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.
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.
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 OxFF8 -s
\KEITHLEY\HARDINIT -c OxFF8 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
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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:TICK=0:TOCK=0
220 PASS=0:FILE=0:STAR$="0":H2=0:N2=0:O2=O:VSw=0:COUNT=0
230 AR=0:HE=0:MAR=0:MHE=0:MH2=0:MN2=0:MO2=0
240 '
250 CALL INIT
260 '
270'********************************************************************
280 '*
290 '* Choose the data rate to be recorded
300 '*
310 LOCATE 15,15:INPUT "Data rate to record to disk (seconds/file)";
320 RATE: PRINT
330 IF RATE > 0 THEN GOTO 370
340 IF LEN(INKEY$)>0 THEN GOTO 390
350 AS=INKEY$:IF LEN(A$)=0 THEN GOTO 390
360 IF A$ <> CHR$(13) THEN GOTO 310
370 PRINT "Enter experiment comment line of up to 75 characters."
380 INPUT TOPS: TOPS = LEFTS(TOPS,75)
390 PRINT "Enter the name of the operator (up to 40 characters)."
400 INPUT OPERATORS: OPERATORS = LEFTS(OPERATORS,40)
410 '*
420 '********************************************************************
430 '*
440 '* Turn off "keys" and set up terminal
450 '*
460 CLS:KEY OFF:SCREEN 0:WIDTH 80
470 '*
480 '* Next, write labels to the screen
490 '*
500 LOCATE 1,5:PRINT "TWOMASS.BAS - C L Perry Associates"
510 LOCATE 5,15:PRINT"Mass Spectrometer Data"
520 LOCATE 8,7:PRINT"Gas MGA-1200 MGA-1600"
530 LOCATE 10,5:PRINT"Hydrogen "
540 LOCATE 12,5:PRINT"Helium "
550 LOCATE 14,5:PRINT"Nitrogen "
560 LOCATE 16,5:PRINT"Oxygen "
570 LOCATE 18,5:PRINT"Argon "
580 FOR I= 4 TO 19:LOCATE I,1:PRINT ":";NEXT
590 LOCATE 3,2:PRINT "(";NEXT
600 FOR I= 4 TO 19:LOCATE I,46:PRINT ":";NEXT
610 LOCATE 19,2:PRINT ""
620 LOCATE 23,10:PRINT "Samples OFF":STAR$="0":VSW=0
630 LOCATE 21,1:PRINT TOP$
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640 LOCATE 25,55:PRINT "Press E to exit";
650 LOCATE 25,1:PRINT "Operator: ";OPERATOR$;
660 '*
670 '************************************************************************
680 '*
690 '* This is the main program area.
700 '*
710 '* Set up all data channels (see SOFT500 manual)
720 '*
730 '* WARNING: DO NOT put comments on the lines following
740 ION$="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
CALL ANREAD '("N2",N2,0)
CALL ANREAD '("MN2",MN2,0)
CALL ANREAD '("O2",O2,0)
CALL ANREAD '("MO2",MO2,0)
CALL ANREAD '("H2",H2,0)
CALL ANREAD '("MH2",MH2,0)
CALL ANREAD '("HE",HE,0)
CALL ANREAD '("AR",AR,0)
CALL ANREAD '("MAR",MAR,0)

CALL ANREAD '("N2",N2,0)
CALL ANREAD '("MN2",MN2,0)
CALL ANREAD '("O2",O2,0)
CALL ANREAD '("MO2",MO2,0)
CALL ANREAD '("H2",H2,0)
CALL ANREAD '("MH2",MH2,0)
CALL ANREAD '("HE",HE,0)
CALL ANREAD '("AR",AR,0)
CALL ANREAD '("MAR",MAR,0)

'* scale the values to percents & sum each for averaging
N2=N2*10:MN2=MN2*20:AN2=AN2+N2:BN2=BN2+MN2
O2=O2*10:MO2=MO2*20:AO2=AO2+O2:BO2=BO2+MO2
HE=HE*10:MHE=MHE*20:AHE=AHE+HE:BHE=BHE+MHE

PASS = PASS + 1
'* This is the cycle end - all probes have been read once

CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
GOSUB 2310:' * convert time to string variable
TM1=(HR%*3600+MIN%*60+SEC%):' * real time clock value
'* check the 1 second timer
IF TM1 = TM0 THEN GOTO 1140:' there's time for another reading
TOCK=TOCK+1:COUNT=COUNT+1:IF TOCK=60 THEN TICK=TICK+1:TOCK=0
LOCATE 11,51:PRINT "Elapsed Time ";TICK:"::";TOCK
LOCATE 5,54:PRINT "Real Time ";HR$;":";MIN$;":";SEC$
'* now average the readings
N2=AN2/PASS:MN2=BN2/PASS:AN2=0:BN2=0
O2=AO2/PASS:MO2=BO2/PASS:AO2=0:BO2=0
HE=AHE/PASS:MHE=BHE/PASS:AHE=0:BHE=0
H2=AH2/PASS:MH2=BH2/PASS:AH2=0:BH2=0
LOCATE 10,21:PRINT USING "###.##";H2
LOCATE 10,35:PRINT USING "###.##";MH2
LOCATE 12,21:PRINT USING "###.##";HE
LOCATE 12,35:PRINT USING "###.##";MHE
LOCATE 14,21:PRINT USING "###.##";N2
LOCATE 14,35:PRINT USING "###.##";MN2
LOCATE 16,21:PRINT USING "###.##";O2
LOCATE 16,35:PRINT USING "###.##";MO2
LOCATE 18,21:PRINT USING "###.##";AR
LOCATE 18,35:PRINT USING "###.##";MAR
IF COUNT=RATE THEN GOSUB 2220:COUNT=0:' record data on disk
LOCATE 14,59:PRINT "Rate ";RATE:' * print cycle count
LOCATE 23,59:PRINT "Reads ";PASS :PASS=0
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$="0":LOCATE 23,10:PRINT "Samples OFF":VSW=0
1710 ' Switch the MGA-1200 sample ports using VSW
1720 CALL DIGWRITE("SW04",VSW)
1730 GOTO 1120 :
1740 '*
1750 '******************************************************************
1760 '*
1770 '* Close the data files, reset screen, list data files, exit
1780 '*
1790 VSW=0
1800 CALL DIGWRITE("SW04",VSW)
1810 CLOSE #1
1820 CLS:SCREEN 0:WIDTH 80:PRINT:PRINT:PRINT
1830 PRINT TAB(15) "Data file for this run is named: ";INFILE$
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$;" ran this experiment.
2100 PRINT #1,". Day Time
2110 OPEN "O",#2,"TWOMASS.FIL"
2120 PRINT #2, INFILE$
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 OPEN #1, ".", DA$; "": HR$; "": MIN$; "": SEC$; "": PRINT #1, USING "####.##"; N2; O2; AR; HE; H2; PRINT #1, USING "#####"; PASS; PRINT #1, "", STARS$.
2240 PRINT #1, "."; PRINT #1, USING "#####.##"; MN2; MO2; MAR; MHE; MH2; PRINT #1, USING "#####"; PASS; PRINT #1, "", STARS$.
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
Here is the program title banner

Print: Print: Print Tab(20) "Mass Spectrometer Program": Print: Print

Here is the program title banner

Set up file to be played back

Open "TWOMASS.FIL" for input as #2

Print "Data files in this directory are:"

Files "T*.dat"

Print: Print "The default file is "; Stored$: Print

On error goto 380

Input "Select data file to play back. <CR> selects default"; Infile$

If Infile$ = "" then Infile$ = Stored$

Open Data file and index to first record

Locate 22, 15: Print "Do you want to print the data file <CR> = Yes ?"

If len(INKEY$) > 0 then goto 310

As = Inkey$: If len(As) = 0 then goto 320

If As <>Chr$(13) then goto 370

Close #1: Open "I", #1, Infile$

If EOF(1) then goto 370

Input #1, As: LPrint As: Goto 350

Locate 23, 1: Close #1

If Err = 53 then print "Error - file not found - retry": Goto 200

End
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

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' *
```
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$(13) THEN GOTO 610
460 '*
470 '*
480 PRINT:INPUT"WhichSENSISTOR box is being used ";BOX$: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 *
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
LOCATE 8,1:PRINT "1.5" 'voltage at graph middle
LOCATE 13,1:PRINT "1.0"
LOCATE 16,1:PRINT "N2-
LOCATE 23,1:PRINT "0.0"
'*
'******************************************************************************************
'*
'* This is the main program area.
'*
'* Set up six data channels (see SOFT500 manual)
'*
FOR I = 1 TO 6
ION$="data"+CH$(I):SLOT%=I:CHAN%=CHAN%(I):ACC%=I4:GAIN%=I
CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
NEXT
ION$="H2":SLOT%=I:CHAN%=8:ACC%=I4:GAIN%=I0
CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
ION$="N2":SLOT%=I:CHAN%=I0:ACC%=I4:GAIN%=I
CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
ION$="O2":SLOT%=I:CHAN%=I1:ACC%=I4:GAIN%=I
CALL IONAME '(ION$,SLOT%,CHAN%,ACC%,GAIN%)
'*
'******************************************************************************************
'*
Create and open data file to receive the collected data
'*
GOSUB 2490 :'also saves the setup parameters in PLAYBACK.FIL
'*
'******************************************************************************************
'*
Now we begin to collect the data, graph and record it
'*
CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
CLOCK = (HR%*3600+MIN%*60+SEC%) * convert time to string variable
TM2 = CLOCK+60 :'start of 60 second timer
TM3=CLOCK+1 :'start of 1 second timer
TM4=CLOCK+RATE : 'start of rate timer
GOSUB 2880:' * convert time to string variable
LOCATE 1,65:PRINT "ST ";HR$;".";MIN$;".";SEC$;' * put start time on screen
'Cycle entry point
CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
GOSUB 2880:' convert time to string variable
TM1=(HR%*3600+MIN%*60+SEC%):' * real time clock value
'*
IF TM1=TM3 THEN TOCK%=TOCK%+1:TM3=TM3+1:IF TOCK%=60 THEN TOCK%=0
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1200 IF TM1=TM2 THEN TICK%=TICK%+1:GOSUB 2190:TM2=TM2+60
1210 '*
1220 LOCATE 25,65:PRINT "ET ";TICK%:";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$="*" THEN VX(7)=.3:' * hydrogen marker
1420 '*
1430 '* This is the cycle end - all probes have been read once
1440 '*
1450 '* check the 60 second timer
1460 LOCATE 25,25:PRINT "R = ";RATE:' * print cycle count on screen
1470 '* now look for a keyboard input
1480 Z=1:Z=INKEY$: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 INFILS
1620 PRINT "and this name is saved in PLAYBACK.FIL for auto playback."
1630 END
1640 '*
'**************************************************************************************************

' REAL-TIME GRAPH SUBROUTINE

' GRAPH SET-UP PARAMETERS

' NOTE: You may change any parameter followed by a comment. This will enable you to adjust the size and placement of the active window to any location on the screen. You can also match the input range of the graph with LP and UP. Here they give a range of 0-2V.

LP=0! 'Lower Plot Limit (volts, A/D counts, etc.)
UP=2! 'Upper Plot Limit (volts, A/D counts, etc.)
LX=30 'Left X border (pixels, default = 10)
RX=630 'Right X border (pixels, default = 630)
TY=20 'Top Y border (pixels, default = 10)
BY=190 'Bottom Y border (pixels, default = 190)
YG=4 'Number of graduations on vertical axis
XG=8 'Number of graduations on horizontal axis
SX=RX-LX 'Number of readings plotted on the X axis. equals RX-LX. SX can also be entered as a constant.
SF=SX/(RX-LX)
PY=(UP-LP)/(BY-TY):XX=LX

GOSUB 2170 'Drop down and pick up the frame and tick marks
GOSUB 2390 'Drop down and pick up the grid.
RETURN

\------------------

' POINT PLOTTER

VX(7)=N2/100
FOR I = 1 TO 7
    IF XX>RX THEN XX=LX:GOSUB 2250
    PL=UP-VX(I) ' "VX" is the value of the data point. This is the link between the data acquisition and graphing.
    YY=(PL/PY)+TY
    IF YY<TY THEN YY=TY
    IF YY>BY THEN YY=BY
    PSET (XX,YY),I
    XX=XX+I/SF
NEXT I

\------------------

' DRAW FRAME AND TICK MARKS

\------------------
The first program line in this section draws a frame.
The second program line in this section draws tick marks on the Y axis.
The third program line in this section draws tick marks on the X axis.
You may comment out any line if you do not want that feature.

LINE (LX-I,TY-I)-(RX+I,BY+I),I,B
FOR GY=TY TO BY STEP ((BY-TY)/20): LINE(LX-I,GY)-(LX-9,GY): NEXT GY
GX=XX :LINE(GX,BY+I)-(GX,BY+5)
IF TICK%>0 THEN PRINT #1," "; TICK%; " **minute marker line"
RETURN

-----------------------
CLEAR ACTIVE WINDOW AND DRAW GRID
The first program line in this section erases the active window
when graph reaches the right border. For "page overlay" mode,
comment out this line.
The second program line in this section draws a horizontal grid.
The third program line in this section draws a vertical grid.
Comment out the second or third lines if you do not want grids.
The grids will consist of dotted lines. They are less likely to
obscure the plot line, but take longer to draw and replace when
the active window is erased. The subroutine BGRAPH.SUB uses
solid lines for grids.

LINE (LX,TY)-(RX,BY),0,BF
LINE (30,182)-(630,191),0,BF
FOR GY=(TY+40) TO (BY-40) STEP ((BY-TY)/YG):FOR GR=LX TO RX STEP i0: PSET(GR,GY),I:NEXT GR:NEXT GY
FOR GX=LX TO RX STEP ((RX-LX)/XG):FOR GR=TY TO BY STEP 4: PSET(GX,GR),I:NEXT GR:NEXT GX
RETURN

***********************************************************************
DISK ACCESS SUBROUTINES
Open disk files for data output

CALL CLOCKREAD'(HR%,MIN%,SEC%,DA%,MO%,YR%)
GOSUB 2880
INFILE$="S"+MO$+DA$+HR$+MIN$+".DAT"
LOCATE 25,1: PRINT INFILE$;
OPEN "O",#1,INFILE$
PRINT #1,"Sensistor probe test data file ";INFILE$
PRINT #1,TOPO
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$(VX(I)),6):NEXT I
2810 PRINT #1,STARS;" ";DA$;" ";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$(MI$),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 RETURN
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 '* Open Data file and index to first record
290 '*
300 GOSUB 1740
310 IF RATE= 0 THEN PRINT " No data recorded in ";INFILE$:CLOSE #1
320 IF RATE > 0 THEN GOTO 400
330 INPUT "Enter <CR> to redo ";INFILE$: IF INFILE$="" THEN GOTO 110
340 ELSE END
350 '*
360 '*******************************************************************
370 '* Turn off "keys" and select high res graphics
380 '*
390 CLS:KEY OFF:SCREEN 1:WIDTH 80
400 '******************************************************************
410 '*
420 ' Before data acquisition, go to the first part of the graphing
430 '* subroutine to set up the graphing parameters.
440 '*
450 GOSUB i000 'Initialize the graphing parameters
460 '*
470 '* Next, write labels to the screen
480 '*
490 LOCATE 3,1:PRINT"2.0"
500 LOCATE 8,1:PRINT"1.5"
510 LOCATE 13,1:PRINT"1.0"
520 LOCATE 16,1:PRINT "N2-"
530 LOCATE 18,1:PRINT"0.5"
540 LOCATE 20,1:PRINT "H2-"
550 DDATE$=MID$(HEAD2$,6,1)
560 LOCATE 25,5:PRINT DDATE$
570 LOCATE 25,62:PRINT "Rate = ";RATE
580 '***********************************************************************
590 ' This is the main program area.
600 '*
610 PROBE1$=MID$(HEAD4$,19,2): PROBE2$=MID$(HEAD4$,26,2):
620 PROBE3$=MID$(HEAD4$,33,2): PROBE4$=MID$(HEAD4$,40,2):
630 PROBE5$=MID$(HEAD4$,47,2):PROBE6$=MID$(HEAD4$,54,2)
640 IF EOF(1) THEN GOTO 1850
650 IF STARS="+" THEN GOSUB 1440: GOTO 680
660 VX$(1)=MID$(ALINE$,17,5):VX$(2)=MID$(ALINE$,24,5)
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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$(6)
820 '* now look for keyboard input
830 Z=I$:I$=INKEY$:Z=Z+I$:IF (INKEY$="" AND Z<2) THEN 830
840 IF I$="" THEN GOTO 1830
850 GOSUB 1200
860 GOTO 680
870 '*
880 '*
890 '***********************************************************************
900 '*************** REAL-TIME GRAPH SUBROUTINE ***************
910 'GRAPH SET-UP PARAMETERS
920 'NOTE: You may change any parameter followed by a comment ( ' ).
930 'This will enable you to adjust the size and placement of the
940 'active window to any location on the screen. You can also match
950 'the input range of the graph with LP and UP. Here they give a
960 'range of 0-2V.
970 '1000 LP=0!
1010 UP=2!
1020 LX=30
1030 RX=630
1040 TY=20
1050 BY=180
1060 YG=4
1070 XG=8
1080 SX=RX-LX
1090 SF=SX/(RX-LX)
1100 PY = (UP-LP)/(BY-TY):XX=LX
1110 GOSUB 1420 'Drop down and pick up the frame and tick marks
1120 GOSUB 1630 'Drop down and pick up the grid.
1130 RETURN
1140 '*
1150 '***********************************************************************
1160 'POINT PLOTTER
1170 '*
1180 FOR I = 1 TO 7
1190 IF XX>RX THEN XX=LX:GOSUB 1610
1220 VX(I)=VAL(VX$(I)) : VX(7)=VX(7)/100
1230 PL=UP-VX(I) ' "VX" is the value of the data point. This is the 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 when graph reaches the right border. For "page overlay" mode, comment out this line.
1520 ' The second program line in this section draws a horizontal grid.
1530 ' The third program line in this section draws a vertical grid.
1540 ' The grids will consist of dotted lines. They are less likely to obscure the plot line, but take longer to draw and replace when the active window is erased. The subroutine BGRAPH.SUB uses solid lines for grids.
1550 '
1560 LINE (LX,TY)-(RX,BY),0,BF: LOCATE 24,5
1570 LINE (30,182)-(630,191),0,BF
1580 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
1590 '* FOR GX=LX TO RX STEP ((RX-LX)/XG):FOR GR=TY TO BY STEP 4: PSET(GX,GR),1:NEXT GR:NEXT GX
1600 LOCATE 22,20:PRINT "Touch space bar to stop playback"
1660 RETURN
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1670 '  
1680'**********************************************************************
1690 '  
1700 '  
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 '  
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
**Title and Subtitle:** Remote Hydrogen Sensing Techniques

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**Abstract:**
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.