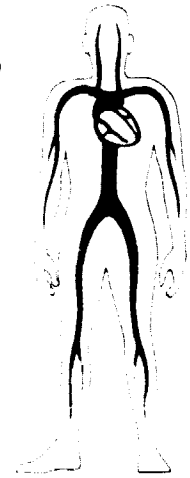


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TECHNOLOGY INCORPORATED

LIFE SCIENCES DIVISION

SPECIAL REPORT
ON THE
METABOLIC RATE MEASUREMENT SYSTEM

Prepared for the NASA Johnson Space Center
Environmental Physiology Laboratory

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SYSTEM (Technology, Inc., Houston, Tex.)
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HOUSTON, TEXAS 77058

TECHNOLOGY INCORPORATED
Life Sciences Division
Houston, Texas

SPECIAL REPORT

Metabolic Rate Measurement System

Environmental Physiology Laboratory
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center

Contract NAS 9-14880

Project 0175-80

Prepared by:

Kenneth Koester

Kenneth Koester
Technology Incorporated

William G. Crosier

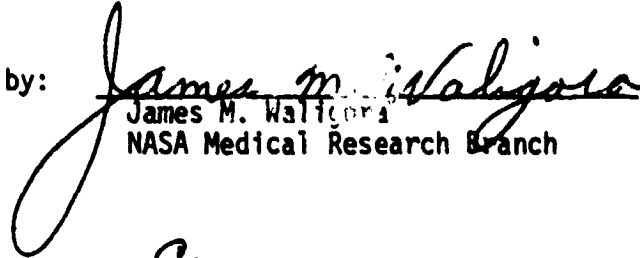
William Crosier
Technology Incorporated

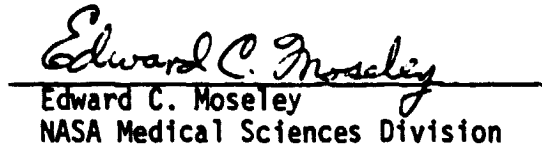
Approval Sheet

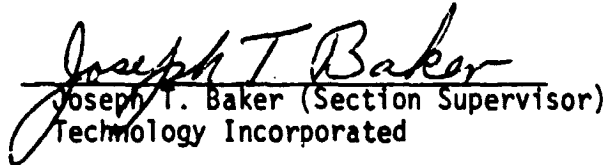
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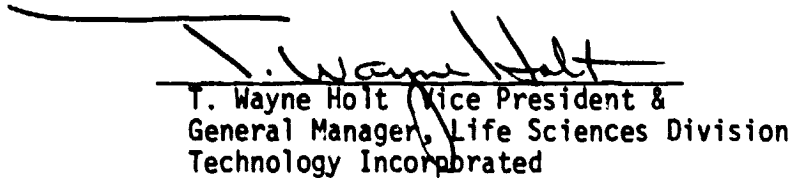
The Metabolic Rate Measurement System

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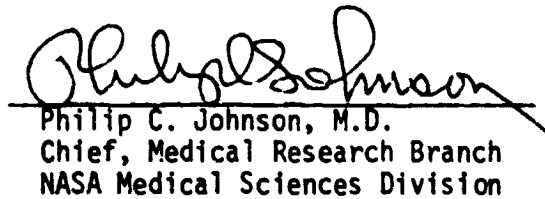

Philip C. Johnson, M.D.
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INTRODUCTION

The Metabolic Rate Measurement System (MRMS) is an uncomplicated and accurate apparatus for measuring oxygen consumption and carbon dioxide production of a test subject. From this one can determine the subject's metabolic rate for a variety of conditions, such as resting or light exercise.

MRMS, like its predecessor (Metabolic Measurement - X75 Ident. No. 55005-0), utilizes an LSI/11-03 microcomputer to monitor and control the experimental apparatus. However, accuracy and efficiency have been improved by utilizing more refined equipment and techniques. Future plans include configuring the LSI/11 to communicate with a larger central computer. This will also be done with several other LSI/11 controlled experiments, such as the Skin Temperature System so that as much data as possible can be collected and stored in highly efficient manner.

GENERAL DESCRIPTION

To measure the oxygen consumed and the carbon dioxide produced for a test subject, a somewhat constant flow of ambient air is pulled through the face mask and mixed with the subject's expired air. A mass spectrometer is used to determine the concentrations of gases in both the inspired and expired air. These concentrations as well as temperature, pressure and flow rate are monitored by a Digital Equipment Corporation LSI-11 Microcomputer. The computer programs, which are written in Fortran and reside on a floppy diskette, automatically calibrate this equipment, control the sampling of the various parameters, calculate the minute volumes of the gases, and display the results on the teletype.

The LSI-11 measures the gas concentrations from the Mass Spectrometer, as well as the temperature and pressure measurements by means of an ADAC 1030 A/D converter. A parallel interface board provides the communication link from the flow meter output, and to the solenoid valve controls.

The ADAC 1030 accepts up to 16 analog input signals. Output is an integer in the range 0-2047. Channel selection as well as gain are programmable. The counts are converted to a value signifying a measurement (such as l/min, deg. cent. etc.) by means of the linear equation $\text{value} = \text{slope} * \text{counts} + \text{intercept}$. The slope and intercept values are determined by calibration techniques.

The temperature and pressure transducers are assumed constant devices, and so were calibrated once during hardware assembly.

The measurements from the Mass Spectrometer are calibrated during experimentation. Two calibration gases, of precisely known composition, are analyzed to provide slopes and intercepts.

The selection of gas (cal. gas 1, cal. gas 2, exhaled or ambient) picked up by the mass spectrometer probe is controlled by a set of solenoid valves. A digital control device converts the interface board signal to the 110 v. signal needed to actuate the proper valve.

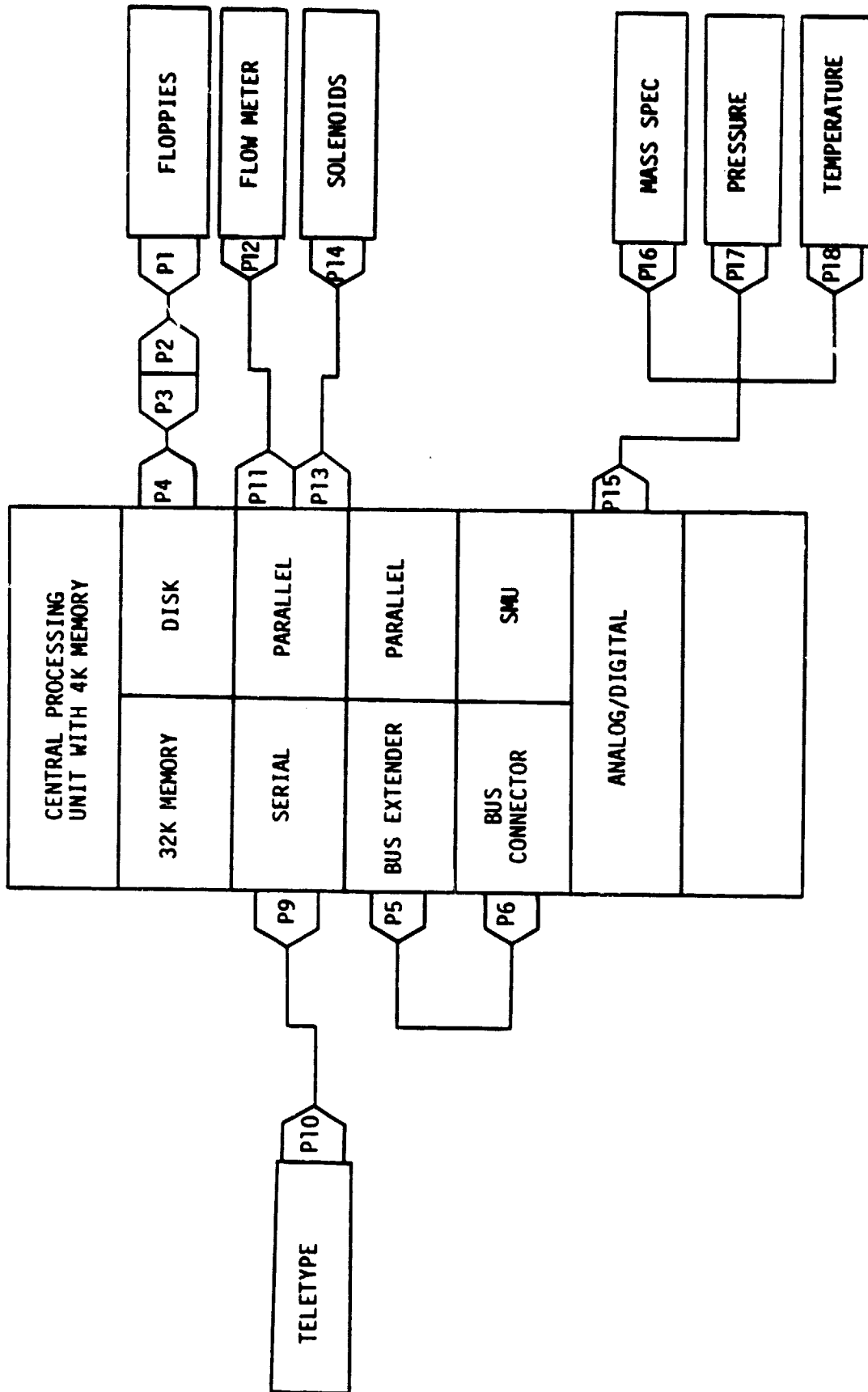
To measure flow, a turbine-like transducer sends a signal to an amplifier/signal conditioner, which generates a square wave. This is sent to a frequency counter which then generates a BCD signal on the parallel interface as well as displaying the results on the LED display. The flow measurement system was also calibrated during hardware assembly. The flow is governed by a variac controlled exhaust fan.

A complete block diagram of hardware arrangement appears in the hardware description.

Board Configuration of the LSI-11 Microcomputer

<u>Slot Location</u>	<u>DEC Module No.</u>	<u>Device No.</u>	<u>Description</u>
1	M7264	KD11-F	Microprocessor with 4K RAM
2A	M8044	MSV11-D	32K words x 16 bit memory
2C	M7946	RXV11-A	Dual floppy disk drive controller
3A		DLV11	Serial line interface for teletype
3C & 4C	M7941	DRV11	Parallel line interface
4A	M9400YE	BCV1B	First backplane terminator & bus extender
5A	M9401YE		Bus continuity card
5C		MLSI-SMU	System monitoring unit
6			16 channel A/D & 2 channel D/A interface

		A	B	C	D
First Backplane	1	CPU with 4K memory			
	2	32K memory		disk controller	
	3	serial interface		parallel interface	
	4	bus extender		parallel interface	
Second Backplane	5	bus connector		SMU	
	6	analog to digital converter			
	7				
	8				

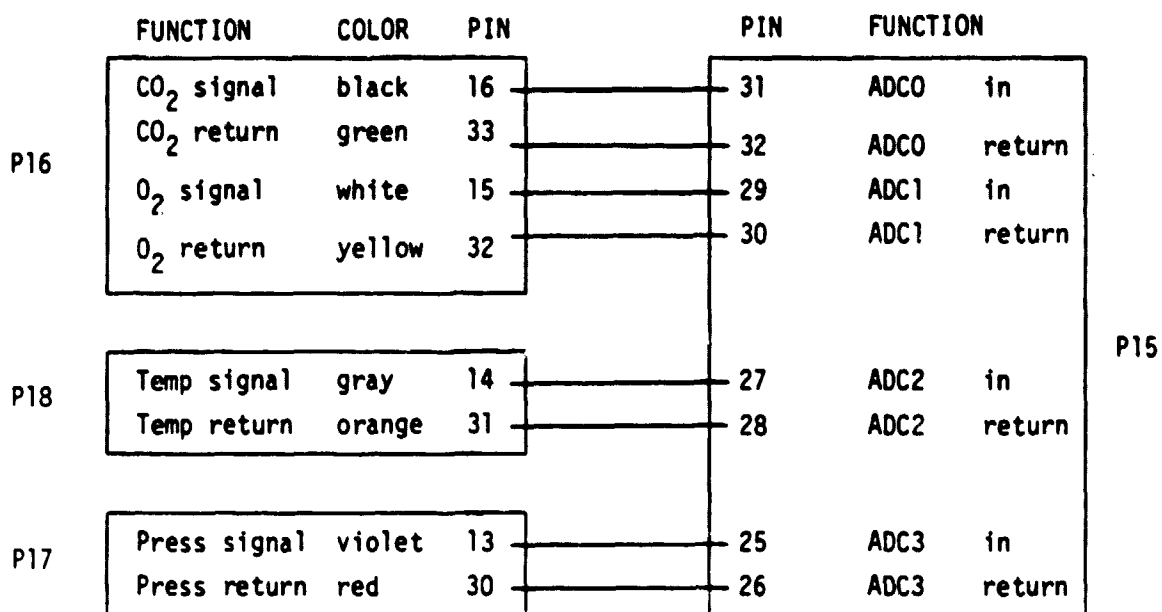


BLOCK DIAGRAM OF HARDWARE SHOWING
DATA CABLES

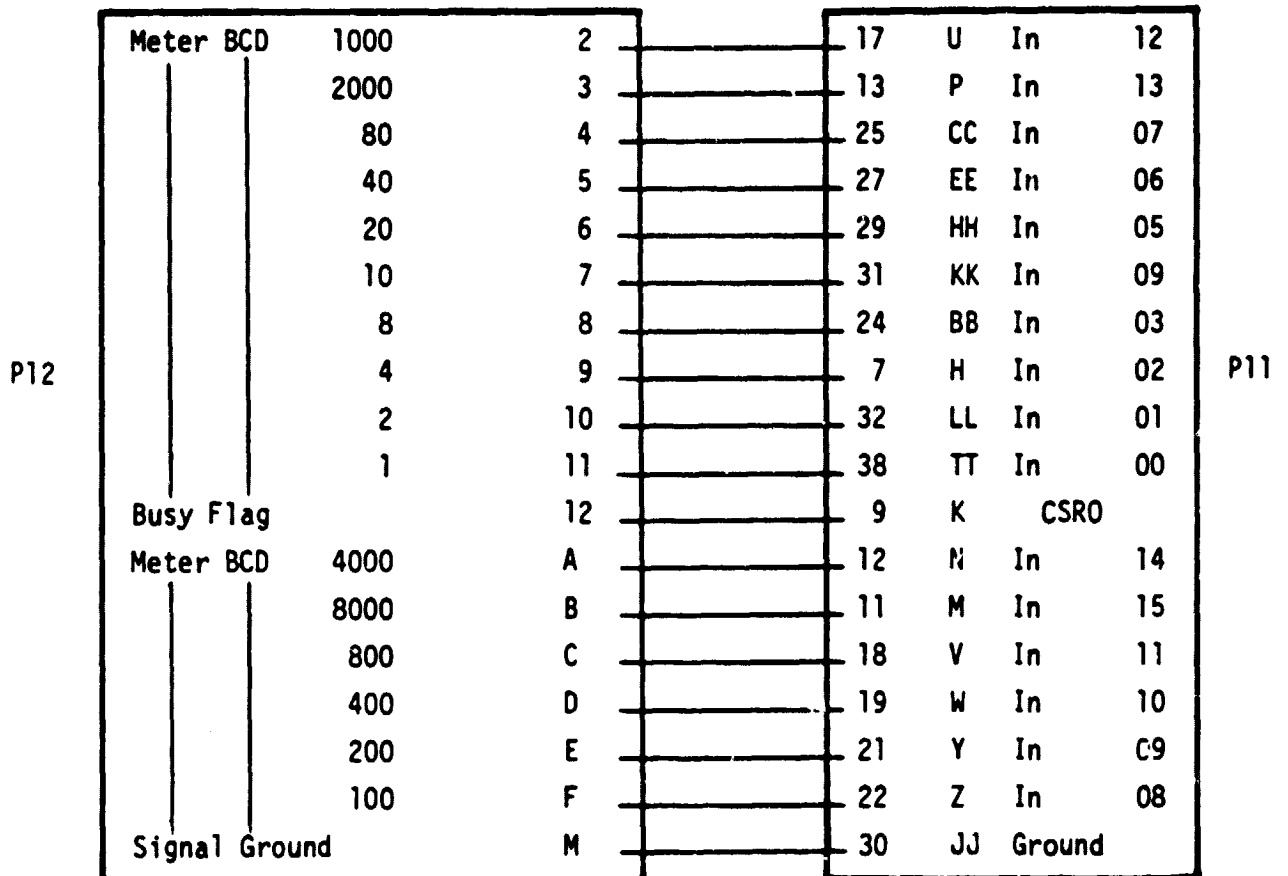
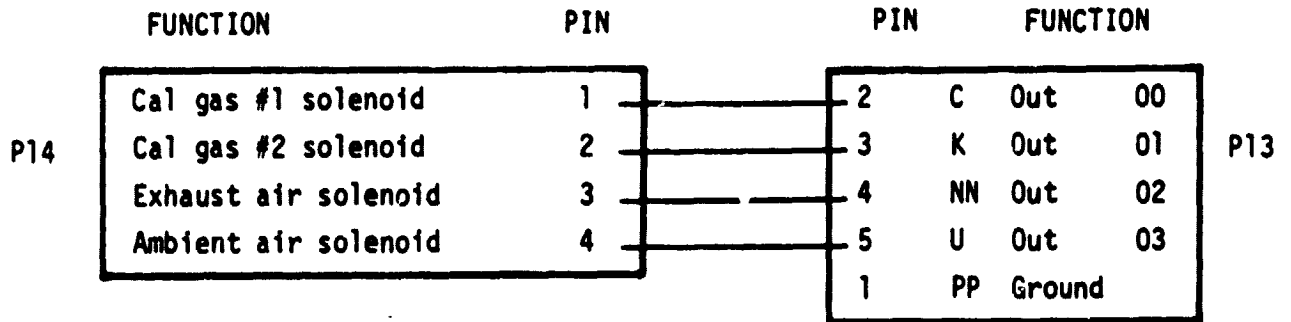
CABLE RUNNING LIST FOR ANALOG/DIGITAL INTERFACE

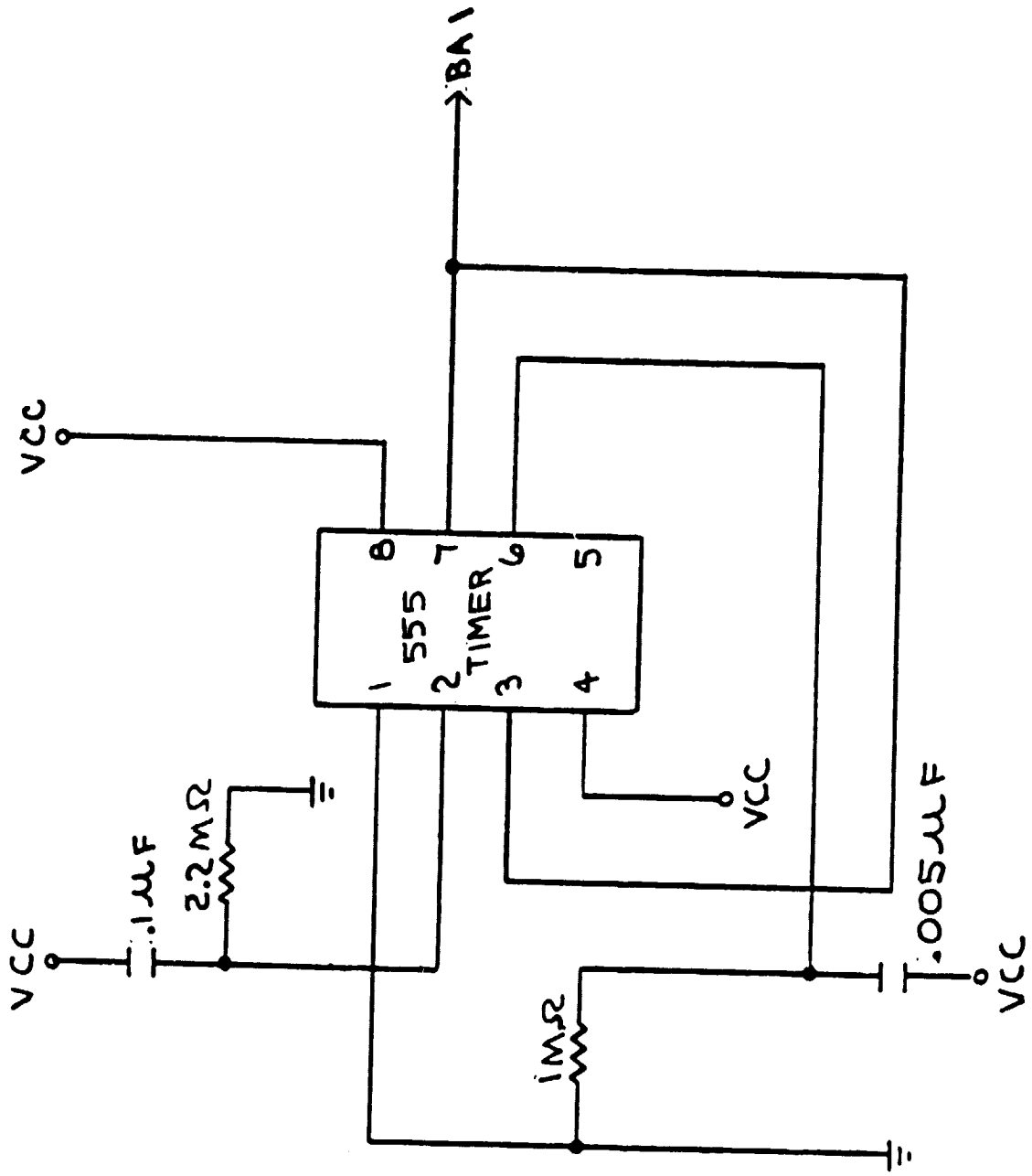
Cannon DD505 50 pin Ribbon
Cable Mounted Connector

Cannon DD50P Mating Connector
on PC Board

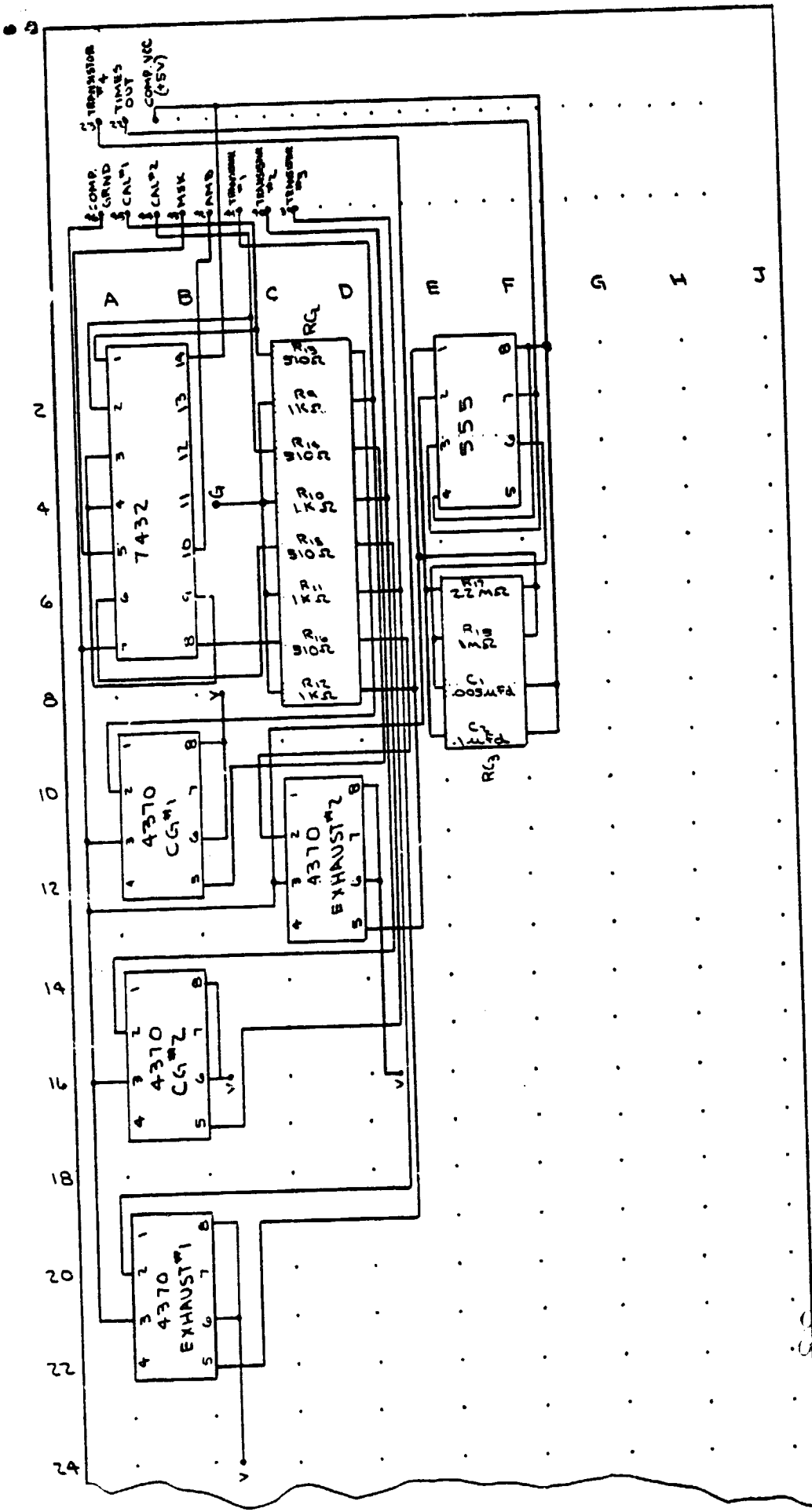


CABLE RUNNING LIST FOR PARALLEL INTERFACE



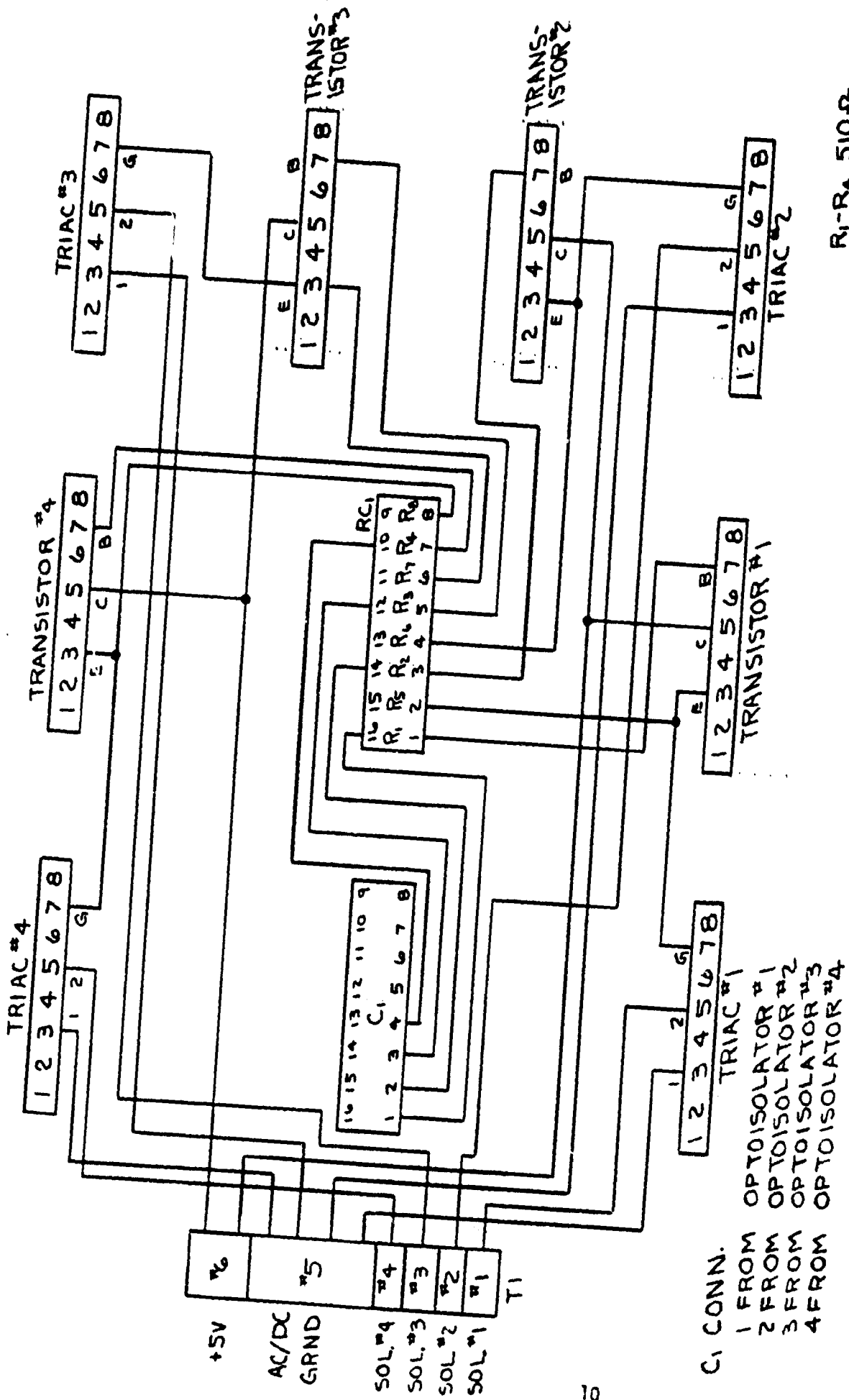


START UP CIRCUIT FOR LS1-11 MICROCOMPUTER



LOGIC BOARD
 START UP CIRCUIT &
 PART OF SOLENOID
 CONTROL CIRCUIT

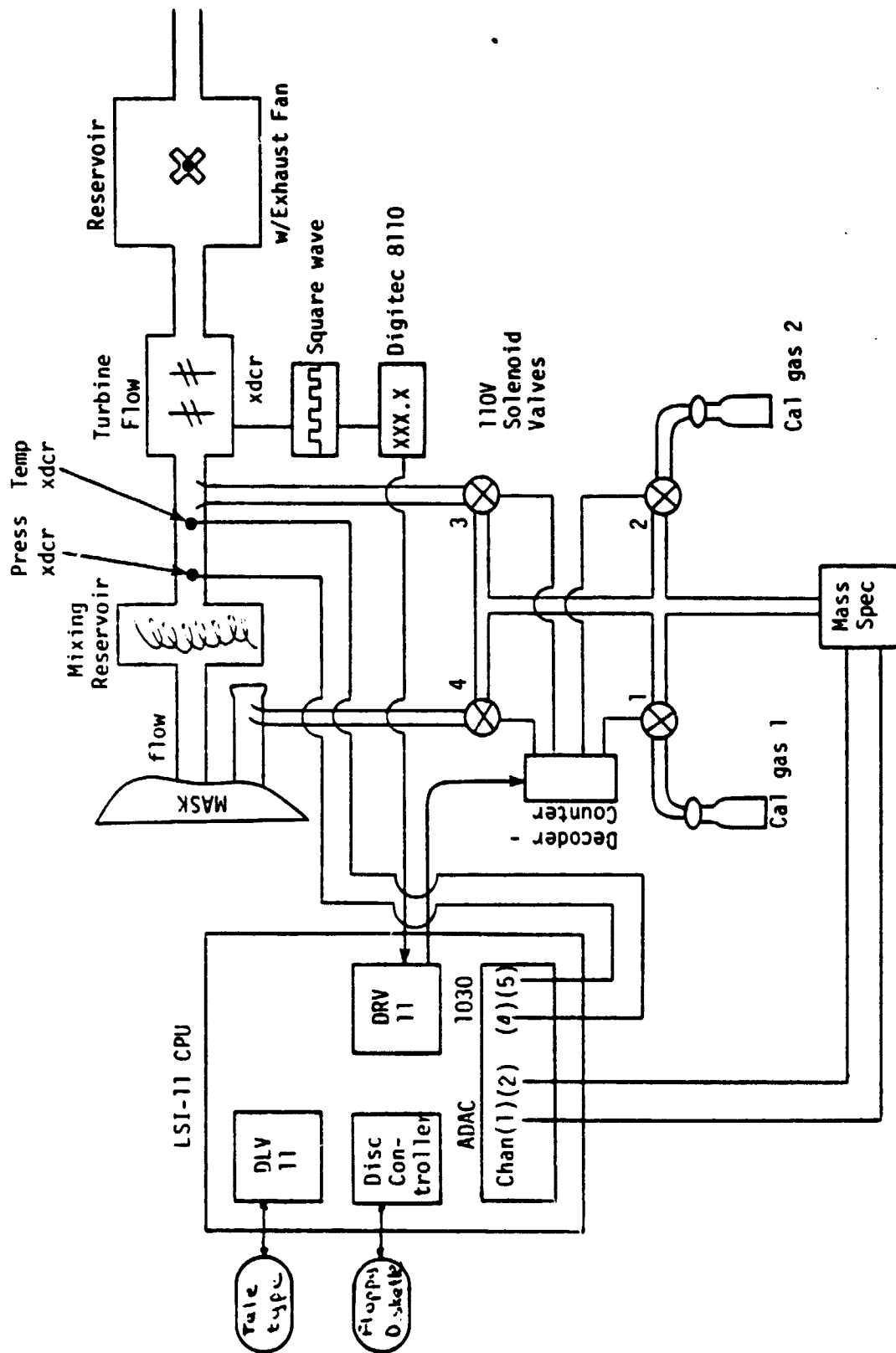
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 OF POOR QUALITY



R₁-R₄ 510Ω
 R₅-R₈ 1KΩ

TRIAC-TRANSISTOR BOARD PICTORIAL
 (PART OF SOLENOID CONTROL CIRCUIT)

C1 CONN.
 1 FROM OPTOISOLATOR #1
 2 FROM OPTOISOLATOR #2
 3 FROM OPTOISOLATOR #3
 4 FROM OPTOISOLATOR #4



SOFTWARE DESCRIPTION

The software package is developed in and supported by RT-11 v3B operating system. The real-time test program is written in Fortran and operates in phases that are user controlled. Although this requires user intervention, it permits software design so as to minimize the number of subroutines and associated overhead.

The main phases of the real-time test program operate in the following manner.

Calibration: Open solenoid valve for a cal. gas and flow for 30 seconds to clear tubing. Average 100 readings each for O₂ and CO₂ concentrations. Repeat for other cal. gas. Calculate slopes and intercepts. Print results.

Test data: Set valve for ambient gas flow for 7 seconds to clear tubing. Then sample ambient data continuously for the next 8 seconds. Set valve for exhaled gas flow for 7 seconds to clear tubing. Then sample exhaled data continuously for the next 38 seconds. During the duty cycles (8 sec./ambient, 38 sec./exhaled), no other operations other than data gathering are performed. Averaging, computational calculations, and printing are done during the 7 sec. wait cycles. This 60 second cycle is repeated until user intervenes.

The resulting program provides good flexibility of initial conditions as well as high sampling rates and efficient use of CPU capability.

OPERATION

- 1) Insure cal gases are operational; verify proper hose connection (gas 1 with hose #1, etc.); bottle has sufficient operating pressure; pressure is adjusted properly (4-8 psi is sufficient).
- 2) Insure mask hoses are properly connected. Hose to tank and tank to flow meter/fan are color coded for proper connection. Capillary tube connects to Inlet connection.
- 3) Insure mass spectrometer is properly configured. Probe is connected to Mass Spectrometer connection. Proper inlet is selected and unit is "ON". Verify mode is % and output signal cables are connected to converter patch panel. (NOTE: A filter/amplifier box may be inserted between the mass spectrometer and the patch panel.)
- 4) Verify the patch panel connections are attached to the proper channel
 - Ch. 1: O₂ signal
 - 2: CO₂ signal
 - 4: Temp. signal
 - 5: Press. signal
- 5) Load floppy diskette into disk drive; Disk ENVIRE contains the RT-11 v3B operating system as well as program into ENVIRE .SAV and data file DATCON .VAL.
- 6) Turn on power to teletype, turn on power to CPU and other hardware.
- 7) The teletype should print "\$". To boot the system; clear the INTRPT light (depress the key once), type "DX" and carriage return. The

system will then boot up ready to accept commands.

- 8) Type "R ENVIRE" <CR>. Envire prints adequate instructions for operator actions required. Appendix D is a hard copy printout containing expanded comments about options etc.

APPENDIX A
PHYSIOLOGICAL EQUATIONS

Indices: $i \rightarrow$ cal gas 1 or 2
 $j \rightarrow 1=O_2, 2=CO_2$

Given $\%(i,j) = m(j) * \xi(i,j) + b(j)$

where $\% \rightarrow$ cal gas percentage

$\xi \rightarrow$ mass spec output, read as counts from A/D

then $m(j) = \frac{\%(2,j) - \%(1,j)}{\xi(2,j) - \xi(1,j)}$

$b(j) = \%(1,j) - m(j) * \xi(1,j)$

Respiratory Quotient $Rq = \frac{\Delta CO}{\Delta O}$

CO_2 Production $\Delta CO = \{STP * fl * [r_2 * \rho_e(3) - r_1 * \rho_e(2)]\}$ averaged

O_2 Consumption $\Delta O = \{STP * fl * [r_1 * \rho_e(3) - \rho_e(1)]\}$ averaged

Temp/Press. Correction $STP = \left[\left(\frac{273.15}{273.15 + T} \right) * \left(\frac{P}{760} \right) \right]$ averaged

Gas Concentration $\rho_r(j) = m(j) * \xi(k,j) + b(j)$

where k denotes ambient or exhaled concentration

and $\rho_r(\text{nitrogen}) = 100. - \rho_r(1) - \rho_r(2)$

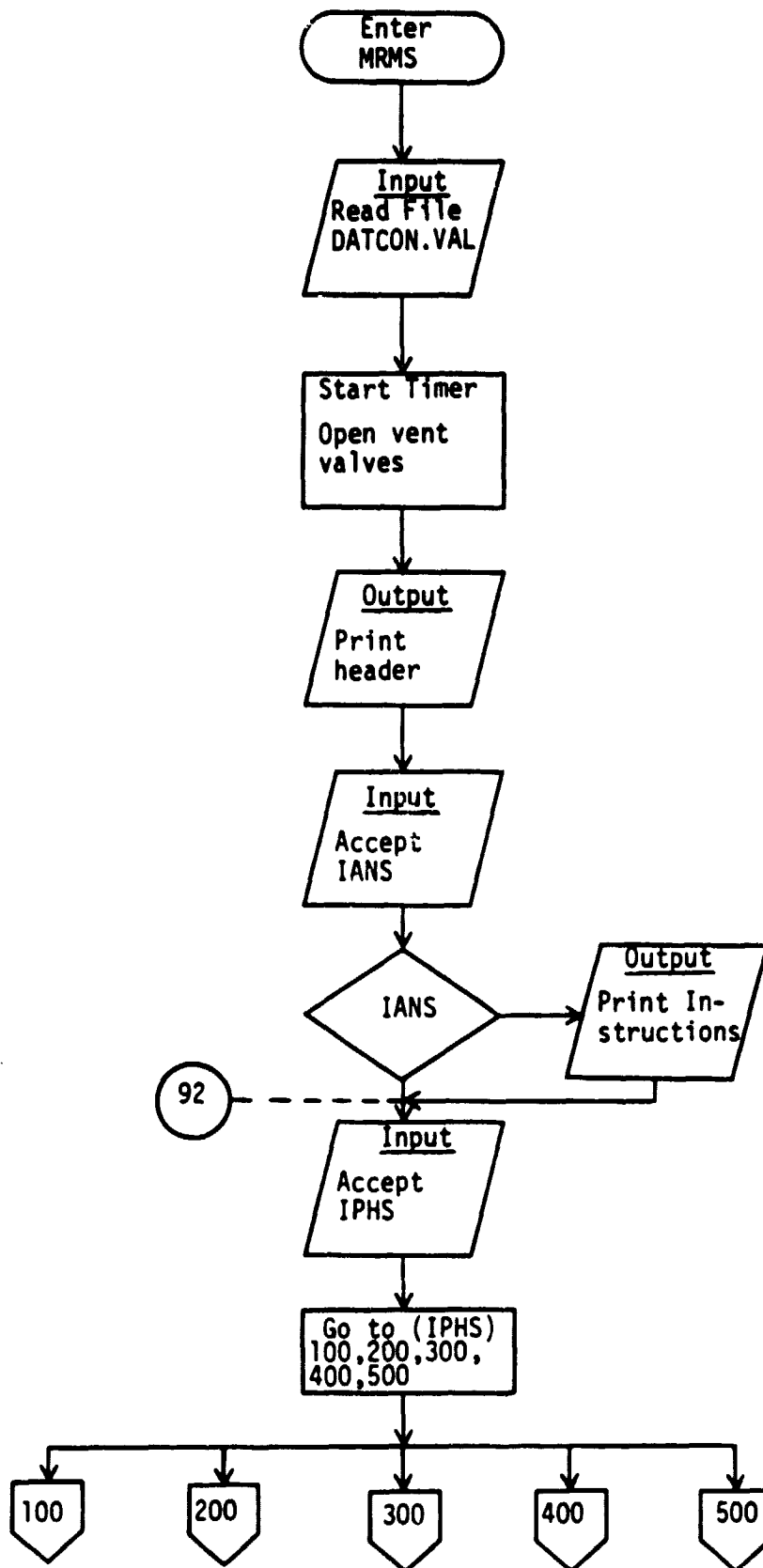
Ratio factor $r_j = \left[\frac{\rho_{amb}(j)}{\rho_{amb}(N_2)} \right]$ averaged

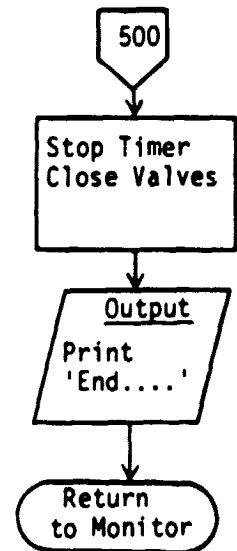
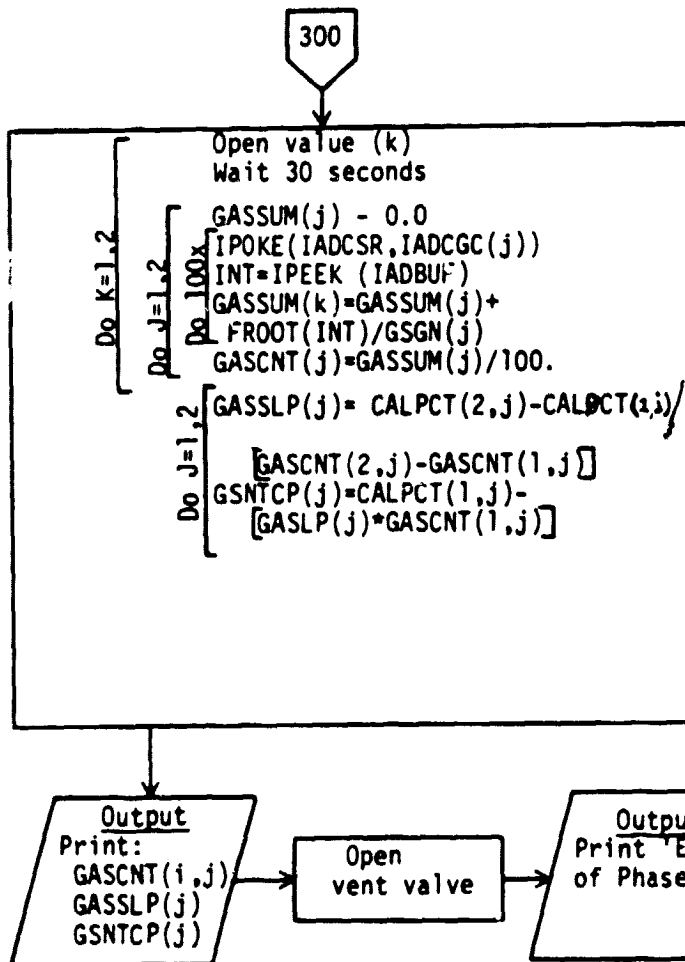
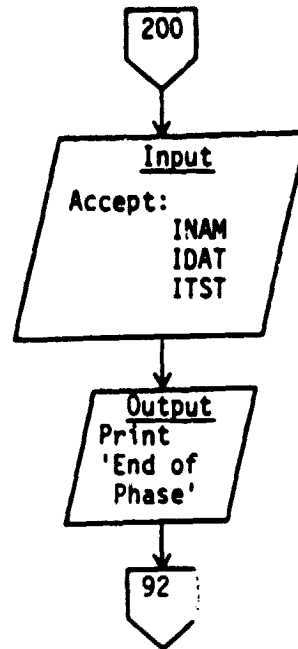
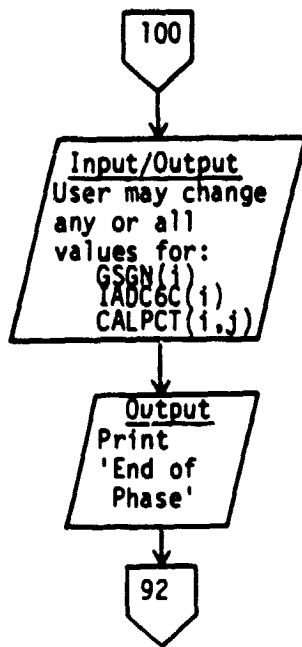
Flow fl measured in litres/minute

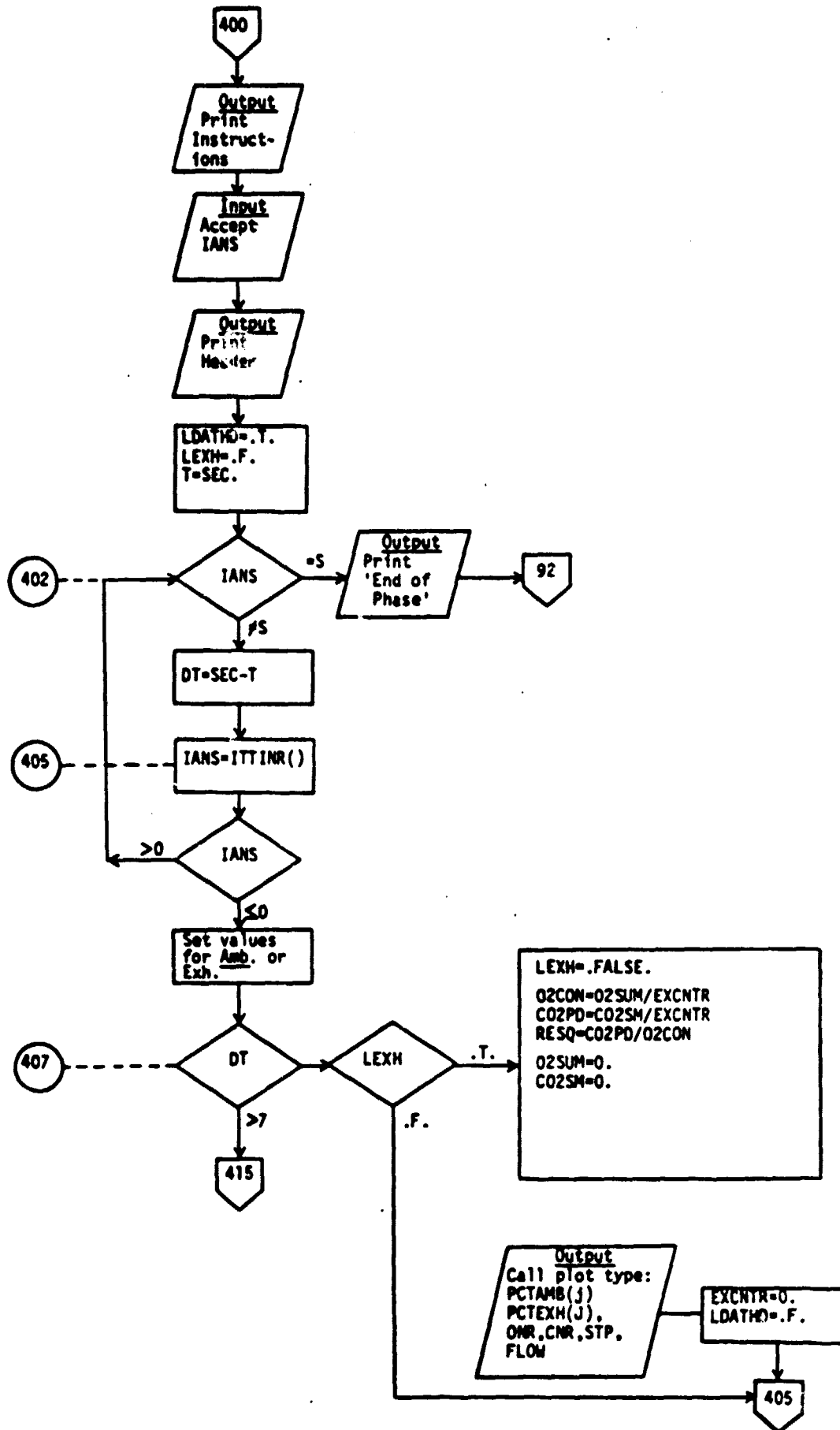
STP and r_j are calculated and then averaged during the ambient duty cycle as described in the Software Description section.

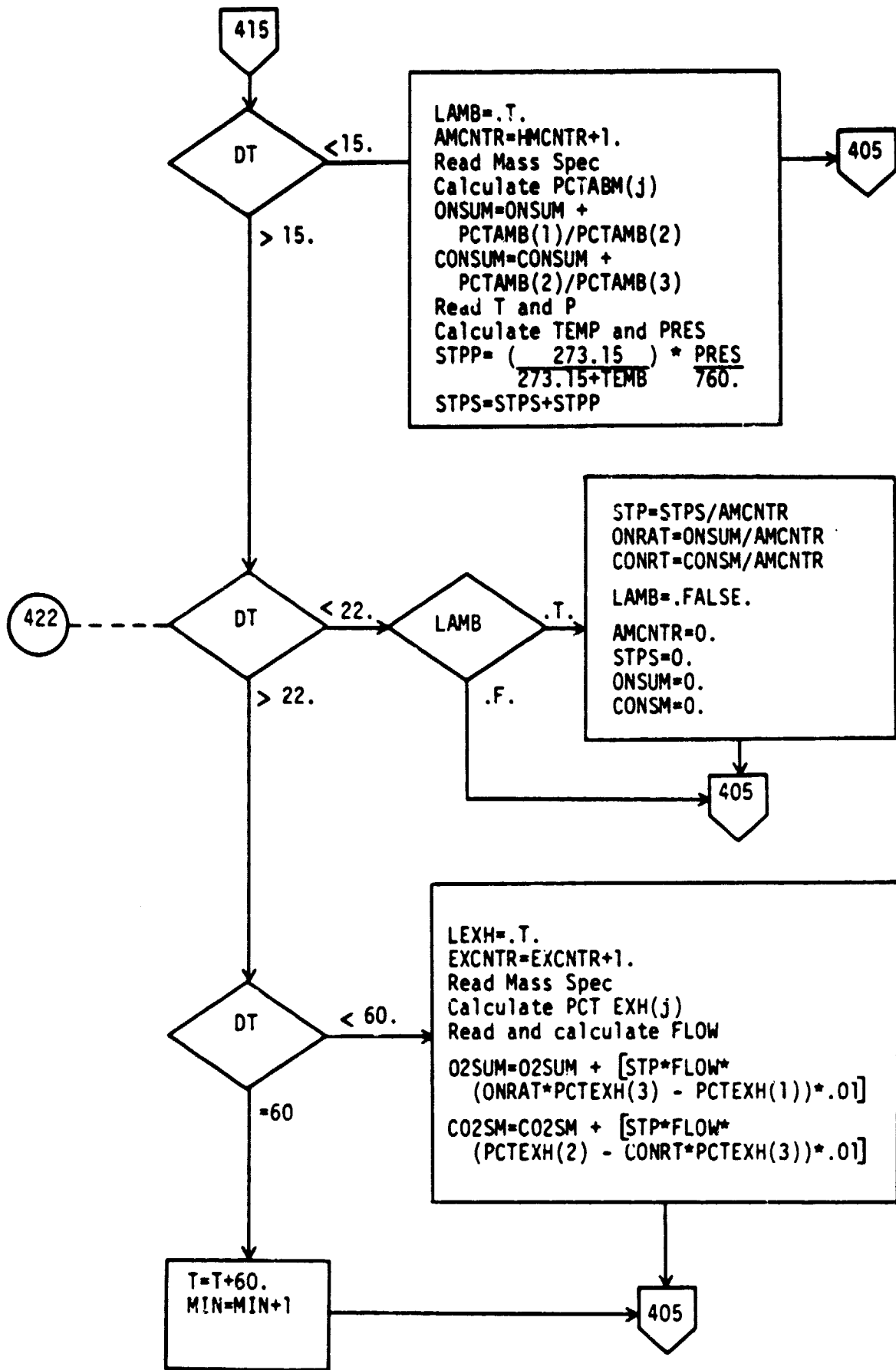
f_l and $p_e(j)$ are measured and a value for $\Delta CO'$ and $\Delta O'$ is calculated. Due to experimental restriction, it is necessary that the ambient measurements (STP and r_j) be considered constant, at least during the exhaled duty cycle. The values of $\Delta CO'$ and $\Delta O'$ are averaged (to get ΔCO and ΔO), as described in the Software Description section. R_q reflects a single value, for the minute of data sampled.

APPENDIX B
PROGRAM FLOW DIAGRAM









APPENDIX C
PROGRAM LISTINGS

0001 C PROGRAM MRMS

0002 C 10 FORMAT (/,17X,

* 'M R M S',//,
 * 5X,'REAL-TIME TEST PROGRAM TO SUPPORT THE',//,
 * 5X,'METABOLIC-RATE-MEASUREMENT-SYSTEM',//,
 * 5X,'ENVIRONMENTAL PHYSIOLOGY LAB',//,
 * 5X,'TECHNOLOGY INCORPORATED ',//)

C KEN KOESTER

C REVISION 1

C TYPE

0003 C IMPLICIT LOGICAL (L)

0004 C LOGICAL*1 IYS,INO,ISTP,IANS

C SIZE

0005 C DIMENSION IDAT(3),INAM(15),IMOD(15)

0006 C DIMENSION CALPCT(2,2),PCTAMB(3),PCTEXH(3)

0007 C DIMENSION GASSLP(2),GSNTCP(2),GSGN(2)

0008 C DIMENSION GASCNT(4,2),GASSUM(2)

0009 C DIMENSION IVLVMD(5),IADCGC(5)

C COMMON

0010 C COMMON/PLOTR/LDATHD,MIN,O2CON,CO2PD,

* RESQ,TEMP,PRES,EXCNTR,LAvg,FLOW,ISCL

0011 C COMMON/TIME/SEC

C EXTERNAL TICK

C DATA

0013 C DATA IYS/1HY/,INO/1HN/,ISTP/1HS/,IRL/"07/

0014 C DATA IVLVMD/"01","02","04","10","14/

0015 C DATA IADCSR/"176770/,IADRUF/"176772/,IDRVBF/"167772/

0016 C DATA STPS/0./,O2SUM/0./,CO2SM/0./,CAMAX/0./

0017 C DATA AMCNT/0./,EXCNTR/0./,ONSUM/0./,CONSM/0./

0018 C DATA SEC/0./,MIN/0/

C READ DATA CONSTANTS

0019 C OPEN(UNIT=2,TYPE='OLD',NAME='DXD:DATCON,VAL')

0020 C READ(2,60)((CALPCT(I,J),J=1,2),I=1,2),

* (GSGN(I),I=1,2),(IADCGC(M),M=1,4)

C ISCL=2

C START PROG CLOCK

12 0022 C ISR=INTSET("104,4,0,TICK)

11 0023 C CALL IPOKE("172542,10000)

10 0024 C CALL IPOKE("172540,"113)

```

C
C   OPEN VALVES FOR VENTING
0025 CALL IPOKE(IDRVBF,IVLVMD(5))
C
C   TYPE HEADER & INSTRUCTIONS
0026 TYPE 10
0027 TYPE 12
0028 ACCEPT 13, IANS
0029 IF(IANS.EQ.IN0) GO TO 92
C
C   GET PHASE & BRANCH
0031 90 CONTINUE
0032 TYPE 14
0033 92 ACCEPT 15, IPHS
0034 IF(IPHS.GT.0) GO TO 94
0036 ACCEPT 15, IPHS
0037 94 GO TO (100,200,300,400,500) IPHS
C
C
C-----PHASE 1 DATA CONSTANTS
0038 100 CONTINUE
C
C   TYPE 50
0039 TYPE 50
C
C   CHECK GAS GAINS
0040 DO 110 I=1,2
0041 TYPE 52,I,GSGN(I)
0042 ACCEPT 13, IANS
0043 IF(IANS.NE.IYS) GO TO 110
0045 TYPE 54
0046 ACCEPT 53,VALUE
0047 GSGN(I)=VALUE
0048 110 CONTINUE
C
C   CHECK PROGRAMMABLE GAINS
0049 DO 120 M=1,4
0050 TYPE 56,M,IADCGC(M)
0051 ACCEPT 13, IANS
0052 IF(IANS.NE.IYS) GO TO 120
0054 TYPE 54
0055 ACCEPT 57,INT
0056 IADCGC(M)=INT
0057 120 CONTINUE
C
C   CHECK CAL-GAS %'S
0058 DO 130 I=1,2
0059 DO 130 J=1,2
0060 TYPE 58,I,J,CALPCT(I,J)
0061 ACCEPT 13, IANS
12 0062 IF(IANS.NE.IYS) GO TO 130
11 0064 TYPE 54
10 0065 ACCEPT 59,VALUE
9 0066 CALPCT(I,J)=VALUE
8 0067 130 CONTINUE
7
6
5
4
3

```

ORIGINAL PART II
OF PART 14100

```

C
C      SET SCALE VALUE
0068      TYPE 62
0069      ACCEPT 13, IANS
0070      IF (IANS.EQ.IY9) GO TO 140
0072      ISCL=1
0073      TYPE 63
0074      140 CONTINUE
C
C      END OF PHASE 1--GET NEW PHASE
0075      TYPE 22, IPHS
0076      GO TO 92
C
C
C-----PHASE 2  HEADER INFORMATION
0077      200 CONTINUE
0078      TYPE 16
0079      ACCEPT 17, (IDAT(M), M=1, 3)
0080      TYPE 18
0081      ACCEPT 19, (INAM(M), M=1, 15)
0082      TYPE 20
0083      ACCEPT 19, (IMOD(M), M=1, 15)
C
C      END OF PHASE 2--GET NEW PHASE
0084      TYPE 22, IPHS
0085      GO TO 92
C
C
C-----PHASE 3  CALIBRATION
0086      300 CONTINUE
C
0087      TYPE 24
C
0088      DO 315 K=1, 2
C
C      OPEN VALVE(K)--WAIT 30 SECONDS
0089      CALL IPOKE(IORVBE, IVLVMD(K))
0090      T=SEC
0091      303 DT=SEC-T
0092      IF(DT.LT.30.0) GO TO 303
C
C      ANALYZE EACH TYPE FOR 100 SAMPLES
0094      DO 315 J=1, 2
0095      GASSUM(J)=0.0
C
0096      DO 305 M=1, 100
0097      CALL IPOKE(IADCSR, IADCC(J))
0098      INT=IPEEK(IADBUF)
0099      GASSUM(J)=GASSUM(J)+FLOAT(INT)/GSGN(J)
12 0100      305 CONTINUE
11
10 0101      GASCNT(K, J)=GASSUM(J)/100.
9 0102      315 CONTINUE
8
7
6
5
4
3

```



```

C      GET SLOPES & INTERCEPTS
0103      DO 320 J=1,2
0104      GASSLP(J)=(CALPCT(2,J)-CALPCT(1,J))
          * / (GASCNT(2,J)-GASCNT(1,J))
0105      GSNTCP(J)=CALPCT(1,J)-(GASSLP(J)*GASCNT(1,J))
0106      320 CONTINUE

C
0107      TYPE 261
0108      TYPE 26,(GASCNT(I,1),I=1,2),GASSLP(1),GSNTCP(1)
0109      TYPE 262
0110      TYPE 26,(GASCNT(I,2),I=1,2),GASSLP(2),GSNTCP(2)

C
C      END OF PHASE 3--GET NEW PHASE
0111      CALL IPOKE(IDRVBF,IVLVMD(5))
0112      TYPE 22,IPMS
0113      GO TO 92

C
C
C      PHASE 4 TEST DATA
0114      400 CONTINUE

C
0115      TYPE 30
0116      ACCEPT 13, IANS

C
0117      TYPE 32,(INAM(J),J=1,15),(IDAT(J),J=1,3),(IMOD(J),J=1,15)
0118      LDATHD=.TRUE.
0119      LEXM=.FALSE.
0120      LAVG=.FALSE.
0121      MIN=0
0122      T=SEC

C
0123      402 IF(IANS.EQ.ISTP) GO TO 495

C
C      START TIMER
0125      405 DT=SEC-T

C
C      CHECK FOR USER REQUEST
0126      IANS=ITINR(DMY)
0127      IF(IANS.EQ.ISTP) GO TO 402
C      SET VALVE CONFIGURATION
0129      IV=4
0130      IF(DT.GT.15.) IV=3
0132      CALL IPOKE(IDRVBF,IVLVMD(IV))

C
C      CHECK TIME PHASE
0133      407 CONTINUE
0134      IF(DT.GT.7.) GO TO 415

C
C      DT<7: MAKE CALC'S &
C      PRINT RESULTS: THEN IDLE...
0136      IF(.NOT.LEXM) GO TO 405

C
12 0138      LEXM=.FALSE.
11
C
10 0139      O2CON=O2SUM/EXCNTR
9 0140      CO2PD=CO2SM/EXCNTR
8 0141      RESQ=CO2PD/O2CON
7
6
5
4
3

```

```

C
0142      O2SUM=0.
0143      CO2SM=0.
C
0144      CALL PLOT
D      TYPE 80,((PCTAMB(J),PCTEXH(J)),J=1,3),ONR,CNR,STP,FLOW
D 80     FORMAT(X,10F9,3)
0145      EXCNTR=0.
0146      LOATHD=.FALSE.
C
0147      GO TO 405
C
C      DT>7, CHECK NEXT PHASE
0148      415 CONTINUE
0149      IF(DT.GT.15.) GO TO 422
C      DT<15: COLLECT AMBIENT DATA
0151      LAMB=.TRUE.
0152      AMCNTR=AMCNTR+1.
C      GAS FRACTIONS
0153      DO 417 J=1,2
0154      CALL IPOKE(IADCSR,IADCGC(J))
0155      INT=IPEEK(IADBUF)
0156      GASCNT(3,J)=FLOAT(INT)/GSGN(J)
0157      PCTAMB(J)=(GASSLP(J)+GASCNT(3,J))+GSNTCP(J)
0158      417 CONTINUE
0159      PCTAMB(3)=100.0-PCTAMB(2)-PCTAMB(1)
0160      IF(CAMAX.LT.PCTAMB(2)) CAMAX=PCTAMB(2)
C      RATIO FACTORS
0162      ONSUM=ONSUM+(PCTAMB(1)/PCTAMB(3))
0163      CONSM=CONSM+(PCTAMB(2)/PCTAMB(3))
0164      PCTSM=PCTSM+PCTAMB(2)
C      TEMP
0165      CALL IPOKE(IADCSR,IADCGC(3))
0166      INT=IPEEK(IADBUF)
0167      TEMP=((4.885*FLOAT(INT))-5.)/10.
C      PRESS
0168      CALL IPOKE(IADCSR,IADCGC(4))
0169      INT=IPEEK(IADBUF)
0170      PRES=((4.8851*FLOAT(INT))+.0071)/10.
C
0171      STPP=(273.15/(273.15+TEMP))*PRES/760.
0172      STPS=STPS+STPP
C
0173      GO TO 405
C
C      DT>15, CHECK NEXT PHASE
0174      422 CONTINUE
0175      IF(DT.GT.22.) GO TO 460
C      DT<22: AVG. AMBIENT DATA:
12      C      ZERO INTEGRATORS; THEN IDLE...
11      0177      IF(.NOT.LAMB) GO TO 405
10
9      C      LAMB=.FALSE.
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0180 STP=STPS/AMCNTR
 0181 ONRAT=ONSUM/AMCNTR
 0182 CONRT=CONSM/AMCNTR
 0183 PCTCAV=PCTSM/AMCNTR
 0184 IF((GAMAX-PCTCAV).GT.2) LAVG=.TRUE.
 0186 IF(LAVG) TYPE 13,IBL

D ONR=ONRAT
 D CNR=CONRT
 C

0188 AMCNTR=0.
 0189 STPS=0.
 0190 ONSUM=0.
 0191 CONSM=0.
 0192 PCTSM=0.0
 0193 GAMAX=0.0

C
 0194 GO TO 405

C
 C DT>22, CHECK LAST PHASE

0195 460 CONTINUE
 0196 IF(DT.LT.60.) GO TO 462
 0198 T=T+60.
 0199 MIN=MIN+1
 0200 GO TO 405

C
 C DT<60.: COLLECT EXHALED DATA

0201 462 LEXM=.TRUE.
 0202 EXCNTR=EXCNTR+1.
 C GAS FRACTIONS
 0203 DO 467 J=1,2
 0204 CALL IPOKE(IADCSR,IADCC(J))
 0205 INT=IPEEK(IADRUF)
 0206 GASCNT(4,J)=FLOAT(INT)/GSCN(J)
 0207 PCTEXH(J)=(GASSLP(J)*GASCNT(4,J))+GSNTCP(J)
 0208 467 CONTINUE
 0209 PCTEXH(3)=100.0-PCTEXH(1)-PCTEXH(2)

C FLOW

0210 CALL IPOKE("167770,1)
 0211 IVAL=IPEEK("167774)
 0212 CALL IPOKE("167770,0)
 0213 FLOW=CON3CD(IVAL,1)*1.52

C
 0214 O2SUM=O2SUM+(STP*FLOW*((ONRAT*PCTEXH(3))-PCTEXH(1))*.01)
 0215 CO2SM=CO2SM+(STP*FLOW*(PCTEXH(2)-((CONRT*PCTEXH(3))))*.01)

C
 0216 GO TO 405

C
 C
 C 495 CONTINUE

0218 CALL IPOKE(IDRVBF,IVLVM(5))
 0219 TYPE 22,IPHS
 0220 ACCEPT 15,IPHS
 0221 IPHS=IPHS
 0222 GO TO 92

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C
C
C*****PHASE 5 TERMINATION
0223 500 CONTINUE
C
C*   STOP CLOCK
0224 CALL IPOKE("172540,"000)
C*
0225 TYPE 40
0226 CALL IPOKE(IDRVBF,"00)
C
C
0227 STOP 'BYE'
C
C
0228 12 FORMAT (X,'TO GET INSTRUCTION, ',
*         'TYPE Y & RETURN',/,X,
*         'TO PROCEED, TYPE N & RETURN ',S)
C
0229 13 FORMAT (A1)
C
0230 14 FORMAT (X,/,X,'TEST LOAD M-R-M-S HAS 5 PHASES',
*         //,5X,'1 DATA CONSTANTS--ALLOWS USER',
*         //,' MODIFICATION OF SELECTED DATA CONSTANTS',
*         //,' (GAS GAINS,CAL=GAS X'S, ETC.)',
*         //,' OTHERWISE PROGRAM USES DEFAULT VALUES.',
*         //,5X,'2 INITIALIZATION--ENTER HEADER INFORMATION',
*         //,5X,'3 CALIBRATE--DETERMINE SLOPES & INTERCEPTS',
*         //,' FOR DATA CURVES BY SAMPLING 2 CAL. GASES',
*         //,5X,'4 TEST-DATA--SAMPLES TEST-DATA CONTINUOUSLY',
*         //,' UNTIL USER TERMINATES',
*         //,5X,'5 TERMINATE--RETURNS CONTROL TO MONITOR',
*         //,3X,'VERIFY CAL GASES ARE OPEN',
*         //,3X,'AND MASS SPEC IS FUNCTIONAL',
*         ///,10X,'ENTER # & RETURN ',S)
C
0231 15 FORMAT (I1)
C
0232 16 FORMAT (X,/,/,10X,'PHASE 2 INITIALIZATION',/,/,
*         2X,'DATE : (MM/DD/YY) ',S)
C
0233 17 FORMAT (I2,X,I2,X,I2)
C
0234 18 FORMAT (2X,'SUBJECT NAME : ',S)
C
0235 19 FORMAT (15A2)
C
0236 20 FORMAT (2X,'TEST NO. ',S)
C
0237 22 FORMAT (X,/,5X,'END OF PHASE ',I3,/,
*         ' ENTER NEW PHASE # ',S)
C
0238 24 FORMAT(X,/,/,10X,'PHASE 3 CALIBRATION')

```

0239 26 FORMAT(4X,'CTR-1',4X,'CTR-2',9X,'SLOPE',
 * 7X,'INTCPT',/,2(3X,F8.2),2X,2(3X,F9.3))

0240 261 FORMAT(/,22X,'OXYGEN')

0241 262 FORMAT(/,18X,'CARBON DIOXIDE')

0242 C 30 FORMAT(X,/,10X,'PHASE 4 TEST-DATA',
 * /,5X,'TO INITIATE:',
 * /,5X,'ADVANCE PAGE AS DESIRED,',
 * /,5X,'THEN RETURN.',
 * /,5X,'TERMINATE AT ANY TIME',
 * /,5X,'BY ENTERING 8 & RETURN.',S)

0243 C 32 FORMAT(X,'NAME: ',15A2,15X,'DATE: ',
 * 2(I2,'/'),I2,15X,'TEST MODE: ',15A2)

0244 C 40 FORMAT (X,/,10X,'END OF REAL-TIME TEST',
 * /,5X,'CONTROL RETURNS TO SYS. MONITOR...',
 * //,5X,'BE SURE TO CLOSE CAL GASES',
 * /,5X,'AND RETURN MASS SPEC TO STANDBY')

0245 C 50 FORMAT(X,/,10X,'PHASE 1 DATA CONSTANTS',
 * /,5X,'TO LEAVE VALUE UNCHANGED, ENTER',
 * /,5X,'N & RETURN. TO CHANGE ENTER Y',
 * /,5X,'8 RETURN, GET "NEW VALUE" PROMPT',
 * /,5X,'ENTER NEW VALUE & RETURN.',/)

0246 C 52 FORMAT(5X,'GSGN('',I1,')=',F4.1,S)

0247 C 54 FORMAT(3X,'NEW VALUE =',S)

0248 C 53 FORMAT(F4.1)

0249 C 56 FORMAT(5X,'IADCGC('',I1,')=',.05,S)

0250 C 57 FORMAT(05)

0251 C 58 FORMAT(5X,'CALPCT('',I1,'.',',I1,')=',F6.2,S)

0252 C 59 FORMAT(F6.2)

0253 C 60 FORMAT(4F6.2,2F4.1,405)

0254 C 62 FORMAT(5X,'SET SCALE = 0=5 ? ',S)

0255 C 63 FORMAT(5X,'SCALE SET = 0=5. 1')

0256 C END

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FORTRAN IV STORAGE MAP FOR PROGRAM UNIT MRMS

LOCAL VARIABLES, PSECT SDATA, SIZE = 000636 (207. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
AMCNTR	R*4	000332	CAMAX	R*4	000326	CONRT	R*4	000546
CONSM	R*4	000342	CO2SM	R*4	000322	DMY	R*4	000514
DT	R*4	000504	I	I*2	000456	IADBUF	I*2	000306
IADCSR	I*2	000304	IANS	L*1	000454	IBL	I*2	000302
IDRVBF	I*2	000310	INO	L*1	000277	INT	I*2	000474
IPMS	I*2	000466	ISR	I*2	000464	ISTP	L*1	000300
IV	I*2	000520	IVAL	I*2	000556	IYS	L*1	000276
J	I*2	000460	K	I*2	000476	LAMB	L*4	000522
LEXH	L*4	000510	M	I*2	000462	ONRAT	R*4	000542
ONSUM	R*4	000336	O2SUM	R*4	000316	PCTCAV	R*4	000552
PCTSM	R*4	000526	STP	R*4	000536	STPP	R*4	000532
STPS	R*4	000312	T	R*4	000500	VALUE	R*4	000470

COMMON BLOCK /PLOT /, SIZE = 000050 (20. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
LDATHD	L*4	000000	MIN	I*2	000004	O2CON	R*4	000006
CO2PD	R*4	000012	RESO	R*4	000016	TEMP	R*4	000022
PRES	R*4	000026	EXCNTR	R*4	000032	LAVG	L*4	000036
FLOW	R*4	000042	ISCL	I*2	000046			

COMMON BLOCK /TIME /, SIZE = 000004 (2. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
SEC	R*4	000000						

LOCAL AND COMMON ARRAYS:

NAME	TYPE	SECTION	OFFSET	*****SIZE*****	DIMENSIONS
CALPCT	R*4	VEC	SDATA	000102	000020 (8.) (2,2)
GASCNT	R*4	VEC	SDATA	000202	000040 (16.) (4,2)
GASSLP	R*4		SDATA	000152	000010 (4.) (2)
GASSUM	R*4		SDATA	000242	000010 (4.) (2)
GSGN	R*4		SDATA	000172	000010 (4.) (2)
GSNTCP	R*4		SDATA	000162	000010 (4.) (2)
IADCGC	I*2		SDATA	000264	000012 (5.) (5)
IDAT	I*2		SDATA	000000	000006 (3.) (3)
IMOD	I*2		SDATA	000044	000036 (15.) (15)
INAM	I*2		SDATA	000006	000036 (15.) (15)
IVLVMD	I*2		SDATA	000252	000012 (5.) (5)
PCTAMB	R*4		SDATA	000122	000014 (6.) (3)
PCTEXH	R*4		SDATA	000136	000014 (6.) (3)

SUBROUTINES, FUNCTIONS, STATEMENT AND PROCESSOR-DEFINED FUNCTIONS:

	NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE
12	CONBCD	R*4	FLOAT	R*4	INSET	I*2	IPEEK	I*2	IPOKE	I*2
11	ITTINR	I*2	PLOT	R*4	TICK	R*4				
10										
9										
8										
7										
6										
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3										

0001 SUBROUTINE TICK(ID)

0002 COMMON/TIME/SEC

0003 SEC=SEC+1.

0004 RETURN

0005 END

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FORTRAN IV STORAGE MAP FOR PROGRAM UNIT TICK

LOCAL VARIABLES, .PSECT SDATA, SIZE = 000002 (1. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
ID	I*2	000000						

COMMON BLOCK /TIME /, SIZE = 000004 (2. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
SEC	R*4	000000						

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0001      SUBROUTINE PLOT
      C
0002      LOGICAL LDATHD,LAVG
0003      LOGICAL*1 ISCAL,IBL,IMN,IO,IC,IST,IBL,IGD
      C
0004      DIMENSION ISCAL(56),SCAL(2)
      C
0005      COMMON/PL0TR/LDATHD,MIN,O2CON,CO2PD,
      *      RESQ,TEMP,PRESS,EXCNTR,LAVG,FLOW,ISCL
      C
0006      DATA IPL/1H+/,IMN/1H-/,IBL/1H /
0007      DATA IO/1MO/,IC/1MC/,IST/1H*/
0008      DATA OXYPR/0.0/,CO2PR/0.0/,RSQPR/0.0/
0009      DATA SCAL/10.0,100.0/
      C
      C      PRINT COL. TITLES ONCE
0010      IF(.NOT.LDATHD) GO TO 8
0012      GO TO (10,100) ISCL
0013      10 TYPE 11
0014      GO TO 4
0015      100 TYPE 101
      C      GO TO 4
0016      4 CONTINUE
0017      RMIN=0.0
      C
      C      SET SCALE LINE BY BRUTE FORCE
0018      DO 5 I=1,56
0019      5 ISCAL(I)=IMN
0020      DO 6 I=1,51,10
0021      6 ISCAL(I)=IPL
      C
0022      8 CONTINUE
0023      ODIS=(O2CON*SCAL(ISCL))+.5
0024      IC=IFIX(ODIS)+1
      C
0025      CDIS=(CO2PD*SCAL(ISCL))+.5
0026      JC=IFIX(CDIS)+1
      C
0027      ISV1=ISCAL(JO)
0028      ISV2=ISCAL(JC)
0029      ISCAL(JO)=IO
0030      ISCAL(JC)=IC
      C
0031      IF(JC.EQ.JO) ISCAL(JO)=IST
      C
0033      IGD=IBL
0034      IF(LAVG) IGD=IST
0036      TYPE 20,MIN,TEMP,PRESS,FLOW,O2CON,CO2PD,RESQ,
      *      IGD,(ISCAL(J),J=1,56),EXCNTR
0037      ISCAL(JO)=ISV1
0038      ISCAL(JC)=ISV2
      C
0039      IF(LAVG) GO TO 9
0041      RMIN=RMIN+.1,0

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0042      OXYPR=OXYPR+O2CON
0043      CO2PR=CO2PR+CO2PO
0044      RSOPR=RSOPR+RESO
      C
0045      IF(RMIN.LT.15.0) RETURN
0047      OXYAVG=OXYPR/RMIN
0048      CO2AVG=CO2PR/RMIN
0049      RSOAVG=RSOPR/RMIN
      C
0050      OXYPR=0.
0051      CO2PR=0.
0052      RSOPR=0.
0053      RMIN=0.
      C
0054      TYPE 30,OXYAVG,CO2AVG,RSOAVG
      C
0055      9 CONTINUE
0056      LAVG=.FALSE.
0057      RETURN
      C
0058      11 FORMAT(/,1X,'MIN T(CG) P(MG) F(L/M) O2-CON',
      *      ' CO2-PO RES=0',5X,'0',AX,'1',AX,'2',
      *      AX,'3',AX,'4',AX,'5',7X,'SMPLS')
      C
0059      101 FORMAT(/,1X,'MIN T(CG) P(MG) F(L/M) O2-CON',
      *      ' CO2-PO RES=0',5X,'0',AX,'1',AX,'2',
      *      AX,'3',AX,'4',AX,'5',7X,'SMPLS')
      C
0060      20 FORMAT(2X,I2,3(1X,F5.1),X,3(2X,F6.3),4X,1A1,
      *      5A1,3X,F5.0,/)
      C
0061      30 FORMAT(5X,'15-MIN. AVERAGES ',3(2X,F6.3),/)
      C
0062      END

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LOCAL VARIABLES, .PSECT \$DATA, SIZE = 000210 (68. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
COIS	R*4	000146	CO2AVG	R*4	000166	CO2PR	R*4	000112
I	I*2	000136	IRL	L*1	000102	IC	L*1	000104
IGD	L*1	000130	IMN	L*1	000101	IO	L*1	000103
IPL	L*1	000100	IST	L*1	000105	ISV1	I*2	000154
ISV2	I*2	000156	J	I*2	000100	JC	I*2	000152
JO	I*2	000144	ODIS	R*4	000140	OXYAVG	R*4	000162
OXYPR	R*4	000106	RMIN	R*4	000132	RSCAVG	R*4	000172
RSQPR	R*4	000116						

COMMON BLOCK /PLOT/ , SIZE = 000050 (20. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
LDATE	L*4	000000	MIN	I*2	000004	O2CON	R*4	000006
CO2PD	R*4	000012	RESO	R*4	000016	TEMP	R*4	000022
PRESS	R*4	000026	EXCNTR	R*4	000032	LAVG	L*4	000036
FLOW	R*4	000042	ISCL	I*2	000046			

LOCAL AND COMMON ARRAYS:

NAME	TYPE	SECTION	OFFSET	SIZE	DIMENSIONS
ISCAL	L*1	\$DATA	000000	000070 (28.)	(56)
SCAL	R*4	\$DATA	000070	000010 (4.)	(2)

SUBROUTINES, FUNCTIONS, STATEMENT AND PROCESSOR-DEFINED FUNCTIONS:

NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE
IFIX	I*2						

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```
0001      FUNCTION CONBCD(IVAL,NDD)
          C
0002      IBCD=IVAL
0003      IONE=(IBCD.AND."000017)
0004      I1=IONE
          C
0005      IBCD=IBCD/16
0006      ITEN=(IBCD.AND."000017)
0007      I10=ITEN*10
          C
0008      IBCD=IBCD/16
0009      IHUN=(IBCD.AND."000017)
0010      I100=IHUN*100
          C
0011      IBCD=IBCD/16
0012      ITOU=(IBCD.AND."000017)
0013      I1000=ITOU*1000
          C
0014      ITOT=(I1000+I100+I10+I1)
0015      DEC=10.**NDD
          C
0016      CONBCD=FLOAT(ITOT)/DEC
          C
0017      RETURN
0018      END
```

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FORTRAN IV STORAGE MAP FOR PROGRAM UNIT CONRCD

LOCAL VARIABLES, .PSECT \$DATA, SIZE = 000040 (16. WORDS)

NAME	TYPE	OFFSET	NAME	TYPE	OFFSET	NAME	TYPE	OFFSET
CONBCD	R*4	000004	EQV DEC	R*4	000034	IBCD	I*2	000010
IHUN	I*2	000022	IONE	I*2	000012	ITEN	I*2	000016
ITOT	I*2	000032	ITOU	I*2	000026	IVAL	I*2	000000
I1	I*2	000014	I10	I*2	000020	I100	I*2	000024
I1000	I*2	000030	NDD	I*2	000002			

SUBROUTINES, FUNCTIONS, STATEMENT AND PROCESSOR-DEFINED FUNCTIONS:

NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE	NAME	TYPE
FLOAT	R*4								

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RT-11 LINK 005.000 LOAD MAP MON 31-MAR-80 10:15:30
 ENVIRE.SAV TITLE: MMS IDENT: FORV02

SECTION ADDR SIZE GLOBAL VALUE GLOBAL VALUE GLOBAL VALUE

. ARS. 000000 001000 (RW,I,GLOBAL,ABS,OVH)

\$RF2A1 000000 .VIR 000000 \$USRSW 000001
 \$NLCHN 000006 \$HRDWR 000006 \$SYSVS 000011
 \$WASIZ 000152 \$LRECL 000210 \$TRACE 004737

DTSSI 001000 021744 (RW,I,LCL,REL,CON)

\$SOTSI 001000 ADFSIM 001000 ADFSPM 001006
 ADFSMM 001012 ADFSMM 001022 SUFSIM 001042
 SUFSMM 001050 SUFSPM 001100 SUFSMM 001104
 \$CVTFB 001134 \$CVTFI 001134 \$CVTCB 001150
 \$CVTCI 001150 \$CVTOB 001150 \$CVTDI 001150
 CICS 001162 CIDS 001162 CLCS 001162
 CLDS 001162 SDI 001162 CIFS 001172
 CLFS 001172 \$RI 001172 CILS 001300
 CLIS 001304 \$CVTIF 001306 \$CVTIC 001322
 \$CVTID 001322 CCIS 001334 CDIS 001334
 \$IC 001334 \$ID 001334 CFIS 001350
 \$IR 001350 RCIS 001434 GCOS 002450
 FCOB 002456 ECOB 002462 DCOB 002470
 DIFBPS 003412 DIFBMS 003416 DIFBIS 003430
 \$DIVF 003436 DIFBSS 003450 \$DVR 003450
 DIIBPS 003454 DIIBMS 003462 DIIBIS 003466
 DIIBSS 003470 \$DVI 003470 MUIBPS 003512
 MUIBMS 003520 MUIBIS 003524 MUIBSS 003526
 \$MLI 003526 \$OTI 003574 \$SOTI 003576
 \$SSET 005456 \$XFI 005752 XFIS 005764
 \$PARI 005764 IORS 006242 ANDB 006246
 EQVB 006254 XORS 006256 OCIS 006272
 ICIS 006300 SECI 006314 OCOS 006474
 ICOB 006502 \$CHKR 006700 \$IOEXI 006724
 \$EOL 006752 EOLB 006754 MOFBIS 007070
 MOFBOS 007076 MOFBMS 007104 MOFBSP 007114
 ADIBSS 007120 ADIBSA 007124 ADIBSM 007130
 ADIBIS 007134 ADIBIA 007140 ADIBIM 007144
 ADIBMS 007150 ADIBMA 007154 ADIBMM 007160
 IFRB 007164 \$IFR 007170 \$SIFR 007174
 IFRBS 007226 IFBS 007250 \$IFW 007254
 \$SIFA 007260 IFBS 007316 MOIBSS 007366
 MOIBSS 007366 MOIBSM 007372 MOIBSA 007376
 MOIBIS 007402 MOIBIS 007402 RELB 007402
 MOIBIM 007406 MOIBIA 007412 MOIBMS 007416
 MOIBMM 007422 MOIBMA 007426 MOIBOS 007432
 MOIBOM 007436 MOIBOA 007442 MOIBIS 007446
 MOIBIM 007454 MOIBIA 007462 MOIBIP 007470
 MOIBSP 007472 MOIBPP 007500 MOIBMP 007504
 MOIBPS 007514 MOIBPM 007522 MOIBPA 007530
 MOIBOP 007536 MOIBIP 007544 ISNB 007554
 \$ISNTR 007560 LSNB 007574 \$LSNTR 007600
 \$OSTMI 007734 \$OSTM 007740 RETSL 011056
 RETSF 011062 RETSI 011070 RETS 011072
 \$STPS 011126 STPS 011134 \$STP 011134
 \$FOOS 011140 \$EXIT 011160 \$OTIS 011304
 \$SOTIS 011306 TVLS 011426 \$TVL 011426
 TVFS 011434 \$TVF 011434 TVDS 011442
 \$TVD 011442 TVGS 011450 \$TVQ 011450
 TVPS 011456 \$TVP 011456 TVIS 011464
 \$TVI 011464 MUIBPS 011620 MUIBMS 011624
 MUIBIS 011636 \$MULF 011644 MUIBSS 011656

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			\$FRMS 012433	\$FCMNL 016126	\$FIO 016762
			\$SFIO 016766	\$GETFI 020116	\$INITI 020154
			\$SOPCL 020266	\$SERR 020400	\$SODIS 020422
			\$PUTRE 020520	\$RRS 021026	\$IRR 021032
			\$RAS 021056	\$IRW 021062	\$GETIN 021436
			\$SETIN 021454	\$DFS 021562	\$DEF 021566
			\$PUTBL 021656	\$GETBL 022066	\$EOPIL 022252
			\$EOPF2 022266	\$AVRGS 022306	\$THRS 022464
			\$WAIT 022466	\$VPRINT 022530	\$DUMPL 022532
			\$AVR4\$ 022660		
OTS\$P	022744	000050	(RW,D,GAL,REL,OVR)		
SYS\$I	023014	000350	(RW,I,LCL,REL,CON)		
			INTSET 023014	IPEEK 023216	IPOKE 023226
			ITTINR 023236	SCMPLT 023246	
USER\$I	023364	000000	(RW,I,LCL,REL,CON)		
SCODE	023364	013420	(RW,I,LCL,REL,CON)		
			\$SOTSC 023364	TICK 034506	PLOT 034532
			CONBCD 036434		
OTS\$O	037004	001040	(RW,I,LCL,REL,CON)		
			\$SOTSO 037004	\$OPEN 037004	
SYS\$D	040044	000366	(RW,I,LCL,REL,CON)		
\$DATAP	040432	004224	(RW,D,LCL,REL,CON)		
OTS\$D	044656	000052	(RW,D,LCL,REL,CON)		
OTS\$S	044730	000002	(RW,D,LCL,REL,CON)		
			\$AGTS 044730		
SYS\$S	044732	000066	(RW,D,LCL,REL,CON)		
			\$SYSLB 045014	\$LOCK 045016	\$CRASH 045017
\$DATA	045020	001110	(RW,D,LCL,REL,CON)		
USER\$D	046130	000000	(RW,D,LCL,REL,CON)		
.\$\$\$\$	046130	000000	(RW,D,GAL,REL,OVR)		
PLOTR	046130	000050	(RW,D,GAL,REL,OVR)		
TIME	046200	000004	(RW,D,GAL,REL,OVR)		
	046204	000210	(RW,I,LCL,REL,CON)		
			\$GETRE 046204	\$TTYIN 046260	

TRANSFER ADDRESS = 023364, HIGH LIMIT = 046414 = 9862. WORDS

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T-11 LINK U05.04A Load Map Mon 31-Mar-80 10:15:30
 ENVIRE.SAV Title: MRMS Ident: FORV02

Section	Addr	Size	Global	Value	Global	Value	Global	Value
. ABS.	000000	001000	(RW,I,GBL,ABS,OVR)					
			\$RF2A1	000000	.VIR	000000	\$USRSW	000001
			\$NLCHN	000006	\$HRDWR	000006	\$SYSV\$	000011
			\$WASIZ	000152	\$LRECL	000210	\$TRACE	004737
DTS\$I	001000	021744	(RW,I,LCL,REL,CON)					
			\$\$OTSI	001000	ADF\$IM	001000	ADF\$PM	001006
			ADF\$MM	001012	ADF\$SM	001022	SUF\$IM	001042
			SUF\$SM	001050	SUF\$PM	001100	SUF\$MM	001104
			\$CVTFB	001134	\$CVTFI	001134	\$CVTCB	001150
			\$CVTCI	001150	\$CVTDB	001150	\$CVTDI	001150
			CIC\$	001162	CID\$	001162	CLC\$	001162
			CLD\$	001162	\$DI	001162	CIF\$	001172
			CLF\$	001172	\$RI	001172	CIL\$	001300
			CLI\$	001304	\$CVTIF	001306	\$CVTIC	001322
			\$CVTID	001322	CCI\$	001334	CDI\$	001334
			\$IC	001334	\$ID	001334	CFI\$	001350
			\$IR	001350	RCI\$	001434	GCO\$	002450
			FCO\$	002456	ECO\$	002462	DCO\$	002470
			DIF\$PS	003412	DIF\$MS	003416	DIF\$IS	003430
			\$DIVF	003436	DIF\$SS	003450	\$DVR	003450
			DII\$PS	003454	DII\$MS	003462	DII\$IS	003466
			DII\$SS	003470	\$DVI	003470	MUI\$PS	003512
			MUI\$MS	003520	MUI\$IS	003524	MUI\$SS	003526
			\$MLI	003526	\$OTI	003574	\$\$OTI	003576
			\$\$SET	005456	\$XFI	005752	XFI\$	005764
			\$PWRI	005764	IOR\$	006242	AND\$	006246
			EQV\$	006254	XOR\$	006256	OCI\$	006272
			ICI\$	006300	\$ECI	006314	OCO\$	006474
			ICD\$	006502	\$CHKR	006700	\$IDEXI	006724
			\$EOL	006752	EOL\$	006754	MOF\$IS	007070
			MOF\$OS	007076	MOF\$SM	007104	MOF\$SP	007114
			ADI\$SS	007120	ADI\$SA	007124	ADI\$SM	007130
			ADI\$IS	007134	ADI\$IA	007140	ADI\$IM	007144
			ADI\$MS	007150	ADI\$MA	007154	ADI\$MM	007160
			IFR\$	007164	\$IFR	007170	\$\$IFR	007174
			IFR\$\$	007226	IFW\$	007250	\$IFW	007254
			\$\$IFW	007260	IFW\$\$	007316	MOI\$SS	007366
			MOL\$SS	007366	MOI\$SM	007372	MOI\$SA	007376
			MOI\$IS	007402	MOL\$IS	007402	REL\$	007402
			MOI\$IM	007406	MOI\$IA	007412	MOI\$MS	007416
			MOI\$MM	007422	MOI\$MA	007426	MOI\$OS	007432
			MOI\$OM	007436	MOI\$OA	007442	MOI\$IS	007446
			MOI\$IM	007454	MOI\$IA	007462	MOI\$IP	007470
			MOI\$SP	007472	MOI\$FP	007500	MOI\$MP	007504
			MOI\$PS	007514	MOI\$PM	007522	MOI\$PA	007530
			MOI\$OP	007536	MOI\$1P	007544	ISN\$	007554
			\$ISNTR	007560	LSN\$	007574	\$LSNTR	007600
			\$OSTMI	007734	\$OSTM	007740	RET\$L	011056
			RET\$F	011062	RET\$I	011070	RET\$	011072
			\$STPS	011126	STP\$	011134	\$STP	011134
			FOO\$	011140	\$EXIT	011160	\$OTIS	011304
			\$\$OTIS	011306	TVL\$	011426	\$TVL	011426
			TVF\$	011434	\$TVF	011434	TVD\$	011442
			\$TVD	011442	TVQ\$	011450	\$TVQ	011450
			TVP\$	011456	\$TVP	011456	TVI\$	011464
			\$TVI	011464	MUF\$PS	011620	MUF\$MS	011624
			MUF\$IS	011636	\$MULF	011644	MUF\$SS	011656
			\$MLR	011656	\$CLOSE	011662	\$ERRTB	012326
			\$ERRS	012433	\$FCHNL	016126	\$FIO	016762

			\$\$\$FIU	016766		\$\$\$DEFI	020116	\$\$\$INITI	020154
			\$\$\$OPCL	020266		\$\$\$ERR	020400	\$\$\$DIS	020422
			\$\$\$PUTRE	020520		IRR\$	021026	\$\$\$IRR	021032
			IRW\$	021056		\$\$\$IRW	021062	\$\$\$GETIN	021436
			\$\$\$SETIN	021454		DEF\$	021562	\$\$\$DEF	021566
			\$\$\$PUTRL	021656		\$\$\$GETRL	022066	\$\$\$EOFIL	022252
			\$\$\$EOF2	022266		SAVRG\$	022306	THRD\$	022464
			\$\$\$WAIT	022466		\$\$\$VRINT	022530	\$\$\$DUMPL	022532
			SAVR4\$	022660					
DTS\$P	022744	000050				(RW,D,GBL,REL,OVR)			
SYS\$I	023014	000350				(RW,I,LCL,REL,CON)			
			INTSET	023014	IPEEK	023216	IPOKE	023226	
			ITTRIN	023236	\$\$\$CHPLT	023246			
USER\$I	023364	000000				(RW,I,LCL,REL,CON)			
\$\$\$CODE	023364	013420				(RW,I,LCL,REL,CON)			
			\$\$\$OTSC	023364	TICK	034506	PLOT	034532	
			CONBCD	036434					
OTS\$O	037004	001040				(RW,I,LCL,REL,CON)			
			\$\$\$OTSO	037004	\$\$\$OPEN	037004			
SYS\$O	040044	000366				(RW,I,LCL,REL,CON)			
\$\$\$DATAP	040432	004224				(RW,D,LCL,REL,CON)			
OTS\$D	044656	000052				(RW,D,LCL,REL,CON)			
OTS\$\$	044730	000002				(RW,D,LCL,REL,CON)			
			\$\$\$AOTS	044730					
SYS\$\$	044732	000066				(RW,D,LCL,REL,CON)			
			\$\$\$SYSLB	045014	\$\$\$LOCK	045016	\$\$\$CRASH	045017	
\$\$\$DATA	045020	001110				(RW,D,LCL,REL,CON)			
USER\$D	046130	000000				(RW,D,LCL,REL,CON)			
\$\$\$\$.	046130	000000				(RW,D,GBL,REL,OVR)			
PLOTR	046130	000050				(RW,D,GBL,REL,OVR)			
TIME	046200	000004				(RW,D,GBL,REL,OVR)			
	046204	000210				(RW,I,LCL,REL,CON)			
			\$\$\$GETRE	046204	\$\$\$TTYIN	046260			

Transfer address = 023364, High limit = 046414 = 9862. words

APPENDIX D
TERMINAL PRINTOUT

9DX
RT-11BJ (S)103B-00

.SET TT:SCOPE

.SET USR NO\$MAP

.ASS D11 BK

.RUN DX\$ENVIRE.SAV

M R N S

REAL-TIME TEST PROGRAM TO SUPPORT THE
METABOLIC-RATE-MEASUREMENT-SYSTEM,
ENVIRONMENTAL PHYSIOLOGY LAB,
TECHNOLOGY INCORPORATED

TO GET INSTRUCTION, TYPE Y & RETURN
TO PROCEED, TYPE N & RETURN Y

45

TEST LOAD M-R-N-S HAS 3 PHASES

1 DATA CONSTANTS--ALLOWS USER
MODIFICATION OF SELECTED DATA CONSTANTS
(GAS GAINS,CAL-GAS I'S, ETC.).
OTHERWISE PROGRAM USES DEFAULT VALUES.

2 INITIALIZATION--ENTER HEADER INFORMATION

3 CALIBRATE--DETERMINE SLOPES & INTERCEPTS
FOR DATA CURVES BY SAMPLING 2 CAL. GASES

4 TEST-DATA--SAMPLES TEST-DATA CONTINUOUSLY
UNTIL USER TERMINATES

5 TERMINATE--RETURNS CONTROL TO MONITOR

VERIFY CAL GASES ARE OPEN
AND MASS SPEC IS FUNCTIONAL

ENTER N & RETURN 1

SE 1 DATA CONSTANTS
 TO LEAVE VALUE UNCHANGED, ENTER
 N & RETURN. TO CHANGE ENTER Y
 & RETURN. GET "NEW VALUE" PROMPT,
 ENTER NEW VALUE & RETURN

```

09GN(1)= 1.0M
09GN(2)= 1.0M
IADCOC(1)= " 431M
IADCOC(2)= " 1031M
IADCOC(3)= " 2001M
IADCOC(4)= " 2401M
CALPCT(1,1)= 14.29N
CALPCT(1,2)= 4.87N
CALPCT(2,1)= 20.60N
CALPCT(2,2)= 0.06Y
NEW VALUE =.05
SET SCALE = 0-.5 T N
SCALE SET = 0-5. 1
  
```

These parameters are read from a data file, DATCON .VAL
 prior to any program execution. Phase 1 allows the user to alter
 these values if necessary.
 GSGN(j) → The gain factor to correct for any hardware gains
 or A/D programmable gains.
 IADCGC(k) → Octal code used to program the A/D converter.
 Contains channel selection and gain information. Refer to ADAC
 1030 User's Manual.
 CALPCT(i,j) → cal gas concentrations.

END OF PHASE 1
 ENTER NEW PHASE # 2

PHASE 2 INITIALIZATION

DATE : (MM/DD/YY) 03/28/80
 SUBJECT NAME : KEN KOESTER
 TEST NO. TESTMODE

END OF PHASE 2
 ENTER NEW PHASE # 3

PHASE 3 CALIBRATION

CTS-1	CTS-2	OXIDEN	SLOPE	INTCPT
291.43	415.17		0.051	-0.571
CARBON DIOXIDE				
CTS-1	CTS-2		SLOPE	INTCPT
996.79	14.83		0.005	-0.023

END OF PHASE 3
 ENTER NEW PHASE # 4

PHASE 4 TEST-DATA
TO INITIATE:
ADVANCE PAGE AS DESIRED,
THEN RETURN.
TERMINATE AT ANY TIME
BY ENTERING 8 & RETURN.

NAME: KEN KOESTER

DATE: 3/28/80

TEST NO: TESTMODE

	0.	1.	2.	3.	4.	5.	SAMPLS
MIX T(C) P(M) F(L/M)	02-COM	RES-0					3913.
1 26.1 766.0 116.7	1.045	0.806	0.771				
2 26.1 763.1 120.2	1.075	0.886	0.824				3915.
3 26.2 768.9 116.1	0.637	0.597	0.938				3909.
4 25.7 765.5 110.5	0.302	0.302	0.997				3910.
5 26.2 765.5 119.0	0.435	0.488	1.121				3909.
6 26.6 771.4 112.2	0.558	0.503	0.901				3909.
7 26.2 764.0 111.0	0.594	0.471	0.793				3909.
8 26.6 770.4 110.7	0.468	0.428	0.916				3904.
9 27.5 768.9 115.2	0.388	0.357	0.919				3907.
10 26.6 767.4 110.2	0.427	0.397	0.929				3905.
11 27.0 766.0 111.0	0.382	0.319	0.836				3911.
12 26.8 773.8 108.7	0.404	0.341	0.844				3906.
13 26.9 761.1 112.6	0.482	0.447	0.928				3906.
14 27.1 770.9 118.6	0.369	0.352	0.954				3908.
15-MIN. AVERAGES	0.559	0.491	0.911				
15 26.9 767.9 108.7	0.441	0.425	0.964				3909.
16 26.6 766.0 112.0	0.431	0.362	0.839				3908.
17 27.0 765.0 123.0	0.711	0.641	0.901				3913.
18 26.9 766.5 93.5	1.821	1.405	0.771				3915.
19 26.5 758.2 96.1	2.228	2.149	0.964				3914.
20 28.5 753.3 97.0	2.370	2.475	1.044				3920.
21 27.3 766.5 109.6	2.548	2.696	1.058				3916.
22 27.2 765.0 117.6	2.668	2.861	1.076				3918.

23	27.1	746.0	122.4	1.937	2.399	1.239	+	-----	0	-----	+	3927.	
24	26.5	767.9	85.3	2.805	2.901	1.034	+	-----	0	-----	+	3923.	
25	27.0	767.9	97.9	1.267	1.981	1.564	+	-----	0	-----	+	3922.	
26	27.1	767.9	101.4	0.904	1.324	1.465	+	-----	0	-----	+	3918.	
27	27.4	763.1	121.6	0.703	0.977	1.309	+	-----	0	-----	+	3911.	
28	27.4	767.0	123.6	0.687	0.854	1.244	+	-----	0	-----	+	3911.	
29	27.2	745.5	123.4	0.461	0.764	1.155	+	-----	0	-----	+	3912.	
	15-MIN. AVERAGES												
30	27.3	781.6	122.5	0.435	0.693	1.093	+	-----	0	-----	+	3914.	
31	26.6	767.4	103.4	0.649	0.680	1.048	+	-----	0	-----	+	3917.	
32	27.5	766.0	171.2	0.545	0.519	0.953	+	-----	0	-----	+	3908.	
33	27.2	767.0	120.2	0.582	0.535	0.920	+	-----	0	-----	+	3909.	
34	27.4	768.4	114.0	0.554	0.492	0.893	+	-----	0	-----	+	3910.	

END OF PHASE 4
ENTER NEW PHASE 0 5

END OF REAL-TIME TEST
CONTROL RETURNS TO SYS. MONITOR...

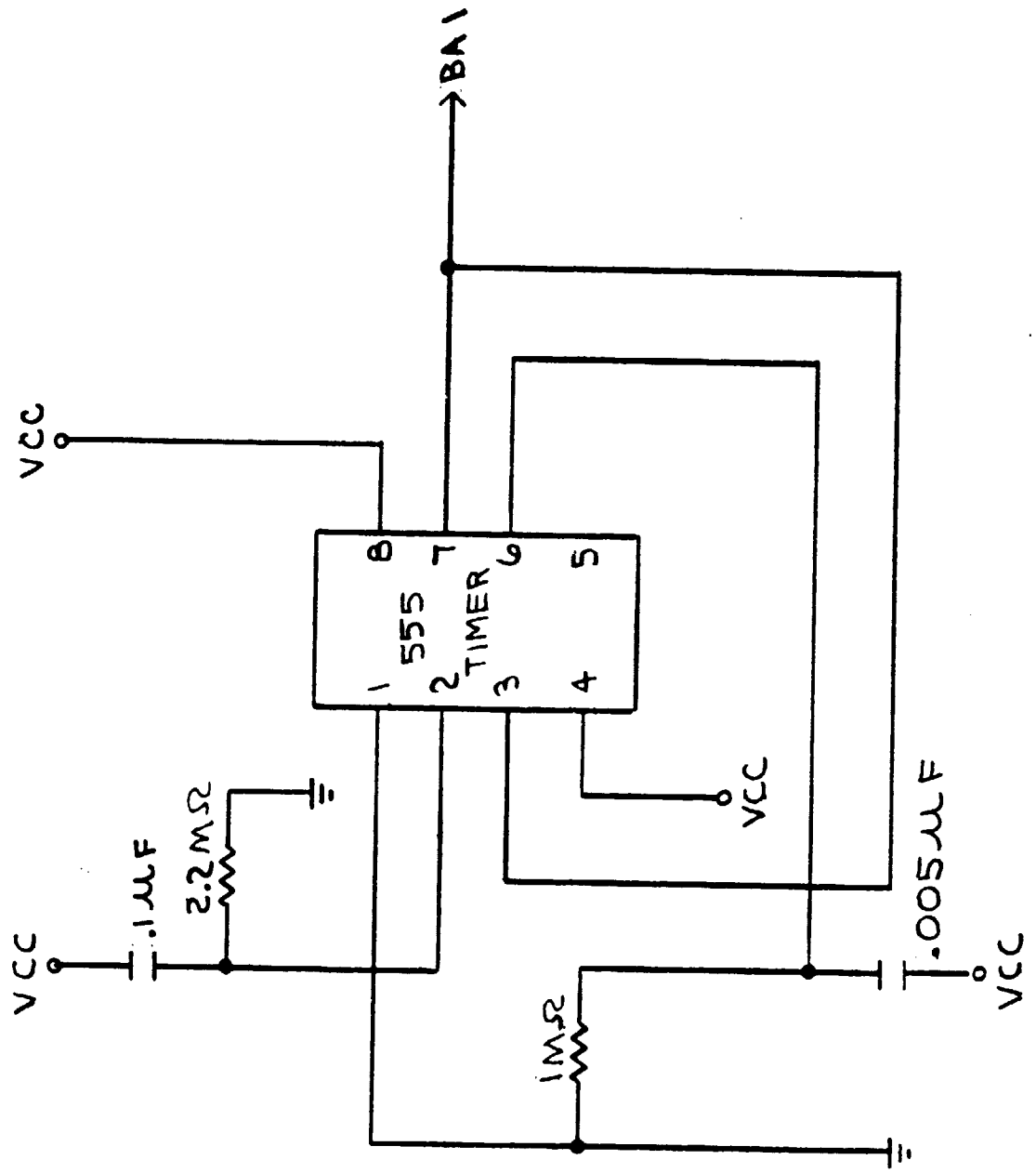
BE SURE TO CLOSE CAL GASES
AND RETURN MASS SPEC TO STANDBY
STOP -- BYE

APPENDIX F
CALIBRATION AND VERIFICATION

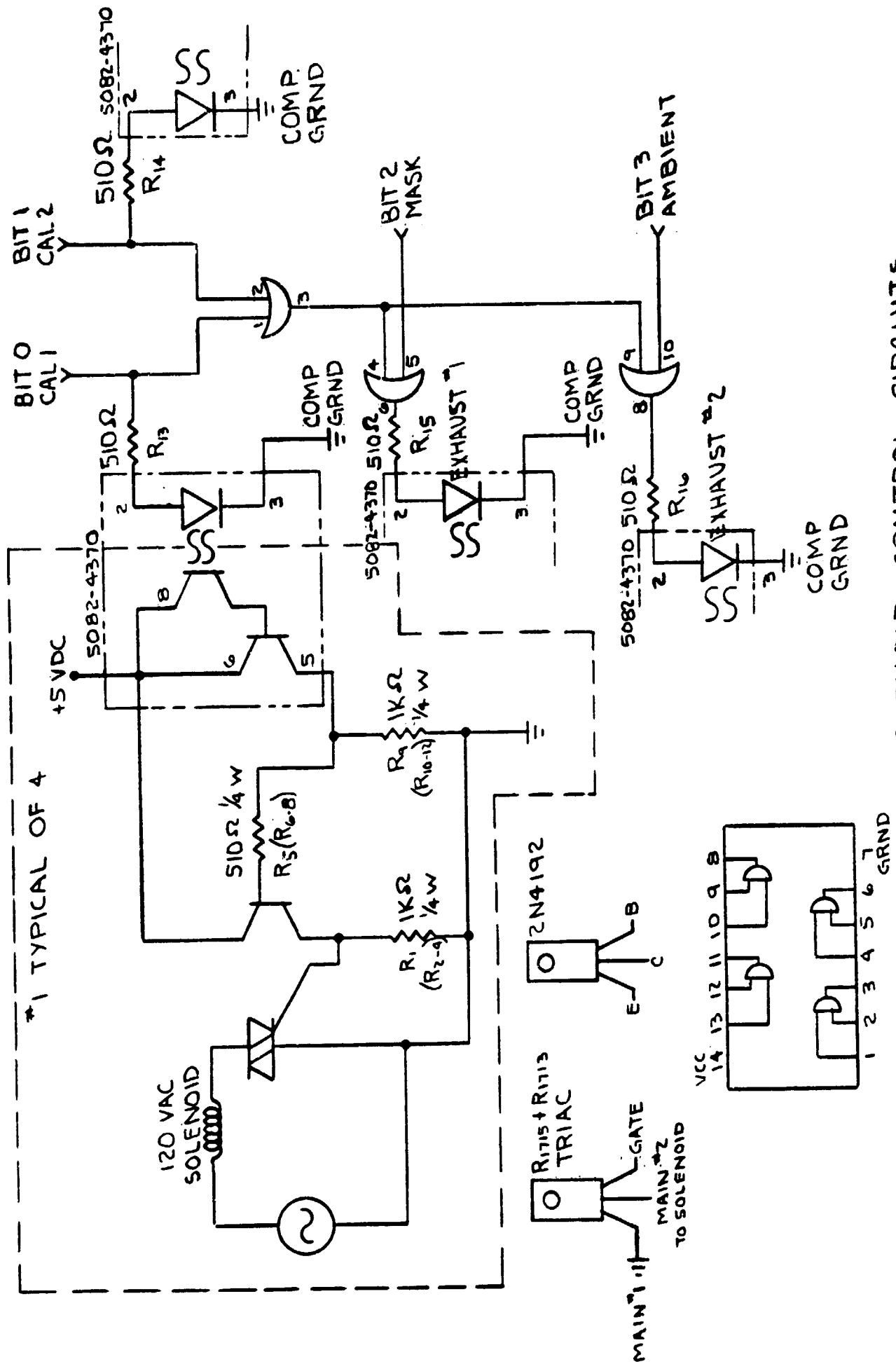
Verification and calibration was done utilizing an alcohol lamp in a vented chamber. The chamber was connected in place of the breathing mask.

Net alcohol weight loss	20.10 grams
Given that 1 gram of alcohol combines with 1.459 litres O ₂ ,	
Net O ₂ consumed	29.326 litres
Time Duration	63 minutes
Net rate of O ₂ consumption	$\Delta O = .4655$ litres/min.
Average experimental value obtained	$\Delta O = .4567$ litres/min.
	1.9% error

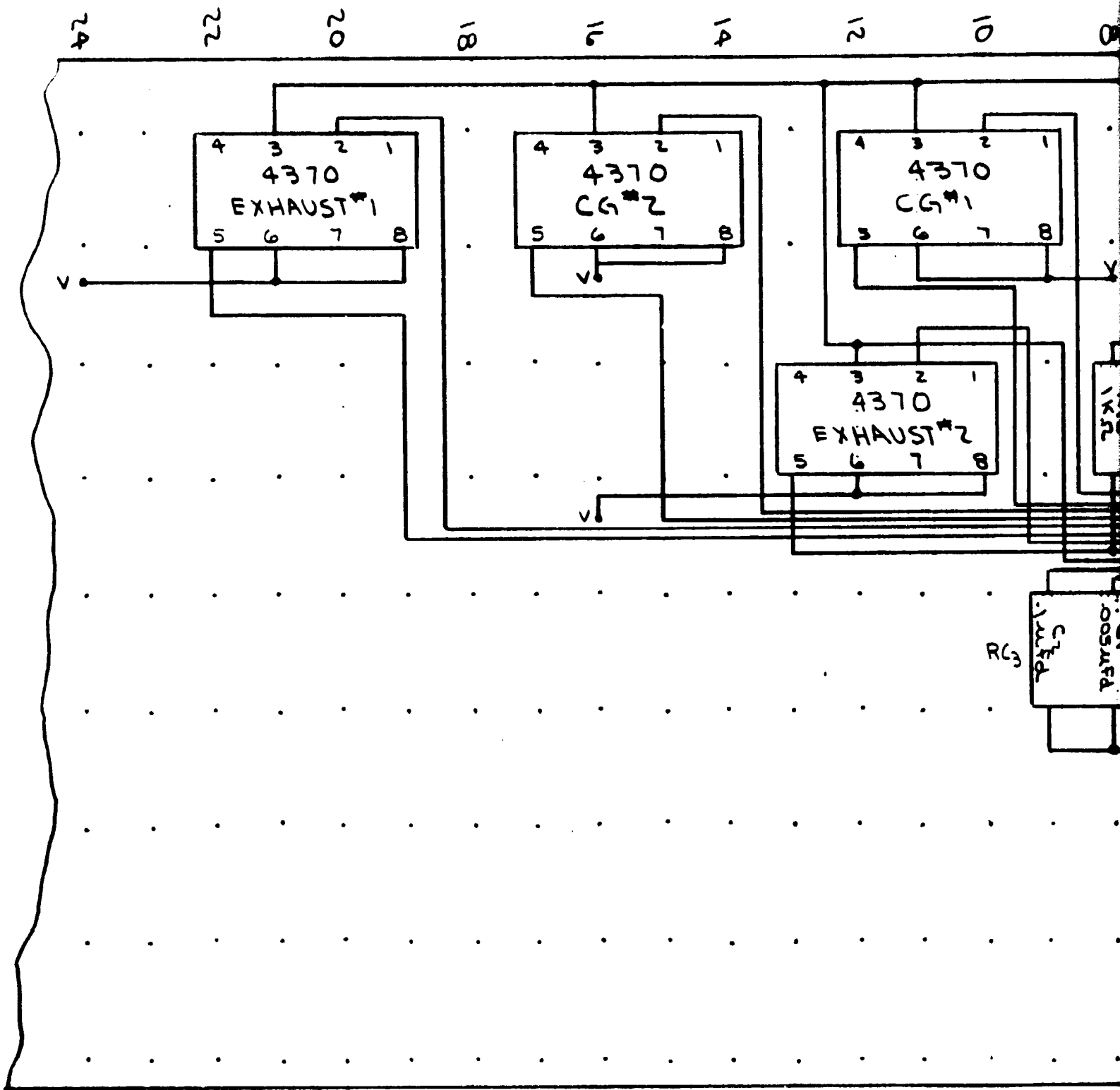
Given that R _q known = .6667	
average R _q observed = .6502	
	2.4% error



START UP CIRCUIT FOR LS1-11 MICROCOMPUTER



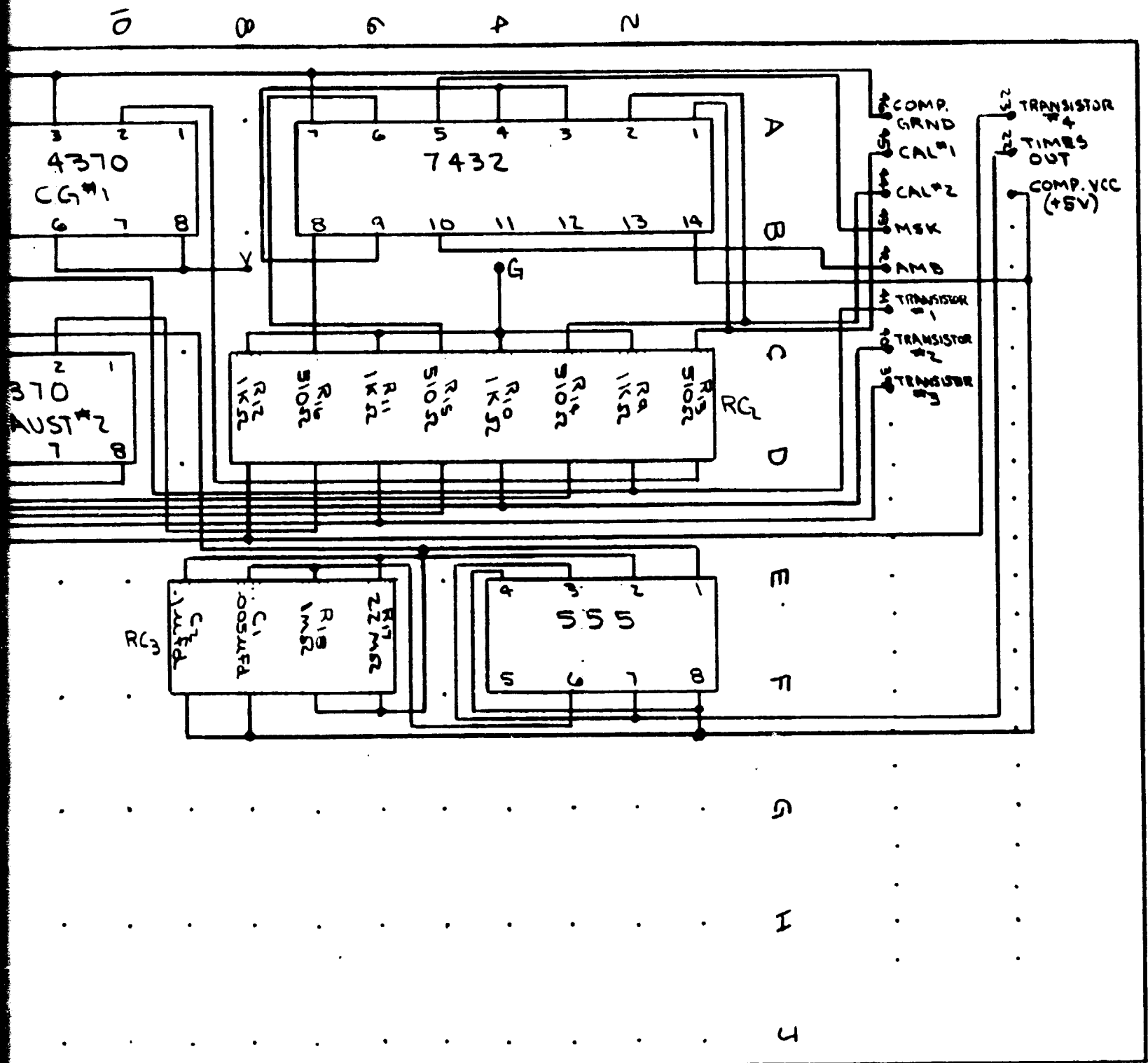
SOLENOID CONTROL CIRCUITS



ORIGINAL PAGE IS
OF POOR QUALITY

FOEDOUT FRAME

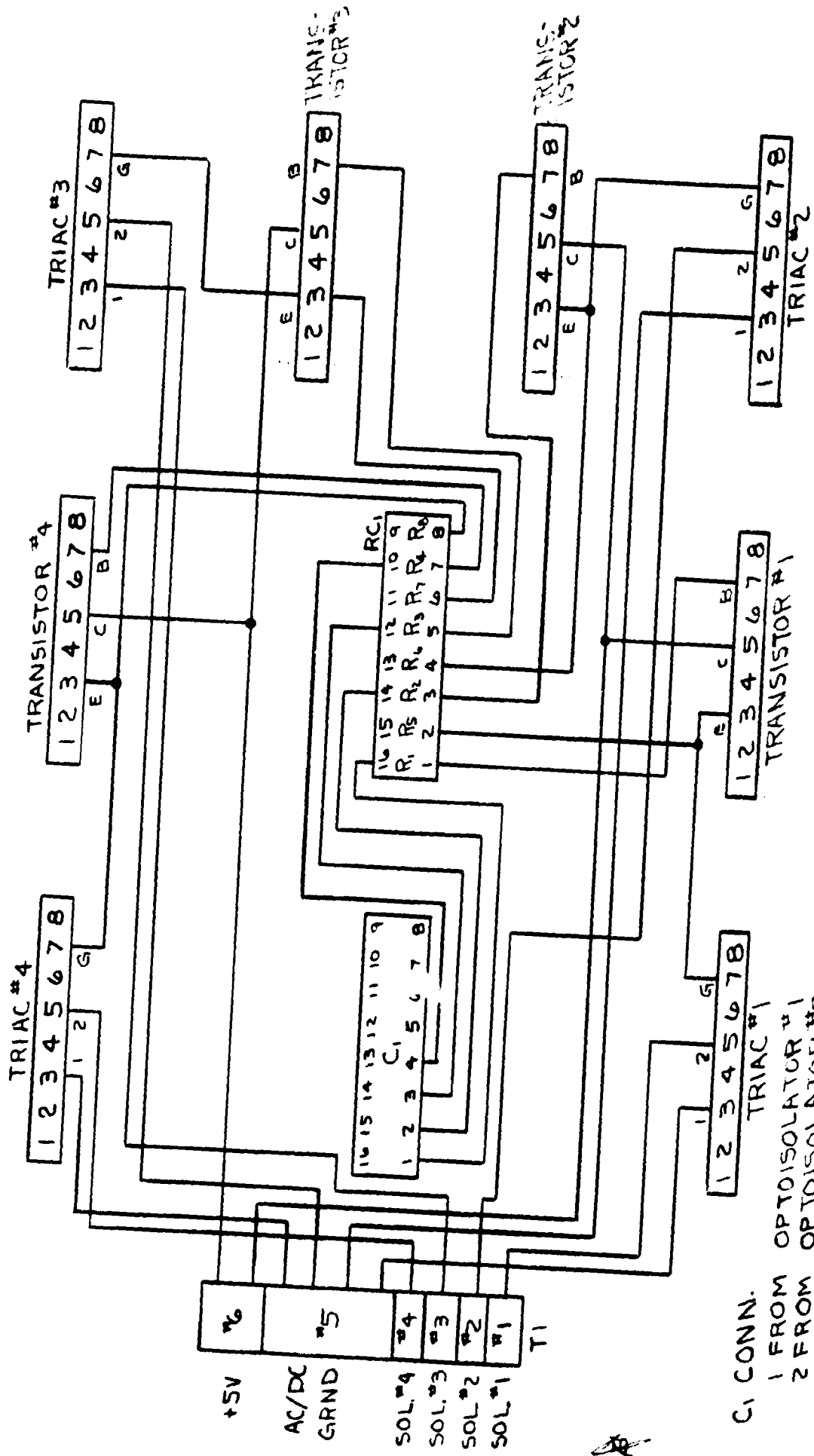
LOGIC BOARD
START UP CIRCUIT
PART OF SOLENOID
CONTROL CIRCUIT



LOGIC BOARD
 PART UP CIRCUIT &
 PART OF SOLENOID
 CONTROL CIRCUIT

BREADBOARD FRAME 2





R₁-R₄ 510Ω
 R₅-R₈ 1KΩ

TRIAC-TRANSISTOR BOARD PICTORIAL
 (PART OF SOLENOID CONTROL CIRCUIT)

C1 CONN.
 1 FROM OPTOISOLATOR #1
 2 FROM OPTOISOLATOR #2
 3 FROM OPTOISOLATOR #3
 4 FROM OPTOISOLATOR #4

+5V
 AC/DC
 GRND
 SOL #4
 SOL #3
 SOL #2
 SOL #1
 T1