLG1
010527  001000          ,JMP*   ,TDEL
010530  100205
010531  014672    CCTM  ,LDA    ,FLG2
010532  001004          ,JAN    ,FC02
010533  010603 R
010534  001010          ,JAZ    ,FO2
010535  010563 R
010536  014647          ,LDA    ,IB00
010537  144660          ,SUB    ,THSF
010540  001002          ,JAP    ,*+4
010541  010544 R
010542  005001          ,TZA    ,
010543  054660          ,STA    ,FLG2
010544  024641          ,LDB    ,IB00
```

```
010545  005001          ,TZA    ,
010546  003010          ,JMPH   ,SCHG
010547  010272 R
010550  057740 I        ,STB*   ,TM00
010551  044647          ,INR    ,CONT
010552  044677          ,INR    ,TM00
010553  014623          ,LDA    ,IB01
010554  057747 I        ,STA*   ,TM01
010555  044677          ,INR    ,TM01
010556  014621          ,LDA    ,IB02
010557  057750 I        ,STA*   ,TM02
010560  044677          ,INR    ,TM02
010561  001000          ,JMP*   ,TDEL
010562  100205
010563  014623    FO2   ,LDA    ,IB01
010564  057747 I        ,STA*   ,TM01
010565  044667          ,INR    ,TM01
010566  014621          ,LDA    ,IB02
010567  057750 I        ,STA*   ,TM02
010570  044667          ,INR    ,TM02
010571  044534          ,INR    ,ED2
010572  054533          ,LDX    ,ED2          BUMP CO2 DELAY COUNTER
010573  001040          ,JXZ    ,*+4
010574  010577 R
010575  001000          ,JMP*   ,TDEL
010576  100205
010577  010112          ,LDA    ,H1
010600  054623          ,STA    ,FLG2
010601  001000          ,JMP*   ,TDEL
010602  100205
010603  014604    ECO2  ,LDA    ,IB02
010604  057750 I        ,STA*   ,TM02
010605  044652          ,INR    ,TM02
010606  044516          ,INR    ,ECO2
010607  054515          ,LDX    ,ECO2
010610  001040          ,JXZ    ,*+4
010611  010614 R
010612  001000          ,JMP*   ,TDEL
010613  100205
010614  014604    CAL   ,LDA    ,CONT
010615  005211          ,CPA    ,
010616  005111          ,IAR    ,
010617  054601          ,STA    ,CONT
010620  005001    REDO  ,TZA    ,
010621  027751 I        ,LDB*   ,TL00
010622  002000          ,CALL   ,DPA
010623  014053 R
010624  011425 R        ,PZE    ,DBLA
010625  054577          ,STA    ,DBLA
010626  064577          ,STB    ,DBLA+1
010627  017752 I        ,LDA*   ,TL01
010630  005012          ,IAB    ,
010631  144601          ,SUB    ,OHIH
010632  001004          ,JAN    ,*+5
```

```
010633  010637 R
010634  001010          ,JAZ     ,*+3
010635  010637 R
010636  064574          ,STB     ,CHIH
010637  005001          ,TZA     ,
010640  167751 I        ,MUL*    ,TL00
010641  002000          ,CALL    ,DPA
010642  014053 R
010643  011437 R        ,PZE     ,DBLO
010644  054562          ,STA     ,DBLC
010645  064562          ,STB     ,DBLC+1
010646  017753 I        ,LDA*    ,TL02
010647  005014          ,TAX     ,
010650  144563          ,SUB     ,CHIH
010651  001004          ,JAN     ,*+6
010652  010657 R
010653  001010          ,JAZ     ,*+4
010654  010657 R
010655  005041          ,TXA     ,
010656  054555          ,STA     ,CHIH
010657  005042          ,TXB     ,
010660  005001          ,TZA     ,
010661  167751 I        ,MUL*    ,TL00
010662  002000          ,CALL    ,DPA
010663  014053 R
010664  011431 R        ,PZE     ,DBLC
010665  054543          ,STA     ,DBLC
010666  064543          ,STB     ,DBLC+1
010667  044563          ,INR     ,TL00
010670  044565          ,INR     ,TL01
010671  044567          ,INR     ,TL02
010672  044526          ,INR     ,CONT
010673  034525          ,LDX     ,CONT
010674  001040          ,JXZ     ,*+4
010675  010700 R
010676  001000          ,JMP     ,REDO
010677  010620 R
010700  014534          ,LDA     ,D30
010701  054502          ,STA     ,DXX
010702  014522          ,LDA     ,DBLA
010703  024522          ,LDB     ,DBLA+1
010704  002000          ,JMPM    ,FDV
010705  010302 R
010706  064556          ,STB     ,DB01
010707  014526          ,LDA     ,D3M
010710  054473          ,STA     ,DXX
010711  014515          ,LDA     ,DBLO
010712  024515          ,LDB     ,DBLO+1
010713  002000          ,JMPM    ,FDV
010714  010302 R
010715  005001          ,TZA     ,
010716  170111          ,DIV     ,TEN
010717  064551          ,STB     ,DB05
010720  014510          ,LDA     ,DBLC
```

```
010721  024310          ,LDB    ,DBLC+1
010722  002000          ,JMPM   ,FDV
010723  010302 R
010724  005001          ,TZA    ,
010725  167111          ,MUL    ,TEN
010726  054527          ,STB    ,DB07
010727  005001          ,TZA    ,
010730  174303          ,DIV    ,D100
010731  054525          ,STB    ,DB03
010732  005001          ,TZA    ,
010733  024537          ,LDB    ,DB07
010734  174534          ,DIV    ,DB05
010735  054537          ,STB    ,DB07
010736  014475          ,LDA    ,CHIH
010737  144364          ,SUB    ,D13
010740  054534          ,STA    ,DB09
010741  014471          ,LDA    ,OHIH          CONVERT TO SDTP FROM DTP
010742  054534          ,STA    ,DB11
010743  014474    XYZE  ,LDA    ,D760
010744  054437          ,STA    ,DXX
010745  010440          ,LDA    ,PB0
010746  140441          ,SUB    ,PH20
010747  005012          ,TAB    ,
010750  005001          ,TZA    ,
010751  167754 I        ,MUL*   ,DDAC
010752  002000          ,JMPM   ,FDV
010753  010302 R
010754  014466          ,LDA    ,D310
010755  054426          ,STA    ,DXX
010756  005001          ,TZA    ,
010757  164464          ,MUL    ,D273
010760  002000          ,JMPM   ,FDV
010761  010302 R
010762  067754 I        ,STB*   ,DDAC
010763  010101          ,LDA    ,TWO
010764  124454          ,ADD    ,DDAC
010765  054453          ,STA    ,DDAC
010766  044456          ,INR    ,CT03
010767  034455          ,LDX    ,CT03
010770  001040          ,JXZ    ,*+4
010771  010774 R
010772  001000          ,JMP    ,XYZE
010773  010743 R
010774  044451          ,INR    ,CNT
010775  014404          ,LDA    ,SOUT
010776  001010          ,JAZ    ,*+4
010777  011002 R
011000  001000          ,JMP    ,QUOT
011001  011035 R
011002  014462          ,LDA    ,DB01
011003  054503          ,STA    ,DB07
011004  014460          ,LDA    ,DB03
011005  054503          ,STA    ,DB09
011006  014462          ,LDA    ,DB05
```

```
011007  054503              ,STA    ,OB11
011010  014462              ,LDA    ,DB07
011011  054503              ,STA    ,OB13
011012  014462              ,LDA    ,DB09
011013  054503              ,STA    ,OB15
011014  014462              ,LDA    ,DB11
011015  054503              ,STA    ,OB17
011016  014427              ,LDA    ,CNT
011017  054465              ,STA    ,OB05
011020  010105              ,LDA    ,SIX
011021  002000              ,JMPM*  ,DOUT
011022  100222
011023  011464 R            ,PZE    ,DB00
011024  014422              ,LDA    ,CESD
011025  001010              ,JAZ    ,CLER
011026  011165 R
011027  010106              ,LDA    ,SVN
011030  002000              ,JMPM*  ,DOUT
011031  100222
011032  011504 R            ,PZE    ,OB04
011033  001000              ,JMP    ,CLER
011034  011165 R
* 5 MILLI-SEC INTERRUPT ENTRY
011035  014427      QUOT    ,LDA    ,DB01
011036  124450              ,ADD    ,OB07
011037  054447              ,STA    ,OB07
011040  014426              ,LDA    ,DB03
011041  124447              ,ADD    ,OB09
011042  054446              ,STA    ,OB09
011043  014425              ,LDA    ,DB05
011044  124446              ,ADD    ,OB11
011045  054445              ,STA    ,OB11
011046  014424              ,LDA    ,DB07
011047  124445              ,ADD    ,OB13
011050  054444              ,STA    ,OB13
011051  014423              ,LDA    ,DB09
011052  124444              ,ADD    ,OB15
011053  054443              ,STA    ,OB15
011054  014422              ,LDA    ,DB11
011055  124443              ,ADD    ,OB17
011056  054442              ,STA    ,OB17
011057  010105              ,LDA    ,SIX
011060  002000              ,JMPM*  ,DOUT
011061  100222
011062  011464 R            ,PZE    ,DB00
011063  001000              ,JMP    ,CLER
011064  011165 R
011065  014514      MS5     ,LDA    ,SOUT          PRINTER OUTPUT ROUTINE F
011066  001004              ,JAN    ,DEL
011067  011144 R
011070  001010              ,JAZ*   ,TDEL
011071  100205
011072  044500              ,INR    ,CT12
011073  074277              ,LDX    ,CT12
```

```
011074  001040          ,JXZ    ,*+4
011075  011100 R
011076  001000          ,JMP*   ,TDEL
011077  100205
011100  014271          ,LDA    ,M12
011101  054271          ,STA    ,CT12
011102  005001    OUT   ,TZA    ,
011103  024411          ,LDB    ,OB13
011104  174331          ,DIV    ,CNT
011105  064407          ,STB    ,OB13
011106  005001          ,TZA    ,
011107  024407          ,LDB    ,OB15
011110  174333          ,DIV    ,CNT
011111  064405          ,STB    ,OB15
011112  005001          ,TZA    ,
011113  024405          ,LDB    ,OB17
011114  174331          ,DIV    ,CNT
011115  064407          ,STB    ,OB17
011116  014327          ,LDA    ,CNT
011117  054365          ,STA    ,OB05
011120  002000          ,JMPM*  ,MSTM
011121  100202
011122  010303          ,LDA    ,MTA
011123  054357          ,STA    ,OB03
011124  010107          ,LDA    ,ATE
011125  002000          ,JMPM*  ,DOUT
011126  100222
011127  011502 R        ,PZE    ,OB02
011130  002000          ,JMPM*  ,TERM
011131  100236
011132  005001          ,TZA    ,
011133  054353          ,STA    ,OB07
011134  054354          ,STA    ,OB09
011135  054355          ,STA    ,OB11
011136  054356          ,STA    ,OB13
011137  054357          ,STA    ,OB15
011140  054360          ,STA    ,OB17
011141  054304          ,STA    ,CNT
011142  001000          ,JMP*   ,TDEL
011143  100205
011144  044303    DEL   ,INR    ,CT30
011145  034302          ,LDX    ,CT30
011146  001040          ,JXZ    ,*+4
011147  011152 R
011150  001000          ,JMP*   ,TDEL
011151  100205
011152  010117          ,LDA    ,M6
011153  054274          ,STA    ,CT30
011154  014271          ,LDA    ,CNT
011155  054327          ,STA    ,OB05
011156  001000          ,JMP    ,OUT
011157  011102 R
011160  005001    CESE  ,TZA    ,
011161  054220          ,STA    ,SOUT
```

```
011162  054264          ,STA    ,CESD
011163  001000          ,JMP*   ,ENRT
011164  100212
011165  005001   CLER   ,TZA    ,
011166  054227          ,STA    ,FLG0
011167  054231          ,STA    ,CONT
011170  054234          ,STA    ,DBLA
011171  054234          ,STA    ,DBLA+1
011172  054234          ,STA    ,DBLO
011173  054234          ,STA    ,DBLO+1
011174  054234          ,STA    ,DBLC
011175  054234          ,STA    ,DBLC+1
011176  054233          ,STA    ,CHIH
011177  054233          ,STA    ,OHIH
011200  010100          ,LDA    ,ONE
011201  054215          ,STA    ,FLG1
011202  054221          ,STA    ,FLG2
011203  014236          ,LDA    ,CDAC
011204  054234          ,STA    ,DDAC
011205  014243          ,LDA    ,TN00
011206  054243          ,STA    ,TM00
011207  054243          ,STA    ,TL00
011210  014243          ,LDA    ,TN01
011211  054243          ,STA    ,TM01
011212  054243          ,STA    ,TL01
011213  014243          ,LDA    ,TN02
011214  054243          ,STA    ,TM02
011215  054243          ,STA    ,TL02
011216  014243          ,LDA    ,M14
011217  054202          ,STA    ,ODLY
011220  054105          ,STA    ,E02
011221  010116          ,LDA    ,M5
011222  054102          ,STA    ,EC02
011223  054177          ,STA    ,CDLY
011224  010114          ,LDA    ,M3
011225  054217          ,STA    ,CT03
011226  014153          ,LDA    ,SOUT
011227  001010          ,JAZ    ,*+4
011230  011233 R
011231  001000          ,JMP    ,*+4
011232  011235 R
011233  005001          ,TZA    ,
011234  054211          ,STA    ,CNT
011235  014225          ,LDA    ,JUMP
011236  001010          ,JAZ*   ,TDEL
011237  100205
011240  001000          ,JMP*   ,ENRT
011241  100212
011242  010100   PAUS   ,LDA    ,ONE
011243  054132          ,STA    ,GO
011244  054216          ,STA    ,JUMP
011245  005001          ,TZA    ,
011246  054236          ,STA    ,OB05
011247  054237          ,STA    ,OB07
```

```
011250  054240                  ,STA    ,OB09
011251  054241                  ,STA    ,OB11
011252  054242                  ,STA    ,OB13
011253  054243                  ,STA    ,OB15
011254  054244                  ,STA    ,OB17
011255  054179                  ,STA    ,CNT
011256  010100                  ,LDA    ,ONE
011257  002000                  ,JMPM*  ,KYLT
011260  100220
011261  002000                  ,JMPM*  ,TERM
011262  100236
011263  001000                  ,JMP    ,CLER
011264  011165 R
* ENTER FROM STOP VERB
011265  010110          STOP    ,LDA    ,NINE
011266  006130                  ,ERAI   ,0100000
011267  100000
011270  002000                  ,JMPM*  ,KYLT
011271  100220
011272  010101                  ,LDA    ,TWO
011273  002000                  ,JMPM*  ,KYLT
011274  100220
011275  010104                  ,LDA    ,FIVE
011276  002000                  ,JMPM*  ,KYLT
011277  100220
011300  010100                  ,LDA    ,ONE
011301  002000                  ,JMPM*  ,KYLT
011302  100220
011303  002000                  ,JMPM*  ,CDEL
011304  100204
011305  010337 R                ,PZE    ,MS20
011306  002000                  ,JMPM*  ,CDEL
011307  100204
011310  011065 R                ,PZE    ,MS5
011311  010105                  ,LDA    ,SIX
011312  002000                  ,JMPM*  ,CENC
011313  100214
011314  010107                  ,LDA    ,ATE
011315  002000                  ,JMPM*  ,CENC
011316  100214
011317  002000                  ,JMPM*  ,TERM
011320  100236
011321  001000                  ,JMP*   ,ENRT
011322  100212
*
*
*
011323  000012          D10     ,DATA   ,10
011324  000015          D13     ,DATA   ,13
011325  777773          EC02    ,DATA   ,-5
011326  777762          E02     ,DATA   ,-14
011327  011242 R        ETAD    ,PZE    ,PAUS
011330  010110 R        STAD    ,PZE    ,SWIN
011331  001750          OXG1    ,DATA   ,1000
```

```
011332  004064     CXGT   ,DATA   ,2100
011333  000000     CXG3   ,DATA   ,0
011334  002114     CX3    ,DATA   ,1100
011335  004064     CXG2   ,DATA   ,2100
011336  002114     CXG4   ,DATA   ,1100
011337  000012     PRNT   ,DATA   ,012
011340  147662            ,DATA   ,'O2-CO2 CONSUMPTION  '
011341  125703
011342  147662
011343  120303
011344  147716
011345  151725
011346  146720
011347  152311
011350  147716
011351  120240
011352  002002     SW01   ,DATA   ,02002
011353  004001            ,DATA   ,04001
011354  004401            ,DATA   ,04401
011355  007011            ,DATA   ,07011
011356  007404            ,DATA   ,07404
011357  010010            ,DATA   ,010010
011360  000025     C2D    ,DATA   ,21
011361  000024     C2D    ,DATA   ,20
011362  000026     R0D    ,DATA   ,22
011363  000075     CPD    ,DATA   ,61
011364  000074     CPD    ,DATA   ,60
011365  011522 R   PRT    ,PZE    ,PRTT
011366  011545 R   DIG    ,PZE    ,DIGT
011367  000001     SFIX   ,DATA   ,1
011370  000001     SHFT   ,DATA   ,1
011371  000015     D31    ,DATA   ,13
011372  777764     M12    ,DATA   ,-12
011373  777764     CT12   ,DATA   ,-12
011374  014000     TFIX   ,DATA   ,014000
011375  000031     D25    ,DATA   ,25
011376  000001     GO     ,DATA   ,1
011377  000021     D11    ,DATA   ,021
011400  000040     D20    ,DATA   ,040
011401  000042     D22    ,DATA   ,042
011402  000000     SOUT   ,DATA   ,0
011403  000000     SHFF   ,DATA   ,0
011404  001750     DXX    ,DATA   ,1000
011405  000000     CTZO   ,DATA   ,0
011406  000000     IB00   ,DATA   ,0              FLOW
011407  000000     IB01   ,DATA   ,0              O2
011410  000000     IB02   ,DATA   ,0              CO2
011411  000003     D03    ,DATA   ,3
011412  000010     CN00   ,DATA   ,8              FLOW
011413  000003            ,DATA   ,3              O2
011414  000007            ,DATA   ,7              CO2
011415  002000     MSKX   ,DATA   ,02000
011416  000000     FLG0   ,DATA   ,0
011417  000001     FLG1   ,DATA   ,1
```

```
011420  000024      TMSC   ,DATA   ,20
011421  000000      CONT   ,DATA   ,0
011422  777762      CDLY   ,DATA   ,-14
011423  777773      CDLY   ,DATA   ,-5
011424  000001      FLO2   ,DATA   ,1
011425  000000      DBLA   ,DATA   ,0
011426  000000             ,DATA   ,0
011427  000000      DBLO   ,DATA   ,0
011430  000000             ,DATA   ,0
011431  000000      DBLO   ,DATA   ,0
011432  000000             ,DATA   ,0
011433  000000      CHIN   ,DATA   ,0
011434  000000      CHIN   ,DATA   ,0
011435  000036      D30    ,DATA   ,30
011436  005670      DDM    ,DATA   ,3000
011437  000144      D100   ,DATA   ,100
011440  001370      D760   ,DATA   ,760
011441  011465 R    DBAC   ,PZE    ,DB01
011442  011465 R    CBAC   ,PZE    ,DB01
011443  000466      D310   ,DATA   ,310
011444  000421      D273   ,DATA   ,273
011445  777775      CT03   ,DATA   ,-3
011446  000000      CNT    ,DATA   ,0
011447  000001      CESO   ,DATA   ,1
011450  777772      CT30   ,DATA   ,-6
011451  011570 R    TN00   ,PZE    ,T00
011452  011570 R    TM00   ,PZE    ,T00
011453  011570 R    TL00   ,PZE    ,T00
011454  012411 R    TN01   ,PZE    ,T01
011455  012411 R    TM01   ,PZE    ,T01
011456  012411 R    TL01   ,PZE    ,T01
011457  013232 R    TN02   ,PZE    ,T02
011460  013232 R    TM02   ,PZE    ,T02
011461  013232 R    TL02   ,PZE    ,T02
011462  777762      M14    ,DATA   ,-14
011463  000000      JUMP   ,DATA   ,0
011464  021427      DB00   ,DATA   ,021427
011465  000000      DB01   ,DATA   ,0
011466  021425      DB02   ,DATA   ,021425
011467  000000      DB03   ,DATA   ,0
011470  021424      DB04   ,DATA   ,021424
011471  000000      DB05   ,DATA   ,0
011472  021026      DB06   ,DATA   ,021026
011473  000000      DB07   ,DATA   ,0
011474  020475      DB08   ,DATA   ,020475
011475  000000      DB09   ,DATA   ,0
011476  020474      DB10   ,DATA   ,020474
011477  000000      DB11   ,DATA   ,0
011500  054000      CB00   ,DATA   ,054000
011501  000000      CB01   ,DATA   ,0
011502  054000      CB02   ,DATA   ,054000
011503  000000      CB03   ,DATA   ,0
011504  054000      CB04   ,DATA   ,054000
011505  000000      CB05   ,DATA   ,0
```

```
011506  115427   CB06   ,DATA   ,0115427
011507  000000   CB07   ,DATA   ,0
011510  115425   CB08   ,DATA   ,0115425
011511  000000   CB09   ,DATA   ,0
011512  115424   CB10   ,DATA   ,0115424
011513  000000   CB11   ,DATA   ,0
011514  115026   CB12   ,DATA   ,0115026
011515  000000   CB13   ,DATA   ,0
011516  114475   CB14   ,DATA   ,0114475
011517  000000   CB15   ,DATA   ,0
011520  114474   CB16   ,DATA   ,0114474
011521  000000   CB17   ,DATA   ,0
011522  000025   PRTT   ,DATA   ,21
011523  141717           ,DATA   ,'CO2E'
011524  131305
011525  000024           ,DATA   ,20
011526  147662           ,DATA   ,'O2E '
011527  142640
011530  000026           ,DATA   ,22
011531  151321           ,DATA   ,'R0  '
011532  120240
011533  000075           ,DATA   ,61
011534  141717           ,DATA   ,'CO2 '
011535  131240
011536  000074           ,DATA   ,60
011537  147662           ,DATA   ,'O2  '
011540  120240
011541  000027           ,DATA   ,23
011542  153240           ,DATA   ,'V   '
011543  120240
011544  000000           ,DATA   ,0
011545  000025   DIGT   ,DATA   ,21
011546  004410           ,DATA   ,04410
011547  005020           ,DATA   ,05020
011550  000024           ,DATA   ,20
011551  004021           ,DATA   ,04021
011552  010437           ,DATA   ,010437
011553  000026           ,DATA   ,22
011554  001026           ,DATA   ,01026
011555  017437           ,DATA   ,017437
011556  000075           ,DATA   ,61
011557  004410           ,DATA   ,04410
011560  005037           ,DATA   ,05037
011561  000074           ,DATA   ,60
011562  004021           ,DATA   ,04021
011563  017437           ,DATA   ,017437
011564  000027           ,DATA   ,23
011565  003437           ,DATA   ,03437
011566  017437           ,DATA   ,017437
011567  000000           ,DATA   ,0
011570          T00    ,BSS    ,400          FLOW DATA BUFFER
012410  000000   NBK    ,DATA   ,0
012411          T01    ,BSS    ,400          O2 DATA BUFFER
013251  000000   NBK1   ,DATA   ,0
```

```
013252                  TOS     ,BSS    ,400            CO2 DATA BUFFER
014052  000000          MPK2    ,DATA   ,0
014053  000000          DPA     ,EMTR   ,
014054  007400                  ,ROF    ,               RESET OVERFLOW
014055  037755  I               ,LDX    ,DPA            LOAD ADDRESS A
014056  035000                  ,LDX    ,0,1
014057  054015                  ,STA    ,DPAT
014060  008021                  ,TPA    ,
014061  125001                  ,ADD    ,1,1            ADD LOWER HALF
014062  006150                  ,ANAI   ,077777
014063  077777
014064  005010                  ,TAB    ,
014065  005001                  ,TZA    ,
014066  005511                  ,ACFA   ,               ADD UPPER HALF
014067  007400                  ,ROF    ,
014070  124004                  ,ADD    ,DPAT
014071  125000                  ,ADD    ,0,1
014072  047755  I               ,INR    ,DPA
014073  001000                  ,JMP*   ,DPA
014074  114053  R
014075  000000          DPAT    ,DATA   ,0
        000000                  ,END    ,

LITERALS

POINTERS
  000700  011327
  000701  011330
  000702  011337
  000703  011501
  000704  011503
  000705  011505
  000706  011360
  000707  011361
  000710  011362
  000711  011363
  000712  011364
  000713  011365
  000714  011366
  000715  011374
  000716  011504
  000717  011367
  000720  011370
  000721  011375
  000722  011376
  000723  011463
  000724  011323
  000725  011377
  000726  011331
  000727  011332
  000730  011333
  000731  011334
  000732  011335
  000733  011336
```

000731	011471
000735	011461
000736	011472
000737	011473
000739	011464
000741	011467
000742	011476
000743	011413
000744	011477
000745	011410
000746	111472
000747	111453
000750	111461
000751	111457
000752	111456
000753	111461
000754	111441
000755	014033

SYMBOLS

1	014075	R	DPAT
1	014033	R	DPA
1	014032	R	MPK2
1	013032	R	T02
1	013271	R	MPK1
1	012411	R	T01
1	012410	R	MPK
1	011570	R	T00
1	011545	R	DIGT
1	011522	R	PPTT
1	011521	R	0717
1	011520	R	0716
1	011517	R	0715
1	011516	R	0714
1	011515	R	0713
1	011514	R	0712
1	011513	R	0711
1	011512	R	0710
1	011511	R	0709
1	011510	R	0708
1	011507	R	0707
1	011506	R	0706
1	011505	R	0705
1	011504	R	0704
1	011503	R	0703
1	011502	R	0702
1	011501	R	0701
1	011500	R	0700
1	011477	R	0711
1	011476	R	0710
1	011475	R	0709
1	011474	R	0708

Step		Remarks
1.	Unstow personal mouthpiece and nose clip; remove from protective case.	
2.	Attach mouthpiece to 4-position valve, turn valve to position 4; slide valve must be closed; open valve V-1 to ambient. Adjust height of plumbing to suit subject.	
3.	Turn on PBIM. Enter Astronaut Identification, Mission Day, Mission Time, Organ System, Test Number, and Test Value at Numerical Data Entry Panel.	
4.	Set PBIM rear toggle switch to "Normal". Load Airway Resistance Program into Computer: Press Verb 01, Noun 33 and "Enter" buttons, on Processor Keyboard. Press "Input" button, when "standby" lights.	
5.	Log subject, date, test and channel identification; turn pen recorders "ON".	PUL. Ch. 2 AP Ch. 5 F Ch. 9 Vol. Ch. 10 AT Ch. 12
6.	Turn on Respiratory Panel of PBIM by rotating lower function switch to "ON"; switch "ON" main power on Auxiliary Respiratory Rack.	
7.	Set Flowmeter Selector Switch on Respiratory Panel of PBIM to "1" position.	
8.	Perform preliminary adjustments on Respiratory Console and on the 2-pen Recorder according to the Preliminary Adjustment Procedure -- the lower strain gage coupler. Place pre-amp flow setting at 2 and Vol. setting is inconsequential.	
9.	Perform the following steps to set up UPPER Strain Gage Coupler (#9803).	

Switch OR Knob	Setting
Calibrate	0
Polarity	+
Balance	'0'
Pre-Amp Gain Control (481-5)	0.5 MV/cm
Power Supply (Upper right plug-in #392 unit)	'On'

NOTE: Use scope "ground" position to make fine balance adjustment. (Ch

10.	Instruct subject to place nose clip, insert mouthpiece, and to breathe normally.	
11.	Switch automatic Flow-Interrupter on Respiratory Rack to "Insp" position; verify operation of Flow Interrupter on 2-pen recorder. Switch Flow Interrupter to "Exp" position; verify operation.	

Step		Remarks
	Turn Beckman A560 Control to "Operate".	
12.	Push both Analog Tape Recorder "RECORD" buttons. Log subject, date, test and channel identification on intercom and tape settings on pen records.	
13.	Press "CAL" button on Beckman 9801. Then turn "CAL" knob of Beckman 9803 to +1 and return. This represents 1.4 cm of water.	
14.	Switch Flow Interrupter to "Insp" position.	
15.	Proceed with Airway Resistance Measurement. Instruct subject to breathe normally. Press V 08, N 01 and "Enter" buttons. Then repeat after 5 breaths if required.	Verify tracing_____
16.	Switch Flow Interrupter to "Exp" position; continue breathing quietly. Press V 08, N 02 and "Enter" buttons, then repeat after 5 breaths if required.	Verify tracing_____
17.	Turn pen recorders "OFF". Log subject, test, complete, date, identification and tape settings on pen records and intercom.	
18.	Push Analog Tape Recorder "OFF" button.	
19.	Switch Flow Interrupter to "OFF" position. Push "Clear" and V09.	
20.	If additional measurements are not to be done at this time, instruct subject to remove mouthpiece and nose clip; disconnect mouthpiece from 4-position valve; clean and store equipment.	
21.	Turn PBEM and Aux. Resp. Rack "OFF" if no further testing.	

MEASUREMENT MODEL AND DATA FORM

SUB-SYSTEM : Respiratory

MEASUREMENT GROUP : Respiratory

MEASUREMENT : Airway Resistance (R_1)

MEASUREMENT DESCRIPTION : Obtain measurement of pulmonary airway resistance from the simultaneous detection of tracheal pressure and airway flow (Flow-Interrupter Technique)

1. Input signal characteristics	Airway flow and tracheal pressure- both biphasic repetitive waveforms.
2. Electrodes, transducers, vest, harness	Airway flow--mouthpiece, Mainland pneumotach head, AMID capsule in Greer micromanometer. Tracheal pressure--pressure transducer (Statham, PM-5.
3. Signal conditioner(s)	Airway flow-- Greer micromanometer Tracheal pressure-- strain gage coupler (Beckman, #9803)
4. Range of measurement	0.2- 10.0 cm H_2O / liter / second
5. Frequency of measurement	Once per 1-2 weeks
6. Output signal characteristics	
analog/digital	Analog -- See #13
amplitude	0-5 volts
frequency range	N/A
accuracy/sensitivity	± 2 % per parameter
7. Calibration	
type & technique	Precalibration of pneumotach head: will provide electrical calibration for both flow and pressure
frequency	Once, prior to each series of measurements.

8. Data handling

display analog/digital (raw, processed; local, remote; continuous, intermittent)	Airway flow and tracheal pressure-- Both analog, raw, and intermittent.
recording analog/digital (raw, processed; continuous, intermittent)	Airway flow and tracheal pressure-- Both analog, raw, and intermittent.
manual/programmed A or D switching	Programmed signal routing to Display Monitor and to 2-pen recorder.
manual/verbal data entry	Subject identification and measurement number
A/D conversion frequency	100 sps
storage time analog/digital	Digitized until next data dump
recording/storage quantity per subject	Approx. 30 seconds per measurement

9. Derived quantities

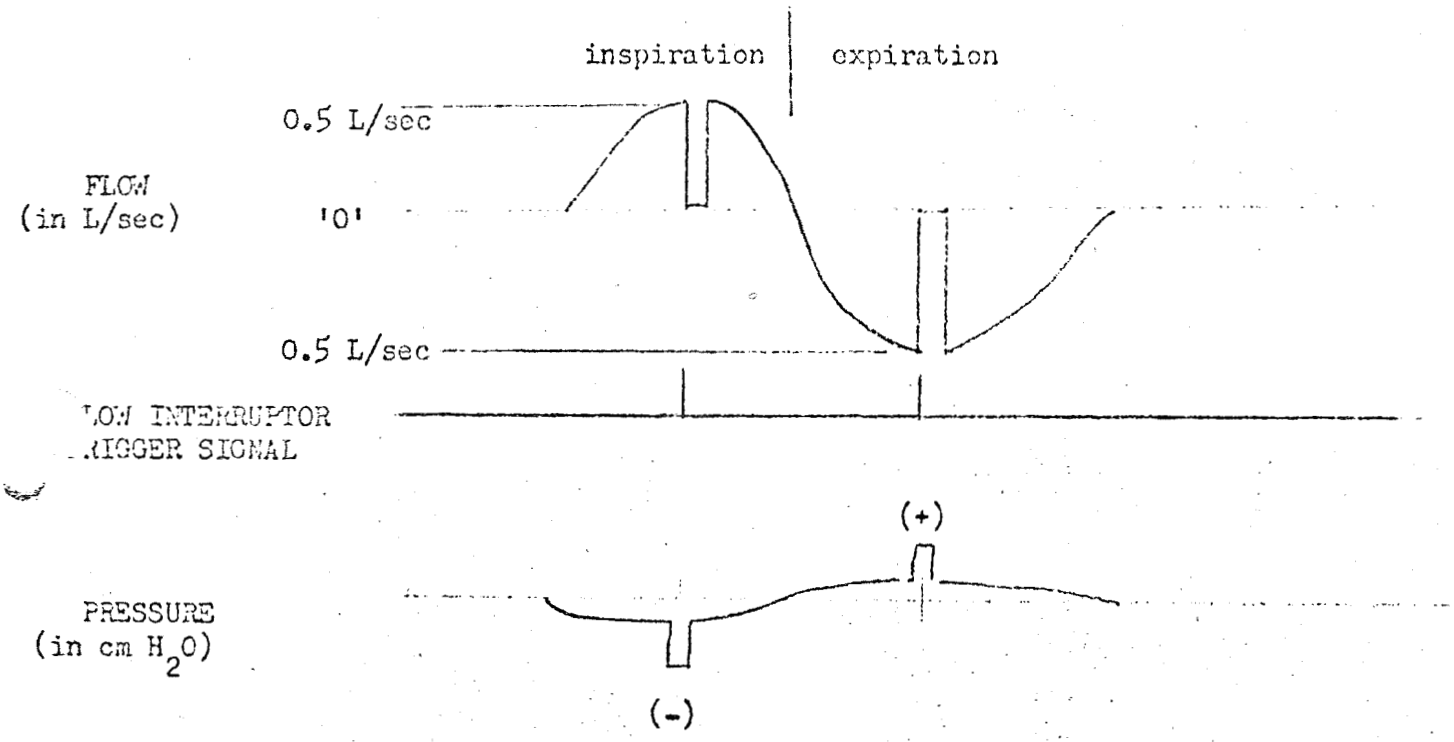
other measurements required simultaneously for calculations	N/A
digital computation	R_A (see #13)
display analog/digital; location; updating frequency	Digital on processor readout, after each measurement
recording analog/digital	Digital computed values
storage time analog/digital	Until next data dump

10. Comparison with previous data	N/A
11. Analog/digital display range & resolution/accuracy	Digital, 0.3 to 10.0 cm H_2O /liter/sec., $\pm$ 5%.design goal
12. Printout frequency & other requirements	Once at the end of each measurement.

13. Miscellaneous information, details on reference items, etc.

Procedural Note:

During this measurement the subject is instructed to breath normally. The air flow is interrupted during the breathing cycle at flow rates of 0.5liters per second. The trigger for the flow interruption is controlled by a flow detection circuit. The two values necessary for the computation of airflow resistance are: flow rate--this will be constant at 0.5 liters per second, and alveolar pressure--detected during the flow interruption period. See below.



Computation:

$$\text{Airway resistance} = \frac{\text{pressure}}{\text{flow}}$$

```
*
* AIRWAY RESISTANCE*
* OF 5 BREATHS AFTER DISKEY *START* INPUT.
* A NOUN INPUT, IN CONJUNCTION WITH *START* VERB OF 0
* IS INSPIRED BREATHS A NOUN OF 2 IS EXPIRED BREATHS.
* RUN WILL BE REPEATED EVERY TIME *START* VERB
* PLUS NOUN IS ENTERED.
*
        000313   VNON   .EQU   .0313
        000325   SVRB   .EQU   .0325
        000103   FOUR   .EQU   .0103
        000225   ANSW   .EQU   .0225
        000213   SENC   .EQU   .0213
        000235   LOOP   .EQU   .0235
        000110   NINE   .EQU   .0110
        000224   PRDR   .EQU   .0224
        000306   ASTR   .EQU   .0306
        000324   MDAY   .EQU   .0324
        000315   DSP1   .EQU   .0315
        000316   DSP2   .EQU   .0316
        000317   DSP3   .EQU   .0317
        000320   DSP4   .EQU   .0320
        000321   DSP5   .EQU   .0321
        000323   DGAD   .EQU   .0323
        000322   PRAD   .EQU   .0322
        000112   M2     .EQU   .0112
        000116   M5     .EQU   .0116
        000202   MTOM   .EQU   .0202
        000303   MTA    .EQU   .0303
        000102   THRE   .EQU   .0102
        000222   DOUT   .EQU   .0222
        000203   SDEL   .EQU   .0203
        000212   ENRT   .EQU   .0212
        000205   TDEL   .EQU   .0205
        000104   FIVE   .EQU   .0104
        000221   FLSH   .EQU   .0221
        000220   KYLT   .EQU   .0220
        000134   MSKE   .EQU   .0134
        000136   MSKG   .EQU   .0136
        000101   TWO    .EQU   .0101
        000100   ONE    .EQU   .0100
        000200   ADRN   .EQU   .0200
        000123   M10    .EQU   .0123
        000111   TEN    .EQU   .0111
        000204   CDEL   .EQU   .0204
        000214   CENC   .EQU   .0214
        000236   TERM   .EQU   .0236
010000                  .ORG   .010000
        000700   IAGR   .BEGIN .0700
010000  014361   AIRW   .LDA   .AAA        LOAD START VERB ADDRESS
010001  050325          .STA   .SVRB
010002  010103          .LDA   .FOUR
010003  002000          .JMPM* .ANSW
010004  100225
```

TWIN EQU 0223

5

```
010005  010283 R        .PZE     .SW01
010006  014317          .LDA     .D30
010007  002000          .JMPM*   .SENC
010010  100213
010011  010280 R        .PZE     .BEGN
010012  014314          .LDA     .D31
010013  002000          .JMPM*   .SENC
010014  100213
010015  010276 R        .PZE     .ENDA
010016  014375          .LDA     .D16
010017  002000          .JMPM*   .SENC
010020  100213
010021  010102 R        .PZE     .ARB
010022  014364          .LDA     .ARD
010023  050315          .STA     .DSP1
010024  014363          .LDA     .APS
010025  050316          .STA     .DSP2
010026  006001          .TZA     .
010027  050317          .STA     .DSP3
010030  050320          .STA     .DSP4
010031  050321          .STA     .DSP5
010032  014356          .LDA     .PRT
010033  050322          .STA     .PRAD
010034  014355          .LDA     .DIG
010035  050323          .STA     .DGAD
010036  002000          .JMPM*   .ENRT
010037  100212
010040  010110    BEGN  .LDA     .NINE
010041  002000          .JMPM*   .KYLT      STBY LIGHT OFF
010042  100220
010043  014260          .LDA     .K2
010044  002000          .JMPM*   .KYLT      EXP-ACTY LIGHT ON
010045  100220
010046  014262          .LDA     .PRNT      PRINT PROGRAM NAME
010047  002000          .JMPM*   .PRDR
010050  100224
010051  010332 R        .PZE     .PRNT+1
010052  010306          .LDA     .ASTR      ASTRONAUT ID
010053  004250          .LRLA    .8
010054  054321          .STA     .OB01
010055  010324          .LDA     .MDAY      MISSION ID
010056  054321          .STA     .OB03
010057  002000          .JMPM*   .MTSM
010060  100202
010061  010303          .LDA     .MTA       TIME
010062  054317          .STA     .OB05
010063  010102          .LDA     .THRE
010064  002000          .JMPM*   .DOUT
010065  100222
010066  010375 R        .PZE     .OB00
010067  002000          .JMPM*   .SDEL      SET 10 MS INTERRUPT
010070  100203
010071  040001          .DATA    .040001        ON COMP ACTY
010072  010165 R        .PZE     .MS01
```

JMPM* TWICE
PZE ASTR

```
010073  001000          ,JMP*   ,ENRT
010074  100212
010075  005000   STRT   ,NOP    ,          TURN OPERATOR ERROR OFF
010076  005000          ,NOP    ,
010077  010313          ,LDA    ,VNON
010100  150134          ,ANA    ,MSKE
010101  001010          ,JAZ    ,*+4
010102  010105 R
010103  001000          ,JMP    ,*+7
010104  010112 R
010105  014231   ERR    ,LDA    ,K5        IMPROPER NOUN
010106  002000          ,JMPM*  ,FLSH      FLASH OPERATOR ERROR
010107  100221
010110  001000          ,JMP*   ,ENRT
010111  100212
010112  140101          ,SUB    ,TWO
010113  001004          ,JAN    ,PLUS
010114  010135 R
010115  001010          ,JAZ    ,*+4
010116  010121 R
010117  001000          ,JMP    ,ERR
010120  010105 R
010121  005001          ,TZA    ,          EXPIRED AR REQUEST
010122  054235          ,STA    ,GO
010123  054235          ,STA    ,FLG3
010124  014217          ,LDA    ,PREX      PRINT *EXPIRED*
010125  002000          ,JMPM*  ,PRDR
010126  100224
010127  010345 R        ,PZE    ,PREX+1
010130  014237          ,LDA    ,K1
010131  002000          ,JMPM*  ,KYLT
010132  100220
010133  001000          ,JMP*   ,ENRT
010134  100212
010135  005001   PLUS   ,TZA    ,
010136  054221          ,STA    ,GO
010137  010100          ,LDA    ,ONE
010140  054220          ,STA    ,FLG3
010141  014207          ,LDA    ,PRIN      PRINT *INSPIRED*
010142  002000          ,JMPM*  ,PRDR
010143  100224
010144  010352 R        ,PZE    ,PRIN+1
010145  014222          ,LDA    ,K1            ON COMP ACTY
010146  002000          ,JMPM*  ,KYLT
010147  100220
010150  001000          ,JMP*   ,ENRT
010151  100212
010152  014205   ARB    ,LDA    ,GO            ENTER ON FLOW
010153  001010          ,JAZ    ,*+4           INTERRUPTION
010154  010157 R
010155  001000          ,JMP*   ,ENRT
010156  100212
010157  005001          ,TZA    ,
010160  054234          ,STA    ,OG
```

72

```
010161  014235          .LDA    .M36
010162  054237          .STA    .CT36
010163  001000          .JMP*   .EKRT
010164  100212
010165  013227    MS01  .LDA    .OG
010166  001010          .JAZ    .*+4
010167  010172 R
010170  001000          .JMP*   .TDEL
010171  100205
010172  010100          .LDA    .ONE
010173  002000          .JMPH*  .ADRN
010174  100250
010175  010367 R        .PZE    .IB00
010176  010421 R        .PZE    .CN00
010177  044216          .INR    .CT36
010200  014215          .LDA    .CT36
010201  001010          .JAZ    .*+4
010202  010205 R
010203  001000          .JMP*   .TDEL
010204  100205
010205  014161          .LDA    .IB00
010206  150136          .ANA    .MSKG
010207  054157          .STA    .IB00
010210  014150          .LDA    .FLG3
010211  001010          .JAZ    .*+4
010212  010215 R
010213  001000          .JMP    .PREI
010214  010226 R
010215  014151          .LDA    .IB00
010216  124155          .ADD    .DB03
010217  054154          .STA    .DB03
010220  044107          .INR    .CT05
010221  014106          .LDA    .CT05
010222  001010          .JAZ    .CALU
010223  010235 R
010224  001000          .JMP    .REST
010225  010232 R
010226  010136    PREI  .LDA    .MSKG
010227  144137          .SUB    .IB00
010230  001000          .JMP    .*-10
010231  010216 R
010232  054162    REST  .STA    .OG
010233  001000          .JMP*   .TDEL
010234  100205
010235  010100    CALU  .LDA    .ONE        RESET FOR NEXT RUN
010236  054156          .STA    .OG
010237  054120          .STA    .GO
010240  010116          .LDA    .M5
010241  054066          .STA    .CT05
010242  005001          .TZA    .
010243  024130          .LDB    .DB03
010244  170104          .DIV    .FIVE
010245  005001          .TZA    .
010246  164153          .MUL    .D395
```

```
010247  174143          ,DIV    ,D1M
010250  064123          ,STB    ,DB03
010251  064134          ,STB    ,OB09
010252  005001          ,TZA    ,
010253  160101          ,MUL    ,TWO
010254  064115          ,STB    ,DB01
010255  064126          ,STB    ,OB07
010256  010101          ,LDA    ,TWO
010257  002000          ,JMPM*  ,DOUT
010260  100222
010261  010371 R        ,PZE    ,DB00
010262  010101          ,LDA    ,TWO
010263  002000          ,JMPM*  ,DOUT
010264  100222
010265  010403 R        ,PZE    ,OB06
010266  005001          ,TZA    ,
010267  054102          ,STA    ,DB01
010270  054103          ,STA    ,DB03
010271  010100          ,LDA    ,ONE
010272  002000          ,JMPM*  ,KYLT
010273  100220
010274  001000          ,JMP*   ,TDEL
010275  100205
010276  014026    ENDA  ,LDA    ,K9
010277  002000          ,JMPM*  ,KYLT
010300  100220
010301  010101          ,LDA    ,TWO
010302  002000          ,JMPM*  ,KYLT
010303  100220
010304  002000          ,JMPM*  ,CDEL
010305  100204
010306  010165 R        ,PZE    ,MS01
010307  014104          ,LDA    ,D16
010310  002000          ,JMPM*  ,CENC
010311  100214
010312  014013          ,LDA    ,D30
010313  002000          ,JMPM*  ,CENC
010314  100214
010315  014011          ,LDA    ,D31
010316  002000          ,JMPM*  ,CENC
010317  100214
010320  002000          ,JMPM*  ,TERM
010321  100236
010322  001000          ,JMP*   ,ENRT
010323  100212
010324  100002    K2    ,DATA   ,0100002
010325  100011    K9    ,DATA   ,0100011
010326  000006    D30   ,DATA   ,6
010327  000010    D31   ,DATA   ,8
010330  777773    CT05  ,DATA   ,-5
010331  000012    PRNT  ,DATA   ,10
010332  140711          ,DATA   ,'AIRWAY RESISTANCE '
010333  151327
010334  140731
```

```
010335  120322
010336  142723
010337  144723
010340  152301
010341  147303
010342  142640
010343  120240
010344  000004     PREX   .DATA   .4
010345  142730            .DATA   .'EXPIRED '
010346  150311
010347  151305
010350  142240
010351  000005     PRIN   .DATA   .5
010352  144716            .DATA   .'INSPIRED '
010353  151720
010354  144722
010355  142704
010356  120240
010357  100005     K5     .DATA   .0100005
010360  000001     GO     .DATA   .1
010361  000000     FLG3   .DATA   .0
010362  010075 R   AAA    .PZE    .STRT
010363  002403     SW01   .DATA   .02403
010364  004401            .DATA   .04401
010365  007411            .DATA   .07411
010366  010005            .DATA   .010005
010367  000000     IB00   .DATA   .0
010370  100001     K1     .DATA   .0100001
010371  121065     DB00   .DATA   .0121065
010372  000000     DB01   .DATA   .0
010373  121071     DB02   .DATA   .0121071
010374  000000     DB03   .DATA   .0
010375  054000     OB00   .DATA   .054000
010376  000000     OB01   .DATA   .0
010377  054000     OB02   .DATA   .054000
010400  000000     OB03   .DATA   .0
010401  054000     OB04   .DATA   .054000
010402  000000     OB05   .DATA   .0
010403  111065     OB06   .DATA   .0111065
010404  000000     OB07   .DATA   .0
010405  111071     OB08   .DATA   .0111071
010406  000000     OB09   .DATA   .0
010407  000065     ARD    .DATA   .065
010410  000071     APS    .DATA   .071
010411  010423 R   PRT    .PZE    .PPRT
010412  010432 R   DIG    .PZE    .DIGP
010413  001750     DIM    .PZE    .1000
010414  000020     D16    .PZE    .16
010415  000001     OG     .DATA   .1
010416  777734     CT36   .DATA   .-36
010417  777734     M36    .DATA   .-36
010420  001774     MSK0   .DATA   .01774
010421  000004     CN00   .DATA   .4
010422  000613     D395   .DATA   .395
```

```
010423  000065    PPRT  .DATA   .065
010424  140722          .DATA   .PAR  '
010425  120240
010426  000071          .DATA   .071
010427  150322          .DATA   .'PRES'
010430  142723
010431  000000          .DATA   .0
010432  000065    DIGP  .DATA   .065
010433  006402          .DATA   .06402
010434  017437          .DATA   .017437
010435  000071          .DATA   .071
010436  002002          .DATA   .02002
010437  012437          .DATA   .012437
010440  000000          .DATA   .0
        000000          .END    .
```

LITERALS

POINTERS

SYMBOLS

```
1  010432 R  DIGP
1  010423 R  PPRT
1  010422 R  D395
1  010421 R  CN00
1  010420 R  MSKQ
1  010417 R  M36
1  010416 R  CT36
1  010415 R  OG
1  010414 R  D16
1  010413 R  DIM
1  010412 R  DIG
1  010411 R  PRT
1  010410 R  APS
1  010407 R  ARD
1  010406 R  OB09
1  010405 R  OB08
1  010404 R  OB07
1  010403 R  OB06
1  010402 R  OB05
1  010401 R  OB04
1  010400 R  OB03
1  010377 R  OB02
1  010376 R  OB01
1  010375 R  OB00
1  010374 R  DB03
1  010373 R  DB02
1  010372 R  DB01
1  010371 R  DB00
1  010370 R  K1
1  010367 R  I900
1  010363 R  SW01
```

Step		Remarks	
1.	Follow Procedure D for Initialization and Calibration of N_2 Analyzer. Set range at 0-100%.		
2.	Set Flowmeter Selector Switch on Respiratory Panel of PBEM to "2" position.		
3.	Allow 5 minutes for thermal stabilization of pressure transducers and flowmeter.		
4.	Perform preliminary adjustments on respiratory console and on the 2-pen recorder according to Prelim. Adj. Procedure for the Lower Strain Gage Coupler; and the resetting integrator. Verify Flow Amp at 2 setting and Volume at 5 setting.		
5.	Turn PBEM On. Enter Astronaut Identification, Mission Day, Mission Time, Organ System, Test No. and Test Value at Numerical Data Entry Panel.		
6.	Set toggle switch on rear of PBEM Console to "Normal". Load "Respiratory Dead Space" Program into Computer. Press Verb 01, Noun 50 and "Enter" buttons on Processor Keyboard. Press "Input" button when "Standby" lights.		
7.	Mount mouthpiece on Respiratory J Valve; turn Valve V2 to ambient.		
8.	Verify that oxygen tank is connected and demand regulator is pressurized. Set high pres. regulator on oxygen tank to 40 or 50 psi (less than half scale on gage).		
9.	Check height of mouthpiece with subject in an upright position; vertical adjustment may be made by supporting the Equipment Mounting Plate with one hand and loosening of the two holding knobs with the other; retighten knobs upon completion of height adjustment.		
10.	Log subject, date, test and channel identification; turn pen recorders "On".	N_2 F Vol.	Ch. 5 Ch. 9 Ch. 10
11.	Push both Analog Tape Recorder "RECORD" buttons. Log subject, date, test and channel identification on intercom and tape settings on pen records.	ΔT	Ch. 12
12.	Insert mouthpiece, place nose clip, and breathe normally.		
13.	Setup Verb 08, Noun 01. Turn Beckman A 560 Control to "Operate".		

Step		Remarks
14.	Instruct subject to stop breathing at the end of an expiration and to plug the mouthpiece opening with his tongue. Turn V2 to oxygen and flush the system by pushing the special tool into the hole of the demand regulator. Subject should permit oxygen to intermittently leak around mouthpiece during O_2 flushing. Stop flushing when N_2 analyzer reads 0.	
15.	During the first inspiration of pure oxygen, press "Enter" button. Instruct subject to unplug mouthpiece, inspire a very shallow breath, then expire, then inspire.	
16.	Turn Valve V2 back to ambient and breathe till N_2 reading is 80%. After a 2 minute pause, repeat steps 14 and 15, if required.	
17.	Turn pen recorders "OFF". Log subject, date, test complete, identification and tape setting on pen records and intercom. Push "Clear" and V 09.	
18.	Push Analog Tape Recorder "OFF" button.	
19.	If additional respiratory measurements are not to be performed at this time, instruct subject to remove mouthpiece and nose clip; clean and store equipment.	
20.	Turn PBIM "OFF" if no further testing.	
21.	Turn Nitrogen Analyzer, its vacuum pump, and the Main Power Switch of the Aux. Resp. Rack OFF, if no further tests are to be performed.	
22.	Close valve on oxygen tank.	

MEASUREMENT REQUIREMENTS DATA SHEET

SUB-SYSTEM : Respiratory

MEASUREMENT GROUP : Respiratory

MEASUREMENT : Respiratory Dead Space (V_D), Alveolar ventilation ($\dot{V}_A$), and Residual Volume (V_R).

MEASUREMENT DESCRIPTION : Obtain the three measurements from inspired and expired volume and expired nitrogen concentration as indicated o diagrams.

1. Input signal characteristics — Biphasic waveform of inspired and expired air flo Biphasic waveform of fractional N_2 concentration.

2. Electrodes, transducers. — Mouthpiece, Mainland pneumotachometer, pressure transducer (Statham, PM15), N_2 gas sampling head.

3. Signal conditioner(s) — Strain gage coupler(Beckman, #9803) , Volume Integrator (Beckman, #9873B), and N_2 gas analyzer(Electro/Med #700 PR)

4. Range of measurement

Dead Space:	100 to 350 ml.
Alveolar ventilation:	0 to 10 %.
Residual volume:	800 to 2000 ml.

5. Frequency of measurement — Once every 1 - 2 weeks.

6. Output signal characteristics

analog/digital	See # 13 (waveforms).
amplitude	0 - 5 volts.
frequency range	N/A.
accuracy/sensitivity	± 2 % per parameter

7. Calibration

type & technique	N_2 analyzer: atmospheric N_2 and/or calibration ga
frequency	At beginning of each series of measurements.

8. Data handling:

display analog/digital (raw, processed; local, remote; continuous, intermittent)	Raw, analog, continuous on Display Monitor and 2-pen recorder.
recording analog/digital (raw, processed; continuous, intermittent)	Raw, analog, digitized, continuous.
manual/programmed A or D switching	Programmed signal routing to Display Monitor and recorder.
manual/verbal data entry	Subject identification and measurement number.
A/D conversion frequency	100 sps.
storage time analog/digital	Digitized until next data dump.
recording/storage quantity per subject	10 minutes.

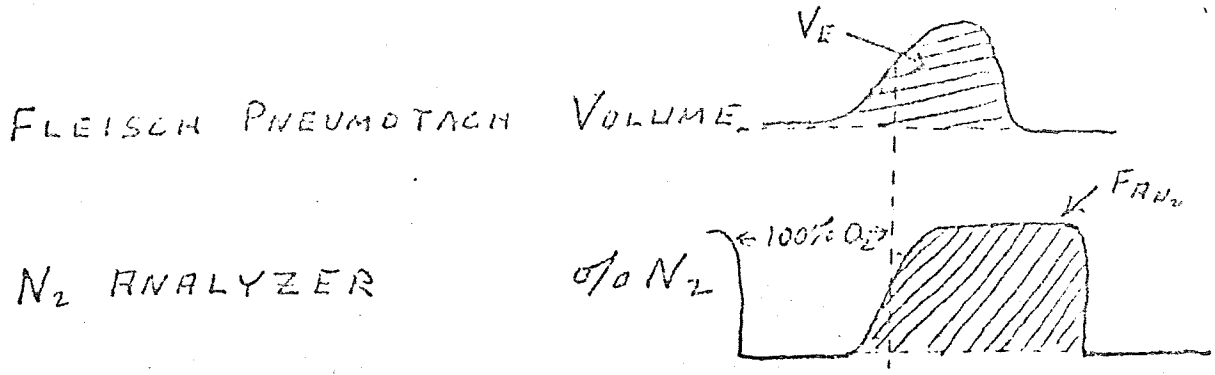
9. Derived quantities

other measurements required simultaneously for calculations	Time base.
digital computation	V_D, $\dot{V}_A$, and V_R (See # 13); TLC.
display analog/digital; location; updating frequency	All values in digital form on processor readout
recording analog/digital	Digital values after computation.
storage time analog/digital	Computed values until next data dump.

10. Comparison with previous data	N/A.
11. Analog/digital display range & resolution/accuracy	V_D : 100 - 400 ml, ± 5 %. $\dot{V}_A$: 0 - 20 % N_2, ± 5 %. V_R : 800 - 2000 ml, ± 5 %.
12. Printout frequency & other requirements	Once per run.

13. Miscellaneous information, details on referenced items, etc.

$$\underline{\text{RESPIRATORY DEAD SPACE}}\ (V_D) = \frac{(F_{A_{N_2}} - F_{E_{N_2}})(V_E)}{F_{A_{N_2}}}$$

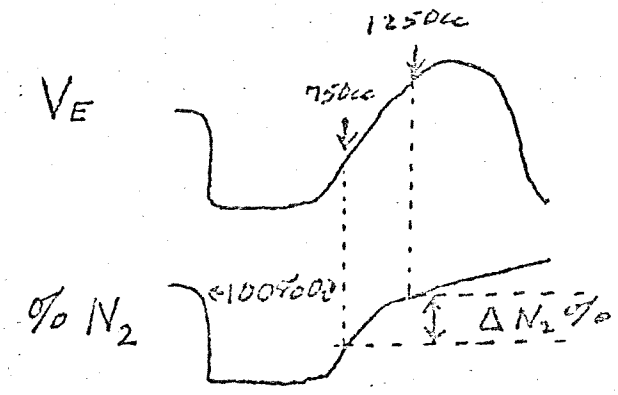


$F_{A_{N_2}}$ = % N_2 IN ALVEOLI

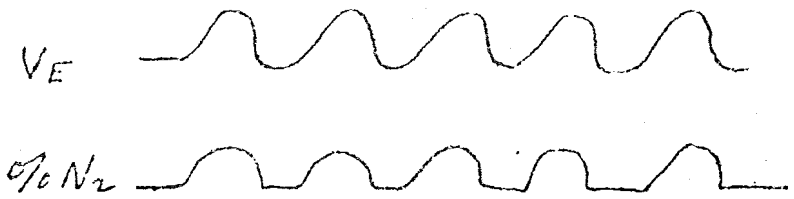
$F_{E_{N_2}}$ = % N_2 IN EXPIRED AIR $\left(\frac{V_{E_{N_2}}}{V_E}\right)$

V_E = EXPIRED VOLUME

$$\underline{\text{ALVEOLAR VENTILATION}}\ (V_A) = \%N_{2_{1250cc}} - \%N_{2_{750cc}}$$



RESIDUAL VOLUME $(V_R) = V_{E_{N_2}} \times \frac{100}{80}$



COMPUTATION INVOLVES IN-PHASE MULTIPLIER FUNCTION OF V_E AND $\%N_2$; THE RESULTA SIGNAL MUST BE TOTALIZED DURING THE 7 M MEASUREMENT PERIOD.

$V_R + VC = TLC$

VC = VITAL CAPACITY

TLC = TOTAL LUNG CAPACITY

```
* RESPIRATORY HEAD GRAPH
* [illegible]
* N2 SCALE=[illegible] TO [illegible]
* V SCALE=[illegible] TO 2.[illegible] LITERS
* F SCALE=[illegible] TO 100 LITERS/MIN.
* SINGLE BREATH MEASUREMENT INITIATED BY *START*
* VERB.
*
*
        000104    FIVE   ,EQU    ,0104
        000236    TERM   ,EQU    ,0236
        000325    SVRR   ,EQU    ,0325
        000227    [illegible]   ,EQU    ,0226
        000213    [illegible]   ,EQU    ,0213
        000227    LOOP   ,EQU    ,0226
        000224    FRDR   ,EQU    ,0224
        000306    ASTR   ,EQU    ,0306
        000307    PROS   ,EQU    ,0307
        000202    MTOM   ,EQU    ,0202
        000303    MTA    ,EQU    ,0303
        000322    PRAD   ,EQU    ,0322
        000323    RCAR   ,EQU    ,0323
        000315    PSP1   ,EQU    ,0315
        000316    PSP2   ,EQU    ,0316
        000317    PSP3   ,EQU    ,0317
        000320    PSP4   ,EQU    ,0320
        000321    PSP5   ,EQU    ,0321
        000222    DOUT   ,EQU    ,0222
        000203    SPEL   ,EQU    ,0203
        000212    FURT   ,EQU    ,0212
        000205    TPEL   ,EQU    ,0205
        000220    KVLT   ,EQU    ,0220
        000136    MSKG   ,EQU    ,0136
        000200    ADRN   ,EQU    ,0200
        000204    CREL   ,EQU    ,0204
        000214    CEMC   ,EQU    ,0214
        000100    ONE    ,EQU    ,0100
        000101    TWO    ,EQU    ,0101
        000102    THRE   ,EQU    ,0102
        000103    FOUR   ,EQU    ,0103
        000110    NINE   ,EQU    ,0110
        000106    SVN    ,EQU    ,0106
        000105    SIX    ,EQU    ,0105
        000107    ATE    ,EQU    ,0107
*
*
*
010000                   ,ORG    ,010000
        000700    IADR   ,BEGIN  ,0700
010000  010504    [illegible]   ,LDA    ,AAA
010001  000[illegible]          ,STA    ,SVRR
010002  010[illegible]          ,LDA    ,SIX
010003  000[illegible]          ,[illegible]   ,ANS
010004  100[illegible]
```

```
010330  010173          .BZE    .RTT
010331  014[illegible]  .LDA    .AIN
010332  002[illegible]  .JMPM*  .SEQ
010333  100317
010334  010[illegible] R  .BZE    .TCON
010335  014[illegible]  .LDA    .ATT
010336  002[illegible]  .JMPM*  .SFUC
010337  100[illegible]
010340  010[illegible] R  .BZE    .EKB
010341  014[illegible]  .LDA    .DSP
010342  057[illegible]  .STA    .DSP1
010343  014[illegible]  .LDA    .VOLT
010344  057[illegible]  .STA    .DSP2
010345  014[illegible]  .LDA    .ATT
010346  057[illegible]  .STA    .DSP3
010347  014[illegible]  .LDA    .TKOM
010350  057[illegible]  .STA    .DSP4
010351  005[illegible]  .ZZA    .
010352  057[illegible]  .STA    .DSP5
010353  014[illegible]  .LDA    .PRT
010354  057[illegible]  .STA    .PRAP
010355  014[illegible]  .LDA    .TIC
010356  057[illegible]  .STA    .DSAP
010357  014[illegible]  .JMP*   .PRST
010360  100212
*
* ENTER FROM START BUTTON
*
010361  010110     BEGV  .LDA    .VIBE
010362  002[illegible]  .JMPM*  .KYLT
010363  100220
010364  014404          .LDA    .K2
010365  002[illegible]  .JMPM*  .KYLT
010366  100221
010367  014432          .LDA    .PRUT
010370  002[illegible]  .JMPM*  .PRDA
010371  100224
010372  010[illegible] R  .BZE    .PRUT+1
010373  010[illegible]  .LDA    .ASTA
010374  004[illegible]  .LSRA   .0
010375  056[illegible]  .STA    .DRT1
010376  010[illegible]  .LDA    .DRDS
010377  150[illegible]  .ANA    .MSMG
010400  056[illegible]  .STA    .DRDS
010401  002[illegible]  .JMPM*  .HTSK
010402  100[illegible]
010403  010[illegible]  .LDA    .HTA
010404  056[illegible]  .STA    .DRDS
010405  010[illegible]  .LDA    .THTF
010406  002[illegible]  .JMPM*  .HCHT
010407  100[illegible]
010410  010[illegible] R  .BZE    .DRDS
010411  002[illegible]  .JMPM*  .SFTI
010412  100[illegible]
```

```
010070  [illegible]          ,[illegible]   ,[illegible]
010071  [illegible]          ,[illegible]   ,[illegible]
010072  [illegible]          ,JMP*   ,[illegible]
010073  [illegible]
*
* ENTER FROM START VERB
*
010074  014[illegible]   STRT  ,LDA    ,K1
010075  [illegible]          ,JMPM*  ,KYLT
010076  [illegible]
010077  [illegible]          ,LDA    ,FIVE
010100  [illegible]          ,JMPM*  ,KYLT
010101  [illegible]
010102  [illegible]          ,[illegible]   ,
010103  [illegible]          ,STA    ,GO
010104  [illegible]          ,JMP*   ,ENDT
010105  [illegible]
*
* ENTER FROM TIME DELAY
*
010106  014[illegible]   MSDE  ,LDA    ,GO
010107  [illegible]          ,JAZ    ,*+4
010110  [illegible]
010111  [illegible]          ,JMP*   ,TDEL
010112  [illegible]
010113  [illegible]          ,LDA    ,THDF
010114  [illegible]          ,JMPM*  ,[illegible]
010115  [illegible]
010116  [illegible] R        ,PZE    ,IBOU
010117  [illegible] R        ,PZE    ,CNDC
010120  014364               ,LDA    ,IBOU
010121  154371               ,ANA    ,MSKX
010122  [illegible]          ,JAZ    ,*+4
010123  [illegible] R
010124  014[illegible]          ,LDA    ,IBOU
010125  [illegible]          ,ANA    ,MSKG
010126  054[illegible]          ,STA    ,IBOU
010127  014[illegible]          ,LDA    ,IBOU
010130  [illegible]          ,ANA    ,MSKG
010131  054[illegible]          ,STA    ,IBOU
010132  014[illegible]          ,LDA    ,IBOU          TEST FOR VOL GREATER TH
010133  144[illegible]          ,SUB    ,THSV
010134  [illegible]          ,JAZ    ,*+4
010135  [illegible] R
010136  [illegible]          ,JAP    ,*+7
010137  [illegible] R
010140  014[illegible]          ,LDA    ,FLG1
010141  [illegible]          ,JAZ    ,[illegible]
010142  [illegible] R
010143  [illegible]          ,JMP*   ,TDEL
010144  [illegible]
010145  014[illegible]          ,LDA    ,[illegible]          FIND PEAK VOLUME
010146  [illegible]          ,LDA    ,IBOU
010147  144[illegible]          ,SUB    ,[illegible]
```

```
0[illegible]  [illegible]          .[illegible]   .**[illegible]
0[illegible]  [illegible]
0[illegible]  [illegible]          .[illegible]   .**[illegible]
0[illegible]  [illegible]
0[illegible]  [illegible]          .[illegible]   .V[illegible]
0[illegible]  [illegible] I        .[illegible]   .T[illegible]
0[illegible]  [illegible]          .[illegible]   .T[illegible]
0[illegible]  [illegible]          .[illegible]   .C[illegible]
0[illegible]  014271               .LDA     .CCNT
0[illegible]  [illegible]          .JAN     .**[illegible]
0[illegible]  [illegible] R
0[illegible]  [illegible]          .LDA     .K5
0[illegible]  [illegible]          .JMP*    .KYL1
0[illegible]  [illegible]
0[illegible]  [illegible]          .JMP     .RES1
0[illegible]  [illegible] R
0[illegible]  [illegible]          .TZA     .
0[illegible]  [illegible]          .STA     .FL01
0[illegible]  [illegible]          .LDA     .I[illegible]
0[illegible]  [illegible]          .SUB     .T[illegible]
0[illegible]  [illegible]          .JZ*     .T[illegible]
0[illegible]  [illegible]
0[illegible]  [illegible]          .LDA     .N[illegible]
0[illegible]  [illegible]          .JMZ     .**[illegible]
0[illegible]  [illegible] R
0[illegible]  [illegible]          .JMP     .**4
0[illegible]  [illegible] R
0[illegible]  014266               .LDA     .CCNT
0[illegible]  [illegible]          .STA     .TEMP
0[illegible]  014[illegible]       .LDA     .I[illegible]
0[illegible]  [illegible] I        .STA*    .T[illegible]
0[illegible]  [illegible]          .SUB     .N[illegible]
0[illegible]  [illegible]          .JAN     .**6
0[illegible]  [illegible] R
0[illegible]  [illegible]          .JAZ     .**4
0[illegible]  [illegible] R
0[illegible]  014271               .LDA     .I[illegible]
0[illegible]  [illegible]          .STA     .N[illegible]
0[illegible]  [illegible]          .INR     .T[illegible]
0[illegible]  [illegible]          .INR     .N[illegible]
0[illegible]  [illegible]          .JMP*    .T[illegible]
0[illegible]  [illegible]
0[illegible]  014263       NOO     .LDA     .I[illegible]
0[illegible]  [illegible] I        .STA*    .T[illegible]
0[illegible]  [illegible]          .INR     .T[illegible]
0[illegible]  [illegible]          .INR     .N[illegible]
0[illegible]  [illegible]          .INR     .CT32
0[illegible]  [illegible]          .LDA     .CT32
0[illegible]  [illegible]          .JAZ     .**[illegible]
0[illegible]  [illegible] R
0[illegible]  [illegible]          .JMP*    .T[illegible]
0[illegible]  [illegible]
0[illegible]  [illegible]  CALL    .LDA     .[illegible]
0[illegible]  [illegible]          .STA     .[illegible]
```

012236	011216		.LDA	.UPTR
012237	057[illegible]		.STA	.[illegible]
012240	057[illegible]		.STA	.D711
012241	005[illegible]		.LSPA	.1
012242	057[illegible]		.STA	.UPTR
012243	017[illegible]	I	.LDA*	.TL01
012244	144[illegible]		.SUB	.UPTR
012245	0[illegible]		.JAP	.*+2
012246	01[illegible]	R		
012247	044[illegible]		.INR	.UCOT
012250	044[illegible]		.INR	.TL01
012251	014[illegible]		.LDA	.TL01
012252	005[illegible]		.JAZ	.*+5
012253	012[illegible]	R		
012254	001[illegible]		.JMP	.*-3
012255	012[illegible]	R		
012256	044177		.INR	.UCOT
012257	005001		.ZZA	.
012260	024177		.LDB	.VHOH
012261	15[illegible]		.MUL	.D36
012262	17[illegible]		.DIV	.D10
012263	05[illegible]		.STB	.D[illegible]
012264	05[illegible]		.STB	.D[illegible]
012265	014179		.LDA	.TL00
012266	124167		.SUB	.UCOT
012267	144[illegible]		.SUB	.D[illegible]
012270	054172		.STA	.TL00
012271	005001		.ZZA	.
012272	027777	I	.LDB*	.TL00
012273	15[illegible]		.MUL	.D36
012274	17[illegible]		.DIV	.D10
012275	054277		.STB	.D801
012276	054314		.STB	.D837
012277	017774	I	.LDA*	.TN00
012300	144177		.SUB	.C75
012301	001004		.JAN	.*+3
012302	012311	R		
012303	044177		.INR	.UCOT
012304	014172		.LDA	.UCOT
012305	057775	I	.STA	.TA03
012306	044176		.INR	.TN00
012307	001000		.JMP	.*+6
012310	012317	R		
012311	044170		.INR	.TN00
012312	044144		.INR	.UCOT
012313	001007		.JMP	.*-12
012314	012277	R		
012315	017774	I	.LDA*	.TN00
012316	144151		.SUB	.C125
012317	001004		.JAN	.*+7
012320	012326	R		
012321	044173		.INR	.UCOT
012322	014174		.LDA	.UCOT
012323	054151		.STA	.MTTP

```
010324  001[illegible]          ,JMP     ,*+11
010325  [illegible]
010326  044[illegible]          ,JMP     ,[illegible]
010327  044[illegible]          ,JMP     ,NGCT
010330  014[illegible]          ,LDA     ,NGCT
010331  144[illegible]          ,SUB     ,DOUT
010332  001[illegible]          ,JAN     ,*-13
010333  01[illegible] R
010334  001[illegible]          ,JAZ     ,*-15
010335  01[illegible] R
010336  001[illegible]          ,JMP     ,REST
010337  01[illegible] R
010340  014[illegible]          ,LDA     ,TN01
010341  1[illegible] I          ,ADD     ,TA03
010342  1[illegible]            ,ADD     ,D52
010343  054[illegible]          ,STA     ,TM01
010344  017706 I                ,LDA*    ,TN01
010345  054[illegible]          ,STA     ,STMP
010346  014117                  ,LDA     ,TN01
010347  1[illegible]            ,ADD     ,MTEP
010350  1[illegible]            ,ADD     ,D32
010351  054[illegible]          ,STA     ,TM01
010352  017701 I                ,LDA*    ,TM01
010353  1[illegible]            ,SUB     ,STMP
010354  054226                  ,STA     ,DB07
010355  054245                  ,STA     ,DB13
010356  010[illegible]          ,LDA     ,FCUP
010357  00[illegible]          ,JMPM*   ,DOUT
010360  100222
010361  010574 R                ,BZE     ,DB00
010362  010[illegible]          ,LDA     ,FCUP
010363  00[illegible]          ,JMPM*   ,DOUT
010364  100222
010365  010612 R                ,BZE     ,DB06
010366  010100          REST    ,LDA     ,ONE
010367  002000                  ,JMPM*   ,KYLT
010370  100220
010371  010100                  ,LDA     ,ONE
010372  054077                  ,STA     ,FL01
010373  014074                  ,LDA     ,M32
010374  054074                  ,STA     ,CT32
010375  014062                  ,LDA     ,T00
010376  054063                  ,STA     ,TN00
010377  054063                  ,STA     ,TL00
010400  054060                  ,STA     ,TM00
010401  014062                  ,LDA     ,T01
010402  054062                  ,STA     ,TM01
010403  054063                  ,STA     ,TL01
010404  054061                  ,STA     ,TN01
010405  005001                  ,TZA     ,
010406  054[illegible]          ,STA     ,NGCT
010407  054[illegible]          ,STA     ,NGCT
010410  054044                  ,STA     ,[illegible]
010411  054[illegible]          ,STA     ,VBSP
```

```
010412  [illegible]          ,ATA    ,[illegible]
010413  [illegible]          ,[illegible]    ,[illegible]
010414  [illegible]          ,ATA    ,[illegible]CONT [illegible]
010415  [illegible]          ,JMP*   ,TEPL
010416  [illegible]
*
* ENTER FEED STOP BUTTON
*
010417  [illegible]  END     ,LBA    ,K0
010420  [illegible]          ,JMPM*  ,KYLT
010421  [illegible]
010422  [illegible]          ,LBA    ,TWO
010423  [illegible]          ,JMPM*  ,KYLT
010424  [illegible]
010425  [illegible]          ,LBA    ,FIVE
010426  [illegible]          ,JMPM*  ,KYLT
010427  [illegible]
010430  [illegible]          ,JMPM*  ,CPEL
010431  [illegible]
010432  [illegible] R        ,PRE    ,[illegible]
010433  [illegible]          ,LBA    ,SIX
010434  [illegible]          ,JMPM*  ,CENC
010435  [illegible]
010436  [illegible]          ,LBA    ,ATE
010437  [illegible]          ,JMPM*  ,CENC
010440  [illegible]
010441  [illegible]          ,JMPM*  ,TERM
010442  [illegible]
010443  [illegible]          ,JMP*   ,ENRT
010444  [illegible]
*
*
*
010445  [illegible]  K1      ,DATA   ,0100001
010446  [illegible]  K2      ,DATA   ,0100002
010447  [illegible]  K3      ,DATA   ,0100011
010450  [illegible]  K5      ,DATA   ,0100005
010451  [illegible]  [illegible]  ,DATA   ,-[illegible]
010452  [illegible]  [illegible]  ,DATA   ,-[illegible]
010453  [illegible]  [illegible]  ,DATA   ,0
010454  [illegible]  [illegible]  ,DATA   ,0
010455  [illegible]  [illegible]  ,DATA   ,0
010456  [illegible]  [illegible]  ,DATA   ,0
010457  [illegible]  [illegible]  ,DATA   ,0
010460  [illegible] R  [illegible]  ,PRE    ,TA[illegible]
010461  [illegible] R  [illegible]  ,PRE    ,TA[illegible]
010462  [illegible] R  [illegible]  ,PRE    ,TA[illegible]
010463  [illegible] R  [illegible]  ,PRE    ,TA[illegible]
010464  [illegible] R  [illegible]  ,PRE    ,TA[illegible]
010465  [illegible] R  [illegible]  ,PRE    ,TA[illegible]
010466  [illegible] R  [illegible]  ,PRE    ,TA[illegible]
010467  [illegible] R  [illegible]  ,PRE    ,TA[illegible]
010470  [illegible]  [illegible]  ,DATA   ,-[illegible]
010471  [illegible]  [illegible]  ,DATA   ,-[illegible]
```

```
010472  000001      TLP1   .DATA   .1
010473  000000      TLP2   .DATA   .0
010474  000001      TP2    .DATA   .32
010475  000000      STEP   .DATA   .0
010476  010000 R    CONT   .PZE    .TAP3
010477  000000      P125   .DATA   .477
010500  000455      C75    .DATA   .285
010501  000410      P75    .DATA   .264
010502  001750      DIM    .DATA   .1000
010503  000144      D100   .DATA   .100
010504  000001      SQ     .DATA   .1
010505  000000      IP00   .DATA   .0
010506  000000      IP01   .DATA   .0
010507  000000      IP02   .DATA   .0
010510  000000      TEMP   .DATA   .0
010511  000036      THSN   .DATA   .30
010512  000036      THSV   .DATA   .30
010513  000000      KSKX   .DATA   .02000
010514  000011      PNPG   .DATA   .9
010515  000004             .DATA   .4
010516  000010             .DATA   .8
010517  000006      PONT   .DATA   .6
010520  140705             .DATA   .*PZAP SPACE*
010521  140704
010522  120327
010523  150301
010524  141705
010525  010074 R    AAA    .PZE    .STPI
010526  000027      VOLD   .DATA   .23
010527  000053      M2D    .DATA   .43
010530  000054      ZN2D   .DATA   .44
010531  000055      P3D    .DATA   .45
010532  010542 R    PRT    .PZE    .PRIT
010533  010557 R    DIG    .PZE    .DIGT
010534  002404      SN01   .DATA   .02404
010535  004401             .DATA   .04401
010536  005001             .DATA   .05001
010537  007011             .DATA   .07011
010540  007412             .DATA   .07412
010541  010005             .DATA   .010005
010542  000027      PRIT   .DATA   .23
010543  155240             .DATA   .*V    *
010544  120240
010545  000053             .DATA   .43
010546  147262             .DATA   .*N2   *
010547  120240
010550  000054             .DATA   .44
010551  142316             .DATA   .*PN2  *
010552  131240
010553  000055             .DATA   .45
010554  142307             .DATA   .*PO   *
010555  120240
010556  000000             .DATA   .0
010557  000027      DIGT   .DATA   .23
```

```
010563  [illegible]          ,DATA   ,[illegible]
010564  [illegible]          ,DATA   ,017437
010565  [illegible]          ,DATA   ,40
010566  [illegible]          ,DATA   ,01121
010567  [illegible]          ,DATA   ,017437
010568  [illegible]          ,DATA   ,44
010569  [illegible]          ,DATA   ,05403
010570  [illegible]          ,DATA   ,05037
010571  [illegible]          ,DATA   ,45
010572  [illegible]          ,DATA   ,010025
010573  017437               ,DATA   ,017437
010574  [illegible]          ,DATA   ,0
010575  [illegible]  CB00    ,DATA   ,0121055
010576  [illegible]  CB01    ,DATA   ,0
010577  121027               ,DATA   ,0121027
010578  [illegible]  CB02    ,DATA   ,0
010579  [illegible]  CB03    ,DATA   ,0120453
010580  [illegible]  CB04    ,DATA   ,0
010581  [illegible]  CB05    ,DATA   ,0
010582  [illegible]  CB06    ,DATA   ,0120454
010583  [illegible]  CB07    ,DATA   ,0
010584  [illegible]  CB08    ,DATA   ,054000
010585  [illegible]  CB09    ,DATA   ,0
010586  054000       CB02    ,DATA   ,054000
010587  [illegible]  CB03    ,DATA   ,0
010588  054000       CB04    ,DATA   ,054000
010589  [illegible]  CB05    ,DATA   ,0
010590  115055       CB06    ,DATA   ,0115055
010591  [illegible]  CB07    ,DATA   ,0
010592  115027       CB08    ,DATA   ,0115027
010593  [illegible]  CB09    ,DATA   ,0
010594  114453       CB10    ,DATA   ,0114453
010595  [illegible]  CB11    ,DATA   ,0
010596  114454       CB12    ,DATA   ,0114454
010597  [illegible]  CB13    ,DATA   ,0
010598                TAB0    ,BSS    ,800
012262                TAB3    ,BSS    ,1
012263                TAB1    ,BSS    ,800
        [illegible]           ,END    ,
```

LITERALS

POINTERS

```
000700  110461
000701  110465
000702  110467
000703  110463
000704  110462
000705  012262
000706  110466
```

SYMBOLS

```
1   012263 R   TAB1
```

Step | Remarks

0. TURN ON RESP CONSOLE 1HR. PRIOR TO USE.

1. Follow Procedure "D" for Initialization and Calibration of N_2 Analyzer. Note: CO_2 Analyzer pump should be turned off.

2. Turn "ON" PBEM; switch to "Normal"; place proper leads on scope channels and pen recorder channels.

3. Set Flowmeter Selector Switch on Respiratory Panel of PBEM to "2" position. Allow 5 minutes for thermal stabilization of pressure transducers and flowmeter.

4. Adjust high pressure regulator on Oxygen tank to 40 or 50 psi (less than half scale on gage).

5. Perform preliminary adjustments on respiratory console and on 2-pen recorder. Set right channel of Beckman 462 Main Amp at 1V/cm, pen at left margin for 80% N_2. Perform preliminary Adjustment procedure for Lower strain gage coupler (and the resetting integrator, if required). Verify pre-amp flow setting at 2 and pre-amp volume setting at 5.

RESP/ATP-1

6. Enter Astronaut identification, Mission Day, Time, Organ Sys., Test No. and Test Value at Numerical Data Entry Panel.

7. Log subject, date, test and channel identification; turn pen recorders to "Operate".

8. To display Nitrogen analysis on right-hand pen, set right hand knob of Beckman 462 to 1 V/cm.

	LARGE PEN RECORDER CH.	SCOPE CH.
N_2	5	4
F	9	2
Vol	10	3
AT	12	—

9. Mount mouthpiece on Respiratory J Valve; turn Valve V2 to ambient.

10. Instruct subject to sit on ergometer assembly.

11. Check height of mouthpiece No. 2 with subject seated in an upright position; vertical adjustment may be made for supporting the Equipment Mounting Plate with one hand and loosening of the two holding knobs with the other; retighten knobs upon completion of height adjustment.

12. Press V 01, N 35 and "Enter". When "Standby" lights, press "Input", then "Print". If values are unsatisfactory, press "Clear" and perform Routine Pulmonary procedure for ERV and VC. After obtaining satisfactory values, press V 08, N 01. Do not press "Enter" yet.

13. Insert mouthpiece, place nose clip, and breathe normally.

Step		Remarks
14.	Push both Analog Tape Recorder "RECORD" buttons. Log subject, date, test and channel identification on intercom and tape settings on pen records. Press "CAL" button on Beckman 9801.	
15.	Observe that subject is breathing normally; exactly at the end of a normal expiration, turn Valve V2 to 100% oxygen. During first inspiration, press "Enter" button.	
16.	Have subject continue to breathe 100% oxygen. Press V 09, N 01. When Nitrogen concentration is less than 10%, switch to 0-10% scale on N_2 Analyzer at next end-tidal level. Press "Enter" and note on pen records and intercom.	
17.	When subject's N_2 level is down to the desired level, push "Record" button, but have subject continue breathing until "Computer Activity" light goes Out. Note: If "Record" button is not pressed, data processing continues for 7 minutes from first inspiration of O_2.	
18.	Turn pen recorders OFF. Log subject, date, test complete, identification and tape setting on pen records and intercom.	
19.	Push Analog Tape Recorder "OFF" button.	
20.	If additional respiratory measurements are not to be performed at this time, instruct subject to remove mouthpiece and nose clip; clean and store equipment.	
21.	Turn PBDM "OFF" if no further testing.	
22.	If no further testing is to be done, turn off Nitrogen Analyzer and its pump, and the Auxil. Resp. Rack main power switch.	
23.	Close valve on oxygen tank.	

```
* RESIDUAL VOLUME RV
*
*
* RV=FRC-ERV
* TLC=IC+FRC
* FRC=(VSMP X 100/RS)-(CORRECTION FACTOR) CORT-LOW CORE
*
* MEASUREMENT STARTS BY ENTERING *START* VERB;
* EACH RUN LASTS SEVEN MINUTES.
*
* SUBROUTINES: DPA,DST
*
*
000325    SVRB    .EQU    .0325
000457    CONT    .EQU    .0457
000225    ANSW    .EQU    .0225
000213    SENC    .EQU    .0213
000235    LOOP    .EQU    .0235
000220    KYLT    .EQU    .0220
000224    PBDR    .EQU    .0224
000306    ASTR    .EQU    .0306
000307    CRGS    .EQU    .0307
000324    MDAY    .EQU    .0324
000107    ATE     .EQU    .0107
000315    DSP1    .EQU    .0315
000316    DSP2    .EQU    .0316
000317    DSP3    .EQU    .0317
000320    DSP4    .EQU    .0320
000321    DSP5    .EQU    .0321
000322    PBAD    .EQU    .0322
000323    DGAD    .EQU    .0323
000202    MTSH    .EQU    .0202
000303    MTA     .EQU    .0303
000222    DOUT    .EQU    .0222
000203    SDEL    .EQU    .0203
000212    ENRT    .EQU    .0212
000205    TDEL    .EQU    .0205
000200    ADDN    .EQU    .0200
000136    MSKG    .EQU    .0136
000214    CENC    .EQU    .0214
000236    TERM    .EQU    .0236
000100    ONE     .EQU    .0100
000101    TWO     .EQU    .0101
000102    THRE    .EQU    .0102
000204    CDEL    .EQU    .0204
000112    M1      .EQU    .0112
000106    SVN     .EQU    .0106
000446    ERV     .EQU    .0446
000450    VC      .EQU    .0450
000123    M10     .EQU    .0123
000103    FOUR    .EQU    .0103
000105    SIX     .EQU    .0105
000104    FIVE    .EQU    .0104
000110    NINE    .EQU    .0110
```

```
          000113    M2     .EQU    .0113
          000120    M7     .EQU    .0120
          000223    TWIN   .EQU    .0223
          000137    MSKH   .EQU    .0137
          000114    M3     .EQU    .0114
          000326    EVRB   .EQU    .0326
*
*
010000                     .ORG    .010000
          000700    IAOR   .BEGIN  .0700
*
* ENTER FROM EXEC
*
010000  014565    FRC    .LDA    .AAA
010001  050325           .STA    .SVRB          START VERB ADDRESS
010002  014576           .LDA    .BBB
010003  050326           .STA    .EVRB          STOP VERB ADDRESS
010004  010104           .LDA    .FIVE
010005  002000           .JMPM*  .ANSW          SET UP A/D SWITCHES
010006  100225
010007  010567 R         .PZE    .SW01
010010  014564           .LDA    .D30
010011  002000           .JMPM*  .SENC          SET ENCODER START ADDRES
010012  100213
010013  010035 R         .PZE    .BEGN
010014  014561           .LDA    .D31
010015  002000           .JMPM*  .SENC          SET ENCODER STOP ADDRESS
010016  100213
010017  010443 R         .PZE    .ENB
010020  002000           .JMPM*  .TWIN
010021  100223
010022  000306           .PZE    .ASTR
010023  010106           .LDA    .SVN
010024  002000           .JMPM*  .SENC          ENABLE PRINT SWITCH
010025  100213
010026  010506 R         .PZE    .OLD
010027  010110           .LDA    .NINE
010030  002000           .JMPM*  .SENC          ENABLE RECORD SWITCH
010031  100213
010032  010502 R         .PZE    .CESE
010033  001000           .JMP*   .ENRT
010034  100212
*
* ENTER FROM START SWITCH
*
010035  014555    BEGN   .LDA    .K2            TURN ON LIGHTS
010036  002000           .JMPM*  .KYLT
010037  100220
010040  010110           .LDA    .NINE
010041  002000           .JMPM*  .KYLT
010042  100220
010043  014552           .LDA    .PRNT
010044  002000           .JMPM*  .PRDR          PRINT PROGRAM HEADING
010045  100224
```

```
010046  010617 R        .PZE    .PRNT+1
010047  010200          .LDA    .ASTR          SAVE ASTRO NUMBER AND M
010050  004000          .LSPA   .0
010051  054473          .STA    .OB01
010052  010207          .LDA    .ORGS
010053  150137          .ANA    .MSKH
010054  054472          .STA    .OB03
010055  002000          .JMPM*  .MTSM          READ MISSION TIME AND SA
010056  100202
010057  010203          .LDA    .MTA
010060  054470          .STA    .OB05
010061  010152          .LDA    .THRE
010062  002000          .JMPM*  .DOUT          PRINT ASTRO NO. MISSION
010063  100222
010064  010564 R        .PZE    .OB00          MISSION TIME
010065  002000          .JMPM*  .SDEL          SET TIME DEALY
010066  100203
010067  040062          .DATA   .040062
010070  010154 R        .PZE    .MSSO
010071  014510          .LDA    .PRT
010072  050322          .STA    .PRAD          PRINTER ID TABLE ADDRESS
010073  014507          .LDA    .DIG
010074  050323          .STA    .DGAD          DIGITAL DISPLAY ID TABL
010075  014506          .LDA    .RVD           SET DIGITAL DISPLAY IDS
010076  050315          .STA    .DSP1
010077  014505          .LDA    .FRCD
010100  050316          .STA    .DSP2
010101  014504          .LDA    .TLCD
010102  050317          .STA    .DSP3
010103  014503          .LDA    .NWD
010104  050320          .STA    .DSP4
010105  014502          .LDA    .VND
010106  050321          .STA    .DSP5
010107  001000          .JMP*   .ENRT
010110  100212
*
* ENTERED FROM START VERB INTERRUPT
*
010111  005001     STRT .TZA    .
010112  054531          .STA    .GO            SET DATA READ READY
010113  014531          .LDA    .NEX           TEST FOR NEW RUN
010114  001010          .JAZ    .*+4           NO
010115  010120 R
010116  001000          .JMP    .*+0
010117  010127 R
010120  010100          .LDA    .ONE
010121  054523          .STA    .NEX
010122  014467          .LDA    .K1
010123  002000          .JMPM*  .KYLT
010124  100220
010125  001000          .JMP*   .ENRT
010126  100212
010127  002000          .JMPM*  .MTSM          READ MISSION TIME
010130  100202
```

```
010131  010303          ,LDA    ,MTA
010132  054416          ,STA    ,OB05
010133  010100          ,LDA    ,ONE
010134  002000          ,JMPM*  ,DOUT          PRINT MISSION TIME
010135  100222
010136  010650 R        ,PZE    ,OB04
010137  014476          ,LDA    ,PRIT
010140  002000          ,JMPM*  ,PRDR          PRINT NEXT RUN INDICATIO
010141  100224
010142  010637 R        ,PZE    ,PRIT+1
010143  014446          ,LDA    ,K1
010144  002000          ,JMPM*  ,KYLT
010145  100220
010146  001000          ,JMP*   ,ENRT
010147  100212
*
* ENTER FROM STOP VERB
*
010150  014576    SCCH  ,LDA    ,D1M
010151  054566          ,STA    ,JJJ
010152  001000          ,JMP*   ,ENRT
010153  100212
*
* ENTER FROM TIME DELAY INTERPUPT
*
010154  014467    MS50  ,LDA    ,GO
010155  001010          ,JAZ    ,*+4
010156  010161 R
010157  001000          ,JMP*   ,TDEL
010160  100205
010161  010101          ,LDA    ,TWO        SET A/D INPUTS-FLOW,N2
010162  002000          ,JMPM*  ,ADRN
010163  100200
010164  010650 R        ,PZE    ,IB00
010165  010646 R        ,PZE    ,CN00
* MASK DATA AND SET ZERO IF NEGATIVE
010166  014461          ,LDA    ,IB00
010167  154421          ,ANA    ,MSKX
010170  001010          ,JAZ    ,*+4
010171  010174 R
010172  014455          ,LDA    ,IB00
010173  150136          ,ANA    ,MSKG
010174  054453          ,STA    ,IB00
010175  014453          ,LDA    ,IB01
010176  154412          ,ANA    ,MSKX
010177  001010          ,JAZ    ,*+4
010200  010203 R
010201  014447          ,LDA    ,IB01
010202  150136          ,ANA    ,MSKG
010203  054445          ,STA    ,IB01
010204  014445          ,LDA    ,FD0        FLAG SET=1 AT START
010205  001004          ,JAN    ,FL0            INITIAL READINGS
010206  010223 R
010207  001010          ,JAZ    ,RUN            ACCUMULATING DATA
```

```
010210  010237 R
010211  014437          ,LDA    ,IB01
010212  001010          ,JAZ    ,*+4          FLOW EQUAL TO ZERO
010213  010216 R
010214  001000          ,JMP*   ,TDEL      FLOW NOT=0 YET
010215  100205
010216  057700 I        ,STA*   ,TMAA
010217  010112          ,LDA    ,M1           SET FLOW INDICATOR TO NE
010220  054431          ,STA    ,FDO
010221  001000          ,JMP*   ,TDEL
010222  100205
010223  044511    FLO   ,INR    ,TMAA
010224  014424          ,LDA    ,IB01
010225  057700 I        ,STA*   ,TMAA         SAVE FLOW
010226  044522          ,INR    ,CT02         N2 DELAY
010227  014521          ,LDA    ,CT02
010230  001004          ,JAN*   ,TDEL
010231  100205
010232  054417          ,STA    ,FDO          SET FLOW INDICATOR TO ZE
010233  014502          ,LDA    ,TMAB         RESET TABLE POINTER
010234  054500          ,STA    ,TMAA
010235  001000          ,JMP*   ,TDEL
010236  100205
010237  005001    RUN   ,TZA    ,
010240  024407          ,LDB    ,IB00
010241  167700 I        ,MUL*   ,TMAA
010242  174475          ,DIV    ,JJJ
010243  005001          ,TZA    ,
010244  002000          ,CALL   ,DPA
010245  011040 R
010246  010742 R        ,PZE    ,DBLA
010247  054472          ,STA    ,DBLA         ACCUMULATE N2  X FLOW
010250  064472          ,STB    ,DBLA+1
010251  014377          ,LDA    ,IB01
010252  057700 I        ,STA*   ,TMAA
010253  044461          ,INR    ,TMAA
010254  044323          ,INR    ,CT03         THIRD CALCULATION
010255  014322          ,LDA    ,CT03
010256  001004          ,JAN    ,*+6
010257  010264 R
010260  014455          ,LDA    ,TMAB         YES
010261  054453          ,STA    ,TMAA         RESET BUFFER ADDRESS
010262  010114          ,LDA    ,M3
010263  054314          ,STA    ,CT03
010264  044461          ,INR    ,CT1M         ACCUMULATION COMPLETE
010265  014460          ,LDA    ,CT1M
010266  001004          ,JAN*   ,TDEL
010267  100205
010270  ~~001040~~ 5000 ~~,JXZ    ,*+4~~
010271  ~~010274~~ R[illegible]
010272  ~~001000~~ [illegible] ~~,JMP*   ,TDEL~~
010273  100205 [illegible]
010274  014445    RCAL  ,LDA    ,DBLA
010275  024445          ,LDB    ,DBLA+1
```

```
010276  005014          ,TAX    ,                    PREVENT DIVIDE OVERFLOW
010277  144452          ,SUB    ,DM12
010300  001004          ,JAN    ,*+9
010301  010311 R
010302  001010          ,JAZ    ,*+7
010303  010311 R
010304  005041          ,TXA    ,
010305  004501          ,LASR   ,1
010306  044444          ,INR    ,CTXO
010307  001000          ,JMP    ,RCAL+2
010310  010276 R
010311  005041          ,TXA    ,
010312  174437          ,DIV    ,DM12
010313  005001          ,TZA    ,
010314  034436          ,LDX    ,CTXO
010315  005244          ,CPX    ,
010316  005144          ,IXR    ,
010317  001040          ,JXZ    ,*+5
010320  010324 R
010321  004401          ,LASL   ,1
010322  001000          ,JMP    ,*-4
010323  010316 R
010324  002000          ,CALL   ,DPA
010325  011040 R
010326  010744 R        ,PZE    ,CBLA
010327  054414          ,STA    ,CBLA                ADD 1 MINUTE INTEGRATIO
010330  064414          ,STB    ,CBLA+1
010331  005001          ,TZA    ,
010332  054407          ,STA    ,DBLA
010333  064407          ,STB    ,DBLA+1
010334  014417          ,LDA    ,M120          RESET 1 MIN. COUNTER
010335  054410          ,STA    ,CTIM
010336  044416          ,INR    ,CT07
010337  014415          ,LDA    ,CT07
010340  001010          ,JAZ    ,*+7
010341  010347 R
010342  014415          ,LDA    ,CESD
010343  001010          ,JAZ    ,*+4
010344  010347 R
010345  001000          ,JMP*   ,TDEL
010346  100205
010347  014300          ,LDA    ,IB00
010350  054212          ,STA    ,OB15                STORE DATA
010351  054167          ,STA    ,DB09
010352  010100    CALU  ,LDA    ,ONE
010353  054270          ,STA    ,GO                  SET DATA READ NOT READY
010354  024370          ,LDB    ,CBLA+1        ASSUME VE(N2) IS ON THE OPD
010355  064207          ,STB    ,OB17          OF 2-4 LITERS +OR- .01
010356  064164          ,STB    ,DB11
010357  005001          ,TZA    ,
010360  164375          ,MUL    ,D100
010361  174375          ,DIV    ,D80
010362  005021          ,TBA    ,
010363  144213          ,SUB    ,CCRT          SUBTRACT CORRECTION FACTOR
```

```
010364  054146          ,STA    ,DB03
010365  054167          ,STA    ,OB09        STORE FRC
010366  147446          ,SUB*   ,EPV
010367  054141          ,STA    ,DB01        STORE RV
010370  054162          ,STA    ,OB07
010371  127450          ,ADD*   ,VC
010372  054142          ,STA    ,DB05
010373  054163          ,STA    ,OB11
010374  017450          ,LDA*   ,VC
010375  054141          ,STA    ,DB07
010376  054162          ,STA    ,OB13
010377  010103          ,LDA    ,FOUR
010400  002000          ,JMPM*  ,DOUT            OUTPUT DATA
010401  100222
010402  010530 R        ,PZE    ,DB00
010403  010105          ,LDA    ,SIX
010404  002000          ,JMPM*  ,DOUT
010405  100222
010406  010552 R        ,PZE    ,OB06
010407  002000          ,JMPM*  ,TERM
010410  100236
010411  010120          ,LDA    ,M7              RESET COUNTERS AND POINT
010412  054342          ,STA    ,CT07
010413  014340          ,LDA    ,M120
010414  054331          ,STA    ,CT1M
010415  005001          ,TZA    ,
010416  054323          ,STA    ,DBLA
010417  054323          ,STA    ,DBLA+1
010420  054323          ,STA    ,CBLA
010421  054323          ,STA    ,CBLA+1
010422  010100          ,LDA    ,ONE
010423  054334          ,STA    ,CESD
010424  054225          ,STA    ,FDO
010425  014310          ,LDA    ,TMAB
010426  054306          ,STA    ,TMAA
010427  054307          ,STA    ,TMAC
010430  014325          ,LDA    ,D100
010431  054306          ,STA    ,JJJ
010432  010113          ,LDA    ,M2
010433  054315          ,STA    ,CT02
010434  010114          ,LDA    ,M3
010435  054142          ,STA    ,CT03
010436  010100          ,LDA    ,ONE
010437  002000          ,JMPM*  ,KYLT
010440  100220
010441  001000          ,JMP*   ,TDEL
010442  100205
*
* ENTERED FROM STOP SWITCH INTERRUPT
*
010443  010100    ENB   ,LDA    ,ONE
010444  002000          ,JMPM*  ,KYLT
010445  100220
010446  010101          ,LDA    ,TWO
```

```
010447  002000          ,JMPM*   ,KYLT
010450  100220
010451  014142          ,LDA     ,K0
010452  002000          ,JMPM*   ,KYLT
010453  100220
010454  010106          ,LDA     ,SVN
010455  002000          ,JMPM*   ,KYLT
010456  100220
010457  002000          ,JMPM*   ,CDEL
010460  100204
010461  010154 R        ,PZE     ,MS50
010462  014112          ,LDA     ,D30
010463  002000          ,JMPM*   ,CENC
010464  100214
010465  014110          ,LDA     ,D31
010466  002000          ,JMPM*   ,CENC
010467  100214
010470  010106          ,LDA     ,SVN
010471  002000          ,JMPM*   ,CENC
010472  100214
010473  010110          ,LDA     ,NINE
010474  002000          ,JMPM*   ,CENC
010475  100214
010476  002000          ,JMPM*   ,TERM
010477  100236
010500  002000          ,JMPM*   ,ENRT
010501  100212
*
* ENTERED FROM RECORD SWITCH
*
010502  005001     CESE ,TZA     ,
010503  054254          ,STA     ,CESD
010504  001000          ,JMP*    ,ENRT
010505  100212
*
* ENTERED FROM PRINT SWITCH
*
010506  014253     OLD  ,LDA     ,ERVD
010507  050315          ,STA     ,DSP1
010510  014250          ,LDA     ,VCD
010511  050316          ,STA     ,DSP2
010512  017446          ,LDA*    ,ERV
010513  054250          ,STA     ,BB01
010514  017450          ,LDA*    ,VC
010515  054250          ,STA     ,BB03
010516  010101          ,LDA     ,TWO
010517  002000          ,JMPM*   ,DOUT
010520  100222
010521  010763 R        ,PZE     ,BB00
010522  014061          ,LDA     ,RVD
010523  050315          ,STA     ,DSP1
010524  014060          ,LDA     ,FBCD
010525  050316          ,STA     ,DSP2
010526  001000          ,JMP*    ,ENRT
```

```
010527  100212
*
* CONSTANTS AND STORAGE
*
010530  021050     DB00   ,DATA   ,021050    RV +OR- .01
010531  000000     DB01   ,DATA   ,0
010532  021051     DB02   ,DATA   ,021051   FRC +OR- .01
010533  000000     DB03   ,DATA   ,0
010534  021052     DB04   ,DATA   ,021052   TLC +OR- .01
010535  000000     DB05   ,DATA   ,0
010536  021037     DB06   ,DATA   ,021037    VC +OR- .01
010537  000000     DB07   ,DATA   ,0
010540  021112     DB08   ,DATA   ,021112
010541  000000     DB09   ,DATA   ,0
010542  021113     DB10   ,DATA   ,021113
010543  000000     DB11   ,DATA   ,0
010544  054000     OB00   ,DATA   ,054000    ASTRO ID
010545  000000     OB01   ,DATA   ,0
010546  054000     OB02   ,DATA   ,054000    MISSION ID
010547  000000     OB03   ,DATA   ,0
010550  054000     OB04   ,DATA   ,054000    TIME
010551  000000     OB05   ,DATA   ,0
010552  115050     OB06   ,DATA   ,0115050   RV +OR- .01
010553  000000     OB07   ,DATA   ,0
010554  115051     OB08   ,DATA   ,0115051  FRC +OR- .01
010555  000000     OB09   ,DATA   ,0
010556  115052     OB10   ,DATA   ,0115052  TLC +OR- .01
010557  000000     OB11   ,DATA   ,0
010560  115037     OB12   ,DATA   ,0115037   VC +OR- .01
010561  000000     OB13   ,DATA   ,0
010562  115112     OB14   ,DATA   ,0115112   NW +OR- .01
010563  000000     OB15   ,DATA   ,0
010564  115113     OB16   ,DATA   ,0115113 VEN2 +OR- .01
010565  000000     OB17   ,DATA   ,0
010566  010111 R   AAA    ,P7E    ,STRT
010567  002404     SW01   ,DATA   ,02404
010570  010005            ,DATA   ,010005
010571  004401            ,DATA   ,04401
010572  007411            ,DATA   ,07411
010573  005001            ,DATA   ,05001
010574  007012            ,DATA   ,07012
010575  000006     D30    ,DATA   ,6
010576  000010     D31    ,DATA   ,8
010577  000053     CORT   ,DATA   ,43
010600  777775     CT03   ,DATA   ,-3
010601  010150 R   BBB    ,P7E    ,SCCH
010602  010767 R   PRT    ,P7E    ,PRTT
010603  011012 R   DIG    ,P7E    ,DIGT
010604  000050     RVD    ,DATA   ,050
010605  000051     FRCD   ,DATA   ,051
010606  000052     TLCD   ,DATA   ,052
010607  000112     NWD    ,DATA   ,0112
010610  000113     VND    ,DATA   ,0113
010611  002000     MSKX   ,DATA   ,02000
```

```
010612  100001    K1      .DATA   .0100001
010613  100002    K2      .DATA   .0100002
010614  100011    K3      .DATA   .0100011
010615  100007    K7      .DATA   .0100007
010616  000017    PRNT    .DATA   .15
010617  143525            .DATA   ."FUNCTIONAL RESIDUAL CAPACITY  "
010620  147503
010621  152311
010622  147716
010623  140714
010624  120322
010625  142723
010626  140704
010627  152701
010630  146240
010631  141701
010632  150301
010633  141711
010634  152331
010635  120240
010636  000005    PRIT    .DATA   .5
010637  147505            .DATA   ."NEXT RUN  "
010640  154324
010641  120322
010642  152716
010643  120240
010644  000001    GO      .DATA   .1
010645  000000    NEX     .DATA   .0
010646  000004    CN00    .DATA   .4
010647  000010            .DATA   .8
010650  000000    IS00    .DATA   .0
010651  000000    IS01    .DATA   .0
010652  000001    F00     .DATA   .1
010653            TM00    .BSS    .50
010735  010653 R  TMAA    .PZE    .TM00
010736  010653 R  TMAB    .PZE    .TM00
010737  010653 R  TMAC    .PZE    .TM00
010740  000144    JJJ     .DATA   .100
010741  000000    CTZO    .DATA   .0
010742  000000    DBLA    .DATA   .0
010743  000000            .DATA   .0
010744  000000    CBLA    .DATA   .0
010745  000000            .DATA   .0
010746  775520    CTIM    .DATA   .-1200
010747  001750    DIM     .DATA   .1000
010750  000125    D85     .DATA   .85
010751  777776    CT02    .DATA   .-2
010752  002260    DM12    .DATA   .1200
010753  000000    CTXO    .DATA   .0
010754  775520    M120    .DATA   .-1200
010755  777771    CT07    .DATA   .-7
010756  000144    D100    .DATA   .100
010757  000120    D80     .DATA   .80
010760  000001    CESO    .DATA   .1
```

```
010761  000037    VCH    .DATA   .037
010762  000034    FRVD   .DATA   .034
010763  021034    BB00   .DATA   .021034
010764  000000    BB01   .DATA   .0
010765  021037    BB02   .DATA   .021037
010766  000000    BB03   .DATA   .0
010767  000050    PRTT   .DATA   .050
010770  151326           .DATA   .'RV  '
010771  120240
010772  000051           .DATA   .051
010773  143322           .DATA   .'FRC '
010774  141640
010775  000052           .DATA   .052
010776  152314           .DATA   .'TLC '
010777  141640
011000  000037           .DATA   .037
011001  153303           .DATA   .'VC  '
011002  120240
011003  000112           .DATA   .0112
011004  147327           .DATA   .'NW  '
011005  120240
011006  000113           .DATA   .0113
011007  153305           .DATA   .'VEN2'
011010  147262
011011  000000           .DATA   .0
011012  000030    DIGT   .DATA   .050
011013  001016           .DATA   .01016
011014  017437           .DATA   .017437
011015  000051           .DATA   .051
011016  011002           .DATA   .011002
011017  004437           .DATA   .04437
011020  000052           .DATA   .052
011021  000006           .DATA   .06
011022  004437           .DATA   .04437
011023  000037           .DATA   .037
011024  007011           .DATA   .07011
011025  017437           .DATA   .017437
011026  000113           .DATA   .0113
011027  003417           .DATA   .03417
011030  001417           .DATA   .01417
011031  000112           .DATA   .0112
011032  001420           .DATA   .01420
011033  017437           .DATA   .017437
011034  000034           .DATA   .034
011035  007402           .DATA   .07402
011036  007037           .DATA   .07037
011037  000000           .DATA   .0
*
* DOUBLE PRECISION ADDITION
*
* ADDRESS OF A IN JMPM+1.
* DATA B IN A AND B
*
* EXIT WITH ANSWER IN A AND B
```

```
*
011040  000000     DPA    ,ENTR   ,
011041  007400            ,RCF    ,                RESET OVERFLOW
011042  037701 I          ,LDX    ,DPA             LOAD ADDRESS A
011043  035000            ,LDX    ,0,1
011044  054015            ,STA    ,DPAT
011045  005021            ,TRA    ,
011046  125001            ,ADD    ,1,1             ADD LOWER HALF
011047  006150            ,ANAI   ,077777
011050  077777
011051  005012            ,TAB    ,
011052  005001            ,TZA    ,
011053  005511            ,ACFA   ,                ADD UPPER HALF
011054  007400            ,RCF    ,
011055  124004            ,ADD    ,DPAT
011056  125000            ,ADD    ,0,1
011057  047701 I          ,INR    ,DPA
011060  001000            ,JMP*   ,DPA
011061  111040 R
*
011062  000000     DPAT   ,DATA   ,0
        000000            ,END    ,
```

LITERALS

POINTERS

```
000700  110735
000701  011040
```

SYMBOLS

```
1  011062 R  DPAT
1  011040 R  DPA
1  011012 R  DIGT
1  010767 R  BRTT
1  010766 R  BB03
1  010765 R  BB02
1  010764 R  BB01
1  010763 R  BB00
1  010762 R  ERVD
1  010761 R  VCD
1  010760 R  CESD
1  010757 R  D80
1  010756 R  D100
1  010755 R  CT07
1  010754 R  M120
1  010753 R  CTX0
1  010752 R  DM12
1  010751 R  CT02
1  010750 R  D85
1  010747 R  DIM
1  010746 R  CT1M
1  010744 R  CBLA
```

Step		Remarks
1.	PERFORM INITIALIZATION AND CALIBRATION OF CO_2 ANALYZER - PROCEDURE C.	
2.	PERFORM INITIALIZATION AND CALIBRATION OF O_2 ANALYZER - PROCEDURE B. Then set both the rotary and the toggle switches at Range 3.	
3.	PERFORM PROCEDURE A, PRELIMINARY ADJUSTMENT OF FLOW/VOLUME EQUIPMENT AND 2-PEN RECORDER. Verify Pre-Amp Flow Setting on 2 and Volume Setting on 5. Use Flowmeter 2.	
4.	Turn PBEM On. Enter Astronaut Identification, Mission Day, Mission Time, Organ System, Test No. and Test Value at Numerical Data Entry Panel.	
5.	Switch PBEM to "Normal" on rear of Console. Load Minute Alveolar Vol. Program into Computer and initiate operation: Press Verb 01, Noun 34 and "Enter" buttons on Processor Keyboard, and "Input" button, when "Standby" lights.	
6.	Log subject, date, test, and channel identification; turn pen recorders "On".	O_2 Ch. 4 CO_2 Ch. 8 F Ch. 9 V Ch. 10 AT Ch. 12
7.	Unstow personal mouthpiece and nose clip; remove from protective case.	
8.	Mount mouthpiece on Respiratory J Valve; turn Valve V2 to ambient; Verify that handle of V3 is horizontal.	
9.	Check height of mouthpiece with subject in an upright position; vertical adjustment may be made by supporting the Equipment Mounting Plate with one hand and loosening of the two holding knobs with the other; retighten knobs upon completion of height adjustment.	
10.	Instruct subject to insert mouthpiece, place nose clip, and breathe normally. Press "Input", then press Verb 08, Noun 01; then during inspiration, press "Enter".	
11.	Verify operation of gas analyzers on 2-pen recorder. (Set both Beckman 462 amplifiers to 1 V/cm).	Verify tracings: pCO_2 _____ pO_2 _____
12.	Push both Analog Tape Recorder "RECORD" buttons. Log subject, date, test and channel identification on intercom and tape settings on pen records.	

Step		Remarks
	Turn Beckman A 560 Control to "OPERATE".	
13.	Record for approximately 1-1/2 minutes.	
14.	Press "CAL" button on Beckman 9801. Momentarily turn CO_2 meter selector knob to Red Dot position.	
15.	Turn pen recorders "OFF". Log subject, date, test complete, identification and tape setting on pen records and intercom.	
16.	Push Analog Tape Recorder "OFF" button.	
17.	If additional respiratory measurements are <u>not</u> to be done at this time, instruct subject to remove mouthpiece and nose clip, clean and store equipment.	
18.	Turn PBIM "Off" if no further testing. Turn the CO_2 and O_2 Analyzers and the Auxil. Resp. Rack Main Power "OFF" if no further testing is to be performed.	

MEASUREMENT REQUIREMENTS DATA SHEET

SUB-SYSTEM : Respiratory

MEASUREMENT GROUP : Respiratory

MEASUREMENT : Minute Alveolar Ventilation ($\dot{V}_{AMIN}$)

MEASUREMENT DESCRIPTION : Obtain measurement of minute alveolar ventilation from total expired volume (V_E) and expired CO_2 (V_{ECO_2})

1. Input signal characteristics — Expired volume - Biphasic repetitive waveform
   Expired CO2 - Biphasic repetitive waveform

2. Electrodes, transducers — Mouthpiece, Fleish pneumotachometer and pressure transducer (Statham, PM15); gas analyzer sampling head.

3. Signal conditioner(s) — Strain gage coupler (Beckman, #9803), Volume Integrator (Beckman, #9873B); CO_2 gas analyzer (Godart, KK5S002)

4. Range of measurement — Normal - 3.0 to 7.0 liters/min.
   Exercise - 4.0 to 200 liters/min.

5. Frequency of measurement — Once per 1-2 weeks

6. Output signal characteristics

analog/digital	Analog waveforms
amplitude	0-5 volts
frequency range	N/A
accuracy/sensitivity	± 2% per parameter

7. Calibration

type & technique	CO_2 analyzer - use electrical calibration
frequency	Before each series of measurements

8. Data handling

display analog/digital (raw, processed; local, remote; continuous, intermittent)	Waveforms; raw, analog, intermittent on Display Monitor and on 2-pen recorder.
recording analog/digital (raw, processed; continuous, intermittent)	Waveforms; raw, digitized, continuous for 90 seconds.
manual/programmed A or D switching	Programmed signal routing to Display Monitor and recorder.
manual/verbal data entry	Subject identification and measurement number
A/D conversion frequency	100 sps
storage time analog/digital	Digitized until next data dump
recording/storage quantity per subject	Approx. 100 seconds, including derived value

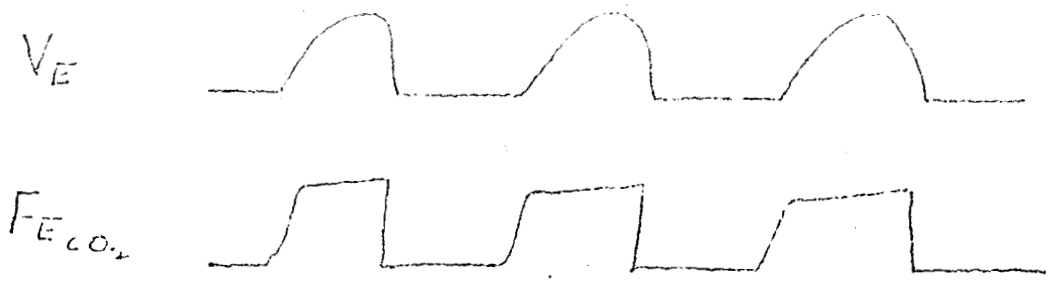
9. Derived quantities

other measurements required simultaneously for calculations	Time base
digital computation	Minute alveolar ventilation ($\dot{V}_{AMIN}$) See #13
display analog/digital; location; updating frequency	Display of derived values on digital readout.
recording analog/digital	Digital values
storage time analog/digital	Digitized until next data dump

10. Comparison with previous data	N/A
11. Analog/digital display range & resolution/accuracy	Digital; 3-200 liters/minute ± 5%
12. Printout frequency & other requirements	Once at end of run.

13. Miscellaneous information, details on referenced items, etc.

Sample Waveforms--



Miscellaneous Calculations:

$$V_A = \frac{\dot{V}_{CO2}}{\%\ \text{alveolar}\ CO_2}$$

$$\dot{V}_{CO2} = \dot{V}_E \times F_{E\,CO2}\ ^{*}$$

$\dot{V}_E$ is obtained from the totalized expired volume

$F_E\ CO_2$ is obtained directly from the output of the CO_2 analyzer corrected for H_2O vapor

V_E and $F_{E\,CO_2}$ are multiplied continuously during the measurement period

% alveolar CO_2 is the peak CO_2 concentration during the respiratory cycle.

* Also see gas correction factors and "true" CO_2 correction on Measurement Data Sheet

MEASUREMENT REQUIREMENTS DATA SHEET

SUB-SYSTEM : Respiratory

MEASUREMENT GROUP : Respiratory

MEASUREMENT : Alveolar PO_2 and PCO_2 (P_{AO_2} and P_{ACO_2})

MEASUREMENT DESCRIPTION : Obtain measurement of alveolar PO_2 and PCO_2 from gas analyzer curves

1. Input signal characteristics — Biphasic, repetitive waveform

2. Electrodes, transducers — Mouthpiece; analyzer sampling heads

3. Signal conditioner(s) — CO_2 analyzer - Godart Capnograph, KK 58002; O_2 analyzer Westinghouse Model 211M

4. Range of measurement — PAO_2 = 70-120 mm Hg; $PACO_2$ = 20-70 mm Hg

5. Frequency of measurement — Once per 1-2 weeks

6. Output signal characteristics

analog/digital	Analog waveforms, See #13
amplitude	0-5 volts
frequency range	N/A
accuracy/sensitivity	± 2% of true values

7. Calibration

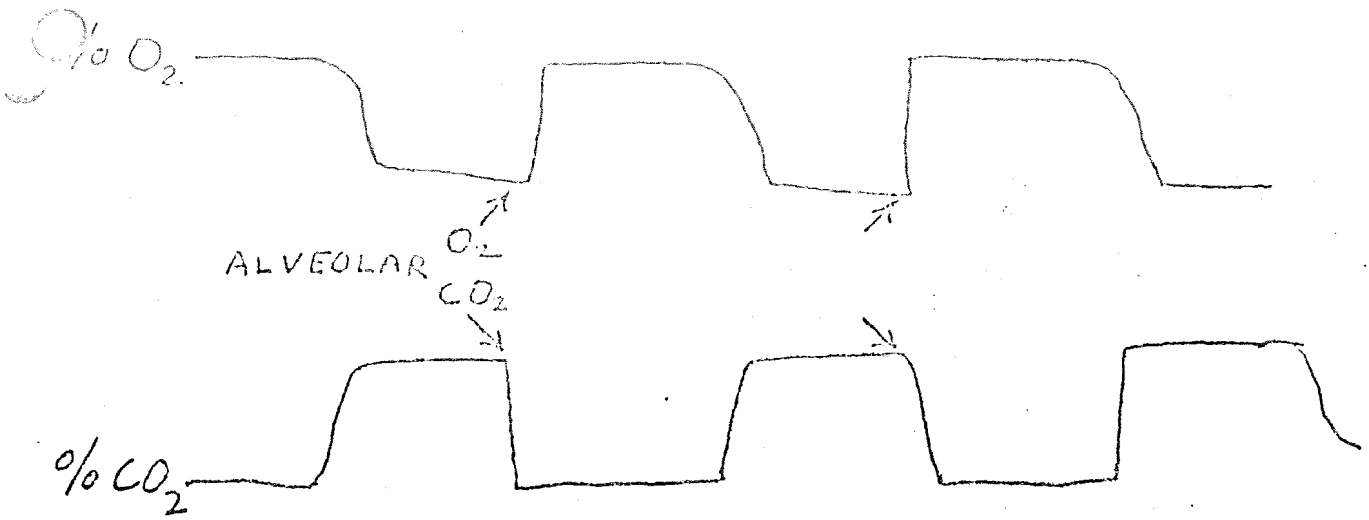
type & technique	Calibration gases and/or equipment controls
frequency	Before each series of measurements

8. Data handling

display analog/digital (raw, processed; local, remote; continuous, intermittent)	Waveform; raw, analog, continuous on Displ Monitor and on 2-pen recorder.
recording analog/digital (raw, processed; continuous, intermittent)	Waveform, raw, digitized, continuous.
manual/programmed A or D switching	Programmed signal routing to Display Monito and recorder.
manual/verbal data entry	Subject identification and measurement number.
A/D conversion frequency	100 sps.
storage time analog/digital	Digitized until next data dump.
recording/storage quantity per subject	30 sec./subject, including derived values.

9. Derived quantities	PAO_2 and $PACO_2$
other measurements required simultaneously for calculations	Absolute barometric pressure (P_B) PH_2O = 47 mm Hg.
digital computation	PAO_2 or $PACO_2 = \%O_2$ or $\%CO_2 \times \frac{P_B - PH_2O}{100}$
display analog/digital; location; updating frequency	Digital display of computed values on digital readout: every 10 sec.
recording analog/digital	Digitized average PAO_2 and $PACO_2$ at end of each recording
storage time analog/digital	Digitized until next data dump
10. Comparison with previous data	N/A
11. Analog/digital display range & resolution/accuracy	Digital, PAO_2: 70 to 120 mm Hg; $PACO_2$: 20 to 70 mm Hg Accuracy: Both $\pm$ 2%.
12. Printout frequency & other requirements	Once every 30 sec.

13. Miscellaneous information, details on referenced items, etc.



Analog O_2 and CO_2 analyzer outputs. Minimum value of O_2 and maximum value of CO_2 are to be used for computations.

3/30

```
*  [illegible] VOLUME
*  [illegible] BY [illegible] *START* VERB.
*  [illegible] BITS [illegible]
*  [illegible] INITIATED BY RCE'TERMS
*  [illegible] VERB.
*  [illegible] AND [illegible] TO STDS
*
*  [illegible] PRO.,DST
*
*
```

[illegible]	[illegible]	,EQU	,0335
[illegible]	[illegible]	,EQU	,0136
[illegible]	[illegible]	,EQU	,0335
[illegible]	[illegible]	,EQU	,0213
[illegible]	[illegible]	,EQU	,0235
[illegible]	[illegible]	,EQU	,0110
[illegible]	[illegible]	,EQU	,0230
[illegible]	[illegible]	,EQU	,0234
[illegible]	[illegible]	,EQU	,0336
[illegible]	[illegible]	,EQU	,0337
[illegible]	[illegible]	,EQU	,0135
[illegible]	[illegible]	,EQU	,0137
[illegible]	[illegible]	,EQU	,0332
[illegible]	[illegible]	,EQU	,0333
000315	[illegible]	,EQU	,0315
[illegible]	[illegible]	,EQU	,0316
000317	[illegible]	,EQU	,0317
[illegible]	[illegible]	,EQU	,0320
000321	[illegible]	,EQU	,0321
000444	[illegible]	,EQU	,0444
000443	[illegible]	,EQU	,0443
[illegible]	[illegible]	,EQU	,0440
000442	[illegible]	,EQU	,0442
000441	[illegible]	,EQU	,0441
[illegible]	[illegible]	,EQU	,0232
[illegible]	[illegible]	,EQU	,0333
000102	[illegible]	,EQU	,0102
[illegible]	[illegible]	,EQU	,0222
[illegible]	[illegible]	,EQU	,0203
[illegible]	[illegible]	,EQU	,0212
[illegible]	[illegible]	,EQU	,0235
[illegible]	[illegible]	,EQU	,0130
[illegible]	[illegible]	,EQU	,0230
[illegible]	[illegible]	,EQU	,0136
[illegible]	[illegible]	,EQU	,0110
000111	[illegible]	,EQU	,0111
000101	[illegible]	,EQU	,0101
[illegible]	[illegible]	,EQU	,0103
[illegible]	[illegible]	,EQU	,0103
[illegible]	[illegible]	,EQU	,0204
000214	[illegible]	,EQU	,0214
[illegible]	[illegible]	,EQU	,0236
[illegible]	[illegible]	,EQU	,0104
[illegible]	[illegible]	,EQU	,0223

440 → 0130₈

441 → 057₈

```
[illegible]                    [illegible]   ,0177
[illegible]                    ,ORG    ,010000
[illegible]          [illegible]   ,[illegible]
[illegible]          NAV       ,LDA    ,AAA        LOAD ADDRESS OF [illegible]
[illegible]                    ,STA    ,SVDR                START
[illegible]                    ,LDA    ,NINE
[illegible]                    ,JMPM*  ,ANSW
[illegible]
[illegible]          P         ,PZE    ,SW01
[illegible]                    ,LDA    ,D30
[illegible]                    ,JMPM*  ,SENC
[illegible]
[illegible]          P         ,PZE    ,BEGN
[illegible]                    ,LDA    ,D31
[illegible]                    ,JMPM*  ,SENC
[illegible]
[illegible]          P         ,PZE    ,ENDA
[illegible]                    ,JMPM*  ,TWIN
[illegible]
[illegible]                    ,PZE    ,ASTR
[illegible]                    ,LDA    ,PNT
[illegible]                    ,STA    ,PRAD
[illegible]                    ,LDA    ,DIG
[illegible]                    ,STA    ,DGAD
[illegible]                    ,LDA    ,ACD
[illegible]                    ,STA    ,DSP1
[illegible]                    ,LDA    ,ACOD
[illegible]                    ,STA    ,DSP2
[illegible]                    ,LDA    ,MAVD
[illegible]                    ,STA    ,DSP3
[illegible]                    ,LDA    ,RPD
[illegible]                    ,STA    ,DSP4
[illegible]                    ,LDA    ,COD
[illegible]                    ,STA    ,DSP5
[illegible]                    ,JMP*   ,ENRT
[illegible]
[illegible]          BEGN      ,LDA    ,NINE       STBY LIGHT OFF
[illegible]                    ,JMPM*  ,KYLT
[illegible]
[illegible]          I         ,LDA    ,K2
[illegible]                    ,JMPM*  ,KYLT       EXP-ACTY LIGHT ON
[illegible]
[illegible]                    ,LDA    ,PRNT
[illegible]                    ,JMPM*  ,PRDP       PRINT PROGRAM NAME
[illegible]
[illegible]          P         ,PZE    ,PRNT+1
[illegible]                    ,LDA    ,ASTF       ASTRONAUT ID
[illegible]                    ,LSRA   ,8
[illegible]          I         ,STA    ,OR01
[illegible]                    ,LDA    ,ORGS
[illegible]                    ,ANA    ,MSKH
[illegible]          I         ,STA    ,OR03
```

```
010061  [illegible]                  ,JMPM*   ,MTSN        TIME
010062  [illegible]
010063  [illegible]                  ,LDA     ,MTA
010064  [illegible] I                ,STA     ,DROB
010065  [illegible]                  ,LDA     ,THPF
010066  [illegible]                  ,JMPM*   ,DOUT
010067  [illegible]
010068  [illegible] P                ,PZE     ,DROC
010069  [illegible]                  ,JMPM*   ,SDEL
010070  [illegible]
010071  [illegible]                  ,DATA    ,040012
010072  [illegible]                  ,PZE     ,MSTO
010073  [illegible]                  ,JMP*    ,ENRT
010074  [illegible]
010075  [illegible] I   STRT         ,LDA     ,KI          COMP-ACTY LIGHT ON
010076  [illegible]                  ,JMPM*   ,KYLT
010077  [illegible]
010100  [illegible]                  ,TZA     ,
010101  [illegible]                  ,STA     ,GO
010102  [illegible] I                ,JMP*    ,ENRT
010103  [illegible]
010104  [illegible] I   MSSO         ,LDA     ,GO
010105  [illegible]                  ,JAZ     ,*+4
010106  [illegible] P
010107  [illegible]                  ,JMP*    ,TDEL
010108  [illegible]
010109  [illegible]                  ,LDA     ,THPF
010110  [illegible]                  ,JMPM*   ,ADRN
010111  [illegible]
010112  [illegible] P                ,PZE     ,IB00
010113  [illegible] P                ,PZE     ,CN00
010114  [illegible] I   OK           ,LDA     ,IB00
010115  [illegible]                  ,ANA     ,MSKG
010116  [illegible] I                ,STA     ,IB00
010117  [illegible] I                ,LDA     ,IB01
010118  [illegible]                  ,ANA     ,MSKX
010119  [illegible]                  ,JAZ     ,*+4
010120  [illegible] P
010121  [illegible]                  ,JMP     ,*+3
010122  [illegible] P
010123  [illegible] I                ,STA     ,IB01
010124  [illegible] I                ,LDA     ,IB01
010125  [illegible]                  ,ANA     ,MSKG
010126  [illegible] I                ,STA     ,IB01
010127  [illegible] I                ,LDA     ,IB02
010128  [illegible]                  ,ANA     ,MSKX
010129  [illegible]                  ,JAZ     ,*+4
010130  [illegible] P
010131  [illegible]                  ,JMP     ,*+3
010132  [illegible] P
010133  [illegible] I                ,STA     ,IB02
010134  [illegible] I                ,LDA     ,IB02
010135  [illegible]                  ,ANA     ,MSKG
010136  [illegible] I                ,STA     ,IB02
```

116

```
[illegible]  [illegible]                  ,LDA    ,FDO
[illegible]  [illegible]                  ,JAZ    ,**4
[illegible]  [illegible] R
[illegible]  [illegible]                  ,JMP    ,DUM
[illegible]  [illegible] R
[illegible]  017710 I                     ,LDA    ,IBO2
[illegible]  [illegible]                  ,SUB    ,THSF
[illegible]  [illegible]                  ,JAN*   ,TDEL
[illegible]  [illegible]
[illegible]  [illegible]                  ,JAZ*   ,TDEL
[illegible]  [illegible]
[illegible]  017710 I                     ,LDA    ,IBO2
[illegible]  [illegible]                  ,STA    ,TMDO
[illegible]  [illegible]                  ,LDA    ,ONE
[illegible]  [illegible]                  ,STA    ,FDO
[illegible]  [illegible]                  ,JMP*   ,TDEL
[illegible]  [illegible]
[illegible]  [illegible]      DUM         ,JMP    ,TMAA
[illegible]  017710 I                     ,LDA    ,IBO2
[illegible]  [illegible] I                ,STA*   ,TMAA
[illegible]  017710 I                     ,LDA    ,FLG1
[illegible]  [illegible]                  ,JAZ    ,**4
[illegible]  [illegible] R
[illegible]  [illegible]                  ,JMP    ,RCO2
[illegible]  [illegible] R
[illegible]  [illegible]                  ,JMP    ,DL28
[illegible]  [illegible]                  ,LDX    ,DL28
[illegible]  [illegible]                  ,JXZ    ,**4
[illegible]  [illegible] R
[illegible]  [illegible]                  ,JMP*   ,TDEL
[illegible]  [illegible]
[illegible]  [illegible]                  ,LDA    ,ONE
[illegible]  [illegible] I                ,STA    ,FLG1
[illegible]  [illegible]                  ,STA    ,FLG2
[illegible]  017711 I                     ,LDA    ,TMAA
[illegible]  [illegible] I                ,SUB    ,TMAB
[illegible]  [illegible]                  ,ADD    ,ONE
[illegible]  [illegible]                  ,CPA    ,
[illegible]  [illegible]                  ,IAB    ,
[illegible]  [illegible] I                ,STA    ,COUT
[illegible]  [illegible] I                ,STA    ,BOUT
[illegible]  [illegible]                  ,ADD    ,M1
[illegible]  [illegible] I                ,STA    ,RCUT
[illegible]  [illegible] I                ,STA    ,SOUT
[illegible]  017711 I                     ,LDA    ,TMAB
[illegible]  [illegible]                  ,SUB    ,ONE
[illegible]  [illegible] I                ,STA    ,TMAA
[illegible]  [illegible] I      RCO2      ,LDA    ,IBO1
[illegible]  [illegible]                  ,TAX    ,
[illegible]  [illegible]                  ,TAB    ,
[illegible]  [illegible]                  ,TZA    ,
[illegible]  [illegible] I                ,MUL*   ,TMAC
[illegible]  [illegible] I                ,DIV    ,D100
[illegible]  [illegible]                  ,TZA    ,
```

NUMBER OF VALUES OF F BUFFERE

```
[illegible]  [illegible]  .CALL   .DPA    DOUBLE PRECISION ADD
                                          2's COMPLEMENT
[illegible]  [illegible] B
[illegible]  [illegible] I  .PTE   .DBLA   LITERS +OR- .0001
[illegible]  [illegible]    .STA   .DBLA
[illegible]  [illegible]    .PTB   .DBLA+1
[illegible]  [illegible]    .TAB   .CTIM
[illegible]  [illegible]    .LDX   .CTIM
[illegible]  [illegible]    .JXZ   .CALL
[illegible]  [illegible] B
[illegible]  [illegible] I  .INP   .CCUT
[illegible]  [illegible] I  .LDX   .CCUT
[illegible]  [illegible]    .JXZ   .+4
[illegible]  [illegible] I
[illegible]  [illegible]    .JMP   .+6
[illegible]  [illegible] B
[illegible]  [illegible] I  .LDA   .BOUT
[illegible]  [illegible] I  .STA   .COUT
[illegible]  [illegible] I  .LDA   .TMAB   RESET TMAC= TMOD
[illegible]  [illegible] I  .STA   .TMAC
[illegible]  [illegible]    .JMP   .+5
[illegible]  [illegible] B
[illegible]  [illegible] I  .LDA   .TMAC
[illegible]  [illegible]    .ADD   .ONE
[illegible]  [illegible] I  .STA   .TMAC
[illegible]  [illegible] I  .INP   .BOUT
[illegible]  [illegible] I  .LDX   .BOUT
[illegible]  [illegible]    .JXZ   .+4
[illegible]  [illegible] B
[illegible]  [illegible]    .JMP   .+7
[illegible]  [illegible] B
[illegible]  [illegible] I  .LDA   .TMAB
[illegible]  [illegible]    .SUB   .ONE
[illegible]  [illegible] I  .STA   .TMAA
[illegible]  [illegible] I  .LDA   .SCUT
[illegible]  [illegible] I  .STA   .BOUT
[illegible]  [illegible]    .LDA   .FLSP
[illegible]  [illegible]    .JAN   .EVEN   VALUE AT MINIMUM
[illegible]  [illegible] B
[illegible]  [illegible]    .JAZ   .DOWN   VALUE DIMINISHING
[illegible]  [illegible] B
[illegible]  [illegible] I  .LDA   .IBB1
[illegible]  [illegible]    .ADD   .BAND
[illegible]  [illegible]    .TAX   .
[illegible]  [illegible] I  .SUB   .CCBA
[illegible]  [illegible]    .JAN   .+9
[illegible]  [illegible] B
[illegible]  [illegible]    .JAZ   .DBDM
[illegible]  [illegible] B
[illegible]  [illegible]    .TXA   .
[illegible]  [illegible]    .SUB   .BAND
[illegible]  [illegible] I  .STA   .CCBA
[illegible]  [illegible]    .JMP   .DBDM
[illegible]  [illegible] B
[illegible]  [illegible] I  .LDA   .CCBA
```

```
[illegible]  [illegible] I        .ADD    .000F
[illegible]  [illegible] I        .STA    .000E
[illegible]  [illegible] I        .ADD    .000C
[illegible]  [illegible]          .TXA
[illegible]  [illegible]          .STA    .FLG2
[illegible]  [illegible]          .LDA    .THSC
[illegible]  [illegible] I        .STA    .CCBA
[illegible]  [illegible]          .JMP    .020M
[illegible]  [illegible] P
[illegible]  [illegible] I  ZOUT  .LDA    .IB01
[illegible]  [illegible]          .SUB    .THSL
[illegible]  [illegible]          .JAN    .*+6
[illegible]  [illegible] P
[illegible]  [illegible]          .JAZ    .*+4
[illegible]  [illegible] P
[illegible]  [illegible]          .JMP    .020M
0100340  [illegible] P
[illegible]  [illegible]          .LDA    .41
0100345  [illegible]              .STA    .FLG2
[illegible]  [illegible]          .JMP    .020M
[illegible]  [illegible] P
[illegible]  [illegible] I  ZVEN  .LDA    .IB01
0100351  [illegible] I            .SUB    .CCBA
[illegible]  [illegible]          .JAN    .020M
0100357  [illegible] P
0100354  [illegible]              .JAZ    .020M
[illegible]  [illegible] P
[illegible]  [illegible]          .LDA    .ONE
0100357  [illegible]              .STA    .FLG2
0100360  [illegible]      020M    .LDA    .FLG3
0100361  [illegible]              .JAN    .STDY
[illegible]  [illegible] P
0100363  [illegible]              .JAZ    .DECL
[illegible]  [illegible] P
0100365  [illegible] I            .LDA    .IB00
0100366  [illegible]              .SUB    .ZOUT
0100367  [illegible]              .TAX    .
0100370  [illegible]              .SUB    .02A
0100371  [illegible]              .JAN    .DECL-4
0100372  [illegible] P
0100373  [illegible]              .JAZ*   .TDEL
0100374  [illegible]
0100375  [illegible]              .LDA    .02A
0100376  [illegible]              .ADD    .02B
0100377  [illegible]              .STA    .02B
0100400  [illegible]              .INB    .02C
0100401  [illegible]              .LDA    .THSO
0100402  [illegible]              .STA    .02A
0100403  [illegible]              .TXA    .
0100404  [illegible]              .STA    .FLG3
0100405  [illegible]              .JMP*   .TDEL
0100406  [illegible]
0100407  [illegible]              .TXA    .
0100410  [illegible]              .ADD    .ZOUT
```

```
[illegible]                    ,STA    ,D2A
[illegible]                    ,JMP*   ,TDEL
[illegible]
[illegible]  I   DECL  ,LDA    ,IB00
[illegible]                    ,SUB    ,THSC
[illegible]                    ,JAN*   ,TDEL
[illegible]
[illegible]                    ,LDA    ,M1
[illegible]                    ,STA    ,FLG3
[illegible]                    ,JMP*   ,TDEL
[illegible]
[illegible]  I   STDY  ,LDA    ,IB00
[illegible]                    ,SUB    ,THSC
[illegible]                    ,JAN    ,*+4
[illegible]  R
[illegible]                    ,JMP*   ,TDEL
[illegible]
[illegible]                    ,LDA    ,ONE
[illegible]                    ,STA    ,FLG3
[illegible]                    ,JMP*   ,TDEL
[illegible]
[illegible]      CALU  ,LDA    ,ONE
[illegible]  I                 ,STA    ,GC
[illegible]                    ,LDA    ,FLG2
010441  001004                 ,JAN    ,*+12
010442  010455  R
[illegible]                    ,JAZ    ,*+10
010444  010455  R
010445  010100                 ,LDA    ,ONE          ADD ONE TO RR COUNT
010446  127726  I              ,ADD    ,CC2C
010447  057727  I              ,STA    ,DB07
010450  057730  I              ,STA    ,OB13
010451  120112                 ,ADD    ,M1
010452  057726  I              ,STA    ,CC2C
010453  001000                 ,JMP    ,*+3
010454  010460  R
010455  017726  I              ,LDA    ,CC2C
010456  057727  I              ,STA    ,DB07
010457  057730  I              ,STA    ,OB13
010460  017731  I              ,LDA    ,DIM
010461  054247                 ,STA    ,DXX
010462  005001                 ,TZA    ,
010463  027725  I              ,LDB    ,CC2B
010464  177726  I              ,DIV    ,CC2C
010465  057732  I              ,STB    ,OB15
010466  057733  I              ,STB    ,DB09
010467  057725  I              ,STB    ,CC2B
010470  005001                 ,TZA    ,
010471  160440                 ,MUL    ,PB0
010472  002000                 ,JMPN   ,EDV
010473  010621  R
010474  057724  I              ,STB    ,DB03
010475  057725  I              ,STB    ,OB09
010476  005001                 ,TZA    ,
```

#20

```
[illegible]  [illegible]      .STA    .D23
[illegible]  [illegible]      .STA    .D22
[illegible]  [illegible]      .TZA    .
[illegible]  [illegible]      .STA    .D110
[illegible]  [illegible]      .TZA    .
[illegible]  [illegible]      .TZA    .
[illegible]  [illegible]      .MUL    .P20
[illegible]  [illegible]      .JMPM   .FDV
[illegible]  [illegible] R
[illegible]  [illegible] I    .STA    .DB21
[illegible]  [illegible] I    .STA    .DB27
[illegible]  [illegible]      .LDA    .D120
[illegible]  [illegible]      .STA    .DXX
[illegible]  [illegible]      .LDA    .DBLA
[illegible]  [illegible]      .LDB    .DBLA+1
[illegible]  [illegible]      .JMPM   .FDV
0107[illegible]  [illegible] R
[illegible]  [illegible]      .STA    .DBLA
0107[illegible]  [illegible]  .STB    .DBLA+1
0107[illegible]  [illegible] I .LDA   .CC2B
0107[illegible]  [illegible]  .STA    .DXX
0107[illegible]  [illegible]  .LDA    .DBLA
0107[illegible]  [illegible]  .LDB    .DBLA+1
[illegible]  [illegible]      .JMPM   .FDV
0107[illegible]  [illegible] R
[illegible]  [illegible]      .TZA    .
[illegible]  [illegible]      .MUL    .D20
[illegible]  [illegible] I    .STB    .DB25
[illegible]  [illegible] I    .STB    .DB11
[illegible]  [illegible]      .LDA    .FIVE
[illegible]  [illegible]      .JMPM*  .DOUT
[illegible]  [illegible]
[illegible]  [illegible] R    .P7E    .DB30
[illegible]  [illegible]      .LDA    .FIVE
[illegible]  [illegible]      .JMPM*  .DOUT
[illegible]  [illegible]
[illegible]  [illegible] R    .P7E    .DB36
[illegible]  [illegible]      .LDA    .ONE
[illegible]  [illegible]      .JMPM*  .KYLT
[illegible]  [illegible]
[illegible]  [illegible]      .TZA    .
[illegible]  [illegible]      .STA    .DBLA
[illegible]  [illegible]      .STA    .DBLA+1
[illegible]  [illegible] I    .STA    .CC2A
[illegible]  [illegible] I    .STA    .CC2E
[illegible]  [illegible] I    .STA    .CC2C
[illegible]  [illegible]      .STA    .D22
[illegible]  [illegible]      .STA    .D23
[illegible]  [illegible]      .STA    .FD0
[illegible]  [illegible]      .STA    .D22
[illegible]  [illegible] I    .STA    .FLG1
[illegible]  [illegible]      .LDA    .ONE
[illegible]  [illegible]      .STA    .FLG2
[illegible]  [illegible]      .STA    .FLG3
```

```
[illegible]  [illegible]  [illegible]  .LDA   .M100
[illegible]  [illegible]  [illegible]  .STA   .CTMP
[illegible]  [illegible]  [illegible]  .LDA   .TMAP
[illegible]  [illegible]  [illegible]  .STA   .TMEA
[illegible]  [illegible]  [illegible]  .STA   .TKAC
[illegible]  [illegible]  [illegible]  .LDA   .YY00
[illegible]  [illegible]  [illegible]  .STA   .DL00
[illegible]  [illegible]  [illegible]  .JMP*  .TREL
[illegible]  [illegible]  [illegible]
[illegible]  [illegible]  [illegible]  ENDA  .LDA   .K9
[illegible]  [illegible]  [illegible]  .JMPM* .KYLT
[illegible]  [illegible]  [illegible]
[illegible]  [illegible]  [illegible]  .LDA   .TN0
[illegible]  [illegible]  [illegible]  .JMPM* .KYLT
[illegible]  [illegible]  [illegible]
[illegible]  [illegible]  [illegible]  .JMPM* .CREL
[illegible]  [illegible]  [illegible]
[illegible]  [illegible]  [illegible] R .PZE   .MSRO
[illegible]  [illegible]  [illegible]  .LDA   .D30
[illegible]  [illegible]  [illegible]  .JMPM* .CENC
[illegible]  [illegible]  [illegible]
[illegible]  [illegible]  [illegible]  .LDA   .D31
[illegible]  [illegible]  [illegible]  .JMPM* .CENC
[illegible]  [illegible]  [illegible]
[illegible]  [illegible]  [illegible]  .JMPM* .TERM
[illegible]  [illegible]  [illegible]
[illegible]  [illegible]  [illegible]  .JMP*  .ENPT
[illegible]  [illegible]  [illegible]
[illegible]  [illegible]  [illegible]  ERV   .PZE   .0
[illegible]  [illegible]  [illegible]  .TAX   .
[illegible]  [illegible]  [illegible]  .SUB   .DXX
[illegible]  [illegible]  [illegible]  .JAN   .*+10
[illegible]  [illegible]  [illegible] R
[illegible]  [illegible]  [illegible]  .TXA   .
[illegible]  [illegible]  [illegible]  .LASR  .1
[illegible]  [illegible]  [illegible]  .TNR   .CTZC
[illegible]  [illegible]  [illegible]  .LDX   .CTZC
[illegible]  [illegible]  [illegible]  .JYZ   .*+7
[illegible]  [illegible]  [illegible] R
[illegible]  [illegible]  [illegible]  .JMP*  .ERV
[illegible]  [illegible]  [illegible]
[illegible]  [illegible]  [illegible] R
[illegible]  [illegible]  [illegible]  .TXA   .
[illegible]  [illegible]  [illegible]  .TIV   .DXX
[illegible]  [illegible]  [illegible]  .LDA   .CTZC
[illegible]  [illegible]  [illegible]  .CPA   .
[illegible]  [illegible]  [illegible]  .TAB   .
[illegible]  [illegible]  [illegible]  .JAZ   .XYZB
[illegible]  [illegible]  [illegible] R
[illegible]  [illegible]  [illegible]  .STA   .CTZC
[illegible]  [illegible]  [illegible]  .TZA   .
[illegible]  [illegible]  [illegible]  XYZC  .LASL  .1
[illegible]  [illegible]  [illegible]  .INR   .CTZC
[illegible]  [illegible]  [illegible]  .LDX   .CTZC
[illegible]  [illegible]  [illegible]  .JYZ   .*+4
```

```
010653  010656 R
010654  [illegible]                  ,[illegible]    ,XYZC
010655  010647 R
010656  001520      XYZC   ,[illegible]    ,FRV
010657  110621 R
010660  777732      XY28   ,DATA   ,-38
010661  777732      FL28   ,DATA   ,-38
010662  000170      S120   ,DATA   ,120
010663  000024      B20    ,DATA   ,20
010664  010077 R    AAA    ,PZE    ,STRT
010665  002002      SW01   ,DATA   ,02002      O2   IN
010666  004001             ,DATA   ,04001      CO2  IN
010667  004401             ,DATA   ,04401      F    IN
010670  005001             ,DATA   ,05001      V    IN
010671  006001             ,DATA   ,06001      AT   IN
010672  010011             ,DATA   ,010011     F    OUT
010673  007412             ,DATA   ,07412      V    OUT
010674  006404             ,DATA   ,06404
010675  007010             ,DATA   ,07010
010676  000014      PRNT   ,DATA   ,12
010677  146711             ,DATA   ,*MINUTE ALVEOLAR VOLUME  *
010700  147325
010701  132305
010702  120301
010703  146326
010704  142717
010705  146301
010706  131240
010707  133317
010710  146325
010711  146705
010712  120240
010713  000006      B30    ,DATA   ,6
010714  000010      B31    ,DATA   ,8
010715  764220      CTIM   ,DATA   ,-6000
010716  764220      M120   ,DATA   ,-6000
010717  000000      BBLA   ,DATA   ,0
010720  000000             ,DATA   ,0
010721  001750      C2A    ,DATA   ,1000
010722  000000      [illegible]    ,DATA   ,0
010723  000000      C2C    ,DATA   ,0
010724  000000      OG     ,DATA   ,0
010725  000000      DXX    ,DATA   ,0
010726  000050      THSF   ,DATA   ,40
010727  000100      THSL   ,DATA   ,0100
010730  000400      THSC   ,DATA   ,0400
010731  001522      THSO   ,DATA   ,01522
010732  000010      RAND   ,DATA   ,010
010733  000010      POND   ,DATA   ,010
010734  011655 R    PNT    ,PZE    ,POUT
010735  011675 R    DIG    ,PZE    ,DIGT
010736  000045      AOD    ,DATA   ,37
010737  000025      COD    ,DATA   ,21
010740  000046      ACOD   ,DATA   ,38
```

```
011741  000002   FB0    .DATA   .2
011742  000036   FB1    .DATA   .30
011743  002000   MAX    .DATA   .02000
011744  000000   FB0    .DATA   .0
011745  001100   FB10   .DATA   .1100
011746  000074   FB9    .DATA   .60
011747  777776   FB02   .DATA   .-1
011750  777777   FB03   .DATA   .-1
011751           TM00   .BSS    .400
011771  130000   K0     .DATA   .0130002
011772  130001   K1     .DATA   .0130001
011773  130011   K2     .DATA   .0130011
011774  000003   0000   .DATA   .3
011775  000007          .DATA   .7
011776  000010          .DATA   .8
011777  000001   00     .DATA   .1
011600  011751 R TMAA   .PZE    .TM00
011601  011751 R TMAB   .PZE    .TM00
011602  011751 R TMAC   .PZE    .TM00
011603  000000   FLG1   .DATA   .0
011604  000000   0OUT   .DATA   .0
011605  000000   FOUT   .DATA   .0
011606  000000   FOUT   .DATA   .0
011607  000000   0OUT   .DATA   .0
011610  000000   0O2A   .DATA   .0
011611  000000   0CO2   .DATA   .0
011612  000000   0O2C   .DATA   .0
011613  001770   DIM    .DATA   .1000
011614  000144   0100   .DATA   .100
011615  000000   0T20   .DATA   .0
011616  054000   0500   .DATA   .054000     ASTRONAUT ID
011617  000000   0501   .DATA   .0
011620  054000   0502   .DATA   .054000     MISSION ID
011621  000000   0503   .DATA   .0
011622  054000   0504   .DATA   .054000     TIME
011623  000000   0505   .DATA   .0
011624  114447   0506   .DATA   .0114447
011625  000000   0507   .DATA   .0
011626  114447   0508   .DATA   .0114447
011627  000000   0509   .DATA   .0
011630  115047   0510   .DATA   .0115047
011631  000000   0511   .DATA   .0
011632  114002   0512   .DATA   .0114002
011633  000000   0513   .DATA   .0
011634  115025   0514   .DATA   .0115025
011635  000000   0515   .DATA   .0
011636  000000   IP00   .DATA   .0          O2   INPUT
011637  000000   IP01   .DATA   .0          CO2  INPUT
011640  000000   IP02   .DATA   .0          F    INPUT
011641  000000   IP03   .DATA   .0          V    INPUT
011642  000000   IP04   .DATA   .0          AT   INPUT
011643  130445   IP05   .DATA   .0130445
011644  000000   IP06   .DATA   .0
011645  130446   IP07   .DATA   .0130446
```

```
011640  [illegible]  [illegible]  ,DATA  ,0
011647  [illegible]  [illegible]  ,DATA  ,0121047
011650  [illegible]  [illegible]  ,DATA  ,0
011651  [illegible]  [illegible]  ,DATA  ,0120002
011652  [illegible]  [illegible]  ,DATA  ,0
011653  [illegible]  [illegible]  ,DATA  ,0121025
011654  [illegible]  [illegible]  ,DATA  ,0
011655  [illegible]  [illegible]  ,DATA  ,37
011656  [illegible]  [illegible]  ,DATA  ,*A02 *
011657  [illegible]
011660  [illegible]  [illegible]  ,DATA  ,38
011661  [illegible]  [illegible]  ,DATA  ,*ACO2*
011662  [illegible]
011663  [illegible]  [illegible]  ,DATA  ,39
011664  [illegible]  [illegible]  ,DATA  ,*MAV *
011665  [illegible]
011666  [illegible]  [illegible]  ,DATA  ,2
011667  [illegible]  [illegible]  ,DATA  ,*PP  *
011670  [illegible]
011671  [illegible]  [illegible]  ,DATA  ,21
011672  [illegible]  [illegible]  ,DATA  ,*CO2 *
011673  [illegible]
011674  [illegible]  [illegible]  ,DATA  ,0
011675  [illegible]  [illegible]  ,DATA  ,37
011676  [illegible]  [illegible]  ,DATA  ,06410
011677  [illegible]  [illegible]  ,DATA  ,013037
011700  [illegible]  [illegible]  ,DATA  ,38
011701  [illegible]  [illegible]  ,DATA  ,06411
011702  [illegible]  [illegible]  ,DATA  ,04002
011703  [illegible]  [illegible]  ,DATA  ,39
011704  [illegible]  [illegible]  ,DATA  ,012015
011705  [illegible]  [illegible]  ,DATA  ,07037
011706  [illegible]  [illegible]  ,DATA  ,21
011707  [illegible]  [illegible]  ,DATA  ,04410
011710  [illegible]  [illegible]  ,DATA  ,013037
011711  [illegible]  [illegible]  ,DATA  ,2
011712  [illegible]  [illegible]  ,DATA  ,01002
011713  [illegible]  [illegible]  ,DATA  ,017477
011714  [illegible]  [illegible]  ,DATA  ,0
*
* DOUBLE PRECISION ADDITION
*
* ADDRESS OF A IN JMPM+1
* DATA B IN A AND B
*
* EXIT WITH ANSWER IN A AND B
*
011715  [illegible]  [illegible]  ,ENTR  ,
011716  [illegible]  [illegible]  ,PCF   ,                RESET OVERFLOW
011717  [illegible]  [illegible]  ,LDX   ,DPA             LOAD ADDRESS A
011720  [illegible]  [illegible]  ,LDX   ,0,1
011721  [illegible]  [illegible]  ,STA   ,DPAT
011722  [illegible]  [illegible]  ,TPA   ,
011723  [illegible]  [illegible]  ,ADD   ,1,1             ADD LOWER HALF
```

```
011731  [illegible]          ,ANAI   ,077777
011732  [illegible]
011733  [illegible]          ,TAD    ,
011734  [illegible]          ,TRA    ,
011735  [illegible]          ,AOFA   ,                    ADD UPPER HALF
011736  [illegible]          ,DOF    ,
011737  [illegible]          ,ADD    ,DPAT
011738  [illegible]          ,ADD    ,0,1
011739  [illegible]          ,IMP    ,DPA
011740  [illegible]          ,JMP*   ,DPA
011741  [illegible]
*
011742  [illegible]  DPAT    ,DATA   ,0
        [illegible]          ,END    ,

LITERALS

POINTERS
  000700  011771
  000701  011617
  000702  011621
  000703  011623
  000704  011572
  000705  011577
  000706  011636
  000707  011637
  000710  011640
  000711  011623
  000712  111600
  000713  011603
  000714  011601
  000715  011604
  000716  011605
  000717  011606
  000720  011607
  000721  111600
  000722  011614
  000723  011602
  000724  011610
  000725  011611
  000726  011612
  000727  011650
  000730  011633
  000731  011617
  000732  011635
  000733  011634
  000734  011646
  000735  011627
  000736  011644
  000737  011633
  000740  011650
  000741  011631
  000742  011717

SYMBOLS

1  011737 A  DPAT
```

1	011215	R	[illegible]
1	011527	R	[illegible]
1	011537	R	[illegible]
1	011538	R	[illegible]
1	011539	R	[illegible]
1	011570	R	[illegible]
1	011571	R	[illegible]
1	011572	R	[illegible]
1	011573	R	[illegible]
1	011574	R	[illegible]
1	011575	R	[illegible]
1	011576	R	[illegible]
1	011577	R	[illegible]
1	011578	R	[illegible]
1	011579	R	[illegible]
1	011580	R	[illegible]
1	011581	R	[illegible]
1	011582	R	[illegible]
1	011583	R	[illegible]
1	011584	R	[illegible]
1	011585	R	[illegible]
1	011586	R	[illegible]
1	011587	R	[illegible]
1	011588	R	[illegible]
1	011589	R	[illegible]
1	011590	R	[illegible]
1	011591	R	[illegible]
1	011592	R	[illegible]
1	011593	R	[illegible]
1	011594	R	[illegible]
1	011595	R	[illegible]
1	011596	R	[illegible]
1	011597	R	[illegible]
1	011598	R	[illegible]
1	011599	R	[illegible]
1	011600	R	[illegible]
1	011601	R	[illegible]
1	011602	R	[illegible]
1	011603	R	[illegible]
1	011604	R	[illegible]
1	011605	R	[illegible]
1	011606	R	[illegible]
1	011607	R	[illegible]
1	011608	R	[illegible]
1	011609	R	[illegible]
1	011610	R	[illegible]
1	011611	R	[illegible]
1	011612	R	[illegible]
1	011613	R	[illegible]
1	011614	R	[illegible]
1	011615	R	[illegible]
1	011616	R	[illegible]
1	011617	R	[illegible]
1	011618	R	[illegible]
1	011619	R	[illegible]
1	011620	R	[illegible]
1	011621	R	[illegible]
1	011622	R	[illegible]
1	011623	R	[illegible]
1	011624	R	[illegible]
1	011625	R	[illegible]
1	011626	R	[illegible]
1	011627	R	[illegible]
1	011628	R	[illegible]
1	011629	R	[illegible]
1	011630	R	[illegible]
1	011631	R	[illegible]
1	011632	R	[illegible]
1	011633	R	[illegible]
1	011634	R	[illegible]
1	011635	R	[illegible]
1	011636	R	[illegible]
1	011637	R	[illegible]
1	011638	R	[illegible]
1	011639	R	[illegible]
1	011640	R	[illegible]
1	011641	R	[illegible]
1	011642	R	[illegible]
1	011643	R	[illegible]
1	011644	R	[illegible]
1	011645	R	[illegible]
1	011646	R	[illegible]
1	011647	R	[illegible]
1	011648	R	[illegible]
1	011649	R	[illegible]
1	011650	R	[illegible]
1	011651	R	[illegible]
1	011652	R	[illegible]
1	011653	R	[illegible]
1	011654	R	[illegible]
1	011655	R	[illegible]
1	011656	R	[illegible]
1	011657	R	[illegible]
1	011658	R	[illegible]
1	011659	R	[illegible]
1	011660	R	[illegible]
1	011661	R	[illegible]
1	011662	R	[illegible]
1	011663	R	[illegible]
1	011664	R	[illegible]
1	011665	R	[illegible]
1	011666	R	[illegible]
1	011667	R	[illegible]
1	011668	R	[illegible]
1	011669	R	[illegible]
1	011670	R	[illegible]
1	011671	R	[illegible]
1	011672	R	[illegible]
1	011673	R	[illegible]
1	011674	R	[illegible]
1	011675	R	[illegible]
1	011676	R	[illegible]
1	011677	R	[illegible]
1	011678	R	[illegible]
1	011679	R	[illegible]
1	011680	R	[illegible]
1	011681	R	[illegible]
1	011682	R	[illegible]
1	011683	R	[illegible]
1	011684	R	[illegible]
1	011685	R	[illegible]
1	011686	R	[illegible]
1	011687	R	[illegible]
1	011688	R	[illegible]
1	011689	R	[illegible]
1	011690	R	[illegible]
1	011691	R	[illegible]
1	011692	R	[illegible]
1	011693	R	[illegible]
1	011694	R	[illegible]
1	011695	R	[illegible]
1	011696	R	[illegible]
1	011697	R	[illegible]
1	011698	R	[illegible]
1	011699	R	[illegible]
1	011700	R	[illegible]
1	011701	R	[illegible]
1	011702	R	[illegible]
1	011703	R	[illegible]
1	011704	R	[illegible]
1	011705	R	[illegible]
1	011706	R	[illegible]
1	011707	R	[illegible]
1	011708	R	[illegible]
1	011709	R	[illegible]
1	011710	R	[illegible]
1	011711	R	[illegible]
1	011712	R	[illegible]
1	011713	R	[illegible]
1	011714	R	[illegible]
1	011715	R	[illegible]
1	011716	R	[illegible]
1	011717	R	[illegible]
1	011718	R	[illegible]
1	011719	R	[illegible]
1	011720	R	[illegible]
1	011721	R	[illegible]
1	011722	R	[illegible]
1	011723	R	[illegible]
1	011724	R	[illegible]
1	011725	R	[illegible]
1	011726	R	[illegible]
1	011727	R	[illegible]
1	011728	R	[illegible]
1	011729	R	[illegible]
1	011730	R	[illegible]
1	011731	R	[illegible]
1	011732	R	[illegible]
1	011733	R	[illegible]
1	011734	R	[illegible]
1	011735	R	[illegible]
1	011736	R	[illegible]
1	011737	R	[illegible]
1	011738	R	[illegible]
1	011739	R	[illegible]
1	011740	R	[illegible]
1	011741	R	[illegible]
1	011742	R	[illegible]
1	011743	R	[illegible]
1	011744	R	[illegible]
1	011745	R	[illegible]
1	011746	R	[illegible]
1	011747	R	[illegible]
1	011748	R	[illegible]
1	011749	R	[illegible]
1	011750	R	[illegible]
1	011751	R	[illegible]

1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	010772	R	DAUD
1	010771	R	THRC
1	010770	R	THRC
1	010727	R	THSL
1	010725	R	THSF
1	01072?	R	LYX
1	01072?	R	DS
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]
1	010721	R	OCA
1	010717	R	DTLA
1	010716	R	DI20
1	010715	R	CTIM
1	010714	R	UTI
1	010713	R	D30
1	010675	R	PRNT
1	010665	R	SR01
1	010664	R	AAA
1	010657	R	D20
1	010652	R	DI20
1	010651	R	DL20
1	010650	R	YY20
1	01064?	R	XY20
1	010647	R	XYZ0
1	010621	R	FDV
1	010577	R	ENDA
1	010476	R	CALU
1	010424	R	STDY
1	010414	R	STDL
1	010367	R	C2C1
1	010330	R	EVEN
1	010374	R	DSUM
1	010302	R	CCCM
1	010236	R	RCD2
1	010127	R	[illegible]
1	010120	R	DX
1	[illegible]	R	[illegible]
1	010077	R	STRT
1	[illegible]	R	[illegible]
1	[illegible]	R	[illegible]

1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
0	[illegible]	[illegible]
0	[illegible]	[illegible]
1	[illegible]	[illegible]
0	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
0	[illegible]	[illegible]
0	[illegible]	[illegible]
1	[illegible]	[illegible]
0	[illegible]	[illegible]
0	[illegible]	[illegible]
1	000331	DSP5
1	[illegible]	DSP4
1	[illegible]	DSP3
1	[illegible]	DSP2
1	[illegible]	DSP1
1	[illegible]	[illegible]
1	[illegible]	[illegible]
0	[illegible]	ATF
0	[illegible]	SIX
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	MINE
0	[illegible]	[illegible]
1	[illegible]	[illegible]
1	[illegible]	[illegible]
0	[illegible]	SWN
1	[illegible]	[illegible]

Step | Remarks

1. Perform Initialization and Calibration of CO_2 Analyzer - Procedure C.

2. Turn "ON" PBEM; insert "Backup" mode; place proper leads on scope channels and pen recorder channels.

3. Log subject, date, test and channel identification; turn pen recorders "ON".

4. Turn on Respiratory Panel and 2-pen recorder. Allow 5 minutes for thermal stabilization of pressure transducers and flowmeter.

5. Set Flowmeter Selector Switch on Respiratory Panel of PBEM to "1"

6. Perform preliminary adjustments on respiratory console and on 2-pen recorder according to Preliminary Adjustment procedure for the Lower Strain Gage coupler; and the resetting integrator. Set Flow setting at 2 and Volume setting at 5.

7. To display CO_2 analysis on right hand pen, set right hand knob of Beckman 462 to 1 v/cm and press buttons as tabulated at right. (Press "Enter" after second digit of Noun is pressed, each time.)

	LARGE FEM RECORDER			SCOPE		
	Ch.	V	N	Ch.	V	N
CO_2	8	57	01	4	67	1
F	9	60	01	1	64	1
Vol	10	61	01	2	65	1
AT	12	63	01	--	--	-

8. Mount 1 mouthpiece on Respiratory J Valve and one on four position valve. Turn Valve V2 to ambient, turn V3 to horizontal position.

9. Instruct subject to sit on ergometer assembly.

10. Check height of mouthpiece with subject seated in an upright position; vertical adjustments may be made by supporting the Equipment Mounting Plate with one hand and loosening of the two holding knobs with the other; retighten knobs upon completion of height adjustment.

11. Verify that rebreathing bag is empty; if not, turn Valve V-9 to Position 1 and turn 4-Position Valve to Position 3; squeeze contents of bag upward toward 4-position valve; then turn 4-position valve to position 2.

12. Connect fill gas (93% O_2 and 7% CO_2) to Gas Connector C; turn Valve V-9 to position 2; CAREFULLY OBSERVE RE-BREATHING BAG WHILE FILL GAS MANIFOLD VALVE IS OPENED; when bag is three-fourths full, turn "OFF" fill gas manifold valve.

Step		Remarks
13.	Repeat steps #11 and #12 three times to completely flush re-breathing bag. Turn Beckman A560 Control to "Operate".	
14.	Push both Analog Tape Recorder "RECORD" buttons. Log subject, date, test and channel identification on intercom and tape settings on pen records. Press "CAL" button on Beckman 9801.	
15.	Place nose clip and insert mouthpiece; breathe normally for 5 minutes on Respiratory J Valve to obtain CO_2 Production and Alveolar pCO_2.	
16.	Change position of V-3 handle to vertical. Instruct subject to change to 4-position valve and breathe normally.	
17.	Observe subject and, at the end of a normal expiration, turn 4-position valve to position 3. Allow subject to breathe until equilibration point is reached. Observe CO_2 waveform on 2-pen recorder or 4-channel scope. Immediately turn 4-position valve to Position 2, after equilibrium is reached, to record equilibration pCO_2 level.	
18.	To repeat Cardiac Output Measurement, begin at Step #11.	
19.	Instruct subject to remove mouthpiece and nose clip; clean and stow equipment.	
20.	Turn PBIM "OFF" if no further testing. Turn Off gas analyzers and Aux. Resp. Rack Main Power switch if no further testing is to be performed.	
21.	Turn off large pen recorders. Turn two pen recorder to "ON".	

MEASUREMENT REQUIREMENTS DATA SHEET

SUB-SYSTEM : Respiratory

MEASUREMENT GROUP : Respiratory

MEASUREMENT : Cardiac Output (Q)

MEASUREMENT DESCRIPTION : Obtain measurement of cardiac output from analysis of the expired carbon dioxide ($V_{E_{CO_2}}$), alveolar carbon dioxide ($F_{A_{CO_2}}$) and the mixed venous carbon dioxide ($F\bar{v}_{CO_2}$)

1. Input signal characteristics — Inspired and expired CO_2 concentration--biphasic, repetitive waveform

2. Electrodes, transducers, vest, harness — Mouthpiece, CO_2 gas sampling head.

3. Signal conditioner(s) — CO_2 gas analyzer (Codart, KK58002)

4. Range of measurement — 3 to 35 liters

5. Frequency of measurement — Once per 1-2 weeks

6. Output signal characteristics

analog/digital	Analog waveforms
amplitude	0-5 volts
frequency range	N/A
accuracy/sensitivity	± 2% per parameter

7. Calibration

type & technique	CO_2 analyzer--use calibration gases and/or equipment controls.
frequency	Once per run.

8. Data handling

display analog/digital (raw, processed; local, remote; continuous, intermittent)	Analog, raw, continuous for 10-20 seconds on CRT and recorder.
recording analog/digital (raw, processed; continuous, intermittent)	Analog, raw, continous for 10-20 seconds.
manual/programmed A or D switching	Programmed signal routing to Display Monitor and recorder.
manual/verbal data entry	Subject identification and measurement numbe
A/D conversion frequency	100 sps
storage time analog/digital	Digitized until next data dump.
recording/storage quantity per subject	45 seconds per measurement, 2 measurements per subject.

9. Derived quantities

other measurements required simultaneously for calculations	Alveolar CO_2 concentration ($F_{A_{CO_2}}$), CO_2 production (V_{CO_2})
digital computation	Mixed venous C O_2 concentration
display analog/digital; location; updating frequency	Digital display of mixed venous CO_2 concent ion ($F_{\bar{V}CO_2}$)
recording analog/digital	Digitized values.
storage time analog/digital	Digitized until data dump

10. Comparison with previous data	N/A
11. Analog/digital display range & resolution/accuracy	Mixed venous CO_2 concentration-30 to 90mm Cardiac output 3-40 liters/minute ± 10% d goal
12. Printout frequency & other requirements	Once at end of measurement.

13. Miscellaneous information, details on referenced items, etc.

Computations:

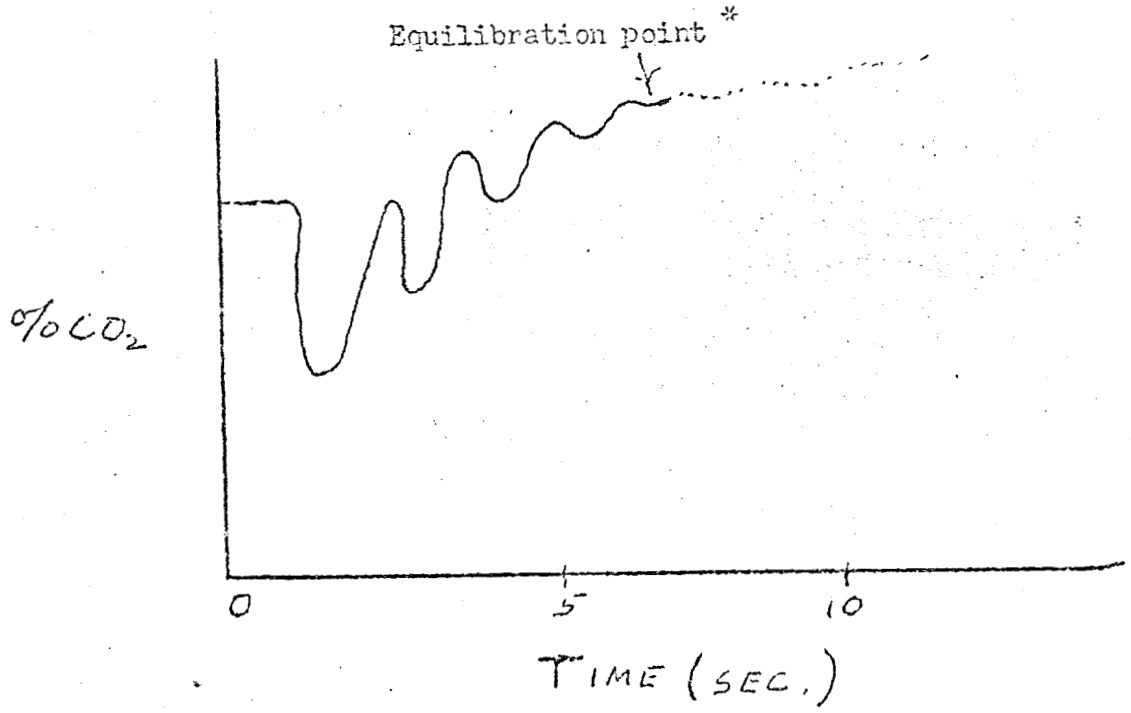
$$Q = \frac{\dot{V}CO_2}{F\bar{v}_{CO_2} - F_{A_{CO_2}}}$$

where,

Q = cardiac output (in liters/minute

$F\bar{v}_{CO_2}$ = fractional concentration of CO_2 in mixed venous blood, obtained from equilibration curve(see be

$F_{A_{CO_2}}$ = fractional concentration of CO_2 in the alveoli, obtained prior to cardiac output determination



* The "equilibration point" is defined as the fractional concentration of CO_2, at the time when the change in CO_2 percentage is less than 1.5 mm Hg between the subject's expired gases and the contents of the rebreathing bag.

CARDIAC OUTPUT DETERMINATION : AN IMPROVED EXTERNAL PROCEDURE

ABSTRACT

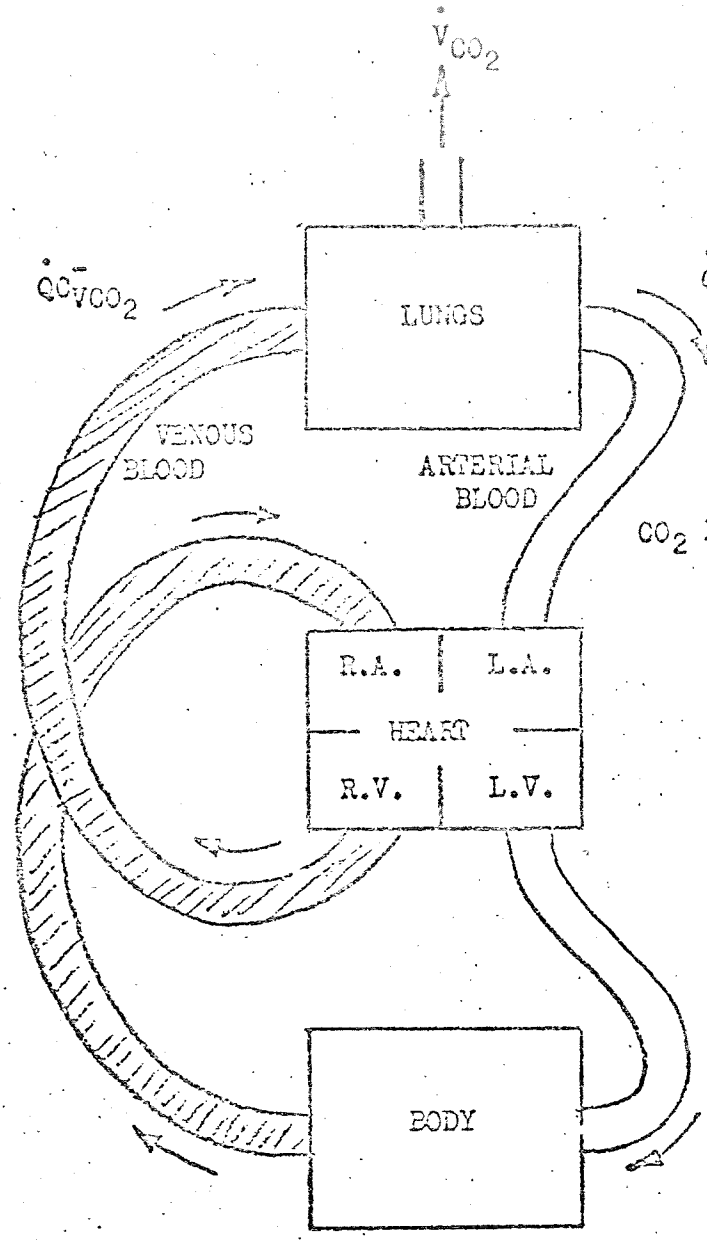
A method and experimental results are described for the determination of cardiac output at rest, based on some simple breathing maneuvers by the subject.

The method uses continuous measurements of instantaneous and average respired carbon dioxide, and the volume of exhaled gas as a function of time.

Arterial carbon dioxide concentration is derived from the gas composition at the end of a maximum exhalation. Mixed venous carbon dioxide concentration is obtained from an exponential staircase function generated by the subject as he rebreathes an oxygen-rich mixture. Exhaled carbon dioxide flow is determined from exhaled volume, time, and the average carbon dioxide content of the exhaled air.

The method assumes constant cardiac output during the three steps that comprise the procedure. The assumption is verified by measurement of the vertical thoracic cage impedance after each step.

Results of a total of 30 tests on three subjects on different days show mean cardiac outputs of 4.6, 4.4, and 4.0 liters per minute. Standard deviations are 0.7, 0.9, and 0.8 liters/minute and standard errors of the mean are 0.2, 0.4, and 0.4 liters/minute.



CO_2 FLOW INTO LUNGS - CO_2 FLOW FROM LUNGS = 0

$$\dot{Q}\, C_{\bar{V}CO_2} - \dot{Q}\, C_{ACO_2} - \dot{V}_{CO_2} = 0$$

$$\dot{Q}\,(\, C_{\bar{V}CO_2} - C_{ACO_2}\,) = \dot{V}_{CO_2}$$

$$\dot{Q} = \frac{\dot{V}_{CO_2}}{C_{\bar{V}CO_2} - C_{ACO_2}}$$ FICK EQUATION

$\dot{Q}$ = CARDIAC OUTPUT OR BLOOD FLOW (LITERS/MINUTE)

$\dot{V}_{CO_2}$ = EXHALED CO_2 FLOW (MILLILITERS/MINUTE)

$C_{\bar{V}CO_2}$ = MIXED VENOUS CO_2 CONCENTRATION (MILLILITERS/LITER)

C_{ACO_2} = ARTERIAL CO_2 CONCENTRATION (MILLILITERS/LITER)

FIGURE 1 - DERIVATION OF FICK EQUATION

INTRODUCTION

The measurement of how much blood the heart is pumping, or cardiac output, is a classical problem, and has been attacked by a multitude of methods.[1] They may be broadly classified as those requiring surgery, those requiring injection, or external methods.

The surgical methods include dye dilution, ascorbate dilution, thermal dilution, and electromagnetic and ultrasonic flowmeters. The injection methods include radioactive tracers and blood sample analysis. The external methods include breathing measurements, ballistocardiography, mechanical or optical plethysmography, and electrical impedance determinations.

The most widely accepted and used method today is dye dilution, which employs surgical catheterization. It's use is limited mainly to experimental animals or to human patients whose condition is tentatively diagnosed as serious enough to warrant surgery for confirmatory diagnosis.

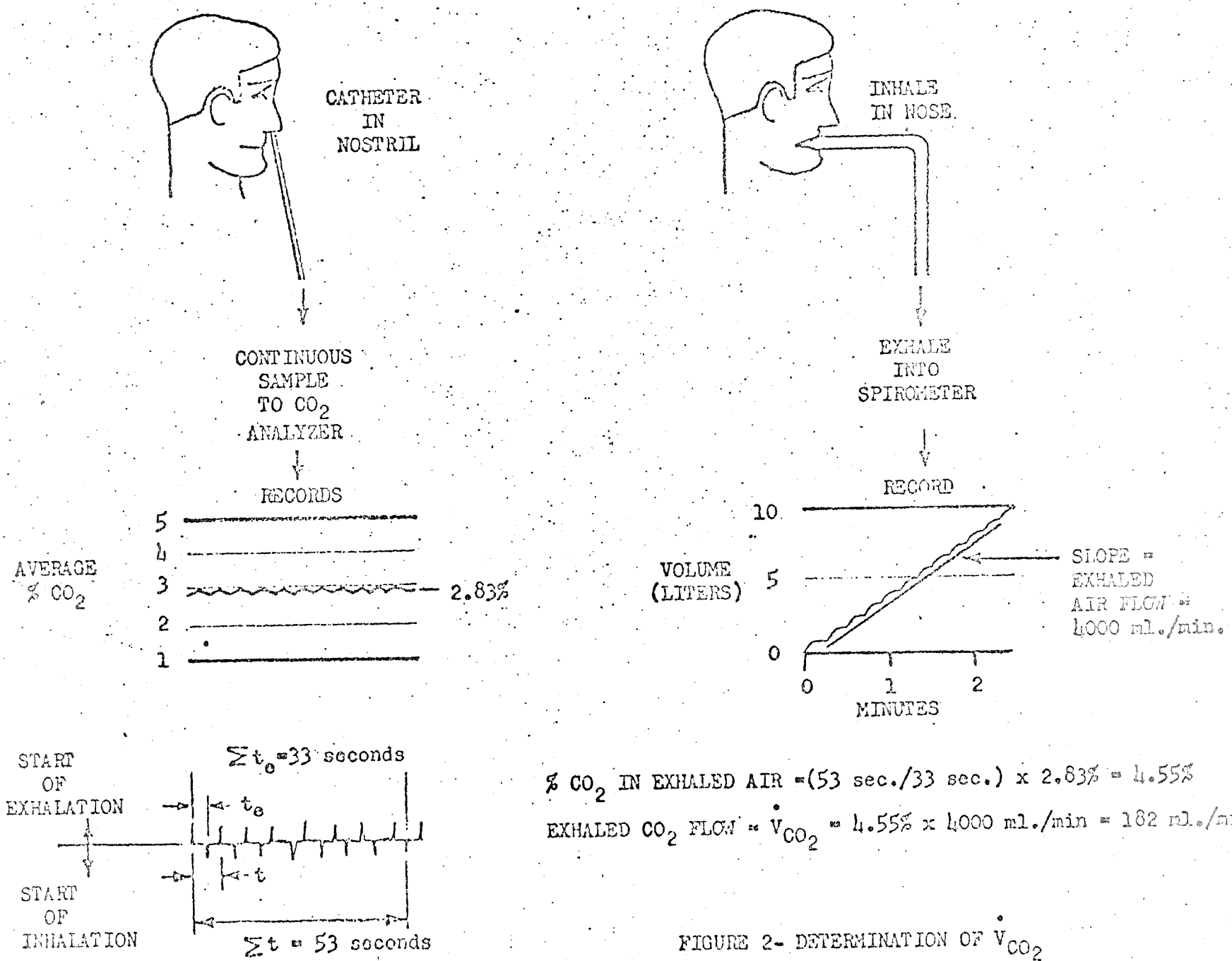
Of the external methods, breathing measurements have the firmest theoretical foundation, in the sense that the mathematics leading from the measurements to the final result - blood flow or cardiac output - is explicit, with no arbitrary constants. The theoretical foundation is the Fick equation.

THE FICK EQUATION

Figure 1 shows a simple model of the respiratory-circulatory system, comprising the lungs, the heart, and the body. The blood flow, or cardiac output, is $\dot{Q}$, in liters of blood per minute. The exhaled carbon dioxide flow from the lungs to the atmosphere is $\dot{V}_{CO_2}$, in milliliters of CO_2 per minute. The arterial CO_2 concentration is C_{ACO_2}, in milliliters of total CO_2 per liter of blood. The mixed venous CO_2 concentration is $C\bar{v}_{CO_2}$, in the same units as arterial CO_2 concentration.

We may consider the average flow of carbon dioxide analagous to a steady electrical current, with the lungs as a nodal point. Kirschoff's second law says that the sum of the currents at any node is zero. If we take the direction of CO_2

137



% CO_2 IN EXHALED AIR =(53 sec./33 sec.) x 2.83% = 4.55%

EXHALED CO_2 FLOW = $\dot{V}_{CO_2}$ = 4.55% x 4000 ml./min = 182 ml./min.

FIGURE 2- DETERMINATION OF $\dot{V}_{CO_2}$

flow into the lungs as positive, we get:

$$\dot{Q}\, C_{\bar{V}CO_2} - \dot{Q}\, C_{ACO_2} - \dot{V}_{CO_2} = 0$$

Factoring terms and transposing:

$$\dot{Q}\,(\, C_{\bar{V}CO_2} - C_{ACO_2}\,) = \dot{V}_{CO_2}$$

and dividing, we get the Fick Equation:

$$\dot{Q} = \frac{\dot{V}_{CO_2}}{C_{\bar{V}CO_2} - C_{ACO_2}}$$

To use the Fick equation in this form, the problem boils down to how to get reliable determinations of each of the three terms on the right side of the equation.

RATIONALE AND METHOD

Consider first the exhaled carbon dioxide flow $\dot{V}_{CO_2}$. Historically, this has been measured by collecting all of the exhaled air in a bag[2] for a fixed or known time, and then measuring the volume and composition of the contents.

For measurement of the other terms in the Fick equation, it is useful to be able to measure the CO_2 percentage of the exhaled gas continuously. Since this is so, continuous measurements may also be used for the determination of $\dot{V}_{CO_2}$.

Figure 2 shows how this is done. First, the subject sits quietly with a thin catheter in a nostril, and breathes normally through his nose. A continuous sample of the respired air is sucked through a CO_2 gas analyzer. The output of the analyzer is both integrated and differentiated. The integral gives a measure of the average % CO_2 of the continuous respiration, and the differential gives up-and-down spikes, showing the times when exhalation and inhalation begin. The percentage of CO_2 in just the exhaled air is then found by multiplying the ratio of total time Σt to exhalation time Σt_e by the average % CO_2 during continuous breathing.

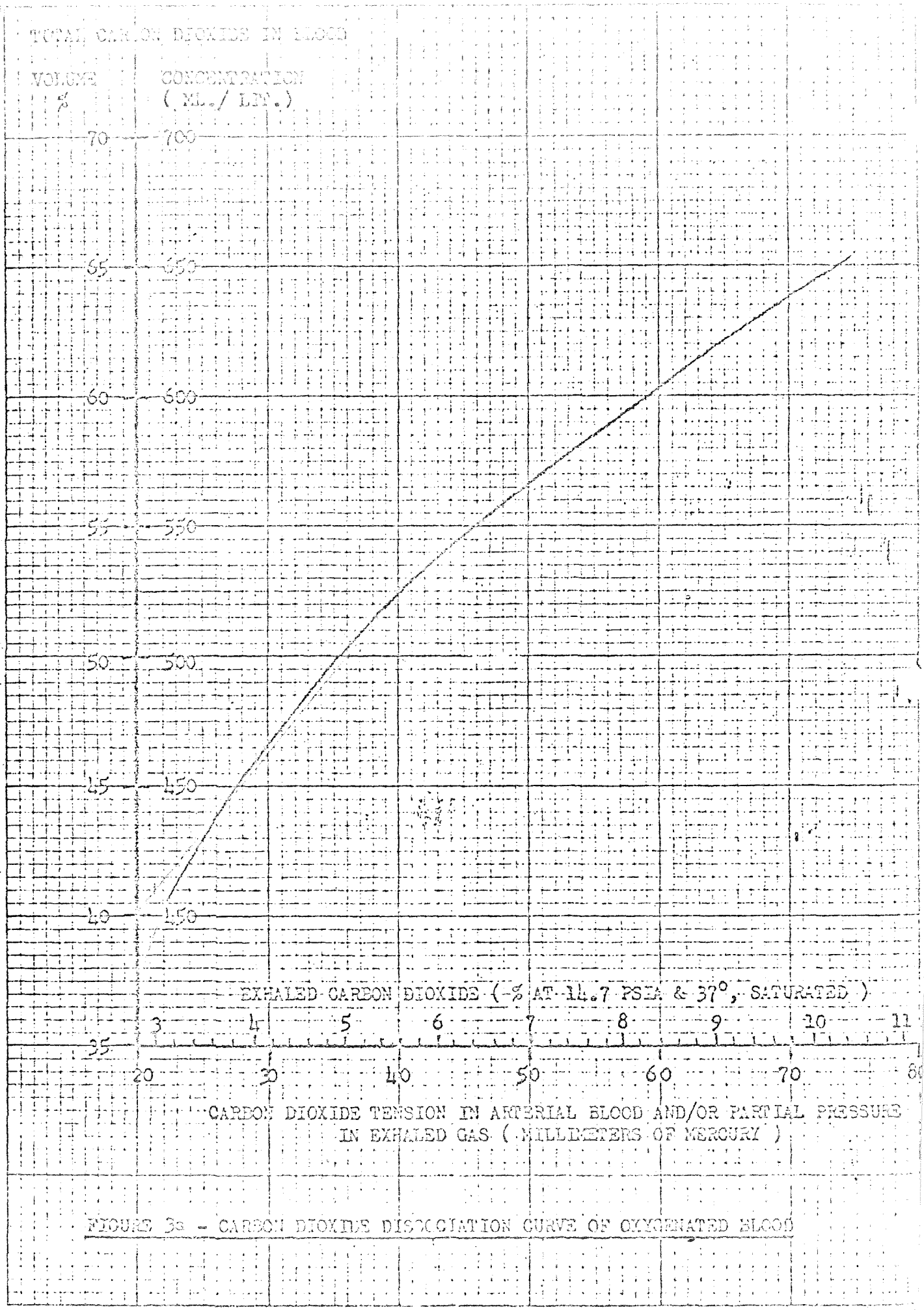


FIGURE 3a - CARBON DIOXIDE DISSOCIATION CURVE OF OXYGENATED BLOOD

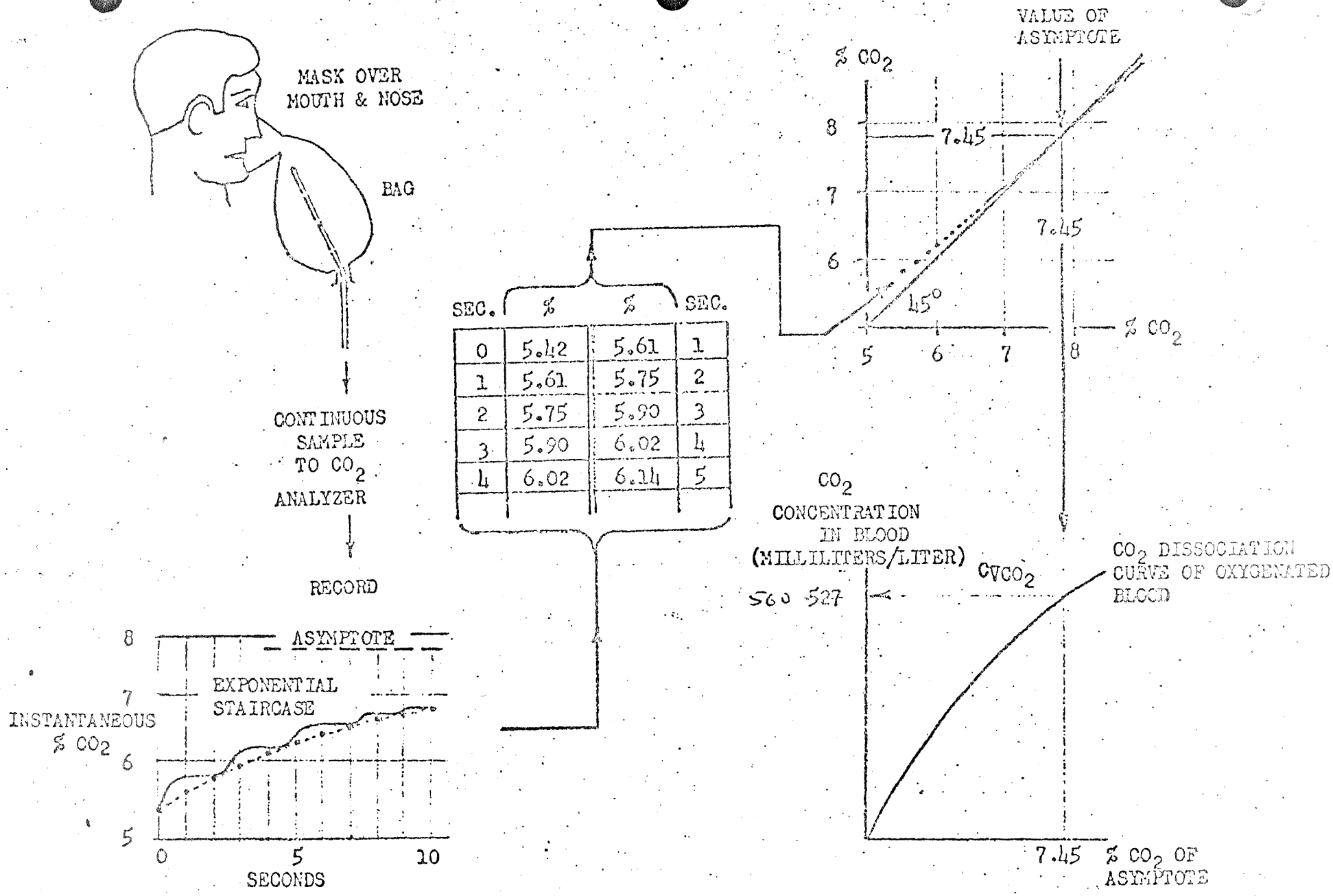


FIGURE 3- DETERMINATION OF $C\bar{v}CO_2$

Second, let us consider the mixed venous CO_2 concentration $C\bar{v}_{CO_2}$. Refer to figure 3. Recent work [3-6] has shown that when a subject breathes from and into a bag (rebreathes) containing almost pure oxygen, the CO_2 percentage in the bag during the first few breaths builds up as an exponential staircase function. The asymptote that the exponential approaches may be used for determining the mixed venous CO_2 concentration. The resolution of the method is improved by having some initial CO_2 in the bag with the oxygen. A mixture of 95% oxygen and 5% CO_2 is about optimum for the starting contents of the bag.

From the record, a smooth exponential curve is drawn, shown as a dashed line. the values of the curve are read off at one second intervals and tabulated as shown in figure 3. Note that for each line of the table, the entry on the right is one second later than that on the left. The values of % CO_2 in the table are then plotted against each other. Successive points on the plot always fall closer and closer together, and tend toward a straight line. The last few points are extrapolated via a straight line, which intersects another straight line drawn at 45° from the origin. The intersection gives the value of the asymptote.

The reason for this may be seen from the nature of the exponential. If the exponential curve were continued and remained an exponential beyond the first few breaths, successive amplitudes of the curve at equal time intervals would converge toward a single value - the asymptote. Since the exponential never reverses and goes down, none of the points can fall below the 45° line on the plot. The limit of the trend of points must hence fall on the 45° line, and the intersection then defines the asymptote.

The value of the asymptote is then used with a standard CO_2 dissociation curve of oxygenated blood, figure 3a, to determine the mixed venous CO_2 concentration $C\bar{v}_{CO_2}$

Third and last, the subject sits quietly with a tube in his mouth, figure 2. He inhales through his nose, and exhales through the tube into a wedge spirometer. The exhaled volume record is a linear staircase function, whose slope gives the exhaled air flow. The exhaled CO_2 flow, $\dot{V}_{CO_2}$, is then found by multiplying the exhaled air flow by the percentage of CO_2 in the exhaled air.

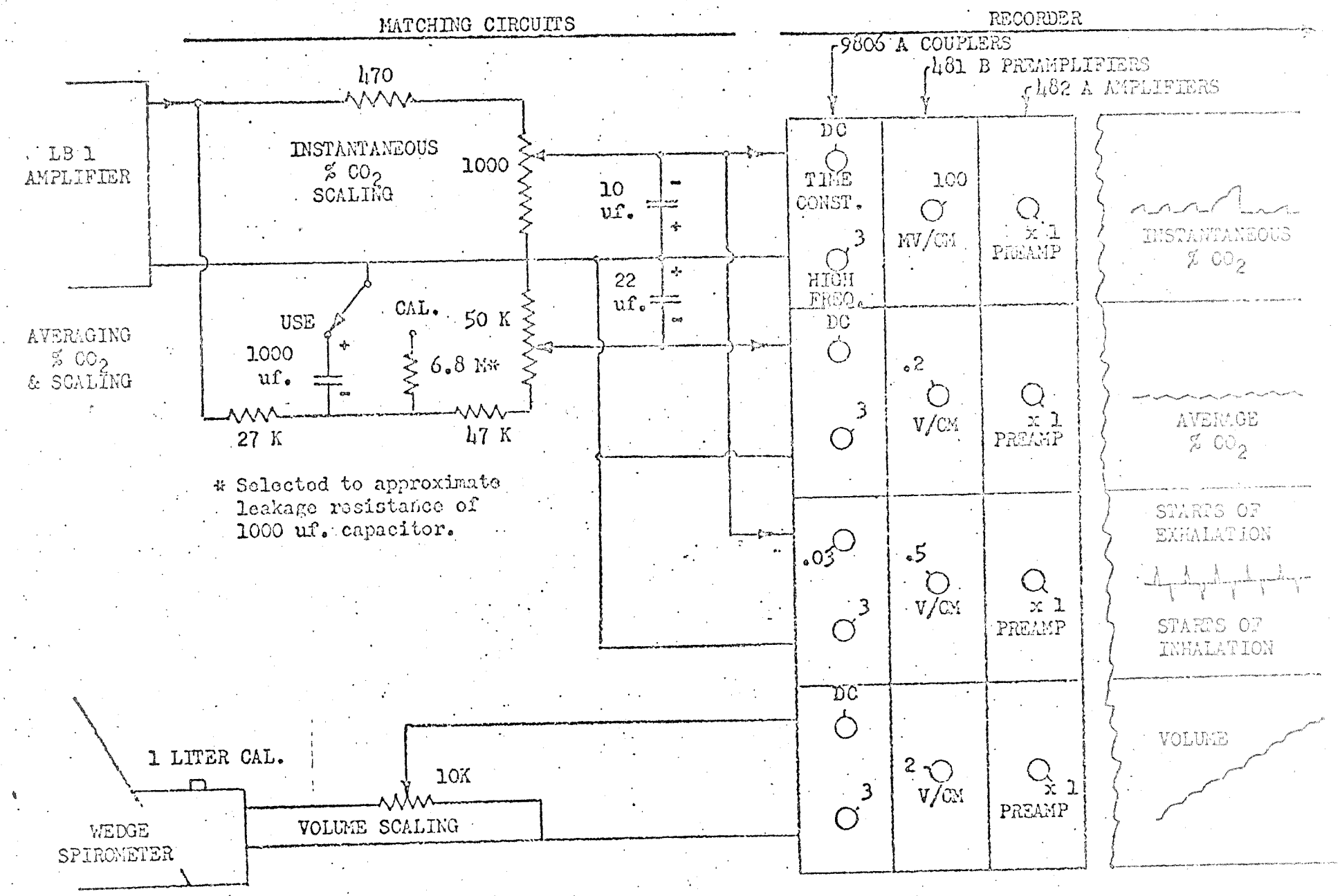


FIGURE 7 - MATCHING CIRCUITS & RECORDER SETTINGS

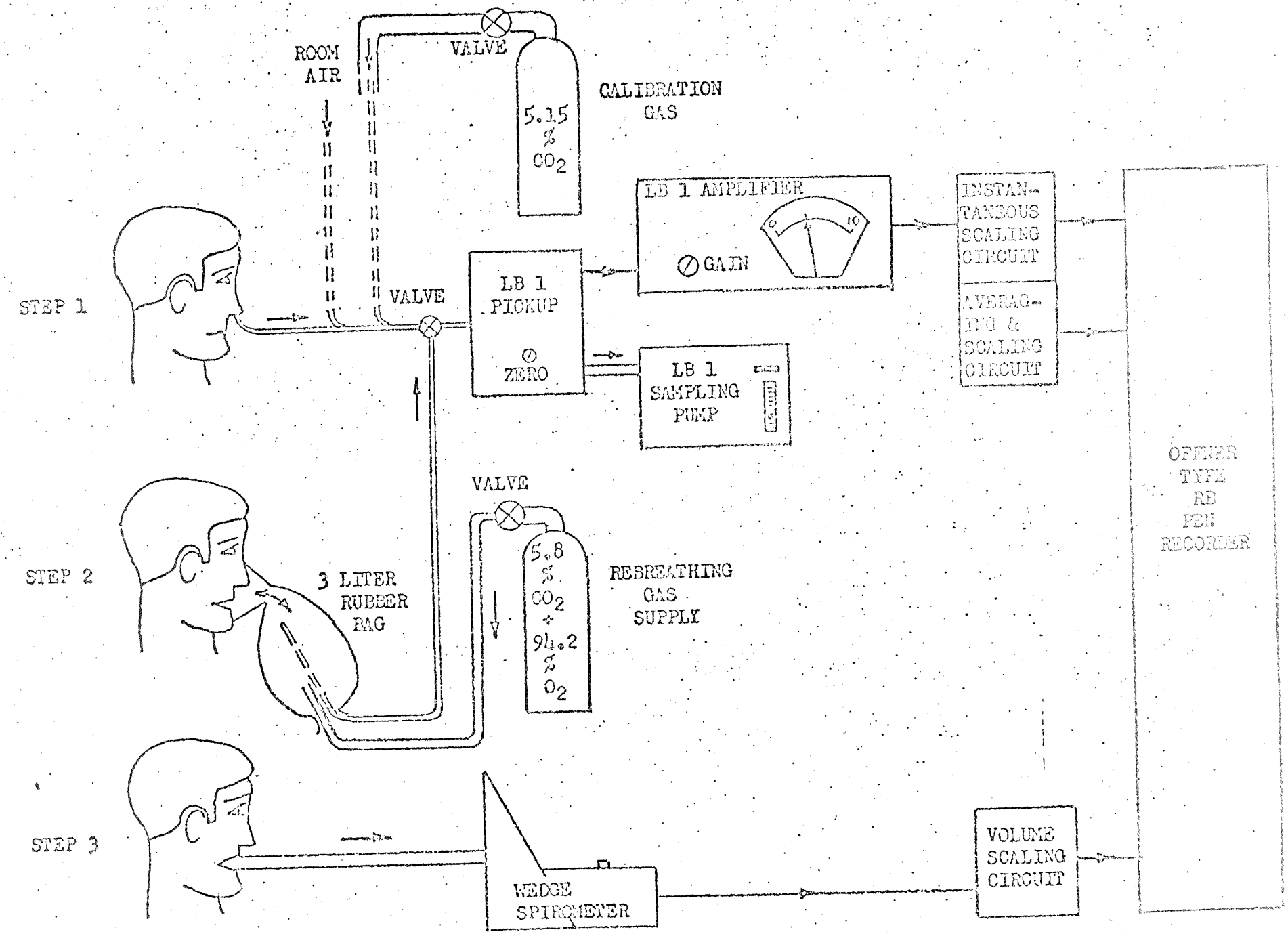


FIGURE 6 - EQUIPMENT SETUP

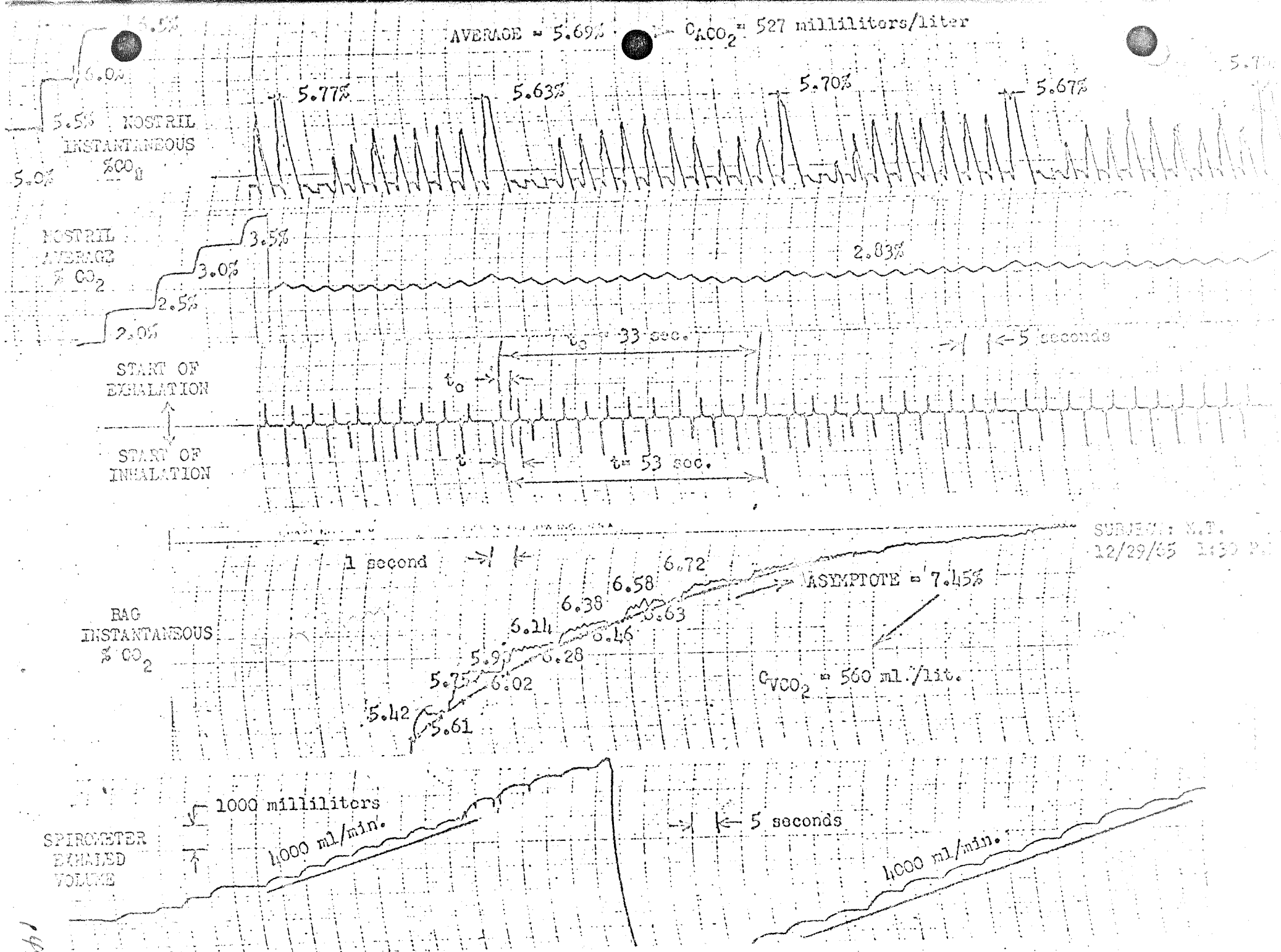


FIGURE 5 - TYPICAL RECORDING

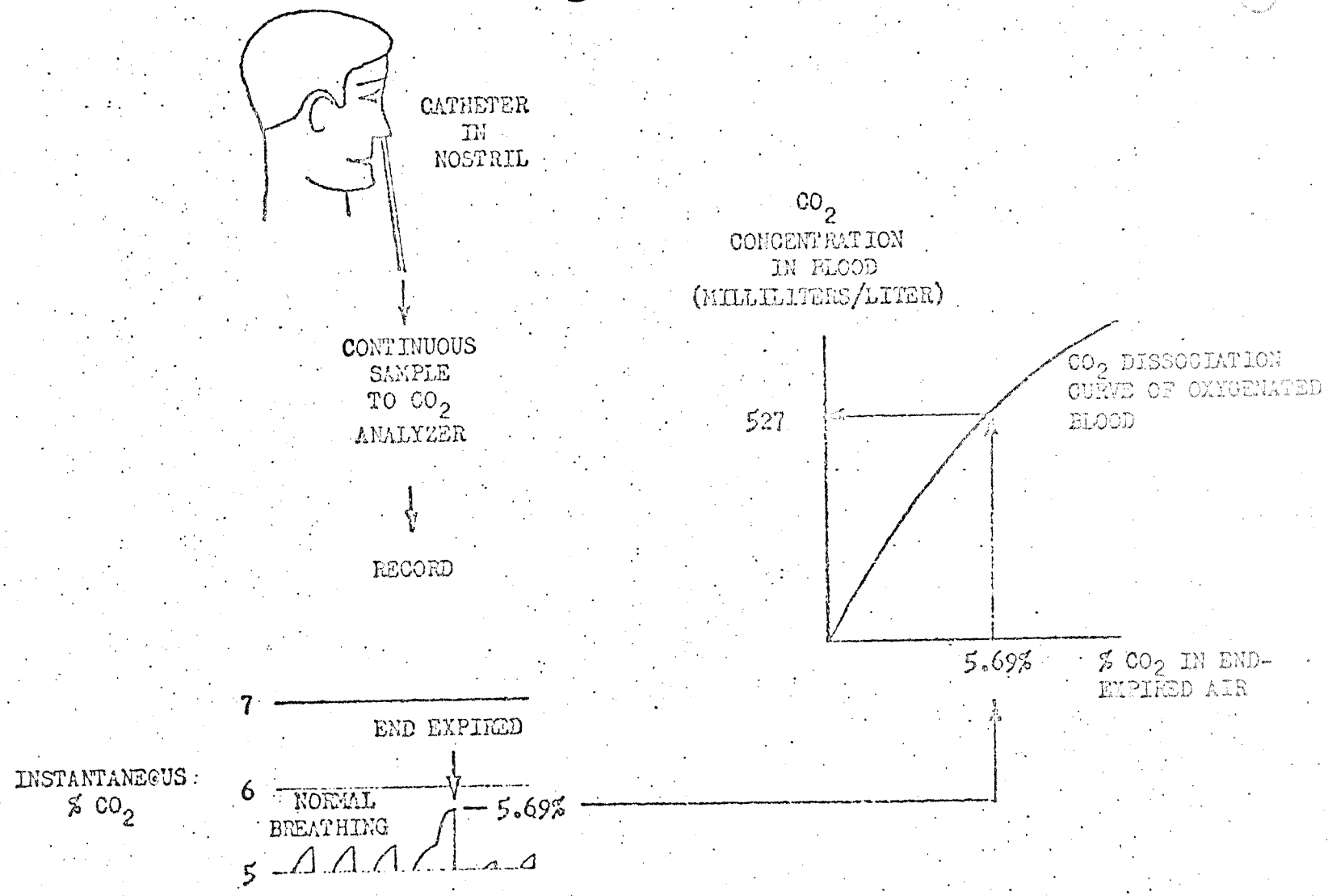


FIGURE 4 - DETERMINATION OF C_{ACO_2}

Now consider the arterial carbon dioxide concentration C_{ACO_2}, figure 4. It is well established[2-7] that the partial pressure of CO_2 in the alveoli of the lungs closely approximates the CO_2 tension in the arterial blood. We may ask our subject to breathe normally, and then at the end of a normal exhalation, to continue exhaling quickly and forcefully. The end of the forceful exhalation provides a sample of air from the alveoli of the lungs. The CO_2 percentage in this end-expired sample then permits us to determine the arterial CO_2 concentration C_{ACO_2}, using the standard CO_2 dissociation curve of oxygenated blood, figure 3a.

Figure 5 shows the recording from which the data on figures 2, 3 and 4 was obtained. The upper three traces were run simultaneously. The calibration and recorder channel of the fourth trace is the same as the first trace. For the typical example illustrated, the cardiac output is

$$\dot{Q} = \frac{182 \text{ milliliters/minute}}{(560 - 527) \text{ milliliters/liter}} = 5.5 \text{ liters/minute.}$$

EQUIPMENT AND PROCEDURE

Figure 6 shows the equipment setup. The carbon dioxide analysis is made with a Beckman/Spinco Model LB 1 Medical Gas Analyzer. The sampling pump is set to suck a sample of gas through the pickup at about 250 ml/min. The zero adjustment on the pickup is used to simulate different percentages of gas, as read on the amplifier scale. The output of the amplifier is fed to matching circuits shown in figure 7.

The upper two matching circuits are used for integrating the output of the LB 1 to give the average % CO_2, and for providing continuous attenuation for both the instantaneous and average input signals into the recorder. This permits setting full scale ranges on the recorder chart paper from 5.00 to 7.00 % CO_2 for the instantaneous record, and from 1.00 to 5.00 % CO_2 for the average record. The use of a 1000 uf capacitor in the averaging circuit makes it's response very slow - about one minute time constant. To speed up the calibration, a resistor is switched in to replace the capacitor. The resistor value is selected to approximate

the leakage resistance of the capacitor.

When the instantaneous and average % CO_2 scales have been calibrated on the chart paper, the LB 1 is then calibrated. This is done by first having the catheter sample room air, figure 6, while adjusting the zero control on the LB 1 pickup to give zero on the amplfier scale. The calibration gas is then allowed to flow slowly from its tank, and the catheter is inserted into the gas tank's outlet tube to sample the calibration gas. The LB 1 gain control is then set so that the meter reads the value of CO_2 in the calibration gas. The gas tank is shut off, and the capacitor in the averaging circuit is switched in.

The volume channel is then calibrated. This is done by pushing a one liter calibration button on the wedge spirometer. The spirometer used is a Med-Science Electronics model 270. Simultaneously, the volume scaling circuit is adjusted until the record shows a deflection of one-tenth of full scale. The calibration is checked by increasing the recorder gain by a factor of 10 and making sure the push button then shows full scale deflection. The recorder gain is then reduced to it's original value.

The entire calibration procedure takes about two minutes.

In step 1 of figure 6, the recorder is set to run at a speed of one millimeter per second, and the subject puts the catheter in his nostril. He breathes normally for about a minute, or until the average % CO_2 on the record has reached a stable value. He is then asked, after the end of a normal exhalation, to continue exhaling as much as possible, and then breathe normally again. After the maximum exhalation, it usually takes three or four breaths until the instantaneous record shows the same repetitive amplitude pattern as before the exhalation. The maximum exhalation procedure is repeated three more times, and the average of the four maximum exhalation is used to determine C_{ACO_2} as in figure 4. Note that this step of the procedure also provides the average % CO_2 record of the continuous respiration, and the time of normal exhalation and inhalation, figure 2. To provide the spikes on the time channel, the recorder coupler in this channel is set to differentiate the continuous signal.

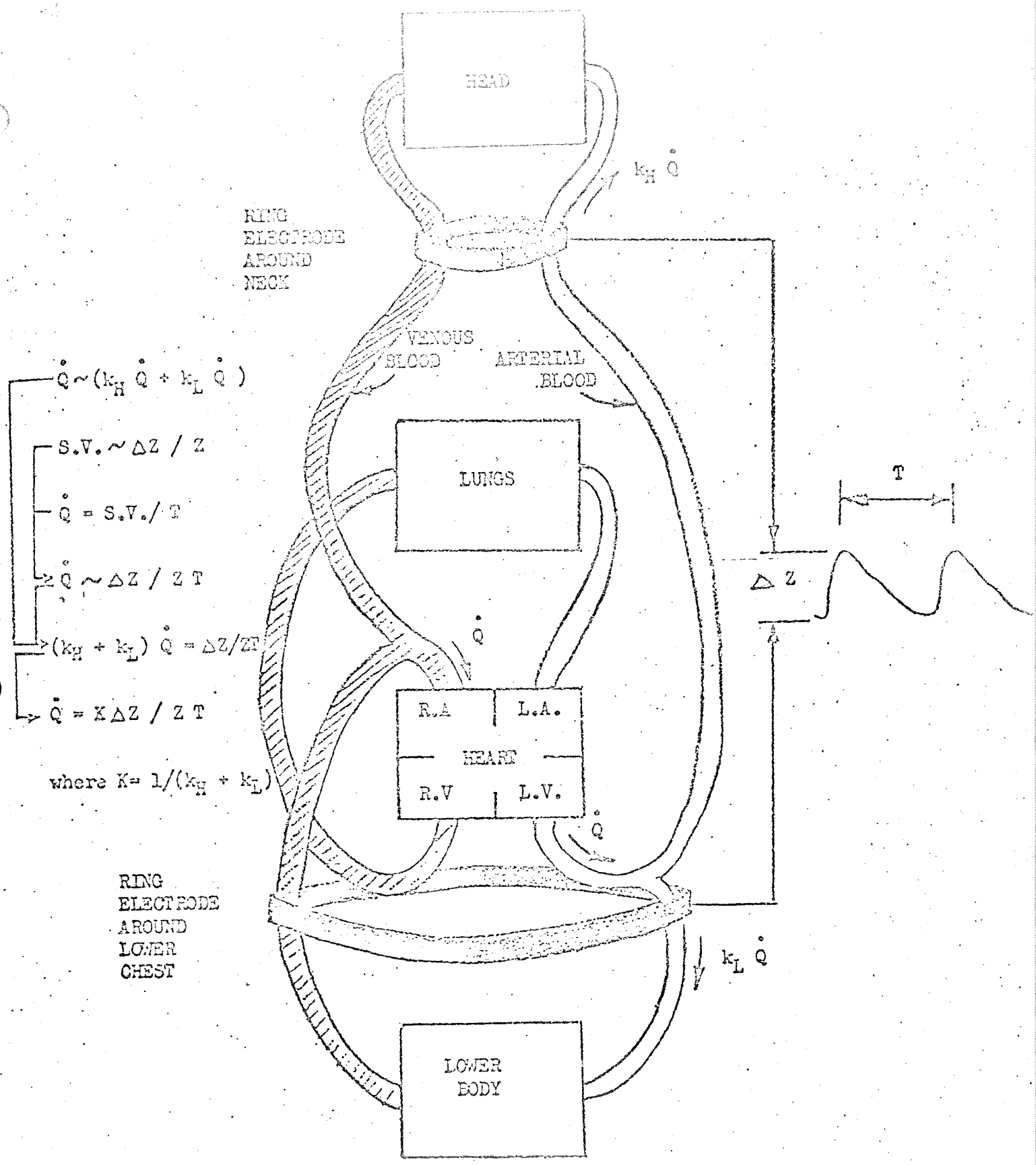


FIGURE 8 - IMPEDANCE MEASUREMENT CHECK FOR CONSTANT CARDIAC OUTPUT

In step 2, the three liter rubber gas bag is filled with rebreathing gas from the tank, with the bag held clamped at it's junction with the mask. The recorder speed is changed to 5 millimeters per second. The subject dons the mask, the junction is unclamped , and he breathes into and out of the mask for about 15 seconds. He then removes the mask and breathes room air again.

In step 3, the subject is given the end of the tube from the wedge spirometer. He is asked to inhale through his nose and exhale through his mouth. He continues this until the record shows that he has exhaled about 10 liters. He then removes the tube from his mouth, the spirometer is emptied, and he repeats the procedure of inhaling through his nose and exhaling into the wedge twice more. The average slope of the linear sections of the three staircase functions is used to determine the exhaled air flow as in figure 2.

Steps 1, 2, and 3 together usually take less than 15 minutes.

VERTICAL THORACIC CAGE IMPEDANCE

It is appropriate to ask whether the cardiac output changes during the 10-15 minutes it takes for the breathing procedure. To answer this question, the stability of the cardiac output, though not it's absolute value, was determined by a simple technique performed immediately after each step of the breathing procedure. This technique uses the change in electrical impedance between two ring electrodes - one around the neck and the other around the lower chest.

Figure 8 shows the rationale for this approach. We assume that for small cardiac output changes, there will be proportional changes in the blood flow into the head and lower body. In the diagram of figure 8, $\dot{Q} \sim (k_H \dot{Q} + k_L \dot{Q})$.

The venous blood flow is essentially steady, since by the time the blood enters the venous return paths, the damping effects of the microcirculation have eliminated the pulsations we find in the arterial system.

Recent work [8] has indicated that a reasonable proportionality exists between the stroke volume S.V. and the ratio of impedance change to impedance $\Delta Z / Z$, between ring electrodes. If the time between successive strokes or heartbeats is

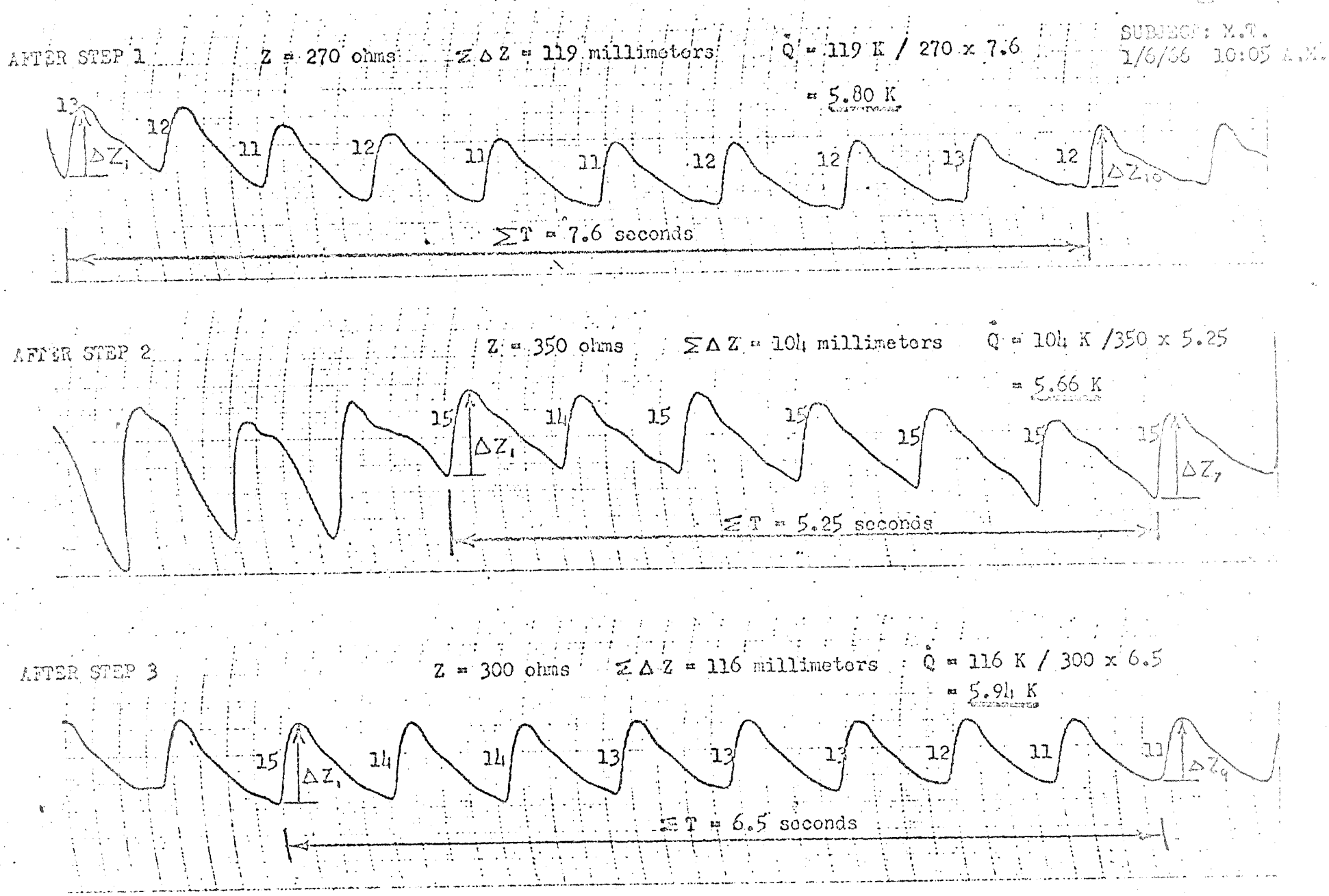


FIGURE 9 - VERTICAL THORACIC CAGE IMPEDANCE

T, then the heart rate is 1 / T. Cardiac output equals stroke volume times heart rate, or $\dot{Q} = S.V. / T$, and we may then say that $\dot{Q} \sim \Delta Z / Z T$.

Equating the two proportionalities for cardiac output:

$$k_H \dot{Q} + k_L \dot{Q} = \Delta Z / Z T$$

and letting $k_H + k_L = 1 / K$, we get:

$$\dot{Q} = K \Delta Z / Z T$$

Since K is a constant, any changes in cardiac output will be proportional to changes in $\Delta Z / Z T$. As a practical matter, the impedance Z is in the order of 100-500 ohms and the changes ΔZ are in the order of 0.1 ohms or less at a frequency of about 100 kilocycles.

The measurement is made by having the subject hold his breath long enough to record several complete cycles of cardiac pulsations ΔZ. During each measurement the base impedance Z is read from a meter on the signal conditioner. The signal conditioner used is an E & M Impedance Rheograph.

Figure 9 shows a typical set of recordings. The first trace was taken immediate after step 1 of the breathing procedure, etc. Note that ΔZ is not calibrated in ohms, but is read in millimeters of vertical chart deflection. This is allowable, since the relative cardiac outputs computed from the traces have an arbitrary constan K. The magnitudes of $\dot{Q}$ from these traces are used only for comparing against one another.

The values of cardiac output of 5.80 K, 5.66 K, and 5.94 K from the traces are all within ± 2.4 % of each other, indicating that the cardiac output during the three steps of the breathing procedure was constant to within ± 2.4 %.

152

SUBJECT	CATHETER IN NOSTRIL				RE-BREATHING	EXH. INTO WEDGE	CALCULATED						
	AV'G % CO_2	Σt_c (SEC.)	Σt (SEC.)	END EXP. % CO_2	ASYMPTOTE % CO_2	EXH. FLOW (ML/MIN)	$\frac{\Sigma t}{\Sigma t_c}$	AV'G EXH. % CO_2	$\dot{V}_{CO_2}$ (ML/MIN)	C_{ACO_2} (ML/LT)	$C_{\bar{V}CO_2}$ (ML/LT)	$C_{\bar{V}CO_2} - C_{ACO_2}$ (ML/LT)	$\dot{Q}$ (LIT/MIN)
N.T.	2.3	55	100	5.25	6.65	4750	1.80	4.14	176	513	557	44	4.00
MALE, 36	2.8	33	53	5.69	7.45	4000	1.61	4.55	182	527	560	33	5.53
220 LB.	2.7	36	62	5.55	7.65	5000	1.72	4.65	232	523	582	59	3.93
6' 2"	2.8	40	66	5.70	7.85	5400	1.65	4.62	249	528	591	63	3.96
	2.9	37	57	5.85	7.00	5300	1.54	4.47	238	533	568	35	6.80
	2.95	40	68	5.91	7.25	6000	1.70	5.02	301	536	575	39	7.70
	3.0	32	49	5.57	6.90	5170	1.53	4.59	237	524	565	41	5.78
	2.8	45	83	5.76	7.13	4270	1.85	5.20	222	529	573	44	5.06
	2.7	30	46	5.75	7.09	4000	1.53	4.34	166	530	570	40	4.15
	2.8	36	60	5.83	7.19	4500	1.67	4.66	210	533	572	39	5.40
	2.8	32	49	5.43	6.95	4125	1.53	4.22	174	519	566	47	3.70
	2.5	29	49	5.82	7.13	7500	1.69	4.23	317	532	571	39	8.13
	2.8	21	35	4.68	7.57	5080	1.67	3.60	238	531	581	50	4.76
	2.8	37	54	5.72	7.05	4170	1.46	4.09	170	526	570	44	3.87
	3.0	45	60	5.88	7.45	4120	1.33	4.00	160	536	571	35	4.57
	2.9	37	55	5.70	7.97	7166	1.49	4.31	309	526	592	64	4.83
R.L.	1.8	22	48	4.50	5.76	8830	2.18	3.93	347	482	530	48	7.22
MALE, 34	1.9	23	46	4.40	5.88	6830	2.00	3.80	260	476	537	61	4.26
175 LB.	1.8	25	47	4.60	5.97	7000	1.88	3.38	236	486	537	51	4.63
6' 2"	2.0	30	55	4.58	5.90	7500	1.65	3.68	276	484	536	52	5.32
	1.9	25	43	4.40	6.58	6580	1.72	3.27	215	476	556	80	2.69
	2.25	31	50	4.95	6.75	5370	1.61	3.63	195	503	561	58	3.37
	1.8	23	43	4.32	5.99	6250	1.87	3.37	211	471	537	66	3.20
	2.1	27	48	4.90	6.52	6500	1.76	3.74	243	500	554	54	4.50
L.T.	2.0	19	35	5.45	7.02	5380	1.84	3.78	203	517	570	53	3.84
MALE, 37	2.0	26	49	5.00	6.20	6250	1.89	3.77	234	504	544	40	5.85
167 LB.	1.8	17	34	5.75	6.95	3250	2.00	3.60	117	529	567	38	3.25
5' 10½"	2.25	22	42	4.29	6.00	6083	1.91	4.29	261	537	593	56	4.76
	2.1	22	40	6.10	8.50	7000	1.81	3.82	267	540	605	65	4.12
	2.7	25	46	6.05	7.65	7000	1.84	4.96	344	539	585	46	7.47

TABLE 1 - DATA AND CALCULATIONS

RESULTS

Refer to figure 10

Table 1 and Figure 10 show the data, the calculations, and the cardiac outputs. Considering all the data, the resulting statistics are below.

SUBJECT	CONDITION	NO. OF DETERMIN-ATIONS	MEAN CARDIAC OUTPUT	STANDARD DEVIATION	STANDARD ERROR OF THE MEAN
M.T.	Sitting at rest	16	5.14	1.33	.34
L.T.	" " "	6	4.88	1.41	.63
R.L.	" " "	8	4.38	1.32	.52

For purposes of comparison with the literature, it is useful to consider the data exclusive of the evident "oddballs". Figure 10 shows that the five points above six liters/minute are clearly outside the main groupings. Excluding these, the statistics are below.

Check table 1 last column. There is gradient so the low ends ought to be scraped off too whether there are valid groupings.

REFERENCE	SUBJECT	CONDITION	NO. OF DETERMIN-ATIONS	MEAN CARDIAC OUTPUT	STANDARD DEVIATION	STANDARD ERROR OF THE MEAN
This study	M.T.(AM)	Sitting at rest	6	4.35	.70	.31
	M.T.(PM)	" " "	7	4.77	.60	.25
	M.T.(Both)	" " "	13	4.58	.68	.21
	L.T.(AM)**	" " "	5	4.37	.89	.44
	R.L.(Both)	" " "	7	3.97	.82	.36
Defares [3]	9 (AM)	Basal & prone at rest	4	6.14*	.15*	.09*
Jernerus [5]	G.L.(AM)	Basal & almost prone at rest	23	3.3	.31	.07*
Klausen [6]	A (AM)	Basal & prone at rest	12	6.69	4.5*	1.36

Subject 3 had no "cluster"

* Computed from data in cited references.

** For subject L.T., the only oddball determination was in the P.M.

Suggest deletion as a result of statistical test not hunch.

The mean results are in general agreement. In Defares' work, "Thirty six technically satisfactory experiments on eight subjects were performed. In 31 cases the experimental results were in agreement with theory..." Defares then gives the results of " 18 experiments on 9 subjects under essentially basal conditions...". The maximum number of experimental determinations presented in detail for any one of the

subjects is four, on subject number 9. In Jernerus' work, " The first experiments were done at rest on subject G.L. to test the reproducibility of the method... All values where the CO_2 elimination per minute at rest is higher than 250 ml are excluded (usually the first 2-3 experiments.)....". The twelve determinations presented by Klausen are from a total of 17 on subject A at rest.

In this study, out of a total of 30 determinations, 5 were excluded as oddballs, 3 on subject M.T. and one each on subjects L.T. and R.L. In view of the above, direct comparisons of standard deviations and standard errors of the mean among the results can yield only somewhat limited conclusions. In general, the smaller spread of data of this study as compared to Klausen's is probably due to the use of continuous measurements rather than timed samples for determining points on the exponential staircase during rebreathing.

The larger standard deviation of this study as compared to those of Defares and Jernerus, are attributed to the fact that our measurements were not confined to the basal condition. We would hence expect our cardiac outputs to show more variation

DISCUSSION

The weakest link in the procedure appears to be the determination of the asymptot The extrapolated points intersect the 45° line at a very acute angle, and a small angular error in the extrapolation can lead to marked variation in the mixed venous CO_2 concentration. This might be improved by using a least squares fit to the points, and an algebraic solution for the point of intersection.

Jernerus and Klausen used a sound cue (metronome) for the subject, to insure constant breathing rate during the rebreathing into the bag. The purpose of this was to provide more evenly timed exponential steps and a more reliable exponential curve. This was tried in some of our early experiments prior to those reported on in this study. It was found, however, that a sound cue apparently put enough psychological stress on our subjects so that it presented more problems than it solved. The breathi was less normal and regular with the cue than without it.

We did find that a marked degree of smoothing of the exponential curve could be attained by blocking off the end of the sampling catheter, piercing the last terminal

with needle holes, and inserting the pierced section into the rebreathing bag. The effect of turbulence in the bag is then averaged out and the exponential record shows smoother steps, though not a smooth exponential.

Normal breathing is usually through the nose, with no apparatus on the face or in the mouth. Most respiratory work, however, requires some connection to the mouth and/or nose of the subject. For step 1 of this procedure, this is kept at a minimum by the use of the thin catheter in one nostril. The catheter has no disturbing effect on normal respiration. Just prior to step 2, the subject is again breathing normally with nothing on his face. He then lifts the mask to his face and breathes into it for 15 seconds. The variation from the previous normal equilibrium is hence minimal. Step 3 takes several minutes. Here the subject exhales into the wedge spirometer. Instead of having the subject inhale through his nose and exhale into the spirometer, it is possible to use a nose clip and a non-rebreathing valve, or a face mask and a non-rebreathing valve [3-6]. With either of the latter alternatives the subject does not have to exert voluntary control over his breathing. Those alternatives were tried. It was found, however, that involuntary adaptations to the additional apparatus on the face gave more variation from normal breathing than the procedure finally used for step 3. For this step, the subject is instructed to " Breathe normally, in through your nose and out through your mouth." He establishes this regular pattern within a few breaths, and is then relaxed and able to maintain i

In one of the experimental runs (subject L.T.) during step 3, the record suddenl changed from an increasing linear staircase to a regular up-and-down wave pattern. It was discovered that the subject had fallen asleep, and was breathing through his mout only. Such complete relaxation is rare, but serves to indicate the minimum deviation from normal inherent in the procedure.

When the basic method of steps 1, 2 and 3 had been tried on enough runs to indicate that the results were consistent, it was felt to be useful to add on the impedance check. This was tried on several runs, interspersed with the main steps. The results showed stable cardiac outputs during the breathing procedure to within a few percent. In view of this, it is likely that steps 1,2, and 3 may be used as

a method of calibration for the impedance technique. Once calibrated, the impedance method may be used directly for determinations of stroke volume and cardiac output. At this stage in the evolution of the impedance approach, the calibrations must be done individually on each subject. When enough data has been gathered on a variety of subjects, it will be possible to see whether generalizations based on sex, age, and body weight and height may be used for bypassing the breathing procedure.

REFERENCES

1. J.P. Payne and P.J. Armstrong, "Measurement of Cardiac Output," Brit. J. Anaesth. , vol. 34, pp. 637-645; 1962.
2. E. Asmussen and M. Nielsen, "Physiological Dead Space and Alveolar Gas Pressures at Rest and During Muscular Exercise," Acta Physiol. Scand., vol. 27, pp. 217-230; 1952.
3. J. G. Defares, "Determination of $P\bar{v}CO_2$ from the Exponential CO_2 Rise During Rebreathing," J. Appl. Physiol., vol. 13, pp. 159-161; 1958.
4. J. G. Defares, M.E. Wise and J.W. Duyff, "New Indirect Fick Procedure for the Determination of Cardiac Output," Nature, vol. 192, pp 760-761; Nov, 1962
5. R. Jernerus, G. Lundin and D. Thomson, "Cardiac Output in Healthy Subjects Determined with a CO_2 Rebreathing Method," Acta Physiol. Scand., vol. 59, pp 390-399; 1963
6. K. Klausen, "Comparison of CO_2 Rebreathing and Acetylene Methods for Cardiac Output," J. Appl. Physiol., vol. 20, pp 763-766; July, 1965.
7. P.H. Rossier, A.A. Buhlmann, and K. Wiesinger, "Respiration Physiologic Principles and their Clinical Applications," C.V. Mosby Co, St. Louis, 1st English ed., p.77; 1960.
8. E. Kinnen, W. Kubicek and R. Patterson, " Thoracic Cage Impedance Measurements: Impedance Plethysmographic Determination of Cardiac Output," Technical Documentary Report No. SAM-TDR-64-15; March, 1964.