UNITED STATES AIR FORCE

SUMMER RESEARCH PROGRAM -- 1992

HIGH SCHOOL APPRENTICESHIP PROGRAM (HSAP) REPORTS

VOLUME 16

ARNOLD ENGINEERING DEVELOPMENT CENTER
CIVIL ENGINEERING LABORATORY

RESEARCH & DEVELOPMENT LABORATORIES
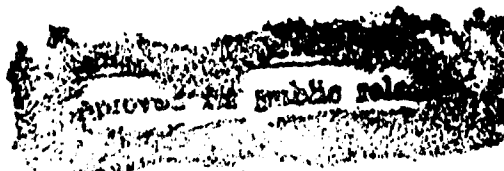
5800 Uplander Way

Culver City, CA 90230-6608

DTIC
ELECTE
APR 2 0 1994
S
G
D

Program Director, RDL Gary Moore	Program Manager, AFOSR Lt. Col. Claude Cavender
Program Manager, RDL Billy Kelley	Program Administrator, RDL Gwendolyn Smith

94-12303

Submitted to:

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

Bolling Air Force Base

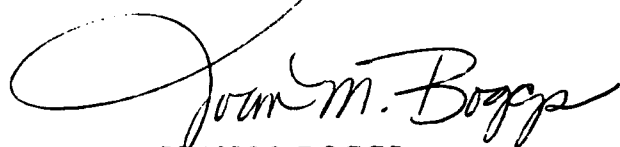Washington, D.C.

December 1992

94   087

MEMORANDUM FOR DTIC (Acquisition)
                (Attn: Pat Mauby)

SUBJECT: Distribution of USAF (AFOSR Summer Research Program (Air Force
Laboratories) and Universal Energy Systems, Inc., and the Research Initiation Program

FROM: AFOSR/XPT
        Joan M. Boggs
        110 Duncan Avenue, Suite B115
        Bolling AFB DC 20332-0001

1. All of the books forwarded to DTIC on the subjects above should be considered
Approved for Public Release, distribution is unlimited (Distribution Statement A).

2. Thank you for processing the attached information.

JOAN M. BOGGS
Chief, Technical Information Division

(1992   HSAP + SFRP Reports
        Vol 13, 14, 16)   (Vol 1, 2, 3, 4) - 1991

            GSRP (Vol 10 + 11) - 1993
                SRP

        HSAP (Vol 12-16 - 1993)

                14 Books

PREFACE

This volume is part of a 16-volume set that summarizes the research accomplishments of faculty, graduate student, and high school participants in the 1992 Air Force Office of Scientific Research (AFOSR) Summer Research Program. The current volume, Volume 16 of 16, presents the final research reports of high school (HSAP) participants at Arnold Engineering Development Center and Civil Engineering Laboratory.

Reports presented herein are arranged alphabetically by author and are numbered consecutively -- e.g., 1-1, 1-2, 1-3; 2-1, 2-2, 2-3. Research reports in the 16-volume set are organized as follows:

VOLUME	TITLE
1	Program Management Report
2	Summer Faculty Research Program Reports: Armstrong Laboratory
3	Summer Faculty Research Program Reports: Phillips Laboratory
4	Summer Faculty Research Program Reports: Rome Laboratory
5A	Summer Faculty Research Program Reports: Wright Laboratory (part one)
5B	Summer Faculty Research Program Reports: Wright Laboratory (part two)
6	Summer Faculty Research Program Reports: Arnold Engineering Development Center; Civil Engineering Laboratory; Frank J. Seiler Research Laboratory; Wilford Hall Medical Center
7	Graduate Student Research Program Reports: Armstrong Laboratory
8	Graduate Student Research Program Reports: Phillips Laboratory
9	Graduate Student Research Program Reports: Rome Laboratory
10	Graduate Student Research Program Reports: Wright Laboratory
11	Graduate Student Research Program Reports: Arnold Engineering Development Center; Civil Engineering Laboratory; Frank J. Seiler Research Laboratory; Wilford Hall Medical Center
12	High School Apprenticeship Program Reports: Armstrong Laboratory
13	High School Apprenticeship Program Reports: Phillips Laboratory
14	High School Apprenticeship Program Reports: Rome Laboratory
15	High School Apprenticeship Program Reports: Wright Laboratory
16	High School Apprenticeship Program Reports: Arnold Engineering Development Center; Civil Engineering Laboratory

1992 HIGH SCHOOL APPRENTICESHIP REPORTS

Arnold Engineering Development Center
Civil Engineering Laboratory

Report Number	Report Title	Author
	Arnold Engineering Development Center	
1	Graphics Library Routines for ETF Analysis Software	Ryan Bond
2	Set-up Criteria for Blackbody Calibration by ECPR Detector	Steven Cortner
3	Visualization of Quantum Chemical Calculations for Molecules	Genetta Gibson
4	Development of a Versatile Spreadsheet for Estimating Electrical Power and Operating Hours for AEDC's Tunnel 16T	Laura Lynn Hill
5	Power Coordination Study	Heather Hopwood
6	A Study of dBase III+ Computer Language and the Development of an Inventory Control Program	Richard Ian Lee
7	Instrumentation and Controls Inventory Program	David Lineberry
8	SGAP Model Building	Chris Marlow
9	Calibration and Application of a Spectrapro^{TM} -275 Spectrometer	Ryan M. Mason
10	A Study of the Continuous Monitoring Station at Arnold Engineering Development Center	Sara Kathryn Waterman
	Civil Engineering Laboratory	
11	A Study of *Littorina irrorata* and Its Environment	Philip C. Dorsch
12	Comparison of the HNU 311 Portable and Hewlett Packard 5890 Series II Gas Chromatographs	Corey D. Fogleman
13	Microbiology Studies and Cup Burner Experiment	Angela D. Foth
14	An Observation of Pluviation in Preparation for Dynamic Experimentation	Mark W. Giles
15	Photo Dissociation of NO_2 in Various Media at PPM Levels	Richard C. Hartzer
16	Solar Detoxification of Contaminated Groundwater	Eric W. Haseltine
17	Description of Weather Station and Its Datalogging Program	Robert L. Kuhn
18	(Report not received)	

ARNOLD ENGINEERING DEVELOPMENT CENTER

GRAPHICS LIBRARY ROUTINES
FOR
ETF ANALYSIS SOFTWARE

Ryan Bond

Mentor:
Stephen M. Powell
Sverdrup Technology, Inc.
AEDC Group

Final Report For:
Summer Research Program
Arnold Engineering Development Center

August 1992

GRAPHICS LIBRARY ROUTINES
FOR
ETF ANALYSIS SOFTWARE

Ryan Bond

Abstract

Graphics software was tested to determine the feasibility of composing a library of graphics subroutines able to interpret calls for the PLOT-10 graphics library and to make the PHIGS calls necessary to perform the same functions. The routines were written and debugged to run in PHIGS on a PHIGS workstation window similar to the way the original calls ran in PLOT-10 on a Tektronix terminal emulator. Using the routines, the test program created a plot in PHIGS almost identical to the PLOT-10 plot, and all features of the test program worked properly.

GRAPHICS LIBRARY ROUTINES
FOR
ETF ANALYSIS SOFTWARE

Ryan Bond

Acknowledgements

Introduction

The standard graphics software for ETF (Engine Test Facility) uses subroutine calls for the PLOT-10 graphics library. The ETF graphics programs can currently be run on a Tektronix terminal, a PC, or an Apollo workstation using a Tektronix 4014 terminal emulator which allows an Apollo or a PC to run the programs by emulating the Tektronix terminal. This terminal emulator software is no longer supported by the Apollo manufacturer, therefore newer releases of the Apollo AEGIS operating system cannot be installed since the terminal emulator is a necessity. Not being able to go above AEGIS version 9.7 limits capabilities now and will continue to cause

progressively greater problems until the current operating system is upgraded.

One way to allow use of the current graphics programs without the terminal emulator is to convert the graphics programs to use another standard graphics package such as PHIGS (Programmers Hierarchical Interactive Graphics Standard). Using PHIGS eliminates the need for the emulator, and PHIGS also provides more powerful features than PLOT-10. PHIGS is hardware independent, so a program written in PHIGS can be transported from one machine to another with only minor difficulties. PHIGS also possesses three-dimensional, RGB color graphics.

The best method of converting the software to PHIGS is to rewrite all the programs from scratch and implement the capabilities of PHIGS not available in PLOT-10. However, this conversion would be very expensive and would take many man-hours to accomplish. A faster and more cost effective method of converting the programs is to compose a library of graphics routines that can interpret the PLOT-10 calls and can perform the same functions by making the proper PHIGS calls. If this method is feasible, it allows use of all software without changing the programs themselves. This method does not implement the new capabilities of PHIGS into the programs, but writing the set of subroutines allows near immediate use of the programs.

Objective

The project objective was to determine the feasibility of using a library of graphics subroutines to allow all current ETF software using PLOT-10 graphics calls to run in PHIGS with little or no change to the main programs themselves.

Methodology

In order to determine whether the use of a graphics library to convert the current software was feasible, it was necessary to compose a set of subroutines and test those routines, attempting to minimize any changes to the main programs. A minimum set of forty-one subroutines would have been necessary to run all four of the main ETF plotting graphics programs (GIANT, PROFILE, PODPLOT, and BTDPLOT), but by choosing a single program, a smaller set of routines was written and debugged much more quickly.

Plotit is the test program that was chosen for the project. Plotit is an interactive program that reads data from a sequential input file and plots the data on a graphics terminal. Plotit is 542 lines long and requires twenty-nine of the forty-one subroutines to run in PHIGS.

Equipment

The library of subroutines was written and debugged on a Sun workstation running the UNIX operating system. A SunPHIGS software package containing library routines for PHIGS was used

on the workstation. An Apollo workstation with a Tektronix 4014 terminal emulator was used as a guide on how the plot should look and how the program functions should work.

Results

All the subroutines were completed and the test program was able to run in PHIGS with only one line of the main program changed while using the routines. The one line that had to be changed was an Apollo-specific call that the Sun workstation did not recognize as a subroutine call making it impossible to write a subroutine to nullify this call. The plot in PHIGS looked very similar to the plot in PLOT-10. All functions of the Plotit program worked properly in PHIGS, although not in exactly the same manner as in PLOT-10.

Figure 1 shows the PLOT-10 plot on an Apollo workstation using the Tektronix 4014 terminal emulator, and Figure 2 shows the PHIGS plot on a Sun workstaion. These figures differ in only one way. The PHIGS plot comes up in a window, where the PLOT-10 plot uses the entire terminal. By working through a window, PHIGS makes it possible to use other features of the workstation in neighboring windows while the program is in operation. This is an advantage of PHIGS that was able to be added without changing the main program. Figures 3 and 4 show the help screen on the Apollo in PLOT-10 and on the Sun in PHIGS, respectively. This screen, which is available to the

user at any time during operation of Plotit, lists all the functions of the program.

Conclusions

The results indicated that it is feasible to use a library of graphics subroutines in order to allow all current ETF analysis software to run in PHIGS, rather than PLOT-10. The library of twenty-nine routines for Plotit worked well enough after limited work to indicate that an experienced programmer could complete the entire set in a reasonable amount of time. However, a problem could arise in some of the more complex graphics programs now in use. PHIGS is a much more structured system than PLOT-10, therefore certain PHIGS calls must be made in proper order. PLOT-10 contains no such limitations, so some of the more complex programs may need to be reorganized to allow full use of the graphics library.

References

Brown, Maxine D. Understanding PHIGS. Megatek Corp., 1985.

Merchant, Michael J. FORTRAN 77 Language and Style. California: Wadsworth, Inc., 1985.

PLOT-10 360-370 Graphics Software User's Manual. Tektronix, Inc., 1971.

SunFORTRAN User's Guide. Sun Microsystems, Inc., 1990.

SunPHIGS 1.3 Manual Set. Sun Microsystems, Inc., 1989.

Figure 1

HOURS PER WEEK FOR EIGHT WEEKS

Figure 2

HOURS PER WEEK FOR EIGHT WEEKS

1-9
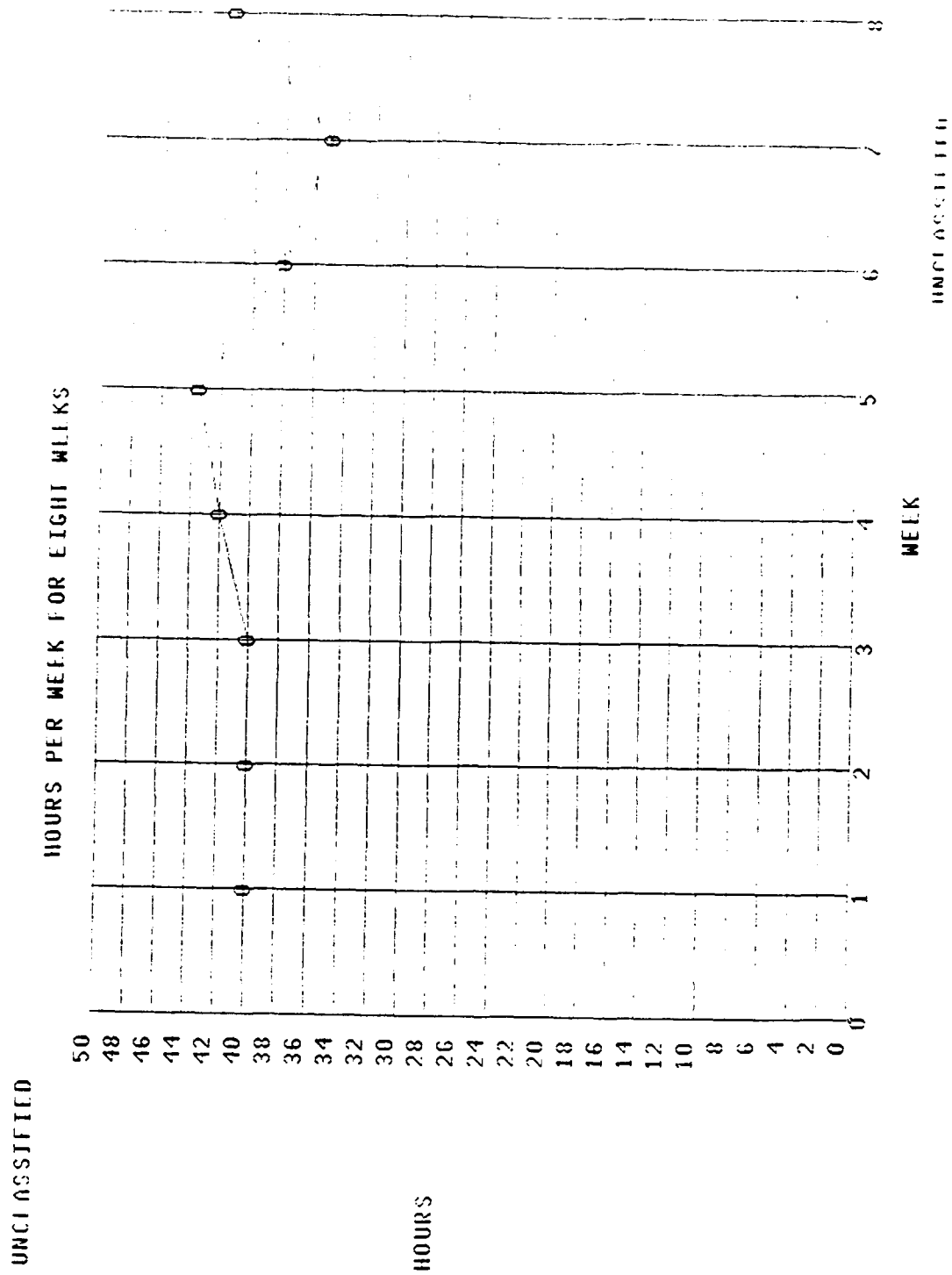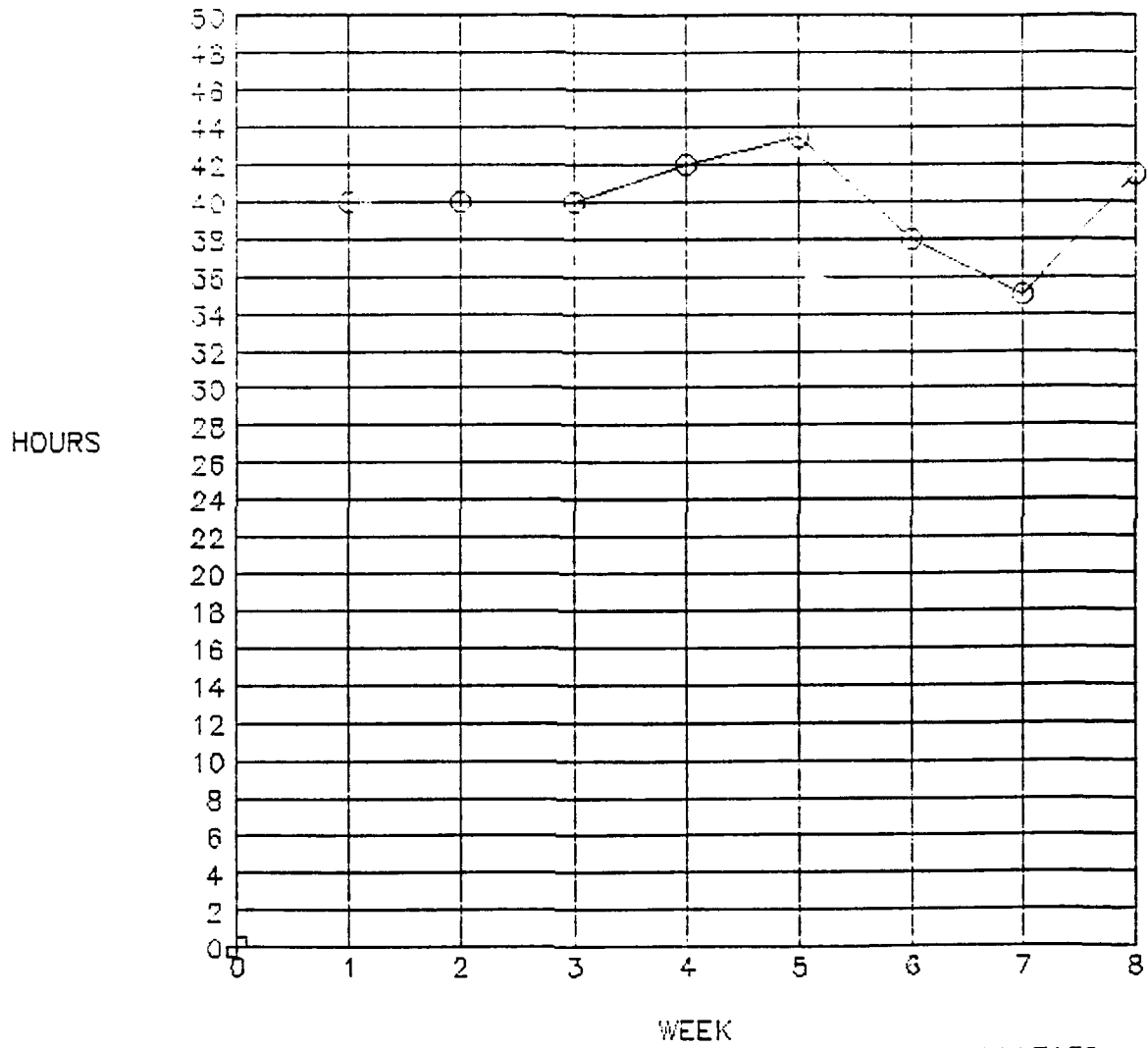
Figure 3

PLOT PROGRAM HELP LIST

KEY   DESCRIPTION

D   DECIMAL PLACES
E   EXIT FROM PROGRAM
G   REDRAW THE PLOT
H   HELP (DISPLAY THIS LIST)
I   INDICATE SCREEN COORDINATES
L   GRID LINES
S   RESCALE
U   UPDATE THE PLOT TITLE
V   LINES AND SYMBOLS
W   LINES ONLY
X   DISPLAY X AXIS MIN. & MAX.
Y   DISPLAY Y AXIS MIN. & MAX.
> (TC) SET SYMBOL NO. TO PLOT DATA
@ (TC) SYMBOLS ONLY

HIT ANY KEY (NO RETURN) TO RETURN TO PLOT

Figure 4

```
          PLOT PROGRAM HELP LIST
 KEY      DESCRIPTION
 ---      ─────────────────────────────────

  D       DECIMAL PLACES
  E       EXIT FROM PROGRAM
  G       REDRAW THE PLOT
  H       HELP (DISPLAY THIS LIST)
  I       INDICATE SCREEN COORDINATES
  L       GRID LINES
  S       RESCALE
  U       UPDATE THE PLOT TITLE
  V       LINES AND SYMBOLS
  W       LINES ONLY
  X       DISPLAY X-AXIS MIN. & MAX.
  Y       DISPLAY Y-AXIS MIN. & MAX.
  v (LC)  SET SYMBOL NO. TO PLOT DATA
  w (LC)  SYMBOLS ONLY


HIT ANY KEY (NO RETURN) TO RETURN TO PLOT
```

SET-UP CRITERIA FOR BLACKBODY CALIBRATION
BY BCPR DETECTOR

Steven Cortner
Shelbyville Central High School
Shelbyville, Tennessee

Final Report for:
Summer Research Program
Precision Measurement Equipment Laboratory

Sponsored by:
Air Force Office of Scientific Research
Arnold Engineering Development Center

August 1992

SET-UP CRITERIA FOR BLACKBODY CALIBRATION
BY ECPR DETECTOR

Steven Cortner
Shelbyville Central High School
Shelbyville, Tennessee

Abstract

In preparing for a blackbody calibration, the electrically calibrated pyroelectric radiometer (ECPR) detector must be set up so that it will detect radiation directly from the blackbody and not from the walls or the blackbody throat. This is a time-consuming task when done by hand due to many tedious calculations. With this in mind, a computer program was written to reduce the workload and the time it consumed. The program uses geometry - specifically similar triangles - to determine a minimum distance the ECPR detector should be from the aperture so that it can detect the radiation from the blackbody. It also uses the Stefan-Boltzmann law to compute the maximum and minimum distances of the power operating range.

SET-UP CRITERIA FOR BLACKBODY CALIBRATION
BY ECFR DETECTOR

Steven Cortner
Shelbyville Central High School
Shelbyville, Tennessee

Acknowledgements

SET-UP CRITERIA FOR BLACKBODY CALIBRATION
BY ECPR DETECTOR

Steven Cortner

Introduction

"Blackbody" is a term used to describe a surface that
absorbs all radiant energy on it. In 1900 Max Planck developed an
emperical equation that satisfactorily represented the energy
distribution in the spectrum of a blackbody. However, he could not
justify this equation by theoretical reasoning based on laws of
classical physics. He concluded that these laws did not apply to
energy transformations on an atomic scale. He postulated that a
radiating body consisted of an enormous number of elementary
oscillators, vibrating at all possible frequencies. Albert
Einstein later added that the energy radiated by these oscillators
was propagated through space according to classical electro-
magnetic theory (Sears, 1949).

The electrically calibrated pyroelectric radiometer (ECPR)
is designed as a standard for the calibration of radiation sources
(blackbodies), optical components, and other radiometric
instruments from UV to far IR wavelengths. The basic ECPR system
consists of an electrically calibrated pyroelectric detector, a
fixed-shaped chopper, and a readout (Laser Precision Corp.,1983).
The actual blackbody calibration set-up is shown in figure 1.

Discussion of Problem

In preparing the set-up for a blackbody calibration, the
ECPR detector must be at or beyond a certain distance from the

Figure 1

2-5

aperture, so that it can detect radiation emitted from the black-body, not after it has deflected off the walls of the blackbody throat. It also must be at a distance that is within the power operating range of the ECPR. The problem is that the calculations to find these distances are very long and time-consuming. A computer program was needed to calculate these distances much quicker.

Methodology

In order to find the minimum distance the ECPR detector could be from the aperture, a geometric operation involving similar triangles was used. From the basic calibration set-up, shown in figure 2, two similar triangles are formed, figure 3. The height of the smaller triangle is found with the following formula:

HEIGHT1 = DIAMETER OF APERTURE/2 + DIAMETER OF DETECTOR/2. By taking half of the diameter of the aperture, one finds the distance from the center of the detector to the base of the smaller triangle. The remaining half of the detector is added to this to find the total height. The height of the larger triangle is then found using the formula,

HEIGHT2 = (DIAMETER OF INLET − DIAMETER OF APERTURE)/2. By subtracting the diameter of the aperture from the diameter of the inlet, the sum of two equal distances is found. Dividing by two then gives the measurement of one of the distances, which is the height of the larger triangle. The unknown distance, which is the geometric minimum distance the ECPR can be from the aperture,
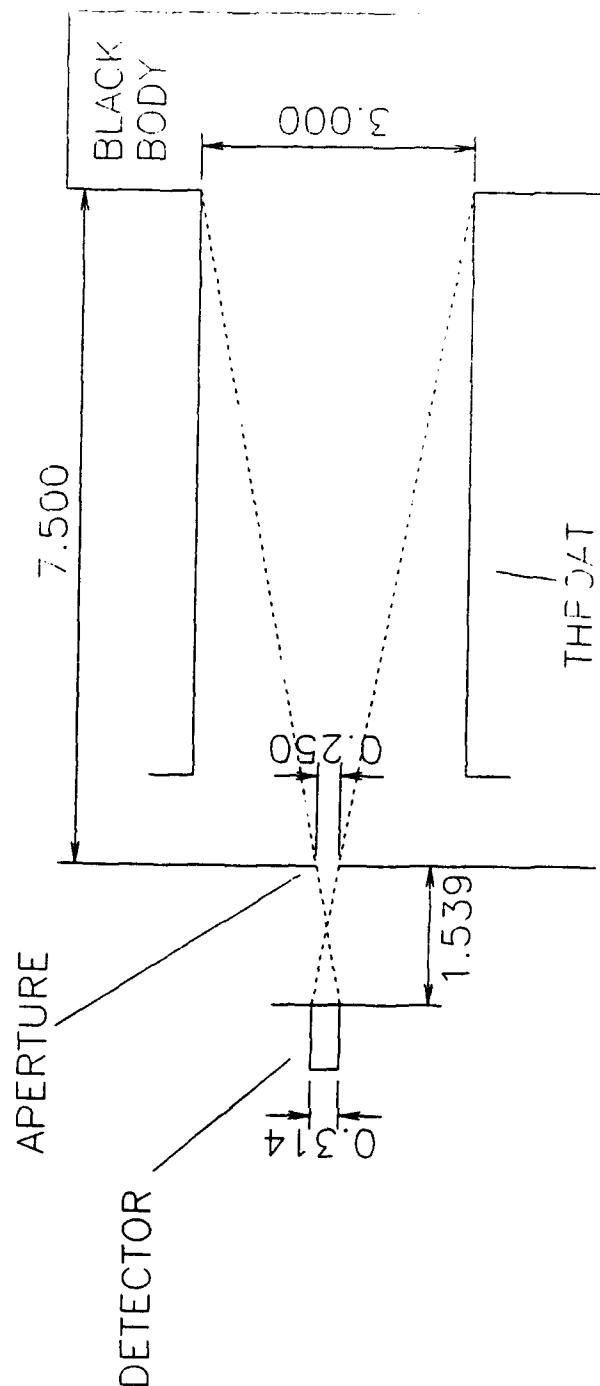
2-6

BASIC DIAGRAM OF BLACKBODY CALIBRATION SET-UP

BLACK BODY

3.000

7.500

THROAT

0.250

1.539

0.314

APERTURE

DETECTOR

Figure 2

Figure 3

2-8
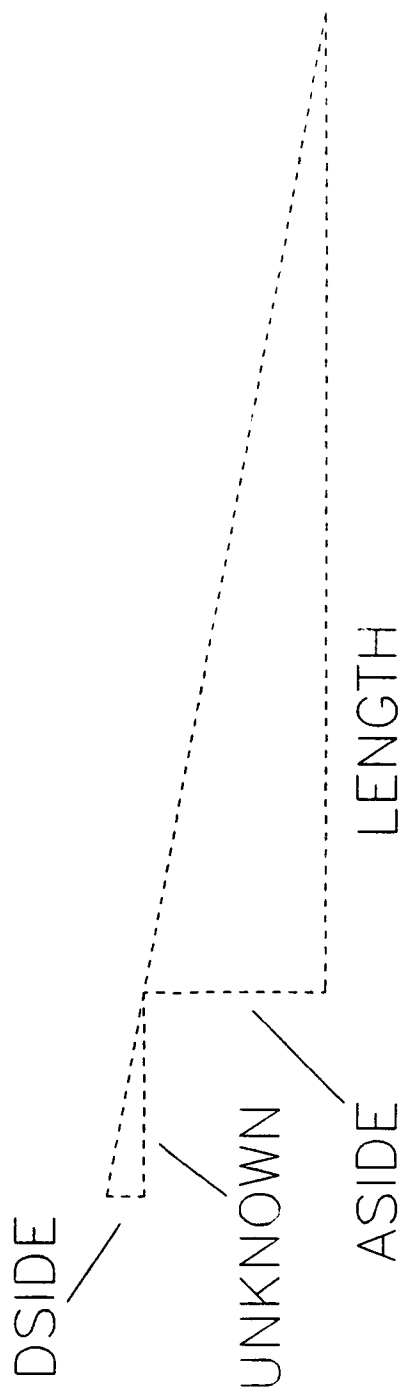
is found by using the transposed proportion.

MINIMUM DISTANCE = (HEIGHT1 * LENGTH OF INLET)/ HEIGHT2.

The power is calculated by using the formulas listed in figure 4. First the radii of the detector and aperture and the area of the aperture are found. Then three variables are used to shorten the long equations that are used later. X and Y are the first two variables. They are found using the two radii and the length of the window, which is found between the detector and the aperture in the actual blackbody calibration set-up. The third variable, Z, is found by using the X and Y variables. All three variables are then used to find the shaping factor. This is then multiplied by the estimated emissivity, the transmittance of the window, the Stefan-Boltzmann constant, the temperature of the blackbody raised to the fourth power, and the area of the aperture (Shepherd and Sherrell, 1987). The power is then used to find the maximum and minimum distances of the ECPR power operating range.

A computer program was written to do all of these calculations quickly. The flowchart in figure 5 represents the basic flow of the program. It prompts the user to input six pieces of information: the diameter of the detector, the diameter of the aperture, the diameter of the inlet, the length of the inlet, the temperature of the blackbody, and the estimated emissivity. All distances are in inches and the temperature is in degrees Celsius. Using this information, the computer will calculate the geometric minimum distance. The Stefan-Boltzmann constant, the transmittance, and the length of the window are then hardwired into the program. Also, distances are converted from inches to centimeters

2-9

FORMULAS

- FORMULAS:
  RADIUS OF DETECTOR = (DIAMETER OF DETECTOR)/2
  RADIUS OF APERTURE = (DIAMETER OF APERTURE)/2
  AREA OF APERTURE = (PI)(RADIUS OF APERTURE)^2
  X = (RADIUS OF DETECTOR)/ MIN.
  Y = MIN. /(RADIUS OF APERTURE)
  Z = 1 + (1 + X^2)(Y^2)
  SHAPING FACTOR = (Z - SQR(Z^2 - 4X^2 * Y^2))/2
  POWER = (EMISSIVITY)(TRANSMITTANCE)(STEFAN/BOLTZMANN CONSTANT)
      (TEMPERATURE)^4(AREA OF APERTURE)(SHAPING FACTOR)

Figure 4

2-10
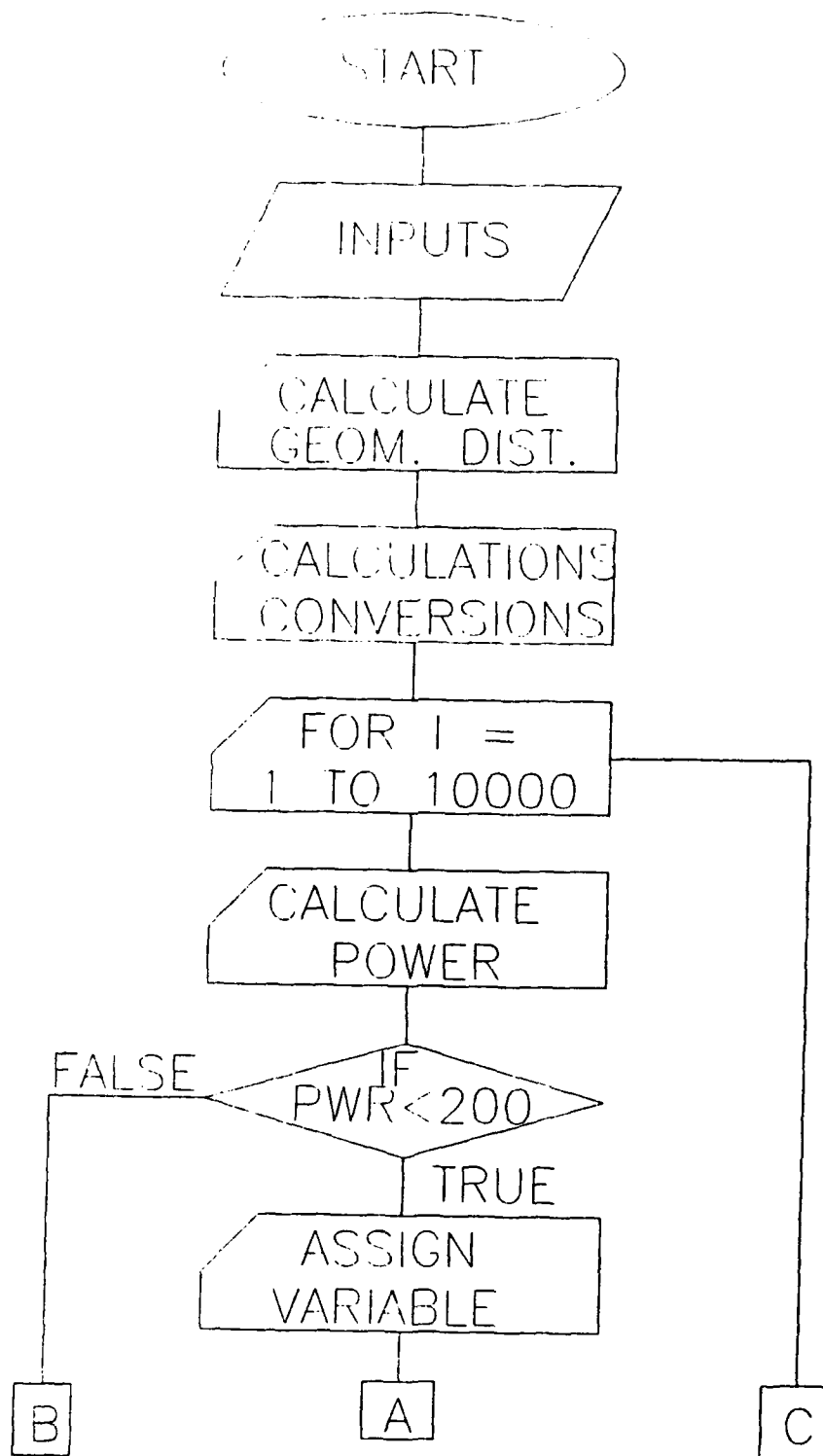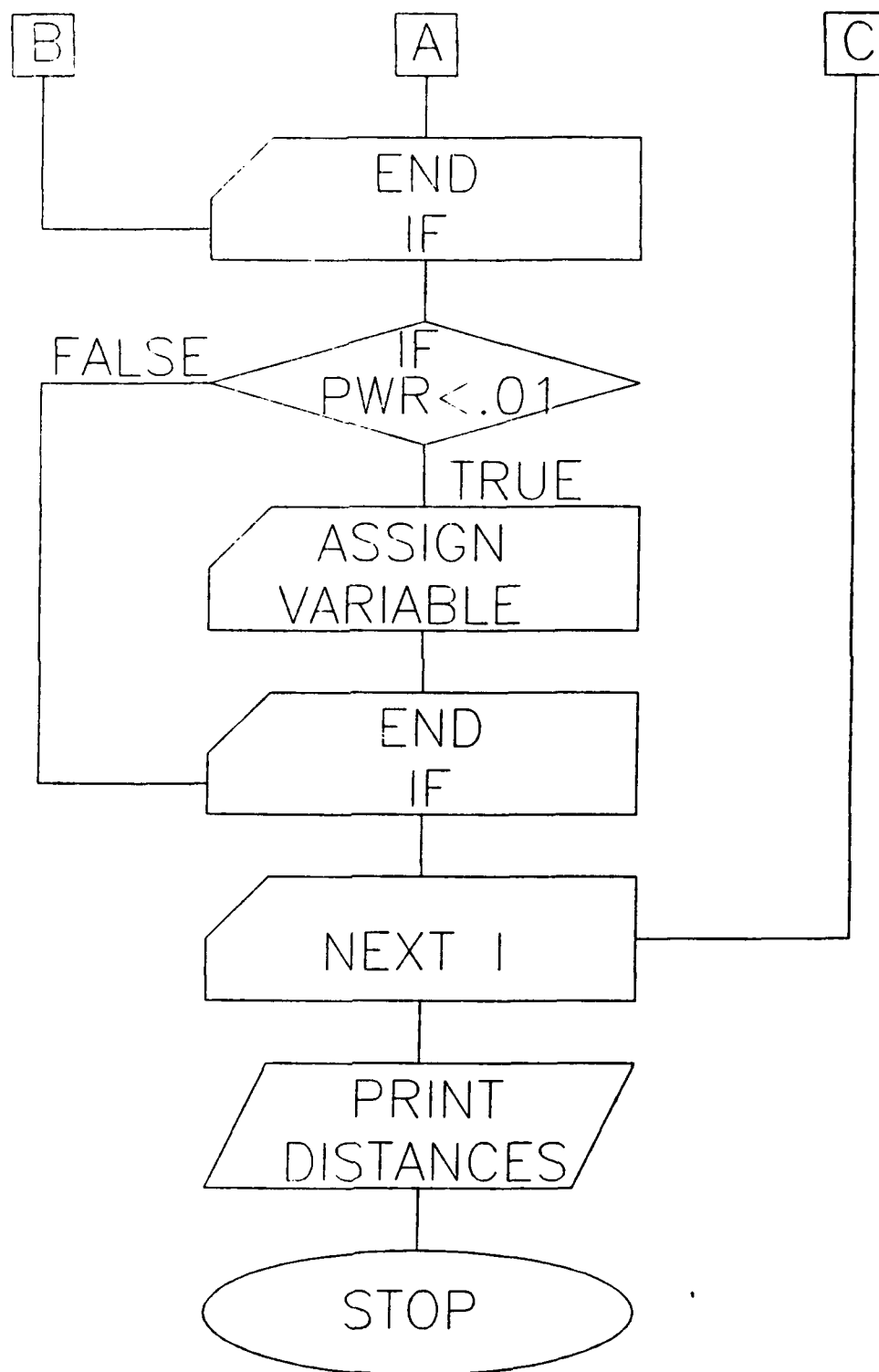
Figure 5

Figure 5 Cont.

and the temperature is converted to degrees Kelvin in order to accomodate the units of the Stefan-Boltzmann constant. The program then begins an iterative routine in which the power is calculated. "If...Then...Else" statements are used to find the minimum, then maximum distances of the ECPR power operating range. When the two distances are found, the program kicks out of the loop and the computer prints all three distances.

Results

Data from this program were correlated with data from a previous calibration. This correlation is shown in the chart in figure 6. The temperature is the only one of the six inputs that changes. Therefore, it is used in the calculations to find the experimentally calculated power. This is then compared with the correct power value in the previous calibration to find the percent of error. The graph in figure 7 plots the percent of error against the temperature. As shown the percent of error is very low, meaning it is very nearly accurate.

Conclusion

Unfortunately, the program was not used in a new calibration set-up. However, comparisons with previous calibrations show that it should work well. It will be used experimentally to test its accuracy. If it works well, it will be used in future blackbody calibrations.

TEMPERATURE IN DEGREES CELSIUS	CORRECT POWER VALUE IN mW	EXPERIMENTAL POWER VALUE IN mW	PERCENT OF ERROR
622	0.1383	0.1384	0.07
705	0.1975	0.1973	0.10
807	0.2930	0.2934	0.14
911	0.4236	0.4239	0.07
978	0.5277	0.5283	0.11
1010	0.5846	0.5844	0.03

Figure 6

2-14

ACTUAL CORRELATION ERROR

Figure 7

2-15
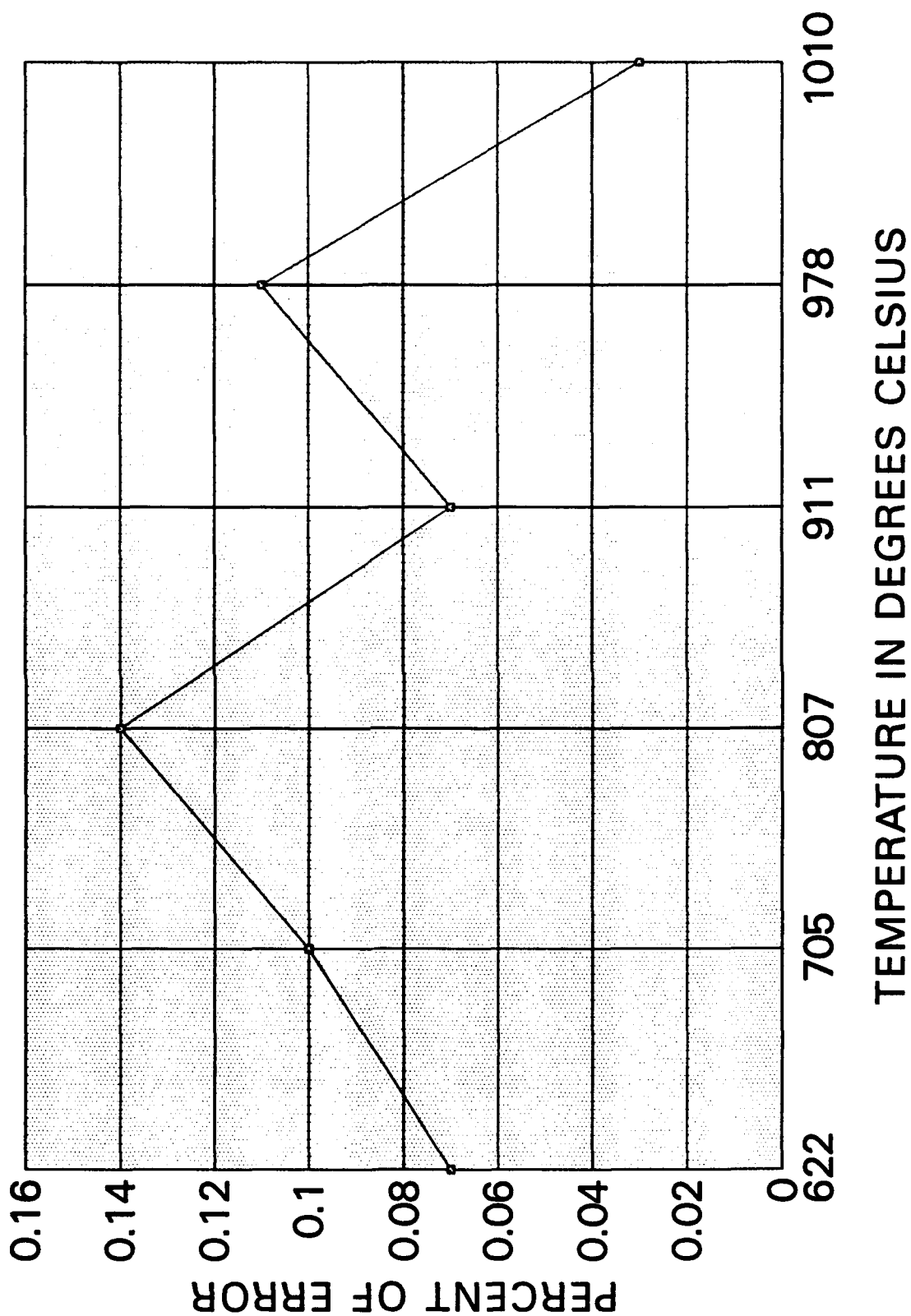
References

Laser Precision Corp., RS-5900 Electrically Calibrated Pyroelectric
    Radiometer Instruction Manual, 1983, pp 8-9.

Sears, Francis Weston, Optics, Cambridge, Mass.: Addison-Wesley
    Press, Inc., 1949, pp 310-312.

Shepherd, T.E. and F.G. Sherrell, Radiometric Qualification of
    Standard Blackbody Sources, 1987.

VISUALIZATION OF QUANTUM CHEMICAL CALCULATIONS FOR MOLECULES

Genetta Gibson
Graduate of Tullahoma High School
Tennessee Technological University

Final Report for:
AFOSR Summer Research Program
Arnold Engineering Development Center

August 1992

VISUALIZATION OF QUANTUM CHEMICAL CALCULATIONS FOR MOLECULES

Genetta Gibson
Graduate of Tullahoma High School
Tennessee Technological University

Abstract

Much of the chemistry that occurs in rocket plumes is a mystery to scientists. Therefore, quantum chemistry, a relatively new field of research, is being used to analyze this chemistry. One of the first steps is visually analyzing single molecules and determining their behavior from the visualization. The behavior of the molecules depends greatly on the electrons that travel around the atomic nuclei in paths called orbitals. Since the paths of these orbitals are not definite, it is difficult to predict the behavior and location of these electrons and, therefore, the structure of the molecule. Since water and diatomic hydrogen are two significant products that are commonly found in rocket exhausts, a computer program was created to visually analyze the electron distribution of these two molecules. The source code to calculate the probability density of the electrons was written in the FORTRAN 77 programming language. Another code which was written in IDL (Interactive Data Language) transfers the probability data into the IDL graphics program. IDL graphics routines are then used to draw a 3D transformation of the electron probability density cloud. Both the FORTRAN and IDL codes are portable to workstations across the network and may be easily modified for the analysis of different molecules.

VISUALIZATION OF QUANTUM CHEMICAL CALCULATIONS FOR MOLECULES

Genetta Gibson

Introduction

Scientists do not fully understand much of the chemistry that occurs in rocket plumes. Therefore, new methods, such as quantum chemistry, are being used to analyze the chemistry. The first step in the analysis process is to visually analyze single molecules. The behavior of these molecules depend greatly upon the location and behavior of the electrons that travel around the atomic nuclei in paths called orbitals. These orbitals are either toward the nucleus or away from it, in all directions around the nucleus, and in more than one plane. Since the paths of these electrons are not definite, it is difficult to predict both the behavior and locations of these electrons and, therefore, the structure of the molecule. Since water and diatomic hydrogen are two significant products found in rocket exhausts, a computer program was created to visually analyze the electron distribution of these molecules.

Acknowledgements

The author would like to thank Jim Drakes for his time in the design of the program and in teaching some basic concepts of quantum chemistry, Tom Daugherty for his instruction using the UNIX operating system, Tim Wallace for his guidance with the various computer systems, Rick Roepke for his help with the operation of the workstations, Robert Hiers for his assistance with the FORTRAN programming, Keith

Bradshaw for his help with IDL and color printing, and the EL3 personnel for all the suggestions and guidance to make this apprenticeship program a successful learning experience.

Description

The orbital shapes of both water and diatomic hydrogen are shown in Figure 1. The 1s orbitals of water and hydrogen have definite paths on which the electrons travel; however, in the p orbital, the electrons can the located on the x, y, or z lobes. Since the electrons positions vary in the p orbital, it is extremely difficult to predict the locations of the orbitals in the water molecule. Since the electrons do not have definite paths or locations, an equation has been developed to predict the probability that an electron will appear at various points in space. The points were selected from a three dimensional cube that surrounds the molecule, as shown in the diagram below.
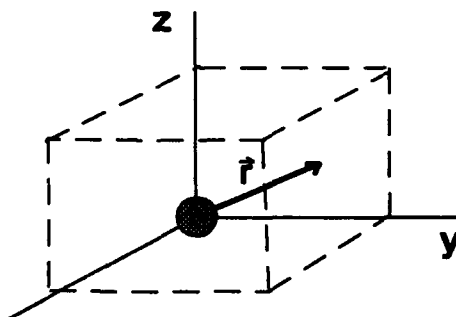
The "r" is the distance from the nucleus of the atom located at the origin to the varying point in space and is the variable for which the probability equation is defined.

$$P(\hat{r}) = \sum_{i,j} P_{ij}\, x_i(\hat{r}) x_j(\hat{r})$$

3-4

Gaussian 90, a computational quantum chemistry package, was used to determine the probability density matrix (P_{ij}) for the two selected molecules. (The mentor performed that task.) The software package was also used to determine some constants in the orbital functions (x_i and x_j). A FORTRAN program was created to solve the probability equation for both diatomic hydrogen and water. The program solved the equation for each variable point inside the dimensioned cube and then wrote these values to a file. The IDL program took these data values and transferred them into a specific format for IDL to use. IDL graphics routines were used to draw three dimensional transformations of the electron probability density cloud for visual analysis.

Results

The drawings of the electron probability density clouds can be found on Figures 2 and 3. (The contour and appearance of the drawings appear much clearer in color.) The first picture of the diatomic hydrogen is a representation of the isosurface at a probability density of 0.95. The IDL graphics routine that drew this representation goes into the image and "slices" the image at that number and then draws the density cloud for all those values plus any numbers of higher value. Therefore, this number, along with the angle of visualization, explains the difference in the two pictures of diatomic hydrogen. The lighter areas of the pictures are the nuclei of the hydrogen atoms that have a high probability density.

The same features of the hydrogen cloud apply to the water probability density cloud. However, these pictures are a representation of the isosurface at a probability density of 0.0002. In the first picture, the light part is the oxygen nucleus, and the hydrogen nuclei are located on either side below the oxygen nucleus. (The hydrogen

3-5

nuclei are difficult to see because they are on the backside of the drawing.) The second drawing is the same representation at a different angle of visualization.

Summary

A computer program that allows scientists to perform visual analysis of electron probability density clouds for water and diatomic hydrogen molecules was created. The software development was mainly performed on the IBM workstation, but the SUN and Silicon Graphics workstations were also both used. The program to generate the probability data was written in the FORTRAN 77 language, and an IDL program was created to transfer the data into IDL for the 3D transformations. Both the FORTRAN and IDL codes may be easily modified for the analysis of different molecules found in rocket exhaust. Also, both codes are portable on workstations across the network.

Observations

Through creating a program to visually analyze the electron probability density clouds of diatomic hydrogen and water, the author was able to learn the fundamentals of the FORTRAN programming language, IDL programming language, UNIX operating system, and vi text editor; learn the operation of the SUN, Silicon Graphics, and IBM workstations; learn some basic concepts of quantum chemistry; and gain a better insight into the physics, mechanical engineering, and electrical engineering professions.

The author considers the High School Apprenticeship Program to be a success in the field of technology and an excellent learning experience for any teenager who expresses an interest in a technical field. The author would and has recommended the program to interested students.

Bibliography

Asimov, Isaac. **Understanding Physics**. Dorset Press, 1988.

Beyer, William H. **Standard Mathematical Tables**. Ohio: CRC Press, 1976.

Gray, Harry B. **Electrons and Chemical Bonding**. New York: W.A. Benjamin Inc., 1964.

IDL User's Guide. Colorado: Research Systems, Inc., 1991.

Kernigham, Brian and Rob Pike. **The UNIX Programming Environment**. New Jersey: Prentice Hall, Inc., 1984.

Merchant, Michael J. **FORTRAN 77 Language and Style**. California: Wadsworth Publishing Company, 1981.

Physical Interpretation

Oxygen (O)

Hydrogen (H$_2$)

Water (H$_2$O)

Figure 1

H2 Electron Probability Density Cloud

Light-source shaded isosurface of probability density value 0.95 with 20 degrees x-axis rotation and 70 degrees z-axis rotation.
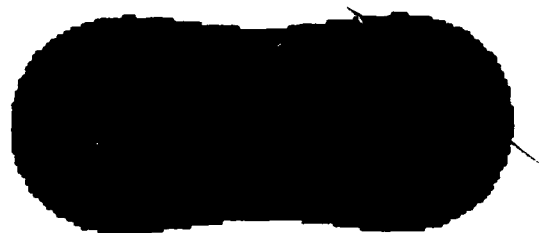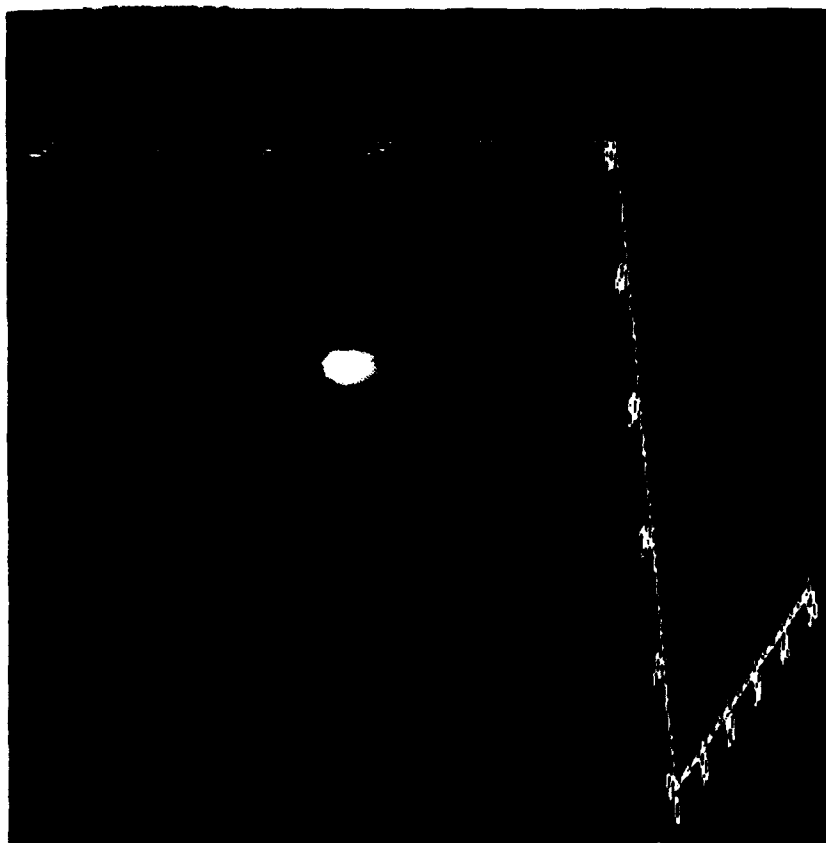
Light-source shaded isosurface of probability density value 0.9 with 10 degrees x-axis rotation and 90 degrees z-axis rotation.

Figure 2

H2O Electron Probability Density Cloud

Light–source shaded isosurface of probability density value 0.0002 with 20 degrees x–axis rotation and 70 degrees z–axis rotation.
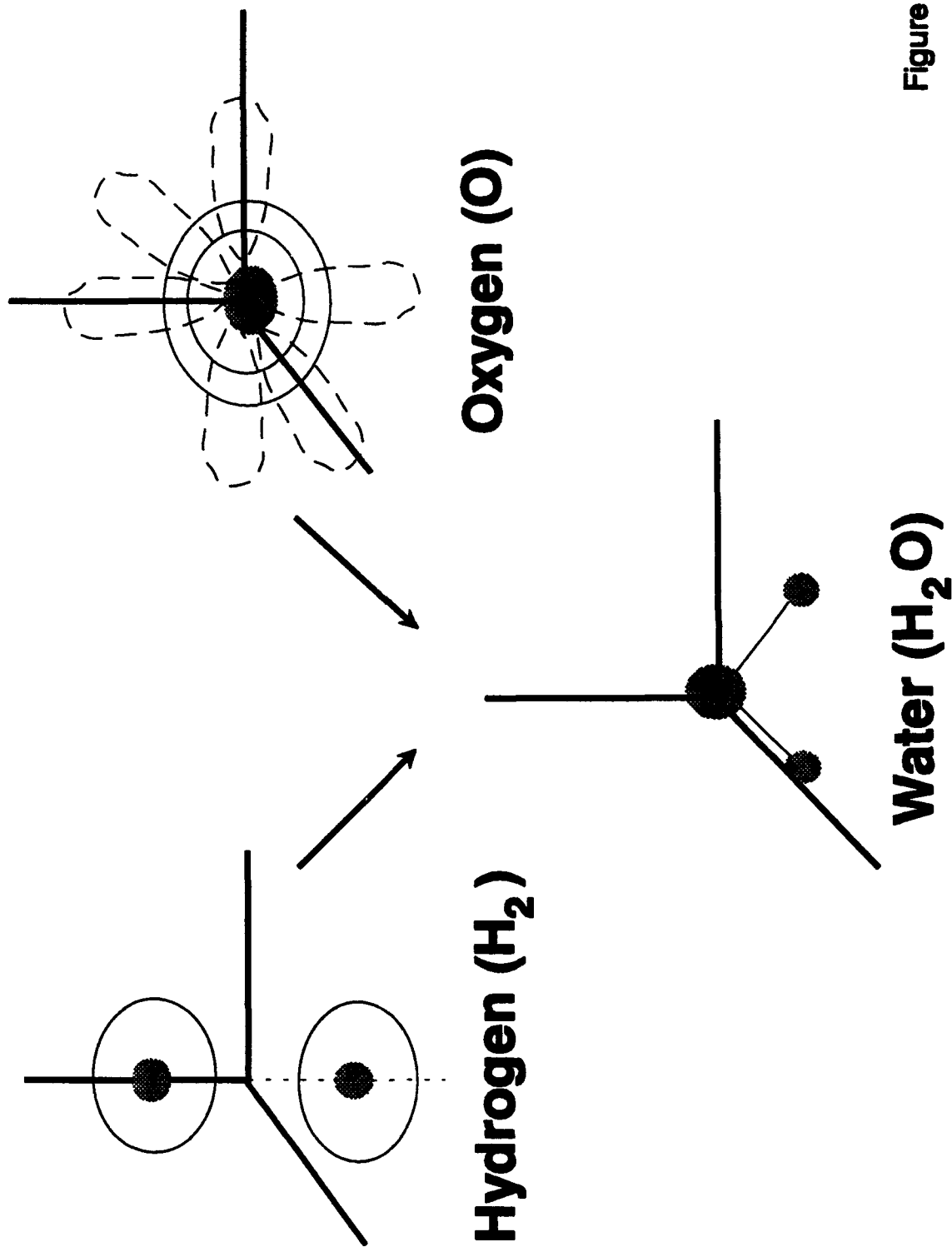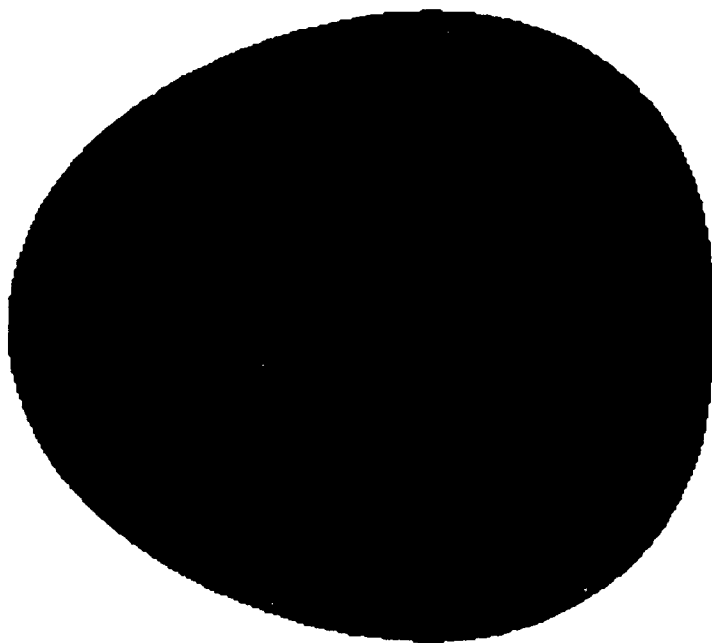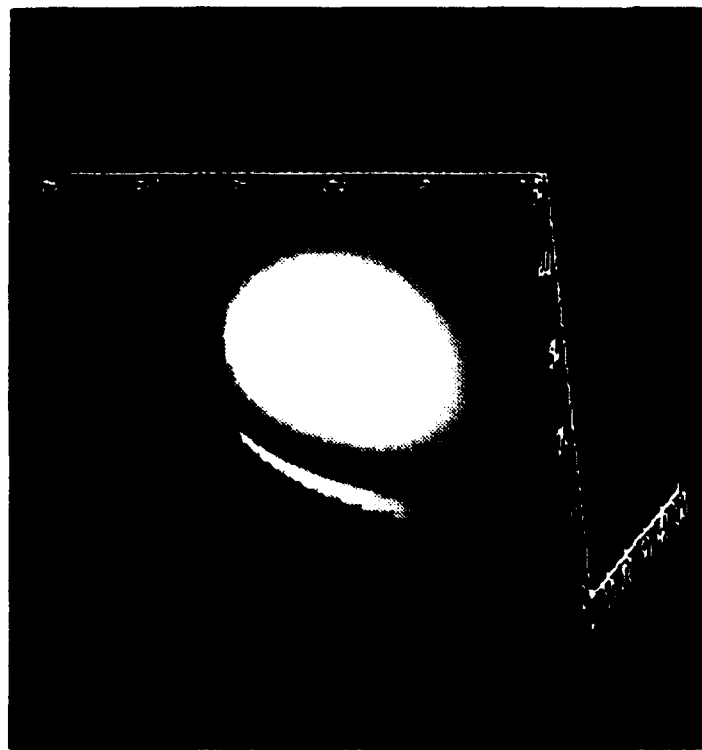
Light–source shaded isosurface of probability density value 0.0002 with 0 degrees x–axis rotation and 90 degrees z–axis rotation.

Figure 3

DEVELOPMENT OF A VERSATILE SPREADSHEET FOR ESTIMATING ELECTRICAL POWER AND OPERATING HOURS FOR AEDC'S TUNNEL 16T

Laura Lynn Hill
Summer Research Apprentice
Propulsion Effects Section

University of Tennessee, Knoxville
Knoxville, Tennessee

DEVELOPMENT OF A VERSATILE SPREADSHEET
FOR ESTIMATING ELECTRICAL POWER AND
OPERATING HOURS FOR AEDC'S TUNNEL 16T

Laura Lynn Hill
Summer Research Apprentice
Propulsion Effects Section
University of Tennessee

Abstract

The cost of the electrical power required to operate the 16-foot Propulsion Wind Tunnel at the Arnold Engineering Development Center (AEDC) is usually a major portion of the resource estimate provided by the project engineer for a particular test. The standard AEDC computer program used to calculate the power estimate does not allow for easy recalculations based on test matrix changes which often occur. To provide more flexibility for the users, the algorithm of the standard program, written in Basic (computer language), was duplicated in a spreadsheet format. The Excel spreadsheet version allows the user to make changes quickly and easily because of the many features available in this format. Formulas written into the spreadsheet cells can be easily modified as required by the user - a feature not available in the Basic program. Transposing different functions from Basic to Excel was the most difficult task of developing the new power estimate program. Because of the many features of the Excel spreadsheet, the power estimate program is now more user-friendly, easily modified to the needs of the user, and can quickly recalculate the power estimate based on last minute changes to the test schedule.

ACKNOWLEDGEMENTS

DEVELOPMENT OF A VERSATILE SPREADSHEET
FOR ESTIMATING ELECTRICAL POWER AND
OPERATING HOURS FOR AEDC'S TUNNEL 16T

Laura Lynn Hill

INTRODUCTION

One major concern in conducting a test in a wind tunnel is the cost of the electrical power that will be consumed during the course of the test. My summer project was to create an Excel spreadsheet that would calculate the power and operating hours required for any test in the 16T tunnel. The existing standard estimate program, written in Basic, was to be transformed to the spreadsheet format which was easy for th ser to modify quickly. The spreadsheet format (Excel) was chosen for various reasons:

  ie cells in the spreadsheet allow the user to quickly change formulas to his own needs. The cell references automatically increment by an appropriate amount as the formula is copied to succeeding cells.

2) Blank columns can be left so that other text or formulas can be added without corrupting already existing cells.

3) Users with test peculiar situations can easily add new formulas to calculate needed information.

4) The user can see all the text and formulas directly on the monitor.

5) Very powerful IF statements and other macro commands allowed complete duplication of the algorithms contained in the original standard program.

For these reasons, the Excel spreadsheet was an excellent way to create a program that would be more user friendly and could quickly recalculate the power estimate based on last-minute changes of the test schedule.

Also during my eight-week apprentice program, I was fortunate enough to be allowed to work in the control room of the 16 foot Propulsion Wind Tunnel while an actual test was taking place. I learned many ways in which computers were vital in that environment. I became involved with making plots of the data from the test and learned a lot about the operation of the wind tunnel.

METHODOLOGY

Steps For Writing the Excel Power Estimate Program

Step 1: A macro sheet was developed which introduced the program to the user and also contained macros and a dialog box that allowed Option 1, 2, 3, or 4 to be selected. A macro is a sequence of functions and commands, similar to a subroutine, that automatically runs different operations for the user such as opening and closing different spreadsheets. Once an option is selected from the dialog box, the

SELECTOPT macro opens the desired spreadsheet.

Several spreadsheet files make up the new power estimate program and are interrelated as shown in Figure 1. The box at the top of the page represents the macro sheet entitled POWEREST.XLM. When the user opens POWEREST.XLM, he only sees the left side of the top box as shown in Figure 2. The two macros in Figure 3 are "hidden" from the viewer to the right. The four test condition options (Option 1, 2, 3, 4.XLS), TestCon.XLS, and RunSched.XLS are all spreadsheets. Options 1, 2, 3, 4.XLS are opened by the dialog box and the SELECTOPT macro. RunSched.XLS communicates with TestCon.XLS and looks up values that it needs for calculating set-up time and the remainder of the power estimate.

Step 2: The formulas in the Basic program had to be interpreted and duplicated in the Excel Spreadsheet. The results from both sets of equations were required to match.

Step 3: Four different options were required to set up the tunnel test conditions and to calculate the power rate per condition. The user chooses from any of the four options shown below:

OPTION 1: Input M (Mach Number), TT (Total Temperature), and PT (Total Pressure)
OPTION 2: Input M, TT, and Rel (Reynolds Number)
OPTION 3: Input M, TT, and Q (Dynamic Pressure)
OPTION 4: Input M, TT, and H (Altitude)

An example of the Option 1 spreadsheet is shown in Figure 4. The shaded columns indicate the values that the user inputs. Values in the other columns, including power rate, are automatically calculated by the spreadsheet.

After these four options were programmed in the spreadsheet format, calculated values were verified from duplicate calculations from the standard program.

Step 4: After the user inputs all known test conditions, he is instructed to press CNTL + r. This command copies the values into another spreadsheet called TestCon.XLS. The command CNTL + r operates a separate macro program (SELECTRUN) from the macro sheet. This macro also opens the Run Schedule spreadsheet (RunSched.XLS) which communicates with TestCon.XLS (see Figure 1). The calculations of set-up time for the test and other calculations such as mega-watt hours, air-on hours, and user-occupancy hours are contained on the lengthy spreadsheet, RunSched.XLS. An example of this spreadsheet is shown in Figure 5. The shaded areas are the values that the user inputs. All other values are calculated.

4-5

One very important feature of the Run Schedule spreadsheet is the Look-up command. This command is an example of the powerful capabilities of Excel. The Look-up command reads specific data from the test condition spreadsheet and writes these numbers into the Run Schedule spreadsheet cells which are used to calculate other values.

Step 5: After the Excel program was completed, an accurate checkpoint had to be made. The checkpoint verifies that the Excel spreadsheet calculations match the Basic program. This checkpoint was accomplished by inputing a group of data that qualified each IF-statement in the Excel version. After the checkpoint was accomplished on the spreadsheet, the same input data was processed with the standard estimate program. Figure 6 shows examples of the matching Excel version and Basic program calculations.

SIMILARITIES OF THE TWO PROGRAMS

Even though the Basic and Excel programs use different commands and functions, they both share common programming techniques. Both have input and output functions that work in similar ways. Three other techniques used in both programs are looping, branching, and subroutine functions. These functions may look different in each of the two programs, but they accomplish the same goal.

DISCUSSION OF PROBLEMS AND DIFFERENCES BETWEEN THE TWO PROGRAMS

A significant problem in creating the spreadsheet version was accurately transposing the same algorithms from Basic to Excel. Even though the final results were required to match, some things had to be handled differently in Excel. The following examples illustrate two of the differences that had to be overcome in creating the new program.

Example 1: Branching and Looping

Branching and looping are two very important techniques in computer programming. IF-statements, Goto Statements, and For-Next Statements are examples. In the Basic program, branching and looping are used extensively. If a value is input into the program, it goes through a long list of statements until it qualifies in one of them. After the input value has qualified an output, the program loops back to the beginning to repeat this process. In the Excel spreadsheet version, all branching and looping are contained in the Excel formulas. The powerful spreadsheet capability automatically increments the cell references when they are copied into succeeding cells. The Excel version does not have to loop when a new value is input. IF-statements are combined in long strings allowing the program to perform complex branching operations.

Example 2: Incrementing Values

```
┌─────────────────────────────────────────┐
│      NOMENCLATURE FOR EXAMPLE 2          │
├─────────────────────────────────────────┤
│      UOH - User Occupancy Hours          │
│      UOHc - Cumulative UOH               │
│      Pc - Cell P Current Value           │
│      Pp - Cell P Previous Value          │
│      UOHcp - Previous UOH Cumulative     │
│      UOHpsc - Current UOH Per-Set Up     │
└─────────────────────────────────────────┘
```

Another difficult requirement was to add an increment to the cumulative UOH value at specific intervals. The first increment of 3 UOH was to be added when half of the interval was accumulated. Additional increments were to be added after each succeeding interval was reached. The requirement was accomplished in the Basic program by a loop that contained an IF-statement which was based on accumulated UOH and a Flag constant that was increased by one for each loop. The intervals were fixed with the first interval equal to 9 and succeeding intervals equal to 17. Thus, the UOH intervals would be 9, 26, 43, 60,...etc. If UOHc > (Flag * 17) - 8, then the increment of 3 was added. The initial increment equaled 9 and the corresponding Flag equaled 1. When UOHc became equal to or greater than 9, the Flag value was increased by 1 and UOHc was increased by 3 The process was then repeated at each succeeding interval of 17 UOH.

To convert this requirement to the Excel version, the interval is set up as a variable which immediately gives the user more flexibility. An increment of 3 UOH is added to the desired intervals. The increments are 1/2 UOH/day, 1/2 UOH/day + UOH/day, 1/2 UOH/day + 2UOH/day...etc. The Flag method in the Basic program was replaced by the following formula which was placed in Cell P of the spreadsheet:

CELL P

Flag= TRUNC((UOHc + 1/2 UOH/day)/UOH/day)

The P1 value is equal to 0 since there is no previous value. The formula for Flag first appears in Cell P2. The formula for UOHc (located in Cell N) is: If $P_c > P_p$ then UOHc = UOHcp + UOHpsc + 3. Otherwise, UOHc = UOHcp + UOHpsc.

When the Cell P value qualifies and the Cell N value is to be incremented, instructions to increment

4-7

the Flag are not necessary since the TRUNC function, which deletes all of the numbers to the right of the decimal place, calculates the appropriate value for Flag. For example, if the first P value is 0, no action takes place. If the second P value is .7, the TRUNC function shows the number as 0 and no increment is added to UOHc. However, if the third P value is 1, the increment is added to UOHc.

Unlike the Basic program, Excel does not need loops to fulfill this increment requirement. One other difference between the two programs is that the IF-statements in the spreadsheet are based on the Flag value and not on the UOHc value as in the Basic program. Both of these techniques accomplish the same requirement but have different approaches. Learning to overcome differences in Basic vs. Excel was crucial in developing the Excel power estimate program, and at the same time, was a great teacher. The Excel capabilities developed during this effort will greatly benefit me and the project engineers I worked with.

RESULTS

Many benefits are attributed to the improved power estimate program. The Excel spreadsheet capability can quickly recalculate the power estimate when last minute changes need to be made to the test schedule. The calculations may be seen directly on the monitor and can be modified to the specific needs of the user. This capability was not possible in the Basic program since the user was only allowed to input values and see the final calculations. Blank columns have been inserted into the spreadsheet to accommodate the needs of test peculiar applications. One user may need to add text while another needs to write a new formula into the spreadsheet. It is easy to make these changes without corrupting any nearby cells with only a modest understanding of the Excel application. These results indicate that the Excel spreadsheet is an improved way for project engineers to calculate power estimates which will save both money and time.

CONCLUSION

The goal of creating a power estimate program with spreadsheet capability that would save both money and time has been accomplished. The resulting program was much needed by project engineers to calculate power for their different wind tunnel tests. Even though this application uses only a few of the many capabilities of Excel, it represents a great beginning from which the project engineer can adapt a very useful tool. In later years, as new technology is developed, the program may easily be updated because of the easy editing capabilities in Excel. For example, when the power estimate program was first written, it was in Excel version 2.1; however, during the course of my apprenticeship, Excel was updated to version 4.0. The 2.1 version works exactly the same in version 4.0 which has greatly expanded capabilities.

4-8

FIGURE 1

POWER ESTIMATE PROGRAM IN SPREADSHEET
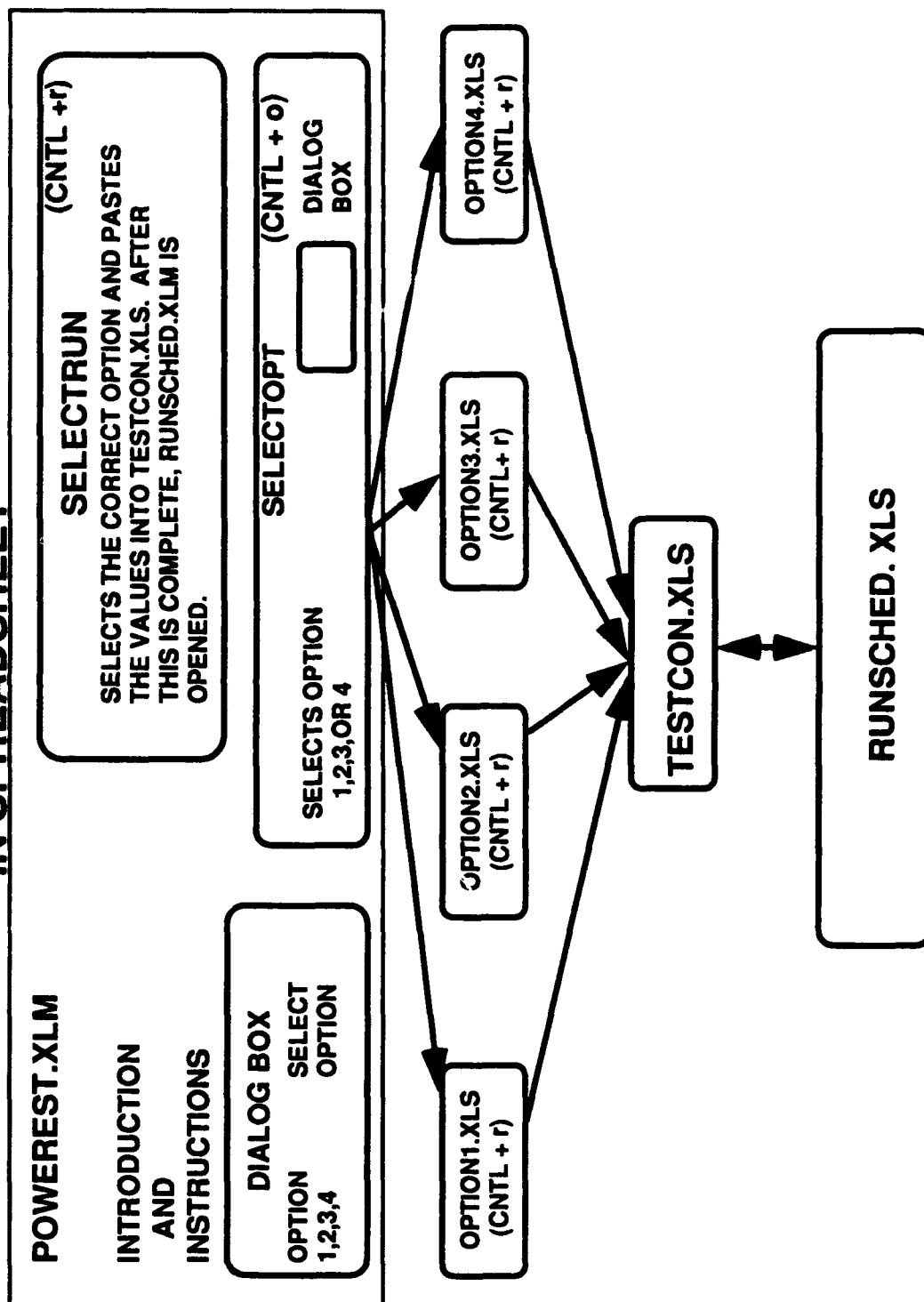
FIGURE 2

INSTRUCTIONS FOR USING THE POWER ESTIMATE PROGRAM

WELCOME TO THE POWER ESTIMATE PROGRAM ADAPTED TO EXCEL SPREADSHEET

FIRST THING TO DO IS FILL OUT THE TEST CONDITIONS TABLE

YOU MUST ENTER MACH NO., TOTAL TEMPERATURE(TT), AND EITHER TOTAL PRESSURE(PT), UNIT REYNOLDS NUMBER(Rel), DYNAMIC PRESSURE(Q), OR ALTITUDE(H)

TEST CONDITION NO. 1 IS ALWAYS AS SHOWN BELOW:

TEST CONDITIONS

TEST COND. #	MACH NO.	TT deg F	PT psf	P psf	Q psf	Rel. *10-6/ft	T deg F	V ft/sec	RHO lbm/ ft^3	H ft	MW mwh /hr
1	0	80	2040	2040	0	0	80	0	.0708	1012	5

FIGURE 3

MACRO SHEET

```
SELECTOPT
=DIALOG.BOX(N1:U8)
=IF(T3=1,GOTO(M4),GOTO(M6))
=OPEN("A:OPTION1.XLS")
=RETURN()
=IF(T3=2,GOTO(M7),GOTO(M9))
=OPEN("A:OPTION2.XLS")
=RETURN()
=IF(T3=3,GOTO(M10),GOTO(M12))
=OPEN("A:OPTION3.XLS")
=RETURN()
=IF(T3=4,GOTO(M13),GOTOM14))
=OPEN("A:OPTION4.XLS")
=RETURN()
```

ONCE THE USER SELECTS THE DESIRED OPTION, MACRO #1 OPENS THE CORRECT OPTION AND DISPLAYS IT ON THE SCREEN.

```
SELECTRUN
=SELECT(!A4:Z31,!A4)
=COPY()
=OPEN("A:TESTCON.XLS:)
=SELECT(TESTCON.XLS!A4)
=PASTE()
=OPEN("A:RUNSCHED.XLS")
=RETURN()
```

MACRO #2 SELECTS THE ENTIRE OPTION AND PASTES IT INTO TESTCON.XLS. ONCE THE VALUES HAVE BEEN PASTED, RUNSCHED.XLS IS OPENED.

When test conditions are complete, open
runsched.xls by typing cntl +r.

FIGURE 4

TEST CONDITIONS											
TEST COND. #	MACH NO.	TT deg F	PT psf	P psf	Q psf	Rel. x10^-6/ft	T deg F	V ft/sec	RHO lbm/ft^3	H ft	MW mwh/hr
1	0.000	80.0	2040.0	2040.0	0.0	0.000	80.0	0	0.0708	1012	5.0
2	0.200	80.0	3672.0	3571.0	100.0	2.299	535.7	227	0.1250	-15203	53.9
3	0.400	80.0	2991.0	2678.8	300.0	3.554	523.3	448	0.0960	-6663	96.3
4	0.600	105.0	1518.0	1190.1	299.9	2.347	527.1	675	0.0423	15068	81.8
5	0.800	105.0	1021.0	669.8	300.1	1.880	500.9	878	0.0251	28558	79.6
6				0.0	0.0	0.000	0.0	0	0.0000	0	0.0
7				0.0	0.0	0.000	0.0	0	0.0000	0	0.0
8				0.0	0.0	0.000	0.0	0	0.0000	0	0.0
9				0.0	0.0	0.000	0.0	0	0.0000	0	0.0
10				0.0	0.0	0.000	0.0	0	0.0000	0	0.0
11				0.0	0.0	0.000	0.0	0	0.0000	0	0.0
12				0.0	0.0	0.000	0.0	0	0.0000	0	0.0
13				0.0	0.0	0.000	0.0	0	0.0000	0	0.0
14				0.0	0.0	0.000	0.0	0	0.0000	0	0.0
15				0.0	0.0	0.000	0.0	0	0.0000	0	0.0

INPUT TEST CONDITION NO. (TC) AND TIME ON CONDITION (TOC)
YOU MAY WRITE EQUATIONS FOR TOC AND MISC AS REQUIRED

INPUT
UOH PER DAY OF TESTING
HERE-> 17

FIGURE 5

RUN SCHEDULE

SET UP NO.	TC	TOC (min.)	SET UP TIME(min)	COMMENTS	MISC	PER SET UP				CUMULATIVE			
						MWH	AOH(hr.)	UOH(hr.)	DAYS	MWH	AOH	UOH	DAYS
1	1	0	0			0	0.0	0.0	0	0	0.0	0.0	0
2	2	60	15			74	1.3	1.3	0	74	1.3	1.3	0
3	3	60	7			116	1.1	1.1	0	190	2.4	2.4	0
4	4	60	15			116	1.2	1.2	0	306	3.6	3.6	0
5	5	60	6			99	1.1	1.1	0	405	4.7	4.7	0
6			0			0	0.0	0.0	0	0	0.0	0.0	0
7			0			0	0.0	0.0	0	0	0.0	0.0	0
8			0			0	0.0	0.0	0	0	0.0	0.0	0
9			0			0	0.0	0.0	0	0	0.0	0.0	0
10			0			0	0.0	0.0	0	0	0.0	0.0	0
11			0			0	0.0	0.0	0	0	0.0	0.0	0
12			0			0	0.0	0.0	0	0	0.0	0.0	0
13			0			0	0.0	0.0	0	0	0.0	0.0	0
14			0			0	0.0	0.0	0	0	0.0	0.0	0
15			0			0	0.0	0.0	0	0	0.0	0.0	0
16			0			0	0.0	0.0	0	0	0.0	0.0	0
17			0			0	0.0	0.0	0	0	0.0	0.0	0
18			0			0	0.0	0.0	0	0	0.0	0.0	0
19			0			0	0.0	0.0	0	0	0.0	0.0	0

INPUT TEST CONDITION NO. (TC) AND TIME ON CONDITION (TOC)
YOU MAY WRITE EQUATIONS FOR TOC AND MISC AS REQUIRED

INPUT
UOH PER DAY OF TESTING
HERE--> 17

FIGURE 8

RUN SCHEDULE

SET UP NO.	TC	TOC (min.)	SET UP TIME (min)	COMMENTS	MISC	PER SET UP				CUMULATIVE			
						MWH	AOH(hr.)	UOH(hr.)	DAYS	MWH	AOH	UOH	DAYS
1	1	0	0			0	0.0	0.0	0	0	0.0	0.0	0
2	1	60	12			6	0.0	1.7	0	6	0.0	1.7	0
3	4	60	15			109	1.3	1.3	0	127	1.3	3.0	0
4	1	60	12			15	0.2	1.7	0	144	1.5	4.7	0
5	9	60	30			108	1.5	1.5	0	267	3.0	6.2	0
6	1	60	12			14	0.2	1.7	0	283	3.2	7.9	0
7	5	60	20			96	1.3	1.3	0	392	4.5	12.2	1
8	4	60	9			110	1.1	1.1	0	513	5.6	13.3	1
9	3	60	6			61	1.1	1.1	0	586	6.7	14.4	1
10	6	60	22			106	1.4	1.4	0	705	8.1	15.8	1
11	4	60	9			110	1.1	1.1	0	826	9.2	16.9	1
12	10	60	31			140	1.5	1.5	0	981	10.8	18.5	1
13	7	60	14			103	1.2	1.2	0	1097	12.0	19.7	1
14	4	60	13			118	1.2	1.2	0	1225	13.2	20.9	1
15	8	60	21			115	1.4	1.4	0	1354	14.6	22.3	1
16	6	60	5			87	1.1	1.1	0	1452	15.7	23.4	1
17	10	60	16			114	1.3	1.3	0	1578	16.9	24.6	1
18	3	60	28			88	1.5	1.5	0	1681	18.4	29.1	1
19	9	60	30			119	1.5	1.5	0	1815	19.9	30.6	1
20	7	60	9			96	1.2	1.2	0	1922	21.1	31.8	2
21	9	60	9			98	1.2	1.2	0	2031	22.2	32.9	2
22	10	60	8			103	1.1	1.1	0	2146	23.3	34.0	2
23	7	60	14			103	1.2	1.2	0	2261	24.6	35.3	2

FIGURE 6 (con't)
BASIC PROGRAM PRINTOUT

16T ENERGY ESTIMATE

SET UP	COND	MACH #	PT	TOC (min)	SET UP	UOH	MW LEVEL	MWH
1	1	0.00	2040	0	0	0.00	0.0	0.0
2	1	0.00	2040	90	0	1.50	0.0	0.0
3	4	0.40	2991	60	15	1.25	96.3	108.4
4	1	0.00	2040	90	12	1.70	0.0	9.6
5	9	1.20	722	60	30	1.50	85.1	106.3
6	1	0.00	2040	90	12	1.70	0.0	8.5
7	5	0.60	1518	60	20	1.33	81.8	95.3
8	4	0.40	2991	60	9	1.15	96.3	109.7
9	3	0.20	3672	60	6	1.10	53.9	61.4
10	5	0.60	1518	60	22	1.36	81.8	106.2
11	4	0.40	2991	60	9	1.15	96.3	109.7
12	10	1.40	696	60	31	1.52	91.3	139.8
13	7	0.90	895	60	14	1.24	82.3	103.3
14	4	0.40	2991	60	13	1.22	96.3	116.4
15	8	0.95	849	60	21	1.36	83.3	115.4
16	6	0.80	1021	60	5	1.09	79.6	86.7
17	10	1.40	696	60	16	1.27	91.3	114.1
18	3	0.20	3672	60	28	1.47	53.9	87.8
19	9	1.20	722	60	30	1.49	85.1	119.2
20	7	0.90	895	60	9	1.16	82.3	95.6
21	9	1.20	722	60	9	1.16	85.1	98.3
22	10	1.40	696	60	8	1.13	91.3	103.1
23	7	0.90	895	60	14	1.24	82.3	103.3

BIBLIOGRAPHY

Using Excel 3
Ron Person
Publisher: Lloyd J. Short
Carmel, Indiana
Copyright 1991

Power Estimate Program
Pete Lauer, AEDC

POWER COORDINATION STUDY

Heather Hopwood
Apprentice
SSI Electrical Engineering

Tullahoma High School

Final Report for:
AFOSR Summer Reasearch Program

Sponsored by:
Arnold Engineering Development Center
Tullahoma, TN

August 1992

THE POWER COORDINATION STUDY

Heather Hopwood
SSI Electrical Engineering
Arnold Air Force Base

Abstract

The Power Coordination Study updates information on the protective function that a relay performs. Specifically the study provides information concerning the effectiveness of the protective devices. If a fault is found in the protection, modifications are recommended. Electrical Distribution System Analysis program (EDSA) will display any problems with the relays through time curves.

THE POWER COORDINATION STUDY

Heather Hopwood

The Power Coordination Study will accumulate pre-recorded data. The old information is gathered from existing drawings and databases. After the information is accumulated and entered into Electrical Distribution System Analysis (EDSA), EDSA will be able to display a problem with one of the relays.

The study researches the protective equipment operating at AEDC. The devices, known as relays, communicate with circuit breakers to insure the safety of transformers, lines, and loads. A relay is an electrical device that provides the logic to tell a circuit breaker to trip. The circuit breaker will shut down the power on the line before more damage occurs. If the relays are inoperative, a disturbance could occur and travel undetected.

The relays' settings have gone without examination for several years. New additions, such as loads, may have been added to a facility without changing a relay's settings to meet the new load's criterion. Therefore, the relay is not working up to it's full potential until it has its settings adjusted.

Arnold Air Force Base receives all of its power from Tennessee Valley Authority (TVA). The power travels at one hundred and sixty-one thousand volts. Once at AEDC, the power is reduced by transformers to a more suitable voltage which loads can use. The power must travel on the lines at high voltages to decrease power loss. After the power reaches a facility, a transformer will reduce the amount of energy for the loads at the facility.

A relay monitors the amount of current flowing through a load. The relays will pick up an overload or another electrical malfunction and trip the circuit breakers which will shut down the load. If the circuit breaker is not warned by the relay, it will not shut down the load. If the overload goes undetected, the whole substation and all the lines the substation feeds can shut down. For a center where tests are the primary element, this could mean a rather costly and timely repair for the damaged equipment.

This has been the second year I have worked on this study. Last year my primary job was to work out in the field and with the computer. I also worked on Aeropropulsion Systems Test Facility (ASTF) and completed several databases concerning this building. This year I learned to read the electrical drawings and locate information concerning relays, circuit breakers, nodes, and branches. I used all the

databases this year in my research on the facility. I have completed ASTF and all of my data has been entered into EDSA.

This year I worked with four other people on this project. Each person involved in the study was responsible for a specific area. I was responsible for recording information on relays, nodes, circuit breakers, and branches. Without my work completed none of the others could progress in their work. The next member of the team would enter all of the data into EDSA and work on the time curves the motors and relays would produce through EDSA. The next member would analyze the curves and decide what settings needed to be changed. The following member would get the job going on replacing the faulty relays.

Diagram I is an one-line diagram. This one-line diagram is a section of ASTF. A one-line diagram is the electrical layout of a building. Transformer A3 transforms the voltage from 161kv to 6.9 kv. Then the voltage travels to synchronous motor BCRC 3.1. Relay A protects other transformers in ASTF and relay B is a primary relay that protects transformer A3. Relay D is a main breaker which protects transformer A3 from the section. Relay E and F are feeder breaker relays that guard the transformer. Relay H is an alarm relay and will sound an alarm if there is an overload. Relay G will try to

ASTF999

(A)

1200/5

OCB1004

ASTF001

(B)

300/5

ASTF001C

(C)

Transf. A3
35/46.6/58.3 MVA
161 - 6.9/6.9 KV
Z = 8.10 %

ASTF983

(D)

1500/5

A3B4-1

ASTF050

(E)

1200/5

A3B4-3

ASTF050B

(F)

1200/5

A3B1-01

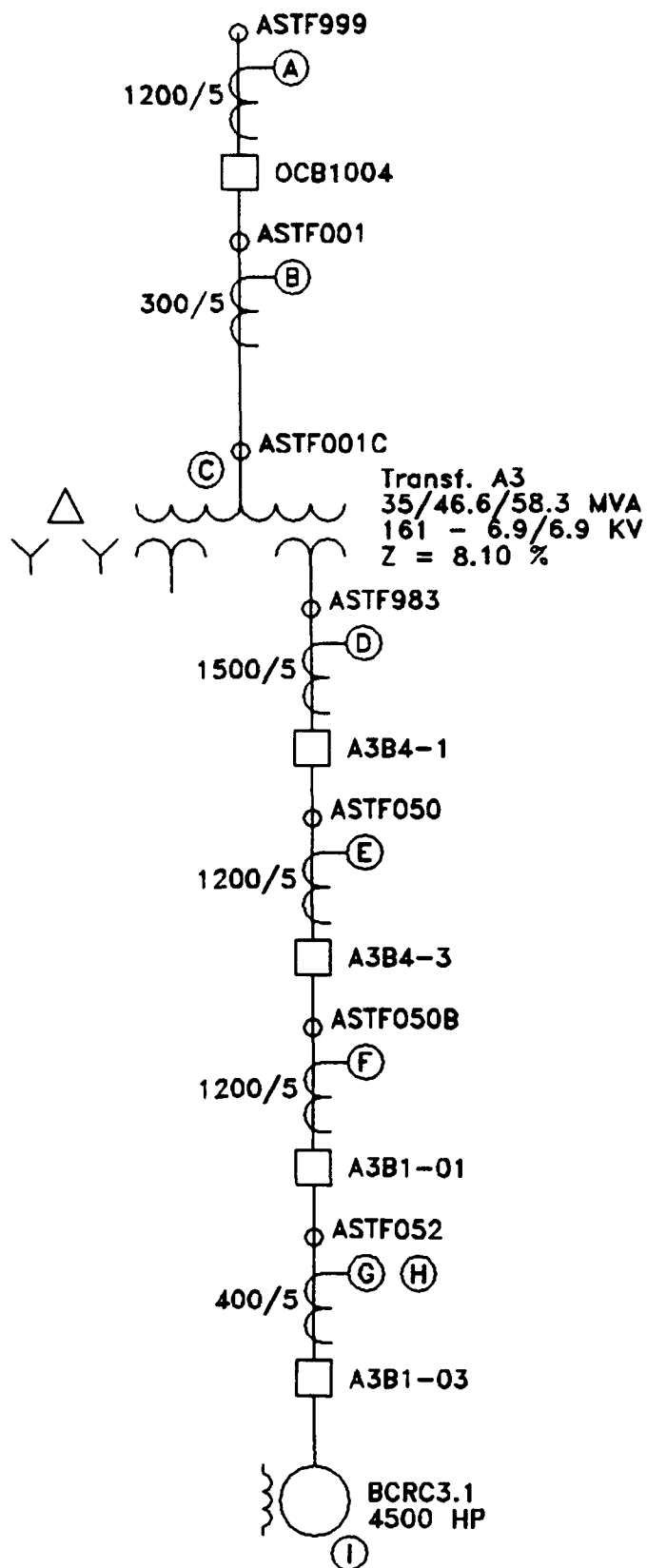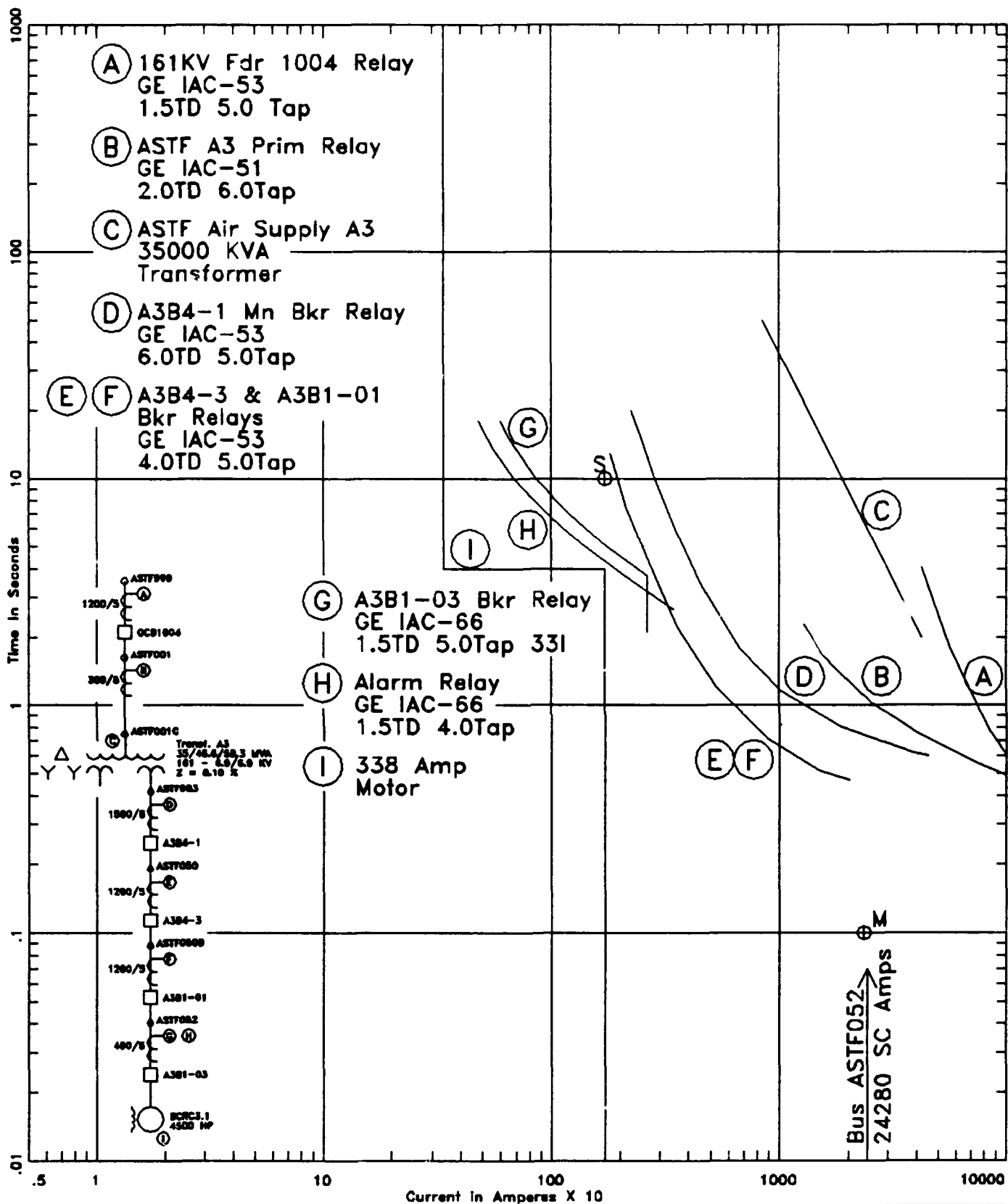ASTF052

(G) (H)

400/5

A3B1-03

BCRC3.1
4500 HP

(I)

Diagram I

trip the motor and shut it down. The Power Coordination Study tries to determine if the relays are working to their full potential. If relay G fails to trip the motor relay F will try to trip the motor, until one relay is successful in shutting down the system.

Diagram II is the data that EDSA has produced concerning ASTF. The y-axis is time, and the x-axis is tap. All relays have a tap and time setting. Curve i is the time curve for motor BCRC 3.1. The alarm relay H will sound if the maximum acceleration time reaches beyond 100%. Relay G will trip the motor at 118%. Relays E, F, D, and B protect transformer A3 represented by line C. Relay B's settings are not correct. Curve B is not directly under line C. Relay A guards other transformers from this station in ASTF. Diagram III shows the correction made to relay B. The tap was decreased and the time was increased. Now that the correct settings have been installed into EDSA, there needs to be a physical change on the relay.

As a second year participant I have seen many advances in the Air Force Apprenticeship Program. This year has been another great success. I have enjoyed working with the same people as last year. They utilized me to my fullest potential. I hope to participate in the program next summer.

(A) 161KV Fdr 1004 Relay
GE IAC-53
1.5TD 5.0 Tap

(B) ASTF A3 Prim Relay
GE IAC-51
2.0TD 6.0Tap

(C) ASTF Air Supply A3
35000 KVA
Transformer

(D) A3B4-1 Mn Bkr Relay
GE IAC-53
6.0TD 5.0Tap

(E) (F) A3B4-3 & A3B1-01
Bkr Relays
GE IAC-53
4.0TD 5.0Tap

(G) A3B1-03 Bkr Relay
GE IAC-66
1.5TD 5.0Tap 33I

(H) Alarm Relay
GE IAC-66
1.5TD 4.0Tap

(I) 338 Amp
Motor

Time in Seconds

Current in Amperes X 10

Bus ASTF052
24280 SC Amps

6900 Volt Phase
Time-Current Characteristic Curves

08/03/92
08:50:56

(1)

Diagram II

5-8

A 161KV Fdr 1004 Relay
GE IAC-53
1.5TD 5.0 Tap

B ASTF A3 Prim Relay
GE IAC-51
4.0TD 5.0Tap

C ASTF Air Supply A3
35000 KVA
Transformer

D A3B4-1 Mn Bkr Relay
GE IAC-53
6.0TD 5.0Tap

E F A3B4-3 & A3B1-01
Bkr Relays
GE IAC-53
4.0TD 5.0Tap

G A3B1-03 Bkr Relay
GE IAC-66
1.5TD 5.0Tap 33I

H Alarm Relay
GE IAC-66
1.5TD 4.0Tap

I 338 Amp
Motor

Time In Seconds

Current In Amperes X 10

Bus ASTF052
24280 SC Amps
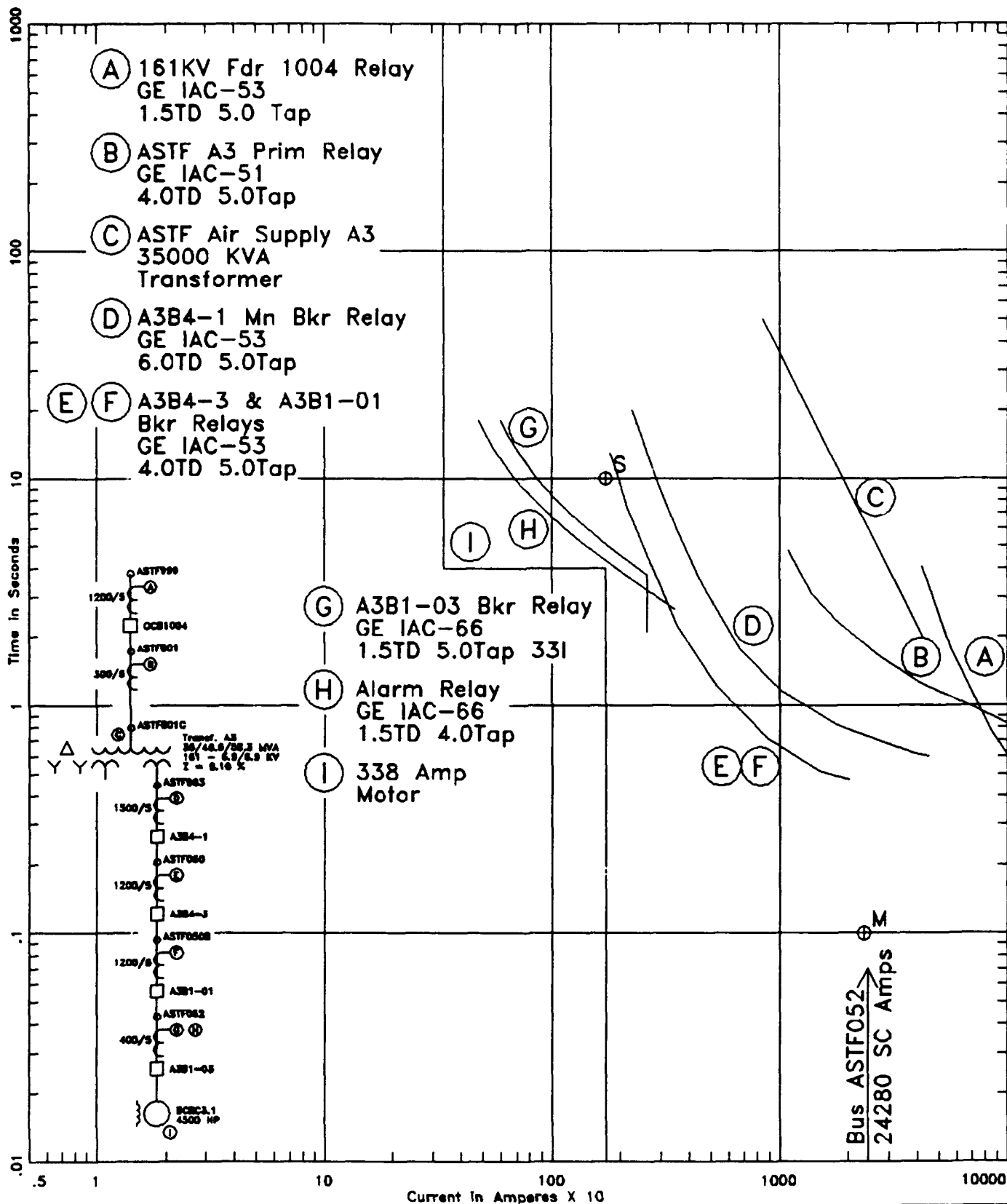
6900 Volt Phase Time-Current Characteristic Curves	08/03/92 10:19:09

1X Changed ASTF A3 Prim Relay from 2.0TD 6.0Tap to 4.0TD 5.0Tap

Diagram III

5-9

A STUDY OF dBASE III+ COMPUTER LANGUAGE AND THE DEVELOPMENT OF AN INVENTORY CONTROL PROGRAM

Richard Ian Lee
Freshman

Tennessee Technological University
Box 5006
Cookeville, TN 38505

Final Report for:
Summer Research Program
AEDC

August 7, 1992

A STUDY OF dBASE III + COMPUTER LANGUAGE AND THE DEVELOPMENT OF AN INVENTORY CONTROL PROGRAM

Richard Ian Lee
Freshman
Tennessee Technological University

Abstract

The dBASE III + computer language was studied and an inventory control program was developed using dBASE III +. In order to learn dBASE III +, the manuals were studied and a practice program was developed. The practice program, an address and telephone management program was successfully written and is being used by Sverdrup personnel. Upon the completion of the address management program, a generic inventory control program was successfully completed and is being used by personnel involved in the CADDMAS program at Arnold Engineering Development Center (AEDC). Compilation of the final inventory program to provide a stand-alone capability was attempted, but a good compilation was not achieved. Due to lack of time, no further attempts to compile the program were made.

A STUDY OF dBASE III+ COMPUTER LANGUAGE AND THE DEVELOPMENT OF AN INVENTORY CONTROL PROGRAM

Richard I. Lee

INTRODUCTION

In previous years, electronics components inventory of the propulsion technology electronics labs at Arnold Engineering Development Center (AEDC) has relied on visual inspection. This method of inventory control is very slow and can cost a company many manhours of looking through trays for parts to make a specified product. Through the use of a computer controlled inventory program, a single person can determine exactly how many parts necessary to build a product, the number of parts already in stock, and the number of parts must be ordered and needs to order in only a very few minutes. In order to write such a program, dBASE III+ computer language had to be learned first. As part of the practice with dBASE an address and telephone management program was written. This program will also be a very useful and timesaving program for all users at AEDC. Due to the fact that both of these programs are in source code, they can be modified for use in many other areas of AEDC, thus saving the money needed to buy costly copyrighted programs.

METHODOLOGY

The method of accomplishing the goal predefined took three basic steps. First, dBASE III+ programming language had to be learned. It was mostly self-taught through the use of manuals and through the study of sample dBASE programs. The second step, which overlaps the first, was writing an address and telephone management

program. Writing this program provided the understanding and practice of dBASE necessary to accomplish the final step in the completion of the project. The final step was the actual writing of the inventory control program. Writing the inventory control program and the address management program consisted of many basic programming steps. First, I had to talk to the customer or user of the program and find out exactly what the program was suppose to accomplish and any specifics about the program that the customer required. In the case of the inventory control program, this also involved visiting the lab where the program would be used and inspecting the parts to assure that the program met all requirements necessary to be as useful and user-friendly as possible. Next, the outline of the program was written out in an easy to understand way so that all parts of the program would be written as easily and correctly as possible. This step also prevented any specific features that the customer required from being forgotten during the weeks between the start and finish of the program. The next step was the actual writing of the source code and entering it into the computer. After all of the source code was written and entered, the program was run and debugged. Debugging was found to be the most complicated and time consuming step in the programming. After the program was successfully debugged and all of the program was working as desired, it was then given to the customer for a final testing of the program and a chance to apply the program. Any changes that the customer requested were then made.

Finally, compilation of the program was attempted. Before compilation the programs written in dBASE were only executable with the use of the dBASE environment package, which is very expensive. After compilation of the program, it becomes executable from DOS (the Disk Operating System supplied with any IBM compatible computer).

RESULTS

The inventory control program was very successful and is already in use by members of the CADDMAS team at AEDC. And, although the program was not successfully compiled it will eventually save users money and time. The reasons for the unsuccessful compilation of the program are unknown and due to very limited time no further attempts at compilation will be attempted.

The address management program was also a success. Several personnel at AEDC are already using this program and have had very little problems or complaints about it's operation. Through the process of writing these programs a very good understanding of dBASE III+ has been accomplished and many useful programming and debugging skills were developed.

CONCLUSION

The overall project was a success and a very rewarding and educational experience. The performance of the inventory program seems to be exceptional and will hopefully be a time and money saving investment for AEDC. The knowledge of dBASE III+ programming language will surely be a skill which will be rewarding to have. As a future engineer with an emphasis on computers it is important that I become familiar with as many computer-related products as possible. I feel that this project has been very rewarding. I would like to thank my mentor, Tom Bentley, for his guidance and assistance throughout the project. Also, I would like to thank Gary Ledbetter, Brenda McDonald, and all other members of the Sverdrup Technology Group for the help that they provided throughout the summer.
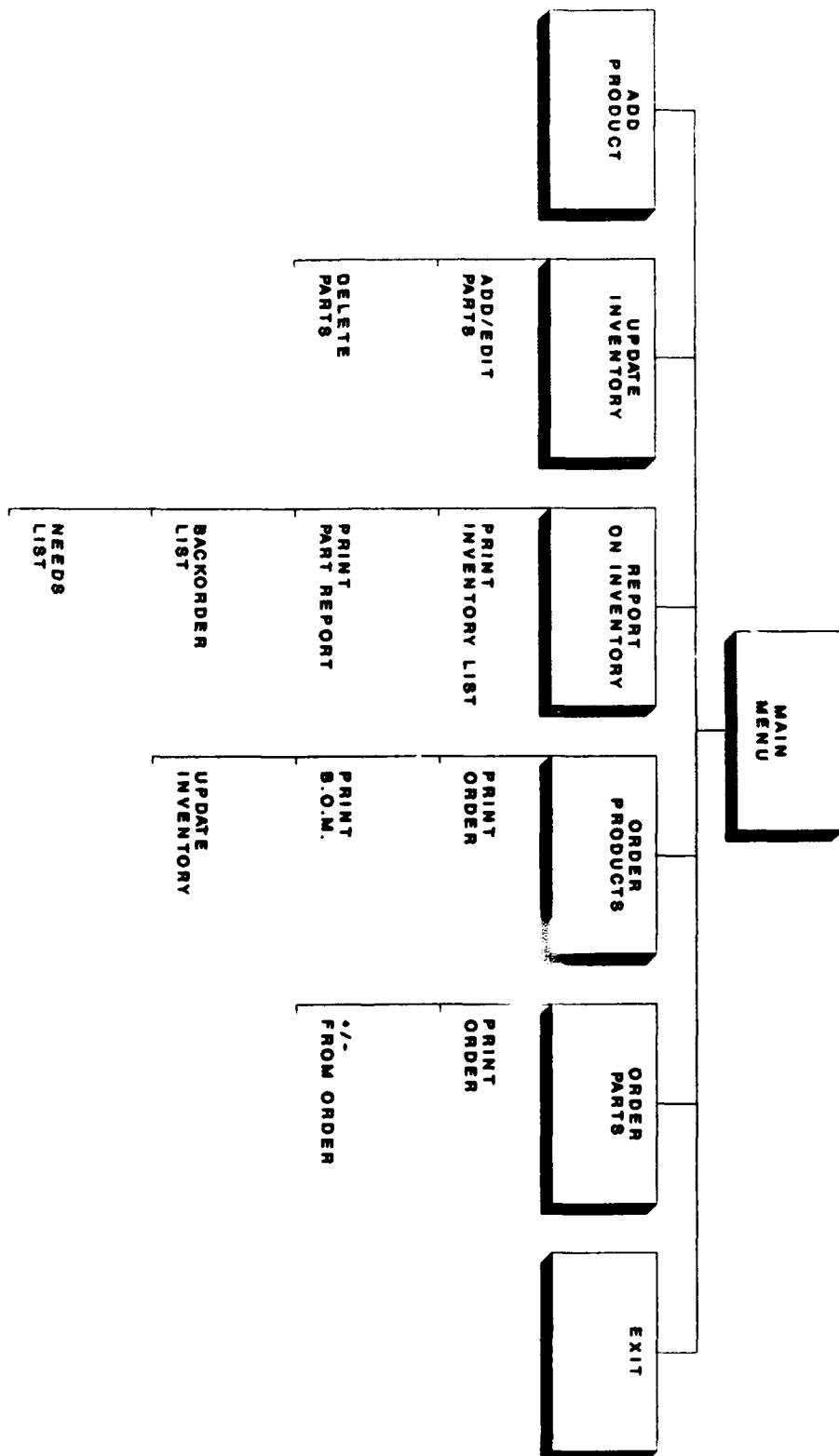
Fig. 1 - Organization of Inventory Control Program

INSTRUMENTATION AND CONTROLS
INVENTORY PROGRAM

David Lineberry
Freshman :
University of Notre Dame

Final Report for :
AFOSR Summer Research Program
Arnold Engineering Development Center

August 7, 1992

INSTRUMENTATION AND CONTROLS
INVENTORY PROGRAM

David Lineberry
Freshman
University of Notre Dame

Abstract

A PC based inventory program for the Instrumentation and Controls Department (I&C) at Arnold Engineering Development Center (AEDC) was written. This program improved the current system of inventory control. The program was written in FOXBASE, a database programing language. The program was designed to manipulate three related database. The program also was designed to keep track of removal dates and keep track of both used and unused storage space. The final program consisted of about seventy total files.

INSTRUMENTATION AND CONTROL
INVENTORY PROGRAM

David Lineberry

INTRODUCTION

The Instrumentation and Controls Department (I&C) at Arnold Engineering Development Center (AEDC) had a very limited inventory control system. What records were kept were done so on paper by hand. The new storage coordinator wanted a new computer inventory program that would keep track of necessary data and be easy to use. The coordinator also wanted the program to keep track of where each item was stored, where there was available storage space, when the stored item was to be removed, and who was in charge of the stored item. In addition he needed the ability to print out specific reports on stored inventory.

METHODOLOGY

A summary of the procedure I used to write the program follows. First my mentor and I met with the Storage Coordinator. He led us on a tour of the facilities that were being used for storage by the Instrumentation and Controls Department (I&C). After the tour we discussed the parameters of the program with the storage coordinator and began working on the structure of the databases. While working on the structure I self-learned FOXBASE programing language. When the databases were devised I began writing the program. When I finished with a

first copy of my program it was shown to my mentor. She checked for errors and listed some changes to be made then gave it back to me. After correcting these changes program was tested and debugged again. Finally the program shown to the storage coordinator of the Instrumentation and Controls department. After modifying the program to his suggestions the program was delivered to him and I helped set it up for him. The program was then made operational for the Instrumentation and Controls Department.

DESCRIPTION OF PROGRAM

The program that I designed and wrote contained many special features designed specifically for the Instrumentation and Controls Department.

The program uses three different databases: main location, storage space, and inventory. The first database ,main location database, contained information about each of the Instrumentation and Control Department's storage facilities. In this database each location was given a unique areacode. This areacode was to be a key field in all three databases. It related the other two databases to the main location database. By using the areacode relation information about each facility did not have to be repeated in each individual record. Instead, each record contained an areacode which referred to a specific set to information. The second database, storage space, contains

information about each individual spot in a main location where a stored item might be put. Each spot in a location was given a specific spot code. For example, floor spot 1 was given the spotcode F01. This field was used in a similar way to areacode to relate the third database, inventory, to the storage space database. Inventory, the third database contained specific information about stored items. The first two fields were areacode, to indicate a location, and spotcode, to indicate a storage space. By using three different databases and relating them in this way, the program eliminates unnecessary repetition of crutial inventory information.

My inventory program was written in a database programing language called FOXBASE. When I began this summer I had no experience or knowledge of programing in such a language. The first week of the program was spent learning the concepts of DBASE III , another database language. Once I started to understand this language, I moved on to learning FOXBASE which is very similar. The FOXBASE language is somewhat similar to basic of which I did have both knowledge and experience. This helped me to master the language quicker. Diagram 7-9 is an example of a subprogram that I wrote in FOXBASE language. This program is the subprogram for the main menu of my program.

The basic structure of the program consisted of several menus which allowed the user to manipulate any data stored in the database. By making the program menu driven, the program was

very simple to use and was user friendly. The program produced

menus for adding records, editing records, deleting records,

viewing records, printing reports, and checking on removal dates.

Diagram 7-10 shows the structure of the program. It is a simple

chart of menus and menu choices rather than programs which would

have taken several pages. In the main menu a loop was created

for the whole program. When the end of any branch was reached,

the program looped back to the main menu and brought up the four

main choices again.

On completion of the modify branch of the program, an

integrity check was called. This check was essential in

maintaining the integrity of the computerized inventory system.

The check had four main functions. First, it made sure that when

an areacode or spotcode was added, an identical areacode or

spotcode did not already exist. Second, the check made sure that

the user did not use an illegal or nonexistent areacode and

spotcode when an adding inventory to a location and storage spot.

Third, the check managed the storage space, it made sure that the

storage coordinator did not have more area for storage than was

actually available for him. Fourth, this check worked with file

deletion. If the user tried to delete a spotcode, the program

would flag the user that he would also be deleting any item in

inventory with the same spotcode. If the user tried to delete an

areacode, it would also flag the user that he would be deleting

all inventory stored in that areacode as well as any spotcodes

with that areacode. Finally, the check verified that removal dates had not arrived or been surpassed. If this was the case, the program would give the user the option of changing the removal date and the program would give a print out of information about the item if it was desired.

Another feature of my program was the ability to search for specific information for adding, deleting, editing, printing, or viewing. This feature is called setting up a filter. In this subprogram the user picked any field from any database then pick an operator like equals, contains, greater than, etc.. Then the user had to input the data that would complete the condition. Once this data is verified the user was allowed to add additional conditions or stop adding conditions. When stop was chosen, the program found all records in a selected database that met the condition. The user could then work with only the data that met the condition. When the user was finished, the computer cancels the filter and all files were useable again.

This program will greatly assist the Instrumentation and Controls Department at AEDC. It will improve their current system immensely. Because of its custom design, the program will work almost uniquely for the I&C. However, with little modification, the program could be made to work for the purpose of inventory control at any similar facility. The program improves on the old system through the following attributes. It aids in keeping track of all necessary data for each stored item.

It will keep an accounting of both occupied and available storage space. It will flag the user when a removal date arrives or is pasted. The program assists the user in finding stored items. Finally the program cuts down on the time required to locate storage inventory and cuts down on time required to store an item to inventory. This easy to use menu-driven program should prove invaluable to the I&C Department.

```
*   Main Menu Program
*   Written by:  David Lineberry
*   Date 7-10-1992

DO WHILE .T.
SET COLOR TO &MCOLOR
CLEAR
@  4, 10, 20, 65 BOX CHR(176)
IF mrecno > 0
    SET COLOR TO &highlite
    @ 24,  0  CLEAR TO 24, 80
    @ 24, 15  SAY 'There are '+ STR(mrecno,3)+' record(s) with
removal date before today'
    SET COLOR TO &mcolor
ENDIF
@  4, 32  CLEAR TO  4, 42
@  4, 33  SAY 'MAIN MENU'
@ 20, 24  CLEAR TO 20, 56
@  8, 28  PROMPT '   ADD/EDIT FILES    '
@ 10, 28  PROMPT '     VIEW FILES      '
@ 12, 28  PROMPT '     REPORT MENU     '
@ 14, 28  PROMPT ' CHECK REMOVAL DATES '
@ 16, 28  PROMPT '        QUIT         '
MENU TO mchoice
DO CASE
    CASE mchoice = 1
        fsel = "ADD/EDIT"
        DO I_ADED
    CASE mchoice = 2
        fsel= "VIEW A FILE"
        DO I_VIEWFL
    CASE mchoice = 3
        fsel = "REPORT MENU"
        DO I_REPORT
    CASE mchoice = 5
        EXIT
    CASE mchoice = 4
        IF mrecno = 0
            CLEAR
            @ 10, 10  SAY 'No records exist with a removal date
before today'
            WAIT ' Hit any key to continue '
        ELSE
            SELECT A
            SET RELATION TO STR(AREACODE,2)+SPOTCODE INTO C
            SET RELATION TO STR(AREACODE,2) INTO B
            DO REMOVAL
        ENDIF

    ENDCASE
    LOOP
ENDDO
RETURN
```
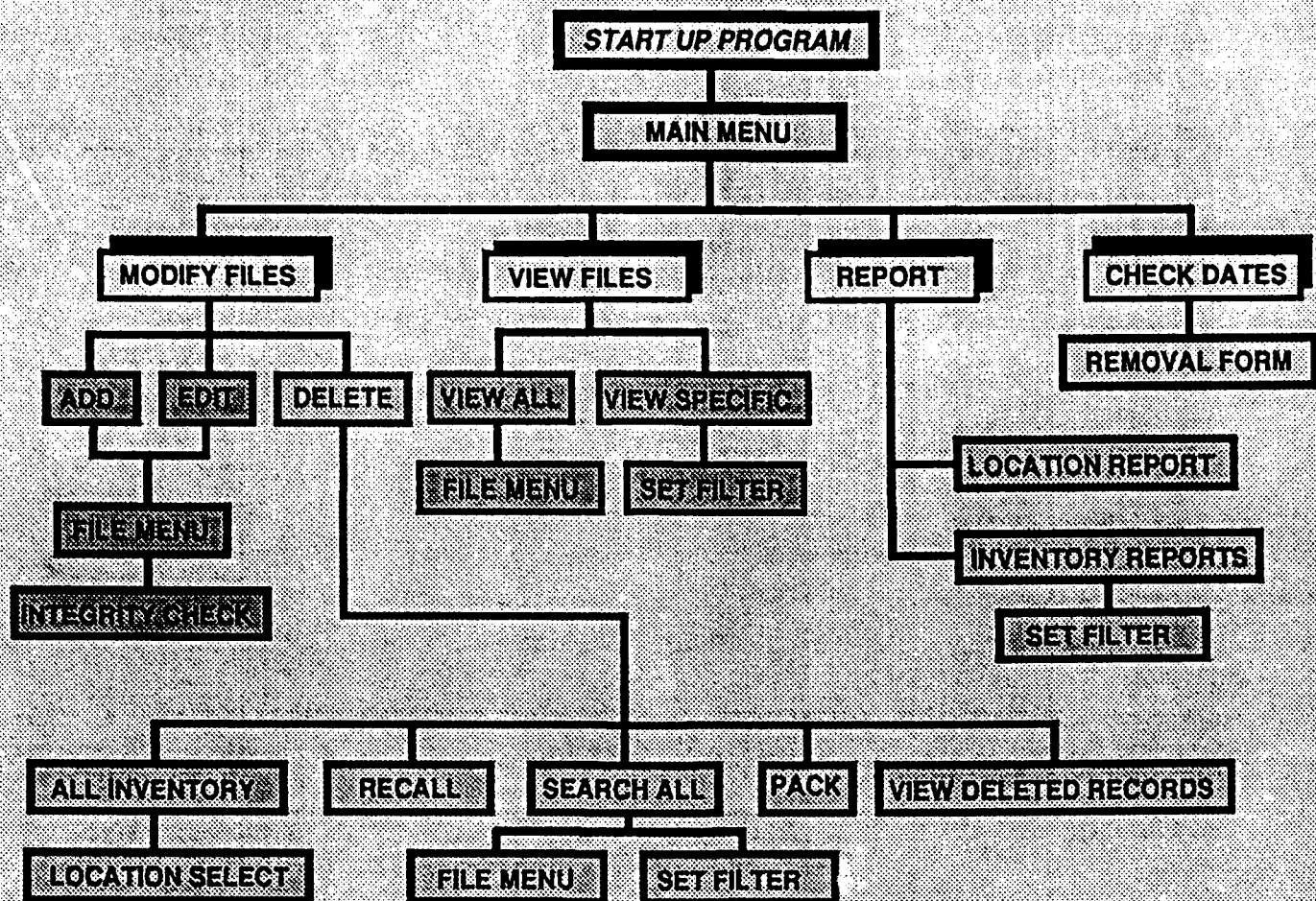
PROGRAM STRUCTURE - FLOW DIAGRAM

SGAP MODEL BUILDING

CHRIS MARLOW

FRANKLIN COUNTY HIGH SCHOOL

RICKY ARTERBURY

CALSPAN
AEDC

JUNE – AUGUST 1992

SGAP MODEL BUILDING

CHRIS MARLOW
FRANKLIN COUNTY HIGH SCHOOL
AEDC

ABSTRACT

Wire-frame or panel computer models were built for the F-14 aircraft. SGAP model building involves many steps. Locating dimensions for the part is the first necessary step to build a SGAP geometry model. Critical points must be located and then the coordinates for the points must be assigned. When the information is placed in a data file, an executable program is run to convert the coordinates into facets. With the facets a picture can be drawn and then a verification of the dimensions and the model accuracy can be made. Once SGAP models have been made for all the individual pieces, they can be put together in the correct configuration in accordance to the wind tunnel tests. The SGAP model can finally be used to show trajectories of missiles to provide the user with visual aid of the performance of the missile.

ACKNOWLEDGEMENTS

I would like to acknowledge the people who made my visit to Arnold Engineering and Development Center possible. I would like to thank Mr. Ricky Arterbury for teaching me about SGAP, computers, and engineering, and giving me a new outlook on the engineering field. I would also like to thank everyone in the Flight Dynamics section for taking the time to show me the realistic side of engineering. I also would like to thank AEDC for giving me this opportunity. Finally I would like to give thanks to Research and Development Center for giving me the opportunity to spend my summer learning about engineering. The eight weeks this summer have truly been a wonderful experience.

SGAP MODEL BUILDING

Chris Marlow

INTRODUCTION

The Store-separation Graphical Analysis Package, commonly called SGAP, was used this summer to make geometry models of the F-14 aircraft. Geometry files are lists of the x,y,z coordinates of the vertices of the panels ,or facets ,that comprise the wire-frame model of a body. The surfaces of the item to be modeled are approximated by a mesh of straight line segments that intersect to form triangles or quadrilateral panels. The intersections or vertices are described in x,y,z coordinates from an origin. Often a point which is most upstream and is in the center of the piece for symmetrical reasons is selected as the origin. A geometry file of the F-14 and its attachments and various missile and fuel tank configurations was obtained. The file can then be used as a visual aid to show trajectories of predictions made about missiles and their flight paths. In summary SGAP simulates wind tunnel tests on the computer.

METHODOLOGY

One method of graphically simulating tests on the computer is by using the SGAP software. Many steps are involved in making a SGAP geometry file. First, points must be assigned on the part as reference for coordinates. Next, coordinates must be located for all of the assigned points by studying extensive drawings, dimensions and by applying trigonometry to the dimensions. The drawings used to find the coordinates are the model assembly drawings and usually lack necessary dimensions needed to build a SGAP geometry model. Often the actual wind tunnel model must be used in order to see different views and sometimes the model must be measured to obtain necessary dimensions. Once coordinates have been located for all of the points, they are put in a data file. The points must then be connected in a clockwise manner in order to form each individual facet or panel. When each individual facet is put together, they will actually form the piece of the aircraft which is to be modeled. So in a complex piece there would be more facets to show each curve, radius, and each complex side. The coordinates and point orders are put in a data file, shown in Figure 1. An executable program is then run which uses the data file to build a geometry file, shown in Figure 2, which contains the coordinates of each individual facet. The geometry file can then be run through a program called Checkgap which draws the facet cards on 'he screen as a 3-dimensional picture which can be rotated to different views or scaled to enlarge or reduce the size of the picture. A hard copy can also be made of the picture. After making a geometry file of each piece they must be put together with respect to each other in a configuration file. Origin points are changed so the piece will be drawn in the proper position on the airplane. Dimensions for the new origins are obtained from drawings using the buttock line, water line and fuselage station of the aircraft. Also different missiles and tanks can be placed in various places on the plane. A configuration file is made with the missiles and tanks in the correct places in accordance to the wind tunnel test model configuration. The configuration file can be made by using a program

called Autoconf. Autoconf will build the configuration file after a series of prompts is answered. With the final SGAP model, predictions can be made to show trajectories of missiles and their flight paths with respect to the airplane according to the data taken from the wind-tunnel tests. The final picture provides a visual simulation and prediction about how the missile will perform in the presence of the aircraft under real flight conditions.

DESCRIPTION

Besides,using the SGAP software I was able to use a database. With the database, report titles, authors, and dates were categorized so future reference will be made quick and easy. The database is also a good way to keep organized and to eliminate losing the report or being unable to locate it. As a result of my effort if anyone in the future wants to locate a report on a specific subject or test, they will only have to quickly search through the database. The database is a more efficient way to keep up with information. Also I was able to observe wind tunnel testing. I was able to see tunnel 16S, a 16-foot supersonic tunnel which ranges from Mach number 1.6 to 5.0. This tunnel is not run very often due to the large amount of energy which it consumes. Being able to see the wind tunnel running was a great and fascinating experience. I was also able to see tunnel 4T, a 4-foot transonic wind tunnel, which ranges from Mach number 0.5 to 2.0. While in the wind tunnel control room I had the opportunity to operate some of the controls and interact with the project engineer. In the wind tunnel different flight conditions can be obtained. Pressures, temperatures, Mach numbers, roll, pitch, and yaw angles can all be varied according to actual flight conditions.

RESULTS

At the time of my departure SGAP geometry files had been built for the F-14 with many different configurations including glove pylons, Compressed Carriage Missile (CCM) adaptors, missiles, and fins, shown in Figures 3 thru Figures 8. Wind tunnel testing had not yet been completed, and therefore, the trajectories and predictions were not final, but the models were ready. The database is still a long way from being completed, but my effort was a small step in having a database of many reports dealing with vehicle flight dynamics and tests.

OBSERVATIONS

The High School Apprenticeship Program gave me the chance to observe the engineering field with a different light. Mentors and engineers taught me a great deal about computers, aerodynamics and airplanes. I was able to learn much about engineering that can not be taught in school or read in books. While I was at AEDC I saw many things on the base and was taken on some extensive tours. I saw the entire base including the rocket and engine test facilities. I was able to go inside tunnels 16S and able to see 4T. I had the chance to see things that I would never have seen if I had not worked here this summer.

13
669.4822 90 141
788.87 81.88 141
818.378 93.4 136.98
821.07 192.89 134.51
809 196.25 134.51
796.93 192.53 134.51
835.94 178.3 135.6
715.75 90 144.35
760.02 85.98 143.68
762.32 93.4 143.34
715.75 90 137.65
760.02 85.98 138.32
762.32 93.4 138.176
8
6 5 8 1
4 9 8 5
3 2 9 10
7 3 10 4
5 6 1 11
4 5 11 12
2 3 13 12
7 4 13 3

Figure 1. F-14 Horizontal Tail Coordinates

CHORIZONTAL TAIL RIGHT SIDE
FACET   727 NVERT 4 COL Y
D   796.9300000 192.5300000 134.5100000 809.0000000 196.2500000 134.5100000
D   715.7500000   90.0000000 144.3500000 669.4822000   90.0000000 141.0000000
FACET   728 NVERT 4 COL Y
D   821.0700000 192.8900000 134.5100000 760.0200000   85.9800000 143.6800000
D   715.7500000   90.0000000 144.3500000 809.0000000 196.2500000 134.5100000
FACET   729 NVERT 4 COL Y
D   818.3780000   93.4000000 136.9800000 788.8700000   81.8800000 141.0000000
D   760.0200000   85.9800000 143.6800000 762.3200000   93.4000000 143.3400000
FACET   730 NVERT 4 COL Y
D   835.9400000 178.3000000 135.6000000 818.3780000   93.4000000 136.9800000
D   762.3200000   93.4000000 143.3400000 821.0700000 192.8900000 134.5100000
FACET   731 NVERT 4 COL Y
D   809.0000000 196.2500000 134.5100000 796.9300000 192.5300000 134.5100000
D   669.4822000   90.0000000 141.0000000 715.7500000   90.0000000 137.6500000
FACET   732 NVERT 4 COL Y
D   821.0700000 192.8900000 134.5100000 809.0000000 196.2500000 134.5100000
D   715.7500000   90.0000000 137.6500000 760.0200000   85.9800000 138.3200000
FACET   733 NVERT 4 COL Y
D   788.8700000   81.8800000 141.0000000 818.3780000   93.4000000 136.9800000
D   762.3200000   93.4000000 138.1760000 760.0200000   85.9800000 138.3200000
FACET   734 NVERT 4 COL Y
D   835.9400000 178.3000000 135.6000000 821.0700000 192.8900000 134.5100000
D   762.3200000   93.4000000 138.1760000 818.3780000   93.4000000 136.9800000
END OF FILE

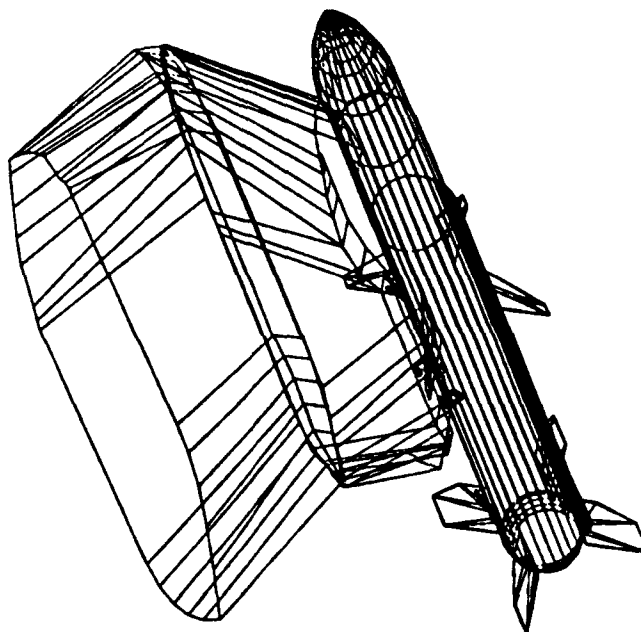Figure 2. F-14 Horizontal Tail Facets

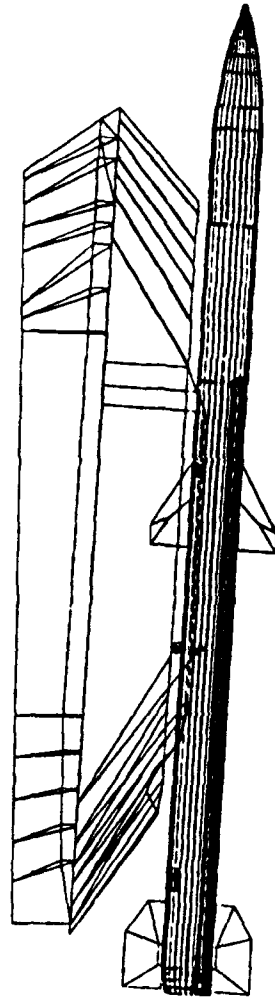Figure 3. Assembly of Wing Glove Pylon, Missile Adaptor, and Missile, Isometric View

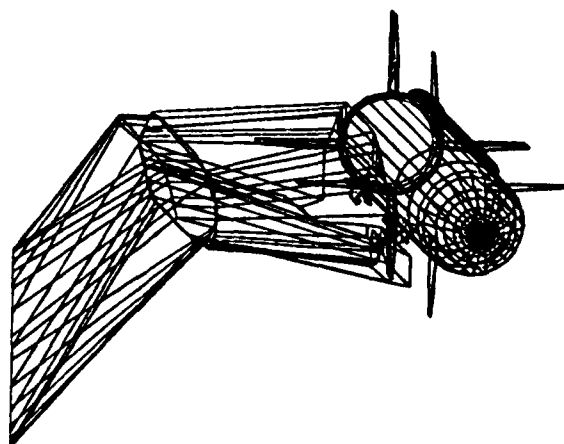Figure 4. Assembly of Wing Glove Pylon, Missile Adaptor, and Missile, Side View

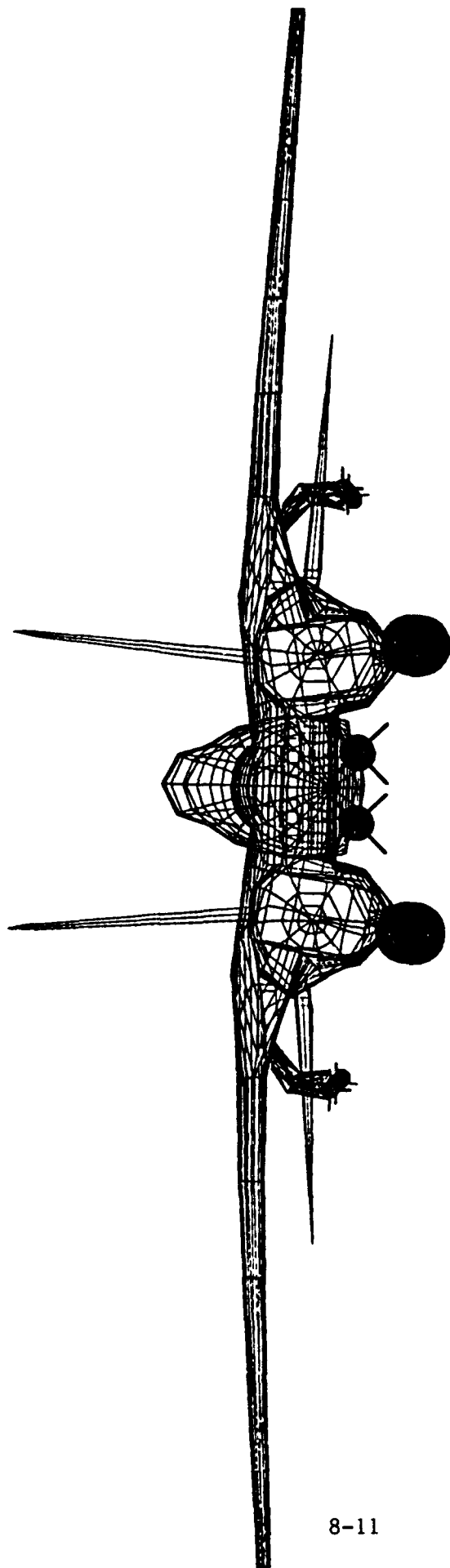Figure 5. Assembly of Wing Glove Pylon, Missile Adaptor, and Missile, Front View

Figure 6. F-14 Front View
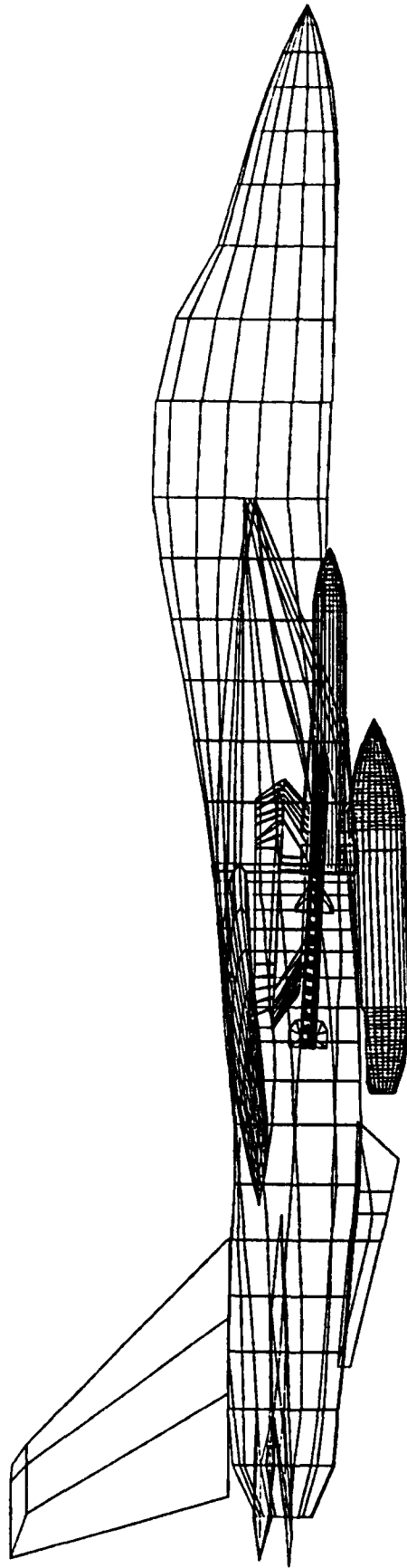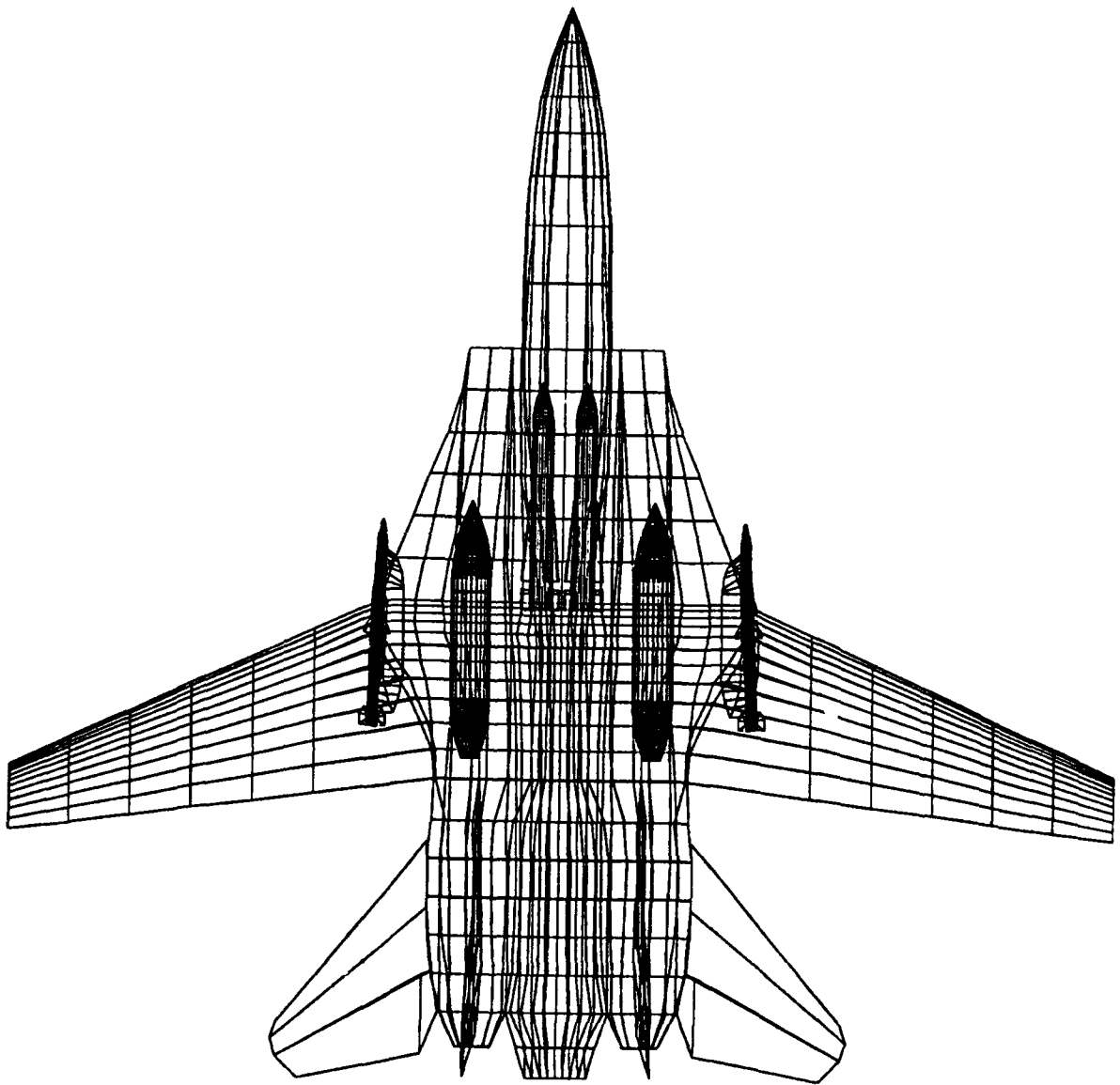
Figure 7. F–14 Side View

Figure 8. F-14 Top View

CALIBRATION AND APPLICATION OF A
SPECTRAPRO™-275 SPECTROMETER

Ryan M. Mason
Summer Student
Department of Physics

The University of the South
735 University Avenue
Sewanee, TN 37375

CALIBRATION AND APPLICATION OF A
SPECTRAPRO™-275 SPECTROMETER

Ryan M. Mason
Summer Student
Department of Physics
The University of the South

Abstract

A SpectraPro™ -275 spectrometer was calibrated and then used to gather data from the flowfield of the H2 test cell. The SpectraPro™ -275 was calibrated by using a mercury lamp and three Pfleuger tubes filled with argon, neon, and helium. Twenty three spectra were taken at the H2 test cell. The radiating atoms and molecules were identified by analyzing the wavelengths of their radiation. In an ideal test situation, no spectral lines at all would occur. The copper and copper oxide lines which were identified were most likely caused by copper atoms and oxidized copper atoms which came from the facility's arc heating system. Because the background light represented by these spectra was low, future non-intrusive flow diagnostic techniques appear feasible to apply in H2.

CALIBRATION AND APPLICATION OF A
SPECTRAPRO™-275 SPECTROMETER

Ryan M. Mason

INTRODUCTION

Non-intrusive flow diagnostics has become a goal of many researchers over the past forty years. The advantages of a non-intrusive diagnostic technique is that no interference or perturbation from the equipment is evident in the flowfield. Through emission spectroscopy, one technique of non-intrusive flow diagnostics, a person may obtain the density, temperature, area of flow visualization, and the velocity of a gas. Spectroscopy involves the collecting of light waves for the purpose of determining the atom or molecule that is radiating the light waves. A linear diode array camera is attached to the spectrometer in order to record data and convert that data into an image that can be displayed by the computer. The non-intrusive technique of emission spectroscopy proves to be equally important in identifying the material, element, or molecule which is emitting the electromagnetic radiation. Emission spectroscopy is especially important in analyzing the contents of flowfield gases.

CALIBRATION

Before actually running the experiment in H2, a calibration of the spectrometer had to be done in order to be able to correctly analyze the data. The Acton Research Corporation SpectraPro™-275 (See Figs.1-3) spectrometer has three built-in gratings. Grating one has 3600 grooves/mm blazed at 240 nm, grating two has 2400 grooves/mm and is holographically ruled, and grating three has 1200 grooves/mm and is holographically ruled. Each grating has its own particular range of reciprocal dispersion which is measured in nm/diode. The finer the grating spacing, the smaller the reciprocal dispersion and the greater the resolution of acquired spectra. To obtain a spectral calibration, the source was mounted in front of the entrance slit of the spectrometer. Second, a standard slit width was established for each grating. The slit width was

9-3

constant for each grating but varied between gratings. The slit width which produced the most intense signal was used. Next, either the mercury light or a Pfleuger tube (See Fig. 4) was connected to a power supply and mounted in front of the entrance slit of the spectrometer. A wavelength with a high intensity was chosen from the Handbook of Chemistry and Physics (Ref. 1), and the spectrometer was set on that wavelength. Then, by using the manufacturer's computer program OSMA, the spectrum was taken and recorded on disk.

The linear diode array in the camera made it possible to assign a diode number to the various peaks which appeared on the computer screen. Two methods exist for determining the reciprocal dispersion of a grating: (1) if two spectral lines have been identified, then the difference of the diode numbers of both peaks must be recorded or (2) if only one line appeared in a spectrum, the spectrometer can be set at two wavelength positions and the change in diode number recorded. If using method (1), a person must first approximate the reciprocal dispersion to correctly identify the spectral features. When using both methods, a person can simply use the equation, $\Delta\lambda/\Delta d = P$, where $\Delta\lambda$ is the difference in wavelength, Δd is the difference in the diode number, and P is the reciprocal dispersion. Then by comparing the change in the wavelength ($\Delta\lambda$) with the change in diode number (Δd), a person can obtain the values of reciprocal dispersion. These values, when plotted against wavelength, decrease with an increase in wavelength. The values, which are measured in nanometers/diode number, are used to predict the precise location at which a peak is to be found or to identify unknown spectral features by their wavelengths. The results for each grating are found in Figs. 5-8.

APPLICATION

The H2 test cell is a large chamber in which a models are mounted on a rotating sting (see Fig. 9). Air, which has been superheated by the facility's arc heating system, is fed through a diverging nozzle and across the model. The H2 test cell is equipped with a hinged door which contains three windows. The upstream pyrex window was replaced with a fused silica window.

Fused silica was used so that ultraviolet light could pass through the window. Ordinary glass would not have allowed the ultraviolet light to pass through. A ganged pair of 11-in. diameter fused silica lenses were used to focus the H2 self-emitted light onto the entrance slit of the spectrometer. The spectrometer and diode array detector were placed on a movable table so that the equipment could be moved easily out of the path of the hinged door.

A SpectraPro™ -275 spectrometer was used to take spectra of the H2 test cell flowfield on 25 June 1992. Background (no arc heater running) and mercury spectra were also taken by the spectrometer at the H2 test cell. Twenty three scans of the flowfield were recorded and analyzed using the Handbook of Chemistry and Physics (Ref. 1) and The Identification of Molecular Spectra (Ref. 2). The results were as follows: the two spectral lines in spectrum number five were unknown (see Fig. 10), the two spectral lines in spectrum number sixteen were identified to be atomic copper (see Fig. 11), one line in spectrum number twenty was identified as atomic copper, while the other four spectral lines were unknown (see Fig. 12), and one of the two spectral features in spectrum number twenty-one was identified as atomic copper oxide, while the other feature was a band of copper oxide (see Fig. 13). Experimental results indicate that, for two of the scans, light was emitted by parts of the models, which were heated by the high enthalpy flowfield, instead of by self-emission of the free stream.

CONCLUSION

The SpectraPro™ -275 spectrometer was successfully calibrated by using various ultraviolet and visible light sources. The results were presented as three calibration charts, one for each of the three gratings of the spectrometer. These charts were used to help identify atomic copper and copper oxide spectra in the H2 test cell flowfield.

1. Beam Path
2. Acton SpectraPro-275 Spectrometer
3. Entrance Slit
4. Plane Mirror
5. Spherical Mirrors
6. Triple Grating Turret
7. Exit Slit
8. Linear Diode Array Camera
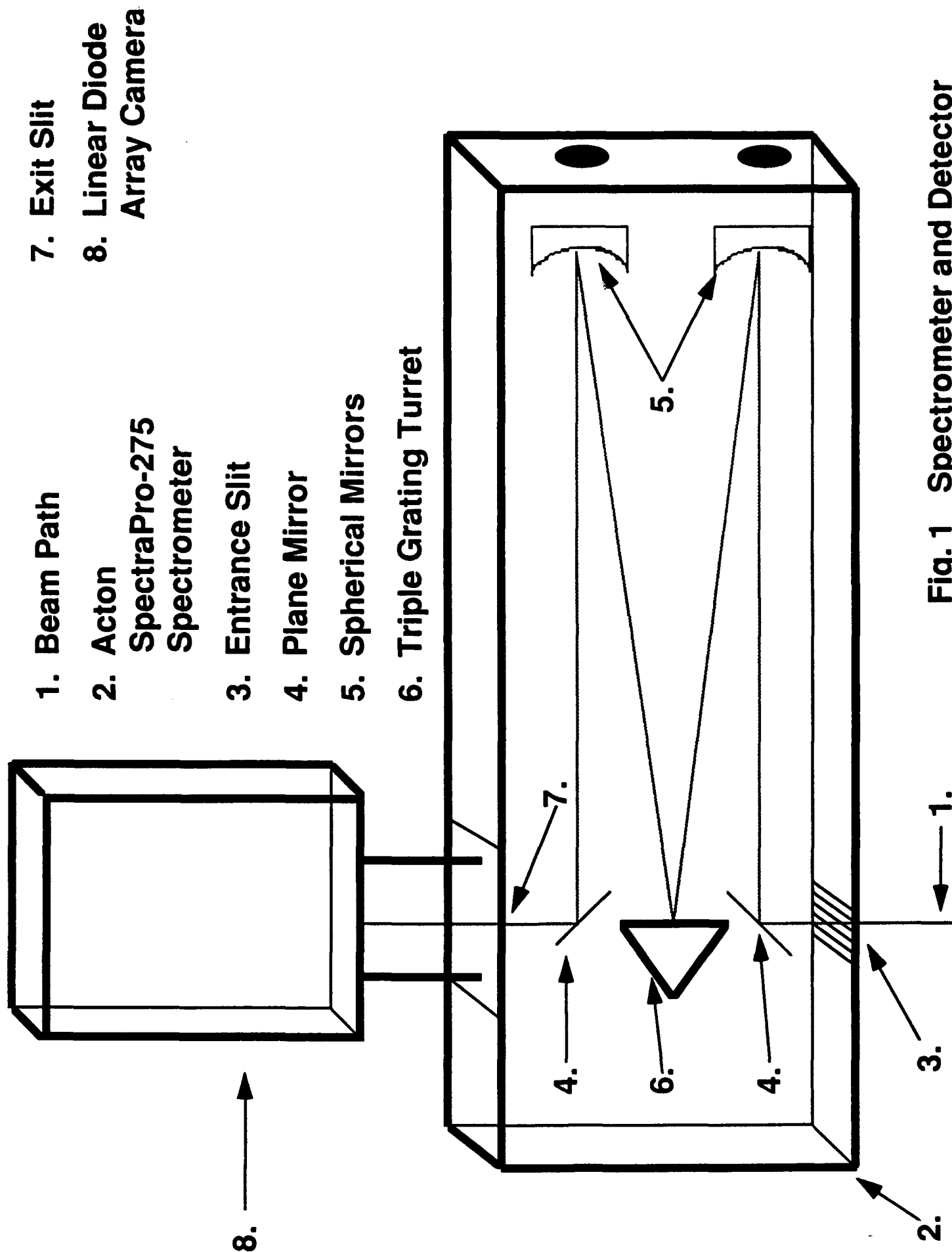
Fig. 1 Spectrometer and Detector

9-6
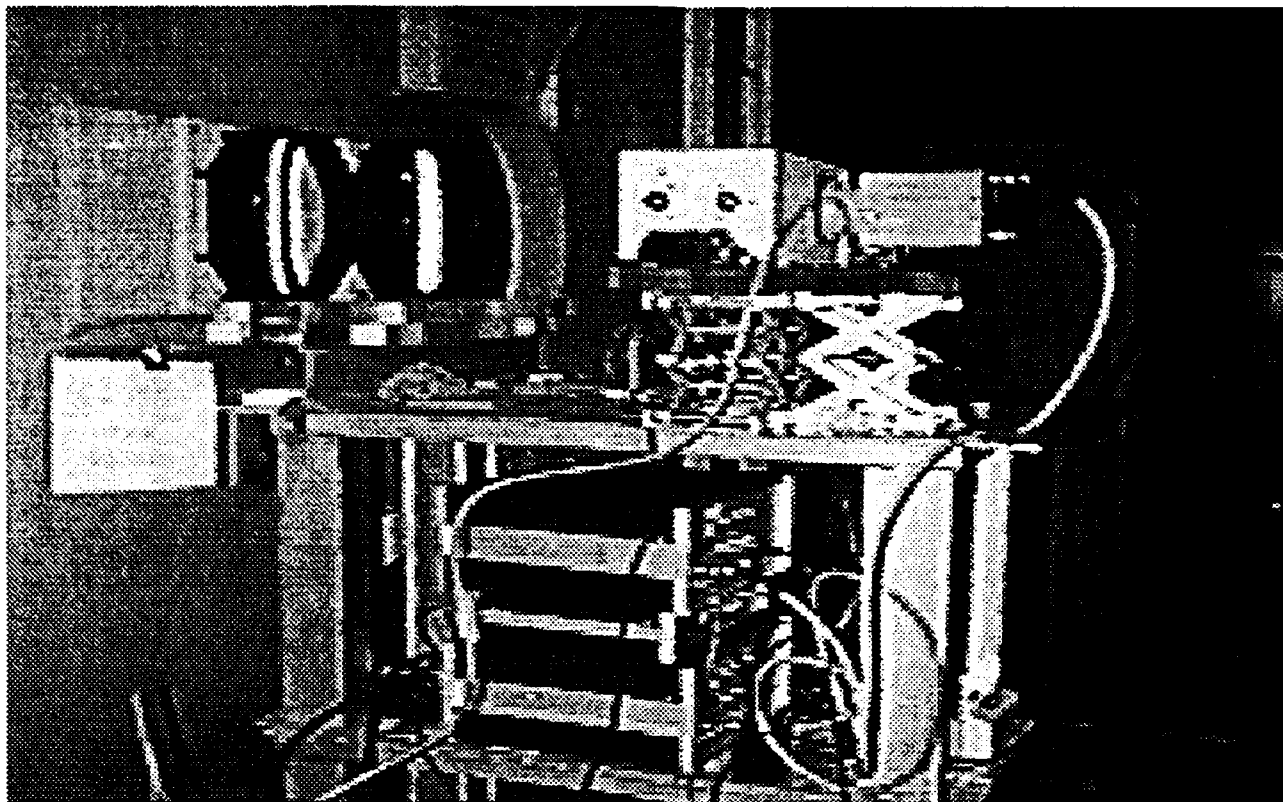
SpectraPro-275 at the H2 test cell (Fig. 2)
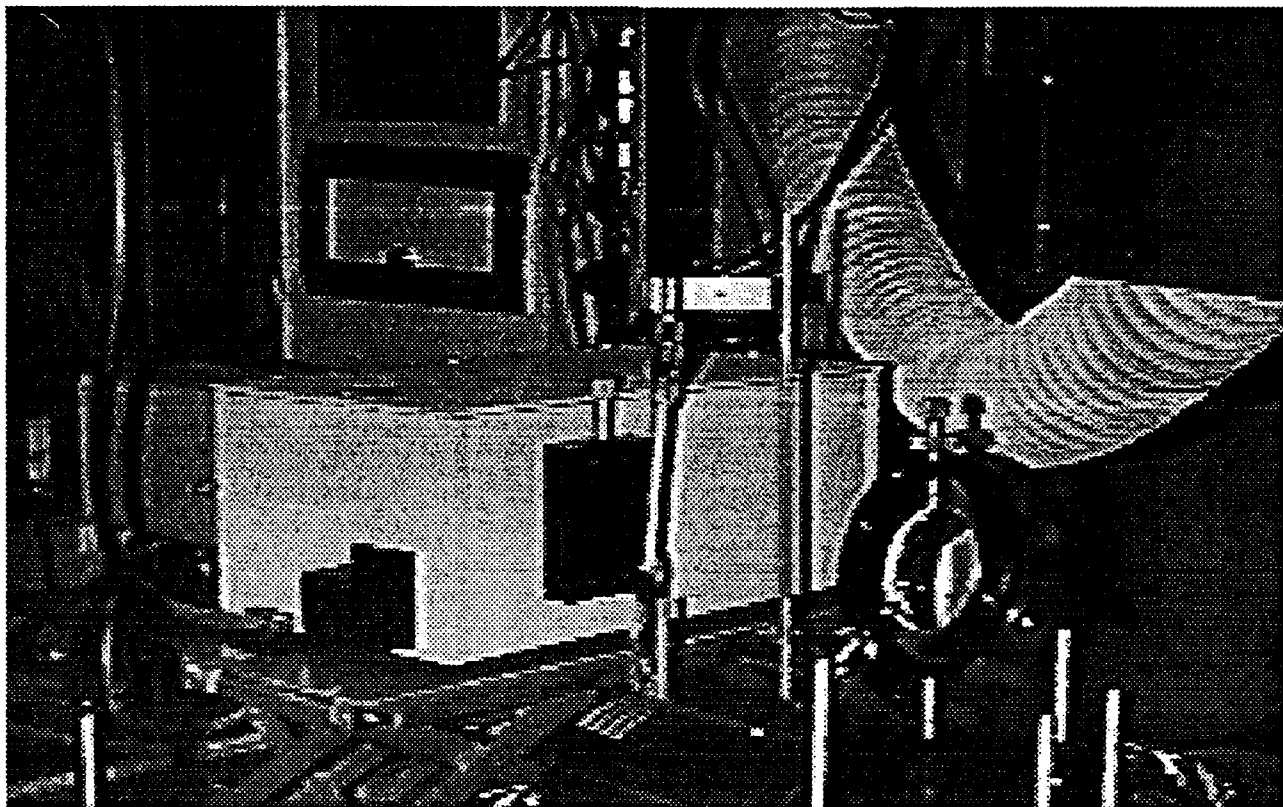
SpectraPro-275 and Pfleuger tube (Fig. 3)

Clip

Electrode

Pfleuger Tube

Gas
Electrode

Clip

Power Supply

Pfleuger tube (Fig. 4)
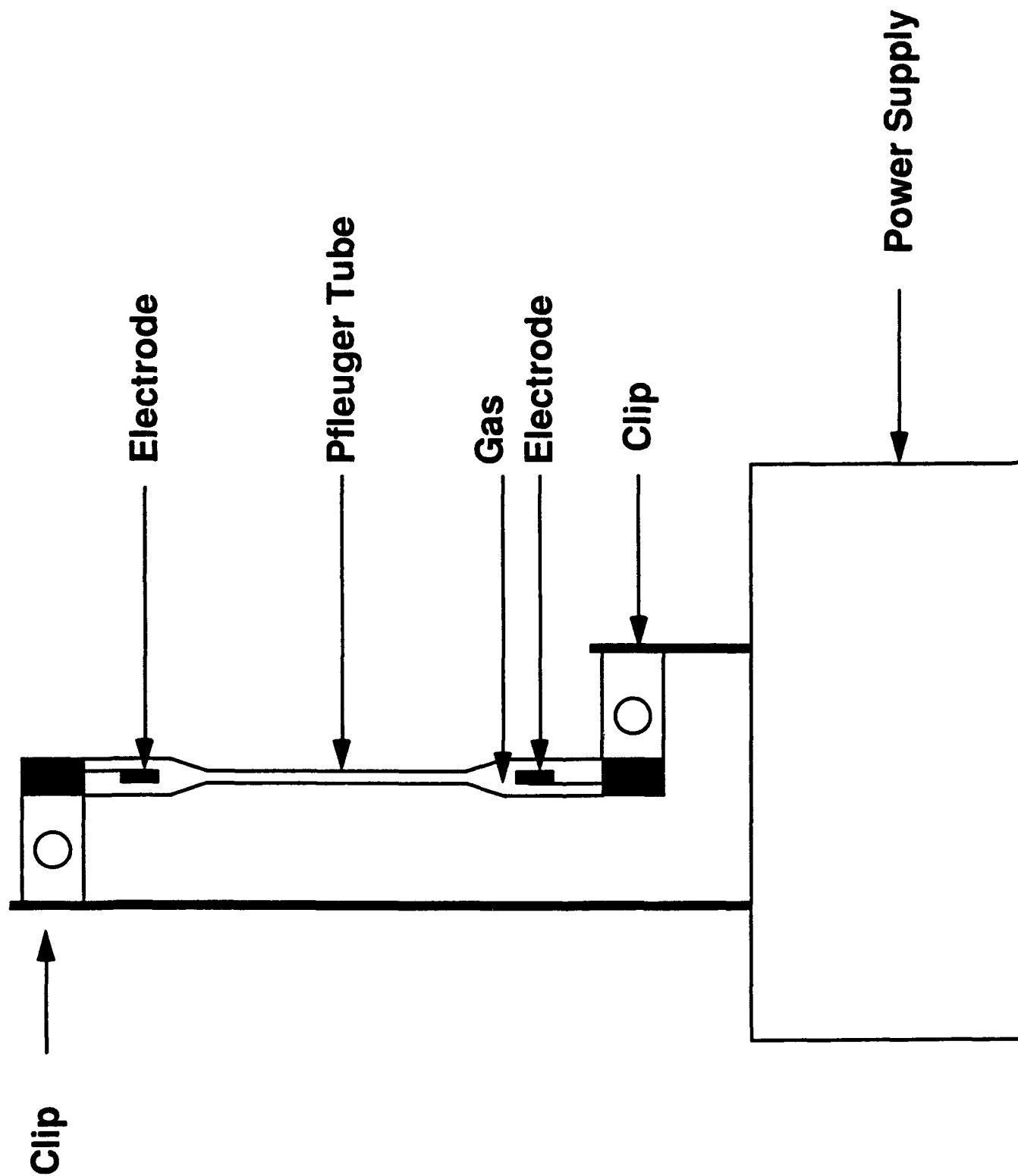
Grating #1 (3600 grooves/mm)
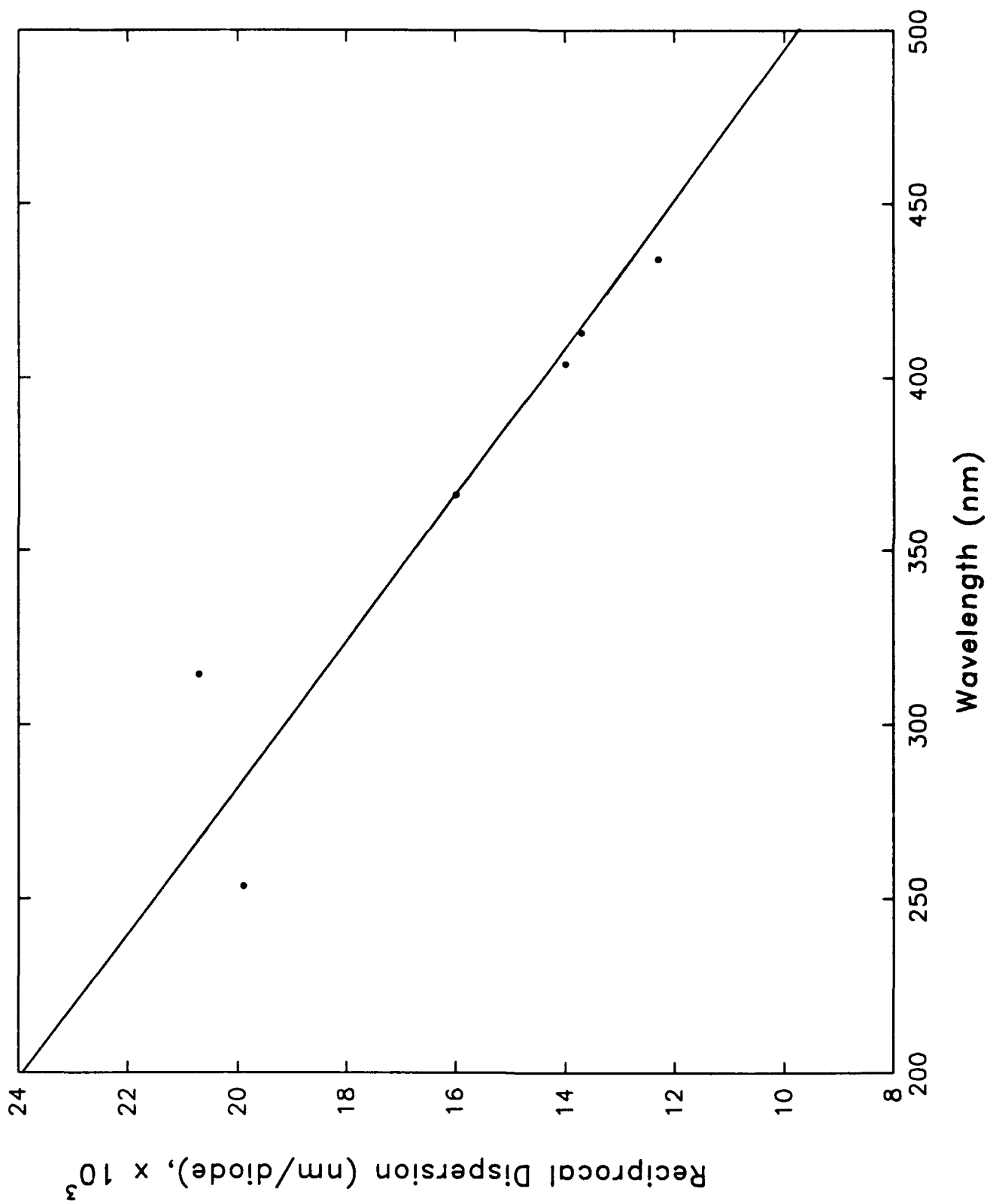
Reciprocal Dispersion for Grating 1 (Fig. 5)

Grating #2 (2400 grooves/mm)

Reciprocal Dispersion for Grating 2 (Fig. 6)

Wavelength (nm)
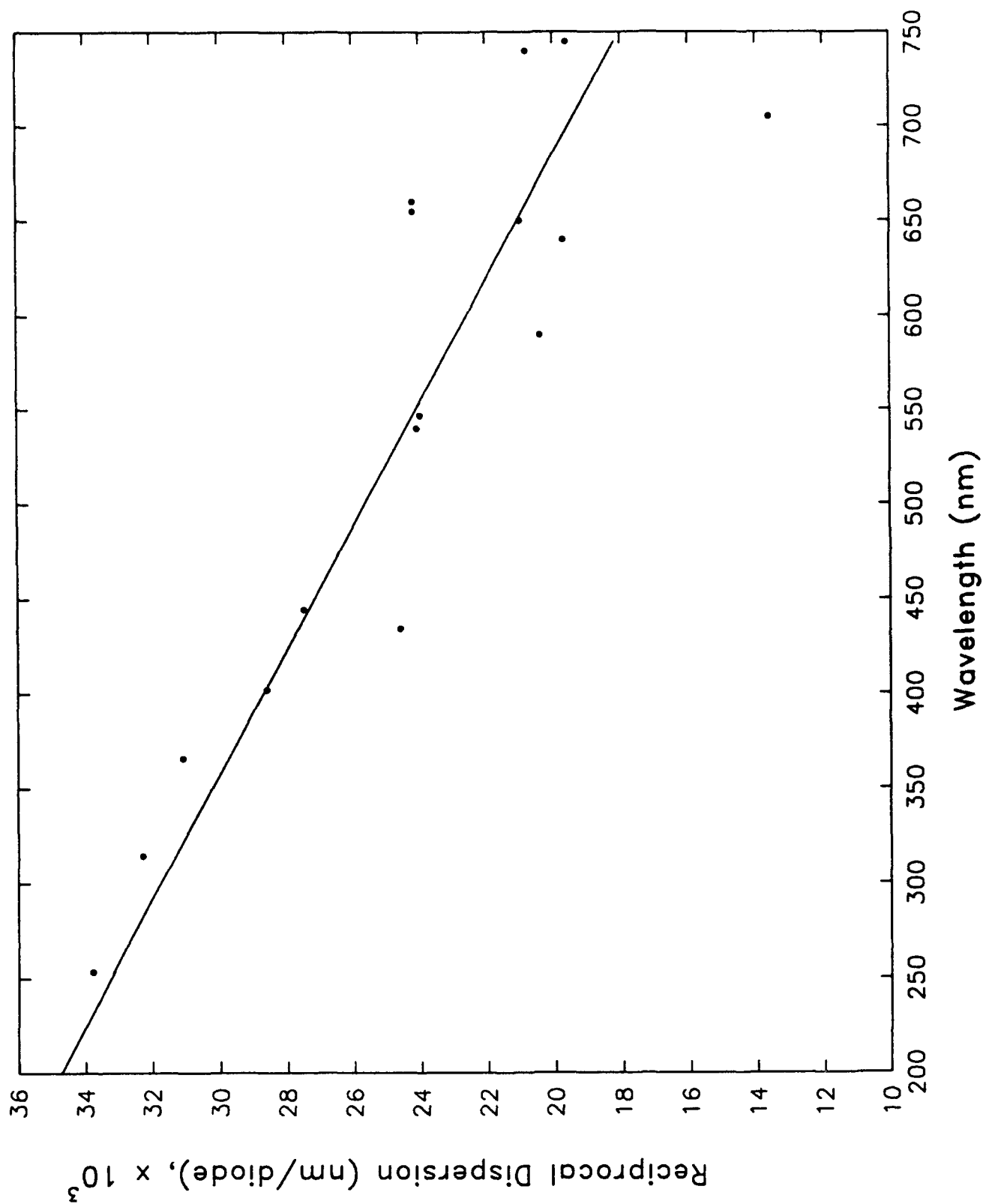
Reciprocal Dispersion (nm/diode), $\times 10^3$

Grating #3 (1200 grooves/mm)

Reciprocal Dispersion (nm/diode), $\times 10^3$

Wavelength (nm)

Reciprocal Dispersion for Grating 3 (Fig 7)
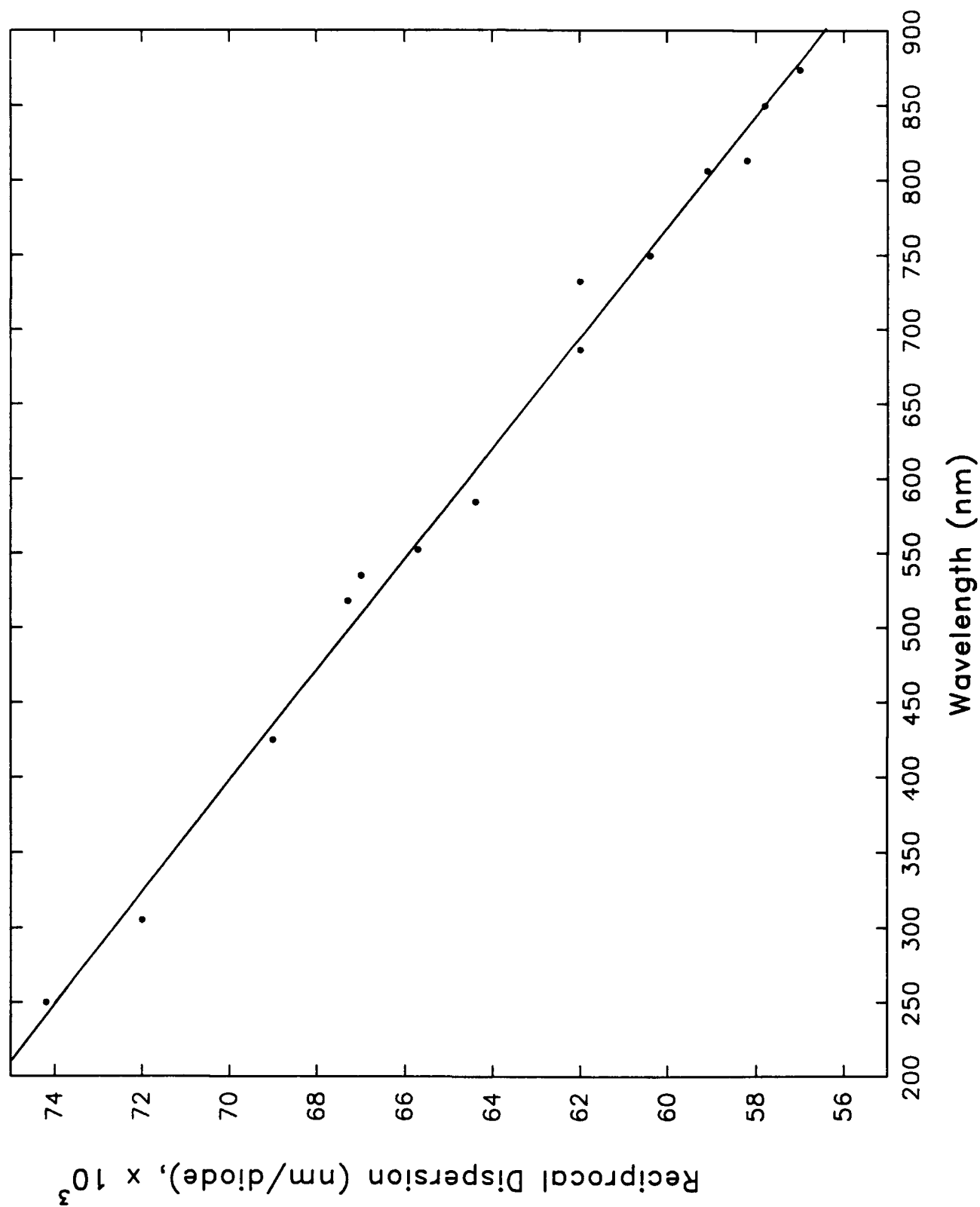
Acton 0.275 Monochromator Calibration

1200 grooves/mm

2400 grooves/mm

3600 grooves/mm

Reciprocal Dispersion (nm/diode), x 10^3

Wavelength (nm)
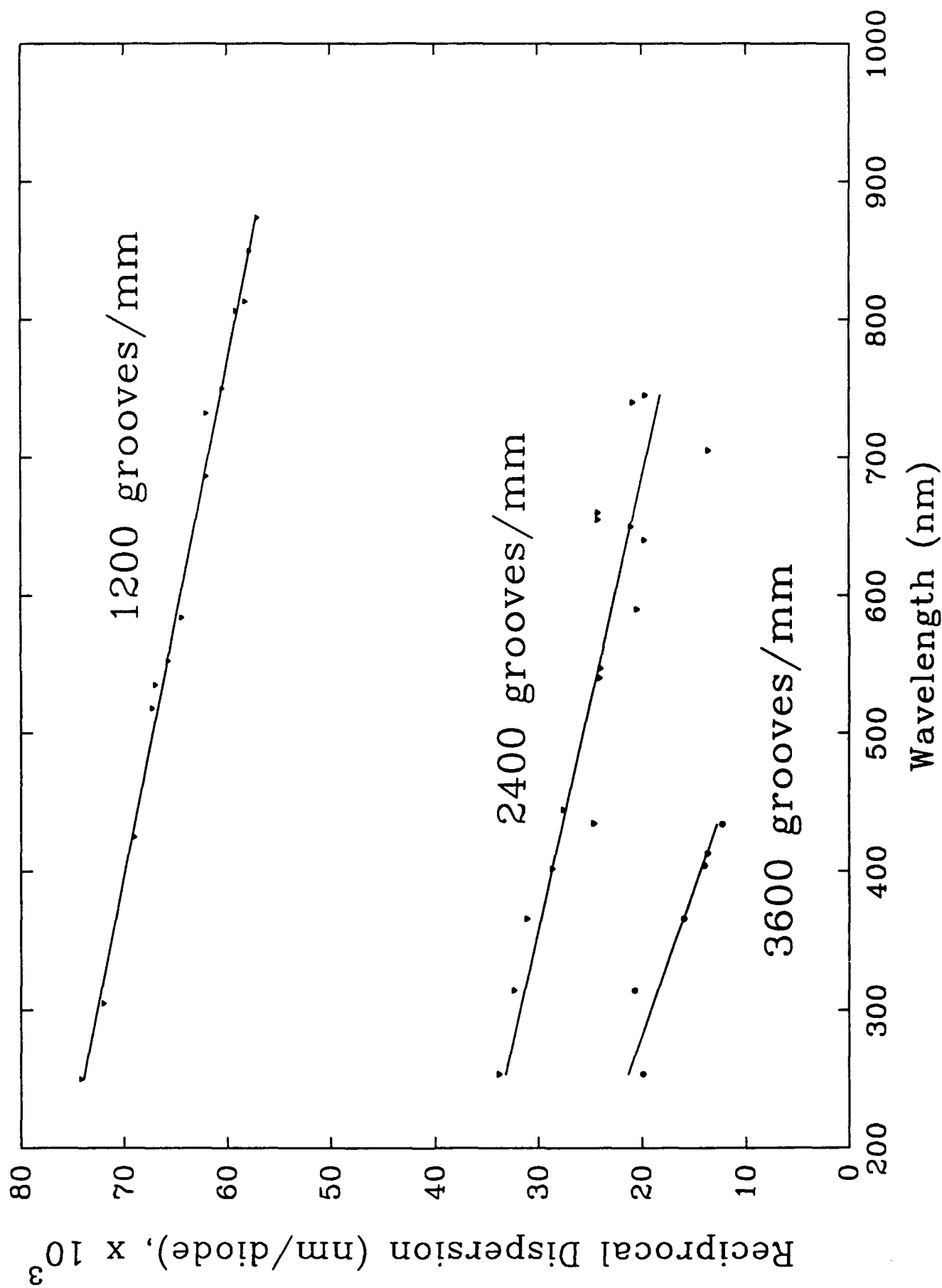
Reciprocal dispersion for all gratings (Fig.8)

9-12

H2 TEST FACILITY
(Fig. 9)

H2 Emission Spectrum

Spectrum No. 5

Unknown

Unknown

Pixel No.

Intensity
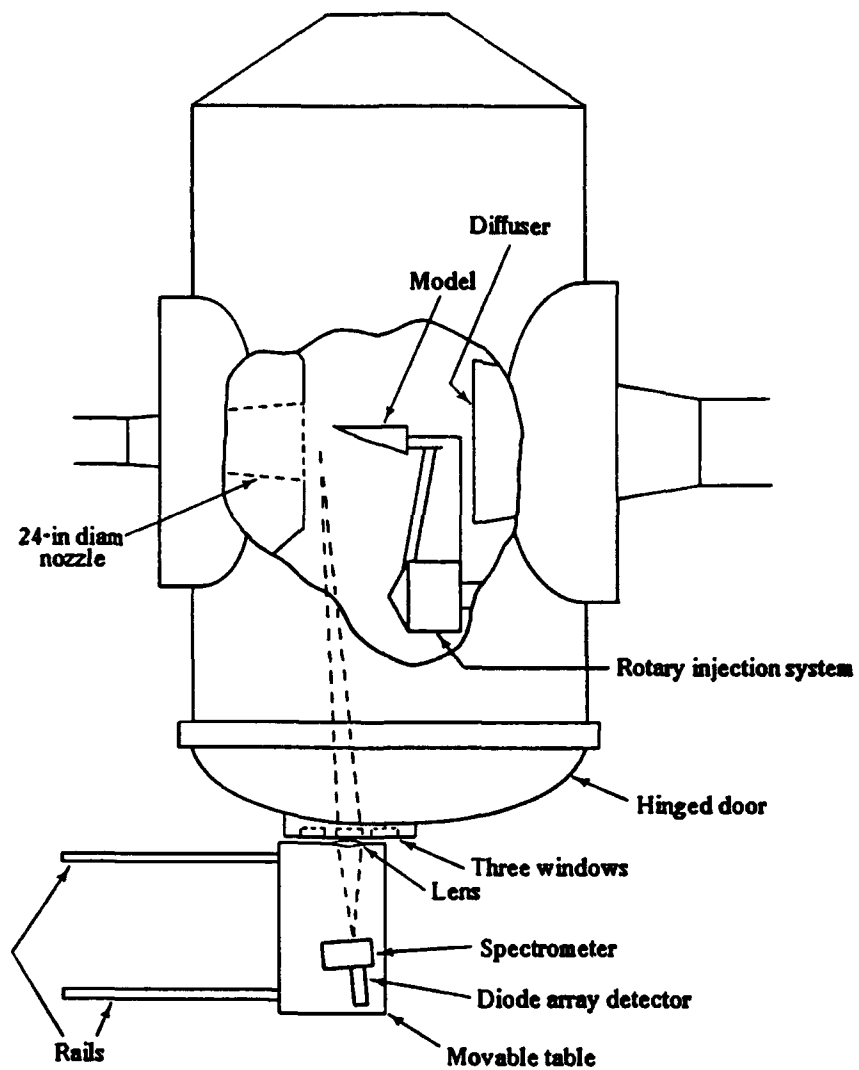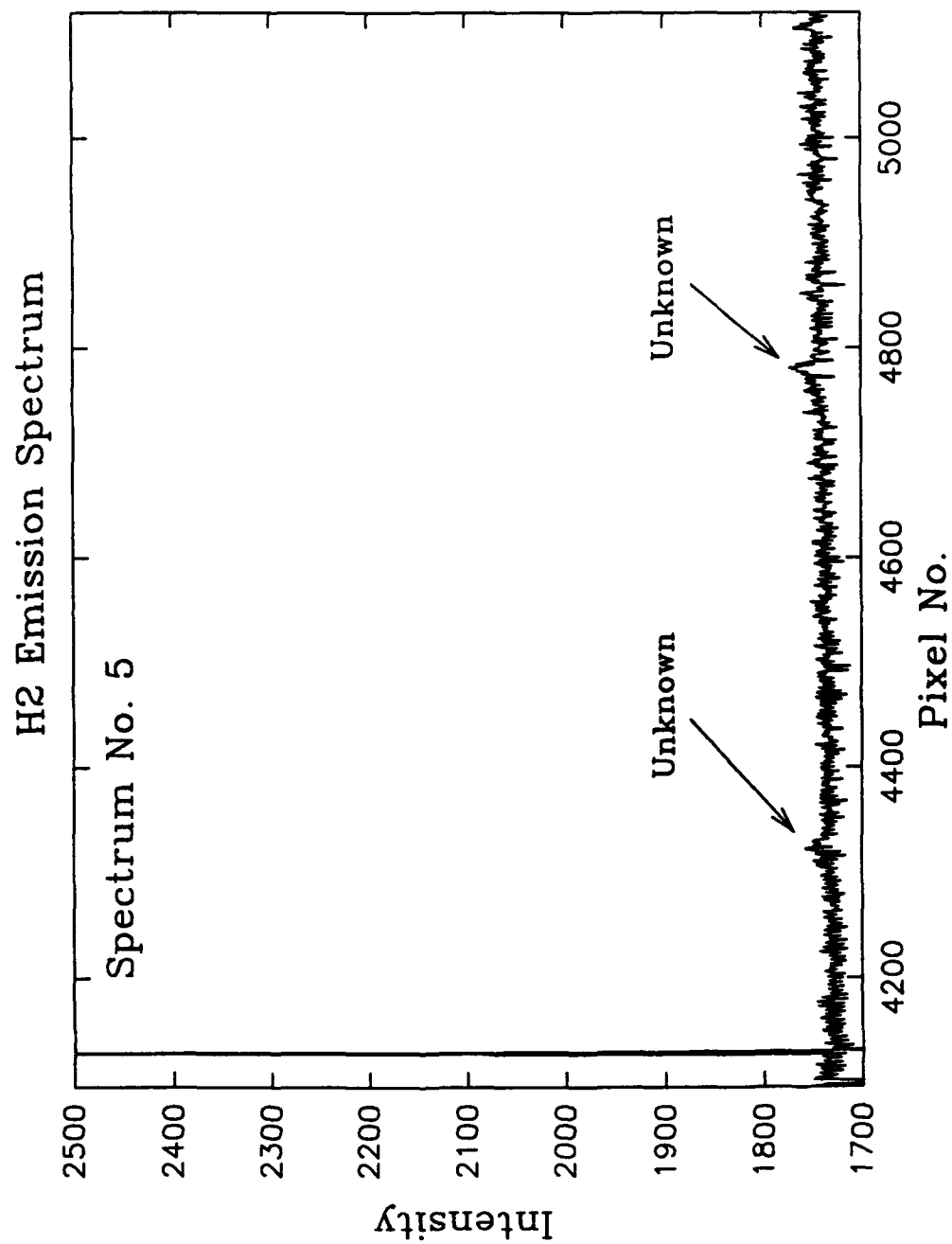
Emission spectrum for setting of 425 nanometers (Fig. 10)

H2 Emission Spectrum

Spectrum No. 16

Cu I, 327.3 nm

Cu I, 324.7 nm

Intensity

2500 2400 2300 2200 2100 2000 1900 1800 1700

15400 15600 15800 16000 16200

Pixel No. x Spectrum No.
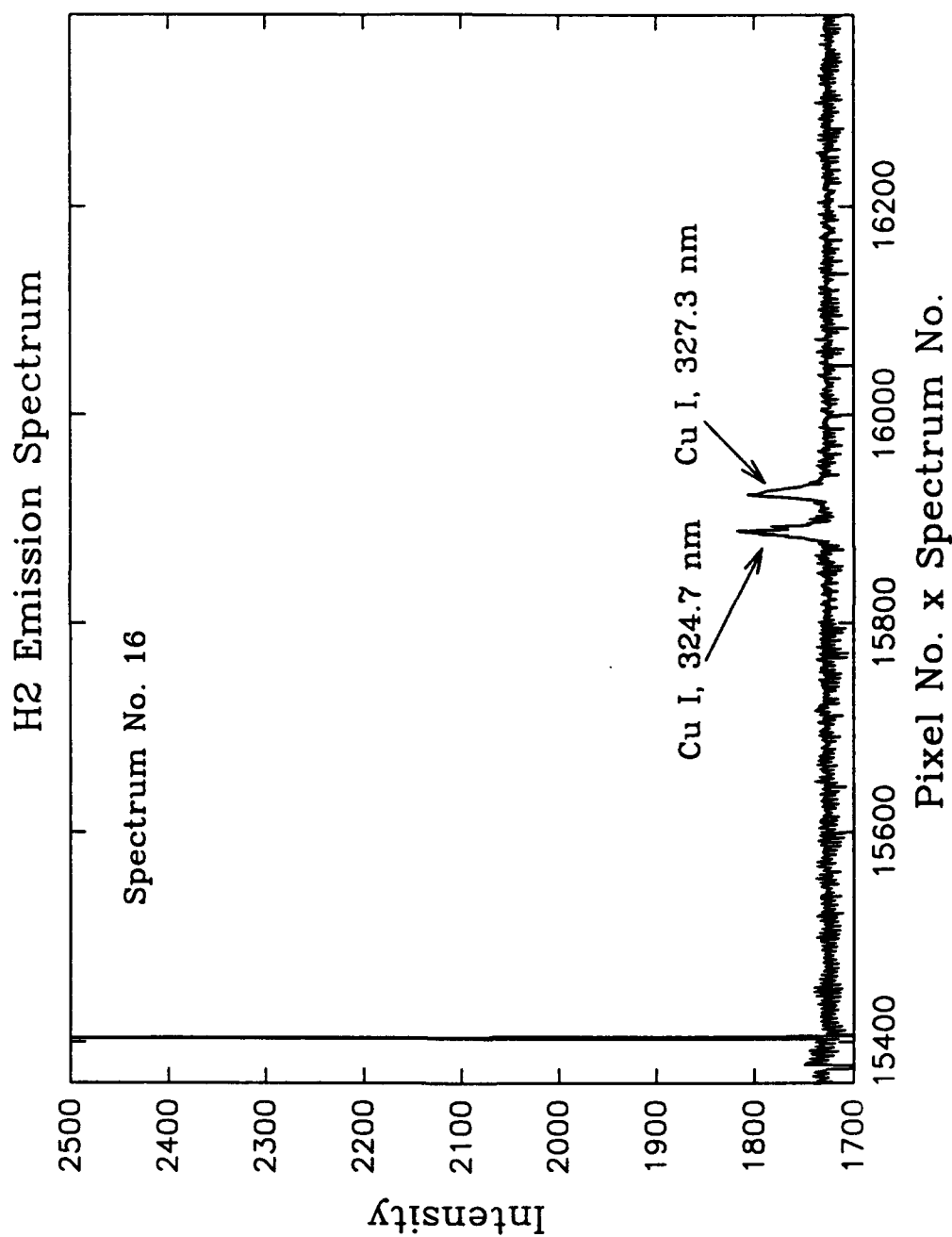
Emission spectrum for setting of 325 nanometers (Fig. 11)

H2 Emission Spectrum

Spectrum No. 20

Cu I, 510.6 nm

Unknown

Unknown

Pixel No. x Spectrum No.

Intensity
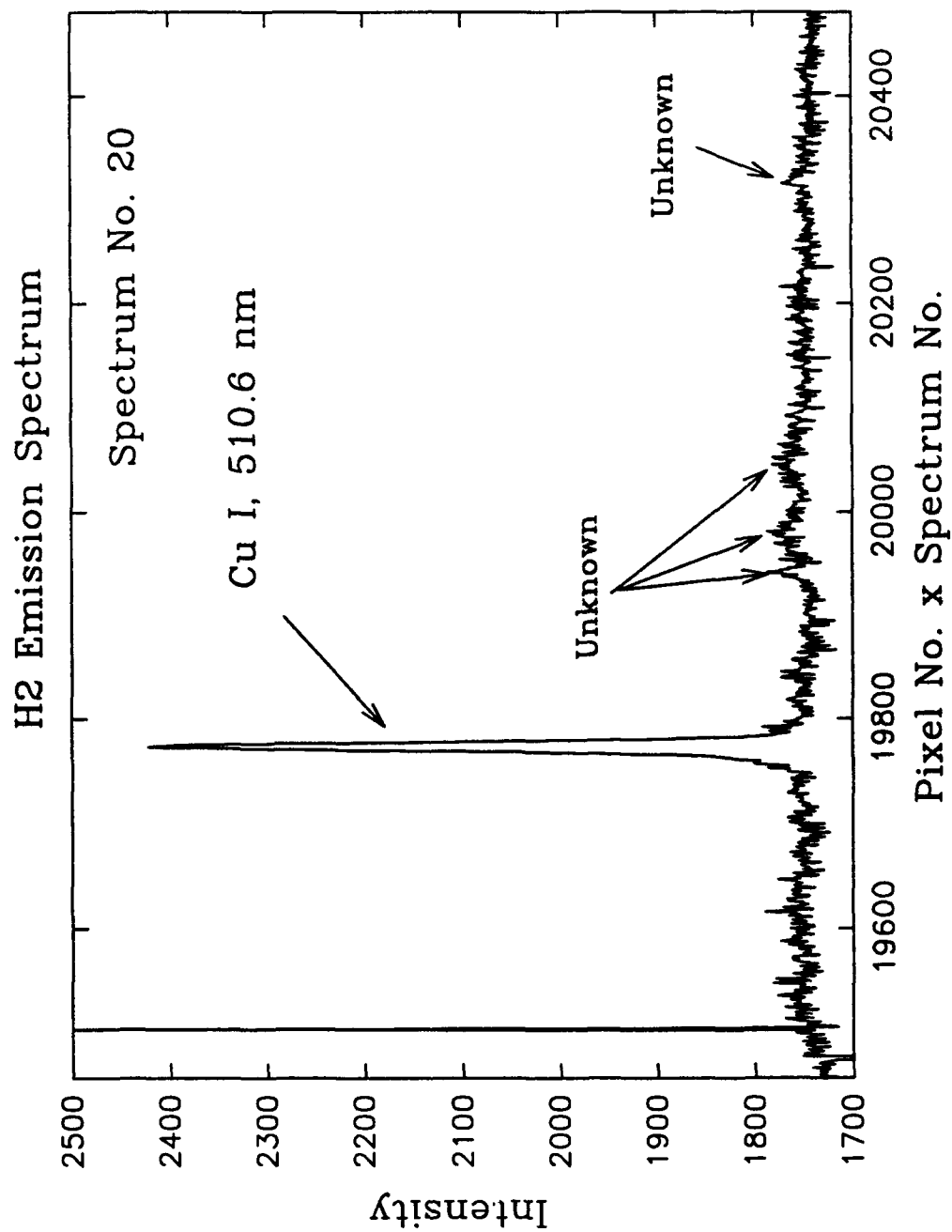
Emission spectrum for setting of 525 nanometers (Fig. 12)

H2 Emission Spectrum

Spectrum No. 21

Cu I, 578.2 nm

Cu 0, 606.7 nm

Intensity

Pixel No. x Spectrum No.
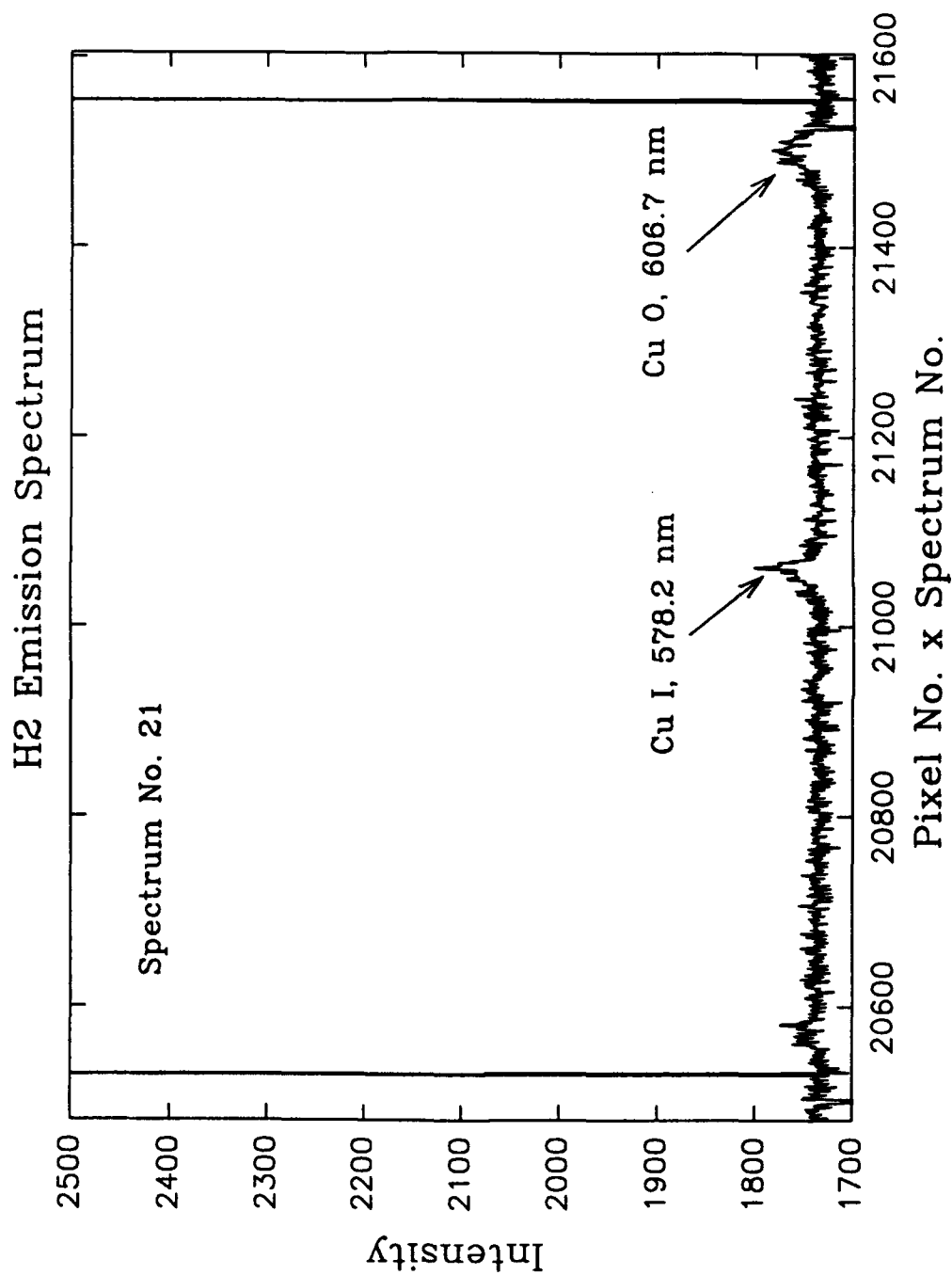
Emission spectrum for setting of 575 nanometers (Fig. 13)

REFERENCES

1. Handbook of Chemistry and Physics, Chemical Publishing Co., Cleveland. 1956.

2. Pearse, R. W. B., and A. G. Gaydon, The Identification of Molecular Spectra. Chapman and Hall Ltd., 1963.

A STUDY OF THE CONTINUOUS MONITORING STATION AT ARNOLD ENGINEERING DEVELOPMENT CENTER

Sara Kathryn Waterman

United States Air Force Apprentice

Arnold Engineering Development Center

Arnold Air Force Base, Tennessee

A STUDY OF THE CONTINUOUS MONITORING STATION AT ARNOLD ENGINEERING DEVELOPMENT CENTER

Sara Kathryn Waterman

United States Air Force Apprentice

Arnold Engineering Development Center

Arnold Air Force Base, Tennessee

ABSTRACT

The extensive testing which is performed at Arnold Engineering Development Center {AEDC}, Arnold Air Force Base, Tennessee, requires careful monitoring of environmental conditions. The newest piece of equipment the chemistry lab and AEDC has acquired is an automated water monitoring system. The system, known as the continuous monitoring station, examines the water flowing through Rowland Ditch, one of the outlets for the cooling water used for testing purposes, for organic pollutants at the part per billion {ppb} level. The SICHROMAT 1-4 is a new instrument at AEDC. Thus, a complete standardization of the instrument must be performed in order to accurately record and analyze the data received. There are also many questions concerning its sensitivity, consistency, required maintenance, and needs in calibration. For approximately one month, constant time has been assigned to a complete calibration and experimentation process for the monitoring station. During this time, much data had been acquired; however, there are still many more questions to be answered.

A STUDY OF THE CONTINUOUS MONITORING STATION AT
ARNOLD ENGINEERING DEVELOPMENT CENTER

Sara Kathryn Waterman

INTRODUCTION

The extensive testing which is performed at Arnold Engineering Developing Center (AEDC), Arnold Air Force Base, Tennessee, requires careful monitoring of environmental conditions. The chemistry lab at AEDC is a support facility which examines fuels, oils, water, gases, etc. for contaminants which may be harmful to the environment. Since the knowledge about the environment and the laws concerning it are constantly being updated, new equipment must be added continuously to fulfill AEDC's needs. The newest piece of equipment the chemistry lab and AEDC has acquired is an automated water monitoring system. The system, known as the continuous monitoring station, examines the water flowing through Rowland Ditch, one of the outlets for the cooling water used for testing purposes, for organic pollutants at the part per billion (ppb) level. The strategy in developing this testing station is that the possibly polluted water may be diverted to an isolation pond before being discharged into the water supply, and the source of the pollution emission may be located and eliminated or controlled.

PROBLEM

The instrumentation of the continuous monitor is new and relatively unfamiliar to the employees of the chemistry lab. Thus, a complete standardization of the instrument must be performed in order to accurately record and analyze the data received. The Siemens SiCHROMAT 1-4 is a gas chromatograph which analyzes water for volatile hydrocarbons. This instrument must be calibrated to accurately record pollutant levels. The sensitivity of the instrumentation concerning fuels which could seep into the cooling water must be discovered. The machine's reactions to outside stimuli is unclear; thus, a record of these reactions must be collected for future reference.

The first problem encountered with the SICHROMAT 1-4 occurred in the timed events program. A command had been installed which instructed the instrument to dump the sample at the beginning of each run. This procedure affected the accuracy of the results. Many attempts were made to delete this command from the program. However, they all proved unsuccessful. Thus, in a final attempt to remedy this problem, an expert was contacted. Although his method, saving the changes in the timed events program under the method and then reloading the entire program, was successful, the manuals did not clearly state this procedure. This produced many questions about the availability of information on this machine.

10-4

Another problem concerned the stability of the SiCHROMAT 1-4. During one weekend, the power to the monitoring station was disconnected. Because of this upset, the instrument began reacting strangely. The integrator's attenuation was completely unstable. A productive range for this feature is between 1000 and 10000. During this time the range fluctuated from 20000 to 0. Constant maneuvering of the range was necessary to retain the target range. Instability was apparent for approximately one week, and after stability was regained, the peaks of the chromatograph were smaller and the baseline wandered. If all power outages affect the instrumentation in this way, information received after an outage may be false and misleading.

The gas consumption of the monitor requires constant maintenance. The continuous monitoring station uses hydrogen, helium, nitrogen, and pure breathing air. The nitrogen is purged through the sample in preparation. The helium is the carrier gas which transports the prepared sample to the sparger. The hydrogen and air are both necessary for the operation of the flame ionization detector (FID). The gases must be regularly checked to maintain appropriate levels. In addition, the breathing air is prone to leaks. Although the maintenance of the gases is not difficult, it is extensive.

Occasionally, it is necessary to update the programming of the monitoring station. The integrator is unable to translate the peak areas to a concentration without a known response factor. Many of the compounds had no response factor written into the program; therefore, a response factor had to be assigned using the area count and the knowledge concerning the standard.

The integrator automatically adjusts the response factor during the calibration mode. However, the integrator must have an original response factor to perform this function. The program may need changes in the retention times of the compounds. Careful observation is required in oroer to know if the retention time of a compound has slightly shifted. If the retention time of a compound has changed, the integrator may not assign a name for the compound. The retention times may be examined by comparing the results from a standard containing known elements. The program adjustments should be checked approximately once a week unless suspicions arise concerning their accuracy.

METHODOLOGY

The sensitivity of the SICHROMAT 1-4 is questionable. Possible interferences from the jet fuels present at AEDC are unknown. Therefore, a four week standardization and calibration process was performed in order to answer some of these questions. The SICHROMAT 1-4 is programmed to detect seventeen volatile compounds. These compounds are freon; methylene chloride; 1,1 dichloroethane; 1,1,1 trichloroethane; carbon tetrachloride; benzene;

trichloroethylene; 1,2 dichloroethane; toluene; perchloroethylene; ethylbenzene; m,p-xylene; chlorobenzene; o-xylene; 1,1,2,2 tetrachloroethane; 1,3 dichlorobenzene; and 1,4 dichlorobenzene.

To make standards to test the sensitivity of the instrument, various combinations of these compounds were mixed at a 100 ppb concentration in a ten thousand milliliter container. After careful observation of the stability of the SiCHROMAT 1-4, the calibration procedure was performed. This procedure told the machine that the actual concentrations of the compounds were 100 ppb. Using this information, accurate analysis of the compound levels flowing through Rowland Ditch was possible.

The components of the standard rapidly evaporated; thus, careful consideration was given to the most successful time to calibrate the instrument. It was observed that the best opportunity to calibrate was during the second full run of the standard. To calibrate during this run, the machine must be given the command at the conclusion of the first run. If the standard was injected at the beginning of a run, it was probable that the next run was the best one to calibrate. Since standards can deteriorate, it was mandatory that the standards were fresh during calibration.

After calibration, standards were made for the jet fuels present on AEDC which could be in the water in Rowland Ditch and could be interfering with the SiCHROMAT 1-4. These standards had concentrations at the part per million {ppm} level of the fuels. "Mystery peaks" which had been appearing in the chromatographs of the Rowland Creek samples also appeared in the chromatographs of the fuels standards. These fuels, JP-4 and JP-8, also had

traces of other compounds: benzene, toluene, ethylbenzene, m,p-xylene, chlorobenzene, and o-xylene; which are impurities from testing. Whether the fuels caused any interference with the operation of the continuous monitor has always been a concern. The standards of the fuels revealed no interference by the "mystery peaks" except at 17.79 minutes. Because of the programming, the integrator assigned this time to be 1,1,2,2 TCE. However, the actual presence of this compound in the fuel is highly unlikely. This interference may be helpful in the future because it can be used to detect fuel in Rowland Ditch. It is possible to rename that peak "fuel" because 1,1,2,2 TCE is not currently used at AEDC.

RESULTS

The SICHROMAT 1-4 is a new instrument at AEDC. Therefore, there are many questions concerning its sensitivity, consistency, required maintenance, and needs in calibration. Many of those questions have begun to be answered; however, much more attention of all of the factors must be devoted. For approximately one month, constant time has been given to calibration and experimentation on the monitoring station. the results found are as follows:

o **SENSITIVITY:** The sensitivity of the SiCHROMAT 1-4 has not been completely discovered. The sensitivity of this instrument with the highly volatile compounds, such as freon and carbon tetrachloride, may never be known. Due to their tendency to volatilize, a correct response factor could never be programmed. Nevertheless, the data from the SiCHROMAT 1-4 is much more acceptable since the calibration.

o **CONSISTENCY:** The consistency of the SiCHROMAT 1-4 is questionable. During the month of standardization and calibration, the area counts of the compounds injected remained fairly consistent. However, when compared to the area counts of the first standards which were run in April, the areas had decreased to approximately one-third of the initial area. Constant monitoring of the area counts should be continued to discover if another fluctuation occurs. See attached table concerning comparisons of 1,1,1 trichloroethane; trichloroethylene; perchloroethylene; and o-xylene.

o **REQUIRED MAINTENANCE:** The SiCHROMAT 1-4 requires extensive maintenance. The gases must be checked approximately every two days in order to maintain full levels. The SiCHROMAT 1-4 consumes approximately four bottles of air weekly. It uses a bottle of nitrogen every two months. The helium must be changed once a month. The hydrogen needs changing every three months. These figures are must different than the proposed figures for gas consumption. These figures stated that the instrument would use two bottles of hydrogen a month, two bottles of nitrogen a month, four bottles of helium a

month, and four bottles of air monthly.

Occasionally, the sparger unit must be cleaned with 1 to 1 HCl to remove dirt and algae deposits. The printer on the integrator requires one to change the paper and the pen when necessary. When this is needed, the printer gives the necessary commands to return to functional use. If the printer is without paper, the machine goes into a remission state until the paper is reloaded.

o NEEDS IN CALIBRATION: Calibration of the SICHROMAT 1-4 is a vital part of the operation and usefulness of this instrument. In order to receive accurate data, calibration should be done approximately once a week unless occasion arrives for it more often. The entire calibration procedure requires the mixing of a standard which can be calibrated after the first run. By calibrating during this time, the second run will actual be calibrated to 100 ppb. The standard needs the include as many compounds as possible. Otherwise, only a select few of the programmed compounds will be relaying the actual ppb.

It is possible that the SICHROMAT 1-4 could be calibrated to detect the jet fuels present at AEDC using the interference of the peak with 1,1,2,2 TCE. Otherwise, there is relatively little interference from the jet fuels.

CONCLUSION

The Continuous Monitoring Station at AEDC is an automated water quality analyzer. This instrumentation could prove to be a helpful tool in analyzing the cooling water of the base for organic pollutants. Due to the unfamiliarity of the SiCHROMAT 1-4, the results are still in the development stage in the overall analysis of this water. However, a better understanding of the machine and the calibration should reverse this problem. If a constant record of maintenance and calibration is maintained, this instrument should prove itself very useful to AEDC. Although this instrument is completely automated, constant maintenance of the machine is necessary. Fixed warning levels for each compound still need to be installed to properly limit the amount of pollution flowing out of AEDC. Although the Continuous Monitor will never be a trouble-free apparatus, the possibilities concerning its usefulness to AEDC are limitless.

COMPARISONS OF SENSITIVITY

DATE	1,1,1 TCE	TCE	PCE	O-XYLEN
APRIL 1, 1992	310910	301956	247263	- - - - -
APRIL 21, 1992	415940	429087	339875	1439359
JULY 9, 1992	101010	95186	58216	444702
JULY 10, 1992	132179	117257	73686	536728
JULY 13, 1992	81649	81844	52919	344373
JULY 14, 1992	61284	62059	39151	290566
JULY 15, 1992	106925	115547	70752	515767
JULY 16, 1992	47680	106646	68140	447134
JULY 17, 1992	96632	105371	65953	505972
JULY 20, 1992	94558	106971	65733	461881
JULY 21, 1992	94636	99414	58562	431533

ACKNOWLEDGMENTS

I would like to sincerely thank the United States Air Force for allowing me to have this great experience this summer. Not only have I learned much from seeing the operation of a chemistry lab, but I have also been given the opportunity to apply my skills and explore my interests in a real life situation. I would also like to thank RDL for all the organizing of this opportunity. I also have many people to recognize at AEDC. I would first of all like to thank Captain Greg Nordstrom for selecting me as an interviewee for this position and for being there to answer my questions as they arose. I would also like to acknowledge all of the wonderful employees of the Chem/Met Lab at AEDC. They made it so easy for me to fill at ease and do the best job possible. To Sherry Binion and Jim Thomas, I would like to give my deepest gratitude for working with me at the Continuous Monitor {even when you did not want to}. To Steve Ary I give a huge thank you for selecting me to apprentice at the chemistry lab. Thank you for having confidence in my ability to do this project. I hope I have lived up to these expectations. Thank you, everyone!! I hope I see you again next year.

10-13

CIVIL ENGINEERING LABORATORY

A STUDY OF LITTORINA IRRORATA
AND ITS ENVIRONMENT

Philip C. Dorsch
Student Lab Assistant
Bay High School

Final Report for:
Summer Research Program
AFESC Laboratory

Sponsored by:
Air Force Engineering and Services Center
Tyndall Air Force Base, Florida

August 1992

A STUDY OF LITTORINA IRRORATA
AND ITS ENVIRONMENT

Philip C. Dorsch
Student Lab Assistant
Bay High School

Abstract

Research was done on Littorina irrorata to see how they would react to a change in their enviroment. Sites were selected in the upper intertidal zone of Crooked Island Sound, Tyndall AFB and certain areas were marked off as control or test areas. First, the snails were observed in thier natural surroundings and observations were made. Then the grass in the test areas was replaced with wooden dowels and the results recorded. The final results from both the natural and artificial environments were compared and little change was found.

A STUDY OF LITTORINA IRRORATA
AND ITS ENVIRONMENT

Philip C. Dorsch

INTRODUCTION

The project to which I was assigned included conducting experiments on Littorina irrorata. The purpose was to explore the possibility of Littorina irrorata living in an artificial environment and analyzing the effects it had on them. Because of previous research, it was my belief that Littorina irrorata are not particular to their environment as long as it is in the upper intertidal zone of some type of bay or wetland. The experiment I conducted included three steps: first, to mark off certain areas as control sites and study the Littorina in their natural surroundings, the intertidal grasses; second, select similar locations in the grass beds and replace the grasses with an artificial substitute; and third, to observe and record the Littorina's behavior in their new environment. After the experiment was completed, the results from both environments were compared and the littorina were released.

METHODOLOGY

While doing research on these snails, I found that they live in the upper intertidal zone of beaches along the Gulf of Mexico. The Gulf Periwinkles live on the mud flats and marsh grasses in this area. These snails ascend and descend

the marsh grasses with the changing tides. The snails are higher on the grasses at high tide and lower on the grasses, or even on the mud flats, at low tide. The two types of grasses in the testing sites were Spartina and Juncus. Spartina has a wide leaf (1-1.5cm) and is fairly flexible. The Juncus grass is very tall (130 cm+) with a thin (.5cm-) round stalk. I conducted tests on both grasses to see if one snail group might respond better to a different environment.

First, I selected the control and testing sites. I tried to eliminate as many variables as possible in order for the experiments to be successful. The four sites I selected were all close together. The experiment groups were 2 meters from the control groups. The two sites, one in Spartina and one in Juncus, were 12 meters apart. All four areas were on the same parallel of the beach slope. All four areas were in the same type of soil or sand and exposed to the same weather conditions.

Second, after selecting the sites and planning what to do, I enclosed each area with hardware cloth leaving the top open. Each enclosure was circular and had an area of 75 sq. cm. The enclosure had a height of 45 cm. The snails in the control group in the Spartina were painted orange and the experimental Spartina group were orange with a big white dot. The snails in the control group in the Juncus were painted white and the experimental Juncus group were painted white with an orange dot on their backs (S.E. Collard, PERS. Comm). There were 122 snails in the Spartina control group and 114

in the Spartina test group. In the Juncus grass there were
210 in the control group and 226 in the test group. A total
of 673 snails were under study.

The next thing I did was to study the snails in nature.
I made observations and recordings of the snails at different
times and temperatures. I also recorded their height on the
grasses at different tides and with different weather
conditions. All the data I collected went on to one of three
field charts (see Figure 1,2,3). These field charts helped
summarize the Gulf Periwinkles' behavior in its natural
environment.

After studying the Littorina for three weeks in their
natural surroundings, I decided it was time to change their
environment. In both the Spartina and Juncus test sites, I
removed all the grass and replaced it with wooden dowels.
The dowels had different heights and widths. The width of
the dowels were 1", 3/4", 3/8", 7/16", 5/16" , 1/8", 3/16".
Thirty wooden dowels were placed in each test site. That was
a great reduction from their original environment. There was
over 250 Juncus stalks in the Juncus test site and over 140
Spartina leaves in the Spartina site. I believed that the
all the snails would climb the dowels. I believed that the
snails would climb the dowels with the rising of the tides
just like they did with the grass leaves in the control
groups. As long as the snails were placed in the upper
intertidal zone, I thought they would climb anything to
escape the tide and predators.

Conclusion

After three weeks of studying the test groups, I found that my hypothesis was correct. The snails did climb the dowels, like the leaves, to escape the tide and predators. If there was no room on a dowel for more snails, then the snails climbed the cage. I found that the smaller snails climbed higher on the dowels than the larger ones, just as they did in nature. The observations and data collected from test sites were almost exactly the same as the ones from the control groups. These results proved that Littorina irrorata can adapt to an artificial environment as long as this environment is in the intertidal zone of some type of bay or wetlands.

<u>Littorina irrorata</u> FIELD DATA SHEET NO. 1

DATE	TIME	DEPTH POLE #2	AIR TEMP	WATER TEMP	PPT SALINITY	CLOUD COVER	SITE NO.	GRID SIZE
07/ /92								

NOTES: Weather, Predators observed, etc. (record Date, Time, Site #).

Littorina FIELD DATA SHEET NO. 2

DATE	TIME	SITE	GRID	AREA # SAMPLED	SNAILS OBSVD	# MARKD	COLOR	# RE- CPTURED
06/ /92								

NOTES:

Littorina FIELD DATA SHEET NO. 3

DATE: TIME: SITE NO.:

SIZE OF AREA SAMPLED (sq. m):   SLOPE/10 m:

TOTAL NO. OF SNAILS IN GRID:

   NO. ON SUBSTRATE: NO. ON PLANT STEMS:

NO.	SIZE	NO.*	SIZE	CM **		

* NO. = number per plant stem; **
** CM = centimeters above the substrate

BIBLIOGRAPHY

1. Hamilton, P. "Intertidal distribution and long-term Movements of Littorina irrorata (Mollusca: Gastropoda)." Springer-Verlag 1978.

2. " The World Book Encyclopedia." Field Enterprises Educational Corporation 1980.

ACKNOWLEDGEMENTS

I would like to thank the follwoing people for sharing their knowledge, enthusiasm, and experience with me: Col. Lamb for his support, Dr. Cornette for his advice and guidance, TSgt Julian and SSgt Volnoff for their patience, and Ms. Hill for all the assistance she gave me. Special thanks go out to Dr. Snead Collard who opened my eyes to the world of Marine Biology and made every day unique. Thanks for making this job an experience I'll never forget.

Comparison of the HNU 311 portable and Hewlett Packard 5890 Series II Gas Chromatagraphs

by Corey D. Fogleman

Apprenticed at the AFCESA Tyndall Air Base, Panama City, Florida

Final Report

12-1

Abstract

Working at the Air Force Civil Engineering and Services Agency laboratories, I gained valuable experience in a number of fields. I learned about plate counting while working with a biologist, about oxygen demand while working with some of the chemists in my laboratory, and about solar detoxification as a means of breaking down BTEX compounds. Besides this work, I vigorously pursued a full time summer research project. The purpose of my project was to compare the accuracy of the relatively new HNU 311 portable gas chromatagraph to that of the EPA approved Hewlett Packard 5890 Series II GC. I did this by first calibrating the portable and then running approximately 50 samples per week in simultaneous succession through both machines. I concluded that although some continuous research may yeild a proper method which would bring the HNU up to standards set by the HP, currently the HNU is not a comparible gas chromatagraph.

My preconcieved notions

I entered the apprenticeship program hoping to arrive at a better understanding of both the techniques that are practiced in a laboratory certain pieces of laboratory equipment. I felt that some hands on work in a real laboratory would be a valueable experience base for my chosen profession, medicine.

My mentor's notions

My mentor, Mr. Ted Marolla, also saw my summer job as an opportunity to deal with aspects of the laboratory in a professional way. As a result of our shared viewpoint on my purpose, he gave me the opportunity to work on research not directly related to my summer project.

Mr. Marolla had a project ready for my analysis when I arrived at the laboratory in June. I was to compare the new HNU portable Gas Chromatograph (from this point, it will be refered to as a GC) to the EPA approved Hewlett Packard 5890 Series II and purge and trap.

The Headquarters Laboratories

The laboratories located at Air Force Civil Engineering and Services Agency are most directly related to the study of toxic compounds such as those found in the fuel propellant JP-4. A Fire Training Facility (FTF) located within a few miles of the labs provides an excellent place for the study of the effects of fuel spills. Bacteria counts to determine the organic destruction of fuel, foam tests to determine the affectiveness of certain fire suppressants such as Aqueous Film Forming Foam (AFFF), and chromatograph studies to determine the presence of components of Jp-4 such as Benzene, Toluene, Ethylbenzene and the Xylenes, all can be performed with the aid of the FTF. This provides area for valueable research.

Plate Counting

While working with my lab partner, Angela Foth, we experimented with Plate Counting. This was done under the supervision of Hubert Attaway, a microbiologist here at AFCESA. We attempted to determine the number of bacteria in the Holding Pond. We began by making agar plates with both agar and nutrient broth. As we did this we also made nutrient broth blanks by placing nine mL of broth solution into each of 96 vials, which were then sealed. Then we performed a serial dilution.

From a vial of water taken from the holding pond, we extracted one mL. This was placed into one of the broth vials. After agitation we extracted one mL from the first vial and placed it into the second vial. These two vials then had a 1/10 and 1/100 dilution respectively. We

continued dilution until we had up to a 1/100000000 dilution. We then spread samples of each vial onto the pre made agar plates, and allowed growth for 48 hours. Each colony on the plate represented a bacteria, and there must be between 30 and 300 colonies to be considered statistically correct.

BOD's and COD's

Although I did not spend much of my time working on this project, I found what I did do to be interesting, so I've decided to take a little space and discuss what I've learned by accompanying Richard Hunter and Ted Marolla.

A COD is a chemical oxygen demand. It measures the reaction rate of an introduced chemical, such as Aqueous Film Forming Foam. For example, a COD test would be run before a chemical is added to a body of water, such as our holding pond. The test involves placing a sample of water in a spectrograph, reading the amount of retained light, and applying this number to a graph of linear regression to determine an oxygen count. Comparing this test to a COD performed after the chemical is added will reveal a chemical oxygen demand.

A BOD is a biological oxygen demand. This is a measure of the respiration of the bacteria which will feed on the introduced chemical such as AFFF. A BOD is performed using a dissolved oxygen meter. The sample chemical is placed in the sample of the host water and the meter registers an oxygen value every five days over a given time period. (Inhibitors are also added to the BOD sample to keep the chemical reactions with the water from interfearing with the biological demand.) These two values are very important, for they tell the possible effect of dumping waste into natural bodies of water.

Solar Detoxification

We have here on the air base a solar detoxification site. It is testing to observe the effectiveness of this hope for decontaminating water. Paul Wyness and Andrew Martin are working with a " one sun" skit site in which ground water, spiked with BTEX compounds, are catalized with titanium dioxide, hydrogen peroxide, and other chemicals. This water is then run through a column of tubing layed along a trough. It is exposed to both direct and indirct UV rays. The hope is that by experimenting with different combinations of coloring and catalysts, a method will be developed to break down BTEX in a quantitative measure in a minimum time period.

I played a very important role in this process. As I was learning the use of gas chromatographs, I was able to moniter the progress of the solar detoxification process. Each day I provided the two with an analyzed readout on how well each day's tests had destroyed BTEX compounds. It was interesting being a part of a move to further science in a new and innovative way.

Summer Research Project

The objective of my summer project was to create an evaluation of the portable HNU GC. This means a comparison of the accuracy of its results with that of the Hewlett Packard 5890 Series II and O.I. Corporation 4460 A Sample Concentrator (purge and trap).

The equipment used was specific. The EPA approved Hewlett Packard 5890 Series II Gas Chromatograph had the following specifications; initial oven temperature: 40 degrees C; initial oven time: 5 minutes; ramping rate: 5 degrees/ minute; final oven time: 5 minutes; injection temp: 200 degrees; detection temp: 250 degrees; carrier gas: He; flow rate: 8mL/min; range: 3; attenuation: 5; make up gas: nitrogen; detector: flame ion detector (FID); column: capillary (DB5 column); detector gas: hydrogen and air. The O.I. purge and trap had the following specifications; purge time: 12 minutes; desorb time: 4 minutes; bake time: 7 minutes; bake temp: 180 degrees C; purge gas: Helium. These two systems work together to give readings of contaminants in a sample. A 5mL sample that is injected into the purge and trap will be purged using nitrogen. After a sufficient amount of time, the contaminants will be trapped on the column and sent through the HP. This has a carrier gas which will allow the contaminants to flow through a detector. The oven heats the contaminants at a ramping variation, so that those contaminants with a lighter molecular weight will flow through faster than heavier contaminats. Benzene, for example, is the lightest of the BTEX compounds and so will flow through the machine faster and will be on the readout faster than other BTEX compounds. The FID is a flame which gives energy to the contaminants as they are fed through, and when this energy is released, the machine measures the amount of energy that each contaminant had stored, and therefore can determine the amount of contaminant in each sample. This imformation shows up in the form of peaks on an intigrator readout, and must then be interpretted by the technician. This method will be explained in a later section.

The HNU 311 Gas Chromatograph had these specifications; detector: photoionization detector; column pressure: 1 psi; carrier gas: helium; injection temperature: 90 degrees C; oven temperature: 60 degrees C; attenuation: 2; column: capillary; injection temperature: 90 degrees. The HNU requires the injection of headspace. This is piped through the machine with helium, and is similar to the system in the HP in that the lighter contaminants will flow through the 60 degree oven faster than the heavier contaminants. The photoion- detector bombards the contaminants with light energy, and reads what energy is thus released from the contaminants. In this way the machine prints the readout of the contamination. The PID is considered to be superior to the FID in that it has aromatic efficiency.

The following are the given methods which Ted Marolla had designed prior to my arrival. A 40 mL vial of sample is removed from the freezer and allowed to sit for one half of an hour. This vial is then spiked with internal standard measure (ISM). This is a known standard of two compounds whose weight is such that the peaks it produces fall between those of the BTEX compounds. This allows the observer to note changes in the retention times of certain compounds

by noting the subsequent changes in retention times of the ISM. Ten mL of the sample is then removed using a sterile needle and air replaces the fluid through another needle as it is removed. The vial is then shaken for 2 minutes. Following this it is let rest in a 30 degree C bath for 5 minutes. Two hundred microliters of headspace is then extracted from the vial and injected into the inject port.

In order to create standards by which future samples could be compared, we first ran samples of straight BTEX. Many consecutive runs of known quantity gave both standard retention times and standard peak heights for different quantities of contaminants. An explanation: a known qunatity of BTEX compounds, containing 100 parts per billion of benzene per the solvent, methanol, is run. After several runs of this same compound at the same concentration, an average peak height of 5337 is found. Respectively, at 200 parts per billion, a height of 9900 is found. By using the peak height as the y value, and the parts per billion as the x value, (the peak height is a dependent value) and creating a linear regression, we find that a line of best fit on a cartesian graph has a slope of 55.14 and a y-intercept of -380.3, for benzene. Consistant runs yields that benzene's retention time is approximately 1:28. Similar runs for toluene yield these values: retention time: 2:37, slope: 49.43, y-intercept: -387.19. For ethylbenzene: 4:56, 37.39, 221.8. For m/p xylenes: 5:16, 37.1661, -364.775. For o xylene: 6:13, 22.7117, -202.0904. Thus, any future runs may be compared, using the known equation, $Y = MX + B$. Similar values were already in use by Ted Marolla on the Hewlett Packard. Although there were differing numbers for peak heights and retention times on the HP, this was given account to the fact that the machines were of different make.

In order to apply the new found values for the HNU machine, we ran samples from the solar detoxification site. This was excellent, because there were many samples, giving us the opportunity to run tests over a long period of time. The system was to run each sample from the detoxification site through both the HNU and the HP. As a result, we could compare each day's results from each machine.

After working with both the HNU and the HP for a period of approximately six weeks, I found these things. The HNU has a PID, which has such sensitivity that the slightest alteration in methodology will result in drastic changes in a readout. In order to try to bring the numerical readout of the HNU closer to that of the HP, I developed the following method for sampling on an HNU portable system: 1. A sample should be removed from a cooler and placed in a 40 degree C bath for two minutes. This cuts down the time originally called for. 2. Spike with ISM. 3. Allow the ISM to difuse for two minutes. 4. Withdraw the ten mL of sample and allow headspace to enter just as described above. 5. Shake for two minutes. This must be consistant and steady, prompting my suggestion for a standard shaking instrument. None was available in my laboratory. 6. Allow sample to sit for seven minutes in a 40 degree C bath. 7. Shake the sample for one more minute. 8. Inject 200 microliters of headspace into the inject site. 9. Perform a burn in (bake) for 10 minutes at 100 degrees C for both the injector and oven. This should be done every five samples. This serves to cut down on the contamination build up that forms on the coils and

detector.

Although these standard methods help to stabilize the output of the HNU integrator, they do not fully correct the problem of accuracy. The HNU did eventually deliver data within the 15% range of error of the data delivered by the HP. However, I would not recommend using the HNU system in place of the Hewlett Packard 5890 Series II and purge and trap. At the very least, more research is required to judge the true efficiency of the HNU system.

Figure Decriptions

Figure 1. An artist's depiction of a fire training facility. Fires ignited in the drainage basin may be put out using some means. The remaining liquid is then pumped through a seperator where the fuel is skimmed off and the remaining water is sent to the holding pond.

Figure 2. A photograph of the HNU 311 Gas Chromatograph. Its advantages include the fact that it is compact, relatively inexpensive, and portable. It's disadvantages include a small gas supply, inprecise and inaccurate readouts. Subsequently, it is unreliable.

Figure 3. A copy of an HNU integrator report. This particular readout is for a QC sample. This is a sample of BTEX in a methanol solution. A peak chart is shown, while below it is a list of peak heights, areas, and retention times. As can be seen, benzene, with a retention time of 1:29, has a peak height of 4799. This yields a parts per billion of 94.

Figure 4. A copy of a peak chart from a Hewlett Packard integrator. The retention times for BTEX are: benzene: 4.271, toluene: 7.964, ethylbenzene: 11.680, m/p xylene: 12.002, o xylene: 12.877.

Figure 5. A copy of a graph showing a comparison of the HNU (PID) and the HP (FID) results for a solar detoxification test run. On this particular day, the HNU followed fairly well the graph of the HP. Note that a sample was taken every 30 minutes, and that a considerable amount of benzene is destroyed over the three hour time period.

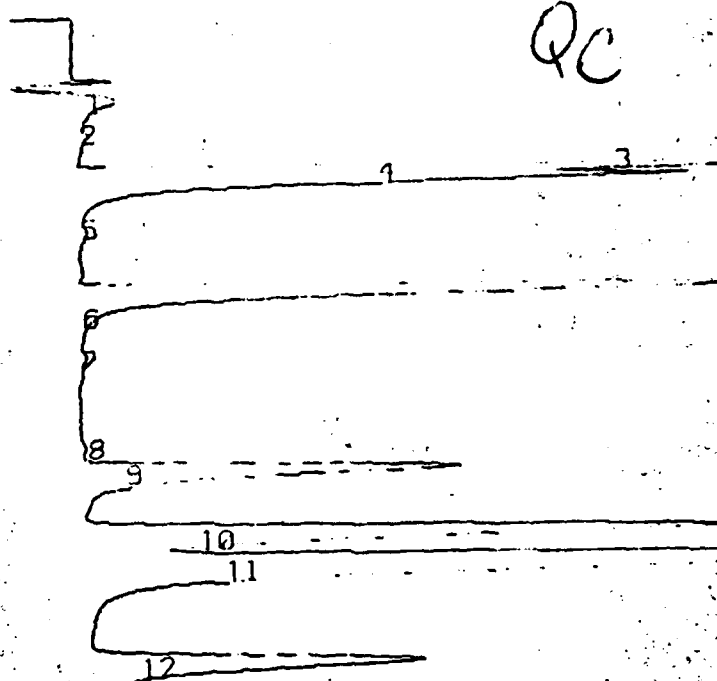# ENVIRONMENTALLY-SAFE FIRE TRAINING FACILITY
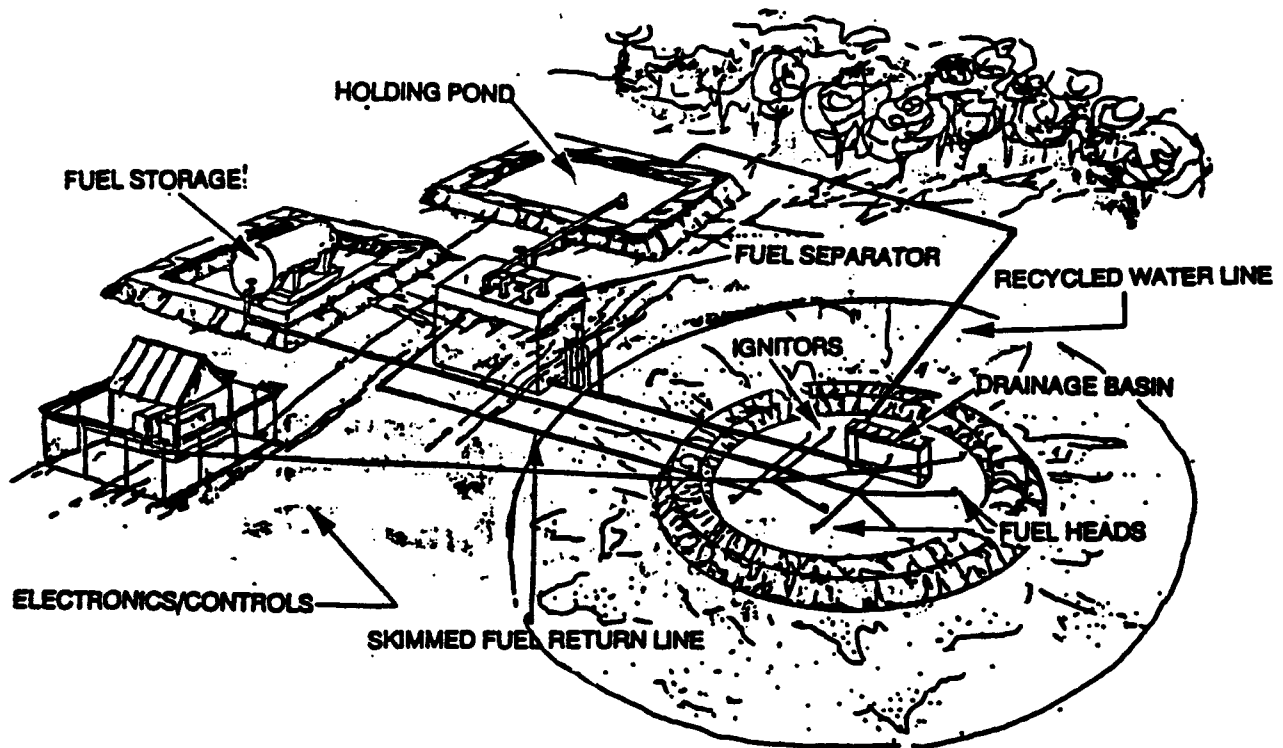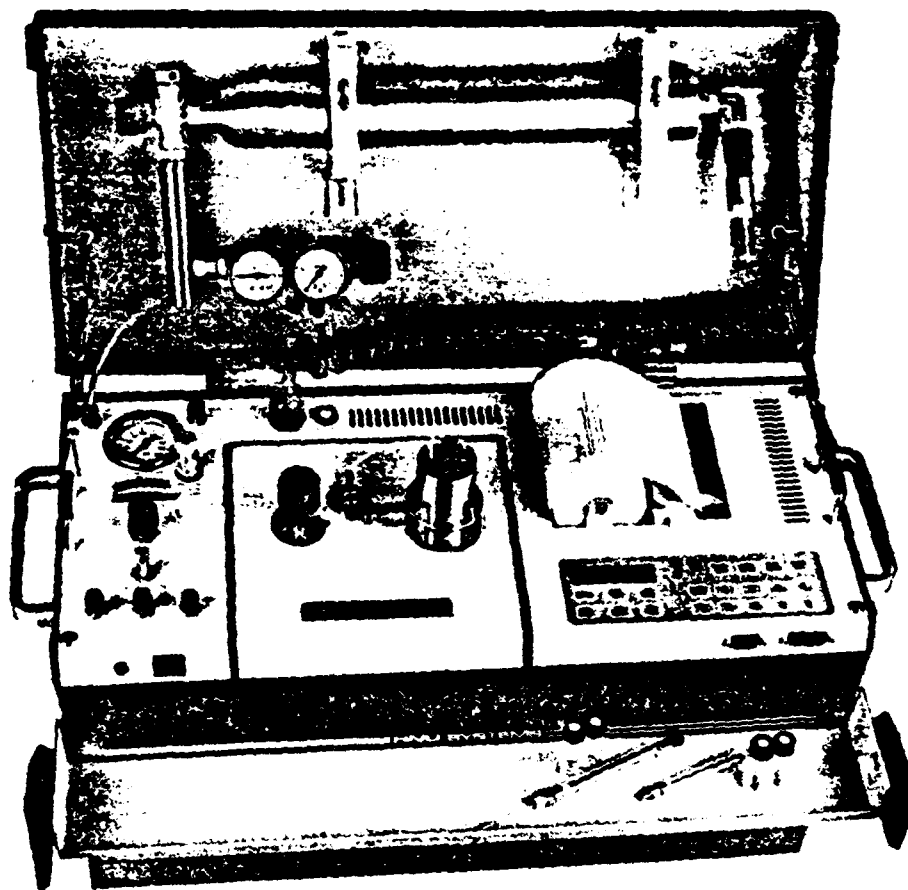
HOLDING POND

FUEL STORAGE

FUEL SEPARATOR

RECYCLED WATER LINE

IGNITORS

DRAINAGE BASIN

FUEL HEADS

ELECTRONICS/CONTROLS

SKIMMED FUEL RETURN LINE

FULL-CAPABILITY DESIGN

UNIT IN SEARCH MODE

QC

DATE   TIME
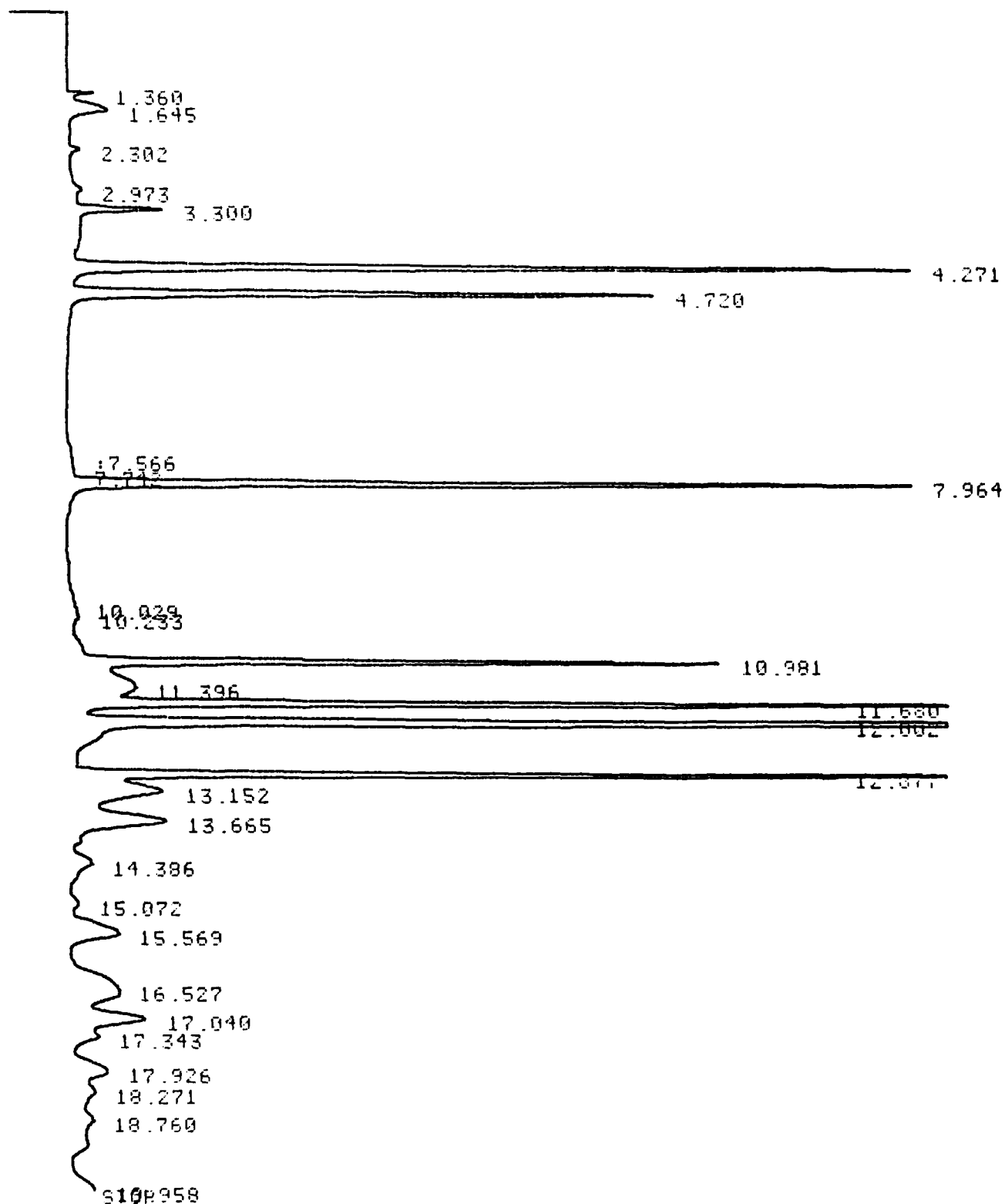07/16/92 ,08:55:25

NOISE   =   0.00488
BASELINE =   0.86203

SEARCH MODE RESULTS

PK#	HEIGHT	AREA	TIME
1	244	4269	0:48
2	70	1019	1:08
3	4799	45926	1:29
4	3495	28254	1:34
5	64	921	2:05
6	4406	62590	2:40
7	42	879	3:20
8	27	476	4:14
9	2198	34676	4:46
10	3658	62899	5:03
11	7662	140685	5:21
12	1975	37912	6:19

* PUN # 356   JUL 16. 1992 19:22:20
START

1.360
  1.645

2.302

2.973
      3.300

4.271

4.720

:7.566
7.964

10.029
10.233

10.981

11.396

11.680

12.002

12.377

13.152

13.665

14.386

15.072

15.569

16.527

17.040
17.343

17.926
18.271
18.760

STOP 18.958

Test 5, Revised Schedule of 7-16-1992
Comparison of Benzene
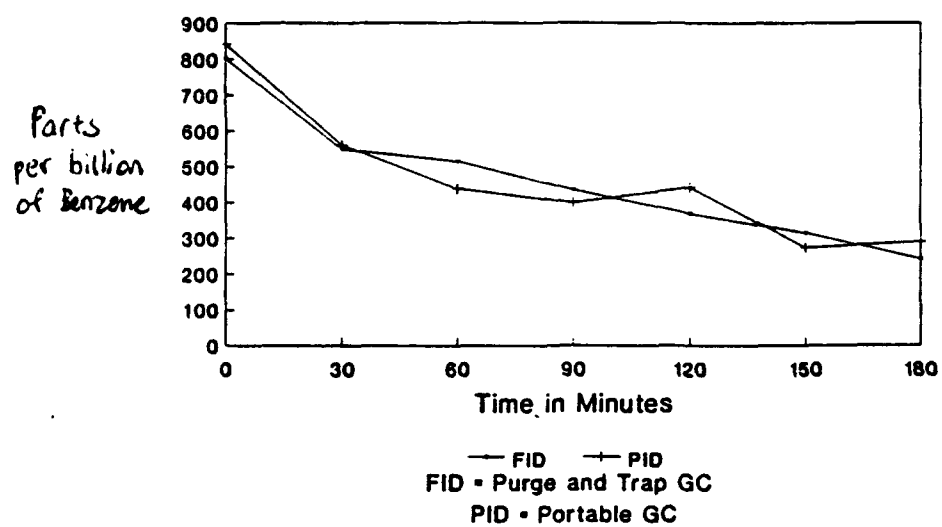
Parts
per billion
of Benzene

	FID	PID

FID = Purge and Trap GC

PID = Portable GC

MICROBIOLOGY STUDIES
and
CUP BURNER EXPERIMENT

ANGELA D. FOTH
High School Apprenticeship Program

A. Crawford Mosley High School
3418 North Palo Alto Avenue
Lynn Haven FL 32444

Final Report for:
Summer Research Program
Tyndall AFB Fire Laboratory

MICROBIOLOGY STUDIES
and
CUP BURNER EXPERIMENT

Angela D. Foth
High School Apprenticeship Program
A. Crawford Mosley High School

Abstract

Microbiology studies and the cup burner experiment
were performed in the Air Force Civil Engineering Support Agency
(AFCESA) Fire Research Lab. The purpose of the microbiology
studies was to determine if the holding pond from which the samples
were taken was biologically active. The purpose of the cup burner
experiment was to determine percent concentration of agent and air
it takes to extinguish a flame.

To grow micro-organisms, this procedure was followed: a
sample from the fire training facility holding pond was obtained
then diluted through serial dilution which is the method of
repeatedly diluting a sample through a series of dilution blanks.
After diluting the sample, 0.1mL was put on three seperate petri
dishes for each dilution then the dishes were incubated for 48-
hours. Results were then counted. The cup burner experiment
involved burning JP-4, measuring the flow rate of air and agent,
and calculating the percent concentration that extinguished the
flame.

MICROBIOLOGY STUDIES AND

CUP BURNER EXPERIMENT

Angela D. Foth

A. INTRODUCTION

Tyndall Air Force Base does many fire research projects involving several different research and analysis technologies. Two technologies and analysis procedures studied during my summer projects involved: 1) microbiology with the study of micro-organisms in the fire training facility holding pond; and 2) the cup burner apparatus.

1. MICROBIOLOGY

In microbiology studies, it is important to know how many live organisms are present in a culture. Micro-organisms are alive if they are capable of forming colonies on a suitable medium. Serial dilution and plating is the best method available for determining viable numbers. Serial dilution and plating is an estimate of the number of live micro-organisms present in a sample (this method frequently produces a low estimate because some cells may be alive, but incapable of division, and some may exist in pairs, chains, or clumps). Serial dilution is the method of repeatedly diluting a culture through a series of sterile blanks. The goal of serial dilution and plating is to determine how many viable colonies are in each milliliter of the

original culture. For counting analysis, select the dilution plate that contains preferably between 30 and 300 colonies. Plates containing a number of colonies in this range give the most accurate count of the number bacteria actually present.
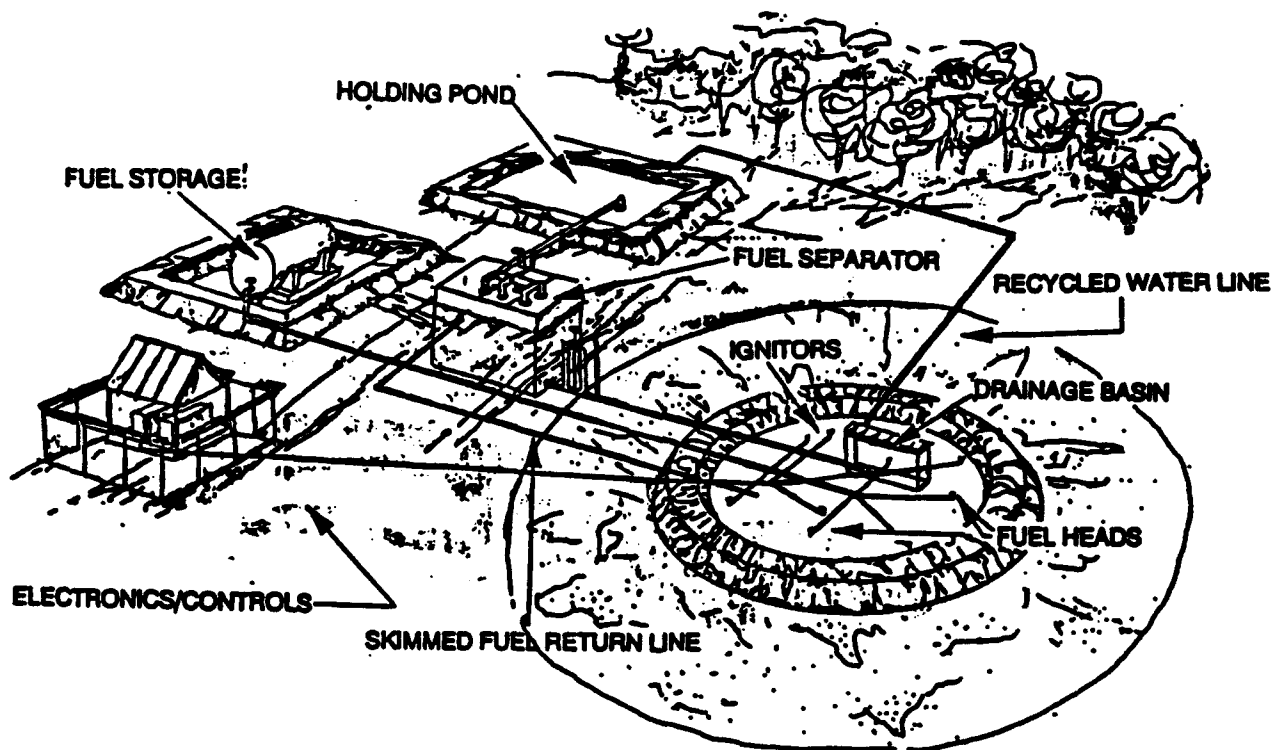
    2.   CUP BURNER

    Cup burning involved burning JP-4, measuring the flow rate of air and agent (Halon 1211), and calculating the percent concentration that extinguished the flame. The cub burner consists of a glass chimney containing a small flame cup. The bottom of the chimney contains glass beads that provide the even dispersion of gases flowing into the chimney. The extinguishing agent enters the bottom of the chimney, then air mixes with the agent. Measured volumetric flow rates of air and agent are used to calculate the agent percent concentration required to extinguish the flame. Reported extinguishment concentrations of the existing halons range from two to four percent.

B.   SITE LOCATION

    1.   MICROBIOLOGY

    The samples were taken from the fire training facility at Tyndall Air Force Base. The fire training facility is located about ten miles east of the main base area it is in an area called 9700. Figure 1. show the fire training facility layout.

ENVIRONMENTALLY-SAFE FIRE TRAINING FACILITY

FULL-CAPABILITY DESIGN

Figure 1.

2. CUP BURNER

The cup burner was located in the Fire and Environmental Laboratory of the Air Force Civil Engineering Support Agency, Tyndall Air Force Base, Florida.

C. METHODOLOGIES

1. MICROBIOLOGY

Samples were obtained by dipping a sterile five-hundred milliliter bottle into the holding pond. From that sample, 0.1 mL of the holding pond water sample was taken out using a sterile pipette and added to a 9.9 mL diluent and mixed. From that tube 1 mL was transferred to a second tube which was 9.0 mL and mixed. From that second tube another 1 mL was taken and added to a third tube which was also 9.0 mL and from the third tube 1 mL was taken and added to the last 9.0 mL tube and mixed. This gave the dilutions: 1:100 or 10-2; 1:1,000 or 10-3; 1:10,000 or 10-4; and 1:100,000 or 10-5. Using a sterile pipette, 1 mL was drawn from the holding tube then from the sterile pipette 0.1 mL was dispensed onto three different plates labeled A, B, and C. There are three separate plates for each dilution. After 0.1 mL of dilution was put on the plate, a spreading utensil is used to smear the dilution evenly over the plate. After 48-hours of incubation the plates are counted for bacteria colonies. Figure 2 shows the dilution procedure and the plates where the dilution was placed for analysis.
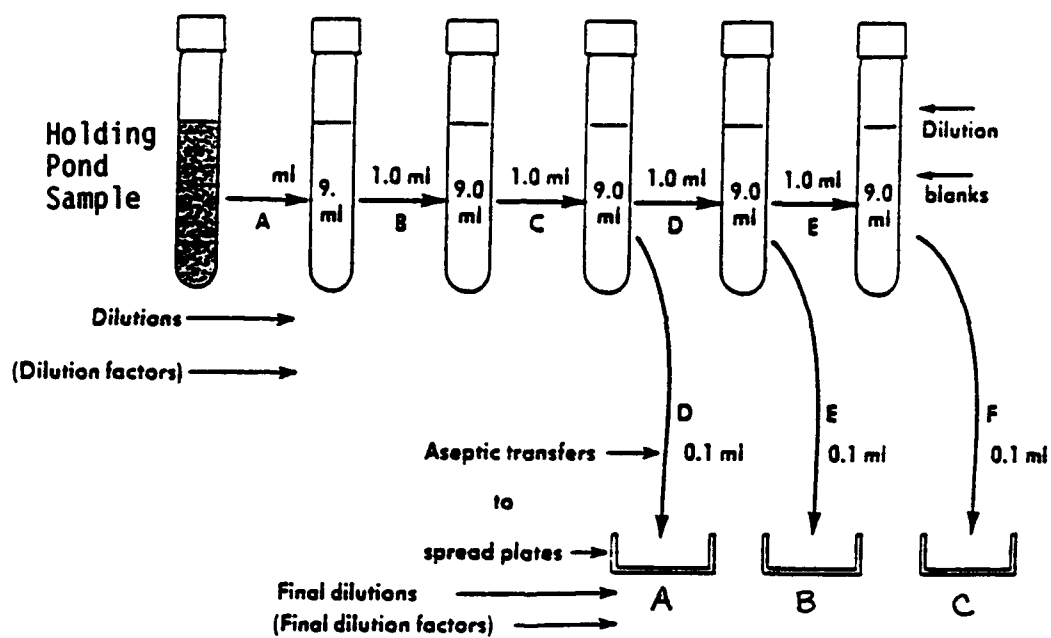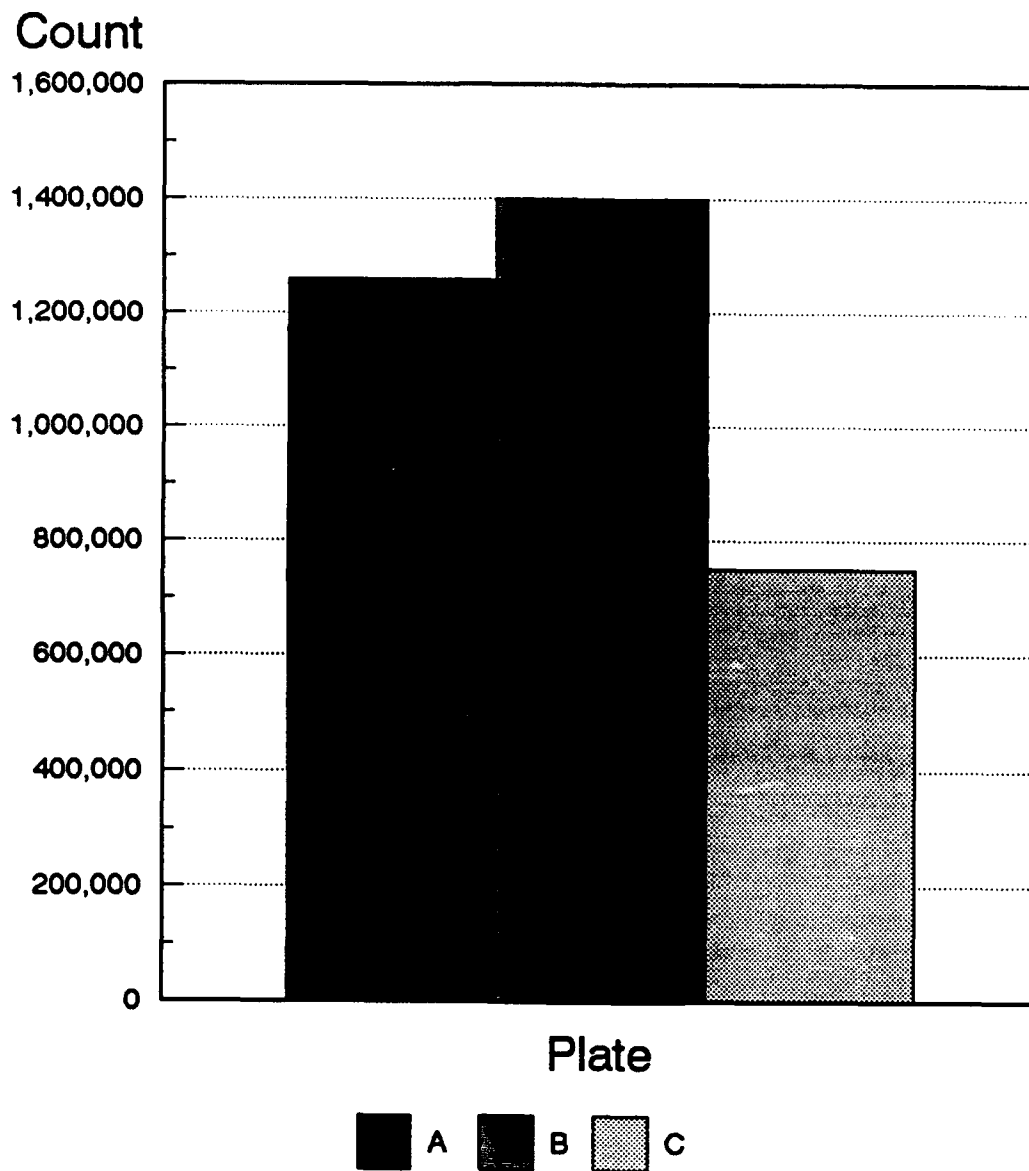
Figure 2.

2. CUP BURNER

The cup burner experiment involved measuring flow rates of air and agent evenly dispersed in the in the cup burner to extinguish the flame. In this experiment a flow meter was not used to measure the flow rate of air or agent. The flow meter was used just to control the amount of agent dispensed into the cup burner. To measure the flow rate of air and agent a one liter cylinder filled with water was inverted into a beaker also filled with water. A tube was then inserted into the cylinder with the air or agent flowing through it. The time was taken and milliliters per second was calculated, which gave the flow rate.

D. RESULTS

1. MICROBIOLOGY

In test one of the microbiology studies 10-4 was the only dilution with a viable amount of colonies on the plates. The dilution 10-3 had more than 300 colonies appear on the plates and dilutions 10-5 and 10-6 had less than 30 colonies on the plates. In test two 10-3 and 10-4 both had viable amounts of colonies to count on the plates as for the dilutions 10-5 and 10-6 they still had less than 30 colonies on the plates. The last test, test three the dilution 10-3 was the only dilution with a viable amount of colonies on the plate. 10-4, 10-5, and 10-6 all had less than 30 colonies (the graphed results for the three test are shown on Figures 3, 4, and 5).

HOLDING POND SAMPLE TEST 1

Test 1 10-3 dilution had more than 300 colonies,
and 10-5, 10-6 had less than 30 colonies.
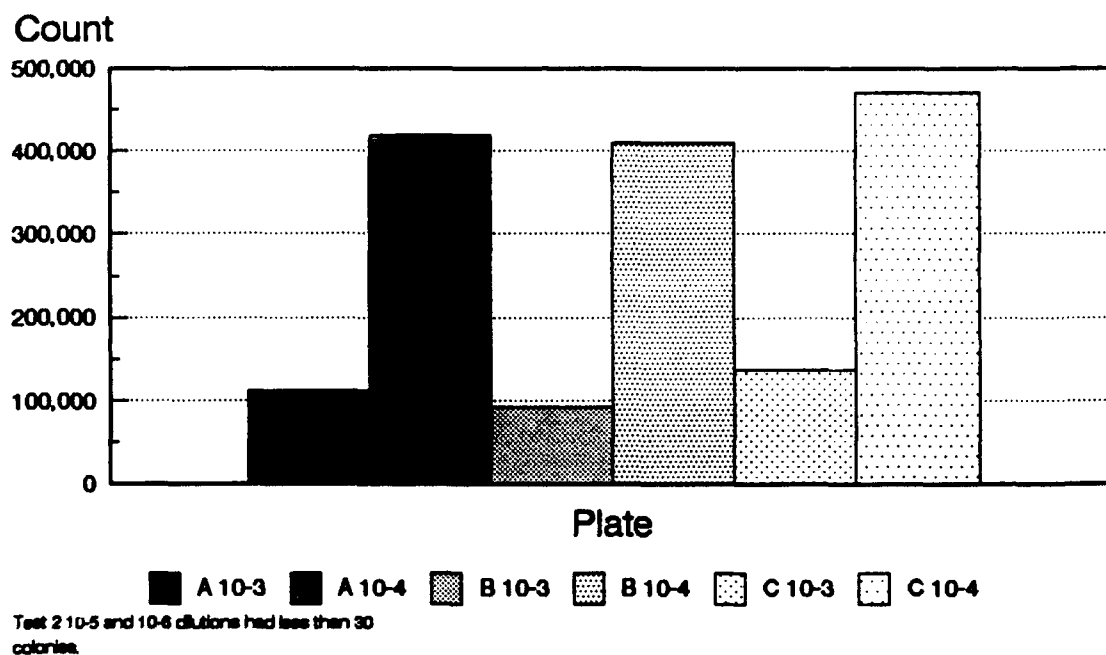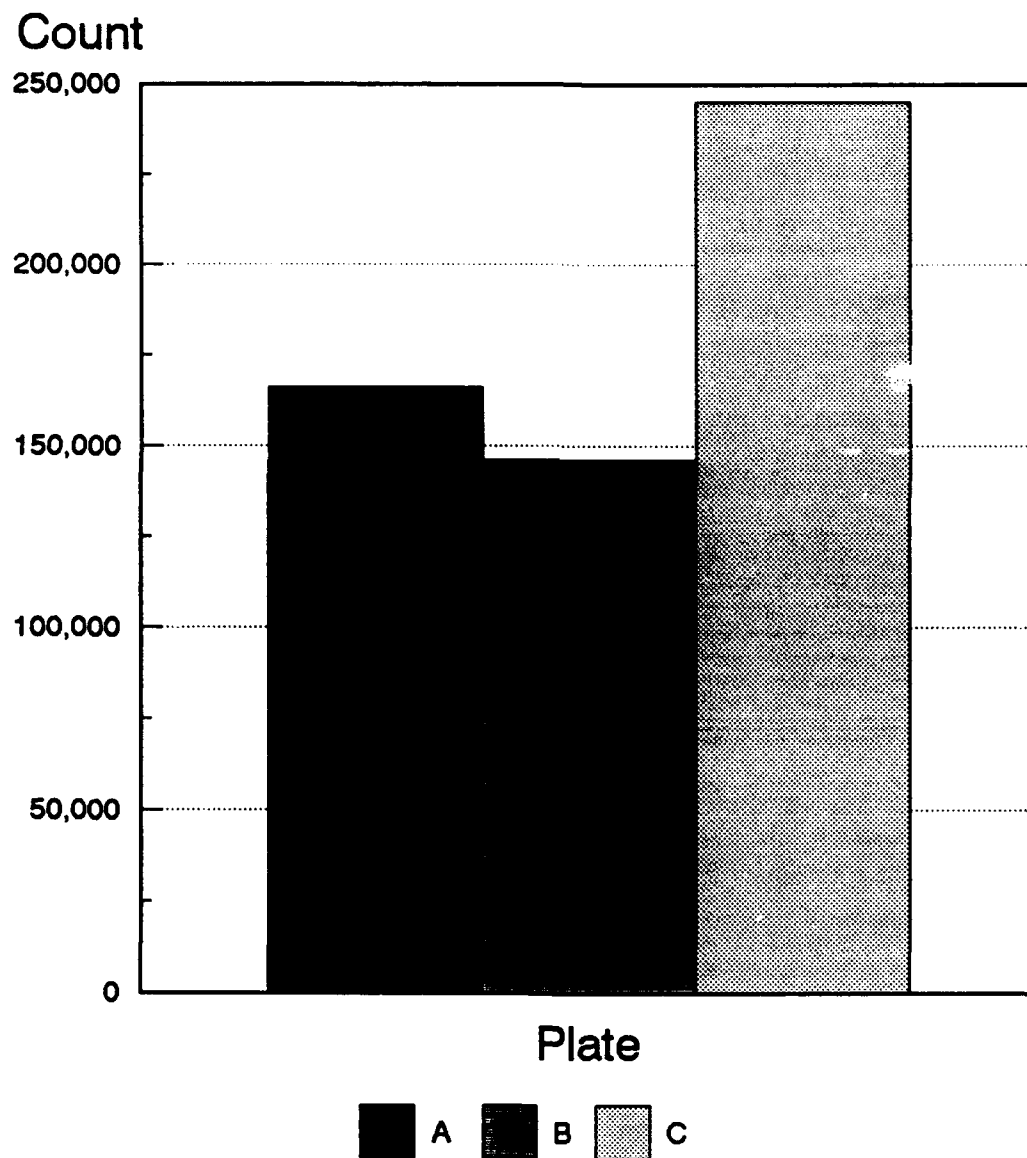
Figure 3.

13-9

HOLDING POND SAMPLE TEST 2

Count

Test 2 10-5 and 10-6 dilutions had less than 30 colonies.

Figure 4.

HOLDING POND SAMPLE TEST 3

Count

Test 3 10-4, 10-5, and 10-6 dilutions all had
less than 30 colonies.

Figure 5.

2. CUP BURNER

The average flow rate of air during the first test of this experiment was twenty milliliter per second and the average flow rate of the agent (Halon 1211) was two milliliters per second. In the second test of the experiment the average flow rate of air was sixty-eight milliliters per second and the average flow rate of Halon 1211 was one milliliter per second. In these two test the equation used to calculate the percent concentration was:

% concentration = Vagent / (Vagent + Vair) x 100

so the average percent concentration in test one was nine percent and in test two it was one percent.

E. CONCLUSIONS

1. MICROBIOLOGY

In the three serial dilution and plating test it was concluded that the fire training facility holding pond was biologically active and environmentally safe. It is also the conclusion that in order to solidify the analysis made here, many more tests must be performed.

2. CUP BURNER

The conclusion made from this cup burner experiment was that the optimum flow rate of air for putting out a flame is 27 mL/second. The optimum flow rate of halon for putting out a flame is 1 mL/second. This is also bound with the conclusion that further testing is required.

AN OBSERVATION OF PLUVIATION IN
PREPARATION FOR DYNAMIC EXPERIMENTATION

Mark W. Giles

Final Report for:
Summer Research Program
HQ AFCESA/RACS

AN OBSERVATION OF PLUVIATION IN
PREPARATION FOR DYNAMIC EXPERIMENTATION

Mark W. Giles

Abstract

The altering of falling sand columns into a uniform foggy mist was observed. To pluviate, particles of sand were released in a controlled fall, or "raining", through the air into a sample bucket. The desired outcome of pluviaton was the preparation of dense samples such that they are sufficiently level, and there is no need to rearrange the surface soil particles. The individual sand particles were acted on by a diffuser (sieve system) that transformed the falling sand jets into a nomogeneous rain of sand.

Pluviation prepares the soil sample for experimentation. Another observed research involved the effect of soil moisture on stress wave transmission and soil structure interaction.

AN OBSERVATION OF PLUVIATION IN
PREPARATION FOR DYNAMIC EXPERIMENTATION

Mark W. Giles

The form of controlled dropping of sand particles through the air is a simulation of the sedimentation process. Reproducing the homogeneous examples trial after trial was a major goal.

Pluviation generally includes dropping sand from a controlled height into a calibrated sample container. Excess soil can be trimmed off with a sample collar. The soil surface is leveled at a predetermined height to acquire an example of an accurately known volume.

The height of pluviation was not critical. A goal of this research was the reproduction of dense soil samples that needed no surface trimming or leveling after the sand raining was completed.

A number of different kinds of sand rainers were used, but the form of pluviation was basically the same. The major components of a sand rainer are a sand bin to hold the soil in the sample formation; a perforated plate and shutter to start and stop the sand columns falling from the bin area; a diffuser, or sieve system, to change the falling sand jets into a uniform rain; and a calibrated sample container to collect the final layout of sand.

Other possible variables in a pluviation system have previously been studied to determine their effect on the final soil sample. Among those additional variables were the size, spacing, and number of holes in the perforated plate; the size and arrangement of the sieve openings, the height of the sand in the storage bin, and the complication of a moving diffuser.

The technique of pluviation, as described above, was used in preparing the soil for dynamic experimentation. The dynamic experiments I observed were blast-induced stress transmissions in partially saturated sands for the purpose of studying the soil and soil structure. The sand was placed and compacted at moisture saturation levels which varied between zero and 60 percent. The dry unit weight of the compacted soil was 100 pounds/cubic foot. The tests involved the detonation of explosives contained in the sand. Acceleration-time histories were measured with accelerometers, and stress-time histories were measured with soil stress gauges. Sub-scale structures in partially saturated sand placed in a centrifuge were used to study the soil-structure stress transmissions.

PHOTO DISSOCIATION OF NO_2 IN VARIOUS MEDIA AT PPM LEVELS

RICHARD C. HARTZER

FINAL REPORT FOR:
AFOSR SUMMER RESEARCH PROGRAM,
AIR FORCE CIVIL ENGINEERING LABORATORY

SPONSORED BY:
AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
BOLLING AIR FORCE BASE, WASHINGTON, D.C.

SEPTEMBER 1992

15-1

PHOTO DISSOCIATION OF NO$_2$ IN VARIOUS MEDIA AT PPM LEVELS

ABSTRACT

The dissociation rate constants and the ultraviolet radiation intensities in a small simulation chamber were determined for nitrogen dioxide (NO$_2$) dissociation in synthetic air, nitrogen, helium, and argon air media. The ultraviolet radiation intensities in the simulation chamber were determined by using the decay data for NO$_2$. The dissociation rate constant, K$_1$, for NO$_2$ was $4.86 \pm$ x 10^{-3} sec. in nitrogen. The calculated ultraviolet intensities were: $6.39 \pm .027$ x 10^6 quanta cm^{-2} sec^{-1} in synthetic air, 5.73 ± 1.9 x 10^{15} quanta cm^{-2} sec^{-1} in nitrogen, $2.62 \pm .581$ x $2.62 \pm .581$ x 10^{15} quanta cm^{-2} sec^{-1} for helium, and $3.513 \pm .764$ x 10^{15} quanta cm^{-2} sec^{-1} in argon. It was observed that the decay of NO$_2$ in synthetic air was non-linear, while the decay of NO$_2$ in argon, helium and nitrogen were fairly linear at NO$_2$ concentrations lower than one ppm. At higher concentrations of NO$_2$ the decay was observed to be non-linear. At lower concentrations of NO$_2$ in synthetic air, the concentration of NO$_2$ was observed to increase with each increase in irradiation time; this behavior was attributed to the rapid combination of NO with excess oxygen to form NO$_2$ as below.

$$NO_2 \underset{K_{-1}}{\overset{K_1}{\rightleftharpoons}} NO + O\ (^3p)$$
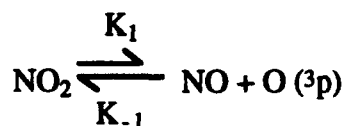
INTRODUCTION

As nitrogen dioxide is released into the atmosphere from various industrial processes, it combines with trace chemicals already existing in the atmosphere such as hydroxyl radicals, oxygen, hydrocarbons, and ozone. Some of the resulting products include compounds such as peroxyacylnitrate. In addition to the formation of these pollutants, high concentrations of NO_2 hinder the ability of plants to absorb carbon dioxide required to carry out photosynthesis [1]. In order to gain a full understanding of the reaction mechanisms of NO_2 with organic compounds and trace chemicals in the atmosphere, the interaction of NO_2 with these chemicals must be researched. There are many applications for the information gained from NO_2 Photo-dissociation. One of these applications which is important to scientists is the use of NO_2 as a gas phase actinometer. This is especially important to those scientists who are concerned with atmospheric simulation and air pollution; since NO_2 is the light absorber associated with this problem where the desired wavelength region for NO_2 is 300-450 nm.

Nitrogen dioxide usually dissociates into the products of NO and $O(^3p)$. But as the $[O(^3p)]$ increases in the presence of traces of oxygen, a number of cyclic reactions begin to occur-as in ordinary air. As a result of these cyclic reactions, the decay of NO_2 is never linear .The dissociation of NO_2 can also be used as a means of determining the radiation intensity in a simulation chamber and to calculate the amount of energy absorbed. The goal of this research was to meet this last use of NO_2 , ie, the use of NO_2 as an actinometric source.

EXPERIMENT

The experiment was begun by filling a Teflon bag with 150 liters of argon, synthetic air, helium, or nitrogen(N_2). While the bag was being inflated, a known quantity of NO_2 was injected into the bag.

Once the bag was full, it was placed inside a small simulation chamber which consisted of an aluminum housing, six black lights, four white lights, an exhaust fan, circulation vents, and a Teflon tube leading from the chamber to the Monitor Labs Nitrogen Oxides Analyzer

model 8841. The Nitrogen Oxides Analyzer was turned on and the room temperature and chamber temperature were recorded. The Nitrogen Oxides Analyzer obtains a reading of the [NOx] and [NO] from the Teflon bag. Since the Nitrogen Oxides Analyzer only measures [NOx] and [NO], the equation $NO_2 + NO = NOx$ was used to determine the [NO_2]. Since the initial [NO_2] was less than five ppm, it was not necessary to make any corrections for the presence of N_2O_4 which exists at equilibrium with NO_2. The measurements were recorded as the Nitrogen Oxides Analyzer read the [NOx] and [NO] in the air. The Teflon bag was then irradiated for 30 seconds. After irradiation, the chamber temperature and room temperature were recorded as the bag was left alone for one minute. After one minute, the Nitrogen Oxides Analyzer measured the [NOx] and [NO]; after three minutes of stabilization, a reading was then taken. These steps were repeated for 60 seconds, 90 seconds, 120 seconds, 150 seconds, and 180 seconds for argon and helium. When using synthetic air, the irradiation times were 30 seconds, 45 seconds, 60 seconds, 75 seconds, 90 seconds, 105 seconds, 120 seconds, 135 seconds, 150 seconds, 165 seconds, and 180 seconds. When using N_2, the irradiation times were 30 seconds, 45 seconds, 60 seconds, 75 seconds, 90 seconds, 105 seconds, 120 seconds, 135 seconds, 150 seconds, 165 seconds, 180 seconds, 195 seconds, 210 seconds, and 225 seconds.

RESULTS AND DISCUSSION

The UV light region of interest is 300 to 450 nm. The formula used to calculate light intensity for NO_2 dissociation in nitrogen is [2]:

$$I_2 = \frac{0.67\ d(\ln[NO2])/dt}{Qk}$$

where Q, quantum yield, = 2.1 and k = 5.21 x 10^{-19} cm ^{2} molecule $^{-1}$ and I_2 is the light

intensity in quanta cm^{-2} sec^{-1}. The light intensity of NO_2 dissociation in nitrogen was

found to be 2.15 x 10^{16} ± quanta cm^{-2} sec^{-1}. The formula used to determine the

dissociation rate constant, K_1, of NO_2 in Nitrogen is[3]:

$$K_1 = 1/\ 2T[(1+R_1-R_2)\ln[NO_2]_0/\ [NO_2]_f + R_2([NO_2]_0/NO_2]_f-1)]$$

where T = final irradiation time minus initial irradiation time, R_1 = 3.26 x 10^{-7} ppm^{-2}

min^{-1}, and R_2 = .52 ppm^{-2} min^{-1}. Typical plots of NO_2 dissociation in nitrogen are shown
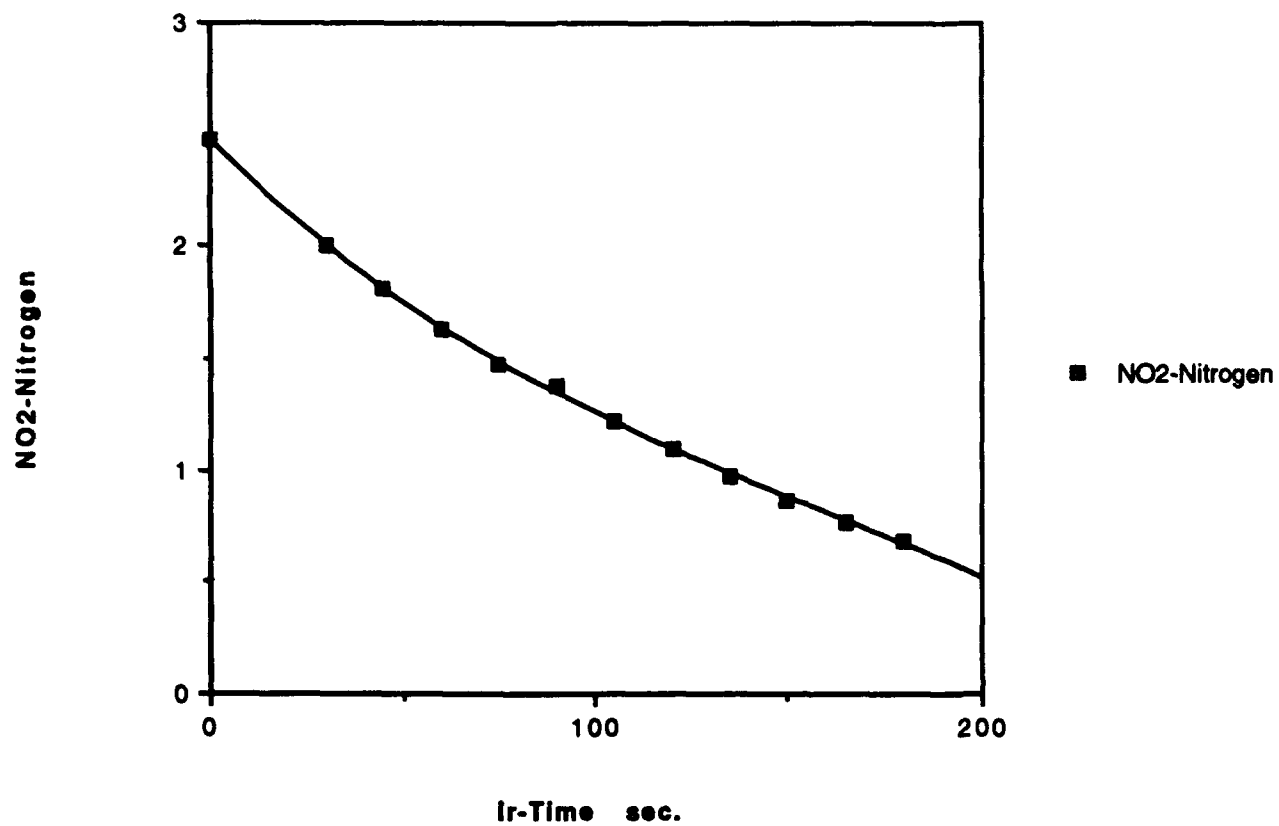
in Figures 1 through 3 at various concentrations.

Data from "NO2 Dissociation Data"

y = 2.4173 - 2.6716e-2x + 1.5057e-4x^2 - 3.1440e-7x^3   R^2 = 0.985
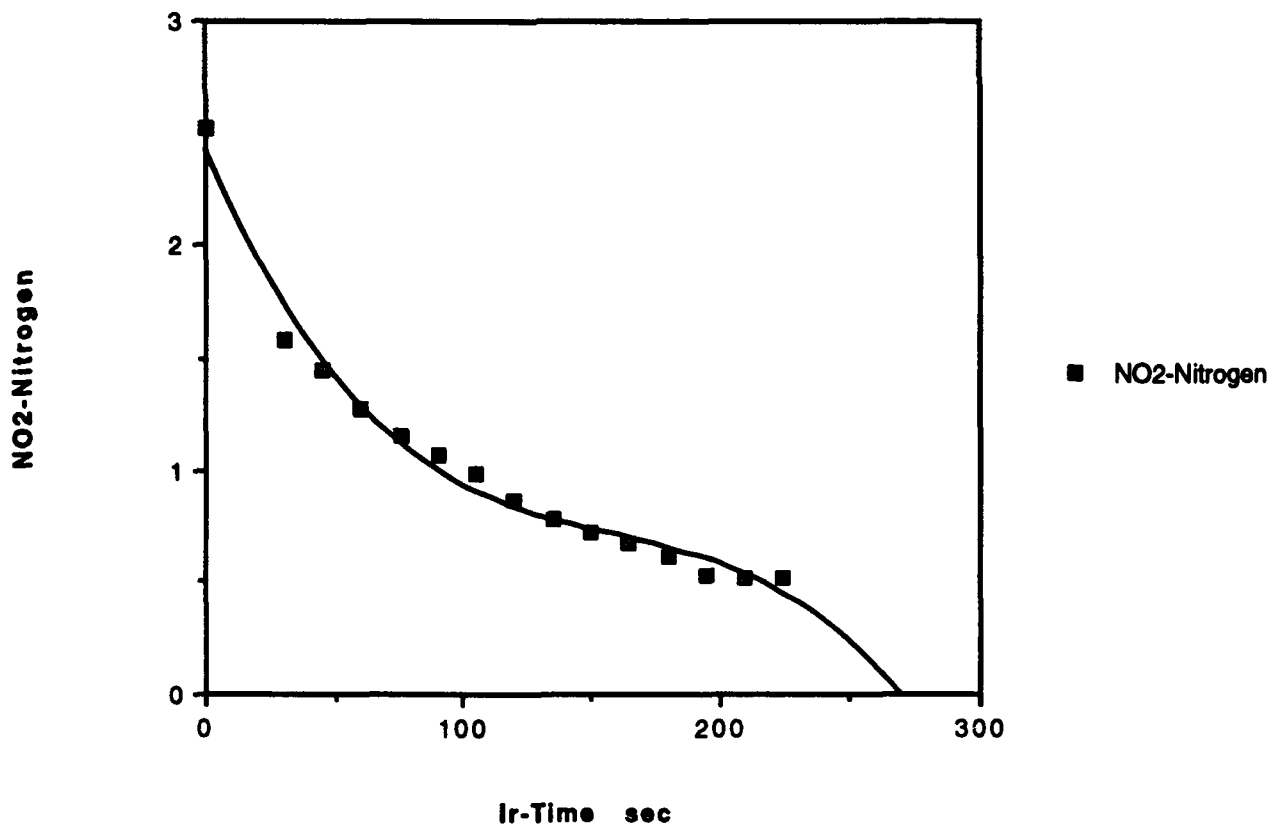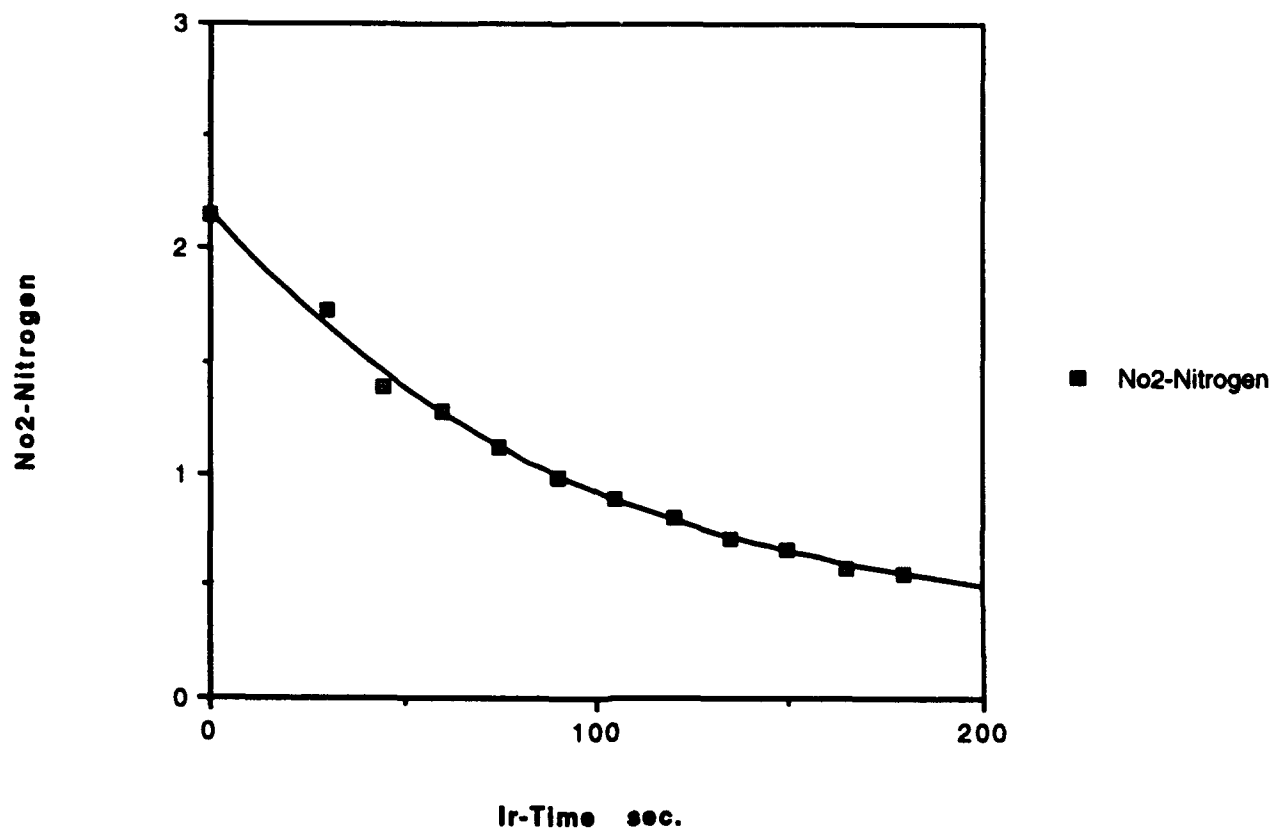
Data from "NO2 Dissociation Data"

$y = 2.4789 - 1.7667\text{e-}2x + 6.8942\text{e-}5x^2 - 1.4763\text{e-}7x^3 \quad R^2 = 0.999$

Data from "NO2 Dissociation Data"

$y = 2.1557 - 1.8970e\text{-}2x + 7.8432e\text{-}5x^2 - 1.2536e\text{-}7x^3$ $R^2 = 0.996$

The light intensity for NO_2 dissociation in argon also uses equation 1 above. But, the coefficient must be changed from 0.67 to 0.63. Based on this equation, $I_2 = 4.62 \times 10^{15}$ quanta cm^{-2} sec^{-1}. See figures 4-6 for typical plots.
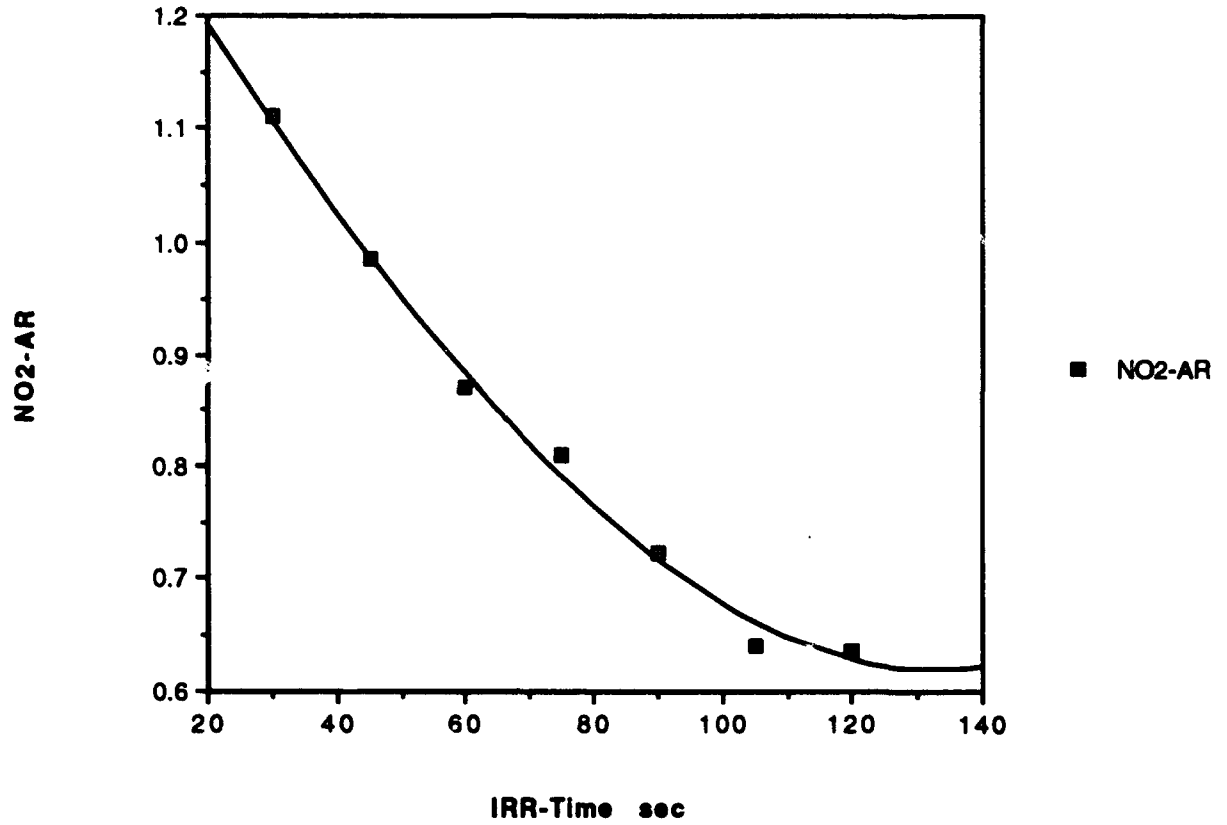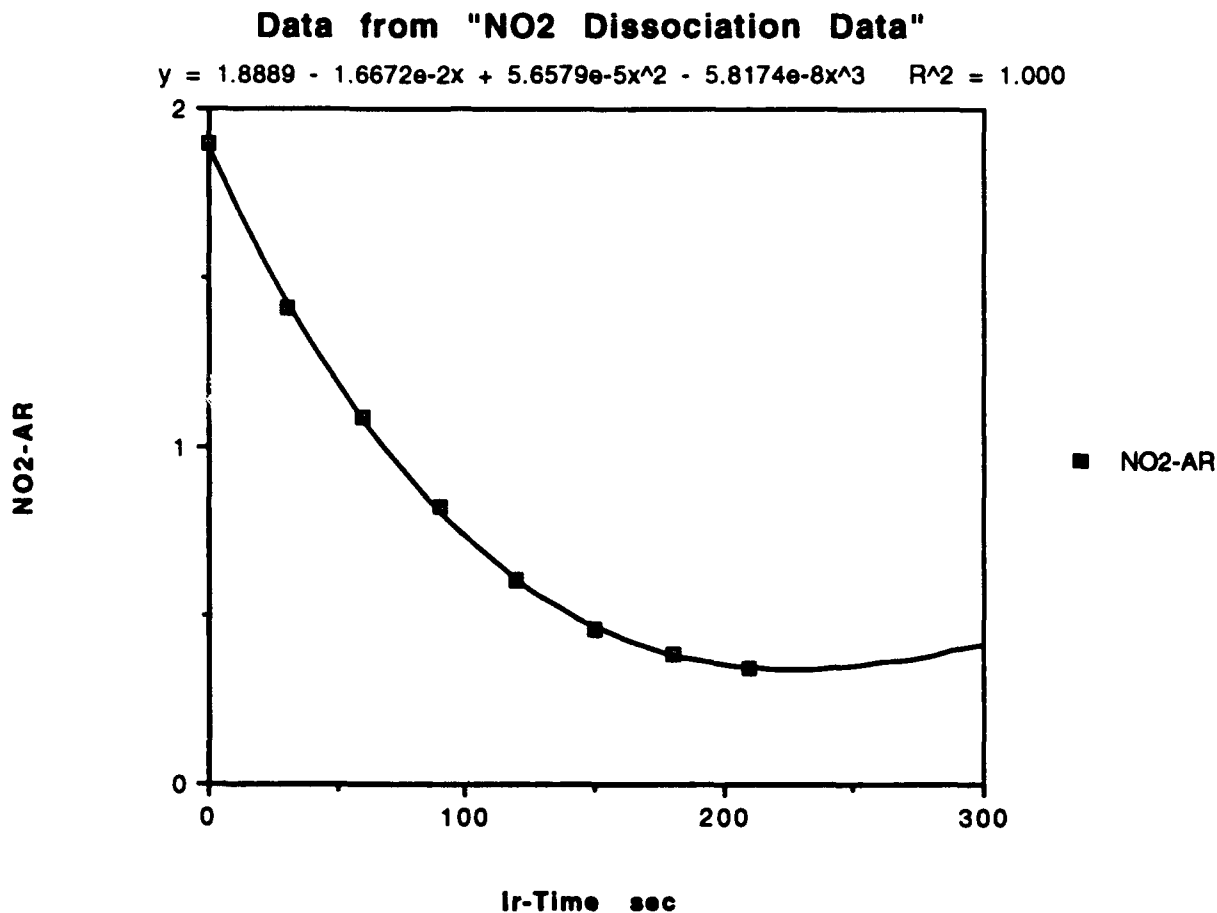
Data from "NO2 Dissociation Data"

y = 0.43100 - 7.7619e-4x   R^2 = 0.983

■ NO2-AR

IR-Time Sec
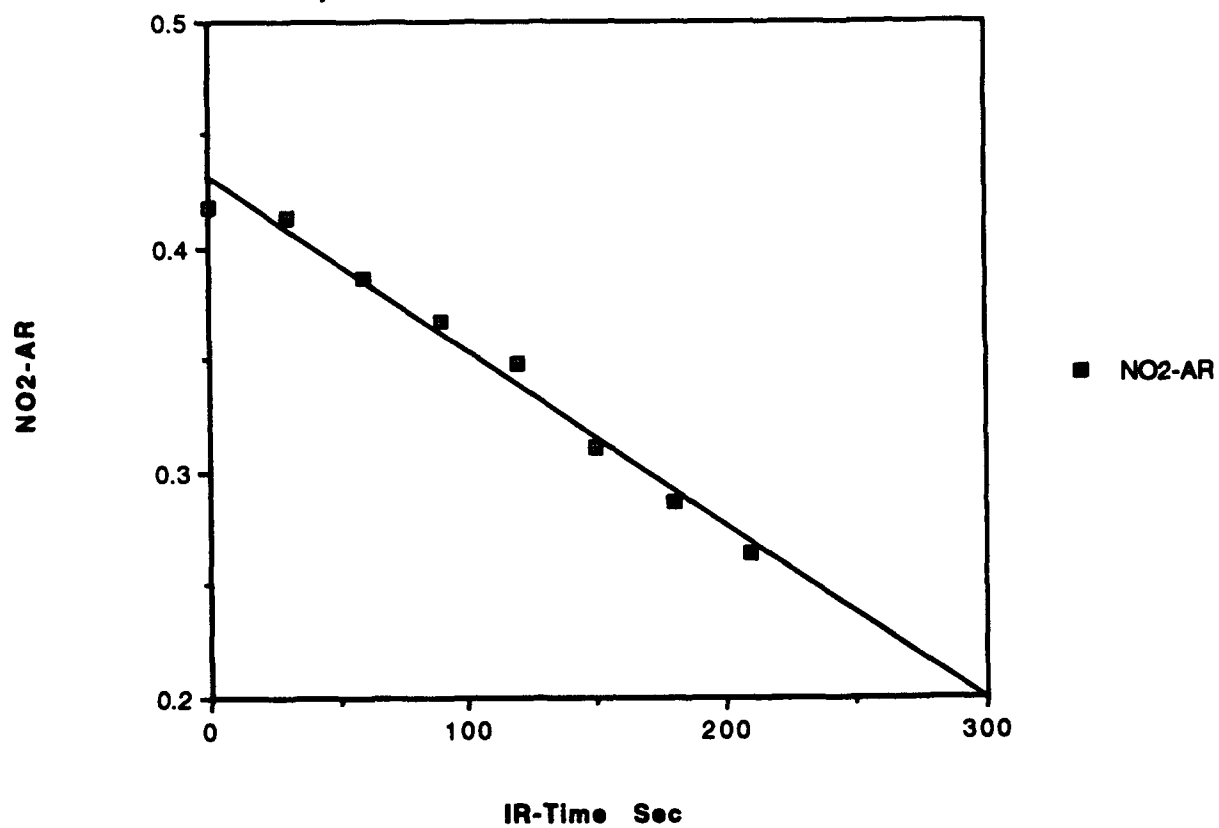
Data from "NO2 Dissociation Data"

$y = 1.3746 - 9.4169e\text{-}3x + 1.3810e\text{-}5x^2 + 1.0700e\text{-}7x^3 \qquad R^2 = 0.994$

IRR-Time sec

NO2-AR

■ NO2-AR

Data from "NO2 Dissociation Data"

$y = 1.8889 - 1.6672e\text{-}2x + 5.6579e\text{-}5x^2 - 5.8174e\text{-}8x^3 \qquad R^2 = 1.000$

In order to determine the light intensity in the chamber based on NO_2 dissociation in synthetic air, the equation[2]

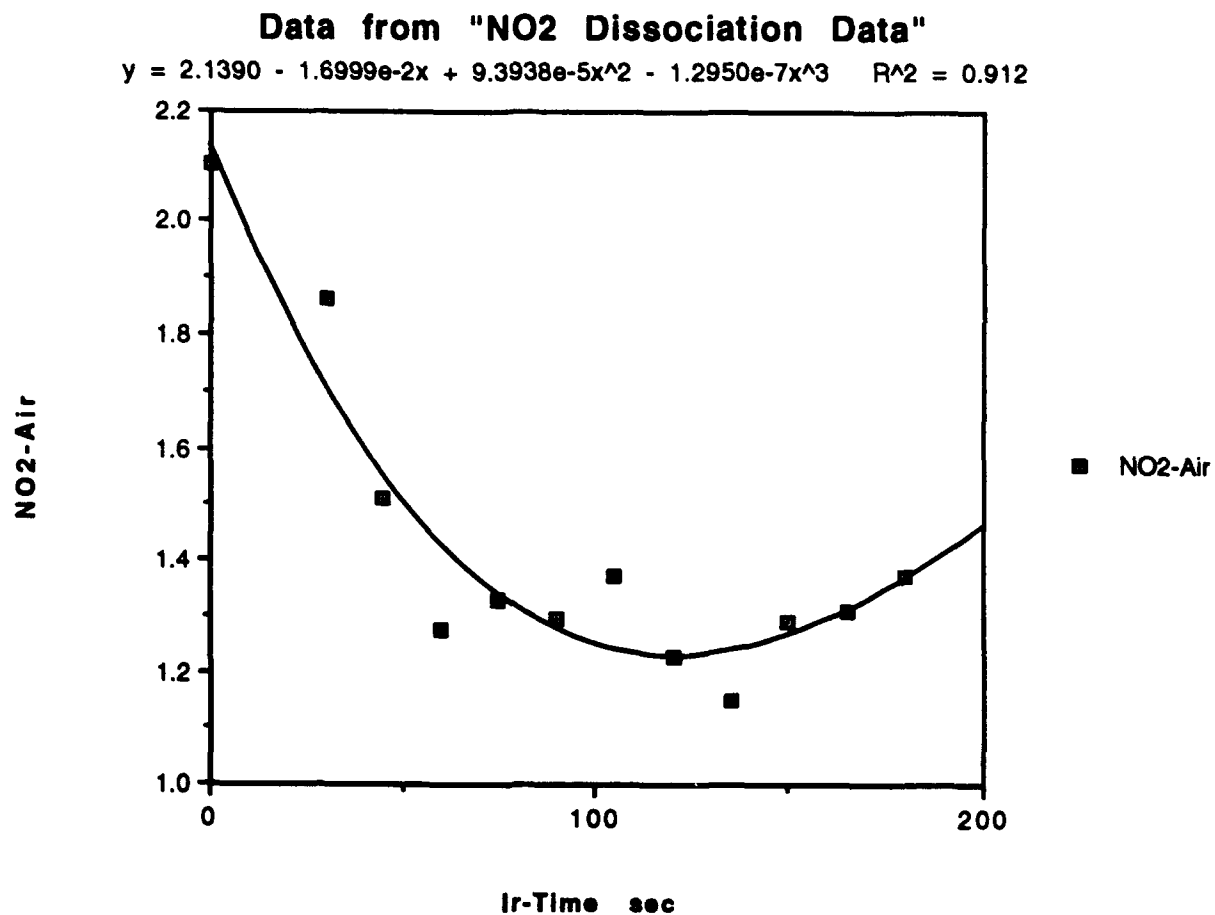$$I_2 = K_{1a}[NO_2]^2[O_2]/QK[NO_2]$$

must be used. The light intensity in the chamber based on NO2 dissociation in synthetic air was

calculated to be 6.38×10^6 quanta cm^{-2} sec^{-1}. At low NO_2 concentrations, as in figures 7 and 8,

the NO and $O(^3p)$ react to produce NO_2. At high NO_2 concentrations, as in figures 9 and 10, NO_2

dissociates steadily until it reaches a low concentration. Once the NO_2 has reached a low concentration, the reaction will reverse and more NO_2 will be produced.

Data from "NO2 Dissociation Data"

$y = 2.1390 - 1.6999e\text{-}2x + 9.3938e\text{-}5x^2 - 1.2950e\text{-}7x^3 \quad R^2 = 0.912$

Data from "NO2 Dissociation Data"

$y = 2.1759 - 8.1270e\text{-}3x - 2.3051e\text{-}5x^2 + 2.0237e\text{-}7x^3 \qquad R^2 = 0.967$

■ NO2-Air
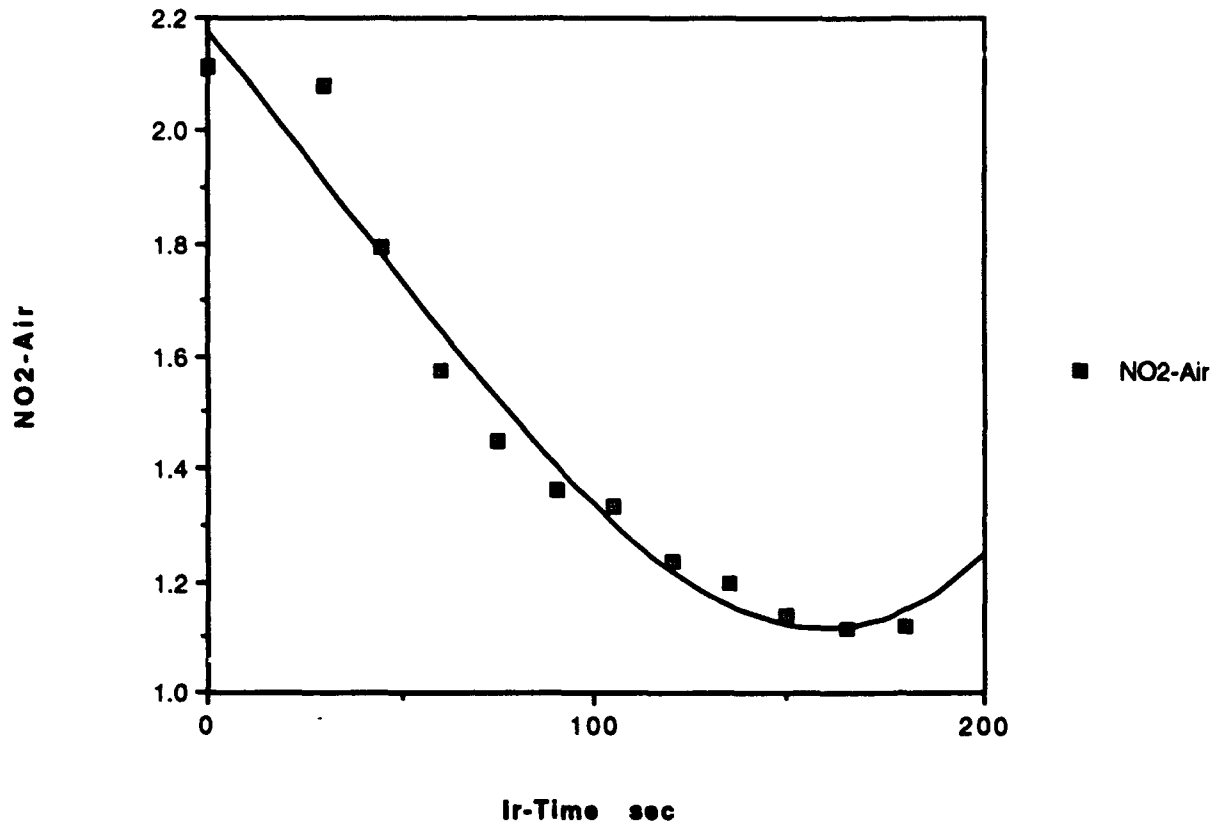
Data from "NO2 Dissociation Data"

$y = 0.71820 + 5.4619e\text{-}4x + 8.6846e\text{-}6x^2 - 2.2965e\text{-}8x^3 \quad R^2 = 0.791$

NO2-Air

Ir-Time sec

■ NO2-Air
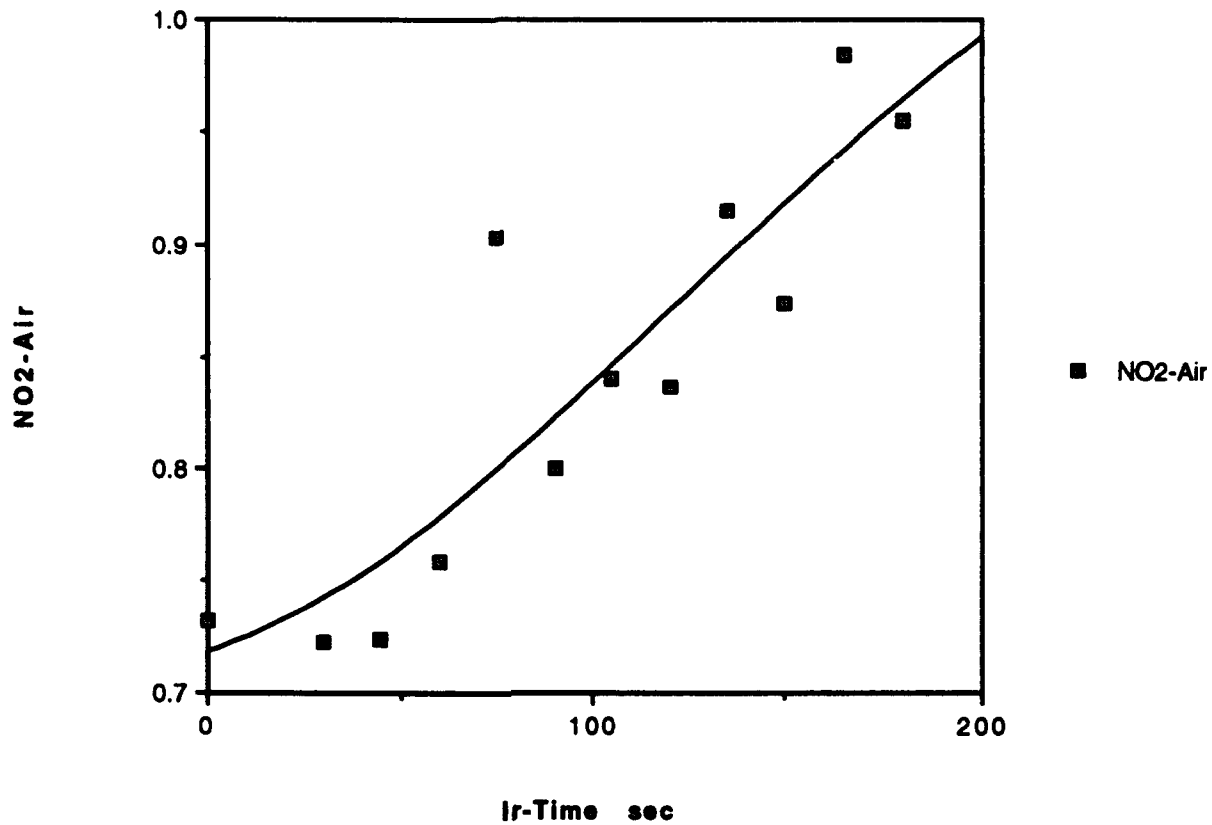
Data from "NO2 Dissociation Data"

$y = 0.45768 + 3.3940e\text{-}3x + 1.8106e\text{-}5x^2 - 1.3805e\text{-}7x^3$ $R^2 = 0.935$
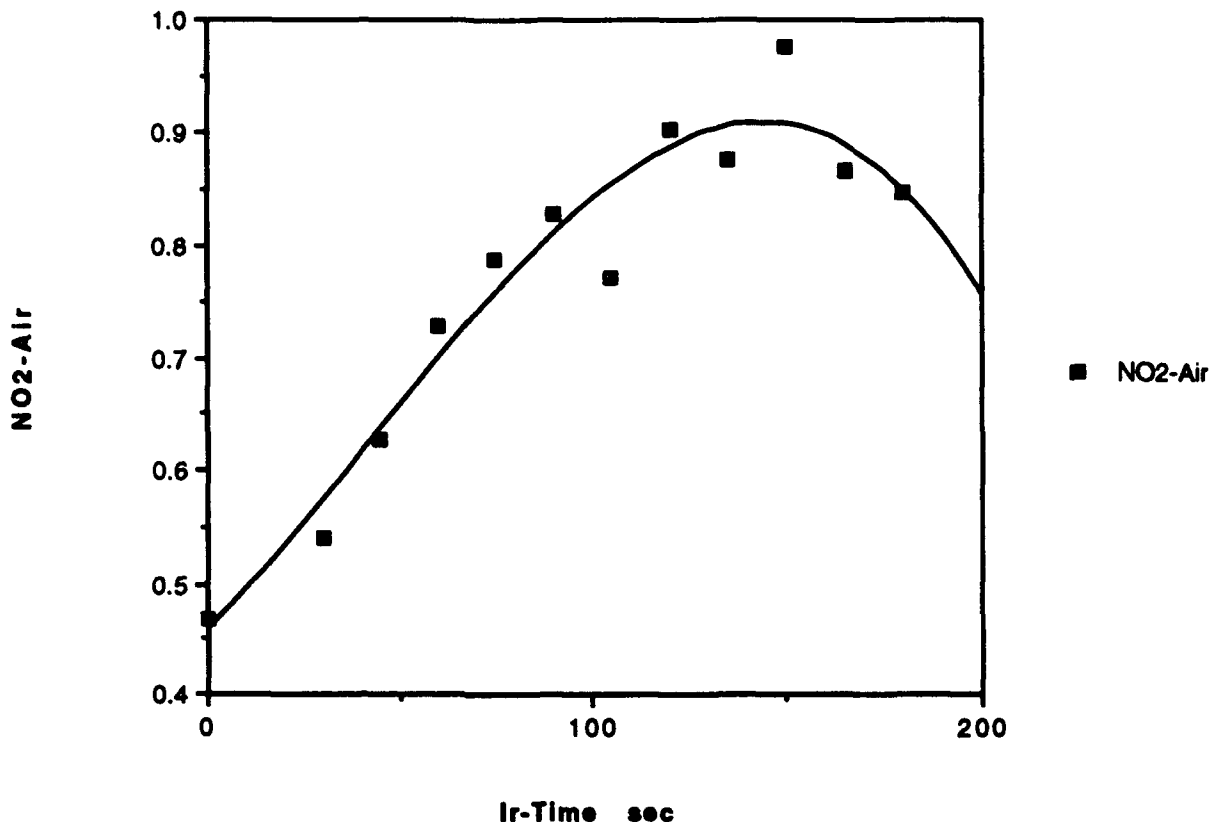
When solving for the light intensity of NO_2 dissociation in helium, the coefficient must be changed to 0.76. The calculated light intensity was $2.62 \pm .581 \times 10^{15}$ quanta cm^{-2} sec^{-1}. It was observed that at low [NO_2], as in figures 11 and 12, the decay curves were more linear than the decay curves of figures 13 and 14 at higher [NO_2]. See figures 11-14 for typical plots.

Data from "NO2 Dissociation Data"

$y = 1.9101 - 5.2881e\text{-}3x \quad R^2 = 0.991$
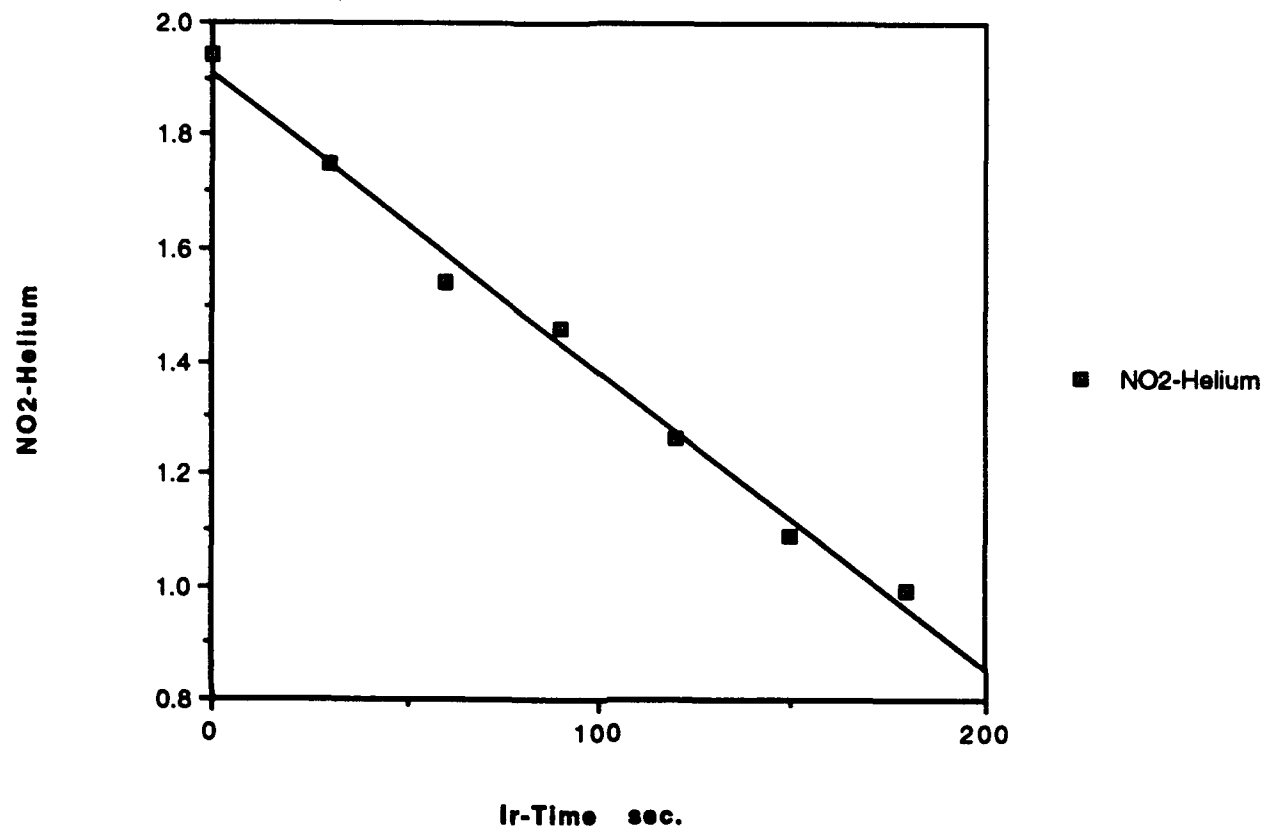
Data from "NO2 Dissociation Data"
y = 1.0441 - 2.1752e-3x   R^2 = 0.991

NO2-Helium

NO2-Helium

Ir-Time sec.
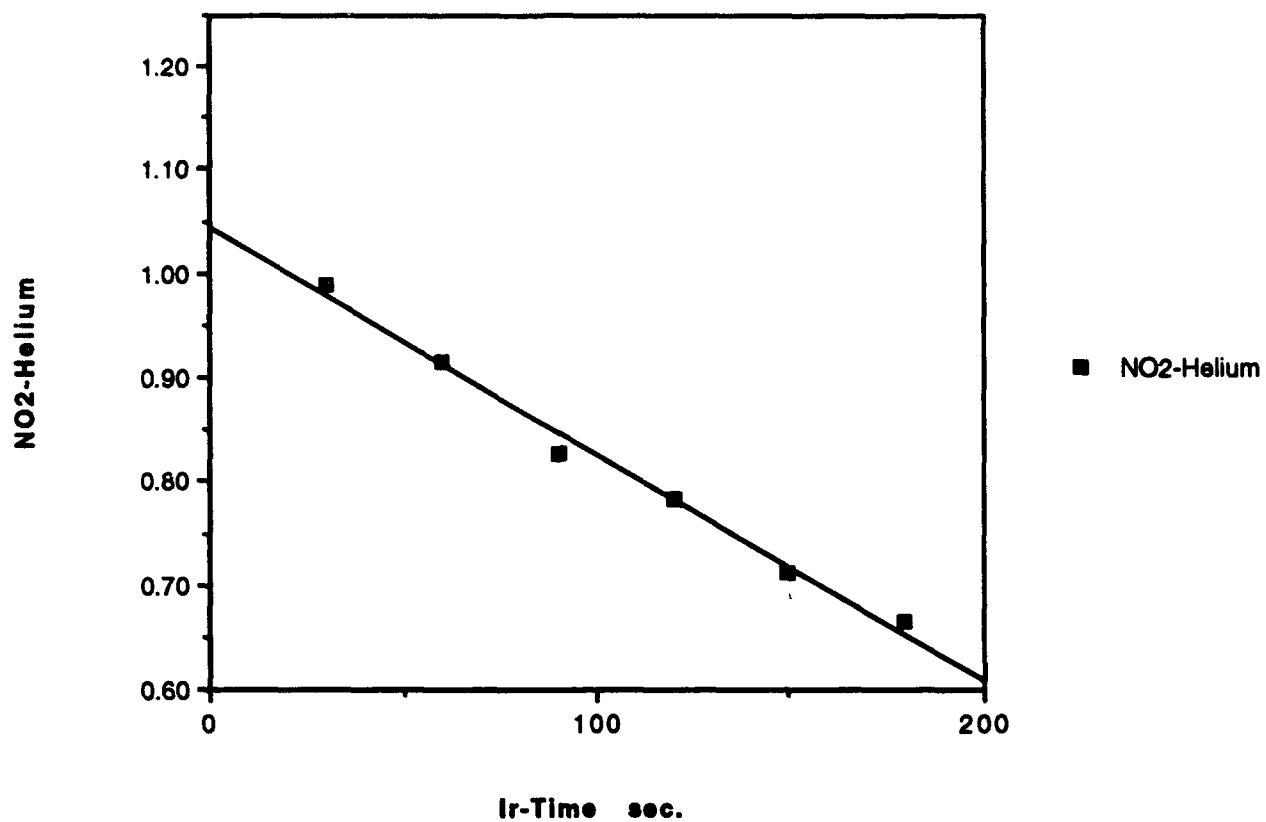
Data from "NO2 Dissociation Data"

$y = 2.1673 - 1.2178e\text{-}2x + 3.5575e\text{-}5x^2 \quad R^2 = 0.973$

Legend: ■ NO2-Helium

X-axis: Ir-Time sec.

Y-axis: NO2-Helium
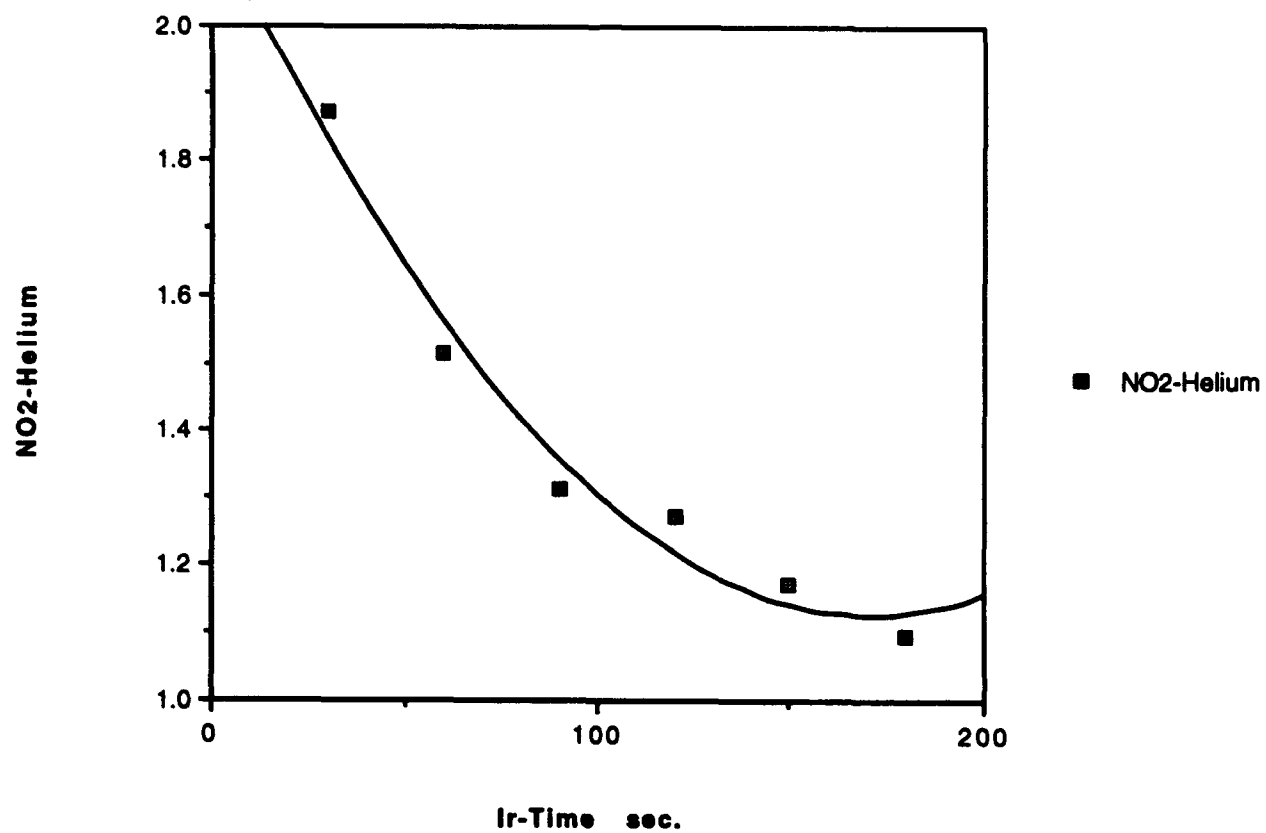
Data from "NO2 Dissociation Data"

$y = 2.1507 - 9.8622\text{e-}3x + 3.6393\text{e-}5x^2 - 5.1097\text{e-}8x^3 \quad R^2 = 0.994$

■ NO2-Helium
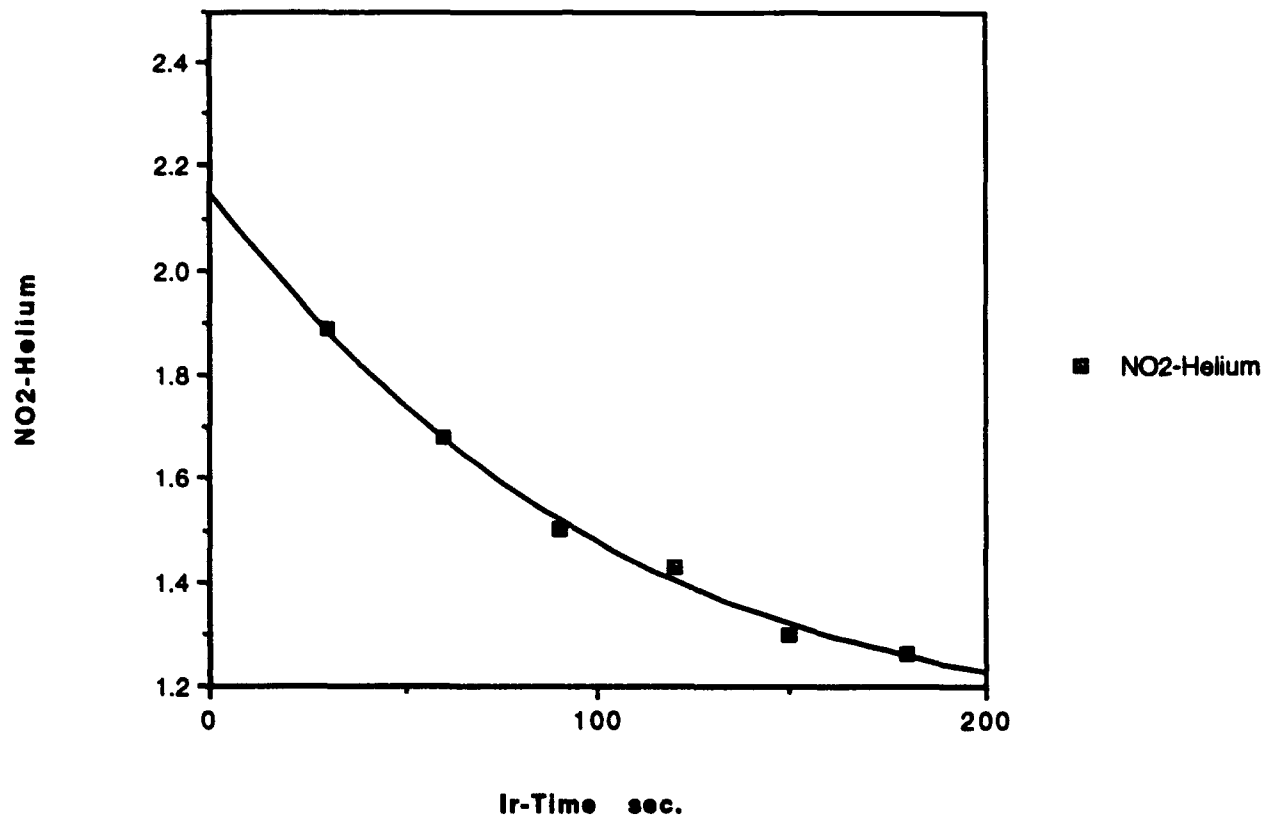
CONCLUSIONS

It was observed that the rate of NO_2 dissociation was dependent upon the concentration of NO_2 as well as the media it was involved with. At lower concentrations, the decay of NO_2 in helium, argon, and nitrogen were somewhat linear. But, the decay of NO_2 in these media at higher concentrations were not linear, and the decay of NO_2 in synthetic air at any concentration was not linear. As NO_2 dissociates, it collides with the oxygen molecules in the media which causes a cyclic reaction to occur and produce more NO_2. In noble gases such as argon and helium, these third-body collisions do not occur, therefore the decay curves were linear and the reaction was not reversed. When lower concentrations of NO_2 were irradiated in synthetic air, the reverse reaction was greater than the initial reaction. As a result, NO_2 was produced rather than being dissociated. When higher concentrations of NO_2 were irradiated in synthetic air, the rate of the forward reaction was greater than that of the reverse reaction, therefore, NO_2 dissociated at a steady pace until it reached lower concentrations, then it began to react with the excess oxygen which then produced NO_2.

REFERENCES

1. Washida, Nobuaki; Inoue, Gen; Akimoto, Hajime; and Okuda, Michio. Potential of Hydrocarbons for Photochemical Conversion of NO to NO_2. Bulletin of the Chemical Society of Japan, Vol. 51 (8). (1978). p. 2215-2221.

2. Stephens, E.R. Adv. in Environ. Sci. Technology. Vol. I. (1969).

3. Holmes, John R.; O'Brien, Robert J.; Crabtree, James H.; Hecht, Thomas A.; and Seinfeld, John H. Measurement of Ultraviolet Radiation Intensity in Photochemical Smog Studies. Environmental Science & Technology. Vol.7, No. 6, June 1973. p. 519

4. Norrish, R. G. J. Chem Soc. (1929). p. 1158.

SOLAR DETOXIFICATION OF
CONTAMINATED GROUNDWATER

Eric W. Haseltine

Final Report for:
Summer Research Program
Tyndall Laboratory

Sponsored by:
Air Force Civil Engineering Support Agency
Tyndall Air Force Base, Panama City, Florida

August 1992

SOLAR DETOXIFICATION OF CONTAMINATED GROUNDWATER

Eric W. Haseltine

Abstract

The one sun method of solar detoxification uses a photocatalytic process to destroy organic compounds in water. The catalyst used is Titanium Dioxide (TiO_2). It is an extremely fine, white powder. The TiO_2 is suspended in contaminated water in a colloidal suspension. Hydrogen Peroxide is added and the pH is adjusted to slightly acidic (4-6). This mixture is pumped through transparent tubes at a rate of 0.5 L/min. The ultraviolet radiation in sunlight provokes the catalyst into destroying the organics.

SOLAR DETOXIFICATION OF CONTAMINATED GROUNDWATER

Eric W. Haseltine

Introduction

The first series of tests of the solar detoxification of groundwater began at the Lawrence Livermore National Laboratory. These tests were with a parabolic reflector focused on a UV transparent tube with contaminated groundwater running through it. This method was extremely effective on TCE (Trichloroethylene) compounds, but, as stated in publication NREL/TP-250-4676, 01/92 ("Solar Energy versus Hazardous Waste: The First Round Goes To Solar," Jan. 1992.), it was also much more expensive than current groundwater remediation technologies. The tests revealed, however, that a one-sun method could be both more efficient and much cheaper. The next series of tests began in the summer of 1992 using a one-sun reactor at Tyndall Air Force Base, Florida. These tests were conducted by a joint effort between the U.S. Air Force and the University of Florida at Gainesville's College of Engineering. This round of testing was projected to be only slightly more expensive than existing treatment technologies.

The aims of this summers research is to eventually bring the one-sun method down below existing technologies in cost, and to provide a real-life test to determine the technology's effectiveness on petroleum based products, specifically BTEX (Benzene, Toluene, Ethylbenzene, m/p-Xylene and O-Xylene).

16-3

Methodology

The basic process of solar detoxification is a simple process (see fig. 1, pp. 16-7). Contaminated groundwater is pumped from a well, through a 5 micron filter and to a 125 gallon holding tank on an equipment skid. When the tank is full, the catalyst, Titanium Dioxide (TiO_2), Hydrogen Peroxide and acid are added in the desired quantities. These tests were attempted with both a 0.05 wt. % and a 0.1 wt. % concentration of TiO_2, and a varying pH of from four to six. The levels finally decided on for our tests were: a 0.1 wt. % solution of TiO_2, and a 100 ppm concentration of Hydrogen Peroxide with a pH of 5. This solution is recirculated around the skid to ensure a thorough mix of all additives. At approximately one and a half hours before solar noon, the liquid is sent to the reactors. The reactors are simply sets of UV transparent tubes. The tubes are used to capture the maximum direct and indirect UV light. The fluid is circulated through the reactors for three hours at a flow of approximately 0.5 L/min, with a sample taken every thirty minutes. The now manageably clean water is sent to the sewer and sample analysis can begin.

Analytical Methods and Procedures

Two methods of analysis were used on this project. Tests were done to check the levels of BTEX (Benzene, Toluene, Ethylbenzene, m/p-Xylene and o-Xylene), and levels of TiO_2 and color in treated groundwater.

Two methods of analyzing BTEX were tried. A Gas Chromatograph/Mass Spectrometer, with an auto sampler using solid phase extraction technique was tried in the hopes of saving time. Unfortunately, results of these tests had too large a margin of error at the concentration required for our project. The method finally decided upon was a Purge and Trap Gas Chromatograph. The method is slow, requiring six to seven hours a day to process seven samples, but was much more reliable. Figure 2 on pp. 16-8 provides a graph of a sample test showing concentrations of Benzene, Toluene, Ethylbenzene, m/p-Xylene and o-Xylene, at thirty minute time intervals.

As was stated earlier, the amount of TiO_2 in the reactor is required to be at a certain level, usually 0.1 wt. %. A reliable method of measurement was not available at the site itself to weigh the catalyst, so a certain amount of guesswork was needed. A Photo Spectrometer was used to determine if the correct amount of TiO_2 was being measured. To do this, a calibration curve of the Absorbance of different concentrations of TiO_2 was prepared. A sample from each test could then be measured for Absorbance and compared to that curve to see the actual wt. % of TiO_2 in the test water. Later in the test series, a battery of catalyst reuse tests were performed. The photo spectrometer provided a way of determining if the catalyst was being destroyed or physically or chemically altered. Though Titanium Dioxide is

relatively inexpensive, the reuse of the catalyst could significantly reduce the per gallon cost of cleanup.

Conclusion

The preliminary results of the solar detoxification of groundwater appears to be very promising. The destruction of targeted compounds averaged about seventy percent. It is believed that the rate of destruction can be further optimized after a thorough analysis of all the results has been completed, and appropriate changes have been made to the treatment procedures. At the time this report was written, no information had yet been calculated as to the cost per gallon to treat the contaminated water.
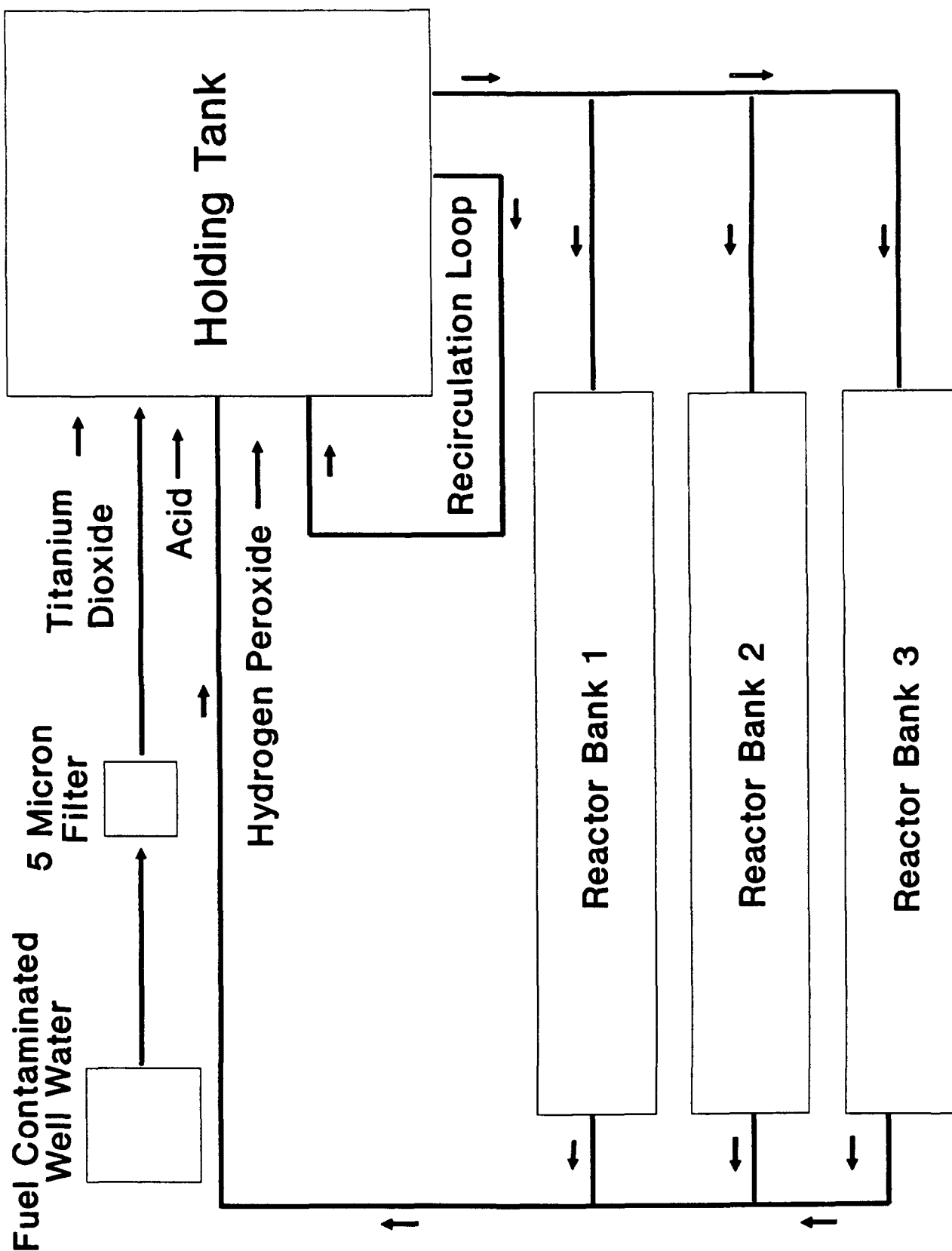
Figure 1

Figure 2
Solar Detoxification of BTEX Compounds
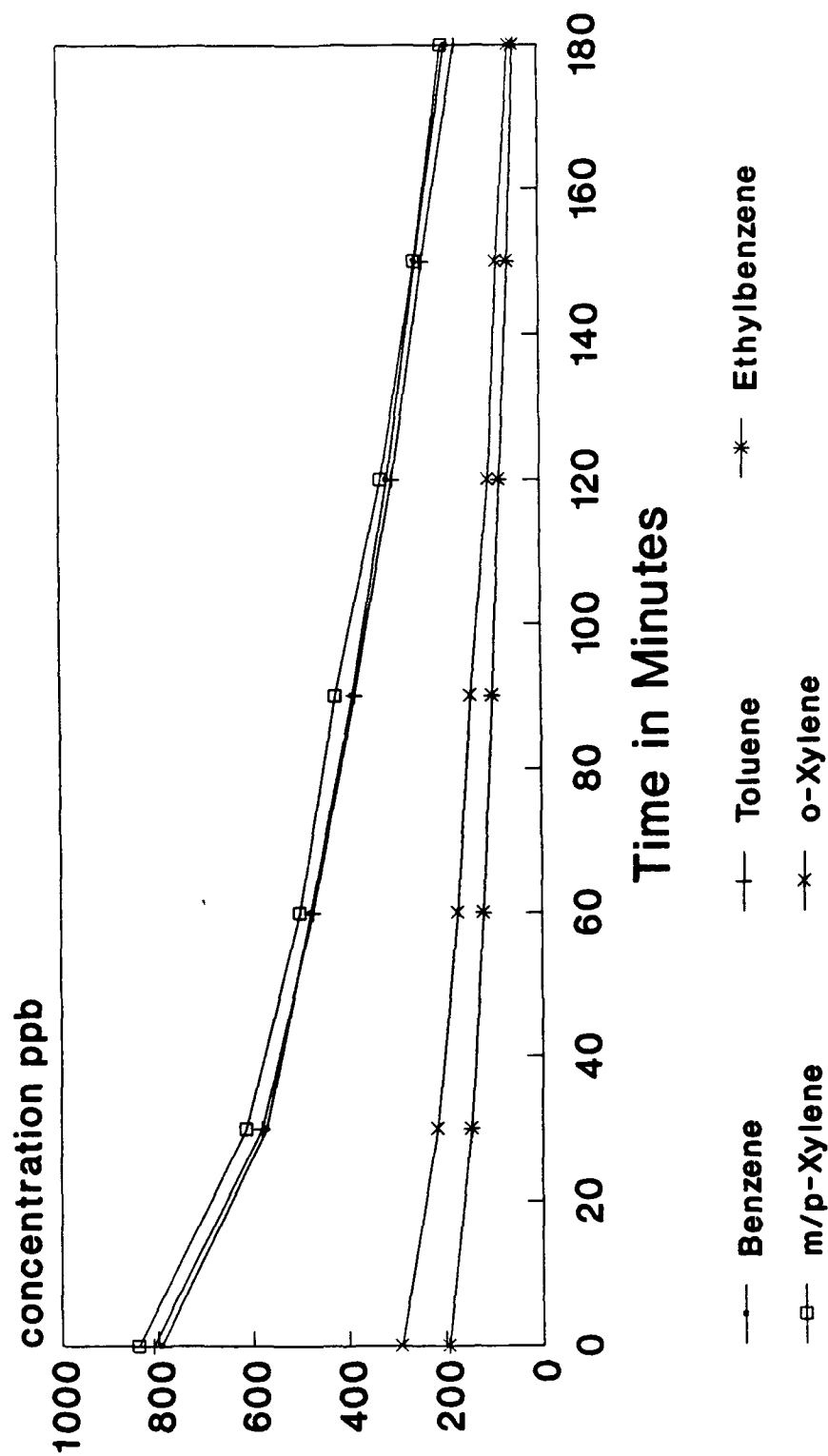
concentration ppb

1000
800
600
400
200
0

0   20   40   60   80   100   120   140   160   180

Time in Minutes

Benzene — Toluene — Ethylbenzene

m/p-Xylene — o-Xylene

DESCRIPTION OF WEATHER STATION
AND ITS DATALOGGING PROGRAM

Robert L. Kuhn
Student
Rutherford High School

Final Report for:
High School Apprenticeship Progam
Air Force Civil Engineering Support Agency

June - August 1992

DESCRIPTION OF WEATHER STATION
AND ITS DATALOGGING PROGRAM

Robert L. Kuhn
Student
Rutherford High School

Abstract

The laboratory at which I was working needed a weather station to monitor not only the weather in the immediate area, but temperature inside several bins of sand. A weather station was ordered, and it contained the following items: a tripod, a wind direction and speed indicator, a barometric pressure sensor, a rain gauge, a temperature and relative humidity sensor, a battery, a solar panel, a datataker and its datalogging program, and a weather proof cabinet. The weather station was assembled on and around a shelter in which the bins were stored. The wind speed, and direction sensors did not work properly, but we assembled them for future use. The datalogging program was used once a link with the datataker had been established. The program was used to convert and store the data from the datataker.

DESCRIPTION OF WEATHER STATION
AND ITS DATALOGGING PROGRAM

Robert Kuhn

INTRODUCTION

One of the projects at the laboratory was in need of accurate and constant monitoring of the weather conditions in the immediate area, as well as temperature inside several bins of sand. This could best be accomplished by setting a weather station up around the project that needed to be monitored, and sending the information directly into a computer in the laboratory. The laboratory ordered a weather station from Earth and Atmospheric Sciences Incorporated (EASI). The weather station included the following: a tripod, a wind direction and speed indicator, a barometric pressure sensor, a rain gauge, a temperature and relative humidity sensor, a battery, a solar panel, a datataker and its datalogging program, and a weather proof cabinet.

WEATHER STATION

The weather station, consisting of the components listed above in the introduction, was to be set up to monitor thetemperature inside bins filled with sand, and the weather conditions the bins were exposed to. The bins themselves were stored within an area that was contained within four walls, but no roof.

There was a roof set up above the bins to prevent any rain from getting into them. The tripod that was provided with the weather station was too tall to be placed under the roof. Therefore some of the components were attached to the roof instead of to the tripod.

The rain gauge would not be needed because the bins were under the roof, and therefore the rain was prevented form entering the bins. The solar panel, which was to be used to charge the battery, was mounted on the edge of the roof so that it was parallel to the ground. The weather proof cabinet was mounted to one of the supports that held the roof up, so that the sensors could be connected to the datataker and battery inside. The relative humidity and temperature sensors were mounted on the tripod, which was then attached to the roof so that it could not be tipped over. The barometric pressure sensor was not encased in a weather proof housing, therefore we had to mount it inside the weather proof cabinet, along with the datataker and the battery, and tubing was run from the sensor through a hole in the cabinet so that it would be able to determine the barometric pressure. We were unable to get the wind speed, and direction sensors working properly. The instructions for these were not very clear, and after support from the company the instruments themselves did not work properly.

After all of the instruments were mounted were they were needed they were wired to the datataker, and to the battery were needed. The datataker also had extra channels so that we could make our own temperature probes to be placed in the bins. To do this we used thermalcouple wire to make the actual sensors. The datataker itself recognized several types of thermalcouples, therefore we did not have to set up any conversions. After we had the sensors made we took wooden

17-4

dowels, and drilled holes in them so that the sensors could be shoved down into the sand. The probes were then also wired to the datataker.

The datataker itself could store the data collected for only a limited time, after that it had to be transferred to the computer. In order for the computer to get the information from the datataker, we had to connect it with the computer inside. We discovered that there was pipe running from the area where the station was set up into the laboratory. This pipe was not, and had not been, being used. Therefore we decided to run the cable through this pipe into the laboratory. The pipe however had quite a few ninety degree turns in it, and we had to disconnect it at most of these turns in order to fish the cable through. Once we had the weather station and the computer connected we could begin to start collecting our weather data.

DATALOGGING PROGRAM

The program that we recieved with the weather station was from Science / Electronics. We connected the datataker to a personal computer using a serial cable. It was connected to a serial port on both the datataker, and the computer. This was the means by which the information was sent and recieved. The dattalogging program was set up with a split screen, with the bottom part set up for commands to be sent to the datataker, and the top part for responses from the datataker. The datataker only takes commands that are in capital letter, except in the parentheses. This could allow comments to be made in lower case, and these would not interfere with the datataker. In order for the datataker to

begin to take the weather data it had to be told which sensors to take from. The data from the datataker must then be converted into the form that you want.

The datataker reads the information from the channels in either miliamps, volts, or ohms. In order to get the readings that we wanted, pressure, humidity etc. we had to tell it how to convert each of the readings. For instance the manual told us that the barometric pressure sensor would send signals of four to twenty miliamps, and this corresponds to 0 to 1100 milibars. In order to see the readout in milibars from channel one, we would type the following lines:

       S2=0,1100,4,20"% RH"

       3I (S2, "Atm. Pressure")

Those lines would take the data from channel one only one time, however you could tell the datataker to take data from however many different channels you wanted at intervals of twenty minutes, or every hour, or however often you wanted to take it. This could be done by setting up different schedules. For instance if you wanted to set up a schedule to read the barometric pressure from channel one every 10 minutes you would type the following lines into the computer:

BEGIN

S2=0,1100,4,20,"% RH"

RA10M

      2I (S2, "Atm. Pressure")

END

GA

The last command (GA) is used to start the sequence.

The datataker was set up to take data from the barometric pressure sensor, the temperature and relative humidity sensors, as well as six extra temperature probes, which were placed in six different bins. The data was collected every twenty minutes, and the datataker could store data for approximately one week before its contents had to transfered to the computer. The following is the exact program that we sent to the datataker followed by a typical set of output that we recieved:

<div align="center">INPUT</div>

```
BEGIN

S2=0,100,4,20,"% RH"

S3=0,1100,4,20,"mbars"

RA20M

      1YS04 ("Atm. Temp.")

      2I (S2,"Atm. Humidity")

      3I (S3,"Atm. Pressure")

      5-TK ("Console Temp.")

      8-TK ("Temp. Bin One")

      8+TK ("Temp. Bin Two")

      5*TK ("Temp. Bin Three")

      5+TK ("Temp. Bin Four")

      7-TJ ("Temp. Bin Five")

      7+TJ ("Temp. Bin Six")

      D

      T
```

END

LOGON

GA

TYPICAL OUTPUT

Atm. Temp. 26.9 Deg C

Atm. Humidity 90.606 % RH

Atm. Pressure 1046.2 mbars

Console Temp. 27.0 Deg C

Temp. Bin One 27.1 Deg C

Temp. Bin Two 27.2 Deg C

Temp. Bin Three 27.2 Deg C

Temp. Bin Four 27.1 Deg C

Temp. Bin Five 27.3 Deg C

Temp. Bin Six 27.2 Deg C

Date 07/23/1992

Time 12:30:25

The following table show where the instruments were connected to the datataker, what the output was, and the range of the output.

Sensor	Output	Range	Channel
Atm. Temp	Deg. C	1 - 200 Deg C	1
Atm. Humidity	miliamps	4 - 20 miliamps (0 - 1100 mbars)	2
Atm. Pressure	miliamps	4 - 20 miliamps (0 1100 mbars)	3
Console Temp.	Deg. C	-200 - 1250 Deg. C	5-
Temp. Bin 1	Deg. C	-200 - 1250 Deg. C	8-
Temp. Bin 2	Deg. C	-200 - 1250 Deg. C	8+
Temp. Bin 3	Deg. C	-200 - 1250 Deg. C	5*
Temp. Bin 4	Deg. C	-200 - 1250 Deg. C	5+
Temp. Bin 5	Deg. C	-200 - 750 Deg. C	7-
Temp. Bin 6	Deg. C	-200 - 750 Deg. C	7+

THIS PAGE INTENTIONALLY LEFT BLANK

THIS PAGE INTENTIONALLY LEFT BLANK

COMPUTER PROGRAMS AND PROJECT OPERATIONS

Jefferey R. Strickland
Summer Student
Mosley High School

Final Report for:
Summer Research Program
Air Force Fire Protection

Sponsored by:
Air Force Fire Research and
Crash Rescue Systems Branch
Tyndall Air Force Base,
Panama City, FL

August 1992

COMPUTER PROGRAMS AND PROJECT OPERATIONS

Jefferey R. Strickland
Summer Student
Mosley High School

Abstract

In a research environment the need for an efficient office computer and machine operator is unprecedented. During the course of the eight week summer program a variety of graphics programs and a program written in basic for the Long Range Agent Delivery System (LRADS)--a system specializing in the fire extinguishment for potential explosive fires at a safe long range distance--were covered. This LRADS computer basic was analyzed preparing it for any possible improvements.

Project operations was learned through the establishment of project files, background research, and producing slides for briefings.

Project Table of Contents

1. Analysis of Software for Long Range Agent Delivery
   System.

    This is an analysis of the LRADS computer software
    in detailed form. Its purpose is to shorten,
    improve, and provide an explanation for commands to
    quicken response time and improve accuracy of the
    software.

2. Learning Graphics Programs

    The use of graphics program for making slides and
    charts and drawings is a basic necessity. Harvard
    Graphics 3.0 and Freelance were used for creating
    graphs, preparations for briefings, and project
    files. Their operations were learned and applied
    to the production of output.

3. Halon Replacement Program

    The use of halons and CFCs is possibly a major cause
    of ozone depletion in the present and near future.
    Replacements for the firefighting agents Halon 1211
    and 1301 are necessary. The research, organization,
    and completion of project files were necessary to
    the programs procedure.

Jefferey R. Strickland

Analysis of Software for Long Range Agent Delivery System

In years past the importance of the effective delivery of fire suppressants to a distant target has long been recognized. A long range delivery system is needed to combat firefighting situation where munitions and volatiles decrease the ability to safely extinguish a fire. The Long Range Agent Delivery System's Computer Software, developed by RACF (See reference 1), is written in HP Basic equipped with a GPIB (IEEE488) interface. The HP Basic programming concept was understood by reviewing and programming in a similar language HT Basic. When programming of HT Basic was fully understood the analysis of the software for the operation of the LRADS began.

The program was broken down from the main program into individual subprograms to better understand the path of the program. Each individual command from this point is displayed in a diagram to follow the program as it progresses. This diagram will be simplified into a flow chart using Freelance, then used to compress the program and improve it for accuracy. This analysis will show possible alternate commands and routes for the program which should enable it to work at greater

speeds and with a greater rate of accuracy. The program in its entirety was laid out in a diagram form showing step by step how the program proceeded through individual commands, subprograms, subexits, and subends. It was found that the program is not yet completed from the revisions made by the previous High School Apprentice, Thor Johnson. The subprogram Nter contains only a prototype of its subprograms Sve, Disc and Edt. Through this analysis the full completion and improvement of the LRADS software will be executed, thus improving the performance of the LRADS as a whole.

The program used at present can predict an estimate of the range of many shots within 2 to 3 percent. The program requires inputs of elevation, barometric pressure, and other constants before this level of accuracy is met. The GPIB interface is a standard operating configuration that was adopted by the Institute of Electrical and Electronical Engineers (IEEE) in 1974. The standard operating rate is 19.2K bytes per second: however, using special configuration techniques, baud rates of 190K bytes per second can be achieved. Each device on the bus interface has an address as well as the bus itself.

The following pages contain the compressed version of the LRADS computer program (See reference 2), in flow chart form and a computer color scanned picture of the LRADS. (Fig. 1 and Fig. 2)

Main Program for Long Range Agent Delivery System

```
MAIN PROGRAM
```

IF A=2 → SUB Tty — TTY Direct Link to Controller

IF A=3 → SUB Plink — Program Link to Controller

IF A=4 → SUB Mnu — Menu Control

IF A=6 → SUB Sysdev — System Development

IF A$="ANG" → SUB Ang — Set Barrel Angle

IF A$="AZM" → SUB Azm — Set Azimuth

IF A$="PRS" → SUB Prs — Set Pressure Chamber

IF A$="DMP" → SUB Extermin — Continuous Fire

IF A$="U" → SUB Sweep — Pre-patterned Laydown

IF Z=1 → SUB Nter — Create new DACU Subroutine

IF Z=2 → SUB Drv — Change Default Drive

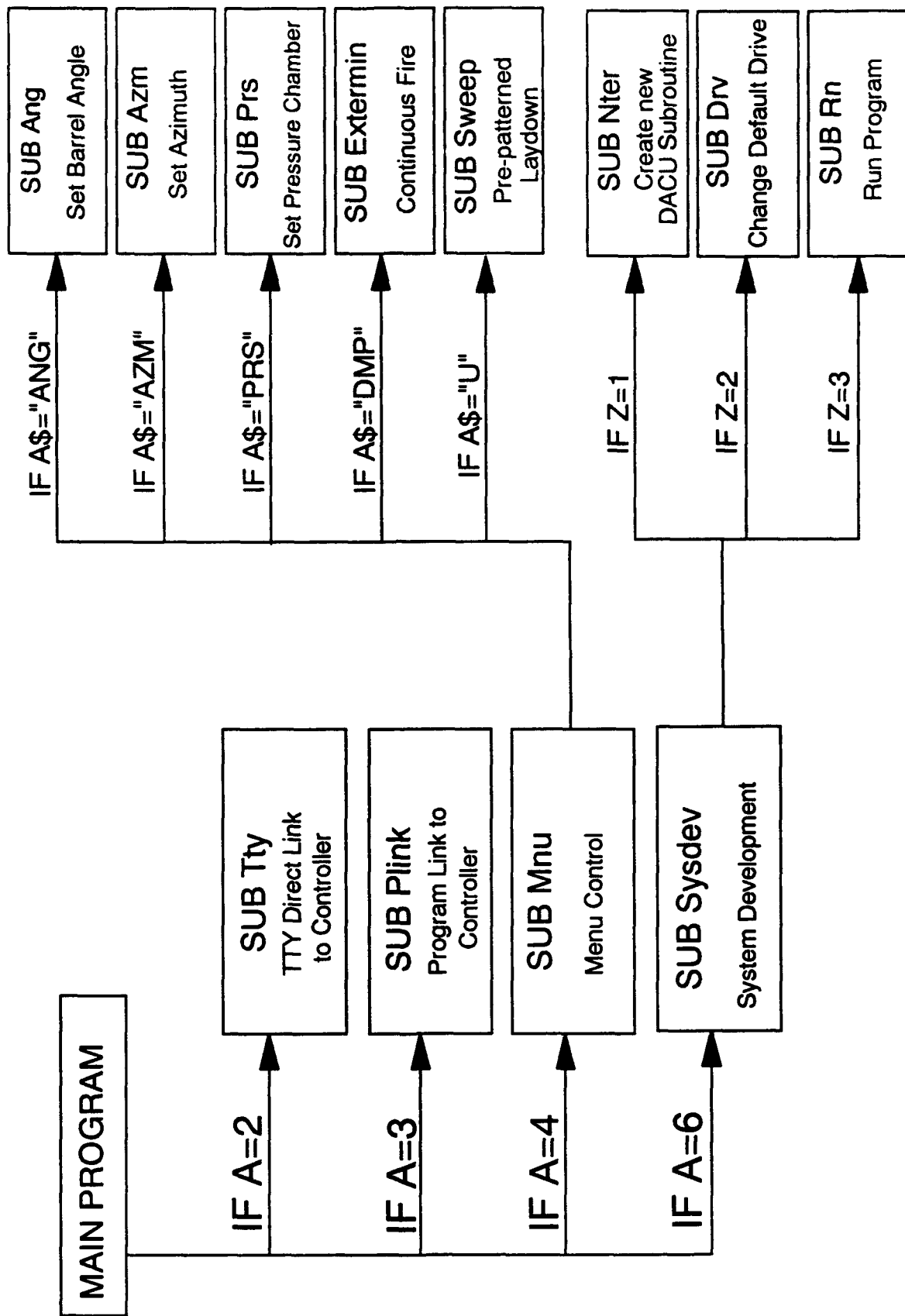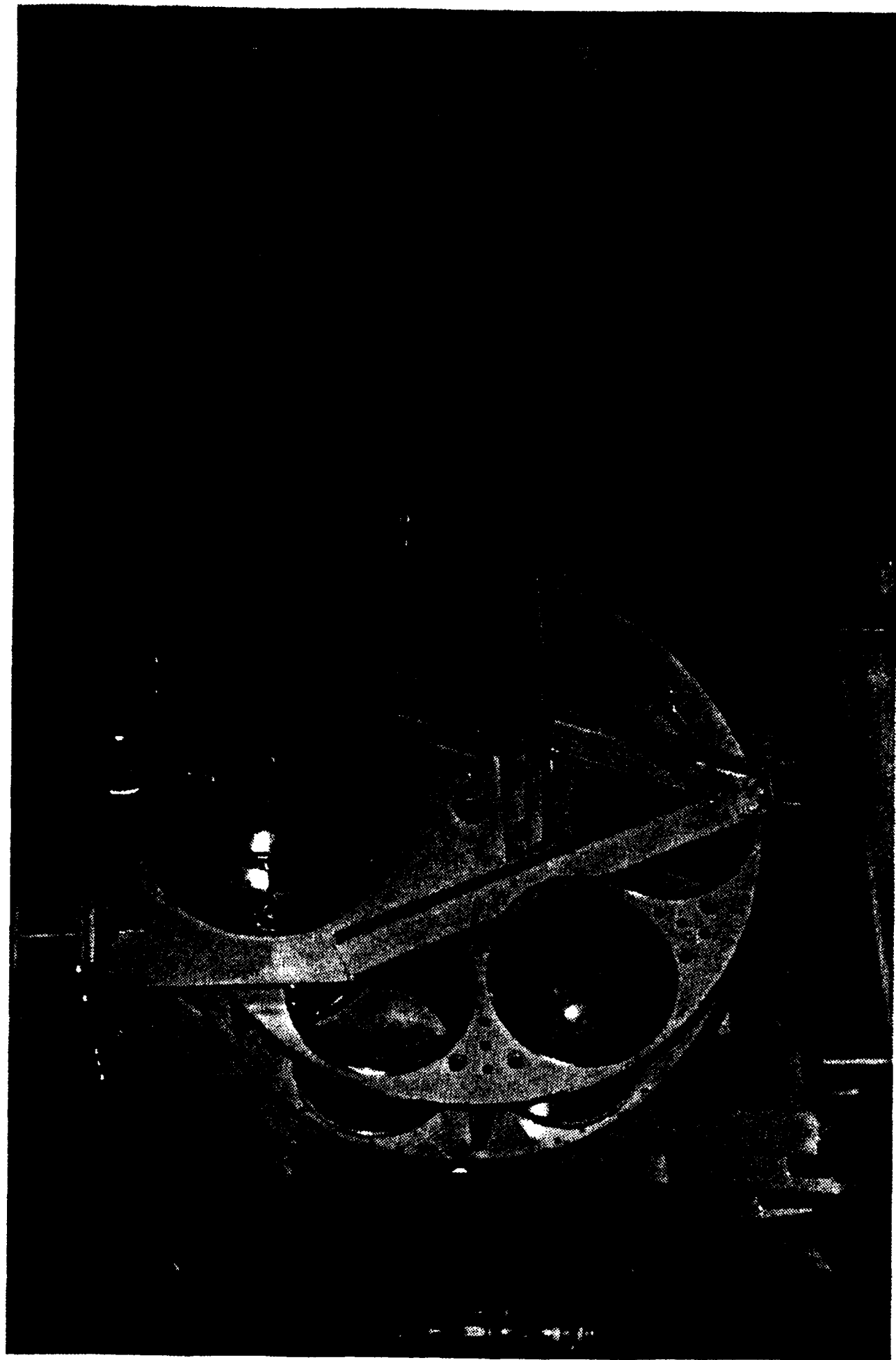IF Z=3 → SUB Rn — Run Program

Fig. 1

Fig. 2

20-7

Learning Graphics Programs

The two major graphics programs dealt with this summer session were Harvard Graphics 3.0 and Freelance Plus. These are programs specialized for business graphs, drawings, and charts. Slides for briefings are sometimes prepared with one of these graphics programs. (See references 1 and 2.)

Harvard Graphics 3.0 automatically chooses the size and layout of both text and graphics, freeing the user from making decisions about their appearance. Although Harvard Graphics creates each type of chart for its optimal appearance and impact, the user can add visual enhancements and change the layout of the charts to suit your special needs. Unique charts of a different design can be created through the built-in drawing package.

Freelance Plus gives you a built in composition capability which produces professional-looking charts easily. When you need precise control over the elements of a chart or drawing, a full set of style choices and editing tools to fine-tune your work are available.

All these graphics programs and applications were preformed on a 386, 20 mhz Unisys microprocessor. The printer from which output is received is a WANG Model LDP8 Laser Printer.

Figures 2 and 3, on the next two pages contain products produced with Harvard Graphics and Freelance. (See references 2 and 3.)

ANECHOIC MATERIALS
FIRE TEST

- Sponsor: Primes

- Purpose: Establish Performance Standards & Determine Fire Behavior
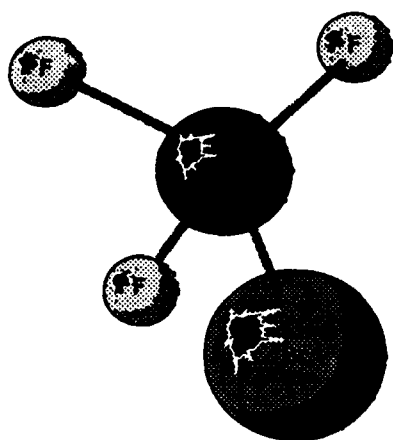
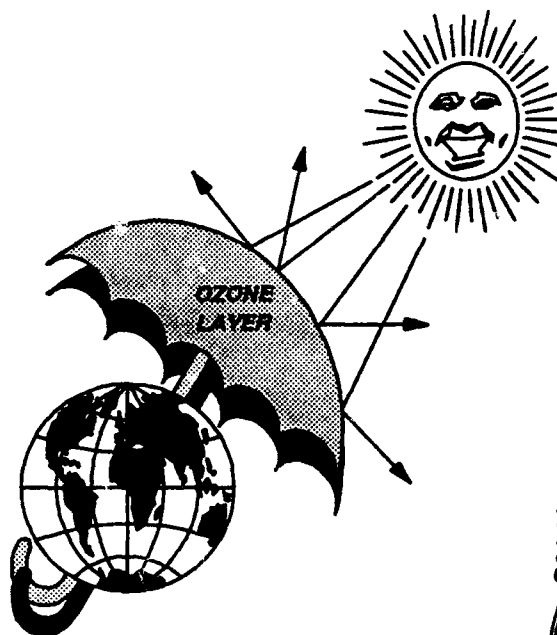- Funds: FY 92 - $50K (RACF)
  FY 93 - $150K (RACF-NIST)

Fig. 3

20-9

HALON REPLACEMENT PROGRAM
VOL. II TECHNICAL

GLOBAL TECHNOLOGY TRANSFER
AND BENEFICIAL
ENVIRONMENTAL IMPACT

HALON 1301

OZONE LAYER

AIRFORCE CIVIL ENGINEERING
TYNDALL AIR FORCE BASE, FLORIDA

JE13TTL

Fig. 4

20-10

Halon Replacement Program

Chlorofluorocarbons (CFCs) are a family of different products, each with a unique set of properties designed to meet important market needs. Recently, Halon 1211, Halon 1301, and chlorofluorocarbon emissions have been linked by the world Meteorological Organization, the National Aeronautics and Space Administration, and other experts to possible future depletion of the stratospheric ozone layer that protects the earth and its inhabitants from damaging ultraviolet radiation. Halon 1211 and Halon 1301 are used principally as fire extinguishing agents. The halons have excellent flame-extinguishing properties which the Air Force prefers for the protection of aircraft, computer centers, and communication systems. The potential threat to the ozone layer has been considered so serious that on September 16, 1987 a protocol was signed in Montreal, Canada to limit the production and consumption of CFCs and halons. The Montreal Protocol of 1987 and The Clean Air Act of 1990 initiated the RACF Halon Replacement Program.

Two project files were established which contained background and technical information on Halon 1211, Halon 1301, CFCs and their effects. Information on The Montreal Protocol and The Clean Air Act of 1990 was also included in the files.

The first project file, Halon Replacement Program Volume 1,

consisted primarily of information consisting of many different technical papers written by a variety of authors. A group of paper consisting around 75 papers containing information varying from CFCs effect on the ozone layer to possible replacement. There are two separate files containing information on The Clean Air Act of 1990 as well as The Montreal Protocol. There is a copy of a Department of Defense Directive on specifically CFCs and Halons. Many of the official documents containing information on the depletion of the ozone layer by Halons and CFCs and the requirements of countries and international agreements on these chemicals were included.

The second project file, Halon Replacement Volume 2 Technical, is a combination of technical papers containing technical characteristics of the agents, tests being conducted and specific research accomplished. Through research and testing conducted RACF has narrowed down the replacement of Halon 1211 to one candidate and now has six candidates for Halon 1301.

A series of graphs were made using Harvard Graphics 3.0 regarding Halon 1211 Emmissions by the U.S. The following pages are examples of the graphs done for this purpose. (Fig. 5 and 6)
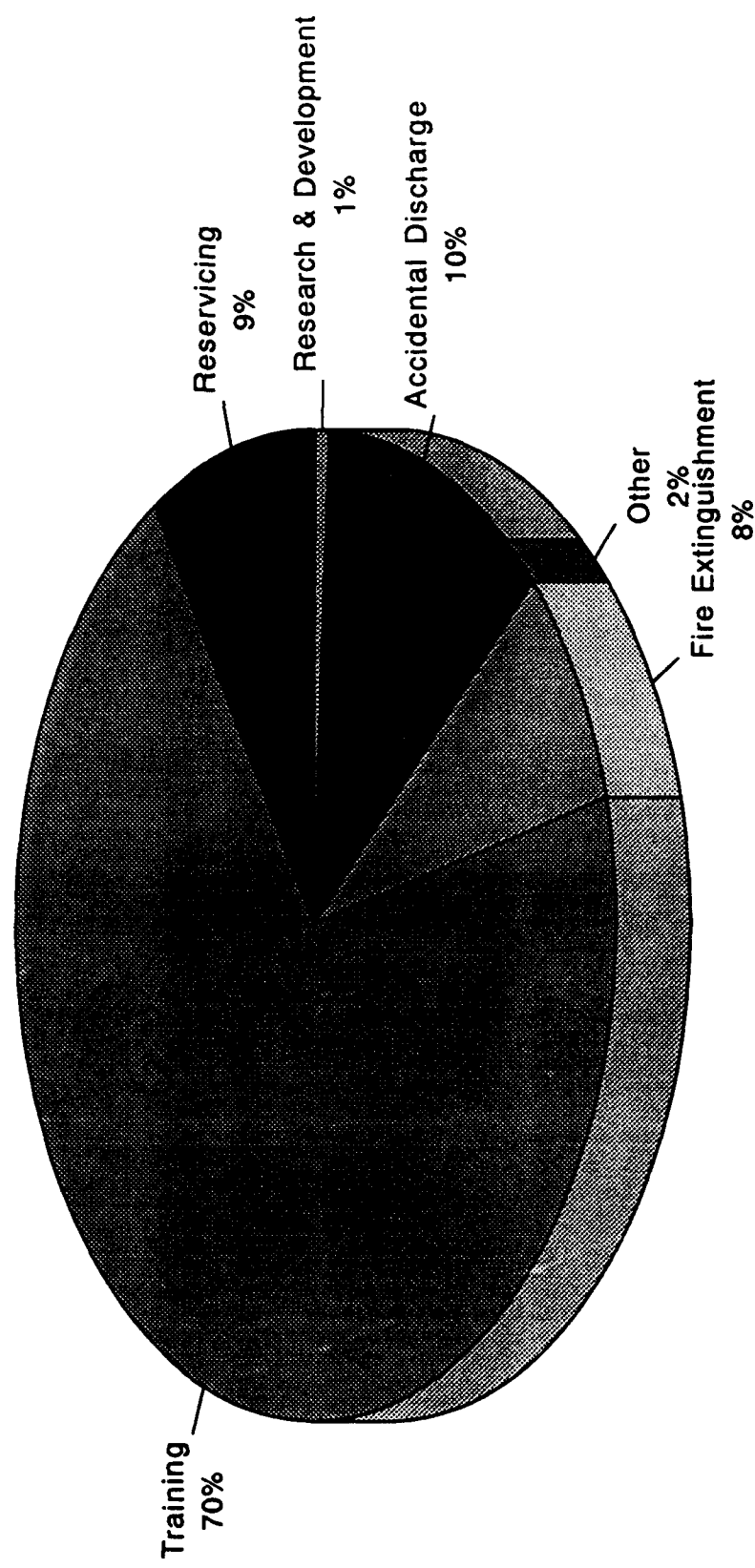
Air Force Halon 1211 Emissions
(783,000 lbs.)

Training
70%

Reservicing
9%

Research & Development
1%

Accidental Discharge
10%

Other
2%

Fire Extinguishment
8%

Fig. 5

20-13

Civilian, Army & Navy Halon 1211 Emissions
(488,000 lbs.)

Discharge Testing
9%

Research & Development
22%

Fire Extinguishment
45%

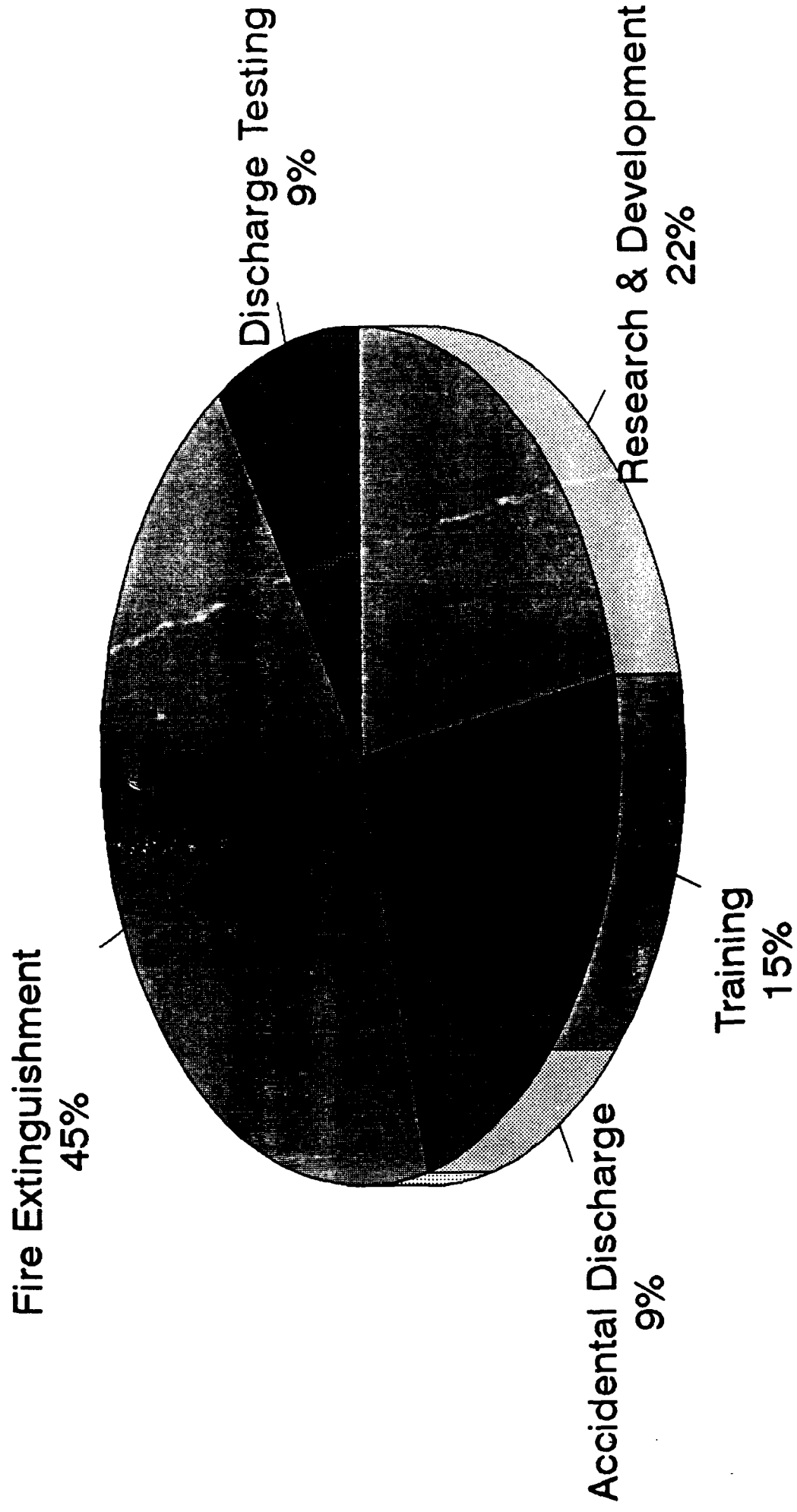Training
15%

Accidental Discharge
9%

Fig. 6

REFERENCES

1. Long Range Agent Delivery System Software

   This software was developed by RACF for the operation of the LRADS system. It was programmed in HP basic and consists of over 3000 lines.

2. Harvard Graphics 3.0

   The Harvard Graphics program is a product of Software Publishing Corporation. The program provides a drawing as well as a pre-programmed chart guideline allowing a variety of options. Copyright June 1991.

3. Freelance Plus

   The Freelance Graphics program is a product of Lotus Development Corporation. This program provides an exellent drawing portion containing editing various tools allowing a very proffesional looking product. Copyright 1989.

ROBOTIC EXCAVATION:
LUNAR AND EARTH BASED

Michael S. Strickland

A. Crawford Mosley High School
501 Mosley Drive
Lynn Haven, FL   32444

Final Report for:
Summer Research Program
AFCESA

August 1992

ROBOTIC EXCAVATION:
LUNAR AND EARTH BASED

Michael S. Strickland
A. Crawford Mosley High School

Abstract

The use of automated construction equipment in hazardous environments, such as, the repair of bombed runway, and working in the harsh lunar environments has been the focus of this study. The equipment used has been a John Deere 690c Excavator, which was modified for remote and automated use. In this time, the vehicle has gone from tethered and remotely controlled, to radio linked and partially automated. The research done on this vehicle is to be applied to Rapid Runway Repair (RRR) excavator which is soon to be delivered. In the long run, the research will also be applied to the making of lunar construction equipment to be used in the construction of a lunar base.

ROBOTIC EXCAVATION:
LUNAR AND EARTH BASED

Michael S. Strickland

INTRODUCTION

Many years man had dreamed about landing on the Moon, and so in 1969 he finally did. Now, though, man dreams of living on the Moon. But how? To live there man must first learn to build there, and he cannot do that alone. Astronauts in bulky spacesuits would take years to build a single establishment. In consequence, he turns to his sciences and comes forth with robotic construction equipment. Though slower, these robots can work twenty-four hours a day a in almost all conditions. On the other hand, astronauts can only work for short periods of time and only when the conditions are right; for instance, not during solar flares or the points of extremely temperature. During these present times, man is quickly turning to robotics to do today's work in harsh and hazardous environments. The number of environments this is adaptable to are many and they range from space construction, to help with radioactive contaminants. This study, though, took a look a two of these environments, specifically: Rapid Runway Repair (RRR), and lunar construction. The piece of equipment that was studied for these environments was an excavator.

EXCAVATOR

The excavator used during this study was a John Deere 690c Excavator, shown in figure 1. The excavator has a trailer on which to carry tools and a quick disconnect hitch for changing them. The vehicle has been modified so that it can be remotely controlled, and was originally tethered. Now though, it has been altered to include a radio link, so that there is not a tether to get in the way. Using the hardware that had been added, the vehicle has been program for partial automation. For example, the digging technique and some navigation. There are many applications just for this vehicle. For instance, in the construction environment the partial automation of this vehicle would make it easier to use, therefore giving an inexperienced operator the ability to use it. By this, the
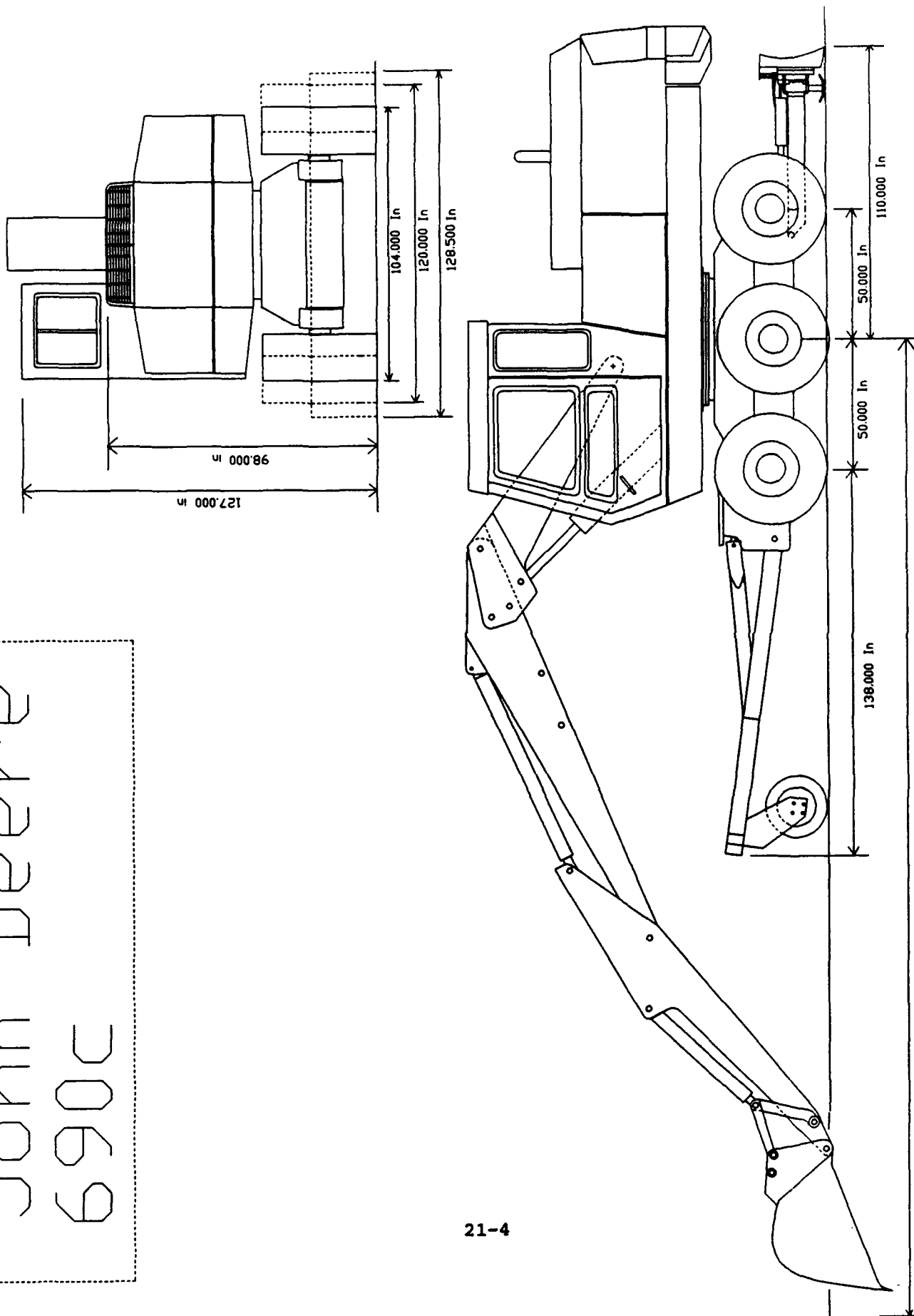
John Deere
690c

104.000 in
120.000 in
128.500 in

98.000 in

127.000 in

110.000 in

50.000 in

50.000 in

138.000 in

31.3 ft. MAX REACH

FIG 1

21-4

many precious hours needed for training on this machinery is drastically reduced. Also, the technological developments acquired through this vehicle can easily be applied to similar machinery.
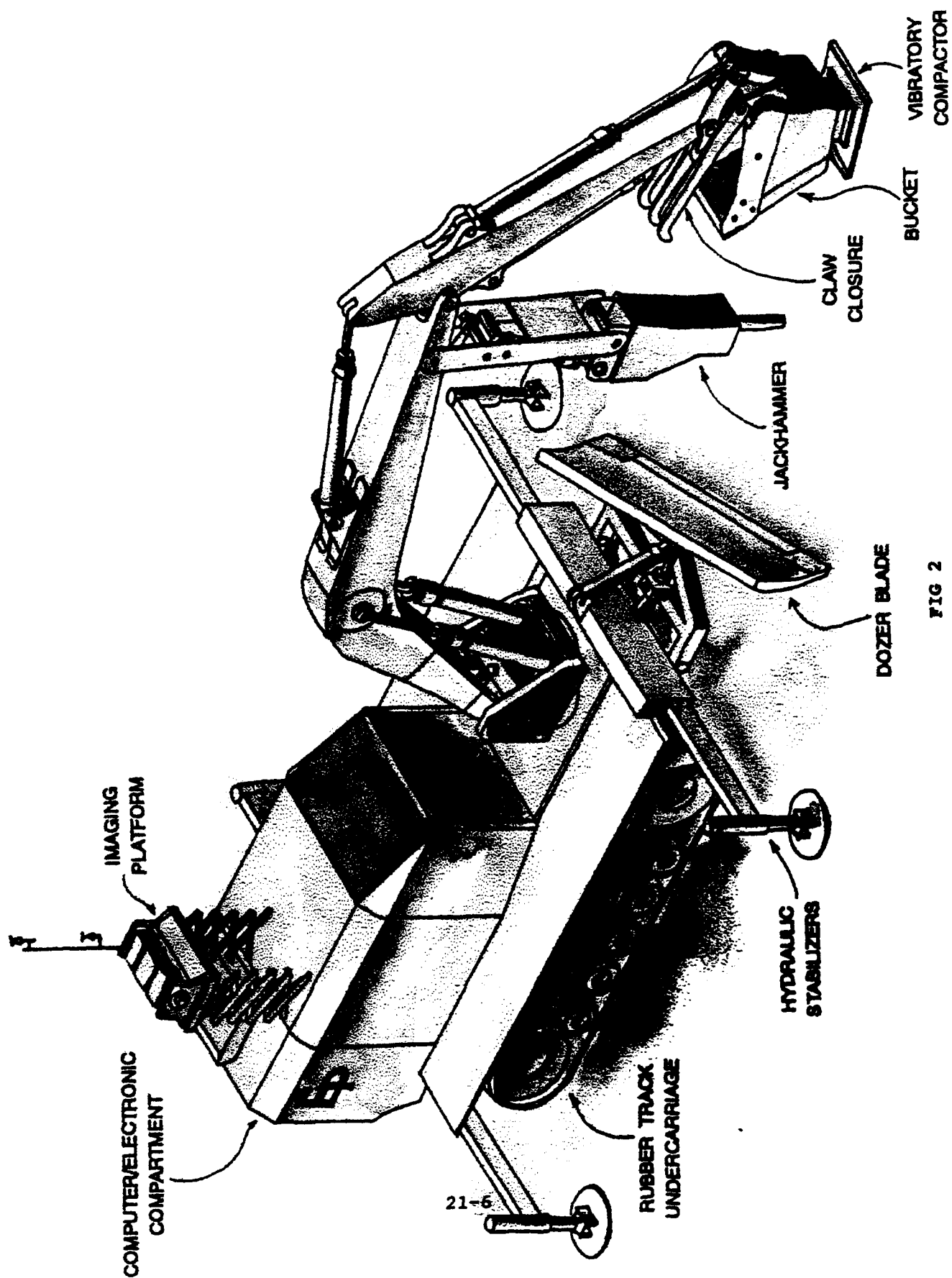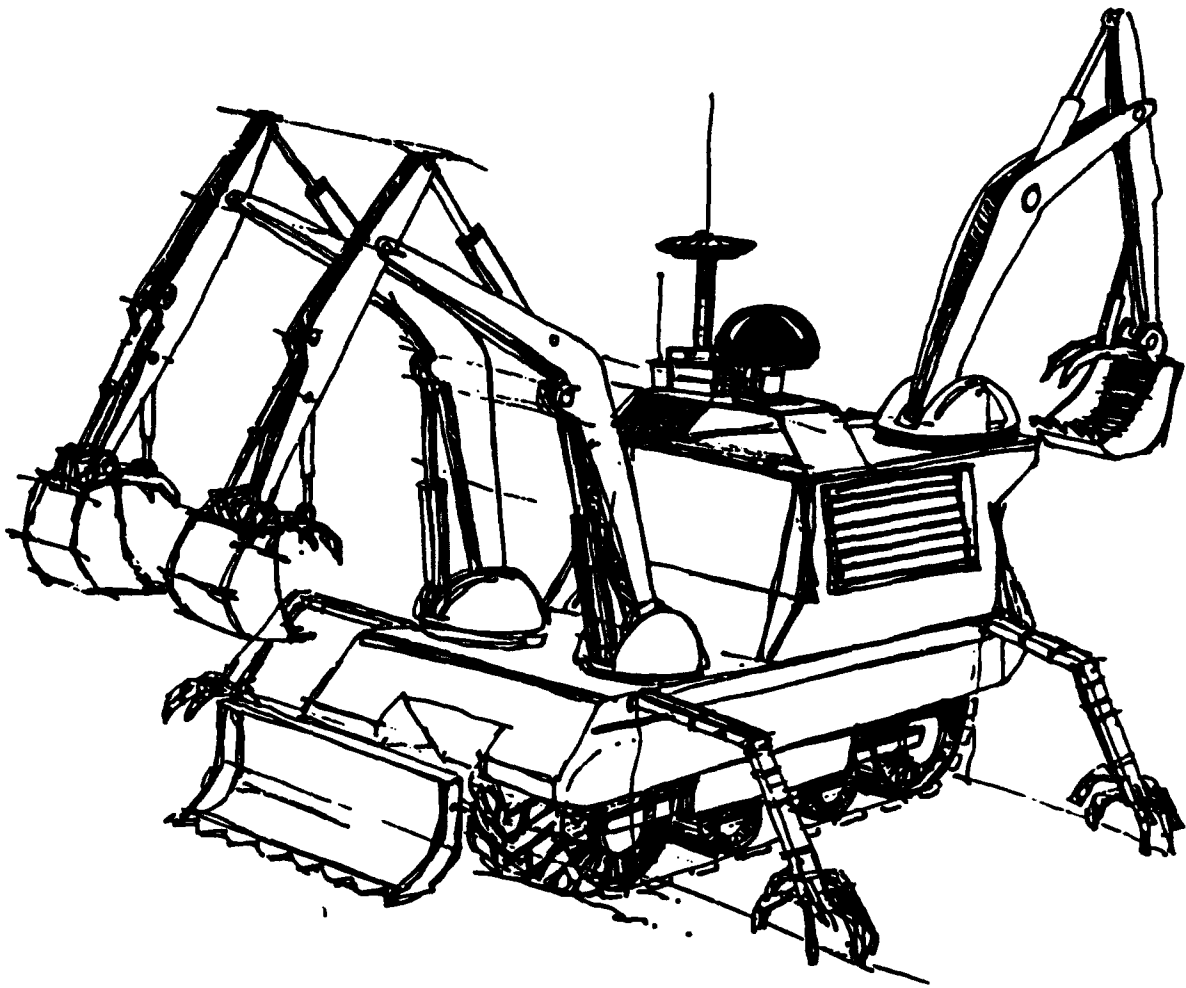
RRR CONSTRUCTION ROBOT

Soon to be delivered is the Rapid Runway Repair Construction Robot, shown in figure 2, on which this laboratory will continue their research. The technology acquired through the 690c will be incorporated into this vehicle. The mission of this robot is to upon deployment, proceed to the site of the crater, clear the rubbish, fill in the crater, and level it off. Unlike the 690c excavator, it does not require a trailer to carry extra tools, for all the tools needed are fixed to the excavator. The robot also includes an advanced imaging platform so that the robot has a clear view of all its surroundings. The platform not only includes the latest in 2D color video, but also supports a 3D laser scanning range finder. By this, the vehicle can have a full 3D view of the surrounding area. It can also be seen that vehicle, being a robot, contains no cab. This is meant to be a fully automated vehicle, capable of performing its mission after being given the rough location of the craters. This robot will work with other robots of its kind to help repair bombed runways in the shortest and safest possible.

SPACE CONSTRUCTION VEHICLE

As plans for the return of man to the moon (to stay this time) proceed, the need for robotic construction vehicles increases. The technology gained from the latter two robots will definitely be applied to the fabrication of this robot. Many other factors, though, must be taken into account. For instance, the robot must be able to withstand the vacuum of space and also be able to work efficiently in a harsh lunar environment. Another major factor to take into consideration, is the matter of launch weight. If the vehicle is to be launched from the earth into orbit for transport, then the cost can be horrendous. If transport to the moon is based on current technology and operational philosophy, then any object imported there would be worth three times its weight in gold

CONSTRUCTION ROBOT

IMAGING
PLATFORM

COMPUTER/ELECTRONIC
COMPARTMENT

VIBRATORY
COMPACTOR

BUCKET

CLAW
CLOSURE

JACK-HAMMER

DOZER BLADE

HYDRAULIC
STABILIZERS

RUBBER TRACK.
UNDERCARRIAGE

21-6

FIG 2

SPACE CONSTRUCTION VEHICLE

FIG 3

(Boles 332). The vacuum of space is also hard to work in, for engines have no natural way of cooling. Extravagant cooling systems must be created to expel the heat. The harshness of the lunar surface provides much wear to moving parts, and so, all bearings and gears must be well sealed and thoroughly lubricated, otherwise they will wear quickly. Even the tires must be extremely durable. Figure 3 shows just one of the proposed vehicles for such an operation. Many different factors must be experimented with, and different robots designed until the best is chosen.

CONCLUSION

Soon man may be seeing construction robots doing more and more of the hard work. The partially automated construction vehicles may very well be seen at construction sites helping in training sometime in the near future. The RRR robot could be repairing bombed runways in just a few years. Are robots really taking over? No, but they shall be a great asset in times to come to all of mankind.

REFERENCES

Boles, Walter W. "Performance-Based Evaluation of Lunar Base Construction Equipment and Methods," Proc. SPACE 92 Engineering, Construction, and Operations in SPACE III, Sadeh, Willy Z., Sture, Stein and Miller, Russell J., Denver, Colorado, 31 May-4 June 1992, ASCE, New York, 1992, pp. 332-340.

HSAP SUMMER APPRENTICESHIP PROGRAM

Summary

Chip Summey
High School Student

Sponsored by:
RACO and ARA
Tyndall Air Force Base, Panama City, Florida

Tyndall Air Force Base in Panama City, Florida served as the location for this year's summer program. Mr. Ed Alexander served as mentor for the eight week period and proved to be an excellent supervisor and teacher. Mr. Alexander went out of his way, more than a few times to make sure that the student could take advantage of all the opportunities offered as possible. The very first day of the apprenticeship program. Mr. Alexander did not assign the student to an area to work, but rather looked into several different work sites and environments and allowed the student to decide not where he would like to work but rather where he thought he would learn the most. Mr. Alexander is a shining example of what this program could be at its highest potential if the mentor is concerned for his summer help.

After the several different work options were presented to the student, the computer department in Applied Research Associates (ARA) Pavements Branch was chosen. Dr. Xiaogong Lee was in charge of this department and agreed to take the summer student in. Equipped with a Silicon Graphics Iris 4-D Workstation (SGI), VAXstation 3100 Workstation, two 386-33 PC's, and a DELL 486-50 PC, this choice had plenty to offer. If Mr. Ed Alexander is the perfect mentor, then without a doubt Dr. Lee is the perfect teacher. With extreme patience and understanding, Dr. Lee helped the summer student get involved with the graphics capabilities on the SGI workstation. Using the FORTRAN language, the student began program at first simple graphical circles, and later more difficult 3-D plots. About the third week into the program, the summer student started writing FORTRAN programs for Dr. Lee. The learning process moved up a notch as this was as close to real-time job experience as possible. Various programs were written to emulate spherical CT scans by entering real data into the program and creating an output file written in PostScript Language. The PostScript file contained the data in graphical form and could then be printed out or previewed as necessary. Throughout this process. Dr. Lee continued to provide assistance and encouragement whenever necessary.

This summer was a very successful one. Good steps were accomplished in learning more about the FORTRAN language, how the VAX and SGI workstations operate and the advantage to having them, and how to relate and work in a real-time job atmosphere. I hope RDL and the Air Force continues this program for future students as it is an excellent foundation for the engineers of tomorrow.