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VOLUME 10

ARMSTRONG LABORATORY

RESEARCH & DEVELOPMENT LABORATORIES
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High school students who live in communities where Air Force laboratories are located have an opportunity to spend eight weeks during the summer doing scientific research at the laboratory. Each student is assigned a mentor from the laboratory. During the summer of 1991 132 students participated in the program. Each student was required to submit a report on their accomplishments. Those student reports were consolidated and bound into this annual report.

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PREFACE

Reports in this document are numbered consecutively beginning with number 1. Each report is paginated with the report number followed by consecutive page numbers, e.g., 1-1, 1-2, 1-3; 2-1, 2-2, 2-3.

This document is one of a set of 13 volumes describing the 1991 AFOSR Summer Research Program. The following volumes comprise the set:

VOLUME	TITLE
1	Program Management Report
	Summer Faculty Research Program (SFRP) Reports
2	Armstrong Laboratory, Wilford Hall Medical Center
3	Phillips Laboratory, Civil Engineering Laboratory
4	Rome Laboratory, Arnold Engineering Development Center, Frank J. Seiler Research Laboratory
5	Wright Laboratory
	Graduate Student Research Program (GSRP) Reports
6	Armstrong Laboratory, Wilford Hall Medical Center
7	Phillips Laboratory, Civil Engineering Laboratory
8	Rome Laboratory, Arnold Engineering Development Center, Frank J. Seiler Research Laboratory
9	Wright Laboratory
	High School Apprenticeship Program (HSAP) Reports
10	Armstrong Laboratory
11	Phillips Laboratory, Civil Engineering Laboratory
12	Rome Laboratory, Arnold Engineering Development Center
13	Wright Laboratory

1991 HIGH SCHOOL RESEARCH REPORTS

Armstrong Laboratory

A STUDY ON HUMAN RESPONSE TO DYNAMIC IMPACT DURING FLIGHT

High School Research Apprentice
Caroline Christine Chuang

ABSTRACT

This summer, I had the opportunity to return to the Biodynamics/Bioengineering Division of the Harry G. Armstrong Aerospace Medical Research Laboratory to work on a research project measuring human response to dynamic impact during flight. Over the course of this summer, I completed various test equipment designs and computer programming tasks for my mentor Mr. Joe Strzelecki and his associates. Most of the test quipment designs dealt with a chair with variable back recline angles designed to simulate pilot seat positions and to measure human response to flight impact. The bulk of my work was designing parts of the seat, drafting assembly drawings, and overseeing the construction of the chair components. As part of the designing process, I learned how to select materials for the test equipment, to calculate the conditions on seat pan loading, to operate the AutoCAD (Computer-Aided Design) system, to run a finite element structural analysis,and to prepare a suborder to begin the construction of parts at the machine shop. In addition to these tasks, I also expanded a Randomized Block Design computer program I wrote for the lab during the previous summer so that it can handle a matrix with more test cells. In between projects, I conducted document searches at the Wright Laboratories Tech Library and observed tests for the other biomedical test programs in the lab. Among the tests were mannequin and human

testing at the Vertical Drop Tower and the Horizontal Accelerator. This is my second summer working in the lab, and I had more opportunities to observe and to work on various test programs at different stages of development. My work on these projects will be described in further detail in the following pages.

I. INTRODUCTION

Most aircraft today have pilot seats tilted back at a standard angle of thirteen degrees from the vertical plane. An exception to this is the F-16 fighter plane. Its seats rest at a steeper angle of 34 degrees from the vertical plane. In the future, other aircraft may also prefer to have seats which recline at angles different from the standard setting. The Variable Back Angle Seat is an experimental seat that will be used on the Horizontal Accelerator. This seat can recline at several different angles and will be used to determine the effect of flight impact at these angles upon the spine. This seat is designed so that its reclining angle changes by simply adjusting the length of its seat truss beams. In the next few years, data gathered by testing this seat at angles of 22.5, 45, 67.5 degrees will provide valuble information about spinal injury and stresses upon the spine.

II. DISCUSSION OF THE PROBLEM

Almost all the parts for the Variable Back Angle Seat had already been designed by my mentor Mr. Joe Strzelecki. My job was to design the three remaining parts: the upper seat pan, the lower seat pan, and the wooden seat pan. The length and width of the pieces were already predetermined by his general design of the seat as a whole. The rest of the design was up to me. In designing the seat pans, I had to take into consideration the construction materials, seat pan loading, and load cell spacing. Other factors in the seat pan design were the number of available channels for data transmission and the lap belt location. With these in mind, I designed and redesigned the seat pans until all the qualifications were met.

III. RESULTS

The first step in designing was to select the materials to be used in making the seat pan. The choice was between steel, aluminum, or wood to construct the upper and lower seat pans. Wood was ruled out since it was too crumbly to drill the necessary holes for the threaded inserts. Because steel is much heavier than aluminum, aluminum was selected to make the seat pan. The next decision was what type of aluminum to use. The types of aluminum which were readily available to the machine shop are: 6061-T6, 2024-T3, & 7075-T6. Below is a chart of some characteristics of the various types of aluminum.

ALLOY	YIELD STRENGTH (psi)	BRINELL HARDNESS
2024-T3	50,000	120
6061-T6	40,000	95
7075-T6	73,000	150

Aluminum 7075-T6 is the strongest of the three, but it was too brittle for our purposes and would crack easily. Thus, Al 7075-T6 was ruled out. Since Al 6061-T6 is so soft, it would be damaged by using tapped holes. This meant that the needed threaded inserts couldn't be used with this material. Therefore, Al 6061-T6 was also eliminated as a possibility. Aluminum 2024-T3 was the best choice because its hardness and strength is in between those of Al 6061-T6 and Al 7075-T6.

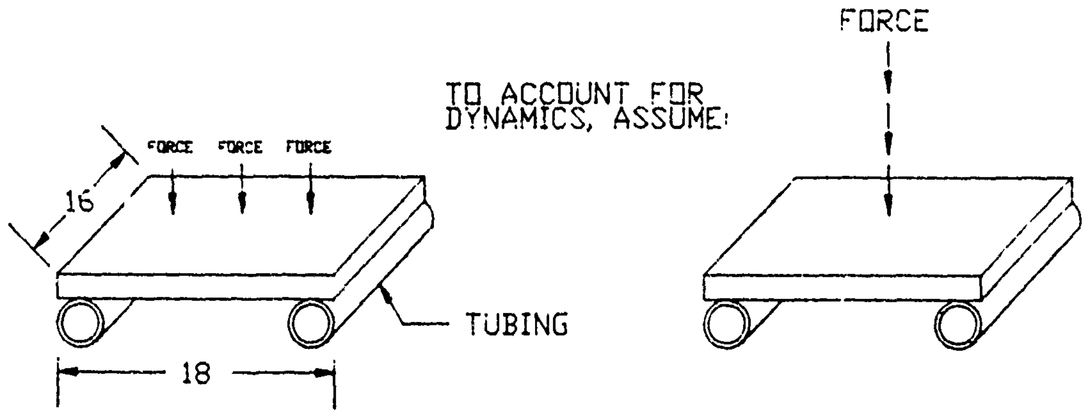
The next step was to calculate the seat pan thickness. The following shows the step by step procedure used to calculate this.

1.) The first step was to calculate seat pan loading. The 95th percentile of pilots weighs 220 pounds. Since the majority of pilots will be lighter that 220 pounds, this weight will be used as the guide for this calculation. Because testing can go up to 12 G, the pilot's weight must be multiplied by the G-level to be used as the maximum force.

$$(220 \text{ lbs.}/1 \text{ G}) \times (12 \text{ G}) = 2{,}640 \text{ lbs.}$$

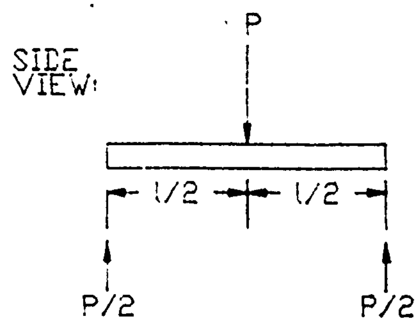
In addition, to account for the dynamics of the system, this force should be multiplied by 2.

$$(2{,}640 \text{ lbs.}) \times (2) = 5{,}280 \text{ lbs.}$$



The result from the seat pan loading will be used later on to calculate the required seat pan thickness.

2.) Then, the moment must be calculated. The following shows the derivation of the moment equation.



m=(P/2)(l/2) where m=moment
=(P*l)/4 P=pressure
=(W*l)/4 W=weight
l=length

The numbers are then plugged into the equation.

$$m = (5{,}280 \text{ lbs.} \times 18 \text{ in.}) / 4$$
$$= 23{,}760 \text{ in-lbs.}$$

3.) Next the bending stress (σ_b) must be calculated.

Aluminum 2024-T3 has a yield strength of 50,000 psi. To account for the safety factor of the material, the strength shou.d be decreased by two.

$$\sigma_b = \text{Yield Strength} / 2$$
$$= (50{,}000 \text{ psi}) / 2$$
$$= 25{,}000 \text{ psi}$$

4.) Using σ_b and m, the equation for bending stress can now be manipulated to calculate the thickness of the material.

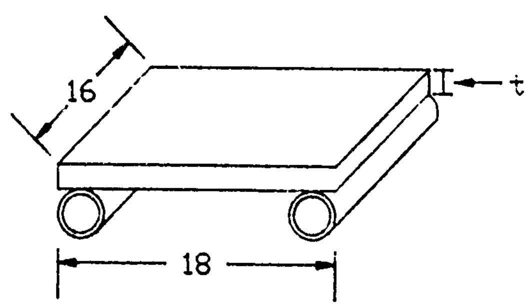
$\sigma_b=(m*c)/I$ where m=moment
c=thickness/2=t/2
$I=(1/12)*(b*h^3)$
$=(1/12)*(b*t^3)$
b=length=l

$$\sigma_b = \frac{m*(t/2)}{(1/12)*(b*t^3)}$$

$$\sigma_b = \frac{6*m}{b*t^2}$$

$$t^2 = \frac{6*m}{b*\sigma_b}$$

$$t = \sqrt{\frac{6*m}{b*\sigma_b}}$$



Then, the numbers are plugged into the formula.

$$t=\sqrt{\frac{6*(23,760)}{(18)*(25,000)}}$$

$$t=\sqrt{.3168}$$
$$t=.562849891$$
$$t\approx.563 \text{ inch}$$

To determine what stock thickness to use, one must select the thickness (to the nearest 1/8 inch) which is closest to and greater than 5/8 inch. This is because the materials come by thicknesses of multiples of 1/8 inch. Thus the required seat pan thickness is 5/8 inch or .675 inch.

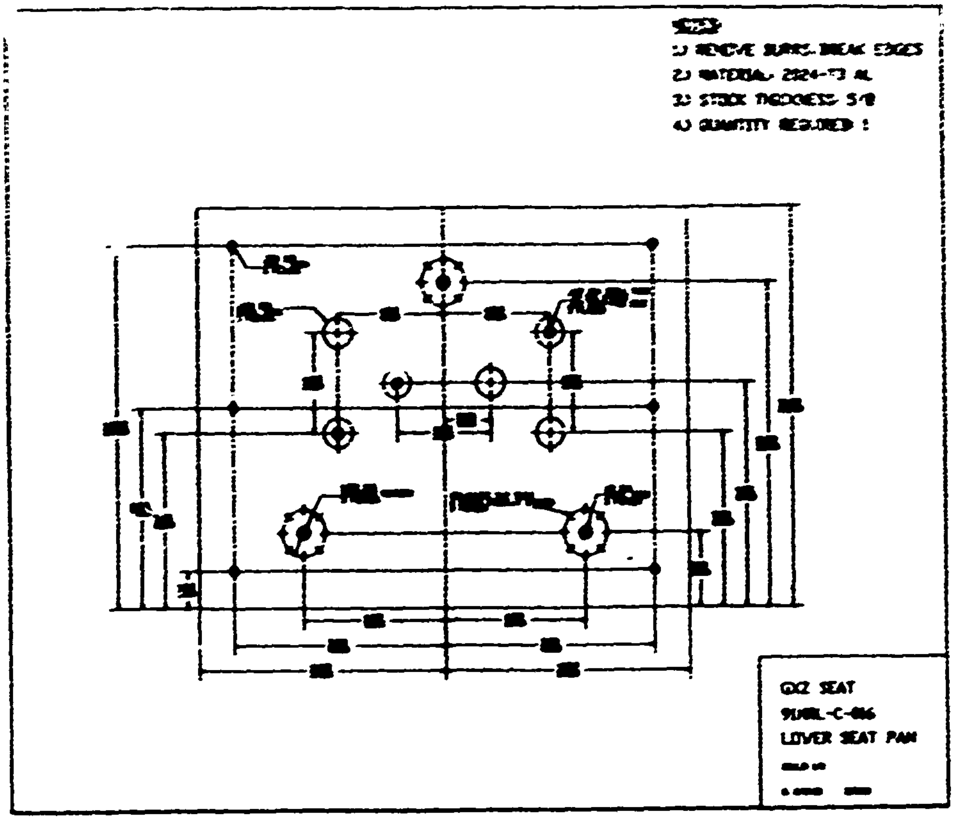
Another factor to take into account was the load cells. Load cells are used to measure compressive forces. On this seat pan design, only three load cells are used for balance and usage reasons. Using three load cells is the minimum number for balancing the seat pan. This balance is essential for measuring all pressures. In addition, three is the ideal number because it requires fewer channels for data transmission. The fewer load cells that are used, the fewer channels that are needed. Therfore, three is just the right number because it provides sufficient data measurements, balances the seat pan, cuts down a bit of the cost, and requires fewer channels than other options.

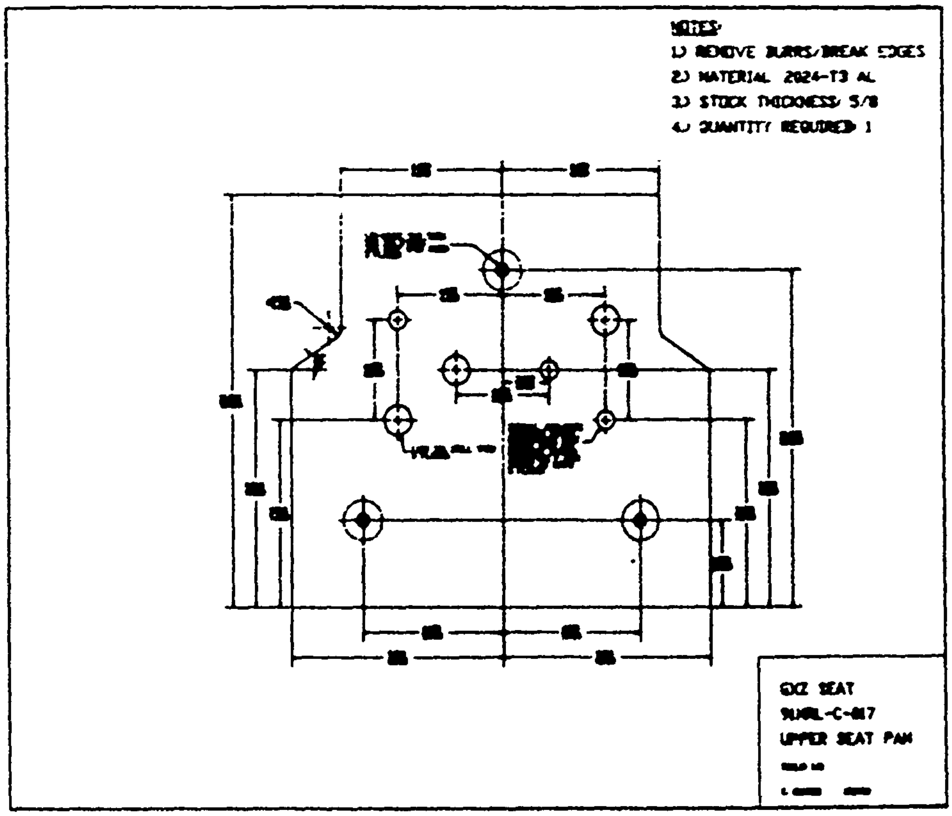
The number of load links to be used was determined in a similar manner. Load links were used to relieve the system of sliding forces while not affecting the measurements of compressive forces. The configuration of load links is designed to take on forces moving side to side, forwards, and backwards. Since this system must also be balanced, three is an ideal number in this situation as well. Like the load cells, using three load links requires few channels and is therefore the best choice. Again, all in all, three is the ideal number for load links.

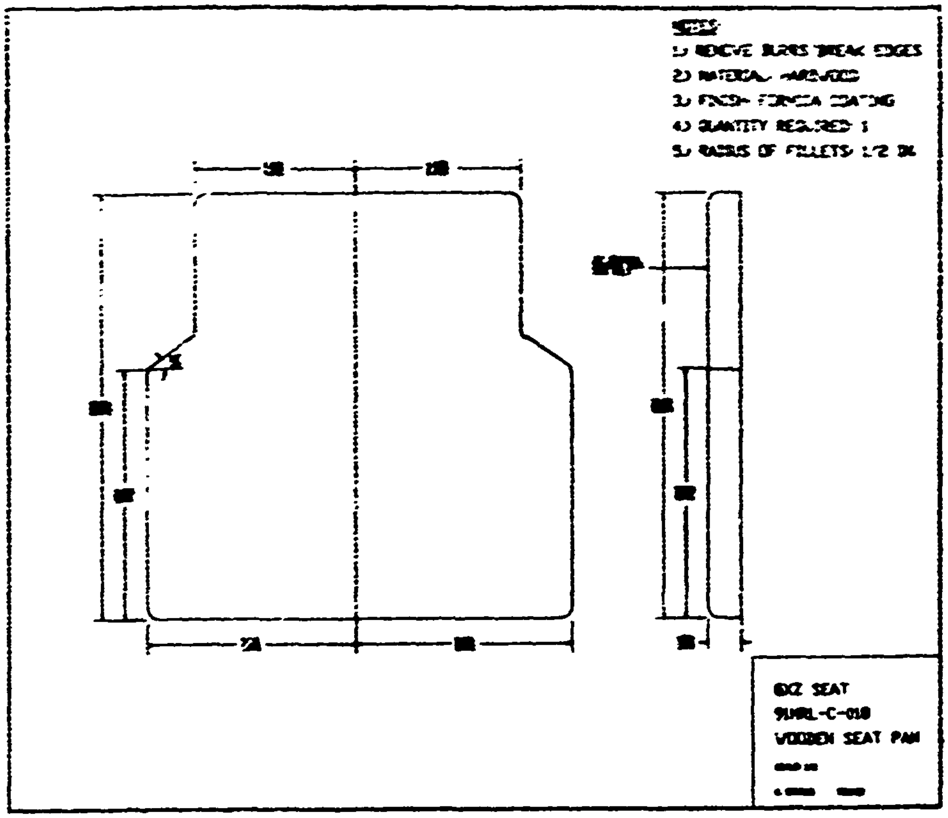
The last major factor in the design was the location of the lap belt. One of the basic worries was that the lap belt would affect the load cell readings by coming into contact with the seat pan. In order to eliminate this problem, 2 1/8 inch strips were cut off on each side of the back of the upper and wooden seat pans. This prevented the lap belt from coming into contact with the seat pan and from affecting the data measured by the load cells.

In addition to the major factors previously described, there were a few spacing stipulations to be met. First, since the upper seat pan is 1/2 inch longer than the lower seat pan, the upper seat pan extends 1/2 inch more forward than the lower seat pan. The same situation applies to the wooden seat pan as compared to the upper seat pan. Secondly, any load cell must be centered at least three inches from the edge. Thirdly, the load cell and load link configurations must be symmetrical and centered. Next, load links and load cells may not touch one another. The last stipulation is that the six holes used to connect the lower seat pan to the truss beams must be at least 1 1/2 inches from the edge.

In keeping with these factors and stipulations, I designed the shape and the layout of each seat pan. The next three drawings show my design of each part carefully labelled for construction at the machine shop.


1) REMOVE BURRS/BREAK EDGES
2) MATERIAL: 2024-T3 AL
3) STOCK THICKNESS: 5/8
4) QUANTITY REQUIRED: 1
GXZ SEAT
LOWER SEAT PAN

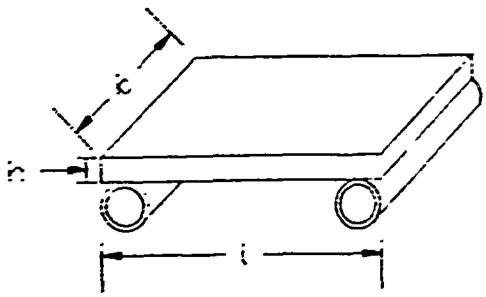

NOTES:
1) REMOVE BURRS/BREAK EDGES
2) MATERIAL 2024-T3 AL
3) STOCK THICKNESS: 5/8
4) QUANTITY REQUIRED: 1
GXZ SEAT
UPPER SEAT PAN



Before beginning the approval process for my work order, I had two more steps to do to confirm the soundness of my designs. The first was to use Rayleigh's Principle to determine the natural frequency of the seat pan. The second was to perform a Finite Element Structural (Static and Dynamic) Analysis.

Rayleigh's Principle was used to make a general estimation of the seat pan's natural frequency. The significance of this is that the natural frequency must be at least ten to twenty times that of the human body so that the frequencies can be separated from one another after data collection. Also, the natural frequency must be high enough so that the impulse acceleration doesn't cause the seat pan to vibrate too much. The calculations are as follows:

$\omega = \pi^2\sqrt{(g*E*I)/(w*l^4)}$ where ω=natural frequency (rad/sec)
g=acceleration of gravity
=386 in/sec^2
E=Young's modulus
=10 x 10^6 lb/in^2
I=Cross-section moment of inertia
=(1/12)*(b*h^3)
=(1/12)(16 in)(.625 in)^3
w=weight per inch (lb/in)
=(Density)*(Cross-sectional area)
=(.1 lb/in^3)(16 in)(.625 in)
l=length of beam
=18 in



$$\omega_1 = \pi^2\sqrt{\frac{(386\ \text{in/sec})(10*10^6\ \text{lb/in}^2)(1/12)(16\ \text{in})(.625\ \text{in})^3}{(.1\ \text{lb/in})(16\ \text{in})(.625\ \text{in})(18\ \text{in})^4}}$$

=(1079.786223 rad/sec)(1 cycle/2 rad)
=171.8533148 Hz
~171.85 Hz

From this estimate, it is determined that the natural frequency is over ten times that of the human body (10 Hz) and above that of the impulse acceleration. Therefore, the natural frequency of the seat pan is high enough so that it can be filtered from the human frequency and so that other frequencies will not interfere.

Following this, the COSMOS/M program was used to perform a Finite Element Structural Analysis on the seat pan. A static analysis was executed to determine if the seat pan was thick enough to withstand the bending stress applied. For this analysis, 255 elements and 224 nodes were used to compose the seat pan. The results showed that the seat pan could withstand the stresses and that the stresses were distributed symmetrically along the center line. Then, due to memory capacities, a coarser model of the seat pan was used for the dynamic (or frequency) analysis. This analysis merely double checked the natural frequency roughly calculated by Rayleigh's Principle. For this analysis, only 81 elements and 64 nodes were used. The computer calculated the natural frequency as 183 Hz, just 12 Hz away from that calculated using Rayleigh's Principle. (The Finite Element Structural Analysis yielded a higher natural frequency, a more favorable result than the roughly calculated estimate.) The Finite Element Structural Analysis indicated that my designs were sound.

Now, I began completing my work order for the parts. First, I showed the branch chief the work order. After his approval, I went to headquarters to get approval. Following both approvals, I submitted my designs and the work order to the machine shop for a cost estimate. When I got a cost approval from the laboratory's finance officer, I signaled the machine shop to begin work on the parts. Periodically, I went to the machine shop to check the progress of the work and to answer any question the machinist might have. On July 9, 1991, the upper and lower seat pans were completed and picked up at the machine shop. On July 12, 1991, the wooden seat pan was completed and picked up as well. All three parts were completed well over three weeks ahead of schedule. At this time, the Variable Back Angle Seat is in the process of being assembled on the Horizontal Accelerator.

IV. CONCLUSION

During this past summer, I had an opportunity to work on several different projects. My primary project was the upper, lower, and wooden seat pans of the Variable Back Angle Seat. During this time, I learned many new skills. Through my work on this project, I learned the following:

1) Material selection
2) Seat pan loading
3) Bending stress
4) Load cells and load links
5) AutoCAD system
6) Drafting
7) Rayleigh's Principle
8) Finite Element Structural (Static and Dynamic) Analysis
9) Procedure and work order for construction of structural components

Now, following the assembly drawings I drafted for the 22.5, 45, and 67.5 degree angles, the contractors have begun to assemble the seat. This seat will be tenatively tested during the next two years, and data will be collected relating seat angles and injuries and stresses on the spine.

ACKNOWLEDGEMENTS

This summer, I had the good fortune to return to the Biodynamics/Bioengineering Division of the Harry G. Armstrong Aerospace Medical Research Laboratory. I'd like to thank the office for making this another enjoyable summer.

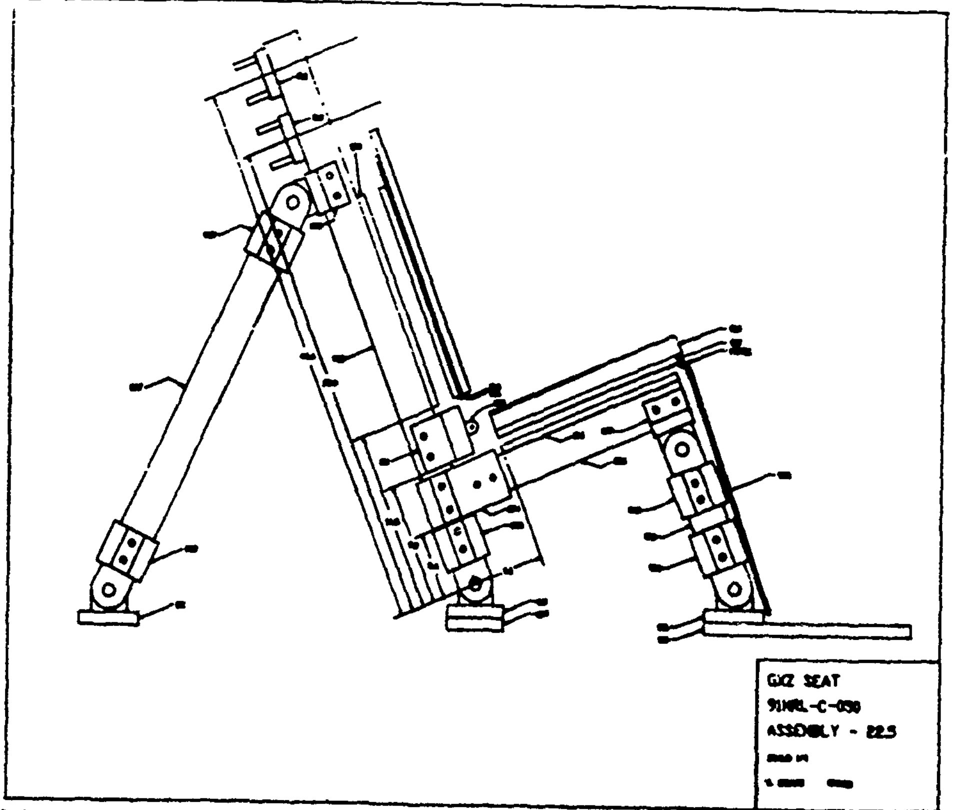
I'd like to thank this summer's mentor Mr. Joe Strzelecki for all the advice and challenging projects.

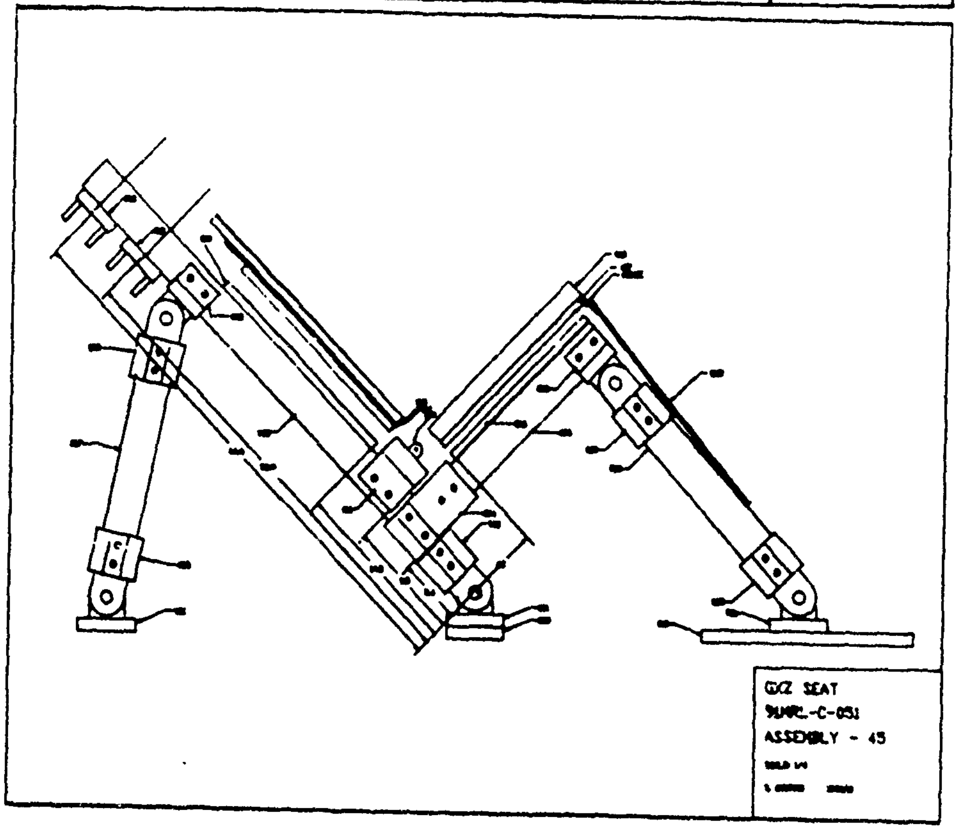
Thanks to last summer's mentor Mr. John Buhrman for allowing me to participate in and to observe the continuation of IPPC project I worked on last year.

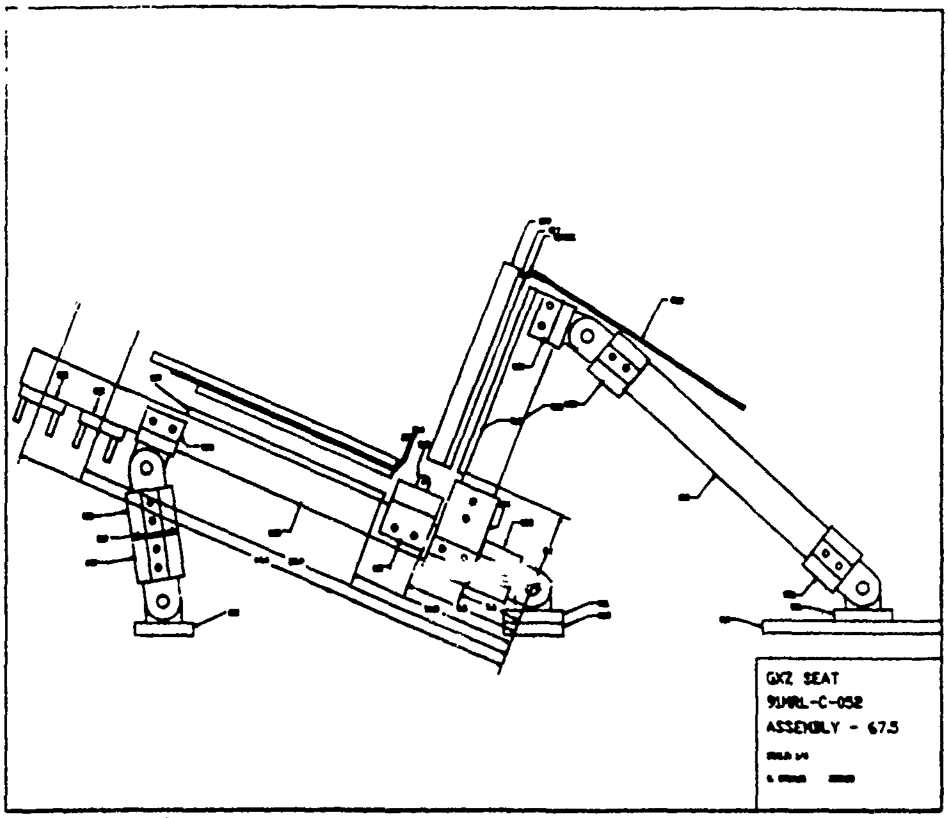
Thanks to the branch chief Dr. Ted Knox for the encouragement and advice.

Finally, I'd like to thank the rest of the staff in the office — Mrs. Jenny Blake, Lt. Dena Bonetti, SSgt. Jeff Briggs, Capt. Scott Gordon, CMSgt. Phillip Lashley, Tsgt. Miguel Maldonaldo, Mr. Chris Perry, Mr. John Plaga, Mr. Larry Specker, Mr. Carl Toler, and Maj. Andrew Tong — for helping me get familiar with new software, allowing me to observe their testing programs, and making me feel at home.

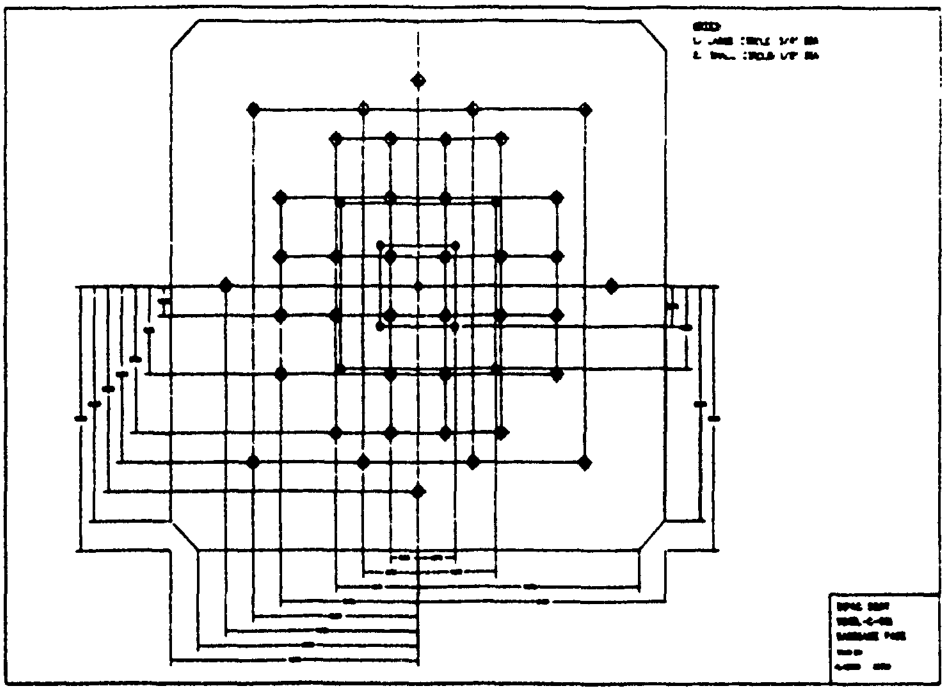
APPENDIX A: Assembly Drawings for Variable Back Angle Seat



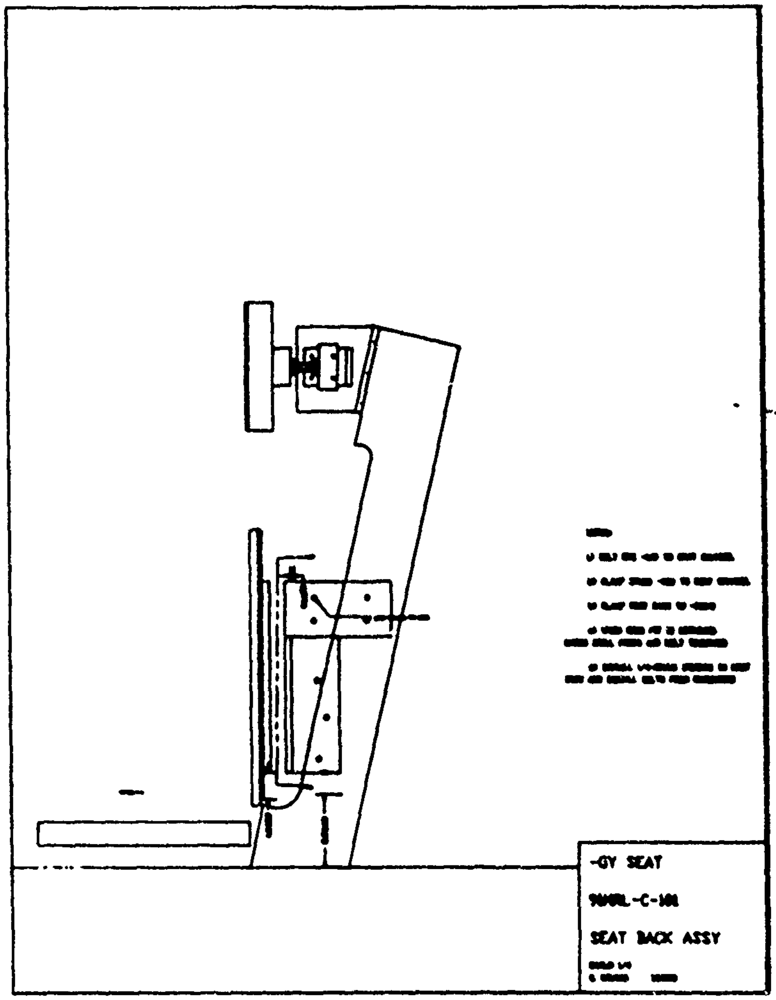


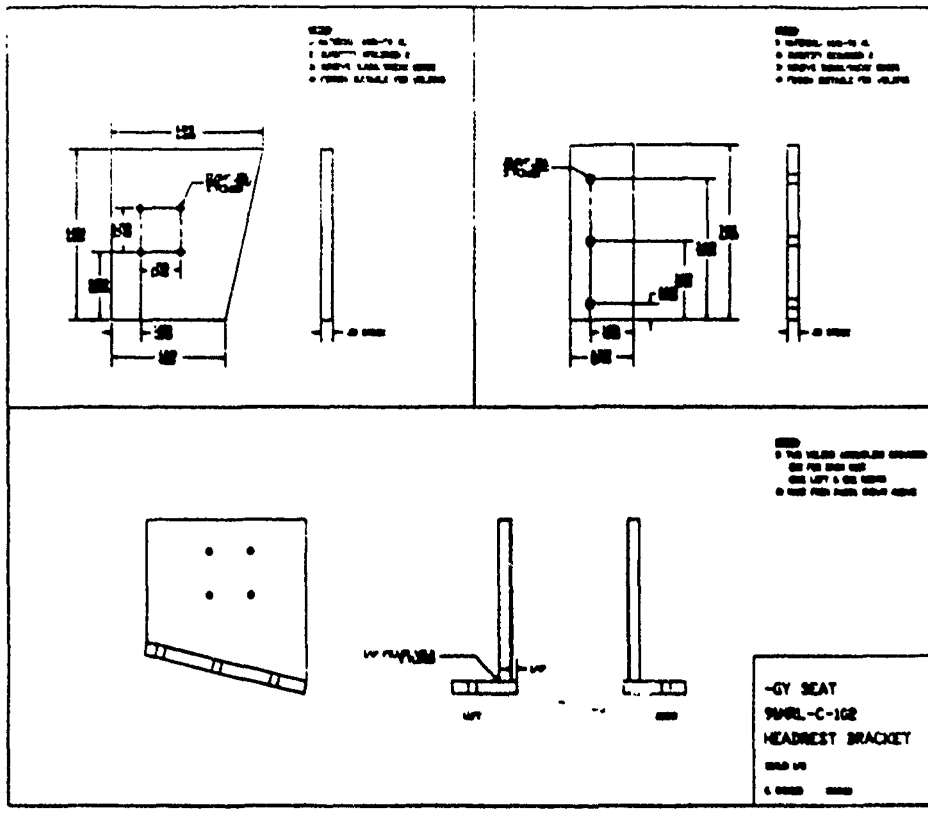

GXZ SEAT
91MRL-C-052
ASSEMBLY - 67.5

APPENDIX B: IMPAC Carriage Face



APPENDIX C: GY Seat Project





-GY SEAT
HEADREST BRACKET

APPENDIX D: Randomized Block Design Program

This is part of the documentation for the program:

The RANDOM1 program is designed to generate random numbers for a test matrix in a randomized block design. this program can handle up to twenty sequences, each with a length of three to fifteen test cells. Some test matrices may require extentded amounts of time to complete. The stipulations for the randomized block design are:

1. Each test cell letter may not appear more than once in each sequence.

2. When the number of sequences is less than the length of the sequences, each test cell letter may not appear more than once in a position.

3. The same sequence may not appear more than once in a test matrix. (The exception occurs when the sequence length is three.)

4. When the sequence length is three, there are only six combinations possible using the three test letters (A,B,C). In this case, the combinations must be allowed to repeat when the number of sequences exceeds six. Thus, the sequences are permitted to repeat the minimal number of times that are necessary.

The two FORTRAN functions used in this program are RAN(x) (the random number command) and SECNDS(x) (the time command). The RAN(x) command uses a SEED which is initialized to a very large number. It performs an algebraic operation on the SEED to generate random numbers. This SEED is initialized to the SECNDS(x) function which converts the time at the moment of execution into the equivalent number of seconds, providing the seed with its large number.

This is a sample run of the program:

This program is designed to create a test matrix using the
  randomized block design. It can randomly pick numbers for
  no more than twenty sequences with a length no larger
  than fifteen and no less than three.

Some combinations of sequences may take an excessive amount of
  time to complete due to stipulations within the program.

Further details concerning how this program rauns can be found
  in the file called RANDOM1.DOC .

Results of this program are stored in a file called RANDOM1.OUT .

```
ENTER THE NUMBER OF SEQUENCES TO BE RANDOMIZED (1 TO 20).
13

ENTER THE LENGTH OF THE SEQUENCES (3 TO 15).
10


RANDOM SEQUENCE # 1 IS A J G F B I H C D E

RANDOM SEQUENCE # 2 IS I J H A C E F G D B

RANDOM SEQUENCE # 3 IS D B C A E J G H I F

RANDOM SEQUENCE # 4 IS E I H B D G A J C F

RANDOM SEQUENCE # 5 IS C E G I A F J B H D

RANDOM SEQUENCE # 6 IS E G D C B A I F J H

RANDOM SEQUENCE # 7 IS G H A J I D E B F C

RANDOM SEQUENCE # 8 IS F E A I H G J D C B

RANDOM SEQUENCE # 9 IS B I C G F E D H J A

RANDOM SEQUENCE #10 IS B A F H J C G I E D

RANDOM SEQUENCE #11 IS D A I B G J F C H E

RANDOM SEQUENCE #12 IS G B F J D A C I E H

RANDOM SEQUENCE #13 IS C D E F I B H J G A
```

IMPLEMENTATION OF THE CLEAN AIR ACT RELATIVE TO TOXICOLOGICAL RESEARCH

D. Joshua Finch

During my summer term at the Toxic Hazards Division of Wright Patterson Air Force Base I encountered many new opportunities for learning. I worked with two new computer programs; Autocad and Word Perfect 5.1. I also worked in the labs with various scientists. My main reasearch project was to describe how the Clean Air Act Amendments of 1990 relate to toxicological research. This paragraph is followed by the report which was submitted to my focal point, Dr. Jeffery Fisher.

The Clean Air Act Amendments of 1990 were signed into law by President Bush on November 15, 1990. The poor condition of the nation's air and the diminishing ozone above the country's larger metropolitan areas has called for these revisions to be conceived. Many major reductions of automotive and industrial emissions are to be achieved over the next twenty years. Much information about the chemicals and compounds involved in these reductions must be obtained through research. This opens up many possibilities for toxicology research labs.

Brief Summary of Titles from Clean Air Act Amendments of 1990

*Title I- Provisions for Attainment and Maintenance of National Ambient Air Quality Standards

Title I addresses the problems of ozone, carbon monoxide, and particulate matter. It offers clarification on the amount of reductions that must be made in the nation's metropolitan areas.

*Title II- Provisions Relating to Mobile Sources

Title II establishes firmer reduction standards relating to emissions from all types of mobile sources.

*Title III- Hazardous Air Pollutants

Title III contains a list of 189 toxic air pollutants. It also proposes emission standards for stationary sources that are in keeping with the Maximum Achievable Control Technology.

*Title IV- Acid Deposition Control

Title IV defines the problem of acid rain while setting a time table for the reduction of sulfur dioxide and nitrogen oxide emissions.

*Title V- Permits

Title V requires the EPA to issue operating permits to facilities. Through this program the EPA can better enforce the Clean Air Act.

*Title VI- Stratospheric Ozone Protection

Title VI requires a phase out of substances that damage the ozone layer. The chemicals involved are separated into two classes, each class having its own phase out date.

*Title VII- Provisions Relating to Enforcement

Title VII authorizes the issuance of citations and penalties for noncompliance of the Clean Air Act.

*Title VIII- Miscellaneous Provisions

Title VIII describes provisions on topics such as visibility and attainment for offshore facilities.

*Title IX- Clean Air Research

Title IX reports the need for improved research techniques for use in studies concerning releases of chemicals.

*Title X- Disadvantaged Business Concerns

Title X states that at least 10% of EPA funds from Clean Air Act research will be made available for disadvantaged business concerns.

Title III of the Clean Air Act is titled,"Hazardous Air Pollutants." It is the title most related to toxicological research. In this title the Environmental Protection Agency (EPA) has compiled a list of 189 hazardous air pollutants. Stationary sources that emit ten tons or more per year,of any one of the pollutants on the list, or twenty-five tons or more per year of any combination of the chemicals, must be regulated using the maximum available control technology (MACT). These substances are being regulated because of health effect concerns from acute or chronic exposures have caused emission reductions to be instated Before emission reductions can be made accurate data must be provided through sampling methods validated by EPA protocol.

The list will be reviewed periodically by the EPA, and any appropriate revisions may be added when the results are published. A pollutant must be shown to cause adverse human health or environmental effects through any route of exposure do to any type of exposure except that caused by an accidental release of a chemical already listed on the list of substances considered hazardous in the case of an accidental release. Petitions for additions or deletions may be submitted to the EPA by any person providing adequate data regarding the health or environmental effects of the pollutant in question. The EPA, in return, must publish a written explanation of their decision to grant or deny the request, within 18 months.

The EPA mu establish a list of categories of major sources and area sources of the listed pollutants within one year. In doing so, the EPA must establish a different category for laboratory or research facilities. Regulations creating exposure standards for the listed categories must be instated by the EPA per the schedule shown on Table I taken from the Clean Air Act.

Table I(From U.S. EPA)

# of Source Categories	Deadline from Enactment
At least 40 categories and subcategories	2 years
and coke oven batteries	December 31, 1992
25%	4 years
50%	7 years
100%	10 years

RESEARCH PROGRAM

-EPA is required to conduct a research program, after consultation with state and local air pollution control officials, on sources of hazardous air pollutants in urban areas.

-The research program must include:

Ambient monitoring of hazardous air pollutants in a representative number of urban areas;

Characterization analysis to identify the sources of the pollution, focusing on area sources and their contribution to public health risk from hazardous air pollutants;

Consideration of atmospheric transformation and any other factors that can increase public health risks from hazardous air pollutants.

-The health effects data base must include, at a minimum, carcinogenicity, mutagenicity, teratogenicity, neurotoxicity, reproductive dysfunction, and other acute or chronic effects (including role as precursors to ozone or acid aerosol formation).

-The preliminary results must be reported no later than 3 years after the enactment date of the Clean Air Act Amendments of 1990.

(U.S. EPA, 1990)

Prior to the preliminary results of the monitoring program described in the previous outline, the EPA must submit a comprehensive national strategy to congress. Research needs related to monitoring, analytical methodology, modeling or pollution control techniques may be described in said strategy. The strategy is to be submitted within five years of enactment of the Clean Air Act Amendments of 1990.

CAS#	Chemical name
64675	Diethyl sulfate
119904	3,3-Dimethoxybenzidine
60117	Dimethyl aminoazobenzene
119937	3,3'-Dimethyl benzidine
79447	Dimethyl carbamoyl chloride
68122	Dimethyl formamide
57147	1,1-Dimethyl hydrazine
131113	Dimethyl phthalate
77781	Dimethyl sulfate
534521	4,6-Dinitro-o-cresol, and salts
51285	2,4-Dinitrophenol
121142	2,4-Dinitrotoluene
123911	1,4-Dioxane(1,4-Diethyleneoxide)
122667	1,2-Diphenylhydrazine
106898	Epichlorohydrin (1-Chloro-2,3-epoxypropane)
106887	1,2-Epoxybutane
140885	Ethyl acrylate
100414	Ethyl benzene
51796	Ethyl carbamate (Urethane)
75003	Ethyl chloride (Chloroethane)
106934	Ethylene dibromide (Dibromoethane)
107062	Ethylene dichloride (1,2-Dichloroethane)
107211	Ethylene glycol
151564	Ethylene imine (Aziridine)
75218	Ethylene oxide
96457	Ethylene thiourea
75343	Ethylene dichloride (1,1-Dichloroethane)
50000	Formaldehyde
76448	Heptachlor
118741	Hexachlorobenzene

CAS#	Chemical name
87683	Hexachlorobutadiene
77474	Hexachlorocyclopentadiene
67721	Hexachloroethane
822060	Hexamethylene-1,6-diisocyanate
680319	Hexamethylphosphoramide
110543	Hexane
302012	Hydrazine
7647010	Hydrochloric acid
7664393	Hydrogen fluoride (Hydrofluoric acid)
7783064	Hydrogen sulfide
123319	Hydroquinone
78591	Isophorone
58899	Lindane (all isomers)
108316	Maleic anhydride
67561	Methanol
72435	Methoxychlor
74839	Methyl bromide (Bromomethane)
74873	Methyl chloride (Chloromethane)
71556	Methyl chloroform (1,1,1-Trichloroethane)
78933	Methyl ethyl ketone (2-Butanone)
60344	Methyl hydrazine
74884	Methyl iodide (Iodomethane)
108101	Methyl isobutyl ketone (Hexone)
624839	Methyl isocyanate
80626	Methyl methacrylate
1634044	Methyl tert butyl ether
101144	4,4-Methylene bis(2-chlorlaniline)
75092	Methylene chloride (Dichloromethane)
101688	Methylene diphenyl diisocyanate (MDI)
101779	4,4'-Methylenedianiline

CAS#	Chemical name
91203	Naphthalene
98953	Nitrobenzene
92933	4-Nitrobiphenyl
100027	4-Nitrophenol
79469	2-Nitropropane
684935	N-Nitroso-N-methylurea
62759	N-Nitrosodimethylamine
59892	N-Nitrosomorpholine
56382	Parathion
82688	Pentachloronitrobenzene (Quintobenzene)
87865	Pentachlorophenol
108952	Phenol
106503	p-Phenylenediamine
75445	Phosgene
7803512	Phosphine
7723140	Phosphorus
85449	Phthalic anhydride
1336363	Polychlorinated biphenyls (Arochlors)
1120714	1,3-Propane sultone
57578	beta-Propiolactone
123386	Propionaldehyde
114261	Propoxur (Baygon)
78875	Propylene dichloride (1,2-Dichloropropane)
75569	Propylene oxide
75558	1,2-Propylenimine (2-Methyl aziridine)
91225	Quinoline
106514	Quinone
100425	Styrene
96093	Styrene oxide
1746016	2,3,7,8-Tetrachlorodibenzo-p-dioxin

CAS#	Chemical name
79345	1,1,2,2-Tetrachloroethane (Perchloroethylene)
7550450	Titanium tetrachloride
108883	Toluene
95807	2,4-Toluene diamine
584849	2,4-Toluene diisocyanate
95534	o-Toluidine
8001352	Toxaphene (chlorinated camphene)
120821	1,2,4-Trichlorobenzene
79005	1,1,2-Trichloroethane
79016	Trichloroethylene
95954	2,4,5-Trichlorophenol
88062	2,4,5-Trichlorophenol
121448	Triethylamine
1582098	Trifluralin
540841	2,2,4-Trimethylpentane
108054	Vinyl acetate
593602	Vinyl bromide
75014	Vinyl chloride
75354	Vinylidene chloride (1,1-Dichloroethylene)
1330207	Xylenes (isomers and mixture)
95476	o-Xylenes
108383	m-Xylenes
106423	p-Xylenes
0	Antimony Compounds
0	Arsenic Compounds
0	Beryllium Compounds
0	Cadmium Compounds
0	Chromium Compounds
0	Cobalt Compounds
0	Coke Oven Emissions

CAS#	Chemical name
0	Cyanide Compounds 1
0	Glycol ethers 2
0	Lead compounds
0	Manganese Compounds
0	Mercury Compounds
0	Fine mineral fibers 3
0	Nickel Compounds
0	Polycyclic Organic Matter 4
0	Radionuclides (including radon) 5
0	Selenium Compounds

NOTE:For all listings which contain the word "compounds" and for glycol ethers the following applies:Unless otherwise specified, these listings are defined as including any unique chemical substance that contains the named chemical (i.e., antimony, arsenic,etc.) as part of that chemical's infrastructure.

1 X'CN where X=H' or any other group where a formal dissociation may occur. For example KCN or Ca(CN)2

2 Includes moni- and di- ethers of ethylene glycol, diethylene glycol, and triethylene glycol R-(OCH2CH)n-OR' where

n=1,2, or 3

R=alky[illegible]yl groups

R'=R, H, or groups which, when removed, yield glycol ethers with the structure: R-(OCH2CH)n-OH. Polymers are excluded from the glycol category.

3 Includes mineral fiber emissions from facilities manufacturing or processing glass, rock, or slag fibers(or other mineral derived fibers) of average diameter 1 micrometer or less.

4 Includes organic compounds with more than one benzene ring, and which have a boiling point greater than or equal to 100 Celsius.

5 A type of atom which spontaneously undergoes radioactive decay.

BASE LIST OF SUBSTANCES KNOWN TO CAUSE ADVERSE EFFECTS TO HUMAN HEALTH OR THE ENVIRONMENT IN AN ACCIDENTAL RELEASE

Chlorine

Anhydrous ammonia

Methyl chloride

Ethylene oxide

Vinyl chloride

Methyl isocyanate

Hydrogen cyanide

Ammonia

Hydrogen sulfide

Toluene diisocyanate

Phosgene

Bromine

Anhydrous hydrogen chloride

Hydrogen fluoride

Anhydrous sulfur dioxide

Sulfur trioxide

NOTE: The chemicals listed above are the basic chemicals that must included in a list of 100 chemicals that may cause death, injury, or serious adverse human health or environmental effects. The EPA must announce this list within two years of enactment of the Clean Air Act.

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My summer's research at the Toxic Hazards Division was a success. I acquired many skills which I did not recognize I was capable of comprehending. I felt very welcome and needed the entire summer and I am looking forward to returning next year.

RDL SUMMER APPRENTICESHIP FINAL REPORT

Brian Gose

During my apprenticeship, I worked on a couple of different projects. The first of which was to write a program in C++ designed to create an output file to be used later next year with a B-52 flight simulator. The project itself was confidential, and hence, I don't know all of the specifics, but the output file I created is to be used as information coming in from the B-52's scanners. The second task I performed was to interview people. During the interview I was required to draw a concept map while the subject brainstormed about the essentials of driving. After this, the subject then designed a storyboard of a car's dashboard. Not only was this task an experiment in how people organize thoughts, but it also prepared a method for the real experiment intended to design a heads-up display for fighter planes.

When I first arrived at Wright Patt, my division wasn't really prepared for an apprentice. My mentor was on TDY and everybody was busy, so it started slow. I learned some basics about repairing and re-configuring computers to pass the time when I didn't have a project to work on. The first one assigned to me was to develop the software described above.

I performed this for Lt. Col. Marshak since my mentor was always on leave. By the time I finished, she was ready to put me to work in her experiments.

The psychological aspect of the experiment was to determine whether people are more efficient when thinking concept-wise or visually. The experiment we designed consisted of two parts : 1)Draw a picture of a car dashboard which contained everything needed to drive a car. 2)Dictate the essential information needed to drive a car while a concept map was drawn to describe what the subject was thinking. The problem being to determine which method produced the best results, some test subjects drew the storyboard and then the concept map while some performed the experiment in reverse order.

The results of our experiments were surprising. We learned that it didn't matter which way the experiment was performed because both items (the concept map and the storyboard) were needed to describe the subject's ideas to the full extent possible. If the subject created a concept map first, then s/he based the storyboard design off of the map while creating a storyboard first tended to make the concept map a description of the items in storyboard. Either way, both elements, as we learned were necessary to describe the subject's ideas. This experiment really did nothing to further the design of an experiment to create a heads-up display, but it did produce an interesting psychological concept to keep in mind during its creation.

I feel as if my work on the base did have an influence on what was happening with my mentor's experiments and the relationship proved fruitful for myself as well. I got to see what engineering is really about and how a real life work situation is structured. I feel that these are valuable lessons which will give me a definite advantage over college peers with no exposure to real engineering. Therefore, this experience was a positive one and I hope to seek more opportunities like it in the near future.

Brian M. Gore

COOPERATIVE LEARNING AND PROBLEM SOLVING

Claire Grazier

The objective of the study was to determine how the cooperative problem-solving processes of a group affected the learning effectiveness of each individual at a later time. The fifty-six subjects were either placed in a group of two members or else they worked individually to solve an ill-defined nature story problem. After they finished that problem and a brief filler task, each subject individually solved a second similar problem to see what knowledge had been transferred. Texts of their verbalized t' ught processes were analyzed and coded to determine metacognitive stratagies. The subjects were also given recall tests to determine memory performance.

More and more people are working in a group setting to accomplish certain tasks, such as are in research and education. There is still, however, a question of what counts as successful cooperative learning. This study is attempting to determine how the cooperative learning processes of a group compare to those of an individual, and also how those processes affect the later learning recognition of each individual membe . The effectiveness of the cooperative learning is th r evaluated as the group-to-individual learning is compared with that of the individual-to-individual.

The subjects for the study were fifty-six randomly selected university students who could read and write and had basic math skills. The subjects were randomly divided into two learning conditions, either a group of two or individual. There were fourteen groups and twenty-eight individuals.

During the first session, the subjects solved an ill-defined nature problem involving a search and rescue task. This problem was called the JASPER II problem, and it was presented on laserdisc. The subjects, either cooperatively or individually, had to identify, define, and solve several inter-related dilemnas in order to solve the whole problem. They had sixty minutes to attempt to solve the task. While solving this problem, as well as the follow-up problem, the subjects spoke their thoughts aloud, and they were recorded both by an audio cassette player and a video camera.

The subjects then completed a filler task for about ten minutes, which required them to give autobiographical information as well as their problem-solving style. This served mainly to get the subjects' minds away from the problems for a little while.

After the filler task, each subject then individually solved the transfer problem, which was called the REPSAJ problem. This problem was similar to the JASPER II problem both in storyline and solution procedure. It was presented on paper, and the subjects only had forty minutes to attempt to solve it. Because the two problems were close analogies of each other, there was opportunity to look for transfer of learning between the first problem and the second one.

A minimum of three days later the subjects returned for the second session, which involved a memory recall/recognition test. The test consisted of forty questions, both multiple-choice and fill-in-the-blank, and the questions covered both stories. The subjects had thirty minutes to answer them.

The analysis of the data began with getting a typewritten manuscript of each subject's verbalized thoughts, taken from an audio cassette. These manuscripts were then edited using the video cassette of each subject. After all of the JASPER and REPSAJ transcripts were edited, they were segmented in preparation for coding. They were segmented between thoughts. A protocol analysis software called SHAPA was used to do the coding. Throughout the problem, there were several different goals, statements, means of obtaining answers, and outcomes. All of these had different codes; there were also codes for segments that were uncodeable, repetition, error, assumption, and so on. Each segment of the text was then encoded using these different codes. Eventually, this will show what type of cognitive strategies the different groups and individuals have used in their problem-solving efforts. This evaluation, however, has not been done yet.

As well as being coded, the text was also evaluated as to the quality of the solution. Certain important elements were looked for in the solution, and it was noted whether they were mentioned, attempted or solved correctly. A percentage was then calculated for solution quality. Their total time of problem-solving was also considered, as was the total number of words which they spoke. For the groups, the texts were analyzed for evidence of a dominant member and a passive member. The data from the JASPER problem will be compared to that from the REPSAJ problem to see how much transfer of learning actually took place. Some points of comparison are as follows:

1) Does the group condition do better than the individual condition on transfer, recall, or both?

2) Does the shared group member condition do better on all stages than the dominant member or passive member condition?

3) Does the dominant member do better than the passive member (of the same group)?

4) Does the passive or dominant group member do better than the individual problem solver?

The study so far has not progressed enough to have fully analyzed all the data or to have answered the above questions and come to any conclusions. When those questions are answered, there will be a concrete way to determine what constitutes success in a cooperative learning situation, and if indeed it is generally better to work in a group as opposed to working individually.

This is a summary of proposed and current research being conducted by Michael D. McNeese at the Harry G. Armstrong Aerospace Medical Research Laboratory at Wright-Patterson Air Force Base, Ohio. As a summer research associate, I assisted with the preliminary reduction and analysis of the data which had been previously collected.

DEANNA JENDE

REPORT NOT AVAILABLE

AT TIME OF

PUBLICATION

COMPARISON OF 3-D NOISE HEADTRACKERS

Miss Jennifer M. Kim

My work at Wright Patterson Air Force Base consisted of research in the area of Bioacoustics. After performing a study to become familiar with the various pieces of equipment and types of noise and pure tones, I began work comparing two 3-D noise headtracker systems to discover the more efficient one. The two systems, the Polyhemus 3SPACE and the Ascension Technologies BIRD, were set in a lab testing environment and the same test was done on each. The collected data was compared for speed of transmission and for accuracy. I also spent time working in an anechoic chamber, calibrating speakers within an auditory localization facility, which was a sphere containing 272 speakers at 15 degree spacings. This sphere was used to collect data to synthetically test 3-D sound over headphones.

The Polyhemus 3SPACE Isotrak utilizes low frequency magnetic field technology to determine the position and orientation of a sensor in relation to a source or other specified reference frame. This provides a 6 degree-of-freedom measurement device, in which the provided information may be transmitted to a computer in ASCII, Binary, or C language format. The source generates the low frequency magnetic field which is then picked up by the sensor. This data is then measured by a computer. The Isotrak configuration comprises a system electronics unit (SEU), which contains all the hardware and software necessary for the 3SPACE system to compute the location of the sensor in position and orientation. The SEU contains analog circuitry to generate and sense the magnetic fields, and digitize the sensed analog signals. Because the sensor works by picking up the low frequency magnetic field put out by the generator, the 3SPACE is very susceptible to metal and magnets.

The Ascension Technology Corporation's BIRD also provides a six degrees-of-freedom input device, but uses some new technology that claims to overcome problems found in the 3SPACE, such as blocking, interference, and metal problems. The system reads low power pulsed DC magnetic fields to calculate the spatial coordinates and direction of movement. The size of the source and sensor are quite small in comparison to the 3SPACE. To ensure accuracy, the BIRD first measures the earth's magnetic field and then measures the steady magnetic field generated by the transmitter. The earth's field is then subtracted from the total, yielding the true position and orientation measurements, supposedly in the prescence of metals.

The problem tested was to see if the BIRD really was more acurate than the 3SPACE, as Ascension Technologies claims, with less limiting factors in the measuring and applying of 3-

D sound. The difference stems in that the BIRD utilizes a DC magnetic field, which is much more steady than the AC magnetic field used in the 3SPACE. As the AC field varies, it induces eddy currents in any nearby metals, causing them to become electromagnets. These new electromagnets produce a field that can be picked up by the 3SPACE sensor and distort the measurements. The DC magnetic field of the BIRD also generates eddy currents, but only when the field is turned on or off, since eddy currents are created only when the magnetic field changes. The BIRD's transmitter generates a DC field in a sequence of pulses, one for each measurement. The rising edge of each DC pulse causes an initial burst of eddy currents in nearby metals, but once the field reaches a steady rate, no new eddy currents are generated. The initial eddy currents supposedly decay very quickly, so that a virtually error free measurement can be made if a short time period is allotted for the eddy currents to decay. The eddy currents decay so rapidly that, at 100 measurements per second, the BIRD is still the fastest 6D position and orientation measuring device available. The speed and accuracy of transmission were the objectives of the lab study. Due to the above information, the BIRD would be the more accurate and faster of the two systems. Both systems were set up in the same environment, and the tests were actuated.

KEMAR
TEST DATA

OPERATOR: **DATE:**
SYSTEM NAME:

AZIMUTH(FIXED)	AZIMUTH	ELEVATION
0	0.0	0.0
15	15.4	0.20
30	29.90	0.44
45	45.64	0.73
60	60.12	1.05
75	74.82	1.88
90	89.96	1.69
105	105.16	1.96
120	120.06	2.18
135	135.07	2.35
150	150.60	2.46
165	165.72	2.48
180	-179.38	2.37

0' Az

ELEVATION(FIXED)	AZIMUTH	ELEVATION
0	0.02	0.02
15	-0.13	-14.94
30	-0.93	-31.79
45	-3.60	-45.15
60	-9.82	-59.61
75	-26.31	-72.53
90	-126.87	-76.75

KEMAR
TEST DATA

OPERATOR:
SYSTEM NAME:

DATE:

AZIMUTH(FIXED)	AZIMUTH	ELEVATION
0	0.0	0.0
15	15.4	0.20
30	29.90	0.44
45	45.04	0.73
60	60.12	1.05
75	74.82	1.38
90	89.90	1.69
105	105.16	1.96
120	120.06	2.18
135	135.07	2.35
150	150.60	2.46
165	165.72	2.48
180	-179.38	2.37

15° Az

ELEVATION(FIXED)	AZIMUTH	ELEVATION
0	15.10	0.29
15	14.88	-14.77
30	14.15	-29.99
45	11.47	-45.22
60	5.14	-59.83
75	-14.74	-72.42
90	-117.00	-76.07

[illegible]

TEST DATA

OPERATOR: **DATE:**

SYSTEM NAME:

AZIMUTH(FIXED)	AZIMUTH	ELEVATION
0	0.0	0.0
15	15.4	0.20
30	29.90	0.44
45	45.04	0.73
60	60.12	1.05
75	74.82	1.38
90	89.96	1.69
105	105.16	1.96
120	120.06	2.18
135	135 07	2.35
150	150.60	2.46
165	165.72	2.48
180	-179.38	2.37

30° Az

ELEVATION(FIXED)	AZIMUTH	ELEVATION
0	30.21	0.55
15	29.95	-14.39
30	28.89	-29.47
45	26.70	-[illegible].63
60	19.09	-60 2
75	-2 59	-72.18
90	-110.76	-[illegible]6.71

KEMAR
TEST DATA

OPERATOR: DATE:
SYSTEM NAME:

AZIMUTH(FIXED)	AZIMUTH	ELEVATION
0	0.0	0.0
15	15.4	0.20
30	29.90	0.44
45	45.04	0.73
60	60.12	1.05
75	74.82	1.38
90	89.96	1.69
105	105.16	1.96
120	120.06	2.18
135	135.07	2.35
150	150.60	2.46
165	165.72	2.48
180	-179.38	2.37

45° Az

ELEVATION(FIXED)	AZIMUTH	ELEVATION
0	44.74	1.01
15	44.41	-14.50
30	44.03	-29.31
45	41.73	-44.56
60	33.86	-59.55
75	7.73	-72.80
90	-95.45	-77.08

KEMAR
TEST DATA

OPERATOR: DATE:
SYSTEM NAME:

AZIMUTH(FIXED)	AZIMUTH	ELEVATION
0	0.0	0.0
15	15.4	0.20
30	29.90	0.44
45	45.04	0.73
60	60.12	1.05
75	74.82	1.38
90	89.96	1.69
105	105.16	1.96
120	120.06	2.18
135	135.07	2.35
150	150.60	2.46
165	165.72	2.48
180	-179.38	2.37

60° Az

ELEVATION(FIXED)	AZIMUTH	ELEVATION
0	59.92	1.58
15	59.48	-13.36
30	59.68	-28.61
45	57.46	-43.58
60	48.89	-58.75
75	21.29	-73.06
90	-87.65	-77.85

KEMAR
TEST DATA

OPERATOR: DATE:
SYSTEM NAME:

AZIMUTH(FIXED)	AZIMUTH	ELEVATION
0	0.0	0.0
15	15.4	0.20
30	29.10	0.44
45	45.04	0.73
60	60.12	1.05
75	74.82	1.38
90	89.96	1.69
105	105.16	1.96
120	120.06	2.18
135	135.07	2.35
150	150.60	2.46
165	165.72	2.48
180	-179.38	2.37

75° Az

ELEVATION(FIXED)	AZIMUTH	ELEVATION
0	74.93	1.69
15	75.08	-13.40
30	75.37	-28.34
45	75.56	-43.35
60	61.83	-58.43
75	35.16	-73.04
90	-68.01	-79.10

KEMAR
TEST DATA

OPERATOR: **DATE:**
SYSTEM NAME:

AZIMUTH(FIXED)	AZIMUTH	ELEVATION
0	0.0	0.0
15	15.4	0.20
30	29.90	0.44
45	45.04	0.73
60	60.12	1.05
75	74.82	1.38
90	89.96	1.69
105	105.16	1.96
120	120 06	2.18
135	135.07	2.35
150	150.60	2.46
165	165.72	2.48
180	-179.38	2.37

90° A_z

ELEVATION(FIXED)	AZIMUTH	ELEVATION
0	90.02	1.82
15	90.86	-12.68
30	90.73	-27.36
45	90.26	-43.24
60	88.81	-57.61
75	44.65	-72.40
90	-42.69	-7991

KEMAR
TEST DATA

OPERATOR: DATE:
SYSTEM NAME:

AZIMUTH(FIXED)	AZIMUTH	ELEVATION
0	0.0	0.0
15	15.4	0.20
30	29.90	0.44
45	45.04	0.73
60	60.12	1.05
75	74.82	1.38
90	89.96	1.69
105	105.16	1.96
120	120.06	2.18
135	135.07	2.35
150	150.60	2.46
165	165.72	2.48
180	-179.35	2.37

105° Az

ELEVATION(FIXED)	AZIMUTH	ELEVATION
0	105.05	2.00
15	105.78	-12.24
30	105.62	-27.31
45	104.68	-42.45
60	102.28	-57.30
75	129.13	-71.50
90	-23.14	-80.66

KEMAR
TEST DATA

OPERATOR: DATE:
SYSTEM NAME:

AZIMUTH(FIXED)	AZIMUTH	ELEVATION
0	0.0	0.0
15	15.4	0.20
30	29.90	0.44
45	45.04	0.73
60	60.12	1.05
75	74.82	1.38
90	89.96	1.69
105	105.16	1.96
120	120.06	2.18
135	135.07	2.35
150	150.60	2.46
165	165.72	2.48
180	-179.38	2.37

120° Az

ELEVATION(FIXED)	AZIMUTH	ELEVATION
0	120.12	2.11
15	121.11	-11.25
30	120.72	-26.96
45	118.81	-42.19
60	116.87	-56.69
75	134.34	-75.37
90	-6.20	-80.49

The results of the lab tests showed that the BIRD system was indeed faster in transmitting the data to the computer. This is because the BIRD can handle 100 hz where the 3SPACE handles much less (about 30hz). This would allow more power to go through and the information to be carried more quickly. However, the BIRD system did not prove to be more accurate than the 3SPACE system. Both lost accuracy after 60 degrees of elevation (probobly good up to 70 degrees, but measurements were done in 15 degree increments) but the azimuth stayed true for 180 degrees as long as the elevation remained at zero. When the elevation changed to the point of losing accuracy, the azimuth readings also lost accuracy. Therefore, I conclude that due to the increased power capacity of the BIRD, the Ascension Technologies system is faster in transmitting data than the Polyhemus 3SPACE. However, both systems are strongly affected by metals, the 3SPACE because of the eddy currents caused by its use of AC flow, the BIRD because the sequences of pulses emitted by the DC flow per measurement caused eddy currents in the metals that did not decay as quickly as they were supposed to. These currents then caused the surrounding metal to become electromagnetic, producing a current that interfered with the data collection of the BIRD sensor. This was discovered by the BIRD's inability to properly function near its metal stand. Consequently, an all wood structure had to be built to get accurate readings from the system. Both systems are very susceptible to magnets of any kind. This was discovered with the KEMAR manikin, whose mouth piece contains a magnet that, for a while, interfered with all data readings until it was removed.

In conclusion, the BIRD has some definite advantages over the 3SPACE in the capacities of time for transmission. However, in the aspect of accuracy, both systems are very similar in that they lose their accuracy around magnets, metals, and when the elevation is beyond 60 degrees.

The Characteristics of Noise

Purpose: To become familiar with various pieces of equipment used in acoustical research and the characteristics of noises and frequencies this equipment measures.

Equipment:
HP 8116A Pulse/Function Generator
2131 Digital Frequency Analyzer
454 Oscilloscope
HP RMS Voltmeter
1382 Random-Noise Generator
HP Universal Filter

Procedure: Assemble equipment in orderly fashion with signal and noise generators located at left or right side. Hook up cables so that every piece of equipment is accessible to generators.

1. Observation of the signal generator
   a. Set up generator with indicator on sine waves.
   b. Measure from the voltmeter the RMS voltage and from the oscilloscope the peak to peak voltage for frquencies of 100,500, 1K, 4K, and 8KHz.
   c. Calculate crest factor = Vp-p/Vrms.
   d. From the digital frequency analyzer, measure the 1/3 octave band output.
   e. Calculate the OA =   (1/3OB).
   f. Repeat for triangle and square waves.
   NOTE: For square waves, measure the peak voltage instead of the peak to peak voltage.

2. Observation of the noise generator
   a. Set spectrum on pink noise.
   b. Measure RMS voltage and peak voltage for the following:
      i) Low pass filter at 500, 2K, and 4KHz.
      ii) High pass filter at 100, 1K, and 4KHz.
      iii) Band pass filter at 250, 1K, and 4KHz.
   c. Calculate the crest factor as shown above.
   d. Repeat for white and USASI noise.

Signal Generator

Sine wave

	100Hz	500Hz	1KHz	4KHz	8KHz
Vp-p(mV)	260	101	175	300	225
Vrms(mV)	183.82	71.407	123.73	212.1	159.075
Vp-p/Vrms	1.414	1.414	1.414	1.414	1.414
Vp-p/Vrms (dB)	3.01	3.01	3.01	3.01	3.01
1/3 OB(dB)	87.6	87.9	90.6	90.5	90.325

OA= (1/3 OB) 96.57

Triangle wave

	100Hz	500Hz	1KHz	4KHz	8KHz
Vp-p(mV)	400	210	300	250	240
Vrms(mV)	240	126	180	150	144
Vp-p/Vrms	1.67	1.67	1.67	1.67	1.67
Vp-p/Vrms (dB)	4.45	4.45	4.45	4.45	4.45
1/3 OB(dB)	82.45	83.13	83	87.5	86.74

OA= (1/3 OB) 92.08

Square wave

	100Hz	500Hz	1KHz	4KHz	8KHz
Vp-p(mV)	220	250	250	180	80
Vrms(mV)	220	250	250	180	80
Vp-p/Vrms	1	1	1	1	1
Vp-p/Vrms (dB)	0	0	0	0	0
1/3 OB(dB)	88.53	91.77	90.84	91.1	88.83

OA= (1/3OB) 97.39

Random Noise Generator

Pink noise

	Low Pass			High Pass			Band Pass		
	500Hz	2KHz	4KHz	100Hz	1KHz	4KHz	250Hz	1Khz	4KHz
Vpk (V)	1.5	1.5	1.6	2.0	1.6	1.5	0.4	0.2	0.2
Vrms (V)	0.51	.508	.612	0.62	0.44	0.43	0.11	.061	.051
Vpk/ Vrms	2.91	2.95	2.64	3.23	3.64	3.49	3.64	3.28	3.92
Vpk/ Vrms(dB)	9.28	9.40	8.35	10.2	11.2	10.9	11.2	10.3	11.9

White noise

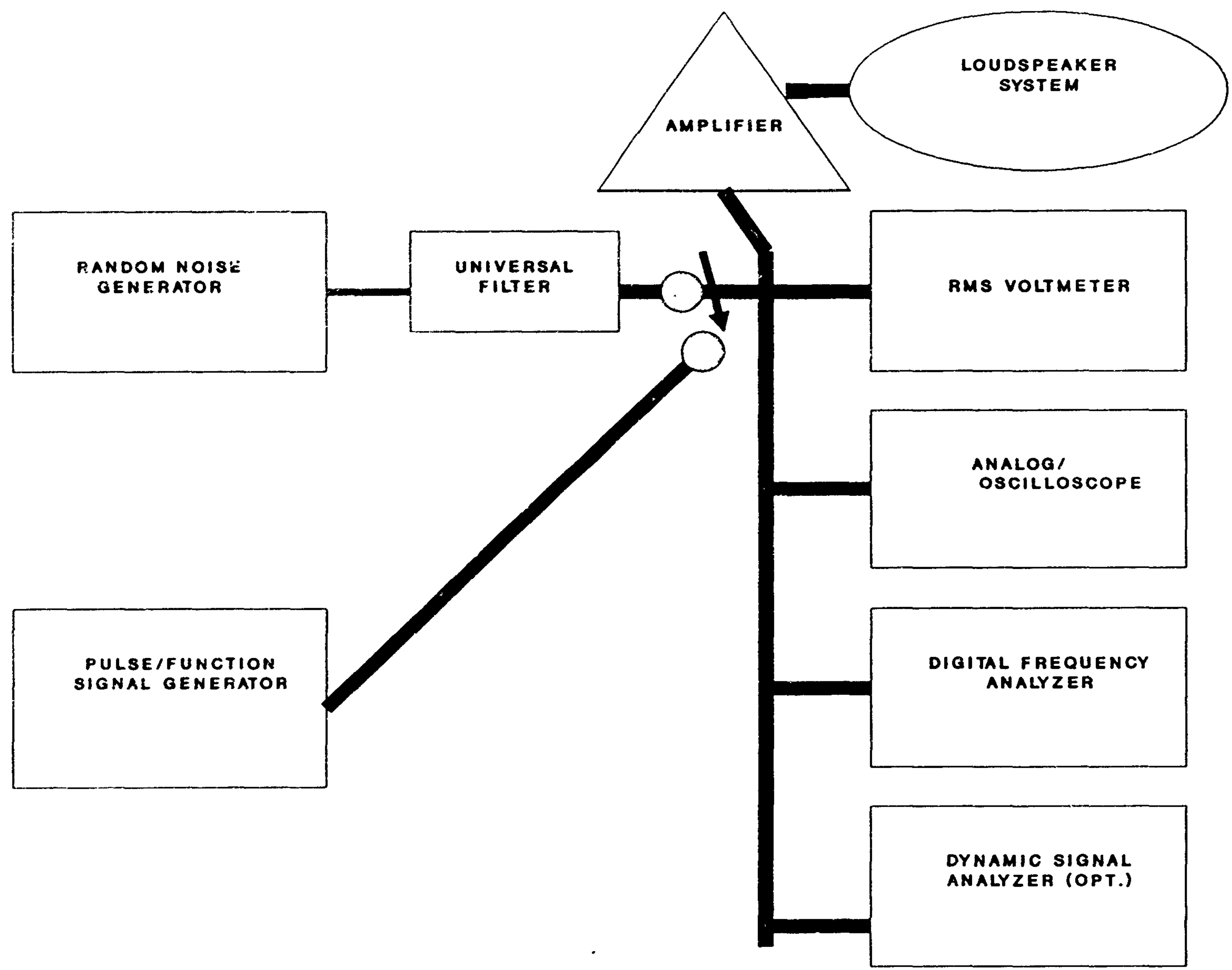
	Low Pass			High Pass			Band Pass		
	500Hz	2KHz	4KHz	100Hz	1KHz	4Khz	250Hz	1Khz	4Khz
Vpk (V)	3.0	0.6	0.85	2.0	2.2	2.3	.04	.12	.22
Vrms (V)	.079	.146	0.20	0.66	0.66	0.64	.016	.029	.056
Vpk/ Vrms	3.797	4.11	4.25	3.03	3.33	3.59	2.50	4.14	3.93
Vpk/ Vrms(dB)	11.6	12.3	12.6	9.63	10.5	11.1	7.96	12.3	11.9

USASI noise

	Low Pass			High Pass			Band Pass		
	500Hz	2Khz	4KHz	100Hz	1KHz	4KHz	250Hz	1KHz	4KHz
Vpk (V)	2.0	3.0	3.0	3.0	2.0	1.0	0.4	0.4	0.2
Vrms (V)	0.53	0.68	0.69	0.68	.449	.271	0.11	0.09	0.05
Vpk/ Vrms	3.77	4.41	4.35	4.41	4.45	3.69	3.64	4.44	4.0
Vpk/	11.53	12.9	12.8	12.9	12.9	11.3	11.2	12.9	12.1

Conclusion: In the case with the signal generator, the sine waves were shown to generate a purer tone than the square or triangle waves, both of which contain higher frequencies than the sine waves. At the levels of higher frequency, the square waves generate a slightly higher level of output than the triangle waves.

In the case of the random - noise generator, the pink noise, in comparison with the white and USASI noise, generates a more evenly distributed output which favors the lower frequencies over the high ones. With white noise, the high frequencies are mainly favored over the lower ones. USASI noise generates fewer high frequencies than the pink noise, but has a higher level of output with the frequencies found towards the middle of the high and low.


AMPLIFIER
LOUDSPEAKER SYSTEM
RANDOM NOISE GENERATOR
UNIVERSAL FILTER
RMS VOLTMETER
ANALOG/ OSCILLOSCOPE
PULSE/FUNCTION SIGNAL GENERATOR
DIGITAL FREQUENCY ANALYZER
DYNAMIC SIGNAL ANALYZER (OPT.)

TERATOGENICITY OF D-LIMONENE TO XENOPUS EMBRYOS

RESEARCH PAPER
SUMMER of 1991

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TERATOGENICITY OF D-LIMONENE TO XENOPUS EMBRYOS

Rosalie D. Hemeyer

ABSTRACT

d-Limonene is a naturally occurring compound found in several new aircraft cleaners. Although considered relatively non-toxic, the exposure potential for Air Force workers and limited chronic health effect data made it desireable to determine the teratogenicity of d-limonene. The FETAX teratogen assay was selected for this purpose. Much information was collected on the p-oper operation of the FETAX assay, and limited data collected showed some teratogenic effect from d-limonene exposure. Further studies will be carried out to confirm or deny these initial observations.

INTRODUCTION

d-Limonene (4-isoprophenyl-1methyl-1cyclohexane) is a naturally occurring compound derived from citrus fruit. It is effective as a cleaning agent and is used by several Air Force installations to clean and inspect aircraft. From an acute toxicity standpoint, d-limonene is generally regarded as a safe compound (TOMES 1991). Limited data are available concerning the chronic effects of d-limonene exposure. Homberger and Boger (1968) noted that d-limonene could cause skin tumors when applied dermally to some animal species. Traul et al. (1981)

demonstrated that d-limonene was a promoted transformation in rat embryo cells.

Significant potential exists for worker exposure to d-limonene at Air Force installations. In addition, a potential also exists for environmental contamination, as the excess cleaner is often washed down the sanitary or industrial waste system. Thus, it is important to assess the potential health effects of d-limonene to military and civilian Air Force personnel. proper identification of the health effects will lead to the incorporation of proper personal protective equipment (PPE) for workers using d-limonene.

Bioassay is typically . ·d to determine the effect of chemical compounds on living organisms. Basic bioassay theory involves exposing a group of test organisms to varying concentrations of the compound and observing the effect at each concentration. An unexposed set of control organisms are core compared to the test organisms as well (Holck, 1990). Classically, bioassays have looked at the death of the test organisms as an endpoint. Recently, chronic effects such as reproductive changes, mutagenicity, carcinogenicity, and teratogenicity are being assessed using bioassay techniques as well.

As a part of the Occupational and Environmental Health Directorate of the Armstrong Laboratory (AL/OEMB), we were interested in expanding our bioassay capability to include teratogenicity assays. A project to

felt that d-limonene would be an ideal compound to test while bringing on-line the Frog Embryo Teratogen Assay - Xenopus (FETAX) assay described by Dumont et al. (1983).

MATERIALS AND METHODS

Proposed standard methodology (ASTM 1991) for the FETAX assay was used. Details relevant to these experiments are as follows:

Geometric standard concentration of d-limonene (in acetone) in FETAX solution were prepared from 0.00114 ppm to 114ppm. The higher represented the maximum concentration soluble in 1% (v/v) with acetone. Positive lethal and teratogenic controls using 6-aminonicotinamide were also performed. Non-lethal controls using FETAX solution and 1% (v/v) acetone in FETAX solution were also performed.

Adult male and female Xenopus laevis (Daudin) were injected with human chorionic gonadotropin to induce mating. Eggs collected were reared to the blastula stage as determined by Nieuwkoop and Faber (1967) and Bantle et al. (1991). Groups of 25 blastulae were exposed for 96-h to the above mentioned concentrations of d-limonene and control solutions, with the solution being replaced every 24-h. Mortality was also recorded at 24-h intervals. After the 96-h exposure period was complete, the remaining immature Xenopus were fixed in 3% formalin and examined for anatomical mutations using Bantle et al. (1991) as a guide.

RESULTS

This effort represented the first time that the FETAX assay was performed at AL/OEMB. As such, a considerable amount was learned on performing the FETAX assay as well as some information on d-limonene teratogenicity. Great strides forward were made in Xenopus colony maintenance, reproductive stimulation, egg viability determination, and assay scheduling. The data collected will be incorporated into a complete set of Operating instructions (OI's) for the FETAX assay at AL/OEMB.

Survivorship of Xenopus embryos did not differ significantly from the appropriate controls. Teratogenicity was observed at the 0.00114 ppm concentration, but did not show dose-response effect. Further trials are planned to better elucidate the response.

CONCLUSION

This research represents an initial attempt to scientifically determine the teratogenic effects of d-limonene using the FETAX assay. Although we observed some mutations, many more trials will need to be conducted before we feel comfortable in stating that d-limonene is or is not teratogenic.

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THE USE OF SPECTROPHOTOMETERS IN METALS ANALYSIS

Physical Science Technician
Marsha Gayle Henke

This summer I worked as a physical science technician analyzing water and soil samples for the presence of metals. Though no research was involved, these analyses are important in determining possible environmental and/or occupational hazards in United States military bases throughout the world. To test for metals including copper, iron, manganese, nickel, zinc, magnesium, potassium, calcium, sodium, chromium, cadmium, silver, lead, beryllium, and barium, a Flame Atomic Absorption Spectrophotometer was utilized. My time was spent working this spectrophotometer along with a Hydride Generator to test these samples for mercury. In addition, I aided in general and preventive maintence of the flame spectrophotometer, logged out results to be sent to customers, kept statistics on the percision and accuracy of both spectrophotometers, and spent two weeks training a new technician to run the flame. The experience of working as a laboratory technician has enhanced my knowledge of chemistry and laboratory work in general. and I hope to continue my learning next summer.

For eight weeks this summer I worked in the Occupational and Environmental Health Directorate of the Armstrong

Laboratories at Brooks Air Force Base, San Antonio, Texas. The Occupational and Environmental Health Directorate, or OEHD, assesses occupational and enviornmental health risks of military bases throughout the world. The directorate consists of five divisions including Radiation Services, Health Surveillance, Water Quality, Industrial Hygiene, and Analytical Services where I conducted my work testing soil, potable, and nonpotable water for the presence of metals. This division is composed of the Environmental Chemistry, Occupational Chemistry, Quality Assurance, and Technical Operations branches.

The Armstrong Laboratories were formed from the consolidation of the Environmental Health Laboratories at Kelly Air Force Base in Texas and McClellan Air Force Base in California as well as the Radiological Health Laboratory at Wright-Patterson Air Force Base, Ohio. This consolidation was based on a 1976 proposal by the United States Air Force, Senators Hubert H. Humphrey and John Glenn, and Congressmen Charles W. Whalen Jr. and John E. Moss. The purposes of the consolidation were to improve the effectiveness of the Air Force's Occupational and Environmental Health program and avoid the cost of facility construction at the three labs. Later studies further showed that the consolidation would allow people to work with colleagues in similar fields, utilize already existent equipment at Brooks Air Force Base, and share facilities with United States Air Force School of Aerospoace Medicine. Consequently, the United States Air Force Occupational and Environmental Health Laboratory was activated, effective September 30, 1976.

Because of the consolidation of the three laboratories, OEHD consists of many branches to cover the diversity of work including Enviornmental Chemistry. This branch provides chemical analysis for the United States Air Force's Environmental Control Program. For example, soil, air, and Vegetation samples are tested for pesticides and other harmful organic materials. In addition, wastewater and drinking water samples are analyzed in compliance with the Environmental Protection Agency's safe drinking water and permitted wastewater discharge standards.

Likewise, the Occupational Chemistry Branch analyzes air samples for potential occupational hazards. These samples are collected on various solid substrates such as filter papers and charcoal tubes, and analyzed for the presence of chemical contaminants found in industrial areas. These analyses pinpoint possible health hazards to workers.

To assure the reliability of these quality control programs, the Quality Assurance Branch administers the Laboratory's certification program in compliance with government and independent accrediting agencies. Besides maintaining federal standards, the branch conducts additional studies to assure the accuracy of the analyses.

In conjunction with the laboratory branches, the Technical Operations Branch provides the development and use of new technology, supervises sample control and management, and communicates with customers on sample status.

I conducted my work in the Metals Section of the Analytical Services Division. This branch analyzes the chemical makeup of various samples including water, soil, air, gas, and biological specimens.

The metals section of this branch analizes these samples for the presence of metals by utilizing Flame Atomic Absorption, Graphite Furnace Atomic Absorption, Inductively Coupled Plasma Emission, and Hydride Generator spectrophotometers. The analyses of water and soil samples are monitered by the Environmental Protection Agency while Air samples are tested in compliance with OSHA and NIOSH standards. All analyses are also monitered by state agencies. Besides these general analyses, the section also engages in special projects such as the Air Force Lead Assessment Program (LAP) which moniters drinking water for the presence of lead at Air Force bases worldwide. Other analyses include the testing blood of POW's in Iraq for the presence of lead, the analyses of soap for Boron content, and the analyses of make-up in the Middle East for suspected lead content in conjunction with a national university.

A majority of the incoming samples are water and soil from United States Military bases. These samples are shipped to Sample Control in OEHD. There they are given a sample number and sent to the metals section if the customer has requested that the sample be tested for a metal. A computer printout, or worksheet, listing which metals need to be tested for is provided. If the sample is listed as a priority it is run as soon as possible and the results are given to the sender over the phone. These results are then logged out onto the corresponding worksheet, typed up, and mailed to the customer. However, if the sample is not a priority, it is placed on a shelf with the other regular samples, and the worksheet is placed on a clipboard with the others. Since each spectrophotometer except the ICP can only run one elemental analysis at a time, the technician checks the worksheets and runs samples that need to be tested for the same element together. The results are then logged into the worksheets, typed up, and mailed to the customer.

The Hydride Generation System, one of the four spectrophotometers used in the section, analyzes samples for the presence of mercury. By adding sodium borohydride to the sample, gaseous hydrides of mercury are produced. These hydrides are swept from the sealed reaction cup holding the sample to a heated quartz cell by an argon purge. To determine the amount of mercury in the sample, a peak absorbance level is produced from the atomization of the vapor, and the concentration is calculated from this.

To screen for metals at higher concentrations, the Inductively Coupled Plasma Atomic Emission Spectrophotometer (ICP) is utilized. This machine has the lowest detection limits for refractory elements and lanthaids. It uses plasma to evaporate, dissociate, and excite atoms or ions. After being subjected to high energy from the plasma, the excited atom emits light at a particular wavelength for that element. These wavelengths, or emission lines, are used as "fingerprints" of elements because each element's electron configuration causes it to emit light at a unique wavelength. In quatitative analysis the intensity of the light at the wavelength of that element is measured and compared with the concentration calibration curves to determine the concentration of that element in the sample. The result is then printed out and logged into the worksheets.

The Graphite Furnace utilizes atomic absorption to analyze blood and water samples for lead. As in all atomic absorption units, free ground state atoms absorb light at certain wavelength and enter an excited state. In this particular spectrophotometer, light from a spectral lamp passes through the center of a graphite tube where the sample is placed. This supplies the energy for atomization. When the furnace is fired, the sample produces an atomic vapor which absorbs light from the lamp. As the atom concentration in the furnace rises the absorption signal peaks and then falls as the atoms diffuse from the furnace. The detection limits on the Graphite Furnace are one thousand times lower than those in flame atomic absorption.

The Flame Atomic Absorption Spectrophotometer is similar in the method of metal detection to the Graphite Furnace, yet a flame is used as the sample cell as opposed to a furnace. Here, lamps for a particular wavelenght emit light. This light beam runs through an aligned flame. Samples are read into the machine through an aspirating needle and sucked into a tube connecting the needle to the burner chamber which holds the burner head. It enters the platform through a nebulizer which sprays the drops as fine mist into the mixing chamber where it is mixed with fuel and oxidant gasses. The fuel enters through the fuel inlet and the oxident gasses come through the nebulizer oxidant. Large droplets of the sample are removed from the mixing chamber through a drain. The remaining aerosol then enters the flame where it is vaporized, and bonds are broken to form free state atoms. These atoms absorb the light comming from the light beam. When running the flame spectrophotometer, the first sample, deionized water, is auto zeroed. This flushes the system of previous samples. Then three standards of known concentrations are run followed by a quality control sample, the first sample, a spike consisting of five milliliters of a known standard and five milliliters of the previous sample, and the remaining samples. The absorbance level of the first standard is measured. The computer knows the concentration of the first three standards from a magnetic card inserted before the run begins. It plots the first known concentration with the absorbance level read to form a basis for the linear relationship between absorbance and concentration levels. For the remaining samples the absorbance levels are read and concentrations are calculated. The concentrations are then printed out in milligrams per liter. Three times during the run which can analyze thirty-five samples, deionized water is run and autozeroed, and a standard, or reslope, is analyzed to make sure the insturment is reading the samples correctly. A spike, a quality control sample, and the three standards are then tested upon the completion of the sample analyses.

The Occupational and Environmental Health Laboratories conduct various analyses of materials worldwide, and my experience working there this summer has proven to be challenging and very interesting. I feel that the experience I have gained from working in a lab of such high credentials has improved my academic and research qualifications and given me insight to the applications of chemistry. The laboratory scientists were very patient and eager to answer my many questions, and I greatly appreciate this. I am grateful for the opportunity to have worked at OEHD this summer, and I strongly hope to continue next year.

ACKNOWLEDGEMENTS

Thank you to:

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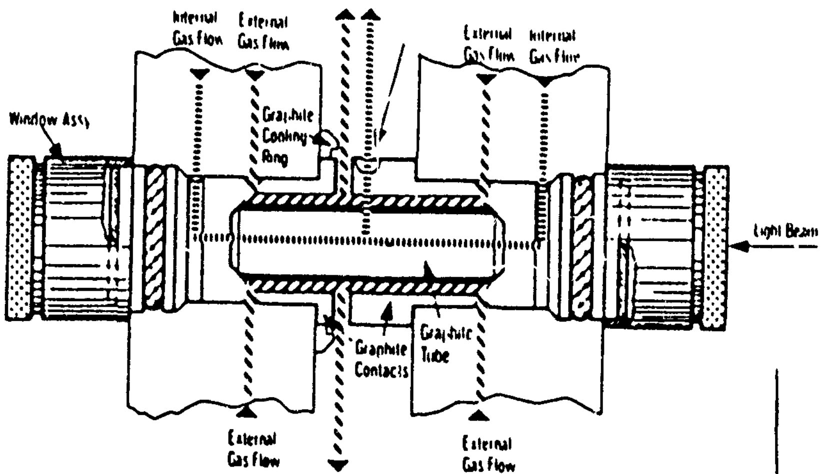
Everyone in the Analytical Services Division for making me feel so welcome;

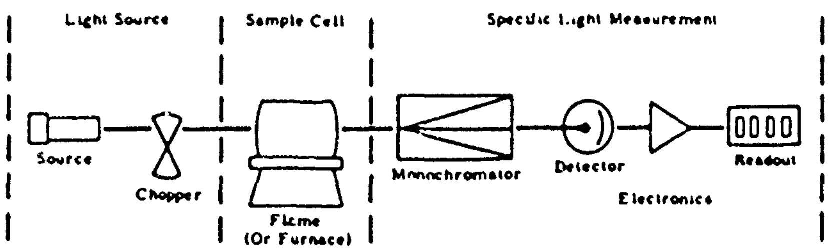
Mr. Burt Harrison and RDL for giving me the opportunity to work at Armstrong Laboratories this summer.

All diagrams from
Concepts and Techniques in Atomic Absorption Spectrophotometry

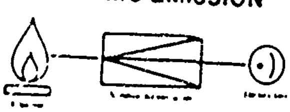
Graphite Furnace



SINGLE-BEAM ATOMIC ABSORPTION SPECTROPHOTOMETER



ATOMIC EMISSION



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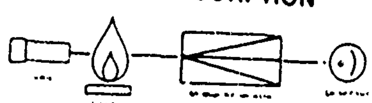
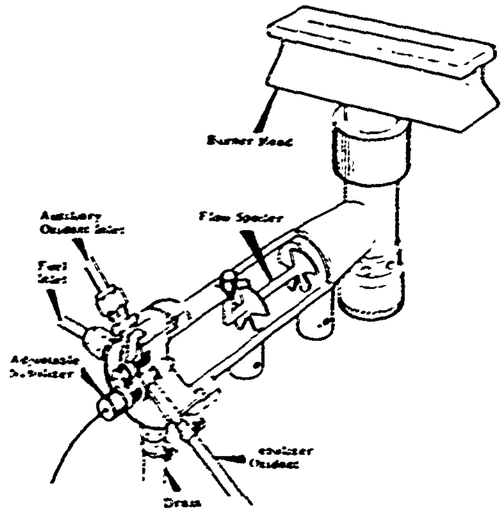
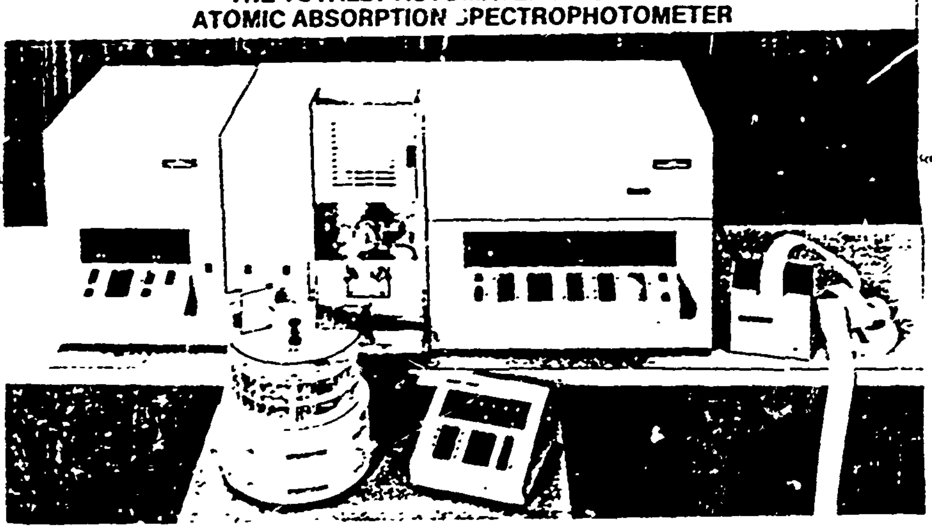


PREMIX BURNER SYSTEM



THE TOTALLY AUTOMATED MODEL 5000 ATOMIC ABSORPTION SPECTROPHOTOMETER



ELEMENTS WHICH CAN BE DETERMINED BY ATOMIC ABSORPTION SAMPLING SYSTEMS

Element	Flame	Furnace	Hydride	Boat	Element	Flame	Furnace	Hydride	Boat
Ag	x	x		x	Nb	x			
Al	x	x			Nd	x			
As	x	x	x	x	Ni	x	x		
Au	x	x			Os	x	x		
B	x	x			P	x	x		
Ba	x	x			Pb	x	x		x
Be	x	x			Pd	x	x		
Bi	x	x	x	x	Pr	x			
Ca	x	x			Pt	x	x		
Cd	x	x		x	Rb	x	x		
Co	x	x			Re	x	x		
Cr	x	x			Rh	x	x		
Cs	x	x			Ru	x	x		
Cu	x	x			Sb	x	x	x	
Dy	x	x			Sc	x	x		
Er	x	x			Se	x	x	x	x
Eu	x	x			Si	x	x		
Fe	x	x			Sm	x	x		
Ga	x	x			Sn	x	x	x	
Gd	x	x			Sr	x	x		
Ge	x	x	x		Ta	x			
Hf	x				Tb	x	x		
Hg	x	x	x	x	Tc	x	x		
Ho	x	x			Te	x	x	x	x
In	x	x			Ti	x	x		
Ir	x	x			Tl	x	x		x
K	x	x			Tm	x	x		
La	x	x			U	x	x		
Li	x	x			V	x	x		
Lu	x	x			W	x			
Mg	x	x			Y	x	x		
Mn	x	x			Yb	x	x		
Mo	x	x			Zn	x	x		x
Na	x	x			Zr	x			

Table 4-2

ADVENTURES IN PROGRAMMING

High School Apprentice Nathan Pritchard

My apprenticeship for the Air Force Offices of Scientific Research during the summer of 1991 consisted less of research and more of the application of previously gained knowledge. I have obtained an extensive background in computer programming: five years of BASIC, two years of Pascal, and several months of C. Upon the discovery of my computer-oriented skills, my supervisor, Dr. George Lee, assigned several programming tasks to me. I began the software development with the approval of my mentor, Maj. Ed Brown. The first project involved the alteration of data files produced by the laboratory's software system. The second began as a complex calculator program designed to compute concentrations and volumes.

The software system utilized by the Volatile Organics Function of the Armstrong Laboratory at Brooks Air Force Base, my place of employment, satisfied many of the needs of the lab technicians, yet it fell short of expectations in several areas. My first task was designed with the intention of filling one of these gaps.

The software system interfaces with gas chromatographs, scientific tools used for the identification of trace contaminants in water, soils, and tissues. The information obtained from the GC's by the computers can be translated into graphs, with peaks indicating the presence of compounds. The software identifies a peak by comparing the time elapsed before the emergence of the peak, known as the retention time, with retention times stored in a file, known as a method file. The method files contain lists of compounds and their retention times as dictated by various EPA methods for detecting and identifying the compounds.

The compounds are separated from a sample by purging. The sample is placed into a glass sparge tube. Small bubbles of helium, the carrier gas, pass through the sample, removing any volatile compounds. The cluster of compounds passes through a glass column, which separates the compounds. One or two detectors, depending on the system, follow the column. The detectors determine the presence of and concentration of compounds, but cannot distinguish the compounds. The retention times are used for the actual identification.

These chromatographic retention times, particularly in such purge and trap analyses, are subject to variability due to changes in room temperature, carrier gas flow rates, and other factors. When using such methods as EPA 502.2, which addresses the Safe Drinking Water Act analytes, certain peak clusters require unusually small identification windows due to the close proximity of the peaks. In this case, shifts of more than 0.2 minutes will cause misidentification of the peaks in the computer report. Many types of correction can be applied, but the most straightforward technique involves the direct modification of the method file to reflect the retention time changes. The data must then be reanalyzed with the new method file.

The software currently used in this laboratory allows the direct modification of the retention times of the compounds, but the process is designed for the adjustment of more variables than just the retention time. Therefore, the alteration of the single field can be tedious and can occasionally lead to errors. My project centered on facilitating the modification and alteration of the retention times stored in method files of the type created by this particular software system.

The first task undertaken towards the completion of the program involved analyzing and interpreting the data stored in the method files. Each method file is merely a text file. The initial ninety-eight lines of each file comprises numbers and strings containing various values of importance to the lab's software system. The only values relevant to my purpose are the number of compounds stored in the file and the number of calibration levels, indicating the number of lines occupied by each compound. Each compound's "unit" in the file begins with the compound's name, in quotes, followed by the values of several variables associated with that compound. The first number specifies the retention time, in seconds.

The initial goal I strived for involved the ability to increment or decrement all the retention times in a method file by a set amount. While it was not an impossible one, this goal required some time to attain. I spent several days "brushing up" on my BASIC skills. My most recent programming experiences have been with Borland's TurboPascal in Computer Science II Advanced Placement, and I prefer it, or even TurboC, to BASIC. Microsoft QuickBASIC (version 4.50), however, was the only programming resource available for my use in the laboratory.

After the period spent in review, I quickly accomplished the fundamental purpose of altering all retention times in a method file at once using a blanket offset applied to all times. A short demonstration of the relatively simple program to several of the laboratory technicians in the area prompted the revelation of several shortcomings. The revised list of goals read as follows:

1. be able to enter new times for all compounds in addition to using a blanket offset
2. be able to alter retention times one at a time by entering new values
3. be able to alter a group of retention times (i.e., the first five, the second through the tenth, etc.) with an offset or by entering new values

Other goals were added as I interacted with the lab technicians who would be using this program the most. The abilities to delete compounds from the list and to copy the entire method file to a new name manifested as potential candidates for new features.

Several weeks of development later, a nearly finished product emerged. Although some "polishing" and "touching up" remained, the program was ready to face the world. The first "real" test for the program was conducted by Gloria Gover, a staff chemist working with the gas chromatographs.

Ms. Gover needed to take a method file for a "long mix" and change it to a "short mix." The long mix refers to a set of compounds used in this lab as a control to verify the correct operation of the instrument. A long mix contains twenty-nine compounds, and the last compound takes approximately forty-five minutes to emerge from the column. A short mix contains fifteen of the compounds from the long mix, and the last compound is retained for approximately thirty minutes.

When asked for the method name, Ms. Gover entered "A1G," the name of the method file for the aromatic compounds of the long mix. "B1G" is the method file for the halogenated compounds. First, Ms. Gover used the copy function to copy "A1G" to "A1GS " Then, she determined which compounds needed to be deleted and utilized the delete function to trim the unnecessary compounds. Next, Ms. Gover chose to alter all the retention times by entering new values for each one. This task quickly accomplished, Ms. Gover proceeded to modify "B1G" to "B1GS." The program passed its first test easily by successfully modifying the two methods. The program has remained essentially unchanged. A few modifications, however, were implemented.

First, an on-line help system was developed. Should the user encounter an unfamiliar situation, he or she may press F1, and the help menu will appear. The help menu displays options pertaining to several areas of the program. The user simply selects the appropriate option from the menu and a small description of the function or action is displayed on the screen.

The only other major change became necessary when a problem developed. The compounds in a method file are stored in order of elution, or the order of emergence from the glass column. Therefore, the retention times in the file must be in order from least to greatest. My program, however, left the order of the compounds unchanged, despite changes in retention times. A situation arose in which Ms. Gover needed to change the retention times in a method file due to the usage of a different column. This change, implemented with my program, resulted in an irregular list of retention times. To solve the problem, I incorporated a sort into the save routine. Each time a method file is saved, the list of compounds is sorted by retention time.

The sort is a simple bubble sort. While it is not overly efficient, the bubble sort suited my purposes. Most method files contain less than thirty compounds, ergo, efficiency is less of a concern. Also, the retention times will only infrequently be in disarray. The bubble sort routine looks through the list, starting from the beginning. The current compound is compared with the next one. If the retention time of the current compound is greater, the two compounds are "swapped." The process is repeated until the end of the list is reached. In this manner, the compound with the largest retention time "bubbles" to the end, hence the name. The routine repeats the perusal of the list until no swaps are made on one complete pass. If the list contains no out-of-order compounds, the sort will only examine the list once.

Before I completed the final additions to my first project, my second task was outlined.

Several formulae frequently enter the world of the technicians of this laboratory. One is as follows:

$$V1 \times C1 = V2 \times C2$$

In words, the original volume multiplied by the original concentration equals the final volume multiplied by the final concentration. This formula is used repeatedly in the calculation of dilutions and the determination of concentrations.

My second project was intended to simplify the task of solving the aforementioned formula. The user would enter the three known values, and the computer would calculate the unknown value. At first glance, this appeared to be a relatively simple task. However, many unforeseen problems remained in hiding.

The first edition of the program embodied the basics of the formula. The user could choose which of the four values was the unknown. Then, the user would be prompted for the three known values. Finally, the program ended. Apparently, a few revisions were in order.

The first problem to be tackled was that of obtaining the appropriate values from the user in the correct format. Such a problem would not be considered a problem if it was known that the user would always enter the values correctly. Unfortunately, such is not the case, and extensive error-checking is required to prepare for every possibility. Once a feasible routine was developed to counteract any mistake on the part of the user, other problems required attention.

The manner in which the program solved the formula for the unknown value lent itself to displaying the "work," the intermediate steps, on the screen. Unfortunately, the answer remained in the unit that resulted from the natural solution of the formula. Knowing that this unit was not necessarily the desired unit, I allowed the user to enter a unit into which the program would convert, if necessary, the final answer. This almost became a problem in itself.

Suppose the user wishes to leave the final answer in the "natural" unit? The program was eventually altered so that the user could indicate that the solution should remain "as is."

I periodically allowed Ms. Gover to test my program in order to obtain feedback on errors and potential future features. Two of the most important aspects of the program that resulted from the tests are the abilities to "copy" and "paste" values and to save and print the work.

Ms. Gover's first concern involved taking the final answer and using it to derive the next solution. I then researched the "trapping" of the "function" keys, F1 through F10 or F12. This eventually resulted in the on-line help system implemented in this program as well as the first one. I allocated F1 as the help key, F2 as the copy key, and F3 as the paste key.

While entering values, one may copy the value on the current line by pressing F2. This value may be placed into a different slot by pressing F3 on that line. While these features allow for the copying of entered values, the value originally intended to be copied, the solution, is not an entered value. Therefore, after the solution is displayed, the user is asked if the final value is to be stored. If so, that value may then be pasted onto a line by pressing F3.

Lab technicians and chemists often keep a lab notebook in which they place important information and calculations. Ms. Gover previously kept track of all calculations done with the volume/concentration formula by simply writing them down in her notebook. She expressed the desire to be able to enter the calculations performed by my program into her notebook without copying them by hand.

Ms. Gover's desires prompted the final major revision of this program. The modification allows the user to indicate that the work and the solution should be saved in a data file. The user also has the option of entering a compound name to be saved prior to the storage of the initial entered values and a three-line comment to be saved following the actual work. Work from more than one problem can be saved during the same session. The data file can be printed, erased, or viewed on the screen. When viewing it, the user may also delete unwanted lines from the file. The printed work may be trimmed to an appropriate size and affixed to any desired location in a lab notebook.

The only drawback to saving and printing the work is the mortality of the data files. Each time the user runs the program, a new data file is created. To prevent the accidental deletion of other files, random characters compose the data file's name. This file is destroyed when the user exits the program. I considered but discarded the possibility of allowing the user to name the data files for future reference. The data files would grow rapidly in number with heavy usage of the program and would seldom be used again.

The first heavy-duty test of my second project occurred when Ms. Gover and A1C Darryl Mason needed to determine what amounts of a purchased control should be used to make various concentrations. Concentrations of 1 ug/L (microgram per liter), 5 ug/L, 10 ug/L, 20 ug/L, 50 ug/L, and 100 ug/L were to be made from the control, which was 2000 ug/mL. After some quick mental estimations, the appropriate numbers were entered as follows:

V1 = ? (the unknown)

C1 = 2000ug/mL

V2 = 100mL

C2 = 100ug/L (then 50ug/L, 20ug/L, etc.)

The solution to this initial problem was 5 uL. Five microliters of the 2000 micrograms per milliliter solution placed into 100 milliliters would result in a concentration of 100 micrograms per liter. The solutions to the other problems followed some quick changes to the entered values. Ms. Gover and A1C Mason determined that double dilutions would be needed for the 10 ug/L, 5 ug/L, and 1 ug/L solutions. After all calculations were completed, the work was printed, trimmed, and stored in Ms. Gover's lab notebook.

The final addition to my second project became, essentially, a project in and of itself. The purpose was to facilitate the construction of a standards preparation worksheet.

Lab technicians and chemists use the form during the preparation of a standard sample, such as the long mix or the short mix. Each time a standard is prepared, the technician must fill out the name, supplier, lot number, concentration, expiration date, and amount of each compound. Then, the final yield, or concentration, must be calculated. The final solution is prepared by following several steps. First, each of the compounds is placed into a certain volume, called the stock solution, which is usually 10 mL. Then, some of the stock solution, usually 1 mL, is placed into another flask, usually 100 mL, called the working solution. The final solution is formed when some of the working solution, usually 10 uL, is placed into a vial, usually 100 mL. The final concentration is often varied by changing the 10 uL figure.

While the figures stated above are the ones most often used, variations may be necessary. Therefore, the program allows the user to modify the figures to their needs. As the user enters the mass of each compound, the program calculates the final yield using the same portions of the program utilized by the original calculation routines. No "real" test has been performed on the standards preparation worksheet portion of my program, but it appears to satisfy the needs of those who would use it.

While I did not participate as much in the conventional laboratory activities as I expected to, I feel that I have made contributions to the lab that will last beyond my participation in the program. The method-alteration program has already become a useful addition to the in-house software system and is used regularly. The calculation/worksheet program promises to do the same.

APPENDIX

For a better look at the actual usage of my programs, I included on the following pages the instruction manuals created for them.

Method Alteration
Program by Nathan Pritchard

This program was designed to facilitate the alteration and modification of method files of the type created by PENelson software. The aspects of the method files that can be changed by using this program are the number of and retention times of the components.

First, you must enter the program by choosing "Alter a Method" from the PENelson menu. When you are asked for a method name, enter the name of a method file. It may be necessary to provide a path (such as "E:" or "DATA\"). The current directory will be displayed. Pressing the ESC (escape) key at this point will terminate the program and return control to the PENelson menu.

The program is essentially self explanatory. If you have problems, consult the following program description.

ANSWERING QUESTIONS

Most questions not asking for numerical answers will have possible letter-choices shown in parentheses after the question. When you press a letter, the corresponding word-answer will be displayed in brackets. When you are satisfied with the answer, press [ENTER].

CHOOSING AN OPTION FROM A MENU

All of the possible choices and their numbers are displayed in a list. Simply press the number of the desired option and press [ENTER]. If you change your mind before you press [ENTER], simply type a different number.

ALTERING ALL COMPONENTS

Choosing "1" (ALTER ALL) from the main menu will allow you to alter all components at once. You will be given the option of altering all retention times by a uniform offset (increment or decrement) or by entering new values for all retention times. When entering new values, simply press [ENTER] if you wish to retain the original value for a particular component.

ALTERING A GROUP

Choice "2" (ALTER A GROUP) allows you to pick a group of components to edit all at once. Simply enter the numbers of the first and last components to be altered. Then, choose whether to alter the retention times by an offset or by entering new values, similar to the method used for altering all components.

ALTERING INDIVIDUAL COMPONENTS

The third choice (ALTER SOME ENTRIES) allows you to pick and choose which components to alt... Simply choose the number of a component to be altered. Then, either type a new value or press [ENTER] to retain the original one. Repeat the process until all desired changes have been made. To exit, enter "0" when prompted for a component number.

WHEN THE COMPONENTS HAVE BEEN CHANGED

After you have finished the alteration of retention times, a list will be shown of all the components, the old retention times, and the new retention times. If necessary, press [ENTER] to page through the list. Finally, you must verify the changes. Press "Y" to accept them or "N" to reject them, then press [ENTER].

DELETING COMPONENTS

Choosing "4" (DELETE SOME ENTRIES) from the main menu will allow you to delete components. Choose the number of a component to be deleted. Then, confirm or deny the deletion. Repeat the process until all desired deletions have been made, then enter "0" to exit. If necessary, press [ENTER] to page through the list of deleted components. Accept or reject the deletions by entering "Y" or "N" and pressing [ENTER].

COPYING A METHOD FILE

You may save the current method file under a different name by choosing "5" (COPY A METHOD) from the main menu. Enter a new filename, then confirm or deny the copy.

ALTERING ANOTHER METHOD FILE

If you wish to edit a different method file, choose "6" (ALTER ANOTHER METHOD) from the main menu. This will restart the program.

RESTORING A BACKUP

Every time you alter a method, the program creates a backup file which stores the information originally contained in the file. The backup file's name is the same as the method file's name except for the .BAK extension replacing the .MET extension. For example, GASOLINE.BAK is the backup file for GASOLINE.MET. If you save a changed method file and decide that the change was a mistake, and you wish to restore the old information, choose "7" (RESTORE BACKUP) from the main menu. You will be asked if that is what you really want to do. If so, press "Y" and [ENTER]. Otherwise, press "N" and [ENTER].

WARNING: If you restore a backup file, the changed information cannot be recovered.

THOSE PESKY BAK FILES

Sometimes, backup files (extension .BAK) files can be a nuisance. If so, choose "8" (DELETE BACKUP FILES) to eradicate them.

GETTING HELP

Pressing the F1 key at any time during the program will bring up the on-line help menu. The help menu contains choices naming various parts of the program. Simply choose the area you are having difficulty with. The help screens basically consists of excerpts from this manual.

Calculating Concentrations and Volumes
Program by Nathan Pritchard

$$V1 * C1 = V2 * C2$$

This formula is often used in the field of gas chromatography, and it is the basis for this program. If any three values are known, the fourth one can be found. To utilize this property, simply execute the program (type "calcconc" at the appropriate prompt). You will be given several options. The first four deal with the actual usage of the formula. Choose the option appropriate for your needs. If you are looking for the final concentration, the original concentration, the final volume, or the original volume, choose accordingly.

AFTER CHOOSING AN OPTION (1-4)

After choosing an option, you will be asked for the three known values. Then, you will be asked to enter a unit for the final answer. The numbers entered can be any positive number. Units can be as follows:

Volume:	Weight:	
uL	ug	(micro)
mL	mg	(milli)
L	g	

"u"'s, "m"'s, and "g"'s are automatically put into lower case, and "L"'s are automatically capitalized. No spaces are allowed. If no unit is given after a number, L or g/L is automatically assumed. Also, you need enter nothing more than the prefixes. 200um would be interpreted as 200 uL or 200 ug/mL, depending on the unit expected. If a prefix is desired for the second unit only, the first unit (or a "/") must appear. 200gm, 200/m, and 200g/m all result in 200 g/mL.

When entering the desired final unit, you may press "d" for "default." This will cause the program to leave the final result in the final unit resulting from the calculations.

AFTER ENTERING ALL THE VALUES

The program will calculate the value of the unknown variable. The answer, along with the work done, will be displayed on the screen. First, you will be asked if you wish to store the final value. This will be addressed under "USING THE FUNCTION KEYS." After this question, you will be asked if you wish to save the work. This will be addressed under "SAVING AND PRINTING." Finally, you will be asked if you wish to do another problem of the same type. Answer accordingly.

USING THE FUNCTION KEYS

There are three function keys utilized by this program. F1 is the "help" key. At any time you feel you need help, press F1 and you will be shown a menu of items on which you can get help. When you exit the Help Menu, you will return to the place you left off.

F2 is the "copy" key. If you are on a line with a value that you wish to store for later use, press the F2 key and it will be stored. Only one value can be stored at a time. When you come to a line in which you wish the value to be placed, press F3, the "paste" key.

When the final answer of a problem is displayed, you will be asked if you wish to store the final value. Answering YES causes the program to store the final answer as if you had pressed F2.

Note: the F2 and F3 keys are not operable when you are using the Standards Preparation Worksheet area of the program.

SAVING AND PRINTING

After you answer the question about storing the final result of calculations, you are asked if you wish to save the work. If you answer YES, the initial values entered, as well as the work displayed, will be stored in a file. First, you are asked if you wish to enter a compound name to precede the initial values. Then, you are asked if you wish to enter a three-line comment to follow the work. If you enter a comment, you must press [ENTER] at the end of each of the three lines. After these questions have been answered and the optional information has been entered, the data will be stored on disk. If you have previously saved work during the current session, the data will be added at the end of the file. A new file is created every time the program is run and is destroyed upon exiting. Selecting the PRINT option from the main menu will send all data stored in the file to the printer. The data remains in the file until you exit or choose the ERASE option from the main menu.

VIEWING WORK

If you wish to view the work saved without printing it, simply select the view option from the main menu. The contents of the data file will be displayed on the screen. Each line will be numbered. If necessary, press [ENTER] to page through the display. If you wish to delete any lines from the file, simply press "Y" and [ENTER]. You will be asked for the numbers of the first and last lines to be deleted. To abort the deletion, press ESC.

THE ESCAPE KEY

The escape (ESC) key will get you out of almost any jam. If you are uncertain of what to do or don't think you want to do what you are doing, press ESC. If that fails, keep going, trying ESC at any new question that appears. Eventually, you will probably come to a place where it will work.

STANDARDS PREPARATION WORKSHEET

The Standards Preparation Worksheet option takes you to what is essentially a program in itself. It has a separate help screen, also. This portion of the program is designed to allow you to prepare, save, and/or print a Standards Preparation Worksheet. The rest of this document will be devoted to this section.

LONG AND SHORT MIXES

You can enter the information for all components in either a long or short mix. The long mix contains 29 analytes, the short, only 15. When you select a long or short mix from the SPW menu, you will start over with a clean slate.

You will be allowed to enter various preparatory facts, such as the analyst's name, the date/control number, the volume of the stock solution, how much of the stock solution will be used to make the working solution, and how much of the working solution will be used for the final yield. You will also be asked if you wish to enter a concentration for each component. Then you will be asked to enter the information for each component. Specifically, you will input the supplier, lot number, concentration (if desired), the date (usually the expiration date), and the amount of the component used. The computer will calculate the final yield in micrograms per liter (ug/L).

The process is repeated through all the components. When you proceed to a new component, the default values for all the fields will be those entered for the last component. This circumvents the need to repeatedly enter the same names, such as the supplier. You may back up field by field by pressing ESC. At the end of each component, you will choose whether you wish to go to the NEXT component, the PREVIOUS component, or to QUIT. QUITting will return you to the SPW menu. At the end of the last component, you may select END to indicate that you are finished entering values.

Upon completion of the worksheet, a table showing all the values entered will be displayed on the screen. If necessary, press [ENTER] to page through them. You will then be returned to the SPW menu.

VIEWING A WORKSHEET

Selecting the VIEW option will display a table in the same format as the one shown upon completion of a worksheet.

EDITING A WORKSHEET

Choosing the EDIT option allows you to go through and change various values stored in a worksheet. This is done in essentially the same method as originally entering the worksheet.

SAVING/LOADING A WORKSHEET

Worksheets may be saved or loaded by selecting the appropriate option from the SPW menu. Choosing the SAVE option will store the current worksheet. You will asked to supply a name. If you do not give an extension, .SPW will automatically be added. The current directory is displayed.

Choosing the LOAD option will retrieve a stored worksheet from the disk. Again, you will be asked for a filename. An extension of .SPW will be added if none is supplied.

PRINTING A WORKSHEET

Choosing the PRINT option from the SPW menu will allow you to print a table similar to the VIEW table. First, you will be asked if the default header is satisfactory. If not, you may enter a new one.

SEEING/PRINTING WORK FROM WORKSHEET

It is possible to view the work done en route to the final yield without using the FIND options (1-4) of the main menu. To do so, select the SEE/PRINT option from the SPW menu. You will then be shown the work (two steps) for each of the components, one step at a time. Reaching the end of the list or pressing ESC will bring up the print menu. You may print the work for all the components, a group of components, or one component.

If you decide to print a group of components, you will be asked to provide the numbers of the first and last components to be printed. If you choose to print one component, you will be asked for the number of the component to be printed. You can continue to print as many components as you wish. Enter "0" as a component number to exit.

THE DEVELOPMENT OF A FIXATION MONITOR

Mireille Bean

Abstract:

The ophthalmology laboratory is an important part of the Aerospace Medical Division. The work done at the ophthalmology laboratory ranges from research to the designing of new equipment to be used in the lab and exam room. My work at the laboratory included the gathering of information from the medical files to be used in a contact lens study, and the use of a computer and the OSDP program for lens design. The objective of the main project with which I was involved was to develop a fixation monitor, which would aid in testing for glaucoma. Though these projects were not closely related, each of them both required and provided information for the growing technology in optics. Research such as this contributes to the need for high-tech optical care that is so important to the Air Force.

Introduction:

Glaucoma is an eye disease that causes pressure to build up in the eye which can damage the optic nerve, and cause decreased visual acuity and blindness. The clinical assessment of retinal function for potential glaucoma condition requires to take what is known as a Fields Test. The Fields Test involves a session in which the patient is required to fixate his/her vision on a single point, while a small point of light is directed in various spots of the patient's peripheral field. The response is recorded and analyzed to determine the health of the eye. Loss of fixation during the test, however, is common and the test has to be redone, which compounds the data and makes this a very lengthy test. A method for the automatic detection of fixation loss would allow immediate correction, and would be a valuable improvement.

Discussion:

The first approach to building a fixation monitor was to use infrared illumination from a source such as a LED or laser to illuminate the pupil of the subject's eye. An infrared sensitive CCD-37 camera with a close up lens was mounted and connected to a monitor and video printer, both sources to evaluate the illumination of the pupil. In a completely darkened environment, the subject eye was not able to see the 880nm LED, but a central bright spot in the center of the pupil was evident on the monitor. As the subject eye was moved about to various areas of the peripheral field, this central bright spot was expected to change intensity. While a slight change was noted, the amount of change was not great enough to detect small amounts of fixation loss.

In the second approach to building a fixation monitor, an 880nm infrared laser was used for eye illumination instead of an infrared LED. The laser was pointed toward a beam splitter in front of the subject eye. The beam splitter allowed part of the light to be reflected into the subject eye, and part of it to pass through the beam splitter. The result was less than sixty microwatts of the laser to enter the eye, which is a harmless amount. A device called a photodiode was used for detecting the amount of infrared light reflected from the eye. The photodiode was built into a small lens system, which allowed it to detect only the infrared light comming through the lens system from the eye. This system was then connected to a voltmeter so that an exact amount of light from the eye could be recorded. Again, a change in the amount of light reflected from the eye was noted. However, it was not distinct when the movement occurred because of the constant changing of the reading. Also, the amount of change which the voltmeter showed was small and insufficient for detection of fixation loss.

To begin another approach to building a fixation monitor, a Radio Shack 880nm LED was put through a 50/50 beam splitter cube. The light was focused through a lens system and into a single fiber optic tube. This single fiber optic was placed close to the subject pupil and both illuminated and carried back the reflected light. The light reflected from the eye was carried to the photodiode system, and back to the voltmeter. When this set up was tested, the voltmeter was flooded with light due to the reflection of the original LED on the beam splitter and the fiber optic clamp. The LED was replaced with an infrared laser which reduced the false reflective reading, but again the change of the numbers with eye movement was very small.

The final approach to building a fixation monitor used a dual fiber optic design. The approach was similar to the single fiber optic design, only a separate fiber was used to carry back the reflected light from the subject eye to the photodiode system and voltmeter. This approach proved to have the best results.

Results:

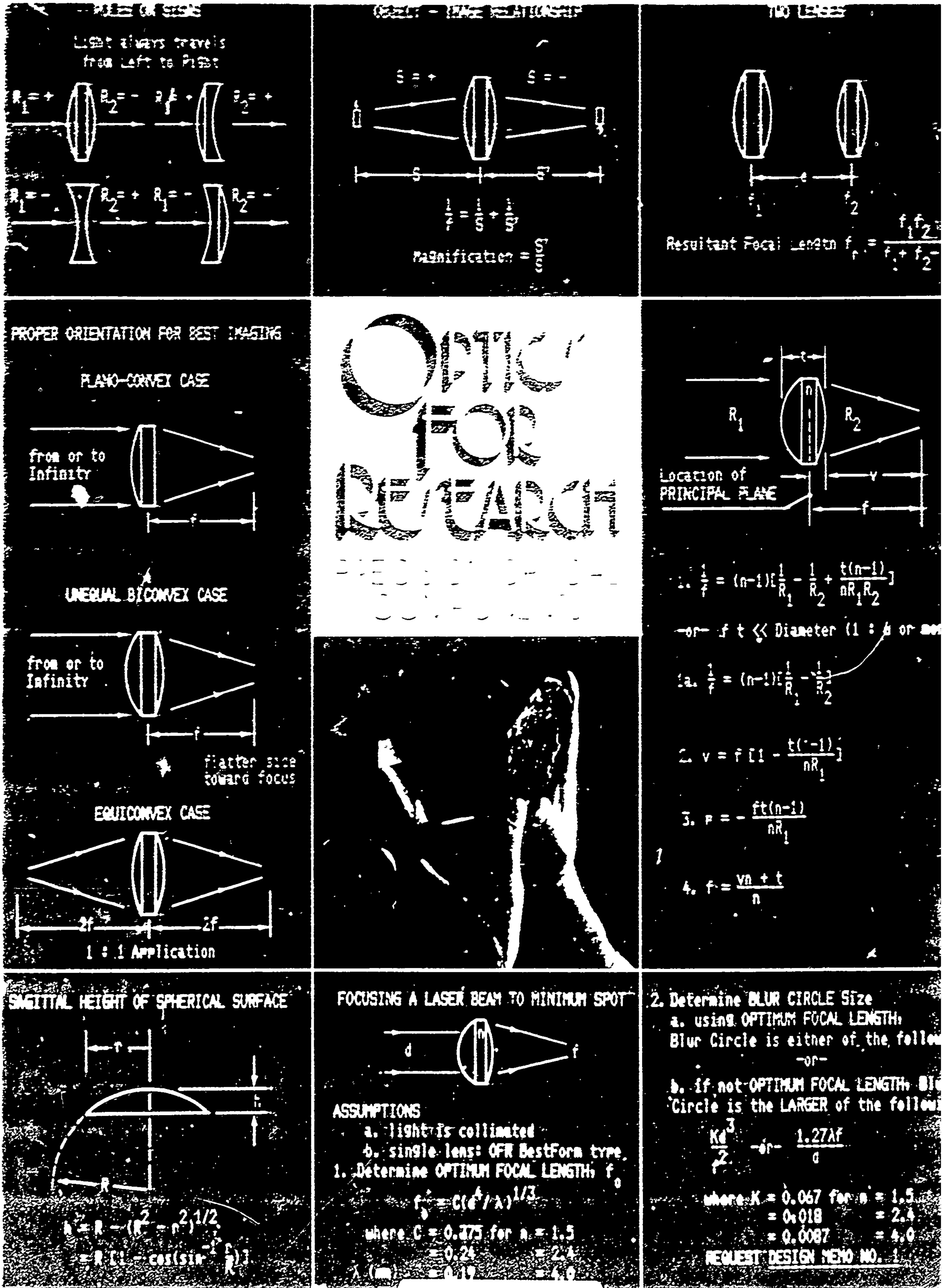
In testing the dual fiber approach, the subject was asked to fixate his eye on a point straight ahead. The end of the two fiber optic tubes were placed side by side, then placed about two centimeters from the subject eye. The reading from the voltmeter was recorded.

The subject was then asked to follow the movement of an object in front of him. As the eye moved from the original fixation point, the reading on the voltmeter changed. As the eye was returned to it's original fixation point, voltmeter returned to its original reading. Through this process, the loss of fixation or eye movement could be detected quickly.

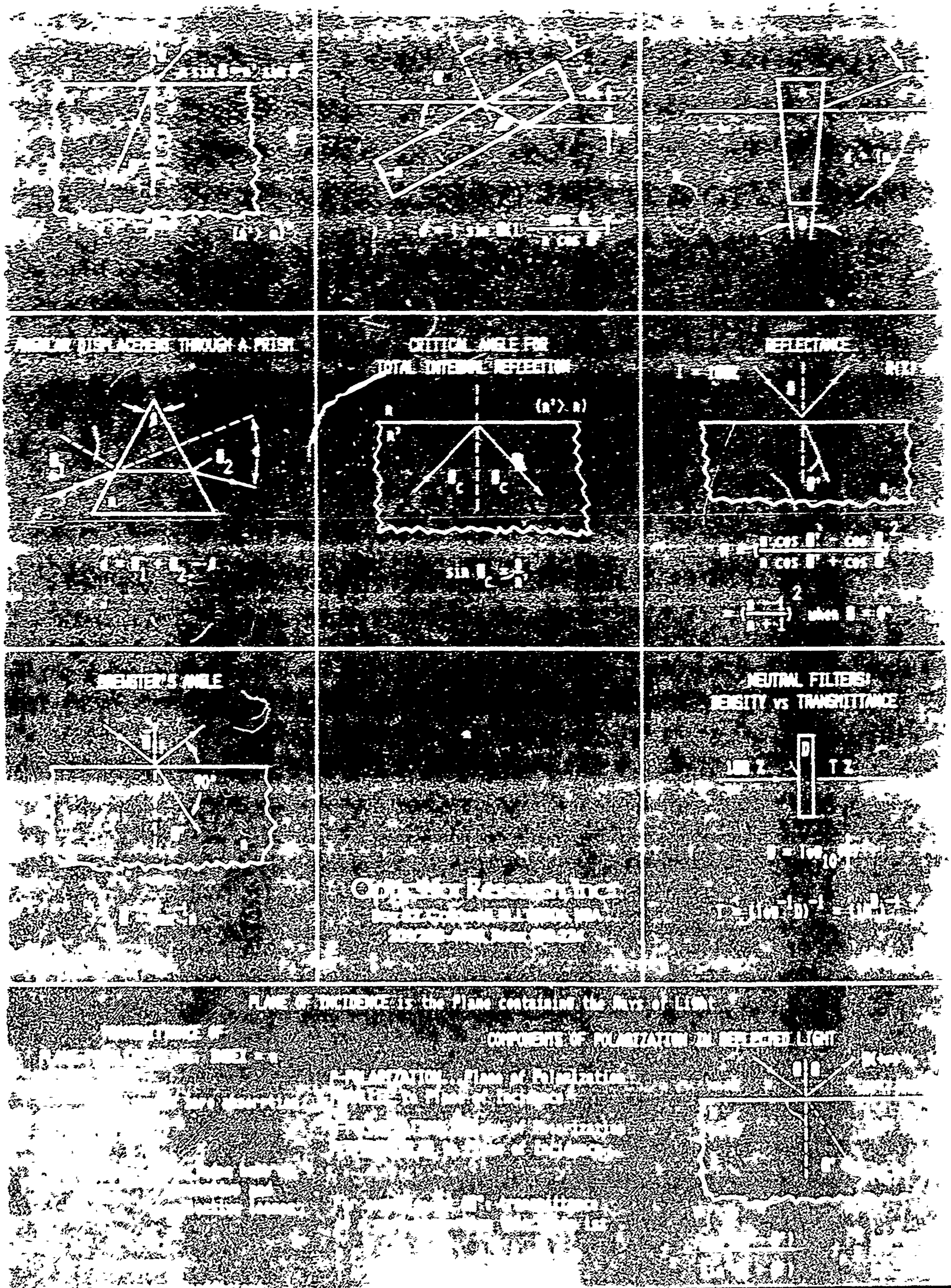
Conclusion:

The success of the fixation monitor design will help in the improvement of the method used in the Fields Test. While it is not yet a final product, it is a beginning idea that has been tested and proved acceptable. It will aid in a quicker and more accurate test for glaucoma in the future.

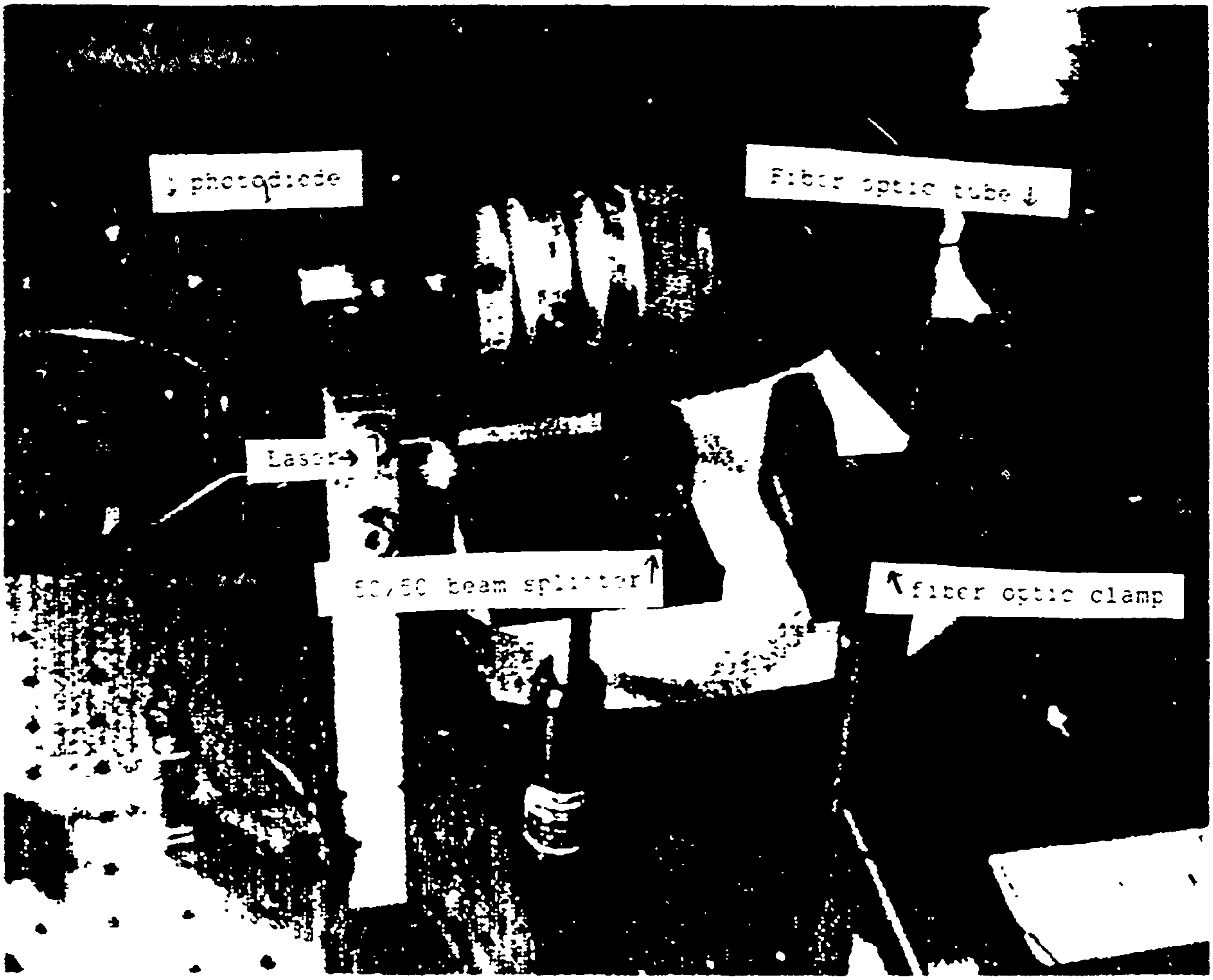
THE FOLLOWING CHARTS CONTAIN A FEW OF THE EQUATIONS WHICH I USED WITH THE OSDP PROGRAM FOR DESIGNING LENSES.

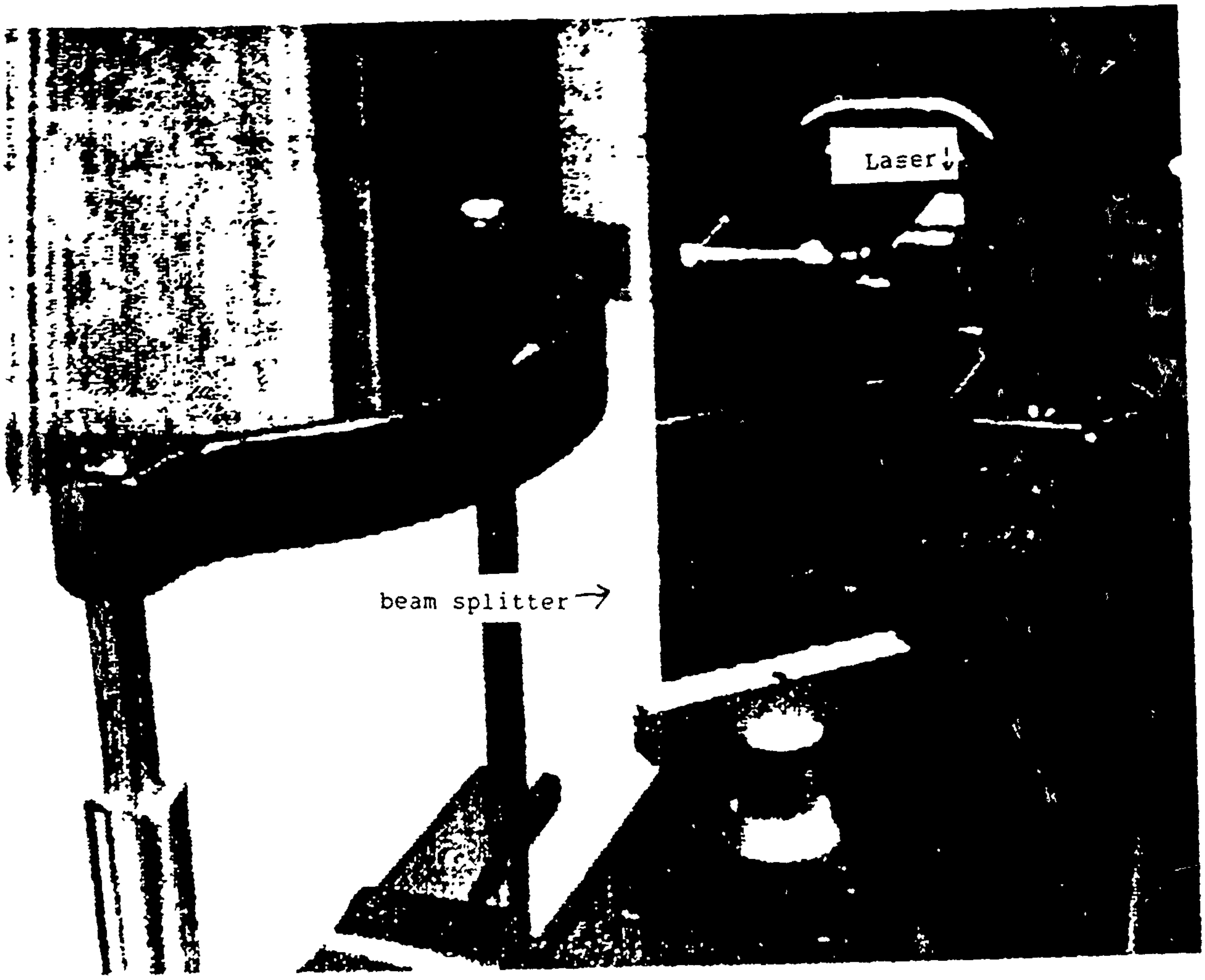


Light always travels from Left to Right
R1 = + R2 = - R1 = + R2 = +
R1 = - R2 = + R1 = - R2 = -
S = + S' = -
S S'
1/f = 1/S + 1/S'
Magnification = S'/S
f1 f2
Resultant Focal Length
PROPER ORIENTATION FOR BEST IMAGING
PLANO-CONVEX CASE
from or to Infinity
f
UNEQUAL BICONVEX CASE
from or to Infinity
f
flatter side toward focus
EQUICONVEX CASE
2f 2f
1 : 1 Application
OPTICS FOR RESEARCH
R1 R2
n
t
Location of PRINCIPAL PLANE
v
f
1. 1/f = (n-1)[1/R1 - 1/R2 + t(n-1)/(nR1R2)]
-or- if t << Diameter
1a. 1/f = (n-1)[1/R1 - 1/R2]
2. v = f [1 - t(n-1)/(nR1)]
3. p = - ft(n-1)/(nR1)
4. f = (vn + t)/n
SAGITTAL HEIGHT OF SPHERICAL SURFACE
r
h
R
h = R - (R^2 - r^2)^1/2
= R [1 - cos(sin^-1 r/R)]
FOCUSING A LASER BEAM TO MINIMUM SPOT
d
f
ASSUMPTIONS
a. light is collimated
b. single lens: OFR BestForm type
1. Determine OPTIMUM FOCAL LENGTH, f0
f0 = C(d^4/λ)^1/3
where C = 0.275 for n = 1.5
= 0.24 = 2.4
2. Determine BLUR CIRCLE Size
a. using OPTIMUM FOCAL LENGTH, Blur Circle is either of the following
-or-
b. if not OPTIMUM FOCAL LENGTH, Blur Circle is the LARGER of the following
Kd^3/f^2 -or- 1.27λf/d
where K = 0.067 for n = 1.5
= 0.018 = 2.4
= 0.0087 = 4.0
REQUEST DESIGN MEMO NO. 1

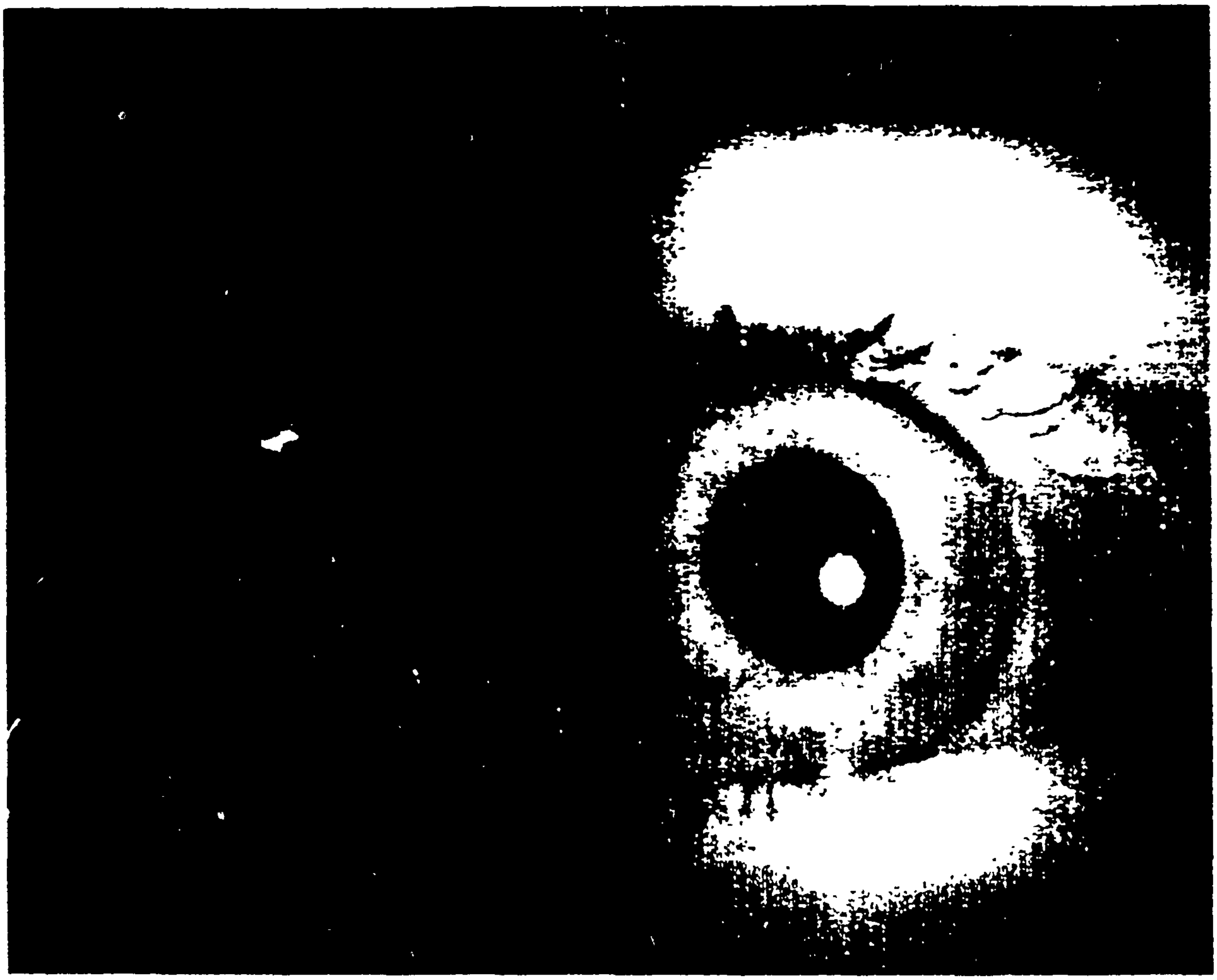


ANGULAR DISPLACEMENT THROUGH A PRISM
CRITICAL ANGLE FOR
TOTAL INTERNAL REFLECTION
(n' > n)
sin θc = n/n'
REFLECTANCE
BREWSTER'S ANGLE
90°
NEUTRAL FILTERS:
DENSITY vs TRANSMITTANCE
100 %
T %
D
PLANE OF INCIDENCE is the Plane containing the Rays of Light
COMPONENTS OF POLARIZATION IN REFLECTED LIGHT


photodiode
Fiber optic tube
Laser
50/50 beam splitter
fiber optic clamp



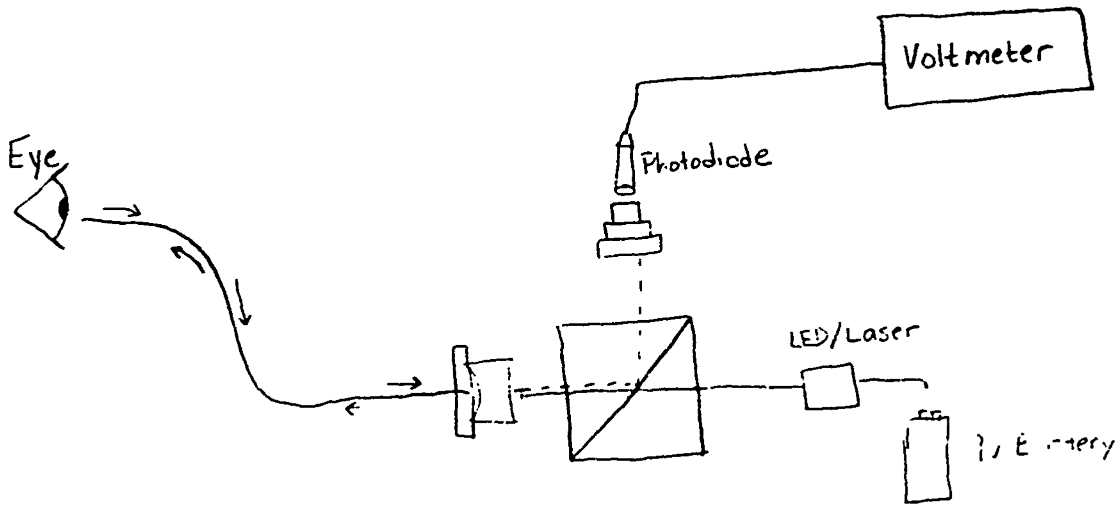
The second design used a laser and beam splitter.



The eye is illuminated by an infrared LED, and filmed with a CCD-37 video camera.

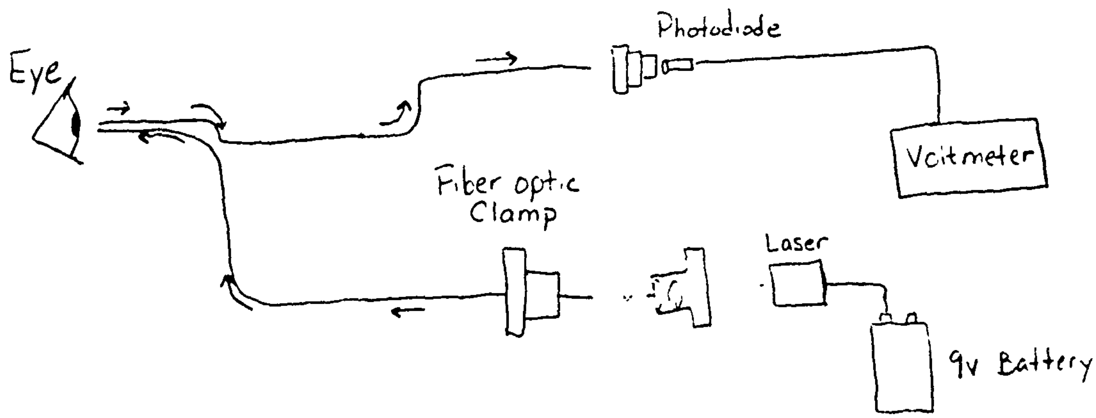
Design #3

Single-Fiber



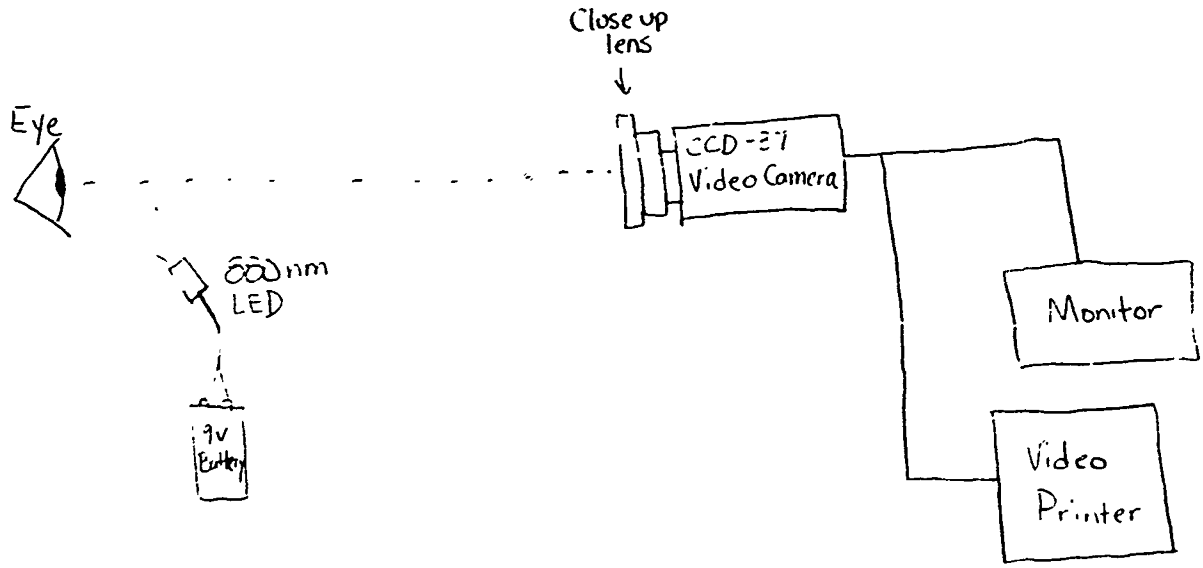
Design #4

Dual-Fiber

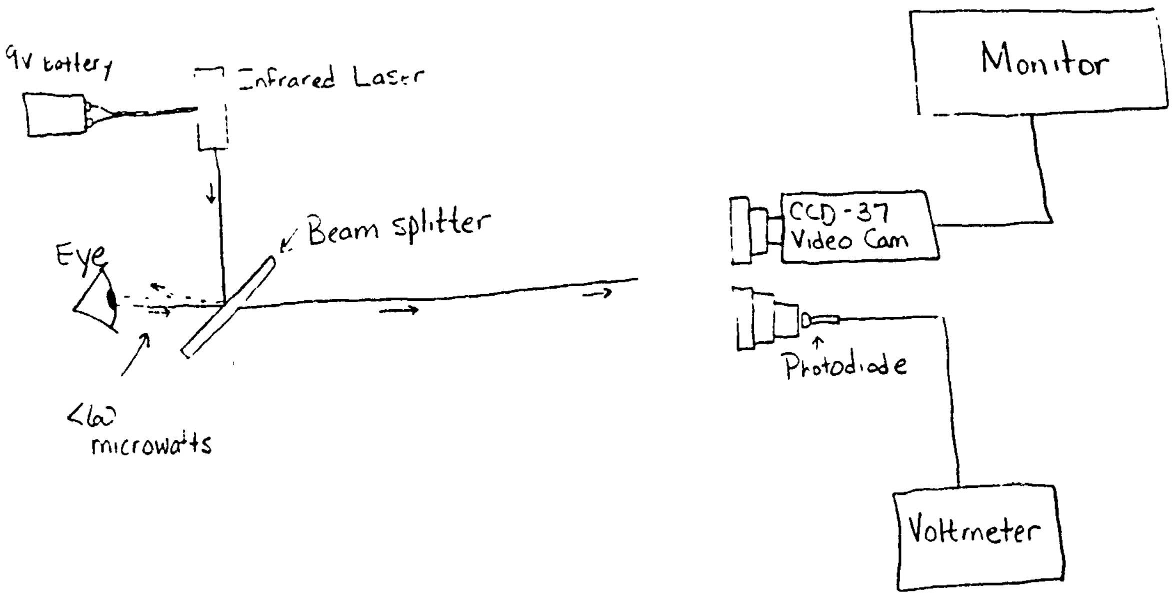


Best Results

Design #1



Design #2



OSDP - Optical System Design Program.

OSDP is created for the student, technician, engineer, and optical designer for analysis and design of optical systems. This current version does not use a command driven interface, which requires constant reading of a manual, but uses a single pull down menu to access all the routines. This is particularly useful for the occasional user (maybe a few times a month), who wishes to get right to work rather than re-familiarizing themselves with a manual each time the program is used. Due to a single menu, and to many prompt default values, OSDP should prove fast and easy to use for those that will use it every day.

NOTE: It is the author's desire that the user be fully satisfied with the performance of this software. At the end of this manual, you will find a suggestion page that the user can fill out with bugs, changes, new routines desired, and other ideas to help improve the program. It is suggested that the user copy that page before sending it in, to always leave the page in the manual for future suggestions. Please fill out the registration form included and send it in, - it will be needed for future upgrades.

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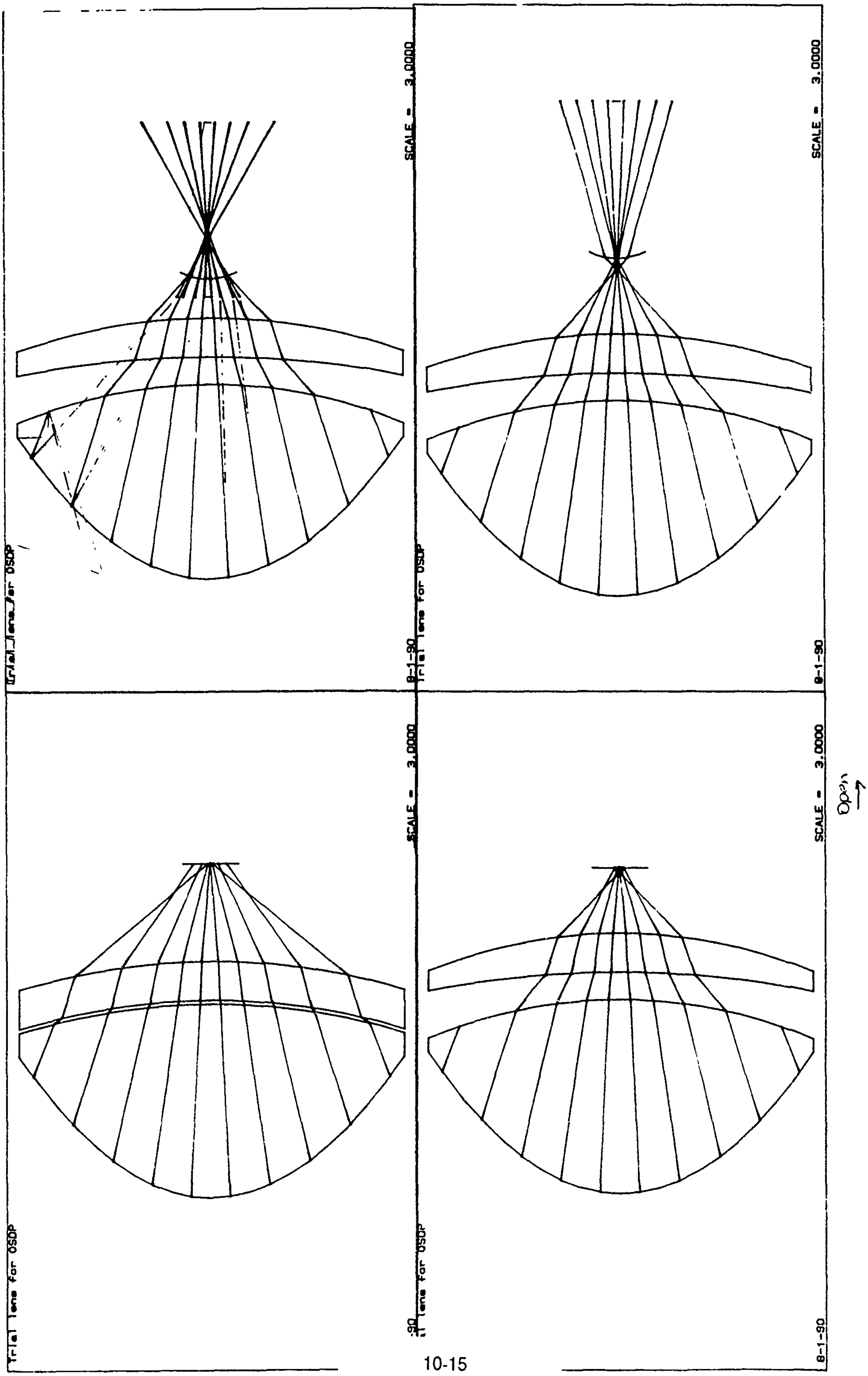
Trial lens for OSDP
8-1-90
SCALE = 3.0000
Trial lens for OSDP
8-1-90
SCALE = 3.0000
Trial lens for OSDP
8-1-90
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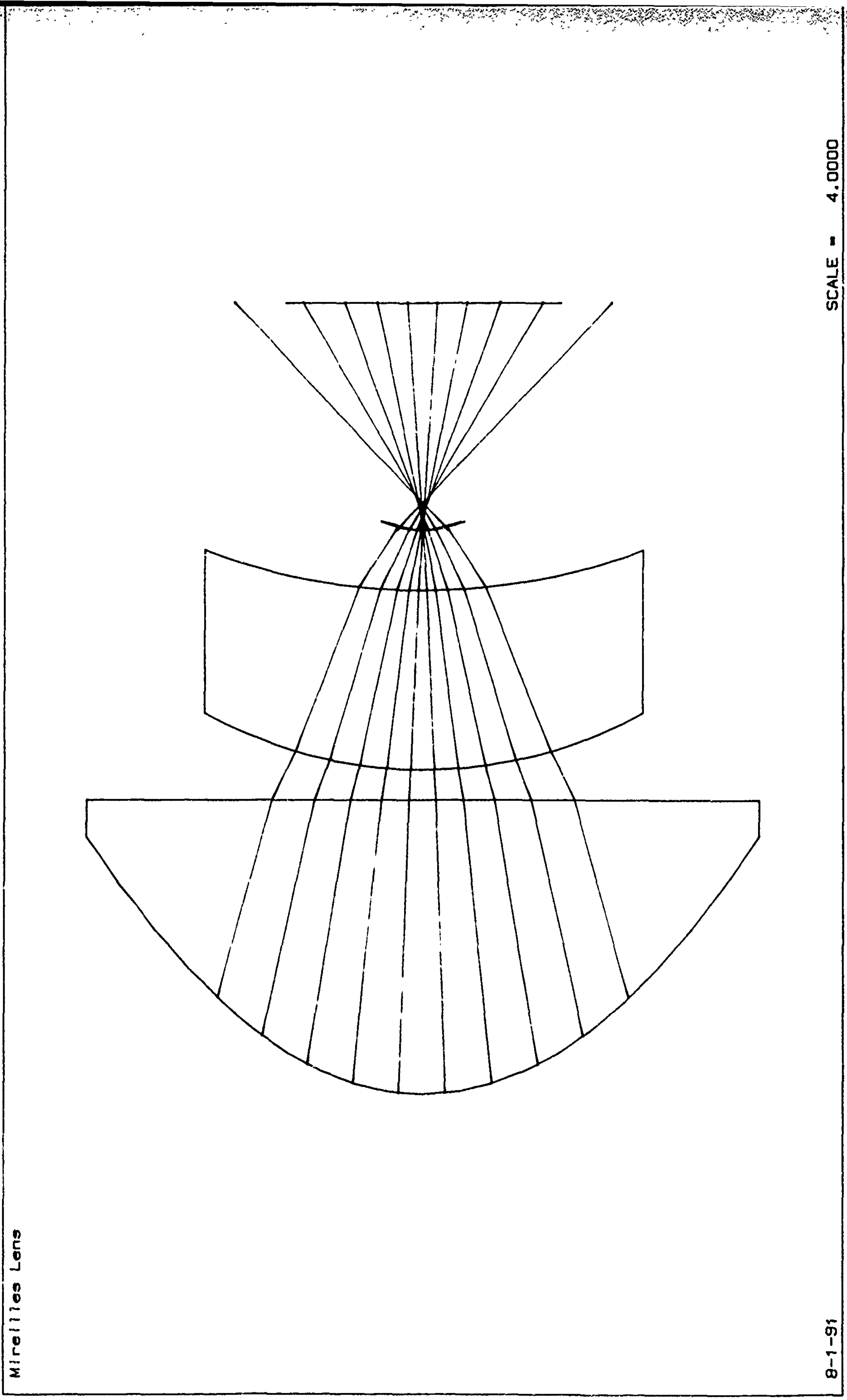
8-1-90
SCALE = 3.0000
Open



open →

Comparison of Perceived Breathing Resistance in Four Mask Configurations

Whitney Brandt
High School Apprenticeship Program

Introduction

Because of the possible threat of chemical warfare, aircrew members and pilots wear protective respiratory devices to prevent the inhalation of poisonous vapors. Because of the exposure to hazardous chemicals, these devices include a full face mask to provide eye and respiratory protection. According to Epstein et al. "The use of respiratory devices produce a deterioration in pulmonary ventilation, lengthening and shallowing of the respiratory wave, increase in functional residual capacity, accumulation of CO2 in the alveolar air and excessive respiratory work" (1). Work performance is significantly decreased because of these problems during submaximal exercise.

Besides the determination of the problems associated with the use of chemical defense masks, it has become important to develop criteria by which individuals can be evaluated on their ability to wear a respirator (2). Specific regulations require that each worker be evaluated to determine his or her medical suitability for respirator use. The Occupational Safety and Health Administration requires that "the local physician shall determine what health conditions are pertinent. The user's medical status will be reviewed periodically (for instance, annually)" (3). Industrial respirators should be designed to operate with a minimal decrease in the efficiency of the work of the wearer. Therefore, the first major requirement of scientists today is to determine the degree of work impairment that occurs during the use of a respiratory device (4).

Methods

Protocol

This experiment consisted of twelve subjects, ranging in age from 25 to 35 with normal physical fitness, participating in five different tests. However, only four of the subjects have completed the series, (N-F, 1-F, AB1, and AB2). These subjects were evaluated based on their responses to the perceived inspiratory effort, expiratory effort, and breathing discomfort. Their responses to the post-test questionnaire were also evaluated as a means of determining the effects of the mask on performance. For these results, the data that was recorded from each subject was averaged and a mean was obtained. This mean was used to rank the configurations according to the amount of breathing resistance.

The subjects for this experiment participated in separate tests using five different mask configurations. The experiment took place in a climate control chamber set at a dry bulb temperature at approximately 26°C and a wet bulb temperature of 16°C. Subjects arrived wearing a tee-shirt, shorts, and comfortable walking shoes. After the subject inserted a rectal probe, he was instrumented with six thermistors placed on the face, chest, back, upper forearm, thigh, and calf. A telemetry heart monitor was also placed on the subject to measure constant heart rate. Once this was done, the subject was asked to fill out a pre-test questionnaire describing any physical exercise he had performed in the last 24 hours, or any other unusual happening which might affect his performance.

The mask, with the specific experimental configuration, was then placed on the subject's face. The edge of the mask was then taped to the subject to prevent any leakage of air. The front of the mask was tied to a suspended rope to help alleviate some of the weight added by the measurement instrumentation. Once everything was in place, the subject walked on a treadmill set at three miles per hour with five percent grade for sixty minutes and then rested for five minutes. While the subject was walking, he was asked to evaluate his inhalation and exhalation effort, and breathing discomfort. This was done by using charts (Figure 1,2,3) specifically designed to adequately measure perceived effort on a scale of one to seven. Seven was the most severe and one represented little or no effort. After the experiment ended, the sensors were removed from the subject, and he was asked to fill out a post-test questionnaire about the mask.

Calibration

A Macintosh LabVIEW computer program was used to collect and interpret the data from this experiment. This experiment was designed to measure the physiological problems associated with the MCU-2P chemical defense mask. To do this, inhalation and exhalation pressures and flows were measured along with the volume of air taken in during breathing. To calibrate the volume, a manikin head was attached to a five liter syringe which was pumped giving constant breath values. A mask was fitted to the manikin and sealed to prevent any leakage of air. The proper configuration was attached to the mask and the volume was calibrated. The pressure transducer was calibrated independently using a manometer. The subject was instrumented with six thermistors; these thermistors were attached to a logging device that sent the data to the computer. This device was calibrated using a set temperature gauge. Once the computer program had been calibrated, the experiment could begin.

Results

The first item subjects were asked to evaluate, was the resistance the mask placed on inhalation pressure (Figure 4). Subjects 1, 2, and 4, all ranked air blower 1 as having the least resistance. However, in Subject 1, air blower 2 caused more pressure than no filters, but less than one filter. Subject 2 ranked air blower 2 as causing the most resistance. In Subject 4, the no filter and one filter configurations were equal, with the air blower 2 mean slightly lower.

Next, they were asked to evaluate their expiratory effort. Again, Subjects 1, 2, and 4, all ranked air blower 1 as being the lowest. Subject 1 recorded that the air blower 2 configuration and the no filter were equal. They were higher than air blower 1, but less than one filter. On the other hand, Subject 2 reported that air blower 1 and no filter were similar in breathing resistance. He ranked air blower 2 as being the highest even above one filter. Subject 4 once again noted that one filter and no filters were equal. He also placed air blower 2 between air blower 1 and the other two configurations. Note, that for both inspiratory and expiratory effort, Subject 2 gave all four configurations equal values.

The final topic the subjects were asked to evaluate was any breathing discomfort caused by the mask. For this area, Subjects 1, 2, and 3, again ranked the air blower 1 configuration as causing the lowest level of discomfort in breathing. Subject 1 placed no filter above air blower 1, but only by a small fraction. Once more, air blower 2 was perceived as being higher than air blower 1 and no filter, but less than one filter. Subject 2 unusually reported that the no filter configuration caused the most breathing discomfort, above one filter, air blower 2 and air blower 1. The next subject ranked no filter, one filter, and air blower 2 equally, greater than air blower 1. Surprisingly, Subject 4 recorded that air blower 2, although only slightly, caused less discomfort than any of the other configurations.

After completing each different mask configuration experiment, the subject was asked to fill out a post-test questionnaire. This questionnaire consisted of three pages of questions asking the subject to comment on any problems that might have arisen during the course of the experiment.

Beginning with the no filter configuration, the problems that arose seemed to be similar among each subject. Subjects 1, 3, and 4, stated that the mask gave them a slight headache, which could have been caused by the added weight of the measuring devices. Subjects 1, 2, and 4, also noted a slight increase in breathing difficulty, which would accompany the use of any protective mask.

The next configuration, one filter, seemed to increase the intensity of the problems caused by the added breathing resistance. All four subjects recorded an inc ise in the strength of the headache they received from the mask as compared to the no filter configuration. They also noted an increase in the difficulty they had breathing, caused by the added filter. Subject 3 also stated that he felt moderate sinus pressure in the nose caused by the mask.

Air blower 1 had the best results in all four subjects. They all had fewer comments about this particular configuration, and they noted less problems associated with the mask. Only two subjects, Subjects 1 and 4, reported a slight difficulty in breathing. Subject 2 noticed a small amount of sinus pressure, and Subject 4 recorded that the mask caused a slight headache.

The results for air blower 2 were not as promising as air blower 1. Both Subjects 2 and 3, received moderate to extreme headaches from this configuration, and it caused both of them slight sinus pressure. Subjects 2, 3, and 4, reported that this configuration caused them slight breathing difficulty. Subject 4 even commented on how air blower 2 had made him slightly light-headed.

Discussion

Throughout the calibration process many questions and problems arose. During the calibration of volume, one mask was placed on the mannequin head and used constantly. The question arose whether or not the size of the mask might change the calibrated values. Changing the mask from subject to subject would be too cumbersome. It was finally determined that the constant mask would not affect the calibration. Along with volume and pressure, the peak flows of each breath were measured. The instrumentation used to record these peak flows had to be read by hand which was very difficult. Because of this, the computer program that was used to record data was altered to also receive the peak flow data.

The results of the performance of the air blowers show that air blower 1 performed significantly better than air blower 2. This most likely occurred because air blower 1 provided more air flow through the mask than air blower 2.

Conclusion

The results of this experiment show that the use of an air blower helps minimize the resistance to breathing while wearing the MCU2P chemical defense mask. However, air blower 1 significantly lessened the resistance as compared to air blower 2. If the MCU2P plus a filter must be utilized and air blower 1 is not available, air blower 2 still surpasses the use of a single filter. Even with the addition of an air blower, the presence of breathing discomfort is inevitable. When an air filter is attached to the mask, headache and sinus pressure appear. These problems must be taken into consideration when aircrew members are needed to work in hazardous environments so that proper workloads can be arranged. Overall, if the MCU2P must be worn, it would be advantageous to have the addition of an air blower, particularly air blower 1.

<u>**References**</u>

1) Epstein, Y., G. Keren, Y. Lerman, and A. Shefer. Physiological and Psychological Adaptation to Respiratory Protective Devices. *Aviation, Space, and Environmental Medicine.* 53: 663-665, 1982.

2) Morgan, William P. Psychological Problems Associated with the Wearing of Industrial Respirators: A Review. *Am. Ind. Hyg. Assoc. J.* 44: 671-676, 1983.

3) Johnson, A. T. and R. H. McCuen. Prediction of Respiratory Period on Men Exercising While Wearing Masks. *Am. Ind. Hyg. Assoc. J.* 42: 707-710, 1981.

4) Birkner, L. R. An Industry Viewpoint on Respirator Research Needs. *Am. Ind. Hyg. Assoc. J.* 41: A30-A34, 1980.

Figure 1. This is the chart that was used by the subjects to evaluate their inspiratory effort. If their perceived effort was not exactly labeled on the chart, they would use half values.

Figure 2. This is the list that subjects used to indicate their expiratory effort.

Figure 3. Figure 3 was used to measure perceived breathing discomfort. The rating for this chart are slightly different from those of inspiratory and expiratory effort.

Figure 4. The three graphs in this figure represent the mean perceived inspiratory effort, expiratory effort, and breathing discomfort. Each subject is labeled with his appropriate number, and the configuration is labeled at the bottom of each group of columns. The column labeled mean is the mean value for all for subjects for that particular configuration.

Indicate the sensation that better describes your

INSPIRATORY EFFORT at this moment

1) NOT NOTICEABLE

2) NOTICEABLE BUT NOT DIFFICULT

3) SLIGHTLY DIFFICULT

4) MODERATELY DIFFICULT

5) VERY DIFFICULT

6) EXTREMELY DIFFICULT

7) INTOLERABLE

Indicate the sensation that better describes your

<u>EXPIRATORY</u> <u>EFFORT</u> at this moment

1) NOT NOTICEABLE

2) NOTICEABLE BUT NOT DIFFICULT

3) SLIGHTLY DIFFICULT

4) MODERATELY DIFFICULT

5) VERY DIFFICULT

6) EXTREMELY DIFFICULT

7) INTOLERABLE

Indicate the statement that describes your

perception of BREATHING DISCOMFORT

at this moment

1) NO DISCOMFORT

2) SLIGHT DISCOMFORT

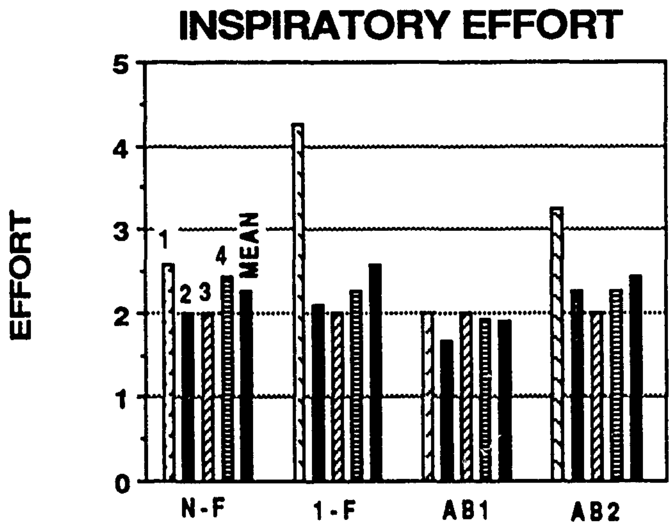
3) MODERATE DISCOMFORT

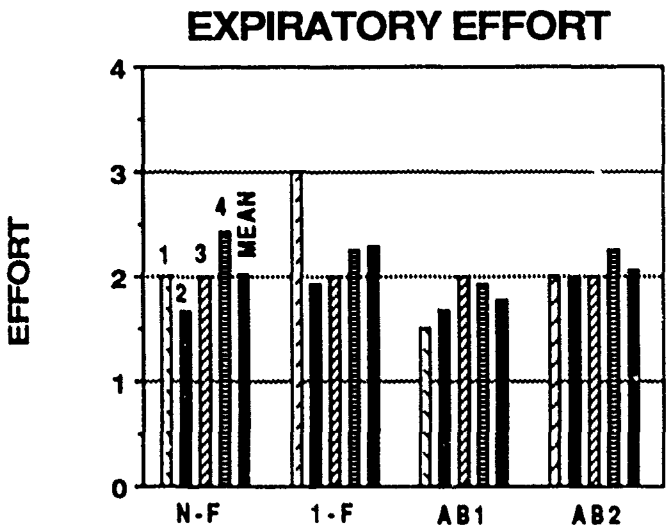
4) MODERATE-HIGH DISCOMFORT

5) HIGH DISCOMFORT

6) EXTREMELY HIGH DISCOMFORT

7) INTOLERABLE DISCOMFORT


INSPIRATORY EFFORT
EFFORT
5
4
3
2
1
0
1
2
3
4
MEAN
N-F
1-F
AB1
AB2


EXPIRATORY EFFORT
EFFORT
4
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MEAN
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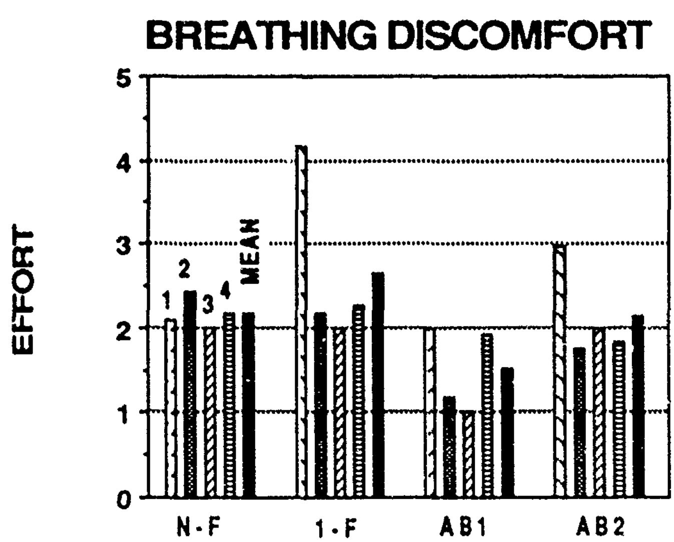
AB1
AB2


BREATHING DISCOMFORT
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MEAN
N-F
1-F
AB1
AB2

NMDA induces light phase shifts of the circadian activity rhythm and c-fos expression in the hamster suprachiasmatic nuclei.

Eduardo Carrillo
Sustained Operations Branch
Armstrong Laboratory
Brooks AFB, Texas 78230

ABSTRACT

The suprachiasmatic nuclei (SCN) have been identified as a pacemaker for many circadian rhythms in mammals. Entrainment of circadian rhythms to the environmental light-dark cycle is mediated by the direct retinohypothalamic tract (RHT). Recent findings suggest that excitatory amino acids (EAA) could be involved in the transmission of photic information to the SCN via the RHT. Exposure of rodents to light can induce expression of a number of immediate-early genes, including c-fos, in cells of the SCN. This paper describes whether injections of EAA agonist into the SCN could mimic the effects of light pulses in inducing c-fos expression, and phase shifting of the circadian pacemaker.

INTRODUCTION

Recent studies involving the use of rats and hamsters have led to the recognition of the suprachiasmatic nuclei (SCN) of the hypothalamus as a primary pacemaker for circadian rhythms in mammals.[1,2] Other studies have shown that bilateral destruction or surgical isolation of the SCN abolishes circadian rhythmicity in rodents,[5,6] and that transplantation of fetal SCN tissue into the third ventricle of SCN-lesioned hosts restores rhythmicity.[3,4]

Circadian rhythms in mammals have two outstanding properties. Under constant environmental conditions, mammals exhibit free-running rhythms with a period deviating slightly from 24 hrs. The observation of free-running rhythms implies that an organism is "endowed" with an intrinsic physiological mechanism capable of generating self-sustaining circadian oscillations. When an animal is exposed to light-dark cycles with a period sufficiently close to 24 hours, its circadian rhythms establish a constant phase relation with this environmental regimen.

A characteristic of these endogenous oscillations, and one that confers more adaptive significance, is that they can be entrained to periodic signals from the environment. Light is the major entraining agent of the circadian pacemaker. The daily light-dark cycle entrains all known circadian oscillators, and in the golden hamster a brief flash of light presented once a day is sufficient. In rodents maintained under constant darkness, the free-running activity rhythm can be phase shifted by light pulses in a phase-dependent manner. Light pulses given late in the subjective night cause phase advances, while light pulses administered early in the subjective night result in phase delays of the pacemaker.[7,8] The effects of dark pulses differ from those obtained by light pulses in that dark pulses induce phase advances of the free-running activity rhythm when applied during the animals subjective day.[8,9] In mammals, photoreceptors that are located in the retina project to the hypothalamus via a monosynaptic fiber tract known as the retinohypothalamic tract or RHT. The RHT projection appears to mediate the effect of light on the circadian system.[10,11,12] The fibers terminate at the (SCN).

Recently, it has been shown that stimulation of the optic nerve in an _in vitro_ hypothalamic slice preparation that contains the SCN induces a calcium-dependent release of [^{3}H] glutamate and [^{3}H] aspartate.[13] Moreover, glutamate and aspartate, which are major neurotransmitters in the mammalian central nervous system, are present in the optic nerve and SCN neurons are responsive to glutamate.[14,15] These studies suggest that excitatory amino acids

(EAA) may be involved in the transmission of the RHT. Three major subtypes of postsynaptic EAA receptors have been identified in the central nervous system and named for their specific agonists: N-methyl-D-aspartate (NMDA), Kainate (KA), and quisqualate (QUIS). MK-801 ((+)-5-methyl-10, 11-dihydro-5h-dibenzo [a,b] cyclohepten-5, 10-imine maleate) is a potent and specific antagonist of the NMDA receptor.[16] Its mechanisms of action is believed to involve blockade of the ion channnel associated with the NMDA receptor. Studies have found that MK-801 blocks the phase shifting effects of light pulses on the behavioral circadian rhythm of locomotor activity of golden hamsters. Furthermore, our laboratory has shown that agents which block the effect of glutamate prevent light-induced phase shifts of the hamster activity rhythm by acting directly on the SCN.[17]

The proto-oncogene c-fos is induced in both neuronal and nonneuronal cells in response to a variety of stimuli, and appears to play a role in the specific regulation of transcription of several genes.[18] In neuronal cells, c-fos expression is enhanced by a number of stimuli, including treatment with nerve growth factor[19] and neurotransmitters,[20] and by induction of seizure activity.[21] The c-fos gene has been suggested to act as a "third messenger" molecule in signal transduction systems. In our laboratory and elsewhere, it has been demonstrated that light exposure during the subjective night induces c-fos expression among SCN cells. However, c-fos expression only occurs when light is administered at a circadian time at which a phase shift of the circadian pacemaker results.[22,23]

The primary objective of this investigation is to determine whether injections of EAA agonist into SCN could mimic the effects of light pulses in inducing c-fos expression, and phase shifting the circadian pacemaker.

METHODS

Stereotaxic Surgery

Male, Syrian hamsters obtained from Charles River were initially housed in groups under a light-dark (LD) schedule of 14 hours of light, 10 hours of darkness (LD 14:10) for at least two weeks prior to the implantation of guide cannulae. Hamsters weighing 120-180 grams were anesthestized with sodium pentobarbital (0.2 ml initial dose) and implanted with 26-guage guide cannulae stereotaxically aimed at the SCN. The cannulae were fixed to the skull with dental acrylic, and a wire (stylet), manufactured from 33-gauge stainless steel wire, was inserted in the cannula in order to keep it protected. The animals were sutured and placed in separate cages until the anaesthesia wore off.

EAA agonist induced Phase Shifts

After the recovery period they were transferred to individual cages equipped with computer-monitored running wheels and maintained under constant darkness (DD) with free access to food and water. Hamsters remained in DD for several days before treatment. At mid-subjective night (CT18), animals received an injection of artificial cerebral spinal fluid (aCSF) containing 1mM NMDA (a competitive, NMDA-type EAA agonist). After treatment, the hamsters were returned to their cages for an additional 8-10 days. Using the onset of wheel running activity as a phase reference point, the effect of the treatment on the phase of the free-running activity rhythm was determined as described by Daan and Pittendrigh.[7]

EAA agonist induced Gene Expression

After the recovery period, the cannulated hamsters [illegible] ed in groups under LD14:10 of at least 1 week after the surgery. The animals were transferred to DD at lights-out of the day before the experiment. At CT18 (mid-subjective night) the animals were given a 300nl injection of one of the following: aCSF (vehicle control), a solution of 1mM NMDA agonist in aCSF , and light stimulation (40 lux) for 10 minutes. The light stimulation apparatus was a Vivitar Model slide projector containing a 150 W tungsten-halogen lamp. Light intensity was determined using a Tektronix J16 digital luminometer with an illuminance probe. A stimulation chamber that kept the animal's head oriented towards the light source was used in order for the animal to get constant retinal stimulation during the ten minute period.

Immunohistochemistry

Two hours after treatment, the hamsters were anesthetized with 0.35 ml of pentobarbital and perfused transcardially with 100 ml heparinized saline and 100 ml of 4% paraformaldehyde in 0.1 M sodium phosphate buffer (pH 7.4). Brains were removed, cut into blocks, and incubated overnight in 4% paraformaldehyde at 4 C. Following the incubation period, the brains are placed in 0.1 M sodium phosphate buffer (pH 7.4). The brain blocks were then cut into 50 micron slices on the Vibratome. The tissue was washed with phosphate buffer and incubated at room temperature in 0.1 M sodium phosphate buffer containing 0.2% Triton X-100, 0.1% bovine serum albumin (TPB). Next, the sections were incubated in primary fos antiserum. The antiserum is a rabbit, affinity purified polyclonal antibody raised against the peptide corresponding to residues 4 to 17 of human fos. After incubation, sections were rinsed with PBS and processed with the Vectastain ABC Kit using diaminobenzidine (DAB) as the chromagen. The stained sections were then mounted, dehydrated, coverslipped, and examined with a Nikon microscope. The (+) control incubations were performed using brains from hypertonic saline injected rats and (-) controls were performed by omitting the primary antiserum.

Discussion of Results

The effect of light in shifting the phase of the circadian pacemaker is dependent on the circadian time at which the light occurs. At circadian times during the subjective day, light cannot induce phase shifts; at other circadian times (during the subjective night) light specifically causes either a phase advance or a phase delay. It has been shown that light pulses at CT18-19, which cause a phase advance, lead to an induction in c-fos expression.[22,23] In

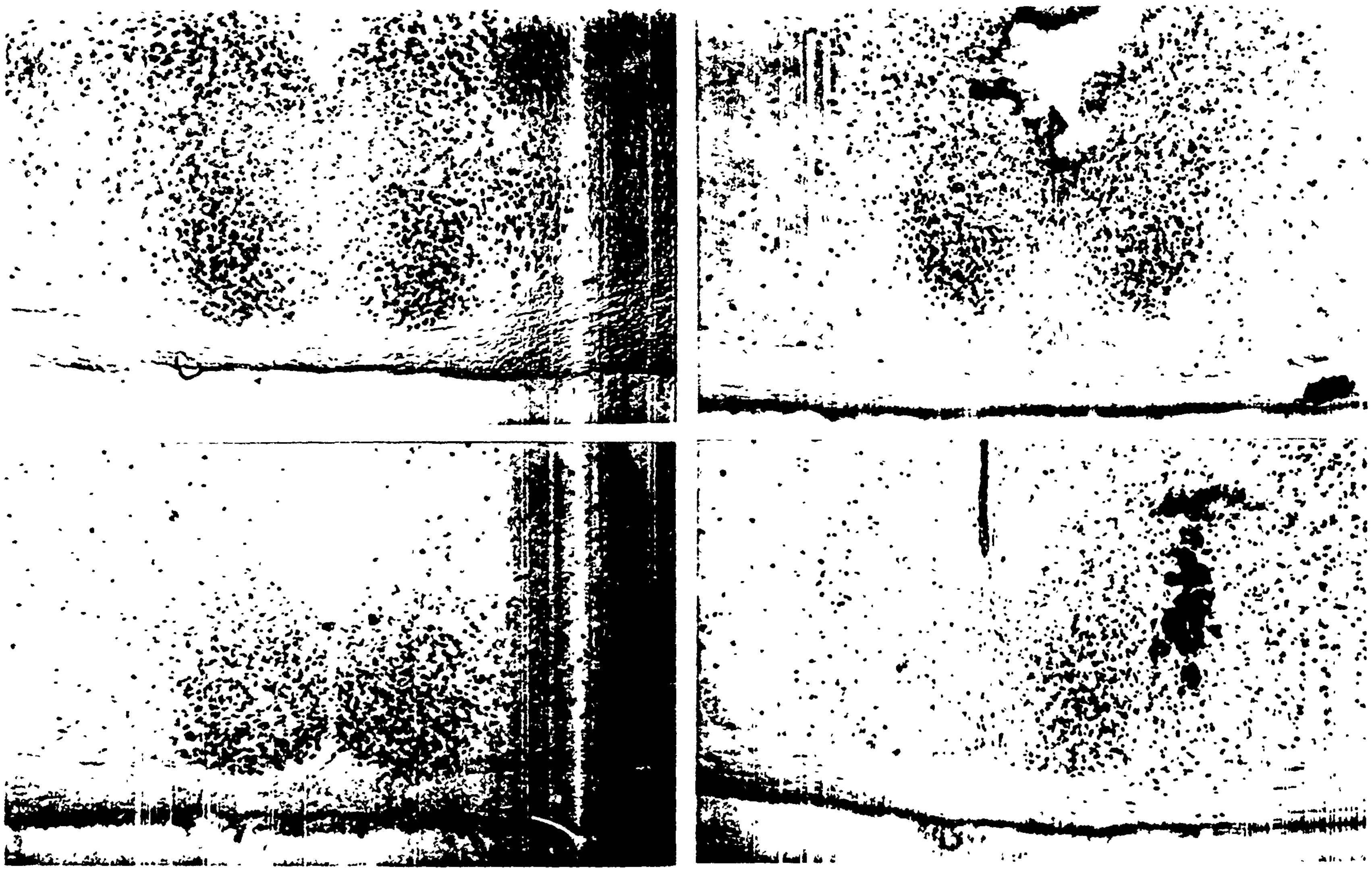

Figure I Light treatments at CT18-19 (upper left) induced c-fos expression in the SCN. ImM NMDA microinjections at CT18-19 (upper right) also induced c-fos expression. Light treatments at CT9 (lower left) expressed c-fos on both sides of the SCN, while NMDA microinjections (lower right) expressed c-fos more significantly throughout the hypothalamus on the side of injection.

contrast, during the subjective day, light pulses at CT3 and CT9, which do not induce phase shifts, do not cause detectable increases in fos expression.[23]

The primary objective of this investigation was to determine if c-fos expression and phase shifts could be induced by using the excitatory amino acid agonist, NMDA, at CT18-19. Fos expression was also determined at CT9 to determine the phase specificity of this response. Syrian hamsters received injections of either drug/ aCSF, aCSF (vehicle) alone, or light alone into the region of the SCN.

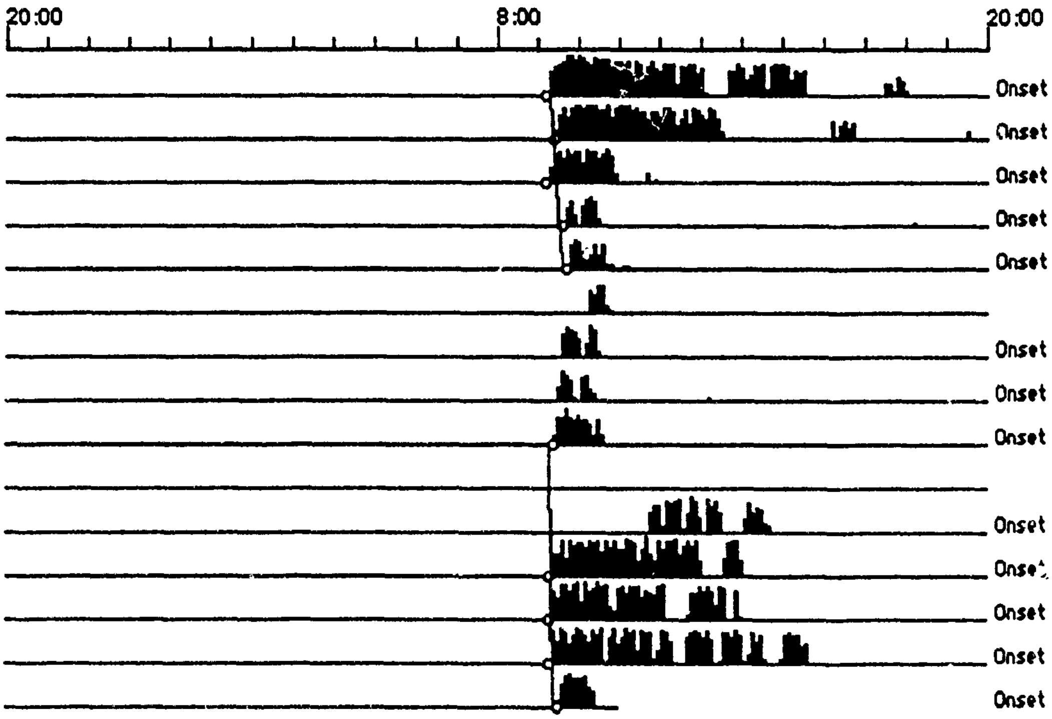

Figure 2. Excitatory amino acid agonist, NMDA, injections of 1mM into the SCN region seem to induce a slight phase advance during the hamsters subjective night at CT18-19.

__** Computer malfunction

According to the data, light treatments induced c-fos expression on both sides of the SCN at CT18 (Figure 1). Similarly, NMDA microinjections at CT18 also induced c-fos expression in the SCN and in the SON. Artificial CSF(vehicle) animals did not express any c-fos. A significant number of immunoreactive cells were expressed along the ventricle in both NMDA and light treated animals, but not in aCSF(vehicle) treated animals. Light treated animals at CT9 expressed c-fos cells specifically in the SCN and some in the SON, but the expression was not as intense as the NMDA microinjected animals who displayed more c-fos cells on the injection side of the SCN. Also, in NMDA treated animals, the c-fos expression was not specific to the SCN, but was rather scattered throughout the hypothalamus on side of injection. Also, similar to results at CT18, a significant number of immunoreactive cells were expressed along the ventricle. The stress control at CT18 did not express c-fos cells, but expression was observed after stress at CT9. Stress controls were used as a basis to judge fos expression.

Initially, it was hypothesized that NMDA injections would mimic the effects of light in inducing c-fos expression only during the hamster's subjective night (CT18), but not during its' subjective day

(CT9). The results show that NMDA does mimic the effects of light in inducing c-fos expression in the hamster SCN at CT18-19. Although, NMDA microinjections induce c-fos expression at CT9, there are differences in the pattern of expression. Different degrees of c-fos expression were observed in the SCN of hamsters given various treatments at CT18-19. The drug stimulated hamster exhibited the greatest amount of c-fos expression, while the light stimulated animal displayed a lesser amount of c-fos on both sides of the SCN. Injections using aCSF (vehicle) alone caused no c-fos expression whereas those using light and NMDA/aCSF had a significant amount of fos expression in the SCN. In addition, there seems to be a greater abundance of immunoreactive cells along the injection side of the SCN. NMDA injections of 1mM into the SCN region seem to induce small phase advances during the subjective night at CT18 (Figure 2).

In conclusion, NMDA injections of 1mM into the SCN region of hamsters do mimic the effect of light during the subjective night, but not during the subjective day. NMDA also seems to mimic light in inducing a slight phase advance of the circadian pacemaker which suggests that excitatory amino acids might be involved in the transmission of the retino-hypothalamic tract.

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MILLIMETER WAVE RADIATION

RESEARCH APPRENTICE: JOHN CERDA

BROOKS AFB SUMMER 1991

As an apprentice for research at Brooks AFB in San Antonio, Texas, I have achieved knowledge that is beyond what I have expected from this summer program. The work that I have undertaken and have accomplished here are the studies of The Physiological Effects of Whole-Body Exposure to Millimeter Waves. My duties as an Apprentice were to show proper care and handling of the experimental rats.

The procedures I performed while at the Directed Energy Bioeffects Laboratory were to oversee Ketamine - anesthetized Sprague-Dawley rats that were being exposed to 35-GHz continuous-wave radiofrequency radiation of average Specific Absorption Rate (SAR) of 13 W/kg. During experimentation, colonic, tympanic, right and left subcutaneous temperatures, arterial blood pressure, and respiratory rate were continuously recorded. Under one exposure condition (E-Orientation), there was a 3 minute delay in initiation of Tc change, and a 0.5 degree Celsius Tc "overshoot" when irradiation was stopped. Irradiation to accomplish a 1 degree Celsius Tc increase from 38.5 C to 39.5 C was accompanied by subcutaneous temperature increase of 6.0 C. These observations indicate that circulatory transfer of heat from the periphery was responsible from internal heating. Two different patterns of cardiovascular response were noted. During the 1 degree Celsius Tc increase, there was a significant linear increase in heart rate (HR) and mean arterial pressure (MAP). However, during an initial period of irradiation performed to establish the baseline Tc, HR increased monotonically while MAP increased to a point and then decreased dramatically; a reaction characteristic of cardiovascular responses shock with heatstroke.

INTRODUCTION:

The recent development of hardware systems capable of generating that portion of the electromagnetic spectrum referred to as millimeter waves (MMW) (30-300 GHz), as well as the increased use of MMW for military and civilian purposes, has spawned significant interest in the possible bioeffects and health hazards of exposure to these waves. During the past decade, studies of MMW bioeffects have primarily employed models such as bacterial and yeast cultures, and animal cell cultures.

OBJECTIVES:

The objectives of this study were: 1) to observe the pattern of absorption of MMW energy and to compare and to contrast this pattern with those seen at other lower frequencies; 2) to achieve a more thorough understanding of the relationships among exposure frequency, exposure orientation, and physiological response; and 3) to gain more insight into the effects of MMW electromagnetic radiation on whole-animal physiology. In order to accomplish these objectives, anesthetized rats were exposed to 35- GHz radiofrequency radiation (RFR) in E-orientation.

METHOD:

A number of Sprague-Dawley rats (Charles River Laboratories), weighing between 342 and 385 g were used in this study. Animals were housed in cages with free access to Purina rodent chow and water, and were maintained on a 12h/12h, light/dark cycle in a climatically controlled environment.

Prior to irradiation, a carotid catheter was installed via the left carotid artery to measure arterial blood pressure along with a Doppler flow probe that was attached to a mesenteric artery to measure blood flow. Ketamine HCl 150 mg/kg I.M., was administered as the general anesthetic, with supplemental doses provided as necessary. Ketamine administration at this dose level has been shown to produce adequate prolonged anesthesia in Sprague-Dawley rats. Immediately after surgery, the rat was placed in a Plexiglas holder in the RFR exposure chamber. Instrumentation was designed to continuously monitor and record blood pressure, blood pressure, temperature, respiratory and heart rate. Temperatures were monitored at 6 sites. Those sites were: left subcutaneous, right subcutaneous, tail, colonic, tympanic, and chamber room temperature.

RESULTS:

During the initial exposure period, the rats were exposed until Tc increased to 39.0 C. Following exposure, the Tc continued to "overshoot". Mean Arterial Pressure increased to a critical point and then decreased dramatically while Tc was still increasing. The downturn of the Mean Arterial Pressure began at Tc of 37.5 C during E-orientation. Respiratory rate did not significantly change during the warm-up phase.

The times required for Tc to increase from 38.5 to 39.5 C during E-orientation exposure, and times required for Tc to return to 38.5 C when irradiation was stopped. The time to accomplish a 1 C Tc increase was similar during a few exposures; however, the recovery time was greater following E-orientation irradiation. The left skin increase was significantly greater (6X) than the colonic temperature change; the right skin was significantly less; and the tail temperature change increased with the colonic temperature increase. As the colonic temperature increased from 38.5 to 39.5 C Tc, Heart Rate and the Mean Arterial Pressure significantly increased. Respiratory Rate did not significantly change during the 1 C Tc increase. In all cases, values returned to near baseline levels during the recovery period.

SUMMARY:

Results of the present study of whole-body irradiation with 35- GHz Radio Frequency Radiation show interesting patterns of thermal deposition and distribution, and equally interesting cardiovascular responses to the heating. As shown by the delay in onset of Tc change upon initiation of irradiation and the

prolonged overshoot after irradiation ceased while the subcutaneous temperature immediately responded to transmitter status, the change in core temperature was almost exclusively achieved through heat transfer from the periphery. Two different patterns of cardiovascular response were noted. During the irradiation to increase colonic temperature from 38.5 to 39.5 Celsius, Heart Rate and Mean Arterial Pressure increased during exposure and returned to near baseline when irradiation was terminated. However, Mean Arterial Pressure increased to a critical point and then decreased dramatically. Such a reaction is characteristic of cardiovascular shock seen during heat stroke and terminal exposure to Radiofrequency Radiation. However, these shock reactions normally occur at colonic temperatures of 41.5 degrees Celsius or higher, while in the present study they occurred at colonic temperatures of 38 degrees Celsius. The results also show that during irradiation at 35 GHz, animal orientation relative to the electric and magnetic fields does not influence the pattern of heat distribution or the cardiovascular responses to heating.

A Comparison of Sweat Rates and Mean Skin Temperatures in the CDE+BDU and CWU-77P Chemical Defense Ensembles

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9 August 1991

ABSTRACT

To compare how proposed chemical defense ensembles (CDEs) would perform in desert conditions, subjects wearing different protective suits walked briskly on a treadmill in a climate-controlled chamber (T_{db} = 40°C) until their body's core temperature rose 1.5°C. The two CDEs studied each consisted of a charcoal-foam layer, shielding chemical agents, encased within an insulated cloth garment. The CWU-77P, weighing 4.5 kg, is worn alone, while the CDE+BDU, combined with its additional required clothing layer, weighs 6.5 kg. The CDEs were evaluated by measuring the quantity of sweat a person exercising in the suit produced, what percent of this sweat evaporated, the subject's mean skin temperature throughout the trial, and the duration of work performed before core temperature elevated 1.5°C. Subjects wearing the CWU-77P produced 26.25 ml/min of sweat, evaporated 12.91 ml/min (46.9% of production), and had a mean skin temperature of 37.3°C after completing 52.77 minutes of work. For these same subjects wearing the CDE+BDU, production rose to 30.63 ml/min, evaporation fell to 9.34 ml/min (30.6% of production), and the mean skin temperature recorded was 38.0°C following only 31.32 minutes of work. The CWU-77P ensemble kept the subjects significantly cooler than the CDE+BDU probably because of its light weight, single layer, and permeability to sweat. However, these same factors may cause the CWU-77P to provide less protection from chemical agents.

INTRODUCTION

Thermal stress occurs when the equilibrium between heat lost through the skin and heat gained from metabolic production is disrupted. Though stress may be attributed to sources varying from the thermal environment to aircraft to aircrew, clothing is the factor of concern in this study. Clothing creates a barrier which inhibits the normal flow of heat between the skin and environment (5). A person wearing a chemical defense ensemble becomes especially susceptible to heat stress since this garment is not only insulated, preventing convective heat loss, but also somewhat impermeable to water vapor, decreasing the effects of sweat evaporation (1).

As a person either begins working or is placed in an environment of high temperature (>28°C), the body begins to store heat (4). Soon blood flow increases, bringing more heat to the skin while increasing surface temperature. Heat may be lost to the environment through convection as long as the skin temperature exceeds ambient temperature. When the skin temperature reaches a critical point, estimated at 34.5°C, the sweat glands begin generating sweat to cool the body (4). Though sweat rates vary greatly among people, a person acclimated to thermal stress sweats more than someone not accustomed to heat. A typical man can produce between two and three liters of sweat an hour. Sweat rates eventually slow in a warm environment despite the drinking of liquids to replace fluid lost. This reduction in sweat may be due either to the saturation of the skin with perspiration or the swelling of tissue around the sweat ducts (2,3). The less a CDE interferes with a person's normal sweat production and evaporation cycle, the more successful it is.

The recent events in the Persian Gulf are a poignant example of the necessity of a CDE which better enables crew to perform sustained operations in a potentially poisonous environment. Current CDE's provide protection from chemicals through an absorbent charcoal-foam layer. This foam layer is surrounded by some type of cloth garment. A complete CDE and its accessories, including boots, gloves, mask, and hood, encloses the entire body. CDEs, designed to prevent chemical penetration, also effectively inhibit water from leaving the suit. This creates a number of problems. Rapidly increasing body temperature reduces the duration and quality of work that can be performed. As a person works, metabolic rate rises causing increased sweat production. Since the CDE is sealed, perspiration cannot evaporate and remains inside the suit. This water produces an additional layer of insulation, causing the internal temperature to rise even further. The CDE also prevents other means of heat dissipation including conduction, convection, and radiation. These, however, are not truly significant since once ambient temperature surpasses skin temperature, radiation and convection are no longer viable cooling methods. If normal work loads were attempted in a CDE, body temperature might reach a level high enough to cause heat stroke and eventual death. It is apparent that to ensure the safety and comfort of troops involved in a chemical battle, every effort must be taken to produce the coolest, most effective CDE possible.

Methods

Subjects

The subjects in the study consisted of ten men and one woman (Figure 1). All subjects were fully aware of the environment they would be exposed to as well as the risks they might incur. Subjects were free to end their participation if they felt too much discomfort. Standard protocol limits for thermal exposure were observed, and medical personnel monitored the subjects throughout the experiment

Protocol

All subjects completed eight trials. Seven of these involved wearing different CDEs; the eighth trial was a control in which the subject wore only a shirt and shorts. The experiments were carried out in a simulated desert situation produced by a monitored, climate-controlled chamber. The conditions, similar to those found in Saudi Arabia during Operation Desert Storm, were identical for each run (40°C with a relative humidity of 20%). Heat lamps were employed to imitate radiant heat from the sun.

After first entering the chamber, a subject's initial weight was taken. Next, a rectal probe used for measuring core temperature was inserted, and an ECG telemeter was attached followed by thermistor/heat flux sensors on the chest, forearm, calf, thigh, and back. The subject dressed in the chemical defense ensemble and an initial clothed weight was obtained. In this experiment, the suits considered are the CDE+BDU and the CWU-77P uniform. Each ensemble shields its wearer from chemicals through a charcoal-foam medium. The CDE+BDU assembly has an additional clothing layer worn on the skin. Finally, after getting into the suit, the mask and hood were donned and the last two probes were inserted. These measured temperature and humidity. One was placed between the subject's shirt and skin; the other went between the CDE and shirt. Upon completion of the instrumentation, the subject stepped onto the treadmill and walked three miles per hour at a five percent grade until core temperature increased 1.5°C from the initial measurement.

After the core temperature attained the desired level, the subject was removed from the treadmill and allowed to rest for fifteen minutes. During this time, heart rate and temperature were still monitored for signs of heat stress. Also, the subject was permitted to consume measured quantities of water *ad lib.* Following the rest period, instrumentation was removed and final clothed and nude weights were recorded.

Measurements

Combined heat flux transducers and thermistors were used to determine heat flux and skin temperature. The data from these instruments was measured and recorded continuously through a Macintosh computer data-acquisition system. The computer calculated the mean skin temperature by assigning certain factors to each thermistor:

chest	.50
thigh	.36
forearm	.14
	1.00

The rectal probe and the two other humidity/temperature probes were connected to a Squirrel, an automatic logging device. Wet and dry bulb readings were recorded every five minutes. In addition, psychological data was taken each five minute interval by asking the subject about perceived exertion and thermal sensations.

Results

The experiments demonstrated the enormous change in thermal balance encountered when increasing metabolism through work and simultaneously inhibiting evaporative heat loss in desert conditions. Each run was analyzed in terms of the rates of sweat production and evaporation, the percent of sweat produced which evaporated, the mean skin temperatures throughout the work period, and the duration of work.

For all but two of the subjects, the sweat rate was greater in the

CDE+BDU than in the CWU-77P (Figure 2). Production in the CDE+BDU averaged 30.63 ml/min for all subjects. In the CWU-77P, the mean rate was 26.25 ml/min. Thus, the subjects generated 4.38 ml/min more sweat in the CDE+BDU. Though this amount might seem inconsequential, supposing that a worker labored for an hour in the suit, the excess sweat produced (263 ml) would be quite significant. Of the additional 263 ml of perspiration, less than one-third would vaporize. The rest would wet the skin, making evaporation difficult in the places where sweat collected. This is dangerous since a failure in heat regulation can result when the body's sweating mechanisms work too hard, become fatigued, and slow sweat production. Also, there is the additional risk of dehydration if water loss is not replaced through adequate liquid intake.

Nine of the eleven subjects evaporated more sweat in the CWU-77P assembly. Mean sweat evaporation rates were 12.91 ml/min and 9.34 ml/min in the CWU-77P and CDE+BDU, respectively (Figure 3). The experimental group as a whole evaporated almost 4 ml more sweat a minute in the CWU-77P though they actually produced 4 ml/min less perspiration.

Since evaporative cooling helps maintain low core temperature, while perspiration collecting in the suits causes higher readings, it is important to determine which suit allows sweat to be more effectively used. This is accomplished by comparing percent evaporation in the two ensembles. Percent evaporation was greater in the CWU-77P for every person. The average percent evaporation was 46.9% in the CWU-77P but only 30.6% in the CDE+BDU (Figure 4). Due to water's high heat of vaporization (580 kcal/l), evaporation provides an excellent means of cooling the body. When water evaporates from the skin, the skin becomes colder due to the energy required to change liquid water into a vapor. However, water produced that does not vaporize and remains on the skin only serves to further wet a person.

Just as the CWU-77P exceeded the performance of the CDE+BDU in terms of sweat production and evaporation, it continued to function well when considering mean skin temperatures. Observing the average skin temperature in each suit at five minute intervals, the CDE+BDU was higher in every instance (Figure 5). As time progressed, the gap in temperature between the two suits became increasingly evident. At the study's commencement, the difference in mean skin temperatures was only 0.1°C; after twenty-five minutes, a full degree discrepancy was recorded. The maximum temperature measured in subjects wearing the CWU-77P was 37.3°C, following fifty minutes of exercise. The CDE+BDU achieved this point before fifteen minutes had elapsed. The CDE+BDU's highest temperature was 38°C, recorded after thirty minutes of work.

The duration of work before the body's core temperature elevated 1.5°C was 31.32 minutes in the CDE+BDU and 52.77 minutes in the CWU-

77P, a difference of 21.45 minutes (Figure 6). Therefore, the subjects were able to work for a time period 68% longer wearing the CWU-77P, while still maintaining a lower sweat rate, higher evaporation rate, and a reduced skin temperature compared to those found when the CDE+BDU was worn.

Discussion

The results of the experiments were quite clear. In almost every case, subjects working in the CWU-77P remained cooler than those exercising in the CDE+BDU. However, there were four individual instances of unexpected data. Two subjects produced more sweat in the CWU-77P than in the CDE+BDU, while two evaporated less. None of the atypical results involved skin temperature or duration of work. The unusual measurements all dealt with sweat, which may be influenced by many variables besides clothing.

The sweat production of Subject 4 was the most significant deviation from the mean results. This subject's sweat rate was 38.11 ml/min in the CWU-77P, but only 33.95 ml/min in the CDE+BDU. The one other subject to generate more sweat in the CWU-77P did so by only 0.37 ml/min. Subject 4's gap was 4.16 ml/min. A difference this large suggests a human error in measurement, but all calculations were verified as correct. It is also possible that since sweat loss is calculated by subtracting a person's final and initial weights, an error occurred in one of these numbers artificially adding to the sweat loss; this, too, is doubtful since the before and after weights of the subject were within 1.5 kg of each other on both occasions. It is interesting to note that the subject's initial nude weight was 84.42 kg on the day he tested the CDE+BDU and 79.63 kg when he later tested the CWU-77P. If Subject 4 lost this 5 kg through an increased exercise regimen, he might have developed an elevated metabolic rate capable of producing increased sweat volumes. However, this is rather speculative. The most reasonable explanation for the deviating values is that Subject 4 had a very high percent evaporation (42%) while wearing the CWU-77P but a rather small evaporated percent (25%) in the CDE+BDU. He sweat larger quantities per minute in the CWU-77P since he was able to utilize his sweat to relieve his heat imbalance. In the CDE+BDU, he did not sweat heavily because his skin became saturated early and prevented evaporation.

Since only a limited number of suit sizes were available, a subject might have worn an improperly fitted CWU-77P suit, restricting airflow and causing a higher sweat production rate. This is a definite possibility for Subject 2 who had unexpected results and weighed 98 kg. Weighing this much, it is likely that Subject 2 had a low surface area to mass ratio, causing him to sweat more, though he probably should have sweat more in both suits.

Two of the other non-conforming results, the sweat production of

Subject 11 and evaporation of Subject 7, did not show that the CDE+BDU worked better but that both suits functioned similarly since the variation in sweat between the two suits was less than .5 ml/min in each of these cases. Factors which may have artificially contributed to higher sweat rates and temperature during a particular day of testing include sickness, eating or exercise previous to the run, or uncontrolled variations in the temperature and humidity of the chamber. Because the method used to determine sweat evaporation involves subtracting a person's final and initial clothed weights, sweat dripping off a person on the treadmill and lowering the subject's final clothed weight, would incorrectly increase the measured amount of evaporated sweat. Also, there is always the chance that for some unknown reason a given suit might perform better for a very specific group of people.

Since the data showed that the CWU-77P worked better than the CDE+BDU on all but four occasions, instead of trying to explain the few exceptional instances, it is more important to decide what made the suit better in the majority of cases. There are at least three significant possibilities. First, the CDE+BDU weighs more than the CWU-77P. It also appears to be more insulated. Insulation interferes with convective heat exchange through preventing conductance between the air and skin. By keeping the skin warmer, it induces the body to produce more sweat. Second, the design of the CWU-77P seems to allow airflow within the suit, while the CDE+BDU consists of three tightly packed layers restricting movement. This air movement aids convection and sweat evaporation. Third, the permeability of the suit may itself be a factor. The CWU-77P seems to allow more sweat to seep through the cloth. Though this certainly keeps the suit cooler, does it also suggest that the suit is more permeable to chemicals as well? Further studies must be carried out to determine whether chemical impregnation is a problem in the CWU-77P. Other factors, including cost, must be considered, too. In this case, the performance of the CWU-77P surpassed the CDE+BDU so completely that it would obviously be worth paying more for the suit which provided 68% more work time, but in more ambiguous cases, cost might become one of the deciding factors.

Conclusion

The performance of the CWU-77P suit significantly exceeded that of the CDE+BDU. The CWU-77P, by allowing its wearer to efficiently evaporate the sweat produced, afforded a cooler and longer duration of work. However, the subjects in this clothing assembly still performed less than an hour of work in a desert climate before their core temperature elevated 1.5°C. The two suits compared in this study demonstrate the impact of simple changes in CDE design upon the time period a suit may be worn. Using the CWU-77P as a prototype, the Air Force might aim to produce a suit in which crew performance times were extended to two hours with the same 1.5°C increase in core temperature. Perhaps a new suit could be manufactured, similar to the CWU-77P but even lighter, though loose enough to allow air circulation, while not compromising impermeability to chemicals for user comfort. In any event, it is imperative that the Air Force continue its quest for a CDE, which through ultimately maximizing sweat evaporation with minimal production, would allow aircrew to perform moderate levels of work in a toxic environment.

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Captions for Figures

<u>Figure 1</u>. Subject characteristics.

<u>Figure 2</u>. Sweat production rates of each subject in both the CDE+BDU and CWU-77P. Figure 1 may be consulted to determine the specific subject referred to by number on the graph's axis. The results in the column labeled twelve are the mean values for the entire experimental group.

<u>Figure 3</u>. Sweat evaporations rates. Details as in Figure 2.

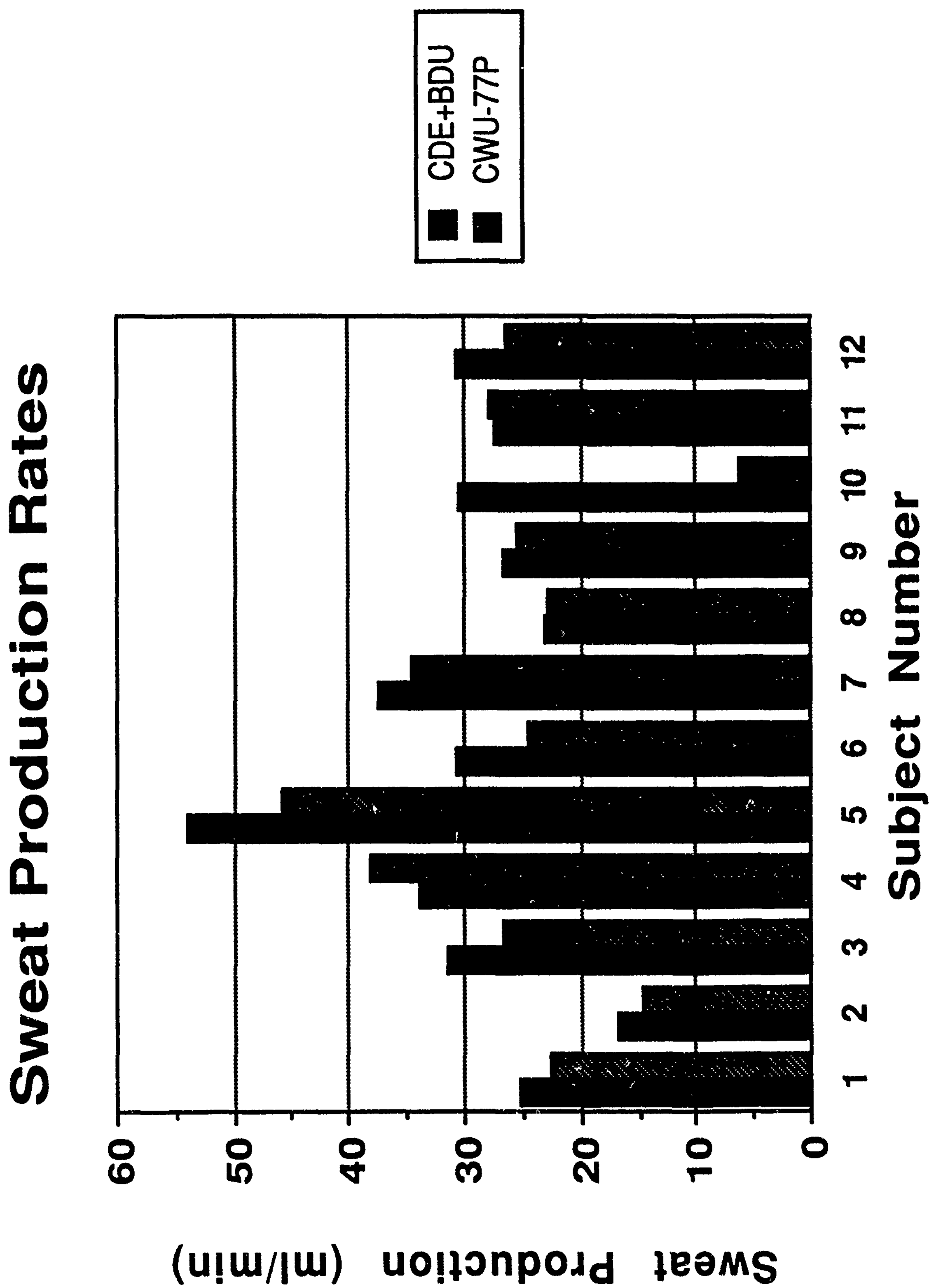
<u>Figure 4</u>. Percent evaporation of sweat. Details as in Figure 2.

<u>Figure 5</u>. Mean skin temperature varying over time. The discrepancy in the length of the lines graphed is due to the difference in the average duration of time subjects worked in the two suits. See Figure 6 for more detail.

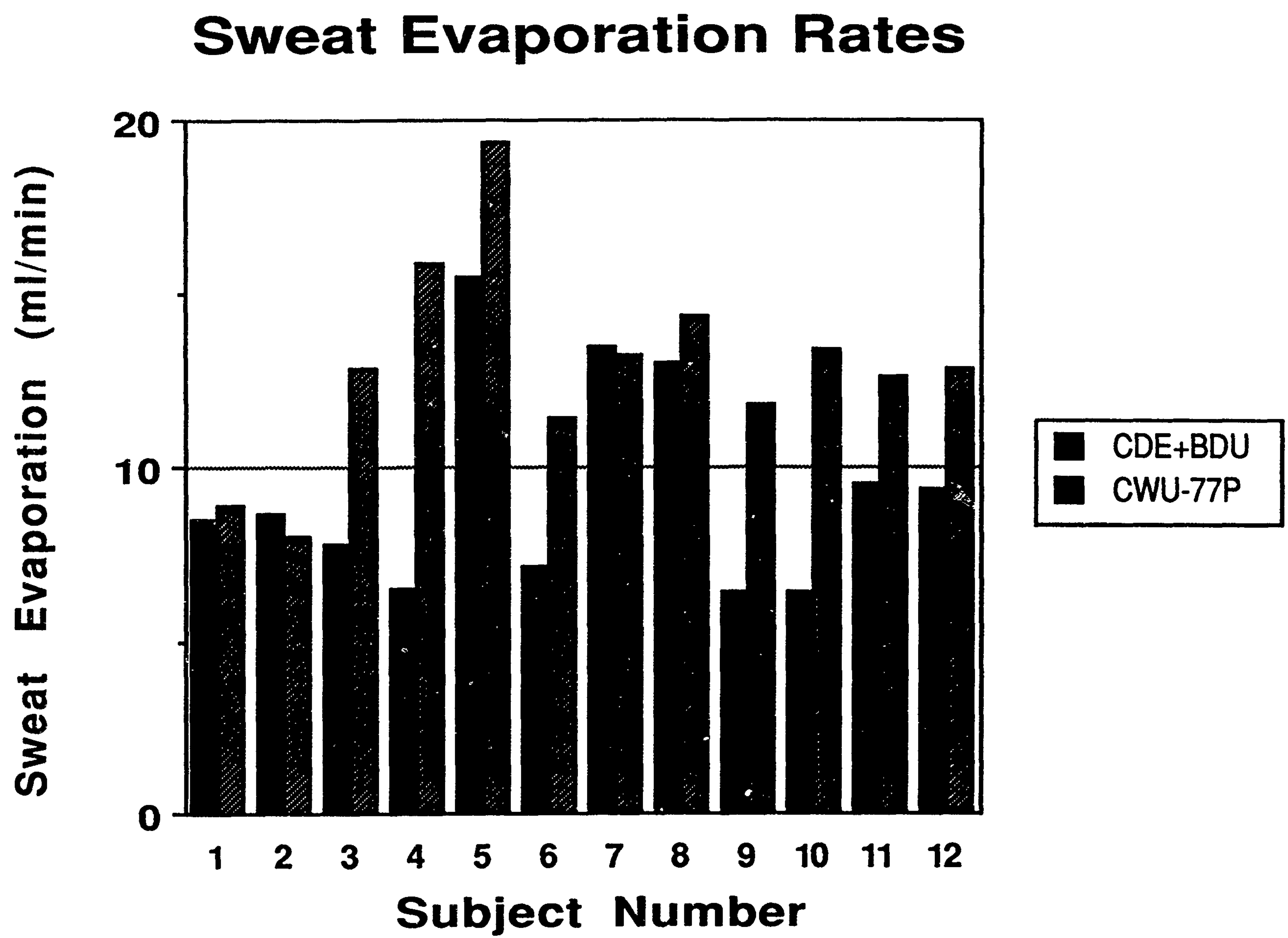
<u>Figure 6</u>. Mean work times for the CDE+BDU and CWU-77P. The actual time values, rounded to the nearest minute on the graph, are 31.32 min for the CDE+BDU and 52.77 min for the CWU-77P.

Experimental Group Statistics

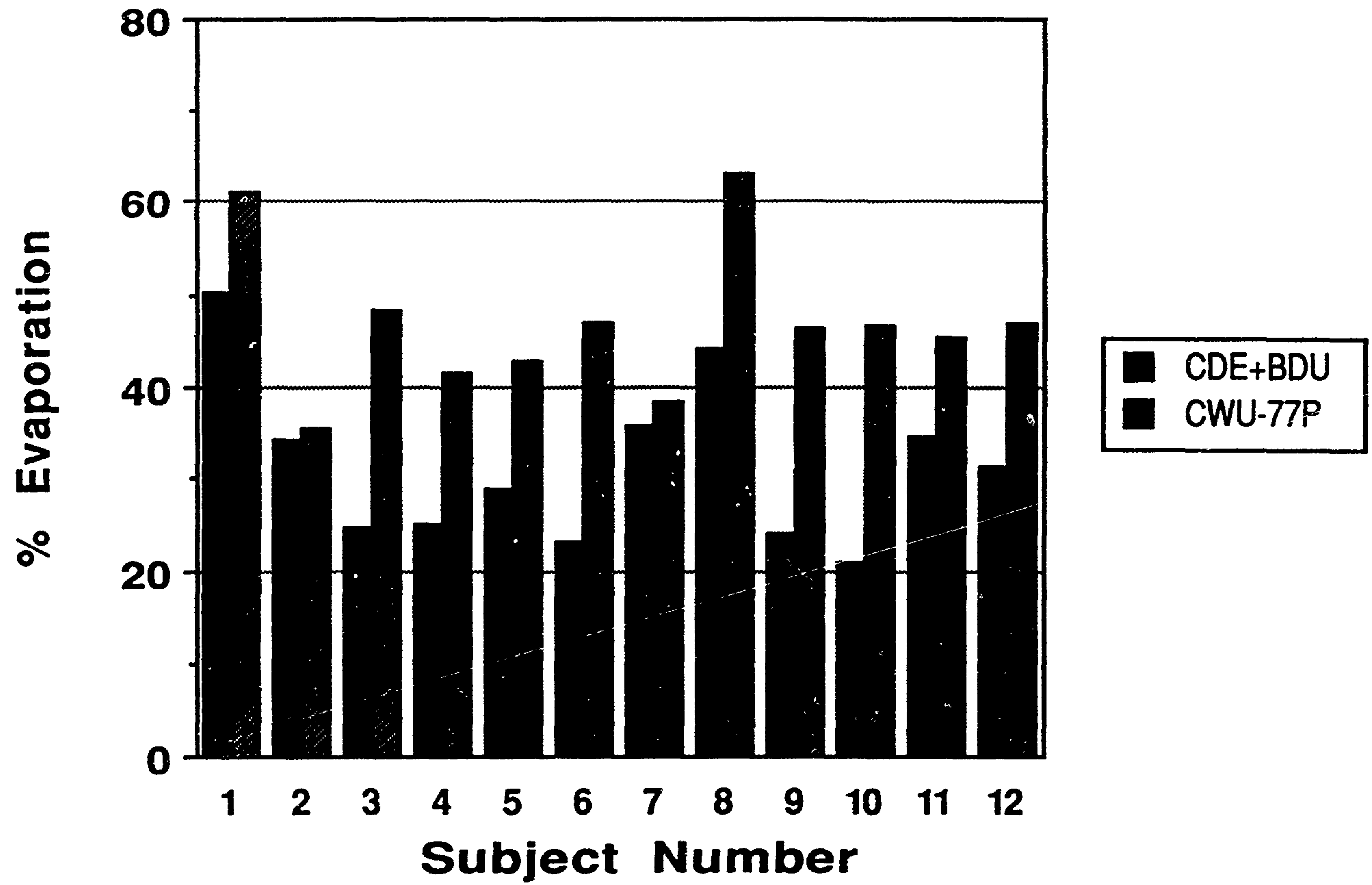
Number	Height(cm)	Weight(kg)	Age	Sex
1	172.5	60.0	35	F
2	180.0	98.0	28	M
3	180.0	82.9	24	M
4	173.7	83.8	42	M
5	177.5	88.6	34	M
6	172.5	81.8	41	M
7	172.5	79.0	41	M
8	170.6	77.2	37	M
9	177.0	81.9	32	M
10	175.0	76.8	37	M
11	180.0	81.8	28	M
mean	175.6	81.1	34.5	
std dev	3.3	8.7	5.7	



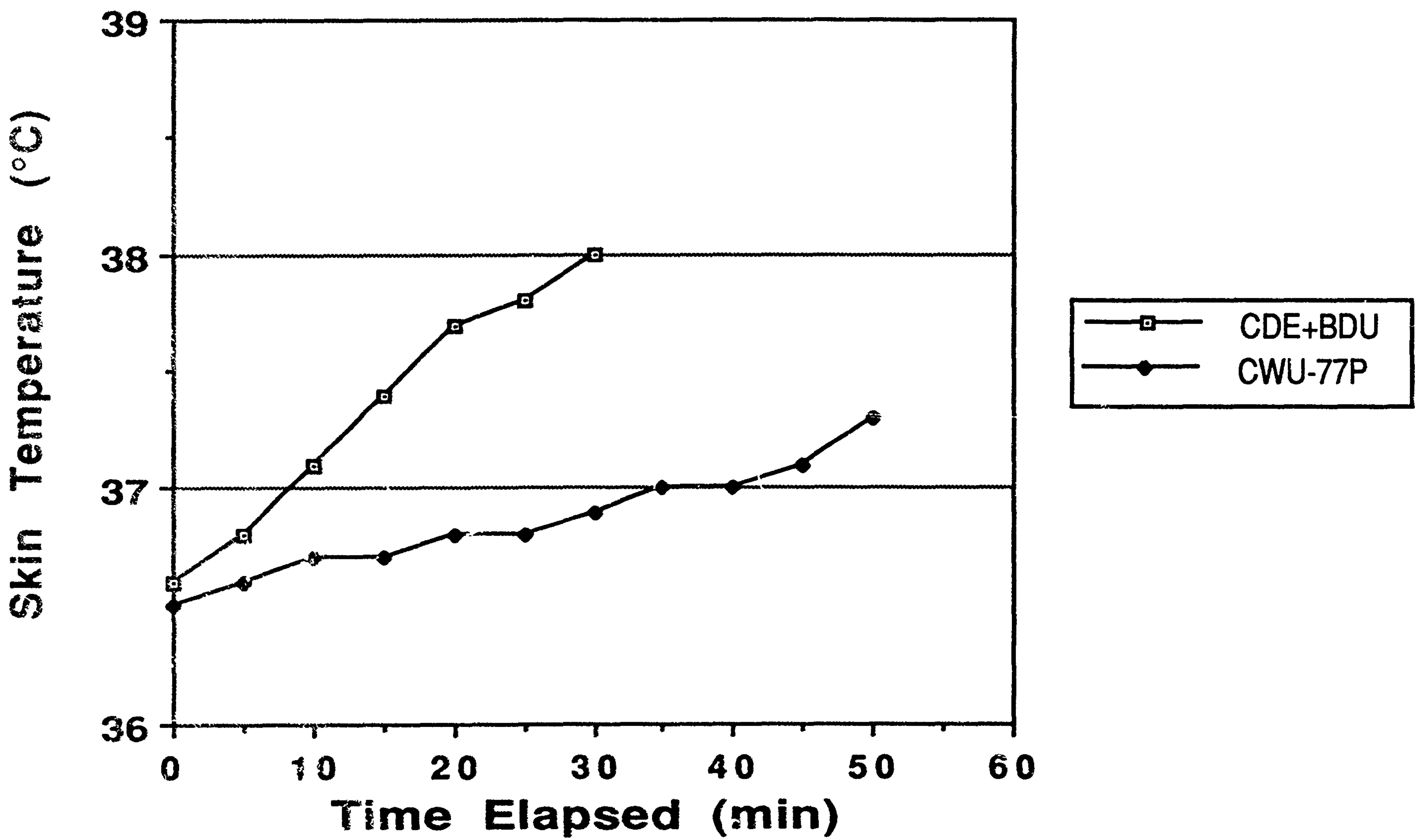
Sweat Production Rates
CDE+BDU
CWU-77P
Sweat Production (ml/min)
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
Subject Number


Sweat Evaporation Rates
20
10
0
Sweat Evaporation (ml/min)
1
2
3
4
5
6
7
8
9
10
11
12
Subject Number
CDE+BDU
CWU-77P

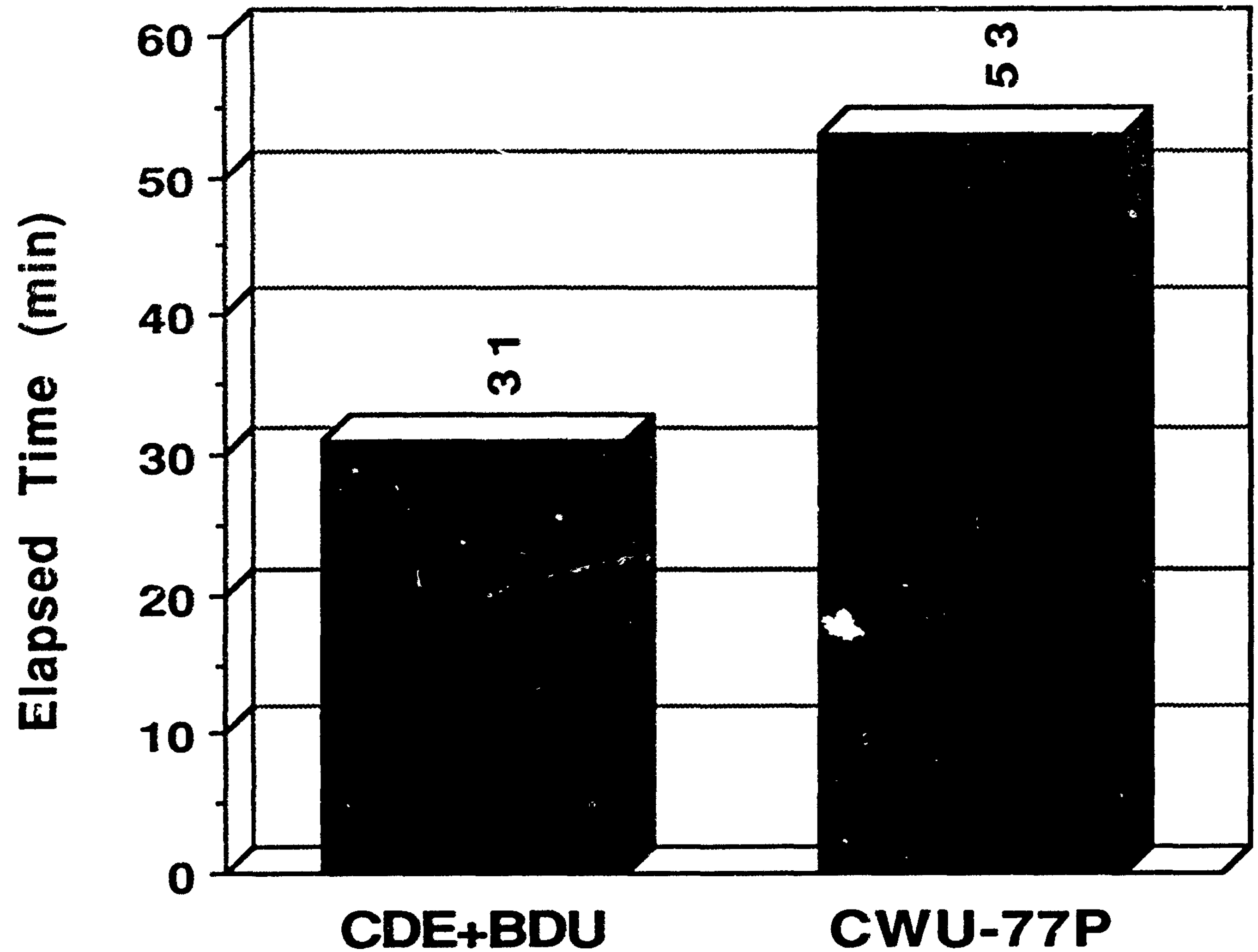
Percent Evaporation



Mean Skin Temperature



Total Duration of Work



RELATIVISTIC AND CLASSICAL CATEGORIZATION OF ATOMIC ORBITS

BY:Mark Eslinger

The purpose of this research is to simulate the orbital path of an electron at one standard Bohr radius from a proton and, subsequently, perturb these orbits using radiation. The first step of this research is to categorize and understand classical orbits for an electrostatic potential active at atomic or molecular distances. Once the classical orbits are categorized, relativistic effects will be added to the equations, and all departures from the classical orbits will be recorded. With a clear picture of undisturbed orbits, it will be possible for researchers to determine if electron and nuclear movement can generate enough radiation to influence the orbits. The final phase of the research will simulate different types of external radiation impacting the atom, and investigate the radiation's affect on the electron orbits.

HYPOTHESIS

Based upon information in "University Physics" by Francis W. Sears, Mark W. Zemansky, and Hugh D. Young, the classical electron orbital types will follow Keppler's laws, resulting in six orbital classes:capture, small ellipse, circular, large ellipse, parabolic, and hyperbolic. In the capture orbit the velocity of the electron in insufficient to escape the
central force field of the proton. The determining factor between a small ellipse and a capture orbital is the radius of the proton,

The addition of relativistic effects to orbits will cause orbital precession.

METHODS

In order to commence the first phase of the research it was necessary that the researcher create a program that would, using classical equations, plot the path of an electron through a central force field. We decided, in order to simplify the simulation, that all particle motions would be two dimensional, and consequently, the entire simulation would take place within a Cartesian plane. We decided that all motions and forces on the particle would be simulated using their component X and Y vectors. With the declaration of these basic parameters, it was possible to create seven basic equations, using Euler's time increment method, that would describe the electrons movement (the actual program contained 12 equations in the calculation module, but all additional equations were Y vector versions of X vector equations SEE PROGRAM). The classical equations used were:

$$DISTANCE=\sqrt{(Y\ POSITION)^2+(X\ POSITION)^2}$$

$$FORCE=-\frac{CHARGE\ ELECTRON*CHARGE\ PROTON*CONSTANT}{DISTANCE^2}$$

$$FORCE\ X=-\frac{X\ POSITION\ ELECTRON}{DISTANCE}FORCE$$

$$ACCELERATION\ X=\frac{kkk(SCALING\ MULTIPLIER)*FORCE\ X}{MASS\ ELECTRON}$$

$$VELOCITYX=INITIALVELOCITYX+ACCELERATIONX*\Delta T$$

$$MOVEMENT\ X=\frac{VELOCITY\ X+INITIAL\ VELOCITY}{2}\Delta T$$

$$POSITION\ X=INITIAL\ POSITION\ X+MOVEMENT\ X$$

The program was constructed so that it would print the position of the electron each time it performed Z iterations. In addition, the position of the electron would be printed each time the electron crossed an axis. The end conditions for the program could be activated by three seperate results. The first end condition was the completion of an orbit. The statement that printed the position of the electron upon its crossing of the Y axis also performed the function of terminating the program the second time the electron had a zero Y value and a positive X value (it must the second time for the electron's initial position lies on the X axis). The second end condition was the impact of the electron with the proton. Impact with the proton was determined by a statement, directly below the distance equation, that terminated the program if the distance between the particles was equal to or less than .001 Angstroms(the radius of the proton). The final end condition was user discretion, for if the orbit was a parabola or a hyperbola it did not orbit and would continue infinitely. The user had to determine at what point he would declare the orbit an escape and terminate the run. The final program was written in ANSI C and run on an IRIS-4D minicomputer. This a flow chart of the program and a copy of the program itself (classical only)

```
			}
			if (horbit <=0.0 && hy_electron >= 0.0)
			{
				printf("the location of hx_electron at y = 0 is %lf\n",hx_electron);
				++orbit;
				fprintf(outfile,"the location of hx_electron at y = 0 is %lf\n", hx_electron);
				printf("the number of orbits is %d\n",orbit-1);
				fprintf(outfile,"the number of orbits is %d\n",orbit-1);
			}
			if (orbit== 2)
				{
				  fprintf(outfile,"vel_x = %lf\nvel_y = %lf\ndelt =%lf",vx_int,vy_int,delta);
				  fclose(outfile);
				  exit(1);
				}
			if (horbit >=0.0 && hy_electron <= 0.0)
			{
				printf("the location of hx_electron at y = 0 is %lf\n",hx_electron);
				fprintf(outfile,"the location of hx_electron at y = 0 is %lf\n",hx_electron);
			}
			if (hhorbit <=0.0 && hx_electron >= 0.0)
			{
				printf("the location of hy_electron at x = 0 is %lf\n",hy_electron);
				fprintf(outfile,"the location of hy_electron at x = 0 is %lf\n", hy_electron);
			}
			if (hhorbit >=0.0 && hx_electron <= 0.0)
			{
				printf("the location of hy_electron at x = 0 is %lf\n",hy_electron);
				fprintf(outfile,"the location of hy_electron at x = 0 is %lf\n", hy_electron);
			}
			if ((++z% 1000)==0)
			 {
				printf("%lf, %lf\n",hx_electron, hy_electron);
				fprintf(outfile,"%lf, %lf\n ",hx_electron,hy_electron);
				++torbit;
			 }

			hvx_electron = vx_electron;
			hvy_electron = vy_electron;
			if (torbit >= 10)
			{
			   torbit = 0;
			   fclose(outfile);
			   outfile = fopen(file_name,"a");
			   printf("c/o\n");
			 }
		}
	}
}

/* variables */

cr_elements()
{
	hx_electron = 0.5291770644;
	hy_electron = 0.0;
	hvx_electron = 0.0;
	hvy_electron = 30.93;
}
```

Upon the completion of the first phase of the research, phase two of the research began. The modification of the program for relativity was, in reality, quite simple. First, the X and Y velocity vectors had to be translated into a single velocity. This was accomplished using the equation

$$Velocity=\sqrt{(velocityx)^2+(velocityy)^2}$$

This cumulative velocity was only used in the relativistic equations, all other pars of the program remained the same. With the equation for velocity active in the program, simply modifying the equation for acceleration

$$ACCELERATION=\frac{kkk(SCALINGMULTIPLIER)*FORCE\ X}{MASS\ ELECTRON}$$

to

$$ACCELERATION=\frac{kkk(SCALINGMULTIPLIER)*FORCE\ X}{MASS\ ELECTRON}*\sqrt{(1-\frac{VELOCITY^2}{C^2})^{1.5}}$$

makes the program relativistic. The multiplier used was taken from "University Physics" as was the orbital information in the Hypothesis.

Once the program was completed, the next step was to input the correct variables. For, while the accurate measurements of mass, distance, and charge were easily accessible, this information needed to be properly scaled to proportions that the computer could handle. It was decided by researchers to use Angstroms (1E-10 meters) for distance, atta coulombs (1E-18 coulombs) for charge, femptoseconds (1E-15 seconds) for time, and femptofemptc kilograms (1E-30 kilograms) for mass. The equation for electrostatic attraction is

$$FORCE=\frac{KQ_1Q_2}{R^2}$$

where K is the constant

$$K=8.98755*10^9\frac{NEWTONS\ METERS^2}{COULOMBS^2}$$

In this problem Q is 1.6021917E-19 coulombs for the proton, -.6021917E-19 for the electron and r is the distance between the two particle (radius of the orbit at that point if a circular orbit was based upon the proton and the electron in their current positions). R is in angstroms, so the resulting equation in this case is

$$FORCE=8.98755E+9\frac{(1.6021917E-19)(-1.6021917E-19)}{(1E-10)(1E-10)}$$

If, however, the charge is measured in atta coulombs the equation becomes

$$FORCE=8.98755E+9\frac{10E-18}{10E-10}\frac{10E-18}{10E-10}\frac{(.16021917)(-.16021917)}{(1)(1)}$$

reducing the equations yields

$$FORCE=8.98755E-7\frac{(.16021917)(-.16021917)}{1}$$

If force is measured in micro Newtons then the constant becomes .898755. So for the force equations in the program 1 angstrom of distance will equal 1, the constant will be .898755 micro Newtons, and the charges will equal .16021917 atta coulombs and -.16021917 atta coulombs.

As previously stated, the formula for acceleration is

$$A=\frac{FORCE}{MASS\ ELECTRON}$$

with femptofempto kilograms for mass and micro Newtons for force the equation becomes

$$A=\frac{10^{-6}}{10^{-30}}\frac{FORCE}{MASS\ ELECTRON}$$

The product of this equation, however, is in meters per second

$$AE{+}24\,\frac{METERS}{SECONDS^{2}}=\frac{FORCE}{MASS\ ELECTRON}$$

while the desired result should be in angstroms per femptosecond. To achieve the desired units the equation becomes

$$\frac{AE{+}24}{10^{-10}}10^{-15}10^{-15}=\frac{FORCE}{MASS\ ELECTRON}$$

$$AE{+}4\,\frac{ANGSTROMS}{FEMPTOSECONDS^{2}}=\frac{FORCE}{MASS\ ELECTRON}$$

As a result, the acceleration equation in the program must have a multiplier of 10000 (kkk is the variable used to represent this multiplier in the program).

The categorization of the capture, small ellipse, circular, and large ellipse orbits was uncomplicated. These orbits terminate, and by graphing the points it is possible to determine the orbital type. Once a method for determining orbital type is known it, is only a matter of bisection to find the interface. As stated in the Hypothesis, however, it is impossible to differentiate between the parabolic and hyperbolic orbital trajectories with graphical means as the sole determining factor. We instead derived an equation that would make it possible to differentiate between parabolic and hyperbolic orbitals. The universal equation for conic sections is

$$(1)\quad Ax^2+Bxy+Cy^2+Dx+Ey+F=0$$

since at starting point X=S,Y=0, one obtains from Equation 1

$$(2)\quad As^2+Ds+F=0$$

subtracting Equation 2 from Equation 1 yields

$$(3)\quad A(x^2-s^2)+Bxy+Cy^2+D(x-s)+Ey=0$$

Equation 3 can be rewritten into the quadratic Equation 4

$$(4)\quad Y=\frac{-[Bx+E]\ \sqrt{[Bx+E]-4c[A(x^2-s^2)+D(x-s)]}}{2c}$$

To allow orbital symmetry about the X axis, there must be two values of y for each X such that one Y has the same absolute magnitude but opposite sign as the other. Therefore

$$(5)\quad (-[Bx+E]+SQR)=-(-[Bx+E]-SQR)$$

$$(6)\quad -[Bx+E]+SQR=[Bx+E]+SQR$$

$$(7)\quad -2[Bx+E]=0$$

For the curve to be symmetrical, B and E must both be zero. Altering the universal equation for statring point and symmetry results in

$$(8)\quad A(x^2-s^2)+Cy^2+D(x-s)=0$$

Referring to equation 1, the curve described by this equation is

(i) *a parabola if* $B^2-4AC=0$

(ii) *a ellipse if* $B^2-4AC<0$

(iii) *a hyperbola if* $B^2-4AC>0$

Fitting equation 8 to data results in

$$(9)\quad y^2=-\frac{A}{C}(x^2-s^2)-\frac{D}{c}$$

or

$$(10)\quad y^2=P_1(x^2-s^2)-P_2(x-s)$$

$$if\ P_1>0\ then\ \frac{A}{C}<0 so\ -4AC>0\rightarrow HYPERBOLA$$

$$if\ P_1<0\ then\ \frac{A}{C}>0\ so\ -4AC>0\rightarrow Ellipse$$

$$if\ P_1=0\ then\ -4AC=0\rightarrow PARABOLA$$

finding an Equation for P1 is possible by using two points on the curve.

$$(11)\quad Y_1^2=P_1(x_1^2-s^2)+P_2(x_1-s)$$

$$(12)\quad y_2^2=P_1(x_2^2-s^2)+P_2(X_2-s)$$

multiply equation 11 by

$$(x_2-s)$$

and equation 12 by

$$(x_1-s)$$

results in

$$(13)\quad Y_1^2(x_2-s)=P_1(x_1^2-s^2)(x_2-s)+P_2(x_1-s)(x_2-s)$$

and

$$(14)\quad y_2^2(x_1-s)=P_1(x_2^2-s^2)+P_2(x_1-s)(x_2-s)$$

subtracting equation 13 from 14 results in

$$(15)\quad y_2^2(x_1-s)-y_1^2(x_2-s)=P_1[(x_2^2-s^2)(x_1-s)-(x_1^2-s^2)(x_2-s)]$$

which can be rewritten

$$P_1=\frac{y_2^2(x_1-s)-y_1^2(x_2-s)}{(x_2^2-s^2)(x_1-s)-(x_1^2-s^2)(x_2-s)}$$

RESULTS

The program described in the "Methods" section was not the original program, nor was the IRIS-4D the computer research was begun on. The initial program was based on the estimate that a time increment of .01 femptoseconds would give accurate pictures of orbital shapes. Due to the apparent simplicity of the problem, the prototype program was written in Microsoft BASIC 7.0 and allowed for both proton and electron movement. The initial experimentation with this program was performed on a Zenith 286 chip 8 megahertz computer. This machine was, however, far to slow as it took 9 mins and 44.25 secs to run 1000 points. The same program was, after one week of use on the slower machine, transferred to a Unisys 386-chip 22 megahertz computer which could run 1000 points in 3 mins and 22.56 secs. Research was continued on the Unisys PC for 11 days.

At the 11 day mark we decided that the orbital shapes the program was outputting were impossible and that this must be attributal to numerical error that is always present in the Euler method. In order to decrease to acceptable levels or even eliminate this numerical error, the time increment was decreased drastically (the largest change was from .001 to .0000000001). It became apparent, through the two ensuing days, that, in order to achieve accuracy, a different time increment would have to be used for each category of orbit. Decreasing the time increment, however, increases the number of points needed to complete an orbit. As a of the now huge number of iterations result the program was rewritten in the ANSI C language, the proton motion was taken out to simplify the program (and in reality all this did was to move the experimental viewpoint from outside the system to on the proton), and the experimentation transferred to a VAX 8650 minicomputer (15 seconds for 1000 points). Problems arouse with acquiring enough cpu time on the VAX 8650 so the program was transferred to an IRIS-4D (8 seconds for 1000 points).

Experimental results followed the hypothesis; the orbital categories were capture, small ellipse, circular, large ellipse, parabolic, and hyperbolic. At a delta of .0000000001 fempto seconds, the interface between capture and small ellipse is at

$$1.38\ \frac{ANGSTROMS}{FEMPTOSECOND}$$

or

$$1.38E{+}5\ \frac{METERS}{SECONDS}$$

(SEE APPENDIX-1 and APPENDIX-2 for raw data and a graph of this orbit) At a delta of .00000001, the interface between circular and small ellipse orbits is at

$$21.88\ \frac{ANGSTROMS}{FEMPTOSECOND}$$

or

$$2.188E{+}6\ \frac{METERS}{SECOND}$$

(SEE APPENDIX-3 and APPENDIX-4 for raw data and a graph of this orbit) The circular orbit occurs only at one velocity so the interface between circular and large ellipse orbits is same as between circular and small ellipse orbits. At delta of .000001, interface between large ellipse and parabolic orbits is at

$$30.93\ \frac{ANGSTROMS}{FEMPTOSECOND}$$

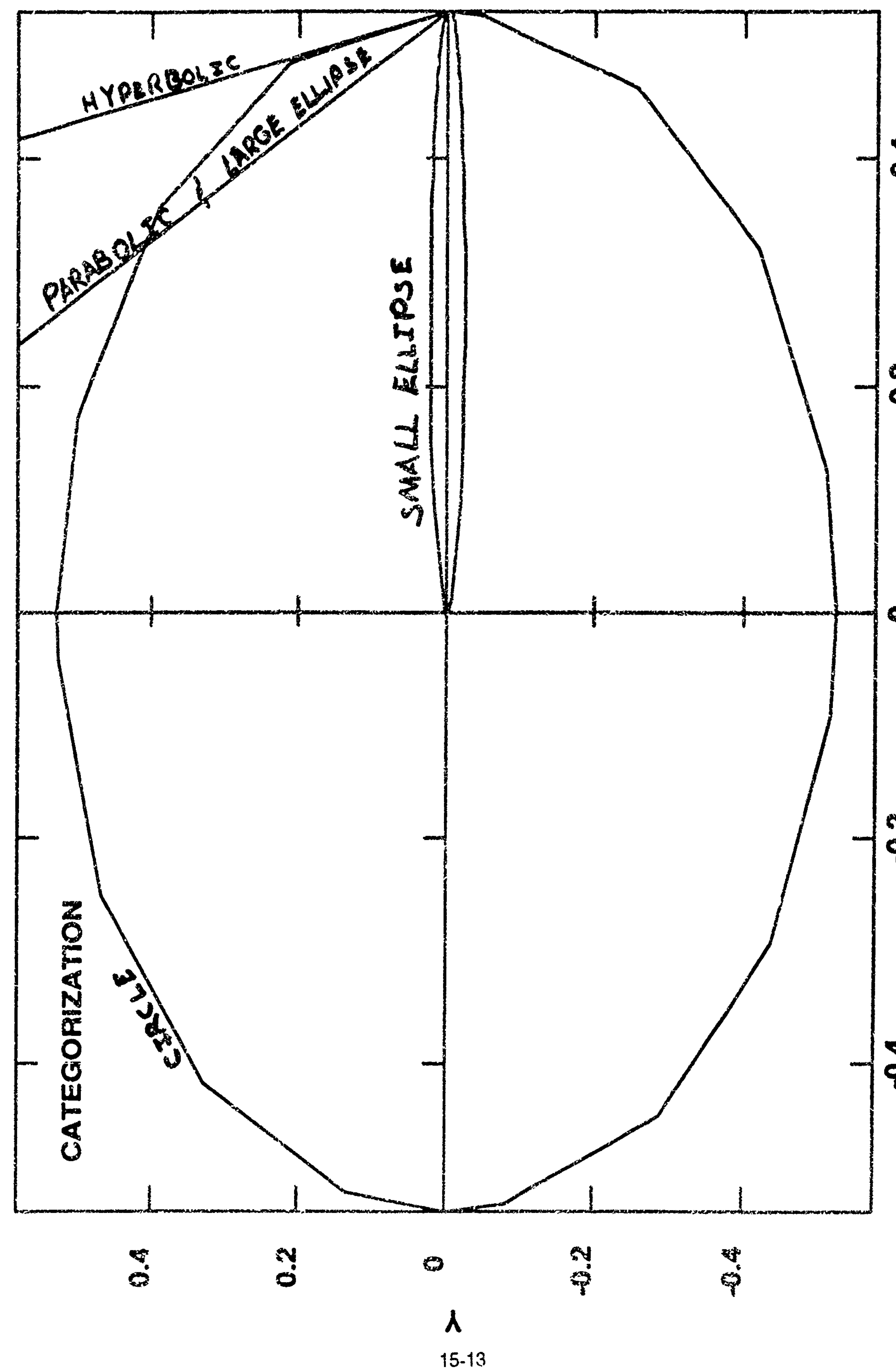
or

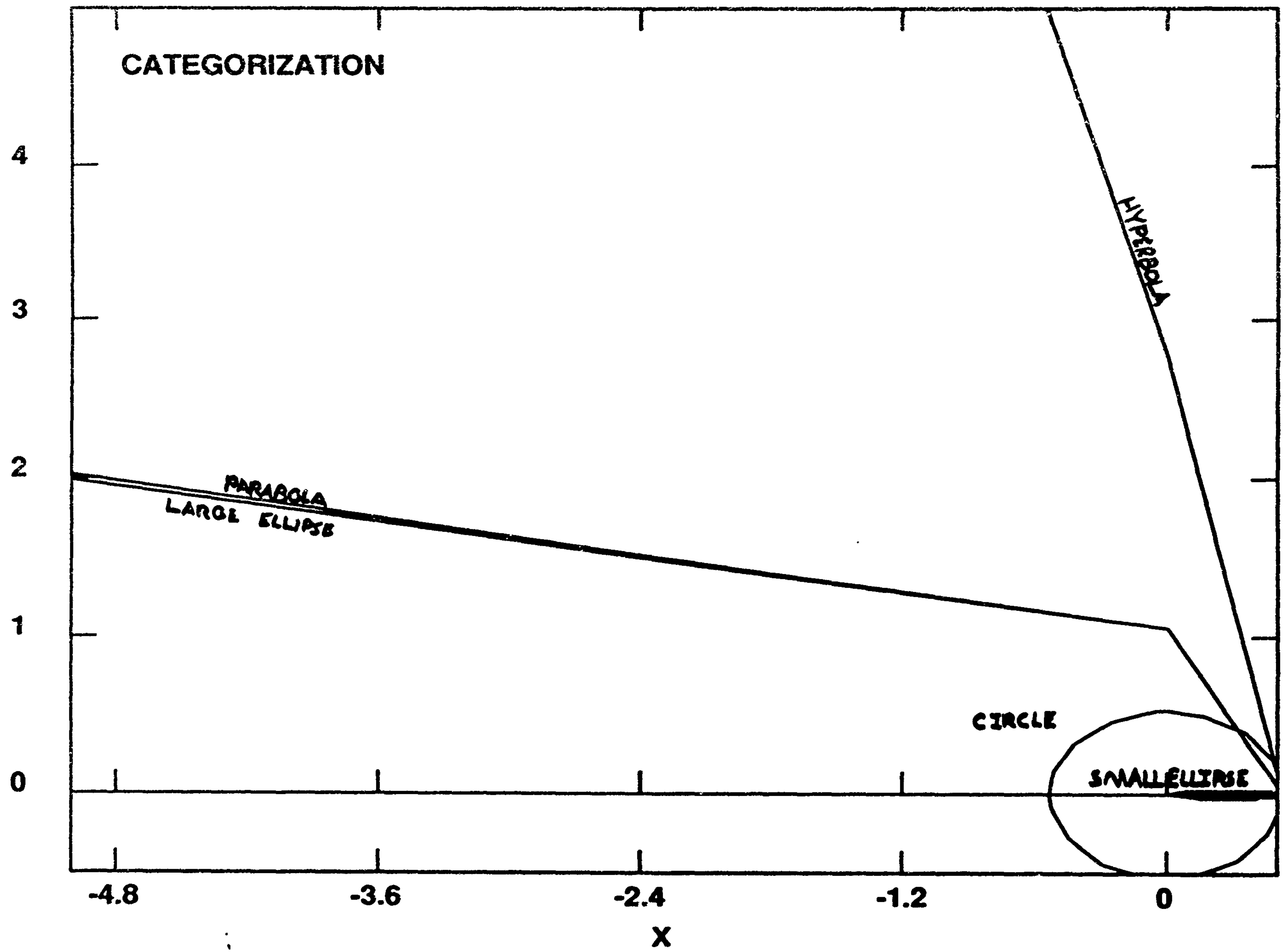
$$3.903E{+}6\ \frac{METERS}{SECONDS}$$

(SEE APPENDIX-5 and APPENDIX-6 for raw data and a graph of this orbit) The parabola, like the circle, only exists at a single velocity so that the velocity for the parabolic and hyperbolic orbits is same as that for the interface of small ellipse and parabolic. (SEE APPENDIX-7 and APPENDIX-8 for raw data and a graph of a hyperbolic orbit at .000001 delta) With only classical effects active all velocities above

$$30.93\ \frac{ANGSTROMS}{FEMPTOSECOND}$$

are hyperbolic escape trajectories. These numbers yield the CATEGORIZATION graphs, which show the interfaces between orbital categories. Remember when looking at these graphs that the differences in size are so enormous that, in order to make the circle visible, only one or two points of the hyperbolic, parabolic, and large ellipse orbits are on the graph.


CATEGORIZATION
CIRCLE
HYPERBOLIC
PARABOLIC / LARGE ELLIPSE
SMALL ELLIPSE
0.4
0.2
0
-0.2
-0.4
X
Y


CATEGORIZATION
HYPERBOLA
PARABOLA
LARGE ELLIPSE
CIRCLE
SMALLELLIPSE
4
3
2
1
0
-4.8
-3.6
-2.4
-1.2
0
X

Only a cursory examination of the relativistic effects has been made at this point in the research. The speed of light is

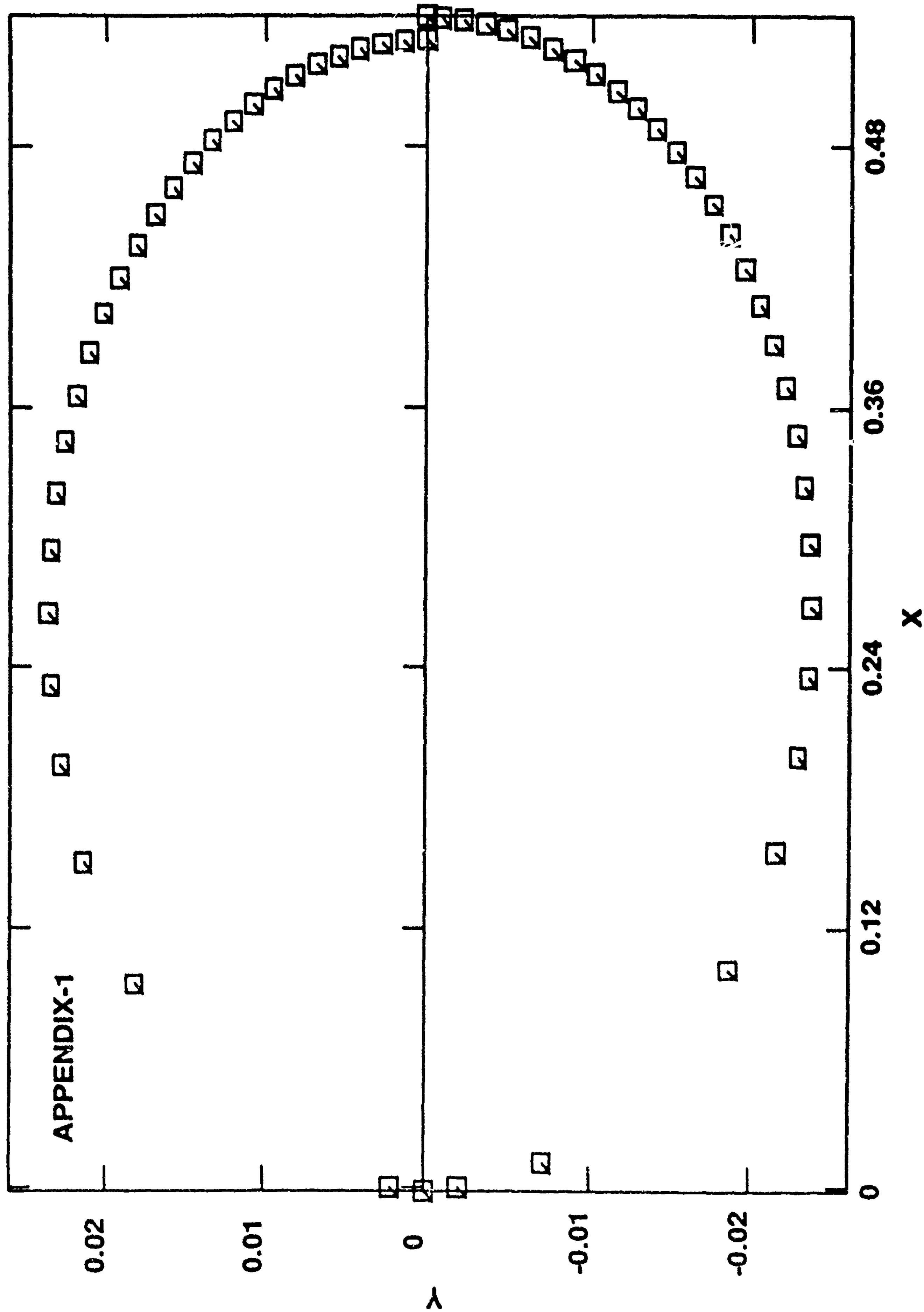
$$3.0E+3\,\frac{ANGSTROMS}{FEMPTOSECOND}$$

and the highest non-escape initial velocity is

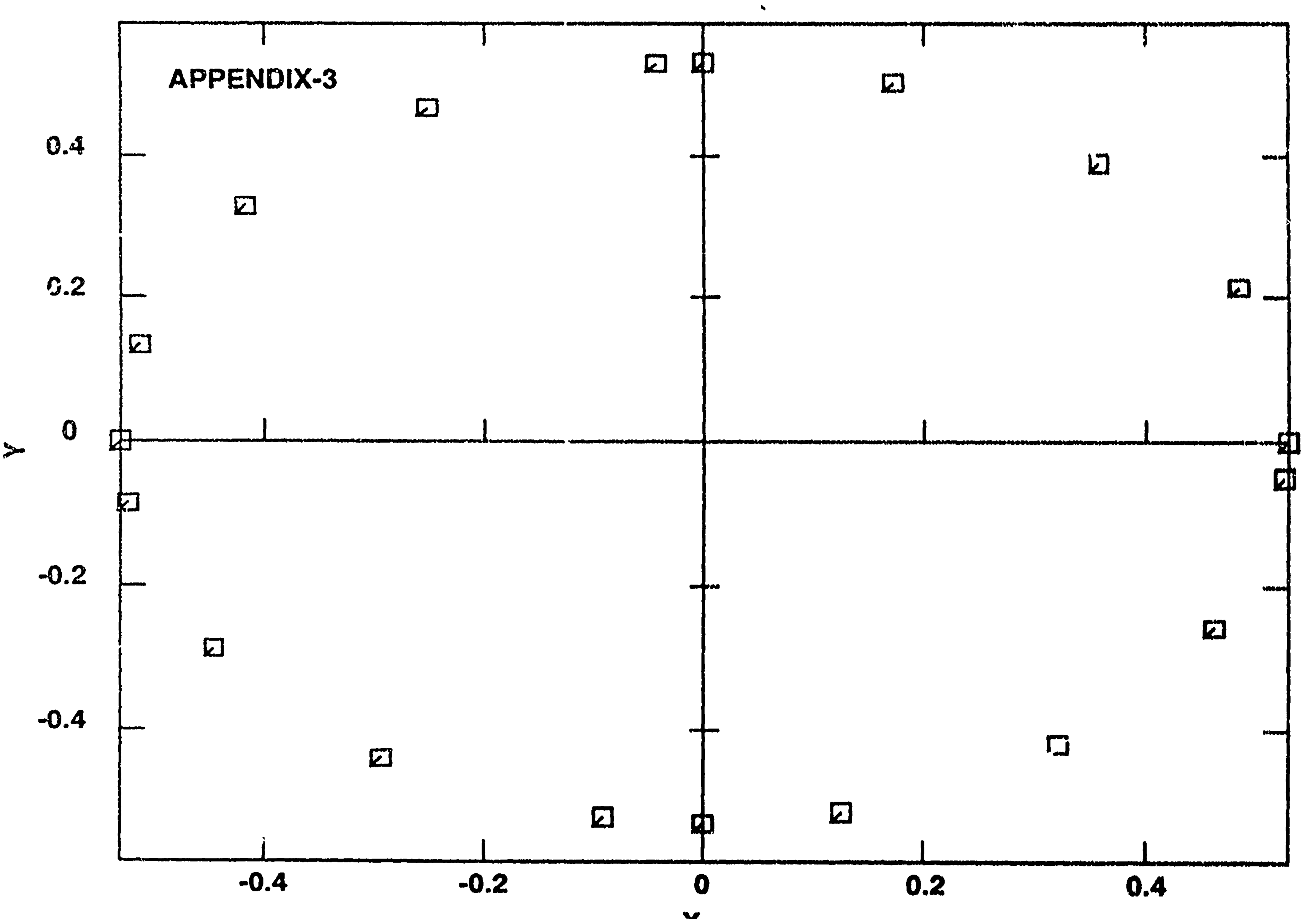
$$30.93\,\frac{ANGSTROMS}{FEMPTOSECOND}Z$$

. Relativistic effects therefore do not appear to be common. One type of orbit, however, appears to have sufficient velocity for relativity to affect orbital shape. The small ellipse has the lowest initial velocity of any of the stable orbits, but as the electron nears the proton its velocity increases. At its perigee, the electron is going fast enough for relativity to affect its trajectory. Only one example of this phenomena has been simulated at this point in time but, it clearly show orbital precession and that the relativistic orbit has a larger area than its counterpart. (SEE APPENDIX-9, APPENDIX-10, APPENDIX-11, APPENDIX-12, and APPENDIX-11 for raw data and graphs)

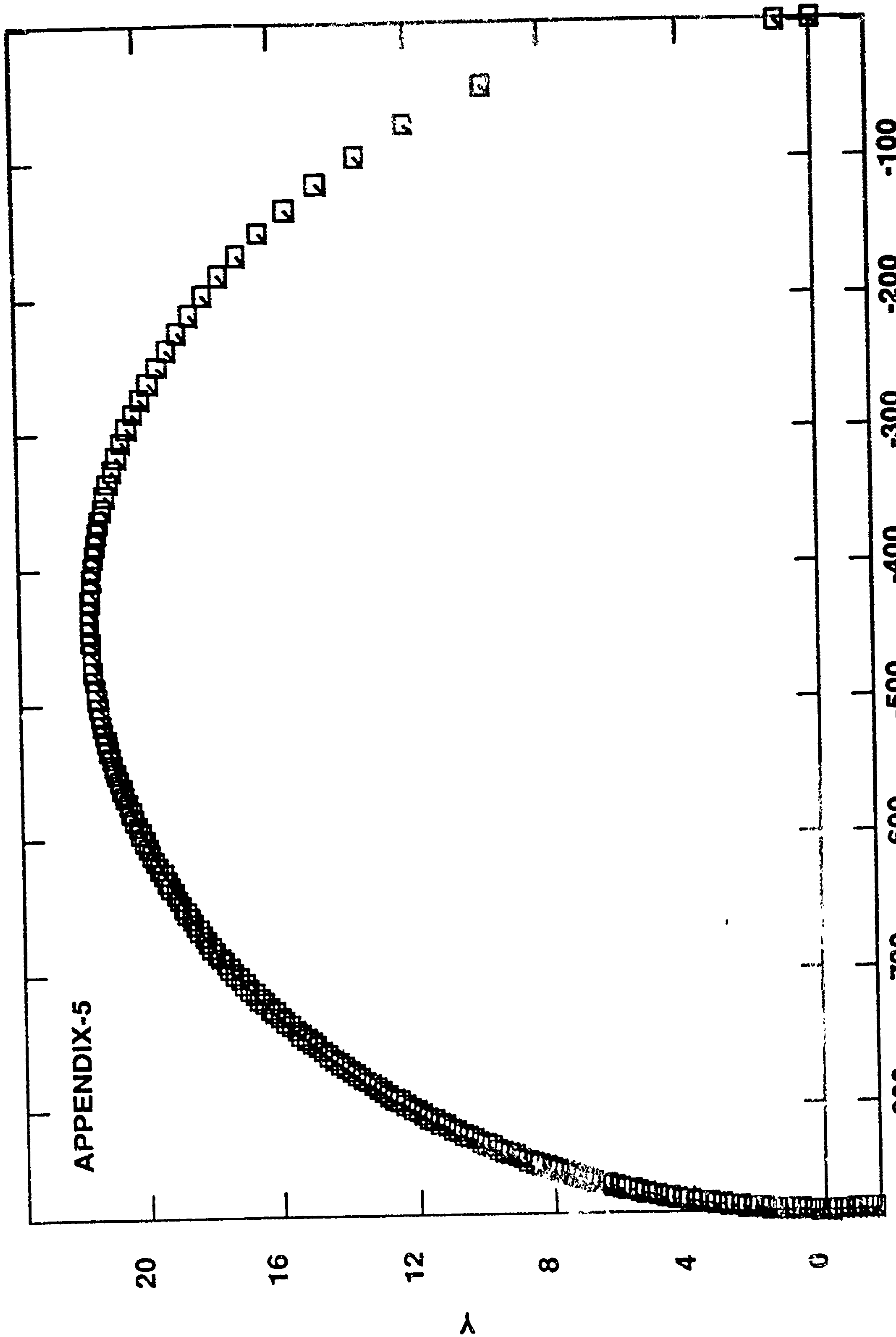
This research has immense potential and should be continued. The detailed analysis of relativistic orbits will yield volumes of information on the construction of the hydrogen atom. In addition, the forthcoming third and fourth phases of this research might make it possible to describe an atom using only classical and relativistic equations, a possibility that would tempt any theorist.


APPENDIX-1
0.02
0.01
0
-0.01
-0.02
Y
0
0.12
0.24
0.36
0.48
X

0.529177,	0
0.528725,	0.001380
0.527366,	0.002757
0.525096,	0.004129
0.523908,	0.005495
0.517790,	0.006850
0.512727,	0.008193
0.506700,	0.009520
0.499687,	0.0108[illegible]9
0.491660,	0.012116
0.482586,	0.013376
0.472424,	0.014609
0.461129,	0.015804
0.448644,	0.016959
0.434902,	0.018067
0.419823,	0.019119
0.403310,	0.020105
0.385243,	0.021014
0.365473,	0.021830
0.343813,	0.022532
0.320017,	0.023094
0.293757,	0.023478
0.264572,	0.023626
0.231779,	0.023451
0.194274,	0.0227[illegible]3
0.150010,	0.021323
0.094038,	0.018128
0,	0.002106
-0.001055,	0
0,	-0.002106
0.011694,	-0.007241
0.100984,	-0.018672
0.155374,	-0.021639
0.198923,	-0.023038
0.236034,	-0.023680
0.268605,	-0.023861
0.297676,	-0.023730
0.323899,	-0.023370
0.347717,	-0.022837
0.369446,	-0.022165
0.389326,	-0.021383
0.407539,	-0.020509
0.424231,	-0.019558
0.439518,	-0.018542
0.453496,	-0.017471
0.466244,	-0.016352
0.477828,	-0.015193
0.488304,	-0.013998
0.497718,	-0.012773
0.506111,	-0.011521
0.513515,	-0.010248
0.519958,	-0.008954
0.525465,	-0.007645
0.530055,	-0.006322
0.533743,	-0.004989
0.536542,	-0.003647
0.538460,	-0.002300
0.539505,	-0.000948
0.539719,	0


APPENDIX-3
0.4
0.2
0
-0.2
-0.4
Y
-0.4
-0.2
0
0.2
0.4
X

.529177, 0
.484596, .212716
.358385, .389604
.171847, .500919
0, .529769
-.043590, .528021
-.251716, .466468
-.417639, .326691
-.513606, .132185
-.530362, 0
-.523587, -.084452
-.445918, -.286951
-.293567, -.441386
-.092008, -.521823
0, -.529770
.124987, -.514671
.320967, -.421019
.462930, -.256523
.526924, -.048826
.529178, 0


APPENDIX-5
Y
20
16
12
8
4
0
X
-800
-700
-600
-500
-400
-300
-200
-100

0.529177	0
0	1.057707
-46.422718	9.694686
-74.114214	12.018115
-97.050290	13.543389
-117.296829	14.687923
-135.716007	15.601810
-152.773247	16.358330
-168.756289	16.999420
-183.858907	17.551588
-198.219558	18.032783
-211.941587	18.455785
-225.104763	18.830058
-237.772315	19.162826
-249.995459	19.459744
-261.816431	19.725332
-273.270591	19.963265
-284.387928	20.176576
-295.194162	20.367804
-305.711566	20.539093
-315.959598	20.692276
-325.955383	20.828933
-335.714097	20.950435
-345.249271	21.057983
-354.573038	21.152632
-363.696330	21.235318
-372.629043	21.306874
-381.380172	21.368044
-389.957927	21.419498
-398.369825	21.461840
-406.622772	21.495617
-414.723135	21.521327
-422.676794	21.539422
-430.489203	21.550317
-438.165423	21.554395
-445.710172	21.552003
-453.127847	21.543467
-460.422561	21.529083
-467.598170	21.509130
-474.658288	21.483863
-481.606316	21.453522
-488.445455	21.418331
-495.178724	21.378496
-501.808974	21.334213
-508.338901	21.285665
-514.771060	21.233022
-521.107871	21.176446
-527.351632	21.116089
-533.504528	21.052092
-539.568638	20.984592
-545.545939	20.913716
-551.438318	20.839584
-557.247577	20.762310
-562.975434	20.682003
-568.623533	20.598766
-574.193446	20.512697
-579.686679	20.423888
-585.104676	20.332428
-590.448818	20.238401
-595.720433	20.141888
-600.920797	20.042966
-606.051134	19.941708
-611.112622	19.838185
-616.106393	19.732463
-621.033539	19.624608
-625.895109	19.514680
-630.692116	19.402738
-635.425537	19.288841
-640.096311	19.173042
-644.705350	19.055393
-649.253529	18.935946
-653.741696	18.814748
-658.170672	18.691847
-662.541247	18.567287
-666.854189	18.441112
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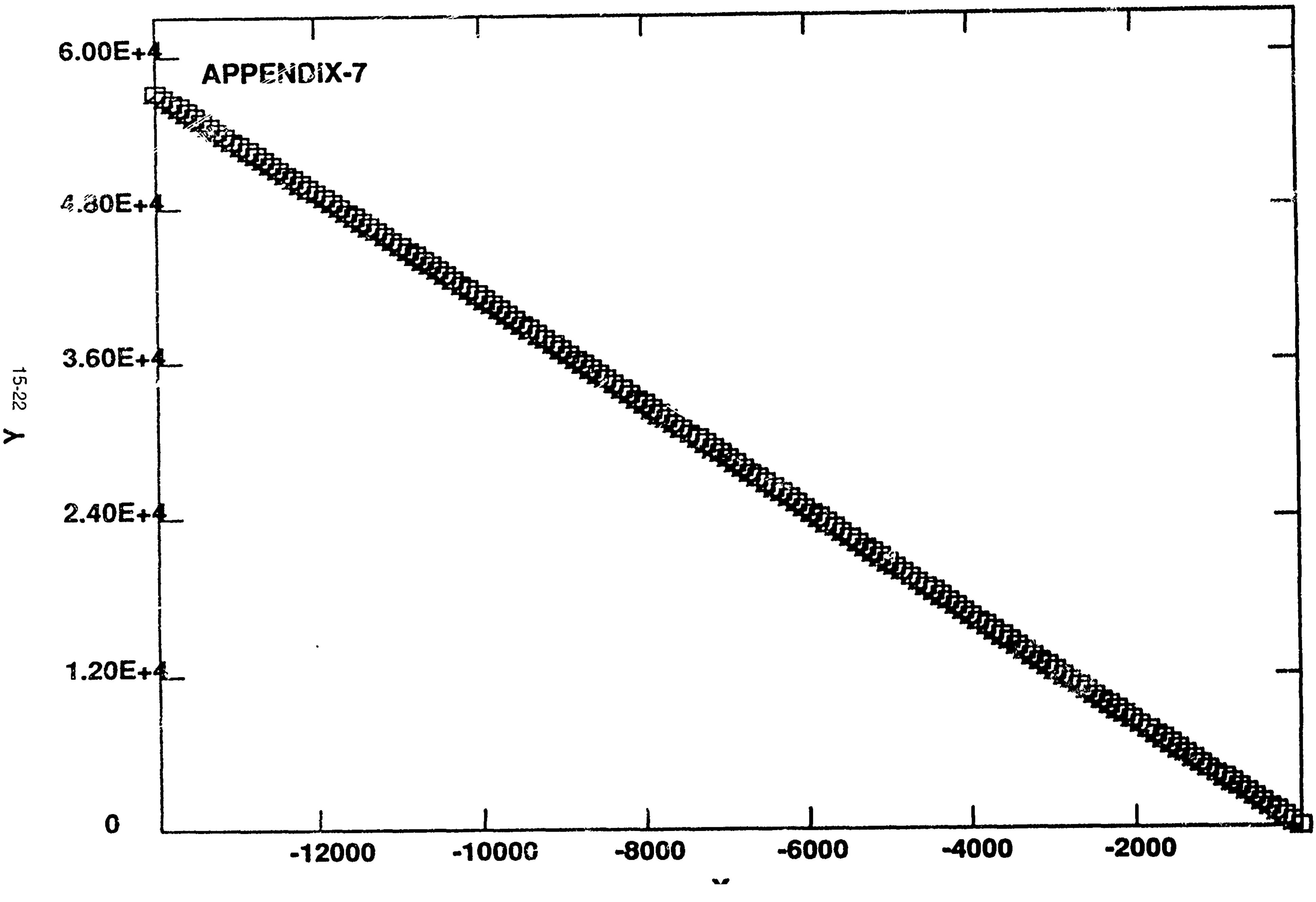

APPENDIX-7
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APPENDIX-10 relativistic orbit

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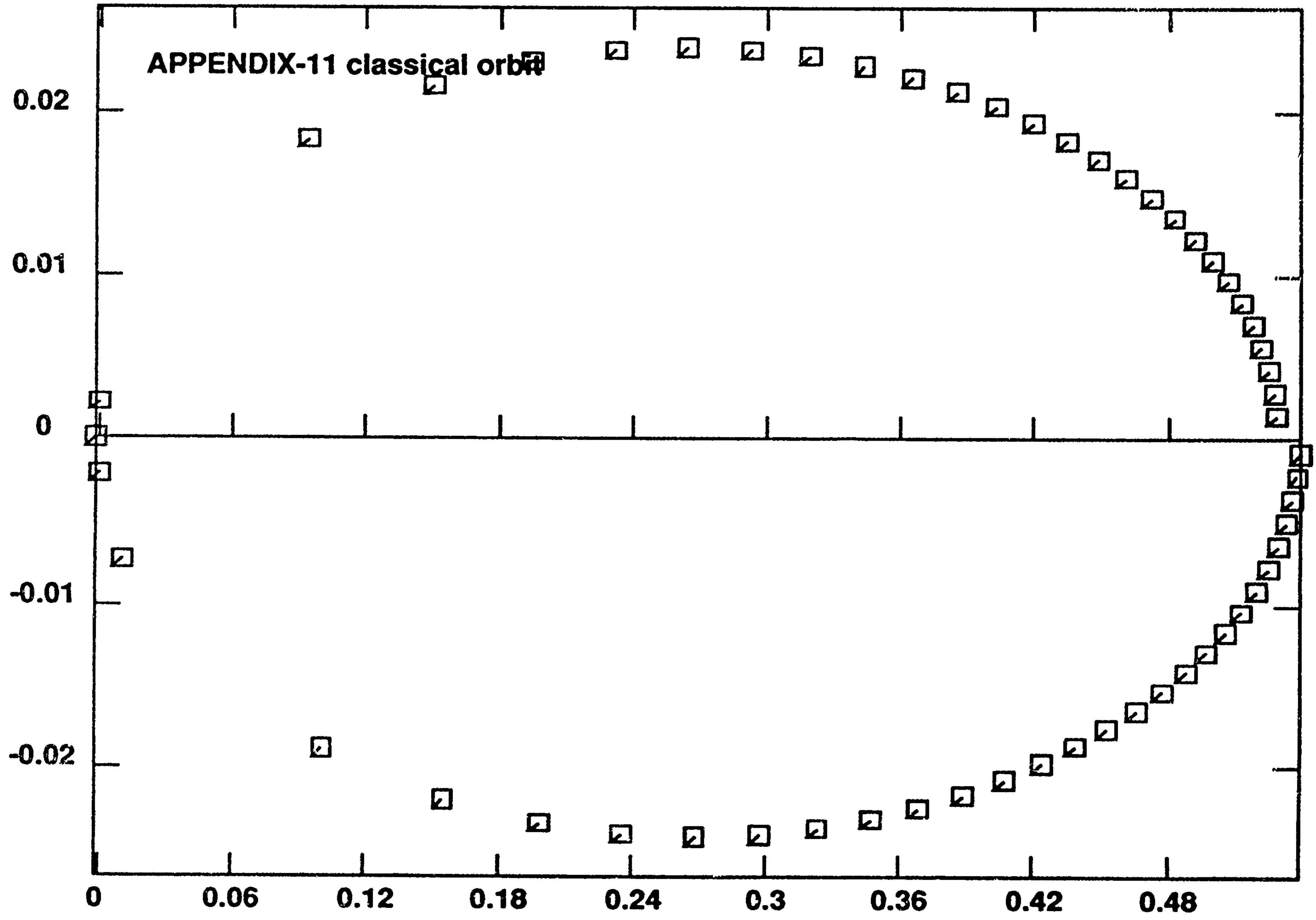
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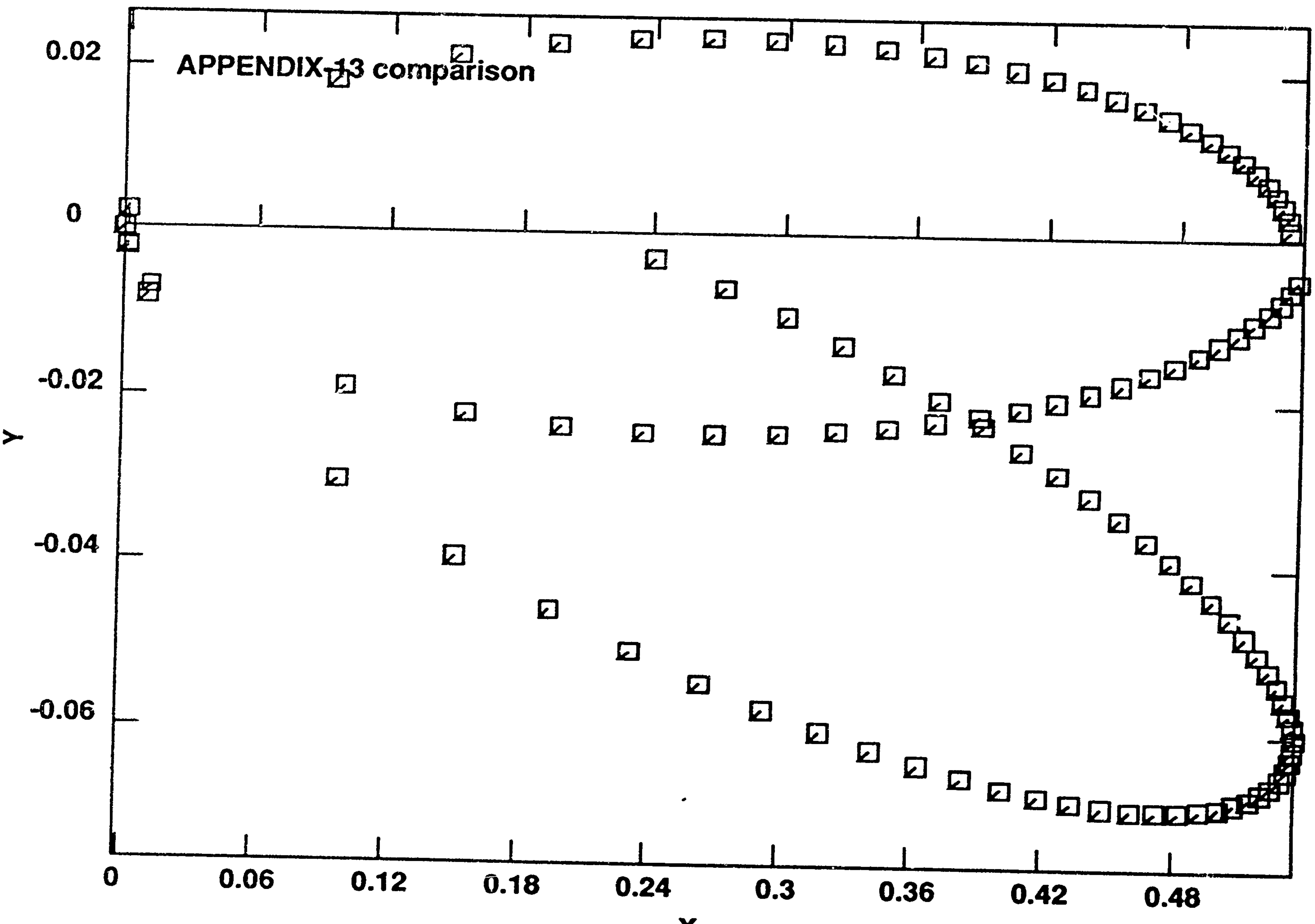
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RELIABILITY OF THE CONDUCTANCE CATHETERS FOR MEASUREMENT OF LEFT VENTRICULAR VOLUME AND AFFECTS OF ANTI-G STRAINING MANEUVERS ON BLOOD PRESSURES IN MAN

Mr. Matthew Felder

My accomplishments during the 1991 summer term were multifold. I contributed much effort in many small projects, but I had two primary projects. The first was to further the data collection for my research last year, 'Affects of Anti-G Straining Maneuvers on Blood Pressures in Man.' The second subject was to research and test the reliability of a series of conductance catheters.

The first study entailed data collected from Army pilots at Brooke Army Medical Center during elective heart catheterization. The study examined the effects of anti-G straining maneuvers on blood pressures. The straining maneuvers consisted of a valsalva held, an L-1 held, a valsalva with three second breathing intervals, and an L-1 with three second breathing intervals. Blood pressures were recorded as a function of time using a Honeywell fiberoptic UV recorder onto light sensitive paper (example of tracing is included at the end of the report.) The measurements were taken off the strip-chart recorder and entered into Simplaplot 3.0 at one second intervals. Graphs of average pressures were printed for systolic, diastolic, and pulse pressures during the valsalva and L-1 maneuvers held and with breathing. The graphs are included at the end of the report.

The results of the blood pressure experiment with the added data showed the mean value of the systolic and diastolic blood pressures to be higher with the L-1 maneuver over the valsalva only. Yet, the standard deviation showed no statistical difference between the two pressures on any graph.

The second subject, 'The Reliability of Conductance Catheters for Measurement of Left Ventricular Volume,' included the testing of two Webster catheters and one Millar catheter (specially made) with a Leycom Box model Sigma 5DF (from the Netherlands). The catheter specs. were:

1) Webster Labortories, Inc.
   7.1mm spacing, 5cm overall
   5fr, 8 electrodes, non-lumen
2) Webster Labortories,. Inc.
   8.6mm spacing, 8.6cm overall
   7fr, 11 electrode, lumen
3) Millar Mikro-tip Catheter with pressure transducer
   3fr pressure sensor with standardized output of 5 microV/V/mmHg
   6 electrodes

The Sigma 5DF calculated volume with the following formula:

$$V(t) = (1/\alpha)(L^2/\sigma_b)\,G(t) - V_c$$

V(t) is the time varying left ventricular volume

α is the dimensionless constant

L is the electrode separation

σ_b is the conductivity of blood in the sampling cuvette

G(t) is the measured conductance within the left ventricular cavity

Vc is the correction term caused by the parallel conductance of structure surrounding the cavity (which can be calculated by reducing the volume to zero or by altering σ_b by injecting a small bolus of saline)

I never reached the stage of actual heart catheterization, therefore I wasn't able to experiment with the Vc correction factor.

The volume was totaled with the formula:

$$G(t) = \sum_{n=1}^{5} G_n(t) + 1/3\,G_1(t)$$

The one-third is a correction factor for the space at the apex of the heart. For an accurate measurement the catheter should be positioned with the tip at the apex and the second to last electrode at the valve.

Each catheter was tested for its ability to produce accurate measurements through the use of various sized volumetric cylinders. The conductance catheter has a series of six to twelve electrodes equally spaced along its tip. The basic single field catheter has eight electrodes. When connected to the Leycom box, a small voltage is applied through the two end electrodes. The remaining electrodes provide a series of five potential differences. Electrical impedance is then calculated from the voltages. The electrical impedance is inversely related to the left ventricular cavity volume. Therefore, the Leycom box can calculate five segmental volumes inside the cavity which, when totaled, provide a total volume reading. Catheters with more than eight electrodes provide the ability to expand the effective catheter length and/or provide a dual field feature.

The procedure for implementation of the conductance catheter is as follows:

1) Introduce catheter into the left ventricle
2) Attach catheter to Leycom box using respective catheter box (single or dual field)
3) Test the rho constant of the blood using the rho cuvette
   A) Draw a 6 ml sample of blood into a syringe
   B) Transfer it to the cuvette using a stopcock
   C) Set switch on box to 'rho'

D) Enter the rho display reading into the rho switch

4) Make catheter selections (from catheter specs.)

   A) Select field (SF, DF .25, or DF .30)

   B) Enter the electrode distance into the electrode distance switch

   C) Select the desired number of extra electrodes

5) Put switch on 'cath.'

6) Test location of electrodes

   A) Connect the outputs to a stripchart recorder

   B) Switch off electrodes 4 and/or 5 if they lie outside the ventricle (noticed by an irregular wave form)

7) Dial 'Vtot' on the box for the total volume reading

Both Webster catheters produce accurate measurements with readings +/-1ml. The effective range of calculation was greater for the 7fr catheter. The 5fr catheter is good for cylinders with a diameter less than 5cm; while the 7fr catheter is correct up to 8cm. The 7fr catheter, since it had eleven electrodes, was tested for results using the dual field capability and the extra electrodes feature. These also provided fair results. The Millar catheter was specially designed with an added pressure transducer and only six electrodes. Therefore, segment four and five were switched off on the Leycom box and electrode six was mapped to electrode eight on the Leycom box using a specially designed adapter. I failed to receive accurate readings from the Millar catheter. The third segment gave erroneous readings of negative resistivity and extreme volume. I theorize that when segment four and five are switched off, the charge is still sent through electrode eight rather than six. This would cause a great difference in the expected distance between electrode five and six. In other words the Leycom box is calculating for the distance between electrode five and six three times greater than its actual distance. The resulting output does not indicate a three fold resistivity, but I feel that the reading may be out of range (therefore causing the negative reading.)

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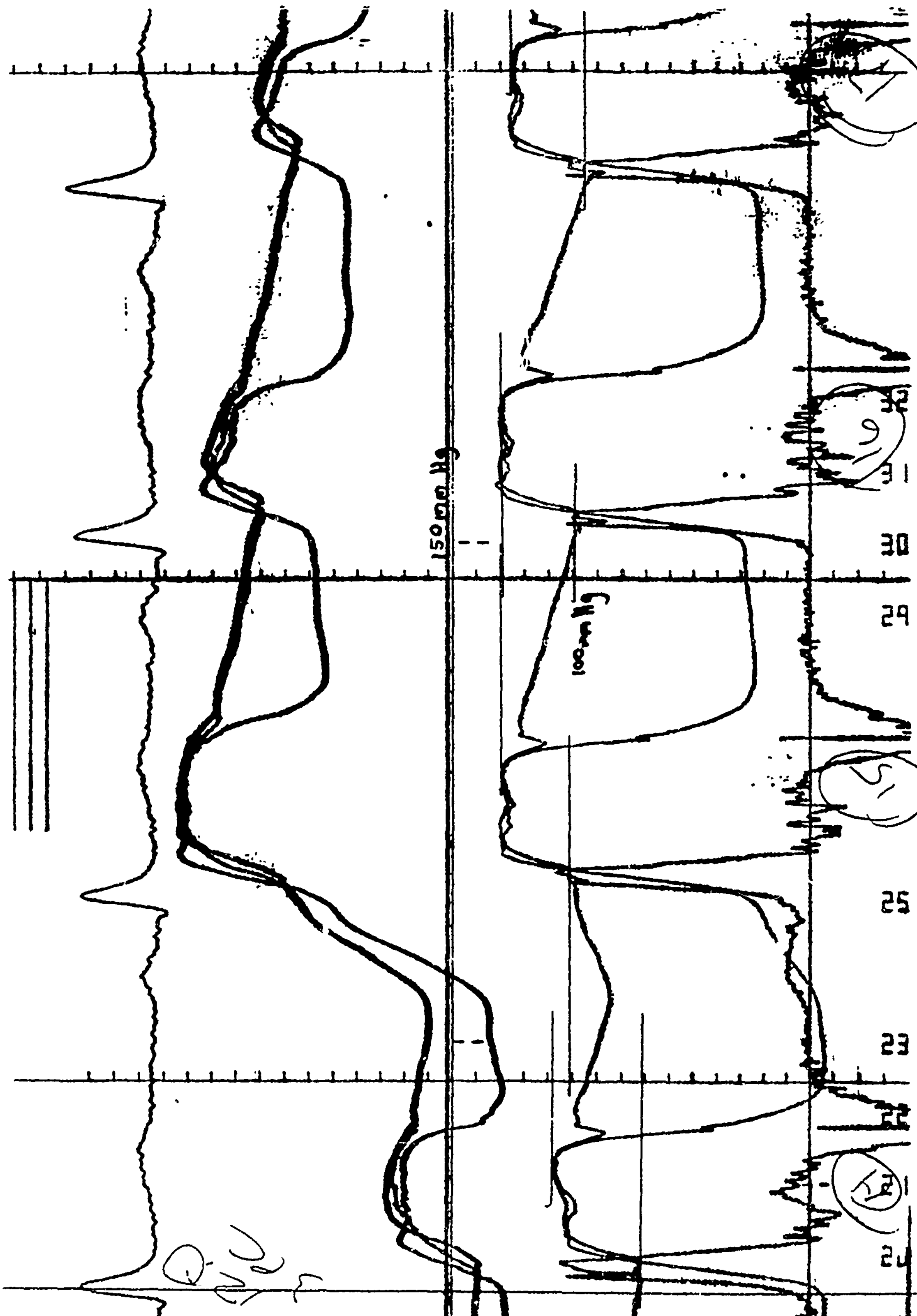
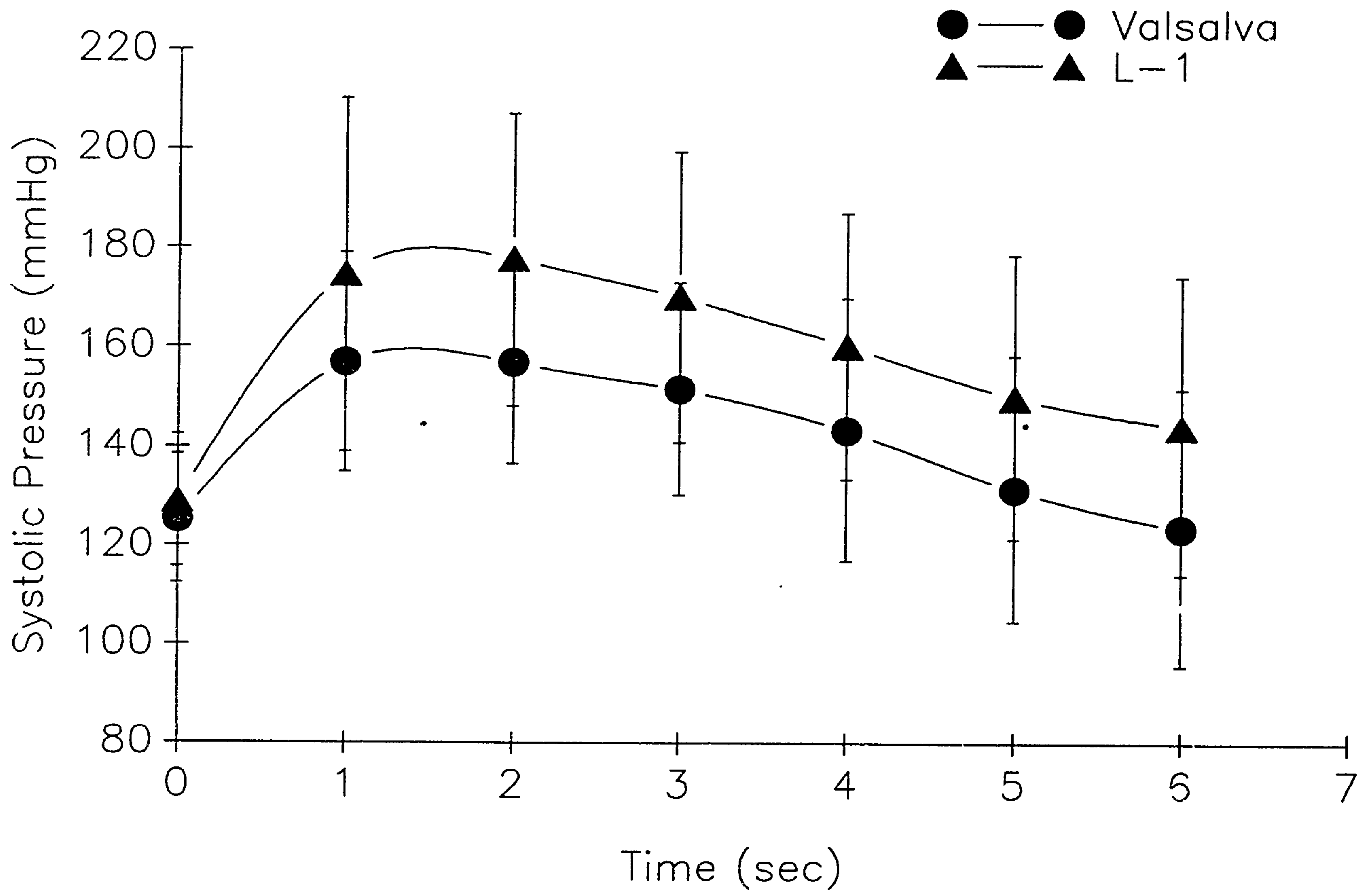
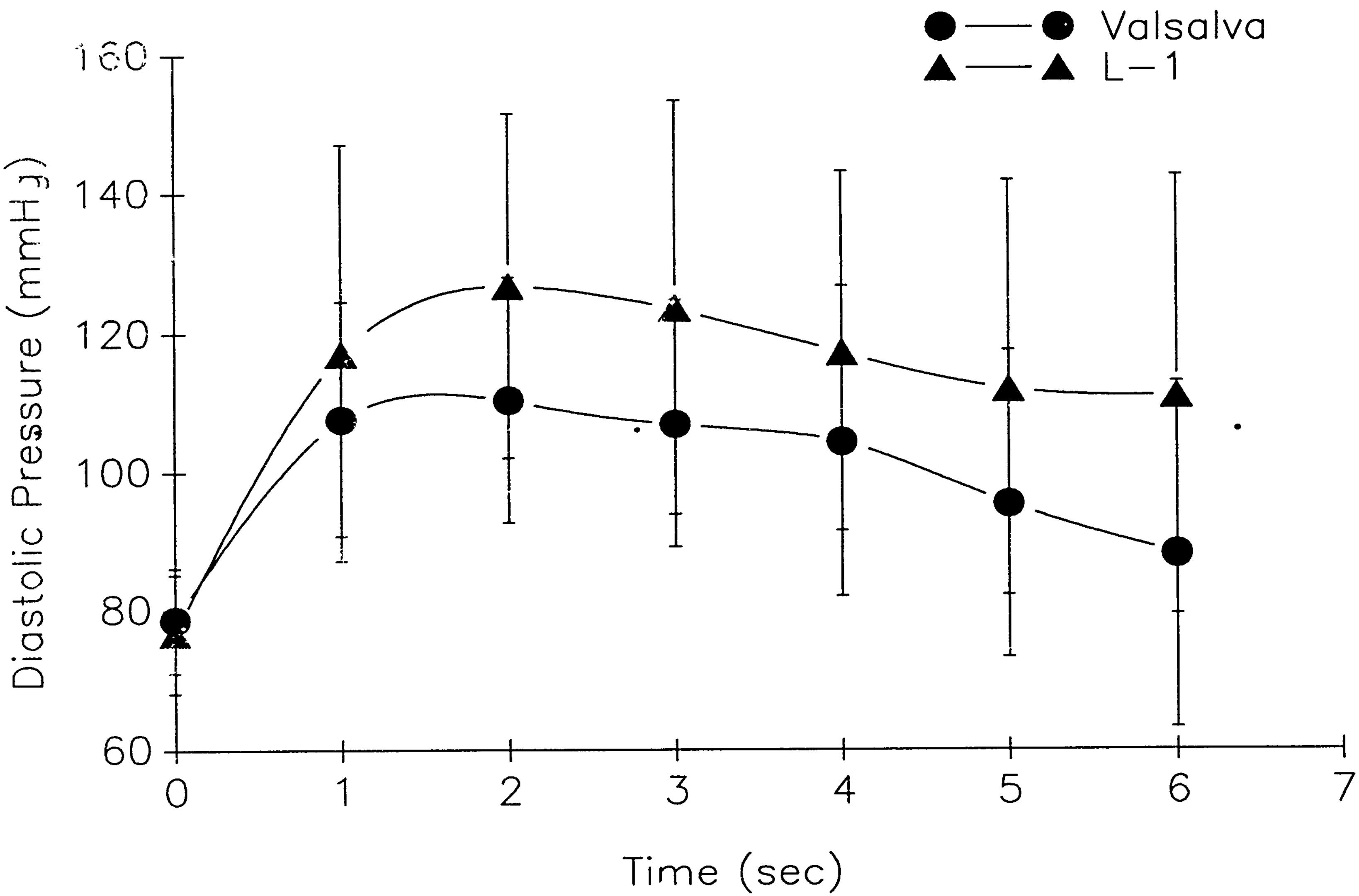
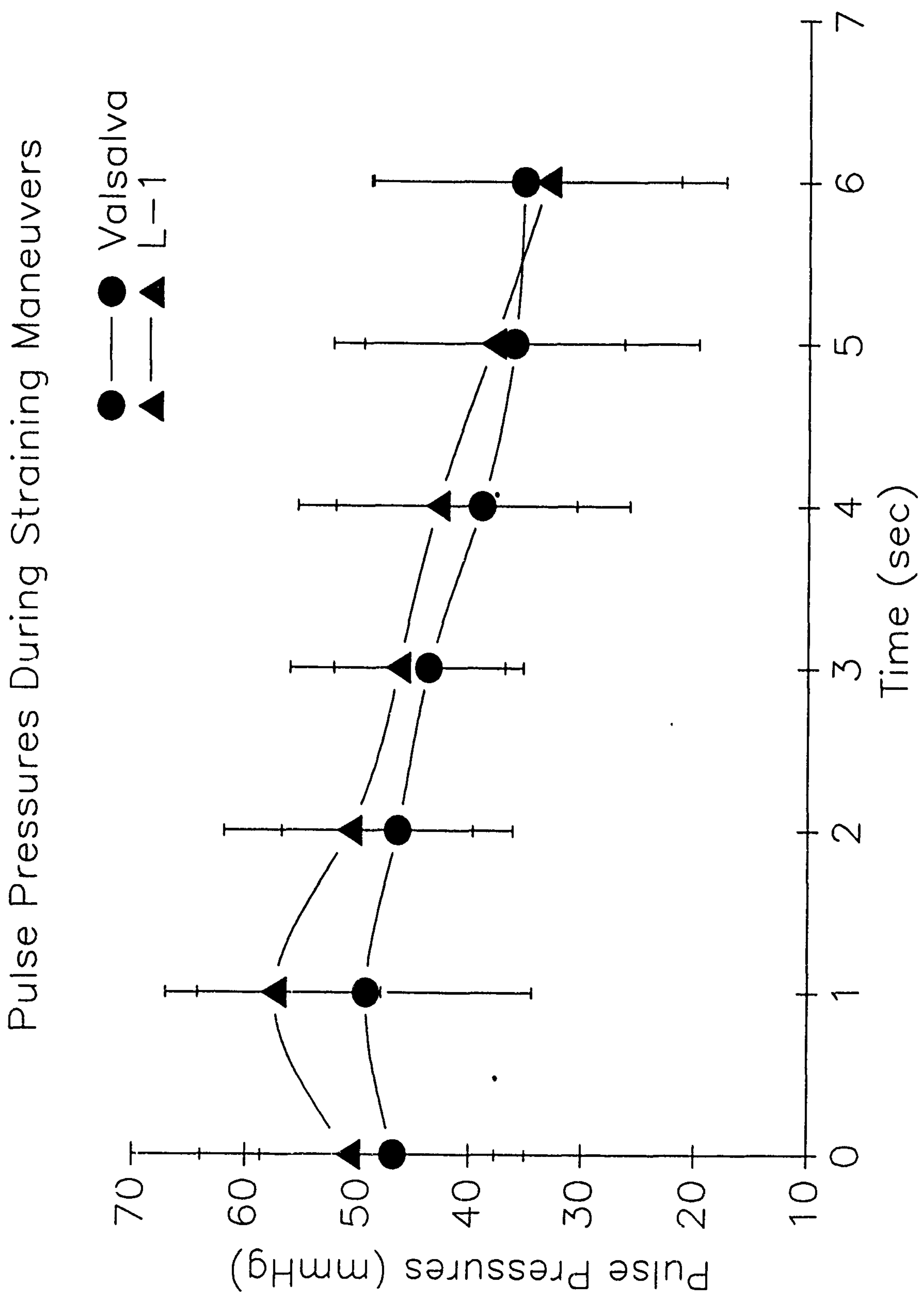

150 mm Hg
100 mm Hg

Systolic Pressures During Straining Maneuvers

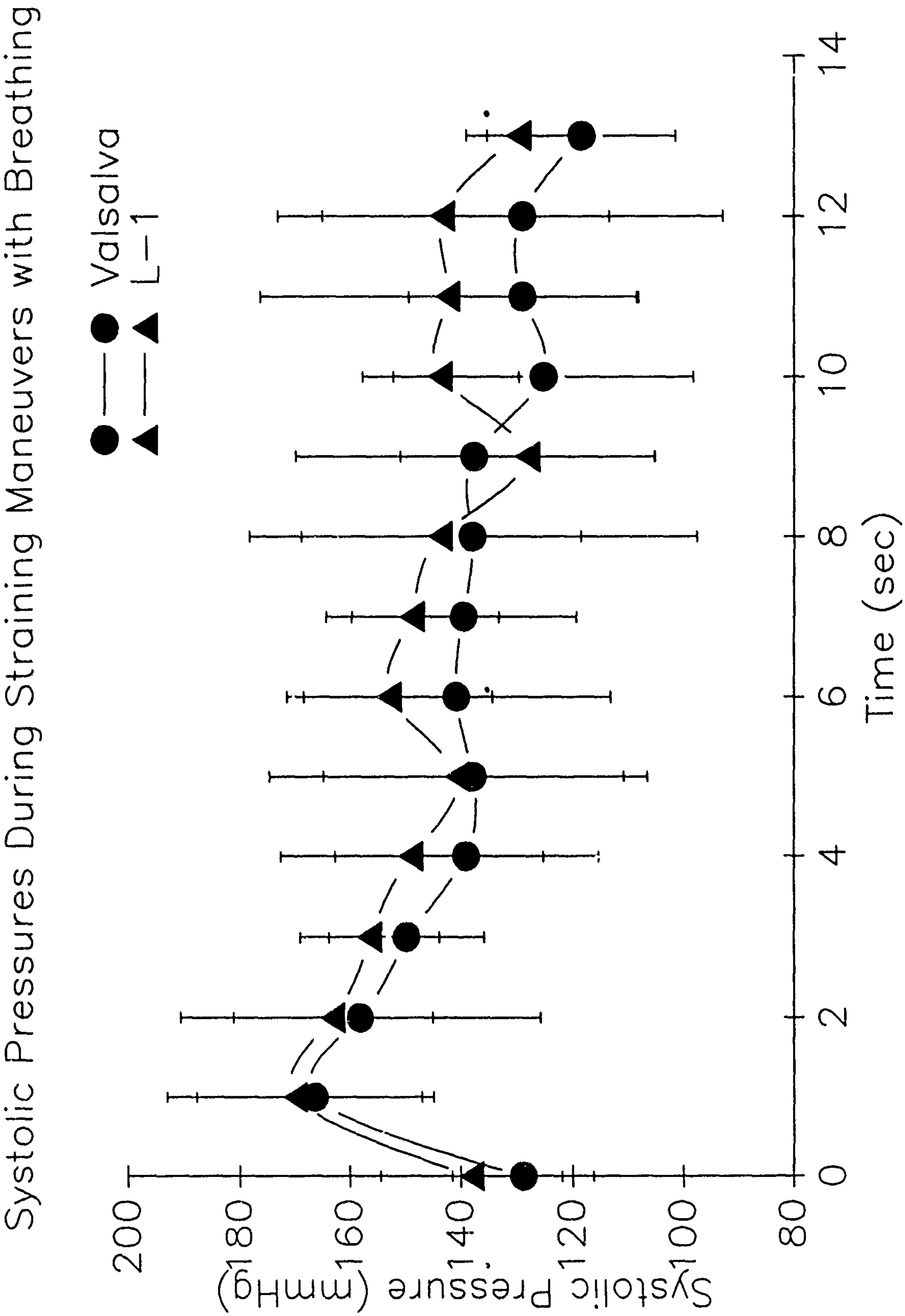


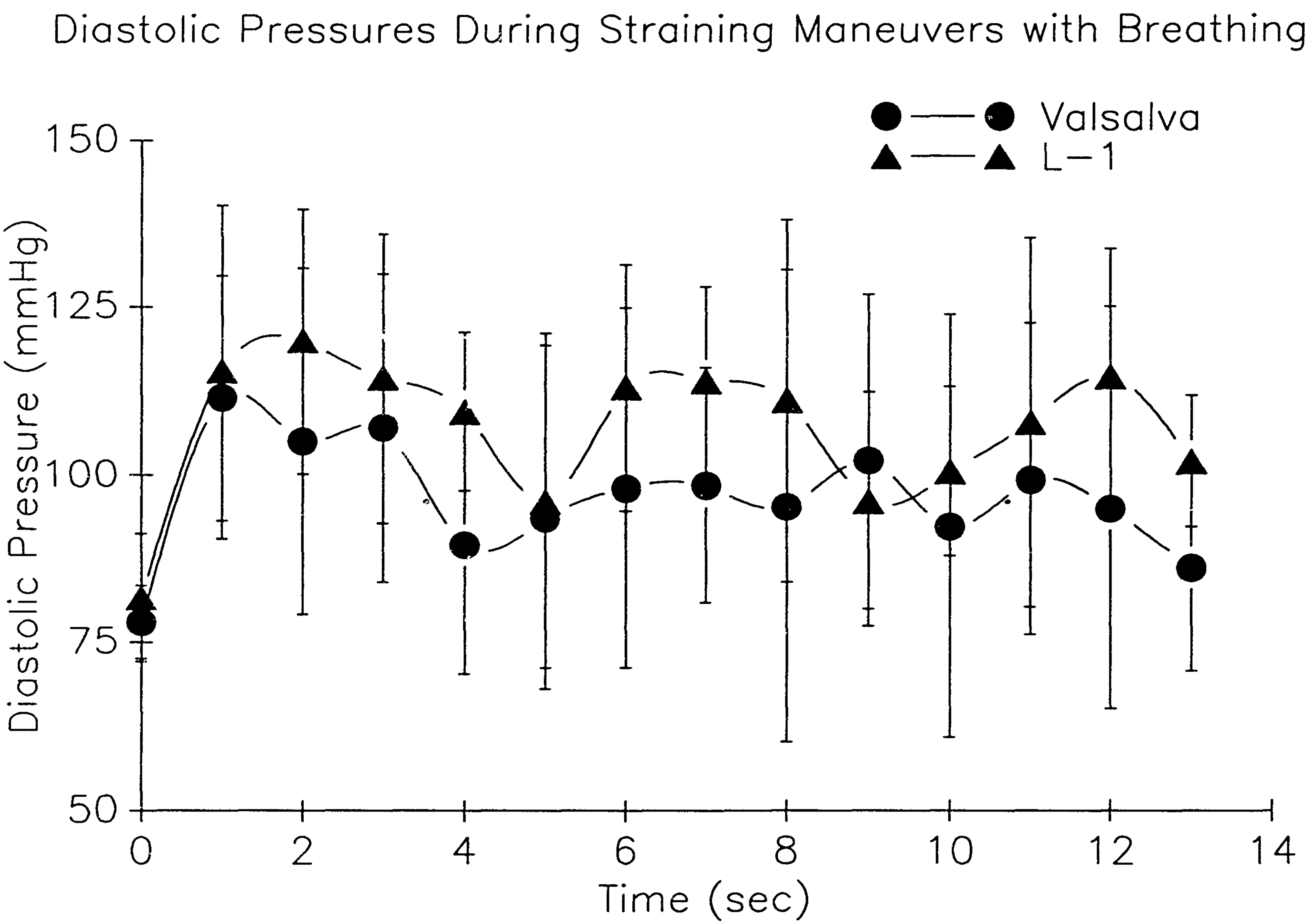
Diastolic Pressures During Straining Maneuvers



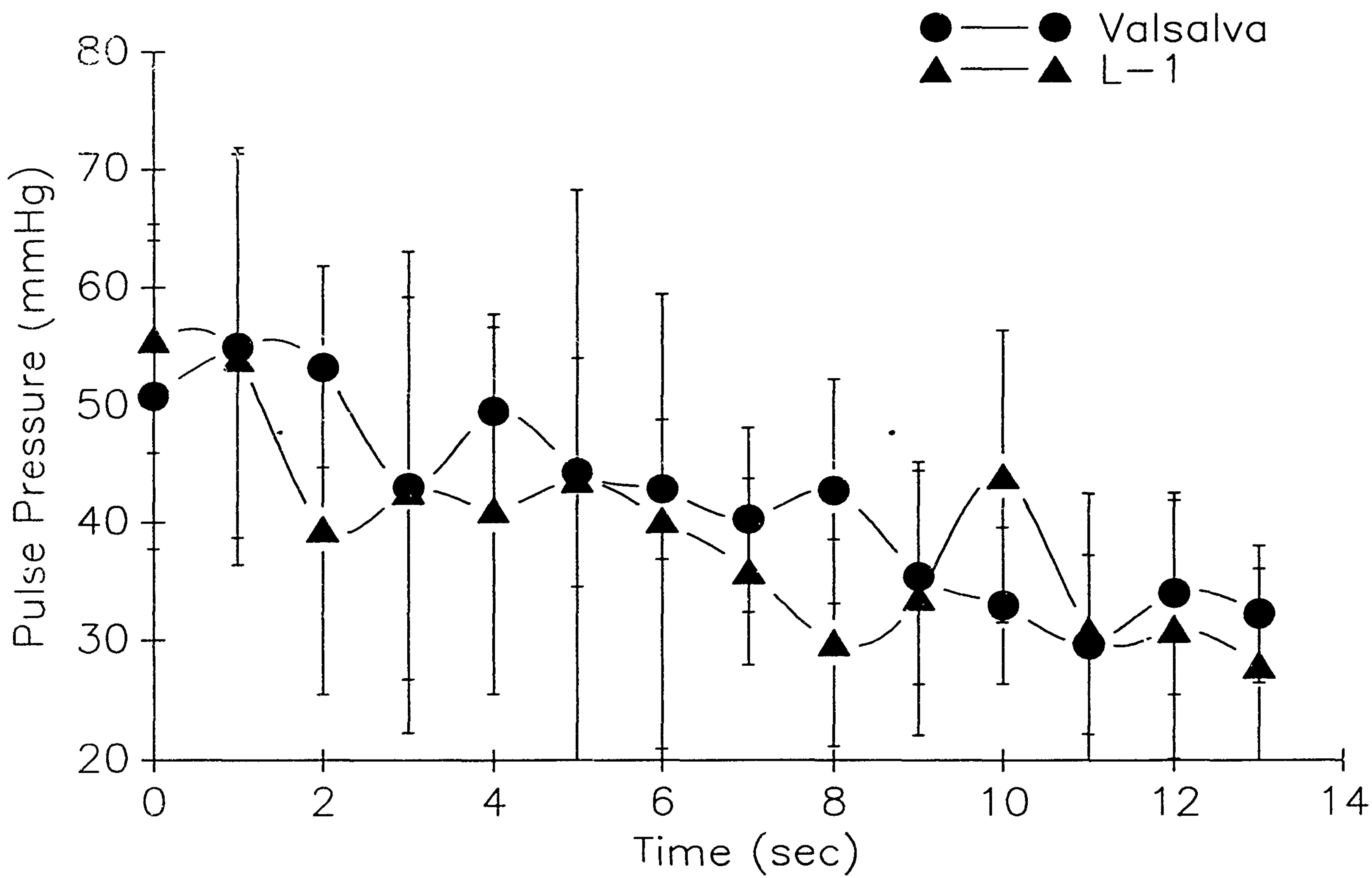


Pulse Pressures During Straining Maneuvers
Valsalva
L−1
Pulse Pressures (mmHg)
10
20
30
40
50
60
70
Time (sec)
0
1
2
3
4
5
6
7


Systolic Pressures During Straining Maneuvers with Breathing
Valsalva
L-1
Systolic Pressure (mmHg)
200
180
160
140
120
100
80
0
2
4
6
8
10
12
14
Time (sec)


Diastolic Pressures During Straining Maneuvers with Breathing
Valsalva
L-1
150
125
100
75
50
Diastolic Pressure (mmHg)
0
2
4
6
8
10
12
14
Time (sec)

Pulse Pressures During Straining Maneuvers with Breathing



RESEARCH SUPPORT ACTIVITIES AT THE ARMSTRONG LABORATORY

Julie Grinde

This past summer I had the priviledge to participate in helping with and learning from several of the research projects under Dr. John Fanton's supervision in the Research Support Systems Division of the Brooks Air Force Base in San Antonio, Texas. While everything was new and strange to me, I learned a great deal- from the elementary basics to some of the more difficult procedures- until I believe I was able to be of service to the persons with whom I was working. While some of my personal accomplishments were learning the basic operating room procedures, it was imperative that these be learned well before any real work could be done with any of the many types of animals that they work with there. I will attempt to relate some of these exciting aspects, from the ordinary to the unique.

When one is assisting in surgery, one must be sterile. The first order of business is to change into scrubs. These are worn to protect both oneself and the patient from any contamination. Shoe covers and a hair net that are disposable as to not infect the next patient are also worn. A face mask is worn to protect the sterile environment from the germs that are found in one's breath.

One of the main highlights of the summer was when I was able to scrub up and help with a surgery on a herniated Rhesus monkey. Besides myself, Dr. Fanton and an animal technician were the only others who were sterile. The knowledge that I had about being sterile and surgery procedures allowed me to be a beginner animal technician.

Now one is ready to scrub up, a term for the sterilization of the hands and arms. A scrub brush/sponge is used (also disposable) along with povidone-iodine liquid soap. To scrub, one is to hold their hands up and elbows down away from the body. This allows any dirty soap to run down the arm away from the sterile parts. Also, one must always scrub down from the hand to the elbow; from the clean to the dirty, not from the dirty to the clean. To start to scrub, one is to put several pumps of soap onto the sponge from the foot pump operated soap dispenser. The fingers are washed first. Each finger is treated as if it has four planes. Each plane must be scrubbed with the brush for five minutes. Then the cracks in between the fingers are done. Next the fronts and the backs of the hands, not forgetting the sides. For big areas like these, working in circles is best. After the hands are clean, the arms are next. While still having the arms up and without touching anything, one must scrub both arms. It is best to scrub all the way up to two inches above the elbow. After everything has been scrubbed, the brush/sponge is thrown away. Still without touching anything, the water must be turned on with a leg by moving the bar below the sink. The hands and arms are rinsed by letting the water wash the soap away. The hands must not touch together. After the soap is off, the water is turned off the same way as it was turned on - with a leg. With both arms still vertical in the air, and not touching anything, one proceeds to the operating room.

Once in the operating room, one will be met by another sterile person with a hand towel. One must lay the towel open across ones hand and pat the other hand dry. The towel is then moved to the other hand

and, with a different part of the towel, one must pat dry the other hand. All this is done without touching any of ones surroundings because they are not sterile. One usually drops the towel in a corner to get it out of the way.

One sterile person will help another put on a sterile gown. He will open the gown and hold it open. One must carefully and quickly stick ones hands down into the sleeves. That person will pull the gown the rest of the way on and tie it or a non-sterile person can tie it. To pull a gown up on someone else, one must touch only the insides where being sterile is not as important. The front tie is passed over so the non-sterile person can touch only the card attached to the tie which will be thrown away. The one dressing then turns around which pulls the gown around him. One can then grab the tie, and rip it off the card. The card is thrown away.

The next step is to put on the gloves. If there is a sterile person, he can help. He can hold the glove by its cuff so ones hand can be shoved into the glove. It has to be done right the first time, because it is not a sterile technique to pull the hand back out to try again. To put gloves on by oneself, one must stick ones hand into the cuff of the other hand's glove. Then the glove can be put on the hand. The same is done for the other hand. One must make certain to have the sleeve of the gown tucked inside the cuff of the glove. This is to ensure that the arm is sterile. The arms still need to be vertical to keep germs from falling onto the gloves and arms. Once finished, the hands can rest on any sterile field.

If a person is running the anesthesia machine, or is a helper, or is an observer, he does not need to be sterile. If one is not sterile, he still needs to wear scrubs, shoe covers, a hair net, and a face mask. Instead of wearing sterile gloves, he would wear examining gloves. A non-sterile person cannot touch any part of the sterile field or reach over part of the sterile field. A non-sterile person can give sterile items to a sterile person by carefully opening the wrap around the sterile item only by touching the outside of the item's wrap. The sterile person can then take the sterile item out of the wrap only by touching the item itself.

I was taught two methods of sterilizing items used in operational procedures. It became a daily responsibility of mine to keep the inventory adequate by sterilizing the items that were in insufficient supply.

The two procedures of sterilizing items that I learned and used both used an autoclave: one with gas; the other with steam. A gas autoclave uses Ethylene Oxide, a poisonous gas. One has to be careful not to open the autoclave before the cycle is complete. Near the beginning of the cycle, a pin punctures the gas cylinder that has been placed in the autoclave. The gas is allowed time to circulate all around the objects. Fresh air is then pumped in to air out all of the harmful gases. This type of autoclave is used for delicate objects like catheters, cords, cables, and plastics. The minimum temperature that is reached inside the chamber is ninty-six degrees celsius.

In a steam autoclave, high pressure steam is used to sterilize the items inside. Steam is used to sterilize all metal and cloth objects. The minimum temperature in a steam autoclave in one hundred thirty-two degrees celsius.

For both autoclaves, there are biological indicators that tell if the autoclave reached a high enough temperature to sterilize. Inside the indicator is a type of bacteria. The bacteria for gas autoclaves is green; for steam autoclaves, it is purple. One indicator should be run each day that the autoclave is used. The indicator is wrapped similarly to the way the other items are wrapped. The indicator should be placed in the area of the autoclave that is least likely to receive full sterilization.

After the autoclave has completed its cycle, the indicator is taken out of its wrapper and squeezed until a crack is heard. This allows air to get to the bacteria so it can grow. The indicator is then placed into an incubater for forty-eight hours. At the end of this time, the indicator is taken out. If the color is still green or purple, then the autoclave worked and all of the bacteria is dead. If the color is yellow, then the autoclave is not working correctly and all of the items run during that day have not been sterilized correctly and need to be redone.

There are two ways to wrap items for the autoclaves. One way is for large items like operating instrument sets, bowls, and hand towels. Large square pieces of special disposable cloths are used to wrap these. To wrap the item, the cloth is turned on end so it looks like a diamond. The item to be sterilized is placed on the center of this cloth diamond. A piece of special paper is placed in the center of the item: green for gas, beige for steam. (These will later have either red stripes or brown stripes to indicate if the item was sterilized completely.) The bottom flap is brought up over the item snugly. The overlap is folded back towards the bottom. This is continued until there is no more extra cloth hanging over the edge. For easier removal of the wraps in a sterile surrounding, it is important that the last fold has the point pointing towards the origination of the flap. Next one would bring the right flap over the top and pull snugly. Any extra cloth is folded like the first, but with the point pointing right. The same is done with the left and the top flaps. The next step is adding the second wrap in the same way as the first wrap, but this time the top flap is folded differently. The top wrap is wrapped all the way around the item until there is no more extra cloth. Then a piece of autoclave tape is used to tape the end down, using the green tape for the gas items and the beige tape for the steam items.

When the items have been correctly sterilized, the green tape will have red stripes and the beige tape will have brown stripes.

The other way to wrap an item for sterilization is to use special bags. This method is used for small items- like instruments. The bags have a paper back and a see-through plastic front. There are pre-cut bags that are heat sealed on three sides, and there are long rolls of bags that are sealed on two sides. The latter allows for the cutting of the correct length that is needed. After an item is placed in a bag, along with a piece of test paper that was mentioned earlier, the open end is sealed with a heat pressure sealer. Most items are bagged twice for easier handling in sterile environments.

After the items have been sterilized, they can be put in storage. All items are good up to a month after sterilization. Some items can be put up for six months. A dust cover is needed to protect the item before it is stored. It comes on a roll and is like a clear plastic tube. After the required amount is cut off of the roll, the item is sealed into the cover. The sealer is the same as for the bags, but a lower temperature is better so the plastic does not disintegrate.

With all sterilized items, certain precautions have to be made. Once the wrapper gets wet, it is no longer sterile because there is bacteria in water. It is the same with any item that has dropped as any tiny hole or tear will let bacteria into the package. After their expiration dates have expired, the items are considered no longer sterile. With all of the above cases, it is necessary to repackage and resterilize, unless the item was damaged. Any damaged or rusty items must not be used because they may not be completely sterile, or they could malfunction during their use.

Sutures are the threads that are used to sew together the different layers of skin. In learning the procedures in applying sutures, I first practiced on towels, then a deceased goat, and finally a live goat. It was important that I learned the different types and sizes of sutures and needles used during surgeries to be of assistance.

There are many kinds of sutures. Most can be classified into four groups, absorbable and nonabsorbable, monofilament and braided. The braided sutures include silk and vicryl. Silk is normally black in color, while coated vicryl is violet or undyed. The monofilament sutures include prolene, PDS, and Ethilon (nylon). Prolene is blue in color, PDS is clear or violet, and Ethilon is black. Another example of a braided suture is chromic gut. It is an old wives tale that chromic gut is from cat gut, but it is really sheep intestines.

There are advantages and disadvantages when comparing monofilament and braided sutures. Braided suture is stronger and does not have memory. But braided suture can not be used on the outer layers of skin because germs and bacteria can travel up the suture in between the braids. Monofiliment suture, on the other hand, consists of only one strand so germs can not travel up the suture. This makes it practical for the outer layers of the skin. One problem with monofilament suture is that it has memory. Some monofilament sutures have more memory than others, but all of them have it. With memory, the suture returns to the shape it was in in its packaging.

We worked with many types of animals in our laboratory. They included: mice, rats, guinea pigs, hamsters, rabbits, Rhesus monkeys, and olive baboons. I did not work with the research projects with the mice, rats, guinea pigs, and hamsters directly, but I did help with their care. On some days it was my job to feed, water, and change the housing of these animals. I also helped with their daily health checks.

The mice are kept in small plastic plastic cages, called shoeboxes, with a half scoop of wood shavings for their bedding. These shoeboxes could then be hung in rodent racks or set on shelves or carts. The lids must be kept on securely because mice are excellent escape artists. Since mice are small, seven or eight can be kept in one box. As they get older and bigger, five to a box is better.

Tail biting can be a real problem with mice. Usually the mouse with the least number of lesions on its tail is the culprit.

The best way to pick up a mouse is to use the tail. If the tail is grabbed at its base, it will be less likely to be injured.

Mice eat rodent chow which is made up of pellets measuring one half inch by one inch.

Rats can either be kept in plastic shoeboxes or in hanging metal cages. Six or seven small rats can be kept in the large shoeboxes on one scoop of shavings. As they grow, the rats must be separated until there are only three in each box. In extreme cases, when the rats are very big, only two rats should be together. In some experiments, the rats need to be singularly housed. Then the hanging wire cages are the best. Instead of wood shavings, paper is used in trays underneath the cages.

To pick up a rat, the same method as used as on the mice. Rats eat rat chow which is made up of pellets measuring one inch by one half inch.

The Guinea pigs are kept in shoeboxes with two scoops of wood shavings for bedding. Guinea pigs are best kept in pairs where they have the needed company, but are not overcrowded.

Guinea pigs eat small pellets, so a J-feeder is needed to hold their food.

To pick up a guinea pig, they are grabbed behind the shoulder blades and gently lifted.

Hamsters are also kept in shoeboxes with wood shavings. The medium sized shoeboxes house several hamsters, while the small shoeboxes house one hamster. Some hamsters are also excape artists.

Hamsters eat rodent chow like the mice.

To pick up a hamster, the loose skin at the back of the neck is used.

The rabbits are housed individually in rabbit cages, six cages per rack. Instead of wood shavings, pans are used without paper.

Rabbits eat rabbit chow which is made up of little pellets.

To pick a rabbit up, the loose skin at the back of the neck is used, while at the same time supporting their hind legs with the other hand. The handler has to be very careful while holding rabbits. They have very strong hind feet, and while they are trying to scratch, they can break their back or hip.

I did not have much time to work with the rabbits as they came the last week I was working. I helped with their feeding, watering, and their cleaning. I helped hold the rabbits while the animal technicians practiced shaving their hair. I collected feces samples to send for testing to make certain that the rabbits were healthy. I also helped with their daily health checks. During the health checks, we had to really watch for any rabbits with the snuffles or with diarrhea. When a rabbit has diarrhea, it is usually near death.

The Rhesus monkeys, Macaca Mulatta, are harder to work with than the previously discussed animals. The Rhesus are quicker and stronger than they look. They are kept in primate squeeze cages that hang from the wall. The squeeze mechanism is used to capture the Rhesus or to give it medication. The back of the cage is manually brought forward and can be locked in several different widths.

The Rhesus monkey can be handled without anesthesia. This is done by wearing double thickness leather gloves and by holding the Rhesus facing away from the person holding it with the Rhesus' arms held behind it. This works well on all Rhesus except large males and the very old monkeys. Large males, being heavy and strong, are very difficult to control. Most of the time. a little Ketamine is administered to slow them down. When carrying the older Rhesus, one has to be careful not to pull the arms back too far. The extra stress of putting their arms behind them causes can cause their respiration to be adversely affected.

Rhesus eat monkey chow or primate chow. The chow is in the form of large biscuit. They measure one inch by one inch by two inches. Rhesus monkeys have cheek pouches in which they can store their food for a while to soften. Older Rhesus that have lost some of their teeth use this method all of the time because the biscuits tend to be hard. Rhesus also love fruit. The Rhesus monkeys have different personalities and preferences just like people. Some are picky. Some will eat oranges, apples, and bananas, while others will not touch apples.

In the sick bay, one has to watch the diets closely of the Rhesus. Once there were several older Rhesus and one Rhesus that was recovering from a hernia. The older Rhesus were given fruits more often than normal. The hernia Rhesus got fruit at the same time. Soon he stopped eating his biscuits so he would get more fruit. It did not work; all fruit was withheld from him. He soon caught on and ate normally again with an occasional fruit treat.

Rhesus monkeys show aggression in several different ways. One way is by opening their mouths. Depending on the amount of aggression, they may show their teeth. In order to show more teeth, they often yawn. To make themselves appear larger, Rhesus can make their mane and the rest of their hair stand on end. Staring is another way of showing aggression as well as by bouncing against the front of the cages. Some Rhesus would even grab the bottom of their cage and shake the whole cage as if to shake it off of the wall.

I worked a little with the Rhesus monkeys, mainly with those that were either sick or old. I did help with the transportation of some of the Rhesus, with the feeding of them, and with their daily health checks. I also helped with their dental work. With most of the Rhesus, the four canine teeth had to be removed. These are the teeth that do the most damage to the handler. Also any infected or severly worn teeth in the older Rhesus were removed. It was also our responsibility to keep the teeth of the Rhesus clean. The same tools used by human dentists were used with the Rhesus, such as an ultrasound cleaner. Its small wand had a continual flow of water through it to keep the instrument from getting hot.

Baboons use the same aggressive signs as that of the monkeys. Staring is the main method used along with raising their eyebrows. If a person even looks into their eyes or at their face, it is taken as a sign of aggression. Baboons yawn a lot to show off their impressive canines. They also slap their cages and grunt to show disgust or aggression. For a person to show non-aggression to them, they can turn sideways or even backwards to them. This will indicate that the person is not posing a threat to them. Also, if a person will lipsmack, it will show the baboon that the person is a friend. If a person is friends with a baboon and that baboon feels safe, the baboon will lipsmack back and may even want to touch the person. If the baboon wants to be left alone, he ignores everyone. He may concentrate on picking his nose or picking at something else and ignore his surroundings. They think that if they ignore others, others will ignore them. Often, this is true. An aggressive baboon will lose interest in a baboon that is ignoring him.

Baboons are kept in large primate cages. These cages also have a squeeze mechanism. This was very necessary in handling the baboons as they are heavy and very strong. A little Ketamine was administered to slow the activities of the baboon. If a baboon started to wake up, they were given a apple. This was done so that they would concentrate on the apple, which they love, not on their surroundings.

Each baboon has his own circle of friends. This circle includes their mate, their girl friends, their boy friends, and their infant friends. Friends watch out for each other and give help in a time of need. If an infant is being picked on, its older friends will come and chase away the bully. If a older baboon is being picked on, he picks up one of his infant friends so the bully would not pick on him, because infants are important to baboons. I was lucky enough to become a girl friend with a couple of the baboons.

When one of the baboon projects required use of the centrifuge, I became an important part. I would help ready the baboon for the spin and would help with the transportation of the baboon and equipment. Before and after the spin, it was my job to keep the baboon calm by feeding him peanuts and Tang. During the spin, I helped watch the baboon to make certain he was doing well. After the spin, I helped take the equipment and the baboon back to the main lab.

One of my responsibilities was to monitor the animals in sick bay. Most of the animals in sick bay were older Rhesus. At the slightest change of diet or behavior, an exam was done of the animal. Any treatment was started immediately to help the Rhesus. Sometimes the treatment was to put the animal to sleep. If this was the case, the animal would g from our department to the Pathology Lab. There, a necropsy was performed. This involved taking samples of all of the different kinds of tissue. While I was there, two Rhesus were found with constrictures of the intestine. These had been very rare in the past, with only one other Rhesus having one in the study group.

The battlefield nursing classes for students were held in our department. It was our responsibility to collect and set up all of the necessary equipment. For this set of classes, I put the equipment trays together. I also helped get the rooms ready.

For the first group of classes, I was in charge of one of five rooms. I monitered the respiration of the Rhesus monkey that the students were intubating. After the tube was in place, the students would bag the Rhesus a couple of times to make certain that they were not in the stomach. This action took over the Rhesus' need to breathe on his own. In the excitment and stress, the Rhesus would then sometimes forget to breathe on their own. When this happened, it was my job to bag them to get them to breathe again.

After the Rhesus, the students would practice suturing and inserting I.V. catheters in a goat leg. I would take the Rhesus to the recovering area and bring in a goat.

During the second group of classes, I monitered their recovering Rhesus monkeys. There were a couple that had difficulty starting to breathe on their own again. I had to bag them so they would not die. In the end all of the Rhesus were fine.

When both classes were over, I was able to practice the procedures that I had been taught and had practiced only on towels. I first practiced suturing on a dead goat. I also was able to put a catheter in his hind leg, but the vessel collapsed because there was no blood circulation. I was then given the opportunity to work on a live goat. I put in a successful catheter, and I performed a cut down on another blood vessel.

Besides the above mentioned responsibilities, I also helped in the operating room. I would set the equipment out and get the room ready before the operation. I would then help get the animal ready by sometimes administering Ketamine and by shaving the area to be operated. During the operation, I would moniter the animal and get any extra materials needed. After the operation, I would moniter the animal to make certain there was a satisfactory recover I would also help clean the room and the instruments.

My personal accomplishment from this unique summer's opportunity was that I altered my choice of careers. I have wanted to be a veterinarian for as long as I can remember. I now want to work in medical research instead of having my own private practice. I knew that medical research was being done, but I did not know, until this summer, what it really involved. I was extremely impressed with the humane manner in which the animals were treated. I enjoyed the challenge it gave me, the opportunity to work with a group of fantastic people, as well as the thought of being able to perhaps help the human race.
I am not certain I would have grown as much as I have if I had been limited to an individual project instead of helping with such diverse animals and procedures. I would welcome a chance to work again at any time at Research Support in the Armstrong Laboratories.

Exercise and Health

Kathryn Kawazoe
High School Apprentice

ABSTRACT

My main project this summer was in aiding Dr. Larry Krock with his study of nervous system signals that control heart function. Male subjects were observed at given speeds and levels on a stationary bicycle and on a treadmill to determine their VO2 max, possibly the most valuable measure of physical fitness obtainable by our standards. Significant differences were found between the high fit subjects' and low fit subjects' percent body fat, body densities, VO2 maxes, heart rates before, during, and after exercise, blood pressure, and levels of performance. Through other various lectures and observations, I also became more familiar with the effects of exercise, both good and bad, but mainly how exercise drastically improves overall physical fitness.

INTRODUCTION

Health -- the most valuable thing one will ever possess, yet something which so many people too often ignore. A person's health decides how good or bad and how long or short one's life is. So why do so many people abuse their bodies by eating twinkies and ice cream, by spending their life in front of the television, or get their exercise by walking from their car to their office? Probably because they are too tired, too lazy, or because they are too uninformed of what health and exercise really mean. However, there are some brave souls who dare to meet the heat and exercise frequently. These same people are usually the ones who eat right and take care of not only what is on the outside, but also on the inside. For this heartrate variability study, both types of people were chosen in order to observe the difference between what is happening in what is considered to be a healthy body as compared to what is happening in a body that is considered physically unfit.

Before beginning the actual tests in this study, each subject was weighed to find total body fat and body density, making some results rather obvious. Knowing that a sedentary lifestyle usually leads to higher body fat because of little or no exercise, it was most likely that the sedentary group of subjects had low plasma HDL concentrations, and the endurance-trained subjects had high plasma HDL concentrations (2,3). Also, because of lower HDL levels, circulation was expected to be less efficient in the sedentary subjects. Since the maximum oxygen uptake during exercise is limited by central circulation (1), the amount of oxygen able to be used by sedentary subjects was predicted to be much less than the highly active group of subjects. The higher hemoglobin concentration in the more aerobic subjects (1) also led to the assumption that oxygen-carrying capabilities would be much higher in the high-fit group of subjects.

Although many factors to health are related to heredity, it is possible to greatly influence when and to what extent the effects of health will occur. For example, habitual physical activity can decrease deterioration of maximal oxygen uptake abilities (1). Through studying the changes in heart activities before, during, and after exercise, it is possible to see the difference in stroke volume and maximal cardiac output between a physically fit person and a sedentary person.

DISCUSSION OF METHODS

Before administering any exercise tests, each of the twenty-three subject's weight in water was found in order to determine body density. I programmed my calculator (TI81) to find body density and percent body fat by entering a subject's water weight, weight in air, density of the water, and residual volume, a measurement of withheld air in the lungs that was dtermined earlier.

The next part of our experiment was to administer the cycle ergometer tests for predictions of each subject's VO2 max when tested on a treadmill. By testing subjects on both the cycle and the treadmill, comparisons could be made to determine through which exercise one reaches more of a physical peak, therefore allowing for more accurate measurements of one's physical fitness.

During the treadmill test, whish lasted six to twelve minutes, depending on the fitness of the subject, atmosphetic balloons were set up to collect the expired gases from the subject. Head gear, moseclips, and heart monitors were also required to insure accurate measurements and to allow for examination of the heart. The high fit group ran at a seven mile per hour pace, with the exception of two very highly fit runners who ran at an eight and one half mile per hour pace, and the sedentary group walked/ran at a five mile per hour pace. Every two minutes the elevation would rise two and one half percent. After the test, the gases were immediately measured using a mass spectrometer and analyzed for expired oxygen and carbon dioxide levels. The results were then entered into a computer, and the VO2 max was found and compared with the predicted measurements.

Echocardiograms were also administered to a select group of the high fit subjects to observe how longterm training affects the heart at rest and after vigorous exercise. Leaks and valve movements were measured and recorded to be used in another study.

The next process in the study was to draw blood samples to determine plasma levels. After having two samples drawn and resting ten minutes, each subject breathed oxygen mixed with carbon dioxide for another ten minutes, when two more samples were taken. All four samples were spun on a centrifuge for three minutes.

PROBLEMS ENCOUNTERED

Getting this study started took more effort than first expected; just finding a lab to test the subjects in became a major task Finally, when we were able to begin experiments, another problem was found. The treadmill was calibrated to only three miles per hour, so when raised to seven miles per hour, the speed was actually six miles per hour. This was fixed by simply measuring one rotation as compated to one mile, and the speed was adjusted accordingly. In addition, after checking the body fat results, I found an error in the body fat computer program and proceeded to correct the results. I also noticed there had been errors in assuming all the subjects had released all possible air from their lungs during underwater weighing and found there to be several body densities and percents of body fat that seemed rather awkward. The last problem occurred when entering the results into the computer; the program did not allow for a different temperature for each different bag of expired air. Soon, however, the program was modified for the input data, allowing the output data to be more accurate.

RESULTS AND CONCLUSIONS

As predicted, the low fit subjects had a much higher average percent body fat and a much lower average body density. These results allowed us to predict how well each subject would perform on the following tests. The cycle ergometer test evaluated work load according to heart rate, while the treadmill test evaluated heart rate according to work load. The low fit group's VO2 maxes ranged around approximately thirty ml/kg/min, while the high fit group's VO2 maxes were approximately seventy-two ml/kg/min. The great differences in efficiency of the cardiovascular system is due to the physical training by the highly fit subjects. These subjects' specificity in aerobic training was obvious because of their circulatory response to exercise. Not only were they able to maintain a consistent heart rate for each workload, but there was also an increase in capillary density and available surface area for a more efficient exchange of gases. Another contributing factor to the results was the ability of the olw fot subjects to perform. Their inactivity affected their strength in muscle, bones, and junctions (1), making them exhausted after walking with increasing grades only a short time. Since physical activity is the "most variable component of energy expenditure" (Astrand 16), people who stay physically fit through exercise not only keep their muscles and circulatory and respiratory systems in shape, but also effect their energy levels more intensely.

OTHER EXPERIENCES

In addition to working on the heart variability study, I also attended weekly luncheons and lectures guven by doctors in various fields. These were available for the summer high school students in order to offer knowledge that might help in decisions concerning the future. From each, I learned about a different aspect of engineering and technological research. These meetings allowed me to view areas I would have otherwise not had the chance to learn about. My schedule want as follows:

week 1-introduced and shown around work area, altitude chambers, and centrifuge.

week 2-Dr. Jon French discussed melatonin and the effects of lighting concern fatigue.

week 3-Dr. Lisa Weinstein explained psychological engineering and the head up device (HUD) in aircraft as well as the effects of the "big hand."

week 4-Dr. Fisher discussed statistical inference.

week 5-The summer students discussed careers in science and engineering with Dr. Antunano.

week 6-Students discussed how models are used to determine fatigue, performance, and recommended rest time for Military Airlift Comand (MAC) crews.

-Dr. Myhre explained physical fitness in detail.

week 7-Dr. Chubb explained task taxonomies and how they apply to our research.

week 8-Dr. Nunnely expanded on what to include on resumes for future reference.

*****Many thanks to my mentor, Dr. Larry Krock, and everyone who helped make my experience possible: Dr. Jon French, Dr. Harley Hartung, and Craig Crandall.

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PROTOCOL TO DETERMINE THE BIOEFFECTS OF 5.6 GHz RADIATION

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ABSTRACT

In order to discover the bioeffects of electromagnetic radiation, neurochemical studies were conducted by exposing rats to an electromagnetic field. Rats were surgically implanted with a microdialysis probe into either the lateral hypothalamus or preoptic area. The rats were then exposed to a 5.6 GHz field and neurochemical samples were collected. These samples were assayed by high pressure liquid chromatography. In addition, neural tissue was stained for c-fos, an intermediary gene.

INTRODUCTION

The effects of electromagnetic radiation are of particular interest to the United States Air Force as relatively little is presently known about them. The USAF now uses systems of emitters that produce radiofrequency radiation. Currently in the developmental stage are high power microwave devices. They produce short, high peak power electromagnetic pulses. In the future, these will most likely be important for things such as communication. The key goal in this research is to find out if these exposures to electromagnetic radiation are hazardous to the people that work around them. Research will help to develop accurate safety guidelines.

Some studies have tried to show the possible link of electricity to cancer, for example; however, the effects of electromagnetic fields on the human body remain virtually unknown. Humans are known to have similar physiological responses as animals. Therefore, this research is done on rats with no endangerment to human lives.

The predominant biological effects of microwave exposure are in response to the heating of an organism (Erwin, 1988), which results in the stimulation of its thermoregulatory system. This system has thermal sensors that detect changes in skin temperature due to changes in the environment. If warm receptors are activated, cutaneous vasodilation occurs to increase heat transfer from the body core to the skin through the circulation. However, deep tissue heating by a resonant frequency inadequately stimulates these peripheral thermosensors and thermoregulation of deep body temperature is impaired (Adair, 1990). Fortunately, there are also thermosensitive neurons in the preoptic region of the hypothalamus (Nakayama et al., 1963; Hellon, 1967) and midbrain regions (Hensel, 1974) that detect changes in internal body temperature, such as that caused by exercise (Nielsen and Nielsen, 1965). It appears that the outputs of these thermosensors are integrated by the hypothalamus. Lesioning the anterior portion of the hypothalamus compromises an animal's ability to thermoregulate (Satinoff and Rutsein, 1970; Carlisle, 1972; Chambers et al., 1974; Liu, 1979).

The neurochemical substrate of temperature modulation seems quite diverse. An intracerebroventricular injection of norepinephrine produces either hypothermia or or hyperthermia, depending on ambient temperature (Lin et al., 1981). Activation of central serotonergic receptors inhibits heat production and increases heat loss (Lin et al., 1978). Changes in vascular tone, blood volume, and heart rate are other physiological methods by which an animal thermoregulates. Cardiovascular changes occur in response to changes in peripheral concentrations of neurochemicals. For example, an intravenous infusion of norepinephrine produces vasoconstriction and hyperthermia. An increased concetration of circulating serotonin causes vasoconstriction and blood flow arrest in small vessels. Although it is known that various neurochemicals influence blood flow, heart rate, and body temperature, there has been only limited research pertaining to the interaction between endogenous neurochemicals and radiofrequency radiation.

When an organism experiences external stimuli, it reacts to maintain a state of homeostastis. In this state, it functions properly despite changing external conditions. This is the principle in effect on the cellular level. C-fos is a certain type of long-term antigen that is released after stress occurs, perhaps including stress resulting from electromagnetic radiation. Various immunocytochemical procedures have been developed and used to allow the observation of c-fos expression in neural tissue. In the present experiments, the peroxidase antiperoxidase (PAP) technique was used. This is an indirect method, where the marker compound for identification of the site of the antigen-antibody reaction is attached indirectly to an anti-intermediary immunoglobulin (IgG). There are three steps of the PAP technique: 1) applying antiserum produced in a rabbit species and prepared against the specific tissue antigen, 2) applying anti-IgG produced in a goat species against the rabbit IgG, and 3) applying the PAP solution. After the process is completed, c-fos can be observed in the cross sections with light microscopy.

METHODS

Microdialysis probe-making technique

Microdialysis probes were made to allow the collection of neurochemicals from the rat's brain during the time of exposure in the microwave chamber. The following process has been developed to make microdialysis probes specifically for this use. Fused-silica was used for the inner and outer cannulae and polyethylene (PE) tubing was used for the in-flow and out-flow tubes. The smallest size combinations possible to limit the amount of damage to the brain tissue was 75/142 um (ID, OD) for the inner cannula and 250/450 um for the outer cannula. A dremel drill was used to cut the outer cannula to be 2 cm in length and smooth the ends. A dissection microscope was used in this step for greater precision. With a razor blade, the inner cannula was cut 4 cm long and the PE tubing was cut 15 cm. One end of each piece of the PE 10 tubing was cut at a 45 degree angle.

After this tubing was cut to its proper length, the outer cannula was inserted 2 mm into an end of the PE20 tubing widened by a 25 gauge needle. A hole 5 mm from the same end was made by bending the tubing and pushing a 25 gauge needle through. While it was still bent, the inner cannula was pushed into the hole and through the outer cannula to extend it exactly 1 mm. Bone wax was applied by gently rubbing it at the point where the inner cannula goes into the PE20 tubing. This prevented epoxy from clogging the probe in later steps.

For the following steps the probe was held in a clay support stand. The PE 10 tubing was inserted over the longer part of the inner cannula that is outside the the PE 20 tubing. The angled end of the PE 10 tubing was pushed to meet the PE

20 tubing. With a metal spatula, epoxy was applied to the place where the outer cannula went into the the PE 20 tubing and where the PE 10 and PE 20 tubing met. The epoxy was used liberally to ensure proper connection and strength and to prevent leaks from occurring. The PE 10 connection faced down so that gravity would pull the epoxy down before it set and the hole would be completely covered. One hour was allowed for the epoxy to set before the next steps were continued.

Spectrum membrane (#132275) was cut with micro dissection scissors in 1 cm pieces. With tweezers it was inserted between the inner cannula and that outer cannula (around the inner and inside the outer) so that 5 mm extended out. The membrane could not be touched with skin because oil would clog the pores and reduce the recovery rate. With a 25 gauge needle, a small amount of epoxy was touched to the opening of the membrane and capillary action pulled it into the membrane so that there was between 0.5 and 1 mm of epoxy in the tip. It had to dry for at least 30 minutes before continuing. The sealed membrane was pushed up to the inner cannula so that there was a very small gap between the epoxy tip and the inner cannulae. Epoxy was applied around the membrane where it touched the tip of the outer cannula, but the membrane could not be totally covered with epoxy. It had to dry for 30 minutes, and in the meantime epoxy was added to the upper connections and to the tip of the membrane. Another small amount of epoxy was added to the connection of the membrane and the outer cannula. The probe was allowed to dry for at least 4 hours and then it was ready for use.

Animal surgery

The rat was weighed and injected intraperitoneally with Urethane (1.25 g/kg). The areas of the sites of incision (around the throat and the top of the head) were shaved. The rat was then placed on a heating pad set at 35°C. Once the anesthesia had taken effect so that the rat did not respond to a tail or toe pinch, the surgery began with a tracheotomy. To clean the area, betadine scrub was applied twice with cotton swabs in a circular motion from the inside to the outside and then betadine solution was applied twice in the same manner. The area was patted dry with a piece of sterilized gauze. Xylocaine (1.5 ml) was injected in four parts along the line of incision. The incision was made with a scalpel and the muscle and fat tissue were moved away with forceps. The trachea was elevated with blunted forceps and suture was pulled underneath. The respirator was used with a speed of 85 breaths per minute at 3 cc per breath. A hole was cut in the trachea with microdissecting scissors and the trachea tube was inserted. The sutures were tightened and the throat was sutured closed.

The anesthetized rat was placed into the ear bars on the stereotaxic. The rat's head could move up and down but not sideways. The mouth bar was at -3.3 mm. Xylocaine (1.5 ml) was injected in four parts along the line to be cut. The top of the head was scrubbed in the same manner as the throat area. With a scalpel, a straight incision was made from between the eyes to between the ears. All the skin layers to the cranium were cut and cleared away so that the plates that form bregma, sagittal sinus, and lambda were exposed. The muscles surrounding the head were left undamaged. Grooves were made in the skull with a scalpel to roughen the surface. The four corners of the lower layer of skin were clamped with hemostats to fully expose the skull. The skull was kept moist with saline irrigation. Two holes were drilled on the frontal plates of the skull so that they went only through the skull but did not pierce the dura. Caution had to be taken so that the sagittal sinus was not punctured. The holes were rinsed with saline and dried with gauze. If bleeding continued pressure was applied with a swab. These holes were for nylon support screws to hold the cranial cement anchored to the skull. Screws were picked up with tweezers and screwed down with a screwdriver. A gap of 1 mm was left between the head of the screw to the skull. Two holes in the skull on opposite sides of the sagittal sinus in front of lambda were drilled for temperature probe guides. The temperature probe guides were made of two pieces of clear heat shrink tubing cut 1.5 cm in length. They were put into the holes down to dura.

The microdialysis probe was tested for unrestricted flow and no leaks. With a syringe and a 25 gauge blunted needle, saline was forced into one of the PE tubing to see if it came out of the other tube. The probe was placed in a stereotaxic manipulator and the manipulator was put on the stereotaxic. The tip of the probe was centered at the exact point where sagittal sinus and bregma crossed, and the measurement was taken. To align the probe over the lateral hypothalamus region, 1.8 mm was subtracted from each of these measurements. The spot where the tip pointed was marked with a marker. The manipulator with the probe was moved aside and the skull was drilled at that point. In later experiments, the area of interest was changed to the preoptic region. In this case, the coordinates were 1.2 mm to the right of sagittal sinus and 0.8 mm posterior to bregma. Dura was pierced with a 25 gauge needle, if it was not already torn, and the area was rinsed with saline. After the bleeding stopped, the probe was inserted. It was slowly lowered to the top of the dura and the measurement there was taken. The probe was lowered 9.1 mm for the lateral hypothalamas region and 9.2 mm for the preoptic region.

To make the skull cap, cranioplastic cement was used. The first layer of cement was watery so that the screws were surrrounded and the holes were filled. When this first layer hardened, more cement was applied until it was built up to the bottom of the probe holder on the manipulator. After the cement dried firmly the manipulator was removed from the stereotaxic leaving the probe securely in place. The hemostats were removed. On the right side of the rat's head the skin was cleared from the cement to keep it open for one of the temperature probes in the chamber. The cement was applied until it was built up so that the epoxy bulb of the probe was covered. The surgery was completed with this final step, and the rat was removed from the stereotaxic and set up in the chamber.

Chamber protocol

Immediately after the surgery was completed, the rat was taken to the microwave chamber. The assigned military person had already started warming up the transmitter. The Narda probe should have read 8, 11, and 14 without the rat in place. Caution was taken so the radio frequency (RF) horn and stands were not bumped or moved. If this happened, the assigned military person had to recheck the Narda values. A cloth cover was placed over the heating pad with the cotton side facing up. The rat was placed on the cloth cover and the temperature probes were inserted. These were positioned to measure the rat's rectal, contralateral brain (4 mm), ipsilateral brain (4 mm), skin (horn side), and tympanic (horn side) temperatures. The contralateral brain, ipsilateral brain, and tympanic temperatures should have been similar. The rat was carefully positioned under the horn and was covered with another cloth cover with the cotton side against it. A computer programmed to display the temperatures. The rectal temperature was continually monitored. It was kept between 38.0 and 39.0°C by turning the heating pad on and off as needed. A 3 ml syringe half filled with modified Ringer's solution was placed in the infusion pump. The flow rate was set on high to flush air from the tubing. The flow rate was then set at 1 ul/min. The syringe tubing was connected to the inflow tubing of the microdialysis probe and the outflow tubing of the microdialysis probe was connected to the fraction collector. All tubes were taped down in the direction of the H-field (magnetic field) so that there was less chance of the tubing getting heated. All temperature probe fibers and microdialysis tubes were checked to be sure that they were at least 1 cm below the horn. If they were caught up in the horn they could have caught on fire. The microdialysis computer was set up to collect a total of 20 samples at 15 minutes each: 8 baseline samples, 4 RF samples, and then 8 additional baseline samples.

If the ipsilateral brain, contralateral brain, and rectal temperatures had been approximately 38°C for at least 30 minutes, it was time to begin the radiation. The cloth cover was removed from the rat. The power to the horn of the transmitter was turned on and was started at 19 watts. This should have raised the ipsilateral brain temperature by 2°C within 7 minutes. The transmitter power was lowered to 10 watts. Then the power was lowered or raised as necessary to maintain the 2°C temperature elevation. After 60 minutes, the power to the horn of the transmitter was stopped, but the transmitter was left running to eliminate the variable resulting from the noise. Two hours after the termination of the power to the transmitter the computer program was stopped. The temperature probes and the respirator were removed from the rat. It was quickly decapitated. With a funnel, trunk blood was collected in a heparinized (200 U/l) tube. The brain had to be removed within 90 seconds to prevent degradation of some neurochemicals. It was placed on wet ice and then on dry ice. The brain was placed in a scintillation vial and stored at -80°C. Two hematocrit tubes were used to remove blood for hematocrit measurements. Remaining blood was poured into two microcentrifuge tubes and spun for 5 minutes. Plasma osmolality and Na+/K+ concentrations were determined.

C-fos procedure

Two hours after exposure, some of the rats were intraperitoneally injected with 100 mg/kg of Ketamine. After approximately 20 minutes when the rats did not respond to a tail or toe pinch, the chest was opened and the descending aorta was clamped. They were intracardially perfused with 200 ml of heparinized saline and then with 4% paraformaldahyde solution until they became stiff. After the rats were decapitated, the brains and spinal cords were floated in 4% paraformaldehyde for 24 hours. Next they were placed in a solution of 30% sucrose in a sodium phosphate buffer until they sunk, which took around 48 hours. The tissues were placed in dry ice, mounted on cryostat chucks and then cut in a cryostat at -18°C into sections 40 uM thick. The sections were placed in tissue culture plate wells and first stored in 0.1 M phosphate-buffered saline with 0.01% thimersol.

The actual process of staining for c-fos began next with the removal of the 0.1 M PBS and then washing with 0.5% Triton X-100/0.01 M PBS for 5 minutes. A 500 ul pipette with disposable tips was used to rinse and remove each solution. Then they were rinsed in 0.01 M PBS three times for 5 minutes each. The sections were incubated for 20 in 2.5% goat serum/0.1 M PBS to suppress non-specific binding of IgG and rinsed two times with 0.01 M PBS for 5 minutes each. For two hours at room temperature they were incubated with c-fos primary antibody and rinsed three times with 1% goat serum in 0.01 M PBS for 5 minutes each. The sections were incubated with biotinylated secondary antibody for 30 minutes at room temperature and again rinsed with 1% goat serum/0.01 M PBS three times for 5 minutes each. Then they were incubated with Elite ABC reagent for 30 minutes at room temperature and rinsed 5 times with 0.01 M PBS for 5 minutes each.

Next, they were incubated in a diaminobenzidine tetrahydrochloride (DAB) solution for 2 minutes. This is a very crucial step. The DAB was enhanced with a silver intensification process. For this, they were rinsed two times with 0.05 M AMPP (2-amino-2-methyl-1,3-propanediol) for 15 minutes each time, then once with 1% glacial acetic acid for 3 minutes, once with 0.01 M cupric sulfate for 10 minutes, two times with distilled water for 2 minutes each, once with 3% hydrogen peroxide for 15 minutes, and 3 times with 1% sodium acetate anhydrous. Following these rinses were one rinse with silver developer for 15 minutes, 3 times with 1% glacial acetic acid for 10 minutes each, and 2 times with 0.05 M cacodylate for 5 minutes each.

The sections were mounted on clean coated glass slides. The slides were placed in 70% alcohol, then 90% alcohol, and 100% alcohol for 10 minutes in each one. Then they were rinsed in Americlear for 5 minutes. Permount was used to mount coverslips and the slides were allowed to dry overnight at room temperature. The c-fos was then observed in the sections by light microscopy.

RESULTS AND DISCUSSION

The c-fos staining procedure was modified many times before its final form. The cryostat had to be within a certain temperature range for the tissue to be cut properly. If it was -18°C or warmer, the tissue was too soft. If it was -20°C or colder, the slices were not cut smoothly and therefore no good to stain. As a result, -19°C was found to be the best temperature. The concentration of PBS for the rinsings was 0.1 M at first, but it was changed to 0.01 M. This was because more literature recommended that 0.01 M be used. The staining for c-fos was much more effective after adding a step where 0.01% goat serum in 0.01 M PBS was applied to the tissue. The purpose this served was to prevent any unspecific binding of c-fos. The incubation in the DAB solution was the most important step in the staining procedure. If too low of a concentration was used or if it was not applied for long enough, the c-fos would not be adequately stained. On the other hand, a concentration too strong or too much time for the application left the tissue too dark to distinguish the c-fos from the rest of the tissue. A solution made by adding 200 ul of reconstituted DAB to 7.8 ml of 0.01 M PBS and then adding 10 ul of 3% hydrogen peroxide worked best. The amount of time for the application of the DAB solution was 2 minutes (or until it looked ideally stained). This was arrived at through experimenting with different concentrations for different amounts of time.

Inactin was used for anesthesia at first. It was discovered that if it was not freshly made, it broke down and the byproducts were toxic. This caused many rats to die either during the surgery or while they were in the chamber. Urethane was used afterwards with much better results. Problems were also encountered with the respirator. When nylon thread was used for the sutures, it did not hold properly and the trachea tubing sometimes slipped out. Silk thread was found to work much better and was used instead of the nylon. When the rat was moved from the surgery room to the chamber, the tubing in the trachea sometimes got shifted around and became clogged. This caused many rats to die from either air not able to get in or air not able to get out. The respirator was used to maintain constant blood gas levels. A good solution to prevent the respirator from clogging has not yet been found.

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RESEARCH PAPER

NATASHA LINDSAY

The work that I have done at the Engineering Center in Panama City, Florida, has proved to be not only useful, but also very interesting. I would like to take this opertunity to tell you about my experiences working at the Center. A few week before I was to report to work, I contacted my mentor, Maj. Michael Shelly, and he informed me that he would not be there the first week. I would be answering to a man by the name of TSgt. Jeffery Julian, and he would be helping me to get settled into the Center. On the first day I was given a full tour of the Engineering and Services Center. In addition, I was shown some of the basic functions around the main Administration building. Paula Coakley showed me the main computer that the center deals with, the Wang Computer. Next, I had the opportunity to explore the Harvard Graphics Program. This would would prove to be one of the most valuable programs I would learn. The Harvard Graphics designs and producing output that can be used in either the laboratory or everyday buissness functions. Using the mannuals and some common sense, I found this system very straight forward and simple to learn. At the close of the first week, i had become fairly familiar with the majority of the equiptment that was used in the front offices. There were other programs that I learned to use, which included

Abstract:

My main function at the Tyndall Air Force Base, Engineering and Services Center, would consist of a few different things. I would be working with a variety of computer programs, which included; Harvard Graphics, Database III, Database IV, and Word Perfect. All of these I would be using at some time or another while I was here at the center. I would also be working in the laboratory with Doug Klarup. He is working on a project that involves trying to find a more productive and cost effective way of salvaging pleating baths. This plays a major part in trying to prevent the contamination of the environment, which inevitably happens every time one of the waste hazardous baths is disposed of. I will be working with him on this project, and hopefully we will be successful in our endeavors.

Windows, Database III, and Database IV. The program that I enjoyed the most was the Word Perfect System, which I had just finished taking in a college course through the school. In fact, the work that you are reading is a product of the Word Perfect System. In the weeks that followed, I spent my time filing research work in Database III program for Dr. Stone. This activity occupied most of my time, but whenever I had a free moment, I worked on stregnthening my skills with various computer programs. I thought it was remarkable that so many options can be made available to you, just by pressing a button. I even got the chance to attend a Harvard Graphics workshop. The center also described the various jobs and functions of the entire center. Their main function is to "Enhance through Technology". They have many main roles, including the performance of research and development that covers the entire spectrum of Air Force engineering and services peactime and warfighting requiremnts. Ofcourse, the main focal point rests on the laboratories, which are located in my building. The laboratory primarily deals with research, development, test, and evaluation for the civil and environmental engineering agency. In addition, the Laboratory Director serves as the focal point for environmentalquality technology, facilities energy research and airbase operability science and technology facilities of technology on the base. I soon learned that I would be working with a multitude of scientific, administrative, and engineering co-workers. Each had their own specific duties, yet all of them were connected in some way. The third week that I was there, they gave us a full presentation and tour of the center and its facilities. This helped me to better understand what the center did and what types of things they were they were responcible for. The people that I would be working with in the lab have degrees that range from structural engineering to plant physiology. The engineering research division is responcible for most of the studies that range from done on response of materials to high strain rate and high impact, and anticipation mechanics. These are basically on going research projects, but the information they provide is very important. Their accomplishments range from Air-cushened Rescue Vehicles to the NATO Facility Test. The office that I worked in before I started back in the lab, is called the Enveronics Division (RDV). They are responcible for Air Force Environmental Quality research and development programs. They investigate and provide the technology base to meet Federal and state environmental regulations and solve environmental problems. The lab is equipped to evaluate bench-scale chemical, physical, and biological processes for control of toxic industrial wastes and the testing of systems to prototype technologies are evaluated on site, at the source of the pollutants. The people that I worked with were very helpful and friendly. This made the working environment very enjoyable.

After a few weeks had passed, I was then informed that I would be working in the laboratories with a man by the name of Doug Klarup, who is on a research grant from the University of Montana (the place where he is employed full time). To fully understand the work that I have been doing in the lab, it is important that you know as much as possible about the problem. The problem is this; Purifying Air Force Plating Baths by using Chelate Ion Exchange. The definition of a Chelate is that it relates to a heterocyclic ring containing a mental ion attatched by coordinating bonds to at least two nonmetal ions in the same molecule. The Air Force logistics center work on plating operations, and the plating baths that they use become contaminated with heavy metals. The Air Force deals with them by replacing the baths and getting rid of the contaminated baths. this study's goal is to determine the feasibility of using the purification and reusing the plating baths. You can remove the contaminant metals without removing the pleating metals to extend the operating life of the pleating baths. The test program was carried out in pilot scale ion exchange columns and showed that electroless nickel, electrolytic nickel, nickel strike, and hydrochloric acid etch baths could be successful with three chelate resins:

Amberlite	IRC-718
Doulite	ES-467
Dowex	XFS-4195

The test results were used in design of a scale up chelate ion exchange system to retreat plating baths at ALC. The results of the study show that purification and reuse of contaminated plating baths. Future research should be directed at the on site testing of the system at ALC. The people at TAFB are trying to find the most affective way of dealing with these plating baths.

The following that you are about to read, is a description that details the daily procedures that I was to do in the lab each day.

1) <u>Make 1 L of Na-Citrate Buffer Solution</u>

   a. Weigh 40 gm of NaOh, sodium hydroxide, into a beaker and transfer into 1000ml Erlenmeyer Flask.

   b. Weigh 63.2 gm citric acid, $H_3C_6H_5O_7$, and transfer beaker.

   c. Weigh 50 gm NH_4HCl, ammonium chloride, and transfer to the flask.

   d. Weigh 10 gm Nah_2PO_2, sodium hypophosphate, and transfer to beaker.

   e. Dilute up to 1000ml mark.

2) <u>Make a metal standard solution (1ppm Cu, 1ppm Pb, 1ppm Zn, 20 ppm Ni).</u>

   Accuracy is extreemly important in this experiment.

3) <u>Mark and Weigh 20 collection vessels.</u>

Be sure to label all buffer and substance names and amounts.

Also, I would work with making Humic Acid Mixtures:

1; **<u>1000ml volumetric flasks (4) mix solutions of humic acid.</u>**

a. .05gm

b. .01gm

c. .005gm

d. .001gm

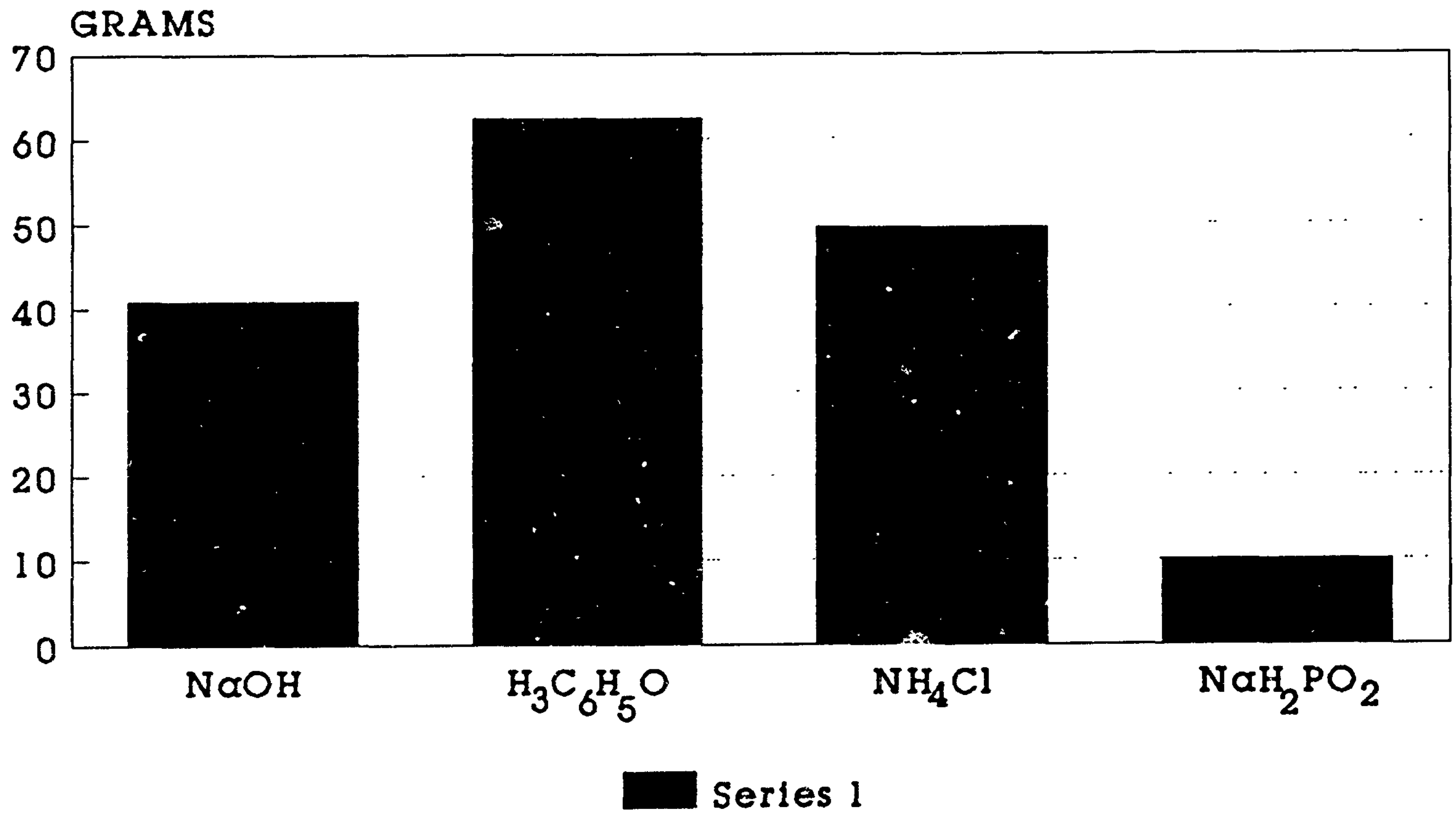
All of these are to be diluted up to 100.0 ml's.

These samples would be ran through the Spectrophotometer, this makes it possible to see how much light is absorbed in the different substances.

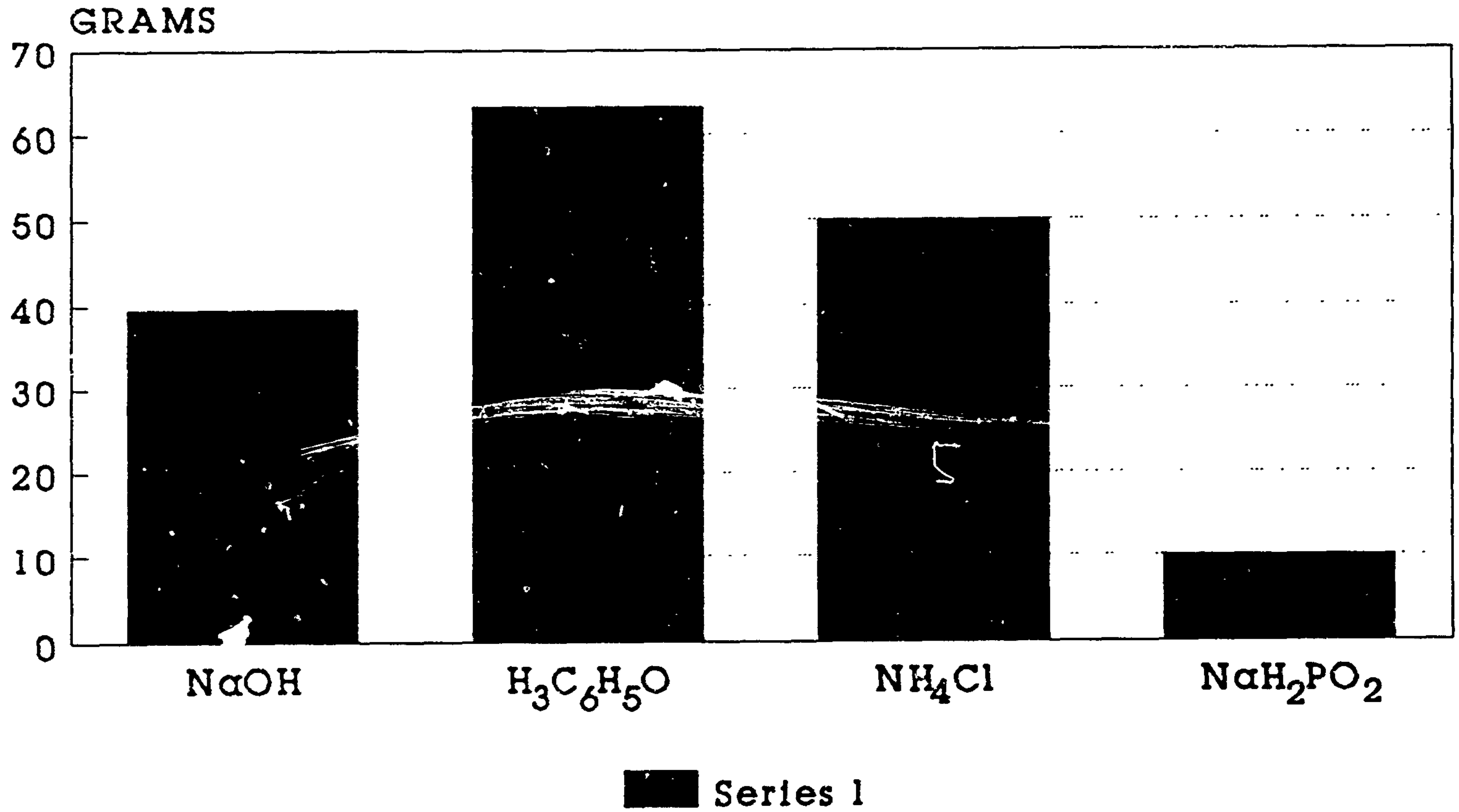
The time that I am not working back in the lab is spent on computers and lab write ups. I have really enjoyed working at the lab, and have found it to be very benificial to me. It has helped me to better understand how different calculations can be solved more easily than a drawn out proccess. Even when I did have to do long calculations, my lab contact helped me better understand how it could be worked. I especially enjoyed working with the computer systems in the office. It is suprising how much one can learn when there is no pressure of being tested for a grade in school. I will definately be reapplying next year to be considered for the RDL Program. I found it has been a very benificial experience, and I am glad that I had decided apply for the job. Thankyou for taking the time to read about my experiences at the TAFB Engineering and Services Center. I hope to have the opportunity of working for you in the future.

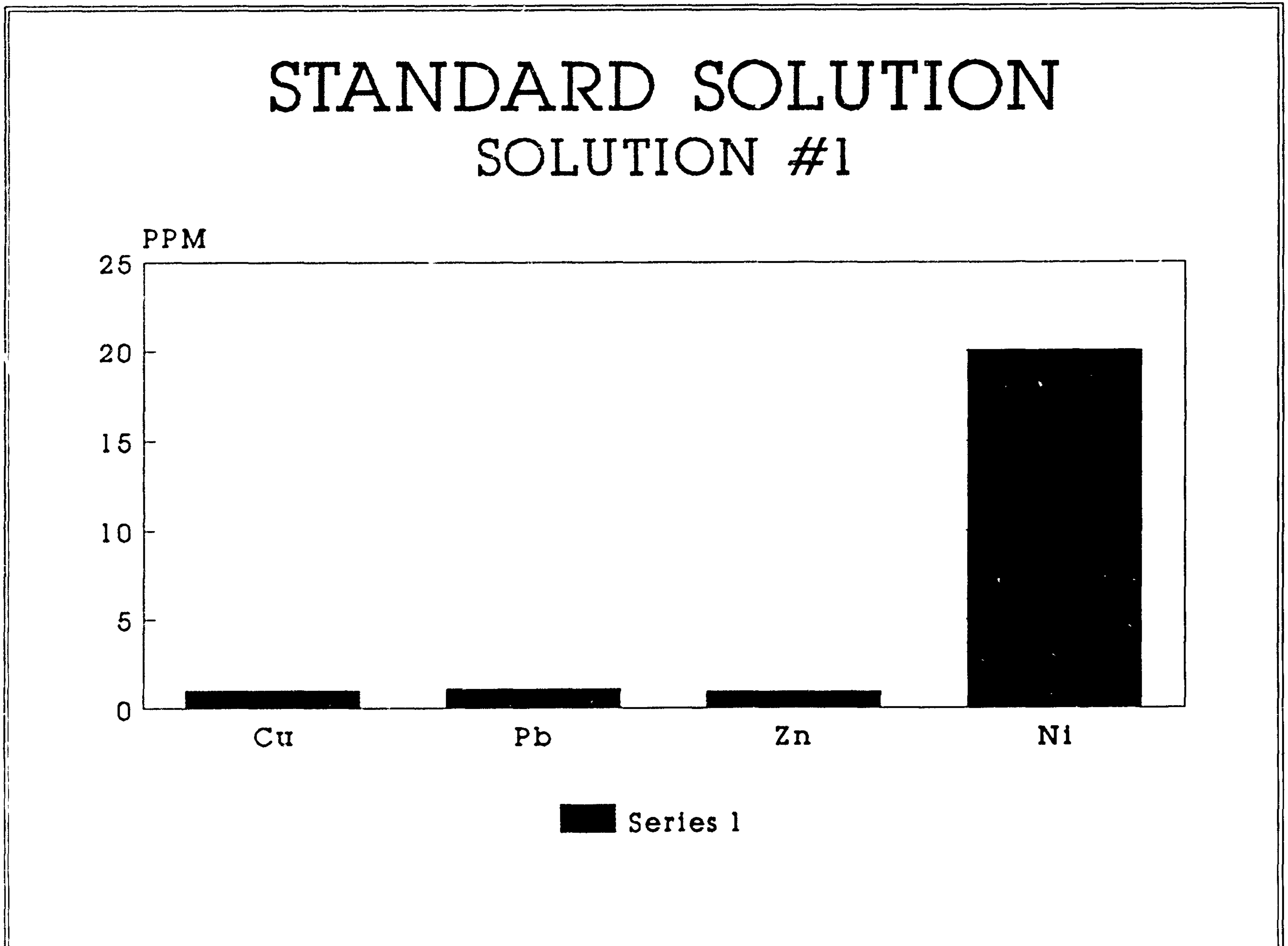
I have encluded a few examples of the scientific work I have recorded on the Harvard Graphics System, as well as an example what else the program is capable of doing. I also wrote two calculations that coinside with work that has been done on the buffer solutions.

CITRATE BUFFER
SOLUTION #1

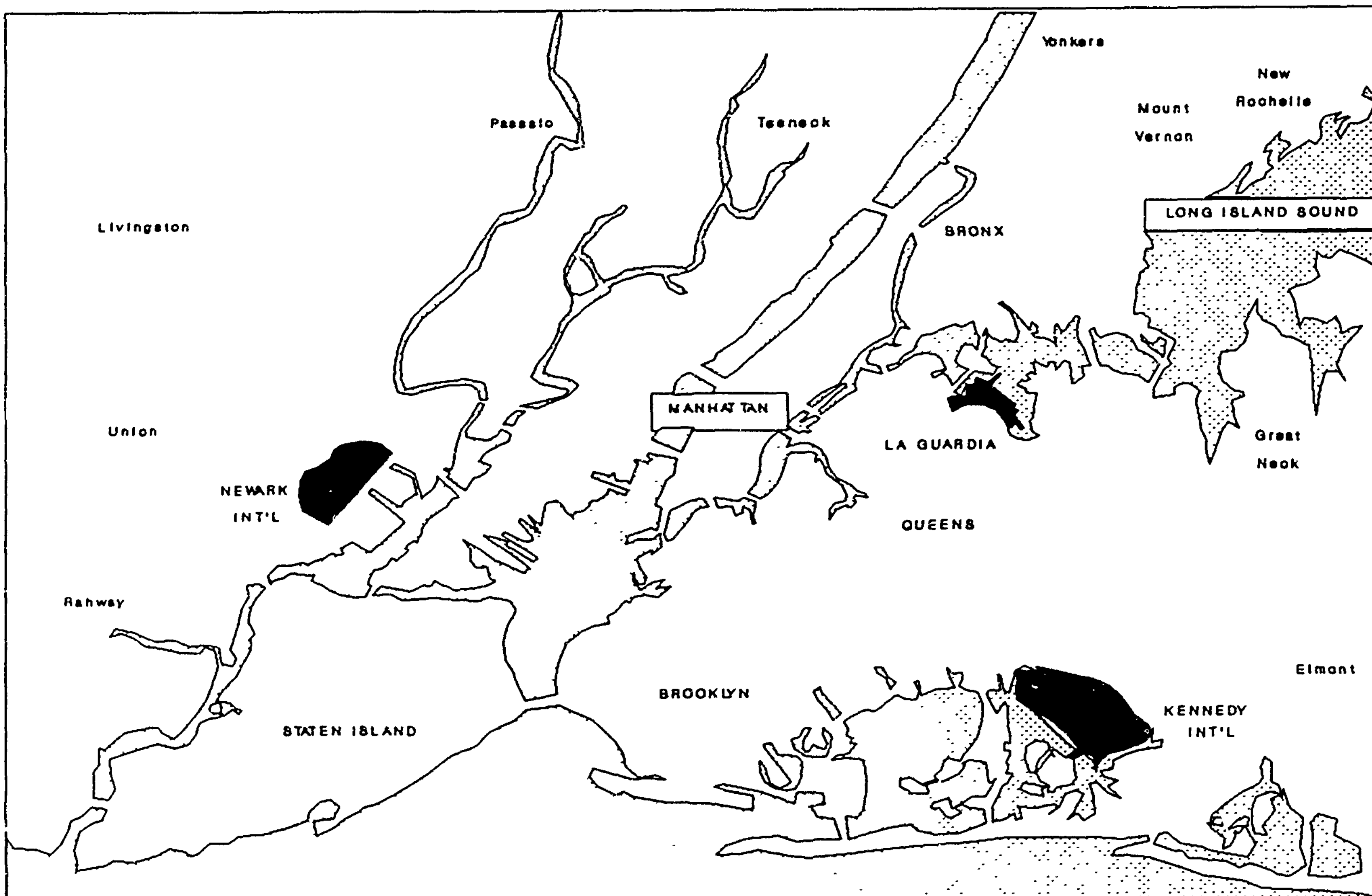


CITRATE BUFFER
SOLUTION #2




STANDARD SOLUTION
SOLUTION #1
PPM
25
20
15
10
5
0
Cu
Pb
Zn
Ni
Series 1

NEW YORK


Yonkers
New Rochelle
Mount Vernon
LONG ISLAND SOUND
Passaic
Teaneck
Livingston
BRONX
MANHATTAN
LA GUARDIA
Great Neck
Union
NEWARK INT'L
QUEENS
Rahway
Elmont
BROOKLYN
KENNEDY INT'L
STATEN ISLAND

→ 1000 ppm Ni and in buffer

1) Want 1 gm of Ni

$NiSO_4 \cdot 7H_2O \longrightarrow MW(262.852)$

→ $\frac{1 \cancel{gm}\ Ni}{58.7 \cancel{gm}/mole} = .017$ moles

→ $.017 \cancel{moles}\ NiSO_4 \cdot 7H_2O \times \frac{262.852}{\cancel{mole}} =$

→ = 4.47 (Amount needed to be weighed)

Solution # 1

→ $\frac{4.3536 \cancel{gm}}{262.852 \cancel{gm}} = .0165629$ moles

→ $.0165629 \cancel{moles} \times 58.7 / \cancel{moles}$

= .972/4229m of Ni

Using significant Didgits

Amount is less than 1000ppm and will provide enough of the solution chemicals.

$\rightarrow \dfrac{4.4220\ \cancel{gm}}{262.852\ \cancel{gm}} = .0168232$ moles

$\rightarrow .0168232\ \cancel{moles} \times 58.7\ gm/\cancel{moles}$

$= \underline{.972}/24222$ gm of Ni

Using Significant Didgits

Amount is less than 1000ppm and will provide enough of the solution chemicals.

Neurophysiology Research Assistant Job | 1991 Sonya Longbotham

I. Acknowledgements and Introduction.

I'd like to thank UES first of all for providing this chance for me to be introduced into the the work field. Because the area I am interested in pursuing in college and later life, (nuerophysiology and biopsychology), was the same area I was allowed to be an apprentice in, I felt this program to be extremely beneficial for me and more of a glance of what could be my future. Secondly, I'd like to thank LTC Mickley, and the people working in his team (Brenda Cobb and SSG Nemeth) for taking me under their wing a second summer. Their interest and skills have helped to solidify my interest in this field of study.

II. Cell Counts.

During the course of my work experience I was able to perform a task most beneficial for LTC Mickley's study with the hippocampal cells of the experimental animals. Because LTC Mickley's goal was to expose only the hippocampal cells to radiation and not other areas of the brain, the need arose to check on the success of what was intended. In performing these cell counts I counted a set area of cells from different parts of the brain, namely the olfactory bulb, cerebellum, and dentate gyrus.(The results of these counts are shown in the included supplement.) To insure that my counts weren't completely out of range, Tom Nemeth did counts of his own. Tom's numbers are not represented in the supplementary chart because it is an ongoing procedure unfinished at the time of my departure of the project. The slides counted were from radiated and nonradiated rats, also the slides were from subjects with different doses of the experimental drug - all of which I was blind to when I counted. I feel the cell counts to be an important check point within LTC Mickley's experiment and I'm thankful he let me help.

III. Animal Care.

Another aspect of my experience at Brooks Air Force base was learning more about the care of animals and habituation techniques. Brenda Cobb led me through this course, showing me how to handle the rats with care, and how much space, food, water, etc., each rat requires. Then, as the project developed we needed to make sure the rats would not be affected during the actual experiment by anything except the radiation and doses of medicine. Therefore, the rats went through an adjustment period well before their experiment date in which each rat was placed in its special holder, transported to the anechoic chamber and left alone the amount of time necessary. In addition, probes were used to take temperatures so as to mimic the measurements taken in the future. In all, the main purpose was to eliminate all factors which would cause the animal stress, due to uncomfortableness or unfamiliarity.

IV. Computer Experience.

I had a unique opportunity of learning about a computer system while I was working at Brooks.I learned about a package called 'RS1' on a Unisys computer. With this knowledge I can make tables, charts, and graphs. Of these I used the tables primarily to incorporate the data from experiments. (The Supplement is such a table.) I'm glad I had a chance to learn about computers because I knew almost nothing about them previously.

V. Surgery.

The experience I hold most dear and eye opening was that encountered in the surgery room. During the summer I was allowed to perform one decapitation procedure for Dr. Mason. The reason was to explore the physiological effects of his experiment after recording all psychological tests. Under Brenda Cobb's supervision I helped to anesthetize our rats and prepare them for surgery. This involved shaving and cleansing. I learned proper hygiene responsibilities such as mask and glove use. I assissted Brenda in her surgical procedure and then actually was able to sew up the patient afterwards on my own. This is by far the most rewarding experience of the summer.

VI. Conclusion.

I greatly appreciate LTC Mickley and his staff's trust in me and not to mention the deep friendship we have established. I feel graced by their presence and guidance. Everyone I met at Brooks Air Force Base was completely open and willing to sit down at a moments notice to explain their goings on. It seems to be the ideal work setting and I am lucky to have been introduced to such a place.

MK801 CELL COUNTS

		1	2	3	4	5	6	7	8
1		RAT_#	SLIDE #	GROUP	OB#S	OB#T	CB#S	CB#T	DG#S
2									
3		634	R5	10	550.000000		671.000000		1737.000000
4									
5		521	R15&R5	11	414.000000		688.000000		175.000000
6		527	R18	11	253.000000		615.000000		202.000000
7	AVE				333.500000		651.500000		188.500000
8	SEM				80.500000		36.500000		13.500000
9		542	R17	20	311.000000		700.000000		1379.000000
0		547	R18	20	331.000000		685.000000		1849.000000
1		635	R10	20	629.000000		539.000000		1752.000000
2		644	R5	20	492.000000		933.500000		1982.000000
3		652	R8	20	506.000000		388.000000		1971.000000
4	AVE				453.800000		649.100000		1786.600000
5	SEM				59.308853		90.845528		110.320714
6		540	R19	21	384.000000		685.000000		1965.000000
7		545	R17	21	331.000000		777.000000		349.000000
8		660	R1	21			544.000000		349.000000
9	AVE				357.500000		668.666667		887.666667
0	SEM				26.500000		67.755279		538.666667
1		649	R8	22	462.000000		436.000000		195.000000
2		650	R4	22	610.000000		517.000000		213.000000
3		656	R1	22	536.000000		766.000000		247.000000
4	AVE				536.000000		573.000000		218.333333
5	SEM				42.723920		99.292497		15.246129
6		585	R15	30	89.000000		603.000000		2234.000000
27		592	R12	30	360.000000		636.000000		2109.000000
28		654	R6	30	522.000000		592.000000		1706.000000
29		672	R5	30	380.000000		479.000000		2583.000000
30	AVE				337.750000		577.500000		2158.000000
31	SEM				90.417896		34.138200		180.994015
32		582	R13	31	364.000000		764.000000		258.000000
33									
34		687	R12	32	482.000000		347.000000		169.000000
5		692	R8&R2	32	75.000000		784.000000		216.000000
6	AVE				278.500000		565.500000		192.500000
7	SEM				203.500000		218.500000		23.500000

GROUP #S DECIPHER AS
1ST#; 1 = 0.0 DOSE, 2 = 0.1 DOSE, 3 = 0.2 DOSE
2ND#; 0 = SHAM, 1 = 850 RAD, 2 = 1200 RAD

#MKCELLS_MEAN 37R x 11C 09-AUG-91 9:27

MK801 CELL COUNTS

)	9	10	11
1	DG#T	CA-1#S	CA-1#T
2			
3		1.333000	
4			
5		3.333000	
6		2.333000	
7 AVE		2.833000	
8 SEM		0.500000	
9		4.000000	
.0		4.333000	
.1		1.333000	
.2		1.667000	
.3		2.333000	
l4 AVE		2.733200	
.5 SEM		0.609165	
.6		2.333000	
.7		2.333000	
.8		1.667000	
.9 AVE		2.111000	
'0 SEM		0.222000	
:1		1.000000	
'2		1.333000	
.3		3.333000	
:4 AVE		1.888667	
'5 SEM		0.728537	
'6		3.500000	
:7		4.333000	
:8		5.667000	
:9		2.000000	
·0 AVE		3.875000	
·1 SEM		0.767967	
·2		2.000000	
:3			
·4		1.667000	
·5		3.667000	
:6 AVE		2.667000	
·7 SEM		1.000000	

;ROUP #S DECIPHER AS
ST#; 1 = 0.0 DOSE, 2 = 0.1 DOSE, 3 = 0.2 DOSE
ND#; 0 = SHAM, 1 = 850 RAD, 2 = 1200 RAD

Summer Research High School Apprenticeship Program

Summer Apprenticeship Research Paper:

A Subjective Evaluation of the Effects of Cockpit Instrumentation on Spatial Disorientation and Workload

VIRGINIA AMALIA MIKSCH

Mentors:

KENT K. GILLINGHAM, M.D., Ph.D.

LISA F. WEINSTEIN, Ph.D.

29 July 1991

A Subjective Evaluation of the Effects of Cockpit Instrumentation on Spatial Disorientation and Workload

Virginia Amalia Miksch

Information needed to be obtained concerning cockpit displays and their effectiveness in reducing spatial disorientation and workload. A questionnaire was developed for this purpose. It was separated into two sections -- a rating scale and a suggested improvements section. It was divided into five phases of a sortie and five displays were listed. Twenty questionnaires were distributed at Randolph AFB. Fifteen were returned and the ratings were averaged and the suggested improvements were sorted and studied. The attitude indicator was the most efficient according to the pilots ratings. The pilots mentioned using color to indicate changes on displays. They also mentioned creating warnings that would indicate when a pilot is not paying attention to his aircraft instruments. These suggested improvements will be investigated in further research of cockpit displays.

INTRODUCTION

A pilot's cockpit consists of three main types of displays referred to as control, performance, and navigation instruments. These displays help the pilot to interact efficiently with the aircraft.

The control displays of an aircraft allow the pilot to regulate and guide the operation of his aircraft. The main control displays of an aircraft are the attitude indicator and power (RPM) indicator. "The attitude indicator shows the pilot the attitude of the aircraft in relation to the earth's horizon" (Crane, 1988, p.32).

The performance displays are a second type of cockpit instrument, and this set of displays reveals the aircraft motion. A car's speedometer and odometer are examples of this type of display. Examples of performance displays in an aircraft are the altimeter, the airspeed indicator, and vertical velocity indicator (VVI). "The altimeter measures the difference between the pressure of the air that surrounds it and a reference pressure which is adjusted into the barometric pressure dial on the face of the instrument. The pressure difference is expressed in feet or meters" (Crane, 1988, p.18). "The airspeed indicator measures the difference between impact, air pressure, and the local static air pressure. The dial converts the differential pressure into knots or miles per hour" (Crane, 1988, p.14). "The VVI is an instrument that gives the pilot an indication of the rate at which an aircraft is rising or descending. The VVI is measured in feet per minute" (Crane, 1988, p.544).

Navigation instruments comprise the final type of display. These displays can be compared to a map that is used in a car. The main navigation display is the horizontal situation indicator (HSI). "The HSI presents the position and heading of the aircraft relative to a map of the area" (Roscoe, 1968, p.323).

Pilots rely on these displays when flying a sortie. A sortie is a pilot's mission from beginning to end. There are six phases of a sortie: ground operations, takeoff, departure, enroute mission specific, approach and landing. The first phase mentioned was irrelevant for instrument evaluation and therefore was not used in the questionnaire.

The way in which a pilot interacts with his aircraft is through his senses -- touch, sight, vestibular (balance) sense, and hearing. When a pilot misinterprets or ignores these senses he can experience spatial disorientation. A pilot's inability to correctly interpret the control/performance instruments can also cause spatial disorientation. A formal definition of spatial disorientation is a "state characterized by an erroneous sense of one's position and motion relative to the plane of the earth's surface" (Gillingham, personal communication, 1991).

"Spatial disorientation incidents cost the USAF $100 million per year. Spatial disorientation kills 7-10 aircrew each year" (Gillingham, source AFISC/SEL, 1980-1989 data). "In the time span of ten years (1980-1989) a total of 81 mishaps occurred in which spatial disorientation was suspected or found to be a definite contributor to the mishap. Also in that same time span a total of 115 fatalities occurred in which spatial disorientation was suspected or found to be a definite contributor to the fatality" (Lt. Col. Freeman, Loss of situational awareness and spatial disorientation 1980-1989 data).

High workload can also be a factor in aircraft mishaps and fatalities. Workload is the "relation between resource supply and task demand" (Wickens, 1984, p.311). The brain can take in numerous sources of information, but organizing and registering it requires that the information be separated and stored separately. A pilot's workload may exceed his normal workload capacity and if this occurs a performance breakdown may occur.

For example, when a person drives a car on a typical clear and sunny summer day, the workload is light because there is nothing degrading the driver's ability to use his senses (sight, touch and hearing) to help him control the car. However, driving a car at night during fog involves greatly increased workload because his ability to receive accurate, useful information out the window has been degraded. He is unable to use his sight to help him control his car. A driver is more likely to have an accident in the second example than in the first due to increased workload.

The same is true for a pilot flying through clouds or at night. His workload automatically increases with the loss of an out-the-window visual scene. The pilot must rely solely on his instruments, but sometimes the pilot relies on his senses which can cause him to become spatially disoriented. Therefore, to help prevent aircraft crashes and mishaps, a pilot's cockpit displays must be effective in minimizing workload and spatial disorientation.

METHOD

Questionnaire

The purpose of the research project was to obtain useful information concerning the effectiveness of current head-down cockpit displays in reducing spatial disorientation and workload. It was decided that the most practical way of obtaining this individual information was to elicit it in the form of a questionnaire. The questionnaire had to be designed in such a way that it allowed each pilot the freedom to answer it truthfully. The questionnaire was also anonymous, thus allowing each pilot to express opinions freely, without pressure from fellow peers. The questionnaire is shown in Appendix A.

After meeting with a retired United States Air Force pilot, it was decided to limit the questionnaire to five sections, each section corresponding to a specific phase of a sortie: takeoff, departure, enroute -- mission specific, approach and landing. These were listed as the main headings. Under each of these headings were subheadings comprised of the five basic head-down displays: attitude indicator, altimeter, airspeed indicator, horizontal situation indicator (HSI), and vertical velocity indicator (VVI).

Next to each subheading was a rating scale of "0" to "7". On the introduction page instructions were given on how to rate the displays. Rating the display a "1" meant that the display was not effective for reducing spatial disorientation and workload, while a rating of "7" meant that the display was highly effective. A rating of "0" signified that the display was not used in that particular phase of flight.

Below each rating scale was a blank area headed "Suggested Improvements". This portion of the questionnaire was created so that feedback could be obtained pertaining to improvements that the pilot felt would reduce spatial disorientation and workload. On the introduction page the pilots were informed that they should not limit their comments to current technology, they should use their own imagination to create an ideal design for each display. Also on the introduction page were a few general questions to gather background information about the pilots.

Subjects

The questionnaires were distributed to current USAF pilots at a safety meeting at Randolph Air Force Base, TX. Twenty questionnaires were distributed and fifteen were returned. The age of the pilots ranged from 23 to 42. They had a mean total flight time of 2,700 hours. The types of aircraft flown included T-38, T-39, B-52, C-141, KC-135, A-10, and F-15.

Procedure

The questionnaires were distributed, a brief summary of the purpose of the questionnaire was given, and questions were answered. It was requested that the questionnaire be completed in the time period of a week.

Once the questionnaires were returned the ratings were averaged according to their sections. For example, during takeoff, all the attitude indicator ratings were averaged. Ratings of 0 were not included in the averages since they were used when the instrument was not used in a particular phase of flight. The displays were also averaged including all phases of flight. After averaging the ratings, the suggested improvements were sorted according to the displays -- attitude indicator, altimeter, airspeed indicator, HSI, and VVI. It was found that most of the suggested improvements were general, that is, they did not pertain to any particular phase of a mission, they pertained to most of the phases. A few were written for particular phases of a sortie so in the data these phases are mentioned with the suggested improvements.

RESULTS

The ratings and opinions from the pilots also indicate that the basic head-down displays can be improved to make the displays more effective in reducing spatial disorientation and workload. Table 1 shows the average ratings for the 5 displays during the various sortie phases, and an overall average rating for each display collapsed across the five sortie phases.

Table 1: The subjective ratings of the effectiveness of the five flight displays during the five phases of the sortie. The last row gives average ratings collapsed across sortie phase. These means do not include ratings of zero.

DISPLAY

SORTIE PHASE	ATTI-TUDE	ALTI-METER	AIR-SPEED	HSI	VVI
TAKEOFF	5.84	4.41	3.50	4.60	4.79
DEPARTURE	5.59	4.25	5.27	5.48	4.15
ENROUTE	6.11	5.16	4.38	5.01	4.46
APPROACH	5.92	5.51	5.27	6.00	5.57
LANDING	3.41	3.11	5.17	3.62	3.21
AVERAGES	**5.37**	**4.49**	**4.72**	**4.94**	**4.44**

As shown, none of the displays acquired a mean rating of 7 (the highest) or a rating of 1 (the lowest). There were 20 ratings of 0 in various displays in different phases of flight, which were discarded. The highest mean rating was the attitude indicator during enroute with an average of 6.11. The lowest averaged rating was the VVI during landing with an average of 3.21, with four pilots giving it a rating of 0.

The overall averages for the five displays showed that the attitude indicator was the most effective display overall, with a rating of 5.37 while the lowest overall rating was the VVI with a rating of 4.44.

The "Suggested Improvements" section contained many interesting comments. These comments will be further analyzed and researched to propose improvements to reduce spatial disorientation and workload. The pilot's comments indicate that changes can be made in reducing spatial disorientation and workload, but their improvement methods varied. Below is a sample of these comments. A complete listing of the "Suggested Improvements" can be found in Appendix B.

One pilot mentioned using the "outside-in" type of attitude direction indicator (ADI) on a head-down display. His reasoning for this was that it would help to prevent the pilots from initially rolling the wrong direction when recovering from unusual attitudes or a lost wingman procedure. Another pilot stated that the displays cannot allow the pilot to misinterpret, they have to be "no brainers". One pilot also mentioned that he would like to see the use of the head-up display (HUD) more.

Concerning the altimeter, one pilot wanted to have a digital display using green, red, or amber numerals to indicate above, on, or below altitude. Pilot's also mentioned having a color change for the airspeed indicator- green=on speed, red= too slow, yellow or amber = caution fast, something similar to the T-38 angle-of-attack (AOA) indexer lights.

Concerning the HSI, one pilot mentioned that if the "tails" on the bearing pointers could show the pilot which radial the aircraft is on, it would aid in eliminating errors. Another pilot wrote that with the VVI there should be indicators to assist the pilot with selection of the best rate of climb, and most fuel efficient rate/speed.

In general it was stated that something is needed in the cockpit to inform the pilot that he is not looking at his instruments. This might help in avoiding the effects of temporal distortion or simple inattention. No instrument can solve the problem, except one that knows you are disoriented or one that gives a pilot first glance information. It was stated that the instruments themselves do not need to be changed, they just need to be integrated to create one or two displays. In doing this, a reduction in workload would occur. Another mentioned that having knowledge on spatial disorientation and being smart on how you fly will lower the possibilities of it occurring significantly.

CONCLUSIONS

The basic rationale for creating the questionnaire was to gain insightful information from pilots to aid in further research of current cockpit displays. The questionnaire was successful in accomplishing this goal.

The pilots showed a strong indication that the use of color on displays would help reduce spatial disorientation and workload. They indicated that colors should be used to show changes in airspeed and altitude. Further study will need to be made to decide which colors would be best to use, and which displays could benefit from the inclusion of color. The pilots did seem to have a strong indication that the colors green = on speed, red = too slow and amber or yellow = too fast, should be used. Also, integrating multiple instruments into one or two displays would help to reduce workload.

It was mentioned in the data that the "outside-in" type of attitude indicator would help pilots to recover from unusual attitudes or trying to execute a lost wingman procedure. The topic of "inside-out" versus "outside-in" has been one of the most widely discussed and debated issues in human factors. It appears that the pilots surveyed still feel that it is an important research topic especially in light of the expanded role of CRT displays in the cockpit. These displays present an opportunity to include a variety of novel ideas into the design of displays. The ratings, however, indicated that the "inside-out" attitude display was overall the most effective display in reducing spatial disorientation and workload. The attitude indicator should be centrally located so pilots can have a quick and easy reference to the pitch and bank of the aircraft.

Although not mentioned too often, the HUD and the helmet-mounted display will be used in future instrument display systems. Also, the development of a warning device that will issue a warning to the pilot if he is not paying attention to his displays should be explored. This warning system could help pilots to avoid the effects of temporal distortion.

These and other topics for research can be elicited from pilots if the proper elicitation process is employed. The questionnaire used in this study was helpful in generating new ideas, and discovering that pilots and researchers believe that many of the same issues need attention. Researchers should continue to query experts in their field to aid them in their research efforts. It is difficult, however, to draw any definite conclusions from a survey such as this as to which displays need to be revised. The expert opinion elicitation process used here has paved the way for further study and analysis.

Technology is ever changing in today's world. Cockpit displays are not immune from this fact of life. By combining current technology with pilot's know-how, the end result will be a positive step up the ladder that works to reduce spatial disorientation and workload.

ACKNOWLEDGEMENTS

The author would like to thank Mr. William Ercoline for his assistance on this project and Lt. Col. Edward Saflarski, USAF IFC for his help administering the questionnaires.

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AFISC/SEL, 1980-1989 data.

APPENDIX A

PILOT QUESTIONNAIRE

This questionnaire is intended to elicit expert opinions from you, the pilot, on the effectiveness of current cockpit displays for minimizing spatial disorientation and workload. When filling out this questionnaire, please refer to the head-down cockpit instruments. The questionnaire will first request that you rate the effectiveness of several displays in several different phases of a mission. Then you will be asked to use your imagination and suggest improvements to the current designs.

The questionnaire is divided into five specific phases of a mission - takeoff, departure, enroute, approach and landing. Listed under each phase are the following five displays: attitude indicator, altimeter, airspeed indicator, horizontal situation indicator (HSI), and vertical velocity indicator (VVI). Please rate each of the five displays in each of the five phases of the mission on the scale beside the display. Rating the display a "1" means that the display is not effective for reducing spatial disorientation and workload, while a rating of "7" means that the display is highly effective. A rating of "0" signifies that the display is not used in that particular phase of flight.

Once you have marked a rating on the scale, please suggest any design improvements to the display that would reduce the chance of becoming spatially disoriented or would allow you to extract information from the display more easily. When writing your suggested improvements do not limit your comments to current technology. Use your imagination to create an ideal design for each display. The ideal design for a display may be different for the five phases of flight. We will use the information you give us to guide our future research. First, we would like to gather some background information on you. Please <u>do not</u> include your name.

AGE:_____

FLYING HOURS:________

HUD PILOT: yes/no

AIRCRAFT FLOWN:______________________________________

TAKE OFF

<u>Attitude Indicator:</u> |---|---|---|---|---|---|---|

0 1 2 3 4 5 6 7

Suggested Improvements:

<u>Altimeter:</u> |---|---|---|---|---|---|---|

0 1 2 3 4 5 6 7

Suggested Improvements:

Airspeed: |---|---|---|---|---|---|
0 1 2 3 4 5 6

Suggested Improvements:

HSI: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

VVI: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

DEPARTURE:

Attitude Indicator: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Altimeter: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Airspeed: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Airspeed: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6

Suggested Improvements:

HSI: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

VVI: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

DEPARTURE:

Attitude Indicator: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Altimeter: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Airspeed: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

HSI: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

VVI: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

ENROUTE: NAVIGATION

Attitude Indicator: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Altimeter: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Airspeed: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

HSI: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

VVI: |---|---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

APPROACH: FAF to MAP

Attitude Indicator: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Altimeter: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Airspeed: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

HSI: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

VVI: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

LANDING: from "transition to land" to "touchdown"

Attitude Indicator: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Altimeter: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

Airspeed: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

HSI: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

VVI: |---|---|---|---|---|---|---|
0 1 2 3 4 5 6 7

Suggested Improvements:

APPENDIX B

SUGGESTED IMPROVEMENTS

Attitude Indicator:

Put actual climb/dive angle on the attitude indicator in addition to pitch reference. Make pitch reference optional.

During take off, the attitude indicator should provide true horizon reference (i.e., compensate for angle of attack, airspeed, and flap setting).

During departure, enroute, and approach, the display pitch attitudes needed to meet SID climb gradients up to a specified altitude.

On a head down display (CRT), it should be just as easy to display an "outside-in" type of ADI vice the type currently used in the T-38. I've noticed a very pronounced tendency for pilots to initially roll the wrong direction when recovering from unusually attitudes or trying to execute a lost wingman procedure from a known attitude. The current ADI only becomes partially intuitive, if it is in motion when being looked at. May explain wrong initial moves in recovering from unusual attitudes. Once the display is moved even a little it does become apparent what needs to be done to recover.

On good weather days, I don't use the attitude indicator during take off and departure. The T-37 attitude indicator is very poor and susceptible to precession. I suggest placing a large ADI (like T-38's) in cockpit. The precession in the T-37 attitude indicator results in difficulty maintaining proper pitch during the approach.

In any phase of flight the symbology must provide for first glance recognition of an erroneous conception of orientation. The most important factor would be a reduction in symbols contributing to the misperception of "expectancy." The ADI must give the pilot an instant view of his/her relationship relative to the earth..."a God's eye view." Simply put, you can't let the pilot misinterpret. The attitude reference must be a "no brainer."

During take off, keep the attitude indicator big and centrally located high on the panel (not needed at all if HUD is present). During departure, enroute, and approach, even with the HUD (current HUDs) add horizon pointing arrows (trees?) are needed on dive portion. Make it 3-D.

During take off, prevent over rotation at low airspeeds, unless override button depressed. During approach, lengthen artificial horizon. Automatic correlation of angle-of-attack for achieving level flight with airplane symbol (no need for manual adjustment). During landing, a warning if bank angle exceeds 20° on final approach.

Altimeter:

Altitude set markers would help to reduce spatial disorientation and workload. Combine the digital indicator analog better.

Add radar altimeter when below 2000 AGL. Put in markers to reference desired altitudes (i.e., cruise, level-offs, FAF, and minimum descent altitude/decision height).

During take off, departure, and enroute, a digital readout in the middle to preclude misreading the instruments by 1000 or 10,000 feet. Again, be able to select an altitude and have digital display use green, red, or amber numerals as described below to indicate above, on, or below altitude.

During departure, enroute, and approach, keep the analog pointer to indices. Provide easy one step "bug" function for referencing specific altitudes. (Old F-106 tape altimeters had an easy method).

During enroute, feedback if aircraft drifts above/below pre-set limits. During Landing, indications whenever you pass through instrument approach altimeter restrictions MDA/DH.

Airspeed Indicator:

Airspeed set markers (BUGS) would help determine critical speeds. Add optional groundspeed readout.

Incorporate a digital readout that would display in green (on speed), red (slow), or amber (fast), similar to what the T-38 A-O-A indexer lights do now.

During take off, departure, enroute, and approach, it provides easy one step "bug" function for referencing specific airspeeds. Make it increase in a clockwise motion and decrease counterclockwise (not just digits).

During enroute, have it so you can remove pointer and indices when in benign, cruise mode. Need them back during aggressive changes.

During takeoff, tape or dial which automatically changes color if airspeed is below/above preset parameters (e.g., green = on speed, red = too slow, yellow = caution). During departure, aural warnings if too fast/too slow. Also, color changes to reflect on speed vs. too fast/slow. During approach, auto throttle to assist with airspeed control. During landing, maybe color?

HSI:

I personally like an HSI which has both head and tail on the bearing pointers.

During take off, the HSI should be able to electronically display the channel selected and the navigation aid identifier.

Some HSI's have "tails" on the bearing pointer which shows the pilot which radial the aircraft is on. All aircraft should have this feature. It eliminates errors in having to use the reciprocal (180° out) with the head of the bearing pointer.

Would be nice to have a CRT in the cockpit that would show the approach procedure being flown (i.e., TACAN, ILS and where the aircraft is in the IAP both in the profile view and the plan view). The plan view would be a sophisticated type of HSI display. It would have to be coupled to navigation equipment.

The T-37 J-2 system is poor. The CDI has a tendency to stick. I suggest placing an ADI/HSI system in aircraft. During approach, there is a loss of spatial orientation when having to change from VOR to LOC frequencies.

During take off, just need current heading. During departure, use "plan" or "God's eye" view like F-18 and F-15E. During enroute, keep full compass nose. Adopt plan view format (selectable).

During departure, an increase size, longer horizon line. Warning for too much/too little bank. Display drift information if selected. During enroute, drift information. During approach: 1) computerized prediction of attitude to achieve rate of descent/landing, 2) add drift information.

VVI:

During departure, you would only need this if without a climb/dive marker. Then you only need it to ensure sufficient climb gradient if in a very slow climbing aircraft. During enroute, you don't need it at all if climb/descent marker is present. If no CDM only needed during significant altitude changes such as enroute descent or penetration should "flag" limits if applicable to specific aircraft. During approach, it is only needed if without CDM. During landing, it is only needed if aircraft has a limiting VVI for touchdown - then it should be flagged to avoid exceeding.

During departure, indications to assist with selection of best rate of climb, most fuel efficient rate/speed. During enroute, recommended value to descend/climb to next assigned altitude in a given distance/time. During landing, a warning reference of sink rates in order to make an early transition..

General Suggested Improvements:

Keep the basic "T". Trash all mechanical instruments - replace them with electronic displays.

The problem is many of the pilots we are losing in SD accidents are not looking at the gauges when they hit the ground. They are using external cues where an illusion exists. In addition, they are in the Type 1 misorientation. Perhaps we need something that tells a pilot "you are not looking at your instruments", perhaps this could avoid the effects of temporal disorientation or simple inattention. Pilots don't crash from Type 2, recognized events (rarely do), they are losing it because they don't know they've lost proper orientation. No instrument can solve that except one that knows you are misoriented or one that a pilot looks at and gets first glance information.

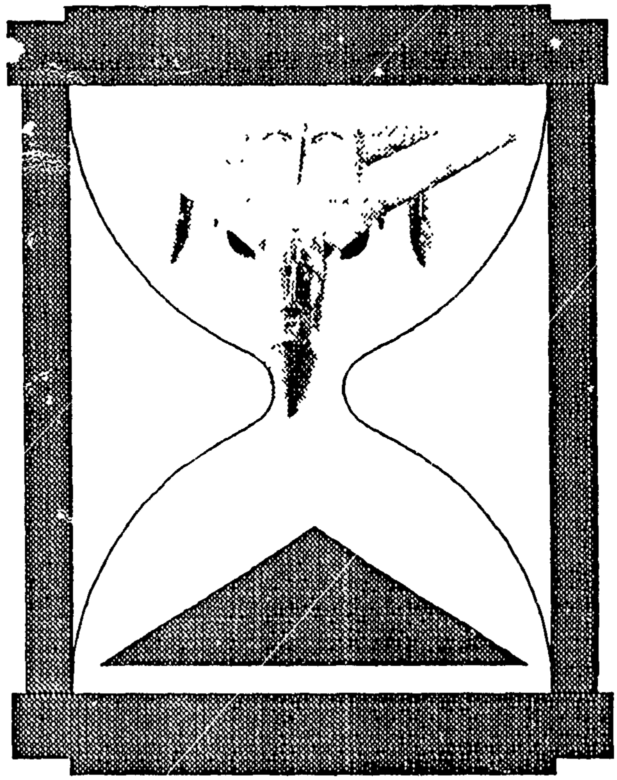
I don't really feel the displays themselves really need changing anymore. It's really a question of how well each instrument can be integrated with the other to create one or two displays. This in itself reduces cockpit workload (especially instrument scan) enormously. Unfortunately the workload in the cockpits today exist in our flight management systems. They take away from keeping our head out of the cockpit and flying the aircraft which is a safety issue.

EFIS (Electronic Flight Instrumentation System) has numerous possibilities with which we can integrate all of our current instruments. Type of aircraft and mission should be factors considered when the instruments are integrated onto the EFIS.

Unfortunately, future cockpits will be so automated that the pilot really becomes a system monitor. However, I don't think the basic instrumentation is going to change. Cockpits will always have an attitude indicator even though it may not be on the screen all the time.

Spatial disorientation occurs more frequently within the fighter community of which I have no experience. I think knowledge on spatial disorientation and being smart on how you fly your aircraft will lower the possibilities of it occurring significantly.

General overall comments on T-37 instruments:
Very poor crosscheck from right seat. Poor left attitude indicator due to incredible precession. Poor situational awareness ability from J-2 system and CDI due to having to use "toilet bowl" method as well as having to change 2 frequencies to change VOR stations (VOR frequencies and TACAN DME channel) - this causes task saturation. Recommend switching over to TACAN receiver (to eliminate need to change 2 channels) as well as replacing this system with ADI/HSI in T-38's. That system is a lot more reliable and better for situational awareness. The T-38 ADI does not precess as much. Also, the J-2 fast slave cycle is unbelievably slow. This could result in some rather dramatic heading differences. Overall, I am very disappointed with the T-37 instruments other than the airspeed indicator, VVI, and altimeter. They are fine, reliable, and easy to read. I've had cases where the CDI has stuck to the wall and I've had to hit the glass case to get it to come off the wall for a localizer intercept. I wasn't very comfortable with that.



CALCULATING CREW REST INTERVALS FOR ACCELERATED MAC MISSIONS: LESSONS FROM DESERT STORM.

Summer High School Apprenticeship Program
Armstrong Laboratory / CFTO
Brooks AFB, TX

by

Lori Reneé Olenick
McCollum High School

August 1991

ABSTRACT

Four mathematical models are compared which attempt to predict adequate rest periods following a commercial airline flight. The accuracy of these models as predictors of fatigue in military pilots is described. Subjective fatigue scores were obtained from five MAC air crew every four waking hours for thirty days as they flew operational AF missions during the Persian Gulf crisis. These crews were part of a larger experiment attempting to determine fatigue levels and the safety of flying 150 hours per month during wartime conditions.

Greater fatigue was associated with larger fatigue scores throughout the 30 day study. Fatigue scores were graphed against the predicted rest periods from the models. It was assumed that the longer the predicted rest period was, the more fatigue was implied by the models.

The models were found to be inadequate to predict the level of fatigue experienced by MAC crews flying resupply missions during Desert Storm. One model, Gerathewohl's, was preferred because it allowed for longer crew rest periods in all cases and considered the most causes of fatigue in the equation. However, there were serious deficiencies in all models in predicting military air crew rest periods. Therefore, a new model, developed by Armstrong Labs is described which includes many factors relative to fatigue generation in MAC air crew.

CALCULATING CREW REST INTERVALS FOR ACCELERATED MAC MISSIONS: LESSONS FROM DESERT STORM.

by Lori Reneé Olenick

INTRODUCTION

August 2, 1990 is a day that will live in the minds of Americans for years to come and in history books even longer. That day, when Iraq invaded Kuwait, marked the beginning of a seven month long crisis in the Persian Gulf, characterized by the rapid buildup and domination by American forces.

The task of providing these forces with necessary equipment and supplies fell to members of the Military Airlift Command (MAC). During the first few weeks of Operation Desert Shield, practically everything arriving in the Persian Gulf got there via a 7000 mile air bridge from the United States. By the sixth week of Operation Desert Shield, the total tonnage transported equaled that of the 65-week long Berlin Air Lift of the late 1940 s

This tremendous effort required MAC crews to often fly the maximum number of hours and rest the minimum number of hours allowed by Air Force regulations. Obviously, such an accelerated pace had a substantial effect on the people involved. As ground troops and fighter bombers prepared for battle ceaselessly, MAC crew members were fighting a more insidious and potentially more perilous enemy--their own fatigue.

The most obvious factor contributing to MAC crews' fatigue is that they worked long days, sometimes as long as 24 hours. But there were other factors that compounded their fatigue as well. Crew members often had to sleep during the day and work at night, forcing them to alter their personal sleep patterns. Sleeping during the day also meant encountering disruptions like the noise outside their quarters as the rest of the world went on with its daily routine. This often meant a restless sleep with frequent interruptions. Yet another factor to consider was that MAC crews crossed several time zones during their trips and most certainly may have experienced circadian desynchronosis or jet lag.

Realizing that the stressful conditions under which the MAC crews were duty bound to perform could be debilitating, the MAC Surgeon General requested a field study to determine the extent of the fatigue. Researchers from Armstrong Laboratories, Brooks Air Force Base, Texas, experienced in fatigue assessment, were engaged by the MAC Surgeon General to evaluate the issue of fatigue and safety of MAC crews.

METHODS

Previously the limit for MAC was 125 flying hours per month. During Desert Shield/Desert Storm operations, the limits had to be raised to 150 hours to maintain the steady stream of supplies into the desert. The MAC Surgeon General, interested in the safety of the air crews during these heightened demands of the Desert operation, requested a 30 day evaluation of fatigue in air crew by researchers from Armstrong Laboratories/CFTO.

Seven researchers from Armstrong Laboratories accompanied five MAC crews flying supply missions during Operation Desert Storm for 30 days and measured their fatigue. Researchers observed crew members for any unusual behavior or errors that may have resulted from fatigue. This was accomplished by collecting piloting data during landing and at cruise altitude from the digital flight data recorder (DFDR), the "little black box". This may be the first time that the DFDR was used in a scientific investigation. Qualified pilots are currently evaluating DFDR information to determine the accuracy of piloting. In addition, crew members completed the Profile of Mood State (POMS) survey and a variant of the School of Aerospace Medicine (SAM) fatigue scale at key times throughout the 30 day period. Temperature and sleep patterns were also studied for evidence of desynchronosis. This paper will focus on the fatigue scale measure as a subjective means to predict the most appropriate crew rest period length for air crews. Currently, the length of the crew rest period for the military is not based on any objective metric.

Fatigue has long accompanied travelers, and has been an especially prominent problem since the advent of the jet, which allows for rapid trans-meridian travel. Some investigators have attempted to counter fatigue by designing sleep schedule calculations that recommend sleep/rest times for pilots. Although these sleep schedules were designed for commercial airline flights, this paper will apply the models to MAC flights during the end of Operation Desert Storm.

The fatigue scale used is shown in Table 1 and rates fatigue from 1 (no fatigue), to 7 (great fatigue). Air crews provided a fatigue score every four hours while awake throughout the 30 day study.

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Table 1: Subjective Fatigue Scale

Write the number of the statement which describes how you feel RIGHT NOW.

1=Fully Alert; Wide Awake; Extremely Peppy

2=Very Lively; Responsive; but Not at Peak

3=Okay;Somewhat Fresh

4=A Little Tired; Less Than Fresh

5=Moderately Tired; Let Down

6=Extremely Tired; Very Difficult to Concentrate

7=Completely Exhausted; Unable to Function Effectively; Ready to Drop

==

The fatigue scores used were from MAC crews flying in Desert Storm operations. Researchers from Armstrong Laboratories at Brooks Air Force Base flew with the crews along their regular Air Force routes and lived with them for 30 days shortly after Desert Storm, sharing their lifestyle, including their meals, sleep time, recreation time (though little), and duty time. The researchers were able to make some observations as they collected their data, but most important to this review are the fatigue scores that they collected. These data were used to determine how close the models came to predicting actual fatigue and to help determine what factors need to be included in the model currently being developed at Armstrong Labs.

A typical day began for crew members when they became legal for alert (at the end of crew rest with 12 hours being the minimum allowable crew rest). Once legal for alert they were called and notified to be prepared to fly within the next 6 hours. It should be noted that the duty day clock did not start ticking until the crew was finally called and told to report; (ie alerted). Since the maximum allowable duty day is 20 hours, a six hour legal for alert period could mean a 26 hour awake day for the crew, not an uncommon experience during Desert Shield and Storm. The beginning of crew rest began when the plane landed, and included time used for traveling to headquarters and briefings and billeting as well as time to eat, laundry and other personal chores.

Crew members recorded their activities on activity logs every thirty minutes for the thirty day duration of the study (Appendix 1). Information on flight time and layover periods were also recorded. The data necessary to calculate each formula were extracted from the activity logs. Data used included layover time (the time between flights), sleep time, duty time, flight time, night duty time, number of time zones transversed, direction of travel, age, and number of transits.

The way the data were prepared depended on the formula being used. The typical procedure was to go through a computer printout of the activity log data and find the variables necessary to the particular formula being used. These variables were then either put directly into the equation being used or were converted into coefficients by using tables provided in the models.

MODELS

In 1970, L.E. Buley (1) published a model to predict adequate rest periods for pilots. Through his study, Buley hypothesized that "the most likely practical determinant of rest period durations would be the sum of functions of flight duration and the number of time zones transversed, weighted accordingly to the psychophysiological unfavorability of local times of departure and arrival and including an eastward/westward (geodirectional) travel differential" (p. 681). Buley's formula is:

$$\mathbf{R.P.=T/2 + (Z\text{-}4) + C_D + C_A}$$

where R.P. is the rest period, T is the flight duration, Z is the number of time zones crossed (minus four, because Buley believed that only time zones in excess of four had substantial effect), C_D is the departure time coefficient, and C_A is the arrival time coefficient.

Coefficients were developed as weights to the equation adjusting the rest period for night flights and day sleep periods. For Buley's model and the others to follow, it is assumed that the longer the rest period calculated the greater the fatigue.

Anthony Nicholson (2) published a workload model in 1972. This model attempted to indicate the workload that is associated with particular flight routes. In this case, the greater the workload the more fatigue built upon a particular route. His workload model was based on a study of the Boeing 707 Fleet of the British Overseas Airways

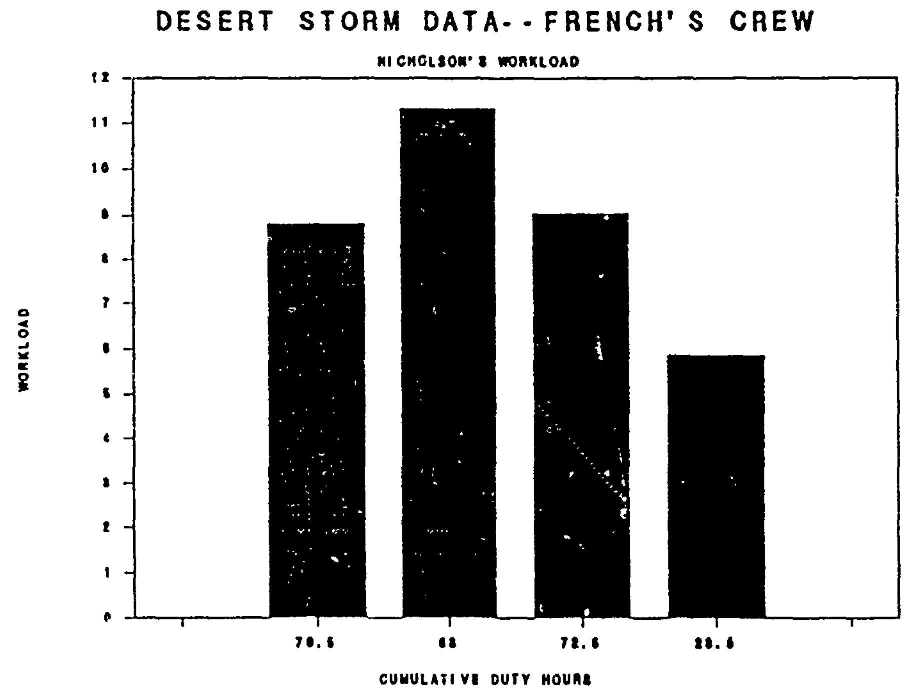
Corporation. The captains kept logs that provided the duration of duty periods and time of sleep. Nicholson then used the data to calculate projected sleep patterns and workload for similar routes. This model evaluates an entire flight route which can stretch for a number of days. Each route may have several landings and takeoffs which are stops or "legs" along the route. Workload was calculated as total duty hours at the completion of each leg divided by the number of days on route plus 1, or in symbolic form:

$$W = l/n+1$$

where W=workload, l=duty hours per leg, n=number of days on route. Nicholson added 1 to these figures because he assumed that at least one day would be spent preparing the plane and crew for flight.

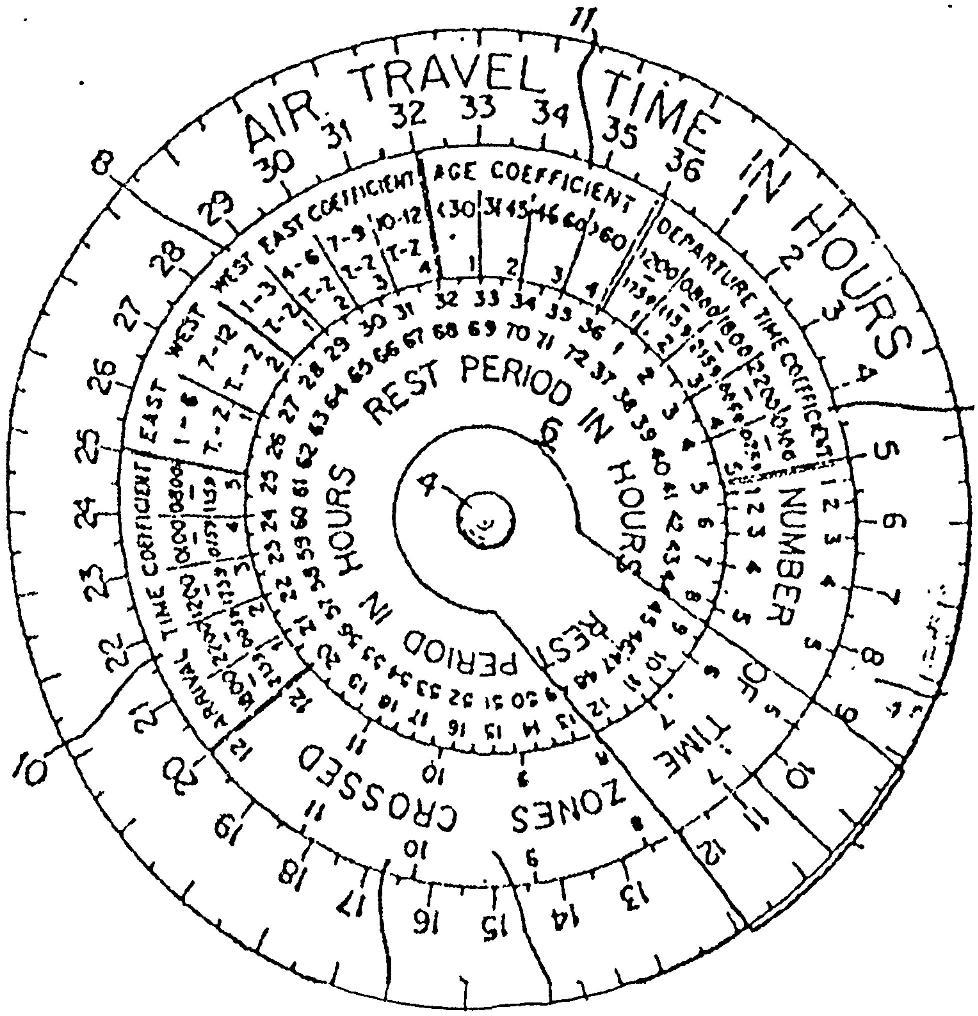
Nicholson's present data indicates that the workload is reduced as the number of days in the schedule is increased. This implies that fatigue accumulates in the route. His model suggests that the most critical parameter determining an acceptable sleep pattern for a given workload may not be the duration of each duty period but the total duty hours in relation to the progress of the schedule (Figure 1).

S. J. Gerathewohl (3) expanded on Buley's formula when he published his own in 1973. He criticized Buley's formula for leaving out what he termed as factors which aggravate the adverse effects of long-distance flights. These factors are geodirectional travel and age. Gerathewohl also expanded the local departure and arrival time



coefficients and considered even time zone shifts less than four hours as being important. Gerathewohl was concerned with making his model easily applicable to crew, so he created an equation wheel (U.S. Patent No. 3681572) to help determine suggested rest period (Figure 2).

To determine the numerical values to use, subjects' cycles of sleep, body temperature , psychomotor functions and urinary excretions of 17-OH corticosteroid (a marker of circadian cycle and measure of stress) were studied during west/east and east/west displacements. This determined the subjects' desynchronization curves, which were then used to derive numerical values used in the formula.



Gerathewohl's formula is:

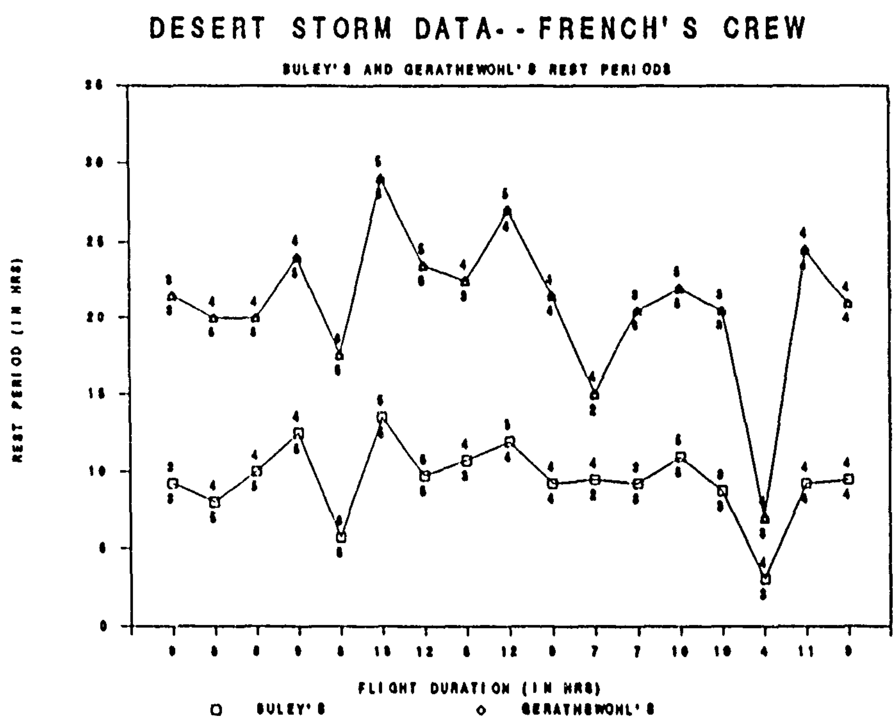
$$R.P. = T_t + D_{te} + N_{tz} + A_{te} + G_e + A_{co}$$

where R.P. = the physiological rest period, T_t is the travel time (expressed in hours), D_{te} is the departure time coefficient, N_{tz} is the number of time zones crossed, A_{te} is the arrival time coefficient, G_e is the geodirectional coefficient, and A_{co} is the age coefficient.

Because Gerathewohl's model accounts for more variables, the suggested rest period it provides is an average of 12 hours higher than that of Buley's, which would probably make his model more popular with MAC air crews. When graphed, it is easy to see the similarities in the predictions of the two models. Figure 3 is an illustration of the similarity in Buley's and Gerathewohl's models. The top line shows Gerathewohl's recommended rest period, with the numbers above each point showing the pilot's subjective fatigue score. The lower line shows Buley's recommended rest period, with the numbers below the points showing the copilots subjective fatigue rating. There is a generally close fit of the scores to the calculated rest periods, i.e. higher fatigue scores are associated with longer calculated rest periods (hence greater calculated fatigue). On other occasions, for example the 5th flight duration point, show a poor fit since both models predict less sleep for this point yet it has the greatest fatigue scores, 6 and 5 for pilot and copilot, respectively. The 10th, 11th and 12 flight duration points also show that Gerathewohl's model may be a more sensitive equation than Buley's predicting 22, 15 and 20 hours of rest period for the copilot's fatigue scores of 4, 2 and 3 respectively.

The work of developing crew rest models so far had progressed from Buley's original model to the more complex one Gerathewohl created. But in 1976, Stanley Mohler published his model, presenting an altogether new formula rather than building on the work of Buley and Gerathewohl. Mohler's formula was multiplicative rather than additive, with the values of five coefficients are multiplied together to attain a "physiological index." Mohler's model may not be as easy to use as he may have hoped it would be.

The use of several coefficients, which vary according to specific conditions, complicates matters.



To understand the difficulty of using this model, one must understand the variables employed and the conditions under which the aircraft commander would have to attempt to use it. The coefficients used are found on a table, and each step of the formula has several questions that must be answered to attain the correct variable. Attaining the variables to use in the formula is somewhat difficult, and attempting to calculate the physiological index without the help of a computer would prove to be frustrating (Figure 4). Table 2 describes the factors used in calculating Mohler's physiological index. There is also agreement between the index and pilot fatigue scores; higher fatigue scores are associated with higher indices (which is assumed to imply a longer rest period). However, Mohler too, was unable to account for some fatigue scores like the 5th x-axis point (which in Mohler's equation refers to cumulative trip hour). This point (41) is associated with 6 and 5 fatigue scores, respectively yet with low physiological index values. It can be seen that Mohler's model considers cumulative fatigue since the last x-axis point (146) reflects the fact that this was the last flight for the 150 hr maximum for this crew in the 30 day study. No other model demonstrates this concern with cumulative fatigue.

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Table 2: Mohler's Physiological Index Factors

▸ Three major fatiguing factors:

1. Number of time zones traversed
2. Multiple night flights in close sequences
3. 24 hour layovers after night arrival

▸ Five moderately fatiguing factors:

1. The first day of a pattern
2. Multiple transits
3. Day sleep
4. Flight in easterly direction
5. Patterns in excess of 7 days

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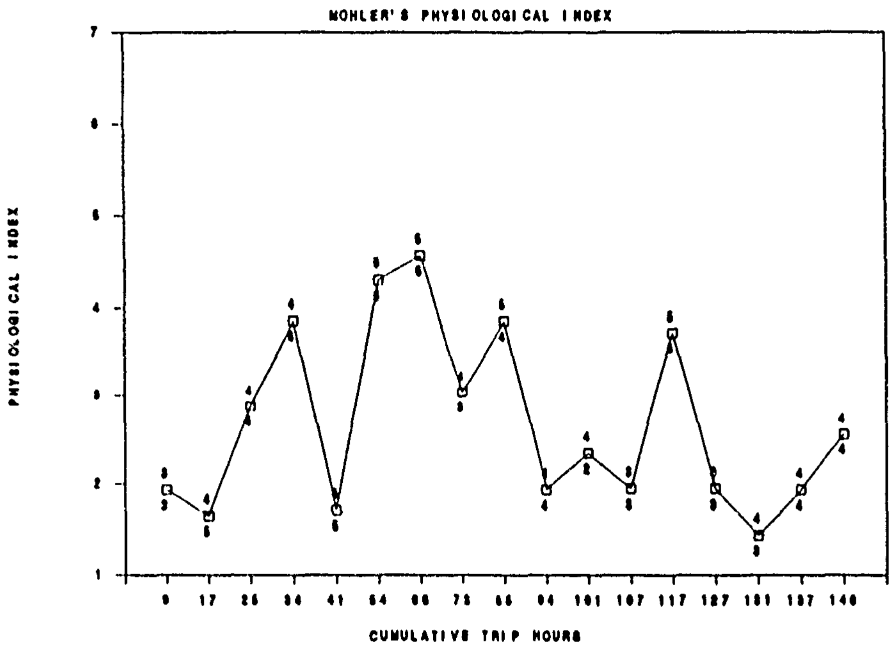
DESERT SHIELD/ STORM DATA



DISCUSSION:

Because no model has been published for use by military crews, it is necessary to study those models developed for civilian air crews in order to develop one of potential use to the United States Air Force and other service branches. The models were applied to data from one of the Armstrong Labs researchers. Application of the models to the other researchers data is underway. However, the concerns of the models, expressed in this paper, still hold true.

Nicholson's model does not apply to our needs because his model predicts workload level for a specific route. MAC crews rarely get the luxury of flying specific routes The models are too simplistic for military use and leave out many factors important when considering rest periods for MAC crews. Nicholson uses only duty time and number of consecutive duty days and disregards several important factors such as time zone shifts and local times of departure and arrival, that had already been used in a model developed by L. E. Buley in 1970. Buley's formula considers many more factors than Nicholson's. He employs the use of flight direction, local times of departure and arrival, and time zones crossed. Buley's formula perhaps comes the closest to concerns of military pilots since his suggests rest periods for long distance travelers. However, Buley's model was not developed for air crews but for passengers. In addition, the model does not account for cumulative fatigue and sustained performance but instead suggests a rest period for business travelers.

Gerathewohl's model is a variation of Buley's. In fact, Gerathewohl used Buley's data in developing his own model. However, Gerathewohl includes factors Buley left out, such as age, geodirection of travel, and even small (<4) time zone shifts. Gerathewohl's model allows for longer rest periods, a benefit for air crews, and Gerathewohl's development of a wheel to help determine rest period made his formula somewhat more usable. However, the wheel is cumbersome to use and does not account for cumulative fatigue.

The model developed by Stanley Mohler, on the other hand, does account for cumulative fatigue and was developed for commercial air crews. Mohler's model was developed to help assist people who develop schedules to avoid crew patterns that "would impose a severe physiological load on personnel." But while Mohler's model is suited for use by air crews, it provides a "physiological index"--like Nicholson's workload number--and not a suggested sleep period. Therefore, these are hard to translate into a recommended crew rest period. Also, while Mohler's formula itself is fairly simple, obtaining the variables to use in the model is not simple. It is not a "user friendly" model, which is necessary when the model is to be used in real life situations by people who may already be tired and frustrated.

Currently, a new model is being developed by researchers at Armstrong Laboratories/CFTO. This model will take into account factors not considered by earlier models and will use the data obtained from the MAC crews the researchers flew with to refine the model. It is hoped that an easy to use model can be used by air crew to provide a rational basis for determining the length for a maximally restorative crew rest period. At present, factors not considered in previous models that will be included in the Armstrong Laboratories model are: how long a crew has been legal for alert in the past 48 hours; the crew's cumulative flight hours, recent flight hours, and recent sleep history; the time of day that crew rest occurred (day or night rest time); and the recent number of landings and time in transit to billeting.

It is hoped that the model under development will assist military air crews in determining rest periods after they have flown. Determining a rest period is not a simple matter, because there are more factors that are important than just asking "How long have you been awake?" The goal of the Armstrong Labs model is to help aircraft commanders determine how long their rest should be to be most effective.

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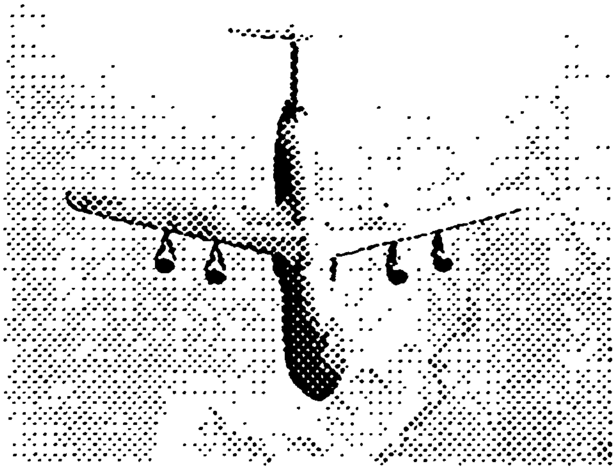

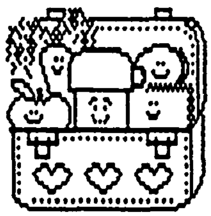

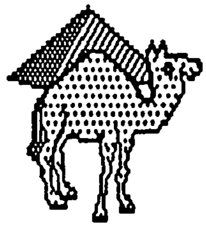

AIR CREW DIETS DURING DESERT STORM

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by

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Incamate Word School
August 1991

ABSTRACT

This study evaluated the nutritional components of boxed lunches collected from MAC air crew at the end of Desert Storm. A thirty day field experiment was conducted by Armstrong Labs/CFTO to evaluate fatigue data in MAC air crew. Additionally, boxed lunch information was collected from one crew of five subjects during the study as they flew on operational AF missions. Nutritional analysis was conducted on these lunches for kilocalories, proteins, carbohydrates, fat, cholesterol, sodium, potassium, and saturated fats. The means for these components were 1758.07 Kcal, 53.75 g, 233.50 g, 66.75 g, 136.94 mg, 3240.05 mg, 1551.20 mg, and 20.87 g, respectively. It was found these components were about half of the minimum daily requirements for key nutritional components for air crew and, by themselves, would not constitute an adequate day's nutrition. Although boxed lun   s were not intended to be the sole source of daily nutrient intake, often, particularly during long duty days, they became the most important source of nutrition. However, the lunches were prepared by MAC kitchens as carefully and as thoroughly as resources permitted. It is recommended that a daily vitamin supplement pill be added to each boxed lunch.

AIR CREW DIETS OF DESERT STORM

by Carol Salinas

INTRODUCTION

Proper nutrition is important to everyone, but especially for the many ranks of military personnel who defend our nation's vital interests. This group of brave men and women have a variety of extremely demanding tasks placed upon them, and therefore, it goes to reason that their diets should be nutritionally sound in relation to their activities and sometimes hostile surrounding environments. Prolonged inadequate nutrition and/or improper eating habits can produce severe physiological and neurological consequences, as various comprehensive studies and research projects conducted in the past have shown (1). Among these consequences are an increasing level of fatigue, a lack of the proper attitude for people who must constantly deal with high-stress situations, a greater possibility for human error, and a possible increase in aircraft accidents (2). Therefore, in order to prevent these maladies and their like from ever developing within our military personnel, the standards of the Military Recommended Dietary Allowances are slightly higher (in relation to kilocalories, proteins, carbohydrates, vitamins and minerals) than are those of the United States Recommended Dietary Allowances, which are set primarily for civilians. However, this report will be based on data collected by Armstrong Laboratory/ CFTO from Military Airlift Command (MAC) air crew on a thirty-day operation immediately after Desert Storm hostilities ceased. This report will describe the collection and evaluation of boxed lunch data during a field study under wartime conditions. The boxed lunch often serves as the most important source of nutrition for aircrew during long (20 hours) duty days. They are provided by MAC base kitchens and consumed by air crew during their flights carrying cargo into the area of operation.

METHODS

Armstrong Laboratory/CFTO has much experience in collecting data from air crew. Five investigators from CFTO accompanied five crews throughout the thirty-day study, collecting data on temperature, mood, sleep patterns, and flying performance at MAC's direction. One CFTO investigator, Dr. Jonathan French, also collected data on the lunches prepared for his crew and it is these data upon which this study will be based. Dr. French's data consisted of a listing of each item in fifteen lunch menus which were provided for crew and researcher alike throughout the thirty-day study. The duration of the study was spent mainly on transporting goods after the hostilities during Desert Storm were over. This brief dietary record consisted of the boxed lunches eaten on each actual mission flown (see Appendix 1). The crew of five men were aged between 22-31 years, with an average age of 27.6 years; these men weighed between 155-215 lbs., with an average weight of 172.4 lbs.; they were between 68-78 inches tall, with an average height of 71.8 inches.

The dietary evaluation began by confirming and correcting the portion sizes (and some of the ingredients) which were either contained or implied by the dietary record. These things were confirmed by four means. First, various MAC bases that supplied the meals, all over the United States and some in Europe, were called (for eg., Charleston AFB in South Carolina and Travis AFB in California), and their in-flight kitchens were contacted. Second, Major Ester Myers at the USAF Medical Center at Scott AFB in Illinois was contacted (MAC Dietician Office). A third measure taken was an interview, along with several subsequent phone calls, made with Captain Tammy Cook, who is a research dietician at Brooks AFB in Texas. Major Myers and Captain Cook were contacted to discover dietary items of interest to MAC and procedural information. Dr. Gene Evans, a registered dietician, guided the evaluation and provided the data on the boxed lunch nutritional analysis content. An analysis of the meals that are ready-to-eat (MRE's), which were occasionally given to the crew, was obtained from the U.S. Army Natick Research, Development and Engineering Center at Natick, Massachusetts. (For more information on this center, see page 52 of Reference 3.)

Finally, all the portion sizes and ingredients were confirmed by phone calls and interviews. The nutritional analysis was done with the help of the Nutritionist III computer program (developed by N-Squared Computing in Salem, Oregon), the Bowes and Church's Food Values For Portions Commonly Used handbook (

fifteenth edition), and from phone calls to the various suppliers of several individual items in the lunches (for example, the distributors of Lance's snacks and Lunch Bucket meals).

The next step was to list the dietary information in the analysis. Several figures were taken from the nutritional analysis of each of the separate menus in the record and this information was compiled into averages for the amounts of kilocalories, proteins, carbohydrates, fats, cholesterol, sodium, potassium, and saturated fats contained within the average boxed lunch. The reason these particular nutritional components were used is because they are emphasized both within current health promotion at MAC (Healthy Heart program) and with ongoing studies of interest to the Air Force's Chief of Staff.

Finally, these averages were taken and compared to the standards of the Military Recommended Dietary Allowances (MRDA), resulting in percentages which showed how well the nutritional content of the average boxed lunch matched up against the MRDA's standards. It should be mentioned that, in order to obtain set values for three of the MRDA's standards, some calculations had to be done. The three nutritional components upon which these calculations were done are carbohydrates, fat, and sodium. The MRDA for the carbohydrate component was set at 55% of kilocaloric intake, so this percentage was multiplied by 3200, which is the amount of kilocalories that are recommended be consumed daily for the military, and the resulting figure was divided by 4 to give the amount of carbohydrate content in grams, since there are 4 kilocalories per gram of carbohydrate. The MRDA for fat was set at no more than 35% of kilocaloric intake, and therefore, this percentage was also multiplied by 3200 and the resulting figure was then divided by 9, since there are 9 kilocalories per gram of fat. The MRDA for sodium was set at about 1700 milligrams per 1000 kilocalories of daily consumption, so the number 3200 was divided by 1000, and then the result was multiplied by 1700 to give a recommended daily intake (for military personnel) of sodium in milligrams.

Since the Military Recommended Dietary Allowances are the standard intended for military menu planning, it was decided that this was probably the best approximation to use for a comparison of the food provided from the base kitchens for the fourteen days (fifteen menus) of MAC flights. However, the recommendations for the general adult U.S. population might also be used under some circumstances, so this information with references is in Appendix 2 at the end of the report.

RESULTS

Of the fifteen daily menus which were recorded within Dr. French's data, only one of them was an MRE dinner. Four of the fifteen meals were provided by Zaragoza AFB in Spain, three were given at Charleston AFB in South Carclina, three were distributed at the AFB at King Faud in Saudi Arabia, three more were prepared at Frankfurt AFB in Germany, one was made at Travis AFB in California, and one was given at Riyadh AFB in Saudi Arabia. For a list of this dietary record see Appendix 1.

The numerical estimation for each of the eight nutritional components of interest were extracted from the analysis for each of the boxed lunches. As was previously mentioned, these nutritional components were quantitative measurements for kilocalories, protein, carbohydrates, fat, cholesterol, saturated fat, sodium, and potassium. (The protein, carbohydrate, fat, and saturated fat measurements were listed in grams; the cholesterol, sodium, and potassium values were recorded in milligrams.) The compilation of the extracted figures for each of these dynamics resulted in an average numerical value for each of the eight components. Together, these eight averages represent what the findings would be if a nutritional analysis were run on the average air crew diet during Desert Storm, were it given out only once during the thirty-day mission. For a list of these eight averages, see Table 1.

Headquarters Departments of the Army, the Navy, and the Air Force in Washington, D.C. [illegible]tacted for a listing of the Military Recommended Dietary Allowances (MRDA's). This list (taken from Air Force Reg. 160-95) underwent an extraction which consequently yielded a list of the MRDA's for kilocalories, protein, carbohydrates, fat, sodium, and potassium. (MRDA values for cholesterol and saturated fat were not available.) For a list of the MRDA's for these six nutritional components, see Table 2.

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Table 1

Averages of Selected Components From the Nutritional Analysis of the Dietary Record

KILOCALORIES =	1758.07 Kcal
PROTEIN =	53.75 g
CARBOHYDRATES =	233.50 g
FAT =	66.75 g
CHOLESTEROL =	136.94 mg
*SATURATED FAT =	20.87 g
SODIUM =	3240.05 mg
*POTASSIUM =	1551.20 mg

*-These measures may be slightly below what it was in actuality, due to some missing information concerning this particular component of the nutritional analysis.

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Table 2

Military Recommended Dietary Allowances (MRDA's)

For Selected Nutritional Components[1]

KILOCALORIES[2] =	3200 (2800-3600) Kcal
PROTEIN =	100 g
*CARBOHYDRATES =	440 g
*FAT =	124 g
CHOLESTEROL =	**
SATURATED FAT =	**
*SODIUM =	5440 mg
POTASSIUM[3] =	3750 (1875-5625) mg

*-These figures are derived from the energy levels (amount of kilocalories) consumed daily.

**-No specific military recommendations exist for this particular component.

***NOTE: Footnotes 1, 2, 3 were taken from Air Force Reg. 160-95

[1]MRDA for moderately active military personnel, ages 17 to 50 years, are based on the Recommended Dietary Allowances, ninth revised edition, 1980.

[2]Energy allowance ranges are estimated to reflect the requirements of 70% of the moderately active military population.

[3]Estimated ranges are provided for this nutrient because sufficient information upon which to set a recommended allowance is not available.

A comparison of Tables 2 and 3 yielded a list of six percentages which represent how well the average boxed lunch met with the standards of the Military Recommended Dietary Allowance concerning the six nutritional components of kilocalories, protein, carbohydrates, fat, sodium, and potassium. For a list of these six percentages, see Table 3.

Table 3

Percentages Representing What the Average Boxed Lunch Provided Based on the MRDA's For Selected Nutritional Components

KILOCALORIES =	54.94% of the MRDA
PROTEIN =	53.75% of the MRDA
CARBOHYDRATES =	53.07% of the MRDA
FAT =	53.83% of the MRDA
SODIUM =	59.56% of the MRDA
POTASSIUM =	41.37% of the MRDA

DISCUSSION

This study found that boxed lunches would have been nutritionally adequate if they had been intended to represent only one of three meals consumed throughout a twenty hour period, the maximum length of a duty day. Unfortunately, this was not always the case. Oftentimes, the boxed lunches described herein had to sustain air crew for the entire twenty hour duty day. Therefore, these meals were often the principal source of nutrition for the crew. Many times the crews would bring extra food with them but these were often unwise nutritionally consisting primarily of potato chips and cookies, according to Dr. French. However, it was found that, of the recommended dietary intake, these boxed meals provided approximately 55% of the kilocaloric intake, 54% of the protein, 53% of the carbohydrates, 54% of the fat, 60% of the sodium, and 41% of the potassium.

There are some inherent methodological errors within this study. First, it was assumed that the meals within the dietary record presented by Dr. French were representative of all meals which were distributed to troops throughout the duration of Desert Storm. However, this may very well be an incorrect assumption. Second, it is a possibility that, after eight months of providing meals for air crew during Desert Shield and Desert Storm, the in-flight kitchens became overworked. Perhaps, toward the end of this eight-month period, these kitchens had either run out of supplies or had spread those that existed too thinly. Third, MAC flew at such a relentless pace that twenty-hour work days were quite common. Consequently, this lack of free time (and the abundant presence of fatigue) may have prevented the crew from going out to an in-flight kitchen to obtain a supplemental meal.

As was previously mentioned, these meals may have been adequate if they had each been one-third of the daily intake. However, due to the rigorous demands of flying under MAC, nutritionally sound meals (which could have composed the other two-thirds of the daily intake) were extremely hard to find. Whenever restaurants were visited by air crew, it was often during the pre-dawn morning hours (due to their flying schedule), and too frequently, all that was served there were pizzas, greasy fried foods, hamburgers, and beer.

This investigator wonders aloud if, after spending billions of dollars on aircraft, a few additional dollars could also be spent on a daily vitamin supplement which might better enable air crew to keep on flying for prolonged periods of time. It would also be very conscientious to do a thorough study concerning the nutritional needs of the air crew, seeing as how there are so many demanding tasks that are required of them. Perhaps Armstrong Labs could be tasked by MAC for such a study with the other experts mentioned herein.

Dr. French indicated that there were indeed lunches which were obviously prepared with great effort. It should be emphasized that, certainly, all of the bases must have done their very best to provide nutritionally adequate lunches. However, some bases really stood out, particularly some of the MAC bases in the U.S. (to be specific, Charleston AFB in South Carolina). Not only did these bases provide a wide range of healthy foods, but their meals were obviously prepared with great pride.

Appendix 1
Boxed Lunch Contents During Desert Storm

18 March (at AFB in Charleston, South Carolina)

2 choices:

1.) chef salad, peanut butter sandwich

2.) pasta, turkey sandwich

Both Had:

crackers, orange juice, milk, pudding, granola bar, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

20 March (at AFB in Zaragoza, Spain)

2 peanut butter sandwiches, roast beef sandwich (all sandwiches were on white bread), 5 crackers, 2 apple juices (200 ml each; 35% fruit), apple, orange, 2 oatmeal cookies, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

21 March (at AFB in Riyadh, Saudi Arabia)

ham or turkey on a sesame seed bun, very small salad, fried eggroll, milk chocolate candy bar, orange soda, orange drink, orange, piece of vanilla cake, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

22 March (at AFB in King Faud, Saudi Arabia)

turkey sandwich (on white bread), Pepsi, 2 apple juices, cherry danish, chocolate chip granola bar, banana pudding, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

28 March (at AFB in Travis, California)

turkey sandwich (wheat bread), pasta salad, 4 crackers (Saltines), trail mix, mixed fruit can (4.5 oz.; light syrup), milk (0.5 pint; 2% milkfat), apple juice (6 oz.; 100% fruit juice), danish pastry with apple center (1.75 oz.), lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

29 March (at AFB in Zaragoza, Spain)

roast beef sandwich (on white bread), ham and cheese sandwich (on white bread), cherry drink, orange drink, apple, orange, Reese's peanut butter cup, 2 Pecan Sandies, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

31 March (at AFB in King Faud, Saudi Arabia)
MRE dinner: ham omelet, potatoes au gratin, crackers, coffee, oatmeal cookie, gum, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

1 April (at AFB in Frankfurt, Germany)
2 turkey and cheese sandwiches (on white bread), cola, 2 apple juices, orange, grape danish, granola pudding, granola bar, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

4 April (at AFB in Charleston, South Carolina)
turkey-and-swiss-on-wheat sandwich, breadsticks, potato chips, orange juice, diet Pepsi, fruit cup, peanut butter creme-filled wafer, tapioca pudding, rye cheese crackers, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

5 April (at AFB in Zaragoza, Spain)
ham sandwich (white bread), roast beef sandwich (white bread), cherry juice, orange juice, apple, orange, Reese's peanut butter cup, 2 cookies, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

6 April (at AFB in Zaragoza, Spain)
turkey sandwich (white bread), ham and cheese sandwich (white bread), cherry drink, orange drink, orange, apple, peanut butter cup, 2 cookies, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

7 April (at AFB in Frankfurt, Germany)
microwaveable chile and beef stew dinners, bun, vanilla pudding, bag of M&M's candies, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

9 April (at AFB in King Faud, Saudi Arabia)
2 turkey and cheese sandwiches (on sesame seed hot dog buns), 2 fruit juices, Pepsi, cinnamon granola bar, banana pudding, danish pastry, lettuce

leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

13 April (at AFB in Charleston, South Carolina)
turkey and cheese sandwich (on white bread), small salad, 2 breadsticks, bag of potato chips, cheese, peanut butter sandwich, Pepsi, can orange juice, fruit cup, vanilla pudding, large fig bar, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

15 April (at AFB in Frankfurt, Germany)
2 turkey and cheese sandwiches (on white bread), 2 cans orange juice, Pepsi, banana pudding, granola bar, lettuce leaf, tomato slice, pickle wedge, teaspoon margarine, and one tablespoon each of mustard, mayonnaise, and catsup

**NOTE: At any AFB that was not directed by Military Airlift Command (MAC) an additional teaspoon of margarine was added to every slice of bread.

Appendix 2

General Healthy U.S. Population Dietary Recommendations

(for males 25-50 years, weight 79 kg, height 176 cm)

Source of Recommendation	Recommendation	Recommendations Kcal-Nutrients
RDA	Kilocalories	2900 Kcal
RDA	Protein	63 g
RDA	Carbohydrate	446 g (>50% Kcal)
NRC	Fat	96 g (30% total Kcal)
NRC	Cholesterol	<300 mg
NRC	Saturated Fat	32 g (<10% total Kcal)
NRC	Sodium	$\leq$2400 mg

RDA-"Recommended Dietary Allowances"
National Academy of Sciences, National Research Council, Food and Nutrition Board. Recommended Dietary Allowances, tenth edition, Washigton: National Academy Press, 1989.
NRC Recommendation
National Academy of Sciences, National Research Council, Food and Nutrition Board. Diet and Health: Implications for Reducing Chronic Disease Risk. Washington: National Academy Press, 1989.

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3.) Baird, Betsy; " Hot Meals in a Hot Spot: How We Feed Our Troops in Saudi Arabia ", Food Technology, February 1991, p.52.

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PROFILE OF MOODS DURING MAC FLIGHTS IN DESERT STORM.

Summer High School Apprenticeship Program
Armstrong Labs /CFTO
Brooks AFB, TX

by

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Taft High School
August 1991

ABSTRACT

During Desert Storm, the coalition forces allied against the invading armies of Iraq depended on a 6,000 mile air bridge created by the USAF MAC for food and supplies. MAC's effort started with the buildup of forces in August of 1990 and continued until the end of hostilities in March of 1991. In an effort to monitor the safety of flight generated by the demands of such a sustained re-supply effort the MAC surgeon general requested that Armstrong Lab evaluate 5 representative air crews for fatigue during the closing days of Desert Storm. Like they had done so often during the campaign, these crews were required to fly the maximum number of hours per month (150 hours) and get the minimum amount of crew rest (12 hrs) during duty days that often extended to 20 hours. This report describes the profile of mood survey (POMS) scores that were collected as one of the instruments used to evaluate fatigue during the 30 day field study. POMS were taken when the crews were legal for alert (LFA) during the start of their duty day and right before crew rest (CR) during the end of their duty day. It was found that fatigue, confusion, anger and tension POMS scores were greater and vigor scores were lower during CR than during LFA as crews built up to 150 hours of cumulative flight time. No effect was found for depression POMS scores. Although there were no differences in scores as cumulative flight hours increased, subsequent analyses needs to consider where the crews were when POMS were taken to evaluate any location effects and to consider the recent sleep and flight history of the crews. It is hoped that the results of these analyses will enable MAC to better manage crew rest options and better protect their flyers from the debilitating effects of fatigue.

PROFILE OF MOODS DURING MAC FLIGHTS IN DESERT STORM

Paul Salinas

INTRODUCTION

In August of 1990, armed forces of the Iraqi dictator, Saddahm Hussein invaded the neighboring country of Kuwait. In response, the U.S. set into motion the largest military airlift in history. For the first two months of the conflict, only an air bridge connected allied forces in Saudi Arabia with supplies. Within six weeks, the tonnage supplied to the desert forces exceeded that carried during the Berlin Airlift of the late 1940's. The task of maintaining that air bridge fell to the Military Airlift Command (MAC). In order to keep a steady flow of supplies into the desert, MAC accelerated the pace of their resupply efforts. MAC air crews were duty bound to fly a maximum of 150 cumulative flight hours in each thirty day period throughout what would turn out to be a year long effort. The 24 hour a day operation was so immense that no other nation on earth could have even contemplated it. As well, most crews were only getting the minimum rest period allowed by regulation; 12 hours. Since this level of sustained effort could induce profound fatigue, the MAC surgeon General wanted to closely watch the subjective mood of the crews. A sample of 5 MAC air crews were selected as representative subjects for a field study of air crew flying operational Air Force missions to the desert. Researchers from Armstrong Laboratories /CFTO have experience assessing air crew subjective states and were tasked with measuring fatigue from the five C-141 MAC air crews for a continuous thirty day period.

As part of the study, researchers administered Profile Of Mood State (POMS) data sheets on a daily basis. POMS is a convenient method of identifying and assessing transient or fluctuating affective mood states. Nowlis and Green (1957) developed it to study the side effects of patients after consuming experimental drugs. POMS identifies six mood dimensions: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor-Activity, Fatigue-Inertia, and Confusion-Bewilderment (McNair et al, 1971). POMS in its present form consists of 65 questions to be answered on a five point scale which represents the refinement of a previous 100 different adjective scales. Scales have been added and subtracted since the original set of 55 scales presented by Nowlis and Green. It has even been modified to a 7th grade education level. Since POMS is able to detect fatigue, the Armstrong Lab scientists set out to determine if fatigue increased as crews approached 150 hrs over the course of the 30 day study. This was obviously not a lab study, but a rare opportunity to collect fieid information on fatigue during the intensity of wartime conditions.

METHODS

All crews in the study received minimal crew rest per day (12 hours) and maximum flight time (150 hours) per month as they carried out their normal supply missions to the desert. POMS were filled out once at the start of Crew Rest (CR) and once when Legal For Alert (LFA). CR began when the airplane landed and lasted for a twelve hour period. CR was also the only time crews could buy food, wash clothes, take showers, and relax and included the time it took the crews to bring down their luggage to and from the plane and the time it took to get to billeting. MAC air crews also had to attend intelligence briefings, report to command post, and go to the armory to turn in their weapons during CR. This sometimes took up to four or five hours so frequently air crews often didn't have much time to sleep at all. LFA started at the end of their twelve hour Crew Rest period and before they were alerted. LFA could last as long as 6 hours before crews were finally alerted or returned to CR if not alerted. Since the maximum duty day was 20 hours and started after the alert came, a 6 hour LFA waiting period could extend a duty day to 26 hours.

POMS sheets were given to the individual subjects and filled out under the supervision of their associated researcher. The 5 point POMS response scale goes from 0 to 4; that is depending on their mood they would choose: "0" indicating Not At All; "1" = A Little; "2" = Moderately; "3" = Quite a Bit; and "4" = Extremely, for each of the 65 questions. Researchers would then label the POMS sheets with: I.D. #, location, CR or LFA, date, and time After thirty days there was at least 300 POMS sheets for each crew and a total of 1,500 POMS data sheets for all crews combined in the study.

POMS sheets were then entered into a computer program called POM-

SCORE to transfer the answers from the POMS sheets into a file. For every POMS sheet, there were 130 entries into the computer. This means that there were over 195,000 keypunches made to enter this vital data prior to the analysis. In addition to the enormous tracking problems with so many forms and files most of the entries were made by this and one other investigator. POMS were then copied onto floppy disks and put into a second program for data analysis. Once POMS were evaluated they were merged into a huge data base that contained mission history, flight history, activity logs, sleep times and oral temperature data used to assess circadian desynchronosis or jet lag. POMS data and cumulative flight data were extracted from this enormous file and statistically analyzed. Graphs were later generated for visual comparison.

RESULTS

The key questions in the analysis refer to the levels of fatigue as crews approached the maximum number of flight hours. Table 1 shows the number of observations (the number of POMS sheets filled out) within each Block Of Time. Block Of Time refers to increasing numbers of cumulative flight hours during the 30 day period. The POMS obtained during LFA or CR are considered as crews approached the 150 hour maximum flight hours in the 30 day experiment. Table 1 can be used to identify the Blocks of cumulative flight hours on all of the subsequent graphs for the POMS data. Another measure, oral temperature, was collected for the crews every 4 waking hours. Only those temperature values that could be associated with the POMS scores (ie during LFA or CR) are plotted against cumulative flight hour blocks in Figure 1.

Table 1. The number of POM scores generated during each cumulative flight hour block for legal for alert and for crew rest sampling times

BLOCK	CUMULATIVE FLIGHT HRS	STATUS LEGAL FOR ALERT	CREW REST
1	< 80 hrs	110	107
2	80 - 90 hrs	27	27
3	90 - 100 hrs	31	24
4	100 - 110 hrs	38	42
5	110 - 120 hr	27	30
6	120 - 130 hrs	39	44
7	130 - 140 hrs	19	26
8	> 140 hrs	23	19

Figure 1 shows that temperature does not vary with LFA or CR. However, there does seem to be a downward trend in the temperature values as crew approach 150 cumulative flight hours, especially during CR.

Figure 2 shows that the Fatigue POMS score for all crew were much greater during CR, essentially the end of the duty day than during LFA essentially the start of the duty day ($F = 115.6$, $p = 0.0001$, $df = 1,25$).

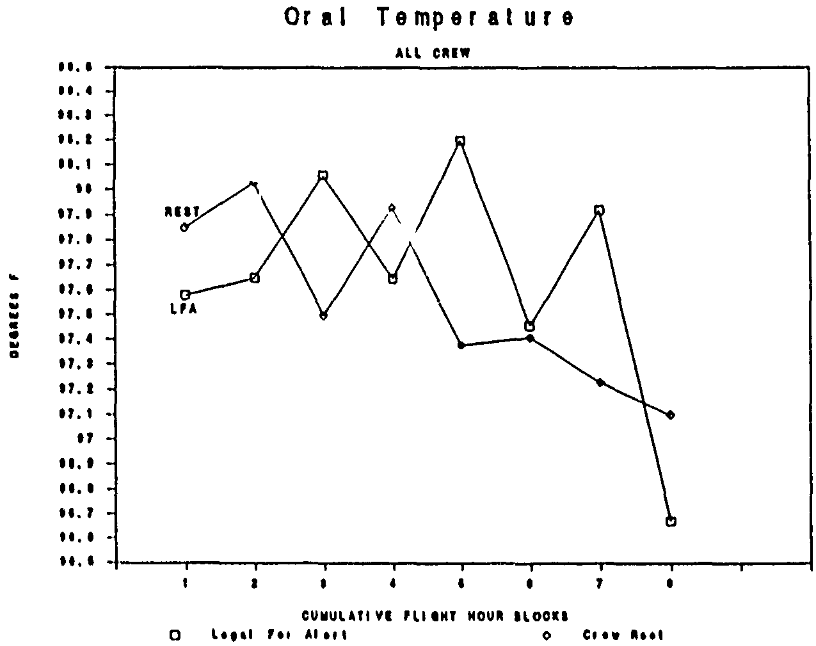

Figure 1

As shown in Figure 2, there does seem to be an upward trend in Fatigue scores during the last 2 cumulative flight hour blocks. The minimum value for the Fatigue Dimension on the POMS represents a score of 34. Minimum and maximum values for all POMS Dimensions are shown in Table 2.

Figure 3 shows the Vigor Dimension does not seem to be the mirror image of Figure 2. The peaks for Vigor during CR shown in Figure 3 are greatest during blocks 3 and 6 whereas Figure 2 does not show a corresponding drop in fatigue at these blocks. LFA has a small drop in fatigue during blocks 3 and 6 but the corresponding peaks in Vigor are less distinct. In the case of Figure 3, vigor

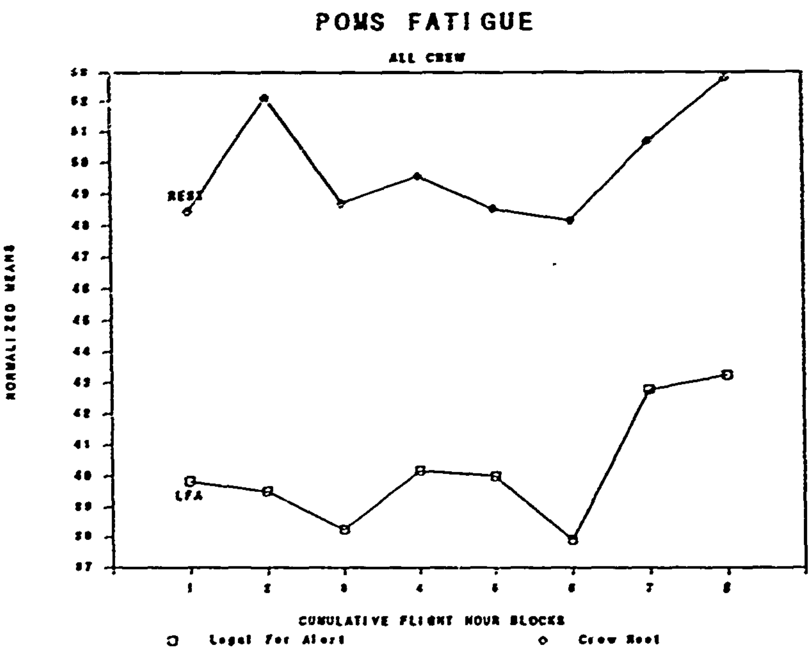

Figure 2

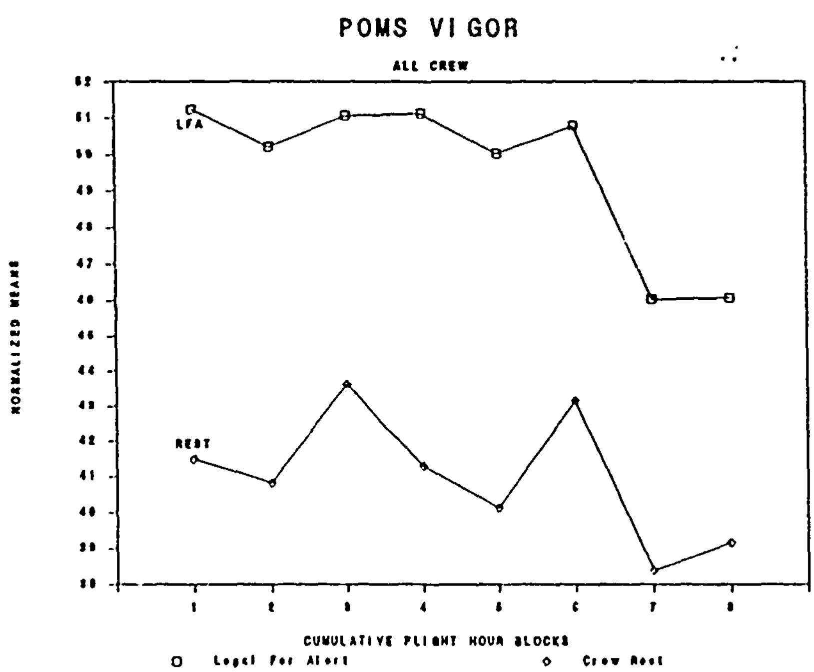

Figure 3

during LFA is greater than that during CR (F=100.65, p=0.0001, df= 1,25) and the last 2 flight hour blocks demonstrate a downward trend rather than an upward trend like that shown in Figure 2.

Table 2. Minimum and maximum scores on POMS for each of the Dimensions evaluated.

	Minimum	Maximum		Minimum	Maximum
Fatigue	34	77	Vigor	26	76
Confusion	30	81	Anger	37	101
Tension	31	81	Depression	37	91

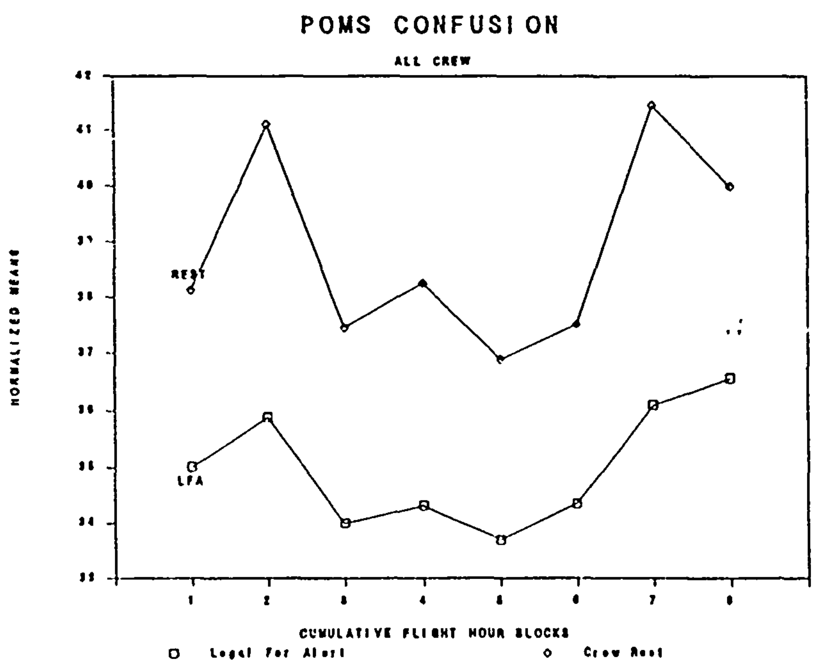

Figure 4

Figure 4 shows that the Confusion Dimension is greater during CR than during LFA across all cumulative flight hour blocks (F=34.49, p=.0001, df= 1,25).

Confusion scores for all subjects seem to more stable during LFA than during CR because of the 2 peaks in the CR data at flight hour block 2 and 7.

Figure 5 shows that Anger scores have the same peaks during CR as do Confusion scores in Figure 4; at cumulative flight hour blocks 2 and 7. The Anger scores are greater during CR than during LFA (F=5.95, p=0.0222, df= 1,25).

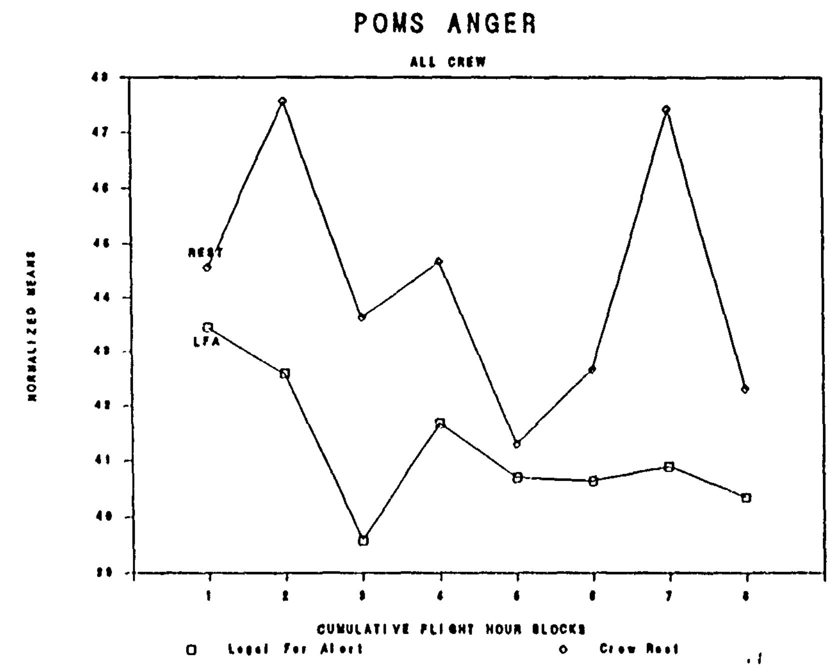

Figure 5

Although only small changes are evident between CR and LFA with regards to the Tension scores, as shown in Figure 6, they are significant (F=7.46, p=0.011, df= 1,25). There is only one peak in the Tension scores, at cumulative flight block 2 for CR, as shown in Figure 6. In contrast, there were no differences between CR and LFA for the Depression scores as shown in Figure 7 (F= 3.15, p= 0.088, df= 1,25).

DISCUSSION

The were no changes in temperature scores associated with the POMS.

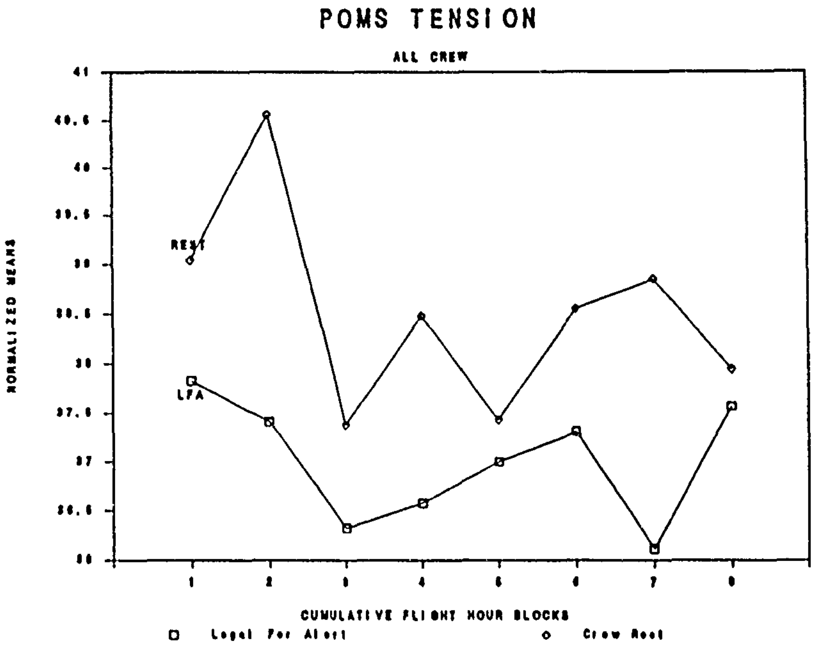

Figure 6

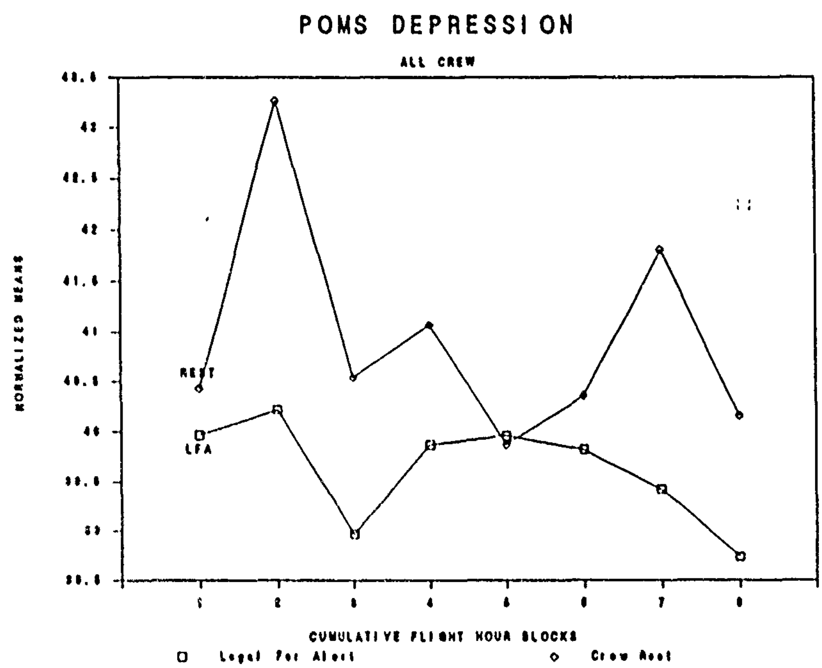

Figure 7

There was a much larger number of temperature scores obtained during the field study (every 4 waking hours) than were evaluated here. As well, temperature scores were always associated with a Fatigue rating score (rising in fatigue from score of 1 through 7). Subsequent temperature analysis will focus on comparing the larger number of temperature scores with the Fatigue rating scores.

The most important question in the analysis concerns the level of fatigue as cumulative flight hours increase. In Figure 2, the Fatigue POMS score had a substantial rise at cumulative flight hour block 2 (80 - 90 hours) and again at blocks 7 and 8 (130 - 140 + hours). The rise for flight hour blocks 7 and 8 also occurred during LFA. This may signal an increase in fatigue as flight hours increase. Although not significant in this analysis, subsequent analysis will evaluate Fatigue scores by location as cumulative flight hours increase. This analysis did not consider whether the crews were at their home base or in Saudi Arabia or elsewhere. It is conceivable that fatigue would be more pronounced during missions rather than at the home base.

There seem to be trends for peaks at the cumulative flight hour block 2 (80 - 90 hours) for Fatigue, Confusion, Anger, Tension and Depression and at flight hour block 7 (130 - 140 hours) for Confusion, Anger and Depression during CR. Only Vigor scores were without peaks at these time blocks and instead Vigor had larger scores associated with cumulative flight hour blocks 3 (90 - 100 hours) and 6 (120 - 130 hours). Most of these changes were associated with CR so LFA may be a more mood stable time in the duty day. The differences between CR and LFA also indicate that POMS is a sensitive measure of air crew subjective states, at least between the extremes of duty day start and duty day end.

This analysis only focused on 30 day history and mood. Future analysis will consider the length of the most recent duty day and the most recent crew rest in an attempt to determine the relationship between recent flight history of the crews and subjective mood states. Now that the data base is in place highly specific questions like these can be answered. These questions are important to the future MAC missions because the newer planes can fly farther and because the U.S. needs to be able to respond as quickly as it did in the Desert campaign. They may also provide MAC a rational basis for deciding where and how long rest periods should be in order to protect their most valuable asset, the individual crew member.

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COMPARISON OF CHEMICAL WARFARE SUITS DURING HOT PHYSICAL WORK SESSIONS

High School Apprentice Program

Patrick Sharkey

ABSTRACT

This summer I kept busy helping out around the laboratories and gaining a working knowledge of how scientific experimentation really works. Most of my time was spent with the ongoing experiments being conducted in the physiology division. My focal point was the work with the chemical warfare suits, which I have documented in this paper. These experiments dealt with testing the physiological effects of physical work, more specifically walking, in a hot environment. Another experiment I helped out in was the testing of various filters in chemical defense masks. This also involved having the subjects walk in a controlled, but cooler, environment. Finally, I helped with the data processing and general work around the laboratories.

I thoroughly enjoyed the program this summer and thank all who made it possible. The knowledge I gained was priceless and will help me throughout my life. This program gave me a great opportunity to learn how things really work in the world and how I can help make things safer for all beings.

INTRODUCTION

The Air Force's need for an effective and safe chemical warfare suit, or chemical defense ensemble (CDE), was recently demonstrated in the Persian Gulf War. Both ground and air crews were under the constant threat of Iraqi missiles carrying massive, concentrated payloads of potentially fatal chemicals. Personnel were forced to perform duties, both mentally and physically taxing, in 100 degree F. conditions to maintain the warplanes at their performance peak.

The ensembles are made of a chemical-absorbing charcoal foam layer within a cloth garment. Because the chemicals can cause internal body complications when skin is exposed to them, the suit and its complements cover the entire surface area of the body. The suits are well-sealed to prevent contaminated air from circulating inside.

Although the ensembles are effective in keeping out chemicals, they have several shortcomings that limit personnel performance. These include poor body heat dissipation and the inability to evaporate sweat freely; both induce potentially fatal heat stress cases in the worker (1). As stated above, the CDE is sealed tightly, so little circulation of outside air is allowed. This prevents heat, which is generated within the body during work, from being released, thus maintaining the body's temperature. Three important methods of heat transfer into the air, convection, conduction, and radiation, are consequently hindered by the CDE. The main method of releasing excess heat, through sweat evaporation (2), is also obstructed by the impermeable nature of the suits and the lack of air turnover. As much as eighty percent of heat dissipation occurs by sweating, so any non-evaporative sweat accumulates inside the suit and may act as a layer of insulation, thereby further heating the worker. Finally, the

CDE restricts the individual's movements and efficiency, adding to the body encumberance.

Under development currently is a cooling unit for use when wearing the ensembles. Scientists plan to have personnel carry the cooling unit, either a liquid or air system, as a backpack. This innovation will only be available for practical use in the future, though. These cooling units will also pose problems in the way of worker fatigue and restricted movement. Therefore, it is imperative that a highly efficient CDE is developed to protect the military personnel sent to perform in dangerous and uncomfortable climates.

The purpose of this study was to compare the ability of different chemical defense ensembles to dissipate body heat into the surrounding air, in the hopes of finding a superior fit or material for safe military use.

METHODS

Subjects

The subjects participating in the experiment were all Air Force personnel and, in terms of physical fitness, were a fairly representative sample of active-duty personnel. The subject group was composed of 10 males and one female. The subjects were in a relatively equal heat acclimation state.

Conditions

The experiment was conducted in a environmental, or climate-controlled, chamber. The conditions were monitored to insure a stable environment within which the subject would work. The environmental values were: T_{wb}= 24 degrees C., T_{db}= 41 degrees C., T_{bg}= 31 degrees C., and a resulting relative humidity of 20%.

Before the experiment, the subject entered the chamber and his initial nude weight was recorded. The subject's rectal probe thermistor, which measured body core temperature, was already implanted. The thermistor/heat flux sensors (left calf, left thigh, upper chest, and left forearm) and ECG telemeter/leads were taped onto the body. Next, the subject was put into the chemical warfare suit and weighed again. This measurement was termed the initial clothed weight. The mask and hood were then put on and two Squirrel probes, which measured temperature and humidity, were placed inside the shirt and between the shirt and the suit. Finally, the subject walked on the treadmill, at a 5 percent grade and 3 miles per hour, under heat lamps simulating the sun's rays. The subject walked until his core temperature rose 1.5 degrees C. from his initial core temperature.

Multiple measurements were taken during each run. The computer recorded the readings from the heat sensors and the heart rate telemeter. The computer also recorded rectal temperature, which was used as the basic body temperature. Each of these readings were averaged at half-minute intervals and stored in a spreadsheet as well as printed out. Squirrel, wet bulb, and dry bulb readings were taken by hand every 5 minutes. The subject was also asked his thermal comfort and perceived exertion (RPE) at the same five-minute intervals.

After the run, the subject was rested for fifteen minutes in a chair, during which time he could drink water. Each serving was 400 ml. and consumed at the subject's option. Following the rest period, the final clothed and nude weights were recorded in the same fashion as the initial weights. These weights were taken to calculate sweat evaporation and sweat production values during the experiment. All water consumed was taken into consideration when doing the calculations.

Equipment

The two types of suits focused on in this study were the CDE + BDU (battle dress uniform, known as fatigues) and the CWU-77P uniform. Both ensembles contain a charcoal-foam protection layer. Both a CDE and battle dress uniform constitute the CDE + BDU ensemble.

Statistical Analysis

The final data displayed in this report are means derived from all data recorded. The data is directly compared and contrasted in both graph and written form. Rigorous and complex statistical models were not created because of the immense amounts of relevant data.

FINDINGS

The two chemical warfare suits on which this study focused were tested in identical conditions and the experimental protocol was followed as closely as possible for each trial. For these reasons, the data presented will be accurate enough to lead to comparisons concerning the general performances of the suits.

Eleven subjects were tested and each one completed the protocol in each of the suits. The means were calculated for each suit every 0.5 minutes. The data is presented here in both line and graph form.

Three variables were presented in the visual representations. Heart rate was chosen because it indicates how hard the heart is working to carry excess heat to the skin for dissipation. Higher average heart rates tend to highlight the hotter suits. Time is shown because it displays how long the subject was able to excercise before his body core temperature rose the preset value (1.5 degrees C.).

Body core temperature is used as a basis for the overall

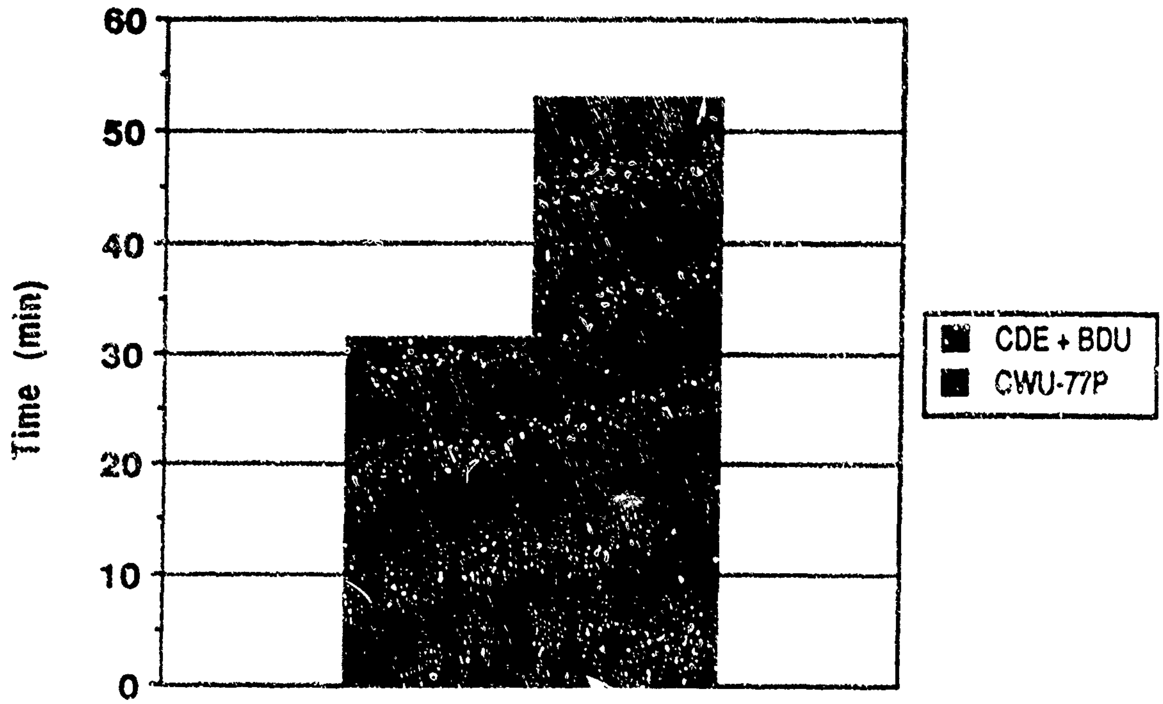

Figure 1: Average tolerance times for each suit

effectiveness of the suit, where higher rates of elevation in core temperature were characteristic of the hotter suits.

The three graphs presented in this paper show the CWU-77P ensemble clearly outperforming the CDE + BDU in the test runs. The mean run lengths in minutes is shown for each suit in diagram one. The CWU-77P's time is 53.18 and the CDE + BDU is graphed at 33.09 minutes. The former performed 61% better in the experimental situation. This is a significant difference in favor of the CWU-77P's performance.

Diagrams two and three compare heart rate and body core temperature with time (bar graph) for each suit. Both show the CWU-77P ensemble allowing more heat to dissipate, proven by the suit's lower initial and final values, and thus lessening the amount of physiological stress on the subject. The CDE + BDU ensemble is shown to have performed worse for the tests, evident in the sharp increase in the graphs.

DISCUSSION

It is conjectured that the CWU-77P suit is better than the CDE + BDU in highly stressful situations for troops.

Several factors could have contributed to the better performance of the CWU-77P suit. First off, all CDE + BDU tests were conducted in February, as opposed to June for the other suit. Because of the generally hotter climate in June, the subjects were more acclimated to the excessive heat and humidity within the

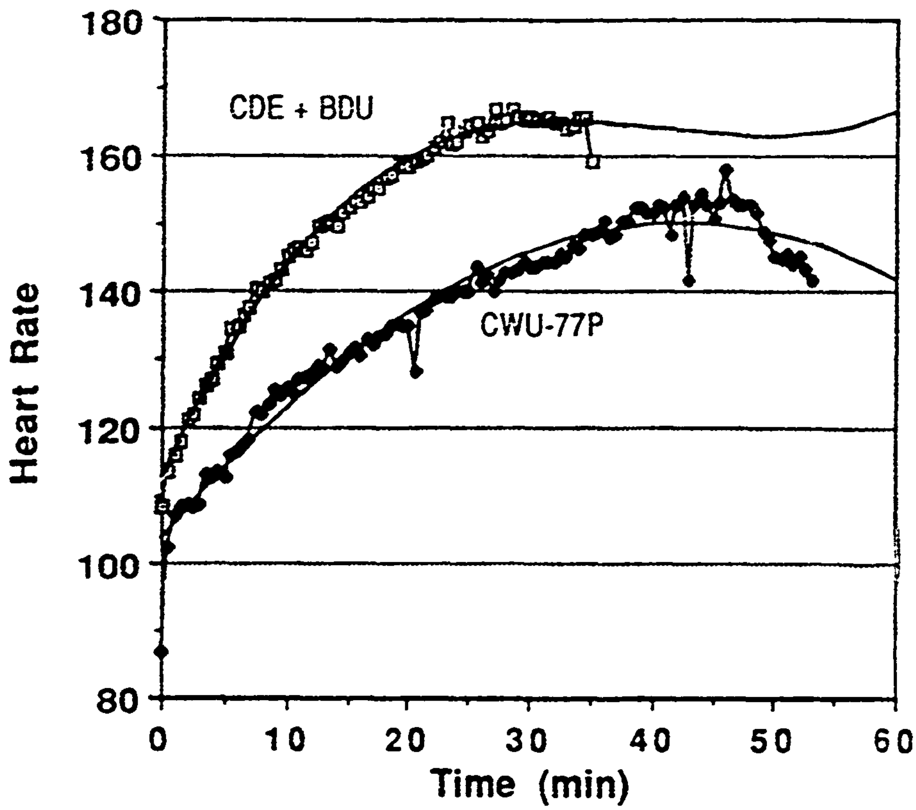

Figure 3: Heart rate plotted against working time for each suit

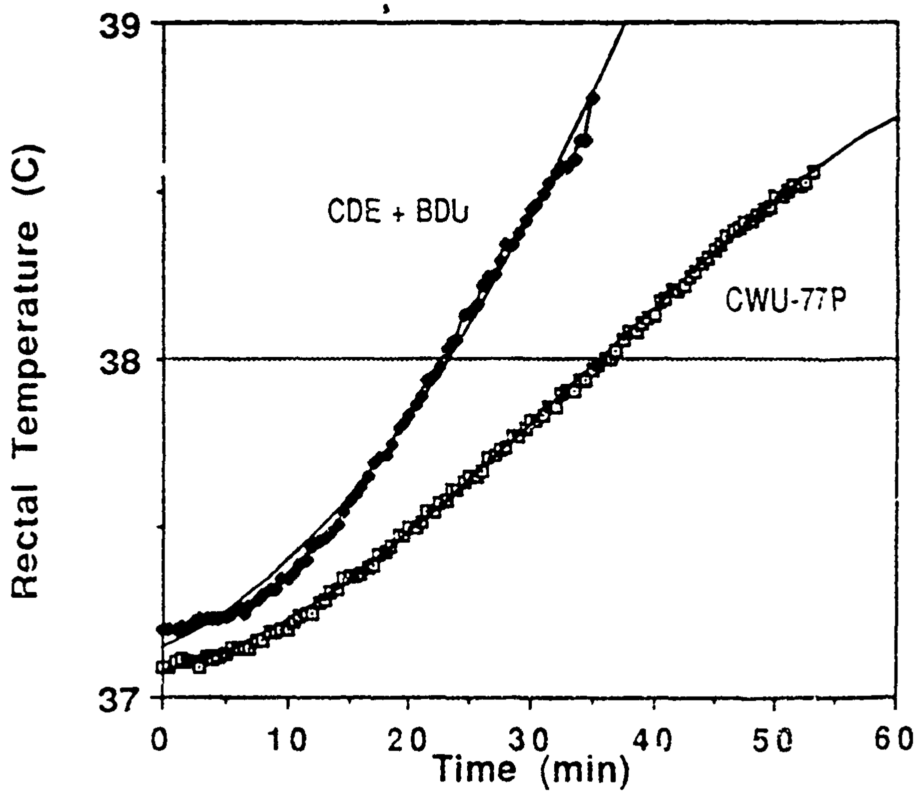

Figure 2: Rectal temperature plotted against tolerance time for each suit

chamber. This leads to more efficient metabolism and thus less heat generated in the body. Also, the CDE + BDU had more clothing layers, decreasing the heat dissipation by significant amounts. Finally, it should be noted that the evaluation of the ensembles did not take into consideration their ability to protect the wearer. One suit may allow more air circulation as well as chemicals inside the suit, eliminating its physiological advantages.

In summary, the CWU-77P ensemble's exemplary performance set it ahead of the competing CDE + BDU ensemble. The former outfit outdistanced the other by a substantial, decisive margin in all three categories analyzed here. Its ability to dissipate heat, generated during physical work sessions, was shown to surpass that of the CDE + BDU. The general thermal comfort of the CWU-77P suit, according to the subjects, suggested an improvement from the CDE + BDU outfit, finally proving the CWU-77P's general physiological superiority in hot physical work sessions.

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Report #1

CALCULATION OF THE FRACTAL DIMENSION OF GRAPHICAL DATA

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High School Apprentice

Abstract

An investigation was made into the construction of recursive fractals and the determination of the fractal dimension of time-series data. The fractal dimension is a quantitative measure of the complexity of the data. Two methods of determining this dimension, the "compass" method and the grid method were tested on objects of known fractal dimension and compared. It was discovered that, while both methods produced dimension estimates accurate to within one decimal place, the compass method was inefficient when a small compass radius was used, and the grid method was inefficient when presented with a large number of data points. It was also found that the grid method is capable of distinguishing between patterned and random data.

Introduction

Fractals are mathematical objects which exhibit complexity on all scales of measurement. This attribute of levels upon levels of complexity is well known in the natural world. Snowflakes, trees, and mountain ranges all contain intricate detail at different viewing scales. Complexity of this type is also inherent in time-series data which is labeled "chaotic". Examples of chaotic phenomena include fluid turbulence, weather patterns, and population growth. The presence or absence of fractal scaling can be measured by a number called the fractal dimension. By determining the fractal dimension of a data set or a physical object, a valuable measure of complexity is obtained. Standard statistical measurements, such as the standard deviation, mean, and correlation coefficient, are ineffective at quantizing the tendency of the data to fall into a pattern. By showing how the intricacy of the information varies as the length scale, the fractal dimension gives a wealth of information about a system's characteristics. For the purposes of modeling physical behavior mathematically, the fractal dimension can also help to determine how many variables are necessary to completely characterize the system. This number, known as "the topological dimension of the phase space plot", is essential to the writing down of a modelling equation.

The mathematics of fractal scaling is based on simple observations of scaling in the number of similar "parts" which make up normal Euclidean objects. For example, consider a straight line. It can be decomposed into three segments each of which is scaled down 3 times from the total length. We say that a line is one-dimensional, because the number of pieces 3 is equal to the scaling factor 3 raised to the power 1. This line of reasoning can also be applied to a square. A square can be broken up into 9 pieces, each of which has a side scaled down by a factor of 3 from the original side. Squares are then two-dimensional, because $9=3^2$. Similarly, cubes can be considered to be made up of 27 smaller cubes with sides scaled down by a factor of three from the whole. Three-dimensionality follows from $27=3^3$. As a generalization, the following assertion can be made. For any object made up of N parts, each scaled down from the whole by a ratio r, $N=r^D$. Taking logarithms of both sides and solving for the dimension gives $D=\log(N)/\log(r)$. The virtue of this seemingly obvious definition is the fact that certain objects can have dimensions which are not integers. Objects for which D is a nonintegral number are known as fractals. The word "fractal" was invented by Benoit Mandelbrot and comes from the Latin fractus, meaning "fragmented" or "irregular". Many objects which are characterized as fractal are indeed rough-looking. " can also be considered to be a contraction of "fractional".

Fractal scaling is characterized by the so-called space-filling curves. One of the best-known fractals is designated the Von Koch construction, after its discoverer, mathematician Helge von Koch. The curve, which resembles a snowflake, is presented in its first few stages in my first illustration. The construction of the Koch curve is performed by the method of successive replacements. To begin with, a line segment is replaced by 4 parts scaled down from the length of the original by a factor of three. Then, each of these segments is replaced in the same manner. This leads to a hierarchy of spikes within spikes. At each stage of construction, the curve increases in length by a factor of 4/3. However, at no point does it intersect itself. Naturally, therefore, the fully constructed Koch curve can be said to consist of an infinite curve length confined to a finite area. The von Koch construction is composed of 4 parts, each scaled down from the whole by a factor of 3. Its fractal dimension is therefore log(4)/log(3) or approximately 1.262. A similar curve to the snowflake is one which replaces the spike with a plateau. This object, which is not given a specific name, is shown in my second illustration. This construction is composed of 5 parts, each scaled down from the whole by a factor of 3. Its fractal dimension is therefore log(5)/log(3) or approximately 1.465. Because this curve has a higher dimension than the Von Koch construction, it can be said to fill more of the plane than the former.

The Von Koch construction and similar fractals have been used as models for coastlines, clouds, and trees, as well as models of the structures of turbulent air flow and crystal growth. The fits have been striking. This has led many scientists to believe that the geometry of the natural world is fractal. For this reason, and because of the usefulness of the fractal dimension as a measure of complexity, much current research has been performed into the problem of measuring and computing D for physical objects and for experimental data. The latter is the object of this paper.

Discussion of Problem

Much of the data obtained in experiments which occur throughout an extended period of time is in the form of time-series. Time-series are sequences of experimental measurements of the numerical values of an observable at different times. Various methods, including statistical tools, are utilized to extract information from these sequences of numbers. In this report, analysis was performed on a phase space plot of the time-series. A phase space plot is a way to visualize the changes in the state of the experimental system. To construct such a representation, one must first decide how many numbers are needed to accurately characterize the system. This will indicate how many dimensions must be incorporated into the diagram. For example, if a piston could be characterized by the temperature, pressure, and volume of the gas inside, then the piston system's phase space plot would have three dimensions, one for each variable. Each point in phase space would then correspond to one combination of variables. Once the values of the variables had been measured at a large number of different times, the actual values could be plotted as points. The final structure which emerges reveals much about the behavior of the system. For phase space plots of less than four dimensions, a picture can be produced which is a powerful visualization tool. In fact, for four dimensions, an animated 3-D phase space plot could be used to view the 4-D object (Assuming that one of the dimensions is time.).

The production of the plot is only the beginning, however. Several analytical tools have been developed to elucidate the implications of the maze of lines produced. The mathematical area of topology has proven useful in determining how the twists and turns of the plot go together to produce a path, or a trajectory, through phase space. Another method frequently employed is the computation of the Lyapunov exponent spectrum. It provides a measure of the tendency of phase space trajectories to remain "close" to each other. In chaotic systems, small changes in initial conditions can bring about huge changes in behavior. If trajectories remain close together, then the Lyapunov exponents are infinite and the system is considered to be "infinitely predictable" (i.e. not chaotic). Finite exponents indicate chaos. The number and signs of the exponents can be used to determine the dimension of the chaotic attractor. As the Lyapunov spectrum can be calculated roughly from a single time-series, knowing the dimension of the attractor can be a great help in the initial problem of how many dimensions to use for the phase space plot. More to the point of this report, however, it has been discovered that the structure of chaotic phase space plots is fractal. This fact makes sense when the closeness of trajectories is taken into account. If, by picking some point a tiny distance away from one trajectory, a completely separate trajectory can be found, then the phase space plot must in some manner incorporate more detail and complexity than a Euclidean surface or line. By computing the fractal dimension, then, one obtains a measure of the complexity and self-similarity of the chaotic phase space attractor. Even for data which may not be strictly chaotic, the fractal dimension gives a quantitative indication of the complexity of the system's activities.

There are a few inherent problems with the determination of the fractal dimension. The dimension is a property which is, by definition, independent of scale. Therefore, decrease in the accuracy of experimental measurements at smaller scales (which is, of course, difficult to avoid) can create a range of dimensions for different scales. This phenomenon has been noted as a real feature of physical phenomena, but the theoretical interpretation of a varying fractal dimension for a phase space plot is unclear. In any event, scaling holds over a wide enough range that it can usually be applied successfully.

Before the fractal dimension can be used, however, it must be measured. A number of methods for performing this operation have been developed, but all of them are dependent upon the logarithmic scaling inherent in the definition of fractals. An obvious method which is, as it turns out, not widely used, is the compass method. This is the method originally tested in the preparation of this report. The compass method follows directly from the recursive generation of fractal images like the Von Koch construction. Simply, this measurement consists of taking a compass open to a specified width and walking it along the curve. The number of compass widths is taken to be N, and the ratio of the distance from the first point to the last point to the compass width is taken to be r. Then D is log(N)/log(r). An example of the analysis of the Koch curve in this manner is provided by my third illustration. One interesting feature of the compass method is that it is usually not necessary to interpolate with all of the data points. The points between radii can be skipped over.

Despite its logical simplicity there are certain disadvantages which one encounters in using the compass method. One problem arises from the fact that the program is required to make calculations of slope and distance and to use an equation to interpolate points. This makes it difficult to program; a number of cases must be checked for, and the program must work for all data, no matter how sparse or complex. Rounding error and floating-point problems also have the potential to produce spurious results. Another thing which is unclear unclear is what should be done about such problems as the implications of fractional radii or how the first to last length of the curve should be computed. In addition, if the length of one radius is very much smaller than the average distance between points, the radii fit very closely to the data line. The large number of interpoint-interpolation calculations performed wastes CPU time and gives very little in terms of fine detail. A problem unique to the compass method is that it is possible to calculate a dimension of greater than 2 for a two-dimensional plot. The basis of the compass method is the assumption that the data set approximates a recursive non-self-intersecting fractal. That is, if each radius was replaced by a scaled down copy of the entire pattern, a fractal would be produced of dimension log(N)/log(r). For, say, random data, the replacement of each radius by the interpolated pattern would produce a fractal, but it would be one which would probably intersect itself a number of times. Conceivably, this could produce a D>2.

A dimension-measuring technique which is often used by practical investigators is the "grid" method. Its programming is exceedingly simple. All that is necessary is to create a two-dimensional array normalized to the range of the data. Then, each point is checked to see if its array element has been filled or not. If it has, nothing happens. If it has not, then the box is filled. For a small number of points (N<5000), this operation of running through the points takes very little time. There are only a few special cases to consider; a point might be outside the grid, or a point might be on a grid line. Both cases are easily dealt with. None of this requires the interpolation and number-crunching of the compass method. This lack of complex calculations means that there are fewer places where something can go wrong with the program.

The drawback to the grid method is that it is inefficient when a large enough number of points is included. Every data point must be counted. When the number of points is fairly small, this is no difficulty, but the determination of an accurate fractal dimension requires a sufficiently large number of points. It has been estimated that the minimum requirement is 30^d, where d is the topological dimension of the phase space plot.

The "grid" and "compass" methods are by no means the final word in fractal-dimension-measuring algorithms. However, these were the only methods tested in this paper. A method based on an "expanding sphere" is often used by mathematicians because it can be implemented with phase space plots of any topological dimension. It entails randomly placing a sphere of known radius amidst the points and counting how many of them fall within it. D is calculated from this number and the radius. This is an improvement over the grid method because the data can be sectioned off so that not every point need be tested. One of the original definitions of fractal dimension involved the minimum number of spheres necessary to fully cover the data set. Conceptually, this sphere packing is useful for proving theorems and deriving equations, but it is difficult to implement as a computer program. The "sausage" method is often used by mathematicians and scientists who have a two-dimensional object to perform on which to perform measurements with rulers and pencils. It involves finding the area of a strip drawn a specified distance from the curve. The length of the curve, from which the dimension can easily be calculated if one knows the specified distance, is simply the area divided by the width of the strip. This method is easy to apply manually, but the computations become too intense for a computer unless approximations are made.

All of the above methods produce a dimension value if supplied a length scale. The fractal dimension, however, should be independent of scale. For this reason, it is necessary to make a plot of log(N) vs log(r). Of course, if the object is fractal on all scales, then the plot will be a straight line with a logarithmic slope equal to the dimension. For natural objects, what is seen generally is that the middle portion of such a curve is relatively straight, while the ends tend to be curved. For the compass method, the equation D = logarithmic slope of N vs r curve is applied directly to the plot. For the grid method, the equation is put into the slightly different form D = 1 - logarithmic slope of (N * grid side) vs grid side. Some plots do not behave properly, of course. The slope may be ambiguous, even in the middle. Such curves do not provide a unique dimension, although the range of dimensions may be useful as a measure of the changes in complexity. For example, for plots of animal behavior versus time, a steadily increasing dimension may be interpreted as an increase in behavioral complexity over time.

Methods

Algorithm for Constructing Koch Curve

(Two procedures, bump2.rpl and dist.rpl, which were used to construct this curve are included in this report. The algorithm for constructing the other fractal is similar to this and is given in procedure bump3.rpl, which is also included.)

All points are specified by Cartesian coordinates.
Create a table in which to store x-y coordinates.
Begin with a single pair of points (0,0) and (1,0).
For each pair of adjacent points in the table, do the following:

- These two points P1(x1,y1) and P2(x2,y2) represent the ends of a segment.
- Compute distance between the points, d=sqrt((y2-y1)^2+(x2-x1)^2)).
- Compute slope of line P1P2, m=(y2-y1)/(x2-x1).
- Interpolate points P4(x4,y4) and P5(x5,y5) on the segment at distances from P1 of d/3 and 2d/3, respectively.
- **Use spike formula to compute the coordinates of P3.

Insert points P3, P4, and P5 into the table of segment coordinates in the correct order. (i.e. P4,P3,P5)

Graph these points.

Repeat until either the desired level of precision is reached or the process becomes too time-consuming for the computer to perform. (Because of the recursive nature of the algorithm, the number of points in the curve will be an exponential function of the number of iterations performed.)

**It is necessary to derive a formula for the coordinates P3(x3,y3) of the spike, using the facts that P3 is d/3 units from P4 and P5, and that the spike is intended to point outward from the surface of the curve. (This entails noting whether x2>x1 or x1>x2. One case is the reverse of the other.)

Results

My original intent was to use the compass method exclusively, because it was the first method to which I was introduced. I developed an algorithm and a procedure written in RPL to perform the computations. The procedure was dubbed fracd.rpl. This first version assumed that the data could be considered to be spaced one unit apart. Because I wanted to test the procedure on a fractal of known dimension, this restriction had to be removed. My revised procedure was named fracdxy.rpl and could accept x and y data. A streamlined version, lenxy.rpl, is included in this report. Lenxy accepts x and y data, checks for empty values, and returns the number of compass widths interpolated and the dimension value calculated. A separate procedure was used to construct a loop so that a range of radii could be tested out and a log-log plot constructed. The plot which was obtained is included. A graph of the point-to-point slope is also provided. The degree of fluctuation of the slope is at first sight astounding for a curve which appears to be a fairly straight line. The definition of the fractal dimension as the absolute value of the slope of this line seems difficult to apply to a line of varying slope. However, the average value of the slope is -1.23, which is very close to the expected value of -1.26. Apparently, the compass method gives values correct to within about one tenth of the accepted value when the slope is averaged.

Problems were encountered in employing the compass method. Because the objects considered are scaled fractally, the number of radii necessary to trace out the curve increases exponentially as the radius decreases. An algorithm which performs in 2^N time is not exceedingly efficient if a small radius is used. Therefore, the grid method was instituted to speed up the process and the compass method was discontinued.

My procedure for executing the grid method was very simple, because it would run through all of the data points and determine whether or not a grid box was filled. If it was not, then it would be filled in. If it was, then it would be left alone. Different length scales could be tested out by changing the fineness of the grid. This was much faster, because no calculations needed to be performed, and the procedure would take approximately the same amount of time to execute no matter what the length scale. (There was an increase in time associated with memory allocation for extremely large grids, but this increase was small compared with the rate at which execution time increased for the compass method.)

Also, the simplicity of the grid algorithm made it clearly superior in terms of debugging time. A number of conceptual problems had arisen for the implementation of the compass method. For example, how should the program deal with the fact that the radii usually did not fill in the line to the end? I tried truncating the number of radii at the last one, but that strategy intensified the slope oscillations. My solution was to draw a fraction of a radius to the final point and add that fraction to the total. Few, if any, researchers have used the compass method, so there were no references that I could find to get guidance as to how these problems should be dealt with. The grid method, which was simple and widely used, eliminated such problems.

A graph of the results obtained from the grid method is included in this report. Certain salient features of this plot should be noted. First, notice that the Koch curve boxes fall into a fairly straight line. As before, the average slope of this line is used to calculate the approximate dimension. In this case, however, the dimension is 1 - slope. A function of the form 'ax^b' is fitted to the line. Logarithmic slope is equal to b. The calculated dimension for the Koch curve is 1.279, which is within about a tenth of 1.262, the accepted value. Note that the diamonds of the "boxed" construction (the other fractal) also fall into a straight line. The logarithmic slope is equal to 1.389, which approximates the expected value of 1.465 to about one decimal place.

An interesting fact can also be obtained from the measurements of random data. Two sets of random data were separately generated and tested. The 2-D Random curve was produced from random x and y data. The Evenly-spaced Random curve was obtained for random y data spaced evenly on the x axis. The two curves fall almost precisely into step. It is obvious also that the data do not fall into a straight line, although the lower range seems to be approaching a line with a logarithmic slope of 1. As this would produce a dimension of zero, this makes sense for a portion of the analysis where the grid is so fine that the points become separated by a relatively large number of boxes.

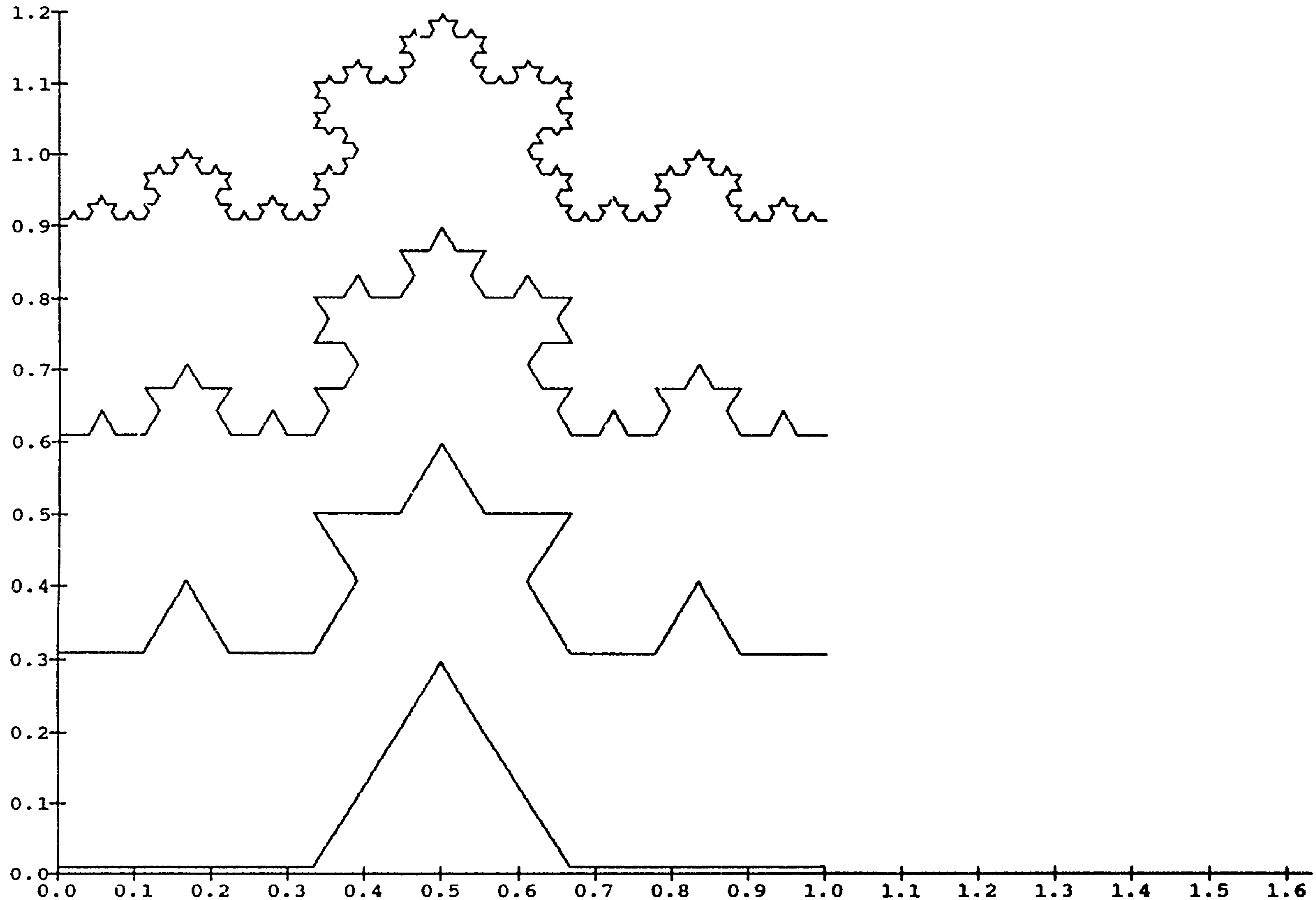
Conclusions

Two methods of fractal-dimension measurement have been tested; these are the compass method and the grid method. The compass method produced conceptual problems and was slow to run. The grid method was faster and simpler. For both methods, accurate dimensions were obtained, although the precision was not as high as desired. That is, dimension measurements were accurate to no more than one decimal place. For objects which were not fractal (the randomly generated data) a logarithmic plot sufficed to produce convincing evidence of this.

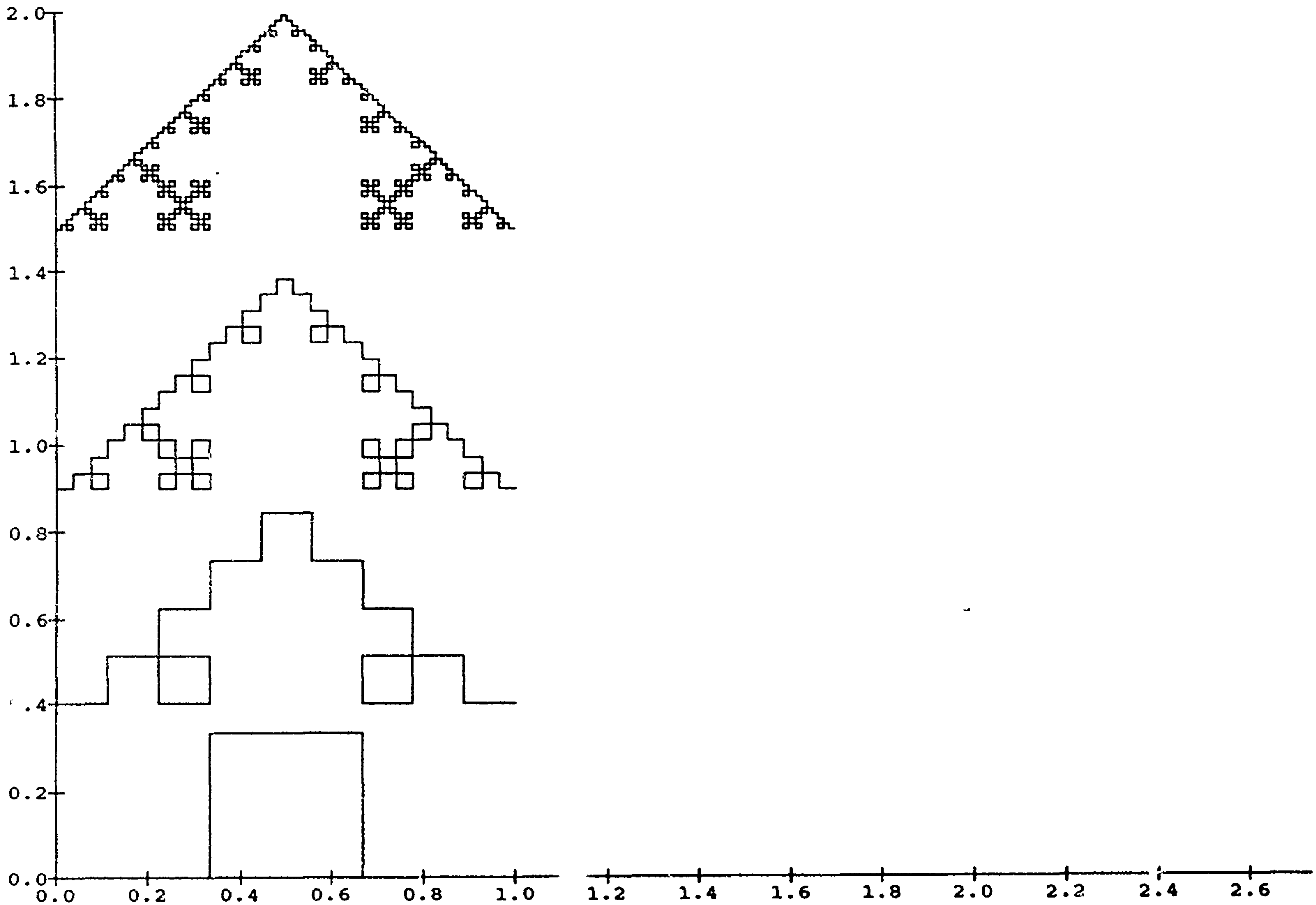
The intended application of this work is as a means of measuring the complexity and patterning inherent in experimental data. Because of this, more work needs to be done in terms of preparing the procedures to work with the raw data. For instance, the grid must be normalized to fit the range of the data. For this report, it was assumed that x and y data would not be outside of the range 0 to 1. This is an artificial assumption which held true for the iteratively-constructed fractals used to test the process. The removal of this restriction will require simple, but as yet unmade, modifications to the procedure.

Another application for which these procedures are intended is as a "moving window" of fractal-dimension measurement. What this means is that, for an experimental curve, a dimension will be calculated as new points are encountered. In this way, a plot of the dimension as a function of the independent variable (probably time), can be obtained. Because the dimension is also a measure of the complexity of the curve, this plot will also serve as an indicator of the complexity of the system's behavior over time. The ability of the grid method to distinguish between fractal scaling and randomness will also be helpful in deciphering random behavior from behavior which has an underlying phase space fractal structure (i.e. chaotic behavior, which is nonrandom but unpredictable).

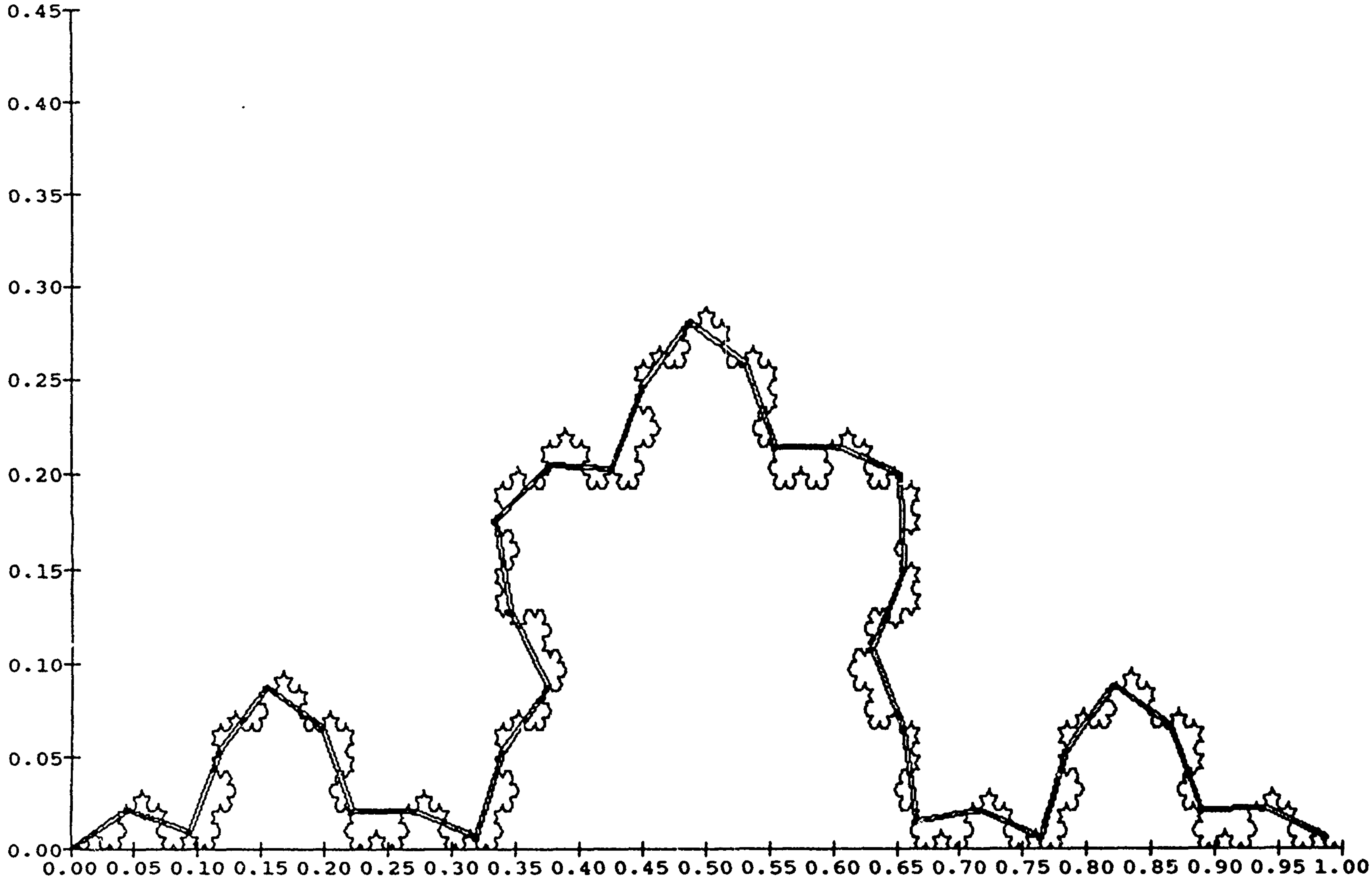
Von Koch Construction - Four Levels of Complexity



Fractal Construction of Dimension 1.465 - Four Levels of Complexity



Compass Method Applied to Koch Curve



N~32.3 r=20

```
/* Bump2 - Uses cols 1,2 of table tab to give points of koch curve. */
procedure(tab);
  if not obj$exists(tab,obj_type)
    then
      call error(cat("No such object as ",tab));
  if obj_type <> "TABLE"
    then
      call error("Object must be a table of x and y values.");
  n=lastrow(tab)-1; /* Number of spikes to make. */
  /* Copy points into temporary table, spreading them out. */
  allocate table(temp) 4*n+1 rows by 2 columns;
  do a=1 to n+1;
      k=4*(a-1)+1;
      temp[k,1]=tab[a,1];
      temp[k,2]=tab[a,2];
  end;
  /* Insert spikes into temp. */
  do i=1 to n;
    x1=tab[i,1]; y1=tab[i,2];
    x2=tab[i+1,1]; y2=tab[i+1,2];
    d=sqrt((x2-x1)**2+(y2-y1)**2);
    m=(y2-y1)/(x2-x1);
    if x1>x2 /* Backward-tilting segment. */
      then
        x4=x1-d/3/sqrt(1+m*m);
      else
        x4=x1+d/3/sqrt(1+m*m);
    y4=y1+m*(x4-x1);
    if x1>x2
      then
        x5=x1-2*d/3/sqrt(1+m*m);
      else
        x5=x1+2*d/3/sqrt(1+m*m);
    y5=y1+m*(x5-x1);
    /* Compute midpoint to use for spike. */
    xm=(x1+x2)/2;
    ym=(y1+y2)/2;
    if x1>x2
      then
        x3=xm+m*d*sqrt(3)/6/sqrt(1+m*m);
      else
        x3=xm-m*d*sqrt(3)/6/sqrt(1+m*m);
    if abs(m)<0.001 then m=0; /* We're working with decimals here. */
    if m=0  /* Protect against division by zero. */
      then
        if x1>x2  /* Going over segment backwards. */
          then
            y3=y1-d*sqrt(3)/6; /* Case - horizontal segment. */
          else
            y3=y1+d*sqrt(3)/6;
      else
        y3=ym-(x3-xm)/m;  /* Normal case. */
    /* Record calculated points in temp. */
    k=4*(i-1)+1;
    temp[k+1,1]=x4; temp[k+1,2]=y4;
    temp[k+2,1]=x3; temp[k+2,2]=y3;
    temp[k+3,1]=x5; temp[k+3,2]=y5;
  end;
  /* Copy points back into tab, for permanent storage. */
  allocate table(tab) lastrow(temp) rows by 2 columns;
  do r=1 to lastrow(temp);
    tab[r,1]=temp[r,1]; tab[r,2]=temp[r,2];
  end;
end;
```

_RZVUX1$DUBO:[ZIRIAX]BUMP3.RPL;1 13-AUG-1991

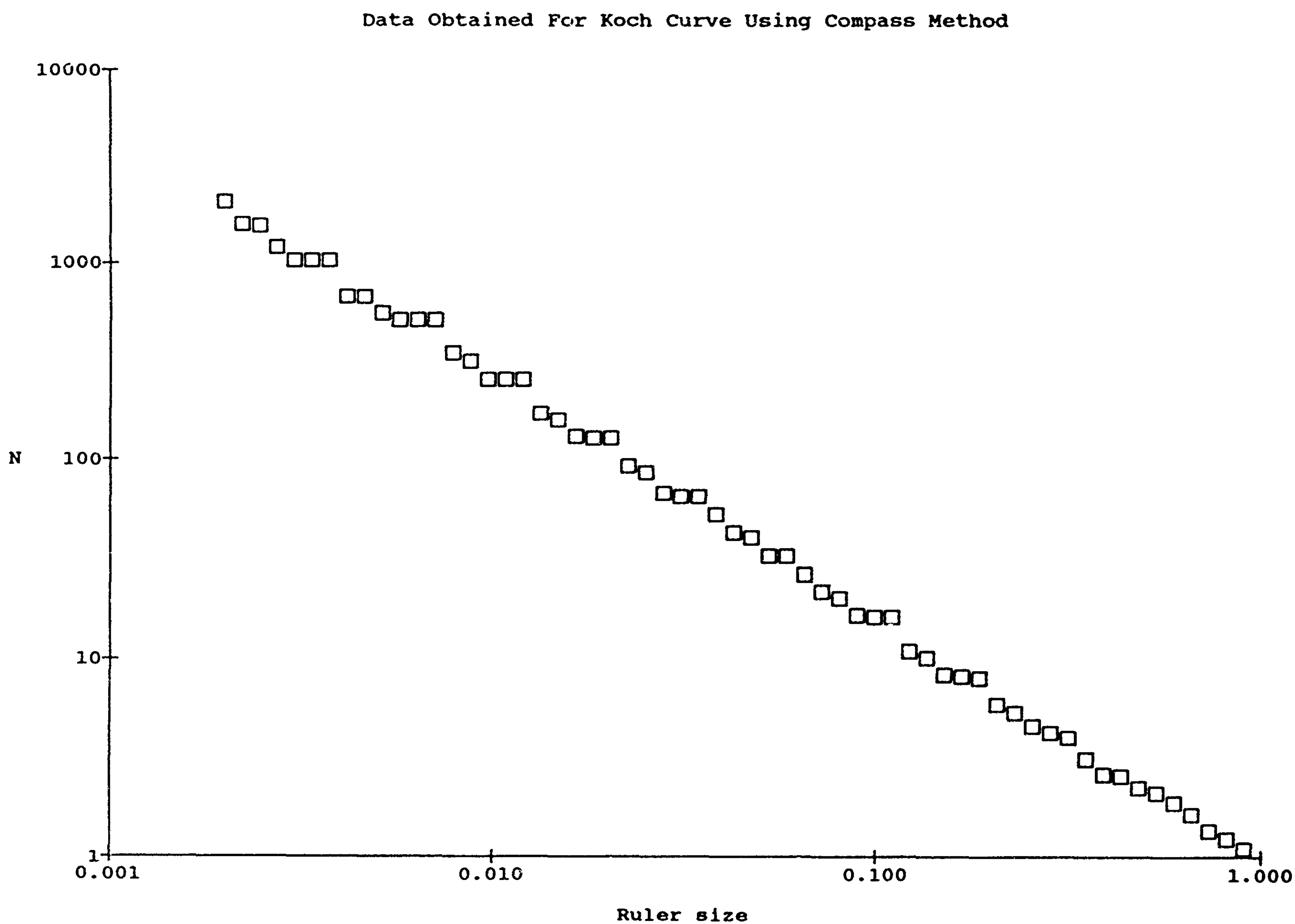
```
/* Bump3 - Uses cols 1,2 of table tab to give a fractal of dimension
    D=ln(5)/ln(3).  Approx. 1.4649.  See Mandelbrot, The Fractal
    Geometry of Nature, New York: W.H. Freeman and Company, 1983, p.139. */
procedure(tab);
  if not obj$exists(tab,obj_type)
    then
      call error(cat("No such object as ",tab));
  if obj_type <> "TABLE"
    then
      call error("Object must be a table of x and y values.");
  n=lastrow(tab)-1; /* Number of spikes to make. */
  /* Copy points into temporary table, spreading them out. */
  allocate table(temp) 5*n+1 rows by 2 columns;
  do a=1 to n+1;
    k=5*(a-1)+1;
    temp[k,1]=tab[a,1]; temp[k,2]=tab[a,2];
  end;
  /* Insert spikes into temp. */
  do i=1 to n;
    x1=tab[i,1]; y1=tab[i,2];
    x2=tab[i+1,1]; y2=tab[i+1,2];
    if y2-y1=0
      then  /* Horizontal case. */
        begin;
          d=x2-x1;
          x3=x1+d/3; y3=y1;
          x4=x3;     y4=y3+d/3;
          x5=x4+d/3; y5=y4;
          x6=x5;     y6=y1;
        end;
      else  /* Vertical case. */
        begin;
          d=y2-y1;
          x3=x1;     y3=y1+d/3;
          x4=x3-d/3; y4=y3;
          x5=x4;     y5=y4+d/3;
          x6=x1;     y6=y5;
        end;

    /* Record calculated points in temp. */
    k=5*(i-1)+1;
    temp[k+1,1]=x3; temp[k+1,2]=y3;
    temp[k+2,1]=x4; temp[k+2,2]=y4;
    temp[k+3,1]=x5; temp[k+3,2]=y5;
    temp[k+4,1]=x6; temp[k+4,2]=y6;
  end;

  /* Copy points back into table, for permanent storage. */
  del table(tab);
  make table(tab) from table(temp);
end;
```

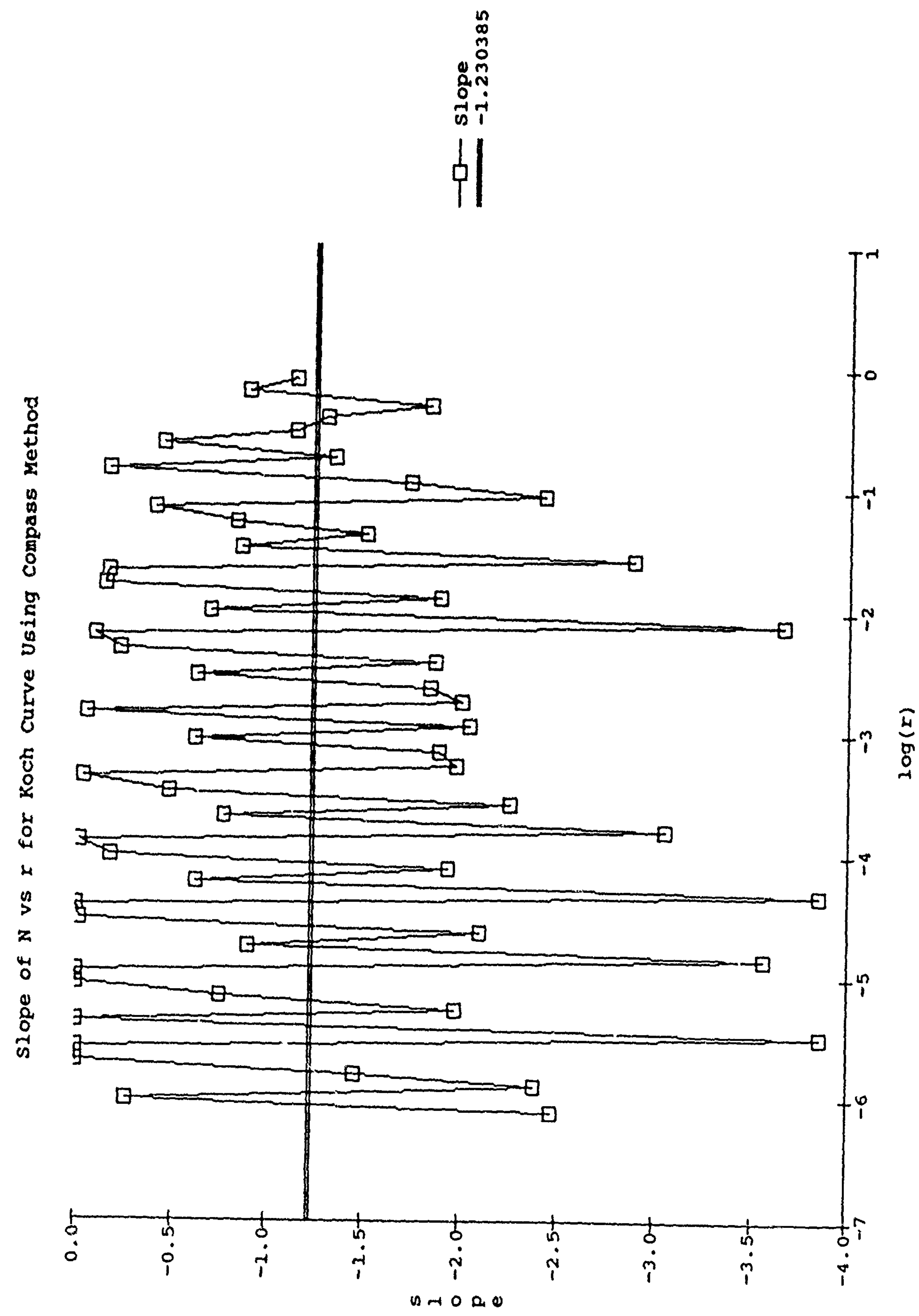
_RZVUX1$DUBO:[ZIRIAX]DIST.RPL;1 13-AUG-1991

```
/* Dist - Returns distance between two points (x1,y1) and (x2,y2). */
procedure(x1,y1,x2,y2);
        return(sqrt((x1-x2)**2+(y1-y2)**2));
end;
```

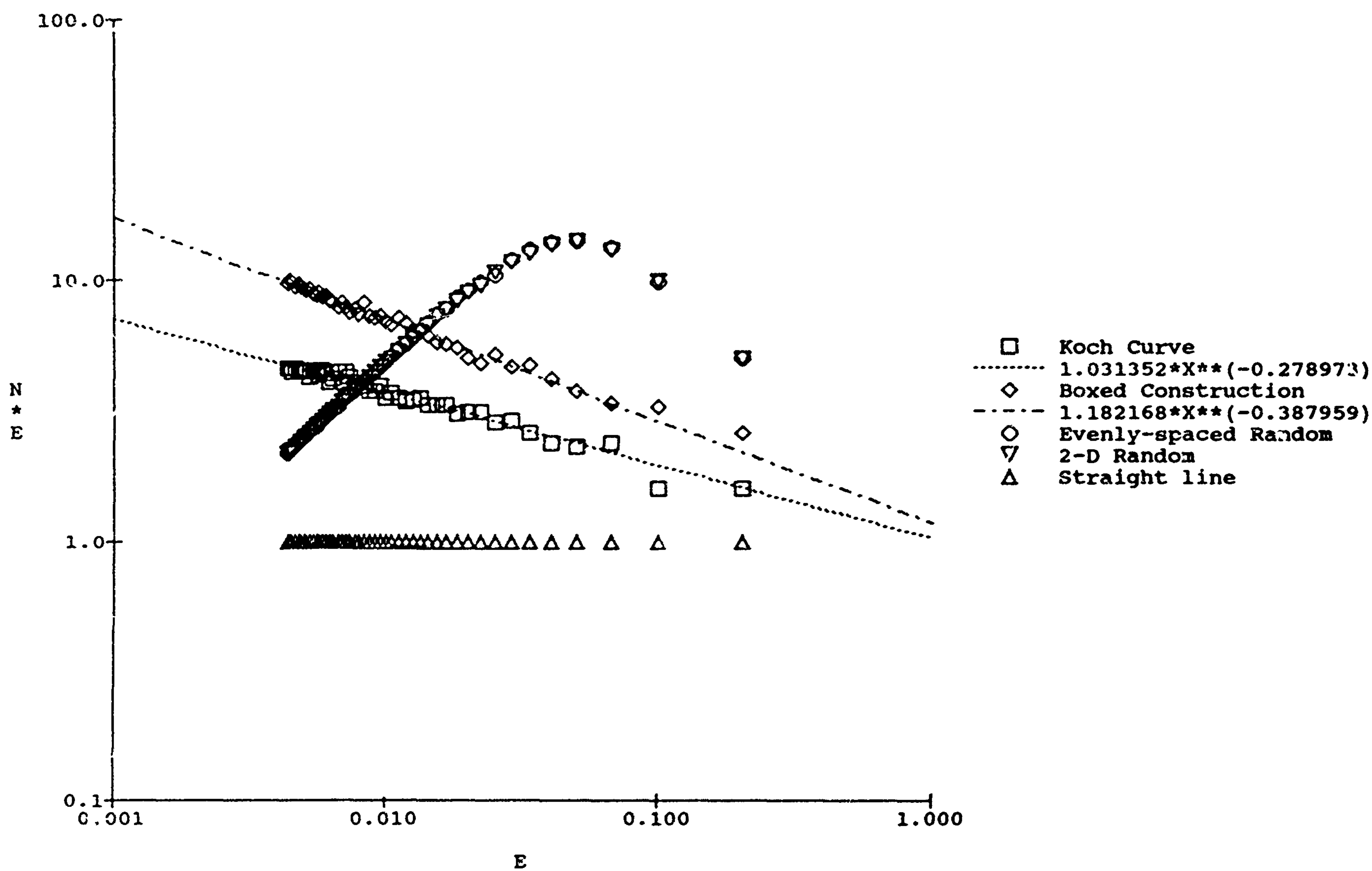
```
/* Lenxy - Returns number of compass widths, given tableportions tpx and tpy
 and ruler length r.  Lenxy records points in table "lenxy_dims"
 if rec_points is set to true. */
procedure(tpx,tpy,r,rec_points);
  tpx=tableportion(tpx);
  tpy=tableportion(tpy);
  if not $tpcheck(tpx) or not $tpcheck(tpy)
    then
      call error("No such tableportion exists.");

  call $tp2t(tpx,t,1);  /* Put tableportions into table t. */
  call $tp2t(tpy,t,2);

  if obj$exists("lenxy_dims")
    then
      tbl$truncate("lenxy_dims");
    else
      maketable("lenxy_dims",lastrow(t),2);
  dims="lenxy_dims";

  xn=0;
  /* Begin with first non-empty point. */
  do while empty(xinit) or empty(yinit);
    xn=xn+1;
    xinit=t[xn,1];
    yinit=t[xn,2];
  end;
  firstn=xn;    /* Records index of first non-empty point. */

  max=lastrow(t);
  /* Use last non-empty point as maximum value. */
  do while (empty(t[max,1]) or empty(t[max,2])) and max>0;
    max=max-1;
  end;

  N=1;
  do while true;  /* Loop terminates at end point. */
    if rec_points
      then
        begin;
          dims[N,1]=xinit;
          dims[N,2]=yinit;
        end;
    /* Get distance to next non-empty point. */
    do while empty(t[xn+1,1]) or empty(t[xn+1,2]);
      xn=xn+1;
    end;
    d=dist(xinit,yinit,t[xn+1,1],t[xn+1,2]);
    looped=false;
    do while (d<r) and (xn<max);
      xn=xn+1;
      if not empty(t[xn,1]) and not empty(t[xn,2])
        then
          d=dist(xinit,yinit,t[xn,1],t[xn,2]);
      looped=true;
    end;
    if (d<r) and xn=max  /* If it has gotten to the end point, stop. */
      then
        begin;
          dims[N+1,1]=xinit;  /* Record final point. */
          dims[N+1,2]=yinit;
          /* Add in fraction of radius left over. */
          N=N+dist(xinit,yinit,t[max,1],t[max,2])/r;
          doexit;
        end;
    if looped
```

```
      then
        xn=xn-1;

    /* Interpolate, using first previous non-empty point. */
    do while empty(t[xn,1]) or empty(t[xn,2]);
      xn=xn-1;
    end;
    xprev=t[xn,1];  yprev=t[xn,2];

    /* Second point must be next non-empty value. */
    do while empty(t[xn+1,1]) or empty(t[xn+1,2]);
      xn=xn+1;
    end;
    xnext=t[xn+1,1]; ynext=t[xn+1,2];

    /* Use distance, slope, and points to compute landing point. */
    xinit=interp(xinit,yinit,r,xprev,yprev,xnext,ynext);
    m=(ynext-yprev)/(xnext-xprev);
    yinit=m*(xinit-xprev)+yprev;
    N=N+1;
  end;
  global lenxy_length_total=dist(t[firstn,1],t[firstn,2],xinit,yinit);
  if global("lenxy_length_total")/r=1
    then
      global lenxy_fractal_dim=1;
    else
      global lenxy_fractal_dim=log(N)/log(global("lenxy_length_total")/r);
  return(N-1);
end;
```


Data Obtained For Koch Curve Using Compass Method
N
10000
1000
100
10
1
0.001
0.010
0.100
1.000
Ruler size


Slope of N vs r for Koch Curve Using Compass Method
Slope
-1.230385
slope
log(r)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-7
-6
-5
-4
-3
-2
-1
0
1

Logarithmic Plot of Curve Length vs Grid Size for Various Curves



E = length of side of one grid element

Paul D. Shocklee

COMPUTER CONTROL OF MICROWAVE TRANSMITTER PULSE CHARACTERISTICS

Abstract

A program was written in SKED to allow computer control of the pulse frequency, and therefore the emitted power, of a COBER microwave transmitter. Several means of sending a variable pulse frequency to the COBER were considered. The most appropriate method found was to have the computer program send a digital signal to a digital-to-analog converter, which sent an analog voltage to a voltage-controlled oscillator. The signal from the analog port of the oscillator was fed into a pulser, which produced the pulses which initiated operation of the COBER. The SKED program was designed to protect the COBER from excessive frequency values and to deal with several possible pulsewidths and ranges. The primary reason for developing the program was to free the laboratory from the necessity of manual adjustment of COBER microwave pulse characteristics and to permit rapid alteration of emitted power for experimental purposes.

Introduction

This laboratory, which is part of the Directed Energy Bioeffects Laboratory (DEBL) at Brooks Air Force Base, is involved in studying the effects of microwave exposure on animal subjects. One of the reasons for performing such experiments is that the exact effects of radio-frequency (RF) radiation on the human body are largely unknown. The investigation of RF as a possible occupational hazard has applications in the fields of satellite transmission, radar, and power generation. Except for the cosmic microwave background radiation, microwaves are not present to a great extent in the natural environment. For this reason, it is unlikely that evolution has provided a means for dealing specifically with the problem of how to behave in a microwave field. If the sensation of heat is felt by an animal only in its skin, it may be totally unaware of the internal heating it is experiencing. Also, if the heating grows gradually, the animal may exhibit different thermoregulatory behavior than if the power comes on suddenly. This project was intended to provide a means of accurately testing the "gradual heating" supposition. Before this project was undertaken, the pulse period could only be adjusted manually. That is, during experiments, the emitted power could not be altered any faster than a knob could be turned. Naturally, this method was imprecise as well as slow, and it was also difficult to reproduce in successive experiments. In order for the appropriate power curve characteristics to be produced, it was necessary to free the microwave transmitter from manual control. This entailed writing a program to effect computer control over the microwave pulse period.

Discussion of Problem

A klystron source, developed by COBER Instruments, is used to generate the radiation. This COBER transmitter is capable of sending out pulses of waves of varying pulsewidth and intensity. However, its range is limited. The transmitter for which the program was written is restricted to pulsewidths of 0.5, 1, and 2 microseconds. The requirement is also stipulated that, for safety purposes, the ratio of the pulse period to the pulsewidth should be one thousand or greater. Operation at a faster level could damage the transmitter. The maximum frequencies for the pulsewidths are then 2000, 1000, and 500 hertz, respectively.

Results

The author gained a facility with the basics of the SKED programming language and proceeded to test methods of controlling an output frequency by means of "calls" from within the body of a program. Each of these calls would send a digital value to a lab module, which was hard-wired to respond in a characteristic manner. Initially, the means for producing an oscillation for which the period could be controlled was to connect two timers together. The timers would each trigger each other, and the period of one of them could be varied, while the other was kept constant. The constant-period timer could have been used to keep the oscillations below the critical frequencies. Much progress was made in programming the timers and getting them to trigger each other, but the initialization and triggering of the timers by the computer introduced initialization patterns in the timers which were hard- wired and created a risk of going beyond a safe frequenc_ We attempted to fix this by having the timers triggered by a voltage-co. ·olled oscillator (VCO) which we could control. Period-matching created further problems.

Finally, it was realized that the timers could be discarded in exchange for the VCO. Digital signals could be sent to a digital-to-analog converter, which would send an analog voltage to the VCO. Measurements indicated that the value sent to the VCO was directly proportional to the frequency generated. This simplified the writing of the program considerably, because only one call was necessary and because the safeguarding procedure was more obvious. To prevent the COBER from being damaged, all that was necessary was to prevent the program from sending a value which was too high. With three pulsewidths and two frequency ranges built into the VCO, there were only a few combinations to consider. The current version of the program at the time of writing is included in this report.

The program was put to the test and managed to keep COBER output within safe limits. The main worry, of course, was that the equipment would be damaged. Because this did not occur, the test was considered successful. A variety of waveforms were experimented with. These included spike, sawtooth, ramping, and chaotic pulse variation. A plot of the power detected by the COBER sensors versus the time elapsed is included in this report. Units are omitted from the line plots, because only general pulse shapes were considered necessary to demonstrate that control could be achieved. Accuracy of incident power will only be necessary when the SKED code is incorporated into a larger psychological experiment as one more parameter. The specific applications of the wave types (edge, ramp, and spike) are dependent upon the nature of the experiment being performed and the requirements of the experimenter.

Conclusion

The objectives of this line of research were realized in the accurate performance of the SKED program in its final tests. A number of modifications remain to be made which will increase the program's abilities. New waveforms will be added. Modifications will also be made so that the program will be able to run on a newer COBER transmitter with fewer pulse characteristic restrictions. The actual code will be transplanted into the skeleton of a much larger experiment. This master experiment will undertake to test the various aspects of animal behavior under electromagnetic bombardment indicated in the Introduction.

```
\op2.skd          14-aug-91
\
\microwave frequency control program
\

\**************************COMMON CALL 8 PARAMETERS**************************
\FORMAT:
\ CALL 8,IN/OUT,csr,ADDR,MASK,VALUE WHERE IN/OUT IS 0 FOR IN AND 1 FOR OUT
^lablinc^=8      \ Call #=8
^write^=1        \write function                                      arg1
^read^=0
^csr^=?164300    \Csr of Third Drv11j                                 arg2
^csr2^=?164200   \Csr of Second Drv11j                                arg3

^masklo^ = ?000377      \mask to permit lo byte data                  arg4
^maskhi^ = ?177400      \mask to permit hi byte data                  arg4

\************************RF CONTROL VARIABLES***************************
\Response and z pulse numbers.
^amplifier^=9
^button^=24     \First button press turns oscillator on. After that, button
                \  presses alternately ramp up and ramp down.
^go^=30
^table_resp^=60
^osc_off^=97
^table^=98
^RF^=99
^up_to_val^=100
^down^=101
^chaos^=102
^nochaos^=103
^saw^=104
^spike^=106
^square^=107
^nosquare^=108
^off^=109

list y=0,0,0,0  \Internal values.
\ y(0)=% of maximum duty cycle. To be calculated.
\ y(1)=Maximum D-A value for range.  To be calculated.
\ Maxima are as follows: Range A: all pulsewidths, 255.
\                        Range B:   Pulsewidth       Max
\                                   2 microseconds    39.
\                                   1 microsecond     87.
\                                   0.5 microseconds 183.
\ y(2)=Approximate frequency being generated. To be calculated.
\ y(3)=Last value sent before a pattern was initiated.

list z=0,20,2   \Values to be altered directly by user.
\ z(0)=Value to be sent to D-A converter. (0-255)
\ z(1)=pulsewidth*10 (0.5,1,2)
\ z(2)=Range of VCO (1=A,2=B)
list t=0.25",0.25"  \Time scale on which calls are sent.
\**********************************************************************

\********************RF CONTROL****************************************
s.s.1:
```

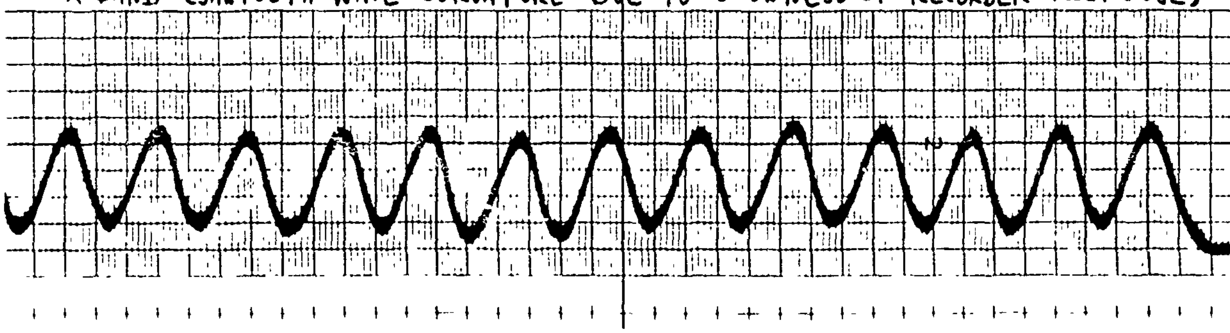
```
  s1:
    #r^button^: on ^amplifier^; type 0,0,!,"Oscillator on.",! ---> s2
  s2:
    #r^off^: off ^amplifier^; type 0,0,!,"Oscillator off.",!;
            z^osc_off^ ---> s1

s.s.2:
  s1:
    #r^button^: ---> s2
  s2:
    #r^button^: z^up_to_val^; type 0,0,!,"Button: Ramping up.",! ---> s3
    #z^osc_off^: ---> s1
  s3:
    #r^button^: z^down^; type 0,0,!,"Button: Ramping down.",! ---> s2
    #z^osc_off^: ---> s1

s.s.3:
  s1:
    #r^go^ ! #z^RF^: if z(1)<>5 & z(1)<>10 & z(1)<>20 [@badwidth,@checkrange]
      \Check that range is either A or B.
      @checkrange: if z(2)<>1 & z(2)<>2 [@range_error,@calculate]
        \Calculate maximum D-A value y(1).
        @calculate: if z(2)=1 [@rangeA,@rangeB]
          @rangeA: set y(1)=255; goto @checkvalue
          \Next line is ad hoc equation to give 183,87,39 from 20,10,5.
          @rangeB: set y(1)=960/z(1) - 9; goto @checkvalue
            \Determine if D-A number will cause fire and smoke.
            @checkvalue: if z>y(1) [@badvalue,@ok]
              @ok: call ^lablinc^,^write^,^CSR2^,?12,^masklo^,z ---> sx

    @badwidth: type 0,1,!,"Pulse width ",z(1)," is not 5,10,or 20.",!;
               z^table^ ---> sx
    @range_error: type 0,1,!,"Range ",z(2)," is neither A nor B.",!;
                  z^table^ ---> sx
    @badvalue: type 0,1,!,"D-A value ",z," out of range.",!; z^table^ ---> sx

s.s.4:
  s1:
    \Table-printing subroutine.
    #r^table_resp^ ! #z^table^:
      \Calculate approximate frequency y(2),% of max y,maximum value y(1).
      if z(2)=1 [@AFreqs,@BFreqs]
        @AFreqs: set y(2)=(104*z+953)/100;
                 set y=y(2)*z(1)/100, y(1)=255; goto @do_table
        @BFreqs: set y(2)=(1045*z+9474)/100;
                 set y=y(2)*z(1)/100, y(1)=960/z(1)-9;
                 goto @do_table
    @do_table:
    type 0,1,!,!,"Variable   Meaning     Value          Allowed";
    type 0,1,"                       Formula",!;
    type 0,1,"^^^^^^^^   ^^^^^^^     ^^^^^          ^^^^^^^  ";
    type 0,1,"                     ^^^^^^^",!;
    type 0,1,"  z(0)     D-A Number     ",z,"        (0-",y(1),")  ";
    type 0,1,"       n=(f/(10**(r-1)))-10",!;
    type 0,1,"  z(1)     Pulsewidth     ",z(1),"     5,10,20 <=> (0.5,1,2)",!;
    type 0,1,"  z(2)       Range        ",z(2),"     1=Range A, 2=Range B",!;
    type 0,1,"Internal   Percent      ",y,"         (";
    \Determine range of percents, based on VCO range and pulsewidth.
```

```
    if z(2)=1 [@Apercents,@Bpercents]
      @Apercents: type 0,1,z(1)/10,"-",2747*z(1)/1000,")  ";
                  goto @freq
      @Bpercents: type 0,1,19*z(1)/20,"-",(1045*y(1)+9474)*z(1)/10000,")  ";
                  goto @freq
    @freq: type 0,1,"          p=fw/100",!;
           type 0,1,"Approx.   Frequency      ",y(2);
           type 0,1,"                         f=(10**(r-1))(n+10)",!;
    type 0,1,!,"where n=D-A #, r=range #, f=frequency, w=pulsewidth",! ---> sx

\Ramping routines.
s.s.5:
  s1:
    \Send value of zero initially.
    0.1": z^RF^ ---> s2

  s2:
    \Ramp up to value of z.
    #r^up_to_val^: z^up_to_val^ ---> sx
    \Ramp down to zero.
    #r^down^: z^down^ ---> sx

    \Square wave on (value of z is height).
    #r^square^: z^square^ ---> sx

    \Sawtooth on (value of z is maximum).
    #r^saw^: z^saw^ ---> sx

    \Short-width spike (value of z is spike height).
    #r^spike^: z^spike^ ---> sx

    \Alternate chaotically.
    #r^chaos^: set z=y(1)/2, l=38 ---> s3

  \Chaos-producing quadratic map.
  s3:
    t(1) #t: set t(1)=t; set z=l*z*(y(1)-z)/y(1)/10; z^RF^ ---> sx
    #r^nochaos^: ---> s1  \Quit chaos.

s.s.6:
  s1:
    \Up_to_val ramps up from zero to z value supplied by user.
    #z^up_to_val^: set y(3)=z, z=0 ---> s2
    \Down simply ramps down to zero.
    #z^down^: ---> s3

  \Up-ramp.
  s2:
    t(1) #t: set t(1)=t; z^RF^; add z; if z>y(3) [@cut_out, @keep_going]
      @cut_out: ---> s1
      @keep_going: ---> sx
  \Down-ramp.
  s3:
    t(1) #t: set t(1)=t; sub z; z^RF^; if z=0 [@quit,@cont]
      @quit: ---> s1
      @cont: ---> sx

s.s.7:
```

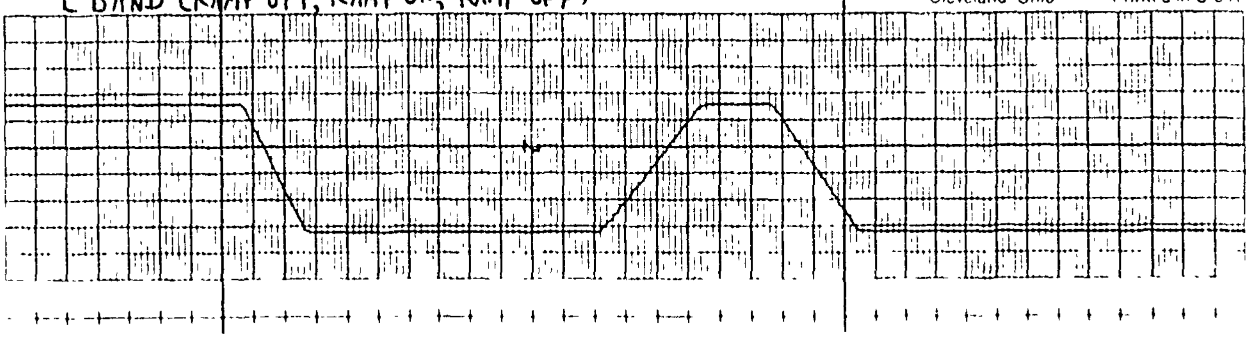
```
  s1:
    #z^square^: set y(3)=z ---> s2
  \Square wave on.
  s2:
    t(1) #t: set t(1)=t, z=0; z^RF^ ---> s3
    #r^nosquare^: ---> s1
  s3:
    t(1) #t: set t(1)=t, z=y(3); z^RF^ ---> s2
    #r^nosquare^: ---> s1

s.s.8:
  s1:
    \Saw between 0 and y(3).
    #z^saw^: set y(3)=z ---> s2
  s2:
    t(1) #t: set t(1)=t; add z; if z>y(3) [@back_down, @more_up]
      @back_down: ---> s3
      @more_up: z^RF^ ---> sx
    #r^down^: z^down^ ---> s1
  s3:
    t(1) #t: set t(1)=t; sub z; z^RF^; if z=0 [@back_up,@down_farther]
      @back_up: ---> s2
      @down_farther: ---> sx
    #r^down^: z^down^ ---> s1

s.s.9:
  s1:
    \Spike and then settle to y(3).
    #z^spike^: set y(3)=z ---> s2
  s2:
    t(1) #t: set z=y(1); z^RF^ ---> s3
  s3:
    t(1) #t: set z=y(3); z^RF^ ---> s1
\*****************************************************************************
```

CONTROLLED RF OUTPUT

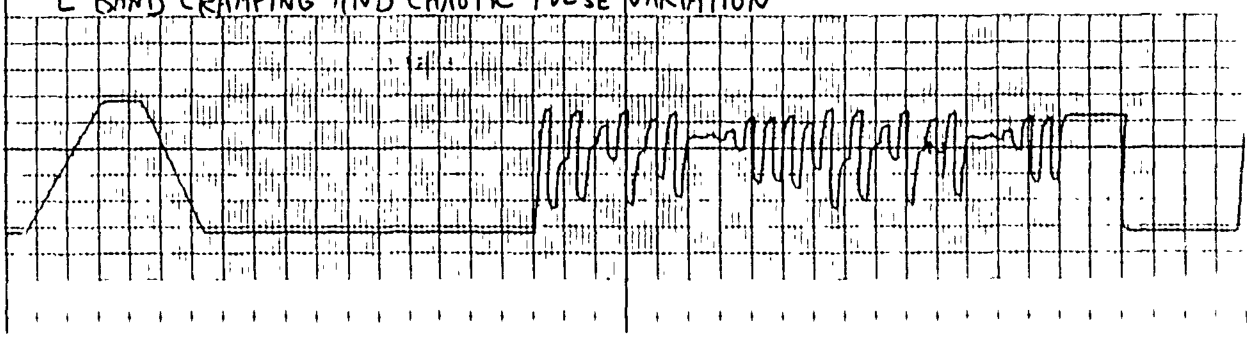
X BAND (SAWTOOTH WAVE - CURVATURE DUE TO SLOWNESS OF RECORDER RESPONSE)



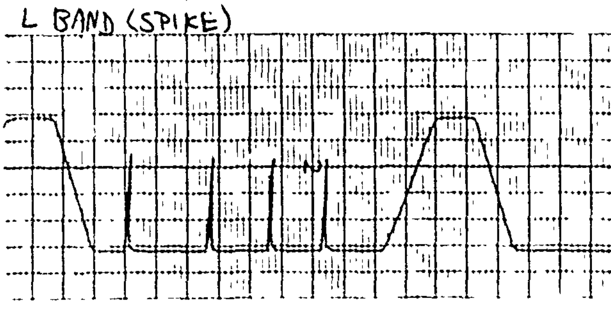
L BAND (RAMP OFF, RAMP ON, RAMP OFF)



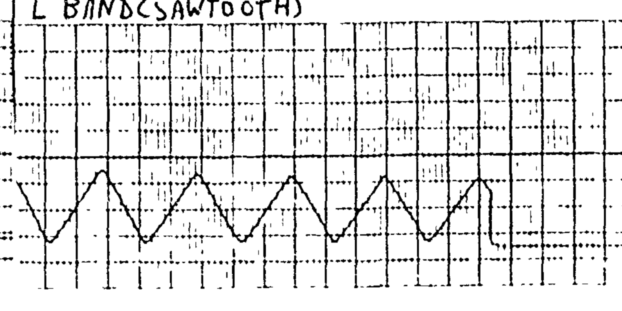
L BAND (RAMPING AND CHAOTIC PULSE VARIATION



L BAND (SPIKE)



L BAND (SAWTOOTH)



OBJECT ORIENTED SIMULATION

Mr. Brandon S. Wadsworth

Abstract

This research has been directed at developing a simplified method for constructing computer simulation models. Normally, a researcher developing a computer simulation model needs to possess an in-depth knowledge of computer programming, graphics techniques, and complex mathematics. This knowledge however is not completely necessary. It is the intent of this research to simplify the construction of simulation models by removing the need for knowledge in areas other than the model at hand.

Introduction

In science and engineering, one of the primary interests is in exploring the dynamic characteristics of systems, that is, their time-varying characteristics. For example, in any system where motion exists, you observe how each of the components moves against time. In simulation, rather than testing an actual system, one tests an analogous "model" of the system. Mathematical representations of systems (analogous representations) that are explored within a computer environment are called "computer simulation models".

When researchers build simulation models, they must concern themselves with several areas:

1. A method for inputing initial values (i.e. flows, rates, pressure, and any other dynamic simulation parameters).

2. A method for inputing constant values (i.e. resistances, compliances, and any other static simulation parameters).

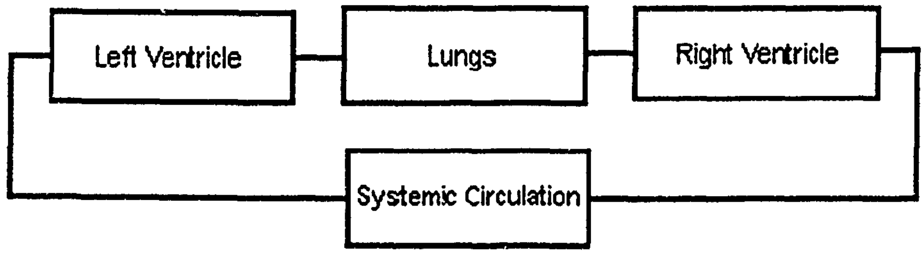
3. A method for outputing data in a coherent form (i.e. graphs, charts, animations...).

4. A method for building the model they are concerned with.

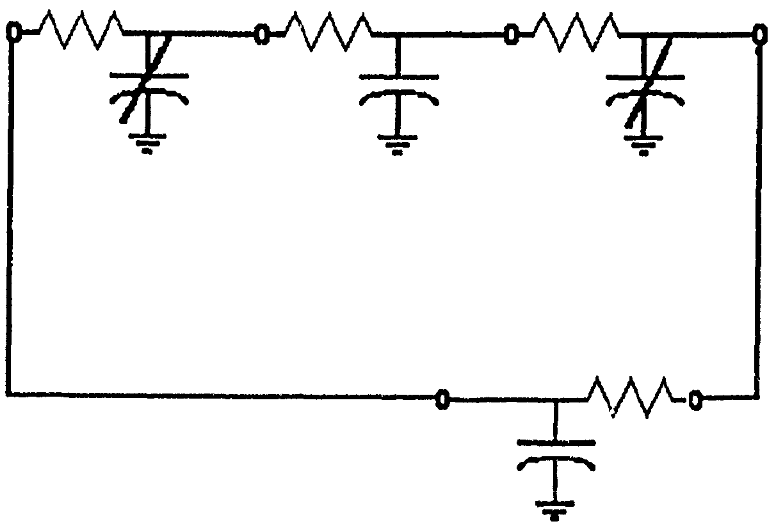
All of these concerns can be taken care of with by a set of generic functions. The only concern now becomes writing the actual simulation specific part of the program (concern #4). Now that we have discussed some of the problems related with developing a simulation via the "old-school" method, let's step through what is required to build a simulation using the method presented here.

Discussion of Problem

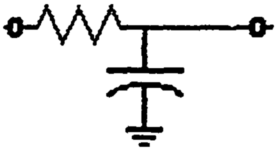
Let us look at a single application, a well known physiological benchmark.



The above is a simple schematic drawing of a human body, with a left and right ventricle, lungs, and a systemic circulation. In the above system, blood flows from the left-ventricle into the lungs and around in a clockwise fashion. Another way of representing this system is to draw the electrical analogy.



You will notice that this is rather simple; more detailed models contain thousands, or even millions of parts. The "model specific" section of code in the program to simulate the above diagram, if we used the "old-method", would be around 45-lines of code. Most of those 45 lines would really be the same code written over and over again. Via the old-method, solving for the pressure in each component (lungs...) would require a separate equation for every individual component. If you study the above diagram, you will notice the following component is found several times in duplicate.



If we only wrote the "simulation specific" code for this circuit diagram, and made four calls to this code, using different data for each component, we would reduce the complexity of c :e by 75%. In this model, the new module of code is used 4 times, thus cutting code size by 4, imagine a system with thousands of components. The following is a more in-depth description of what was actually done to accomplish this.

In studying the problem of building a "lump" (the code necessary for the smaller diagram (the lump)) it was decided that C++ would be ideal, however, given the hardware software configuration available (Vax running VMS & X-Windows), it was decided that C would be used. This decision was tough mostly because a C++ program is much shorter and easier to write than an equivalent C program. Also the X-window graphical user interface was not accessible from C++ (so no graphs or charts could be made). Next, it was decided that a standard format needed to be built for recording data; this is necessary because in an object oriented environment two processes need to be able to easily share information. The following was a start in the standardized direction.

```
struct
 { /* Data type and Variable name       Description    */
  int lump_type;               /* What type of lump?*/
  double values[20];            /* Array to hold
                                   values, such as
                                   volume, pressure, and
                                   other necessary
                                   information */
  /*  Area to store connections(see below) */
 } Lumps_data[10];        /*  Array of ten lumps allowing
                              for ten(0-9) unique lumps.*/
```

Each component has a structure like this behind it. The code section will come later. The above structure was simple, for a start. The area to store connections is sort of complex, but simply stated it stores information so we know what other parts we are connected to. For instance the Lungs will at some time need to know the pressure in the component before it (which happens to be the Right Ventricle). Using the connection scheme developed during the research a person could now connect multiple objects to the front of the Lungs. The method devised to handle the multiple connections is very complex and code intensive (like the connection method itself, involving methods for solving Kirchoffs law via an indirect method). The above mentioned data structure soon expanded and became much more informative. Later additions included an area for a component name (i.e., "Lungs",...), and other information about an element such as a picture to place on the component's button (see appendix for snap-shots from running program).

During a simulation run, data is displayed as it is computed. Each structure (mentioned above as a lump) would lend its data to a graphing routine, that would, as expected, graph the information. This graphics routine is #3 as listed in the concerns of an "old school" modeler. This graphics routine would handle all aspects of graphing including scaling, and storing the data for other purposes, such as redrawing after an "expose event" (an X-Window event). Once this graphics routine has been written to correctly interact with the lumps, it never has to be changed even if drastic changes are made to a model, or even if a new model is written. Concerns 1 and 2 can also be taken care of quite easily. A routine that is written generically finds out from a lump data structure that is has so and so that needs to be filled in by the user and that routine gets the correct information from the user of that particular simulation program.

Now, the only concern of a programmer is to create the code necessary for one lump. The following is an example.

```
lumps[j].values[PRESSURE] = lumps[j].values[VOLUME] /
   lumps[j].values[COMPLIANCE];

sum(j);     /* This is where pressure in and out are computed, since these two calculations need
information from other lumps, it gets sort of hairy(only because multiple lumps may be connected to the
front of this lump)  */


lumps[j].values[FLOW_IN] =
  ( lumps[j].values[PRESSURE_IN] -
    lumps[j].values[OLD_PRESSURE]) /
        lumps[j].values[RESIS_IN];

 lumps[j].values[FLOW_OUT] =
  ( lumps[j].values[OLD_PRESSURE] -
lumps[j].values[PRESSURE_OUT]) /
        lumps[j].values[RESIS_OUT];

lumps[j].values[VOLUME] =
  lumps[j].values[VOLUME] + (( lumps[j].values[FLOW_IN] -
          lumps[j].values[FLOW_OUT] ) * dt);
```

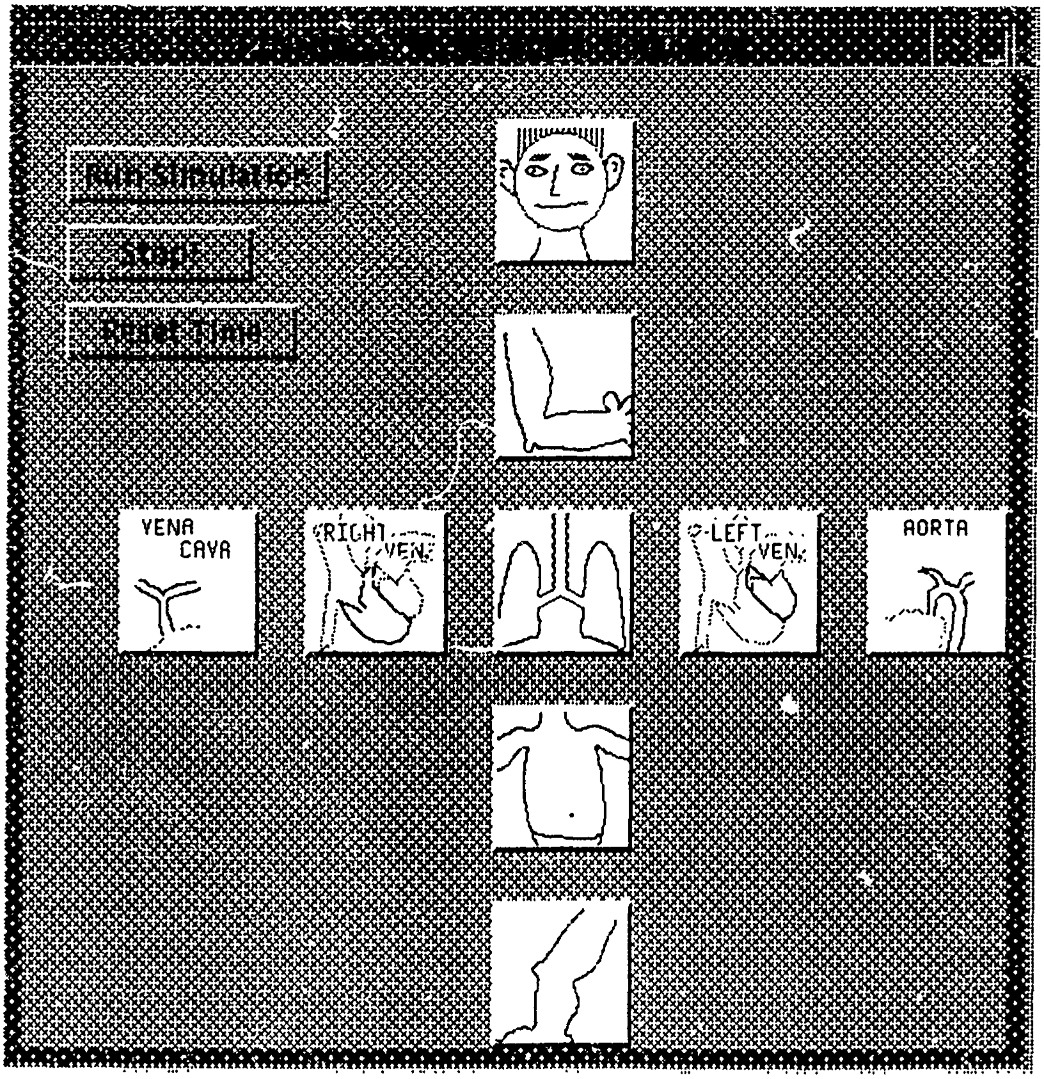
The above code represents (to a knowledgeable simulation guru) only the simple resistor-capacitor-resistor lump shown in the last diagram. The words in all CAPS are what is known as "defines". Earlier in the program a state like #define PRESSURE_OUT 4 was issued, so whenever the word "PRESSURE_OUT" is seen in the program, the computer places a 4 in its place. This feature of C allows programmers to write much more intelligible code. Anyhow, back to the lump code. The above code represents a single lump. The whole model is four of these lumps. So a copy of the above mentioned data structure is made for each lump. The lungs has its own copy of this data structure, in which it stores pressure, flow in, flow out, pressure out, pressure in, resistances, compliances, and so forth. Each component of the model has its own copy of that structure. So, the code shown above is called and when that call is made it is told which copy of that data structure to use (this is done by passing a value in j).

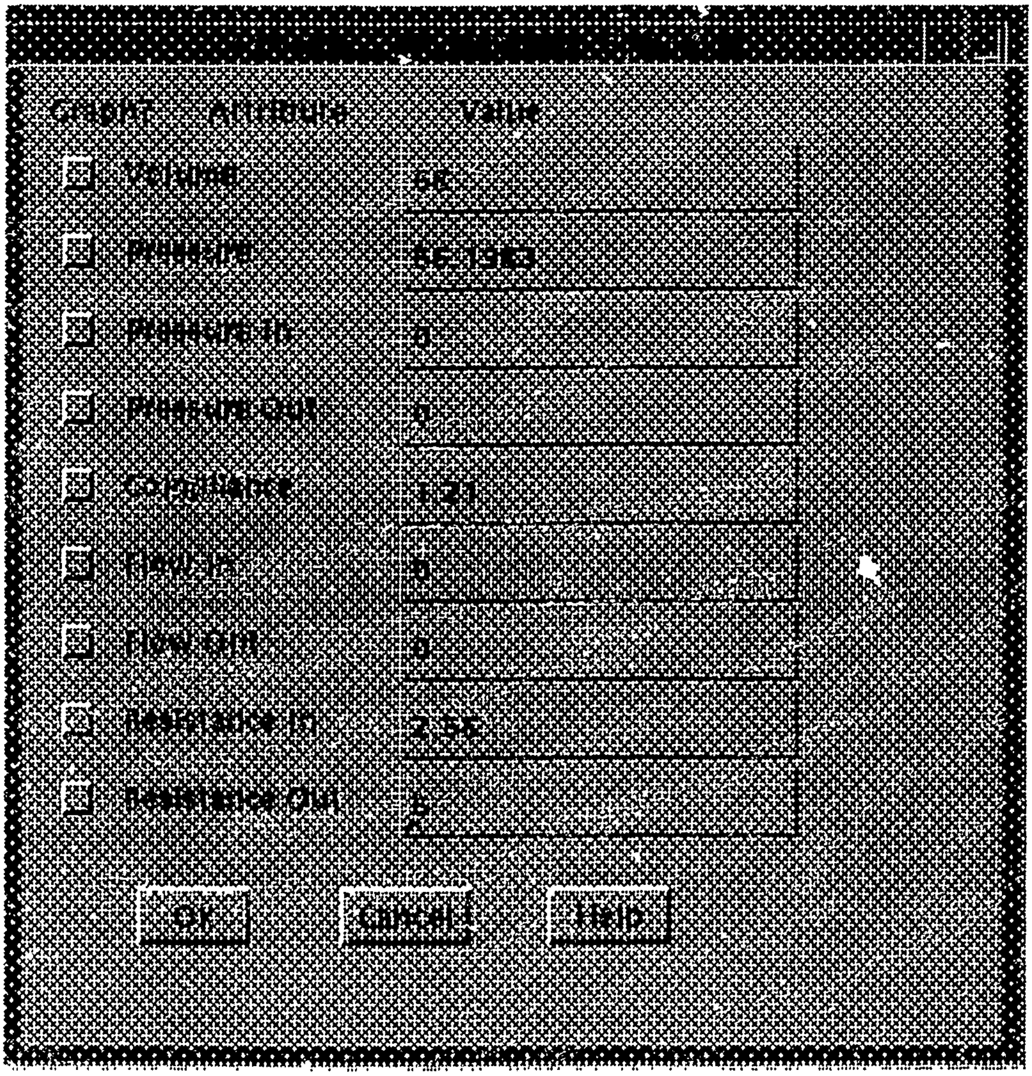
Results

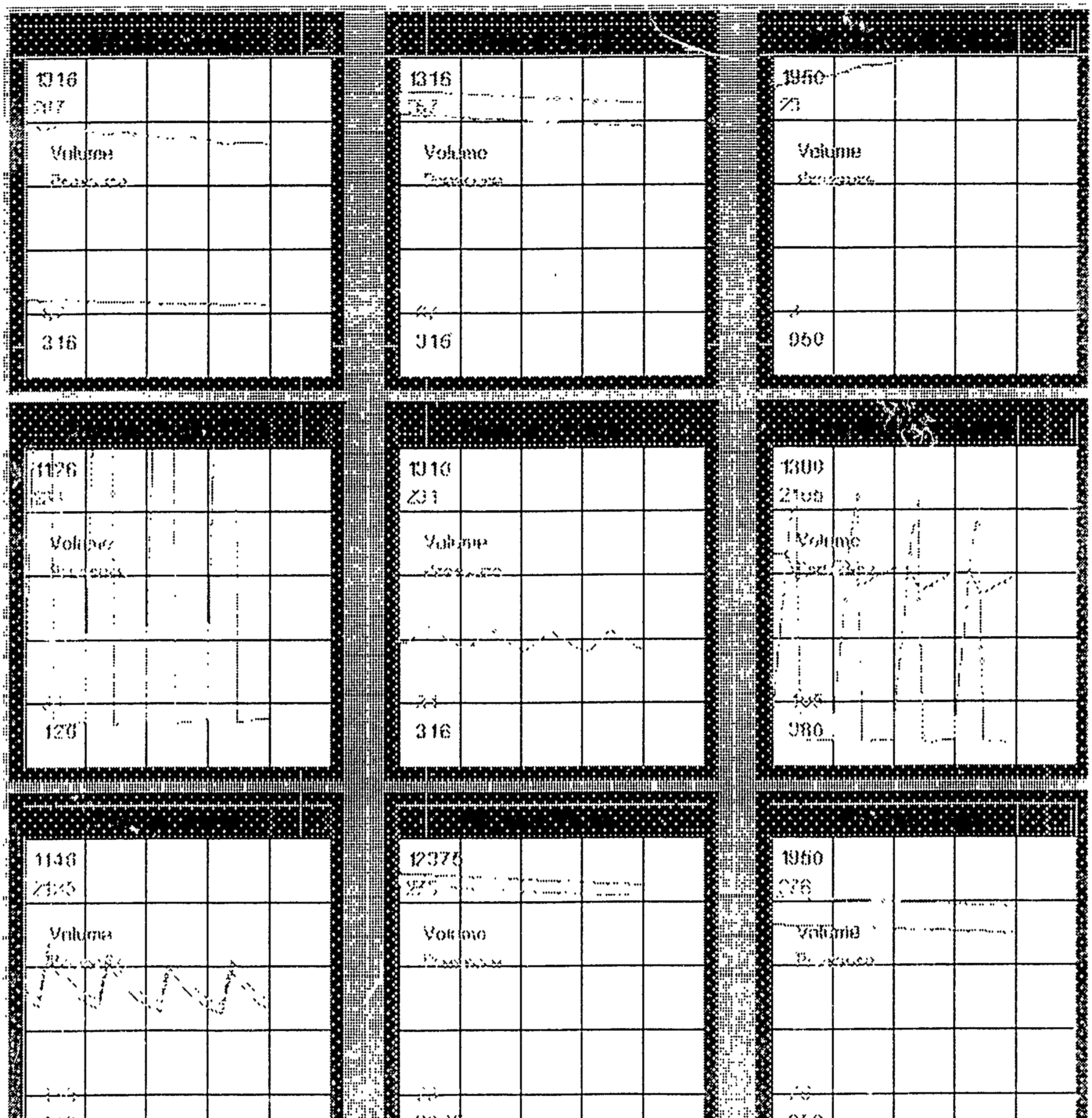
The result of the research was a program which allows the simulation experimenter to simply create a new model. This is done via creating lumps of code to represent each component (there is a trade off of time necessary to run a simulation vs. simplicity). By building a set of functions that automatically get input and graph output, an experimenter who wants to experiment with a new simulation can now really put his or her time to good use.

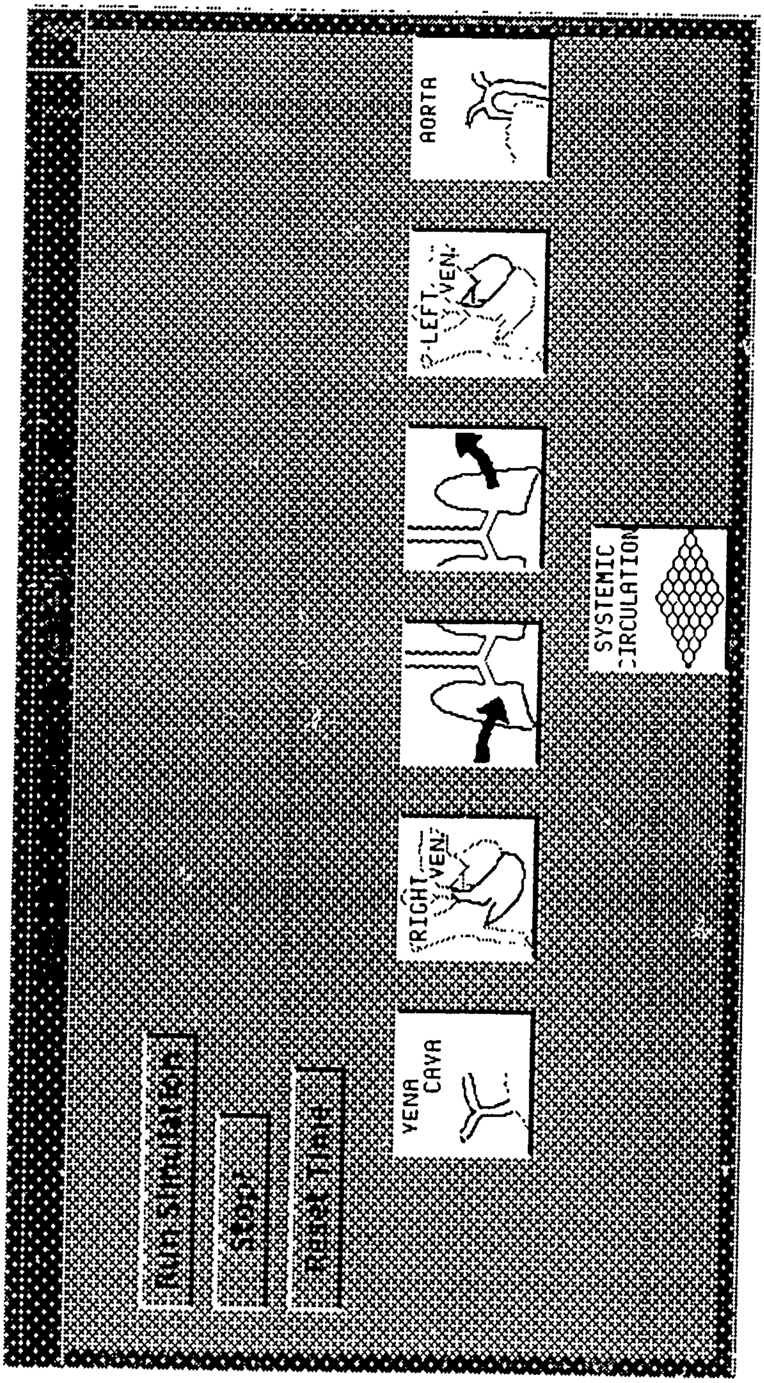
Conclusion

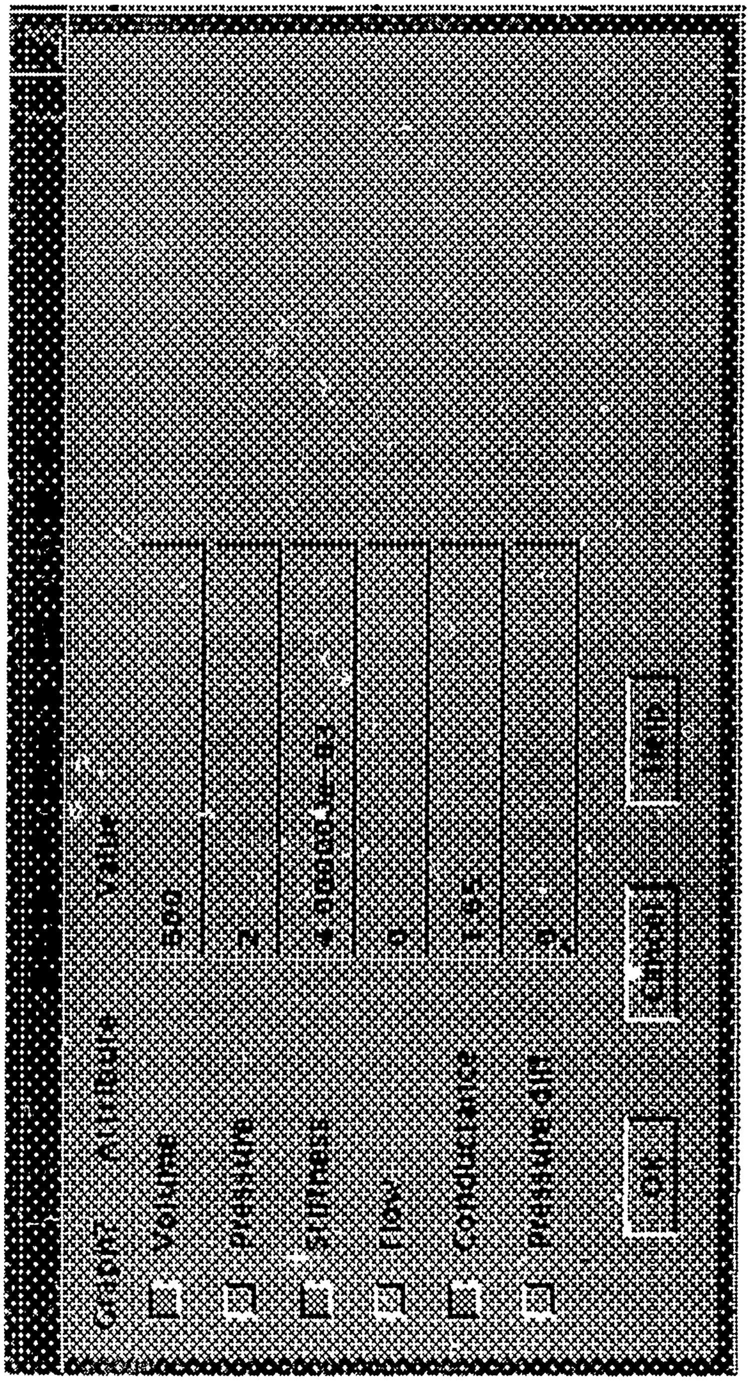
Finally jobs in the world of simulation are put in order. A programmer writes new input and output functions, a simulation expert writes lump code modules (to represent various everyday or even imaginary components), and the casual or professional experimenter uses the already built set of components to create any system he or she wants, such as nuclear power plants, or even a human body. Once all the components are built, an experimenter can connect these components, and begin taking data with a new system in a few hours, not months as had been before. With a system such as the one shown here, an end user (one experimenting with an already built system) can modify the system to an incredible extent; he or she can change values such as resistances, but they can also rearrange the order of components without having to write a new program, using nothing but a mouse!

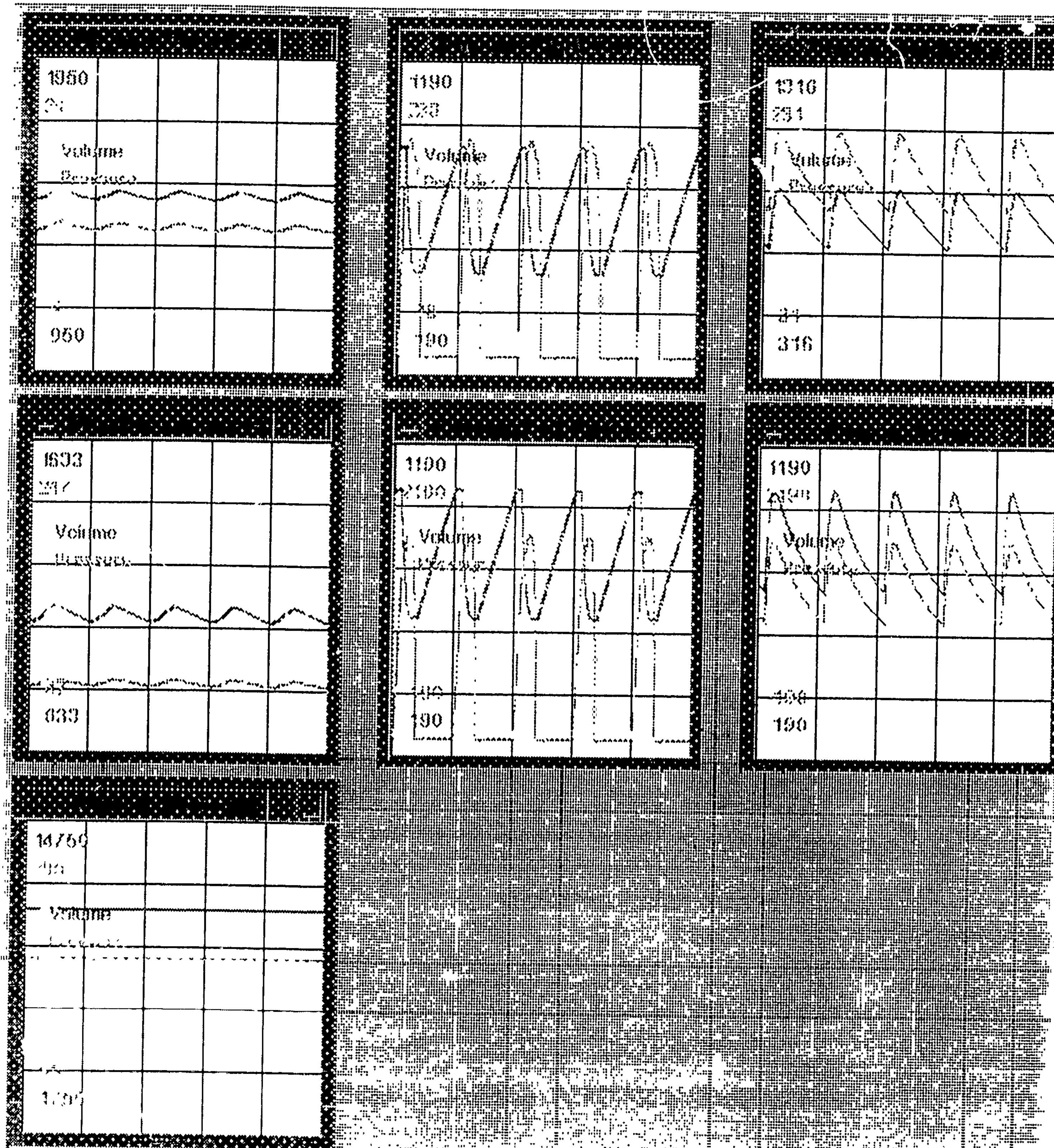

Run Simulation
Stop!
Reset Time
VENA CAVA
RIGHT VEN.
LEFT VEN.
AORTA


Graph? Attribute Value
Volume
Pressure
Pressure In
Pressure Out
Compliance
Flow In
Flow Out
Resistance In
Resistance Out
OK
Cancel
Help


1316
Volume
316
1316
Volume
316
1950
Volume
950
Volume
126
1316
Volume
316
1300
Volume
1148
Volume
148
Volume
1950
Volume
950


AORTA
LEFT VEN.
SYSTEMIC
CIRCULATION
RIGHT VEN.
VENA
CAVA


Attribute
Value
Volume
Pressure
Stiffness
Flow
Conductance
500
2
0
1.65
OK
Cancel
Help



1950
Volume
950
1190
Volume
190
1316
316
1633
Volume
633
1190
Volume
190
1190
Volume
190
Volume

PDL: SUMMER RESEARCH HIGH SCHOOL

APPRENTICE PROGRAM

RESEARCH PAPER

INDEXING SCIENTIFIC REFERENCE DATABASES

by

LEISHA EILEEN WOOD

MENTOR:

JOHN W. BURNS, Ph.D.

INDEXING SCIENTIFIC REFEPENCE DATABASES

Leisha Eileen Wood

ABSTRACT

My summer project dealt with library research rather than experimental research. My task was to sort through twenty-five boxes of scientific article reprints (approx. 2000 reprints) and organize them according to subject areas. To do this, I had to first learn a few basic DOS commands so that I could work with a new personal computer (PC) program called "Pro-Cite." The purpose of this program is to make it easy to manage a bibliographic database and to create and maintain properly formatted bibliographies. The reprints I was working with were located in boxes with their bibliographies and key reference words or phrases and were stored on five data disks. With the search and merge functions within the Pro-Cite program and the five data disks, I was able to sort the reprints into ten specific topic areas.

A small but significant amount of my time was also spent in observation of Dr. Burns' experimental research. He has been working on a study of how coronary artery disease affects the G-tolerance of baboons. His basis for research comes from the Air

Force policy of not allowing fighter pilots to fly high performance aircraft with even minimal coronary artery disease. Dr. Burns is testing the theory that coronary artery disease at minimal stages, possibly up to 30%, would not have any adverse effects on the pilots. If this theory proves correct, then perhaps the rule for grounding could be altered.

About two years ago, Dr. Burns put constrictors on coronary arteries of eight baboons. This summer, he performed catheterizations in order to verify the amount of constriction of the arteries. I observered five of these procedures. Several weeks later, he put some of the baboons on the centrifuge to test their G-tolerance and to see if the constrictions were having any adverse effects on the animals. I observed one of these centrifuge runs. This study is still going on, so no results are available as of yet. Since I only observed a minute amount of this experiment, this summary will be the extent of that topic in this paper. The remainder of the paper will cover my main project which was to sort the scientific reprints.

INTRODUCTION

In order to do any kind of research project, one must be familiar with all of the work previously done in that subject area. This knowledge enables the researcher to take advantage of procedures that worked well in certain situations as well as to avoid or overcome complications previously encountered. In addition, the knowledge obtained from journal articles and books provides the researcher with a strong background in the area he wishes to enter. Documentation is also necessary so that the same experiment won't be repeated.

Journal articles and books become references for researchers, and so they must have some form of organization. For Dr. Burns, subject area such as acceleration, pressure breathing, heart, etc., appears to be the best indexing arrangement. This enables him to look under specific topics for the information he needs. Thus this project came about; to sort and index reprints according to subject area so that they are easily accessible.

METHODS

Twenty-five boxes of reprints were presented without much organization to them. Each box contained anywhere from 16 to 102 reprints (see Table 1) and the only organization of these documents was a bibliographical list of the reprints in alphabetical order according to the first author (see Table 2). Also presented was a program called "Pro-Cite" with its manual and five data disks containing the bibliographies of all the reprints in all but two of the boxes.

The first task was to learn how to use the Pro-Cite program. To do this, the manual had to be thoroughly studied and then experiments done with some of the functions in the program using the manual as a guide. Once the program was understood, the five data disks were downloaded into the Pro-Cite subdirectory. Since two of the boxes were not included on the five data disks, the bibliographic and index terms of all reprints from both boxes had to be entered (see Table 3).

Once all the data (labeled from boxA-boxY) was input into the computer, each box was merged into one large data file. With this one file, several indexes were made. Pro-Cite has four types of indexing available for use: 1)title index, 2)index index, 3)word index, and 4)author index. Any one of these types of indexing can be used on any field in the bibliography (a list of fields are in Table 3, left column). In title indexing, the whole character string can become the index entry. No delimiters such as punctuation marks or spaces are recognized. Examples of title indexing are shown in Tables 4 & 5. In Table 4 the field being indexed is the title (Titl) field. In Table 5, the field being indexed is the key words (Indx) field. The second type of indexing is index indexing. In this type of index, the text, up to or following a slash becomes the index term. As with all types of indexing, if the text is longer than the maximum word size, it is truncated. Table 5 is an example of index indexing of the field of key words. It has the same effect as the title index simply because no slashes are present in the text, so the text wasn't divided. The third type of indexing is the word index. In word indexing, Pro-Cite takes each individual word that is between spaces, or spaces and punctuation marks and enters it as an index term. Word indexing thus breaks up phrases into single words, and compound words that are separated by a space, are divided into two different words. Table 6 is an example of word indexing in the field of key words. Word indexing is of little value since words like "to", "and", "in", "or", "the", etc. become index terms. The final type of index is the author index. In this type of indexing, a set of slashes or a semicolon is used to separate "terms".

The type of index that was most useful in the sorting of the reprints was the author index in the field of key words (see Table 7). This particular type of index allowed a search through the field of key words and phrases and separated them from between semicolons and then put them in alphabetical order. The index list was then printed and given to Dr. Burns to look through so that he could choose the topics into which he wanted the articles sorted.

Once the subject areas were established and index terms were identified (acceleration, heart, artery, muscle, cardiovascular, autonomic nervous system, brain, reflex, positive pressure breathing, and other), new files were created using these terms. Then a search through each box commenced, using the words from the index list that related to each topic (see Table 8). After selecting the reprints that matched from the search, I put them under their proper topic area. For each box, a list was printed of articles to be removed, and their new location (see Table 9). Using these print-outs, articles were removed from the actual boxes and placed under the appropriate new topic area. The articles were then put back into boxes, only this time they were cataloged according to subject area.

RESULTS AND CONCLUSIONS

The final result of the project was that the twenty-five boxes of research articles were sorted into ten topic areas. These areas were chosen by Dr. Burns to simplify later searches for specific articles or specific subject areas. Even with the ten topics, some areas were too large to fit into one box and in general need to be subdivided. For example, the subject area dealing with the heart required boxes A-M. It would be much easier for one to find an article if the boxes were futher divided into areas dealing with specific sections of the heart. However, limited time prevented me from accomplishing futher subdivisions. But, with the current organization of research articles, Dr. Burns will have a much easier time finding particular reprints of particular topic areas.

TABLE 1: CONTENTS OF BOXES

TITLE	# OF REPRINTS	TITLE	# OF REPRINTS
BOX A	63	BOX N	59
BOX B	81	BOX O	73
BOX C	54	BOX P	73
BOX D	88	BOX Q	86
BOX E	43	BOX R	73
BOX F	56	BOX S	102
BOX G	29	BOX T	64
BOX H	66	BOX U	79
BOX I	45	BOX V	53
BOX J	58	BOX W	16
BOX K	75	BOX X	74
BOX L	35	BOX Y	76
	BOX M	74	

TC[illegible]L: 1529 (+ ABOUT 70 NON-PUBLISHED MATERIAL)

This is a table of the twenty-five boxes and the number of articles in each box that had to be sorted and indexed.

TABLE 2: TYPICAL BIBLIOGRAPHY

1. Brown, M.J., D.A. Jenner. Novel double-isotope technique for enzymatic assay of catecholamines, permitting high precision, sensitivity and plasma sample capacity. Clinical Science; 1981; 61: 591-598.

2. Cline, W.H. Role of released catecholamines in the vascular response to injected angiotensin II in the dog. J. Pharmacol. Exp. Thera.; 1981; 216(1): 104-110.

3. Dill, D.B., D.L. Costill. Calculation of percentage changes in volumes of blood, plasma, and red cells in dehydration. J. Appl. Physiol.; 1974; 37(2): 247-248.

4. Ellis, J.P. Biochemical Stress Indices. Note: Notes on talk.

5. Fine, P.M., Hartman, B.O. Psychiatric strengths and weaknesses of typical air force pilots. SAM-TR-68-121; 1968: 1-36.

6. Massingham, R., M.L. Dubocovich, N.B. Shepperson, S.Z. Langer. In vivo selectivity of prazosin but not of WB4101 for postsynaptic alpha-1 adrenoceptors. The Journal of Pharmacology and Experimental Therapeutics; 1981; 217: 467-474.

7. Shepherd, John T., P.M. Vanhoutte. Local modulation of adrenergic neurotransmission. Circulation; 1981; 64(4); 655-666.

8. Siess, W., R. Lorenz, P. Roth, P.C. Weber. Plasma Catecholamines, platelet aggregation and associated thromboxane formation after physical exercise, smoking or norephinephrine infusion. Circulation; 1982; 66(1): 44-48.

9. Torphy, D.E. Effects of immersion, recumbency and activity on orthostatic tolerance. Aerospace Medicine; 1966; 37(2): 119-124.

10. Wu, C.V., W.T. Nickell, P.K. Bhagat. A pratical ultrasonic plethysmograph. Aviat. Space Environ. Med.

TABLE 3: PRO-CITE BIBLIOGPAPHY FOPMAT

```
Auth:Vatner, S.F.
Titl:Effects of hemorrhage on regional blood flow distribution in dogs and
     primates
Jrnl:J. Clinical Investigation
Date:1974
VoID:54
IsID:2
Loc :225-234
ISSN:
Note:
Abst:
Call:
Indx:hemorrhage; regional blood flow; dog; primate
```

```
[ Journals - Short ]              Selected                    [    680 ]

   Next    Prev    Insert    Delete    pRint    Edit    Jump    Workfm    eXit
```

This is an example of the bibliographic format. The abbrieviations (left column) were provided by the Pro-Cite program. Auth=author; Titl=title: Jrnl=journal: VoID=volume: IsID=number: Loc=inclusive pages: Indx=key words At the bottom of the table is a list of optional commands displayed by the computer.

TABLE 4: TITLE INDEX OF THE TITLE FIELD

A pratical ultrasonic plethysmograph
Biochemical Stress Indices
Calculation of percentage changes in volumes of blood, plàsma, and red cel
Effects of immersion, recumbency and activity on orthostatic tolerance
In vivo selectivity of prazosin but not of WB4101 for postsynaptic alpha-1
Local modulation of adrenergic neurotransmission
Novel double-isotope technique for enzymatic assay of catecholamines
Plasma Catecholamines, platelet aggregation and associated thromboxa
Psychiatric strengths and weaknesses of typical air force pilots
Role of released catecholamines in the vascular response to injected

In title indexing, the computer chooses the whole string of words as one index.

TABLE 5: TITLE INDEX AND INDEX INDEX OF THE FIELD OF KEY WORDS

adrenaline, noradrenaline, radio-enxymatic assay; technique
adrenergic; neurotransmission
catecholamines; platelet aggregation; thromboxane formantion; exercise;
catecholamines; vascular response; angiotensin II; dog
hematocrit, hemoglobin, exercise, sweat, body temperature; dehydration
in vitro, prazosin, alpha-1 adrenoceptors
neuropsychiatry, Psychology, personality structure, normality; pilots
stress; stress hormone
ultrasonic plethysmograph
water immersion, bed rest, orthostatic tolerance, deconditioning, tilt tabl

Both title and index indexing have the same effect on the field of key words. Title indexing chooses a whole string of words, while index indexing separates words and phrases between slashes. Since no slashes are presents in the key words, the index indexing treats the whole string of words as one index.

TABLE 6: WORD INDEX OF THE FIELD OF KEY WORDS

adrenaline
adrenergic
adrenoceptors
aggregation
alpha-1
angiotensin
assay
bed
body
catecholamines
deconditioning
dehydration
dog
exercise
formantion
hematocrit
hemoglobin
hormone
II
immersion
in
neuropsychiatry
neurotransmission
noradrenaline
norepinephrine
normality
orthostatic
personality
pilots
platelet
plethysmograph
prazosin
Psychology
radio-enxymatic
response
rest
smoking
stress
structure
sweat
table
technique
temperature
thromboxane
tilt
tolerance
ultrasonic
vascular
vitro
water

In word indexing, Pro-Cite takes the text between spaces, or spaces and punction marks, and makes an entry for each "word." Phrases are thus broken down into separate words.

TABLE 7: AUTHOR INDEXING OF THE FIELD OF KEY WORDS

adrenaline, noradrenaline, radio-enxymatic assay
adrenergic
angiotensin II
catecholamines
dehydration
dog
exercise
hematocrit, hemoglobin, exercise, sweat, body temperature
in vitro, prazosin, alpha-1 adrenoceptors
neuropsychiatry, Psychology, personality structure, normality
neurotransmission
norepinephrine
pilots
platelet aggregation
smoking
stress
stress hormone
technique
thromboxane formantion
ultrasonic plethysmograph
vascular response
water immersion, bed rest, orthostatic tolerance, deconditioning, tilt tabl

Author Indexing uses a set of slashes or semicolons to separate "terms." This type of indexing proved to be the most advantageous because it separated phrases as well as key words.

TABLE 8: TYPICAL SEARCHING TECHNIQUE

ANS

choline or *adrenal* or autonomic or beta* or *cholamine or differential or *epinephrine or *sympathetic or isoproterenol

BRAIN

cerebral or cerebro* or electroencephalography or intracerebral or intracranial or brain

REFLEX

carotid or chemoreceptor* or reflex* or sinoaortic

PPB

"assisted ventilation" or ppb or "positive pressure" or "pressure breathing"

The underlined words represent the topic area. The words underneath each topic area are examples of what was entered into the computer during the search mode. The "*" before the word tells the computer to search for prefixes of this word. Whereas the "*" at the end of the word tells the computer to search for suffixes of this word. The "or" between the words tells the computer to search the records and select any record that has at least one of the words listed within it.

TABLE 9: SELECTED RECORDS BEING MOVED

BOX K CARDIOV

1. Bisnop, V.S., D.F. Peterson. Cardiovascular adaptation to stress. Air Force Progress report; 1976.

2. Fentem, P.H., J.M. Yates. The influence of age and the level of arterial blood pressure on the changes in forearm blood flow resulting from sudden alterations in local vascular transmurial pressure. Cardiovascular Research; 1974; 9(1): 56-64.

3. Kent, K. M., T. Cooper. Cardiovascular Reflexes. Circulation; 1975; 52: 177-178.

4. Levy, M.N., H. Zieske. Factorial analysis of the cardiovascular responses to carotid sinus nerve stimulation. Annals of Biomediccal Engineering; 1976; 4: 111-127.

5. Mahler, F., J.W. Covell, J. Ross. Systolic pressure--diameter relations in the normal conscious dog. Cardiovascular Research; 1975; 9(4): 447-455.

6. Schreiner, G.E. The physiology of arteriovenous fistulas. Medical Annals of the District of Columbia; 1955; 24(1): 1-12.

This is an example of some of the records the computer selected from BOX K and that would be moved into the CARDIOV box. The bibliographical list was labeled "BOX K CARDIOV" to indicate which box the journals were coming from, and to which box they would be transferred.

TABLE 10: NEW TOPICS AND COMPUTER TITLES

TOPIC	FILES FORMED WITH TOPIC
Acceleration	ACCEL 1-2
Heart	HEART A-M
Artery	ARTERY
Muscle	MUSCLE 1-2
Cardiovascular	CARDIOV
Autonomic Nervous System	ANS
Brain	BRAIN
Reflexes	REFLEX
Positive Pressure Breathing	PPB
Other	OTHER 1-4

The ten topics (left) were chosen by Dr. Burns and the files (right) were the representations of the topics. The reason for more than one file in some cases was because the number of journals in some topics exceeded one box and each box needed a separate label.