FINAL CONTRACTOR REPORT
NASA CONTRACT H-07982

REMOTE HYDROGEN SENSING TECHNIQUES

prepared for
MARSHALL SPACE FLIGHT CENTER

prepared by
C L PERRY ASSOCIATES, PO BOX 4325, HUNTSVILLE, AL 35815

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STATEMENT OF WORK

OBJECTIVES

The objective of this project is to evaluate remote hydrogen sensing methodologies utilizing metal oxide semi-conductor field effect transistors (MOS-FET) and mass spectrometric (MS) technologies and combinations thereof.

APPROACH

The research program is to be structured as a feasibility study. Combinations of MOS-FET sensors and MS instrumentation systems shall be assessed for application to remote hydrogen sensing. As remote monitoring through computer data acquisition systems is an accepted technology, it is anticipated that several instrumentation/sensor combinations may exhibit potential for detection and monitoring of hydrogen leaks remotely. It is the goal of the feasibility study to identify the optimum approach by tailoring the system to the engine test stand or test bed configuration. This phase is expected to require approximately four months for completion.

Following the identification of the optimum approach, testing and development of the system or systems selected in the initial phase shall be performed. Test plans shall be defined and the approved test program completed for the optimization of instrumentation combinations. The resulting test methodology shall be demonstrated to MSFC personnel. A final report documenting the accomplished research shall be submitted at the conclusion of the project.

TASK 1 CALIBRATION OF MOS-FET/HYDROGEN DETECTION SYSTEM

The approach governing the assessment is to tailor the government furnished MOS-FET hydrogen sensors, portable mass spectrometers, data acquisition system and computer to the specific research task. The resulting configuration will be calibrated using known gas concentrations for verification and quantification.

TASK 2 INTERFACING OF OPTIMIZED DETECTION SYSTEM TO TEST BED/TEST STAND ENVIRONMENT

The optimized detection system will be interfaced and installed with the hardware provided by EP55 for area monitoring of the test bed/test stand. EP55 will provide a sample transport lines, valving and sequencing, additional data processing capability and support personnel as needed for interfacing.

TASK 3 FINAL REPORT

A final report documenting the research which has been accomplished and including identification of shortfalls or problem areas and recommendations for further work shall be submitted at the conclusion of the project.

COMPLETION OF TASKS

INTRODUCTION

The concept for this project was formulated during the course of a previous contract in which some preliminary tests of a MOS/FET detector as a hydrogen detector were performed. A portable hydrogen leak detector, Sensistor AB model 8012, procured from Sensistor AB, Linkoping Sweden, was used to detect traces of hydrogen from a foam insulated test article.

It was proposed that an array of these small probes could be strategically located in a facility and provide coverage of a wide area with a warning system to detect hydrogen leaks. The Sensistor AB has a multiprobe control box, model 8506, which allows the simultaneous conditioning of six hydrogen sensors, model HS85. It is necessary to supply a 12 volt DC source to the box and monitor the gas dependent output voltage.

Two portable mass spectrometers had recently been procured to provide field support to the Test Laboratory. The Perkin-Elmer model MGA-1200 and Model MGA-1600 were obtained from The Perkin-Elmer Corporation, Applied Science Division, Pomona, CA 91767. The mass spectrometers, along with the MOS/FET probes could cover requirements to monitor for any of the air gasses as needed.

TASK 1 CALIBRATION OF MOS-FET/MS HYDROGEN DETECTION SYSTEM

The MOS-FET Hydrogen sensor system consists of a Sensistor model 8506 six probe control box with six solid state (MOS-FET) sensor probes, a Keithley model 500 data acquisition system with a computer interface, Keithley SOFT500 proprietary software, and a digital computer running under the DOS 3.2 operating system and GWBASIC interpreter. Figure 1 is a schematic of the MOS-FET/MS test setup used for testing and calibration of the system.

The mass spectrometer system (MS) is actually two mass spectrometers, a Perkin-Elmer model MGA-1200 continuous ratio reading mass spectrometer and a Perkin-Elmer model MGA-1600 computer controlled mass spectrometer.

Six channels of the MOS-FET system were assembled into a gas manifold consisting of six 3/4 inch plastic plumbing T's and tested for response and sensitivity. It was discovered that, although the MOS-FET sensors are very sensitive to hydrogen in the low parts-per-million (ppm) range, the recovery to the original voltage levels before having sensed hydrogen was very slow.

The quantitative response to hydrogen also decreased unpredictably after multiple rapid exposures to hydrogen. For this reason, the MOS-FET system will only be recommended for area monitoring to indicate the presence of hydrogen without quantifying the amount present.

The two mass spectrometer systems were calibrated using bottles of gas mixtures as specified in the vendor operating and maintenance manuals. The gas sampling systems of the two mass spectrometers were connected in series so that a given gas sample was analyzed first by one mass spectrometer and then by the other. Monitoring of the outputs showed that both were stable over a period of several days.

Several BASIC language computer programs were written to support this task. One set of programs allow the simultaneous monitoring of six Sensistor MOS-FET probes and the four data channels of the MGA-1200 mass spectrometer with simultaneous recording of data to a disk file and on-screen display. The recorded data can be redisplayed or played back from the disk file. Another similar set of programs allow the same data display, recording and playback for the two mass spectrometers operating in tandem. These programs and documentation are presented in the attached appendix.

TASK 2 INTERFACING OF OPTIMIZED DETECTION SYSTEM TO TEST BED/TEST STAND ENVIRONMENT

Following the calibration and laboratory testing, the MOS-FET/MS system was delivered to EP55 in the East Test area and installed in an instrument trailer for integration into the Test Laboratory environment.

The mass spectrometer systems were given preliminary checkouts and were functioning normally. A system response test was performed and showed a response of about 5 seconds when sampling from a distance of 30 feet.

Test Laboratory personnel decided not to use the Keithley data acquisition system and will provide their own valve and instrument control and data acquisition systems in order to be compatible with test stand operations.

Test Laboratory is in the process of assembling a sampling and calibration valve manifold for the system. Several delays in the delivery of the test article which this project was to support brings this project to the present time with no clear delivery schedule in sight.

RECOMMENDATIONS FOR FURTHER WORK

It is recommended that the MOS-FET/MS system be fully field tested for response to hydrogen and other gases of interest following the completion of the system integration.

Consideration should be given to another mass spectrometer system which EH32 has. It is the Perkin-Elmer Industrial Central Atmosphere Monitoring System model ICAMS-II. This system is capable of analyzing all the air gasses and several organic trace gasses simultaneously and monitoring a large number of locations sequentially. This system should be installed and evaluated as a permanent Test Stand support instrument.

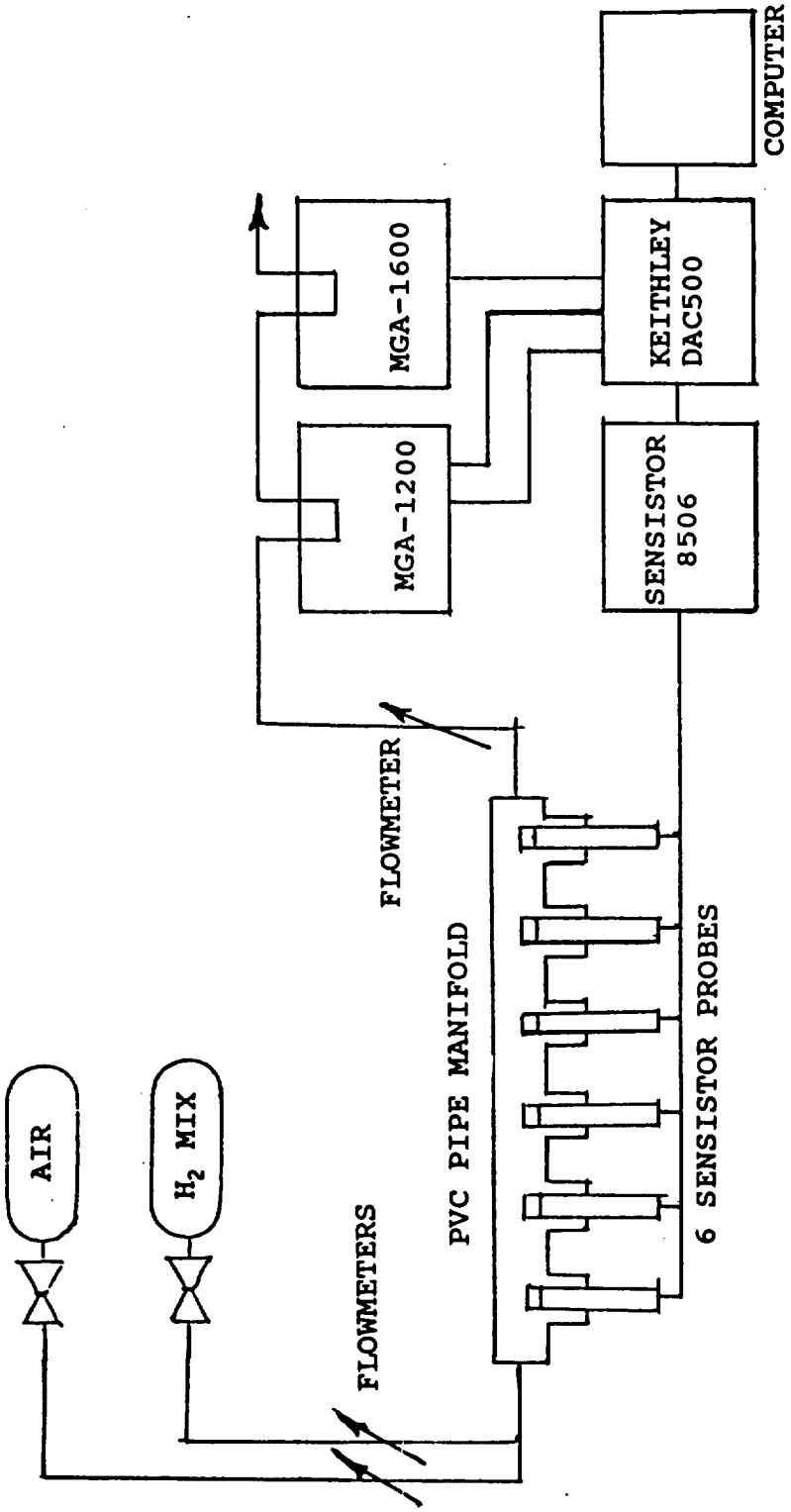

FIGURE 1 - SCHEMATIC DIAGRAM OF MOS-FET/MS TEST SYSTEM

APPENDIX

MGA-1200/1600 Program Document

The program TWOMASS.BAS was written in GWBASIC in order to monitor the MGA-1200 and MGA-1600 Mass Spectrometer systems simultaneously. This program, when used in conjunction with the Keithley SOFT500 data acquisition software package and the Keithley model 500 Data Acquisition interface unit, allow for the acquiring of five channels of data from each mass spectrometer and the subsequent storage of the data on a computer disk. Sampling to the MGA-1200 mass spectrometer can also be controlled from the computer keyboard by typing the number 1 through 4 to select the desired sample inlet valve and by typing 0 to turn all the valves off. The stored data may be recalled and printed in tabular form on paper.

Before running this program, the operator must be assured that all of the proper cabling connections are in place. Reference to the Perkin-Elmer operating manuals for each mass spectrometer will show the connector and pin locations of the various signals from the mass spectrometers. The connections to the data acquisition board in the Keithley model 500 Data Acquisition box can be found in the following BASIC program listing. The CALL IONAME function assigns each signal to the data acquisition slot and channel. Each signal channel from the mass spectrometers must be connected to the channel as specified in the CALL IONAME for each channel.

If the program is to be executed immediately upon computer startup, the following lines must be included at the end of the AUTOEXEC.BAT file in the main directory:

```
\KEITHLEY\SETCLOCK -i OxCFF8 -s
\KEITHLEY\HARDINIT -c OxCFF8 CONFIG.TBL -p
CD\KEITHLEY
SOFT500
```

The SOFT500 software modules and GWBASIC.COM must be in the \KEITHLEY directory. Also in the \KEITHLEY directory is the program, AUTOEXEC.BAS which is used to initialize the SOFT500 system. By inserting the following line, the program will continue on and execute the mass spectrometer program:

```
250 TWOMASS.BAS
```

The program, TWOMASS.BAS, is used for data acquisition, real-time display of the data and recording to the computer fixed disk. The computer system is programmed to autostart the program, TWOMASS.BAS, when it is powered on or when it is reset (Ctrl,Alt,Del). After the startup process, the user is prompted by the system for required inputs. Answering the prompts will allow the user to describe the experiment, collect, record and display data at the desired intervals.

Data recording is in a file which is automatically created by the program. It is of the form:

```
T2041435.DAT
. . .   |||--file extension
. .  ||||--time file was created
. ||--day of the month
 |--month
|--prefix letter
```

After an experiment is completed and the data acquisition is complete, the data can be recalled or played back from the disk storage with TWOPLAY.BAS. This program can be run after exiting TWOMASS.BAS by the following procedure:

```
LOAD "TWOPLAY.BAS"
RUN
```

or it may be run simply by typing:

```
RUN "TWOPLAY.BAS"
```

TWOPLAY.BAS may be run on any computer with GWBASIC capability. The file, TWOMASS.FIL, must also be present as it contains the parameters of the last experiment and is used by TWOPLAY.BAS upon startup. The data file, as described above, must also be present in the same directory.

To run TWOPLAY.BAS without running TWOMASS.BAS, start up the system in the normal manner. When TWOMASS.BAS comes up and asks for its first data entry, just type control-C to escape from the program to BASIC. The computer BASIC will prompt "Ok". Now load TWOPLAY.BAS and run it as above.

Following are the program listings for the above programs:

```
10'*************************************************************
20 ' *
30 ' *    PROGRAM NAME: TWOMASS.BAS                DATE:05/26/1992
40 ' *
50 ' *        Monitors the MGA-1200 & MGA-1600 mass spectrometers
60 ' *
70 ' *    CORTES L. PERRY, C L PERRY ASSOCIATES, HUNTSVILLE, AL
80 ' *
90 ' *************************************************************
100 '*
110 '*     Here is the program title banner
120 '*
130 CLS
140 PRINT:PRINT TAB(30) "TWOMASS.BAS":PRINT:PRINT
```

```
150 PRINT TAB(15) "Mass Spectrometer Data Acquisition Program": PRINT
160 '*
170'*****************************************************************
180 '*
190 '*      Dimension and initialize arrays
200 '*
210 HR%=0:MIN%=0:SEC%=0:DA%=0:MO%=0:YR%=0:TICK=0:TOCK=0
220 PASS=0:FILE=0:STAR$="0":H2=0:N2=0:O2=0:VSW=0:COUNT=0
230 AR=0:HE=0:MAR=0:MHE=0:MH2=0:MN2=0:MO2=0
240 '
250 CALL INIT
260 '
270'*************************************************************
280 '*
290 '*      Choose the data rate to be recorded
300 '*
310 LOCATE 15,15:INPUT "Data rate to record to disk (seconds/file)";
RATE: PRINT
320 IF RATE > 0 THEN GOTO 370
330  PRINT "Data will not be recorded. <CR> to continue."
340 IF LEN(INKEY$)>0 THEN GOTO 340
350 A$=INKEY$:IF LEN(A$)=0 THEN GOTO 350
360 IF A$ <> CHR$(13) THEN GOTO 310
370 PRINT "Enter experiment comment line of up to 75 characters."
380 INPUT TOP$: TOP$= LEFT$(TOP$,75)
390 PRINT "Enter the name of the operator (up to 40 characters)."
400 INPUT OPERATOR$: OPERATOR$= LEFT$(OPERATOR$,40)
410 '*
420 '*************************************************************
430 '*
440 '*      Turn off "keys" and set up terminal
450 '*
460 CLS:KEY OFF:SCREEN 0:WIDTH 80
470 '*
480 '*      Next, write labels to the screen
490 '*
500 LOCATE 1,5:PRINT "TWOMASS.BAS  -  C L Perry Associates"
510 LOCATE 5,15:PRINT"Mass Spectrometer Data"
520 LOCATE 8,7:PRINT"Gas          MGA-1200      MGA-1600"
530 LOCATE 10,5:PRINT"Hydrogen "
540 LOCATE 12,5:PRINT"Helium   "
550 LOCATE 14,5:PRINT"Nitrogen "
560 LOCATE 16,5:PRINT"Oxygen   "
570 LOCATE 18,5:PRINT"Argon    "
580 FOR I= 4 TO 19:LOCATE I,1:PRINT "¦":NEXT
590 LOCATE 3,2:PRINT "_____________________________________________"
600 FOR I= 4 TO 19:LOCATE I,46:PRINT "¦":NEXT
610 LOCATE 19,2:PRINT "_____________________________________________"
620 LOCATE 23,10:PRINT "Samples OFF":STAR$="0":VSW=0
630 LOCATE 21,1:PRINT TOP$
```

```
640 LOCATE 25,55:PRINT"Press E to exit";
650 LOCATE 25,1:PRINT "Operator: ";OPERATOR$;
660 '*
670'*************************************************************
680 '*
690 '*      This is the main program area.
700 '*
710 '*       Set up all data channels  (see SOFT500 manual)
720 '*       WARNING: DO NOT put comments on the lines following
730 '*
740 ION$="H2":SLOT%=1:CHAN%=8:ACC%=14:GAIN%=1
750 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
760 ION$="HE":SLOT%=1:CHAN%=9:ACC%=14:GAIN%=1
770 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
780 ION$="MHE":SLOT%=1:CHAN%=14:ACC%=14:GAIN%=1
790 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
800 ION$="MH2":SLOT%=1:CHAN%=15:ACC%=14:GAIN%=1
810 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
820 ION$="N2":SLOT%=1:CHAN%=10:ACC%=14:GAIN%=1
830 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
840 ION$="MN2":SLOT%=1:CHAN%=6:ACC%=14:GAIN%=1
850 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
860 ION$="O2":SLOT%=1:CHAN%=11:ACC%=14:GAIN%=1
870 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
880 ION$="MO2":SLOT%=1:CHAN%=7:ACC%=14:GAIN%=1
890 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
900 ION$="AR":SLOT%=1:CHAN%=12:ACC%=14:GAIN%=1
910 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
920 ION$="MAR":SLOT%=1:CHAN%=13:ACC%=14:GAIN%=1
930 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
940 ION$="SW04":SLOT%=4:CHAN$="A"
950 CALL IONAME '(ION$,SLOT%,CHAN$)
960 '*
970 '*************************************************************
980 '*
990 '*      Create and open data file to receive the collected data
1000 '*
1010 GOSUB 2000 :'also saves the setup parameters in TWOMASS.FIL
1020 '*
1030 '*************************************************************
1040 '*
1050 '*   Now we begin to collect the data, display and record it
1060 '*
1070 CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
1080 GOSUB 2310:'                * convert time to string variable
1090 LOCATE 8,53:PRINT "Start Time  ";HR$;":";MIN$;":";SEC$:'*screen
1100 '*
1110 '*      cycle entry point -- here's where it all starts
1120 CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
1130 TM0 = (HR%*3600+MIN%*60+SEC%):'      * start of 1 second timer
```

```
1140 CALL ANREAD '("N2",N2,0)
1150 CALL ANREAD '("MN2",MN2,0)
1160 CALL ANREAD '("O2",O2,0)
1170 CALL ANREAD '("MO2",MO2,0)
1180 CALL ANREAD '("H2",H2,0)
1190 CALL ANREAD '("MH2",MH2,0)
1200 CALL ANREAD '("HE",HE,0)
1210 CALL ANREAD '("MHE",MHE,0)
1220 CALL ANREAD '("AR",AR,0)
1230 CALL ANREAD '("MAR",MAR,0)
1240 '*   scale the values to percents & sum each for averaging
1250 N2=N2*10:MN2=MN2*20:AN2=AN2+N2:BN2=BN2+MN2
1260 O2=O2*10:MO2=MO2*20:AO2=AO2+O2:BO2=BO2+MO2
1270 AR=AR/10:MAR=MAR/5 :AAR=AAR+AR:BAR=BAR+MAR
1280 HE=HE*10:MHE=MHE*20:AHE=AHE+HE:BHE=BHE+MHE
1290 H2=H2*10:MH2=MH2*20:AH2=AH2+H2:BH2=BH2+MH2
1300 PASS = PASS + 1
1310 '*
1320 '*       This is the cycle end - all probes have been read once
1330 '*
1340 CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
1350 GOSUB 2310:'                    * convert time to string variable
1360 TM1=(HR%*3600+MIN%*60+SEC%):'            * real time clock value
1370 '*
1380 '*       check the 1 second timer
1390 IF TM1 = TM0 THEN GOTO 1140:'    there's time for another reading
1400 TOCK=TOCK+1:COUNT=COUNT+1:IF TOCK=60 THEN TICK=TICK+1:TOCK=0
1410 LOCATE 11,51:PRINT "Elapsed Time  ";TICK;"::";TOCK
1420 LOCATE 5,54:PRINT "Real Time  ";HR$;":";MIN$;"::"SEC$
1430 '*
1440 '*   now average the readings
1450 N2=AN2/PASS:MN2=BN2/PASS:AN2=0:BN2=0
1460 O2=AO2/PASS:MO2=BO2/PASS:AO2=0:BO2=0
1470 AR=AAR/PASS:MAR=BAR/PASS:AAR=0:BAR=0
1480 HE=AHE/PASS:MHE=BHE/PASS:AHE=0:BHE=0
1490 H2=AH2/PASS:MH2=BH2/PASS:AH2=0:BH2=0
1500 LOCATE 10,21:PRINT USING "###.##";H2
1510 LOCATE 10,35:PRINT USING "###.##";MH2
1520 LOCATE 12,21:PRINT USING "###.##";HE
1530 LOCATE 12,35:PRINT USING "###.##";MHE
1540 LOCATE 14,21:PRINT USING "###.##";N2
1550 LOCATE 14,35:PRINT USING "###.##";MN2
1560 LOCATE 16,21:PRINT USING "###.##";O2
1570 LOCATE 16,35:PRINT USING "###.##";MO2
1580 LOCATE 18,21:PRINT USING "###.##";AR
1590 LOCATE 18,35:PRINT USING "###.##";MAR
1600 IF COUNT=RATE THEN GOSUB 2220:COUNT=0:' record data on disk
1610 LOCATE 14,59:PRINT "Rate     ";RATE:'   * print cycle count
1620 LOCATE 23,59:PRINT "Reads ";PASS :PASS=0
1630 '*  now look for a keyboard input
```

```
1640 Z=1:I$=INKEY$:Z=Z+1:IF (INKEY$="" AND Z<2) THEN 1640
1650 IF (I$="E" OR I$="e") THEN GOTO 1770:'     * this calls exit
1660 IF I$="1" THEN STAR$="1":LOCATE 23,10:PRINT "Sample 1 ON":VSW=16
1670 IF I$="2" THEN STAR$="2":LOCATE 23,10:PRINT "Sample 2 ON":VSW=32
1680 IF I$="3" THEN STAR$="3":LOCATE 23,10:PRINT "Sample 3 ON":VSW=64
1690 IF I$="4" THEN STAR$="4":LOCATE 23,10:PRINT "Sample 4 ON":VSW=128
1700 IF I$="0" THEN STAR$="0":LOCATE 23,10:PRINT "Samples OFF":VSW=0
1710 '* Switch the MGA-1200  sample ports using VSW
1720 CALL DIGWRITE'("SW04",VSW)
1730 GOTO 1120 :'                                  * Go make another pass
1740 '*
1750 '*****************************************************************
1760 '*
1770 '* Close the data files, reset screen, list data files, exit
1780 '*
1790 VSW=0
1800 CALL DIGWRITE'("SW04",VSW)
1810 CLOSE #1
1820 CLS:SCREEN 0:WIDTH 80:PRINT:PRINT:PRINT
1830 PRINT TAB(15) "Data file for this run is named: ";INFILE$
1840 LOCATE 22,15:PRINT "Do you want to print the data file <CR> =
Yes?"
1850 IF LEN(INKEY$)>0 THEN GOTO 1850
1860 A$=INKEY$:IF LEN(A$)=0 THEN GOTO 1860
1870 IF A$ <> CHR$(13) THEN GOTO 1920
1880 CLOSE #1: OPEN "I",#1,INFILE$
1890 IF EOF(1) THEN GOTO 1910
1900 INPUT #1, A$ : LPRINT A$: GOTO 1890
1910 CLOSE #1
1920 END
1930 '*
1940 '*****************************************************************
1950 '*
1960 '*              DISK ACCESS SUBROUTINES
1970 '*
1980 '*     Open disk files for data output
1990 '*
2000 CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
2010 GOSUB 2310
2020 INFILE$="T"+MO$+DA$+HR$+MIN$+".DAT"
2030 LOCATE 18,58: PRINT INFILE$;
2040 OPEN "O",#1,INFILE$
2050 PRINT #1,"Mass spectrometers test data file  ";INFILE$
2060 PRINT #1,TOP$
2070 PRINT #1,"Date ";MO$;"/";DA$;"/";YR%
2080 PRINT #1,". Data recorded every ";RATE;"seconds."
2090 PRINT #1, ". ";OPERATOR$;" ran this experiment.
2100 PRINT #1,". Day   Time         %N2     %O2     %AR     %HE     %H2
  Reads   Valve"
2110 OPEN "O",#2,"TWOMASS.FIL"
```

```
2120 PRINT #2,INFILE$
2130 PRINT #2, RATE
2140 CLOSE #2
2150 RETURN
2160 '*
2170 OPEN "I",#2,"TWOMASS.FIL"
2180 INPUT #2, OLDFILE$: OLDFILE$=LEFT$(OLDFILE$,12)
2190 INPUT #2, RATE
2200 CLOSE #2
2210 RETURN
2220 '*
2230 PRINT #1, ". ";DA$;"  ";HR$;":";MIN$;"::";SEC$;"  ";:PRINT #1,
USING "#####.##";N2;O2;AR;HE;H2;:PRINT #1, USING "######";PASS;:PRINT
#1, " ",STAR$
2240 PRINT #1, ".                  ";:PRINT #1, USING
"#####.##";MN2;MO2;MAR;MHE;MH2;:PRINT #1, USING "######";PASS;:PRINT
#1, " ",STAR$
2250 '*
2260 FILE=FILE+1:LOCATE 16,58:PRINT "Saved   ";FILE
2270 RETURN
2280 '*
2290 '*      Subroutine to convert integers to strings for date line
2300 '*
2310 MI$=RIGHT$(STR$(MO%),2)
2320 IF MI$="10" THEN MO$="O":GOTO 2360
2330 IF MI$="11" THEN MO$="N":GOTO 2360
2340 IF MI$="12" THEN MO$="D":GOTO 2360
2350 MO$=RIGHT$(MI$,1)
2360 '
2370 IF DA% >9 THEN GOTO 2400
2380 DA$="0"+RIGHT$(STR$(DA%),1)
2390 IF DA% <10 THEN GOTO 2410
2400 DA$=RIGHT$(STR$(DA%),2)
2410 '
2420 IF HR% >9 THEN GOTO 2450
2430 HR$="0"+RIGHT$(STR$(HR%),1)
2440 IF HR% <10 THEN GOTO 2460
2450 HR$=RIGHT$(STR$(HR%),2)
2460 '
2470 IF MIN% >9 THEN GOTO 2500
2480 MIN$="0"+RIGHT$(STR$(MIN%),1)
2490 IF MIN% <10 THEN GOTO 2510
2500 MIN$=RIGHT$(STR$(MIN%),2)
2510 '
2520 IF SEC% >9 THEN GOTO 2550
2530 SEC$="0"+RIGHT$(STR$(SEC%),1)
2540 IF SEC% <10 THEN GOTO 2560
2550 SEC$=RIGHT$(STR$(SEC%),2)
2560 '
2570 RETURN
```

```
10'*****************************************************************
20 ' *
30 ' * PROGRAM NAME: TWOPLAY.BAS                    DATE: 05/14/92
40 ' *
50 ' * CORTES L. PERRY, CL PERRY ASSOCIATES, HUNTSVILLE, AL
60 ' *
70 ' *****************************************************************
80 ' *
90 ' *       Here is the program title banner
100 '*
110 CLS
120 PRINT:PRINT:PRINT TAB(20)"Mass Spectrometer Program":PRINT:PRINT
130 '*
140'*************************************************************
150 '*
160 '*       Set up file to be played back
170 '*
180 OPEN "TWOMASS.FIL" FOR INPUT AS #2
190 INPUT #2,STORED$:CLOSE #2
200 PRINT "Data files in this directory are:"
210 FILES "T*.dat"
220 PRINT:PRINT "The default file is  ";STORED$:PRINT
230 ON ERROR GOTO 380
240 INPUT "Select data file to play back. <CR> selects default";INFILE$
250 IF INFILE$="" THEN INFILE$=STORED$
260 '*************************************************************
270 '*
280 '*       Open Data file and index to first record
290 '*
300 LOCATE 22,15:PRINT "Do you want to print the data file <CR> = Yes
?"
310 IF LEN(INKEY$)>0 THEN GOTO 310
320 A$=INKEY$:IF LEN(A$)=0 THEN GOTO 320
330 IF A$ <> CHR$(13) THEN GOTO 370
340 CLOSE #1: OPEN "I",#1,INFILE$
350 IF EOF(1) THEN GOTO 370
360 INPUT #1, A$ : LPRINT A$: GOTO 350
370 LOCATE 23,1: CLOSE #1
380 IF ERR= 53 THEN PRINT "Error - file not found - retry": GOTO 200
390 END
```

TWOMASS.FIL

The following two lines are the contents of TWOMASS.FIL.This file allows the main and playback programs to print out the most immediately run experiment without the need to figure out the name of the file where the data are stored:

```
T5261036.DAT
 15
```

The following two programs allow the simultaneous operation of the Perkin-Elmer MGA-1200 mass spectrometer and six MOS-FET hydrogen detection probes. Data from all channels are graphically presented on the computer monitor and recorded to the disk for subsequent playback and data analysis.

Operation of these two programs is similar to the previous programs.

```
10' ****************************************************************
20 ' *
30 ' * PROGRAM NAME: SENSMASS.BAS                        DATE: 04/21/92
35 ' *         Revised to include N2 analysis by MGA-1200 mass spec
40 ' *
50 ' * CORTES L. PERRY, C L PERRY ASSOCIATES, HUNTSVILLE, AL
60 ' *
70 ' ****************************************************************
80 ' *
90 ' *     Here is the program title banner
100 '*
110 CLS
120 PRINT:PRINT TAB(20) "Sensistor Data Acquisition Program": PRINT
130 '*
140 '************************************************************
150 '*
160 '*      Dimension and initialize arrays
170 '*
180 DIM VX(12):DIM CH$(12):DIM CHAN%(12)
190 HR%=0:MIN%=0:SEC%=0:DA%=0:MO%=0:YR%=0:TICK%=0:TOCK%=0
200 PASS=0:FILE=0:STAR$=".":VA=0:H2=0:N2=0:O2=0
210 CH$(1)="1":CH$(2)="2":CH$(3)="3":CH$(4)="4":CH$(5)="5":CH$(6)="6"
220 CH$(7)="7":CH$(8)="8":CH$(9)="9":CH$(10)="10":CH$(11)="11":
CH$(12)="12"
230 CHAN%(1)=0:CHAN%(2)=1:CHAN%(3)=2:CHAN%(4)=3:CHAN%(5)=4: CHAN%(6)=5
240 CHAN%(7)=6:CHAN%(8)=7:CHAN%(9)=8:CHAN%(10)=9:CHAN%(11)=10:
CHAN%(12)=11
250 CALL INIT
260 '
270 '************************************************************
280 '*
```

```
290 GOTO 330 ' Skip over the next two lines
300 SKIP=0:PASS=0:FILE=0:CLOSE #1:CLS ' Start all over again
310 PRINT "No data channels selected. Redo from start.":PRINT
320 '*
330 '*      Choose the box, probes, and data rate to be recorded
340 '*
350 GOSUB 2690
360 PRINT "Here are the parameters from the previous experiment":PRINT
370 PRINT "Data file ::";OLDFILE$:PRINT "SENSISTOR box :: ";BOX$
380 FOR I = 1 TO 6
390 PRINT "Probe #";I;" :";CHL$(I)
400 NEXT I
410 PRINT "Data Rate ::";RATE:PRINT
420 PRINT "Do you want to repeat the previous experiment <CR> = Yes ?"
430 IF LEN(INKEY$)>0 THEN GOTO 430
440 A$=INKEY$:IF LEN(A$)=0 THEN GOTO 440
450 IF A$ = CHR$(13) THEN GOTO 610
460 '*
470 '*
480 PRINT:INPUT"Which SENSISTOR  box is being used ";BOX$:PRINT
490 PRINT "Assign probe numbers (1-99) to channels, (0) skips channel"
500 PRINT
510 FOR I = 1 TO 6
520 PRINT "Channel ";I;" probe";:INPUT CHL$(I)
530 Y=LEN(CHL$(I)): IF Y < 2 THEN CHL$(I) = "0"+CHL$(I)
540 NEXT I
550 INPUT "Data rate to record to disk (seconds/file)";RATE:PRINT
560 IF RATE > 0 THEN GOTO 610
570  PRINT "Data will not be recorded. <CR> to continue."
580 IF LEN(INKEY$)>0 THEN GOTO 580
590 A$=INKEY$:IF LEN(A$)=0 THEN GOTO 590
600 IF A$ <> CHR$(13) THEN GOTO 550
610 PRINT "Enter experiment comment line of up to 75 characters."
611 INPUT TOP$
619 '*
620 '************************************************************
630 '*
640 '*      Turn off "keys" and select high res graphics
650 '*
660 CLS:KEY OFF:SCREEN 1:WIDTH 80
670 '*
680 '*     Before data acquisition, go to the first part of the 690 '*
graphing subroutine to set up the graphing parameters.
700 '*
710 GOSUB 1760              'Initialize the graphing parameters
720 '*
730 '*      Next, write labels to the screen
740 '*
750 LOCATE 25,35:PRINT"Press E to exit";
760 LOCATE 3,1:PRINT"2.0"    'voltage at graph maximum
```

```
770 LOCATE 8,1:PRINT "1.5"
780 LOCATE 13,1:PRINT"1.0"   'voltage at graph middle
790 LOCATE 16,1:PRINT"N2-"
800 LOCATE 18,1:PRINT "0.5"
820 LOCATE 23,1:PRINT"0.0"   'voltage at graph bottom
840 '*
850 '************************************************************
860 '*
870 '*      This is the main program area.
880 '*
890 '*       Set up six data channels  (see SOFT500 manual)
900 '*
910 FOR I = 1 TO 6
920 ION$="data"+CH$(I):SLOT%=1:CHAN%=CHAN%(I):ACC%=14:GAIN%=1
930 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
940 NEXT
941 ION$="H2":SLOT%=1:CHAN%=8:ACC%=14:GAIN%=10
942 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
943 ION$="N2":SLOT%=1:CHAN%=10:ACC%=14:GAIN%=1
945 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
946 ION$="O2":SLOT%=1:CHAN%=11:ACC%=14:GAIN%=1
947 CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
950 '*
960 '************************************************************
970 '*
980 '*      Create and open data file to receive the collected data
990 '*
1000 GOSUB 2490 :'also saves the setup parameters in PLAYBACK.FIL
1010 '*
1020 '************************************************************
1030 '*
1040 '*       Now we begin to collect the data, graph and record it
1050 '*
1060 CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
1070 CLOCK = (HR%*3600+MIN%*60+SEC%)
1080 TM2 = CLOCK+60 :'                    * start of 60 second timer
1090 TM3=CLOCK+1 :'                       * start of 1 second timer
1100 TM4=CLOCK+RATE :'                    * start of rate timer
1110 GOSUB 2880:'                         * convert time to string
variable
1120 LOCATE 1,65:PRINT "ST ";HR$;":";MIN$;"::"SEC$;:'* put start time
on screen
1130 '*      cycle entry point
1140 '
1150 CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
1160 GOSUB 2880:'                                 convert time to string
variable
1170 TM1=(HR%*3600+MIN%*60+SEC%):'      * real time clock value
1180 '*     these are the timers
1190 IF TM1=TM3 THEN TOCK%=TOCK%+1:TM3=TM3+1:IF TOCK%=60 THEN TOCK%=0
```

```
1200 IF TM1=TM2 THEN TICK%=TICK%+1:GOSUB 2190:TM2=TM2+60
1210 '*
1220 LOCATE 25,65:PRINT "ET ";TICK%;"::";TOCK%'* print elapsed time
1230 GOSUB 2880:'                              * convert time to string
variable
1240 LOCATE 2,65:PRINT "RT ";HR$;":";MIN$;"::"SEC$;:'* put real  time
on screen
1250 '*
1260 FOR I = 1 TO 6
1270 ION$="data"+CH$(I):'                  * next line aborts if all skip
1280 CALL ANREAD '(ION$,VA,0)
1290 VX(I) = VA :'                       * save the data points
1300 '
1310 IF I = 1 THEN LOCATE 1,5  :'  * these 6 lines locate the
1320 IF I = 2 THEN LOCATE 1,25 :'  * channel voltages on screen
1330 IF I = 3 THEN LOCATE 1,45
1340 IF I = 4 THEN LOCATE 2,5
1350 IF I = 5 THEN LOCATE 2,25
1360 IF I = 6 THEN LOCATE 2,45 :'  * next line prints voltages
1370 VX(I) = VA: PRINT "Probe ";CHL$(I);"= ";:PRINT USING "#.###";VX(I)
1380 NEXT I :'                           * go read the next channel
1381 CALL ANREAD '("N2",N2,0)
1382 GOSUB 3150 :'                       * convert N2 to string variable
1390 IF TM1=TM4 THEN GOSUB 1950 :GOSUB 2780:TM4 = TM4 + RATE:' record &
plot
1400 'IF STAR$="." THEN VX(7)=.7:'                 * air stream marker
1410 'IF STAR$="*" THEN VX(7)=.3:'                 * hydrogen marker
1420 '*
1430 '*  This is the cycle end - all probes have been read once
1440 '*
1450 '*   check the 60 second timer
1460 LOCATE 25,25:PRINT "R = ";RATE:'    * print cycle count on screen
1470 '*  now look for a keyboard input
1480 Z=1:I$=INKEY$:Z=Z+1:IF (INKEY$="" AND Z<2) THEN 1480
1490 IF (I$="E" OR I$="e") THEN GOTO 1580:'    * this calls exit
1500 'IF (I$="H" OR I$="h") THEN STAR$="*":LOCATE 25,17:PRINT "H2 ON"
1510 'IF (I$="N" OR I$="n") THEN STAR$=".":LOCATE 25,17:PRINT "N2 ON"
1520 GOTO 1130 :'                                  * Go make another pass
1530 '*
1540 '************************************************************
1550 '*
1560 '* Close the data files, reset screen, list data files, exit
1570 '*
1580 CLOSE #1
1590 CLS:SCREEN 0:WIDTH 80:PRINT:PRINT:PRINT
1600 PRINT TAB(15) "Data file for this run is named:":PRINT:PRINT
1610 PRINT INFILE$
1620 PRINT "and this name is saved in PLAYBACK.FIL for auto playback."
1630 END
1640 '*
```

```
1650 '************************************************************
1660 '
1670 '       ************ REAL-TIME GRAPH SUBROUTINE ************
1680 '
1690 ' GRAPH SET-UP PARAMETERS
1700 '
1710 'NOTE:You may change any parameter followed by a comment.
1720 ' This will enable you to adjust the size and placement of
1730 ' the active window to any location on the screen. You can
1740 '  also match the input range of the graph with LP and UP. Here
they give a range of 0-2V.
1750 '
1760 LP=0!      'Lower Plot Limit (volts, A/D counts, etc.)
1770 UP=2!      'Upper Plot Limit (volts, A/D counts, etc.)
1780 LX=30      'Left X border (pixels, default = 10)
1790 RX=630     'Right X border (pixels,  default = 630)
1800 TY=20      'Top Y border (pixels, default = 10)
1810 BY=180     'Bottom Y border (pixels, default = 190)
1820 YG=4       'Number of graduations on vertical axis
1830 XG=8       'Number of graduations on horizontal axis
1840 SX=RX-LX   'Number of readings plotted on the X axis.
1850            'equals RX-LX. SX can also be entered as a constant.
1860 SF=SX/(RX-LX)
1870 PY = (UP-LP)/(BY-TY):XX=LX
1880 GOSUB 2170  'Drop down and pick up the frame and tick marks
1890 GOSUB 2390  'Drop down and pick up the grid.
1900 RETURN
1910 '
1920
'-------------------------------------------------------------------
1930 '
1940 ' POINT PLOTTER
1950 '
1955 VX(7)=N2/100
1960 FOR I = 1 TO 7
1970 IF XX>RX THEN XX=LX:GOSUB 2250
1980 PL=UP-VX(I)        ' "VX" is the value of the data point. 1990
'This is the link between the data acquisition and graphing.
2000 YY=(PL/PY)+TY
2010 IF YY<TY THEN YY=TY
2020 IF YY>BY THEN YY=BY
2030 PSET (XX,YY),1
2040 NEXT I
2050 XX=XX+1/SF
2060 RETURN
2070 '
2080 '-------------------------------------------------------------
2090 '
2100 ' DRAW FRAME AND TICK MARKS
2110 '
```

```
2120 ' The first program line in this section draws a frame.
2130 ' The second program line in this section draws tick marks on the
Y axis.
2140 ' The third program line in this section draws tick marks on the X
axis.
2150 ' You may comment out any line if you do not want that feature.
2160 '
2170 LINE (LX-1,TY-1)-(RX+1,BY+1),1,B
2180 FOR GY=TY TO BY STEP ((BY-TY)/20): LINE(LX-1,GY)-(LX-9,GY): NEXT
GY
2190  GX=XX :LINE(GX,BY+1)-(GX,BY+5)
2200 IF TICK%>0 THEN PRINT #1," "; TICK%; " **minute marker line"
2210 RETURN
2220 '
2230'-----------------------------------------------------------------
2240 '
2250 ' CLEAR ACTIVE WINDOW AND DRAW GRID
2260 '
2270 ' The first program line in this section erases the active window
2280 ' when graph reaches the right border. For "page overlay" mode,
2290 ' comment out this line.
2300 ' The second program line in this section draws a horizontal grid.
2310 ' The third program line in this section draws a vertical grid.
2320 ' Comment out the second or third lines if you do not want grids.
2330 ' The grids will consist of dotted lines. They are less likely to
2340 ' obscure the plot line, but take longer to draw and replace when
2350 ' the active window is erased. The subroutine BGRAPH.SUB uses
solid lines for grids.
2360 '
2370 LINE (LX,TY)-(RX,BY),0,BF
2380 LINE (30,182)-(630,191),0,BF
2390 FOR GY=(TY+40) TO (BY-40) STEP ((BY-TY)/YG):FOR GR=LX TO RX STEP
10: PSET(GR,GY),1:NEXT GR:NEXT GY
2400 '* FOR GX=LX TO RX STEP ((RX-LX)/XG):FOR GR=TY TO BY STEP 4:
PSET(GX,GR),1:NEXT GR:NEXT GX
2410 RETURN
2420 '
2430'*****************************************************************
2440 '*
2450 '*              DISK ACCESS SUBROUTINES
2460 '*
2470 '*     Open disk files for data output
2480 '*
2490 CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
2500 GOSUB 2880
2510 INFILE$="S"+MO$+DA$+HR$+MIN$+".DAT"
2520 LOCATE 25,1: PRINT INFILE$;
2530 OPEN "O",#1,INFILE$
2540 PRINT #1,"Sensistor probe test data file ";INFILE$
2545 PRINT #1,TOP$
```

```
2550 PRINT #1,"Date ";MO$;"/";DA$;"/";YR%
2560 PRINT #1,"8506 box # ";BOX$;".  Data recorded every ";RATE;
"seconds."
2570 PRINT #1,RATE
2580 PRINT #1," Day  Time  Probe> ";CHL$(1);"     ";CHL$(2);"
";CHL$(3); "     ";CHL$(4);"     ";CHL$(5);"     ";CHL$(6);"   %N2"
2590 OPEN "O",#2,"PLAYBACK.FIL"
2600 PRINT #2,INFILE$
2610 FOR I = 1 TO 6
2620 PRINT #2, CHL$(I)
2630 NEXT I
2640 PRINT #2, RATE
2650 PRINT #2, BOX$
2660 CLOSE #2
2670 RETURN
2680 '*
2690 OPEN "I",#2,"PLAYBACK.FIL"
2700 INPUT #2, OLDFILE$: OLDFILE$=LEFT$(OLDFILE$,12)
2710 FOR I = 1 TO 6
2720 INPUT #2, CHL$(I):CHL$(I)=LEFT$(CHL$(I),2)
2730 NEXT I
2740 INPUT #2, RATE
2750 INPUT #2, BOX$
2760 CLOSE #2
2770 RETURN
2780 '*
2790 FOR I = 1 TO 6
2800 VX$(I)=LEFT$(STR$(VX(I)),6):NEXT I
2810 PRINT #1, STAR$;" ";DA$;" ";HR$;":";MIN$;"::";SEC$;" ";VX$(1);"
";VX$(2);" ";VX$(3);" ";VX$(4);" ";VX$(5);" ";VX$(6);" "N2$
2820 '*
2830 FILE=FILE+1:LOCATE 25,55:PRINT "F = ";FILE
2840 RETURN
2850 '*
2860 '*      Subroutine to convert integers to strings for date line
2870 '*
2880 MI$=RIGHT$(STR$(MO%),2)
2890 IF MI$="10" THEN MO$="O":GOTO 2930
2900 IF MI$="11" THEN MO$="N":GOTO 2930
2910 IF MI$="12" THEN MO$="D":GOTO 2930
2920 MO$=RIGHT$(MI$,1)
2930 '
2940 IF DA% >9 THEN GOTO 2970
2950 DA$="0"+RIGHT$(STR$(DA%),1)
2960 IF DA% <10 THEN GOTO 2980
2970 DA$=RIGHT$(STR$(DA%),2)
2980 '
2990 IF HR% >9 THEN GOTO 3020
3000 HR$="0"+RIGHT$(STR$(HR%),1)
3010 IF HR% <10 THEN GOTO 3030
```

```
3020 HR$=RIGHT$(STR$(HR%),2)
3030 '
3040 IF MIN% >9 THEN GOTO 3070
3050 MIN$="0"+RIGHT$(STR$(MIN%),1)
3060 IF MIN% <10 THEN GOTO 3080
3070 MIN$=RIGHT$(STR$(MIN%),2)
3080 '
3090 IF SEC% >9 THEN GOTO 3120
3100 SEC$="0"+RIGHT$(STR$(SEC%),1)
3110 IF SEC% <10 THEN GOTO 3130
3120 SEC$=RIGHT$(STR$(SEC%),2)
3130 '
3140 RETURN
3150 N2=N2*10
3160 IF N2 >9.99 THEN GOTO 3200
3170 IF(N2 <1 AND  N2>.1) THEN GOTO 3190
3175 IF N2 < .1 THEN N2$="  .09":GOTO 3210
3180 N2$ = " "+MID$(STR$(N2),2,4):GOTO 3210
3190 N2$ = "  "+MID$(STR$(N2),2,3):GOTO 3210
3200 N2$ = MID$(STR$(N2),2,5)
3210 RETURN



10 ' ***************************************************************
20 ' *
30 ' * PROGRAM NAME: PLAYBACK.BAS                    DATE: 04/24/92
40 ' *
50 ' * CORTES L. PERRY, C L PERRY ASSOCIATES, HUNTSVILLE, AL 35815
60 ' *
70 ' ***************************************************************
80 ' *
90 ' *       Here is the program title banner
100 '*
110 CLS
120 PRINT:PRINT:PRINT TAB(20) "Sensistor Playback Program":PRINT:PRINT
130 '*
140 XX=0:VA=0
150'***************************************************************
160 '*
170 '*       Set up file to be played back
180 '*
190 OPEN "PLAYBACK.FIL" FOR INPUT AS #2
200 INPUT #2,STORED$:CLOSE #2
210 PRINT "Data files in this directory are:"
220 FILES "S*.dat"
230 PRINT:PRINT "The default file is  ";STORED$:PRINT
240 ON ERROR GOTO 1720
250 INPUT "Select data file to play back. <CR> selects default";INFILE$
260 IF INFILE$=""  THEN  INFILE$=STORED$
```

```
270'*****************************************************************
280 '*
290 '*       Open Data file and index to first record
300 '*
310 GOSUB 1740
320 IF RATE= 0 THEN PRINT " No data recorded in ";INFILE$:CLOSE #1
330 IF RATE > 0 THEN GOTO 400
340 INPUT "Enter <CR> to redo ";INFILE$: IF INFILE$="" THEN GOTO 110
ELSE END
350 '*
360 '*****************************************************************
370 '*
380 '*       Turn off "keys" and select high res graphics
390 '*
400 CLS:KEY OFF:SCREEN 1:WIDTH 80
410 '*
420 '*****************************************************************
430 '*
440 '*       Before data acquisition, go to the first part of the
graphing
450 '*       subroutine to set up the graphing parameters.
460 '*
470 GOSUB 1000              'Initialize the graphing parameters
480 '*
490 '*       Next, write labels to the screen
500 '*
510 LOCATE 3,1:PRINT"2.0"
520 LOCATE 8,1:PRINT"1.5"
530 LOCATE 13,1:PRINT"1.0"
540 LOCATE 16,1:PRINT "N2-"
550 LOCATE 18,1:PRINT"0.5"
560 LOCATE 20,1:PRINT "H2-"
570 LOCATE 23,1:PRINT"0.0"
580 DDATE$=MID$(HEAD2$,6,13)
590 LOCATE 25,5:PRINT DDATE$
600 LOCATE 25,62:PRINT "Rate = ";RATE
610 LOCATE 25,20:PRINT"Sensistor Probe Data File  ";INFILE$
620 '*
630'*****************************************************************
640 '*
650 '       This is the main program area.
660 '*
670 PROBE1$=MID$(HEAD4$,19,2): PROBE2$=MID$(HEAD4$,26,2):
PROBE3$=MID$(HEAD4$,33,2): PROBE4$=MID$(HEAD4$,40,2):
PROBE5$=MID$(HEAD4$,47,2):PROBE6$=MID$(HEAD4$,54,2)
680 IF EOF(1) THEN GOTO 1830
690 INPUT #1, ALINE$
700 STAR$=LEFT$(ALINE$,1)
710 IF STAR$="+" THEN GOSUB 1440: GOTO 680
720 VX$(1)=MID$(ALINE$,17,5):VX$(2)=MID$(ALINE$,24,5)
```

```
730 VX$(3)=MID$(ALINE$,31,5):VX$(4)=MID$(ALINE$,38,5)
740 VX$(5)=MID$(ALINE$,45,5):VX$(6)=MID$(ALINE$,52,5)
750 VX$(7)=MID$(ALINE$,58,3)
760 LOCATE 1,5: PRINT "Probe ";PROBE1$;"= ";VX$(1)
770 LOCATE 1,25: PRINT "Probe ";PROBE2$;"= ";VX$(2)
780 LOCATE 1,45: PRINT "Probe ";PROBE3$;"= ";VX$(3)
790 LOCATE 2,5: PRINT "Probe ";PROBE4$;"= ";VX$(4)
800 LOCATE 2,25: PRINT "Probe ";PROBE5$;"= ";VX$(5)
810 LOCATE 2,45: PRINT "Probe ";PROBE6$;"= ";VX$(6)
820 '* now look for keyboard input
830  Z=1:I$=INKEY$:Z=Z+1:IF (INKEY$="" AND Z<2) THEN 830
840  IF I$=" " THEN GOTO 1830
850 GOSUB 1200
860 GOTO 680
870 '*
880 '*
890'*************************************************************************
900 '
910 '********************** REAL-TIME GRAPH SUBROUTINE ************
920 '
930 ' GRAPH SET-UP PARAMETERS
940 '
950 ' NOTE: You may change any parameter followed by a comment ( ' ).
960 ' This will enable you to adjust the size and placement of the
970 ' active window to any location on the screen. You can also match
980 ' the input range of the graph with LP and UP. Here they give a
range of 0-2V.
990 '
1000 LP=0!                'Lower Plot Limit (volts, A/D counts, etc.)
1010 UP=2!               'Upper Plot Limit (volts, A/D counts, etc.)
1020 LX=30                  'Left X border (pixels, default = 10)
1030 RX=630                 'Right X border (pixels,  default = 630)
1040 TY=20                  'Top Y border (pixels, default = 10)
1050 BY=180                 'Bottom Y border (pixels, default = 190)
1060 YG=4                   'Number of graduations on vertical axis
1070 XG=8                   'Number of graduations on horizontal axis
1080 SX=RX-LX               'Number of readings plotted on the X axis.
1090             'equals RX-LX. SX can also be entered as a constant.
1100 SF=SX/(RX-LX)
1110 PY = (UP-LP)/(BY-TY):XX=LX
1120 GOSUB 1420      'Drop down and pick up the frame and tick marks
1130 GOSUB 1630      'Drop down and pick up the grid.
1140 RETURN
1150 '
1160'-------------------------------------------------------------------
1170 '
1180 ' POINT PLOTTER
1190 '
1200 FOR I = 1 TO 7
1210 IF XX>RX THEN XX=LX:GOSUB 1610
```

```
1220 VX(I)=VAL(VX$(I)):VX(7)=VX(7)/100
1230 PL=UP-VX(I)    ' "VX" is the value of the data point. This is the
1240                ' link between the data acquisition and graphing.
1250 YY=(PL/PY)+TY
1260 IF YY<TY THEN YY=TY
1270 IF YY>BY THEN YY=BY
1280 PSET  (XX,YY),1
1290 NEXT I
1300 XX=XX+1/SF
1310 RETURN
1320 '
1330'-------------------------------------------------------------
1340 '
1350 ' DRAW FRAME AND TICK MARKS
1360 '
1370 ' The first program line in this section draws a frame.
1380 ' The second program line in this section draws tick marks on the
Y axis.
1390 ' The third program line in this section draws tick marks on the X
axis.
1400 ' You may comment out any line if you do not want that feature.
1410 '
1420 LINE (LX-1,TY-1)-(RX+1,BY+1),1,B
1430 FOR GY=TY TO BY STEP ((BY-TY)/20):LINE(LX-1,GY)-(LX-9,GY):NEXT GY
1440 GX=XX :LINE(GX,BY+1)-(GX,BY+5)
1450 RETURN
1460 '
1470'-------------------------------------------------------------
1480 '
1490 ' CLEAR ACTIVE WINDOW AND DRAW GRID
1500 '
1510 ' The first program line in this section erases the active window
1520 ' when graph reaches the right border. For "page overlay" mode,
1530 ' comment out this line.
1540 ' The second program line in this section draws a horizontal grid.
1550 ' The third program line in this section draws a vertical grid.
1560 ' Comment out the second or third lines if you do not want grids.
1570 ' The grids will consist of dotted lines. They are less likely to
1580 ' obscure the plot line, but take longer to draw and replace when
1590 ' the active window is erased. The subroutine BGRAPH.SUB uses
solid lines for grids.
1600 '
1610 LINE (LX,TY)-(RX,BY),0,BF: LOCATE 24,5
1620 LINE (30,182)-(630,191),0,BF
1630 FOR GY=(TY+40) TO (BY-40) STEP ((BY-TY)/YG):FOR GR=LX TO RX STEP
10: PSET(GR,GY),1:NEXT GR:NEXT GY
1640 '* FOR GX=LX TO RX STEP ((RX-LX)/XG):FOR GR=TY TO BY STEP 4:
PSET(GX,GR),1:NEXT GR:NEXT GX
1650 LOCATE 22,20:PRINT "Touch space bar to stop playback"
1660 RETURN
```

```
1670 '
1680'*************************************************************************
1690 '*
1700 '*     Open disk files for input
1710 '*
1720 IF ERR= 53 THEN PRINT "Error - file not found - retry ":GOTO 230
1730 PRINT "Error - ";ERR : GOTO 1900
1740 OPEN "I",#1,INFILE$
1750 INPUT #1, HEAD1$
1755 INPUT #1, TOP$
1760 INPUT #1, HEAD2$
1770 INPUT #1, HEAD3$
1780 INPUT #1, RATE
1790 INPUT #1, HEAD4$
1800 RETURN
1810 '*
1820 '*     Close disk files before exit
1830 LOCATE 22,15:PRINT "Do you want to print the data file <CR> = Yes
?"
1840 IF LEN(INKEY$)>0 THEN GOTO 1840
1850 A$=INKEY$:IF LEN(A$)=0 THEN GOTO 1850
1860 IF A$ <> CHR$(13) THEN GOTO 1900
1870 CLOSE #1: OPEN "I",#1,INFILE$
1880 IF EOF(1) THEN GOTO 1900
1890 INPUT #1, A$ : LPRINT A$: GOTO 1880
1900 LOCATE 23,1: CLOSE #1
1910 END
```

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CORTES L. PERRY

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C. L. PERRY ASSOCIATES
P. O. BOX 4325
HUNTSVILLE, AL 35815

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Final report on a study to assess the feasibility of a combined Metal Oxide Semiconductor Field Effect Transistor (MOS-FET) and Mass Spectrometer (MS) system for remotely sensing hydrogen leaks in a test stand/test bed environment.

The MOS-FETs are suitable for low level qualitative detection whereas the MS is suitable for higher level quantitative detection.

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