Design and Automation of MEDUSA
(Materials and Electronic Device Universal System Analyzer)

by

Phillip Johnson

Thesis submitted to the Faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Masters of Science

in

Electrical Engineering

APPROVED:

L C Burton
Dr L. C. Burton

F W Stephenson
Dr. F. W. Stephenson

Shiro Onishi
Dr. S. Onishi

February 1990
Blacksburg, VA

Design and Automation of MEDUSA

(Materials and Electronic Device Universal System Analyzer)

by

Phillip L. Johnson

Dr. L.C. Burton, Chairman

Electrical Engineering

(ABSTRACT)

MEDUSA (Materials and Electronic Devices Universal System Analyzer) is a computer controlled automated workstation capable of conducting eight different experiments, under different independent parameters, and plotting twenty-eight different graphs representing basic semiconductor diode and transport characteristics. This thesis discusses the methodology of computer automation, and the development of the MEDUSA experimental test station.

MEDUSA is divided into four different sections: a controlling batch file, a parameter selection routine (PARAMETER), an experimental running routine (RUNIT), and a data manipulation/plotting routine (GRAPHICS). MEDUSA conducts these eight experiments (capacitance and conductance versus time, voltage, current versus voltage, van der Pauw, and four-point resistivity) over a temperature range of 10-600K, with minimal operator interaction.

The graphics routines, using elemental semiconductor equations, process the data, and plots high quality graphs suitable for publication. Device and material results are shown to substantiate the validity of this automated system.

ACKNOWLEDGEMENTS

The author would like to thank Dr. L. C. Burton, who supported my work for more years than he should have, and for giving me much valuable information which will stand me in good stead in the future.

Also, much gratitude to Dr. F. W. Stephenson and Dr. S. Onishi for allowing me to panic in the last days and making time for my defense in their busy schedules. Eric Cole deserves more than thanks for coming up with the MEDUSA concept, and giving me much direction in software development. Also, Sidhartha Sen deserves a second Master's degree for all his help, advise, and friendship. Thanks to Chris Turman for bringing me back to the real world (yeah, thanks Chris!) and keeping things in perspective with his "wit". Also, Gary Kunselman, thanks for your support, editing skills and especially your sense of humor in the early morning.

I appreciate the backing of everyone else who has supported me in the past years (but not to the detractors), including Ashok Vaseashta, Eric Ellis, Monty Hayes, Chen, Keith Kasprak, Lynn Hellbaum, and In Yoo.

Finally, special thanks to Jana Dajani, for her complete support in this time of trauma, and her persistant nudging.

TABLE OF CONTENTS

LIST OF FIGURES

page

page

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1 Introduction

Solid state electronics is based largely upon semiconductor technology. Certain design principles and semiconductor electrical characterization form the basis for current electronic devices. Device quality and electrical parameters are found by electrical testing. Electrical characterization of materials and devices often entail tedious repetitive measurements. Often data points must be taken over a wide temperature range, increasing the time necessary for an experiment. Sometimes, a temperature scan may take a week or more to complete. Another important factor is experimental error. As electrical data frequently changes over time, a measurement taken at different times may yield conflicting results. So, if the time between measurements changes, inconsistencies may be expected. In order to minimize these errors and improve the data acquisition rate, an experimental test station was conceived, developed and implemented. This environment, nicknamed MEDUSA (Materials and Electronic Device Universal System Analyzer) allows the scientist or engineer to concentrate on the more important tasks of analyses and interpretation. The researcher inserts the device under test (DUT), enters which set of experiments to conduct, chooses the various experimental parameters, and then allows the test to run. After concluding the experiments, the controlling software enters a graphics package. This package, depending on the electrical characteristics relevant to the experiment, processes the raw data and converts this data into a graphic display.

This experimental test station is able to conduct eight different electrical experiments, and produce twenty-eight different graphs. The experiments were chosen specifically to produce information necessary to explore the electrical characteristics of both doped and undoped semiconductor regions. These characteristics are divided into two major sections; material and device characteristics. Material characteristics involve ion bombardment damage, doping and trap densities, mobility, and resistivity information, whereas diode characteristics address built-in potential, barrier

height, diode ideality factor, and saturation current. Such characteristic information is vital for quality control considerations and in making "good" and reproducible devices. Ion implantation damage information is especially important for GaAs. The majority of GaAs devices employ ion implantation techniques. When GaAs is implanted, the accelerated ions cause lattice disruptions resulting in an amorphous layer. Even though annealing restores the crystal lattice and activates the dopant, some damage remains [1]. Characterizing this damaged layer allows the researcher to probe the ion implanted layer. This characterization may be accomplished utilizing Deep Level Transient Spectroscopy (DLTS), which is further discussed in Chapter 2.

Doping profiles, mobility, resistivity and trap information provide a designer the parameters necessary for device optimization. The research described is aimed towards obtaining these parameters in a reliable, efficient and timely manner.

1.2 Literature Review

MEDUSA requires intensive data manipulation. An in-depth examination of the equations involved is given in Chapter 2. The resistivity, mobility, and carrier concentration measurements utilize van der Pauw's seminal work [2]. The equations for the average resistivity, mobility and carrier concentration for an arbitrary shape were obtained from Hemenger [3]. Carrier profiling requires expanding van der Pauw's work to take into account the different concentrations throughout the implanted layer [4].

Various diode characteristics can be uncovered from experimental measurements utilizing equations found in the literature [5-9]. The C-V barrier height, doping density, and the build-in potential all emerge from the $1/C^2$ versus voltage characteristic [5-7]. The C-V barrier height is estimated from the slope of the $1/C^2$ versus voltage slope [5-7]. The doping density is also derived from the same slope [5]. The built-in potential is the zero capacitance point of the $1/C^2$ versus voltage curve. The ideality factor, saturation current, and the I-V barrier height emerge from the current voltage equation [5-7]. Finally, the trap parameters originate from capacitance transient measurements at different temperatures [8,9].

Literature is quite extensive concerning laboratory automation in its various guises, both large factory and laboratory layouts. Now, with the advent of an affordable computer system, an automated laboratory test facility is a practical alternative to manual measurements. Various system layouts are presented in the literature [10-13]. The most complete step-by-step automated laboratory design is given by Dessy [12], where an overview is presented of the entire process of building an automated laboratory from computer selection to system design.

The central instrument of any automated work station is a computer. Currently, a wide choice between computer types (mini-computer, micro-computer, or mainframe) allows more flexibility in the design of a work station. Several informative articles explain the differences between the computers and their architectures [14,15]. The articles explain in great detail the differences between central processing units (CPUs), and their utilization of memory. The architecture most frequently used in smaller automation configurations features either the Intel 8088-80X86 micro-processor employed by the IBM compatible computers, or the MC68000 micro-processor series utilized by Apple. MEDUSA employs an IBM-AT, since it is one of the easiest computers to interface with an IEEE-488 bus.

Most interface manufacturers have a profusion of communications boards, including IEEE-488, RS-232C, and A/D-D/A (Analog/Digital-Digital/Analog) converters [11,16-19]. Several papers give an overview of these three interface schemes [20-22]. The first paper explains serial and parallel communications and their major automation off-shoots, RS232C and IEEE-488, respectively [20]. An explanation of A/D-D/A converter functions and a fairly comprehensive list of commercial vendors for digital interface equipment is given by Dessy [21]. Also, one paper gives examples of working configurations utilizing all three types of interfacing [22]. A more detailed look at the differences between the interfaces and an explanation of the IEEE-488 interface is presented in Chapter 3.

The operating systems (OS) and languages available for a computer are varied and wide ranging. The main OS for micro-computers are UNIX, RT-11, and MS/DOS [23-25]. These articles explain the differences between the three OS and several other types, while suggesting RT-11 is the

best for multi-tasking (doing more than one operation at a time), UNIX for multiple users, and MS/DOS being a simple, user friendly OS. MS/DOS was chosen as the OS for MEDUSA because it is easy to use and is the standard system for IBM micro-computers.

The languages available for these systems are even more plentiful than the operating systems themselves. The computer languages found most often in the laboratory are: BASIC, FORTRAN-77, C, Pascal, and Forth [25-31]. The differences are elaborated well in Dessy [25], allowing one to make an informed language selection. References 27-31 are invaluable for showing the syntax of each language and giving the beginner a chance to learn the language. A BASIC compatible language was chosen for MEDUSA. The justification is given in Chapter 3.

1.3 Thesis Objective

The main objective of this research was to build a user-friendly automated experiment workstation. Some of the design considerations are:

- Make the system simple enough to operate so a person unfamiliar with the layout can use it with ease in a relatively short time
- Design a hardware configuration capable of conducting a variety of experiments including:
  - Capacitance versus Time
  - Capacitance versus Voltage
  - Conductance versus Voltage
  - Current versus Voltage
  - Four-point Resistance
- Conduct the above experiments under the following conditions:
  - Different experiment dependent parameters (bias, pulse voltage, delay time, hold time)
  - Over a temperature range (10-600K)
  - Over an extended time period (life testing)
  - At room temperature
- Store the data obtained from the above experiments in a form acceptable to a written data manipulation program and understandable to the researcher.
- Convert the data files into graphs displaying different semiconductor characteristics
- Plot the graphs in a format suitable for publication

How these goals were attained is covered in greater detail in the next four chapters. The second

chapter explains the semiconductor equations utilized by MEDUSA in the graphing program. Also an overview of the hardware layout and the basics of digital interfacing are explained in greater detail. Chapter 3 covers IEEE-488 interfacing, the computer language chosen and the programs necessary to implement MEDUSA in the mode described in the paragraph above. Chapter 4 displays the most important semiconductor plots. Finally Chapter 5 presents the conclusions and future recommendations.

CHAPTER 2: DEVICE PARAMETERS AND HARDWARE OVERVIEW

This chapter provides basic information integral to the design and automation of MEDUSA. Basic semiconductor equations, which are used in the graphing procedures are presented, along with an overview of the MEDUSA hardware layout. Also introduced, is a brief introduction to computer interfacing.

2.1 Semiconductor Characteristics

Semiconductor characteristics can be classified under two broad categories: transport and diode characteristics. Transport characteristics yield carrier density (electrons or holes), resistivity, mobility, and their profiles. Diode characteristics provide a quantitative method of describing the quality of the diode, it's breakdown, forward characteristics, and reverse saturation. Diode capacitance transient measurements at different temperatures provide deep level information about the semiconductor.

2.1.1 Transport Characteristics

Transport characteristics, derived from van der Pauw measurements, may be broken into four sections, (i) resistivity, (ii) mobility, (iii) carrier concentration, and (iv) electrical profiles.

(i) Average Resistivity

Resistivity gives the opposition to a voltage or current through a device. This parameter is extremely important, not only for itself, but for other parameters (mobility and carrier concentration) derived from it. Resistivity is found from the van der Pauw experiment, which is a variation of a four-point resistance measurement. Figure 2.1 shows the three configurations necessary for the experiment. When the experiment is conducted in this manner, the four contact positions are inconsequential, provided they are close to the sample periphery. There are three four-point resistance measurements done immediately for calibration (R_a, R_b, and R_c). These are shown in Figures 2.1 (a)-(c). The

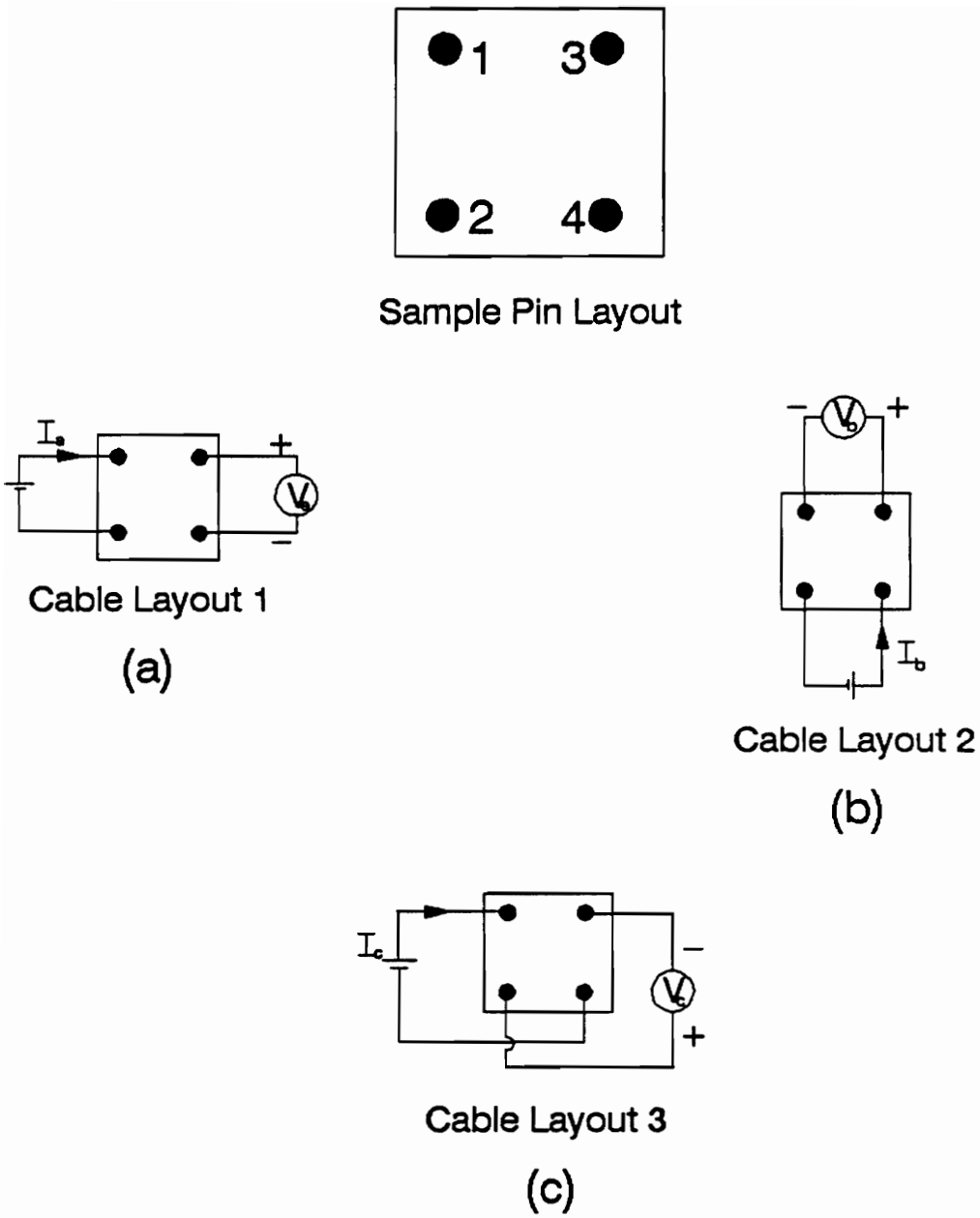


Figure 2.1 Three connector layouts for the room temperature van der Pauw measurements [3]

measurements in (a) and (b) give an average resistivity (ρ) using the equation [3]:

$$\rho = \frac{\pi t}{\ln 2}\left(\frac{R_a + R_b}{2}\right) f\left(\frac{R_a}{R_b}\right) \qquad (2.1)$$

where:

$R_a = V_a/I_a$
$R_b = V_b/I_b$
t = sample thickness
$f(R_a/R_b)$ = function defined in Figure 2.2

(ii) Average Mobility

Mobility (μ) gives a measure of device "speed", a good indication of how quickly the device switches from one state to another. Average μ may be found utilizing the resistivity calculated above, coupled with another resistance measurement [3]:

$$\mu = 10^8 \left(\frac{\Delta R_c t}{B\rho}\right) \qquad (2.2)$$

where:

$$\Delta R_c = \left| \frac{V_c(on)}{I_c(on)} - \frac{V_c(off)}{I_c(off)} \right| \qquad (2.3)$$

ΔR_c represents the change in resistance of the configuration shown in Figure 2.1 (c) with both the magnet on and off, and B is the magnetic Field in Gauss.

(iii) Average Carrier Concentration

The average carrier concentration (n) gives the number of electrons or holes per unit volume, that are active at the temperature probed. Even though this characteristic is found ultimately from the resistivity in section 2.1 (i), it is the origin from which both mobility and resistivity emerge. Average carrier concentration in the active layer is obtained once the the mobility (using equation 2.2)

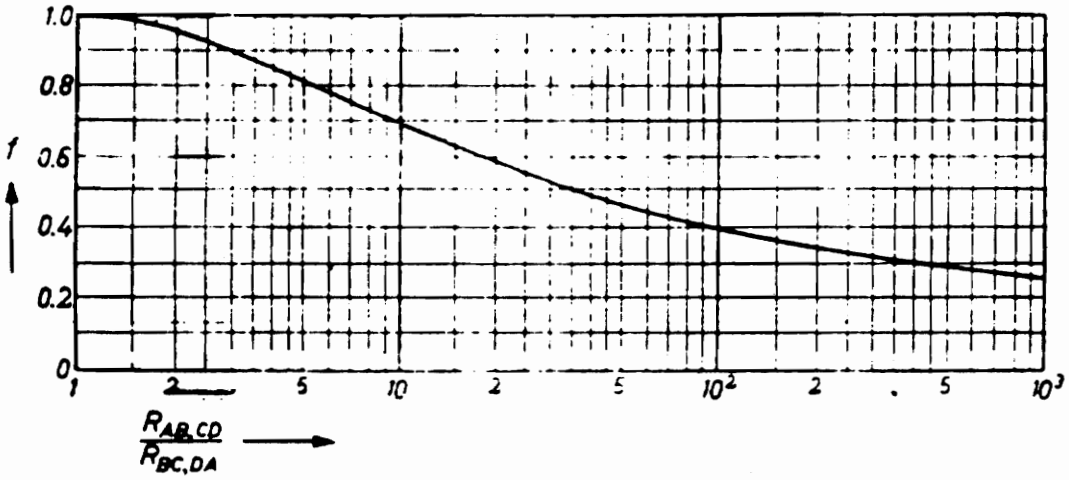


Figure 2.2 The function $f(R_a/R_b)$ [2]

is known, using the relation [3]:

$$n = \frac{1}{\rho q \mu} \tag{2.4}$$

$$n = \left(\frac{B}{\Delta R_c t}\right) 10^{-8} \tag{2.5}$$

where q is the electronic charge

(iv) Electrical Profiling

A carrier profile can be obtained by a combination of wet etching and van der Pauw measurements done repeatedly until the whole active layer is removed. The etching removes the surface of the material, exposing the material underneath. The amount of material etched from the surface depends on the etchant used and the etching time. The measurement is usually taken at room temperature because most of the dopants are activated. It may also be done as a function of temperature.

For depth profiling, these measurements are taken at various depths (d_n) over the thickness desired. The equations are modified for depth profiling by [4]:

$$\sigma_n = \frac{\overline{\sigma}_{n+1} d_{n+1} - \overline{\sigma}_n d_n}{\Delta d} \tag{2.6}$$

$$\mu_n = \frac{\overline{\mu}_{n+1} \overline{\sigma}_{n+1} d_{n+1} - \overline{\mu}_n \overline{\sigma}_n d_n}{\overline{\sigma}_{n+1} d_{n+1} - \overline{\sigma}_n d_n} \tag{2.7}$$

$$n_n = \frac{1}{\mu_n \sigma_n q} \tag{2.8}$$

where:

$\Delta d = d_{n+1} - d_n$, etched away thickness
σ_n, μ_n, & n_n are the conductivity, mobility, and carrier concentration of the n^{th} layer, respectively

2.1.2 Diode Characteristics

Diode characteristics can be divided into the following five sections, (i) barrier height, (ii) doping densities, (iii) built-in potential, (iv) ideality factor, and (v) saturation current.

(i) Barrier Height

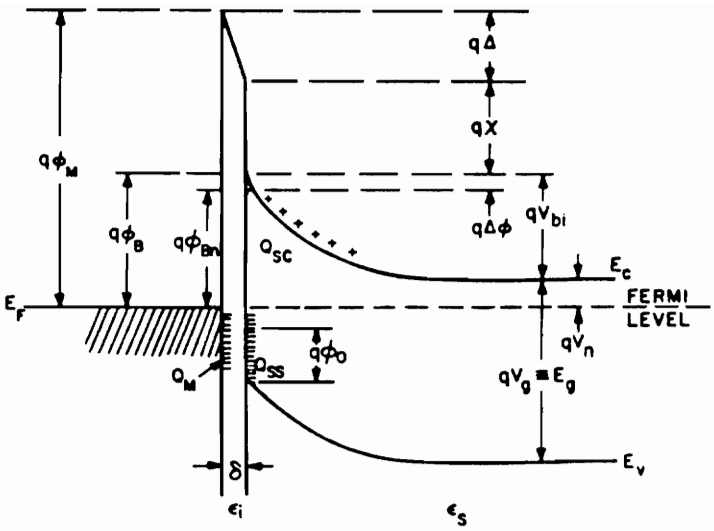
The barrier height is indicated in Figure 2.3 as $q\Psi_b$ [6]. This potential is the difference between the conduction band in the semiconductor at the surface and the Fermi level of the metal. Barrier height (defined for metal-semiconductor junctions, not pn junctions), gives an indication of the quality of the rectifying contact. As the barrier height increases, the reverse current decreases (in the ideal case). This is especially important for Metal-Semiconductor Field Effect Transistors (MESFETS) where many of the transistor characteristics depends on the reverse biased metal-semiconductor gate.

MEDUSA uses two methods for calculating the barrier height: current-voltage and capacitance-voltage. The first method is more accurate for moderately doped semiconductors. The second is better for highly doped semiconductors, but it assumes a perfect contact with no damage or interfacial layer (this layer gives two capacitors in series, leading to an erroneous barrier height). The forward current-voltage equation is [6]:

$$I_f = A\, A^* T^2 \exp\left[\frac{q(V_f - \Psi_B)}{kT}\right] \qquad (2.9)$$

where:

V_f is the forward bias in Volts
I_f is the forward current at V_f
T is the temperature in Kelvin
A is the diode area
A^* is the Richardson constant



ϕ_M = WORK FUNCTION OF METAL
ϕ_{Bn} = BARRIER HEIGHT OF METAL-SEMICONDUCTOR BARRIER
ϕ_B = ASYMPTOTIC VALUE OF ϕ_{Bn} AT ZERO ELECTRIC FIELD
ϕ_0 = ENERGY LEVEL AT SURFACE
$\Delta\phi$ = IMAGE FORCE BARRIER LOWERING
Δ = POTENTIAL ACROSS INTERFACIAL LAYER
χ = ELECTRON AFFINITY OF SEMICONDUCTOR
V_{bi} = BUILT-IN POTENTIAL
ϵ_s = PERMITTIVITY OF SEMICONDUCTOR
ϵ_i = PERMITTIVITY OF INTERFACIAL LAYER
δ = THICKNESS OF INTERFACIAL LAYER
Q_{SC} = SPACE-CHARGE DENSITY IN SEMICONDUCTOR
Q_{SS} = SURFACE-STATE DENSITY ON SEMICONDUCTOR
Q_M = SURFACE-CHARGE DENSITY ON METAL

Figure 2.3 Energy band diagram of a metal n-type semiconductor contact [6]

Ψ_B is the barrier height
k is Boltzmann's constant

The barrier height (Ψ_B) can be obtained from the slope of $\ln(I_f/T^2)$ versus q/kT at a given forward bias.

The capacitance-voltage equation is [6,7]:

$$\frac{1}{C^2} = \frac{2}{q\varepsilon_s N_d A^2}(V_R + V_{bi}) \qquad (2.10)$$

$$\Psi_B = V_{bi} + V_n + \frac{kT}{q} \qquad (2.11)$$

$$V_n = \left(\frac{kT}{q}\right)\left(\frac{N_c}{N_d}\right) \qquad (2.12)$$

where:

V_R is the reverse bias
V_{bi} is the built-in potential
N_D is the doping density

(ii) Doping Densities

The doping density is one of the most important semiconductor characteristics. It can be related to mobility, carrier lifetime, breakdown voltage, transconductance, barrier height and a plethora of other characteristics. The doping density for a uniformly doped semiconductor is found from the slope of the $1/C^2$ versus voltage plot (see Figure 2.4). The doping density (N_d) is found from [5-7]:

$$N_d = \frac{2}{q\varepsilon_s}\left[-\frac{1}{\partial(A^2/C^2)/\partial V}\right] \qquad (2.13)$$

where:

C is the diode capacitance
ε_s is the semiconductor permittivity
$\partial(A^2/C^2)/\partial V$ is the slope of the A^2/C^2 curve versus reverse bias

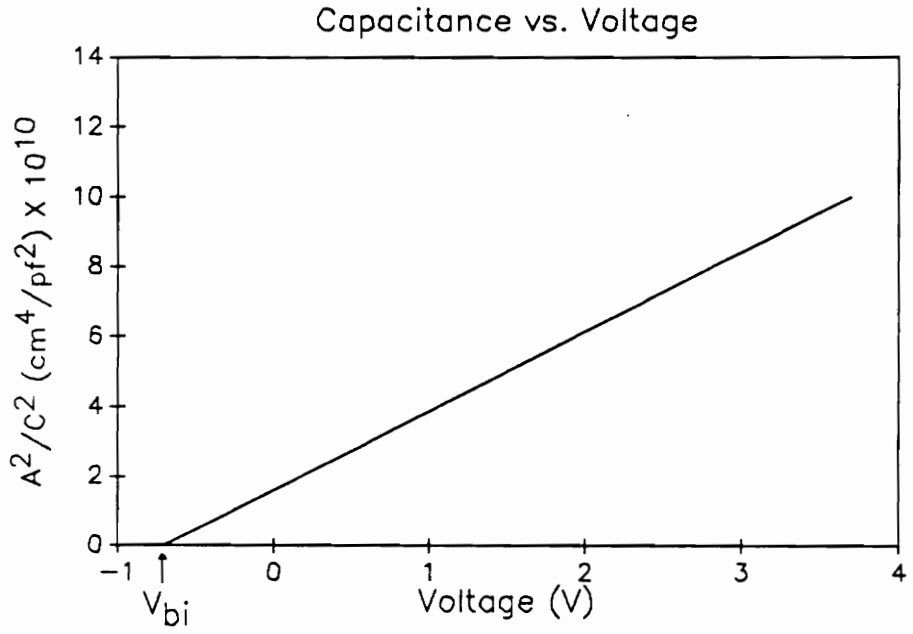


Figure 2.4 Ideal $1/C^2$ versus voltage plot

(iii) Built-In Potential

The built-in potential is shown in Figure 2.4 as V_{bi}. This voltage is the difference between the conduction band at the interface and the bulk. The built-in potential is found from the capacitance versus voltage experiment. This voltage is found at the voltage (zero capacitance point) intercept of the $1/C^2$ versus V curve (See Figure 2.4).

(iv) Ideality Factor

The ideality factor gives an indication of how well the diode follows the thermionic emission characteristic. This factor is given by [6,7]:

$$n = \frac{q}{kT}\left[\frac{\partial V}{\partial \ln(I)}\right] \qquad (2.14)$$

Measuring the ideality factor is accomplished by conducting a current-voltage experiment. The slope of the natural log current versus forward bias curve determines the ideality factor. The ideality factor should be close to one for a good diode at low doping levels [6].

(v) Saturation Current

Saturation current is defined in the thermionic emission model. It gives the reverse current before breakdown and how well the diode behaves at forward voltages. A good diode has a low saturation current. The ideal diode equation (with an ideality factor of unity) is [5-7]:

$$I = I_s\left[\exp\left(\frac{qV}{kT}\right) - 1\right] \qquad (2.15)$$

or

$$\ln(I_s) = \frac{qV}{kT} - \ln(I) \qquad (2.15)$$

where I_s is the saturation current.

The saturation current is found from the current intercept of a natural log current versus voltage plot.

2.1.3 Trap Parameters

Trap energy (E_t) is the position of the trap below the conduction band edge. The energy level and the trap density can be found from Deep Level Transient Spectroscopy (DLTS). A DLTS spectrum, at a fixed rate window, is the plot of a transient capacitance magnitude versus temperature. A peak in the spectrum occurs when the trap emission rate equals the rate window. The sign of the transient will denote the type of trap, electron or hole, and the magnitude of the peak is approximately related to the trap density as [8]:

$$N_t = 2N_d \left|\frac{\Delta C}{C}\right| \qquad (2.17)$$

where

$$\Delta C = \frac{C(t_1) - C(t_2)}{\exp^{-e_n t_1} - \exp^{-e_n t_2}} \qquad (2.18)$$

and

C is the reversed biased capacitance
$C(t_1)$ - $C(t_2)$ are diode capacitances at times t_1 and t_2, respectively
N_d is the donor concentration
e_n is the trap emission rate at the DLTS peak temperature

A trap emission rate, or rate window, for an exponential transient, can be obtained as [9]:

$$e_n = \frac{\ln\left(\frac{t_1}{t_2}\right)}{t_1 - t_2} \qquad (2.19)$$

If the rate window is chosen to be equal to 50 s^{-1}, then the trap energy can be estimated as:

$$E_t = 23.7kT_m \qquad (2.20)$$

where T_m is the temperature of a DLTS peak.

This is accurate to within ±10%.

2.2 Experimental Test Station

The hardware layout for MEDUSA is shown in Figure 2.5. The instruments on the left side are connected to the computer via the IEEE-488 bus. The capacitance-time (C-t/HP 4280A) meter with the assistance of the pulse voltage generator (HP 8112A) controls the first group of experiments, the capacitance/conductance measurements. The picoammeter (pA meter/HP 4140B) controls the second set of experiments, comprised of current-voltage and capacitance-voltage measurements. The pA meter in conjunction with the Keithley 195A multimeter, is used in the four-point resistance measurement. When combined with the Varian magnet, the Van der Pauw/mobility experiment is enabled. The cryostat, consisting of a IEEE-488 temperature controller, the cold head, compressor, and vacuum pump control the temperature setting for the device under test (DUT). On the right side of the figure, the parallel printer port and serial port are connected to the Okidata 192 printer and HP 7475A plotter, respectively.

2.3 DUT Hardware

The most important piece of hardware is the TO-8 header shown in Figure 2.6, which holds the DUT in place during the experiment. Four out of the twelve possible header leads are used. The eight unused leads are removed. For a diode, only two leads are necessary, one for the ohmic and the other for a Schottky contact. Usually, more than one Schottky contact (up to three) are made, to allow a typical diode to be chosen for the capacitance and forward voltage characteristics. Both the

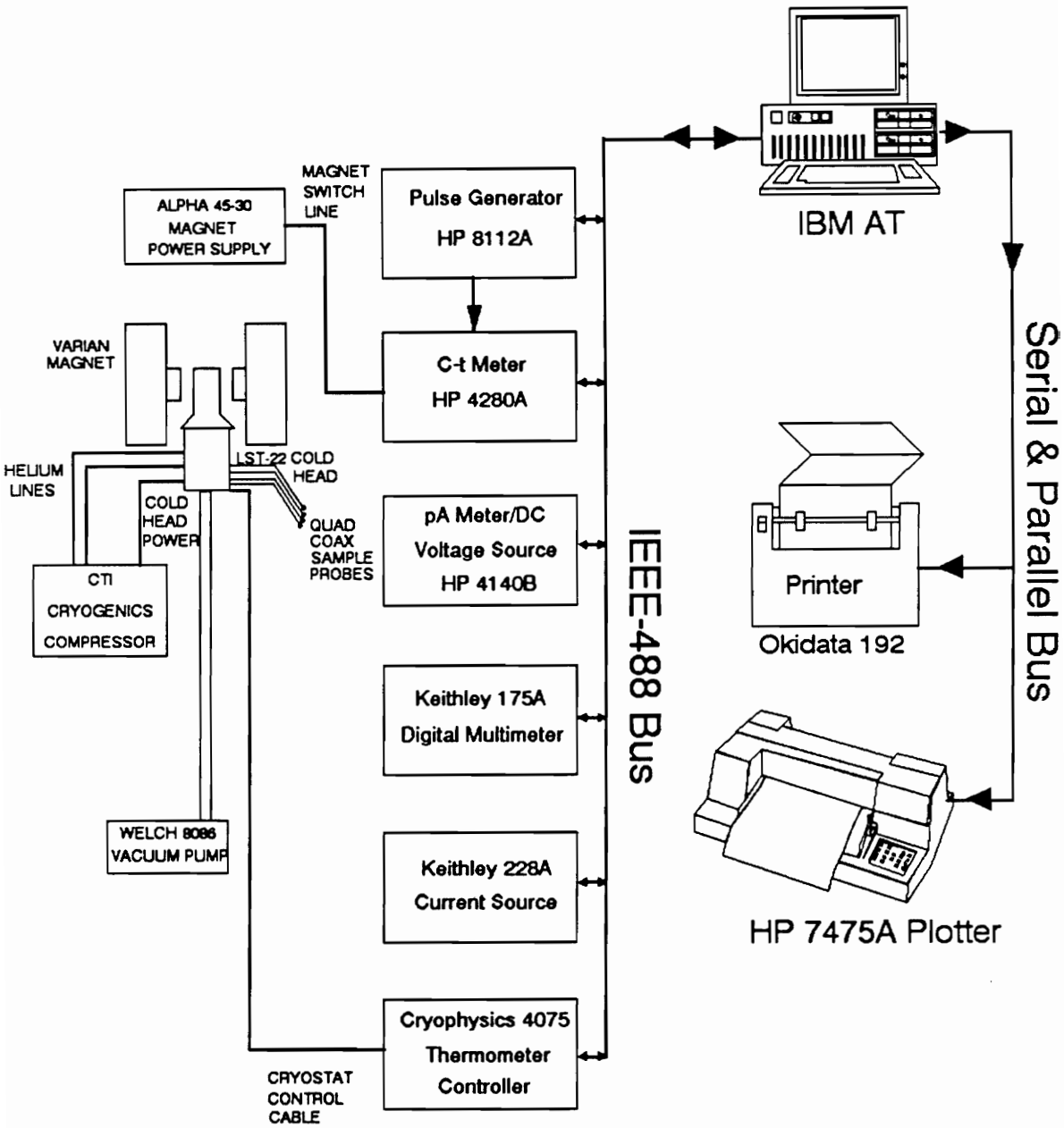


Figure 2.5 MEDUSA hardware layout

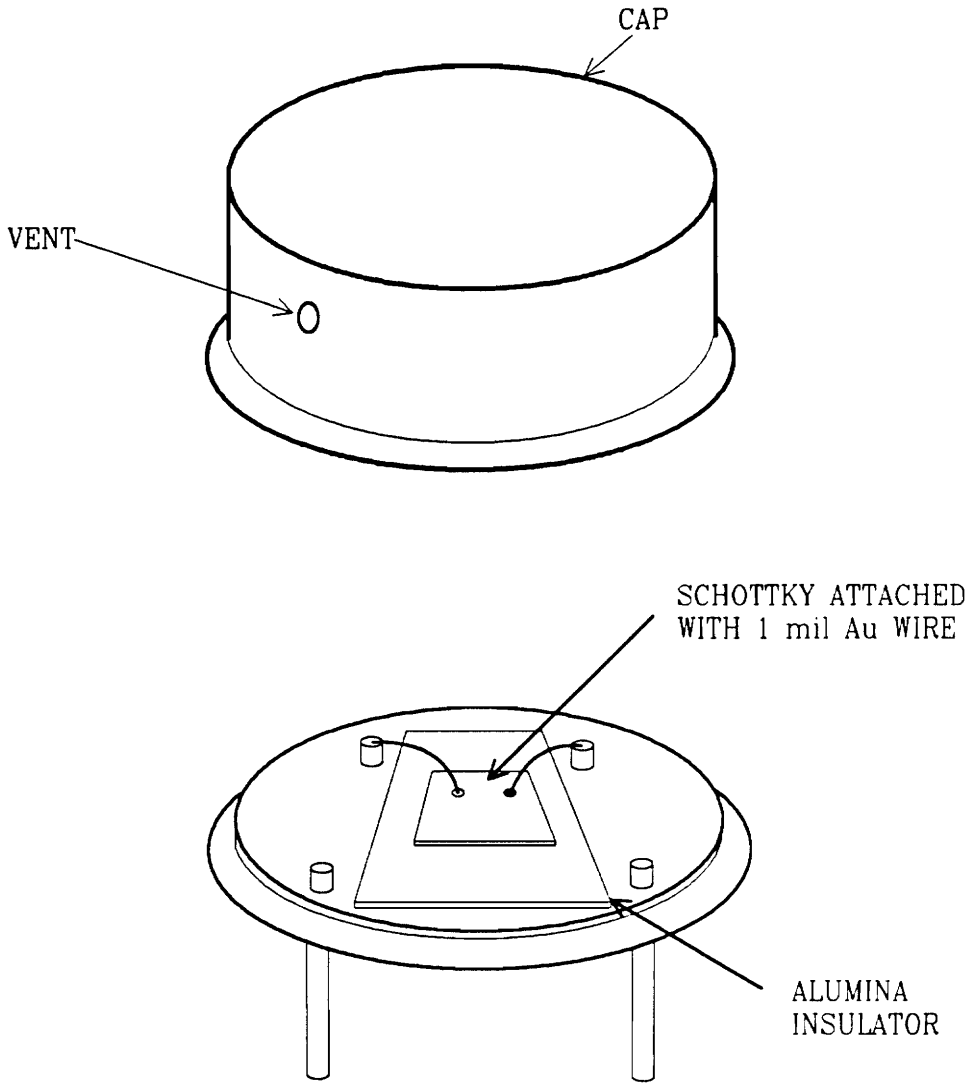


Figure 2.6 TO-8 Can with mounted DUT

van der Pauw and four-point resistance measurements utilize all available leads. An alumina substrate employed as an insulator is connected to the header base utilizing thermally conductive grease, insuring against a common ground through the wafer back. The DUT is then placed on top of the alumina, once again secured with thermally conductive grease. The bridge between the header and the DUT is made with 1 mil (1/1000 inch) gold wire, utilizing Epo-Tek H20E electrically conductive epoxy. The epoxy is subsequently cured at 150°C under nitrogen for 5 minutes. The header cap in Figure 3.2 has a small vent hold drilled through it. This vent allows outgassing of the thermal grease and epoxy at higher temperature (above approximately 290K). The TO-8 header with sample mounted is then placed inside the coldhead and secured with a strap to insure proper electrical and thermal contact during the experiment.

2.4 IEEE Interface

A digital interface is necessary for the computer automation of any laboratory experimental layout. This interface connects the various measurement taking instruments to the computer, providing a pathway for data to flow in both directions. Data from the computer provides the various instruments with the information related to experimental parameters. The instruments send the computer the data acquired from the actual experiment. The interface provides the protocol and pathways necessary for device communication. A standard which has become very popular is the IEEE-488 standard. This standard is further explored in the following chapter.

CHAPTER 3: EXPERIMENTAL TECHNIQUES

This chapter covers two main areas; how the computer interface operates, and MEDUSA's programming layout. The computer interface which works with all the measurement instruments is the IEEE-488 interface. The program layout, broken into four sections, controls the experiments and analyzes the data.

3.1 IEEE-488 Interface

The IEEE-488 interface supplies the connection between the controlling program and the instrumentation responsible for the data acquisition. The following three sections provide information on: (i) IEEE bus lines, (ii) general interface protocol, and (iii) running the IEEE interface.

3.1.1 IEEE BUS Lines

The interface protocol between the computer and the various pieces of electronic equipment is based upon the IEEE interface standard 488-1975 [5]. The IEEE standard also conforms to an ANSI standard (MC1.1) and HP publications. This representation is generally accepted for virtually all digital interface apparatus. Another term frequently used in literature is GPIB (General Purpose Interface Bus). Both notations will be used in this manuscript.

The IEEE standard is based on parallel bus architecture, which implies that one byte (8 bits) is sent along eight lines simultaneously. The cable is connected to 24-pin IEEE-488 connectors. The pin layout, following the IEEE-488 standard, is shown in Table 3.1. It should be noted that lines 1-4 and 13-16 are data lines, which makes up one byte. The bus is designed to accept the following line layout (see Figure 3.1). Five management lines, allow the controller to oversee all bus operations. The handshake lines supervise all data transfer, and data lines allow parallel communications. Finally, the remaining eight lines are grounds.

The management lines consist of EOI (End Or Identify), IFC (Interface Clear), SRQ (Service

Table 3.1 IEEE-488 Line Connections

Contact Number	IEEE-488 Designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN	Management
18	Gnd	Ground
19	Gnd	Ground
20	Gnd	Ground
21	Gnd	Ground
22	Gnd	Ground
23	Gnd	Ground
24	Gnd	Ground

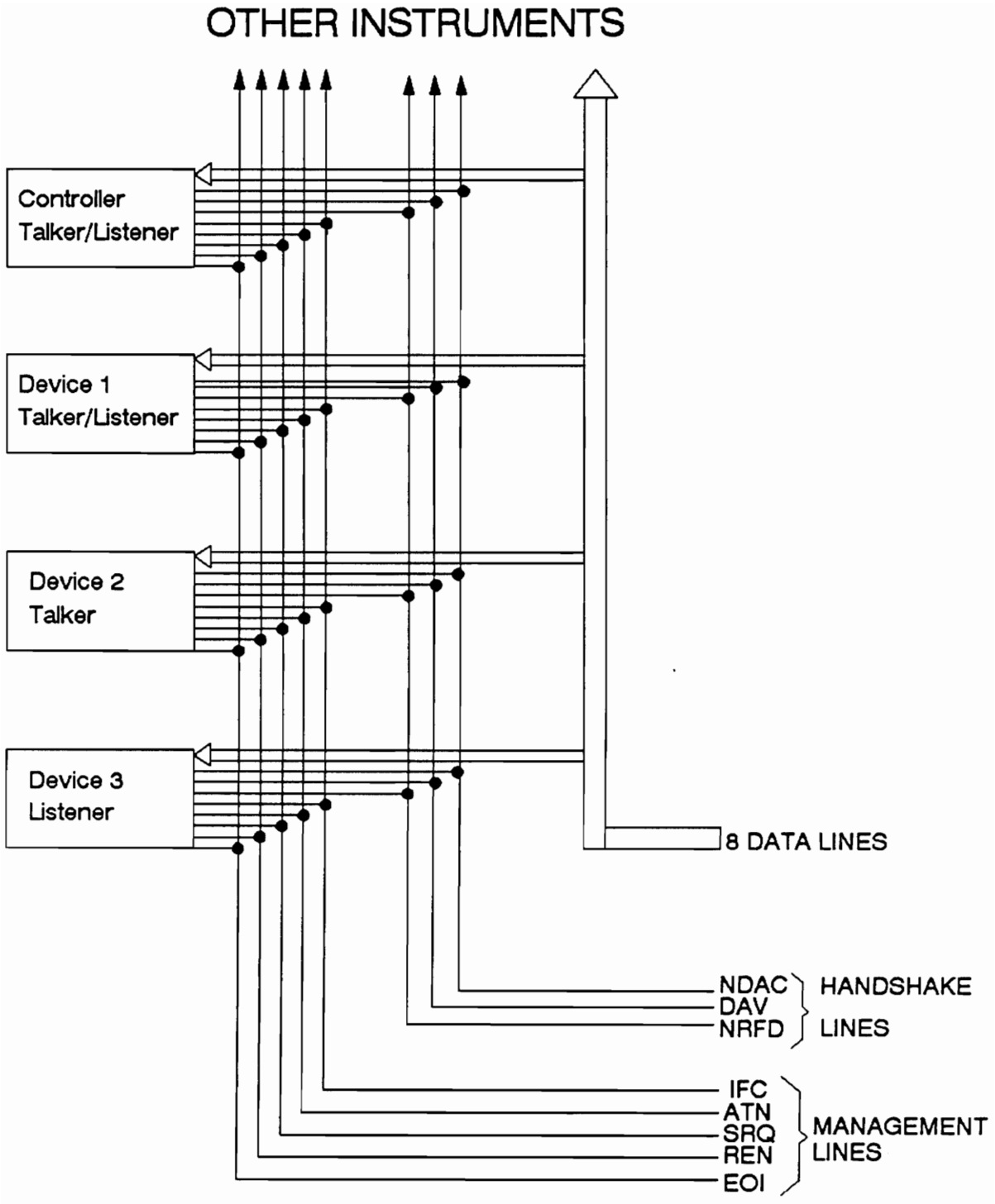


Figure 3.1 IEEE-488 BUS layout

Request), ATN (Attention), and REN (Remote Enable). The EOI identifies the end of a multi-byte transfer. The IFC line takes the addressed instrument(s) out of both talk and listen modes. When the SRQ line is made active by an instrument, it requires some type of service. The ATN line regulates whether the information placed on the bus is data or a controller command. When REN line is set low, either all the devices on the bus are sent to remote, or the one device immediately addressed.

The three handshake lines consist of DAV (Data Valid), NRFD (Not Ready For Data), and NDAC (Not Data Accepted). These handshake lines work together to assure data reliability. Figure 3.2 shows the relative states of the lines for proper data transfer. When the data is placed on the bus by the source, the source checks to see if the NRFD line is high. Concurrently, the NDAC line should be low from previous data transfers. When both of these lines are properly set, the source sets the DAV line low. The NDAC line remains low until the slowest listener has received the data and sets the line high. After all devices are cleared, the NDAC line is sent low. Finally, the eight data lines allow transfer of all information over the bus, one byte at a time.

A typical configuration is shown in Figure 3.1. This configuration can be either serial or parallel, depending on application needs. Parallel connection of all devices enhances data transfer speed, while reducing the total number of allowed devices and cable length.

3.1.2 General Interface Protocol

Figure 3.1 shows a main controller (the computer) with all other instruments in series with it. There are three main types of devices; controller, talker, and listener. The controller supervises all other bus instruments. The talker sends data through the bus, either to other instruments on the bus and/or to the controller. The listener(s) receive any data which has been sent by the talker. Almost any instrument can be a talker, listener or both. A typical listener is a plotter or printer.

At any one time there can only be one operative controller. The general limit for instruments is fifteen. The limit is also controlled by the total cable length between the instruments. This length is dependent on the necessary bit rate, but a maximum length of twenty meters is usually observed.

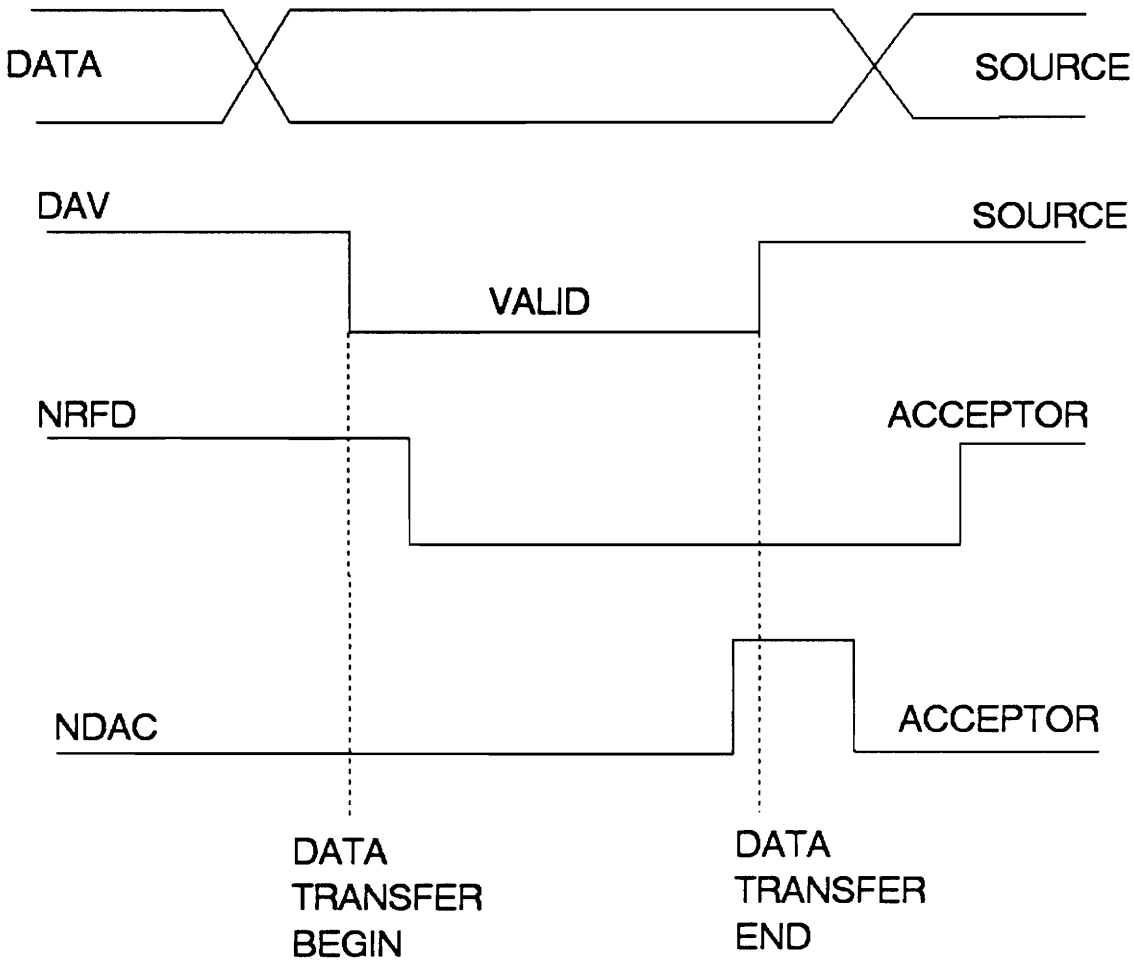


Figure 3.2 IEEE-488 timing diagram [34,35]

Only one talker exists at a time. The other devices are usually addressed as listeners. The talker is chosen by the controller who addresses the instrument and then tells the talker to send the data onto the bus.

A Scientific Solutions IEEE-488 controller was chosen. It was picked for its ease of use, and cost.

3.1.3 Running the IEEE-488 Interface

To get the IEEE-488 interface to run properly, the computer must first initialize the IEEE controller board. This board resides in one of the computer expansion slots. When the controller wants to open the instrument(s) for communications it must send a remote enable signal (REN) through the bus to place each device into a computer controlled mode. Next, the computer will address the device it needs to communicate with. This allows the controller to either give information to (such as instrument experimental parameters), or get information from the device (data). Once the device is addressed, it responds to the controller commands. After finishing the controller instructions, the instrument sends a clear message (NDAC) over the bus, then the controller goes onto the next function [32-34]. All these functions are controlled by a software program which tells the controller, through machine language routines, exactly what steps to take to successfully run an experiment. Once the operations have been concluded, the controller then sends an clear signal over the bus (IFC) and removes the devices from the bus (sends the REN line high).

3.2 PROGRAMMING LANGUAGE

MEDUSA requires a programming language which can fulfill a wide range of objectives. These requirements and the language which satisfies the criteria are detailed in the next two sections.

3.2.1 Language Requirements

MEDUSA places many demands on a programming language. These demands are: large available memory (greater than 256 Kbytes), Scientific Solutions (IEEE-488) compatible (in this case BASIC adaptable), ability to use Enhanced graphics (EGA), ease of programming, and expense.

MEDUSA is a very involved program, so a large amount of memory is necessary to allow utilization of arrays, memory intensive graphics, and data processing sections. Also, Scientific Solution's software is written in BASIC and uses about 40 Kbytes of memory on its own. This precludes using BASIC or many of the other BASIC compatible software packages available at the time, because they allowed a maximum utilization of 64 Kbytes of memory, not nearly enough. Also, in order to get reasonable detail on screen graphics, and to utilize the Paradise EGA card and monitor, a program is necessary which allows enhanced graphics programming.

3.2.2 Language Chosen[27]

The language chosen was BetterBASIC$_{tm}$. It supports complete utilization up to 640 Kbytes of memory, is BASIC compatible, allows enhanced graphics, and has a low cost. It also expands BASIC's limited programming abilities. Some of these enhancements include procedures (or subroutines), local and global variables, recursion, pointers, allows math co-processor programming (speeding up any math calculations), expanded math accuracy (for both math co-processor and decimal math), and program block structures which include IF-THEN and DO-LOOP statements. Another advantage of BetterBASIC$_{tm}$ is the ability to reduce the size of procedures, further decreasing memory usage.

BetterBASIC$_{tm}$ allows three types of program saves. The most memory consuming, yet least likely to have errors, is a file listing. This is an ASCII file (a file readable outside of the BetterBASIC$_{tm}$ environment). The drawback to this method of saving is the lengthy period it takes to reload and compile the program when reentering BetterBASIC$_{tm}$. The second is considered a normal save in BASIC. It is an object code save, which takes less memory and is quick to reload. It is also more likely to have errors in the saved file. The final method is a compressed file. This takes the procedures and removes the symbol and source tables, making the files much smaller. The two drawbacks to compressed file are, the compressed procedures cannot be edited, and the file is the most likely to fail when saved. The advantage is a much smaller file, which allows greater array

allocation because one of the main concerns was memory availability. MEDUSA uses compressed files.

Throughout the programming period, it was necessary to reduce memory requirements at all stages. This was accomplished using BetterBASIC$_{tm}$'s procedure reduction features, creating three software modules and linking the various routines through a DOS batch file. This is further explained in the next section.

3.3 MEDUSA'S SOFTWARE

MEDUSA is broken into a controlling batch file and 3 programming sections (a complete program listing is given in the appendix). The batch file controls the linking between various programs. The primary sections include a parameter setting program (PARAMETER), an experimental measurement program (RUNIT), and a data processing/plotting program (GRAPHICS). These programs are discussed more fully in the following four sections.

3.3.1 MEDUSA.BAT

MEDUSA.BAT (shown in Figure 3.3) is a DOS batch file which links between the three programs and configures BetterBASIC with the correct library modules. These modules configure BetterBASIC$_{tm}$ with the proper math and graphics routines. When the user types MEDUSA <ENTER> while in DOS, the batch file is implemented sending the user into PARAMETER. Once the user is finished with the parameter setting program, the program exits back to DOS where the batch file either links to RUNIT or GRAPHICS, depending upon previously supplied information. If GRAPHICS is chosen, MEDUSA.BAT will find the file "C:\DATA\END", and the user is immediately transferred to the plotting program, bypassing all experimental routines. Selecting RUNIT executes the experimental data acquisition program. After departing RUNIT, MEDUSA.BAT searches for the file "C:\DATA\REDO". If this file is located, the user returns to PARAMETER, otherwise continuing to GRAPHICS. Once the user is done with the graphics section, the batch file clears the screen and returns the user to the main directory.

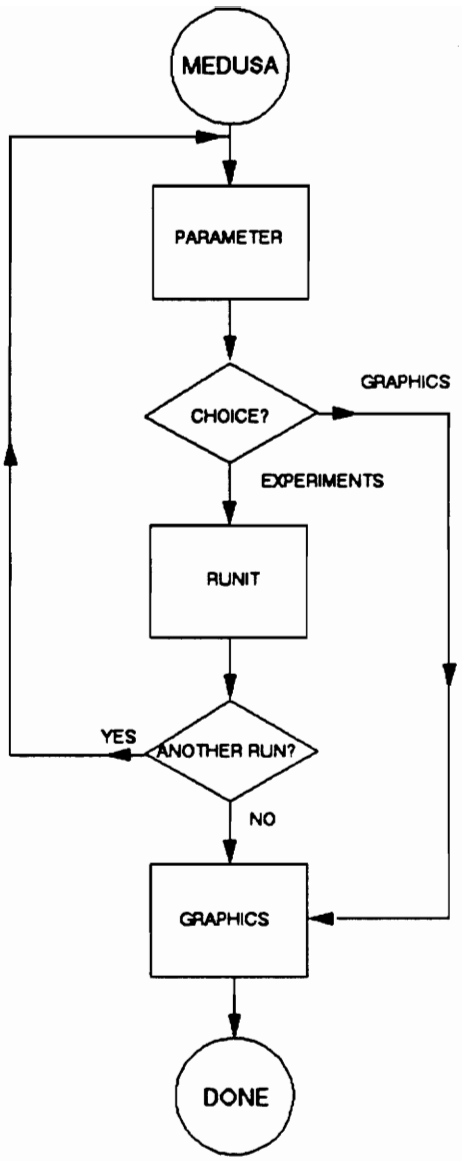


Figure 3.3 Flow chart for MEDUSA.BAT

3.3.2 PARAMETER

The flow charts for PARAMETER are shown in Figures 3.4 and 3.5. Figure 3.4 depicts the program start, where characteristic information about the DUT and rudimentary experimental information is entered. Figure 3.5 concludes the flow chart, giving an outline of each experimental group's parameter setting routine.

When the batch file initiates PARAMETER, the program immediately displays an introductory screen welcoming the user to MEDUSA and requesting instruments to be turned on. Next the program checks for the file "C:\DATA\REDO". If the program finds this record, signifying a return from the program RUNIT, the user is asked if he wants to use the same DUT information block. If a different information block is required, the program continues on to the run type. If the same DUT information block is desired, the user enters the directory for the new experimental run. If this directory has not been previously specified, the data is immediately transferred from the old directory to the new one. Otherwise, the user must authorize clearing old data from this directory. Finally, after the information has been transferred, the program continues on to the run type.

If the program does not find the file "C:\DATA\REDO", the above procedure is bypassed. At this point, the program gives a choice between a time, temperature, room temperature run, or an exit to the graphics routine. If GRAPHICS is chosen, PARAMETER makes a file "C:\DATA\END" then immediately exits to DOS, allowing MEDUSA.BAT to resume control. Otherwise, the program sets the appropriate run type flag. If the program entered from RUNIT and the DUT information copied to a new directory, the program bypasses the DUT information routine and continues to the section choosing the experimental group. Otherwise, the user enters device information, i.e. , the directory, user's name, sample number, cryostat reading, and any desired comments. Upon making an error, the program allows changes to the above information. Now the actual experiments are chosen. Table 3.2 gives the four experimental groups and their individual choices.

After choosing the experimental group, the program breaks off into the specified experimental group (Figure 3.5) where each individual experiment is selected. If the user does not choose any

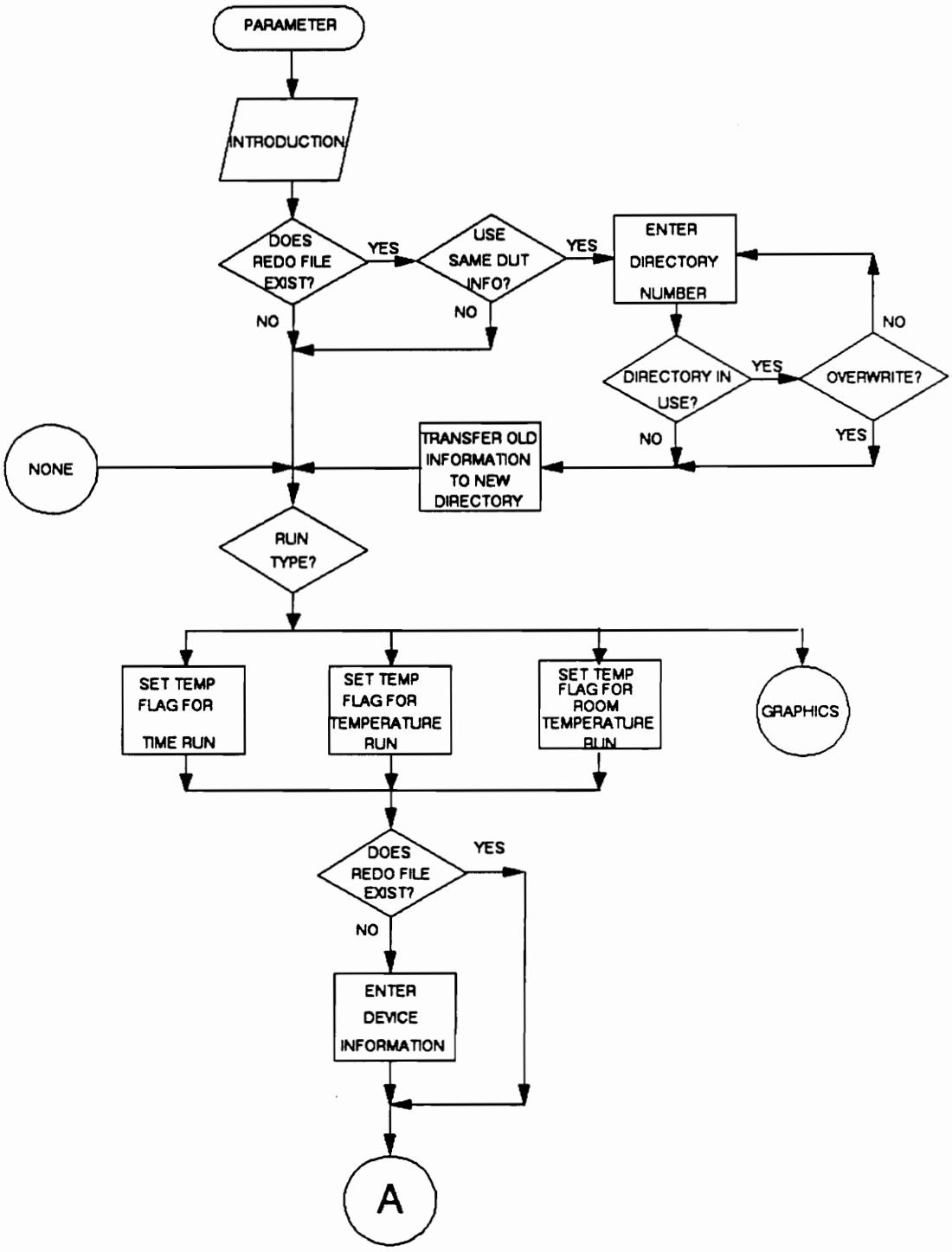


Figure 3.4 First flow chart for Parameter

Table 3.2 Group Experiments

GROUP I	GROUP II
Capacitance vs. Time Conductance vs. Time Capacitance and Conductance vs. Voltage Capacitance and Conductance	Current vs. Voltage Capacitance vs. Voltage
GROUP III	**GROUP IV**
Van der Pauw/Mobility	4-point Resistivity

Table 3.3 Group I Parameters

GROUP I
Capacitance vs. Time and Conductance vs. Time Temperature Range/Increment Bias Voltage Range/Increment Number of Samples Pulse Times and increments Pulse Voltage Range/Increment Step Delay Time
Capacitance and Conductance vs. Voltage Temperature Range/Increment Voltage Range/Increment Hold Time Step Delay Time
Capacitance and Conductance Temperature Range/Increment Bias Voltages/Increment

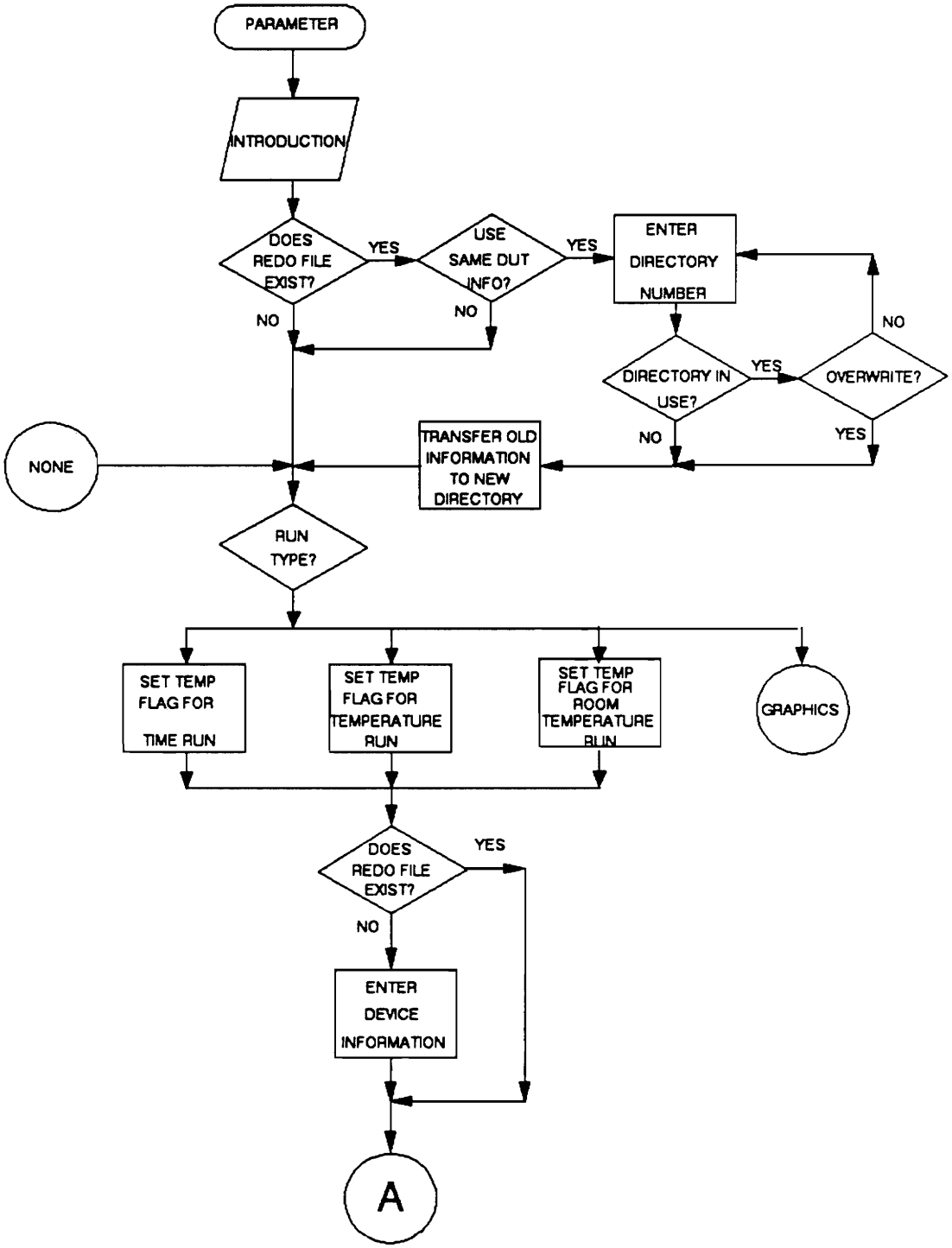


Figure 3.5 Second flow chart for PARAMETER

experiments, the program loops back to the TEMP/TIME/ROOM TEMP/GRAPHICS section (see Figure 3.4 - NONE). Following experimental selection, the user sets the temperature range, time range, or room temperature. If the temperature run has been selected, the program allows the user to enter the overall temperature range and its increment, then checks to ensure these temperatures are within the cryostat's abilities. If a time run is chosen, both the temperature entered and time parameters are checked to confirm that they are within program specifications and temperature controller limits. The room temperature setting defaults to 290K, but allows the user to enter a different temperature.

The next section involves entering each of the chosen experimental parameters (see Tables 3.3-3.6). The program asks for each parameter, one at time, allowing reentry of miskeyed values. After entering all the parameters, the program goes to the IEEE-488 interface and asks the instruments necessary to the experiment (see Table 3.7) if the given parameters are within each instrument's capability. If an instrument cannot handle these values, it returns a service request (SRQ). The program queries the instrument, reads the error message, and prints it to the screen. After pausing five seconds, the program returns to the parameter entry routine and allows the user to reenter their parameters. After the instruments accept the given parameters, the computer proceeds to the next chosen experiment and repeats this procedure. After finishing all the chosen experiments, the program directs the DUT information to a file called "C:\DATA\###\INFO", where ### is the requested directory. This is a permanent file, where the user can later retrieve the device information. Two other files are temporarily saved, "C:\DATA\EXPT", AND "C:\DATA\PARAM". The "EXPT" file holds the experimental directory, chosen experimental group, type of temperature/time run, and the selected individual experiments. The "PARAM" file contains all the experimental parameters. RUNIT utilizes both files. After saving these files, the program exits to DOS, and MEDUSA.BAT proceeds to the experimental program, RUNIT.

3.3.3 RUNIT

The program RUNIT performs the experimental measurements and saves them in

Table 3.4 Group II parameters

GROUP II	
Current vs. Voltage	Capacitance vs. Voltage
Temperature Range/Increment	Temperature Range/Increment
Start Voltage	Start Voltage
Stop Voltage	Stop Voltage
Step Voltage	Step Voltage
Hold Time	Hold Time
Step Delay Time	

Table 3.5 Group III parameters

GROUP III
Van der Pauw/Mobility
Temperature Range/Increment
Current Bias

Table 3.6 Group IV parameters

GROUP IV
Four Point Resistance
Temperature Range/Increment
Current Bias

Table 3.7 Experiments and their related instruments

Capacitance vs. Time and Conductance vs. Time C-t Meter HP 4280A Pulse Generator HP 8112A Cryophysics Thermometer/Controller Model 4075
Capacitance and Conductance vs. Voltage and Capacitance and Conductance C-t Meter HP 4280A Cryophysics Thermometer/Controller Model 4075
Current vs. Voltage and Capacitance vs. Voltage pA meter/DC Voltage Source HP 4140B Cryophysics Thermometer/Controller Model 4075
van der Pauw/Mobility pA meter/DC Voltage Source HP 4140B Keithley 228A Voltage/Current Source Digital Multimeter Keithley 195A Cryophysics Thermometer/Controller Model 4075
Four Point Resistance Digital Multimeter Keithley 195A pA meter/DC Voltage Source HP 4140B Keithley 228A Voltage/Current Source Alpha Model 45-30 Power Supply/Varian Magnet C-t Meter HP 4280A Cryophysics Thermometer/Controller Model 4075

GRAPHICS compatible ASCII files. The two major blocks of RUNIT are the temperature setting section, and instrument setup with data taking/storing routines. Figure 3.6 shows the first section of RUNIT. When the program enters from PARAMETER, the computer immediately inquires if the device is correctly connected to the instruments. When the user finishes the configuration and hits any key on the keyboard, the computer initializes the IEEE-488 interface. The program now loads two files, "EXPT" and "PARAM", which specify the experiments to conduct and their associated parameters. Once these files have been read, the program searches for a van der Pauw experiment. This experiment requires a room temperature four-point resistance measurement coupled with a magnetic field measurement (see chapter 2.2.1 (i)). The room temperature readings are now taken. The experiment requires different cabling to achieve the desired results. The program accomplishes this by pausing and asking the user to switch the coaxial cables to the configuration displayed on the screen. After finishing these measurements, the program returns to the main program flow. At this point the program branches to one of three sections, (i) time run, (ii) room temperature, , or (iii) temperature run.

(i) Time Run

Figure 3.7 gives the flow chart for the TIME run. First, the time is initialized to zero and displayed on the screen. Next, the program goes to the temperature setting routine (Figure 3.9) which sets the proper DUT temperature. After completing the first experimental set, the program loops back to A´, where the time between experimental runs is added to the original time. If this time is greater than the maximum time given for the experiment, the program exits to a finishing routine (Figure 3.19). If the current time is less than the maximum time given by the user, the computer pauses until reaching the next experimental run time. At this point the program prints the new time and again runs the chosen experiment set (Figure 3.10).

(ii) Room Temperature Run

The room temperature flow chart is given in Figure 3.8. The room temperature is simply printed to the screen, and then the program proceeds to the experimental sections (Figure 3.10).

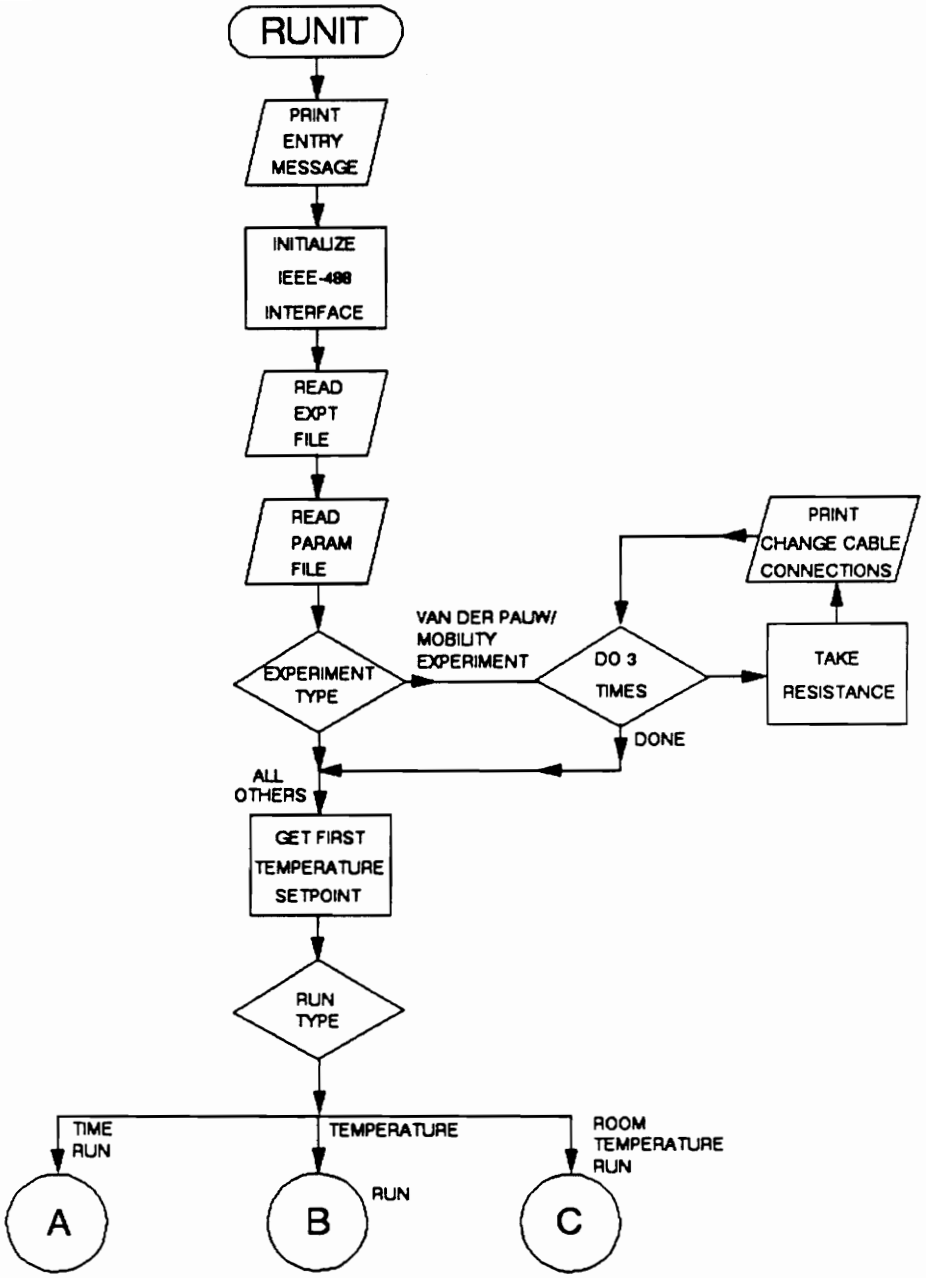


Figure 3.6 First flow chart for RUNIT

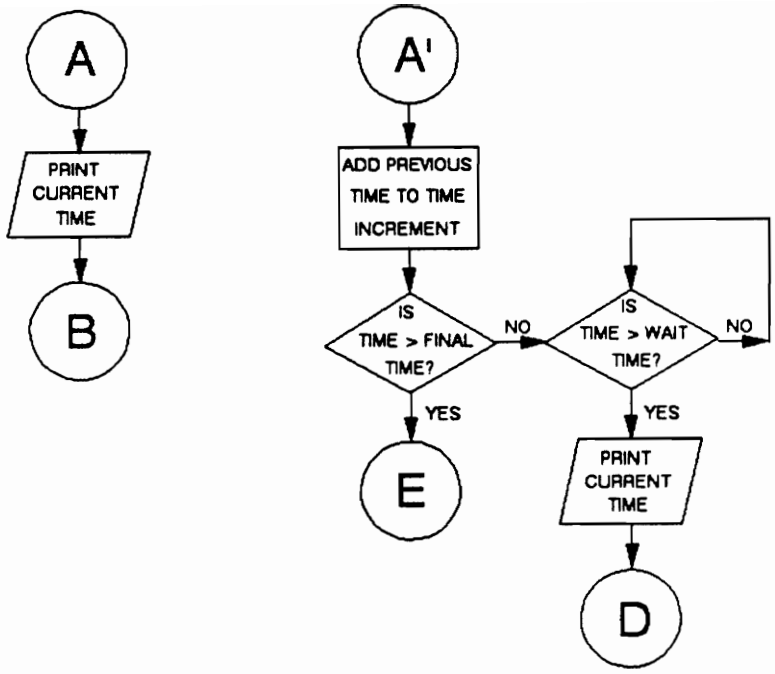


Figure 3.7 Time run flow chart

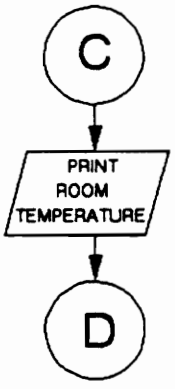


Figure 3.8 Room temperature flow chart

After completing the experimental set, the program continues to the finishing routine (Figure 3.19).

(iii) Temperature Run

The temperature setting routine (Figure 3.9) is the most vital section of the RUNIT program. It consists of setting the correct DUT temperature while ensuring the low temperature silicon sensor does not overheat. The first step prints the sample temperature set-point and determines if the temperature is greater than 290K. If this is true, the computer displays a warning message to the screen, advising the user to turn on the vacuum pump to remove any outgassing from the sample.

The routine now determines the correct temperature-dependent controller parameters. These parameters are implemented by sending them to the temperature controller. The current temperature is read from the controller and compared to the sample set-point. If the temperature varies from the set-point by more than ± 1 K, the program checks the silicon sensor for catastrophic failure which occurs at temperatures greater than 325K. If the coldfinger fails this test, the program prints a coldhead failure message and shuts down the system. Upon passing the test, the above routine repeats until reaching the set-point. Once this occurs, the program pauses for one minute to allow for DUT temperature stabilization. After which, the computer continues to check the DUT's temperature until it once again reaches the set-point. At this time the temperature routine exits to the experiments to be run (Figure 3.10).

After completing the experiment set, the program loops back to the temperature setting routine and increases the temperature by its increment. It then checks the new sample set-point against the maximum temperature. If the set-point is above the maximum temperature, the program exits to the finishing routines (Figure 3.19). If not, the program returns to the beginning of the temperature routine (point B, Figure 3.9) and sets the next temperature.

After executing one of the three above routines, the program branches to the correct experiment(s) (Figure 3.10). First, all IEEE-488 bus instruments are set to their default states. The interface accomplishes this by sending an "all device clear" command over the bus to ensure each experiment group works in the same manner. The routine cycles through all possible experiments.

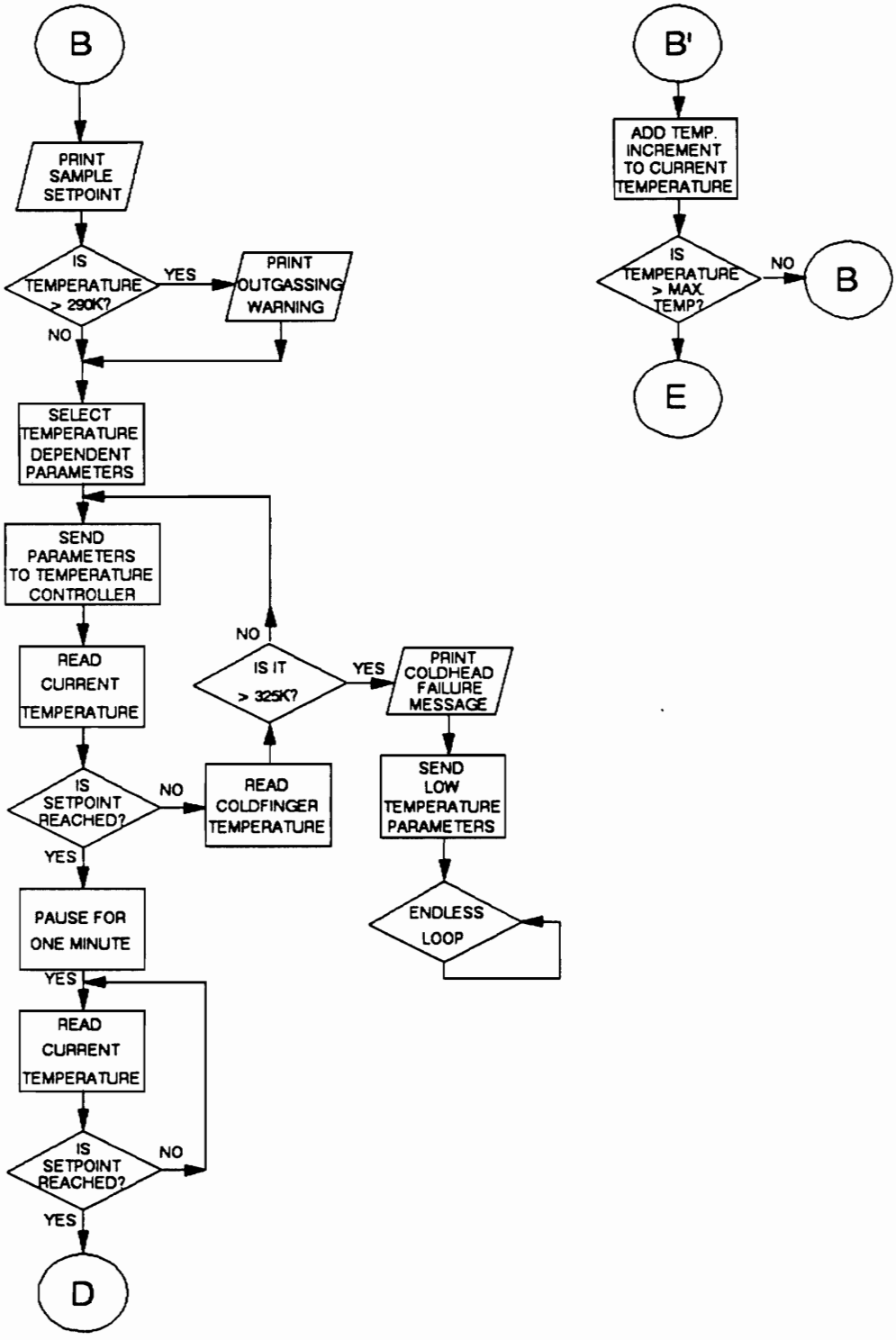


Figure 3.9 Flow chart for temperature run

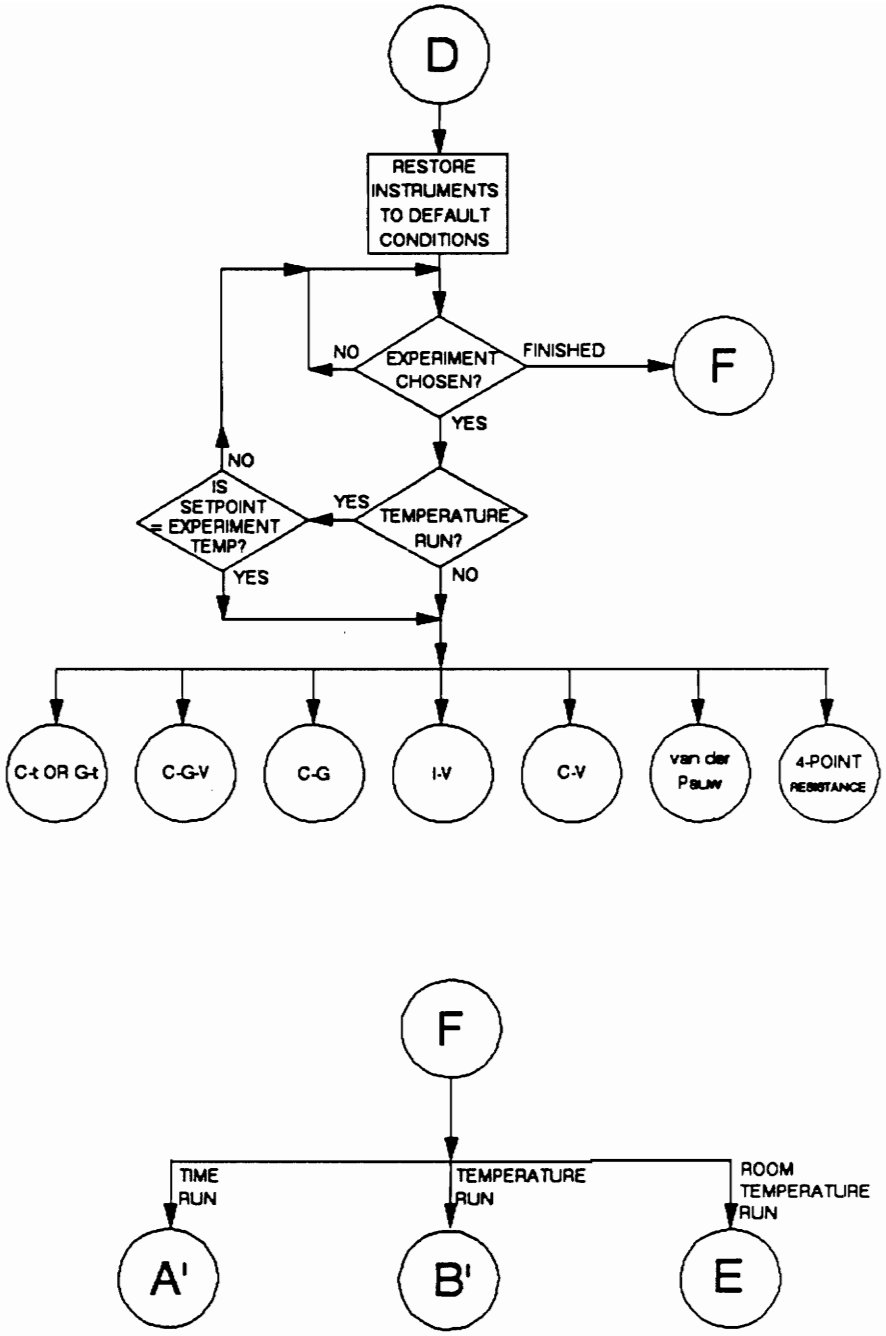


Figure 3.10 Flow chart for experiment selection

If one of these experiments were chosen in PARAMETER, the program branches to that experiment. The program then checks if the experiment is to be run at that temperature (assuming a temperature run), and if so, runs the experiment. After completing the data acquisition, the experiment's new temperature is set by increasing the current temperature by its increment. The program then returns to Figure 3.10. Upon completing all the experiments in the set, the program returns to the correct run type routine.

The experiments are broken up into seven sections as depicted in Table 3.1, with the capacitance versus time and conductance versus time experiments being combined. Each experiment is outlined below.

(i) Capacitance vs. Time or Conductance vs. Time

Figure 3.11 gives the C-t/G-t flow chart. The experiment is specified by the routine in Figure 3.10 in which the computer sets either the capacitance or conductance experiment. After making this decision, the experiment-dependent parameters for the capacitance meter are also set. Following the opening of the output file (either "C:\DATA\###\CT" or "C:\DATA\###\GT"), the experiment name is printed to the screen. The program sends the initial pulse voltage information to the HP 8112A pulse generator. Depending on the specified parameters, the computer decides whether the experimental measurements require block mode which is where the capacitance meter saves all data until completing the experiment, and then sends the entire array to the computer via the IEEE-488 interface. Experiments with short time intervals between readings (less than ten milliseconds) require block mode. Once making this decision, the program sends the setup information to the capacitance meter at which time the experiment is actually performed. If not in block mode, the computer simultaneously reads the data from the capacitance meter while the meter takes data readings. If block mode is enabled, the computer pauses ten seconds and then sends the entire data set to the computer. The program then checks for another hold time. If one exists, the program loops back to point S" in the flow chart and repeats the experiment.

After completing all the hold times, the computer checks for more than one bias voltage. If

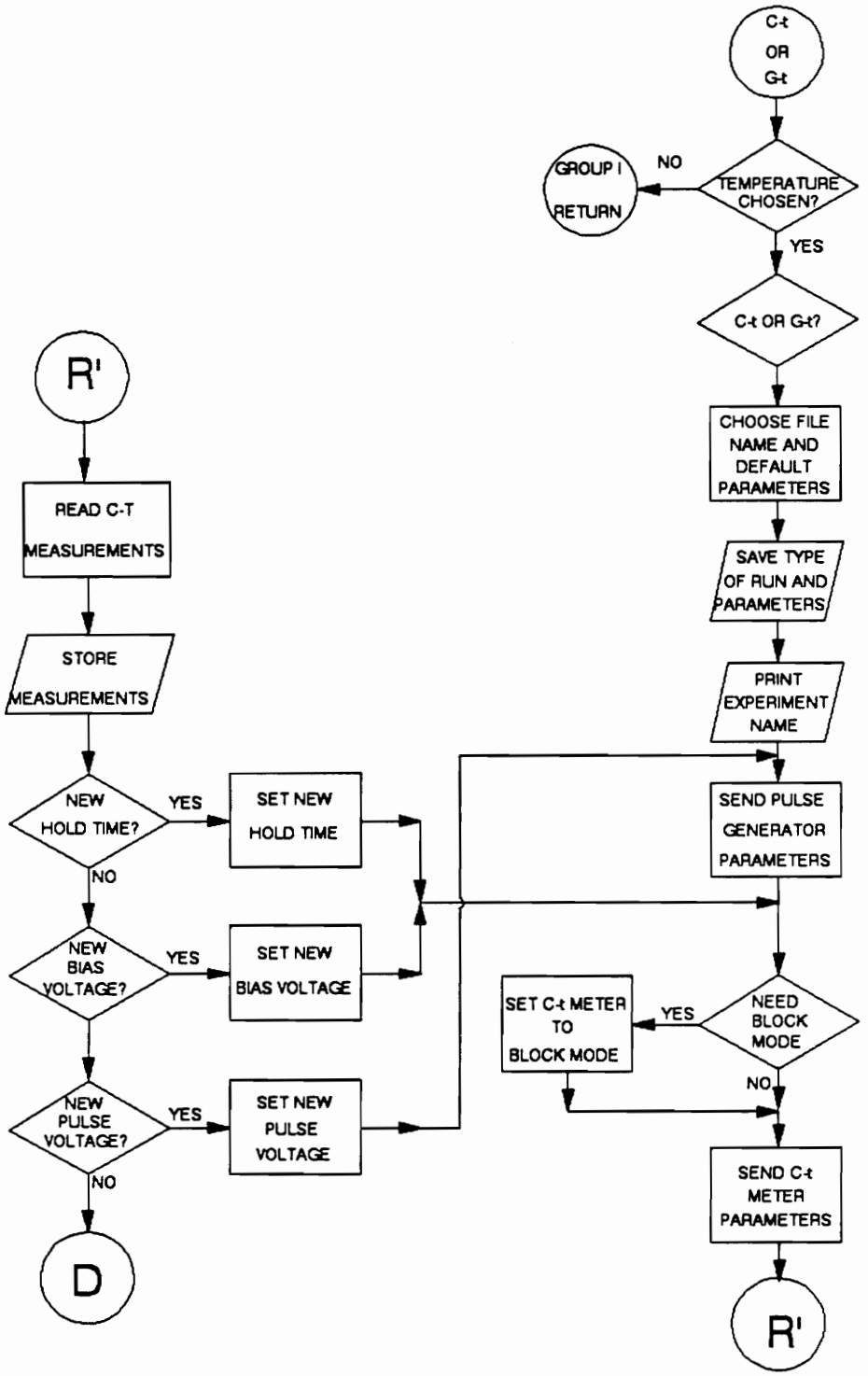


Figure 3.11 Flow chart for C-t and G-t experiments

this occurs, the voltage is incremented, and the program loops back to S" and repeats the experiments until exceeding the maximum bias point. Finally, the pulse generator's voltages are checked. If another voltage is discovered, it is incremented and the program loops back to S´, and the experiment is repeated until all pulse voltages are exhausted. Now, the program returns to Figure 3.10.

(ii) Capacitance and Conductance vs. Voltage

The flow chart for the C-G-V experiment is shown in Figure 3.12. The first step saves pertinent parameters in the file "C:\DATA\###\CGV". The routine after which prints the experiment name and sends the necessary data to the HP 4280A capacitance meter. After turning on the bias voltage, the computer reads the data from the C-t meter and stores them in the data file while checking if all the C-t readings have been achieved. If the experiment requires more data, the program continues reading from the C-t meter until completing all measurements.

After taking all the readings, the program determines if another voltage set is required. If another set exists, the computer loops back and repeats the entire experimental run. Once completing all specified bias voltages, the program continues to Figure 3.10.

(iii) Capacitance and Conductance

The capacitance and conductance experiment is a derivative of the preceding experiment. The flow chart is shown in Figure 3.13. The experimental parameters are saved in "C:\DATA\###\CG" and the experiment name is displayed on the screen. After sending the parameters to the C-t meter and turning on the bias voltage, the program reads the one data point from the capacitance meter and saves this data to disk. The program checks for another bias voltage, if found, the program loops back and runs another capacitance group. After exhausting the voltages, the program continues on to Figure 3.10.

(iv) Current vs. Voltage

The current versus voltage flow chart (Figure 3.14) matches the capacitance and conductance versus voltage flow chart with the only differences being the save file name (C:\DATA\###\IV") and the communications to the picoammeter, instead of the capacitance meter. The computer sends the

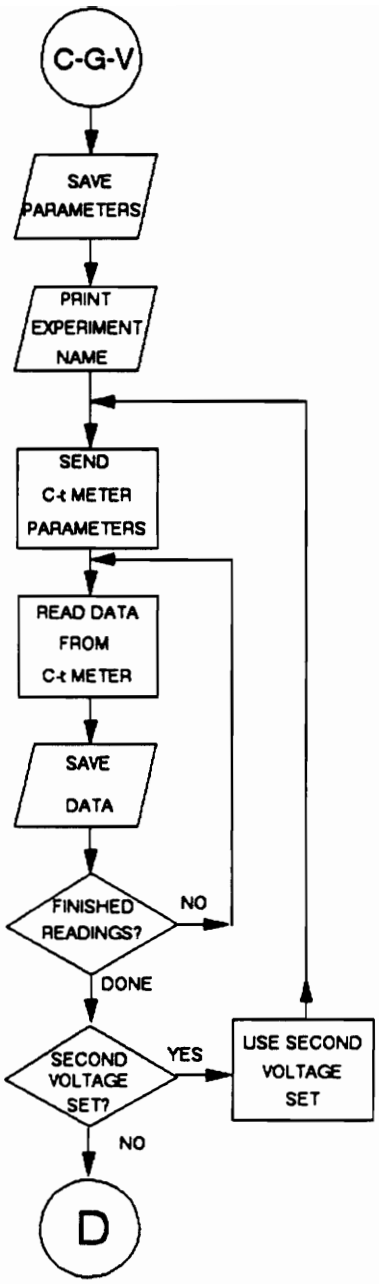


Figure 3.12 Flow Chart for C-G-V Experiment

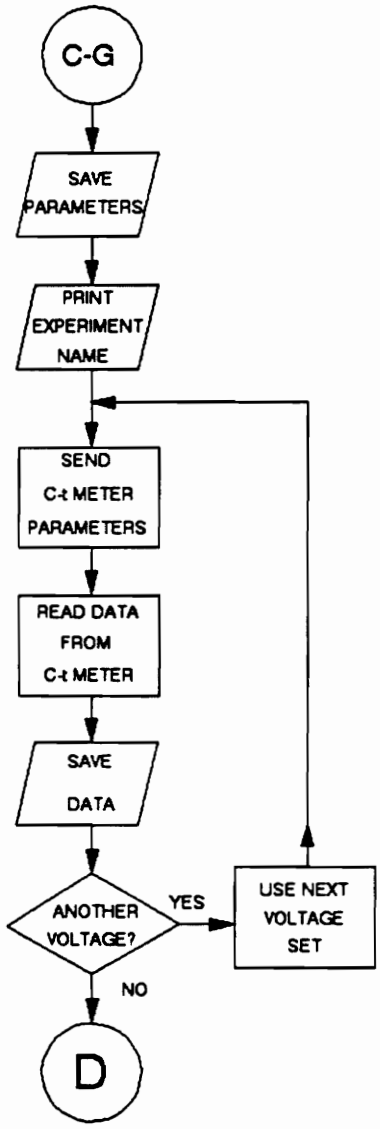


Figure 3.13 Flow Chart for C-G Experiment

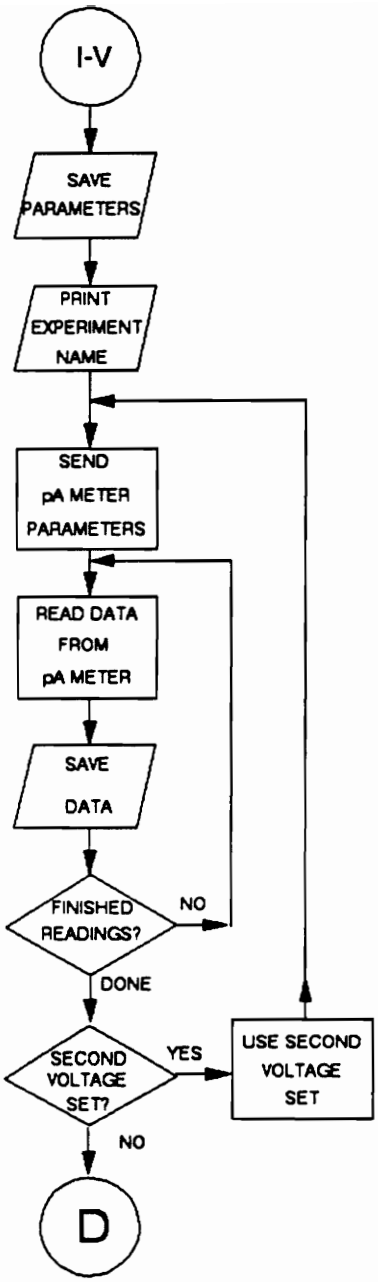


Figure 3.14 Flow Chart for I-V Experiment

proper setup parameters to the pA meter, then reads the current and voltage from the IEEE-488 interface bus while conducting the experiment. After completing the first set of voltages, the experiment checks for a second voltage set, repeating the experiment if these voltages are located. After this second set, the program proceeds to Figure 3.10.

(v) Capacitance vs. Voltage

The capacitance versus voltage experiment is shown in Figure 3.15. This experiment saves the pertinent parameters in "C:\DATA\###\CV" and prints the experiment name on the screen. The routine then sends the setup parameters to the pA meter and proceeds to read the data from the bus for the voltage range taken from the data file. After scanning all the voltages, the program branches to Figure 3.10.

(vi) van der Pauw/ Mobility

As mentioned earlier (at the beginning of 3.2.4), four room temperature resistance measurements are taken for the van der Pauw experiment (refer to Figure 3.6). The program reads a set of current/voltages with and without the magnetic field. The data is saved in a file named "C:\DATA\###\MOB".

The flow chart shown in Figure 3.16 gives the basic outline of the experiment. After saving the parameters necessary for the GRAPHICS program, the experiment name is displayed on the screen. The applicable parameters are sent to the pA meter, C-t meter, and the Keithley digital multi-meter. The C-t meter controls the magnet via a relay through an analog output. The pA meter steps the voltage in a positive manner until achieving the required current. The multi-meter takes the voltage reading once reaching this requested current. After saving the current/voltage data for the magnet-off state, the C-t meter turns on the magnet and repeats the experiment until the current is once again attained. The magnet-on data is then saved, the magnet turned off, and the program continues to Figure 3.11.

(vii) Four-point Resistance

The four-point resistance experiment requires the user to manually set the current using a

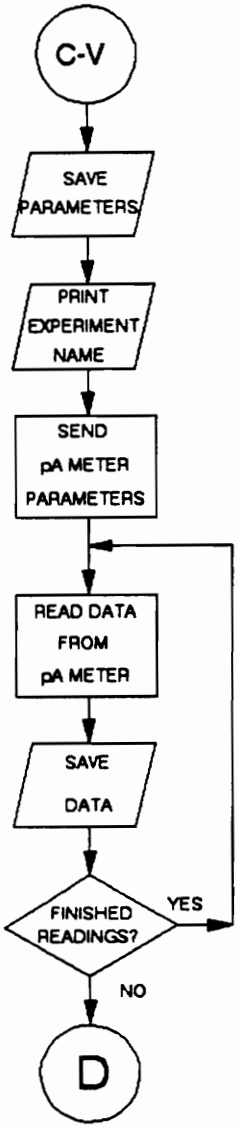


Figure 3.15 Flow Chart for C-V Experiment

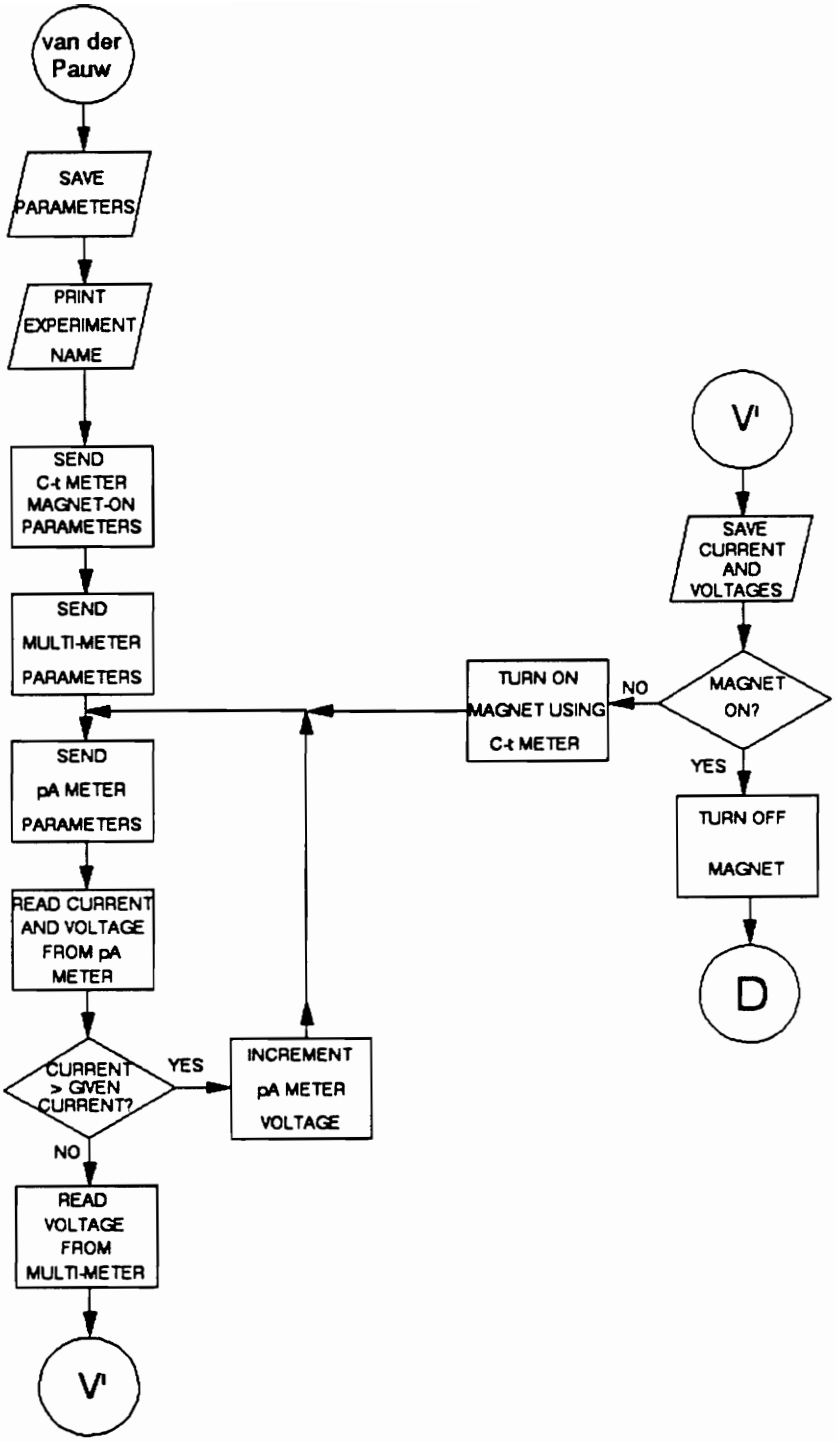


Figure 3.16 Flow Chart for van der Pauw Experiment

current source (Figure 3.18). The current should remain constant throughout the temperature/time scan. This alleviates any temperature fluctuation caused by Joule heating. The experiment saves the pertinent parameters, displays the experiment's name, and sends the parameters necessary to Keithley multi-meter, placing it into voltage reading mode. After zeroing the multi-meter, the experiment reads the voltage and saves it to the file "C:\DATA\###\RES". Once completed, the program branches back to the appropriate run type, (Figure 3.10).

Returning to the Runtype

After completing all the experiments for a given temperature/time, the program branches back to the appropriate run type, the TIME/TEMP RUN/ROOM TEMP section (Figure 3.11).

Finishing RUNIT

After all of the experimental sets are completed as required by the temperature scan, time run, or room temperature run, the program branches to Figure 3.18. First, the program sends default parameters to the cryostat which set the temperature to 2.1K and turn off the heater rapidly cooling the sample. Next, the program clears the IEEE-488 bus (IFC command). Finally, the program asks if another experimental run is required. If one is desired, the program creates a file named "C:\DATA\REDO" which MEDUSA.BAT reads and returns the user to PARAMETER. Otherwise the program exits to DOS where MEDUSA.BAT proceeds to GRAPHICS.

3.2.4 GRAPIIICS

When the batch file MEDUSA.BAT transfers operation to the program GRAPHICS, a welcome screen and the main menu are displayed in order (Figure 3.19). From the main menu the user can access any of the sub-programs within GRAPHICS, utilizing the ten function keys. This menu is also the return point from all other locations in the program. The standard outline for retrieving data and plotting the results is shown in Table 3.7. which gives each step with its explanation and reference to the suitable flow chart.

Choosing a Graph

The first step allows the user to select the graph (see Table 3.8). Figure 3.20 furnishes the

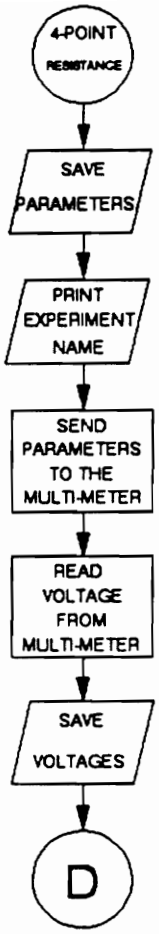


Figure 3.17 Flow Chart for 4-Point Resistance Experiment

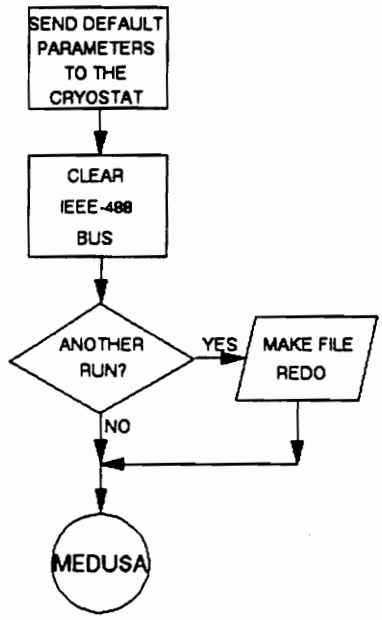


Figure 3.18 Flow Chart for RUNIT End

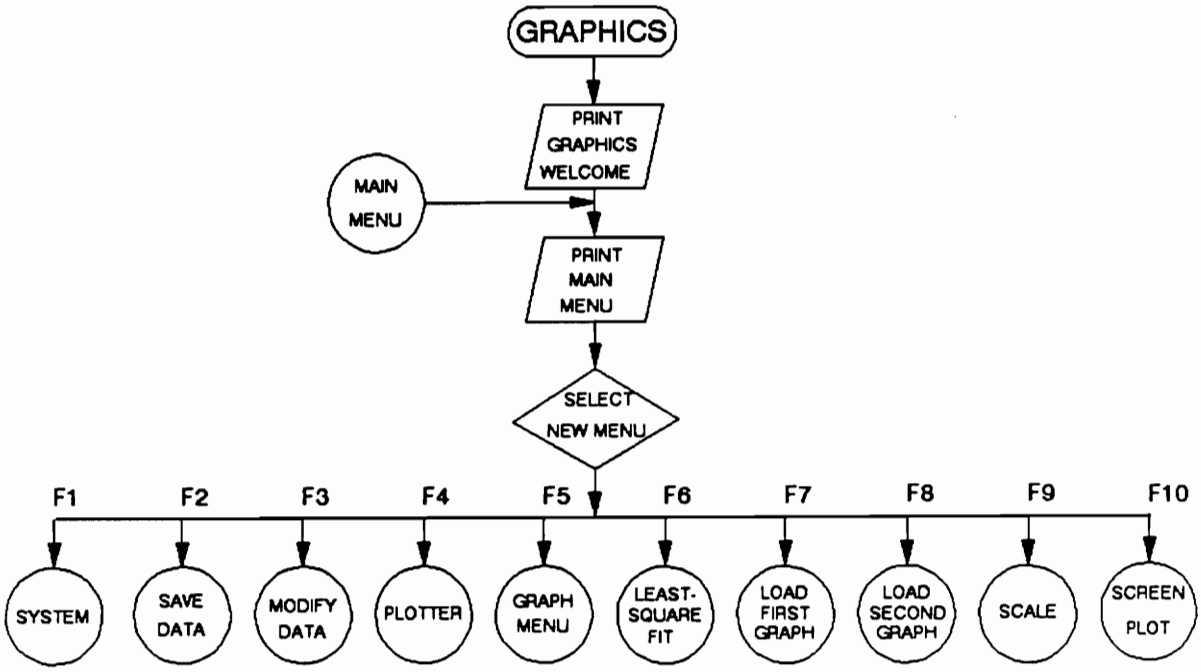


Figure 3.19 MAIN MENU Flow Chart

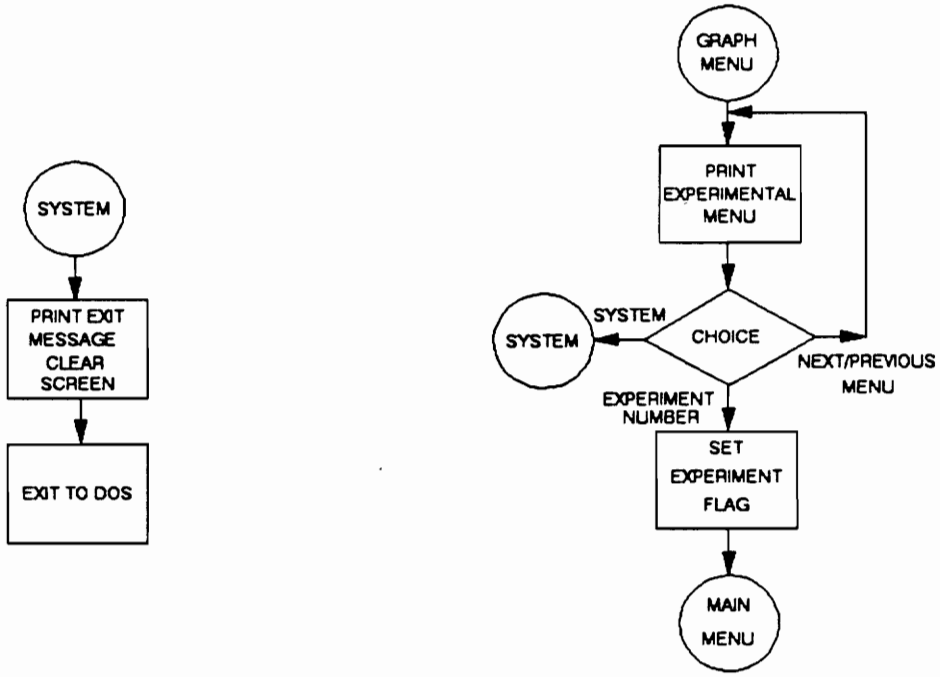


Figure 3.20 SYSTEM and GRAPH MENU Flow Charts

Table 3.8 Standard Choice Sequence for GRAPHICS

FKEYS	Notes:	Figures:
F5	shows possible graphs	Figure 3.21
F7, F8	loads data into graph matrices	Figure 3.XX
F9	allows manipulation of extrema	Figure 3.XX
F10	displays graph on screen	Figure 3.XX
F3	allows manipulation of data	Figure 3.XX
F6	finds fit over specified X range	Figure 3.XX
F4	plots graph on HP 7475A	Figure 3.XX
F2	saves in GRAPHICS compatible form	Figure 3.XX
F1	exits to DOS	Figure 3.21

3.9 Available Graphs in the program GRAPHICS

(1) Hand Entry Graph
(2) Capacitance vs. Time
(3) Conductance vs. Time
(4) Capacitance vs. Voltage (HP 4280A)
(5) Conductance vs. Voltage
(6) Capacitance vs. Temperature
(7) Conductance vs. Temperature
(8) $1/C^2$ vs. Voltage (HP 4280A)
(9) Dopant Profile (HP 4280A)
(10) Barrier vs. Temperature ($1/C^2$)
(11) DLTS Spectrum
(12) Current vs. Voltage
(13) Capacitance vs. Voltage (HP 4140B)
(14) $1/C^2$ vs. Voltage (HP 4140B)
(15) log(I) vs. Voltage
(16) Ln(I) vs. qV/kT
(17) $Ln(I/T^2)$ vs. q/kT
(18) I_{sat} vs. Temperature
(19) Ideality Factor vs. Temperature
(20) Barrier vs. Temperature (HP 4140B)
(21) Resistivity vs. Temperature
(22) Mobility vs. Temperature
(23) Carrier Concentration vs. Temperature
(24) Activation Percentage vs. Temperature
(25) $1/C^3$ vs. Voltage
(26) Barrier vs. Temperature ($1^3/C$)
(27) $Ln(I_{sat})$ vs. Temperature
(28) Four-Point Resistivity vs. Temperature

flow chart. Screen constraints allow a maximum of twenty-four experiments to be shown at a time. Since more than twenty-four graphs exist in MEDUSA, and to allow for expansion into different graphs, the program allows multiple screens. Once the user has chosen the graph, the program returns to the main menu.

Load Data into a Graph

The user must choose between loading a graph into either matrix one or two (Figure 3.21). Two plots on the same axes allow easier comparison between graphs of the same type. After the user selects the graph matrix, the program sets a flag telling the program where to load the experimental data. The program, with the exception of the hand entry graph (explained in the following paragraph), now transfers to the data acquisition section, allowing input of the drive directory and the necessary experimental parameters. After the user enters the drive and directory, the program checks to confirm the existence of the directory and the file conforming to the experiment chosen. If this check fails, the routine loops back and allows the user to reenter the information. After locating the correct data file, the user enters the type of run: room temperature, time or temperature scan. After the program sets the corresponding flag, the user keys in the experimental and graph-dependent information (shown in Table 3.10). After the program finds the proper data, the program loads it into the specified graph matrix, and exits to the main menu. If the specified data is not located, the program returns to the selection of drive and directory, where the user reenters the parameters.

The exception to the above flow chart is the hand entry graph. After the user enters the graph matrix, they are, in this case, transferred to the menu shown in Figure 3.22. This menu is where graph loading occurs for the SAVE DATA point given in the main menu (refer to Figure 3.20). Also, the graph may be saved here. Other options allow the user to enter the graph and axes titles. Data may also be entered and changed at the users discretion. Finally, the last function returns the user to the main directory.

(iii) Scale

The flow chart scale (Figure 3.23) gives the user an opportunity to adjust the plot axes of which default to their minimum and maximum values. The routine allows modification of the axes

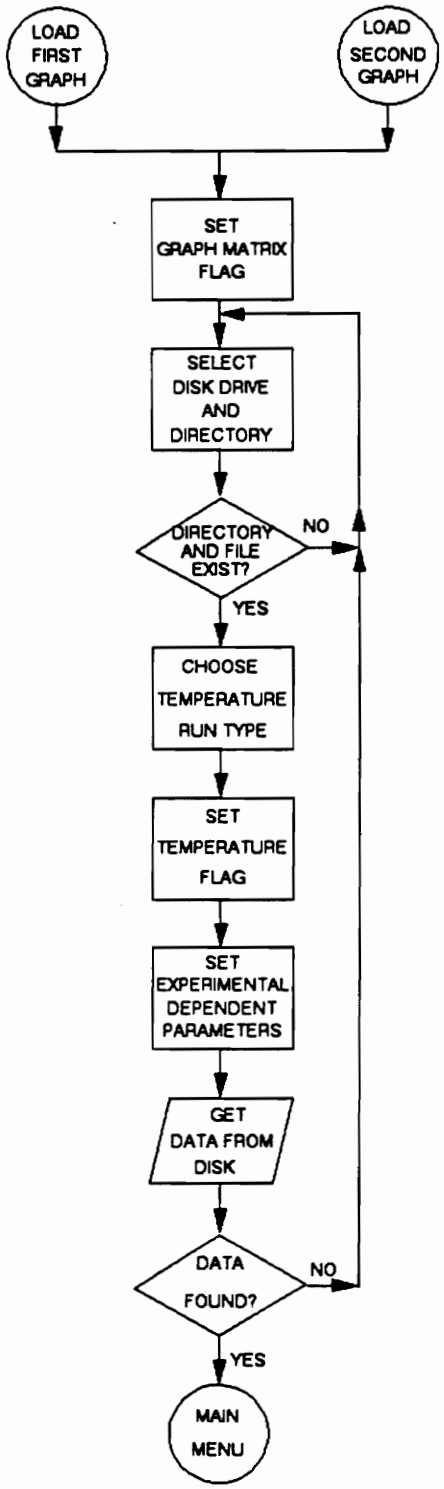


Figure 3.21 LOAD GRAPH 1 and 2 Flow Chart

Table 3.10 Graphs and their Related Parameters

	Area of Device	Bias Voltage	Box Car	Correction Factor	Donor Density	Drive/Directory	Electrical Thickness	Hold Time	Leastsquare Fit	Pulse Voltage	Richardson Constant	Run Type	Temperature	Type of Material
(1) Hand Entry Graph														
(2) Capacitance vs. Time		X				X		X		X		X	X	
(3) Conductance vs. Time						X		X		X		X	X	
(4) Capacitance vs. Voltage (HP 4280A)						X						X	X	
(5) Conductance vs. Voltage						X						X	X	
(6) Capacitance vs. Temperature		X				X						X		
(7) Conductance vs. Temperature		X				X						X		
(8) $1/C^2$ vs. Voltage (HP 4280A)	X					X						X	X	
(9) Dopant Profile (HP 4280A)	X					X						X	X	X
(10) Barrier vs. Temperature ($1/C^2$)	X					X			X			X		X
(11) DLTS Spectrum		X	X			X		X		X		X		
(12) Current vs. Voltage						X						X	X	
(13) Capacitance vs. Voltage (HP 4140B)						X						X	X	
(14) $1/C^2$ vs. Voltage (HP 4140B)						X						X	X	
(15) log(I) vs. Voltage						X						X	X	
(16) Ln(I) vs. qV/kT						X						X	X	
(17) $Ln(I/T^2)$ vs. q/kT						X			X			X		
(18) I_{sat} vs. Temperature						X			X			X		
(19) Ideality Factor vs. Temperature						X			X			X		
(20) Barrier vs. Temperature (HP 4140B)	X					X			X		X	X		
(21) Resistivity vs. Temperature						X	X					X		
(22) Mobility vs. Temperature						X	X					X		
(23) Carrier Concentration vs. Temperature						X	X					X		
(24) Activation Percentage vs. Temperature					X	X	X					X		
(25) $1/C^3$ vs. Voltage	X					X						X	X	
(26) Barrier vs. Temperature ($1/C$)	X				X	X			X			X	X	X
(27) $Ln(I_{sat})$ vs. Temperature						X			X			X		
(28) Four-Point Resistivity vs. Temperature				X		X	X					X		

* see Figure 3.22

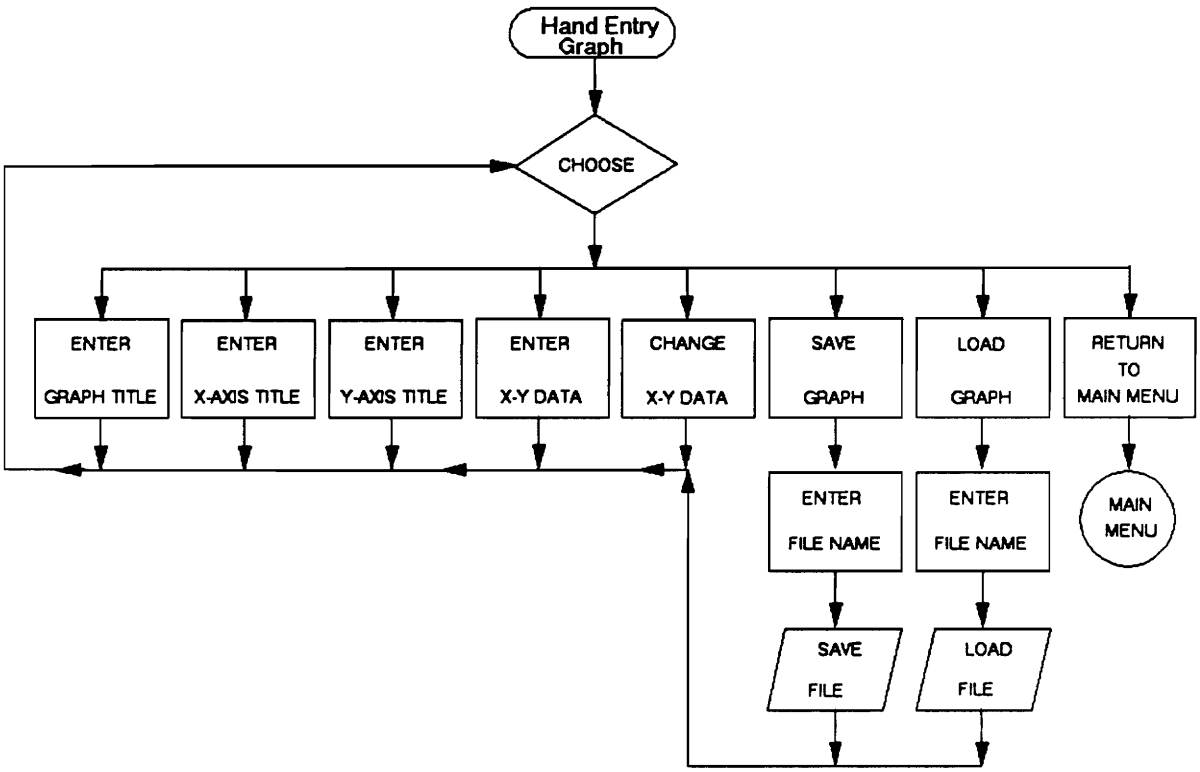


Figure 3.22 Hand Entry Flow Chart

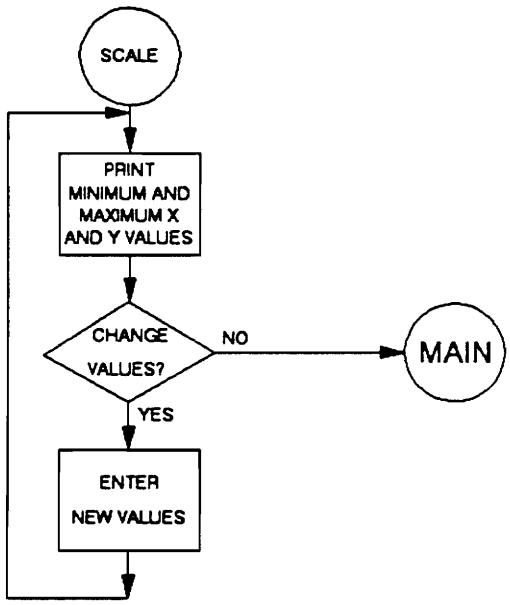


Figure 3.23 SCALE Flow Chart

or an exit back to the main menu. If changes are desired, the program prompts the user to change each value, defaulting to the original values. After entering the four values, the routine loops back and prints the new extrema allowing multiple chances to change the minimum/maximum values for the graph. If the user decides not to change these values, the program returns to the main menu.

(iv) Screen Plot

When the program enters the screen plot menu (Figure 3.24), the routine gives a choice between a dot or line graph. After entering the choice, the program prints the axis and the existing graphs. Following the display of these points, the program adds a line between points if a line graph was previously selected. The computer then waits until any key has been hit to return to the main menu.

(v) Modify Data

This section allows experimental data alteration (Figure 3.25). Table 3.11 shows the basic types of modification. First, the user selects an option or choosing F1 exits the routine and returns to the main menu. Upon selecting an option, the program asks which graph to modify and the routine separates into the individual sections.

For the add, multiply, and power function keys, the user enters the axes to modify and the scalar value, followed by the operation which is performed on either the X- or Y-range, depending on the previous choice. The natural log, exponential function, or absolute value option asks the user for a range before executing the required operation.

For both add and delete points options, the routine prints up to thirteen data points, allowing the user to modify any one of them. If none of these are changed, the program scrolls to the next thirteen data points continuing until a value is either added or deleted or all data points have been shown. The program then loops back to the beginning of the modify routine. Finally, the clear graph function erases the specified graph.

(vi) Least-square Fit

The least-square fit is shown in Figure 3.26. The program queries for an X-axis range and then computes the calculations shown below [17]:

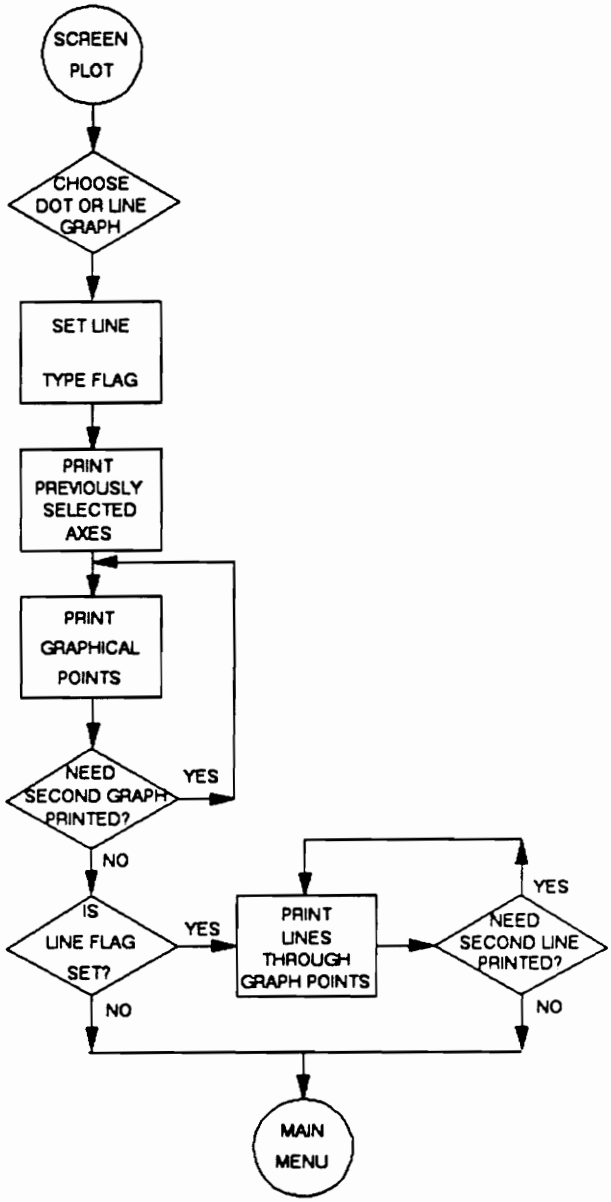


Figure 3.24 SCREEN PLOT flow chart

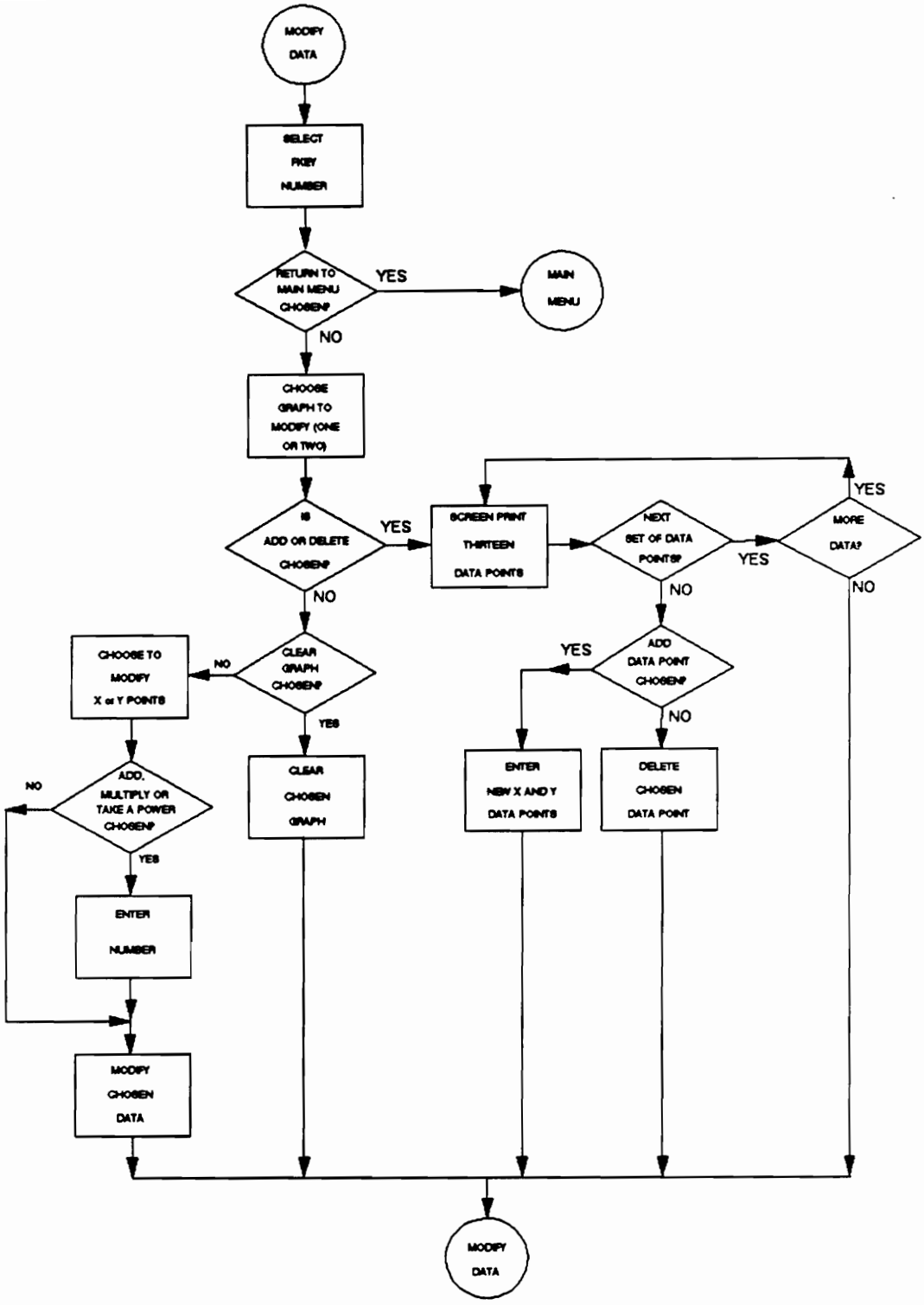


Figure 3.25 MODIFY data flow chart

Table 3.11 MODIFY data options

F1 MAIN MENU	F6 EXPONENTIATE A RANGE
F2 ADD A CONSTANT TO A RANGE	F7 ABSOLUTE VALUE OF A RANGE
F3 MULTIPLY A RANGE BY A CONSTANT	F8 DELETE A POINT IN A RANGE
F4 TAKE RANGE TO A POWER	F9 ADD A POINT IN A RANGE
F5 NATURAL LOG OF A RANGE	F10 CLEAR A GRAPH

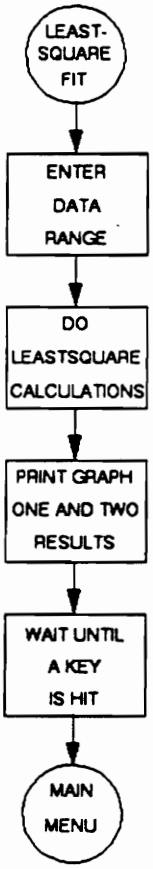


Figure 3.26 LEAST-SQUARE FIT flow chart

$$m = \frac{S_{xy}}{S_{xx}} \tag{3.1}$$

$$y_{int} = \bar{y} - \frac{m}{\bar{x}} \tag{3.2}$$

$$x_{int} = -\frac{y_{int}}{\bar{x}} \tag{3.3}$$

$$\rho = \frac{S_{xy}}{\sqrt{S_{xx}\, S_{yy}}} \tag{3.4}$$

$$\bar{x} = \frac{\sum x}{n} \tag{3.5}$$

$$\bar{y} = \frac{\sum y}{n} \tag{3.6}$$

$$S_{xx} = \sum x^2 - \left(\sum x\right)^2 \tag{3.7}$$

$$S_{yy} = \sum y^2 - \left(\sum y\right)^2 \tag{3.8}$$

$$S_{xy} = \sum xy - \frac{\sum x - \sum y}{n} \tag{3.9}$$

where:

m is the slope
ρ is the correlation

The results, X-axis range, X and Y intercepts, slope and correlation, are shown on the screen in two columns (the first for graph one, the second for graph two) and the program pauses until any key is hit. The program returns to the main menu.

(vii) Plotter

The plotter routine utilizes a different set of function keys as defined in Table 3.12. The flow chart is presented in Figures 3.27 and 3.28. A return to the main menu is accomplished by pressing F1. F2 controls the plotter pen speed which defaults to the correct speed for paper plots. The speed should be reduced for transparencies for better resolution and to reduce smearing. F3, F4, and F5 control default options (see Figure 3.27 (a)). Tables 3.12-3.15 give the options for each key respectively. F3 controls the line type, F4 the symbol style, and F5 the pen color. The user selects the graph and the appropriate line/symbol/color. Finally, the program either returns to the PLOTTER menu or allows another change, depending on the choice given by the user.

F6 controls the plotting of the axes, information block (assuming the information block option has been set), and titles. Figure 3.27 (b) gives the flow chart. First, an option for plotting a grid is given. After this the program plots the axes and titles. Next, if a grid has been chosen, this is plotted. Depending on the F9 choice, the information block may be plotted. Finally, the program returns to the PLOTTER menu.

F6 and F7 controls the first and second plot. After one of these is chosen, the graph is plotted with the appropriate pen color, symbol, and line type (chosen earlier).

F9 controls the information block. Table 3.16 gives the material plotted if this key is enabled. The key acts as a toggle switch, enabling/disabling the information block as the key is pressed.

F10 allows the plotting of a caption. The user simply types in the caption and the plotter prints the caption below the graph.

After the plotting routine is completed, the user presses F1 and the program returns to the

Table 3.12 PLOTTER function key definitions

F1 RETURN TO MAIN MENU
F2 PLOTTER PEN SPEED
F3 LINE TYPE
F4 SYMBOL TYPE
F5 PEN COLOR
F6 PLOT GRAPH AXES
F7 PLOT FIRST GRAPH
F8 PLOT SECOND GRAPH
F9 INFORMATION BLOCK
F10 CAPTION

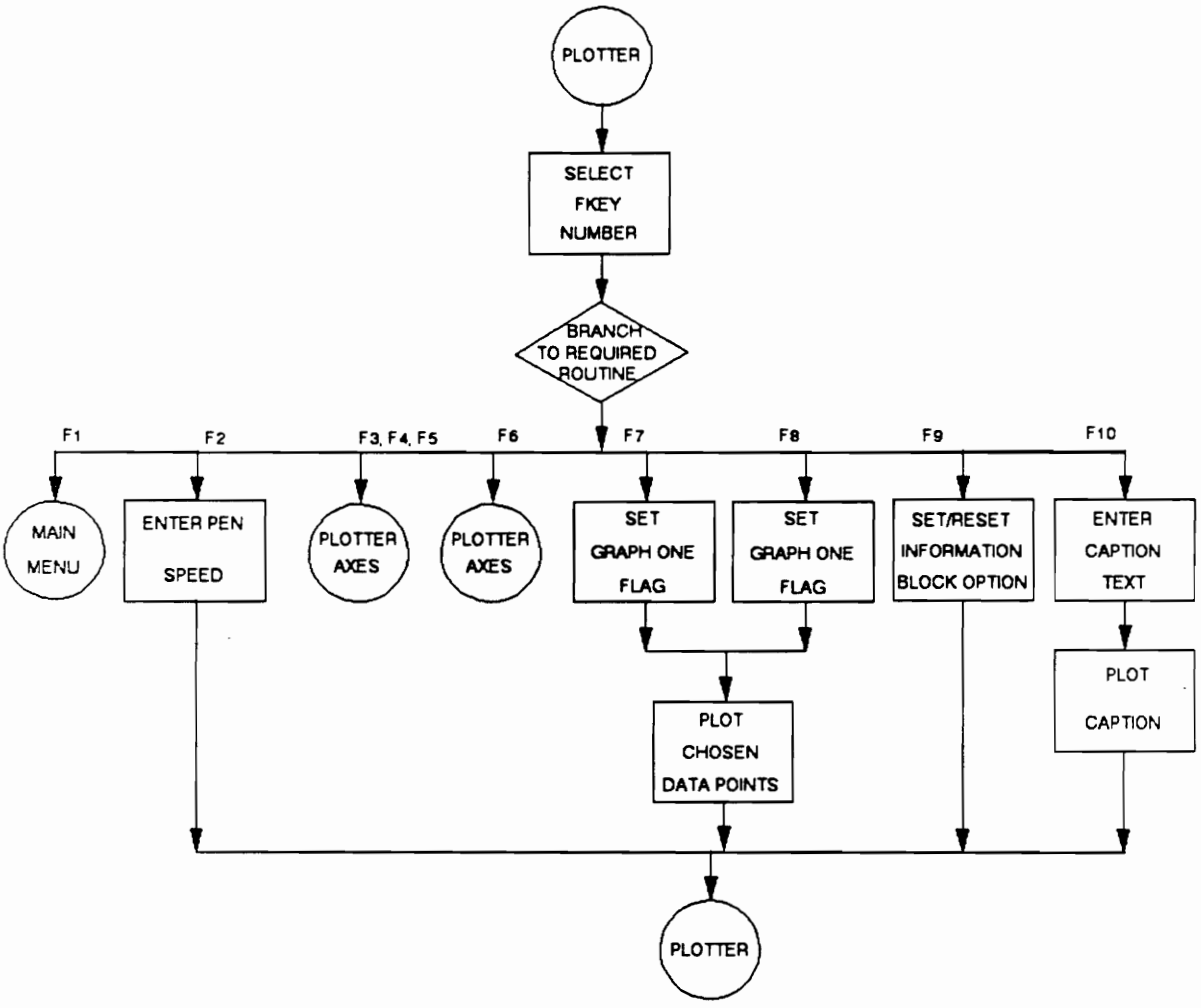
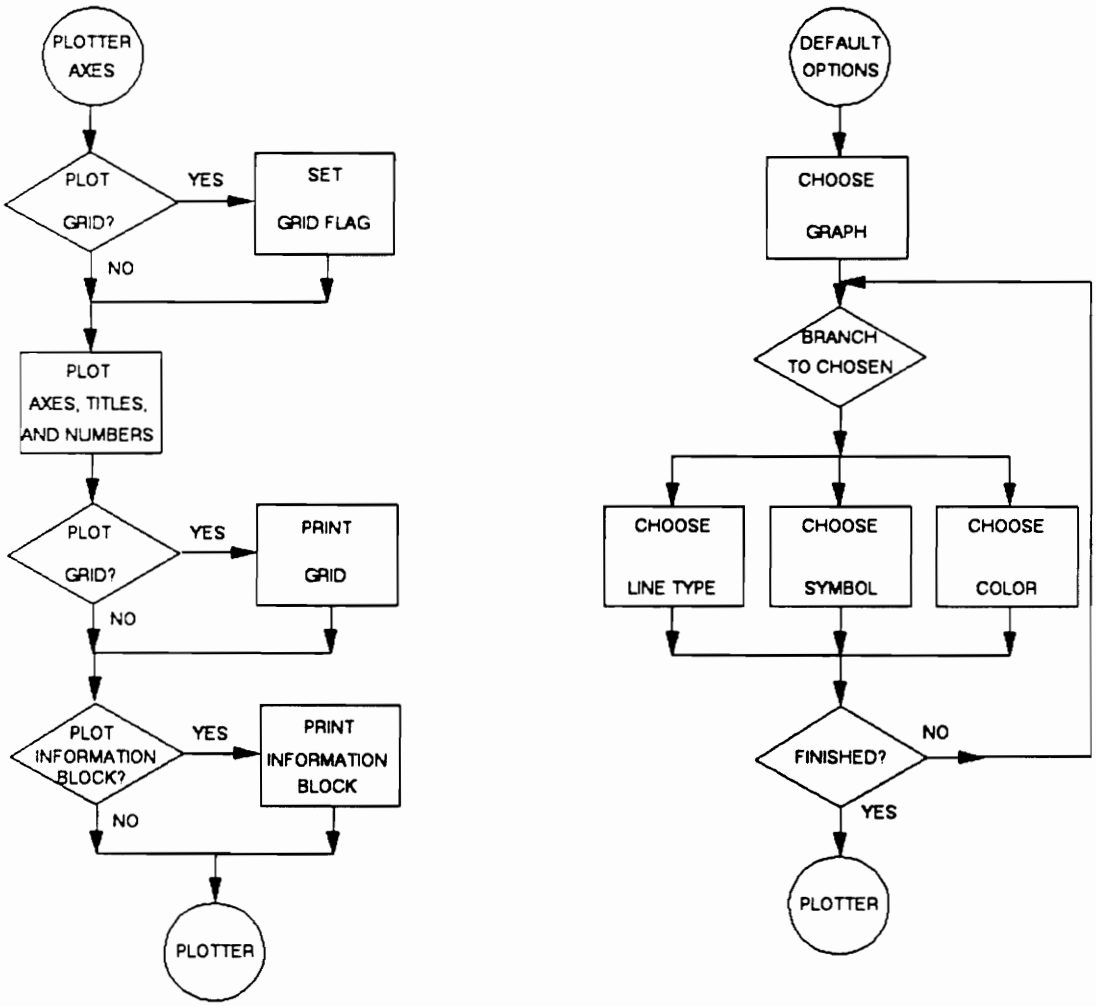


Figure 3.27 First PLOTTER flow chart



(a) (b)

Figure 3.27 Second PLOTTER flow chart

Table 3.13 Line types

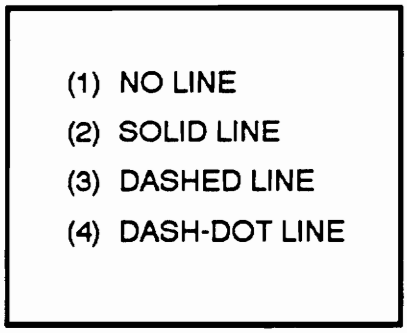


Table 3.14 Symbol types

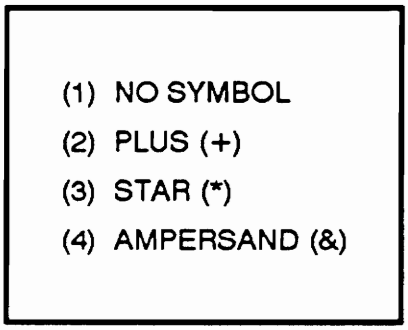


Table 3.15 Color types

Table 3.16 PLOTTER information block

(1) SYMBOL
(2) DIRECTORY
(3) TEMPERATURE
(4) TIME
(5) BIAS VOLTAGE
(6) PULSE HIGH VOLTAGE
(7) HOLD TIME
(8) RATE WINDOW
(9) GRAPH RANGE
(10) SLOPE
(11) X-INTERCEPT
(12) Y-INTERCEPT
(13) RANGE FOR FIT
(14) CORRELATION

main menu.

(vii) Save Data

The GRAPHICS program allows a graph to be saved in an ASCII compatible format by striking F2 (see Figure 3.29). Upon entering the save data routine, the user keys in a graph name, which defaults to the graph title. After choosing the file name, the program queries whether graph one or two is to be stored. Finally, the program saves the requested graph and returns to the main menu.

(viii) Exit To DOS

The program can be exited by striking F1. This is shown in Figure 3.21 (a) where the program thanks the user for using MEDUSA, clears the screen, and exits to DOS.

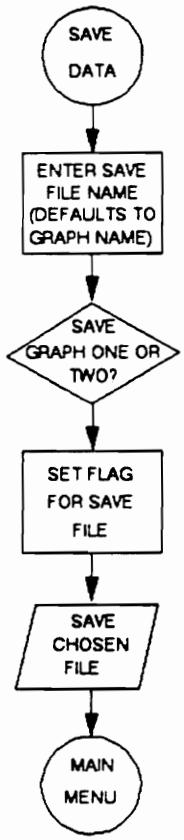


Figure 3.29 SAVE DATA flow chart

CHAPTER 4: EXPERIMENTAL RESULTS AND DISCUSSION

The MEDUSA system was tested and improved by doing a variety of measurements on both Schottky diodes and thick-film superconductors. The graphs shown below, while not inclusive, give the most important plots for a researcher. The sections are broken into five parts: 4.1 Capacitance experiments, 4.2 Conductance Experiments, 4.3 Current Measurements, 4.4 four-point Resistivity, and 4.5 van der Pauw Measurements.

4.1 Capacitance Experiments

The capacitance experiments consist of both capacitance versus time and capacitance versus voltage measurements. All readings were taken from the C-t meter. The pA meter (HP 4140B) can measure capacitances, but these measurements were not included because the C-t meter gives more accurate capacitance values. GaAs schottky diodes were the devices tested in this section.

4.1.1 Capacitance vs. Time

Figure 4.1 gives the capacitance versus time at 330K after the application of a majority trap-filling pulse of 4 volts with a hold time of 10 mS. Thermal emission from traps causes an exponential increase in capacitance values[16]. The tested device does not conform to this theory. There are many factors that may contribute to a non-exponential decay rate [18]:

(i) electric field dependent emission rate
(ii) large deep-level defects may overwhelm the smaller net shallow dopant density
(iii) a non-ideal step junction
(iv) presence of distributed trap levels (transient is the sum of individual transients)
(v) partial trap charging occurring only in a section of the depletion region

4.1.2 Capacitance vs. Voltage

Figure 4.2 shows a capacitance versus voltage plot at room temperature which presents the desired trend with reverse bias. According to the Shockley model, for a uniformly doped sample, capacitance should have an inverse square relationship with voltage. The ideal capacitance versus voltage equation for a Schottky barrier is the same as a one- sided pn junction or, in a slightly

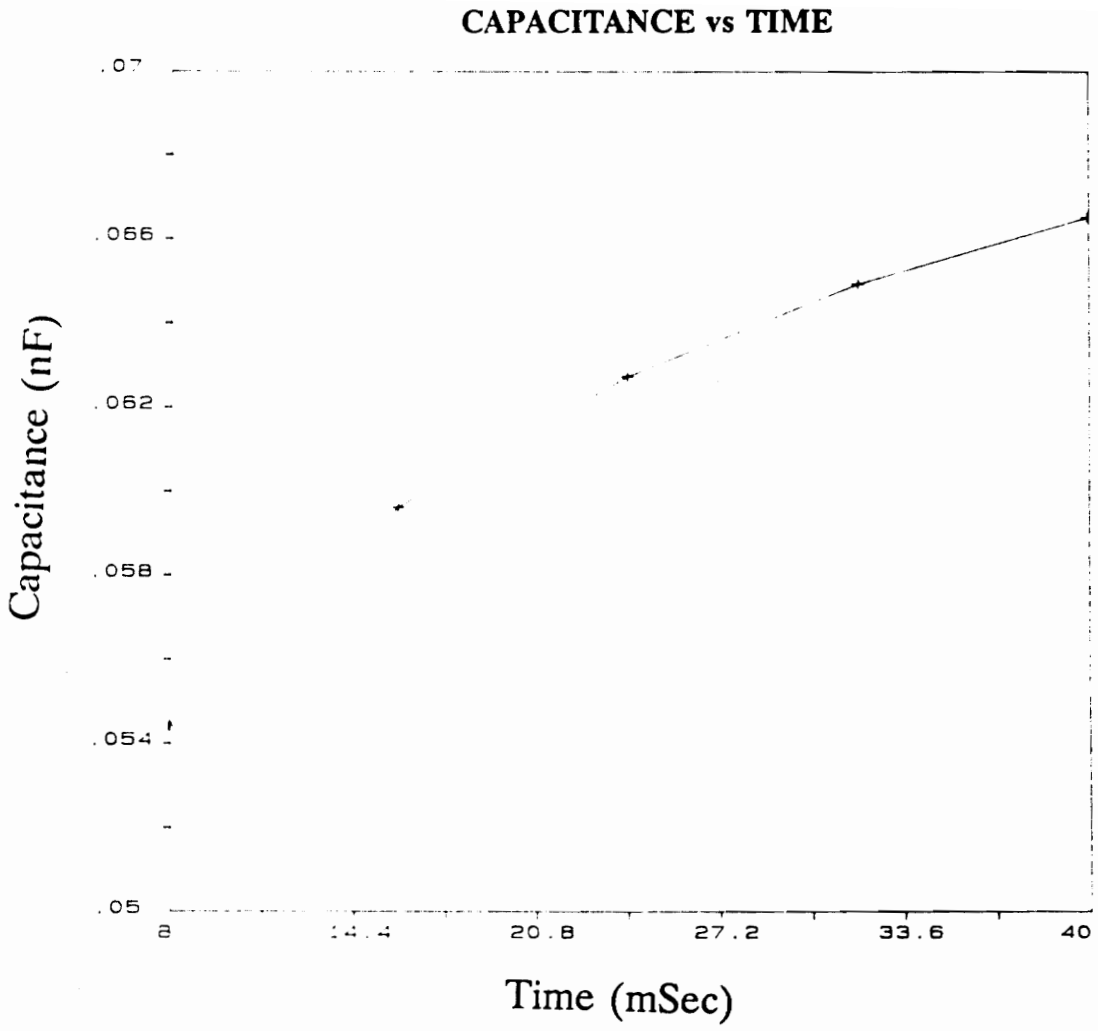


Figure 4.1 Capacitance versus Time

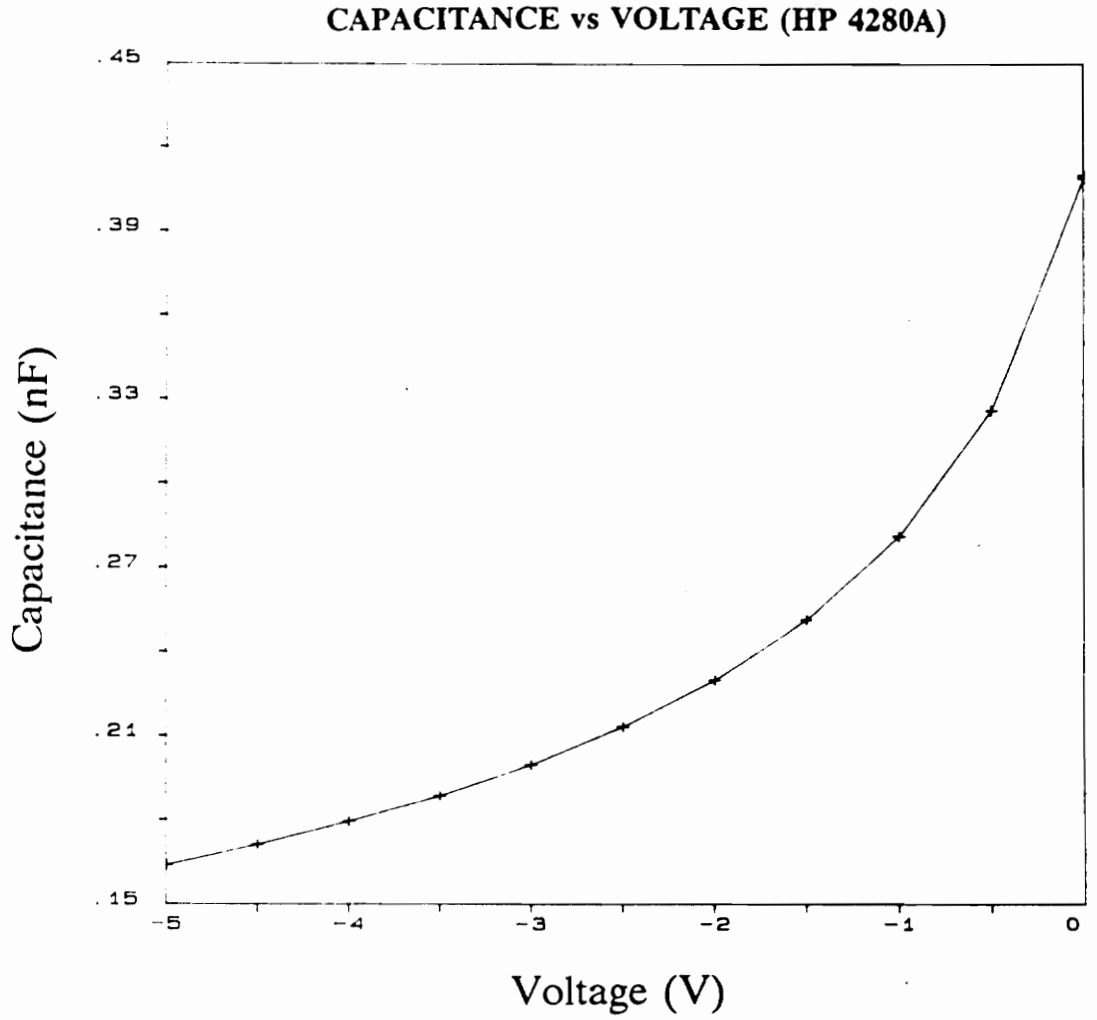


Figure 4.2 Capacitance versus Voltage

different form than equation 2.11 [12],

$$C = \left[\frac{q\epsilon_s \epsilon_0 N_d}{2(\Psi_0 + V_R)} \right]^{\frac{1}{2}} \qquad (4.2)$$

The easiest method for proving that the graph follows an inverse square relationship is by observing the $1/C^2$ versus V plot given in the next section.

4.1.3 $1/C^2$ vs. Voltage

Figure 4.3 shows the graph for the $1/C^2$ versus voltage plot at room temperature which shows good linear behavior as predicted by 2.11 and 4.2. The slope of the plot yields a doping density of $7.6X10^{16}/cm^3$, as compared with the vendor specification of $6X10^{16}/cm^3$. The X-intercept gives a barrier height of 1.10 volts.

4.1.4 Capacitance vs. Temperature

Figure 4.4 gives a plot of capacitance dependence on temperature at a -4 volt bias. Depending upon the material, the plot is expected to either increase or remain invariant with temperature. The steps in Figure 4.4 can be seen as a correlation to the traps obtained from the DLTS spectrum where the trap switches from mostly full to mostly empty [16].

4.1.5 DLTS Spectrum

Figure 4.5 demonstrates a DLTS spectrum for a n-type GaAs sample from 100 to 400K with a bias of -4 volts, a trap filling pulse of 4 volts, a hold time of 10 mS, and a 50.29 $second^{-1}$ rate window. There are three peaks evident at 155K, 240K, and 335K which correspond to trap energy levels of .312, .490, and .684 eV, respectively, based on equation 2.20. The peak height in the spectrum relates to the trap density, through equations 2.17 and 2.18. Accordingly, the trap density for .312, .490, and .684 eV are $2.57X10^{16}$, $1.07X10^{16}$, and $4.72X10^{16}/cm^3$, respectively. These trap densities are close to

the doping density of $7.6X10^{16}/cm^3$ found in section 4.1.3 which may explain the behavior of the capacitance versus time graph (Figure 4.1).

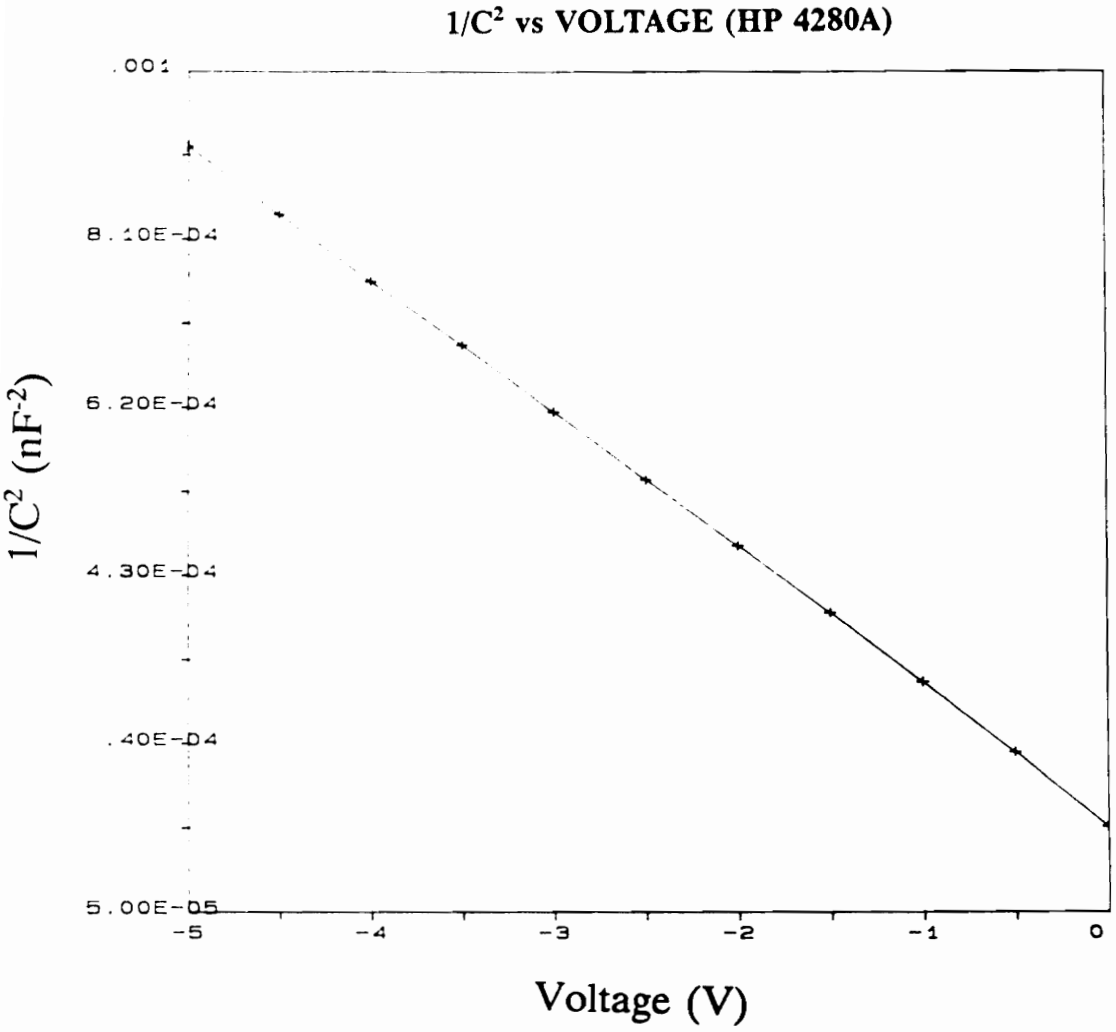


Figure 4.3 $1/C^2$ versus Voltage

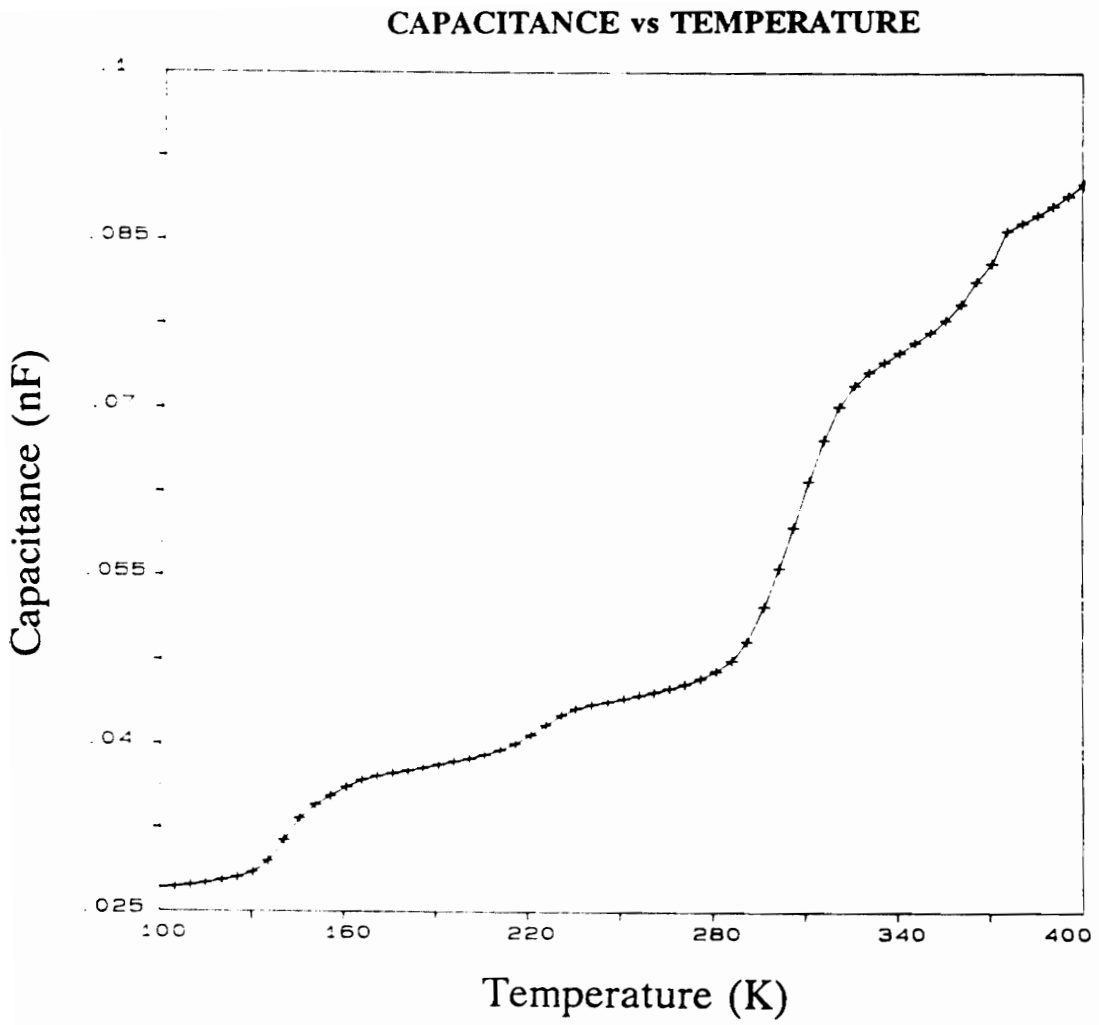


Figure 4.4 Capacitance versus Temperature

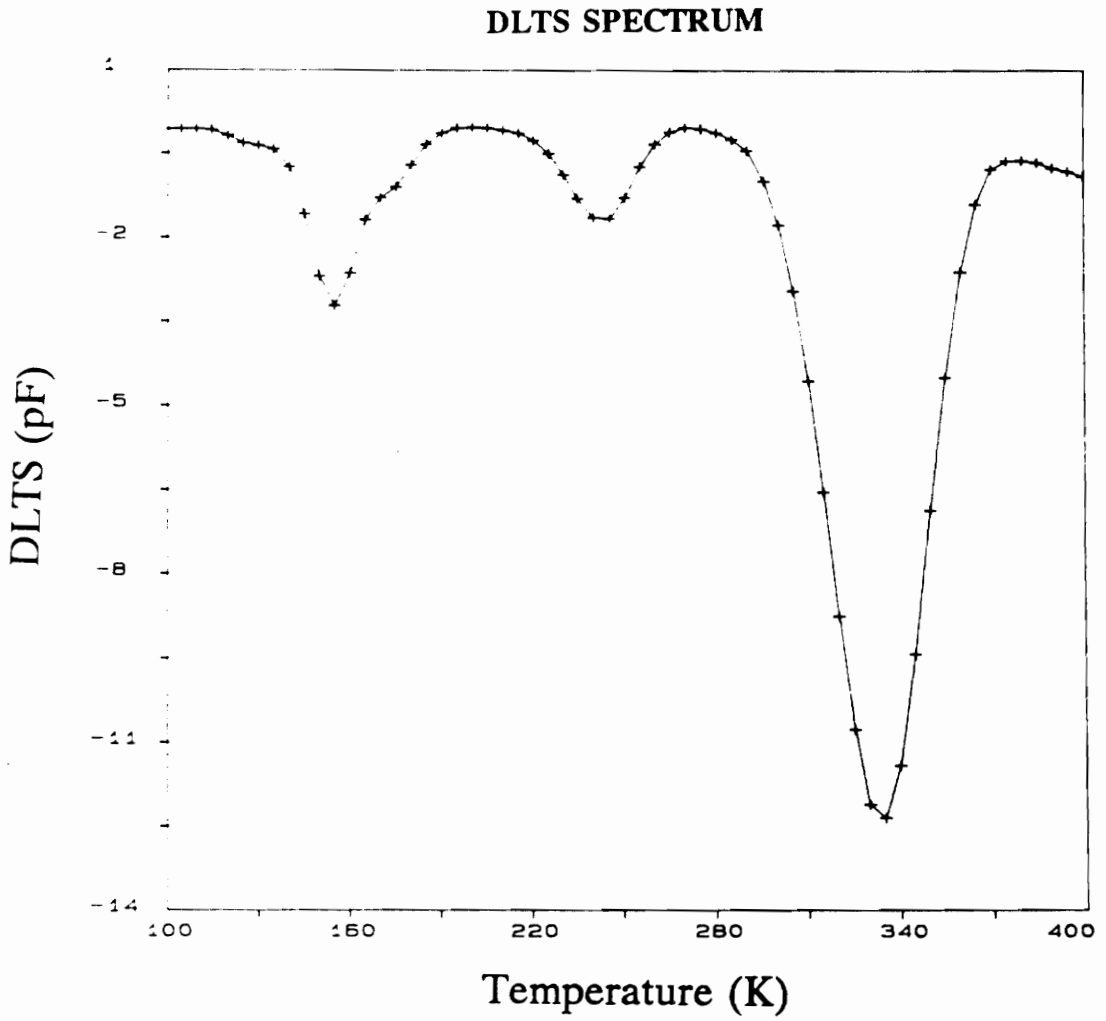


Figure 4.5 DLTS Spectrum

4.1.6 Barrier Height versus Temperature

Figure 4.6 displays a barrier height's (ϕ_b) temperature dependence. This spectrum reveals a high ϕ_b value essentially constant over the given temperature range. The barrier height should increase with temperature as shown in equation 2.12. Some possible reasons for this deviation are [13]:

(i) interface corruption
(ii) an insulating layer between the contact and n-region
(iii) edge leakage current, and deep impurity levels.

Also, the tested wafer was only moderately doped ($6X10^{16}/cm^3$); hence a barrier height deduced from a current-voltage plot would be more reliable (see Chapter 2.1.2 (i)).

4.1.7 Dopant Profile

The room temperature dopant profile shown in Figure 4.7 depicts an essentially flat relationship out to .35 micron depth with an error of +/-10%, correct for the tested uniformly doped sample. Beyond .35 micrometers, the diode must be biased near breakdown causing erroneous C-V measurements.

4.2 Conductance Measurements

The conductance experiments are comprised of both conductance versus time and conductance versus voltage measurements. These experiments are useful in determining both the lossy nature of Schottky diodes and the calculation of trap densities (equation 2.18). The series resistance between Schottky and ohmic contacts constitute a large part of the experimental error in the determination of actual capacitance. A reverse-biased diode's low conductance is of vital importance to the quality of a device, and subsequently to the authenticity of DLTS measurements. The conductance measurements were executed using the C-t meter at different reverse voltages on a GaAs schottky diode.

4.2.1 Conductance vs. Time

The conductance versus time plot (Figure 4.8) at 330K, with a hold time of 10 mS, shows an almost linear increase over the range of 40 mS. This suggests a reverse biased diode becoming

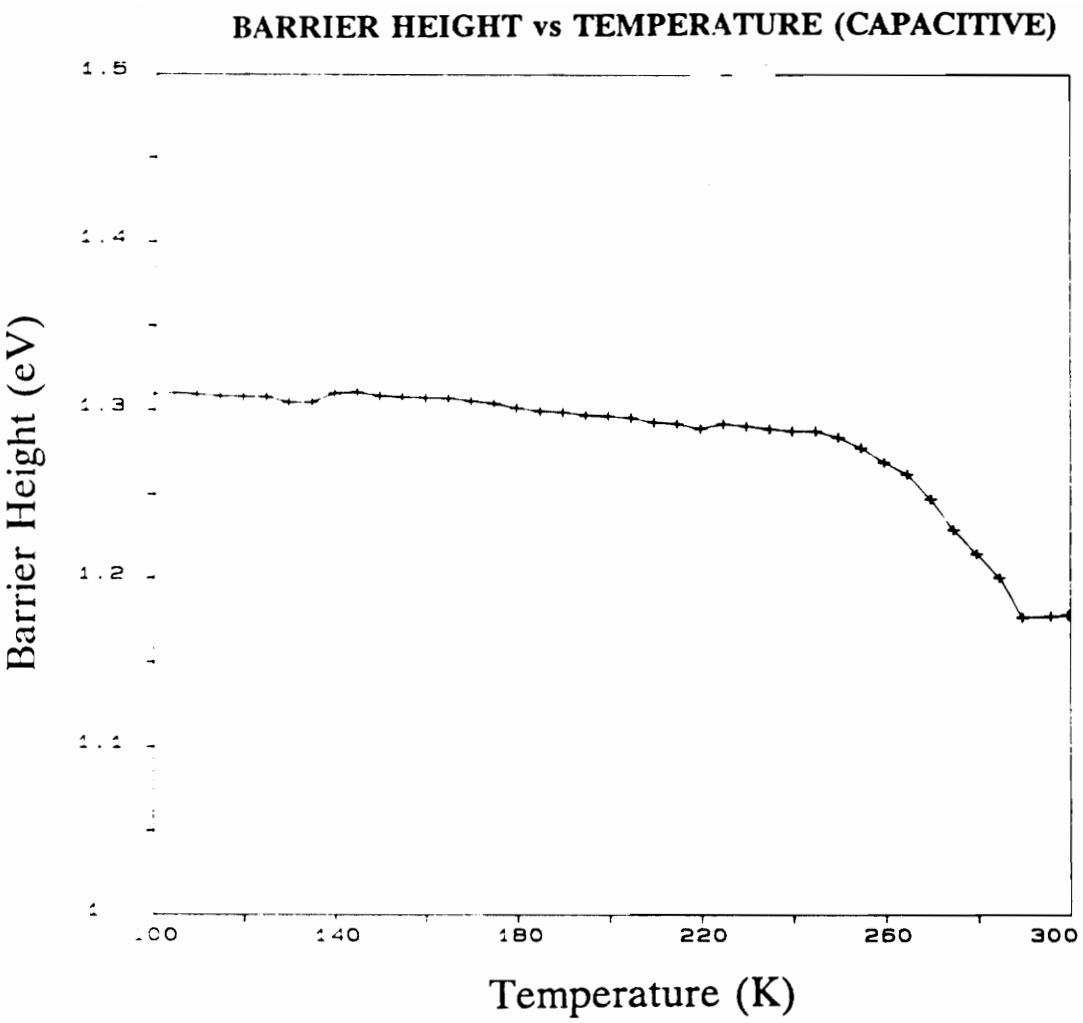


Figure 4.6 C-V Barrier Height

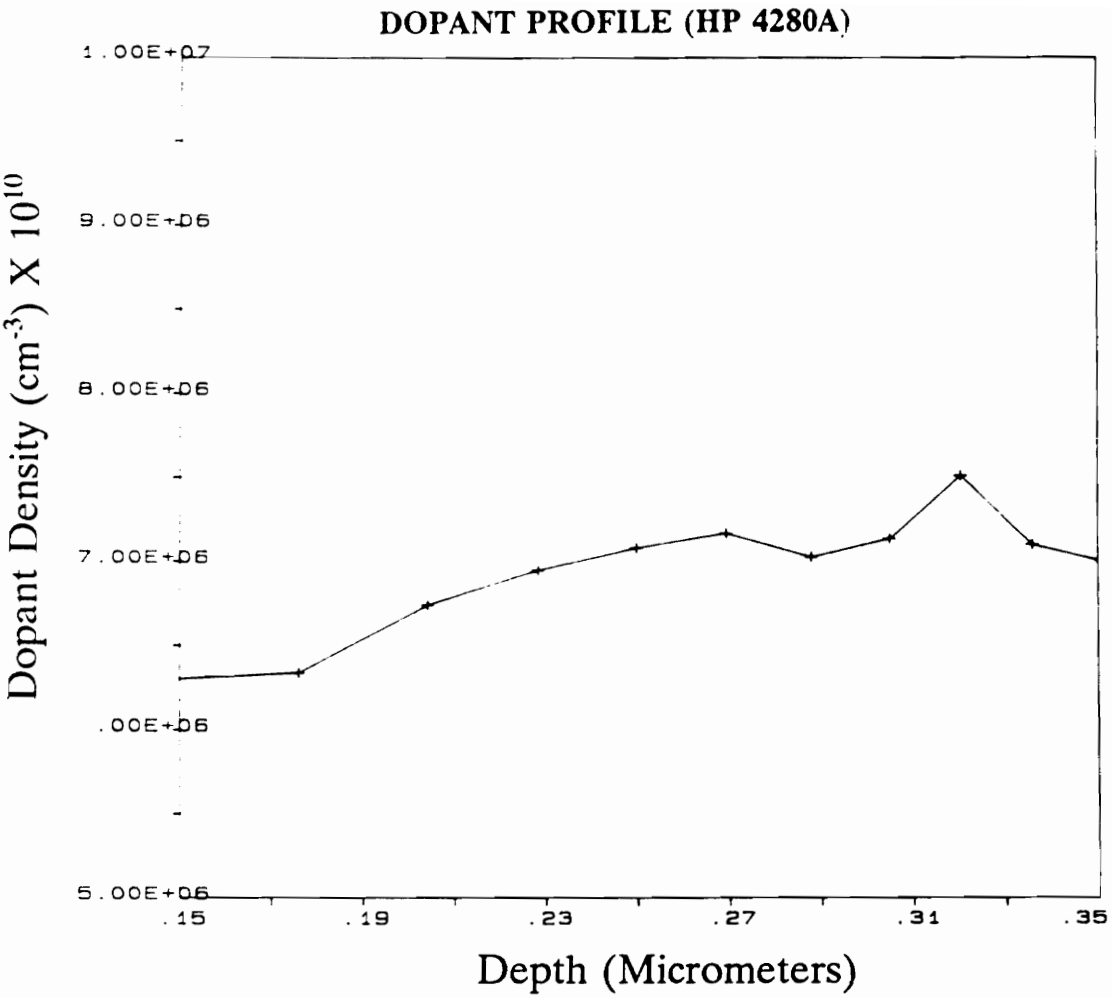


Figure 4.7 Dopant Profile

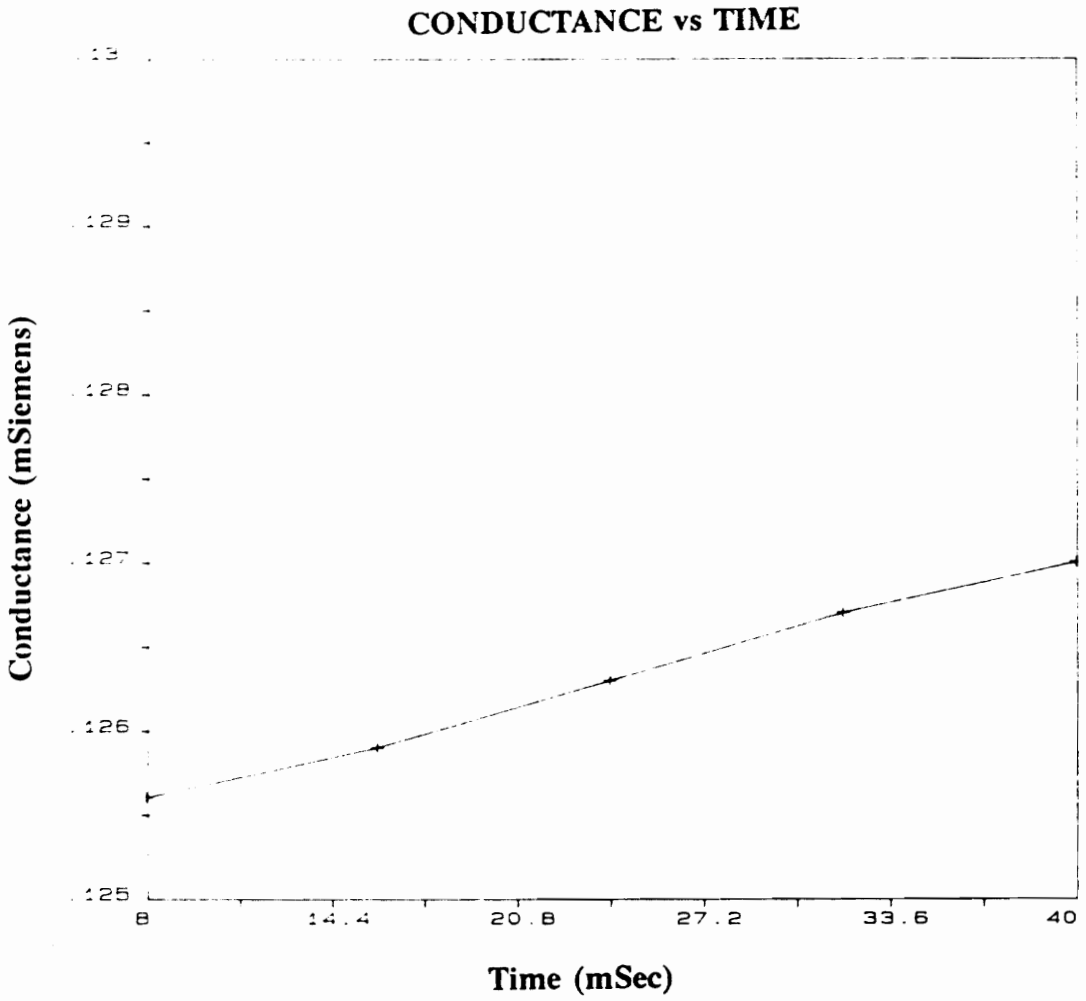


Figure 4.8 Conductance versus Time

increasingly leaky with time. This may explain the poor results of Figure 4.1 (capacitance versus time), because one possible reason for a non-exponential characteristic is a series resistance.

4.2.2 Conductance vs. Voltage

Figure 4.9 gives the room temperature conductance versus voltage graph over a range of -8 to 0 volts at room temperature. The increasing conductance correlates well with a reverse biased diode as it slowly moves toward forward bias. The more rapid increase near zero bias indicates an increase in the dissipation factor of the depletion layer capacitor. The best dissipation factor is found at moderate reverse biases where the saturation current is the smallest. Although the conduction remains below 3 msiemens, the capacitor quality degrades as reverse bias decreases.

4.2.3 Conductance vs. Temperature

Figure 4.10 gives the conductance versus temperature graph at -4 volts, showing an almost exponential increase at higher temperatures. The low temperature noisy behavior may be attributed to the accuracy limitations of the C-t meter. The conductance shows the proper trend because as the temperature increases, the electrons become more active due to thermal effects, causing an increase in the conductivity, i.e., the diode becomes leakier at higher temperatures. The conductivity at room temperature corresponds well with the temperature scan. The room temperature reading in Figure 4.9 at -4 volts is approximately .01 msiemens, while Figure 4.10 gives approximately .012 mmhos. These measurements concur well, within experimental error limits.

4.3 Current Measurements

All the current related graphs are derived from the current versus voltage experiment. The measurements within the group were taken from the pA meter (HP 4140B). The tested devices were GaAs Schottky diodes.

4.3.1 Current vs. Voltage

Figure 4.11, a current versus voltage plot at room temperature, shows diode breaking down at a reverse bias of approximately 10 volts. The forward voltage turn-on appears correct, with the ideality factor found to be about 1.15. The +/- 10 mA flat region shown in the curve is due to the

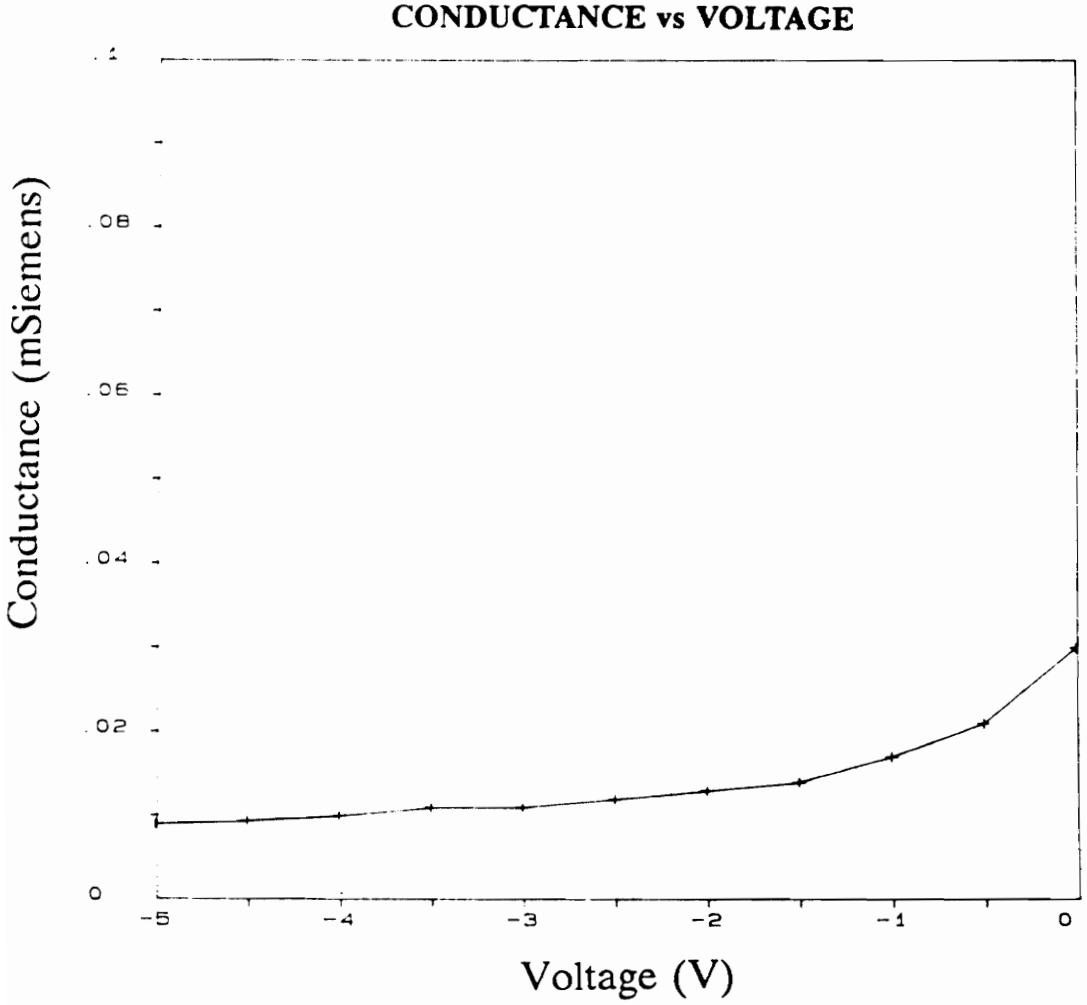


Figure 4.9 Conductance versus Voltage

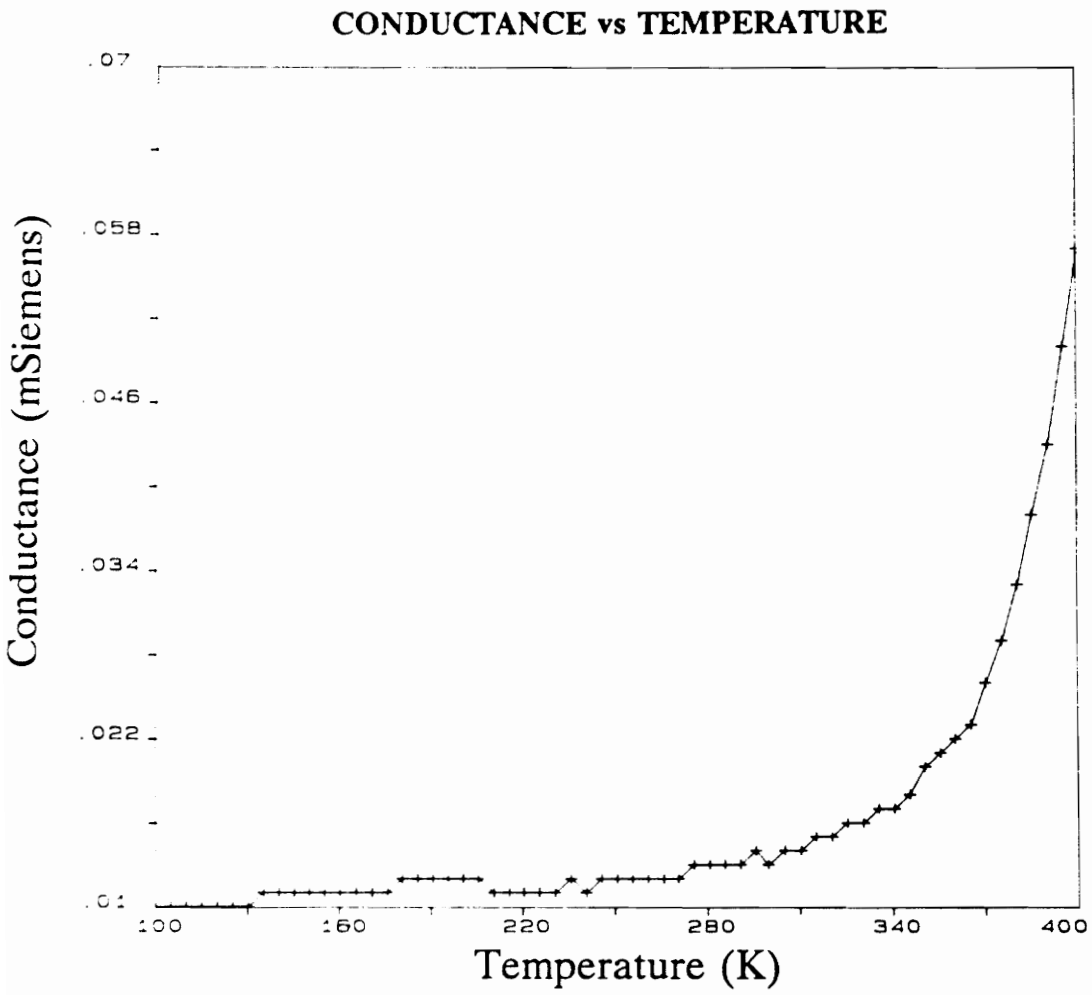


Figure 4.10 Conductance versus Temperature

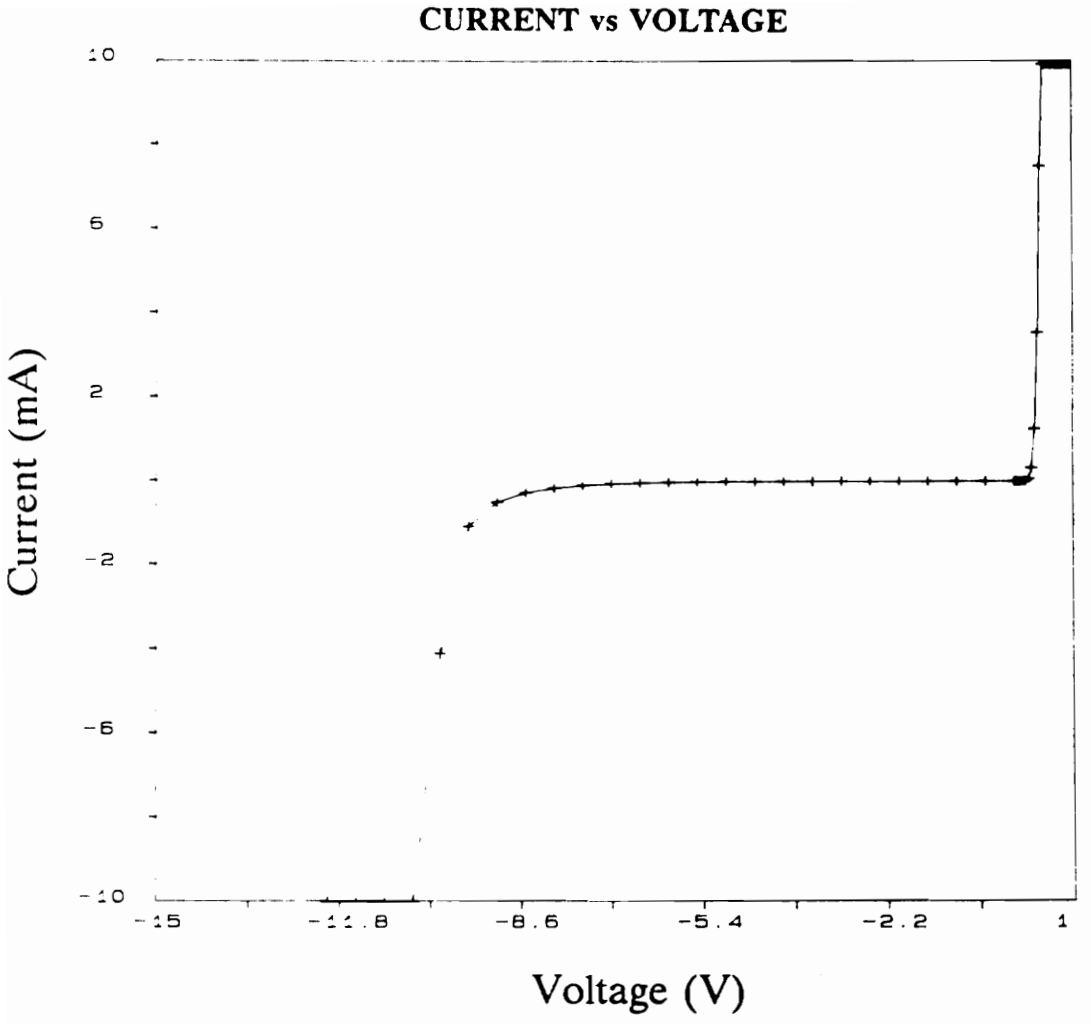


Figure 4.11 Current versus Voltage

current limitation of pA meter (10 mA).

4.3.2 Natural Log Current vs. Voltage

Figure 4.12 gives the Ln(I) versus qV/kT graph at room temperature. The plot shows the correct trend: current decreasing as the voltage approaches zero, a minimum at zero voltage, and approximately an exponential increase at forward biases (the linear slope in this graph). The ideality factor is given as the inverse slope of the forward characteristic, and from the least-square fit explained in the chapter 3.4, the slope is found to be .874 which corresponds to an ideality factor of 1.144. The reverse saturation current at room temperature is found to be $9.26X10^{-10}$ amps from the Y-intercept of the forward characteristic.

4.3.3 $Ln(I_f/T^2)$ vs. qV/kT

Figure 4.13 gives an $Ln(I_f/T^2)$ versus qV/kT plot taken at a forward bias of .15 volts. The curve is approximately linear over the indicated range and provides a range over which to take the least-square fit for the following three graphs. This is especially useful because the graph is derived from equation 2.10 which allows the barrier height to be calculated from the flat section of this graph. The slope of the curve gives a barrier height value of 1.02 eV.

4.3.4 I_{sat} vs. Temperature

Figure 4.14 gives a typical I_{sat} versus temperature graph. The saturation current is basically zero until about 260K where the electrons begin to activate. The saturation current increases approximately exponentially above 290K as predicted by the thermionic emission model (equation 2.16).

4.3.5 Ideality Factor vs. Temperature

Figure 4.15 displays an ideality factor's dependence on temperature. The ideality factor is seen to increase with temperature because the leakage in the diode becomes greater and the current transport deviates from the thermionic model at higher temperatures.

4.3.6 Barrier Height vs. Temperature

The barrier height shown in Figure 4.16 follows an approximately linear increase as predicted

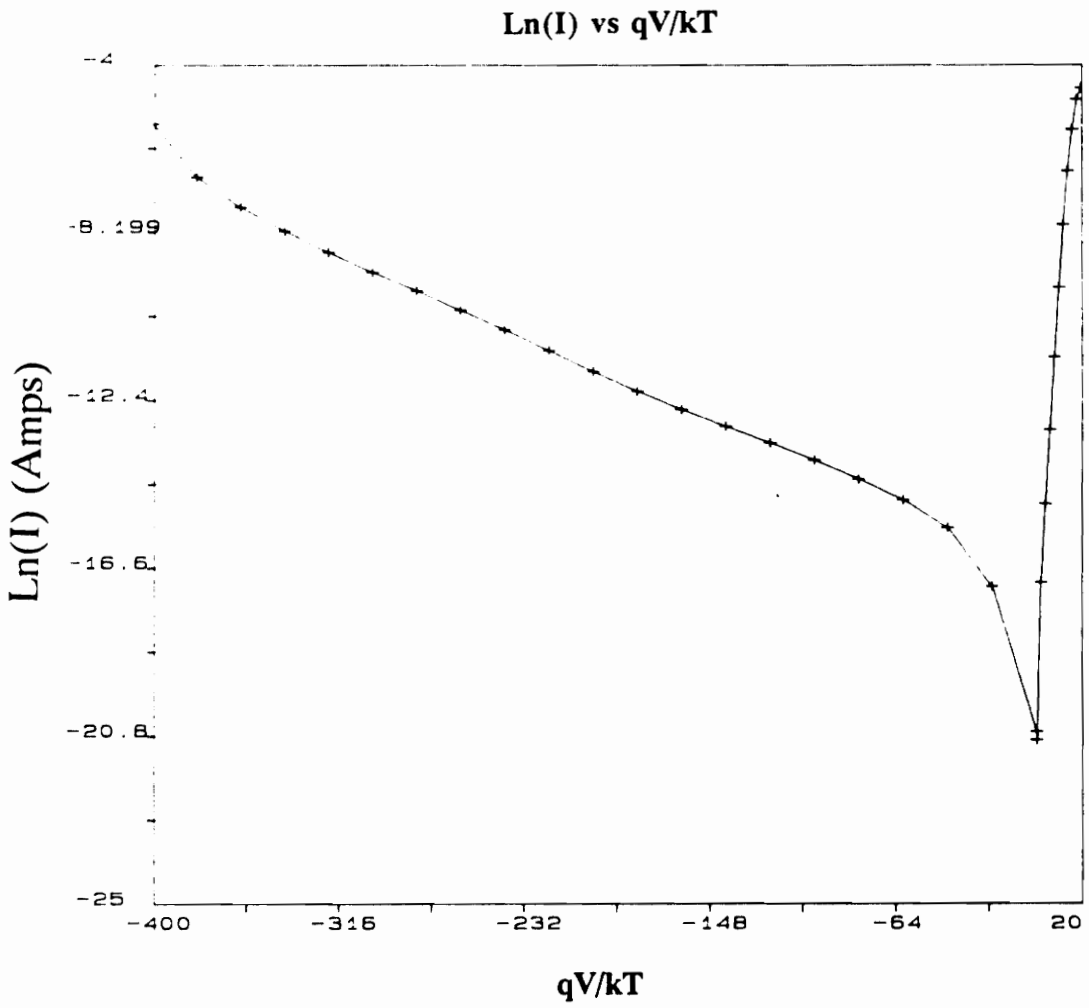


Figure 4.12 Natural Log Current versus Voltage

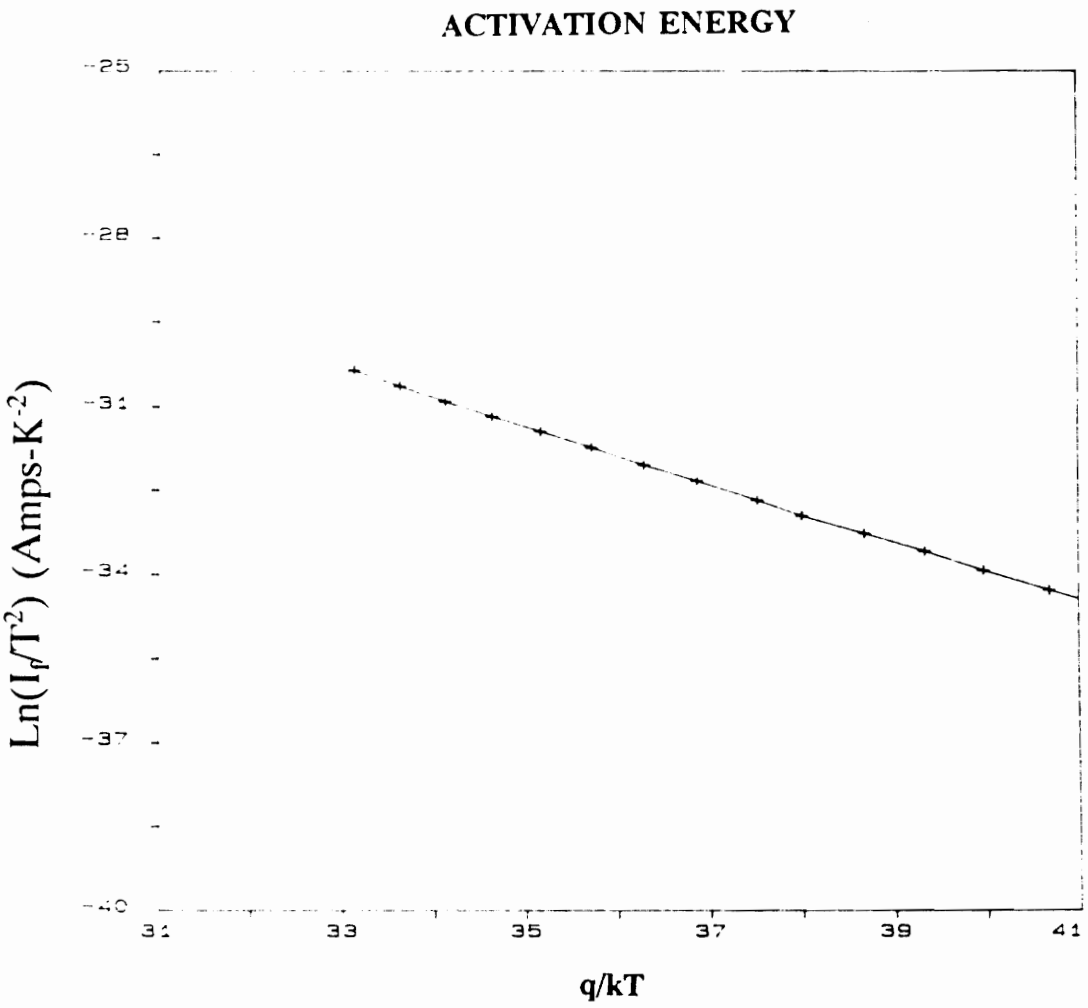


Figure 4.13 Ln(If/T^2) versus qV/kT

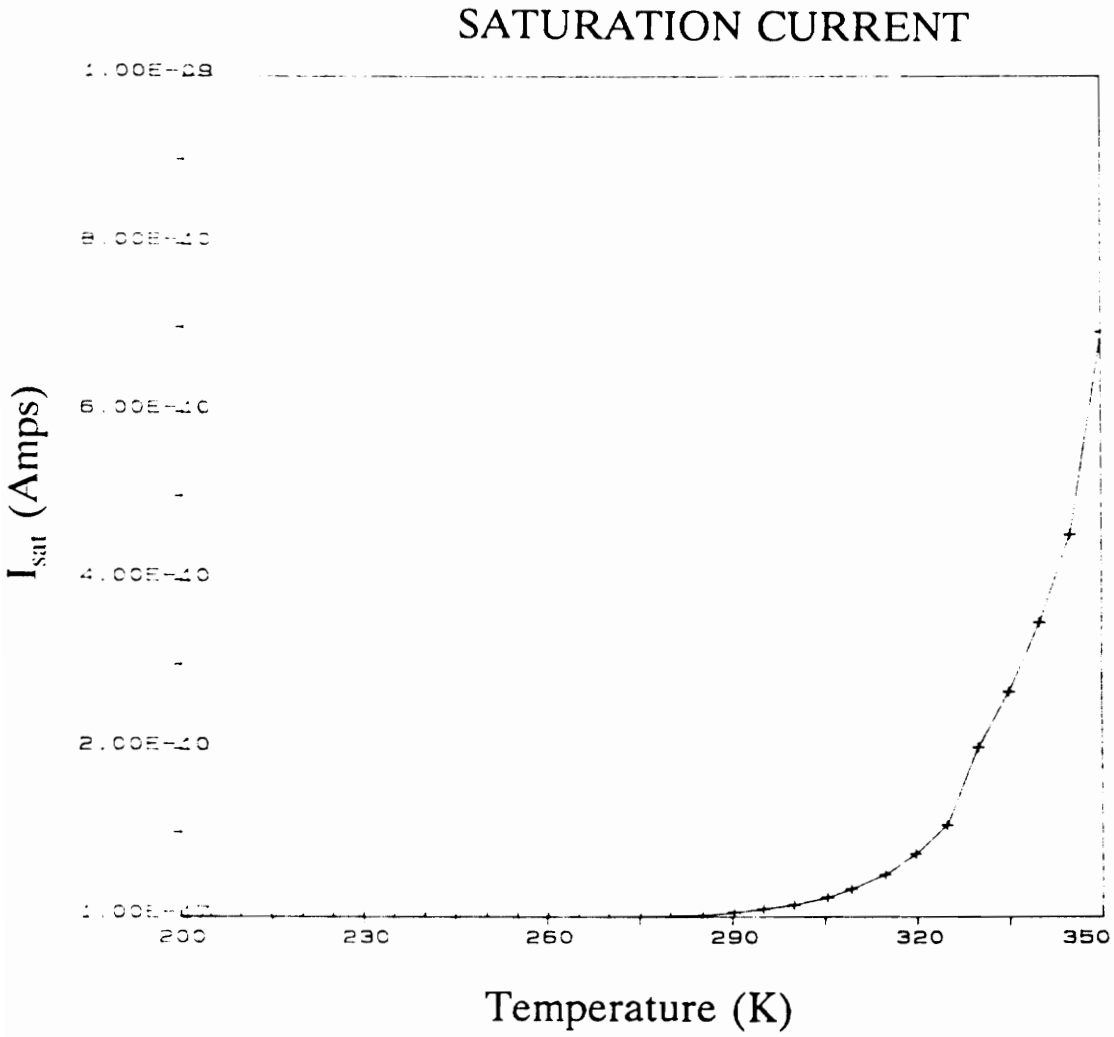


Figure 4.14 I_{sat} versus Temperature

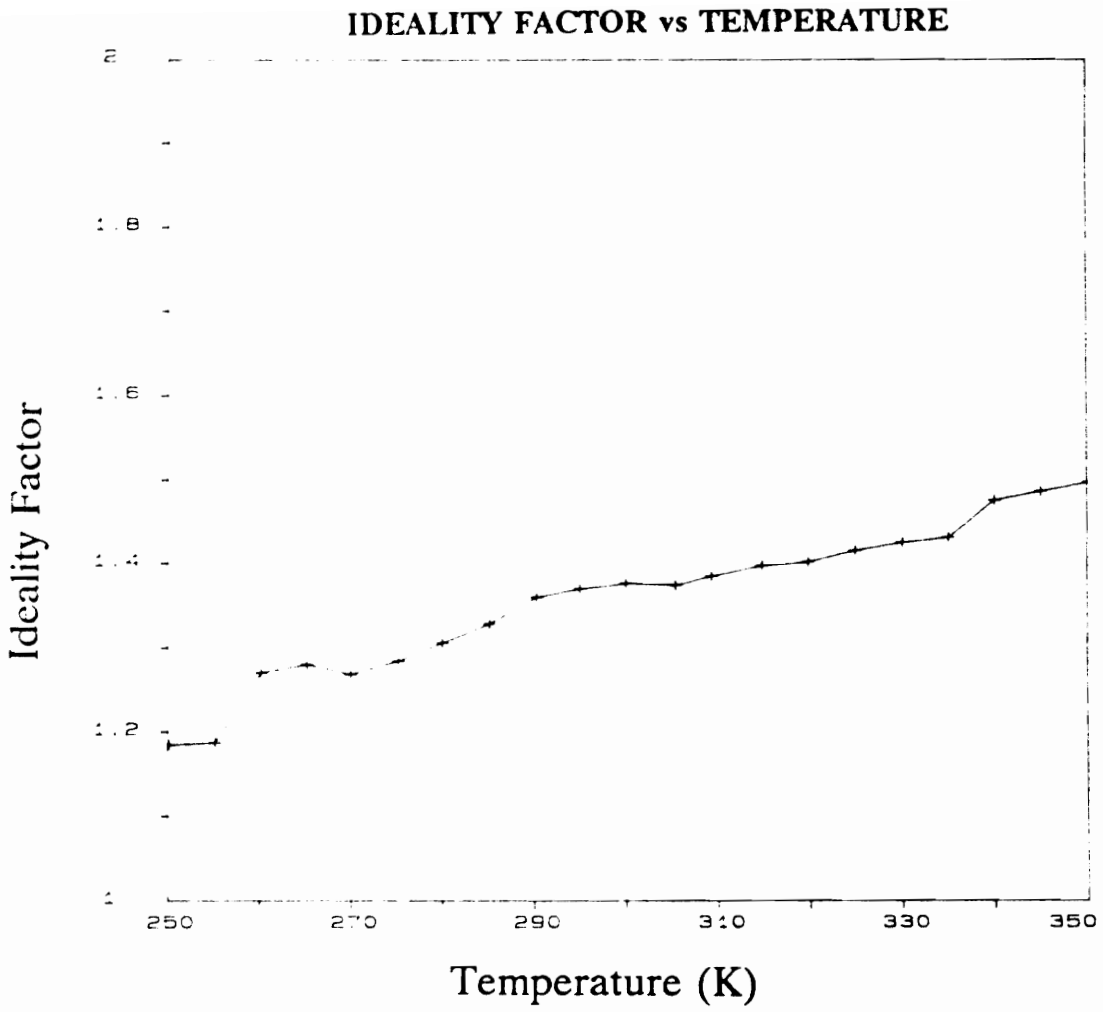


Figure 4.15 Ideality Factor versus Temperature

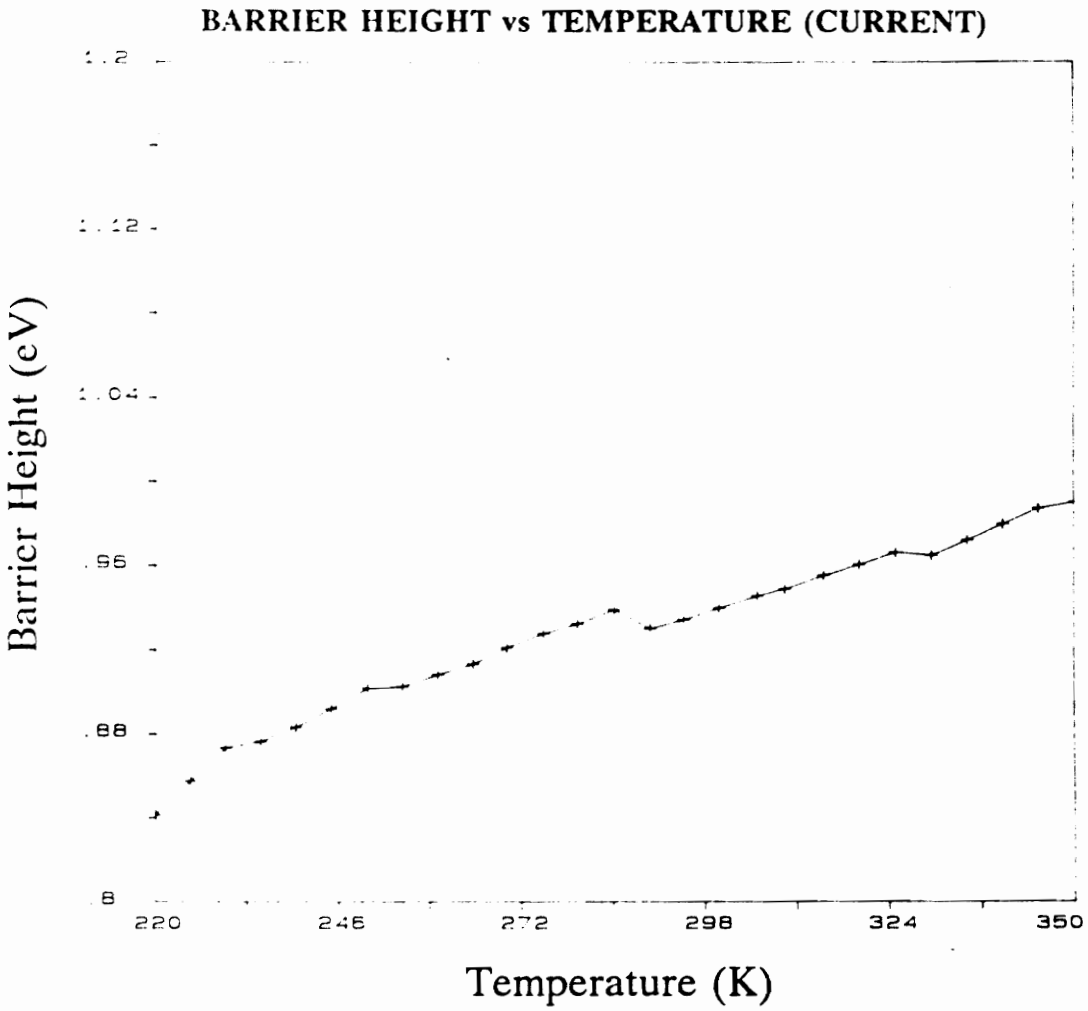


Figure 4.16 I-V Barrier Height versus Temperature

by the equation [13]

$$\phi_b - \frac{kT}{q}\ln\left(\frac{A^*T^2}{J_s}\right) \qquad (4.2)$$

The first-order approximation is roughly linear as shown by the kT/q term. The natural log term should have a second-order impact.

4.4 Four Point Resistivity

The four-point resistivity experiment was implemented using a thick film superconducting sample. Figure 4.17 gives a graph which conforms to the superconductor temperature spectrum. The thick film sample has a small resistance at temperatures above 90K, while the resistance drops rapidly to approximately zero ohms below that.

4.5 van der Pauw Measurements

van der Pauw measurements are used to evaluate transport parameters like resistivity, mobility and carrier concentration in a semiconductor. The resistivity dependence on temperature for a 2 MeV silicon implanted sample is shown in Figure 4.18. The corresponding behavior of mobility and carrier concentration is shown in Figures 4.19 and 4.20 where the mobility values peak at temperatures of around 100K. Below 100K impurity scattering is seen to be dominating, while above 100K lattice scattering governs carrier mobility. Carrier concentration marginally increases over the temperature range investigated.

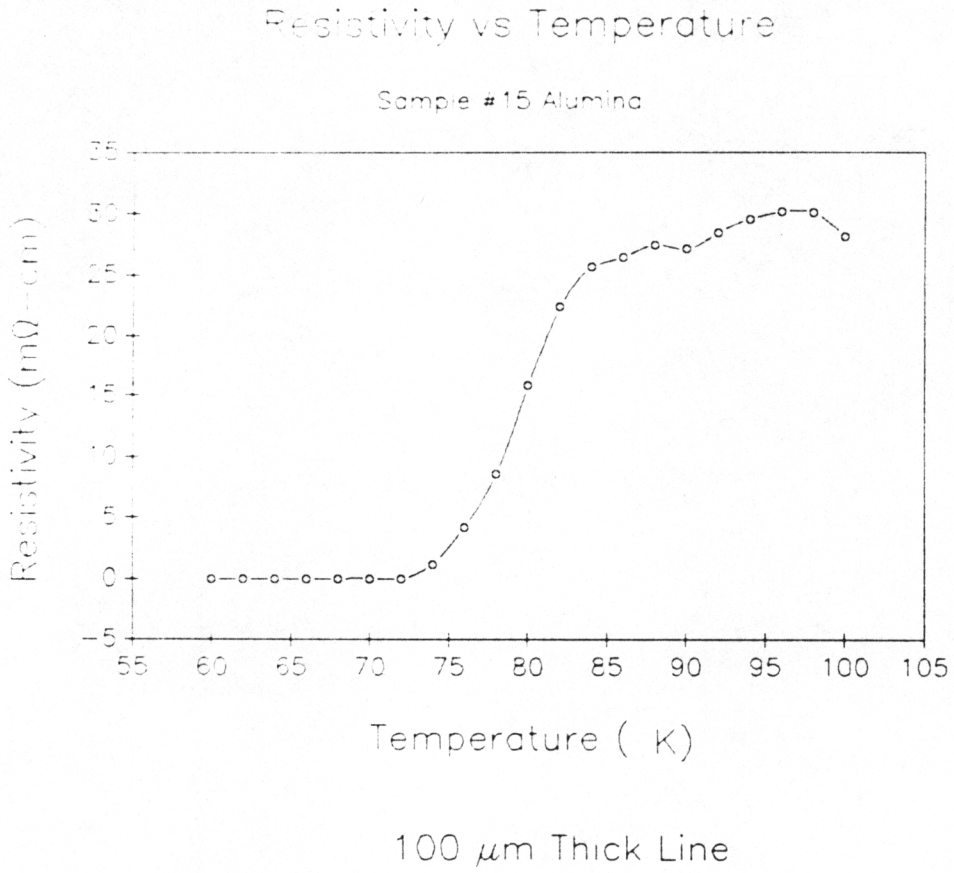


Figure 4.17 Resistivity versus Temperature

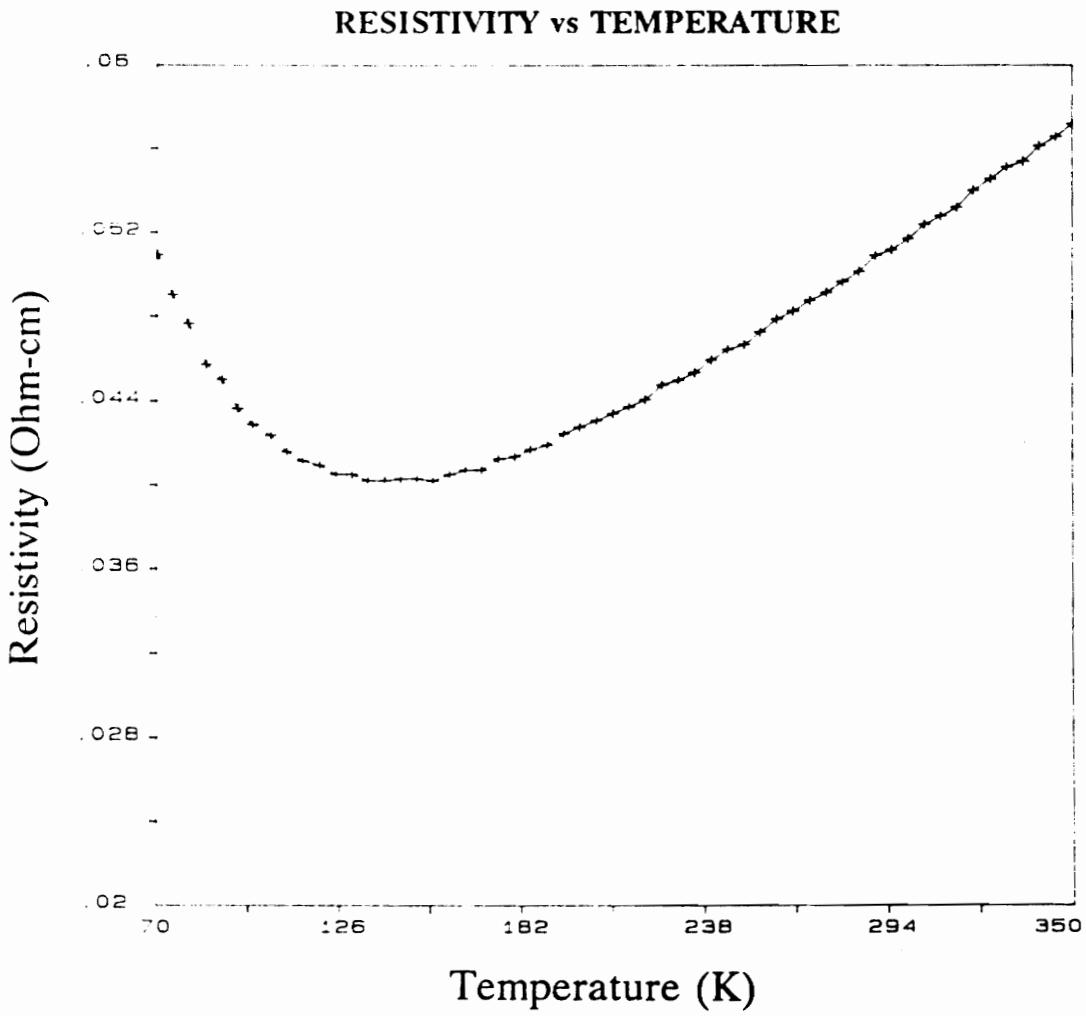


Figure 4.18 Resistivity versus Temperature

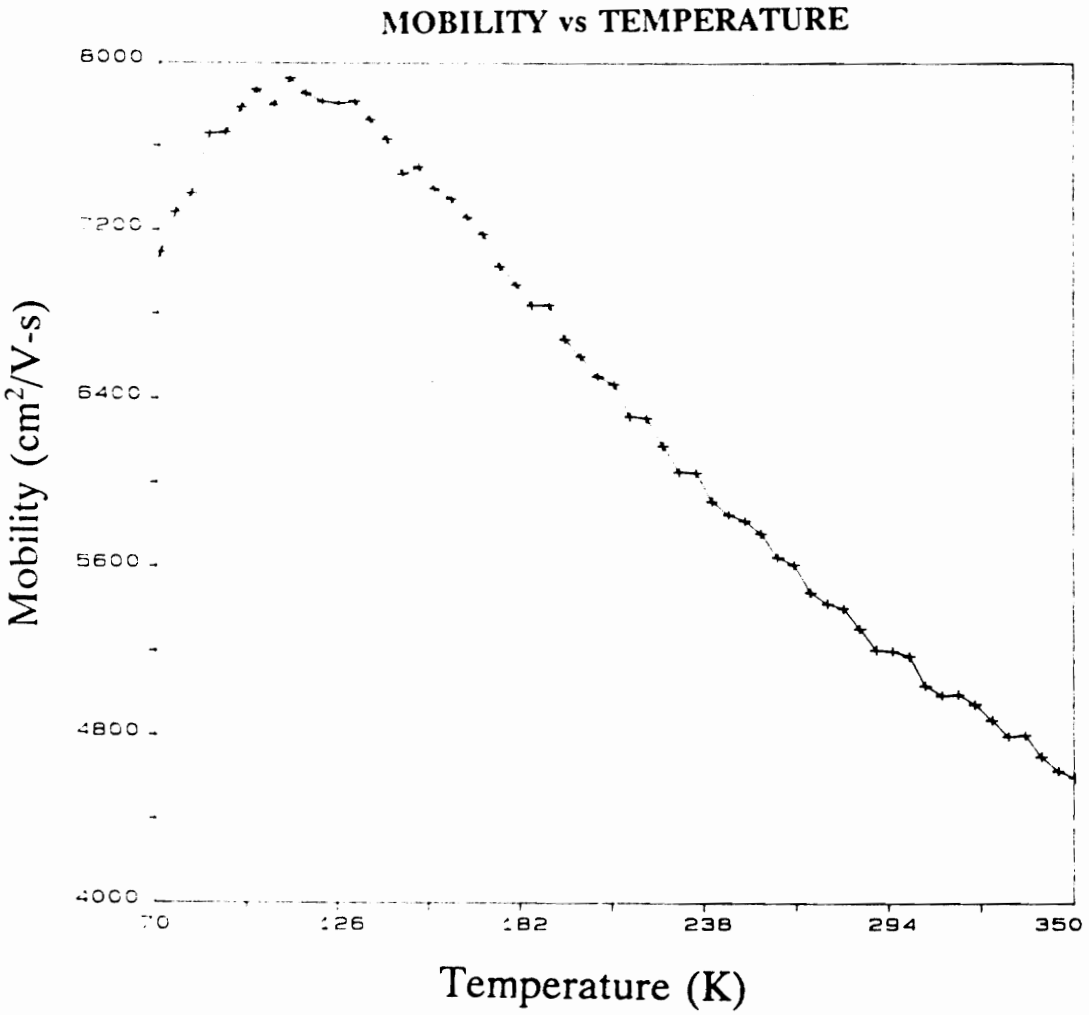


Figure 4.19 Mobility versus Temperature

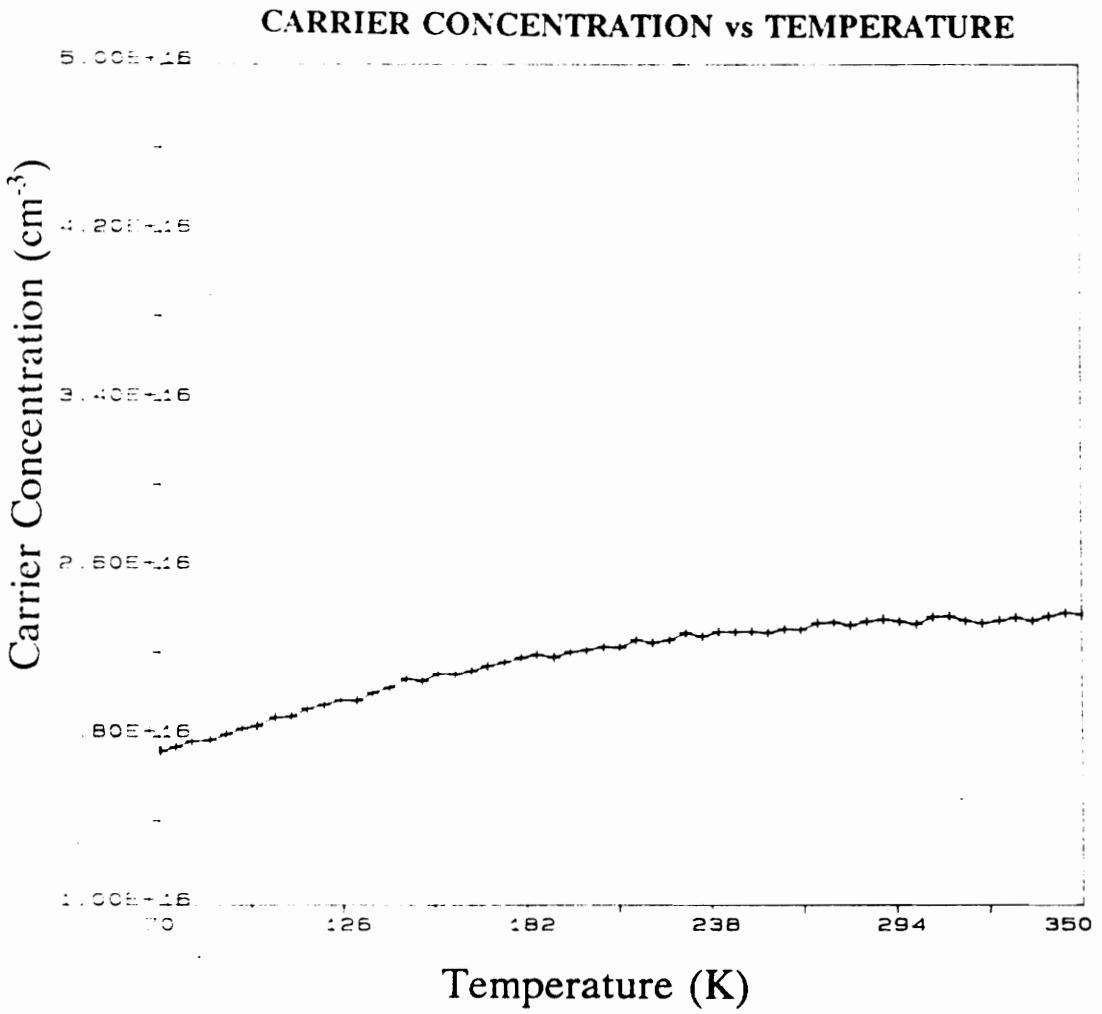


Figure 4.20 Carrier Concentration versus Temperature

CHAPTER 5 CONCLUSIONS AND FUTURE RECOMMENDATIONS

The MEDUSA program has been in operation for over two years. The software has been extensively tested and debugged. Except for minor programming errors and one hardware failure (the cryostat temperature controller failed), the system has been virtually trouble free.

The IEEE-488 parallel interface scheme was chosen over both RS-232C and A/D-D/A converters because the IEEE-488 bus allows simple programming to conduct the experiments. Also, the IEEE-488 advantage in speed helped increase the allowed measurement speed. Finally, the IEEE-488 interface is commonly added to most types of new measurement equipment at a low cost.

The hardware instruments chosen to be utilized by MEDUSA required an IEEE-488 interface board as the digital communications board between the computer and various instruments. The Scientific Solution card was chosen over the competitor's for both it's price and the ease of use.

The Scientific Solution's IEEE-488 controller required a type a BASIC to be employed. BetterBASIC$_{tm}$ was chosen as the best BASIC compatible language available at the time. The major consideration for choosing the language was two-fold: the memory capalities of the software had to be greater than 256Kbytes, and subroutines were required to make the programming more modular, and therefore easier to both program and debug.

MEDUSA was seperated into four sections: a controlling batch file and programs, PARAMETER, RUNIT, and GRAPHICS. PARAMETER provides the experimental parameter setting and checking abilities, RUNIT conducts the experiments, and GRAPHICS manipulates the data utilizing the correct equations to produce the required plots.

MEDUSA is extremely user friendly and the error checking routines are extensive, allowing errors to be made in the entering of variables. For example, if any unsuitable experimental parameters are entered, the program via the IEEE-488 bus, checks them with the instruments and returns the correct error message. It then allows the parameters to be reentered. Also, the configuration has been operated by several people, each learning to use MEDUSA in a matter of hours.

The four experimental groups have been exhaustively tested, especially the Group I, capacitance vs. time and capacitance vs. voltage experiments. All three modes of operation, time, room temperature, and temperature range, along with the various parameters particular to an experiment have been extensively utilized.

Various plots are shown in Chapter 4. Given the limitation of both the instruments and the devices tested, all experiments shown in Chapter 4 yield correct results. The only exceptions are the capacitance versus time and C-V barrier height versus temperature plots. One possible reason for the discrepancy between the plots and literature is a surface insulating layer, causing a non-ideal step junction. More reasons are given in sections 4.1.1 and 4.1.6.

Future Recommendations

The possible improvements to MEDUSA are designed to ease the researcher's difficulty in running experiments and analyzing the data. Some recommended changes are listed below.

- Switch to another IEEE-488 interface card which allows machine language calls rather than BASIC calls, increasing data transfer rates and reducing memory requirements
- Rewrite the software in QuickBASIC$_{tm}$, which allows executable files (as opposed to BASIC interpreted files). Additionally, QuickBASIC$_{tm}$ is a current language, whereas BetterBASIC$_{tm}$ is now defunct
- Incorporate a scanner into the hardware setup allowing all four experiment groups to be conducted at once. This would be accomplished by switching between the different meters (C-t and pA) in the same temperature sweep, increasing accuracy by alleviating a build-up of thermal stress over several temperature scans and quickening the data acquisition phase
- Add an option to the C-t experiment allowing more than one step delay time. This would allow widely different rate windows during the same temperature scan
- Add the necessary software/hardware modules to conduct FET characterization

REFERENCES

1. M.J. Howe, D.V. Morgan, Gallium Arsenide Materials, Devices and Circuits, John Wiley & Sons, Chichester, pp. 161-165, 1985.

2. L.J. van der Pauw, "A Method Measuring Specific Resistivity and Hall Effect of Disc of Arbitrary Shape", Phils Research Reports, Vol. 13, No. 1, pp 1-9, 1958.

3. P.M. Hemenger, "Measurement of High Resistivity Semiconductors using the van der Pauw Method", Review of Scientific Instruments, Vol. 44, No. 6, 698-700, June 1973.

4. N.I. Pavlov, "Measurements of the Electrical Conductivity and Hall Mobility in Inhomogeneous Semiconductor Films of Arbitrary Shape", Electrical Conductivity in Semiconductor Films, 1984.

5. E.S. Yang, Microelectronic Devices, McGraw-Hill, U.S.A., pp. 61-115, 1978.

6. S.M. Sze, Physics of Semiconductor Devices, John Wiley & Sons, New York, pp. 270-311, 1974.

7. A.A. Elshiabini-Riad, Class Notes, Fall, 1989.

8. D.V. Lang, "Deep-Level Transient Spectroscopy: A New Method to Characterize Traps in Semiconductors", Journal of Applied Physics, Vol. 45, No. 7, 1974.

9. E.D. Cole, Electrical Analysis of Low Energy Argon Ion Bombarded GaAs, Ph.D Dissertation, June 1988.

10. "Switching Handbook, A Guide to Signal Switching in Automated Test Systems", Keithley Inc., Cleveland OH, 1987.

11. "1987 Applications Handbook", Data Translation Inc., Marlboro, MA, 1987.

12. R.E. Dessy, "Workstations in the Laboratory, Part 1", Analytical Chemistry, No 57, 228A, 1985.

13. R.E. Dessy, "Workstations in the Laboratory, Part 2", Analytical Chemistry, No 57, 310A, 1985.

14. R.E. Dessy, "Part 1, Choosing a PC", Anal. Chem., Vol. 58, 78A, 1986.

15. Dessy, R.E. "Part 2, Choosing a PC", Analytical Chemistry, Vol. 58, 313A, 1986.

16. "IEEE 488 Solutions", IOtech Inc, Cleveland, OH, 1989.

17. "Data Acquisition & Control", MetraByte Corp., Taunton, MA, 1988.

18. "Data Acquisition & Control", Keithley Inc. Cleveland, OH, 1987.

19. "IEEE-488 Control, Data Acquisiton and Analysis for Your Computer", National Instruments, Austin TX, 1988.

20. R.E. Dessy, "The PC Connection, Part 1", American Chemical Society, Vol. 58, 678A, 1986.

21. R.E. Dessy, "The PC Connection, Part 2", American Chemical Society, Vol. 58, 793A, 1986.

22. R.E. Dessy, "The PC Connection, Part 3", American Chemical Society, Vol. 58, 919A, 1986.

23. R.E. Dessy, "Operating Systems for the Laboratory", Analytical Chemistry, Vol. 55, 883A, 1983.

24. Sobell, Mark, A Practical Guide to the UNIX system, Redwood City, CA, Benjamin/Cummings, 1989.

25. Disk Operating System, IBM and the Microsoft Corp., Boca Raton FL, 1986.

26. R.E. Dessy, "Languages for the Laboratory, Part 1", Analytical Chemistry, Vol. 55, 650A, 1983.

27. R.E. Dessy, "Languages for the Laboratory, Part 2", Analytical Chemistry, Vol. 55, 756A, 1983.

28. The BetterBASIC Programming System Version 2.1, Summit Software Technology, Inc., Norwood, MA, 1985.

29. IBM BASIC Reference,

30. Microsoft FORTRAN Optimizing Compiler, Microsoft, Redmonton, WA, 1987.

31. Kelly, M.G., FORTH, A Text and Reference, Englewood Cliffs, NJ, Prentice Hall, 1986.

32. Kelley, L., Pohl, I., TURBO C, The Essentials of C Programming, Benjamin/Cummings Publishing Company, Inc., Menlo Park, CA, 1988.

33. Schneider, G.M., An Introduction to Programming and Problem Solving with PASCAL, Wiley, New York, 1978.

34. KEITHLEY Model 228 Voltage/Current Source Instruction Manual, Keithley Instruments Inc., Cleveland Ohio, 1984.

35. HEWLETT PACKARD 8112A Pulse Generator 50 MHz, Operating and Instruction Manual, Hewlett Packard, Palo Alto, CA, 1985.

36. Scientific Solutions IEEE488 Interface, Scientific Solutions Inc., Solon, OH, 1985.

APPENDIX

PARAMETER

```
SOURCE
PRECISION= 7
AUTODEF=ON
OPTION BASE=0
ERL=ON
ERRORMODE=GLOBAL
RESUME=STATEMENT
FORMODE=GW
SCOPE=OFF
PROCS=18
STRING ARRAY(?): RECS,FLDS
STRING: PARAMS[?],IEEE_FCTN$[?]
INTEGER: CNTRLR%,TRUE%,COMM%,PORT4%,PORT5%,PORT9%
INTEGER: PORT0%,FUM%,FALSE%,MY_FLAG%,MAX_TIME%
REAL: STROFF
INTEGER: STROFF%
REAL: DSPTR
INTEGER: MY_ADDR%,BD_ADDR%,PORT1%,PORT2%
INTEGER: PORT3%,PORT6%,PORT7%,PORT8%
STRING: CHAR1$[?]
INTEGER: TCIMODE%,MS%,INTR%,INTVECTOR%,INTENABLE%
INTEGER:
INTMASK%,SUBLIB%,TIMEOUT%,INTSETUP%,POLLBYTE%,WRSTR%,WRFIL%,CB_FL
AG%
INTEGER: HCSR%,VCSR%,RDSTR%,RDFIL%
REAL: CSEG
INTEGER: SAVESTAT%,SYC%
STRING: DUMMY$[?]
INTEGER: NEOS%,TERM%,N1%,LAST_INT1%
INTEGER: INT1STAT%,CTR%
STRING: DATA_STRING$[?]
INTEGER: CHAR%,STRLEN%,CB%,DAT%,LAST%,POLL_RESP%,STATUS%
INTEGER: SRQ%,SYS%,BIT%,SENSE%,X%,N2%,Y%,ADSTAT%
STRING: END_SEQ$[?],LAST_CHAR$[?],SEP$[?]
STRING ARRAY(?): SAR$
STRING: TEMP$[?]
INTEGER: Runnumber%,Redo%,M%,Number%,Rownumber%,B%
INTEGER: Col%,Choice%,Row%,Time%,N%,Delay%
STRING: File$[5],Chk$[3],Name$[60]
STRING: Title$[?]
STRING ARRAY(6)[5]: File$
STRING ARRAY(11)[256]: Information$
INTEGER ARRAY(31): Expt%
INTEGER ARRAY(11): Group%
REAL ARRAY(26,31): Parameter!
STRING: Expt$[20]
REAL: Tyme,Min!,Max!,Delta!,Time!
INTEGER: L%
REAL: Timerun!
INTEGER: Startnoerror%
STRING: Function[5],Function$[?],Moniker$[13]
```

```
REAL: Pulsevolt!,L
REAL: M,Bias!,Minholdtime!,Mindelaytime!,Data_string,Pulse!,Maxtemp!,Mintemp!
REAL: TEMP!,I,V,Experiment,Parameters
INTEGER: DATA_STRINGS%
REAL: Mintime!,Maxtime!,L!
REAL ARRAY(?): PARAMETEr!!
INTEGER: DLEAY%
REAL: PARAM
INTEGER: Maxloop%
STRING ARRAY(?): Inofrmation$
REAL: Timer!
INTEGER: EXPT%,Space%
INTEGER: SER_POLL%
STRING ARRAY(?): Ch$
REAL: O
STRING: FILE1$[8],BS$[34]
REAL: M%8,Hello
STRING: X$[?]

PROCEDURE: Border()
  INTEGER ARG: Rownumber%/VAR
END PROCEDURE

PROCEDURE: Title()
  STRING ARG: Title$
END PROCEDURE

PROCEDURE: Menu()
  INTEGER ARG: Number%/VAR,Rownumber%/VAR
  STRING ARG: Name$
  INTEGER ARG: Row%/VAR
END PROCEDURE

PROCEDURE: Finish()
  INTEGER ARG: Rownumber%/VAR,Number%/VAR
  STRING ARG: Name$
END PROCEDURE

PROCEDURE: Filecheck()
  STRING ARG: File$
  INTEGER ARG: Redo%/VAR
END PROCEDURE

PROCEDURE: Placeampersand()
  INTEGER ARG: Number%,Choice%
END PROCEDURE

PROCEDURE: Removeampersand()
  INTEGER ARG: Number%,Choice%
END PROCEDURE
```

```
PROCEDURE: Settempparam()
  INTEGER ARG: Time%,Col%
  REAL ARG: Minimumtemp!/VAR,Maximumtemp!/VAR,Incrementemp!/VAR
  STRING ARG: ExptS,NameS
END PROCEDURE

PROCEDURE: Timeparam()
  REAL ARG: Finaltime!/VAR,Deltatime!/VAR
END PROCEDURE

PROCEDURE: Svolt()
  REAL ARG: Start!/VAR,Stop1!/VAR,Step1!/VAR,Stop2!/VAR,Step2!/VAR
END PROCEDURE

PROCEDURE: DVdt()
  REAL ARG: DVdt!/VAR,Start!/VAR,Stop!/VAR,Step!/VAR
END PROCEDURE

PROCEDURE: Settime()
  REAL ARG: Stepdelay!/VAR,Initialhold!/VAR,Finalhold!/VAR,Deltahold!/VAR
  REAL ARG: Minholdtime!,Mindelaytime!
  INTEGER ARG: Type%
END PROCEDURE

PROCEDURE: Setbias()
  REAL ARG: Initialbias!/VAR,Finalbias!/VAR,Deltabias!/VAR
END PROCEDURE

PROCEDURE: Setsamples()
  REAL ARG: SAMPLES!/VAR
END PROCEDURE

PROCEDURE: Setpulse()
  REAL ARG: Initialpulse!/VAR,Finalpulse!/VAR,Deltapulse!/VAR,Lowpulse!/VAR
END PROCEDURE

PROCEDURE: Copytodisk()
  STRING ARG: FILES
END PROCEDURE

PROCEDURE: Timedelay()
  INTEGER ARG: Delay%/OPT=5
END PROCEDURE

PROCEDURE: Clearscreen()
  INTEGER ARG: Row%
END PROCEDURE


PROCEDURE: Border
  INTEGER: M%
```

```
     9 REM
    10 REM ************************************************************
    11 REM *                                                          *
    12 REM *   The Procedure BORDER prints '*' around the menu.       *
    13 REM *                                                          *
    14 REM *   to call type BORDER (ROWNUMBER%) <RETURN>              *
    15 REM *                                                          *
    16 REM *   INTEGER:  M% - used in a FOR-NEXT loop                 *
    17 REM *                                                          *
    18 REM *   INTEGER ARGUMENT:  Rownumber%/VAR - used to delineate  *
    19 REM *                      the maximum row for the '*'         *
    20 REM *                                                          *
    21 REM ************************************************************
    22 REM
   100 COLOR 2,0
   110 LOCATE 3,1
   120 PRINT "************************************************************";
   130 PRINT "********************"
   140 Rownumber% = Rownumber% + 1
   150 FOR M% = 4 TO Rownumber%
   160 LOCATE M%,1
   170 PRINT "*"
   180 LOCATE M%,79
   190 PRINT "*"
   200 NEXT M%
   210 Rownumber% = Rownumber% + 1
   220 LOCATE Rownumber%,1
   230 PRINT "************************************************************";
   240 PRINT "********************"
   250 Rownumber% = 0
   260 COLOR 7,0
   270 EXIT
END PROCEDURE

PROCEDURE: Title
  INTEGER: Column%
     9 REM
    10 REM ************************************************************
    11 REM *                                                          *
    12 REM *   The Procedure TITLE prints the title of the menu       *
    13 REM *   transferred from the main program by TITLE$ in the     *
    14 REM *   location 1,col%                                        *
    15 REM *                                                          *
    16 REM *   to call:  TITLE (COL%,TITLE$)                          *
    17 REM *                                                          *
    18 REM *   INTEGER ARGUMENT:  Col% - gives the 1-80 column number *
    19 REM *                                                          *
    20 REM *   STRING ARGUMENT:  Title$ - gives the title string      *
    21 REM *                                                          *
    22 REM ************************************************************
    23 REM
```

```
    100 Column% = CINT((79 - LEN(Title$))/2)
    110 COLOR 5,0:CLS
    120 LOCATE 1,Column%
    130 PRINT Title$
    140 COLOR 7,0
    150 EXIT
END PROCEDURE

PROCEDURE: Menu
  INTEGER: Col%
  STRING: Number$[4]
  INTEGER: Row1%
     9 REM
    10 REM ************************************************************
    11 REM *                                                          *
    12 REM *  The Procedure MENU takes the names transferred by the   *
    13 REM *  calling program and prints them as a screen.            *
    14 REM *                                                          *
    15 REM *  to call:  MENU (NUMBER%,ROWNUMBER%,NAMES,ROW%)          *
    16 REM *                                                          *
    17 REM *  INTEGER:  Col%                                          *
    18 REM *                                                          *
    30 REM *  INTEGER ARGUMENT:  Number%/VAR,Rownumber%/VAR,Row%/VAR  *
    32 REM *                                                          *
    40 REM *  STRING:  Number$[4]                                     *
    43 REM *                                                          *
    50 REM *  STRING ARGUMENT:  Name$                                 *
    59 REM *                                                          *
    60 REM ************************************************************
    61 REM
   100 COLOR 3,0
   110 Number% = Number% + 1
   120 Number$ = STR$(Number%)
   130 DEL$(Number$,1,1)
   140 IF Number% < 13 THEN Col% = 5 ELSE Col% = 42
   150 IF Number% = 13 THEN Row% = 1 ELSE Row% = Row% + 1
   160 LOCATE Row%+4,Col%
   170 PRINT "(";Number$;") ";Name$
   180 IF Rownumber% < CSRLIN THEN Rownumber% = CSRLIN
   190 COLOR 7,0
   200 EXIT
END PROCEDURE

PROCEDURE: Finish
  STRING: Number$[4]
  INTEGER: Column%
     9 REM
    10 REM ************************************************************
    11 REM *                                                          *
    12 REM *  The Procedure FINISH prints the message which allows    *
    13 REM *  the user to exit the menu.                              *
```

```
    14 REM *                                                    *
    15 REM *   to call:  FINISH (ROWNUMBER%,NUMBER%,COL%,NAME$)      *
    16 REM *                                                    *
    20 REM *   INTEGER ARGUMENT:  Rownumber%/VAR,Number%/VAR,col%     *
    22 REM *                                                    *
    30 REM *   STRING:  Number$[4]                                  *
    32 REM *                                                    *
    40 REM *   STRING ARGUMENT:  Name$                                *
    43 REM *                                                    *
    50 REM ************************************************************
    51 REM
   100 Column% = CINT((77 - LEN(Name$))/2)
   110 COLOR 3,0
   120 Rownumber% = Rownumber% + 1
   130 Number% = Number% + 1
   140 Number$ = STR$(Number%)
   150 DEL$(Number$,1,1)
   160 LOCATE Rownumber%,Column%
   170 PRINT "(";Number$;") ";Name$
   180 COLOR 7,0
   190 EXIT
END PROCEDURE

PROCEDURE: Filecheck
  STRING: Chk$[16]
  INTEGER: T%,I%
  STRING: A$[?]
  INTEGER: Maxloop%
     9 REM
    10 REM ************************************************************
    11 REM *                                                    *
    12 REM *   The Procedure FILECHECK sees if the directory specified *
    13 REM *   has been previously used.  If it has then it asks the   *
    14 REM *   user if they want to erase all previous files.  If the  *
    15 REM *   directory has not been used, it then creates the asked  *
    16 REM *   for directory.                                    *
    17 REM *   to call:  FILECHECK (FILE$,REDO%)                    *
    18 REM *                                                    *
    20 REM *   INTEGER ARGUMENT:  Rownumber%/VAR, Number%/VAR, col%    *
    23 REM *                                                    *
    30 REM *   STRING:  Number$[4]                                  *
    32 REM *                                                    *
    40 REM *   STRING ARGUMENT:  Name$                                *
    43 REM *                                                    *
    50 REM ************************************************************
    51 REM
    99 CLOSE
   100 ON ERROR GOTO 10000
   110 OPEN "\DATA\" + File$ + "\INFO" FOR INPUT AS #1
   120 IF ERR = 1001 OR ERR=1007 THEN GOTO 180  'If no file goto erase routine
   130 CLOSE #1
```

```
    140 LOCATE 20,5:COLOR 7,0
    150 PRINT "THE FILE NUMBER YOU CHOSE HAS ALREADY BEEN USED."
    160 INPUT "    DO YOU WANT TO OVERWRITE THE EXISTING FILES (Defaults to
NO)";ChkS
    170 IF INSTR(ChkS,"Y") <> 0 OR INSTR(ChkS,"y") <> 0 THEN GOTO 180 ELSE GOTO
1000
    180 RESTORE,50000
    190 READ Maxloop%
    210 I% = I% + 1
    220 READ AS
    230 KILL "\DATA\" + FileS + "\" + AS
    265 IF I% < Maxloop% THEN GOTO 210
    270 RMDIR "\data\" + FileS
    280 MKDIR "\data\" + FileS
    290 Redo% = 0
    300 GOTO 1010
   1000 Redo% = 1
   1010 ON ERROR 0
   1020 COLOR 7,0
   1030 LOCATE 19,5:PRINT SPC(79):PRINT SPC(79):PRINT SPC(79):PRINT SPC(79)
   1040 CLEAR
   1050 EXIT
  10000 REM
  10001 REM ************************************************************
  10002 REM *   These are the ERROR handlers which allows the Procedure *
  10003 REM *   to check to see if the files or directory have been     *
  10004 REM *   used or exist.                                          *
  10005 REM *                                                          *
  10006 REM ************************************************************
  10007 REM
  10010 IF ERR = 1001 THEN RESUME NEXT
  10020 IF ERR=18 THEN RESUME,270
  10030 IF ERR = 1007 THEN RESUME NEXT
  10040 IF ERR=1022 THEN RESUME,280
  10050 PRINT "I'm sorry but the FILECHECK procedure still doesn't work."
  10060 PRINT "This is error number ";ERR;" from line "ERL
  10070 END
  50000 REM
  50001 REM ************************************************************
  50002 REM *                                                          *
  50003 REM *   The DATA statements are for erasing the possible files *
  50004 REM *   from the hard disk.                                     *
  50005 REM *                                                          *
  50006 REM ************************************************************
  50007 REM
  50010 DATA 9
  50020 DATA info,C-t,CGV,CG,G-t,IV,CV,Mob,Res
END PROCEDURE

PROCEDURE: Placeampersand
  INTEGER: Col%,Pos%
```

```
 9 REM
 10 REM ************************************************************
 11 REM *                                                          *
 12 REM *  The Procedure PLACEAMPERSAND takes the numbers passed   *
 13 REM *  by CHOICE% and NUMBER% and arranges them so that an     *
 14 REM *  "@" is placed in the appropriate place to show that     *
 15 REM *  the item chosen has actually been chosen.               *
 16 REM *                                                          *
 17 REM *  to call:  PLACEAMPERSAND (NUMBER%,CHOICE%)              *
 18 REM *                                                          *
 20 REM *  INTEGER:  Pos%, Col%                                    *
 21 REM *                                                          *
 30 REM *  INTEGER ARGUMENT:  NUMBER%, CHOICE%                     *
 33 REM *                                                          *
 40 REM ************************************************************
 41 REM
100 IF Number% < 12 THEN Col% = 3
110 IF Number% > 12 THEN Col% = 40
120 IF Choice% > 12 THEN Pos% = Choice% - 12 ELSE Pos% = Choice%
130 LOCATE Pos%+4,Col%
140 PRINT "@"
150 EXIT
END PROCEDURE

PROCEDURE: Removeampersand
  INTEGER: Col%,Pos%
  100 IF Number% < 12 THEN Col% = 3 ELSE Col% = 40
  110 IF Choice% > 12 THEN Pos% = 12 - Choice% ELSE Pos% = Choice%
  120 LOCATE Pos%+4,Col%
  130 PRINT " "
  140 EXIT
END PROCEDURE

PROCEDURE: Settempparam
  REAL: Initialtemp!,Finaltemp!,Deltatemp!,Chk!,Chk1!,Min!,Max!,Test!
  INTEGER: Error%,Line%
  STRING: ChkS[4]
  REAL: Test
  INTEGER: Delay%
  REAL: Tyme
  STRING: Sign$[16]
  REAL: Increment!,Incrementtemp!,Maxamimumtemp!
   9 REM
  10 REM ************************************************************
  12 REM *  The Procedure SETTEMPPARAM allows the user to 1) set    *
  13 REM *  the initial,final and increment temperature for each    *
  14 REM *  experiment, 2) set the temperature for a TIME run, or   *
  15 REM *  3) choose a room temperature run.  This procedure also  *
  16 REM *  has a variety of error checks to make sure the chosen   *
  17 REM *  temperatures are possible.                              *
  18 REM *                                                          *
```

```
19 REM *                                                    *
20 REM *  to call: SETTEMPPARAM (TIME%,COL%,INITIALTEMP,          *
21 REM *                    FINALTEMP,DELTATEMP,EXPT$,NAME$) *
22 REM *                                                    *
30 REM *  INTEGER: error%,line%                                  *
32 REM *                                                    *
40 REM *  INTEGER ARG: time%,col%                                *
41 REM *       min!,max!,test!                                *
42 REM *                                                    *
50 REM *  REAL: initialtemp!,finaltemp!,deltatemp!,chk!,chk1!    *
51 REM *       min!,max!,test!                                *
52 REM *                                                    *
60 REM *  REAL ARG: minimumtemp!/VAR,maximumtemp/VAR,            *
61 REM *          incrementemp!/VAR                           *
62 REM *                                                    *
70 REM *  STRING: chk$                                           *
72 REM *                                                    *
80 REM *  STRING ARG: expt$,name$                                *
82 REM *                                                    *
85 REM ************************************************************
86 REM
90 ON ERROR GOTO 30000
95 IF Time% = 3 THEN GOTO 800
100 IF Time% = 1 THEN GOTO 600
105 IF Expt$ <> "Cryostat" THEN GOTO 130
110 COLOR 2,0:CLS:LOCATE 1,Col%
120 PRINT "This sets the temperature for the ";Expt$
130 COLOR 4,0:LOCATE 3,5
140 PRINT "These are the Cryostat temperature ";Name$;":"
150 COLOR 3,0:LOCATE 5,16
160 PRINT "Initial";SPC(15);"Final";SPC(15);"Increment"
170 COLOR 9,0:LOCATE 6,17
180 PRINT Minimumtemp!;SPC(17);Maximumtemp!;SPC(18);Incrementemp!
190 COLOR 5,0:LOCATE 10,5
250 LOCATE 10,1:PRINT SPC(79)
260 LOCATE 10,5:INPUT "Enter the initial temperature";Initialtemp!
270 IF Initialtemp! >= Minimumtemp! THEN GOTO 290
280 Error% = 1:Line% = 1:GOTO 2000
290 IF Initialtemp! <= Maximumtemp! THEN GOTO 310
300 Error% = 2:Line% = 1:GOTO 2000
310 LOCATE 12,5:INPUT "Enter the final temperature";Finaltemp!
320 IF Finaltemp! <= Maximumtemp! THEN GOTO 340
330 Error% = 2:Line% = 2:GOTO 2000
340 IF Finaltemp! >= Initialtemp! THEN GOTO 360
350 Error% = 8:Line% = 2:GOTO 2000
360 LOCATE 14,5:INPUT "Enter the temperature increment";Deltatemp!
370 IF Deltatemp! > Incrementemp! THEN GOTO 410
380 IF Deltatemp! = 0 AND Initialtemp! = Finaltemp! THEN GOTO 410
390 IF Deltatemp! >= Incrementemp! THEN GOTO 410
400 Error% = 3:Line% = 3:GOTO 2000
410 GOSUB 1000
```

```
420 COLOR 7,0:LOCATE 20,1
430 INPUT "Do you want to change any of the above (Defaults to No)";ChkS
440 ChkS = MIDS(ChkS,1,1)
450 IF ChkS = "Y" OR ChkS = "y" THEN GOTO 110
460 IF ExptS = "Cryostat" THEN GOTO 560     'If for cryostat goto var. set
470 IF SGN(Incrementemp!) = SGN(Deltatemp!) THEN GOTO 560
480 IF SGN(Incrementemp!) = SGN(Deltatemp!) THEN GOTO 560
490 Minimumtemp! = Finaltemp!
500 Maximumtemp! = Initialtemp!
510 Incrementemp! = SGN(Incrementemp!) * ABS(Deltatemp!)
520 EXIT
560 Minimumtemp! = Initialtemp!
570 Maximumtemp! = Finaltemp!
580 Incrementemp! = Deltatemp!
590 EXIT
599 REM
600 REM ************************************************************
601 REM *                                                          *
602 REM *   This section is used for a time run.  It allows the    *
603 REM *   user to enter the temperature which will be used.       *
604 REM *                                                          *
605 REM ************************************************************
606 REM
610 COLOR 2,0:CLS:LOCATE 12,5
620 PRINT "At what temperature do you want to do the time run (must be ";
630 PRINT " between ";Minimumtemp!;" and ";Maximumtemp!;
640 INPUT " K)";Min!
650 IF Min! >= Minimumtemp! THEN GOTO 670
660 Min! = 10:Error% = 1:Line% = 4:GOTO 2000
670 IF Min! <= Maximumtemp! THEN GOTO 690
680 Max! = 600:Error% = 2:Line% = 4:GOTO 2000
690 Minimumtemp! = Min!
700 Maximumtemp! = Min!
710 Incrementemp! = 0
720 EXIT
799 REM
800 REM
810 CLS:COLOR 2,0:LOCATE 12,5
820 INPUT "Enter The Room's Temperature(defaults to 290K)";Minimumtemp!
825 IF Minimumtemp!=0 THEN Minimumtemp!=290
830 Maximumtemp! = Minimumtemp!
840 Incrementemp! = 400.0
850 EXIT
899 STOP
999 REM
1000 REM ************************************************************
1001 REM *                                                          *
1002 REM *   This section checks to see if the temperatures set     *
1003 REM *   intersect those of the cryostat.                       *
1004 REM *                                                          *
1005 REM ************************************************************
```

```
1006 REM
1009 GOTO 1030
1010 IF Initialtemp! + ABS(Deltatemp!) < Finaltemp! THEN GOTO 1030
1020 Error% = 5:Line% = 1:GOTO 2000
1030 Chk! = (Initialtemp! - Minimumtemp!)/Incrementemp!
1040 Chk1! = FIX(Chk!)
1050 Test! = Chk1! - Chk!
1060 IF Test < 0.0001 OR Test > 0.0001 THEN GOTO 1080
1070 Error% = 6:Line% = 1:GOTO 2000
1080 Chk! = Deltatemp!/Incrementemp!
1090 Chk1! = FIX(Chk!)
1100 Test! = Chk1! - Chk!
1110 IF Test < 0.0001 OR Test > 0.0001 THEN GOTO 1130
1120 Error% = 7:Line% = 3:GOTO 2000
1130 RETURN
1999 REM
2000 REM ************************************************************
2001 REM *                                                          *
2002 REM *   This is the section which prints up the error messages  *
2003 REM *   for temperature settings which are not allowed.         *
2004 REM *                                                          *
2005 REM ************************************************************
2006 REM
2010 COLOR 7,0:LOCATE 20,5
2020 ON Error% GOSUB 2100,2150,2200,2250,2300,2350,2400,2450
2030 Delay% = 3:GOSUB 20000
2040 COLOR 5,0:LOCATE 20,1:PRINT SPC(79):PRINT SPC(79)
2050 ON Line% GOTO 2500,2550,2600,2650
2099 REM
2100 REM ---------This is for a temperature less than the minimum--------
2101 REM          -----------cryostat temperature-----------
2102 REM
2110 PRINT "The temperature must be greater than ";Minimumtemp!;"!"
2120 RETURN
2149 REM
2150 REM ---------This is for a temperature greater than the maximum---------
2151 REM            ----------cryostat temperature-----------
2152 REM
2160 PRINT "The temperature must be less than ";Maximumtemp!;"!"
2170 RETURN
2199 REM
2200 REM ---------This is for an increment less than the cryostat----------
2201 REM            -----------temperature--------------
2202 REM
2210 PRINT "The temperature increment must be greater than";Incrementemp!;"!"
2220 RETURN
2249 REM
2250 REM ----------This is for an increment which is going in-------------
2251 REM           ----------the wrong direction--------------
2252 REM
2255 IF SGN(Finaltemp! - Initialtemp!) = 1 THEN Sign$ = "positive"
```

```
2257 IF SGN(Finaltemp! - Initialtemp!) = -1 THEN Sign$ = "negative"
2258 IF SGN(Finaltemp! - Initialtemp!) = 0 THEN Sign$ = "no slope"
2260 PRINT "The temperature increment must be ";Sign$;"!"
2270 RETURN
2299 REM
2300 REM --------This is for an intersection of less than 2----------
2301 REM
2310 PRINT "The parameters you have set has only 1 experimental reading in"
2320 PRINT "it. It must have at least 2. ";
2340 RETURN
2349 REM
2350 REM ----------This is for a wrong initial temperature----------
2351 REM
2360 PRINT "The cryostat temperatures will never intersect with the initial";
2370 PRINT "temperature set"
2380 RETURN
2399 REM
2400 REM ----------For an impossible temperature increment----------
2401 REM
2410 PRINT "The increment you want is not possible!"
2420 RETURN
2450 REM
2460 PRINT "The Final Temperature must be greater than ";Initialtemp!
2470 RETURN
2499 REM
2500 REM ----------This sends the program back to the initial temp----------
2501 REM
2510 GOTO 250
2549 REM
2550 REM -----This takes the experiment to the final temperature----
2551 REM
2560 LOCATE 12,1:PRINT SPC(79)
2570 GOTO 310
2599 REM
2600 REM ---------This takes the experiment back to the increment----------
2601 REM
2610 LOCATE 14,1:PRINT SPC(79)
2620 GOTO 360
2649 REM
2650 REM ------This takes the experiment back to the time segment------
2651 REM
2660 GOTO 610
19999 REM
20000 REM ************************************************************
20001 REM *                                                          *
20002 REM *   This allows a timed delay for error messages           *
20003 REM *                                                          *
20004 REM ************************************************************
20005 REM
20010 Tyme = TIMER + Delay%
20020 IF Tyme > TIMER THEN GOTO 20020
```

```
  20030 RETURN
  30000 PRINT "The error is ";ERR;" and the line number is ";ERL
END PROCEDURE

PROCEDURE: Timeparam
  STRING: Chk$[4]
     9 REM
    10 REM ************************************************************
    11 REM *                                                          *
    12 REM *  The Procedure TIMEPARAM sets the final and incremental  *
    13 REM *  times for a constant temperature time run.              *
    14 REM *                                                          *
    15 REM *  to call:  TIMEPARAM (FINALTIME!,DELTATIME!)             *
    16 REM *                                                          *
    20 REM *  REAL ARG:  Finaltime!/VAR, Deltatime!/VAR               *
    22 REM *                                                          *
    30 REM *  STRING:  Chk$[4]                                        *
    32 REM *                                                          *
    40 REM ************************************************************
    42 REM
   100 ON ERROR GOTO 10000
   110 COLOR 2,0:CLS:LOCATE 1,25
   120 PRINT "This sets the TIME parameters"
   130 COLOR 5,0
   140 LOCATE 4,3:INPUT "Enter the amount of time this program is to run (> 5
minutes)";Finaltime!
   150 LOCATE 6,3:PRINT "Enter the length of time between experiment";
   160 COLOR 3,0:PRINT " set ";
   170 COLOR 5,0:INPUT "runs ( > 5 minutes)";Deltatime!
   180 COLOR 7,0:LOCATE 20,5
   190 INPUT "Do you want to change any of the above (Defaults to No)";Chk$
   200 Chk$ = MID$(Chk$,1,1)
   210 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 110
   220 Finaltime! = 60 * Finaltime!
   230 Deltatime! = 60 * Deltatime!
   240 EXIT
 10000 CLS:LOCATE 15,5:PRINT "The error is ";ERR;" in line";ERL
 10010 STOP
END PROCEDURE

PROCEDURE: Svolt
  STRING: Chk$[3]
     9 REM
    10 REM ************************************************************
    11 REM *                                                          *
    12 REM *  The Procedure SVOLT allows the user to enter the        *
    13 REM *  voltages (including a break voltage and two different   *
    14 REM *  increments.  It does not include any error checking     *
    15 REM *  for entering incorrect voltages.                        *
    16 REM *                                                          *
    17 REM *  to call SVOLT (START!,STOP1!,STEP1!,STOP2!,STEP2!)      *
```

```
    18 REM *                                                    *
    30 REM *   REAL ARGUMENTS:  Start!/VAR, Stop1!/VAR, Stop2!/VAR     *
    32 REM *                    Step1!/VAR, Step2!/VAR                  *
    40 REM *                                                    *
    41 REM ************************************************************
    42 REM
   100 ON ERROR GOTO 10000
   110 LOCATE 3,1
   120 DO 20 TIMES
   130 PRINT SPC(79)
   140 REPEAT
   145 LOCATE 4,24:COLOR 4,0
   147 PRINT "This sets the Voltage settings"
   150 COLOR 5,0
   160 LOCATE 6,5:INPUT "Enter the Start Voltage (-100 to 100 V)";Start!
   170 LOCATE 8,5:INPUT "Enter the first Stop Voltage (-100 to 100 V)";Stop1!
   180 LOCATE 10,5:INPUT "Enter the first Step Voltage (> abs[0.01] V)";Step1!
   190 LOCATE 12,5:INPUT "Enter the second Stop Voltage (-100 to 100 V])";Stop2!
   200 LOCATE 14,5:INPUT "Enter the second Step Voltage (> abs[0.01] V)";Step2!
   210 COLOR 7,0:LOCATE 20,1
   220 INPUT "Do you want to change any of the above (Defaults to No)";ChkS
   230 ChkS = MIDS(ChkS,1,1)
   250 IF ChkS = "Y" OR ChkS = "y" THEN GOTO 110
   260 ON ERROR 0
   270 Step1! = VAL(STRS(Step1!))
   280 Step2! = VAL(STRS(Step2!))
   290 EXIT
 10000 REM
 10010 IF ERR = 1008 THEN RESUME
 10020 COLOR 7,0:LOCATE 18,3:PRINT "Sorry the procedure ";
 10030 COLOR 20,0:PRINT "SVOLT ";
 10040 COLOR 7,0:PRINT "is bombing.  This is error ";ERR;" and line number";ERL
END PROCEDURE

PROCEDURE: DVdt
  STRING: ChkS[3]
     9 REM
    10 REM ************************************************************
    11 REM *                                                    *
    12 REM *   The Procedure dVdt allows the user the set the slope    *
    13 REM *   for the C-V experiment in group 2.                       *
    14 REM *                                                    *
    15 REM *   to call:  DVDT (Dvdt!,start!,stop!,step!)                *
    16 REM *                                                    *
    30 REM *   real arg:  dVdt!/VAR                                 *
    32 REM *                                                    *
    40 REM ************************************************************
    41 REM
    47 REM *   real arg:start!/var,stop!/var,step!/var
   100 ON ERROR GOTO 10000
   110 LOCATE 3,1
```

```
    120 DO 20 TIMES
    130 PRINT SPC(79)
    140 REPEAT
    150 COLOR 4,0:LOCATE 4,23
    160 PRINT "This sets the dV/dt slope"
    170 COLOR 5,0
    180 LOCATE 6,5:INPUT "Enter the dV/dt setting (0.001 to 1 V/s)";DVdt!
    185 LOCATE 8,5:INPUT "Enter the Start Voltage (-100 to 100 V)";Start!
    187 LOCATE 10,5:INPUT "Enter the Stop Voltage (-100 to 100 V)";Stop!
    188 LOCATE 12,5:INPUT "Enter the Step Voltage (-10 to 10 V)";Step!
    190 LOCATE 20,5:COLOR 7,0
    200 INPUT "Do you want to change any of the above (Defaults to No)";Chk$
    210 Chk$ = MID$(Chk$,1,1)
    220 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 110
    230 EXIT
  10000 REM
  10001 REM ************************************************************
  10002 REM *                                                          *
  10003 REM *   This is the error procedures.  It corrects the expected *
  10004 REM *   errors and kills the program and writes which error     *
  10005 REM *   and line number for an unexpected error                *
  10006 REM *                                                          *
  10007 REM ************************************************************
  10008 REM
  10010 IF ERR = 1008 THEN RESUME
  10020 COLOR 7,0:LOCATE 20,5:PRINT "Sorry the procedure ";
  10030 COLOR 20,0:PRINT "dVdt ";
  10040 COLOR 7,0:PRINT "bombing.  The error is ";ERR;" in line number";ERL
  10050 STOP
END PROCEDURE

PROCEDURE: Settime
  STRING: Chk$[3]
  REAL: Tyme!
  INTEGER: M%
    10 REM
    11 REM ************************************************************
    12 REM *                                                          *
    13 REM *   The Procedure SETTIME allows the user to enter the     *
    14 REM *   Step Delay Time, Initial Hold Time, Final Hold Time    *
    15 REM *   and Delta Hold Time in seconds.                        *
    16 REM *                                                          *
    17 REM *   to call:  SETTIME (STEPDELAY!,INITIALHOLD!,FINALHOLD!, *
    18 REM *             DELTAHOLD!,MINHOLDTIME!,MINDELAYTIME!,TYPE%) *
    19 REM *                                                          *
    20 REM *   REAL ARG: Stepdelay!/VAR, Initialhold!/VAR,            *
    21 REM *             Deltahold!/VAR, Finalhold!/VAR               *
    22 REM *                                                          *
    23 REM ************************************************************
    24 REM
   100 ON ERROR GOTO 10000
```

```
  110 LOCATE 3,1
  120 DO 21 TIMES
  130 PRINT SPC(79)
  140 REPEAT
  150 LOCATE 4,25:COLOR 4,0
  160 PRINT "This sets the Time Parameters"
  170 COLOR 5,0
  180 IF Type% = 3 THEN GOTO 210
  190 LOCATE 6,5:PRINT "Enter the Step Delay Time, in seconds (t > ";Mindelaytime!;
  200 INPUT " seconds)";Stepdelay!
  210 LOCATE 8,5:PRINT "Enter the Initial Hold Time, in seconds (t > ";Minholdtime!;
  220 INPUT " seconds)";Initialhold!
  230 IF Type% = 1 THEN GOTO 290
  240 IF Type% = 3 THEN GOTO 290
  250 LOCATE 10,5:PRINT "Enter the Final Hold Time, in seconds (t > ";Minholdtime!;
  260 INPUT " seconds)";Finalhold!
  270 LOCATE 12,5:PRINT "Enter the Delta Hold Time, in seconds (t > ";Minholdtime!;
  280 INPUT " seconds)";Deltahold!
  290 IF Stepdelay! < Mindelaytime! OR Initialhold! < Minholdtime! THEN GOSUB 10100
  300 LOCATE 20,5:COLOR 7,0
  310 INPUT "Do you need to change any of the above (Defaults to No)";Chk$
  320 Chk$ = MID$(Chk$,1,1)
  330 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 110
  340 EXIT
 9999 STOP
10000 REM
10001 REM ************************************************************
10002 REM *                                                          *
10003 REM *  This error routine takes care of any expected errors.   *
10004 REM *  If an unexpected error occurs, the program prints the   *
10005 REM *  procedure name, error number and line number to screen  *
10006 REM *  then ends the program.                                  *
10007 REM *                                                          *
10008 REM ************************************************************
10009 REM
10010 IF ERR = 1008 THEN RESUME
10020 LOCATE 23,5:COLOR 7,0
10030 PRINT "Sorry the Procedure ";
10040 COLOR 20,0:PRINT "settime";
10050 COLOR 7,0:PRINT " has bombed.  The error number is ";ERR;" from line ";ERL
10099 STOP
10100 REM
10101 REM ************************************************************
10102 REM *                                                          *
10103 REM *  This error is given if either the initial hold time or  *
10104 REM *  the step delay time is less than the asked for values.  *
10105 REM *  It then returns them to the beginning of this routine.  *
10106 REM *                                                          *
10107 REM ************************************************************
10108 REM
10110 LOCATE 20,5:COLOR 7,0
```

```
  10120 PRINT "The times you have chosen are not within the meter's resolution."
  10130 LOCATE 21,5:PRINT "Please choose different parameters."
  10140 Tyme! = TIMER + 5
  10150 IF TIMER < Tyme! THEN GOTO 10150
  10160 RETURN,100
  10170 STOP
END PROCEDURE

PROCEDURE: Setbias
  STRING: Chk$[3]
     9 REM
    10 REM ***************************************************************
    11 REM *                                                             *
    12 REM *   The Procedure SETBIAS sets the different bias voltages    *
    13 REM *                                                             *
    14 REM *   to call:  SETBIAS (INITIALBIAS!,FINALBIAS!,DELTABIAS!     *
    15 REM *                                                             *
    30 REM *   real arg:initialbias!/VAR,deltabias!/VAR,finalbias!/VAR   *
    32 REM *                                                             *
    40 REM ***************************************************************
    41 REM
   100 ON ERROR GOTO 10000
   110 LOCATE 3,1
   120 DO 21 TIMES
   130 PRINT SPC(79)
   140 REPEAT
   150 LOCATE 4,25:COLOR 4,0
   160 PRINT "This sets the Bias Voltages"
   170 COLOR 5,0
   180 LOCATE 6,5:INPUT "Enter the Initial Bias Voltage (-99 to 99 V)";Initialbias!
   190 LOCATE 8,5:INPUT "Enter the Final Bias Voltage (-99 to 99 V)";Finalbias!
   200 LOCATE 10,5:INPUT"Enter the Delta Bias Voltage ( > abs(0.01) V";Deltabias!
   210 LOCATE 20,5:COLOR 7,0
   220 INPUT "Do you need to change any of the above (Defaults to No)";Chk$
   230 Chk$ = MID$(Chk$,1,1)
   240 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 110
   250 EXIT
 10000 REM
 10001 REM ***************************************************************
 10002 REM *                                                             *
 10003 REM *   These are the error messages which take care of the       *
 10004 REM *   expected errors.  If an unexpected error takes place      *
 10005 REM *   an error messages is given along with the line number     *
 10006 REM *   and the program stops.                                    *
 10007 REM *                                                             *
 10008 REM ***************************************************************
 10009 REM
 10010 IF ERR = 10008 THEN RESUME
 10020 LOCATE 23,5:COLOR 7,0
 10030 PRINT "The procedure ";
 10040 COLOR 20,1:PRINT "SETBIAS";
```

```
  10050 COLOR 7,0:PRINT "has bombed.  The error number is ";ERR;" and the line number
";ERL
  10060 STOP
END PROCEDURE

PROCEDURE: Setsamples
  STRING: Chk$[3]
    15 REM *   to call:  SETSAMPLES (samples!)
    30 REM *   REAL ARG:  SAMPLES!/var                                    *
   100 ON ERROR GOTO 10000
   110 LOCATE 3,1
   120 DO 21 TIMES
   130 PRINT SPC(79)
   140 REPEAT
   150 LOCATE 4,25:COLOR 4,0
   160 PRINT "This sets the Number of Samples"
   170 COLOR 5,0
   180 LOCATE 6,5:INPUT "Enter the number of Samples needed ( > 1)";SAMPLES!
   190 LOCATE 20,5:COLOR 7,0
   200 INPUT "Do you want to change any of the above (Defaults to No)";Chk$
   210 Chk$ = MID$(Chk$,1,1)
   220 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 110
   230 SAMPLES! = INT(SAMPLES!)
   240 EXIT
  10000 STOP
  10001 REM ************************************************************
  10002 REM *                                                          *
  10003 REM *   This corrects any expected errors.  If an error is     *
  10004 REM *   unexpected the program bombs and an error message with  *
  10005 REM *   its line number.                                       *
  10006 REM *                                                          *
  10007 REM ************************************************************
  10008 REM
  10010 IF ERR = 1008 THEN RESUME
  10020 LOCATE 1,5:COLOR 7,0
  10030 PRINT "The procedure ";
  10040 COLOR 20,0:PRINT "SETSAMPLES ";
  10050 COLOR 7,0:PRINT "has bombed.  The error is ";ERR;" and line number ";ERL
  10060 STOP
END PROCEDURE

PROCEDURE: Setpulse
  STRING: Chk$[3]
     9 REM
    10 REM ************************************************************
    11 REM *                                                          *
    12 REM *   The Procedure SETPULSE allows the user to enter the    *
    13 REM *   Initial High Pulse, Final High Pulse, Delta High Pulse  *
    14 REM *   and Low Pulses for the voltages in the C-t program      *
    15 REM *                                                          *
    16 REM *   to call:  SETPULSE (INITIALPULSE!,FINALPULSE!,         *
```

```
    17 REM *              DELTAPULSE!,LOWPULSE!)                    *
    18 REM *                                                        *
    20 REM *   REAL ARG:  Initialpulse!/VAR, Finalpulse!/VAR,       *
    21 REM *         Deltapulse!/VAR                                *
    22 REM *                                                        *
    30 REM *   STRING:  Chk$[3]                                     *
    32 REM *                                                        *
    40 REM ****************************************************************
    42 REM
   110 LOCATE 3,1
   120 DO 21 TIMES
   130 PRINT SPC(79)
   140 REPEAT
   150 LOCATE 4,25:COLOR 4,0
   160 PRINT "This sets the Pulse Voltages"
   165 COLOR 5,0
   170 LOCATE 6,5:INPUT "Enter the Initial High Pulse (-7 to +7 V)";Initialpulse!
   180 LOCATE 8,5:INPUT "Enter the Final High Pulse (-7 to +7 V)";Finalpulse!
   190 LOCATE 10,5:INPUT "Enter the Delta High Pulse ( > .01 V)";Deltapulse!
   200 LOCATE 12,5:INPUT "Enter the Low Pulse (-7 to +7 V)";Lowpulse!
   210 LOCATE 20,5:COLOR 7,0
   220 INPUT "Do you want to change any of the above (Defaults to No)";Chk$
   230 Chk$ = MID$(Chk$,1,1)
   240 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 110
   250 IF Deltapulse! = 0 THEN Finalpulse! = 0
   260 EXIT
END PROCEDURE

PROCEDURE: Copytodisk
  INTEGER: Drive%
  STRING: Chk$[3],A$[?]
    20 REM *  integer:drive%
    30 REM *  string:chk$[4]
    40 REM *  STRING ARG:FILE$
   100 Drive% = 1
   110 CLS:COLOR 3,0:LOCATE 12,5
   120 PRINT "Do you want to copy the files to a ";
   130 COLOR 26,0
   140 ON Drive%  GOSUB 1000,2000
   150 LOCATE 12,44:COLOR 3,0:INPUT " floppy diskette (Defaults to No)";Chk$
   160 Chk$ = MID$(Chk$,1,1)
   170 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 180 ELSE GOTO 280
   180 LOCATE 15,5:COLOR 6,0
   190 PRINT "Please insert a BLANK FORMATTED ";
   200 COLOR 24,0
   210 ON Drive% GOSUB 1000,2000
   220 LOCATE 15,7:COLOR 6,0:PRINT " floppy diskette into drive";
   230 ON Drive% GOSUB 1050,2050
   240 PRINT " and press any key to begin copying."
   250 A$ = INKEY$:IF A$ = "" THEN GOTO 250
   260 CLS
```

```
    270 ON Drive% GOSUB 1100,2100
    280 Drive% = Drive% + 1
    290 IF Drive% < 3 THEN GOTO 110 ELSE EXIT
   1000 REM
   1010 PRINT "1.2 Mbyte";
   1020 RETURN
   1050 PRINT "A";
   1060 RETURN
   1100 SHELL "\SEMI\COPYCTOA.BAT " + FILE$
   1110 RETURN
   2000 REM
   2010 PRINT "360 Kbyte";
   2020 RETURN
   2050 PRINT "B";
   2060 RETURN
   2100 SHELL "\SEMI\COPYCTOB.BAT " + FILE$
   2110 RETURN
END PROCEDURE

PROCEDURE: Timedelay
  REAL: Tyme!
     22 REM *   integer arg:delay%/opt = 5
     32 REM *   real:tyme!
    100 Tyme! = TIMER
    110 IF TIMER < Tyme! + Delay% THEN GOTO 110
    120 EXIT
END PROCEDURE

PROCEDURE: Clearscreen
  INTEGER: M%
      1 REM
      2 REM ************************************************************
      3 REM *                                                          *
      5 REM *   to call:  CLEARSCREEN (ROW%)                           *
     19 REM *                                                          *
     20 REM *   INTEGER ARG:row%                                       *
     21 REM *                                                          *
     31 REM ************************************************************
     32 REM
    100 FOR M% = Row% TO 23
    110 LOCATE M%,1:PRINT SPC(79)
    120 NEXT M%
    130 EXIT
END PROCEDURE

'MAIN Program:


 200 REM
 201 REM ************************************************************
 202 REM *                                                          *
```

```
203 REM *   This section prints a welcome message to the screen,    *
204 REM *   clears all variables, changes the drive and directory   *
205 REM *   to "C:", sets the appropriate devices to remote and     *
206 REM *   initializes the error hander.                           *
207 REM *                                                          *
208 REM ************************************************************
209 REM
210 CLS:STATUSLINE OFF
220 COLOR 2,0,8:LOCATE 12,30
230 PRINT "MEDUSA welcomes you"
240 LOCATE 14,12:PRINT "Materials and Electronic Device, Ultimate System Analyzer"
250 Timedelay (5)
260 CLEAR
270 ON ERROR GOSUB 9500
280 DRIVE$ = "C:":DIR$ = "\"
290 PARAM$ = "INIT/1/&H310/P/":GOSUB 50000
300 PARAM$ = "SDR/5,12,16,17,8/":GOSUB 50000
310 REM
311 REM ************************************************************
312 REM *                                                          *
313 REM *   This checks to see if the batch file has come from     *
314 REM *   the program "RUNIT" and if it has it branches to       *
315 REM *   see if the user wants to use the same information      *
316 REM *   block.  If the batch file hasn't come from "RUNIT" then *
317 REM *   a message about turning on the printer is sent to      *
318 REM *   screen and the printer is sent a code to configure it. *
319 REM *                                                          *
320 REM ************************************************************
321 REM
330 OPEN "\DATA\REDO" FOR INPUT AS #1
340 GOSUB 9000
350 COLOR 2,0,0:CLS:LOCATE 12,25
360 PRINT "Please turn on the printer"
390 Timedelay(3)
400 GOTO 1210
401 REM ************************************************************
402 REM *                                                          *
404 REM *   information to correctly identify the sample.          *
405 REM *                                                          *
406 REM ************************************************************
407 REM
410 Redo% = 0
420 COLOR 2,0:CLS:LOCATE 3,5
430 INPUT "Enter the Directory number (between 1 and 999)"File$
440 Information$(1) = File$
450 IF VAL(File$) < 1 OR VAL(File$) > 999 THEN GOTO 420
460 Filecheck (File$,Redo%)
470 IF Redo% = 1 THEN GOTO 410
480 Information$(2) = DATE$
490 COLOR 2,0
500 LOCATE 5,5
```

```
505 LINE INPUT "Enter Experimenter 's Name. ";Information$(3)
510 LOCATE 7,5
515 LINE INPUT "Enter the sample number. ";Information$(4)
520 LOCATE 9,5
525 LINE INPUT "Enter the Cryostat chronometer reading. ";Information$(5)
530 LOCATE 11,5
535 LINE INPUT "Enter any comments. ";Information$(6)
760 LOCATE 20,5:COLOR 7,0
770 INPUT "Do you want to change any of the above (Defaults to No)";Chk$
780 Chk$ = MID$(Chk$,1,1)
790 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 800 ELSE GOTO 1510
800 REM
801 REM ************************************************************
802 REM *                                                          *
803 REM *   This allows the user to change any part of the         *
804 REM *   information block, using the various Procedures.       *
805 REM *                                                          *
806 REM ************************************************************
807 REM
810 Number% = 0:Row% = 0
820 Title$ = "INFORMATION CHANGES"
830 Title (Title$)
840 RESTORE,60010
850 READ Maxloop%
860 DO Maxloop% TIMES
870 READ Name$
880 Menu (Number%,Rownumber%,Name$,Row%)
890 REPEAT
900 Name$ = "Finished changing information"
910 Finish (Rownumber%,Number%,Name$)
920 Border (Rownumber%)
930 DO
940 Clearscreen (20)
950 COLOR 6,0:LOCATE 20,5
960 INPUT "Enter which number you want to change";Choice%
970 IF Choice% < 1 OR Choice% > Number% THEN GOTO 940
980 IF Choice% = Number% THEN EXIT TO,1510
990 Placeampersand (Number%,Choice%)
995 Clearscreen (20)
1000 LOCATE 20,3:COLOR 4,0
1010 PRINT "The current information is:  ";Information$(Choice%)
1020 LOCATE 22,1:LINE INPUT "  What is the new information? ";Information$(Choice%)
1030 IF Choice% <> 1 THEN GOTO 1100
1040 Redo% = 0
1050 Clearscreen (20)
1060 Filecheck (Information$(1),Redo%)
1070 IF Redo% = 1 THEN GOTO 1090
1080 File$ = Information$(1)
1090 Information$(1) = File$
1100 Removeampersand (Number%,Choice%)
1110 REPEAT
```

```
1200 REM
1201 REM ************************************************************
1202 REM *                                                          *
1203 REM *   This section allows the user to choose which type of   *
1204 REM *   temperature run he wishes.  The choses are a 1)Time run *
1205 REM *   2)Temp run; 3)Room Temp; 4)Exit to graphs  *
1206 REM *                                                          *
1207 REM ************************************************************
1208 REM
1210 Number% = 0:Row% = 0
1220 Title$ = "Menu for choosing TIME/TEMPERATURE Run"
1230 Title (Title$)
1240 RESTORE,60410
1250 READ Maxloop%
1260 DO Maxloop% TIMES
1270 READ Name$
1280 Menu (Number%,Rownumber%,Name$,Row%)
1290 REPEAT
1300 Name$ = "EXIT to Graphing Routines"
1310 Finish (Rownumber%,Number%,Name$)
1320 Border (Rownumber%)
1330 Clearscreen (20)
1340 COLOR 6,0:LOCATE 20,5
1350 INPUT "Choose which type of run";Choice%
1360 IF Choice% < 1 OR Choice% > Number% THEN GOTO 1330
1370 IF Choice% = Number% THEN GOTO 8910
1380 Expt%(26) = Choice%
1390 RESTORE,60010
1400 READ M%
1410 M% = M% + 1
1420 RESTORE,60600
1430 DO Choice% TIMES
1440 READ Information$(M%)
1450 REPEAT
1455 IF INSTR(UPPER$(Chk$),"Y")=0 THEN GOTO 410
1500 REM
1501 REM ************************************************************
1502 REM *                                                          *
1503 REM *   This section allows the user to choose between groups.  *
1504 REM *                                                          *
1505 REM ************************************************************
1506 REM
1510 Number% = 0:Row% = 0
1520 RESTORE,60100
1530 Title$ = "GROUP TYPES"
1540 Title (Title$)
1550 READ Maxloop%
1560 DO Maxloop% TIMES
1570 READ Name$
1580 Menu (Number%,Rownumber%,Name$,Row%)
1590 REPEAT
```

```
1600 Border (Rownumber%)
1610 Clearscreen (20)
1620 COLOR 6,0:LOCATE 20,5
1630 INPUT "Which group of experiments do you want to perform";Choice%
1640 IF Choice% < 1 OR Choice% > Number%  THEN GOTO 1610
1650 Expt%(25) = Choice%
1700 REM
1701 REM ************************************************************
1702 REM *                                                          *
1703 REM *   This section allows the user to pick which experiments  *
1704 REM *   he wants to run from the group chosen previously        *
1705 REM *                                                          *
1706 REM ************************************************************
1707 REM
1710 Number% = 0:Row% = 0
1720 RESTORE,60200
1730 Title$ = "EXPERIMENTAL MENU"
1740 Title (Title$)
1750 READ B%
1760 FOR M% = 1 TO B%
1770 READ Group%(M%)
1780 NEXT M%
1790 GOSUB 41000                    'Used to set Read Pointer
1800 DO Group%(Expt%(25)) TIMES
1810 READ Name$
1820 Menu (Number%,Rownumber%,Name$,Row%)
1830 REPEAT
1840 Name$ = "FInished choosing experiments"
1850 Finish (Rownumber%,Number%,Name$)
1860 Border (Rownumber%)
1870 DO
1880 Clearscreen (20)
1890 LOCATE 20,5:COLOR 6,0
1900 INPUT "Which experiment do you want to run";Choice%
1910 IF Choice% < 1 OR Choice% > Number% THEN GOTO 1880
1920 IF Choice% = Number% THEN EXIT
1930 Placeampersand (Number%,Choice%)
1940 Expt%(Choice%) = Choice%
1950 REPEAT
1960 REM
1961 REM -------This asks if any experiments are to be deleted-------
1962 REM
1970 DO
1980 Clearscreen (20)
1990 LOCATE 20,1:COLOR 7,0
2000 INPUT "Do you need to delete any of the above (Defaults to No)";Chk$
2010 Chk$ = MID$(Chk$,1,1)
2020 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 2030 ELSE EXIT
2030 Clearscreen (20)
2040 LOCATE 20,1:COLOR 6,0
2050 INPUT "Which of the above do you need to delete";Choice%
```

```
2060 IF Choice% < 1 OR Choice% > Number% - 1 THEN GOTO 2090
2070 Removeampersand (Number%,Choice%)
2080 Expt%(Choice%) = 0
2090 REPEAT
2100 REM
2102 REM      -------This asks if any experiments are to be added-------
2103 REM
2110 DO
2120 Clearscreen (20)
2130 LOCATE 20,1:COLOR 7,0
2140 INPUT "Do you want to add any to the above (Defaults to NO)";Chk$
2150 Chk$ = MID$(Chk$,1,1)
2160 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 2170 ELSE EXIT
2170 Clearscreen (20)
2180 COLOR 6,0:LOCATE 20,5:INPUT "Which experiment do you want to add";Choice%
2190 IF Choice% < 1 OR Choice% > Number% - 1 THEN GOTO 2220
2200 Expt%(Choice%) = Choice%
2210 Placeampersand(Number%,Choice%)
2220 REPEAT
2230 REM
2231 REM ************************************************************
2232 REM *                                                          *
2233 REM *   This section returns the program to the Temperature    *
2234 REM *   run type choosing section if no experiments were chosen *
2235 REM *                                                          *
2236 REM ************************************************************
2237 REM
2240 FOR M% = 1 TO 24
2250 IF Expt%(M%) <> 0 THEN EXIT TO,2500
2260 NEXT M%
2270 CLS:COLOR 7,0:LOCATE 12,30
2280 PRINT "NO experiments were chosen"
2290 Timedelay (4)
2300 GOTO 1210
2500 REM
2501 REM ************************************************************
2502 REM *                                                          *
2503 REM *   This allows the user to set the Cryostat temperature(s) *
2504 REM *   and the times if it is a TIME run.                      *
2505 REM *                                                          *
2506 REM ************************************************************
2507 REM
2510 ON Expt%(26) GOSUB 2600,2700,2900
2599 STOP
2600 REM
2601 REM ************************************************************
2602 REM *                                                          *
2603 REM *   This subroutine allows the user to set the time        *
2604 REM *   variables and the 1 temperature for a time run.        *
2605 REM *                                                          *
2606 REM ************************************************************
```

```
2607 REM
2610 Parameter!(25,1) = 30.0
2620 Parameter!(25,2) = 600.0
2630 Parameter!(25,3) = 1.0
2640 GOSUB 3500
2650 Timeparam(Parameter!(25,5),Parameter!(25,6))
2660 RETURN,4000
2699 STOP
2700 REM
2701 REM ************************************************************
2702 REM *                                                          *
2703 REM *  This subroutine allows the user to set the temperatures *
2704 REM *  for a temp run.                                         *
2705 REM *                                                          *
2706 REM ************************************************************
2707 REM
2710 Parameter!(25,1) = 30.0
2720 Parameter!(25,2) = 600.0
2730 Parameter!(25,3) = 1.0
2740 GOSUB 3500
2750 RETURN,4000
2799 STOP
2900 REM
2901 REM ************************************************************
2902 REM *                                                          *
2903 REM *  This subroutine allows the user to set the room         *
2904 REM *  temperature.                                            *
2905 REM *                                                          *
2906 REM ************************************************************
2907 REM
2910 GOSUB 3500
2930 RETURN,4000
3499 STOP
3500 REM
3501 REM ************************************************************
3502 REM *                                                          *
3503 REM *  This section goes to the procedure SETTEMPPARAM to      *
3504 REM *  allow the user to set what temperatures for the         *
3505 REM *  cryostat.                                               *
3506 REM *                                                          *
3507 REM ************************************************************
3508 REM
3510 Col% = 20
3520 Expt$ = "Cryostat"
3530 Name$ = "limits"
3540 Settempparam
(Expt%(26),Col%,Parameter!(25,1),Parameter!(25,2),Parameter!(25,3),Expt$,Name$)
3550 Parameter!(25,4) = Parameter!(25,1)
3560 RETURN
3999 STOP
4000 REM
```

```
4001 REM ************************************************************
4002 REM *                                                          *
4003 REM *  This section branches to the parameter setting          *
4004 REM *  subroutines selected by the user.                       *
4005 REM *                                                          *
4006 REM ************************************************************
4007 REM
4010 ON Expt%(25) GOTO 4100,4200,4300,4400
4020 STOP
4100 REM
4101 REM ************************************************************
4102 REM *                                                          *
4103 REM *  This is to branch to the set-up routine for the         *
4104 REM *  experiments in group I.                                 *
4105 REM *                                                          *
4106 REM ************************************************************
4107 REM
4110 L% = 1
4120 ON Expt%(L%) GOSUB 10000,10000,12000,13000
4130 L% = L% + 1
4140 IF L% <= Group%(Expt%(25)) THEN GOTO 4120
4150 GOTO 8010
4199 STOP
4200 REM
4201 REM ************************************************************
4202 REM *                                                          *
4203 REM *  This is to branch to the set-up routine for the         *
4204 REM *  experiments in group II.                                *
4205 REM *                                                          *
4206 REM ************************************************************
4207 REM
4210 L% = 1
4220 ON Expt%(L%) GOSUB 14000,15000
4230 L% = L% + 1
4240 IF L% <= Group%(Expt%(25)) THEN GOTO 4220
4250 GOTO 8010
4299 STOP
4300 REM
4301 REM ************************************************************
4302 REM *                                                          *
4303 REM *  This is the branch to Group III.  Since no parameters   *
4304 REM *  need to be set it goes immediately to the lprint        *
4305 REM *  statements.                                             *
4306 REM *                                                          *
4307 REM ************************************************************
4308 REM
4310 CLS:LOCATE 1,20:COLOR 2,0
4320 PRINT "This sets the";
4330 COLOR 18,0:PRINT " MOBILITY";
4340 COLOR 2,0:PRINT " Parameter Settings"
4350 COLOR 14,0 : SET CURSOR 13,6 : INPUT "Enter the Current Bias in mA ( <9 mA ).
```

```
",Parameter!(1,17)
 4360 IF Parameter!(1,17) <= 0 OR Parameter!(1,17) > 9 THEN GOTO 4310
 4370 Parameter!(1,17) = Parameter!(1,17) * 1E-03
 4380 GOTO 8010
 4400 REM
 4401 REM ************************************************************
 4402 REM *                                                          *
 4403 REM *  This is the branch to Group IV.  Since no parameters    *
 4404 REM *  need to be set it goes immediately to the lprint        *
 4405 REM *  statements.                                             *
 4406 REM *                                                          *
 4407 REM ************************************************************
 4408 REM
 4410 CLS:LOCATE 1,15:COLOR 2,0
 4420 PRINT "This sets the";
 4430 COLOR 18,0:PRINT " 4-point Resistivity";
 4440 COLOR 2,0:PRINT " Parameter Settings"
 4450 COLOR 14,0 : SET CURSOR 13,6 : INPUT "Enter the Current Bias in mA ( <100 mA ).
",Parameter!(1,17)
 4460 IF Parameter!(1,17) <= 0 OR Parameter!(1,17) > 100 THEN GOTO 4410
 4480 GOTO 8010
 8000 REM
 8001 REM ************************************************************
 8002 REM *                                                          *
 8003 REM *  This section saves all the information necessary to     *
 8004 REM *  running the experiments.  It also prints out a list     *
 8005 REM *  of the information block, the cryostat settings, the    *
 8006 REM *  time settings and all the parameters for each           *
 8007 REM *  experiment chosen.                                      *
 8008 REM *                                                          *
 8009 REM ************************************************************
 8010 REM
 8011 REM -------This prints and saves the information block-------
 8012 REM
 8014 LPRINT CHR$(24);CHR$(27);CHR$(58)
 8015 LPRINT
CHR$(27);CHR$(68);CHR$(35);CHR$(45);CHR$(55);CHR$(65);CHR$(75);CHR$(85);CHR$(0)
 8020 OPEN "\DATA\" + File$ + "\INFO" FOR OUTPUT AS #1
 8030 RESTORE,60010
 8040 READ M%
 8050 Maxloop% = M% + 1
 8060 LPRINT CHR$(9);CHR$(9);CHR$(9);CHR$(9);CHR$(9);CHR$(9);DATE$
 8070 FOR M% = 1 TO Maxloop%
 8080 READ Name$
 8090 PRINT #1,Name$
 8100 PRINT #1,Information$(M%)
 8110 IF M% = 2 THEN GOTO 8140
 8120 LPRINT SPC(10);Name$
 8130 LPRINT SPC(10);Information$(M%)
 8140 NEXT M%
 8150 CLOSE #1
```

```
8160 REM
8161 REM  -------This prints and saves the Cryostat and Time Settings--------
8162 REM
8170 OPEN "\DATA\PARAM" FOR OUTPUT AS #1
8180 RESTORE,60320
8190 LPRINT CHR$(10);CHR$(10)
8200 LPRINT SPC(10);"These are the Cryostat and Time settings"
8210 LPRINT
8220 FOR M% = 1 TO 6
8230 READ Name$
8240 PRINT #1,Parameter!(25,M%)
8250 IF M% = 4 THEN GOTO 8270
8260 LPRINT SPC(10);Name$,Parameter!(25,M%)
8270 NEXT M%
8280 CLOSE #1
8290 LPRINT CHR$(10)
8300 REM
8301 REM        -------This prints the parameter settings-------
8302 REM
8310 LPRINT SPC(10)"These are the parameter settings for the chosen experiments"
8320 GOSUB 40000
8330 LPRINT
8340 LPRINT SPC(10);"PARAMETER";CHR$(09);
8350 FOR M% = 1 TO Group%(Expt%(25))
8360 READ Name$
8370 IF Expt%(M%) = 0 THEN GOTO 8390
8380 LPRINT Name$;CHR$(09);
8390 NEXT M%
8400 LPRINT CHR$(10)
8410 RESTORE,60310
8420 READ Maxloop%
8430 FOR M% = 1 TO Maxloop%
8440 READ Name$
8450 IF M% > 3 AND M% < 7 THEN GOTO 8520
8460 LPRINT SPC(10);Name$;CHR$(09);
8470 FOR N% = 1 TO Group%(Expt%(25))
8480 IF Expt%(N%) = 0 THEN GOTO 8500
8490 LPRINT Parameter!(N%,M%);CHR$(09);
8500 NEXT N%
8510 LPRINT CHR$(13);
8520 NEXT M%
8530 LPRINT CHR$(12)
8540 REM
8541 REM -------This saves which experiments are to be run-------
8542 REM
8550 OPEN "\DATA\EXPT" FOR OUTPUT AS #1
8560 PRINT #1,File$
8570 FOR M% = 1 TO 30
8580 PRINT #1,Expt%(M%)
8590 NEXT M%
8600 CLOSE #1
```

```
8610 REM
8611 REM -------This saves the parameters for the experiments-------
8612 REM
8620 OPEN "\DATA\PARAM" FOR APPEND AS #1
8630 RESTORE,60310
8640 READ Maxloop%
8650 FOR N% = 1 TO Group%(Expt%(25))
8660 IF Expt%(N%) = 0 THEN GOTO 8700
8670 FOR M% = 1 TO Maxloop%
8680 PRINT #1,Parameter!(N%,M%)
8690 NEXT M%
8700 NEXT N%
8710 CLOSE #1
8800 REM
8801 REM ************************************************************
8802 REM *                                                          *
8803 REM *   This exits the "PARAMETER" program and goes to the     *
8804 REM *   program "RUNIT".                                       *
8805 REM *                                                          *
8806 REM ************************************************************
8807 REM
8810 CLS
8820 SYSTEM
8899 STOP
8900 REM
8901 REM ************************************************************
8902 REM *                                                          *
8903 REM *   This allows the user to go directly to the graphics    *
8904 REM *   routines if he has chosen to do so in the TEMP RUN     *
8905 REM *   section.                                               *
8906 REM *                                                          *
8907 REM ************************************************************
8908 REM
8910 OPEN "\DATA\END" FOR OUTPUT AS #1
8920 PRINT #1,"Howdy there pardner"
8930 CLOSE
8940 CLS
8950 SYSTEM
8999 STOP
9000 REM
9001 REM ************************************************************
9002 REM *                                                          *
9003 REM *   This subroutine allows the user to reuse the           *
9004 REM *   information block used in the previous experiment.     *
9005 REM *                                                          *
9006 REM ************************************************************
9007 REM
9010 CLOSE
9013 LPRINT CHR$(24)
9020 CLS:COLOR 10,0,0:LOCATE 12,5
9030 INPUT "Do you want to use the same information block (Defaults to No)";Chk$
```

```
9040 Chk$ = MID$(Chk$,1,1)
9050 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 9090 ELSE GOTO 9260
9090 OPEN "\DATA\REDO" FOR INPUT AS #1
9100 INPUT #1,FILE1$
9110 CLOSE #1
9160 RESTORE,60010
9170 READ Maxloop%
9180 OPEN "\DATA\" + FILE1$ + "\INFO" FOR INPUT AS #1
9190 INPUT #1,BS$,BS$
9200 FOR M% = 2 TO Maxloop%
9210 INPUT #1,BS$,Information$(M%)
9220 NEXT M%
9230 CLOSE #1
9233 Clearscreen (17):COLOR 10,0,0
9234 LOCATE 17,5:INPUT "Enter the directory number (between 1 and 999)";File$
9235 IF VAL(File$) < 1 OR VAL(File$) > 999 THEN GOTO 9233
9236 Information$(1) = File$
9237 Redo% = 0
9238 Filecheck (File$,Redo%)
9239 IF Redo% = 1 THEN GOTO 9233
9240 KILL "\DATA\REDO"
9250 GOTO 1210
9260 KILL "\DATA\REDO"
9270 GOTO 1210
9499 STOP
9500 REM ************************************************************
9501 REM *                                                          *
9502 REM *  This is the ERROR handling routines.  It checks to see  *
9503 REM *  what error is and attempts to fix it.                   *
9504 REM *                                                          *
9505 REM ************************************************************
9506 REM
9510 IF ERR = 1008 THEN RESUME NEXT
9520 IF ERR  = 1001 THEN RESUME,350
9530 IF ERR = 1007 THEN RESUME,350
9540 CLS:COLOR 7,0:LOCATE 11,5
9550 PRINT"Sorry the main program is bombing.  This is the error ";ERR
9560 LOCATE 12,5:PRINT "The line number is ";ERL
9570 STOP
9999 STOP
10000 REM
10001 REM ************************************************************
10002 REM *                                                          *
10003 REM *  This is the Capacitance vs. Time and Conductance vs.    *
10004 REM *  Time Subroutine.  It sets the parameters and then sends *
10005 REM *  them to the C-V meter and Pulse Generator for checking. *
10006 REM *                                                          *
10007 REM ************************************************************
10008 REM
10010 CLS:LOCATE 1,19:COLOR 2,0
10020 IF L% = 1 GOTO 10060          'If C-t skip next 2 instructions
```

```
10030 Function$ = "FN6"
10040 Name$ = "G-t"
10050 GOTO 10080                    'Since G-t skip C-t set-up
10060 Function$ = "FN5"
10070 Name$ = "C-t"
10080 COLOR 2,0:PRINT "This sets the ";
10090 COLOR 18,0:PRINT Name$;
10100 COLOR 2,0:PRINT " Experiment Parameters"
10110 Parameter!(L%,1) = Parameter!(25,1)
10120 Parameter!(L%,2) = Parameter!(25,2)
10130 Parameter!(L%,3) = Parameter!(25,3)
10140 Parameter!(L%,4) = Parameter!(25,4)
10150 IF Expt%(26) = 3 OR Expt%(26) = 1 THEN GOTO 10220
10160 REM
10161 REM          -----Sets Temperature Parameters-----
10162 REM
10170 Expt$ = Name$ + " Experiment"
10180 Name$ = "Settings"
10190 Col% = 20
10200 Settempparam
(Time%,Col%,Parameter!(L%,1),Parameter!(L%,2),Parameter!(L%,3),Expt$,Name$)
10210 REM
10211 REM               -----Sets Bias Voltages-----
10212 REM
10220 Setbias (Parameter!(L%,17),Parameter!(L%,18),Parameter!(L%,19))
10230 Parameter!(L%,4) = Parameter!(L%,1)
10240 REM
10241 REM          -----Sets Number of Samples-----
10242 REM
10250 Setsamples (Parameter!(L%,20))
10260 REM
10261 REM            -----Sets Pulse Times-----
10262 REM
10270 Settime
(Parameter!(L%,13),Parameter!(L%,14),Parameter!(L%,15),Parameter!(L%,16),1.0E-05,1.0E-05,0)
10280 REM
10281 REM            -----Sets Pulse Voltages-----
10282 REM
10290 Setpulse (Parameter!(L%,21),Parameter!(L%,22),Parameter!(L%,23),Parameter!(L%,24))
10300 REM
10301 REM ************************************************************
10302 REM *                                                          *
10304 REM *   This section checks the parameters with the C-V meter   *
10305 REM *   and Pulse generator.                                   *
10306 REM *                                                          *
10307 REM ************************************************************
10308 REM
10310 REM----Checks the Initial High Pulse Voltage with the Pulse Generator----
10311 REM
10320 DO 2 TIMES
10330 PARAM$ = "SER.POLL/13/":GOSUB 50000
```

```
10340 PARAM$ = "SDR/13/":GOSUB 50000
10350 DATA_STRING$ = "M4,CT0,T1,W1,HIL" + STR$(Parameter!(L%,21)) + "V,LOL" +
STR$(Parameter!(L%,24)) + "V"
10360 PARAM$ = "WR.STR/13//EOS/":GOSUB 50000
10370 PARAM$ = "RD.STR/13//EOS/":GOSUB 50000
10380 PARAM$ = "SER.POLL/13/":GOSUB 50000
10390 REPEAT
10400 IF POLL_RESP% AND &H40 = 64 THEN GOSUB 10740
10410 IF Parameter!(L%,23) = 0 THEN GOTO 10520
10420 REM
10421 REM----Checks the Final High Pulse Voltage with the Pulse Generator----
10422 REM
10430 DO 2 TIMES
10440 PARAM$ = "SER.POLL/13/":GOSUB 50000
10450 DATA_STRING$ = "M4,CT0,T1,W1,HIL" + STR$(Parameter!(L%,22)) + "V,LOL" +
STR$(Parameter!(L%,24)) + "V"
10460 PARAM$ = "WR.STR/13//EOS/":GOSUB 50000
10470 PARAM$ = "RD.STR/13//EOS/":GOSUB 50000
10480 PARAM$ = "SER.POLL/13/":GOSUB 50000
10490 REPEAT
10500 IF POLL_RESP% AND &H40 = 64 THEN GOSUB 10740
10510 PARAM$ = "SDL/13/":GOSUB 50000
10520 REM
10521 REM -----Checks the Hold Times vs. Bias Voltage with the C-V meter-----
10522 REM
10530 M% = 14
10540 N% = 17
10550 DATA_STRING$ = Function$ + "CN13TR3LE2SA1PC" + STR$(Parameter!(L%,N%)) +
";PN" + STR$(Parameter!(L%,20)) + ";PH" + STR$(Parameter!(L%,M%)) + ";PT" +
STR$(Parameter!(L%,13)) + "SW1"
10560 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
10565 DATA_STRING$ = "SW0"
10567 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
10570 PARAM$ = "SER.POLL/17/":GOSUB 50000
10580 IF POLL_RESP% AND &H40 = &H40 THEN GOSUB 10870
10590 N% = N% + 1
10600 IF Parameter!(L%,19) = 0 OR Parameter!(L%,18) = 0 THEN GOTO 10620
10610 IF N% = 18 THEN GOTO 10550
10620 IF Parameter!(L%,15) = 0 THEN GOTO 10660
10630 M% = M% + 1
10640 IF M% = 15 THEN GOTO 10540
10650 REM
10651 REM -------This checks to see if delaytime/holdtime is > 200-------
10652 REM
10660 IF Parameter!(L%,14) / Parameter!(L%,13) > 200 THEN GOTO 10680
10670 IF Parameter!(L%,16) / Parameter!(L%,13) <= 200 THEN GOTO 10710
10680 COLOR 7,0:CLS:LOCATE 13,5
10690 PRINT "The delay time divided by the pulse times must be less than 200!"
10700 GOTO 10270
10710 PARAM$ = "SDC/13,17/":GOSUB 50000
10720 RETURN
```

```
10738 STOP
10739 REM
10740 REM ************************************************************
10741 REM *                                                          *
10742 REM *  This section prints the error messages if any of the    *
10743 REM *  parameters evoke an "illegal" call from the generator   *
10744 REM *  or C-V meter.                                           *
10745 REM *                                                          *
10746 REM ************************************************************
10747 REM
10748 REM     -----Prints out error message for the Pulse Generator-----
10749 REM
10750 DATA_STRING$ = "IERR"
10760 PARAM$ = "WR.STR/13//EOS/":GOSUB 50000
10770 PARAM$ = "RD.STR/13//EOS/":GOSUB 50000
10780 Clearscreen (3)
10790 LOCATE 10,5:COLOR 7,0
10800 PRINT "The settings chosen are not viable.  You must select new settings."
10810 LOCATE 11,5:PRINT "To aid you the error from the HP8112 A is "
10820 LOCATE 11,47:COLOR 5,0:PRINT MID$(DATA_STRING$,2,18):COLOR 7,0
10830 LOCATE 12,5:PRINT "Please look in the manual on pages 3-21 to 3-23.)"
10840 PARAM$ = "SDL/13/":GOSUB 50000
10850 Timedelay(6)
10860 RETURN,10280
10869 STOP
10870 REM
10871 REM     -----Prints out error message for the C-V meter-----
10872 REM
10880 DATA_STRING$ = "ERR?"
10890 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
10900 PARAM$ = "RD.STR/17//EOS/":GOSUB 50000
10910 Startnoerror% = INSTR(DATA_STRING$,"ER00.0")
10920 IF Startnoerror% <> 0 THEN RETURN
10930 Clearscreen (3)
10940 LOCATE 10,5:COLOR 7,0
10950 PRINT "The settings chosen are not viable.  You must select new settings."
10960 PRINT "To aid you the error number from the HP4280 A is ";
10970 COLOR 5,0:PRINT DATA_STRING$:COLOR 7,0
10980 PRINT "Please look in the manual on pages 3-23 to 3-30.)"
10990 Timedelay(6)
11000 PARAM$ = "SDC/17/":GOSUB 50000
11010 RETURN,10220
11999 STOP
12000 REM
12001 REM ************************************************************
12002 REM *                                                          *
12003 REM *  This subroutine control the C-G-V experiment and allows *
12004 REM *  the user to enter the parameter settings and checks for *
12005 REM *  any possible errors.                                     *
12006 REM *                                                          *
12007 REM ************************************************************
```

```
12008 REM
12010 CLS:LOCATE 1,20:COLOR 2,0
12020 PRINT "This sets the";
12030 COLOR 18,0:PRINT " C-G-V";
12040 COLOR 2,0:PRINT " Parameter Settings"
12050 Parameter!(3,1) = Parameter!(25,1)
12060 Parameter!(3,2) = Parameter!(25,2)
12070 Parameter!(3,3) = Parameter!(25,3)
12080 Parameter!(3,4) = Parameter!(25,4)
12090 IF Expt%(26) = 3 OR Expt%(26) = 1 THEN GOTO 12150
12100 REM
12101 REM        -------Sets the Temperature Parameters-------
12102 REM
12110 Expt$ = "C-G-V Experiment"
12120 Col% = 19
12130 Name$ = "Settings"
12140 Settempparam (Time%,Col%,Parameter!(3,1),Parameter!(3,2),Parameter!(3,3),Expt$,Name$)
12150 REM
12151 REM      --------Sets the Start, Stop and Delta Voltages----------
12152 REM
12160 Svolt (Parameter!(3,7),Parameter!(3,8),Parameter!(3,9),Parameter!(3,10),Parameter!(3,11))
12170 REM
12171 REM      --------Sets the Hold and Step Delay Time--------
12172 REM
12180 Settime (Parameter!(3,13),Parameter!(3,14),Parameter!(3,15),Parameter!(3,16),0.1,0.1,1)
12200 REM
12201 REM ***************************************************************
12202 REM *                                                             *
12203 REM *     This checks the parameters entered with the C-V meter.  *
12204 REM *                                                             *
12205 REM ***************************************************************
12206 REM
12210 REM  --------This checks the first start, stop and delta voltages--------
12211 REM
12220 DATA_STRING$ =
"FN1IB2TR3PS"+STR$(Parameter!(3,7))+";PP"+STR$(Parameter!(3,8))+";PE"+STR$(Parameter
!(3,9))+";PD"+STR$(Parameter!(3,13))+";PL"+STR$(Parameter!(3,14))
12230 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
12240 PARAM$ = "SER.POLL/17/":GOSUB 50000
12250 IF POLL_RESP% AND &H40 = 64 THEN GOSUB 12500
12260 REM
12261 REM  --------This checks the second start, stop and delta voltages--------
12262 REM
12270 DATA_STRING$ =
"FN1IB2TR3PS"+STR$(Parameter!(3,8))+";PP"+STR$(Parameter!(3,10))+";PE"+STR$(Paramet
er!(3,11))+";PD"+STR$(Parameter!(3,13))+";PL"+STR$(Parameter!(3,14))
12280 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
12290 PARAM$ = "SER.POLL/17/":GOSUB 50000
12300 IF POLL_RESP% AND &H40 = 64 THEN GOSUB 12500
12310 PARAM$ = "SDC/17/":GOSUB 50000
12320 RETURN
```

```
12499 STOP
12500 REM
12501 REM ************************************************************
12502 REM *                                                          *
12503 REM *   This subroutine prints the error found by the C-V      *
12504 REM *   meter, then returns the program to reenter the         *
12505 REM *   parameters.                                            *
12506 REM *                                                          *
12507 REM ************************************************************
12508 REM
12510 DATA_STRING$ = "ERR?"
12520 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
12530 PARAM$ = "RD.STR/17//EOS/":GOSUB 50000
12540 Startnoerror% = INSTR(DATA_STRING$,"ER00.0")
12550 IF Startnoerror% <> 0 THEN RETURN
12560 Clearscreen (3)
12570 LOCATE 10,5:COLOR 7,0
12580 PRINT "The settings chosen are not viable.  You must select new settings."
12590 PRINT "To aid you the error number from the HP4280 A is ";
12600 COLOR 5,0:PRINT DATA_STRING$:COLOR 7,0
12610 PRINT "Please look in the manual on pages 3-23 to 3-30.)"
12620 Timedelay(6)
12630 PARAM$ = "SDC/17/":GOSUB 50000
12640 RETURN,12150
12999 STOP
13000 REM
13001 REM ************************************************************
13002 REM *                                                          *
13003 REM *   This is the C-G subroutine.  It controls the parameter  *
13004 REM *   settings and also the data collecting and storing.      *
13005 REM *                                                          *
13006 REM ************************************************************
13007 REM
13010 CLS:LOCATE 1,20:COLOR 2,0
13020 PRINT "This sets the";
13030 COLOR 18,0:PRINT " C-G";
13040 COLOR 2,0:PRINT " Experiment Parameters"
13050 Parameter!(4,1) = Parameter!(25,1)
13060 Parameter!(4,2) = Parameter!(25,2)
13070 Parameter!(4,3) = Parameter!(25,3)
13080 Parameter!(4,4) = Parameter!(25,4)
13090 IF Expt%(26) = 3 OR Expt%(26) = 1 THEN GOTO 13150
13100 REM
13101 REM        -------Sets the Temperature Parameters-------
13102 REM
13110 Expt$ = "C-G Experiment"              'Sets title and names for the
13120 Col% = 19                          'Procedure
13130 Name$ = "Settings"
13140 Settempparam
(Time%,Col%,Parameter!(4,1),Parameter!(4,2),Parameter!(4,3),Expt$,Name$)
13150 REM
```

```
13151 REM          --------Sets the Bias Voltages----------
13152 REM
13160 Setbias (Parameter!(4,17),Parameter!(4,18),Parameter!(4,19))
13170 REM
13171 REM ************************************************************
13172 REM *                                                          *
13173 REM *   This section checks to see if the parameters set are    *
13174 REM *   allowed by the C-V meter.                              *
13175 REM *                                                          *
13176 REM ************************************************************
13177 REM
13178 REM       -------This checks the start voltage--------
13179 REM
13180 DATA_STRING$ = "FN1CN10IB1RA1MS2SL2TR3PV" + STR$(Parameter!(4,17))
13190 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
13200 PARAM$ = "SER.POLL/17/":GOSUB 50000
13210 IF POLL_RESP% AND &H40 = 64 THEN GOSUB 13500
13220 REM
13221 REM       -------This checks the final voltage--------
13222 REM
13230 DATA_STRING$ = "FN1CN10IB1RA1MS2SL2TR3PV" + STR$(Parameter!(4,18))
13240 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
13250 PARAM$ = "SER.POLL/17/":GOSUB 50000
13260 IF POLL_RESP% AND &H40 = 64 THEN GOSUB 13500
13270 PARAM$ = "SDC/17/":GOSUB 50000
13280 RETURN
13499 STOP
13500 REM
13501 REM ************************************************************
13502 REM *                                                          *
13503 REM *   This subroutine prints the error found by the C-V      *
13504 REM *   meter, then returns the program to reenter the         *
13505 REM *   parameters.                                            *
13506 REM *                                                          *
13507 REM ************************************************************
13508 REM
13510 DATA_STRING$ = "ERR?"
13520 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
13530 PARAM$ = "RD.STR/17//EOS/":GOSUB 50000
13540 Startnoerror% = INSTR(DATA_STRING$,"ER00.0")
13550 IF Startnoerror% <> 0 THEN RETURN
13560 Clearscreen (3)
13570 LOCATE 10,5:COLOR 7,0
13580 PRINT "The settings chosen are not viable.  You must select new settings."
13590 PRINT "To aid you the error number from the HP4280 A is ";
13600 COLOR 5,0:PRINT DATA_STRING$:COLOR 7,0
13610 PRINT "Please look in the manual on pages 3-23 to 3-30.)"
13620 Timedelay(6)
13630 PARAM$ = "SDC/17/":GOSUB 50000
13640 RETURN,13150
13999 STOP
```

```
14000 REM
14001 REM ************************************************************
14002 REM *                                                          *
14003 REM *   This is the Current vs. Voltage subroutine. It sets    *
14004 REM *   up the parameters necessary to run the program. It      *
14005 REM *   It also checks to see if the parameters are feasible.   *
14006 REM *                                                          *
14007 REM ************************************************************
14008 REM
14010 CLS:LOCATE 1,20:COLOR 2,0
14020 PRINT "This sets the ";
14030 COLOR 18,0:PRINT "I-V";
14040 COLOR 2,0:PRINT " Experiment Parameters"
14050 Parameter!(1,1) = Parameter!(25,1)
14060 Parameter!(1,2) = Parameter!(25,2)
14070 Parameter!(1,3) = Parameter!(25,3)
14080 Parameter!(1,4) = Parameter!(25,4)
14090 IF Expt%(26) = 3 OR Expt%(26) = 1 THEN GOTO 14150
14100 REM
14101 REM       -------Sets the Temperature Parameters--------
14102 REM
14110 Expt$ = "I-V Experiment"
14120 Col% = 20
14130 Name$ = "Settings"
14140 Settempparam
(Time%,Col%,Parameter!(1,1),Parameter!(1,2),Parameter!(1,3),Expt$,Name$)
14150 REM
14151 REM       --------Sets the Start, Stop and Delta Voltages----------
14152 REM
14160 Svolt (Parameter!(1,7),Parameter!(1,8),Parameter!(1,9),Parameter!(1,10),Parameter!(1,11))
14170 REM
14171 REM         --------Sets the Hold and Step Delay Time--------
14172 REM
14180 Settime (Parameter!(1,13),Parameter!(1,14),Parameter!(1,15),Parameter!(1,16),0.7,0.1,1)
14190 REM
14191 REM ************************************************************
14192 REM *                                                          *
14193 REM *   This checks the parameters set with the I-V meter.      *
14194 REM *                                                          *
14195 REM ************************************************************
14196 REM
14200 M% = 7
14210 N% = 8
14215 X$ = STR$(VAL(STR$(Parameter!(1,N%+1))))
14220 DATA_STRING$ = "F2I2L3PS" + STR$(Parameter!(1,M%)) + ";PT" +
STR$(Parameter!(1,N%)) + ";PE" + X$ + ";PH" + STR$(Parameter!(1,14)) + ";PD" +
STR$(Parameter!(1,13)) + ";W1"
14230 PARAM$ = "WR.STR/5//EOS/":GOSUB 50000
14240 DATA_STRING$ = "W7"
14250 PARAM$ = "WR.STR/5//EOS/":GOSUB 50000
14260 PARAM$ = "SER.POLL/5/":GOSUB 50000
```

```
14270 IF POLL_RESP% AND &H40 = 64 THEN GOSUB 14500
14280 IF Parameter!(1,11) = 0 THEN GOTO 14320
14290 M% = M% + 1
14300 N% = N% + 2
14310 IF M% = 8 THEN GOTO 14215
14320 PARAM$ = "SDC/5/":GOSUB 50000
14330 RETURN
14499 STOP
14500 REM
14501 REM ************************************************************
14502 REM *                                                          *
14503 REM *   This prints the error message sent in binary by the    *
14504 REM *   I-V meter.  It then sends the program back to reenter   *
14505 REM *   the parameters.                                         *
14506 REM *                                                          *
14507 REM ************************************************************
14508 REM
14510 Clearscreen (3)
14520 COLOR 7,0:LOCATE 10,5
14530 PRINT "The settings chosen are not viable.  You must select new settings."
14540 LOCATE 11,5
14550 PRINT "If you are not sure why this occurred please check the HP 4140B."
14560 LOCATE 12,5:PRINT "The BINARY error code is ";
14570 COLOR 5,0:PRINT MID$(BIN$(POLL_RESP%),8)
14580 Timedelay(6)
14590 PARAM$ = "SDC/5/":GOSUB 50000
14600 RETURN,14160
14999 STOP
15000 REM
15001 REM ************************************************************
15002 REM *                                                          *
15003 REM *   This is the Capacitance vs. Voltage subroutine.  It    *
15004 REM *   sets up the parameters necessary to run the program.    *
15005 REM *   It also checks to see if the parameters are feasible.   *
15006 REM *                                                          *
15007 REM ************************************************************
15008 REM
15010 CLS:LOCATE 1,20:COLOR 2,0
15020 PRINT "This sets the";
15030 COLOR 18,0:PRINT " C-V ";
15040 COLOR 2,0:PRINT "Experiment Parameters"
15050 Parameter!(2,1) = Parameter!(25,1)
15060 Parameter!(2,2) = Parameter!(25,2)
15070 Parameter!(2,3) = Parameter!(25,3)
15080 Parameter!(2,4) = Parameter!(25,4)
15090 IF Expt%(26) = 3 OR Expt%(26) = 1 THEN GOTO 15160
15100 REM
15101 REM       -------Sets the Temperature Parameters--------
15102 REM
15110 Expt$ = "C-V Experiment"
15120 Col% = 20
```

```
15130 Name$ = "Settings"
15140 Settempparam
(Time%,Col%,Parameter!(2,1),Parameter!(2,2),Parameter!(2,3),Expt$,Name$)
15150 REM
15151 REM       --------Sets the Start, Stop and Delta Voltages----------
15152 REM
15160 DVdt (Parameter!(2,12),Parameter!(2,7),Parameter!(2,8),Parameter!(2,9))
15170 REM
15171 REM              ----------Sets the Hold Time ----------------
15172 REM
15180 Settime (Parameter!(2,13),Parameter!(2,14),Parameter!(2,15),Parameter!(2,16),0.1,0,3)
15190 REM
15191 REM ************************************************************
15192 REM *                                                          *
15193 REM *   This checks the parameters set with the I-V meter.      *
15194 REM *                                                          *
15195 REM ************************************************************
15196 REM
15200 DATA_STRING$ = "F3I2L3PS" + STR$(Parameter!(2,7)-Parameter!(2,9)) +";PT" +
STR$(Parameter!(2,8)+Parameter!(2,9)) + ";PE" + STR$(Parameter!(2,9)) + ";PV" +
STR$(Parameter!(2,12)) + ";PH" + STR$(Parameter!(2,14)) + ";W1"
15210 PARAM$ = "WR.STR/5//EOS/":GOSUB 50000
15215 DATA_STRING$ = "W7"
15218 PARAM$ = "WR.STR/5//EOS/":GOSUB 50000
15220 PARAM$ = "SER.POLL/5/":GOSUB 50000
15230 IF POLL_RESP% AND &H40 = 64 THEN GOSUB 15500
15240 PARAM$ = "SDC/5/":GOSUB 50000
15250 RETURN
15500 REM
15501 REM ************************************************************
15502 REM *                                                          *
15503 REM *   This prints the error message sent in binary by the    *
15504 REM *   I-V meter.  It then sends the program back to reenter   *
15505 REM *   the parameters.                                        *
15506 REM *                                                          *
15507 REM ************************************************************
15508 REM
15510 Clearscreen (3)
15520 COLOR 7,0:LOCATE 10,5
15530 PRINT "The settings chosen are not viable.  You must select new settings."
15540 LOCATE 11,5
15550 PRINT "If you are not sure why this occurred please check the HP 4140B."
15560 LOCATE 12,5:PRINT "The BINARY error code is ";
15570 COLOR 5,0:PRINT MID$(BIN$(POLL_RESP%),8)
15580 Timedelay(6)
15590 PARAM$ = "SDC/5/":GOSUB 50000
15600 RETURN,15150
39999 STOP
40000 REM
40001 REM ************************************************************
40002 REM *                                                          *
```

```
40003 REM *   This subroutine places the data pointer to the right    *
40004 REM *   experimental group, for the print out.                  *
40005 REM *                                                           *
40006 REM *************************************************************
40007 REM
40010 ON Expt%(25) GOTO 40020,40030,40040,40045
40020 RESTORE,60510:GOTO 40050
40030 RESTORE,60520:GOTO 40050
40040 RESTORE,60530:GOTO 40050
40045 RESTORE,60540:GOTO 40050
40050 RETURN
40999 STOP
41000 REM
41001 REM *************************************************************
41002 REM *                                                           *
41003 REM *   This subroutine places the data pointer to the right    *
41004 REM *   experimental group, for the experiment menu.            *
41005 REM *                                                           *
41006 REM *************************************************************
41007 REM
41010 ON Expt%(25) GOTO 41020,41030,41040,41050
41020 RESTORE,60220:GOTO 41060
41030 RESTORE,60230:GOTO 41060
41040 RESTORE,60240:GOTO 41060
41050 RESTORE,60250:GOTO 41060
41060 RETURN
59999 STOP
60000 REM
60001 REM *************************************************************
60002 REM *                                                           *
60003 REM *   These DATA statements are used for the information      *
60004 REM *   block print statements and correction routine.          *
60005 REM *                                                           *
60006 REM *************************************************************
60007 REM
60010 DATA 6
60020 DATA "Directory Number","Date ","Experimenters Name","Sample Number","Cryostat
Chronometer Reading","Comments","Type of Run"
60099 STOP
60100 REM
60101 REM *************************************************************
60102 REM *                                                           *
60103 REM *   These DATA statements allow the user to choose which    *
60104 REM *   group of experiments to run.                            *
60105 REM *                                                           *
60106 REM *************************************************************
60110 DATA 4
60120 DATA "GROUP I   C-t, G-t, C-G-V, C-G"
60130 DATA "GROUP II  I-V, C-V"
60140 DATA "GROUP III  Van der Pauw/Mobility"
60150 DATA "GROUP IV  4-point Resistivity"
```

```
60199 STOP
60200 REM
60201 REM ************************************************************
60202 REM *                                                          *
60203 REM *  These DATA statements allow the user to choose which    *
60204 REM *  experiments he wants to run from the group choosen       *
60205 REM *  earlier.                                                *
60206 REM *                                                          *
60207 REM ************************************************************
60208 REM
60210 DATA 4,4,2,1,1
60220 DATA "Capacitance (C) vs. Time","Conductance (G) vs. Time","C and G vs.
Voltage","Capacitance and Conductance"
60230 DATA "Current vs. Voltage","Capacitance vs. Voltage"
60240 DATA "Van der Pauw/Mobility"
60250 DATA "4-point Resistivity"
60299 STOP
60300 REM
60301 REM ************************************************************
60302 REM *                                                          *
60303 REM *  These DATA statements are for the PARAMETER (x,y)       *
60304 REM *  array.                                                  *
60305 REM *                                                          *
60306 REM ************************************************************
60307 REM
60310 DATA 24
60320 DATA "Initial Temp","Final Temp","Delta Temp",Current Temp"
60330 DATA "Final Time","Delta Time"
60340 DATA "Start Volt","Stop1 Volt","Step1 Volt","Stop2 Volt","Step2 Volt"
60350 DATA "DV/dt"
60360 DATA "Delay Time","Initial Hold","Final Hold","Delta Hold"
60370 DATA "Initial Bias","Final Bias","Delta Bias"
60380 DATA "Number of Samples"
60390 DATA "Start High Pulse","Final High Pulse","Delta High Pulse","Low Pulse"
60399 STOP
60400 REM
60401 REM ************************************************************
60402 REM *                                                          *
60403 REM *  This data statement is used for the type of temperature *
60404 REM *  run section.                                            *
60405 REM *                                                          *
60406 REM ************************************************************
60407 REM
60410 DATA 3
60420 DATA "Time Run ( > 5 Minutes; 30-600 K)","Temperature Run (30 - 600 K)","Room
Temperature Run (290 K)"
60499 STOP
60500 REM
60501 REM ************************************************************
60502 REM *                                                          *
60503 REM *  These data statements are for the print out of the      *
```

```
60504 REM *   parameter set.                                    *
60505 REM *                                                    *
60506 REM ******************************************************************
60507 REM
60510 DATA "C-t","G-t","C-G-V","C-G"
60520 DATA "I-V","C-V"
60530 DATA "Van der Pauw"
60540 DATA "4-point Resistivity"
60599 STOP
60600 REM
60601 REM ******************************************************************
60602 REM *                                                    *
60603 REM *     This data statement gives what type of temperature run  *
60604 REM *     it is.                                         *
60605 REM *                                                    *
60606 REM ******************************************************************
60607 REM
60610 DATA "TTEMP","LTEMP","RTEMP"

ENDFILE
```

RUNIT

```
PRECISION= 7
AUTODEF=ON
OPTION BASE=0
ERL=ON
ERRORMODE=LOCAL
RESUME=LINE
FORMODE=BB
SCOPE=ON
PROCS=2
STRING ARRAY(?): REC$,FLD$
STRING: PARAMS[?],IEEE_FCTN$[?]
INTEGER: CNTRLR%,TRUE%,COMM%,PORT4%,PORT5%,PORT9%
INTEGER: PORT0%,FUM%,FALSE%,MY_FLAG%,MAX_TIME%
REAL: STROFF
INTEGER: STROFF%
REAL: DSPTR
INTEGER: MY_ADDR%,BD_ADDR%,PORT1%,PORT2%
INTEGER: PORT3%,PORT6%,PORT7%,PORT8%
STRING: CHAR1$[?]
INTEGER: TCIMODE%,MS%,INTR%,INTVECTOR%,INTENABLE%
INTEGER:
INTMASK%,SUBLIB%,TIMEOUT%,INTSETUP%,POLLBYTE%,WRSTR%,WRFIL%,CB_FL
AG%
INTEGER: HCSR%,VCSR%,RDSTR%,RDFIL%
REAL: CSEG
INTEGER: SAVESTAT%,SYC%
STRING: DUMMY$[?]
INTEGER: NEOS%,TERM%,N1%,LAST_INT1%
INTEGER: INT1STAT%,CTR%
STRING: DATA_STRINGS$[?]
INTEGER: CHAR%,STRLEN%,CB%,DAT%,LAST%,POLL_RESP%,STATUS%
INTEGER: SRQ%,SYS%,BIT%,SENSE%,X%,N2%,Y%,ADSTAT%
STRING: END_SEQ$[?],LAST_CHAR$[?],SEP$[?]
STRING ARRAY(?): SAR$
STRING: TEMP$[?]
INTEGER: M%,B%,N%,L%,Maxloop%,NCM%
INTEGER: NGM%,V%,T%,Cryostat%
INTEGER ARRAY(31): Expt%
INTEGER ARRAY(11): Group%
STRING: File$[5],Chk$[3],Name$[60],Function$[?],Moniker$[13]
STRING: Sensor$[4],Temp_wanted$[5],Xtemp$[16],Heater$[4],Int_Gain$[12],A$[3],Sensor1$[4]
REAL ARRAY(26,31): Parameter!
REAL: Delta!,Time
REAL: Timerun!,Pulsevolt!,Bias!,Maxtemp!,Mintemp!,Temp!,O,Cdata!
REAL: Xdata!,Gdata!,Idata!,Delta_temp!,Temp_wanted!
INTEGER: Test_Passed%,Crostat%
REAL: Time!,L!,CURRENT!
REAL: VOLT!,VOLT2!,Test_passed!,Offset!
STRING: X$[?]
REAL: TEMP_SET!,TEMP_PEAK!,Temp1!,Temp2!,TIFF!
REAL: Temp3!
```

```
INTEGER: Print_temp%,ROW%,P%
REAL: ACTUALTEMP,N

PROCEDURE: TIMEDELAY()
  REAL ARG: DELAY!/OPT=5!
END PROCEDURE

PROCEDURE: CLEARSCREEN()
  INTEGER ARG: ROW%
END PROCEDURE


PROCEDURE: TIMEDELAY
  REAL: Tyme!
  STRING: OVERHEAT$[?],Data_string$[?]
  REAL: TEMP_PEAK!,PEAK_TEMP!
    22 REM *   integer arg:delay%/opt = 5
    32 REM *   real:tyme!
   100 Tyme! = TIMER
   110 IF TIMER < Tyme! + DELAY! THEN GOTO 110
   120 EXIT
END PROCEDURE

PROCEDURE: CLEARSCREEN
  INTEGER: N%
   100 FOR N% = ROW% TO 24
   110   SET CURSOR N%,0
   120   PRINT SPC(80)
   130 NEXT N%
END PROCEDURE

'MAIN Program:


 200 REM
 201 REM ***************************************************************
 202 REM *                                                             *
 203 REM *   This section prints the entrance message to RUNIT.  It    *
 204 REM *   also initializes the devices on the IEEE bus.             *
 205 REM *                                                             *
 206 REM ***************************************************************
 207 REM
 210 CLEAR
 220 ON ERROR GOSUB 42000
 230 CLS : STATUSLINE OFF : SCREEN 0,0,0 : COLOR 2,0 : LOCATE 12,23
 240 PRINT "Hit any key to begin Experiments"
 250 COLOR 3,0:LOCATE 14,10
 260 PRINT "All instruments must be on and the proper connections be made"
 270 TIMEDELAY (2)
 280 A$ = INKEY$: IF A$ = "" THEN GOTO 250
 290 PARAM$ = "INIT/1/&H310/P/":GOSUB 50000
```

```
300 PARAM$ = "SDR/5,7,8,12,13,16,17/":GOSUB 50000
310 REM
311 REM ************************************************************
312 REM *                                                          *
313 REM *   This section loads the data from the files stored by   *
314 REM *   the program PARAMETER.                                 *
315 REM *                                                          *
316 REM ************************************************************
317 REM
320 CLS:COLOR 2,0,0:LOCATE 12,30
330 PRINT "Now LOADING data"
340 DRIVE$ = "C:"
350 DIR$ = "\"
360 OPEN " \DATA\EXPT" FOR INPUT AS #1
370 INPUT #1,File$
380 FOR M% = 1 TO 30
390   INPUT #1,Expt%(M%)
400 NEXT M%
410 CLOSE #1
420 OPEN " \DATA\PARAM" FOR INPUT AS #1
430 FOR M% = 1 TO 6
440   INPUT #1,Parameter!(25,M%)
450 NEXT M%
460 RESTORE,60010
470 READ Maxloop%
480 FOR M% = 1 TO Maxloop%
490   READ Group%(M%)
500 NEXT M%
505 RESTORE,60410
507 READ Maxloop%
510 FOR N% = 1 TO Group%(Expt%(25))
520   FOR M% = 1 TO Maxloop%
530     IF Expt%(N%) = 0 THEN EXIT 1 LEVELS
540     INPUT #1,Parameter!(N%,M%)
550   NEXT M%
560 NEXT N%
570 CLOSE #1
575 ACTUALTEMP=Parameter!(25,4)
600 REM
601 REM ************************************************************
602 REM *                                                          *
603 REM *   This section finds which type of temperature run was   *
604 REM *   requested, then stores in in the string XTEMP$         *
605 REM *                                                          *
606 REM ************************************************************
607 REM
610 RESTORE,60110
620 FOR M% = 1 TO 30
630   READ Xtemp$
640   IF M% = Expt%(26) THEN EXIT
650 NEXT M%
```

```
700 REM
704 P% = 0 : Print_temp% = 1
705 RESTORE,62000
710 DO
720   IF Expt%(25) <> 3 THEN EXIT TO,1000
730   CLS : COLOR 4,0,0 : SET CURSOR 0,35
740   PRINT "MOBILITY EXPERIMENT"
750 END DO
765 COLOR 3,0,0 : SET CURSOR 7,6 : PRINT "Connect the cables as follows"
766 COLOR 2,0,0
770 FOR N% = 1 TO 5
780   READ Name$
800   SET CURSOR 7 + N%*2,10
810   PRINT Name$
820 NEXT N%
830 COLOR 7,0,0 : SET CURSOR 22,6
840 PRINT "Hit any key to continue"
850 A$ = INKEY$ : IF A$ = "" THEN GOTO 850
860 P% = P% + 1
870 GOSUB 15000
871 IF P% < 3 THEN GOTO 710
872 CLEARSCREEN(2)
873 COLOR 2,0,0 : SET CURSOR 13,6
874 PRINT "Hit any key to begin the experiment run"
875 A$ = INKEY$ : IF A$ = "" THEN GOTO 875
880 Print_temp% = 2:GOTO 1000
1000 REM
1001 REM ************************************************************
1002 REM *                                                          *
1003 REM *   This section print up the proper screen for each type  *
1004 REM *   of temperature run. Prints the time if a time run,      *
1005 REM *   and goes to the proper subroutine for the experiments   *
1006 REM *   chosen. It also exits to finish routines if either      *
1007 REM *   the final temperature or final time has been reached.   *
1008 REM *                                                          *
1009 REM ************************************************************
1010 REM
1020 Mintemp! = Parameter!(25,1)
1030 Maxtemp! = Parameter!(25,2)
1040 COLOR 5,0:CLS
1050 IF Expt%(26) = 3 THEN PRINT SPC(60);"Room Temperature"
1060 COLOR 4,0:IF Expt%(26) = 3 THEN PRINT SPC(63);Parameter!(25,4);"K"
1070 COLOR 3,0:LOCATE 12,28:PRINT "The Current Program is:"
1080 IF Expt%(26) = 3 THEN GOTO 1100
1090 GOSUB 9000
1100 IF Expt%(26) <> 1 THEN GOTO 1150
1110 Timerun! = 0.0
1120 TIME$ = "00:00:00"
1130 LOCATE 1,8:COLOR 5,0:PRINT "Time"
1140 LOCATE 2,6:COLOR 4,0:PRINT TIME$
1150 COLOR 2,0
```

```
1160 ON Expt%(25) GOSUB 2000,2500,3010,4010
1170 IF Expt%(26) = 1 THEN GOTO 1220
1180 Parameter!(25,4) = Parameter!(25,4) + Parameter!(25,3)
1190 IF Parameter!(25,4) > Maxtemp! THEN GOTO 40000
1210 GOTO 1040
1220 IF TIMER > Parameter!(25,5) THEN GOTO 40000
1230 Timerun! = Timerun! + Parameter!(25,6)
1240 TIMEDELAY (.5)
1250 LOCATE 14,35:PRINT "TIME SET"
1260 LOCATE 2,6:COLOR 4,0:PRINT TIME$
1270 IF TIMER <= Timerun! THEN GOTO 1250
1280 GOTO 1150
1999 STOP
2000 REM
2001 REM ************************************************************
2002 REM *                                                          *
2003 REM *  This subroutine branches to the proper experiments      *
2004 REM *  chosen in group I.  It also checks after each           *
2005 REM *  experiment to see if the COLD HEAD has overheated       *
2006 REM *  (except in the case of a Room Temperature run).         *
2007 REM *                                                          *
2008 REM ************************************************************
2009 REM
2010 L% = 1
2020 ON Expt%(L%) GOSUB 10000,10000,11000,12000
2030 LOCATE 14,1:PRINT SPC(79)
2040 L% = L% + 1
2050 IF Expt%(26) <> 3 THEN GOSUB 9500
2060 IF L% <= Group%(Expt%(25)) THEN GOTO 2020
2070 RETURN
2499 STOP
2500 REM
2501 REM ************************************************************
2502 REM *                                                          *
2503 REM *  This subroutine branches to the proper experiments      *
2504 REM *  chosen in group II.  It also checks after each          *
2505 REM *  experiment to see if the COLD HEAD has overheated       *
2506 REM *  (except in the case of a Room Temperature run).         *
2507 REM *                                                          *
2508 REM ************************************************************
2509 REM
2510 L% = 1
2520 ON Expt%(L%) GOSUB 13000,14000
2530 LOCATE 14,1:PRINT SPC(79)
2540 IF Expt%(26) <> 3 THEN GOSUB 9500
2550 L% = L% + 1
2560 IF L% <= Group%(Expt%(25)) THEN GOTO 2520
2570 RETURN
3000 REM
3001 REM ************************************************************
3002 REM *                                                          *
```

```
3003 REM *   This subroutine branches to the proper experiments      *
3004 REM *   chosen in group III.  It also checks after each         *
3005 REM *   experiment to see if the COLD HEAD has overheated       *
3006 REM *   (except in the case of a Room Temperature run).         *
3007 REM *                                                           *
3008 REM *************************************************************
3009 REM
3010 GOSUB 15000
3020 IF Expt%(26) <> 3 THEN GOSUB 9500
3030 RETURN
4000 REM
4001 REM *************************************************************
4002 REM *                                                           *
4003 REM *   This subroutine branches to the proper experiments      *
4004 REM *   chosen in group IV.  It also checks after each          *
4005 REM *   experiment to see if the COLD HEAD has overheated       *
4006 REM *   (except in the case of a Room Temperature run).         *
4007 REM *                                                           *
4008 REM *************************************************************
4009 REM
4010 GOSUB 16000
4020 IF Expt%(26) <> 3 THEN GOSUB 9500
4030 RETURN
8999 STOP
9000 REM
9001 REM *************************************************************
9002 REM *                                                           *
9003 REM *   This sets the Cryostat to the correct temperature and   *
9004 REM *   then lets the temperature to stabilize to +/-1   degree *
9005 REM *                                                           *
9007 REM *************************************************************
9008 REM
9010 COLOR 2,0:LOCATE 14,24
9020 PRINT "Setting the Cryostat Temperature"
9030 LOCATE 1,30:PRINT SPC(49)
9040 COLOR 5,0:LOCATE 1,60:PRINT "Sample Setpoint"
9050 COLOR 4,0:LOCATE 2,63:PRINT Parameter!(25,4);"K"
9060 Test_Passed% = 0:Cryostat% = 0
9065 IF Parameter!(25,2) > 290 THEN Offset! = 0 ELSE Offset! = 0
9070 Temp_wanted! = Parameter!(25,4) + Offset!
9075 IF Temp_wanted!=>290 THEN LOCATE 22,10:COLOR 30,0:PRINT "Warning:
":LOCATE 22,19:COLOR 7,0:PRINT"the vacuum system should be pulling on the coldhead!!"
9080 IF Temp_wanted! < 15 THEN Heater$ = "7"
9090 IF Temp_wanted! => 15 AND Temp_wanted! < 20 THEN Heater$ = "8" ELSE Heater$
= "9"
9100 IF Temp_wanted! > 290 THEN Int_Gain$="00100000400" ELSE Int_Gain$="00100000500"
9101 IF Temp_wanted!<100 THEN Int_Gain$="00150000600"
9102 IF Temp_wanted!< 50 THEN Int_Gain$="00200000700"
9110 Delta_temp!=1
9120 Sensor$ = "33"
9130 DATA_STRINGS$ = "P"
```

```
9140 PARAM$ = "WR.STR/1//EOS/":GOSUB 50000
9150 Temp_wanted$ = MID$(STR$(Temp_wanted! + 1000),3)
9170 DATA_STRING$ = Temp_wanted$ + Int_Gain$ + Sensor$ + Heater$ + "505"
9180 PARAM$ = "WR.STR/1//EOS/":GOSUB 50000
9190 PARAM$ = "RD.STR/1//EOS/":GOSUB 50000
9200 PARAM$ = "RD.STR/1//EOS/":GOSUB 50000
9205 TIMEDELAY(2)
9210 DO 2 TIMES
9220   PARAM$ = "RD.STR/1//EOS/":GOSUB 50000
9230   Temp! = VAL(MID$(DATA_STRING$,2))
9240   IF Temp!=> Temp_wanted! - Delta_temp! AND Temp! <=Temp_wanted! +
Delta_temp! THEN EXIT TO,9300
9250   TIMEDELAY (1)
9260 REPEAT
9270 Cryostat% = 0
9275 Test_Passed% = 0
9280 IF Temp!< Temp_wanted!-2 OR Temp!>Temp_wanted!+2 THEN GOSUB 9500
9290 GOTO 9130
9299 STOP
9300 Test_Passed% = Test_Passed% + 1
9310 IF Test_Passed% > 1 THEN GOTO 9400
9320 TIMEDELAY(35)
9330 GOTO 9130
9400 LOCATE 1,30:PRINT SPC(79)
9410 COLOR 5,0:LOCATE 1,59:PRINT "Sample Temperature"
9415 COLOR 4,0:LOCATE 2,65:PRINT Parameter!(25,4)
9417 ACTUALTEMP=Temp!
9420 COLOR 2,0
9430 Cryostat% = 1
9440 RETURN
9499 STOP
9500 REM
9501 REM ************************************************************
9502 REM *                                                          *
9503 REM *   This subroutine checks the Cold Head to make sure its  *
9504 REM *   not overheating.                                       *
9505 REM *                                                          *
9506 REM ************************************************************
9507 REM
9510 IF Cryostat% = 0 THEN GOTO 9540
9520 LOCATE 14,1:PRINT SPC(79)
9530 COLOR 2,0:LOCATE 14,30:PRINT "Checking Cold Finger"
9540 DATA_STRING$ = "P"
9550 PARAM$ = "WR.STR/1//EOS/":GOSUB 50000
9555 Sensor1$ = "31"
9560 DATA_STRING$ = Temp_wanted$ + Int_Gain$ + Sensor1$ + Heater$ + "505"
9570 PARAM$ = "WR.STR/1//EOS/":GOSUB 50000
9580 DATA_STRING$ = "R"
9590 PARAM$ = "WR.STR/1//EOS/":GOSUB 50000
9595 TIMEDELAY(3)
9600 DO 5 TIMES
```

```
 9610  PARAM$ = "RD.STR/7//EOS/":GOSUB 50000
 9620  Temp! = VAL(MID$(DATA_STRING$,2))
 9630  IF Temp! > 325 AND Temp! < 900 THEN GOTO 9700
 9640 REPEAT
 9650 IF Cryostat% = 0 THEN GOTO 9670
 9660 LOCATE 14,1:PRINT SPC(79):LOCATE 14,1
 9670 RETURN
 9699 STOP
 9700 REM
 9701 REM ************************************************************
 9702 REM *                                                          *
 9703 REM *   This subroutine is used if the Cold Finger overheats.  *
 9704 REM *   It writes death parameters to the Cryostat and gives    *
 9705 REM *   a warning message.                                     *
 9706 REM *                                                          *
 9707 REM ************************************************************
 9708 REM
 9710 DATA_STRING$ = "P"
 9720 PARAM$ = "WR.STR/7//EOS/":GOSUB 50000
 9730 DATA_STRING$ = "00210000000001117501"
 9740 PARAM$ = "WR.STR/7//EOS/":GOSUB 50000
 9750 DATA_STRING$ = "R"
 9760 PARAM$ = "WR.STR/7//EOS/":GOSUB 50000
 9770 PARAM$ = "RD.STR/7//EOS/":GOSUB 50000
 9780 CLS:COLOR 2,0:LOCATE 11,21
 9790 PRINT "The ";
 9800 COLOR 19,0:PRINT "COLD FINGER";
 9810 COLOR 2,0
 9820 PRINT " has ";
 9830 COLOR 20,0:PRINT "Overheated"
 9840 LOCATE 14,16:COLOR 7,0
 9850 PRINT "PLEASE CHECK FOR DAMAGE AND CONTACT ERIC COLE"
 9860 LOCATE 16,12:COLOR 1,0:PRINT "ALSO TURN THE HEATER SWITCH ABOVE
THE CONTROLLER OFF"
 9870 CLEAR
 9880 GOTO 9880
 9999 STOP
10000 REM
10001 REM ************************************************************
10002 REM *                                                          *
10003 REM *   This subroutine run the experiment [either C-t (1) or  *
10004 REM *   G-t (2)] specified by l%.  It stores the data in the    *
10005 REM *   file C:\DATA\##\?-t where ? is C or G respectively      *
10006 REM *                                                          *
10007 REM ************************************************************
10008 REM
10010 IF Expt%(26) = 1 OR Expt%(26) = 3 THEN GOTO 10030
10020 IF Parameter!(L%,4) <> Parameter!(25,4) GOTO 10500
10030 IF L% = 1 THEN GOTO 10080
10040 Function$ = "FN6"
10050 Name$ = "\G-t"
```

```
10060 Moniker$ = "CONDUCTANCE"
10070 GOTO 10110
10080 Function$ = "FN5"
10090 Name$ = "\C-t"
10100 Moniker$ = "CAPACITANCE"
10110 OPEN "C:\DATA\" + File$ + Name$ FOR APPEND AS #1
10120 LOCATE 14,20:PRINT "Taking ";Moniker$;" vs. TIME Measurements"
10130 Pulsevolt! = Parameter!(L%,21)
10140 DATA_STRING$ = "M4CT0T1W1HIL" + STR$(Pulsevolt!) + "VLOL" +
STR$(Parameter!(L%,24)) + "VD0"
10150 PARAM$ = "WR.STR/13//EOS/":GOSUB 50000
10160 PARAM$ = "RD.STR/13//EOS/":GOSUB 50000
10170 Bias! = Parameter!(L%,17)
10180 Time! = Parameter!(L%,14)
10190 IF Time! <= 0.01 THEN GOSUB 10580:GOTO 10220
10200 IF Time! < 10.1 * Parameter!(L%,13) AND Time! < .1 THEN GOSUB 10580:GOTO
10220
10210 GOSUB 10650
10220 N% = 1
10230 PRINT #1,Xtemp$;Parameter!(25,4)";"ACTUALTEMP
10240 PRINT #1,"TIME = ";Timerun!;"  (";TIMER;" )"
10250 PRINT #1,"BIAS = ";Bias!
10260 PRINT #1,"HIGH PULSE = ";Pulsevolt!
10270 PRINT #1,"HOLD TYME = ";Time!
10280 PARAM$ = "RD.STR/17//EOS/":GOSUB 50000
10290 NCM% = INSTR(DATA_STRING$,"M") + 1
10300 Cdata! = VAL(MID$(DATA_STRING$,NCM%))
10310 T% = INSTR(DATA_STRING$,"T") + 1
10320 Xdata! = VAL(MID$(DATA_STRING$,T%))
10330 PRINT #1,Cdata!;",";Xdata!
10340 N% = N% + 1
10350 IF N% <= Parameter!(L%,20) THEN GOTO 10280
10360 PRINT #1,"END"
10370 IF Parameter!(L%,15) = 0 OR Parameter!(L%,16) = 0 THEN GOTO 10400
10380 Time! = Time! + Parameter!(L%,16)
10390 IF Time! <= Parameter!(L%,15) THEN GOTO 10190
10400 IF Parameter!(L%,18) = 0 OR Parameter!(L%,19) = 0 THEN GOTO 10430
10410 Bias! = Bias! + Parameter!(L%,19)
10420 IF Bias! <= Parameter!(L%,18) THEN GOTO 10180
10430 IF Parameter!(L%,23) = 0 THEN GOTO 10460
10440 Pulsevolt! = Pulsevolt! + Parameter!(L%,23)
10450 IF Pulsevolt! <= Parameter!(L%,22) THEN GOTO 10140
10460 Parameter!(L%,4) = Parameter!(L%,4) + Parameter!(L%,3)
10470 CLOSE #1
10480 DATA_STRING$ = "BL0"
10490 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
10500 REM
10540 IF Parameter!(L%,4) < Parameter!(25,4) THEN Parameter!(L%,4) = Parameter!(L%,3) +
Parameter!(L%,4)
10550 IF Parameter!(L%,4) > Parameter!(L%,2) THEN Parameter!(L%,4) = 600
10560 PARAM$ = "SDC/13,17/":GOSUB 50000
```

```
10570 RETURN
10579 STOP
10580 REM
10581 REM ************************************************************
10582 REM *                                                          *
10583 REM *   This subroutine is used if the step delay time and     *
10584 REM *   hold times does require the meter to be put into       *
10585 REM *   block mode.                                            *
10586 REM *                                                          *
10587 REM ************************************************************
10588 REM
10590 DATA_STRING$ = Function$ + "CN13TR3LE2SA1PC" + STR$(Bias!) + ";PN" +
STR$(Parameter!(L%,20)) + ";PH" + STR$(Time!) + ";PT" + STR$(Parameter!(L%,13)) +
";BL1;SW1"
10600 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
10610 TIMEDELAY(10)
10620 DATA_STRING$ = "BD"
10630 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
10640 RETURN
10649 STOP
10650 REM
10651 REM ************************************************************
10652 REM *                                                          *
10653 REM *   This subroutine is used if the step delay time and     *
10654 REM *   hold times do not require the meter to be put into     *
10655 REM *   block mode.                                            *
10656 REM *                                                          *
10657 REM ************************************************************
10658 REM
10660 DATA_STRING$ = Function$ + "CN13TR3LE2SA1PC" + STR$(Bias!) + ";PN" +
STR$(Parameter!(L%,20)) + ";PH" + STR$(Time!) + ";PT" + STR$(Parameter!(L%,13)) +
";SW1"
10670 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
10680 RETURN
10999 STOP
11000 REM
11001 REM ************************************************************
11002 REM *                                                          *
11003 REM *   This subroutine runs the C-G-V experiment and stores   *
11004 REM *   the data in the file "\DATA\##\CGV".                    *
11005 REM *                                                          *
11006 REM ************************************************************
11007 REM
11010 IF Expt%(26) = 1 OR Expt%(26) = 3 THEN GOTO 11030
11020 IF Parameter!(3,4) <> Parameter!(25,4) GOTO 11310
11030 OPEN "C:\DATA\" + File$ + "\CGV" FOR APPEND AS #1
11040 PRINT #1,Xtemp$;Parameter!(25,4)";"ACTUALTEMP
11050 PRINT #1,"TIME = ";Timerun!;"  (";TIMER;")"
11060 LOCATE 14,10:PRINT "taking CAPACITANCE AND CONDUCTANCE vs. VOLTAGE
measurements"
11070 N% = 6
```

```
11080 M% = 6
11090 N% = N% + 1
11100 M% = M% + 2
11110 IF Parameter!(3,M%+1) = 0 THEN GOTO 11270
11120 DATA_STRING$ = "FN1CN10IB2LE2TR3PS" + STR$(Parameter!(3,N%)) + ";PP" +
STR$(Parameter!(3,M%)) + ";PE" + STR$(Parameter!(3,M%+1)) + ";PL" +
STR$(Parameter!(3,14)) + ";PD" + STR$(Parameter!(3,13)) + ";SW1"
11130 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
11140 L! = Parameter!(3,N%)
11150 PARAM$ = "RD.STR/17//EOS/":GOSUB 50000
11160 NCM% = INSTR(DATA_STRING$,"M") + 1
11170 Cdata! = VAL(MID$(DATA_STRING$,NCM%))
11180 NGM% = INSTR(DATA_STRING$,"GM") + 2
11190 Gdata! = VAL(MID$(DATA_STRING$,NGM%))
11200 V% = INSTR(DATA_STRING$,"V") + 1
11210 Xdata! = VAL(MID$(DATA_STRING$,V%))
11220 PRINT #1,Cdata!;",";Gdata!;",";Xdata!
11240 IF L! < Parameter!(3,M%) THEN L! = L! + Parameter!(3,M%+1): GOTO 11150
11250 DATA_STRING$ = "SW0"
11260 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
11270 IF N% = 7 THEN GOTO 11090
11280 Parameter!(3,4) = Parameter!(3,4) + Parameter!(3,3)
11290 PRINT #1,"END"
11300 CLOSE #1
11310 REM
11350 IF Parameter!(3,4) < Parameter!(25,4) THEN Parameter!(3,4) = Parameter!(3,4) +
Parameter!(3,3)
11360 IF Parameter!(3,4) > Parameter!(3,2) THEN Parameter!(3,4) = 600
11370 PARAM$ = "SDC/17/":GOSUB 50000
11380 RETURN
11999 STOP
12000 REM
12001 REM ************************************************************
12002 REM *                                                          *
12003 REM *   This section takes the C-G readings and puts them in    *
12004 REM *   file \DATA\##\CG"                                      *
12005 REM *                                                          *
12006 REM ************************************************************
12007 REM
12010 IF Expt%(26) = 1 OR Expt%(26) = 3 THEN GOTO 12030
12020 IF Parameter!(4,4) <> Parameter!(25,4) THEN GOTO 12250
12030 OPEN "C:\DATA\" + File$ + "\CG" FOR APPEND AS #1
12040 Bias! = Parameter!(4,17)
12050 LOCATE 14,15:PRINT "taking CAPACITANCE AND CONDUCTANCE measurements"
12060 DATA_STRING$ = "FN1CN10IB1RA1MS3SL2LE2TR3PV" + STR$(Bias!)
12070 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
12072 DATA_STRING$ ="VO1"
12074 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
12080 PRINT #1,Xtemp$;Parameter!(25,4)";"ACTUALTEMP
12090 PRINT #1,"TIME = ";Timerun!;"  (";TIMER;" )"
12100 PRINT #1,"BIAS = ";Bias!
```

```
12105 TIMEDELAY(5)
12110 DATA_STRING$ ="EX"
12120 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
12130 PARAM$ = "RD.STR/17//EOS/":GOSUB 50000
12140 NCM% = INSTR(DATA_STRING$,"M") + 1
12150 Cdata! = VAL(MID$(DATA_STRING$,NCM%))
12160 NGM% = INSTR(DATA_STRING$,"GM") + 2
12170 Gdata! = VAL(MID$(DATA_STRING$,NGM%))
12180 PRINT #1,Cdata!","Gdata!","ACTUALTEMP
12185 DATA_STRING$ ="VO0"
12187 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
12190 IF Parameter!(4,19) = 0 THEN GOTO 12220
12200 Bias! = Bias! + Parameter!(4,19)
12210 IF Bias! <= Parameter!(4,18) THEN GOTO 12060
12220 Parameter!(4,4) = Parameter!(4,4) + Parameter!(4,3)
12225 TIMEDELAY(10)
12230 CLOSE #1
12240 PARAM$ = "SDC/17/":GOSUB 50000
12250 REM
12290 IF Parameter!(4,4) < Parameter!(25,4) THEN Parameter!(4,4) = Parameter!(4,4) +
Parameter!(4,3)
12300 IF Parameter!(4,4) > Parameter!(4,2) THEN Parameter!(4,4) = 600
12310 PARAM$ = "SDC/17/":GOSUB 50000
12320 RETURN
12999 STOP
13000 REM
13001 REM ************************************************************
13002 REM *                                                          *
13003 REM *  This is the subroutine for actually running the I-V     *
13004 REM *  experiment.  It stores the data in the file             *
13005 REM *  \DATA\##\IV                                            *
13006 REM *                                                          *
13007 REM ************************************************************
13008 REM
13010 IF Expt%(26) = 1 OR Expt%(26) = 3 THEN GOTO 13030
13020 IF Parameter!(1,4) <> Parameter!(25,4) THEN GOTO 13290
13030 OPEN "C:\DATA\" + File$ + "\IV" FOR APPEND AS #1
13040 LOCATE 14,20:PRINT "taking CURRENT vs. VOLTAGE measurements"
13050 PRINT #1,Xtemp$;Parameter!(25,4)";"ACTUALTEMP
13060 PRINT #1,"TIME = ";Timerun!;"  (";TIMER;" )"
13070 M% = 7
13080 N% = 8
13085 X$ = STR$(VAL(STR$(Parameter!(1,N% + 1))))
13090 DATA_STRING$ = "F2I2L3PS" + STR$(Parameter!(1,M%)) + ";PT" +
STR$(Parameter!(1,N%)) + ";PE" + X$ + ";PH" + STR$(Parameter!(1,14)) + ";PD" +
STR$(Parameter!(1,13)) + ";W1"
13100 TIMEDELAY(1)
13110 PARAM$ = "WR.STR/5//EOS/":GOSUB 50000
13120 B% = 0
13130 PARAM$ = "RD.STR/5//EOS/":GOSUB 50000
13140 NCM% = INSTR(DATA_STRING$,"I") + 1
```

```
13150 Idata! = VAL(MID$(DATA_STRING$,NCM%))
13160 V% = INSTR(DATA_STRING$,"A") + 1
13170 Xdata! = VAL(MID$(DATA_STRING$,V%))
13180 PRINT #1,Idata!","Xdata!
13190 B% = INSTR(DATA_STRING$,"L")
13200 IF B% = 0 THEN GOTO 13130
13210 TIMEDELAY(2)
13215 PARAM$ = "RD.STR/5//EOS/":GOSUB 50000
13220 IF Parameter!(1,11) = 0 THEN GOTO 13260
13230 M% = M% + 1
13240 N% = N% + 2
13250 IF M% = 8 THEN GOTO 13085
13260 Parameter!(1,4) = Parameter!(1,4) + Parameter!(1,3)
13270 PRINT #1,"END"
13280 CLOSE #1
13290 REM
13330 IF Parameter!(1,4) < Parameter!(25,4) THEN Parameter!(1,4) = Parameter!(1,4) +
Parameter!(1,3)
13340 IF Parameter!(1,4) > Parameter!(1,2) THEN Parameter!(1,4) = 600
13350 PARAM$ = "SDC/5/":GOSUB 50000
13360 RETURN
13999 STOP
14000 REM
14001 REM ***************************************************************
14002 REM *                                                             *
14003 REM *  This actually runs the Capacitance vs. Voltage             *
14004 REM *  experiment.                                                *
14005 REM *                                                             *
14006 REM ***************************************************************
14007 REM
14010 IF Expt%(26) = 1 OR Expt%(26) = 3 THEN GOTO 14030
14020 IF Parameter!(2,4) <> Parameter!(25,4) THEN GOTO 14210
14030 OPEN "C:\DATA\" + File$ + "\CV" FOR APPEND AS #1
14040 LOCATE 14,18:PRINT "taking CAPACITANCE vs. VOLTAGE measurements"
14050 B% = 0
14060 PRINT #1,Xtemp$;Parameter!(25,4)";"ACTUALTEMP
14070 PRINT #1,"TIME = ";Timerun!;"  (";TIMER;" )"
14080 DATA_STRING$ = "F3I2L3PS" + STR$(Parameter!(2,7)-Parameter!(2,9)) +";PT" +
STR$(Parameter!(2,8)+Parameter!(2,9)) + ";PE" + STR$(Parameter!(2,9)) + ";PV" +
STR$(Parameter!(2,12)) + ";PH" + STR$(Parameter!(2,14)) + ";W1"
14090 PARAM$ = "WR.STR/5//EOS/":GOSUB 50000
14100 PARAM$ = "RD.STR/5//EOS/":GOSUB 50000
14110 NCM% = INSTR(DATA_STRING$,"C") + 1
14120 Cdata! = VAL(MID$(DATA_STRING$,NCM%))
14130 V% = INSTR(DATA_STRING$,"A") + 1
14140 Xdata! = VAL(MID$(DATA_STRING$,V%))
14150 PRINT #1,Cdata!","Xdata!
14160 B% = INSTR(DATA_STRING$,"L")
14170 IF B% = 0 THEN GOTO 14100
14180 Parameter!(2,4) = Parameter!(2,4) + Parameter!(2,3)
14190 PRINT #1,"END"
```

```
14200 CLOSE #1
14210 REM
14250 IF Parameter!(2,4) < Parameter!(25,4) THEN Parameter!(2,4) = Parameter!(2,4) +
Parameter!(2,3)
14260 IF Parameter!(2,4) > Parameter!(2,2) THEN Parameter!(2,4) = 600
14270 PARAM$ = "SDC/5/":GOSUB 50000
14280 RETURN
14999 STOP
15000 REM
15001 REM ************************************************************
15002 REM *                                                          *
15003 REM *   This subroutine runs the Van der Pauw/Mobility         *
15004 REM *   experiment and stores it in the file MOB.              *
15005 REM *                                                          *
15006 REM ************************************************************
15007 REM
15009 IF Print_temp% = 1 THEN CLEARSCREEN(1)
15010 COLOR 2,0:LOCATE 14,20
15020 PRINT "taking Van der Pauw/Mobility Measurements"
15030 OPEN "\DATA\" + File$ + "\MOB" FOR APPEND AS #1
15032 DO
15035   IF Print_temp% <> 2 THEN EXIT 1 LEVELS
15040   PRINT #1,Xtemp$;Parameter!(25,4)";"ACTUALTEMP
15050   PRINT #1,"TIME = ";Timerun!;"  (";TIMER;" )"
15055 END DO
15060 DATA_STRING$ = "FN1CN10IB2TR3PS-10;PP10;PE.01;PL2;PD2"
15070 PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
15078 DATA_STRING$ = "L3;"
15079 PARAM$ = "WR.STR/5//EOS/":GOSUB 50000
15089 DATA_STRING$ = "R0" + CHR$(13) + "X"
15090 PARAM$ = "WR.STR/16//EOS/":GOSUB 50000
15092 TIMEDELAY(15)
15095 DATA_STRING$ = "Z1" + CHR$(13) + "X"
15096 PARAM$ = "WR.STR/16//EOS/":GOSUB 50000
15100 FOR M% = 1 TO Print_temp%
15110   DATA_STRING$ = "F2RA1I2J0A3B2L3PS0;PT10;PE0.01;PH1;PD.1;W2"
15120   PARAM$ = "WR.STR/5//EOS/":GOSUB 50000
15130   DO 1000 TIMES
15140     DATA_STRING$ = "W6"
15150     PARAM$ = "WR.STR/5//EOS/":GOSUB 50000
15160     TIMEDELAY (2)
15170     PARAM$ = "RD.STR/5//EOS/":GOSUB 50000
15180     CURRENT! = VAL(MID$(DATA_STRING$,4))
15190     VOLT! = VAL(MID$(DATA_STRING$,16))
15200     IF CURRENT! => Parameter!(1,17) THEN EXIT
15210   REPEAT
15211   DATA_STRING$ = "S1" + CHR$(13) + "X"
15212   PARAM$ = "WR.STR/16//EOS/":GOSUB 50000
15235   TIMEDELAY(10)
15237   PARAM$ = "RD.STR/16//EOS/":GOSUB 50000
15240   VOLT2! = VAL(MID$(DATA_STRING$,5))
```

```
15250   PRINT #1,M%;",";CURRENT!;",";VOLT!;","VOLT2!
15260   IF M% = 1 AND Print_temp%=2 THEN DATA_STRING$ = "SW1" ELSE
DATA_STRING$ = "SW0"
15270   PARAM$ = "WR.STR/17//EOS/":GOSUB 50000
15280   DATA_STRING$ = "W7"
15290   PARAM$ = "WR.STR/5//EOS/":GOSUB 50000
15300   IF M% = 1 AND Print_temp% = 2 THEN TIMEDELAY (20):DATA_STRING$ = "Z1"
+ CHR$(13) + "X":PARAM$ = "WR.STR/16//EOS/":GOSUB 50000:TIMEDELAY(15)
15310 NEXT M%
15320 PRINT #1,"END"
15330 CLOSE #1
15340 PARAM$ = "SDC/5,16,17/":GOSUB 50000
15350 RETURN
16000 REM
16001 REM ************************************************************
16002 REM *                                                          *
16003 REM *   This section takes the RES readings and puts them in   *
16004 REM *   file \DATA\##\RES"                                     *
16005 REM *                                                          *
16006 REM ************************************************************
16007 REM
16030 OPEN "C:\DATA\" + File$ + "\RES" FOR APPEND AS #1
16040 Bias! = Parameter!(1,17)
16050 LOCATE 14,17:PRINT "taking 4-POINT RESISTIVITY measurements"
16080 PRINT #1,Xtemp$;Parameter!(25,4)";"ACTUALTEMP
16090 PRINT #1,"TIME = ";Timerun!;"  (";TIMER;" )"
16100 PRINT #1,"BIAS = ";Bias!
16110 DATA_STRING$ = "R0" + CHR$(13) + "X"
16120 PARAM$ = "WR.STR/16//EOS/":GOSUB 50000
16130 TIMEDELAY(5)
16140 PARAM$ = "RD.STR/16//EOS/":GOSUB 50000
16150 VOLT2! = VAL(MID$(DATA_STRING$,5))
16180 PRINT #1,VOLT2!","VOLT2!","ACTUALTEMP
16225 TIMEDELAY(1)
16230 CLOSE #1
16240 PARAM$ = "SDC/16/":GOSUB 50000
16320 RETURN
16999 STOP
39999 STOP
40000 REM
40001 REM ************************************************************
40002 REM *                                                          *
40003 REM *   This stops the program after a successful run.         *
40004 REM *                                                          *
40005 REM ************************************************************
40006 REM
40010 IF Expt%(26) <> 3 THEN GOSUB 41500
40020 IF Expt%(25) = 1 THEN RESTORE,60210
40030 IF Expt%(25) = 2 THEN RESTORE,60220
40040 IF Expt%(25) = 3 THEN RESTORE,60230
40050 IF Expt%(25) = 4 THEN RESTORE,60240
```

```
40060 IF Expt%(25) = 5 THEN RESTORE,60250
40070 IF Expt%(25) = 6 THEN RESTORE,60260
40080 IF Expt%(25) = 7 THEN RESTORE,60270
40090 IF Expt%(25) = 8 THEN RESTORE,60280
40100 IF Expt%(25) = 9 THEN RESTORE,60290
40110 IF Expt%(25) = 10 THEN RESTORE,60300
40200 FOR M% = 1 TO Group%(Expt%(25))
40210   READ Name$
40220   IF Expt%(M%) = 0 THEN GOTO 40260
40230   OPEN "\DATA\" + File$ + "\" + Name$ FOR APPEND AS #1
40240   PRINT #1,"END"
40250   CLOSE #1
40260 NEXT M%
41000 REM
41001 REM ************************************************************
41002 REM *                                                          *
41003 REM *   This section                                           *
41004 REM *   finds out whether the user wants to                    *
41005 REM *   another experimental run.                              *
41006 REM *                                                          *
41007 REM ************************************************************
41008 REM
41010 PARAM$ = "ABORT/":GOSUB 50000
41030 CLS:COLOR 10,0,0:LOCATE 12,5
41040 INPUT "Do you want to run another set of experiments (Defaults to No)";Chk$
41050 IF Chk$ = "Y" OR Chk$ = "y" THEN GOTO 41060 ELSE GOTO 41100
41060 OPEN "\DATA\REDO" FOR OUTPUT AS #1
41070 PRINT #1,File$
41080 CLOSE #1
41100 CLS
41110 SYSTEM
41499 STOP
41500 REM
41501 REM ************************************************************
41502 REM *                                                          *
41503 REM *   This subroutine gives the Cryostat default parameters  *
41504 REM *   when the program RUNIT is finished.                    *
41505 REM *                                                          *
41506 REM ************************************************************
41507 REM
41510 DATA_STRING$ = "P"
41520 PARAM$ = "WR.STR/7//EOS/":GOSUB 50000
41530 DATA_STRING$ = "00210000000001117501"
41540 PARAM$ = "WR.STR/7//EOS/":GOSUB 50000
41550 DATA_STRING$ = "R"
41560 PARAM$ = "WR.STR/7//EOS/":GOSUB 50000
41570 PARAM$ = "RD.STR/7//EOS/":GOSUB 50000
41580 RETURN
41999 STOP
42000 REM
42001 REM ************************************************************
```

```
42003 REM *                                                    *
42004 REM *  This is the ERROR handling routines.  It checks to see  *
42005 REM *  what error is and attempts to fix it.                  *
42006 REM *                                                    *
42007 REM ************************************************************
42008 REM
42010 IF ERR = 1008 THEN RESUME
42020 PRINT"Sorry the main program is bombing.  This is the error ";ERR
42030 PRINT "The line number is ";ERL
42040 STOP
60000 REM
60001 REM ************************************************************
60002 REM *                                                    *
60003 REM *  This data statement tells the program how many        *
60004 REM *  experiments exist in each group.                      *
60005 REM *                                                    *
60006 REM ************************************************************
60007 REM
60010 DATA 4,4,2,1,2
60099 STOP
60100 REM
60101 REM ************************************************************
60102 REM *                                                    *
60103 REM *  This data statement stores what type of temperature    *
60104 REM *  it is in the string XTEMP$.                           *
60105 REM *                                                    *
60106 REM ************************************************************
60107 REM
60110 DATA "TTEMP = ","LTEMP = ","RTEMP = "
60199 STOP
60200 REM
60201 REM ************************************************************
60202 REM *                                                    *
60203 REM *  These data statements are used to print the word "END"  *
60204 REM *  in each of the data files to show where the file quits. *
60205 REM *                                                    *
60206 REM ************************************************************
60207 REM
60210 DATA "C-T","G-T","CGV","CG"
60220 DATA "IV","CV"
60230 DATA "MOB"
60240 DATA "RES"
60250 DATA ""
60260 DATA ""
60270 DATA ""
60280 DATA ""
60290 DATA ""
60300 DATA ""
60400 REM
60410 DATA 24
62000 REM
```

```
62010 DATA "CABLE 1 to Va","CABLE 2 to I high","CABLE 3 to V- of the Keithley","CABLE 4
to V+ of the Keithley","I low to Ground"
62020 DATA "CABLE 1 to V- of the Keithley","CABLE 2 to I high","CABLE 3 to Va","CABLE 4
to V+ of the Keithley","I low to Ground"
62030 DATA "CABLE 1 to Va","CABLE 2 to V+ of the Keithley","CABLE 3 to I high","CABLE
4 to V- of the Keithley","I low to Ground"

ENDFILE
```

GRAPHICS

```
SOURCE
PRECISION= 7
AUTODEF=ON
OPTION BASE=1
ERL=ON
ERRORMODE=LOCAL
RESUME=LINE
FORMODE=BB
SCOPE=ON
PROCS=49
STRING ARRAY(5,24)[32]: Graph_name$
STRING ARRAY(2,2)[5]: Directory$
STRING ARRAY(2)[20]: Tyme$,Temp$,Bias$,Hold$,Rate$,Slope$,Y_int$,X_int$
STRING ARRAY(2)[20]: Range$
STRING ARRAY(2)[20]: Correlation$,Pulse$
STRING ARRAY(2)[3]: Temp_type$
INTEGER ARRAY(5): Maxloop%
INTEGER ARRAY(2): Max_graph_points%
BYTE ARRAY(4003): Menu1,Menu2,Menu3,Menu4
BYTE ARRAY(10): Plus
REAL ARRAY(2,2,1200): Graph!
REAL ARRAY(2): X_int!,Y_int!,Slope!,Correlation!
REAL ARRAY(2): Min!,Max!
INTEGER: Rownumber%,Col%,Menu_chosen%,Graph_chosen%,Error%,Minloop%,Print_it%
INTEGER:
Which_graph%,Graph_type%,M%,N%,Next_screen%,Choice%,Comp_graph%,Graph%
INTEGER:
File%,Graph_pick%,ID%,Print_out%,Info_pointer%,Max_graph_number%,Pointer%,Return%
INTEGER: Position%
REAL: MinX!,MaxX!,MinY!,Q!,K!,E_sub_S!,Area!,Slope!
REAL: AeA!,Vf!,If!,Min!,Max!,Y_int!,X_int!,Graph!
REAL: MaxY!,Temp_sought!,Time_sought!,Dummy!,DeltaX!,DeltaY!,Y_plot!,X_plot!
REAL: Mintyme!,Maxtyme!,Bias_sought!,Pulse_sought!,Hold_sought!,Temp!,Y!,Nc!
REAL: Nd!,X!,E_sub_O!,Elec_thick!,I!,V1!,V2!,R1!
REAL: R2!,G!,Eric!
STRING: File$[5],Xtitle$[77],Ytitle$[77],A$[3],Check$[3],Temp_found$[25]
STRING:
Time_found$[16],Bias_found$[12],Pulse_found$[17],Hold_found$[33],Name$[30],Save_file$[40],Are
a$[16],Nd$[16]
STRING: V$[?]
INTEGER: Counter%,Skip%
STRING ARRAY(12)[32]: Hand_info$
INTEGER: Run_type%
STRING ARRAY(2)[18]: GRange$
INTEGER: Minloop1%,Maxloop%
STRING: Change$[?],Fit$[?],Symbol$[?]
INTEGER: Error_LS%
STRING: Title$[?],Dummy$[?],I$[?]
INTEGER: Max_graph_points%
STRING ARRAY(?): Ra$
STRING: V1$[?],V2$[?]
```

```
REAL: Power!
INTEGER: Pen_selected%
STRING: Bias$[?],Line_type[5],Line_type$[16],SYMBOLS$[?]
STRING ARRAY(5)[16]: SYMBL$
STRING ARRAY(5)[16]: LINETYPE$
INTEGER ARRAY(8): PEN
REAL: X_plot1!,Y_plot1!
INTEGER: Graph1or2%,G1,G2,G
INTEGER: Onoff
STRING: SOURCE$[16]
REAL: N,T,Voltage,In,Volts,O
INTEGER ARRAY(?): Skippoint%
REAL ARRAY(?): Plot!
INTEGER: O%,P%
INTEGER ARRAY(?): Min%
INTEGER: Min%
REAL: Thick!,GW
STRING: HG$[?]
REAL: CF
INTEGER: MOD,GFLAG,Saveflag
STRING: SPEED$[5]

PROCEDURE: TITLE()
  STRING ARG: Title$
END PROCEDURE

PROCEDURE: MENU()
  STRING ARG: Name$
  INTEGER ARG: Number%
  INTEGER ARG: Rownumber%/VAR
END PROCEDURE

PROCEDURE: FINISH()
  STRING ARG: Title$
  INTEGER ARG: Rownumber%/VAR,Col%/VAR
  INTEGER ARG: Number%
END PROCEDURE

PROCEDURE: BORDER()
  INTEGER ARG: Rownumber%/VAR
END PROCEDURE

PROCEDURE: CLEARSCREEN()
  INTEGER ARG: Row%
END PROCEDURE

PROCEDURE: DIRECTORY()
  STRING ARG: File$
  INTEGER ARG: Dir1or2%,Graph1or2%
  INTEGER ARG: Error%/VAR
END PROCEDURE
```

```
PROCEDURE: TIMEDELAY()
  REAL ARG: Delay!/OPT=5!
END PROCEDURE

PROCEDURE: XTITLE()
  STRING ARG: Title$
  REAL ARG: Min!,Max!
END PROCEDURE

PROCEDURE: YTITLE()
  STRING ARG: Title$
  REAL ARG: Min!,Max!
END PROCEDURE

PROCEDURE: LEASTSQUARES()
  INTEGER ARG: Which_graph%
  REAL ARG: Min!/VAR,Max!/VAR,Slope!/VAR,Correlation!/VAR,X_int!/VAR,Y_int!/VAR
  INTEGER ARG: Skip%
  INTEGER ARG: Error_LS%/VAR
END PROCEDURE

PROCEDURE: RUNTYPE()
  INTEGER ARG: Graph1or2%,Skip%
END PROCEDURE

PROCEDURE: DELTAMULTIPLY()
  INTEGER ARG: Graph1or2%,XorY%
  REAL ARG: Amount!
END PROCEDURE

PROCEDURE: DELTAln()
  INTEGER ARG: Graph1or2%,XorY%
  REAL ARG: Amount!
END PROCEDURE

PROCEDURE: DATARETRIEVAL()
  INTEGER ARG: Graph_chosen%,Graph1or2%,File%
  INTEGER ARG: Error%/VAR
  INTEGER ARG: Run_type%
END PROCEDURE

PROCEDURE: DATAPRINT
END PROCEDURE

PROCEDURE: PARAMETERSET()
  INTEGER ARG: Graph_type%
END PROCEDURE

PROCEDURE: PLOTTING_POINTS()
  STRING ARG: Symbol$
  INTEGER ARG: Graph1or2%,Print_out%
```

```
END PROCEDURE

PROCEDURE: GETDATA()
  INTEGER ARG: Graph%
END PROCEDURE

PROCEDURE: PLOTTERAXES()
  STRING ARG: Title$
END PROCEDURE

PROCEDURE: SAVEDATA()
  INTEGER ARG: Graph%
END PROCEDURE

PROCEDURE: LOADDATA()
  INTEGER ARG: Graph%
END PROCEDURE

PROCEDURE: INVERSEPOWER()
  INTEGER ARG: Graph1or2%,Xory%
  REAL ARG: Amount!,Power!
END PROCEDURE

PROCEDURE: MAINKEY
END PROCEDURE

PROCEDURE: PLOTTER
END PROCEDURE

PROCEDURE: MODIFY
END PROCEDURE

PROCEDURE: COLORS
END PROCEDURE

PROCEDURE: SYMBOLS
END PROCEDURE

PROCEDURE: LINES
END PROCEDURE

PROCEDURE: Info
END PROCEDURE

PROCEDURE: CAPTION
END PROCEDURE

PROCEDURE: Fixpoints
  INTEGER ARG: Type%
  REAL ARG: Plotit!
  REAL ARG: Plt!/VAR,Plt1!/VAR
```

```
END PROCEDURE

PROCEDURE: Cleargraph
  INTEGER ARG: G1orG2
END PROCEDURE

PROCEDURE: CLRGRPH
END PROCEDURE

PROCEDURE: ADDNUM
END PROCEDURE

PROCEDURE: Mltnum
END PROCEDURE

PROCEDURE: POWER
END PROCEDURE

PROCEDURE: NATLOG
END PROCEDURE

PROCEDURE: EXPNT
END PROCEDURE

PROCEDURE: ABSLT
END PROCEDURE

PROCEDURE: DELPT
END PROCEDURE

PROCEDURE: ADDPT
END PROCEDURE

PROCEDURE: SPEED
END PROCEDURE


PROCEDURE: TITLE
  INTEGER: Col%
  EXTERNAL: G1,G2,GRAPH%,GFLAG
    100 CLS:COLOR 5,0
    104 SET CURSOR 0,70:COLOR 2,7:PRINT GFLAG:COLOR 5,0
    105 SET CURSOR 0,74:COLOR 8,7:PRINT G1;G2:COLOR 5,0
    110 Col% = CINT((80-LEN(Title$))/2)
    120 SET CURSOR 0,Col%
    130 PRINT Title$
END PROCEDURE

PROCEDURE: MENU
  INTEGER: M%,Placement%,Row%,Col%
  STRING: Number$[5]
```

```
    90 COLOR 3,0
    95 IF Number% = 1 THEN Row% = -1
   100 FOR M% = 1 TO 4
   110   IF Number% <= M% * 24 THEN EXIT
   120 NEXT M%
   130 Placement% = Number% - (M%-1)*25
   140 IF Number% > 24 THEN Placement% = Placement% + M% - 1
   150 Number$ = STR$(Number%)
   160 DEL$(Number$,1,1)
   170 IF Placement% < 13 THEN Col% = 5 ELSE Col% = 42
   180 IF Placement% = 13 THEN Row% = 0 ELSE Row% =Row% + 1
   190 SET CURSOR Row% + 4,Col%
   200 PRINT "(";Number$;") ";Name$
   210 IF Rownumber% < CSRLIN THEN Rownumber% = CSRLIN
   220 COLOR 7,0
   230 EXIT
END PROCEDURE

PROCEDURE: FINISH
  STRING: Number$[5]
   100 COLOR 3,0
   110 Rownumber% = Rownumber%
   120 Number$ = STR$(Number%)
   130 DEL$(Number$,1,1)
   140 IF Col% = 0 THEN Col% = CINT((73 - LEN(Title$))/2)
   150 SET CURSOR Rownumber%,Col%
   160 PRINT "(";Number$;") ";Title$
   170 Col% = 0
   180 COLOR 7,0
   190 EXIT
END PROCEDURE

PROCEDURE: BORDER
  INTEGER: M%
   100 COLOR 2,0
   110 SET CURSOR 2,1
   120 PRINT "*************************************************************";
   130 PRINT "********************"
   140 Rownumber% = Rownumber% + 1
   150 FOR M% = 3 TO Rownumber%
   160   SET CURSOR M%,1
   170   PRINT "*"
   180   SET CURSOR M% ,79
   190   PRINT "*"
   200 NEXT M%
   210 Rownumber% = Rownumber% + 1
   220 SET CURSOR Rownumber%,1
   230 PRINT "*************************************************************";
   240 PRINT "********************"
   250 Rownumber% = 0
   260 COLOR 7,0
```

```
    270 EXIT
END PROCEDURE

PROCEDURE: CLEARSCREEN
  INTEGER: M%
    100 FOR M% = Row% TO 23
    110   SET CURSOR M%,0
    120   PRINT SPC(80)
    130 NEXT M%
    140 EXIT
END PROCEDURE

PROCEDURE: DIRECTORY
  INTEGER: M%,Start%,Comp_graph%
  EXTERNAL: Directory$()
  STRING: Number$[8]
  INTEGER: N%,Stop%
  REAL: M
  STRING: A$[16]
  EXTERNAL: SOURCE$

  PROCEDURE: TIMEDELAY
  END PROCEDURE

  PROCEDURE: TIMEDELAY
    REAL: Time!
      100 Time! = TIMER + 4
      110 IF TIMER < Time! THEN GOTO 110
      120 EXIT
      130 END
  END PROCEDURE
    90 CLOSE
   100 ON ERROR GOTO 10000
   110 Start% = 1
   115 Stop% = 1
   120 Error% = 0
   131 SET CURSOR 4,6:COLOR 7,0
   133 INPUT"IS THE DATA SOURCE C OR B DRIVE";SOURCE$
   134 SOURCE$=UPPER$(SOURCE$)
   140 FOR M% = Start% TO Stop%
   141   FOR N% = 5+2*M% TO 23
   142     LOCATE N%,1:PRINT SPC(79)
   143   NEXT N%
   170   CLEAR (ERR)
   180   COLOR 2,0:SET CURSOR 5 + 2*M%,6
   190   PRINT "Enter the data source directory number (OR SAMPLE/RUN#)";
   200   INPUT Directory$(Graph1or2%,M%)
   210   IF Directory$(Graph1or2%,1) = "" AND Comp_graph% = 0 THEN GOTO 170
   230   IF INSTR(SOURCE$,"B")=0 THEN OPEN "\DATA\" +  Directory$(Graph1or2%,M%)
+ File$ FOR INPUT AS #M% ELSE OPEN "B:" + File$ +"."+Directory$(Graph1or2%,M%)
FOR INPUT AS M%
```

```
    240 NEXT M%
    245 Directory$(Graph1or2%,2) = "NO"
    250 Comp_graph% = 1
    260 EXIT
    270 STOP
  10000 REM
  10010 COLOR 7,0:SET CURSOR 20,5
  10020 IF ERR = 1001 AND M% = 1 AND Comp_graph% = 0 THEN GOSUB
10500:RESUME,260
  10030 IF ERR = 1001 AND M% = 1 AND Comp_graph% = 1 THEN GOSUB
10600:RESUME,110
  10040 IF ERR = 1001 AND M% = 2 THEN GOSUB 10600:RESUME,120
  10050 IF ERR = 1007 THEN GOSUB 10700:RESUME,120
  10300 PRINT "THIS IS AN UNEXPECTED ERROR IN PROCEDURE DIRECTORY IN
LINE ";ERL;"AND ERROR NUMBER";ERR
  10310 STOP
  10500 REM
  10510 PRINT "The graph you asked for does not exist in the directory chosen."
  10520 SET CURSOR 21,5:PRINT "Please choose another graph."
  10530 TIMEDELAY
  10540 Error% = 1
  10550 RETURN
  10600 REM
  10610 PRINT "The graph you asked for does not exist in the directory chosen."
  10620 SET CURSOR 21,5:PRINT "Please choose another directory."
  10630 TIMEDELAY
  10640 Start% = M%
  10650 RETURN
  10700 REM
  10710 PRINT "The directory you asked for does not exist."
  10720 SET CURSOR 21,5:PRINT "Please choose another directory."
  10730 TIMEDELAY
  10740 Start% = M%
  10750 RETURN
END PROCEDURE

PROCEDURE: TIMEDELAY
  REAL: Waiting!,Waiting
    100 Waiting! = TIMER + Delay!
    110 IF TIMER < Waiting! THEN GOTO 110
    120 EXIT
END PROCEDURE

PROCEDURE: XTITLE
  INTEGER: Col%,M%
    100 ON ERROR GOTO 10000
    110 LOCATE 22,4:PRINT USING "#.##^^^^";Min!
    120 LOCATE 22,72:PRINT USING "#.##^^^^";Max!
    150 DRAW "BM105,163 D3 BR57 U3 BR57 D3 BR57 U3 BR57 D3 BR57 U3 BR57 D3
BR57 U3 BR57 D3 BR57 U150 BD150 L570"
    155 DO 1 TIMES
```

```
    160  DO 1 TIMES
    170    IF ABS(Min!) <> Max! THEN EXIT
    180    LOCATE 22,42:PRINT "0"
    185    EXIT 2 LEVELS
    190  REPEAT
    200  DO 1 TIMES
    210    IF (Max! - Min!) MOD (10) <> 0 THEN EXIT
    220    FOR M% = 1 TO 9
    230      LOCATE 22,5 + M%*7.5
    240      IF M% + Min! = 0 THEN EXIT
    250    NEXT M%
    260    IF M% < 10 THEN PRINT "0"
    270  REPEAT
    275 REPEAT
    280 Col% = CINT((79 - LEN(Title$))/2)
    290 LOCATE 23,Col%:PRINT Title$
    300 EXIT
  10000 REM
  10010 VIEW:SCREEN 0,0,0:COLOR 7,0:SET CURSOR 12,5
  10020 PRINT "Sorry the procedure XTITLE is bombing.  This is error number ";ERR;" from
line number ";ERL
  10030 STOP
END PROCEDURE

PROCEDURE: YTITLE
  INTEGER: Max%,Row%,M%
  STRING: Y$[3]
    100 ON ERROR GOTO 10000
    110 DRAW "BM48,15 R570 BL570 BD15 R3 BD15 L3 BD15 R3 BD15 L3 BD15 R3 BD15
L3 BD15 R3 BD15 L3 BD15 R3 BD15 BL3 U150"
    120 Max% = LEN(Title$)
    130 Row% = CINT((23 - Max%)/2) - 2
    135 IF Row% < 0 THEN Row% = 0
    137 IF Max% > 23 THEN Max% =23
    140 FOR M% = 1 TO Max%
    150   Y$ = MID$(Title$,M%,1)
    160   SET CURSOR Row% + M%,0:PRINT Y$
    170 NEXT M%
    180 SET CURSOR 1,0:PRINT USING "#.##^^^^";Max!
    190 SET CURSOR 20,0:PRINT USING "#.##^^^^";Min!
    200 EXIT
  10000 CLS:VIEW:SCREEN 0,0,0:COLOR 7,0:SET CURSOR 11,5
  10010 PRINT "The Xrocedure YTITLE is ^Ambing.  This is error ";ERR;" from line ";ERL
  10020 STOP
END PROCEDURE

PROCEDURE: LEASTSQUARES
  EXTERNAL: Graph!(),Max_graph_points%()
  INTEGER: Minloop%,Maxloop%,M%,Total_samples%
  REAL: SumX2!,SumY2!,SumXY!,SumX!
  REAL: SumY!,TotalX2!,TotalY2!,Xmean!,Ymean!,Sxx!,Syy!,Sxy!
```

```
  INTEGER: Chich_graph%
  REAL: Min1!,Max1!
  INTEGER: N%
  REAL: XTOTAL!,YTOTAL!
  STRING: Min1$[?],Max1$[?]
  INTEGER: Minloop1%,Step%,Maxloop1%
  STRING ARRAY(?): SLOPE$,X_INT$,Y_INT$
  STRING ARRAY(?): RANGE$,CORRELATION$,GRANGE$
  REAL#: Corelation!
    80 Error_LS% = 0
    90 ON ERROR GOTO 60000
    95 Minloop1% = 1: Maxloop1% = Max_graph_points%(Which_graph%):Step% = 1
   100 CLEAR
(SumX2!,SumY2!,SumX!,SumY!,SumXY!,Sxx!,Syy!,Sxy!,Xmean!,Ymean!,XTOTAL!,YTOTAL!)
   105 IF Skip% = 1 THEN GOTO 165
   107 GOSUB 20000
   110 COLOR 2,0:SET CURSOR 13,1
   120 INPUT "Over What X-axis range do you want your least square fit
(min,max)";Min1$,Max1$
   125 Min1! = VAL(Min1$) : Max1! = VAL(Max1$)
   130 GOSUB 20000
   135 DO
   140   SET CURSOR 13,32
   150   PRINT "Now LOADING data"
   160 END DO
   165 IF Graph!(Which_graph%,1,Max_graph_points%(Which_graph%)) <
Graph!(Which_graph%,1,1) THEN Minloop1% =
Max_graph_points%(Which_graph%):Maxloop1% = 1 :Step% = -1
   168 Min! = Min1! : Max! = Max1!
   170 FOR M% = Minloop1% TO Maxloop1% STEP Step%
   180   IF Graph!(Which_graph%,1,M%) => Min1! THEN EXIT
   190 NEXT M%
   200 Minloop% = M%
   210 FOR M% = Minloop1% TO Maxloop1% STEP Step%
   220   IF Graph!(Which_graph%,1,M%) => Max1! THEN EXIT
   230 NEXT M%
   240 Maxloop% = M%
   300 FOR M% = Minloop% TO Maxloop% STEP Step%
   310   SumX2! = SumX2! + Graph!(Which_graph%,1,M%) ^ 2.0
   320   SumY2! = SumY2! + Graph!(Which_graph%,2,M%) ^ 2.0
   330   SumXY! = SumXY! + Graph!(Which_graph%,1,M%) * Graph!(Which_graph%,2,M%)
   340   SumX! = SumX! + Graph!(Which_graph%,1,M%)
   350   SumY! = SumY! + Graph!(Which_graph%,2,M%)
   360 NEXT M%
   400 DO
   410   TotalX2! = SumX! * SumX!
   420   TotalY2! = SumY! * SumY!
   430   Total_samples% = Maxloop% - Minloop% + 1
   440   Xmean! = SumX!/Total_samples%
   450   Ymean! = SumY!/Total_samples%
   460   Sxx! = SumX2! - TotalX2!/Total_samples%
```

```
    470   Syy! = SumY2! - TotalY2!/Total_samples%
    480   Sxy! = SumXY! - (SumX! * SumY!)/Total_samples%
    490 END DO
    600 DO
    610   Slope! = Sxy!/Sxx!
    620   Correlation! = Sxy!/SQR(Sxx! * Syy!)
    630   Y_int! = Ymean! -(Slope! * Xmean!)
    640   X_int! = -1 * (Y_int! / Slope!)
    650 END DO
    660 Min! = Min1! : Max! = Max1!
    700 EXIT
  10010 STOP
  20000 DO
  20010   FOR N% = 3 TO 23
  20020     LOCATE N%,1 : PRINT SPC(79)
  20030   NEXT N%
  20035 END DO
  20040 RETURN
  60000 IF ERR < 2 AND ERR > 3 THEN GOSUB 20000 ELSE GOTO 62000
  60010 COLOR 7,0 : SET CURSOR 13,1
  60999 COLOR 7,0 : SET CURSOR 13,1
  61000 PRINT "The proc^Aure LEASTSQUARES is boXbing.  ThXs is erro^A";ERR;" from
line ";ERL
  61010 FOR M% = -30000 TO 30000 : NEXT M%
  61020 Error_LS% = 1
  61030 EXIT
  62000 Slope!=0:Correlation!=0:Y_int!=0:X_int!=0
  62010 EXIT
END PROCEDURE

PROCEDURE: RUNTYPE
  STRING: Check$[10]
  INTEGER: M%
  EXTERNAL: Temp_sought!,Time_sought!,Temp_type$()
  STRING: T$[10]
    100 DO
    110   FOR M% = 2 TO 23
    120     LOCATE M%,1:PRINT SPC(79)
    130   NEXT M%
    140   COLOR 2,0,0:SET CURSOR 5,6
    150   INPUT "Enter the Type of Temperature run (T,L,R)";Temp_type$(Graph1or2%)
    160   Temp_type$(Graph1or2%) = UPPER$(Temp_type$(Graph1or2%))
    170   IF INSTR(Temp_type$(Graph1or2%),"L") <> 0 THEN EXIT
    200   IF INSTR(Temp_type$(Graph1or2%),"R") <> 0 THEN EXIT TO,400
    210   IF INSTR(Temp_type$(Graph1or2%),"T") <> 0 THEN EXIT TO,600
    220 REPEAT
    300 DO
    305   IF Skip% = 1 THEN EXIT
    310   SET CURSOR 7,6
    320   INPUT "Enter the Temperature at which to read the data";Temp_sought!
    330 END DO
```

```
    400 DO
    410   COLOR 7,0,0:SET CURSOR 22,6
    420   INPUT "Do you want to change any of the above (Defaults to NO)";Check$
    430   Check$ = UPPER$(Check$)
    440   IF INSTR(Check$,"Y") <> 0 THEN EXIT TO,100
    450 END DO
    500 EXIT
    600 DO
    605   IF Skip% = 1 THEN EXIT 1 LEVELS
    610   SET CURSOR 7,6
    620   INPUT "Enter the time at which to read the data(min)";T$
    625   Temp_sought!=CINT(60*VAL(T$))
    630   EXIT TO,400
    640 END DO
    650 EXIT TO,400
END PROCEDURE

PROCEDURE: DELTAMULTIPLY
  EXTERNAL: Graph!(),Max_graph_points%(),Miny!,Maxy!,Minx!,Maxx!
  INTEGER: M%,Xor%
  REAL: Min!,Max!
  EXTERNAL: G1,G2
    10 DO
    15   IF G1=1 AND Graph1or2% = 2 THEN EXIT 1 LEVELS
    20   DO
    25     IF XorY% = 2 THEN EXIT 1 LEVELS
    30     Minx! = 1E+29 : Maxx! = -1E+29
    35     EXIT 2 LEVELS
    37   END DO
    40   DO
    45     Miny! = 1E+29 : Maxy! = -1E+29
    50   END DO
    55 END DO
   100 DO
   120   Min! = 1E+26 : Max! = -1E+27
   130 END DO
   500 FOR M% = 1 TO Max_graph_points%(Graph1or2%)
   510   Graph!(Graph1or2%,XorY%,M%) = Graph!(Graph1or2%,XorY%,M%) * Amount!
   520   IF Min! > Graph!(Graph1or2%,XorY%,M%) THEN Min! =
Graph!(Graph1or2%,XorY%,M%)
   530   IF Max! < Graph!(Graph1or2%,XorY%,M%) THEN Max! =
Graph!(Graph1or2%,XorY%,M%)
   540 NEXT M%
   550 DO
   560   IF XorY% = 2 THEN EXIT 1 LEVELS
   570   IF Minx! > Min! THEN Minx! = Min!
   580   IF Maxx! < Max! THEN Maxx! = Max!
   590   EXIT 2 LEVELS
   600 END DO
   610 DO
   620   IF Miny! > Min! THEN Miny! = Min!
```

```
    630   IF Maxy! < Max! THEN Maxy! = Max!
    640 END DO
END PROCEDURE

PROCEDURE: DELTAln
  EXTERNAL: Graph!(),Max_graph_points%(),Minx!,Maxx!,Miny!,Maxy!
  REAL: Min!,Max!
  INTEGER: M%
  EXTERNAL: G1,G2
    100 DO
    110   DO
    120     IF G1=1 AND Graph1or2% = 2 THEN EXIT
    130     Min! = 1E+19
    140     Max! = -1E+29
    150     EXIT 2 LEVELS
    160   END DO
    170   DO
    180     IF XorY% = 2 THEN EXIT
    190     Min! = Minx!
    200     Max! = Maxx!
    210     EXIT 2 LEVELS
    220   END DO
    230   DO
    240     Min! = Miny!
    250     Max! = Maxy!
    260     EXIT 2 LEVELS
    270   END DO
    280 END DO
    300 FOR M% = 1 TO Max_graph_points%(Graph1or2%)
    310   DO
    320     DO
    330       IF Graph!(Graph1or2%,XorY%,M%) <> 0 THEN EXIT 1 LEVELS
    340       Graph!(Graph1or2%,XorY%,M%) = -1000
    350       EXIT 2 LEVELS
    360     END DO
    370     Graph!(Graph1or2%,XorY%,M%) =
LOG(ABS(Graph!(Graph1or2%,XorY%,M%))*Amount!)
    380   END DO
    390   IF Min! > Graph!(Graph1or2%,XorY%,M%) THEN Min! =
Graph!(Graph1or2%,XorY%,M%)
    400   IF Max! < Graph!(Graph1or2%,XorY%,M%) THEN Max! =
Graph!(Graph1or2%,XorY%,M%)
    410 NEXT M%
    500 DO
    510   DO
    520     IF XorY% = 2 THEN EXIT 1 LEVELS
    530     Minx! = Min!
    540     Maxx! = Max!
    550     EXIT 2 LEVELS
    560   END DO
    570   DO
```

```
    580     Miny! = Min!
    590     Maxy! = Max!
    600   END DO
    610 END DO
   1000 EXIT
END PROCEDURE

PROCEDURE: DATARETRIEVAL
  EXTERNAL:
Graph!(),Max_graph_points%(),Minx!,Maxx!,Miny!,Maxy!,Temp_sought!,Bias_found$
  EXTERNAL:
Hold_found$,Pulse_found$,Time_sought!,Bias_sought!,Pulse_sought!,Hold_sought!,Temp_type$(),
Temp_found$
  EXTERNAL: Time_found$
  INTEGER: Position%,Magnet_on%,Graph%,M%,N%
  STRING: Data1$[32],Data2$[32],Data3$[32]
  REAL: Min!,Max!
  REAL: X!,Y1!,Y2!,X1!,Tyme!,R31!,R32!,R3!
  REAL: Dummy!,Y1
  EXTERNAL: Mintyme!,Maxtyme!
  STRING: Magnet_on$[?],Dummy$[?],I$[?],V1$[?],Y1$[?]
  INTEGER: Pointer%
  REAL ARRAY(?): Graph
  EXTERNAL: G!,Elec_thick!
  INTEGER: Mistake%
  EXTERNAL: Menu_chosen%
    20 REM *   GRAPH_CHOSEN%                RUN_TYPE%
    30 REM *
    40 REM *   1 = C-t, G-t                0 = Normal Run
    41 REM *   2 = C-V, 1/C**2, 1/C**3        1 = Temp SCAN
    42 REM *   3 = G-V                      2 = Time SCAN
    43 REM *   4 = C-T
    44 REM *   5 = G-T
    45 REM *   6 = I-V
    46 REM *   7 = C-V, 1/C**2     (4140)
    47 REM *   8 = DLTS
    48 REM *   9 = MOB, Rho vs. Temp
    49 REM *  10 = MOB, Mu vs. Temp
    80 Error% = 0
    90 ON ERROR GOTO 50000
   100 DO
   110   ON Graph_chosen% GOTO 150,160,170,160,170,180,190,200,210,210
   120   CLS:COLOR 7,0,0:SET CURSOR 13,6
   130   PRINT "ERROR, the graph_chosen% variable is not defined in the procedure
dataretrieval"
   140   STOP
   150   Min! = 1E-15:Max! = 10E-03:EXIT
   160   Min! =-1E01 : Max! = 2E01 : EXIT
   170   Min! = 1E-08 : Max! = 10E-03 : EXIT
   180   Min! = -.020 : Max! = .020 : EXIT
   190   Min! = 1E-15 : Max! = 10E-06: EXIT
```

```
    200  Min! = 1E-15 : Max! = 2E-09 : N% = 0 : EXIT
    210  Min! = -100 : Max! = 100 : EXIT
    490 END DO
    500 DO
    510  DO
    520   DO 1 TIMES
    530    INPUT #File%,Temp_found$
    540    IF INSTR(Temp_found$,"END") <> 0 THEN Error% = 1:EXIT TO,60000
    550    IF INSTR(Temp_type$(Graph1or2%),"T") <> 0 OR
INSTR(Temp_type$(Graph1or2%),"R") <> 0 OR Graph_chosen% = 4 OR Graph_chosen% = 5
OR Graph_chosen% = 8 THEN EXIT 1 LEVELS
    560    Position% = INSTR(Temp_found$,"=") + 1
    570    IF VAL(MID$(Temp_found$,Position%)) <> Temp_sought! THEN EXIT 2
LEVELS
    580   REPEAT
    590   DO 1 TIMES
    600    INPUT #File%,Time_found$
    610    IF INSTR(Temp_type$(Graph1or2%),"T") = 0 OR Graph_chosen% = 4 OR
Graph_chosen% = 5 OR Graph_chosen% = 8 THEN EXIT 1 LEVELS
    620    Position% = INSTR(Time_found$,"=") + 1
    630    IF VAL(MID$(Time_found$,Position%)) <> Time_sought! THEN EXIT 2 LEVELS
    640   REPEAT
    650   DO 1 TIMES
    660    IF Graph_chosen% <> 1 AND Graph_chosen% <> 4 AND Graph_chosen% <> 5
AND Graph_chosen% <> 8 THEN EXIT 3 LEVELS
    670    INPUT #File%,Bias_found$
    680    Position% = INSTR(Bias_found$,"=") + 1
    690    IF VAL(MID$(Bias_found$,Position%)) <> Bias_sought! THEN EXIT 2 LEVELS
    700   REPEAT
    710   DO 1 TIMES
    720    IF Graph_chosen% <> 1 AND Graph_chosen% <> 8 THEN EXIT 3 LEVELS
    730    INPUT #File%,Pulse_found$
    740    Position% = INSTR(Pulse_found$,"=") + 1
    750    IF VAL(MID$(Pulse_found$,Position%)) <> Pulse_sought! THEN EXIT 2
LEVELS
    760   REPEAT
    770   DO 1 TIMES
    790    INPUT #File%,Hold_found$
    800    Position% = INSTR(Hold_found$,"=") + 1
    810    IF VAL(MID$(Hold_found$,Position%)) <> Hold_sought! THEN EXIT 2 LEVELS
    820    EXIT 3 LEVELS
    830   REPEAT
    875  REPEAT
    880  DO
    890   INPUT #File%,Data1$
    894   DO
    895    IF Graph_chosen% <> 4 AND Graph_chosen% <> 5 THEN EXIT 1 LEVELS
    896    INPUT #File%,Data1$,Data1$
    897    EXIT TO,100
    898   REPEAT
    900   IF INSTR(Data1$,"END") <> 0 THEN EXIT 1 LEVELS
```

```
 980  REPEAT
 990 REPEAT
2000 FOR M% = Max_graph_points%(Graph1or2%) TO 1200
2005  IF Graph_chosen% = 9 OR Graph_chosen% = 10 THEN INPUT #File%,Magnet_on$

2010  INPUT #File%,Data2$
2020  IF Graph_chosen% > 1 AND Graph_chosen% < 6 THEN INPUT #File%,Data3$
2025  IF Graph_chosen% = 9 OR Graph_chosen% = 10 THEN INPUT #File%,Data3$
2030  INPUT #File%,Data1$
2040  IF INSTR(Data1$,"END") <> 0 OR INSTR(Data2$,"END") <> 0 OR
INSTR(Data3$,"END") <> 0 THEN EXIT 1 LEVELS
2050  X! = VAL(Data1$)
2060  Y1! = VAL(Data2$)
2070  Y2! = VAL(Data3$)
2071  DO
2072   IF Graph_chosen% > 2 AND Graph_chosen% < 6 OR Graph_chosen% = 8 THEN
EXIT 1 LEVELS
2074   IF Y1! < Min! OR Y1! > Max! THEN EXIT TO,2005
2075  END DO
2076  DO
2077   IF Graph_chosen% <> 5 THEN EXIT 1 LEVELS
2078   IF Y2! < Min! OR Y2! > Max! THEN EXIT TO,100
2079  END DO
2080  DO
2081   IF Graph_chosen% <> 4 THEN EXIT 1 LEVELS : PRINT Y1!,2081
2082   IF Y1! < Min! OR Y1! > Max! THEN EXIT TO,100
2083  END DO
2084  DO
2085   IF Graph_chosen% <> 3 THEN EXIT 1 LEVELS
2086   IF Y2! < Min! OR Y2! > Max! THEN EXIT TO,2005
2087  END DO
2089  DO 1 TIMES
2090   ON Graph_chosen% GOTO 2100,2100,2200,2300,2300,2100,2100,2600,3000,3300
2100   DO
2110    Graph!(Graph1or2%,1,M%) = X!
2120    Graph!(Graph1or2%,2,M%) = Y1!
2130    EXIT 2 LEVELS
2140   REPEAT
2200   DO
2210    Graph!(Graph1or2%,1,M%) = X!
2220    Graph!(Graph1or2%,2,M%) = Y2!
2230    EXIT 2 LEVELS
2240   REPEAT
2300   REM
2310   DO
2400    Graph!(Graph1or2%,1,M%) = X!
2410    DO
2420     IF Graph_chosen% <> 4 THEN EXIT 1 LEVELS
2430     Graph!(Graph1or2%,2,M%) = Y1!
2440    END DO
2450    DO
```

```
  2460       IF Graph_chosen% <> 5 THEN EXIT 1 LEVELS
  2470       Graph!(Graph1or2%,2,M%) = Y2!
  2480     END DO
  2500     Max_graph_points%(Graph1or2%) = Max_graph_points%(Graph1or2%) + 1
  2520     EXIT 3 LEVELS
  2530   REPEAT
  2600   REM
  2610   DO 1 TIMES
  2620     IF X! <> Mintyme! THEN EXIT 1 LEVELS
  2630     DO
  2635       IF INSTR(Data2$,"END") <> 0 AND INSTR(Data1$,"END") <> 0 THEN EXIT
4 LEVELS
  2636       IF INSTR(Data2$,"END") <> 0 OR INSTR(Data1$,"END") <> 0 THEN EXIT
TO,100
  2640       IF Y1! > Min! AND Y1! < Max! THEN EXIT 1 LEVELS
  2650       INPUT #File%,Data2$,Data1$:Y1!=VAL(Data2$):EXIT TO,2630
  2670     REPEAT
  2680     Graph!(Graph1or2%,2,M%) = Y1!
  2690     N% = 2
  2700     EXIT TO,2010
  2710   REPEAT
  2750   DO 1 TIMES
  2760     IF X! <> Maxtyme! THEN EXIT 1 LEVELS
  2770     DO
  2780       IF Y1! > Min! AND Y1! < Max! THEN EXIT 1 LEVELS
  2790       INPUT #File%,Data2$:INPUT #File%,Data1$:Y1!=VAL(Data2$):GOTO 2770
  2810     REPEAT
  2820     Graph!(Graph1or2%,2,M%) = Graph!(Graph1or2%,2,M%) - Y1!
  2830     N% = 0
  2840     Max_graph_points%(Graph1or2%) = M% + 1
  2850     DO 1 TIMES
  2860       Position% = INSTR(Temp_found$,";") + 1
  2870       Graph!(Graph1or2%,1,M%) = VAL(MID$(Temp_found$,Position%))
  2880     REPEAT
  2890     DO
  2900       INPUT #File%,Data1$
  2910       IF INSTR(Data1$,"END") <> 0 THEN EXIT TO,4955
  2920     REPEAT
  2930   REPEAT
  2935   EXIT TO,2010
  3000   DO
  3010     DO
  3020       IF INSTR(Magnet_on$,"1") <> 0 THEN EXIT 1 LEVELS
  3030       INPUT #File%, Dummy$,Magnet_on$,Data2$,Data3$,Data1$
  3040     REPEAT
  3050     Y2! = VAL(Data3$)
  3060     Y1! = VAL(Data2$)
  3070     Graph!(Graph1or2%,2,M%) = Y2! / Y1! * (Elec_thick!/G!)
  3080     DO
  3090       IF INSTR(Temp_type$(Graph1or2%),"T") <> 0 THEN EXIT 1 LEVELS
  3100       Position% = INSTR(Temp_found$,";") + 1
```

```
3110      Graph!(Graph1or2%,1,M%) = VAL(MID$(Temp_found$,Position%))
3120      OPEN "\BUCKET" FOR APPEND AS #3
3130      PRINT #3,Graph!(Graph1or2%,2,M%)
3140      CLOSE #3
3150      EXIT TO,3700
3160    REPEAT
3170    DO
3180      Position% = INSTR(Time_found$,"=") + 1
3190      Graph!(Graph1or2%,1,M%) = VAL(MID$(Time_found$,Position%))
3191      OPEN "\BUCKET" FOR APPEND AS #3
3192      PRINT #3,Graph!(Graph1or2%,2,M%)
3193      CLOSE #3
3200      EXIT TO,3700
3210    REPEAT
3220  REPEAT
3300  DO
3310    DO
3320      IF INSTR(Magnet_on$,"2") <> 0 THEN Mistake% = 1 : EXIT TO,60000
3330      R31! = X!/Y1!
3340    END DO
3350    DO
3360      INPUT #File%,Magnet_on$,Data2$,Data3$,Data1$
3370      IF INSTR(Magnet_on$,"1") <> 0 THEN Mistake% = 1 : EXIT TO,60000
3380      X! = VAL(Data2$)
3390      Y1! = VAL(Data1$)
3400      R32! = Y1!/X!
3410    END DO
3420    DO
3430      R3! = ABS(R32! - R31!)
3440      Graph!(Graph1or2%,2,M%) = R3!/(Graph!(Graph1or2%,2,M%) * 3.4E-05)
3450    END DO
3460    DO
3470      DO
3480        IF INSTR(Temp_type$(Graph1or2%),"T") <> 0 THEN EXIT 1 LEVELS
3490        Position% = INSTR(Temp_found$,";") + 1
3500        Dummy! = VAL(MID$(Temp_found$,Position%))
3510        EXIT TO,3700
3520      REPEAT
3530      DO
3540        Position% = INSTR(Time_found$,"=") + 1
3550        Dummy! = VAL(MID$(Time_found$,Position%))
3560      END DO
3580      IF Dummy! <> Graph!(Graph1or2%,1,M%) THEN Mistake% = 2 : EXIT
TO,60000
3590      EXIT TO,3700
3600    REPEAT
3610  REPEAT
3700  DO
3710    DO
3720      INPUT #File%,Data1$
3730      IF INSTR(Data1$,"END") <> 0 THEN EXIT 1 LEVELS
```

```
3740      REPEAT
3800      DO
3810        INPUT #File%,Temp_found$
3820        IF INSTR(Temp_found$,"TEMP") <> 0 THEN EXIT 1 LEVELS
3830        IF INSTR(Temp_found$,"END") <> 0 THEN EXIT 4 LEVELS
3835      REPEAT
3840      INPUT #File%,Time_found$
3850      EXIT 1 LEVELS
4940    REPEAT
4950  REPEAT
4955  DO
4957    IF Graph_chosen% = 1 THEN EXIT 1 LEVELS
4958    IF Graph_chosen% = 2 THEN EXIT 1 LEVELS
4960    IF Minx! > Graph!(Graph1or2%,1,M%) THEN Minx! = Graph!(Graph1or2%,1,M%)
4970    IF Maxx! < Graph!(Graph1or2%,1,M%) THEN Maxx! = Graph!(Graph1or2%,1,M%)
4975    IF Miny! > Graph!(Graph1or2%,2,M%) THEN Miny! = Graph!(Graph1or2%,2,M%)
4980    IF Maxy! < Graph!(Graph1or2%,2,M%) THEN Maxy! = Graph!(Graph1or2%,2,M%)
4985    IF Graph_chosen% = 8 THEN EXIT TO,500
4987  END DO
4990 NEXT M%
5000 DO
5005  IF Graph_chosen% = 4 OR Graph_chosen% = 5 THEN EXIT TO,100
5010  IF Graph_chosen% < 9 OR Graph_chosen% > 10 THEN
Max_graph_points%(Graph1or2%) = M% - 1 ELSE Max_graph_points%(Graph1or2%) = M%
5020  IF Run_type% = 0 THEN EXIT 1 LEVELS
5030  DO
5040    IF Run_type% <> 1 THEN EXIT 1 LEVELS
5045    DO
5050      DO
5060        IF Graph_chosen% = 6 OR  Graph_chosen% > 8 THEN EXIT 1 LEVELS
5070        INPUT #File%,Data1$
5100      END DO
5130      IF INSTR(Data1$,"TEMP") = 0 THEN EXIT 1 LEVELS
5150      Position% = INSTR(Data1$,"=") + 1
5160      Temp_sought! = VAL(MID$(Data1$,Position%))
5170      EXIT 4 LEVELS
5180    REPEAT
5181    DO
5182      IF Graph_chosen% <> 2 THEN EXIT 1 LEVELS
5183      IF INSTR(Data3$,"TEMP") = 0 THEN EXIT 1 LEVELS
5184      Position% = INSTR(Data3$,"=") + 1
5185      Temp_sought! = VAL(MID$(Data3$,Position%))
5186      EXIT 4 LEVELS
5187    REPEAT
5190    IF Graph!(Graph1or2%,2,M%-1) = 0 THEN Error% = 1 : EXIT TO,50000
5200    Error% = 1 : EXIT 3 LEVELS
5210  REPEAT
5300  DO
5310    DO
5320      IF Graph_chosen% < 5 THEN EXIT 1 LEVELS
5330      INPUT #File%,Data1$
```

```
   5340    END DO
   5350    IF INSTR(Data1$,"TIME") = 0 THEN EXIT 1 LEVELS
   5360    Position% = INSTR(Data1$,"=") + 1
   5370    Time_sought! = VAL(MID$(Data1$,Position%))
   5380    EXIT 3 LEVELS
   5390  REPEAT
   5400  IF Graph!(Graph1or2%,2,M%-1) = 0 THEN Error% = 1 : EXIT TO,50000
   5410  Error% = 1 : EXIT 2 LEVELS
   5420 REPEAT
   5430 EXIT
  10000 EXIT
  50000 REM
  50010 COLOR 7,0,0:SET CURSOR 24,6
  50500 PRINT "The procedure DATARETRIEVAL is bombing.  This is error ";ERR;" from line
";ERL
  50510 STOP
  60000 REM
  60001 FOR M% = 2 TO 24
  60002   LOCATE M%,1 : PRINT SPC(79)
  60003 NEXT M%
  60010 IF Graph_chosen% = 4 AND Graph!(Graph1or2%,2,1) <> 0 THEN Error% =
0:Max_graph_points%(Graph1or2%) = Max_graph_points%(Graph1or2%) - 1 : EXIT
  60015 IF Graph_chosen% = 5 AND Graph!(Graph1or2%,2,1) <> 0 THEN Error% =
0:Max_graph_points%(Graph1or2%) = Max_graph_points%(Graph1or2%) - 1 : EXIT
  60020 IF Graph_chosen% = 8 AND Graph!(Graph1or2%,2,2) <> 0 THEN Error% =
0:Max_graph_points%(Graph1or2%) = Max_graph_points%(Graph1or2%) - 1
  60030 IF Graph_chosen% > 8 AND Graph_chosen% < 11 AND Graph!(Graph1or2%,2,1) <>
0 THEN Error% = 0
  60040 IF Mistake% = 1 THEN GOTO 60500
  60050 IF Mistake% = 2 THEN GOTO 60600
  60060 IF Graph_chosen% = 8 AND Graph!(Graph1or2%,2,1) <> 0 THEN Error% = 0 :
EXIT
  60070 IF Graph_chosen% = 6 AND Graph!(Graph1or2%,2,2) <> 0 THEN Error% = 0 :
EXIT
  60100 FOR N% = 2 TO 23
  60110   SET CURSOR 2,0 : PRINT SPC(80)
  60120 NEXT N%
  60130 COLOR 7,0 : SET CURSOR 13,6
  60140 PRINT "The parameters you have set are not in the directory chosen.  Please choose new
parameters"
  60150 Tyme! = TIMER + 5
  60160 IF Tyme! > TIMER THEN GOTO 60160
  60200 EXIT
  60500 DO
  60510   CLS : COLOR 2,0,0 : SET CURSOR 13,6
  60520   PRINT "The magnet data does not line up correctly.  This is a major bomb.  Sorry"
  60530   END
  60540 REPEAT
  60600 DO
  60610   CLS : COLOR 7,0,0 : SET CURSOR 13,6
  60620   PRINT "The temperature does not line up from the Rho to Mu data.  This is a major
```

```
bomb.  Sorry"
  60630   END
  60640 REPEAT
  61200 EXIT
END PROCEDURE

PROCEDURE: DATAPRINT
  INTEGER: N%
    50 FOR N% = 1 TO 23
    60   SET CURSOR N%,0 : PRINT SPC(80)
    70 NEXT N%
   100 COLOR 2,0:SET CURSOR 13,23
   110 PRINT "The ";
   120 COLOR 3,0:PRINT "DATA";
   130 COLOR 2,0:PRINT " is now being loaded"
   140 EXIT
END PROCEDURE

PROCEDURE: PARAMETERSET
  EXTERNAL: Bias_sought!,Hold_sought!,Pulse_sought!,Mintyme!,Maxtyme!
  INTEGER: M%,Row%
  REAL: L
  STRING: Check$[10],Dummy$[?],Dummy2$[?]
  REAL: Min!
  REAL#: Max!
    38 REM *   The numbers correspond to graph_type%
    39 REM *
    40 REM *   1 = C-t, G-t
    41 REM *   2 = C-G-V
    42 REM *   3 = C-G
    43 REM *   4 = DLTS
    44 REM *
   100 Row% = 2:GOSUB 10000
   110 COLOR 2,0,0
   120 Row% = 5
   200 DO 1 TIMES
   210   IF Graph_type% <> 1 AND Graph_type% <> 3 AND Graph_type% <> 4 THEN
EXIT L LEVELS
   220   SET CURSOR Row%,6
   230   INPUT "Enter the BIAS Voltage";Dummy$
   235   Bias_sought! = VAL(Dummy$)
   240   Row% = Row% + 2
   250 REPEAT
   300 DO 1 TIMES
   310   IF Graph_type% <> 1 AND Graph_type% <> 4 THEN EXIT 1 LEVELS
   320   SET CURSOR Row%,6
   330   INPUT "Enter the PULSE Voltage";Dummy$
   335   Pulse_sought! = VAL(Dummy$)
   340   Row% = Row% + 2
   350 REPEAT
   400 DO 1 TIMES
```

```
    410   IF Graph_type% <> 1 AND Graph_type% <> 4 THEN EXIT 1 LEVELS
    420   SET CURSOR Row%,6
    430   INPUT "Enter the HOLD Time in seconds";Dummy$
    435   Hold_sought! = VAL(Dummy$)
    440   Row% = Row% + 2
    450 REPEAT
    500 DO 1 TIMES
    510   IF Graph_type% <> 4 THEN EXIT 1 LEVELS
    520   SET CURSOR Row%,6
    530   INPUT "Enter the box car times in seconds (min,max)";Dummy$,Dummy2$
    535   Mintyme! = VAL(Dummy$) : Maxtyme! = VAL(Dummy2$)
    540   Row% = Row% + 2
    550 REPEAT
   8990 DO
   9000   COLOR 7,0,0:SET CURSOR 22,6
   9010   INPUT "Do you need to change any of the above (Defaults to NO)";Check$
   9020   Check$ = UPPER$(Check$)
   9030   IF INSTR(Check$,"Y") <> 0 THEN EXIT TO,100
   9040 END DO
   9050 EXIT
  10000 FOR M% = Row% TO 23
  10010   LOCATE M%,1:PRINT SPC(79)
  10020 NEXT M%
  10030 RETURN
END PROCEDURE

PROCEDURE: PLOTTING_POINTS
  EXTERNAL:
Graph!(),Minx!,Maxx!,Miny!,Maxy!,Max_graph_points%(),Info_pointer%,Directory$()
  EXTERNAL: Temp$(),Bias$(),Pulse$(),Hold$(),Tyme$(),Rate$(),Slope$(),X_int$()
  STRING: Line_type$[3],A$[3]
  INTEGER: N%,Y_pointer%
  EXTERNAL: Y_int$(),Range$(),Correlation$(),GRANGE$()
  REAL: X_factor!,Y_factor!,X!
  REAL: Y!
  STRING: Dummy$[?]
  EXTERNAL: Pen_selected%
  INTEGER: M%
  STRING: FUCK$[?]
  REAL: Ymin!,Xmin!
  EXTERNAL: G,SYMBL$(),LINETYPE$(),PEN()
  REAL ARRAY(?): LINETYPE
  EXTERNAL: ONOFF,SPEED$

  PROCEDURE: TIMEDELAY()
    REAL ARG: Delay!/OPT=1!
  END PROCEDURE

  PROCEDURE: CLEARSCREEN()
    INTEGER ARG: Line%
  END PROCEDURE
```

```
PROCEDURE: EDITDATA()
  STRING ARG: DUMMY$/VAR
END PROCEDURE

PROCEDURE: TIMEDELAY
  REAL: Tyme!
    100 Tyme! = TIMER + Delay!
    110 IF Tyme! > TIMER THEN GOTO 110
    120 EXIT
END PROCEDURE

PROCEDURE: CLEARSCREEN
  INTEGER: N%
    100 FOR N% = Line% TO 23
    110   LOCATE N%,1 : PRINT SPC(79)
    120 NEXT N%
    130 EXIT
END PROCEDURE

PROCEDURE: EDITDATA
  REAL: DUMMY!
  INTEGER: Position%,Sign%,N%
  STRING: Saver$[14]
  REAL: Saver!
  INTEGER: Position1%
  STRING: A$[3]
  REAL ARRAY(?): Sng
    50 OPEN "\CONVERT" FOR OUTPUT AS #1
    60 CLOSE #1
    80 IF INSTR(DUMMY$,"to") <> 0 THEN EXIT 1 LEVELS
    90 CLOSE #1
   100 OPEN "\CONVERT" FOR OUTPUT AS #1
   110 DO
   120   IF INSTR(DUMMY$,",") = 0 THEN EXIT 1 LEVELS
   130   DUMMY! = VAL(DUMMY$)
   135   Sign% = SGN(DUMMY!)
   137   Position1% = INSTR(DUMMY$,",")-1
   145   FOR N% = 1 TO 2
   160     DO
   185       IF Sign% = -1 THEN Position% = INSTR(DUMMY$,"-") ELSE Position% = 1
   200       Saver$ = MID$(DUMMY$,Position%,Position1%)
   210       PRINT #1 Saver$;
   220       IF N% = 1 THEN PRINT #1," to ";
   230       Position% = Position1% + 2
   235       Position1% = 20
   240     END DO
   320     DUMMY$ = MID$(DUMMY$,Position%)
   325     Sign% = SGN(VAL(DUMMY$))
   330   NEXT N%
   335   EXIT TO,5250
   350 REPEAT
```

```
400 DO
410   IF INSTR(DUMMY$,"X") = 0 THEN EXIT 1 LEVELS
420   PRINT #1,"X"
425   EXIT TO,5250
430 END DO
460 DUMMY! = VAL(DUMMY$)
470 Sign% = SGN(DUMMY!)
480 IF Sign% = -1 THEN DUMMY$ = " " + MID$(DUMMY$,INSTR(DUMMY$,"-")+1)
490 IF INSTR(DUMMY$,"E") <> 0 THEN GOTO 5180
491 DO
492   IF DUMMY! <> 0 THEN EXIT 1 LEVELS
493   PRINT #1,MID$(DUMMY$,INSTR(DUMMY$,"0"))
494   EXIT TO,5250
495 REPEAT
500 DO
510   IF DUMMY! > 10 OR DUMMY! < -10 THEN EXIT 1 LEVELS
520   IF Sign% = -1 THEN Saver$ = "-" + MID$(DUMMY$,2,4)
530   IF Sign% = 1 THEN Saver$ = MID$(DUMMY$,2,4)
540   PRINT #1,Saver$
550   EXIT TO,5250
560 REPEAT
600 DO
610   IF DUMMY! > 1000 OR DUMMY! < -1000 THEN EXIT 1 LEVELS
620   IF Sign% = -1 THEN Saver$ = "-" + MID$(DUMMY$,2,5)
630   IF Sign% = 1 THEN Saver$ = MID$(DUMMY$,2,5)
640   PRINT #1,Saver$
650   EXIT TO,5250
660 REPEAT
5000 DO
5010   DUMMY! = VAL(DUMMY$)
5020   Sign% = SGN(DUMMY!)
5030   IF INSTR(DUMMY$,"E") <> 0 THEN EXIT TO,5180
5040   DO
5050     IF DUMMY! > 10000 OR DUMMY! < -10000 THEN EXIT 1 LEVELS
5060     IF Sign% = -1 THEN Saver$ = "-" + MID$(STR$(ABS(DUMMY! - .00001)),2)
5070     IF Sign% = 1 THEN Saver$ = MID$(STR$(DUMMY! + .00001),2)
5080     PRINT #1 USING "\     \"Saver$
5090     EXIT 2 LEVELS
5100   REPEAT
5110   DO
5120     IF Sign% = -1 THEN Saver! = DUMMY! - 1
5130     IF Sign% = 1 THEN Saver! = DUMMY! + 1
5140     PRINT #1 USING "#.##^^^^"Saver!
5150     EXIT 2 LEVELS
5160   REPEAT
5170 REPEAT
5180 DO
5190   Position% = INSTR(DUMMY$,"E")
5192   Position1% = 4
5193   IF Position% < 5 THEN Position1% = Position%
5200   IF Sign% = 1 THEN Saver$ = MID$(DUMMY$,2,4) +
```

```
MID$(DUMMY$,Position%)
     5205   IF Sign% = -1 THEN Saver$ = "-" + MID$(DUMMY$,2,Position1%) +
MID$(DUMMY$,Position%)
     5210   PRINT #1,Saver$
     5220   CLOSE #1
     5230   EXIT TO,5250
     5240 REPEAT
     5250 CLOSE #1
     5260 OPEN "\CONVERT" FOR INPUT AS #1
     5265 CLEAR (DUMMY$)
     5270 INPUT #1,DUMMY$
     5280 CLOSE #1
     5290 KILL "\CONVERT"
     5300 EXIT
  END PROCEDURE
    70 CLOSE #3
    80 OPEN "COM1 : 9600,N,8,1,RS,CS65535,DS,CD" FOR OUTPUT AS #3
   200 DO
   210   X_factor! = (6634) / (Maxx! - Minx!)
   220   Y_factor! = (5969) / (Miny! - Maxy!)
   225   Ymin! = Miny!
   226   Xmin! = Minx!
   230 END DO
   950 DO
   955   CLEARSCREEN (2):SET CURSOR 0,70:COLOR 4,7:PRINT G
   960   COLOR 2,0,0 : SET CURSOR 13,32
   970   PRINT "PLOTTING POINTS"
   980 END DO
  1000 DO
  1010   PRINT #3,"IN ; IP381,1016,6350,7650 ; "
  1020   PRINT #3,"IW381,1016,6350,7650 ; "
  1030   PRINT #3,"SP"PEN(G)"; SI.2,.2 ; SM"SYMBL$(G)" ; LT"LINETYPE$(G)" ; DI 0,1 ;"
  1040 END DO
  1100 FOR N% = 1 TO Max_graph_points%(Graph1or2%) STEP 1
  1110   DO
  1120     X! = Graph!(Graph1or2%,1,N%) * X_factor! + 1016 - Xmin! * X_factor!
  1130     Y! = +Graph!(Graph1or2%,2,N%) * Y_factor! +6350 - Ymin! * Y_factor!
  1132     IF X! > 32767 OR X! < -32768 THEN EXIT TO,1210
  1133     IF Y! > 32767 OR Y! < -32768 THEN EXIT TO,1210
  1140   END DO
  1150   DO
  1160     IF N% <> 1 THEN EXIT 1 LEVELS
  1170     PRINT #3,"PA PU "Y!","X!" PD ;"
  1180   END DO
  1190   PRINT #3,,"PA "Y!","X!" ; PD ;"
  1200   IF VAL(SPEED$)=0 THEN TIMEDELAY(1) ELSE TIMEDELAY(VAL(SPEED$))
  1210 NEXT N%
  1220 IF ONOFF=0 THEN GOTO 4000
  2000 DO
  2010   Info_pointer% = Info_pointer% + 1
  2020   IF Info_pointer% > 5 THEN EXIT 1 LEVELS
```

```
2030  Y_pointer% = 1762 + 1179 * (Info_pointer% - 1)
2040  PRINT #3,"IW ; SM ; SP"PEN(G)" ; SI .16,.2 ; DR0,1 ; "
2050  DO
2060   PRINT #3,"PA PU 7754,"Y_pointer%" ; LB"SYMBL$(G) ; CHR$(3)
2065   TIMEDELAY(5)
2070  END DO
2080  DO
2090   PRINT #3,"PA PU 7954,"Y_pointer%" ; LB"Directory$(Graph1or2%,1);CHR$(3)
2095   TIMEDELAY(5)
2100   IF INSTR(Directory$(Graph1or2%,2),"NO") <> 0 THEN EXIT 1 LEVELS
2110   PRINT #3,"PA PU 7954,"Y_pointer%+480"; LB"Directory$(Graph1or2%,2); CHR$(3)
2115   TIMEDELAY(5)
2120  END DO
2130  DO
2133   Dummy$ = " " + Temp$(Graph1or2%)
2135   EDITDATA(Dummy$)
2140   PRINT #3,"PA PU 8154,"Y_pointer%" ; LB"Dummy$ ; CHR$(3)
2145   TIMEDELAY(5)
2150  END DO
2151  DO
2152   EDITDATA(Tyme$(Graph1or2%))
2153   PRINT #3,"pa pu 8354,"Y_pointer%" ; LB"Tyme$(Graph1or2%) ; CHR$(3)
2154   TIMEDELAY(5)
2155  END DO
2160  DO
2165   EDITDATA(Bias$(Graph1or2%))
2170   PRINT #3,"PA PU 8554,"Y_pointer%" ; LB"Bias$(Graph1or2%) ; CHR$(3)
2175   TIMEDELAY(5)
2180  END DO
2190  DO
2195   EDITDATA(Pulse$(Graph1or2%))
2200   PRINT #3,"PA PU 8754,"Y_pointer%" ; LB"Pulse$(Graph1or2%) ; CHR$(3)
2205   TIMEDELAY(5)
2210  END DO
2220  DO
2225   EDITDATA(Hold$(Graph1or2%))
2230   PRINT #3,"PA PU 8954,"Y_pointer%" ; LB"Hold$(Graph1or2%) ; CHR$(3)
2235   TIMEDELAY(5)
2240  END DO
2250  DO
2255   EDITDATA(Rate$(Graph1or2%))
2260   PRINT #3,"PA PU 9154,"Y_pointer%" ; LB"Rate$(Graph1or2%) ; CHR$(3)
2265   TIMEDELAY(5)
2270  END DO
2271  DO
2272   EDITDATA(GRANGE$(Graph1or2%))
2273   PRINT #3,"PA PU 9354,"Y_pointer%" ; LB"GRANGE$(Graph1or2%) ; CHR$(3)
2274   TIMEDELAY(5)
2275  END DO
2280  DO
2285   EDITDATA(Slope$(Graph1or2%))
```

```
 2290    PRINT #3,"PA PU 9554,"Y_pointer%" ; LB"Slope$(Graph1or2%) ; CHR$(3)
 2295    TIMEDELAY(5)
 2300  END DO
 2310  DO
 2315    EDITDATA(X_int$(Graph1or2%))
 2320    PRINT #3,"PA PU 9754,"Y_pointer%" ; LB"X_int$(Graph1or2%) ; CHR$(3)
 2325    TIMEDELAY(5)
 2330  END DO
 2340  DO
 2345    EDITDATA(Y_int$(Graph1or2%))
 2350    PRINT #3,"PA PU 9954,"Y_pointer%" ; LB"Y_int$(Graph1or2%) ; CHR$(3)
 2355    TIMEDELAY(5)
 2360  END DO
 2370  DO
 2375    EDITDATA(Range$(Graph1or2%))
 2380    PRINT #3,"PA PU 10154,"Y_pointer%" ; LB"Range$(Graph1or2%) ; CHR$(3)
 2385    TIMEDELAY(5)
 2390  END DO
 2400  DO
 2405    EDITDATA(Correlation$(Graph1or2%))
 2410    PRINT #3,"PA PU 10354,"Y_pointer%" ; LB"Correlation$(Graph1or2%) ; CHR$(3)
 2415    TIMEDELAY(5)
 2420  END DO
 3000 END DO
 4000 PRINT #3,"SP0 ; "
 4010 CLOSE #3
 4020 EXIT
30000 FOR N% = 2 TO 23
30010   LOCATE N%,1 : PRINT SPC(79)
30020 NEXT N%
30030 RETURN
END PROCEDURE

PROCEDURE: GETDATA
  EXTERNAL: Graph!(),Minx!,Maxx!,Miny!,Maxy!,Max_graph_points%()
  INTEGER: M%,N%
  REAL: Dummy,Dummy!
  EXTERNAL: G1,G2
   100 DO
   110   IF G1=1 AND Graph% <> 1 THEN EXIT 1 LEVELS
   120   Minx! = 1E+29
   130   Maxx! = -1E+29
   140   Miny! = 1E+29
   150   Maxy! = -1E+29
   160 END DO
   500 OPEN "\BUCKET" FOR INPUT AS #3
   510 FOR M% = 1 TO Max_graph_points%(Graph%)
   520   INPUT #3,Graph!(Graph%,1,M%) , Dummy!, Graph!(Graph%,2,M%)
   530   IF Minx! > Graph!(Graph%,1,M%) THEN Minx! = Graph!(Graph%,1,M%)
   540   IF Maxx! < Graph!(Graph%,1,M%) THEN Maxx! = Graph!(Graph%,1,M%)
   550   IF Miny! > Graph!(Graph%,2,M%) THEN Miny! = Graph!(Graph%,2,M%)
```

```
    560   IF Maxy! < Graph!(Graph%,2,M%) THEN Maxy! = Graph!(Graph%,2,M%)
    570 NEXT N%
   1000 KILL "\BUCKET"
END PROCEDURE

PROCEDURE: PLOTTERAXES
  EXTERNAL: Minx!,Miny!,Maxx!,Maxy!,Xtitle$,Ytitle$
  STRING: Grid$[7],Name$[80],Dummy$[16]
  REAL: Dummy!,Number!
  INTEGER: M%,Maxloop%,Y_POINTER%,X_POINTER%,N%,Mini_pads%
  EXTERNAL: ONOFF,Info_pointer%

  PROCEDURE: TIMEDELAY()
    REAL ARG: Delay!/OPT=10!
  END PROCEDURE

  PROCEDURE: CLEARSCREEN()
    INTEGER ARG: Line%
  END PROCEDURE

  PROCEDURE: EDITDATA()
    REAL ARG: DUMMY!
    STRING ARG: DUMMY$/VAR
  END PROCEDURE

  PROCEDURE: TIMEDELAY
    REAL: Tyme!
      100 Tyme! = TIMER + Delay!
      110 IF Tyme! > TIMER THEN GOTO 110
      120 EXIT
  END PROCEDURE

  PROCEDURE: CLEARSCREEN
    INTEGER: N%
      100 FOR N% = Line% TO 24
      110   LOCATE N%,1 : PRINT SPC(79)
      120 NEXT N%
      130 EXIT
  END PROCEDURE

  PROCEDURE: EDITDATA
    REAL: SAVER!
    INTEGER: Sign%
    STRING: Saver$[?]
    INTEGER: Position%,Position1%
    EXTERNAL: Mini_pads%
    REAL: DUMY!
       1 ON ERROR GOTO 1320
      100 CLOSE #1
      110 OPEN "\CONVERT" FOR OUTPUT AS #1
      111 DO
```

```
      112   IF DUMMY! <.999 AND DUMMY! > -.999 THEN EXIT 1 LEVELS
      113   IF DUMMY! > 10000 OR DUMMY! < -10000 THEN EXIT 1 LEVELS
      117   IF ABS(CINT(DUMMY!)-DUMMY!)<.0009 THEN
DUMY!=CINT(DUMMY!):DUMMY$=STR$(DUMY!):EXIT TO,130
      118 END DO
      120 DUMMY$ = STR$(DUMMY!)
      130 Sign% = SGN(DUMMY!)
      135 DO
      136   IF Sign% <> -1 THEN EXIT 1 LEVELS
      137   DUMMY$ = MID$(DUMMY$,INSTR(DUMMY$,"-"))
      138 END DO
      200 DO
      205   IF Mini_pads% = 1 THEN EXIT 1 LEVELS
      210   IF DUMMY! > .000999 OR DUMMY! < -.000999 THEN EXIT 1 LEVELS
      220   PRINT #1 USING "#.## ^ ^ ^ ^" VAL(DUMMY$)
      230   CLOSE #1
      240   EXIT TO,1250
      250 END DO
      500 DO
      510   IF DUMMY! > 10 OR DUMMY! < -10 THEN EXIT 1 LEVELS
      515   IF INSTR(DUMMY$,".0000") <> 0 THEN DUMMY$ = "0"
      520   Saver$ = MID$(DUMMY$,1,6)
      530   PRINT #1,Saver$
      540   EXIT TO,1250
      550 REPEAT
      560 DO
      570   IF DUMMY! > 1000 OR DUMMY! < -1000 THEN EXIT 1 LEVELS
      580   Saver$ = MID$(DUMMY$,1,6)
      590   PRINT #1,Saver$
      600   EXIT TO,1250
      610 REPEAT
      620 DO
      630   IF DUMMY! > 9999.99 OR DUMMY! < -9999.99 THEN EXIT 1 LEVELS
      640   Saver$ =  MID$(DUMMY$,1,6)
      650   PRINT #1,Saver$
      660   EXIT TO,1250
      670 REPEAT
     1000 DO
     1010   Position% = INSTR(DUMMY$,"E")
     1020   IF Position% = 0 THEN EXIT 1 LEVELS
     1025   DO
     1030     IF Position% <= 5 THEN EXIT 1 LEVELS
     1040     IF Sign% = -1 THEN Saver$ = MID$(DUMMY$,INSTR(DUMMY$,"-"),5) +
MID$(DUMMY$,Position%) ELSE Saver$ = MID$(DUMMY$,1,5) +
MID$(DUMMY$,Position%)
     1050     PRINT #1,Saver$
     1060     EXIT TO,1250
     1070   REPEAT
     1080   PRINT #1 USING "#.## ^ ^ ^ ^" DUMMY!
     1090   EXIT TO,1250
     1100 REPEAT
```

```
   1200 DO
   1210   SAVER! = VAL(DUMMY$)
   1220   PRINT #1 USING "#.##^^^^" SAVER!
   1230   EXIT TO,1250
   1240 REPEAT
   1250 CLOSE #1
   1260 OPEN "\CONVERT" FOR INPUT AS #1
   1270 INPUT #1,DUMMY$
   1280 CLOSE #1
   1290 KILL "\CONVERT"
   1300 IF INSTR(DUMMY$,"E+00") <> 0 THEN DUMMY$ = "0"
   1310 EXIT
   1320 PRINT "Error number "ERR" from line "ERL
   1330 STOP
END PROCEDURE
   90 Info_pointer%=0
  100 CLEARSCREEN(2)
  110 COLOR 2,0,0 : SET CURSOR 13,6
  120 INPUT "Do you want the grid plotted (Defaults to NO)";Grid$
  130 Grid$ = UPPER$(Grid$)
  140 CLEARSCREEN(12)
  150 COLOR 3,0,0 : SET CURSOR 13,36
  160 PRINT "PLOTTING"
  190 CLOSE #3
  200 DO
  210   OPEN "COM1 : 9600,N,8,1,RS,CS65535,DS,CD" FOR OUTPUT AS #3
  220   PRINT #3,"IN ; IP 381,1016,6350,7650 ; "
  230 END DO
  300 DO
  310   PRINT #3, " SP1 ; PA PU 381,1016 PD 381,7650,6350,7650,6350,1016,381,1016"
  320   PRINT #3, " ; PU ;"
  330   TIMEDELAY(5)
  340 END DO
  400 DO
  410   Y_POINTER% = CINT(1016 + (6634 - (LEN(Xtitle$) * 172)) / 2)
  420   PRINT #3, "SP2 ; SI.3,.3 ; DR 0,1 ;"
  430   PRINT #3, "PA PU 6858,"Y_POINTER%" ; LB"Xtitle$;CHR$(3)
  440   TIMEDELAY(7)
  450 END DO
  500 DO
  510   X_POINTER% = CINT(6340 - (5969 - (LEN(Ytitle$) * 172 )) / 2)
  520   PRINT #3,"SP2 ; SI.3,.3 ; DR-1,0 ; "
  530   PRINT #3,"PA PU "X_POINTER%",170 ; LB"Ytitle$;CHR$(3)
  540   TIMEDELAY()
  550 END DO
  600 DO
  610   Y_POINTER% = CINT(1016 + (6634 - (LEN(Title$) * 179)) / 2)
  620   PRINT #3, " SP1 ; SI.3,.3 ; DR0,1 ;"
  630   PRINT #3, "PA PU 254,"Y_POINTER%" ; LB"Title$;CHR$(3)
  640   TIMEDELAY()
  650 END DO
```

```
 700 DO
 710   PRINT #3,"SP1 ; TL.9 ;"
 720   FOR N% = 1 TO 9
 730     X_POINTER% = CINT(381 + N% * 597)
 740     PRINT #3, "PA PU "X_POINTER%",970 ; XT ;"
 750     TIMEDELAY(1)
 760   NEXT N%
 770   FOR N% = 1 TO 9
 780     Y_POINTER% = CINT(1016 + N% * 663)
 790     PRINT #3, "PA PU 6350, "Y_POINTER%" ; YT;"
 800     TIMEDELAY(1)
 810   NEXT N%
 820 END DO
 900 DO
 910   IF INSTR(Grid$,"Y") = 0 THEN EXIT 1 LEVELS
 920   PRINT #3,"LT1,0.5 ; SP2 ;"
 930   FOR N% = 1 TO 9
 940     X_POINTER% = CINT(381 + N% * 597)
 950     Y_POINTER% = CINT(1016 + N% * 663)
 960     PRINT #3, "PA PU "X_POINTER%",1016 PD "X_POINTER%",7650 ;"
 970     TIMEDELAY(25)
 980     PRINT #3, "PA PU 381,"Y_POINTER%" PD 6350,"Y_POINTER%" ;"
 990     TIMEDELAY(25)
1000   NEXT N%
1010 END DO
1200 DO
1210   PRINT #3,"SP2 ; SI.2,.2 ; DI0,1 ;"
1220   FOR N% = 0  TO 10 STEP 2
1225     IF Minx! > .00099 OR Minx! < -.00099 THEN Mini_pads% = 1 ELSE Mini_pads%
= 0
1230     Number! = Minx! + (Maxx! - Minx!) * (N% / 10)
1240     EDITDATA(Number!,Dummy$)
1250     Y_POINTER% = CINT(980 + N% * 663 - LEN(Dummy$)*36)
1260     IF N% = 10 THEN Y_POINTER% = CINT(7585 - LEN(Dummy$) * 72)
1270     PRINT #3,"PA PU 6530,"Y_POINTER%" ; LB"Dummy$;CHR$(3)
1280     TIMEDELAY(2)
1290   NEXT N%
1300 END DO
1400 DO
1410   PRINT #3, "SP2 ; SI.2,.2 ; DI0,1 ;"
1420   FOR N% = 0 TO 10 STEP 2
1425     IF Miny! > .00099 OR Miny! < -.00099 THEN Mini_pads% = 1 ELSE Mini_pads%
= 0
1430     Number! = Miny! + (Maxy! - Miny!) * (N%/10)
1440     EDITDATA(Number!,Dummy$)
1450     X_POINTER% = CINT(6355 - N%*597)
1460     Y_POINTER% = CINT(584 - LEN(Dummy$) * 36)
1470     PRINT #3, "PA PU "X_POINTER%","Y_POINTER%" LB"Dummy$;CHR$(3)
1480     TIMEDELAY(2)
1490   NEXT N%
1500 END DO
```

```
  1510 IF ONOFF=0 THEN GOTO 1710
  1600 DO
  1610   PRINT #3,"PU ; SI.16,.2 ; DR0,1 ; SP2 ;"
  1620   RESTORE,60100
  1630   READ Maxloop%
  1640   FOR N% = 1 TO Maxloop%
  1650     READ Name$
  1660     X_POINTER% = CINT(7554 + N%*200)
  1670     PRINT #3,"PA PU "X_POINTER%",508 ; LB"Name$ ; CHR$(3)
  1680     TIMEDELAY(4)
  1690   NEXT N%
  1700 END DO
  1710 PRINT #3,"SP0;"
  1720 CLOSE #3
  1730 EXIT
 60000 STOP
 60100 DATA 14
 60110 DATA "SYMBOL","DIRECTORIES","TEMPERATURE","TIME","BIAS","PULSE
HIGH"
 60120 DATA "HOLD TIME","RATE WINDOW","GRAPH
RANGE","SLOPE","X-INTERCEPT"
 60130 DATA "Y-INTERCEPT","RANGE","CORRELATION"
END PROCEDURE

PROCEDURE: SAVEDATA
  EXTERNAL:
Graph!(),Max_graph_points%(),Graph_name$(),Xtitle$,Ytitle$,Pulse$(),Directory$(),Temp$()
  EXTERNAL: Tyme$(),Bias$(),Hold$(),Rate$(),Grange$(),Slope$(),X_int$(),Y_int$()
  EXTERNAL: Range$()
  STRING: Save_file$[15]
  INTEGER: Line%,Choice%,Position%,N%
  EXTERNAL: Graph_chosen%,Menu_chosen%,Slope!(),Y_int!,X_int!()
  EXTERNAL: Correlation!(),Min!,Max!,Correlation$(),Y_int!(),Min!(),Max!()
  INTEGER: M%
  REAL ARRAY(?): RAnge!
  STRING: CHOICE$[2]
  EXTERNAL: GFLAG,Saveflag
    1 ON ERROR GOTO 60000
  100 DO
  110   COLOR 6,0 : SET CURSOR 20,6
  120   PRINT "Enter the driver and name you want to save the file under"
  130   SET CURSOR 21,6 : PRINT "(Defaults to
B:";Graph_name$(Menu_chosen%,Graph_chosen%)") ";
  140   INPUT Save_file$
  150   IF Save_file$ = "" THEN Save_file$ = "B:" +
Graph_name$(Menu_chosen%,Graph_chosen%)
  160 END DO
  170 Line% = 19 : GOSUB 20000
  175 Choice% = Graph%
  178 IF Saveflag=1 THEN Saveflag=0:GOTO 300
  180 DO
```

```
    200   SET CURSOR 20,6 : COLOR 2,0 :INPUT "Which do you want to save, (1) G1 or (2)
G2 graph";CHOICE$
    202   Choice%=VAL(CHOICE$):GFLAG=Choice%
    203   SET CURSOR 0,70:COLOR 2,7:PRINT Choice%:COLOR 7,0
    210   IF Choice% < 1 OR Choice% > 2 THEN EXIT TO,170
    220   EXIT 1 LEVELS
    230 REPEAT
    300 Line% = 19 : GOSUB 20000
    304 KILL Save_file$
    305 DO
    310   Position% = LEN(Save_file$)
    320   SET CURSOR 17,10 : COLOR 5,0 : PRINT "SAVING FILE UNDER "
    330   SET CURSOR 17,28 : COLOR 5,0 : PRINT MID$(Save_file$,1,Position%)
    335   CLOSE
    340   OPEN Save_file$ FOR OUTPUT AS #1
    350   PRINT #1,Graph_name$(Menu_chosen%,Graph_chosen%)
    360   PRINT #1,Xtitle$
    370   PRINT #1,Ytitle$
    380   PRINT #1,Directory$(Choice%,1) "," Directory$(Choice%,2)
    390   PRINT #1,Temp$(Choice%)
    400   PRINT #1,Tyme$(Choice%)
    410   PRINT #1,Bias$(Choice%)
    420   PRINT #1,Pulse$(Choice%)
    430   PRINT #1,Hold$(Choice%)
    440   PRINT #1,Rate$(Choice%)
    450   PRINT #1,Grange$(Choice%)
    460   PRINT #1,Slope!(Choice%)
    470   PRINT #1,X_int!(Choice%)
    480   PRINT #1,Y_int!(Choice%)
    490   PRINT #1,Correlation!(Choice%)
    495   PRINT #1,Min!(Choice%)
    496   PRINT #1,Max!(Choice%)
    500   PRINT #1,Max_graph_points%(Choice%)
    510   FOR N% =1 TO Max_graph_points%(Choice%)
    520     PRINT #1,Graph!(Choice%,1,N%) "," Graph!(Choice%,2,N%)
    530   NEXT N%
    540 END DO
    600 Line% = 17 : GOSUB 20000
    610 CLOSE #1
   1000 EXIT
  20000 FOR N% = Line% TO 24
  20010   LOCATE N%,1 : PRINT SPC(79)
  20020 NEXT N%
  20030 RETURN
  60000 IF ERR = 1001 AND ERL = 304 THEN RESUME NEXT
  60010 IF ERR > 999 THEN GOSUB 63000
  62000 CLS : COLOR 7,0 : SET CURSOR 13,1
  62010 PRINT "Sorry the procedure SAVEDATA is bombing.  This is error "ERR" from line
"ERL
  62020 STOP
  63000 Line% = 17 : GOSUB 20000
```

```
  63010 COLOR 7,0 : SET CURSOR 20,1 : PRINT "There is a problem saving your data.  Sorry"
  63020 FOR M% = -30000 TO 30000 : NEXT N%
  63030 RESUME,63040
  63040 EXIT
END PROCEDURE

PROCEDURE: LOADDATA
  EXTERNAL:
Graph!(),Max_graph_points%(),Graph_name$(),Xtitle$,Ytitle$,Pulse$(),Directory$(),Temp$()
  EXTERNAL: Tyme$(),Bias$(),Hold$(),Rate$(),Grange$(),Slope$(),X_int$(),Y_int$()
  EXTERNAL: Range$()
  INTEGER: Line%,Choice%,Position%,N%
  STRING: Load_file$[15],Xdata$[18],Ydata$[18]
  EXTERNAL: Correlation$(),Min!(),Max!()
  EXTERNAL:
Slope!(),X_int!(),Y_int!(),Correlation!(),CLEARGRAPH,G1,G2,COMP_GRAPH%
  INTEGER: COICE%
    1 ON ERROR GOSUB 60000
  100 DO
  110   COLOR 6,0 : SET CURSOR 20,6
  120   PRINT "Enter the file name and source drive to be loaded"
  130   SET CURSOR 21,6 : PRINT "(Defaults to B:";Graph_name$(1,1)")  ";
  140   INPUT Load_file$
  150   IF Load_file$ = "" THEN Load_file$ = "B:" + Graph_name$(1,1)
  160 END DO
  200 Line% = 16 : GOSUB 20000
  210 Choice% = Graph%
  300 Line% = 16 : GOSUB 20000
  310 DO
  320   Position% = LEN(Load_file$)
  330   SET CURSOR 17,10 : COLOR 5,0 : PRINT "LOADING FILE "
  340   SET CURSOR 17,23 : COLOR 5,0 : PRINT MID$(Load_file$,1,Position%)
  350   OPEN Load_file$ FOR INPUT AS #1
  360   INPUT #1,Graph_name$(1,1)
  370   INPUT #1,Xtitle$
  380   INPUT #1,Ytitle$
  390   INPUT #1,Directory$(Choice%,1) , Directory$(Choice%,2)
  400   INPUT #1,Temp$(Choice%)
  410   INPUT #1,Tyme$(Choice%)
  420   INPUT #1,Bias$(Choice%)
  430   INPUT #1,Pulse$(Choice%)
  440   INPUT #1,Hold$(Choice%)
  450   INPUT #1,Rate$(Choice%)
  455   DO
  460     INPUT #1,Xdata$
  462     IF INSTR(Xdata$,"X") <> 0 THEN EXIT 1 LEVELS
  463     INPUT #1,Ydata$
  465     Grange$(Choice%) = Xdata$ + "," + Ydata$
  467   END DO
  470   INPUT #1,Slope!(Choice%)
  480   INPUT #1,X_int!(Choice%)
```

```
    490   INPUT #1,Y_int!(Choice%)
    500   INPUT #1,Correlation!(Choice%)
    507   INPUT #1,Min!(Choice%)
    508   INPUT #1,Max!(Choice%)
    510   INPUT #1,Max_graph_points%(Choice%)
    520   FOR N% = 1 TO Max_graph_points%(Choice%)
    530     INPUT #1,Xdata$,Ydata$
    540     Graph!(Choice%,1,N%) = VAL(Xdata$)
    550     Graph!(Choice%,2,N%) = VAL(Ydata$)
    560   NEXT N%
    570 END DO
    600 Line% = 18 : GOSUB 20000
    610 CLOSE #1
   1000 EXIT
  20000 FOR N% = Line% TO 24
  20010   LOCATE N%,1 : PRINT SPC(79)
  20020 NEXT N%
  20030 RETURN
  59999 EXIT
  60000 IF ERR > 999 THEN GOSUB 61000: RESUME,59999
  60005 Line% = 2 : GOSUB 20000
  60010 SET CURSOR 13,6
  60020 PRINT "The procedure LOADDATA is bombing.  This is error "ERR" from line "ERL
  60030 STOP
  61000 Line% = 19: GOSUB 20000
  61005 SET CURSOR 19,6 : PRINT "There is a file loading error. Check you files"
  61010 FOR N% = -30000 TO 30000 : NEXT N%
  61020 Line% = 13: GOSUB 20000
  61030 RETURN
END PROCEDURE

PROCEDURE: INVERSEPOWER
  EXTERNAL: MINX!,MAXX!,MINY!,MAXY!,GRAPH!(),MAX_GRAPH_POINTS%()
  INTEGER: M%,Minloop%
    10 ON ERROR GOTO 50000
    20 Minloop% = 1
    84 DO
    85   IF Xory% = 2 THEN EXIT 1 LEVELS
    90   MINX! = 1.0E+37: MAXX! = -1.0E+37
    91 END DO
    92 DO
    93   IF Xory% = 1 THEN EXIT 1 LEVELS
    98   MINY! = 1.0E+37: MAXY! = -1.0E+37
    99 END DO
   100 FOR M% = Minloop% TO MAX_GRAPH_POINTS%(Graph1or2%)
   110   GRAPH!(Graph1or2%,Xory%,M%) = 1 / (GRAPH!(Graph1or2%,Xory%,M%) *
Amount!) ^ Power!
   120   DO
   130     DO
   140       IF Xory% <> 1 THEN EXIT 1 LEVELS
   150       IF MINX! > GRAPH!(Graph1or2%,1,M%) THEN MINX! =
```

```
GRAPH!(Graph1or2%,1,M%)
    160       IF MAXX! < GRAPH!(Graph1or2%,1,M%) THEN MAXX! =
GRAPH!(Graph1or2%,1,M%)
    170       EXIT 2 LEVELS
    180     END DO
    190     DO
    200       IF MINY! > GRAPH!(Graph1or2%,2,M%) THEN MINY! =
GRAPH!(Graph1or2%,2,M%)
    210       IF MAXY! < GRAPH!(Graph1or2%,2,M%) THEN MAXY! =
GRAPH!(Graph1or2%,2,M%)
    220     END DO
    230   END DO
    240 NEXT M%
    250 EXIT
  50000 DO
  50010   IF ERR = 2 AND ERL = 110 THEN Minloop% = M% + 1
  50020   EXIT TO,100
  51000   PRINT "The procedure INVERSEPOWER is bombing.  This is error "ERR" from line
"ERL"."
  51010   END
  60000 END DO
END PROCEDURE

PROCEDURE: MAINKEY
  REAL: I,L,N
  STRING ARRAY(10)[16]: KEYFUNC$,FUNC$
  REAL: O
  EXTERNAL: G1,G2,Clearscreen,TITLE,GRAPH_NAME$()
  EXTERNAL: MENU_CHOSEN%,GRAPH_CHOSEN%,GRAPH%,GFLAG
     10 Clearscreen(2):STATUSLINE OFF
     14 SET CURSOR 0,70:COLOR 2,7:PRINT GRAPH%:COLOR 7,0
     15 IF MENU_CHOSEN%=0 OR GRAPH_CHOSEN%=0 THEN GOTO 20 ELSE
TITLE(GRAPH_NAME$(MENU_CHOSEN%,GRAPH_CHOSEN%)):SET CURSOR
0,70:COLOR 2,7:PRINT GFLAG:COLOR 7,0
     20 FOR I=1 TO 10
     30   IF COS(I*3.14159)<0 THEN L=2*I:N=1 ELSE N=14
     40   READ KEYFUNC$(I)
     50   READ FUNC$(I)
     60   KEY I,FUNC$(I)+CHR$(13)
     70   SET CURSOR L,N:COLOR 2,0:PRINT "F";I;" ":COLOR 2,7:SET CURSOR
L,N+4:PRINT KEYFUNC$(I)
     80 NEXT I
     90 COLOR 2,0
     95 STOP
    100 DATA "SYSTEM ",SYSTEM,"SAVEDAT",EXIT TO 8555,"MODIFY
",MODIFY,"PLOTTER",EXIT TO 9000,"MENU   ",EXIT TO 200,"LEAST  ",EXIT TO
6300,"LOAD G1",EXIT TO 1429,"LOAD G2",EXIT TO 8700,"SCALE  ",EXIT TO
3000,"SCRNPLT",EXIT TO 4000
END PROCEDURE

PROCEDURE: PLOTTER
```

```
  REAL: I,L,N
  STRING ARRAY(10)[16]: KEYFUNC$,FUNC$
  EXTERNAL: Onoff,Clearscreen,MENU_CHOSEN%,GRAPH_CHOSEN%,G1
  EXTERNAL: G2,TITLE,GRAPH_NAME$(),G
    10 Clearscreen(2)
    15 IF MENU_CHOSEN%=0 OR GRAPH_CHOSEN%=0 THEN GOTO 20 ELSE
TITLE(GRAPH_NAME$(MENU_CHOSEN%,GRAPH_CHOSEN%)):SET CURSOR
0,70:COLOR 4,7:PRINT G:COLOR 7,0
    20 FOR I=1 TO 10
    30  IF COS(I*3.14159)<0 THEN L=2*I:N=1 ELSE N=14
    40  READ KEYFUNC$(I)
    50  READ FUNC$(I)
    60  SET CURSOR L,N:COLOR 4,0:PRINT "F";I;" ":COLOR 4,7:SET CURSOR
L,N+4:PRINT KEYFUNC$(I)
    70  KEY I,FUNC$(I)+CHR$(13)
    80 NEXT I
    81 IF Onoff=1 THEN SET CURSOR 18,5:COLOR 0,7:PRINT KEYFUNC$(9)
    90 COLOR 4,0
   100 STOP
   110 DATA "MAINKEY",MAINKEY,"SPEED  ",SPEED,"LINES
",LINES,"SYMBOLS",SYMBOLS,"COLORS ",COLORS,"PLOTAXS",EXIT TO 9570,"PLOT
G1",EXIT TO 9640,"PLOT G2",EXIT TO 9220,"ON/OFF ",INFO,"CAPTION",CAPTION
END PROCEDURE

PROCEDURE: MODIFY
  REAL: I,L,N
  STRING ARRAY(10)[16]: KEYFUNC$
  EXTERNAL: Clearscreen,MENU_CHOSEN%,GRAPH_CHOSEN%,G1,G2,TITLE
  EXTERNAL: GRAPH_NAME$()
  REAL: MD
  EXTERNAL: MOD
    10 Clearscreen(2)
    15 IF MENU_CHOSEN%=0 OR GRAPH_CHOSEN%=0 THEN GOTO 20 ELSE
TITLE(GRAPH_NAME$(MENU_CHOSEN%,GRAPH_CHOSEN%)):SET CURSOR
0,70:COLOR 1,7:PRINT MOD:COLOR 7,0
    20 FOR I=1 TO 10
    30  IF COS(I*3.14159)<0 THEN L=2*I:N=1 ELSE N=14
    40  READ KEYFUNC$(I)
    50  KEY I,KEYFUNC$(I)+CHR$(13)
    60  SET CURSOR L,N:COLOR 1,0:PRINT "F";I;" ":COLOR 1,7:SET CURSOR
L,N+4:PRINT KEYFUNC$(I)
    70 NEXT I
    80 COLOR 1,0
    90 STOP
   100 DATA "MAINKEY","ADDNUM ","MLTNUM ","POWER  ","NATLOG ","EXPNT
","ABSLT  ","DELPT  ","ADDPT  ","CLRGRPH"
END PROCEDURE

PROCEDURE: COLORS
  EXTERNAL: PLOTTER
  REAL: I,J
```

```
  STRING: A$[16]
  REAL: N
  INTEGER ARRAY(5): EXIST
  EXTERNAL: Pen_selected%
  REAL ARRAY(?): PN
  EXTERNAL: PEN(),G1,G2,Clearscreen
  STRING: N$[?],J$[?]
    10 EXIST(1)=G1:EXIST(2)=G2
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 Clearscreen(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 4
    40   IF EXIST(I)=0 THEN GOTO 60
    50   IF PEN(I)<>0 THEN SET CURSOR 5,2*I+18:COLOR PEN(I)-2,7:PRINT EXIST(I)
ELSE SET CURSOR 5,2*I+18:COLOR 0,7:PRINT EXIST(I)
    60 NEXT I
    70 SET CURSOR 10,1:COLOR 7,0:PRINT "COLORS:"
    80 FOR I=1 TO 5
    90   SET CURSOR 10,2*I+8:COLOR I-1,7:PRINT I+1
   100 NEXT I
   110 SET CURSOR 15,1:COLOR 7,0:INPUT "WHICH GRAPH" N$
   111 N=VAL(N$)
   120 SET CURSOR 17,1:INPUT"WHICH COLOR" J$
   121 J=VAL(J$)
   125 IF N<1 OR N>2 THEN GOTO 135
   130 PEN(N)=J
   131 FOR I=1 TO 4
   132   IF EXIST(I)=0 THEN GOTO 134
   133   IF PEN(I)<>0 THEN SET CURSOR 5,2*I+18:COLOR PEN(I)-2,7:PRINT EXIST(I)
ELSE SET CURSOR 5,2*I+18:COLOR 0,7:PRINT EXIST(I)
   134 NEXT I
   135 COLOR 7,0
   140 SET CURSOR 20,1:INPUT"FINISHED CHOOSING COLORS";A$
   150 IF INSTR(UPPER$(A$),"Y") THEN GOTO 160 ELSE GOTO 20
   160 PLOTTER
   170 STOP
END PROCEDURE

PROCEDURE: SYMBOLS
  INTEGER ARRAY(10): EXIST,LINES
  EXTERNAL: PLOTTER
  REAL: I,J,N
  STRING: A$[16]
  REAL ARRAY(10): SYMBOLS
  EXTERNAL: Symbol$,SYMBL$()
  STRING ARRAY(5)[16]: SMBL$
  EXTERNAL: G1,G2,CLEARSCREEN
  STRING: N$[?],J$[?]
    10 EXIST(1)=G1:EXIST(2)=G2
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 CLEARSCREEN(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 5
```

```
    40  IF EXIST(I)=0 THEN GOTO 60 ELSE SET CURSOR 5,2*I+18:COLOR 0,7:PRINT
EXIST(I)
    50  IF SYMBOLS(I)<>0 THEN SET CURSOR 5,2*I+18:COLOR
SYMBOLS(I)+10,7:PRINT EXIST(I)
    60 NEXT I
    70 SET CURSOR 10,1:COLOR 7,0:PRINT "SYMBOLS: ":SET CURSOR 10,10:COLOR
11,0:PRINT "1)NONE":SET CURSOR 10,18:COLOR 12,0:PRINT "2) +  ":SET CURSOR
10,23:COLOR 13,0:PRINT "3) *  ":SET CURSOR 10,28:COLOR 14,0:PRINT "4) @  "
    80 SET CURSOR 15,1:COLOR 7,0:INPUT"WHICH GRAPH" N$
    81 N=VAL(N$)
    85 SET CURSOR 17,1:INPUT"WHICH SYMBOL" J$
    86 J=VAL(J$)
    90 IF N<1 OR N>2 THEN GOTO 105
    91 IF J=1 THEN SYMBL$(N)=" "
    92 IF J=2 THEN SYMBL$(N)="+"
    93 IF J=3 THEN SYMBL$(N)="*"
    94 IF J=4 THEN SYMBL$(N)="@"
   100 SYMBOLS(N)=J
   101 FOR I=1 TO 5
   102  IF EXIST(I)=0 THEN GOTO 104 ELSE SET CURSOR 5,2*I+18:COLOR 0,7:PRINT
EXIST(I)
   103  IF SYMBOLS(I)<>0 THEN SET CURSOR 5,2*I+18:COLOR
SYMBOLS(I)+10,7:PRINT EXIST(I)
   104 NEXT I
   105 COLOR 7,0
   110 SET CURSOR 20,1:INPUT"FINISHED CHOOSING SYMBOLS";A$
   120 IF INSTR(UPPER$(A$),"Y") THEN GOTO 130 ELSE GOTO 20
   130 PLOTTER
   140 STOP
END PROCEDURE

PROCEDURE: LINES
  INTEGER ARRAY(10): EXIST,LINES
  EXTERNAL: PLOTTER
  REAL: I,J,N
  STRING: A$[16]
  EXTERNAL: Line_type$,LINETYPE$(),G1,G2,CLEARSCREEN
  STRING: N$[?],J$[?]
    10 EXIST(1)=G1:EXIST(2)=G2
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 CLEARSCREEN(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 5
    40  IF EXIST(I)=0 THEN GOTO 60 ELSE SET CURSOR 5,2*I+18:COLOR 0,7:PRINT
EXIST(I)
    50  IF LINES(I)<>0 THEN SET CURSOR 5,2*I+18:COLOR LINES(I)+1,7:PRINT
EXIST(I)
    60 NEXT I
    70 SET CURSOR 10,1:COLOR 7,0:PRINT "LINES:  ":SET CURSOR 10,7:COLOR
2,0:PRINT "1)NONE":SET CURSOR 10,14:COLOR 3,0:PRINT "2)----":SET CURSOR
10,21:COLOR 4,0:PRINT "3)....":SET CURSOR 10,28:COLOR 5,0:PRINT "4)- - -"
    80 SET CURSOR 15,1:COLOR 7,0:INPUT"WHICH GRAPH" N$
```

```
    81 N=VAL(N$)
    85 SET CURSOR 17,1:INPUT"WHICH LINE" J$
    86 J=VAL(J$)
    90 IF N<1 OR N>2 THEN GOTO 105
    91 IF J=1 THEN LINETYPE$(N)="0"
    92 IF J=2 THEN LINETYPE$(N)=" "
    93 IF J=3 THEN LINETYPE$(N)="1"
    94 IF J=4 THEN LINETYPE$(N)="2"
   100 LINES(N)=J
   101 FOR I=1 TO 5
   102  IF EXIST(I)=0 THEN GOTO 104 ELSE SET CURSOR 5,2*I+18:COLOR 0,7:PRINT
EXIST(I)
   103  IF LINES(I)<>0 THEN SET CURSOR 5,2*I+18:COLOR LINES(I)+1,7:PRINT
EXIST(I)
   104 NEXT I
   105 COLOR 7,0
   110 SET CURSOR 20,1:INPUT"FINISHED CHOOSING LINES";A$
   120 IF INSTR(UPPER$(A$),"Y") THEN GOTO 130 ELSE GOTO 20
   130 PLOTTER
   140 STOP
END PROCEDURE

PROCEDURE: Info
  EXTERNAL: Onoff,Plotter
    10 IF Onoff=0 THEN Onoff=1 ELSE Onoff=0
    20 Plotter
    30 STOP
END PROCEDURE

PROCEDURE: CAPTION
  STRING: CPTION$[80]
  INTEGER: YPOINT
  EXTERNAL: PLOTTER,TIMEDELAY
  REAL: HELLO
     5 WIDTH 80:CLS
    10 SET CURSOR 15,5:COLOR 7,0:PRINT "ENTER THE PLOT CAPTION BELOW(80
CHARACTERS OR LESS)"
    20 SET CURSOR 18,1:COLOR 0,7:INPUT">";CPTION$
    30 CLOSE #3
    40 OPEN "COM1 : 9600,N,8,1,RS,CS65535,DS,CD" FOR OUTPUT AS #3
    50 PRINT #3,"IN; "
    70 PRINT #3, "SP2 ; SI.15,.25 ; DR 0,1 ;"
    80 PRINT #3, "PA PU 7200,900 ; LB"CPTION$;CHR$(3)
    85 TIMEDELAY(15)
    86 PRINT #3, "SP0 ;"
    90 CLOSE #3
    95 COLOR 7,0
   100 PLOTTER
   110 STOP
END PROCEDURE
```

```
PROCEDURE: Fixpoints
  INTEGER: O%
    10 ON Type% GOTO 100,200,300,400,500
   100 Plt! = 48
   110 IF Plt1! < 15 THEN Plt1! = 15 : EXIT
   120 IF Plt1! > 166 THEN Plt1! = 166 : EXIT
   198 EXIT
   199 STOP
   200 Plt! = 618
   210 IF Plt1! < 15 THEN Plt1! = 15 : EXIT
   220 IF Plt1! > 166 THEN Plt1! = 166 : EXIT
   298 EXIT
   299 STOP
   300 Plt1! = 166
   310 IF Plt! < 48 THEN Plt! = 48 : EXIT
   320 IF Plt! > 618 THEN Plt! = 618 : EXIT
   398 EXIT
   399 STOP
   400 Plt1! = 15
   410 IF Plt! < 48 THEN Plt! = 48 : EXIT
   420 IF Plt! > 618 THEN Plt! = 618 : EXIT
   500 EXIT
END PROCEDURE

PROCEDURE: Cleargraph
  EXTERNAL: Pulse$(),Hold$(),Rate$(),Slope$(),X_int$(),Y_int$(),Range$(),Correlation$()
  EXTERNAL: Tyme$(),Temp$(),Grange$(),G1,G2,Comp_graph%
  REAL: I,N
  EXTERNAL: Bias$(),Max_graph_points%()
  EXTERNAL: Graph!()
  INTEGER: J
    10 Bias$(G1orG2) = "X"
    20 Pulse$(G1orG2) = "X"
    30 Hold$(G1orG2) = "X"
    40 Rate$(G1orG2) = "X"
    50 Slope$(G1orG2) = "X"
    60 X_int$(G1orG2) = "X"
    70 Y_int$(G1orG2) = "X"
    80 Range$(G1orG2)= "X"
    90 Correlation$(G1orG2) = "X"
   100 Tyme$(G1orG2) = "X"
   110 Temp$(G1orG2) = "X"
   120 Grange$(G1orG2) = "X"
   130 IF Max_graph_points%(G1orG2)>300 THEN J=Max_graph_points%(G1orG2) ELSE
J=300
   140 FOR I=1 TO 2
   150   FOR N=1 TO J
   160     Graph!(G1orG2,I,N)=0
   170   NEXT N
   180 NEXT I
   185 Max_graph_points%(G1orG2)=1
```

```
    190 IF G1orG2=1 THEN G1=0
    200 IF G1orG2=2 THEN G2=0:Comp_graph%=0
    210 EXIT
    220 STOP
END PROCEDURE

PROCEDURE: CLRGRPH
  EXTERNAL: G2,COMP_GRAPH%,MODIFY,Cleargraph,G1
  REAL ARRAY(10): Exist
  EXTERNAL: Clearscreen
  REAL: I
  STRING: N$[?]
  REAL: N
  STRING: A$[?]
  EXTERNAL: MOD
    10 Exist(1)=G1:Exist(2)=G2
    11 Exist(3)=0:Exist(4)=0:Exist(5)=0
    20 Clearscreen(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 4
    40   IF Exist(I)=0 THEN GOTO 60
    50   SET CURSOR 5,2*I+18:COLOR 0,7:PRINT Exist(I)
    60 NEXT I
    70 SET CURSOR 15,1:COLOR 7,0:INPUT"CLEAR WHICH GRAPH" N$
    80 N=VAL(N$):MOD=N
    81 IF N<1 OR N>2 THEN GOTO 100
    90 Cleargraph N
   100 Clearscreen(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
   105 Exist(1)=G1:Exist(2)=G2
   110 FOR I=1 TO 4
   120   IF Exist(I)=0 THEN GOTO 140
   130   SET CURSOR 5,2*I+18:COLOR 0,7:PRINT Exist(I)
   140 NEXT I
   150 SET CURSOR 18,1:COLOR 7,0:INPUT"FINISHED CLEARING GRAPHS" A$
   160 A$=UPPER$(A$)
   170 IF INSTR(A$,"Y")=0 THEN GOTO 10
   180 MODIFY
   190 STOP
END PROCEDURE

PROCEDURE: ADDNUM
  EXTERNAL: GRAPH!(),G1,G2,MAX_GRAPH_POINTS%()
  INTEGER ARRAY(8): EXIST
  STRING: W$[2],X$[2],NUM$[10],A$[2]
  EXTERNAL: CLEARSCREEN
  INTEGER: I,W
  EXTERNAL: MODIFY
  INTEGER: M
  REAL: NUM
  INTEGER: J
  EXTERNAL: MOD
    10 EXIST(1)=G1:EXIST(2)=G2
```

```
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 CLEARSCREEN(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 4
    40   IF EXIST(I)=0 THEN GOTO 60
    50   SET CURSOR 5,2*I+18:COLOR 0,7:PRINT EXIST(I)
    60 NEXT I
    70 SET CURSOR 15,1:COLOR 7,0:INPUT"ADD TO WHICH GRAPH" W$
    80 W=VAL(W$):MOD=W
    81 IF W<1 OR W>2 THEN GOTO 100
    82 SET CURSOR 17,1:COLOR 7,0:INPUT"ADD TO X OR Y" X$
    83 X$=UPPER$(X$)
    84 M=1
    85 IF INSTR(X$,"X")=0 THEN M=2
    87 SET CURSOR 19,1:COLOR 7,0:INPUT"ADD WHAT NUMBER" NUM$
    88 NUM=VAL(NUM$)
    90 FOR J=1 TO MAX_GRAPH_POINTS%(W)
    92   GRAPH!(W,M,J)=GRAPH!(W,M,J)+NUM
    94 NEXT J
   100 REM
   150 SET CURSOR 21,1:COLOR 7,0:INPUT"FINISHED ADDING" A$
   160 A$=UPPER$(A$)
   170 IF INSTR(A$,"Y")=0 THEN GOTO 10
   180 MODIFY
   190 STOP
END PROCEDURE

PROCEDURE: Mltnum
  EXTERNAL: GRAPH!(),G1,G2,MAX_GRAPH_POINTS%()
  INTEGER ARRAY(8): EXIST
  STRING: W$[2],X$[2],NUM$[10],A$[2]
  EXTERNAL: CLEARSCREEN
  INTEGER: I,W
  EXTERNAL: MODIFY
  INTEGER: M
  REAL: NUM
  INTEGER: J
  EXTERNAL: MOD
    10 EXIST(1)=G1:EXIST(2)=G2
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 CLEARSCREEN(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 4
    40   IF EXIST(I)=0 THEN GOTO 60
    50   SET CURSOR 5,2*I+18:COLOR 0,7:PRINT EXIST(I)
    60 NEXT I
    70 SET CURSOR 15,1:COLOR 7,0:INPUT"MLTNUM WHICH GRAPH" W$
    80 W=VAL(W$):MOD=W
    81 IF W<1 OR W>2 THEN GOTO 100
    82 SET CURSOR 17,1:COLOR 7,0:INPUT"MLT TO X OR Y" X$
    83 X$=UPPER$(X$)
    84 M=1
    85 IF INSTR(X$,"X")=0 THEN M=2
```

```
    87 SET CURSOR 19,1:COLOR 7,0:INPUT"MLT WHAT NUMBER" NUM$
    88 NUM=VAL(NUM$)
    90 FOR J=1 TO MAX_GRAPH_POINTS%(W)
    92   GRAPH!(W,M,J)=GRAPH!(W,M,J)*NUM
    94 NEXT J
   100 REM
   150 SET CURSOR 21,1:COLOR 7,0:INPUT"FINISHED MULTIPLYING" A$
   160 A$=UPPER$(A$)
   170 IF INSTR(A$,"Y")=0 THEN GOTO 10
   180 MODIFY
   190 STOP
END PROCEDURE

PROCEDURE: POWER
  EXTERNAL: GRAPH!(),G1,G2,MAX_GRAPH_POINTS%()
  INTEGER ARRAY(8): EXIST
  STRING: W$[2],X$[2],NUM$[10],A$[2]
  EXTERNAL: CLEARSCREEN
  INTEGER: I,W
  EXTERNAL: MODIFY
  INTEGER: M
  REAL: NUM
  INTEGER: J
  EXTERNAL: MOD
    10 EXIST(1)=G1:EXIST(2)=G2
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 CLEARSCREEN(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 4
    40   IF EXIST(I)=0 THEN GOTO 60
    50   SET CURSOR 5,2*I+18:COLOR 0,7:PRINT EXIST(I)
    60 NEXT I
    70 SET CURSOR 15,1:COLOR 7,0:INPUT"POWER WHICH GRAPH" W$
    80 W=VAL(W$):MOD=W
    81 IF W<1 OR W>2 THEN GOTO 100
    82 SET CURSOR 17,1:COLOR 7,0:INPUT"POWER X OR Y" X$
    83 X$=UPPER$(X$)
    84 M=1
    85 IF INSTR(X$,"X")=0 THEN M=2
    87 SET CURSOR 19,1:COLOR 7,0:INPUT"WHAT POWER" NUM$
    88 NUM=VAL(NUM$)
    90 FOR J=1 TO MAX_GRAPH_POINTS%(W)
    92   GRAPH!(W,M,J)=GRAPH!(W,M,J)^NUM
    94 NEXT J
   100 REM
   150 SET CURSOR 21,1:COLOR 7,0:INPUT"FINISHED POWERING" A$
   160 A$=UPPER$(A$)
   170 IF INSTR(A$,"Y")=0 THEN GOTO 10
   180 MODIFY
   190 STOP
END PROCEDURE
```

```
PROCEDURE: NATLOG
  EXTERNAL: GRAPH!(),G1,G2,MAX_GRAPH_POINTS%()
  INTEGER ARRAY(8): EXIST
  STRING: W$[2],X$[2],NUM$[10],A$[2]
  EXTERNAL: CLEARSCREEN
  INTEGER: I,W
  EXTERNAL: MODIFY
  INTEGER: M
  REAL: NUM
  INTEGER: J
  EXTERNAL: MOD
    10 EXIST(1)=G1:EXIST(2)=G2
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 CLEARSCREEN(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 4
    40   IF EXIST(I)=0 THEN GOTO 60
    50   SET CURSOR 5,2*I+18:COLOR 0,7:PRINT EXIST(I)
    60 NEXT I
    70 SET CURSOR 15,1:COLOR 7,0:INPUT"NATLOG WHICH GRAPH" W$
    80 W=VAL(W$):MOD=W
    81 IF W<1 OR W>2 THEN GOTO 100
    82 SET CURSOR 17,1:COLOR 7,0:INPUT"NATLOG X OR Y" X$
    83 X$=UPPER$(X$)
    84 M=1
    85 IF INSTR(X$,"X")=0 THEN M=2
    90 FOR J=1 TO MAX_GRAPH_POINTS%(W)
    92   GRAPH!(W,M,J)=LOG(GRAPH!(W,M,J))
    94 NEXT J
   100 REM
   150 SET CURSOR 21,1:COLOR 7,0:INPUT"FINISHED NATLOG" A$
   160 A$=UPPER$(A$)
   170 IF INSTR(A$,"Y")=0 THEN GOTO 10
   180 MODIFY
   190 STOP
END PROCEDURE

PROCEDURE: EXPNT
  EXTERNAL: GRAPH!(),G1,G2,MAX_GRAPH_POINTS%()
  INTEGER ARRAY(8): EXIST
  STRING: W$[2],X$[2],NUM$[10],A$[2]
  EXTERNAL: CLEARSCREEN
  INTEGER: I,W
  EXTERNAL: MODIFY
  INTEGER: M
  REAL: NUM
  INTEGER: J
  EXTERNAL: MOD
    10 EXIST(1)=G1:EXIST(2)=G2
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 CLEARSCREEN(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 4
```

```
    40   IF EXIST(I)=0 THEN GOTO 60
    50   SET CURSOR 5,2*I+18:COLOR 0,7:PRINT EXIST(I)
    60 NEXT I
    70 SET CURSOR 15,1:COLOR 7,0:INPUT"EXPNT WHICH GRAPH" W$
    80 W=VAL(W$):MOD=W
    81 IF W<1 OR W>2 THEN GOTO 100
    82 SET CURSOR 17,1:COLOR 7,0:INPUT"EXPNT X OR Y" X$
    83 X$=UPPER$(X$)
    84 M=1
    85 IF INSTR(X$,"X")=0 THEN M=2
    90 FOR J=1 TO MAX_GRAPH_POINTS%(W)
    92   GRAPH!(W,M,J)=EXP(GRAPH!(W,M,J))
    94 NEXT J
   100 REM
   150 SET CURSOR 21,1:COLOR 7,0:INPUT"FINISHED EXPNT" A$
   160 A$=UPPER$(A$)
   170 IF INSTR(A$,"Y")=0 THEN GOTO 10
   180 MODIFY
   190 STOP
END PROCEDURE

PROCEDURE: ABSLT
  EXTERNAL: GRAPH!(),G1,G2,MAX_GRAPH_POINTS%()
  INTEGER ARRAY(8): EXIST
  STRING: W$[2],X$[2],NUM$[10],A$[2]
  EXTERNAL: CLEARSCREEN
  INTEGER: I,W
  EXTERNAL: MODIFY
  INTEGER: M
  REAL: NUM
  INTEGER: J
  EXTERNAL: MOD
    10 EXIST(1)=G1:EXIST(2)=G2
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 CLEARSCREEN(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 4
    40   IF EXIST(I)=0 THEN GOTO 60
    50   SET CURSOR 5,2*I+18:COLOR 0,7:PRINT EXIST(I)
    60 NEXT I
    70 SET CURSOR 15,1:COLOR 7,0:INPUT"ABSLT WHICH GRAPH" W$
    80 W=VAL(W$):MOD=W
    81 IF W<1 OR W>2 THEN GOTO 100
    82 SET CURSOR 17,1:COLOR 7,0:INPUT"ABSLT X OR Y" X$
    83 X$=UPPER$(X$)
    84 M=1
    85 IF INSTR(X$,"X")=0 THEN M=2
    90 FOR J=1 TO MAX_GRAPH_POINTS%(W)
    92   GRAPH!(W,M,J)=ABS(GRAPH!(W,M,J))
    94 NEXT J
   100 REM
   150 SET CURSOR 21,1:COLOR 7,0:INPUT"FINISHED ABSLT" A$
```

```
    160 A$=UPPER$(A$)
    170 IF INSTR(A$,"Y")=0 THEN GOTO 10
    180 MODIFY
    190 STOP
END PROCEDURE

PROCEDURE: DELPT
  EXTERNAL: GRAPH!(),G1,G2,MAX_GRAPH_POINTS%()
  INTEGER ARRAY(8): EXIST
  STRING: W$[2],X$[2],NUM$[10],A$[2]
  EXTERNAL: CLEARSCREEN
  INTEGER: I,W
  EXTERNAL: MODIFY
  INTEGER: M
  REAL: NUM
  INTEGER: J,X
  STRING: D$[4]
  INTEGER: D,N,FLAG
  STRING: DP$[?]
  INTEGER: DP
  REAL: MAIN
  STRING: Null$[?]
  EXTERNAL: MOD
    10 EXIST(1)=G1:EXIST(2)=G2
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 CLEARSCREEN(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 4
    40   IF EXIST(I)=0 THEN GOTO 60
    50   SET CURSOR 5,2*I+18:COLOR 0,7:PRINT EXIST(I)
    60 NEXT I
    70 SET CURSOR 15,1:COLOR 7,0:INPUT"DELPT FROM WHICH GRAPH" W$
    80 W=VAL(W$):MOD=W
    81 IF W<1 OR W>2 THEN GOTO 240
    90 N=-2
   100 M=1
   101 FOR J=3 TO 20
   102   SET CURSOR J,40:COLOR 2,0:PRINT "                                    "
   104 NEXT J
   110 FOR J=M TO MAX_GRAPH_POINTS%(W)
   120   SET CURSOR J-N,40:COLOR 2,0:PRINT J;". ";GRAPH!(W,1,J);",";GRAPH!(W,2,J)
   130   IF J-N=15 THEN EXIT TO,150
   135   FLAG=J
   140 NEXT J
   150 N=J-3:M=J
   160 SET CURSOR 17,1:COLOR 7,0:INPUT"DELETE WHICH POINT";D$
   170 D=VAL(D$)
   180 IF D=0 AND FLAG<>MAX_GRAPH_POINTS%(W) THEN GOTO 101
   190 IF D=0 THEN GOTO 240
   210 FOR J=D TO MAX_GRAPH_POINTS%(W)
   220   GRAPH!(W,1,J)=GRAPH!(W,1,J+1)
   221   GRAPH!(W,2,J)=GRAPH!(W,2,J+1)
```

```
    230 NEXT J
    231 MAX_GRAPH_POINTS%(W)=MAX_GRAPH_POINTS%(W)-1
    240 REM
    250 SET CURSOR 21,1:COLOR 7,0:INPUT"FINISHED DELPT" A$
    260 A$=UPPER$(A$)
    270 IF INSTR(A$,"Y")=0 THEN GOTO 10
    280 MODIFY
    290 STOP
END PROCEDURE

PROCEDURE: ADDPT
  EXTERNAL: GRAPH!(),G1,G2,MAX_GRAPH_POINTS%()
  INTEGER ARRAY(8): EXIST
  STRING: W$[2],X$[2],NUM$[10],A$[2]
  EXTERNAL: CLEARSCREEN
  INTEGER: I,W
  EXTERNAL: MODIFY
  INTEGER: M
  REAL: NUM
  INTEGER: J,X
  STRING: AP$[4]
  INTEGER: AP,N,FLAG
  STRING: XAD$[10],YAD$[10]
  REAL: XAD,YAD
  EXTERNAL: MOD
    10 EXIST(1)=G1:EXIST(2)=G2
    11 EXIST(3)=0:EXIST(4)=0:EXIST(5)=0
    20 CLEARSCREEN(2):SET CURSOR 5,1:COLOR 7,0:PRINT "EXISTING GRAPHS:"
    30 FOR I=1 TO 4
    40   IF EXIST(I)=0 THEN GOTO 60
    50   SET CURSOR 5,2*I+18:COLOR 0,7:PRINT EXIST(I)
    60 NEXT I
    70 SET CURSOR 15,1:COLOR 7,0:INPUT"ADDPT TO WHICH GRAPH" W$
    80 W=VAL(W$):MOD=W
    81 IF W<1 OR W>2 THEN GOTO 240
    90 N=-2
   100 M=1
   101 FOR J=3 TO 20
   102   SET CURSOR J,40:COLOR 2,0:PRINT "                                    "
   104 NEXT J
   110 FOR J=M TO MAX_GRAPH_POINTS%(W)
   120   SET CURSOR J-N,40:COLOR 2,0:PRINT J;". ";GRAPH!(W,1,J);",";GRAPH!(W,2,J)
   130   IF J-N=15 THEN EXIT TO,150
   135   FLAG=J
   140 NEXT J
   150 N=J-3:M=J
   160 SET CURSOR 17,1:COLOR 7,0:INPUT"ADD BEFORE WHICH POINT";AP$
   170 AP=VAL(AP$)
   180 IF AP=0 AND FLAG<>MAX_GRAPH_POINTS%(W) THEN GOTO 101
   190 IF AP=0 THEN GOTO 240
   191 SET CURSOR 19,1:COLOR 7,0:INPUT"ENTER NEW X,Y";XAD$,YAD$
```

```
    210 FOR J=MAX_GRAPH_POINTS%(W) TO AP STEP -1
    220   GRAPH!(W,1,J+1)=GRAPH!(W,1,J)
    221   GRAPH!(W,2,J+1)=GRAPH!(W,2,J)
    230 NEXT J
    231 MAX_GRAPH_POINTS%(W)=MAX_GRAPH_POINTS%(W)+1
    232 GRAPH!(W,1,AP)=VAL(XAD$)
    233 GRAPH!(W,2,AP)=VAL(YAD$)
    240 REM
    250 SET CURSOR 21,1:COLOR 7,0:INPUT"FINISHED ADDPT" A$
    260 A$=UPPER$(A$)
    270 IF INSTR(A$,"Y")=0 THEN GOTO 10
    280 MODIFY
    290 STOP
END PROCEDURE

PROCEDURE: SPEED
  EXTERNAL: SPEED$,PLOTTER
     10 CLS:COLOR 9,1:SET CURSOR 5,1
     20 INPUT"ENTER PLOTTER PEN SPEED .1(fast) to 2(slow)";SPEED$
     30 COLOR 7,0:PLOTTER
     40 STOP
END PROCEDURE

'MAIN Program:


 100 DO
 110   SCREEN 0,0,0 : VIEW : CLS : STATUSLINE OFF : TROFF
 120   COLOR 2,1:CLS:SET CURSOR 13,30:PRINT "Now Entering Graphics"
 130   TIMEDELAY (3)
 140   COLOR 2,0,0
 145   CLS
 150 END DO
 155 SET CURSOR 0,74:COLOR 8,7:PRINT G1;G2:COLOR 7,0
 160 MAINKEY
 200 CLEAR:WIDTH 80
 210 ON ERROR GOTO 55000
 230 CHDIR "\"
 240 MinX! = 1E+19
 250 MaxX! = -1E+19
 260 MinY! = 1E+19
 270 MaxY! = -1E+19
 275 FOR N% = 1 TO 2
 280   Cleargraph N%
 385 NEXT N%
 390 Q! = 1.60218E-19
 400 K! = 1.38066E-23
 410 E_sub_O! = 8.85418E-14
 490 Minloop% = 1
 500 REM
 510 RESTORE,60200
```

```
520 READ Max_graph_number%
530 FOR N% = 1 TO 5
540   FOR M% = 1 TO 24
550     READ Graph_name$(N%,M%)
560     IF (N%-1)*24 + M% => Max_graph_number% THEN EXIT 2 LEVELS
570   NEXT M%
580   Maxloop%(N%) = 24
590 NEXT N%
600 Maxloop%(N%) = M% - 1
605 IF M% = 24 THEN Maxloop%(N%) = 24
610 IF N% = 6 THEN Next_screen% = 5 ELSE Next_screen% = N%
700 REM
710 FOR N% = 1 TO Next_screen%
720   TITLE ("Graphics Menu")
730   FOR M% = 1 TO Maxloop%(N%)
740     MENU (Graph_name$(N%,M%),M%,Rownumber%)
750   NEXT M%
760   DO
770     IF N% = Next_screen% THEN EXIT
780     IF N% > 1 THEN Col% = 5
790     FINISH ("Go to Next Graphics Menu",Rownumber%,Col%,25):EXIT
800   REPEAT
810   DO
820     IF N% < 2 THEN EXIT
830     IF N% < Next_screen% THEN Col% = 42
835     IF N% = Next_screen% THEN Col% = 5
840     FINISH ("Go to Previous Graphics Menu",Rownumber%,Col%,26):EXIT
850   REPEAT
860   DO
870     IF N% < Next_screen% THEN EXIT
875     Col% = 42
880     FINISH ("Exit to DOS",Rownumber%,Col%,27):EXIT
890   REPEAT
895   BORDER (Rownumber%)
900   REM
910   DO
920     ON N% GOTO 940,950,960,970
930     CLS:PRINT "ERROR SAVE SCREEN ROUTINE":STOP
940     SAVE SCREEN 0,0,24,79,MENU1:EXIT
950     SAVE SCREEN 0,0,24,79,MENU2:EXIT
960     SAVE SCREEN 0,0,24,79,MENU3:EXIT
970     SAVE SCREEN 0,0,24,79,MENU4:EXIT
990   REPEAT
1000  REM
1010  DO
1020    CLEARSCREEN (21)
1030    COLOR 6,0:SET CURSOR 21,5
1040    INPUT "Enter the number to be executed";Choice%
1050    IF Choice% > 0 AND Choice% <=Maxloop%(N%) THEN EXIT 2 LEVELS
1060    IF Choice% = 26 AND N% > 1 THEN EXIT TO,1100
1070    IF Choice% = 25 AND N% < Next_screen% THEN EXIT TO,1300
```

```
 1080    IF Choice% = 27 AND N% = Next_screen% THEN CLS:SYSTEM
 1090   REPEAT
 1100   REM
 1110   DO
 1120     N% = N% - 1
 1130     ON N% GOTO 1150,1160,1170,1180
 1140     CLS:PRINT "ERROR IN RESTORE ROUTINE":STOP
 1150     RESTORE SCREEN 0,0,24,79,MENU1:EXIT
 1160     RESTORE SCREEN 0,0,24,79,MENU2:EXIT
 1170     RESTORE SCREEN 0,0,24,79,MENU3:EXIT
 1180     RESTORE SCREEN 0,0,24,79,MENU4:EXIT
 1200   REPEAT
 1210   GOTO 1000
 1300   REM
 1310 NEXT N%
 1320 Col% = CINT((80 - LEN(Graph_name$(N%,Choice%)))/2)
 1330 CLS:COLOR 3,0:SET CURSOR 0,Col%
 1340 PRINT Graph_name$(N%,Choice%)
 1350 Max_graph_points%(1) = 1
 1360 Max_graph_points%(2) = 1
 1400 REM
 1410 Menu_chosen% = N%
 1420 Graph_chosen% = Choice%
 1425 GOTO 160
 1429 Cleargraph 1:G1=1:Graph%=1
 1430 WIDTH
80:GFLAG=Graph%:TITLE(Graph_name$(Menu_chosen%,Graph_chosen%)):ON
Menu_chosen% GOTO 1500,1600,1700,1800,1900
 1440 CLS:COLOR 7,0:PRINT "ERROR IN MENU_CHOSEN ROUTINE (1420)":STOP
 1500 REM
 1510 ON Graph_chosen% GOSUB
20000,10000,10000,23000,23000,17000,17000,23000,23000,23000,10000,11000,11000,11000,11000,110
00,11000,11000,11000,11000,15000,15000,15000,15000
 1520 CLS:PRINT "ERROR IN FIRST MENU ROUTINE (1500)":STOP
 1600 REM
 1610 ON Graph_chosen% GOSUB
23000,23000,11000,25000,2000,2000,2000,2000,2000,2000,2000,2000
 1620 CLS:PRINT "ERROR IN SECOND MENU ROUTINE (1600)":STOP
 1700 REM
 1710 ON Graph_chosen% GOSUB 2000,2000,2000,2000,2000,2000,2000,2000,2000,2000,2000,2000
 1720 CLS:PRINT "ERROR IN THIRD MENU ROUTINE (1700)":STOP
 1800 REM
 1810 ON Graph_chosen% GOSUB 2000,2000,2000,2000,2000,2000,2000,2000,2000,2000,2000,2000
 1820 CLS:PRINT "ERROR IN FOURTH MENU ROUTINE (1800)":STOP
 1900 REM
 1910 ON Graph_chosen% GOSUB 2000,2000,2000,2000,2000,2000,2000,2000,2000,2000,2000,2000
 1920 CLS:PRINT "ERROR IN FIFTH MENU ROUTINE (1900)":STOP
 2000 CLS:PRINT "THESE GRAPHS ARE NOT INSTALLED."
 2010 TIMEDELAY ()
 2020 GOTO 200
 2425 GRange$(Graph%) = STR$(Min!) + "," + STR$(Max!)
```

```
2430 GOTO 160
3000 WIDTH 80:Minloop%=1
3002 IF G1=1 THEN DELTAMULTIPLY(1,1,1.0):DELTAMULTIPLY(1,2,1.0)
3003 IF G2=2 THEN DELTAMULTIPLY(2,1,1.0):DELTAMULTIPLY(2,2,1.0)
3007 CLOSE
3010 DO
3020   TITLE ("Extrema for X and Y axes")
3030   COLOR 4,0:SET CURSOR 2,5
3040   PRINT "Minimum X";SPC(10);"Maximum X";SPC(10);"Minimum Y";SPC(10);"Maximum
Y"
3050   COLOR 3,0
3060   SET CURSOR 3,7:PRINT MinX!
3070   SET CURSOR 3,26:PRINT MaxX!
3080   SET CURSOR 3,45:PRINT MinY!
3090   SET CURSOR 3,64:PRINT MaxY!
3100   COLOR 7,0:SET CURSOR 19,5
3110   INPUT "Do you want to change any of the extrema (Defaults to NO)";Check$
3120   Check$ = UPPER$(Check$)
3130   IF INSTR(Check$,"Y") = 0 THEN EXIT 1 LEVELS
3140   CLEARSCREEN (19)
3150   DO 1 TIMES
3160     COLOR 6,0:SET CURSOR 9,5
3170     PRINT "Enter the Minimum X value (Defaults to ";MinX!;")";
3180     INPUT Change$
3190     IF Change$ <> "" THEN MinX! = VAL(Change$)
3200     COLOR 6,0:SET CURSOR 11,5
3210     PRINT "Enter the Maximum X value (Defaults to ";MaxX!;")";
3220     INPUT Change$
3230     IF Change$ <> "" THEN MaxX! = VAL(Change$)
3240     COLOR 6,0:SET CURSOR 13,5
3250     PRINT "Enter the Minimum Y value (Defaults to ";MinY!;")";
3260     INPUT Change$
3270     IF Change$ <> "" THEN MinY! = VAL(Change$)
3280     COLOR 6,0:SET CURSOR 15,5
3290     PRINT "Enter the Maximum Y value (Defaults to ";MaxY!;")";
3300     INPUT Change$
3310     IF Change$ <> "" THEN MaxY! = VAL(Change$)
3320   REPEAT
3330 REPEAT
3340 GOTO 160
4000 REM
4010 DO
4020   CLS:COLOR 2,0:SET CURSOR 11,5
4030   INPUT "Do you want a dot (1) or a line (2) graph";Choice%
4040   IF Choice% > 0 AND Choice% < 3 THEN EXIT
4050 REPEAT
4060 Graph_type% = Choice%
4500 REM
4510 DO 1 TIMES
4520   COLOR 2,0
4530   SCREEN 2
```

```
4540   DRAW "BM200,100 U2 D4 U2 L2 R4"
4550   GET (198,102) - (202,98),PLUS
4560   CLS
4570 REPEAT
5000 REM
5010 Col% = CINT((79 - LEN(Graph_name$(Menu_chosen%,Graph_chosen%)))/2)
5020 LOCATE 1,Col%:PRINT Graph_name$(Menu_chosen%,Graph_chosen%)
5050 XTITLE (Xtitle$,MinX!,MaxX!)
5060 YTITLE (Ytitle$,MinY!,MaxY!)
5500 REM
5510 DeltaX! = (570)/(MaxX! - MinX!)
5520 DeltaY! = (150)/(MaxY! - MinY!)
6000 REM
6004 ERASE Plot!(),Skippoint%()
6005 DIM Skippoint%(2,600)
6010 FOR M% = 1 TO Max_graph_points%(1)
6015   DO
6017     IF MinX! > Graph!(1,1,M%) THEN Skippoint%(1,M%) = 1 : EXIT 1 LEVELS
6019     IF MaxX! < Graph!(1,1,M%) THEN Skippoint%(1,M%) = 2 : EXIT 1 LEVELS
6021     IF MinY! > Graph!(1,2,M%) THEN Skippoint%(1,M%) = 3 : EXIT 1 LEVELS
6023     IF MaxY! < Graph!(1,2,M%) THEN Skippoint%(1,M%) = 4 : EXIT 1 LEVELS
6025     X_plot! = DeltaX!*(Graph!(1,1,M%) - MinX!) +46
6026     Y_plot! =-DeltaY!*(Graph!(1,2,M%) - MinY!) +165
6030     PSET (X_plot!,Y_plot!)
6031     Skippoint%(1,M%) = 5
6035   END DO
6040 NEXT M%
6045 DO 1 TIMES
6050   IF Comp_graph% = 0 THEN EXIT
6120   FOR M% = Minloop% TO Max_graph_points%(2)
6130     DO
6140       IF MinX! > Graph!(2,1,M%) THEN Skippoint%(2,M%) = 1 : EXIT 1 LEVELS
6145       IF MaxX! < Graph!(2,1,M%) THEN Skippoint%(2,M%) = 2 : EXIT 1 LEVELS
6150       IF MinY! > Graph!(2,2,M%) THEN Skippoint%(2,M%) = 3 : EXIT 1 LEVELS
6155       IF MaxY! < Graph!(2,2,M%) THEN Skippoint%(2,M%) = 4 : EXIT 1 LEVELS
6160       X_plot! = DeltaX!*(Graph!(2,1,M%) - MinX!) +46
6170       Y_plot! =-DeltaY!*(Graph!(2,2,M%) - MinY!) +165
6180       PUT (X_plot!,Y_plot!),PLUS,OR
6190       Skippoint%(2,M%) = 5
6200     END DO
6208   NEXT M%
6209 REPEAT
6210 DIM Plot!(2,2)
6212 DO
6213   IF Graph_type% <> 2 THEN EXIT 1 LEVELS
6214   FOR N% = 1 TO 2
6215     IF N% = 2 AND Comp_graph% <> 1 THEN EXIT 2 LEVELS
6216     FOR M% = 1 TO Max_graph_points%(N%) - 1
6217       DO
6218         FOR O% = 1 TO 2
6219           Plot!(O%,1)= DeltaX!*(Graph!(N%,1,M%+O%-1) - MinX!) +46
```

```
 6220          Plot!(O%,2)=-DeltaY!*(Graph!(N%,2,M%+O%-1) - MinY!) +165
 6224          Fixpoints Skippoint%(N%,M%+O%-1),0,Plot!(O%,1),Plot!(O%,2)
 6233        NEXT O%
 6235        IF N% = 2 AND (Skippoint%(1,M%) = 5 OR Skippoint%(2,M%) = 5) THEN
Plot!(1,1) = Plot!(1,1)+ 2:Plot!(1,2)=Plot!(1,2)+2:Plot!(2,1)=
Plot!(2,1)+2:Plot!(2,2)=Plot!(2,2)+2
 6238        LINE (Plot!(1,1),Plot!(1,2)) - (Plot!(2,1),Plot!(2,2))
 6240      END DO
 6242    NEXT M%
 6244  NEXT N%
 6245 END DO
 6248 DO
 6249  TIMEDELAY(2)
 6250  A$ = INKEY$ : IF INKEY$ = "" THEN GOTO 6250
 6260  SCREEN 0,0,0 : VIEW : CLS
 6265  ERASE Skippoint%(),Plot!()
 6270 END DO
 6275 GOTO 160
 6300 WIDTH 80:TITLE ( Graph_name$(Menu_chosen%,Graph_chosen%))
 6310 Fit$=UPPER$("Y")
 7550 Error_LS%=0
 7560 FOR M% = 1 TO 2
 7562  DO 1 TIMES
 7565    DO
 7568      IF INSTR(Fit$,"Y")=0 THEN EXIT 1 LEVELS
 7569      CLEAR (Slope!(M%),Correlation!(M%),X_int!(M%),Y_int!(M%))
 7570      LEASTSQUARES
(M%,Min!(M%),Max!(M%),Slope!(M%),Correlation!(M%),X_int!(M%),Y_int!(M%),M%-1,Error
_LS%)
 7572      IF Error_LS% <> 0 THEN Fit$ = "END"
 7575    END DO
 7640  REPEAT
 7650  DO
 7655    IF Error_LS% = 1 THEN EXIT TO,160
 7660    IF INSTR(Fit$,"Y") = 0 THEN EXIT
 7670    DO 1 TIMES
 7680      IF M% = 2 THEN EXIT
 7690      CLS : TITLE ("Least Squares Fit")
 7694      COLOR 2,0,0
 7700      SET CURSOR 8,0:PRINT "X - Intercept"
 7710      SET CURSOR 10,0:PRINT "Y - Intercept"
 7720      SET CURSOR 12,0:PRINT "Slope"
 7730      SET CURSOR 14,0:PRINT "Correlation"
 7740      SET CURSOR 16,0:PRINT "Range"
 7750    REPEAT
 7760    DO
 7790      IF M% =1 THEN Col% = 20
 7800      IF M% = 2 THEN Col% = 50
 7810      SET CURSOR 6,Col%
 7820      IF M% = 1 THEN PRINT ". CURVE 1" ELSE PRINT "+ CURVE 2"
 7830      FOR N% = 1 TO 6
```

```
 7840        SET CURSOR N%*2 + 6,Col%
 7850        DO
 7860          ON N% GOTO 7870,7880,7890,7900,7910,7920
 7870          Dummy! = X_int!(M%):EXIT 1 LEVELS
 7880          Dummy! = Y_int!(M%):EXIT 1 LEVELS
 7890          Dummy! = Slope!(M%):EXIT 1 LEVELS
 7900          Dummy! = Correlation!(M%):EXIT 1 LEVELS
 7910          Dummy! = Min!(M%):EXIT 1 LEVELS
 7920          SET CURSOR 16,Col% + 8:PRINT ","
 7930          SET CURSOR 16,Col% + 10:Dummy! = Max!(M%):EXIT 1 LEVELS
 7940        REPEAT
 7945        DO 1 TIMES
 7950          IF Dummy! => .01 AND Dummy! <= 1000 THEN PRINT USING
".";Dummy!:EXIT
 7960          IF Dummy!<= -.01 AND Dummy! >= -1000 THEN PRINT USING
".";Dummy!:EXIT
 7970          IF Dummy! = 0 THEN PRINT "0" ELSE PRINT USING
"#.###^^^^";Dummy!:EXIT
 7975        REPEAT
 7980      NEXT N%
 7990    END DO
 7995  END DO
 8000 NEXT M%
 8015 DO 1 TIMES
 8016   IF INSTR(Fit$,"Y") = 0 THEN EXIT
 8020   TIMEDELAY (4)
 8030   SET CURSOR 21,5:COLOR 7,0:PRINT "HIT ANY KEY TO CONTINUE"
 8040   A$ = INKEY$:IF A$ = "" THEN GOTO 8040
 8050 REPEAT
 8060 IF X_int!(1) <> 0 OR X_int!(2) <> 0 THEN Fit$ = "Y"
 8065 GOTO 160
 8555 DO
 8560   CLEARSCREEN(2) : SET CURSOR 13,6
 8590   SAVEDATA(Comp_graph%+1)
 8595 END DO
 8600 GOTO 160
 8700 Cleargraph 2:G2=2:Graph%=2:Comp_graph%=1
 8796 CLS:COLOR 3,0:SET CURSOR 0,CINT((80 -
LEN(Graph_name$(Menu_chosen%,Graph_chosen%)))/2)
 8797 PRINT Graph_name$(Menu_chosen%,Graph_chosen%)
 8800 EXIT TO,1430
 9000 REM
 9001 TITLE (Graph_name$(Menu_chosen%,Graph_chosen%))
 9040 DO 1 TIMES
 9050   IF Info_pointer% < 5 THEN EXIT 1 LEVELS
 9060   COLOR 7,0 : SET CURSOR 13,6
 9070   PRINT "WARNING!  If you plan on plotting the another graph, the information block"
 9075   SET CURSOR 14,6 : PRINT "will not be printed!"
 9080   TIMEDELAY (5)
 9090 REPEAT
 9095 PLOTTER
```

```
9220 DO
9230   IF INSTR(Fit$,"Y") = 0 THEN EXIT 1 LEVELS
9240   Slope$(2) = STR$(Slope!(2))
9250   X_int$(2) = STR$(X_int!(2))
9260   Y_int$(2) = STR$(Y_int!(2))
9265   Range$(2) = STR$(Min!(2)) + "," +STR$(Max!(2))
9266   Correlation$(2) = STR$(Correlation!(2))
9267 END DO
9350 G=G2:Print_out%=1
9360 PLOTTING_POINTS(Symbol$,2,1)
9370 EXIT TO,9999
9560 GOTO 9000
9570 DO
9580   Title$ = UPPER$(Graph_name$(Menu_chosen%,Graph_chosen%))
9590   PLOTTERAXES (UPPER$(Graph_name$(Menu_chosen%,Graph_chosen%)))
9600 END DO
9601 GOTO 9000
9640 DO
9650   IF INSTR(Fit$,"Y") = 0 THEN EXIT 1 LEVELS
9660   Slope$(1) = STR$(Slope!(1))
9670   X_int$(1) = STR$(X_int!(1))
9680   Y_int$(1) = STR$(Y_int!(1))
9690   Range$(1) = STR$(Min!(1)) + "," + STR$(Max!(1))
9695   Correlation$(1) = STR$(Correlation!(1))
9696 END DO
9700 DO
9701   Temp$(1) = " " + Temp$(1)
9702   Tyme$(1) =  " " + Tyme$(1)
9703   Bias$(1) = " " + Bias$(1)
9704   Pulse$(1) = " " + Pulse$(1)
9705   Hold$(1) = " " + Hold$(1)
9706   Rate$(1) = " " + Rate$(1)
9707   GRange$(1) = " " + GRange$(1)
9708   G=G1
9710   PLOTTING_POINTS(Symbol$,1,0)
9715   Print_out% = 1
9720 END DO
9999 GOTO 9000
10000 REM
10007 Error% = 0
10010 DO
10020   IF Graph_chosen% = 11 THEN EXIT 1 LEVELS
10030   Directory$(Graph%,2) = "NO"
10040 END DO
10400 DO
10410   IF Graph_chosen% = 3 THEN File$ = "\G-T" ELSE File$ = "\C-T"
10415   IF Graph_chosen% = 11 THEN ID% = 0 ELSE ID% = 1
10420   DIRECTORY (File$,ID%,Graph%,Error%)
10430   IF Error% <> 0 THEN EXIT TO,160
10434   DO 1 TIMES
10435     IF Graph_chosen% = 11 THEN ID% = 1 ELSE ID% = 0
```

```
10440    RUNTYPE(Graph%,ID%)
10445    DO
10446      IF Graph_chosen% <> 11 THEN EXIT 1 LEVELS
10447      IF INSTR(Temp_type$(Graph%),"T") = 0 AND INSTR(Temp_type$(Graph%),"R") =
0 THEN EXIT 1 LEVELS
10449      CLEARSCREEN(2)
10451      SET CURSOR 13,6 : COLOR 7,0
10453      PRINT "The DLTS Spectrum cannot be done with either a TIME or ROOM
TEMPERATURE run."
10455      TIMEDELAY()
10457      EXIT TO,10400
10459    REPEAT
10460  REPEAT
10465  IF Graph_chosen% <> 11 THEN ID% = 1 ELSE ID% = 4
10470  PARAMETERSET (ID%)
10480  IF Graph_chosen% = 11 THEN ID% = 8 ELSE ID% = 1
10485  DATAPRINT
10490  FOR N% = 1 TO 2
10500    DO
10510      IF INSTR(Directory$(Graph%,N%),"NO") <> 0 THEN EXIT 1 LEVELS
10520      DATARETRIEVAL (ID%,Graph%,N%,Error%,0)
10525      IF Error% <> 0 THEN EXIT TO,10400
10530    END DO
10540  NEXT N%
10550 END DO
10600 DO
10610  DO
10620    IF Graph_chosen% <> 2 THEN EXIT 1 LEVELS
10630    DELTAMULTIPLY (Graph%,2,1.0E+09)
10640    Ytitle$ = "Capacitance in nF"
10650    DELTAMULTIPLY (Graph%,1,1000.0)
10660    Xtitle$ = "Time in milliSeconds"
10665    IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp$(Graph%) =
STR$(Temp_sought!)
10666    IF INSTR(Temp_type$(Graph%),"T") <> 0 THEN Tyme$(Graph%) =
STR$(Time_sought!)
10667    Bias$(Graph%) = MID$(Bias_found$,INSTR(Bias_found$,"=") + 2)
10668    Pulse$(Graph%) = MID$(Pulse_found$,INSTR(Pulse_found$,"=") + 2)
10669    Hold$(Graph%) = MID$(Hold_found$,INSTR(Hold_found$,"=") + 2)
10670    EXIT 2 LEVELS
10680  END DO
10690  DO
10700    IF Graph_chosen% <> 3 THEN EXIT 1 LEVELS
10710    DELTAMULTIPLY (Graph%,2,1000.0)
10720    Ytitle$ = "Conductance in mMhos"
10730    DELTAMULTIPLY (Graph%,1,1000.0)
10740    Xtitle$ = "Time in milliSeconds"
10741    IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp$(Graph%) =
STR$(Temp_sought!)
10742    IF INSTR(Temp_type$(Graph%),"T") <> 0 THEN Tyme$(Graph%) =
STR$(Time_sought!)
```

```
10743    Bias$(Graph%) = MID$(Bias_found$,INSTR(Bias_found$,"=") + 1)
10744    Pulse$(Graph%) = MID$(Pulse_found$,INSTR(Pulse_found$,"=") + 1)
10745    Hold$(Graph%) = MID$(Hold_found$,INSTR(Hold_found$,"=") + 1)
10750    EXIT 2 LEVELS
10760   END DO
10770   DO
10780    IF Graph_chosen% <> 11 THEN EXIT 1 LEVELS
10790    DELTAMULTIPLY (Graph%,2,1E+12)
10800    Ytitle$ = "DLTS in pF"
10810    Xtitle$ = "Temperature in Kelvin"
10822    Bias$(Graph%) = MID$(Bias_found$,INSTR(Bias_found$,"=") + 1)
10823    Pulse$(Graph%) = MID$(Pulse_found$,INSTR(Pulse_found$,"=") + 1)
10824    Hold$(Graph%) = MID$(Hold_found$,INSTR(Hold_found$,"=") + 1)
10825    Rate$(Graph%) = STR$(LOG(Mintyme! / Maxtyme!) / (Mintyme! - Maxtyme!))
10830    EXIT 2 LEVELS
10840   END DO
10980 END DO
10985 CLOSE
10990 RETURN,160
11000 REM
11010 Counter% = 0
11030 File% = 1
11500 DO
11510   IF Graph_chosen% = 13 OR Graph_chosen% = 14 THEN File$ = "\CV" ELSE File$ =
"\IV"
11515   IF Graph_chosen% > 16 AND Graph_chosen% < 25 THEN ID% = 0 ELSE ID% = 1
11517   IF Graph_chosen% = 3 THEN ID% = 0
11520   DIRECTORY(File$,ID%,Graph%,Error%)
11530   IF Error% <> 0 THEN EXIT TO,160
11540 END DO
11550 DO
11560   IF Graph_chosen% > 16 OR Graph_chosen% = 3 THEN ID% = 1 ELSE ID% = 0
11570   RUNTYPE(Graph%,ID%)
11574   DO
11575    IF INSTR(Temp_type$(Graph%),"R") = 0 OR Graph_chosen% <> 17 THEN  EXIT 1
LEVELS
11576    CLEARSCREEN(2)
11577    COLOR 7,0,0 : SET CURSOR 13,6
11578    PRINT "You cannot do the chosen graph with a room temperature run."
11579    TIMEDELAY(5)
11580    EXIT TO,11500
11581   REPEAT
11589 END DO
11590 DO
11600   IF Graph_chosen% <> 20 THEN EXIT 1 LEVELS
11610   CLEARSCREEN(2)
11620   SET CURSOR 13,6 : COLOR 2,0
11630   INPUT "Enter the AE*A  ",Dummy$
11640   AeA! = VAL(Dummy$)
11650   IF AeA! <= 0 THEN EXIT TO,11590
11660 END DO
```

```
11670 DO
11680   IF Graph_chosen% <> 17 THEN EXIT 1 LEVELS
11685   CLEARSCREEN(2)
11690   SET CURSOR 13,6 : COLOR 2,0,0
11700   INPUT "Enter the forward bias. ",Dummy$
11710   Vf! = VAL(Dummy$)
11730 END DO
11740 DATAPRINT
11885 DO
11886   IF Graph_chosen% < 17 AND Graph_chosen% <> 3 THEN EXIT 1 LEVELS
11887   IF INSTR(Temp_type$(Graph%),"T") <> 0 THEN Run_type% = 2 ELSE Run_type% =
1
11888   IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp_type$(Graph%) = "R"
11889   EXIT TO,11900
11890 REPEAT
11891 Run_type% = 0
11900 DO
11910   IF Graph_chosen% = 13 OR Graph_chosen% = 14 THEN ID% = 7 ELSE ID% = 6
11930   DATARETRIEVAL (ID%,Graph%,File%,Error%,Run_type%)
11942   IF Error% = 1 AND Graph!(Graph%,2,2) <> 0 AND Graph_chosen% = 16 THEN
EXIT 1 LEVELS
11943   IF Error% = 1 AND Graph!(Graph%,2,2) <> 0 AND Graph_chosen% = 12 THEN
EXIT 1 LEVELS
11944   IF Error% = 1 AND Graph!(Graph%,2,2) <> 0 AND Graph_chosen% = 15 THEN
EXIT 1 LEVELS
11945   IF Error% <> 0 AND Graph_chosen% < 17 AND Graph_chosen% <> 3 THEN EXIT
TO,11500
11950 END DO
12000 DO
12010   DO
12020     IF Graph_chosen% <> 12 THEN EXIT 1 LEVELS
12030     DELTAMULTIPLY(Graph%,2,1000.0)
12040     Xtitle$ = "Voltage in Volts"
12050     Ytitle$ = "Current in mA"
12060     EXIT 2 LEVELS
12070   REPEAT
12080   DO
12090     DO
12095       DO
12100         IF Graph_chosen% <> 13 THEN EXIT 1 LEVELS
12110         DELTAMULTIPLY(Graph%,2,1E+09)
12120         Ytitle$ = "Cap in nF"
12130         EXIT 2 LEVELS
12140       REPEAT
12150       DO
12160         IF Graph_chosen% <> 14 THEN EXIT 3 LEVELS
12170         INVERSEPOWER(Graph%,2,1E+09,2.000)
12180         Ytitle$ = "1/C**2  C in nF"
12190       END DO
12195     END DO
12210     Xtitle$ = "Voltage in Volts"
```

```
12220    EXIT 2 LEVELS
12230   REPEAT
12240   DO
12250    IF Graph_chosen% > 16 OR Graph_chosen% = 3 THEN EXIT 1 LEVELS
12260    DELTAln(Graph%,2,1.0)
12270    Ytitle$ = "Ln(I)  I in A"
12280    DO
12290     IF Graph_chosen% <> 15 THEN EXIT 1 LEVELS
12300     Xtitle$ = "Voltage in Volts"
12305     DELTAMULTIPLY(Graph%,2,1/LOG(10))
12310     EXIT 3 LEVELS
12320    REPEAT
12330    DO
12340     Position% = INSTR(Temp_found$,";") + 1
12350     Temp! = VAL(MID$(Temp_found$,Position%))
12360     DELTAMULTIPLY(Graph%,1,(Q!/(K! * Temp!)))
12370     Xtitle$ = "QV / kT"
12375     IF Graph_chosen% = 17 THEN EXIT 1 LEVELS
12380     EXIT 3 LEVELS
12390    REPEAT
12400   END DO
12410   DO
12420    IF Graph_chosen% <> 17 THEN EXIT 1 LEVELS
12430    DO
12440     Position% = INSTR(Temp_found$,";") + 1
12450     Temp! = VAL(MID$(Temp_found$,Position%))
12460    END DO
12470    Counter% = Counter% + 1
12480    DO
12490     FOR M% = 1 TO Max_graph_points%(Graph%)
12500      IF Graph!(Graph%,1,M%) = Vf! THEN EXIT 2 LEVELS
12510     NEXT M%
12515     IF Counter% > 1 THEN EXIT TO,12630
12520     CLEARSCREEN(2)
12530     COLOR 7,0 : SET CURSOR 13,6
12540     PRINT "The Forward bias you specified was not found"
12550     TIMEDELAY (5)
12560     EXIT TO,11670
12570    REPEAT
12580    If! = Graph!(Graph%,2,M%)
12590    X! = (Q!) / (K! * Temp!)
12600    Y! = LOG (ABS(If!) / Temp! ^ 2.0)
12610    OPEN "\BUCKET" FOR APPEND AS #3
12620    PRINT #3,X! "," Y!
12630    CLOSE #File% : CLOSE #3
12632    IF INSTR(SOURCE$,"B")=0 THEN OPEN "\DATA\"+ Directory$(Graph%,File%) +
File$ FOR INPUT AS #File% ELSE OPEN "B:" + File$ +"."+Directory$(Graph%,File%) FOR
INPUT AS #File%
12635    Max_graph_points%(Graph%) = 1
12637    IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp_type$(Graph%) = "L"
12640    IF Error% = 0 THEN EXIT TO,11900
```

```
12642    DO
12643      CLOSE #File%
12644      File% = File% + 1
12645      IF File% = 3 OR INSTR(Directory$(Graph%,2),"NO") <> 0 THEN EXIT 1
LEVELS
12646      IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp_type$(Graph%) = "R"
12647      EXIT TO,11900
12648    REPEAT
12650    DO
12670      Max_graph_points%(Graph%) = Counter%
12680      GETDATA(Graph%)
12710      Ytitle$ = "Ln (If / T**2) If in A"
12720      Xtitle$ = "q / KT"
12725      Graph_name$(1,17) = "Activation Energy"
12730      Bias$(Graph%) = STR$(Vf!)
12740      EXIT 3 LEVELS
12750    REPEAT
12760  REPEAT
12770  DO
12775    DO
12777      IF Graph_chosen% = 3 THEN EXIT 1 LEVELS
12780      IF Graph_chosen% < 18 OR Graph_chosen% > 20 THEN EXIT 2 LEVELS
12785    END DO
12790    Counter% = Counter% + 1
12800    DO
12810      Position% = INSTR(Temp_found$,";") + 1
12820      Temp! = VAL(MID$(Temp_found$,Position%))
12830      DELTAln (Graph%,2,1.0)
12840      DELTAMULTIPLY (Graph%,1,(Q!/(K! * Temp!)))
12850      IF Counter% = 1 THEN ID% = 0 ELSE ID% = 1
12860      LEASTSQUARES
(Graph%,Min!,Max!,Slope!,Dummy!,Dummy!,Y_int!,ID%,Error_LS%)
12862      IF Error_LS% = 1 THEN EXIT TO,160
12865      GRange$(Graph%) = STR$(Min!) + "," + STR$(Max!)
12870    END DO
12880    DO
12890      DO
12900        IF Graph_chosen% <> 18 AND Graph_chosen% <> 3 THEN EXIT 1 LEVELS
12905        DO
12906          IF Graph_chosen% = 3 THEN EXIT 1 LEVELS
12907          IF Y_int! < -39 OR Y_int! > 1 THEN Counter% = Counter% - 1 : EXIT
TO,13313
12910          Y! = EXP(Y_int!)
12920          Ytitle$ = "Isat in Amps"
12924          Graph_name$(1,18) = "I Saturation"
12925        END DO
12926        DO
12927          IF Graph_chosen% <> 3 THEN EXIT 1 LEVELS
12928          Y! = Y_int!
12929          Ytitle$ = "ln(Isat) in Amps"
12930          Graph_name$(2,3) = "ln(Isat)"
```

```
12935       END DO
12936       EXIT 2 LEVELS
12940     REPEAT
12950     DO
12960       IF Graph_chosen% <> 19 THEN EXIT 1 LEVELS
12970       Y! = 1/Slope!
12980       Ytitle$ = "Ideality Factor"
12985       Graph_name$(1,19) = "Ideality Factor n"
12990       EXIT 2 LEVELS
13000     REPEAT
13010     DO
13020       IF Graph_chosen% <> 20 THEN EXIT 1 LEVELS
13025       IF Y_int! < -39 OR Y_int! > 1 THEN Counter% = Counter% - 1 : EXIT TO,13313
13030       Y! = (K! * Temp!/ Q!) * LOG (AeA! * Temp!^2.0/EXP(Y_int!))
13040       Ytitle$ = "Barrier in Volts"
13045       Graph_name$(1,20) = "Barrier Height (Current)"
13050       EXIT 2 LEVELS
13060     REPEAT
13070   END DO
13150   DO
13160     DO
13170       IF INSTR(Temp_type$(Graph%), "T") <> 0 THEN EXIT 1 LEVELS
13180       X! = Temp!
13190       Xtitle$ = "Temperature in Kelvin"
13200       EXIT 2 LEVELS
13210     REPEAT
13220     DO
13230       Position% = INSTR(Time_found$,"=") + 1
13240       X! = VAL (MID$(Time_found$,Position%))
13250       Xtitle$ = "Time in Seconds"
13260     END DO
13270   END DO
13280   DO
13290     OPEN "\BUCKET" FOR APPEND AS #3
13300     PRINT #3, X! "," Y!
13310     CLOSE #File% : CLOSE #3
13312   END DO
13313   DO
13315     Max_graph_points%(Graph%) = 1
13316     CLOSE #File%
13317     IF INSTR(SOURCE$,"B")=0 THEN OPEN "\DATA\"+ Directory$(Graph%,File%) +
File$ FOR INPUT AS #File% ELSE OPEN "B:" + File$ +"."+Directory$(Graph%,File%) FOR
INPUT AS #File%
13318     IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp_type$(Graph%) = "L"
13320     IF Error% = 0 THEN EXIT TO,11900
13330   END DO
13332   DO
13333     CLOSE #File%
13334     File% = File% + 1
13335     IF File% = 3 OR INSTR(Directory$(Graph%,2),"NO") <> 0 THEN EXIT 1
LEVELS
```

```
13336      IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp_type$(Graph%) = "R"
13337      EXIT TO,11900
13338    REPEAT
13340    DO
13350      Max_graph_points%(Graph%) = Counter%
13360      GETDATA(Graph%)
13410    END DO
13420    EXIT 2 LEVELS
13425  END DO
13437 END DO
13440 DO
13442  IF Graph_chosen% > 17 AND Graph_chosen% < 21 OR Graph_chosen% = 3 THEN
EXIT 1 LEVELS
13445  DO
13450    IF INSTR(Temp_type$(Graph%),"T") <> 0 THEN EXIT 1 LEVELS
13460    Position% = INSTR(Temp_found$,";") + 1
13470    Temp$(Graph%) = MID$(Temp_found$,Position%)
13480    EXIT 2 LEVELS
13490  REPEAT
13500  DO
13510    Position% = INSTR(Time_found$,"=") + 1
13520    Tyme$(Graph%) = MID$(Time_found$,Position%,14)
13530  END DO
13540 END DO
13560 RETURN,160
15000 REM
15010 DO
15020  IF Graph_chosen% > 20 AND Graph_chosen% < 25 THEN EXIT 1 LEVELS
15030  CLEARSCREEN(2)
15040  COLOR 7,0,0 : SET CURSOR 13,6
15050  PRINT "The graph for the mobility experiment chosen is not installed (oops)"
15060  END
15070 REPEAT
15090 File% = 1
15095 File$="\MOB"
15100 DO
15110  DIRECTORY(File$,0,Graph%,Error%)
15130 END DO
15140 RUNTYPE(Graph%,1)
15200 DO
15210  CLEARSCREEN(2)
15220  COLOR 2,0,0 : SET CURSOR 10,6
15230  INPUT "Enter the samples electrical thickness. ",Dummy$
15240  Elec_thick! = VAL(Dummy$)
15250  IF Elec_thick! <= 0 THEN EXIT TO,15200
15260 END DO
15300 DO
15310  IF Graph_chosen% <> 24 THEN EXIT 1 LEVELS
15320  CLEARSCREEN(16)
15330  SET CURSOR 16,6
15340  INPUT "Enter the average dopant density. ",Dummy$
```

```
15350  Nd! = VAL(Dummy$)
15360  IF Nd! <= 0 THEN EXIT TO,15300
15370 END DO
15380 DATAPRINT
15500 DO
15510  DO
15516   IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp_type$(Graph%) = "R"
15517  END DO
15520  IF INSTR(Directory$(Graph%,File%),"NO") <> 0 THEN EXIT 2 LEVELS
15530  INPUT #File%,Dummy$,I$,V1$,V2$,Dummy$
15540  R1! = VAL(V2$) /VAL(I$)
15550  INPUT #File%,Dummy$,I$,V1$,V2$,Dummy$
15560  R2! = VAL(V2$)/VAL(I$)
15570  INPUT #File%,Dummy$,I$,V1$,V2$,Dummy$
15575  Dummy! = MIN(R2!,R1!)
15576  Eric! = MAX(R2!,R1!)
15580  G! = 1.0 / ((3.141592654 *VAL(I$) / (2 * VAL(V1$) * .693147181)) *
(R1!+R2!)*(1-.138974234 * LOG(ABS(Eric! / Dummy!))))
15590  DATARETRIEVAL(9,Graph%,File%,Error%,0)
15600  IF Error% <> 0 THEN EXIT TO,15200
15610 END DO
15700 DO
15710  DO
15720   IF Graph_chosen% <> 21 THEN EXIT 1 LEVELS
15725   Graph_name$(1,21) = "Resistivity"
15730   Ytitle$ = "Resistivity in ohms*cm"
15731   DO
15732    CLOSE #File%
15733    File% = File% + 1
15734    IF File% = 3 OR INSTR(Directory$(Graph%,2),"NO") <> 0 THEN EXIT 1
LEVELS
15735    Max_graph_points%(Graph%) = Max_graph_points%(Graph%) + 1
15736    EXIT TO,15500
15737   REPEAT
15740   EXIT 2 LEVELS
15750  END DO
15760  DO
15770   IF Graph_chosen% < 22 OR Graph_chosen% > 24 THEN EXIT 1 LEVELS
15780   CLOSE #File%
15790   DO
15810    IF INSTR(SOURCE$,"B")=0 THEN OPEN "\DATA\"+ Directory$(Graph%,File%) +
File$ FOR INPUT AS #File% ELSE OPEN "B:" + File$ +"."+Directory$(Graph%,File%) FOR
INPUT AS #File%
15820    DO 15 TIMES
15830     INPUT #File%,Dummy$
15840    REPEAT
15850   END DO
15855   IF File% = 1 THEN Counter% = Max_graph_points%(Graph%) + 1
15856   IF File% = 1 THEN Max_graph_points%(Graph%) = 1
15857   IF File% = 2 THEN Max_graph_points%(Graph%) = Counter%
15860   DO
```

```
15870      IF INSTR(Directory$(Graph%,File%),"NO") <> 0 THEN EXIT 1 LEVELS
15880      DATARETRIEVAL(10,Graph%,File%,Error%,0)
15890      IF Error% <> 0 THEN EXIT TO,15200
15900    END DO
15912    DO
15913      CLOSE #File%
15914      File% = File% + 1
15915      IF File% = 3 OR INSTR(Directory$(Graph%,2),"NO") <> 0 THEN EXIT 1
LEVELS
15916      Max_graph_points%(Graph%) = Max_graph_points%(Graph%) + 1
15917      EXIT TO,15500
15918    REPEAT
15919    DELTAMULTIPLY(Graph%,2,Elec_thick!)
15920    DO
15930      IF Graph_chosen% <> 22 THEN EXIT 1 LEVELS
15940      Ytitle$ = "Mobility in cm**2/V-s"
15945      Graph_name$(1,22) = "Mobility"
15950      EXIT 3 LEVELS
15960    END DO
15970    DO
15980      IF Graph_chosen% <> 23 AND Graph_chosen% <> 24 THEN EXIT 1 LEVELS
15990      OPEN "\BUCKET" FOR INPUT AS #3
16000      FOR N% = 1 TO Max_graph_points%(Graph%)
16010        INPUT #3,Y!
16020        Graph!(Graph%,2,N%) = 1/ (Q! * Y! * Graph!(Graph%,2,N%))
16030      NEXT N%
16040      DO
16050        IF Graph_chosen% <> 23 THEN EXIT 1 LEVELS
16060        Ytitle$ = "Carrier Conc in 1/cm**3"
16062        Graph_name$(1,23) = "Carrier Concentration n"
16065        EXIT 3 LEVELS
16070        EXIT 4 LEVELS
16080      END DO
16090      DO
16100        DELTAMULTIPLY(Graph%,2,100.0/Nd!)
16110        Ytitle$ = "% Activation"
16115        Graph_name$(1,24) = "Dopant Activation %"
16120        EXIT 3 LEVELS
16130      END DO
16140    REPEAT
16150  REPEAT
16160 END DO
16165 DO
16170   DO
16180     IF INSTR(Temp_type$(Graph%),"T") <> 0 THEN EXIT 1 LEVELS
16190     Xtitle$ = "Temperature in Kelvin"
16200     EXIT 2 LEVELS
16210   END DO
16220   DO
16230     Xtitle$ = "Time in Seconds"
16240   END DO
```

```
16245 END DO
16250 KILL "\BUCKET"
16260 RETURN,160
17000 REM
17010 DO
17020   IF Graph_chosen% = 6 OR Graph_chosen% = 7 THEN EXIT 1 LEVELS
17030   CLEARSCREEN(2)
17040   SET CURSOR 13,1 : COLOR 7,0
17050   PRINT "The graph chosen has not been implemented (17000)."
17060   STOP
17070 REPEAT
17210 DO
17220   DIRECTORY("\CG",0,Graph%,Error%)
17230   IF Error% <> 0 THEN EXIT TO,160
17235   RUNTYPE(Graph%,1)
17240 END DO
17250 DO
17260   CLEARSCREEN(2)
17270   SET CURSOR 13,6 : COLOR 2,0,0
17280   INPUT "Enter the Bias Voltage. ",Dummy$
17285   Bias_sought! = VAL(Dummy$)
17290 END DO
17500 FOR N% = 1 TO 2
17510   IF INSTR(Directory$(Graph%,N%),"NO") <> 0 THEN EXIT 1 LEVELS
17512   DATAPRINT
17515   IF N% = 2 THEN Max_graph_points%(Graph%) = Max_graph_points%(Graph%) + 1
17520   IF Graph_chosen% = 6 THEN ID% = 4 ELSE ID% = 5
17530   DATARETRIEVAL(ID%,Graph%,N%,Error%,0)
17540   IF Error% = 1 THEN EXIT TO,17210
17550 NEXT N%
17700 DO
17710   IF Graph_chosen% <> 6 THEN EXIT 1 LEVELS
17720   DELTAMULTIPLY(Graph%,2,1E+09)
17730   Ytitle$ = "Capacitance in nF"
17735   Graph_name$(1,6) = "Capacitance vs."
17740 END DO
17750 DO
17760   IF Graph_chosen% <> 7 THEN EXIT 1 LEVELS
17770   DELTAMULTIPLY(Graph%,2,1000.0)
17775   Graph_name$(1,7) = "Conductance vs."
17780   Ytitle$ = "Conductance in mMhos"
17790 END DO
17800 DO
17810   Position% = INSTR(Bias_found$,"=") + 1
17820   Bias$(Graph%) = MID$(Bias_found$,Position%)
17830   DO
17840     IF INSTR(Temp_type$(Graph%),"T") <> 0 THEN EXIT 1 LEVELS
17850     Xtitle$ = "Temperature in Kelvin"
17860     Graph_name$(1,Graph_chosen%) = Graph_name$(1,Graph_chosen%) + "Temperature"
17870     EXIT 2 LEVELS
17880   REPEAT
```

```
17890   DO
17900     Xtitle$ = "Time in Seconds"
17910     Graph_name$(1,Graph_chosen%) = Graph_name$(1,Graph_chosen%) + "Time"
17920   END DO
17930 END DO
17940 RETURN,160
20000 REM
20010 DO
20020   CLEARSCREEN(2)
20030   RESTORE,62000
20040   FOR N% = 4 TO 11
20050     READ Hand_info$(N%)
20060     COLOR 11,0 : LOCATE N%,1
20070     PRINT Hand_info$(N%)
20080   NEXT N%
20090 END DO
20200 LOCATE 4,1, : COLOR 0,7 : PRINT Hand_info$(4)
20210 COLOR 5,0 : LOCATE 13,40 : PRINT "MAKE SELECTION"
20215 LOCATE 4,1
20220 A$ = INKEY$ : IF A$ = "" THEN GOTO 20220
20230 IF ASC(RIGHT$(A$,1)) = 13 THEN GOTO 20300
20240 IF ASC(RIGHT$(A$,1)) = 72 THEN GOSUB 20400
20250 IF ASC(RIGHT$(A$,1)) = 80 THEN GOSUB 20500
20260 GOTO 20220
20300 ON CSRLIN -3 GOSUB 20600,20700,20800,20900,21100,22000,22600,22400
20310 PRINT CSRLIN : STOP
20400 Position% = CSRLIN
20410 COLOR 11,0 : LOCATE Position%,1 : PRINT Hand_info$(Position%)
20420 IF Position% < 5 THEN Position% = 12
20430 COLOR 0,7 : LOCATE Position%-1,1 : PRINT Hand_info$(Position%-1);
20440 RETURN,20220
20500 Position% = CSRLIN
20510 COLOR 11,0 : LOCATE Position%,1 : PRINT Hand_info$(Position%)
20520 IF Position% > 10 THEN Position% = 3
20530 COLOR 0,7 : LOCATE Position%+1,1 : PRINT Hand_info$(Position%+1);
20540 RETURN,20220
20600 GOSUB 22500
20610 DO
20620   LINE INPUT "Enter the TITLE of the graph (up to 60 letters) ";Graph_name$(1,1)
20625   Position% = INSTR(Graph_name$(1,1),"   ") - 1
20627   Graph_name$(1,1) = MID$(Graph_name$(1,1),1,Position%)
20630   CLEARSCREEN (20)
20640 END DO
20650 RETURN,20200
20700 GOSUB 22500
20710 DO
20720   LINE INPUT "Enter the X AXIS title (up to 60 letters) ";Xtitle$
20725   Position% = INSTR(Xtitle$,"   ") - 1
20727   Xtitle$ = MID$(Xtitle$,1,Position%)
20730   CLEARSCREEN(20)
20740 END DO
```

```
20750 RETURN,20200
20800 GOSUB 22500
20810 DO
20820   LINE INPUT "Enter the Y AXIS title (up to 20 letters) ";Ytitle$
20825   Position% = INSTR(Ytitle$,"   ") - 1
20827   Ytitle$ = MID$(Ytitle$,1,Position%)
20830   CLEARSCREEN(20)
20840 END DO
20850 RETURN,20200
20900 GOSUB 22500
20920 PRINT "Enter the X,Y data point <RETURN>  "
20930 COLOR 7,0
20940 FOR N% = Minloop% TO 1200
20947   SET CURSOR 21,43 : PRINT SPC(34)
20950   SET CURSOR 21,43
20955   DO
20960     LINE INPUT V$
20961     IF V$ = "" THEN EXIT TO,21005
20962     Pointer% = INSTR(V$,",")
20963     IF Pointer% = 0 THEN EXIT TO,21005
20964   END DO
20965   Graph!(Graph%,1,N%) = VAL(MID$(V$,1,Pointer%))
20966   Graph!(Graph%,2,N%) = VAL(MID$(V$,Pointer%+1))
20985   SET CURSOR 21,43 : PRINT SPC(34)
20990   CLEARSCREEN(22)
21000 NEXT N%
21005 Minloop% = N%
21007 Max_graph_points%(Graph%) = N%-1
21010 CLEARSCREEN (21)
21020 RETURN,20200
21050 RETURN
21100 GOSUB 22500
21110 SET CURSOR 3,40 : COLOR 5,0 : PRINT "Changing X-Y data"
21120 Minloop1% = 1
21130 FOR N% = Minloop1% TO Max_graph_points%(Graph%)
21140   COLOR 2,0 : SET CURSOR N% + 5 - Minloop1%,45
21150   PRINT Graph!(Graph%,1,N%) "," Graph!(Graph%,2,N%)
21155   IF N%+5-Minloop1% > 17 THEN EXIT 1 LEVELS
21160 NEXT N%
21170 Maxloop% = N% - 1
21200 FOR N% = Minloop1% TO Maxloop%
21210   COLOR 0,2 : SET CURSOR N%+5-Minloop1%,45
21220   PRINT Graph!(Graph%,1,N%) "," Graph!(Graph%,2,N%)
21225   COLOR 0,0 :CLEARSCREEN(20)
21230   SET CURSOR N%+5-Minloop1%,45
21240   COLOR 0,2 : LINE INPUT V$
21245   COLOR 0,0 :CLEARSCREEN(20)
21250   COLOR 0,0 : Position% = INSTR(V$,",") + 1
21260   IF Position% = 1 THEN EXIT TO,21400
21270   Graph!(Graph%,1,N%) = VAL(MID$(V$,1,Position%))
21280   Graph!(Graph%,2,N%) = VAL(MID$(V$,Position%))
```

```
21290   COLOR 2,0 : SET CURSOR N%+5-Minloop1%,45
21295   PRINT SPC(35)
21297   COLOR 2,0 : SET CURSOR N%+5-Minloop1%,45
21300   PRINT Graph!(Graph%,1,N%) "," Graph!(Graph%,2,N%)
21305   CLEARSCREEN(20)
21310 NEXT N%
21400 DO
21410   IF Maxloop% => Max_graph_points%(Graph%) THEN EXIT TO,21500
21411   FOR N% = 4 TO 23
21412     COLOR 7,0 : SET CURSOR N%,30
21413     PRINT SPC(50)
21414   NEXT N%
21420   Minloop1% = Maxloop%
21430   EXIT TO,21130
21440 REPEAT
21500 FOR N% = 2 TO 23
21510   COLOR 7,0 : SET CURSOR N%,30
21520   PRINT SPC(50)
21530 NEXT N%
21540 RETURN,20200
22000 GOSUB 22500
22010 DO
22020   Choice% = 1:Saveflag=1
22030   SAVEDATA(Graph%)
22230 END DO
22240 SET CURSOR 13,40 : PRINT SPC(40)
22250 CLEARSCREEN(16)
22260 CLOSE #1
22270 RETURN,20200
22400 COLOR 7,0
22410 CLEARSCREEN(2)
22420 RETURN,160
22500 REM
22505 COLOR 11,0 : LOCATE CSRLIN,1 : PRINT Hand_info$(CSRLIN)
22510 DO
22520   COLOR 0,0 : CLEARSCREEN(12)
22530   SET CURSOR 13,40:PRINT SPC(39)
22540   SET CURSOR 21,6 : COLOR 2,0
22580 END DO
22590 RETURN
22599 STOP
22600 GOSUB 22500
22610 LOADDATA(Graph%)
22870 RETURN,20200
22999 STOP
23000 REM
23020 DO
23030   IF Graph_chosen% <> 10 OR Graph_chosen% <> 2 THEN Directory$(Graph%,2) =
"NO"
23040 END DO
23500 DO
```

```
23505  IF Graph_chosen% = 10 OR Graph_chosen% = 2 THEN ID% = 0 ELSE ID% = 1
23510  DIRECTORY("\CGV",ID%,Graph%,Error%)
23520  IF Error% <> 0 THEN EXIT TO,160
23530 END DO
23540 DO
23555  IF Graph_chosen% = 10 OR (Graph_chosen% <> 5 AND Graph_chosen% <> 4 AND
Graph_chosen% <> 2 AND Graph_chosen% <> 8 AND Graph_chosen% <> 9) THEN ID%
= 1 ELSE ID% = 0
23560  RUNTYPE(Graph%,ID%)
23570 END DO
23610 DO
23620  IF Graph_chosen% > 2 AND Graph_chosen% < 6 THEN EXIT 1 LEVELS
23630  CLEARSCREEN(2)
23640  SET CURSOR 13,6 : COLOR 2,0,0
23650  INPUT "Enter the area of the device in cm squared.  ",Area$
23660  Area! =VAL(Area$)
23665  IF Area! = 0 THEN EXIT TO,23650
23670 END  DO
23671 DO
23672  IF Graph_chosen% <> 10 AND Graph_chosen% <> 9 AND Graph_chosen% <> 2
THEN EXIT 1 LEVELS
23673  CLEARSCREEN(15)
23674  SET CURSOR 15,6 : INPUT "Enter the type of material you have tested (GaAs,
Si)";Name$
23675  Name$ = UPPER$(Name$)
23676  IF INSTR(Name$,"GAAS") = 0 AND INSTR(Name$,"SI") = 0 THEN EXIT TO,23671
23677  IF INSTR(Name$,"G") <> 0 THEN RESTORE,61000 ELSE RESTORE,61500
23678  READ Nc!,Dummy!
23679  E_sub_S! = E_sub_O! * Dummy!
23680  IF Graph_chosen% = 9 THEN EXIT 1 LEVELS
23681  CLEARSCREEN (17)
23682  SET CURSOR 17,6 : INPUT "Enter the donor density (Nd) ",Nd$
23683  Nd! = VAL(Nd$)
23685  IF Nd! = 0 THEN GOTO 23682
23687 END DO
23689 DATAPRINT
23695 DO
23696  DO
23697    IF Graph_chosen% < 10 AND Graph_chosen% <> 2 THEN EXIT 1 LEVELS
23698    IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp_type$(Graph%) = "R"
23699    IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Run_type% = 1 ELSE Run_type% =
2
23700    EXIT 2 LEVELS
23701  REPEAT
23702  Run_type% = 0
23703 END DO
23704 File% = 1
23705 DO
23710  IF Graph_chosen% = 5 THEN ID% = 3 ELSE ID% = 2
23720  DATARETRIEVAL(ID%,Graph%,File%,Error%,Run_type%)
23730  IF Error% <> 0 AND Graph_chosen% = 10 THEN EXIT 1 LEVELS
```

```
23740  IF Error% <> 0 AND Graph_chosen% = 2 THEN EXIT 1 LEVELS
23745  IF Error% <> 0 THEN EXIT TO,23540
23750 END DO
23800 DO
23810  DO
23820    IF Graph_chosen% <> 4 THEN EXIT 1 LEVELS
23830    DELTAMULTIPLY(Graph%,2,1E+09)
23840    Ytitle$ = "Cap in nF"
23850    EXIT 2 LEVELS
23860  REPEAT
23870  DO
23880    IF Graph_chosen% <> 5 THEN EXIT 1 LEVELS
23890    DELTAMULTIPLY(Graph%,2,1E+03)
23900    Ytitle$ = "Cond in mMhos"
23910    EXIT 2 LEVELS
23920  REPEAT
23930  DO
23940    IF Graph_chosen% <> 8 AND Graph_chosen% <> 1 THEN EXIT 1 LEVELS
23945    IF Graph_chosen% <> 8 THEN Power! = 3.000 ELSE Power! = 2.0000
23950    INVERSEPOWER(Graph%,2,1.0E+09/Area!,Power!)
23960    IF Graph_chosen% = 8 THEN Ytitle$ = "1/C**2 C in nF" ELSE Ytitle$ = "1/C**3 in
nF"
23970    EXIT 2 LEVELS
23980  REPEAT
23990  DO
24000    IF Graph_chosen% <> 9 THEN EXIT 1 LEVELS
24010    INVERSEPOWER(Graph%,2,1.0/Area!,2.000)
24015    MinX! = 1E+37 : MaxX! = -1E+37
24016    MinY! = 1E+37 : MaxY! = -1E+37
24020    FOR N% = 1 TO Max_graph_points%(Graph%)-1
24030      Dummy! = E_sub_S! * SQR(Graph!(Graph%,2,N%))
24040      Slope! = (Graph!(Graph%,2,N%+1) - Graph!(Graph%,2,N%)) /
(Graph!(Graph%,1,N%+1) - Graph!(Graph%,1,N%))
24050      Graph!(Graph%,1,N%) = Dummy!
24060      IF Slope! = 0 THEN  GOTO 24120
24070      Graph!(Graph%,2,N%) = (-2/(Q! * E_sub_S!)) * 1/Slope!
24120    NEXT N%
24130    Max_graph_points%(Graph%) = Max_graph_points%(Graph%) - 1
24140    Ytitle$ = "Dopant Density in 1/cm**3 X 1e+10"
24150    Xtitle$ = "Depth in microns"
24154    DELTAMULTIPLY(Graph%,2,1E-10)
24155    DELTAMULTIPLY(Graph%,1,1E+04)
24160    EXIT 2 LEVELS
24170  REPEAT
24180  DO
24190    IF Graph_chosen% <> 10 AND Graph_chosen% <> 2 THEN EXIT 1 LEVELS
24200    Counter% = Counter% + 1
24201    IF Graph_chosen% <> 10 THEN Power! = 3.0000 ELSE Power! = 2.0000
24205    INVERSEPOWER(Graph%,2,1/Area!,Power!)
24207    DELTAMULTIPLY(Graph%,2,1E-15)
24210    IF Counter% = 1 THEN ID% = 0 ELSE ID% = 1
```

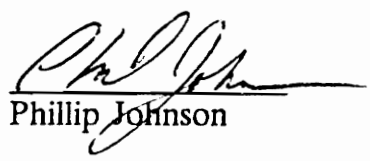
```
24220    LEASTSQUARES(Graph%,Min!,Max!,Dummy!,Slope!,X_int!,Y_int!,ID%,Error_LS%)
24221    IF Counter% = 1 THEN GRange$(Graph%) = STR$(Min!) + "," + STR$(Max!)
24225    IF Error_LS% = 1 THEN RUN,200
24230    Position% = INSTR(Temp_found$,";") + 1
24240    Temp! = VAL(MID$(Temp_found$,Position%))
24250    Y! = X_int! + ((K! * Temp!) / Q!) * LOG(Nc!/Nd!)
24260    DO
24270      DO
24280        IF INSTR(Temp_type$(Graph%),"T") <> 0 THEN EXIT 1 LEVELS
24290        X! = Temp!
24300        EXIT 2 LEVELS
24310      REPEAT
24320      DO
24330        Position% = INSTR(Time_found$,"=") + 1
24340        X! = VAL(MID$(Time_found$,Position%))
24350      END DO
24360    END DO
24370    OPEN "\BUCKET" FOR APPEND AS #3
24380    PRINT #3,X!","Y!
24390    CLOSE #3 : CLOSE #File%
24392    PRINT File%,Graph1or2%
24393    IF INSTR(Directory$(Graph%,File%),"NO") <> 0 THEN EXIT 1 LEVELS
24394    OPEN "C:\DATA\" + Directory$(Graph%,File%) + "\CGV" FOR INPUT AS #File%
24395    IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp_type$(Graph%) = "LH"
24396    Max_graph_points%(Graph%) = 1
24400    IF Error% = 0 THEN EXIT TO,23705
24401    DO
24402      File% = File% + 1
24403      IF File% = 3 OR INSTR(Directory$(Graph%,2),"NO") <> 0 THEN EXIT 1
LEVELS
24404      CLOSE #1 : Error% = 0
24406      IF INSTR(Temp_type$(Graph%),"T") = 0 THEN Temp_type$(Graph%) = "R"
24407      EXIT TO,23705
24408    REPEAT
24410    DO
24430      Max_graph_points%(Graph%) = Counter%
24440      GETDATA(Graph%)
24450      Graph_name$(1,10) = "Barrier Height (Capacitive)"
24470      Ytitle$ = "Barrier in Volts"
24480      IF INSTR(Temp_type$(Graph%),"T") THEN Xtitle$ = "Time in Seconds" ELSE
Xtitle$ = "Temperature in Kelvin"
24485      EXIT TO,3000
24490    END DO
24500  END DO
24510 END DO
24520 DO
24530  IF Graph_chosen% = 9 THEN EXIT TO,24560
24555  Xtitle$ = "Voltage in Volts"
24560  DO
24570    IF Temp_type$(Graph%) = "T" THEN EXIT 1 LEVELS
24580    Position% = INSTR(Temp_found$,";") + 1
```

```
24590    Temp$(Graph%) = MID$(Temp_found$,Position%)
24600    EXIT 2 LEVELS
24610  REPEAT
24615  DO
24620    Position% = INSTR(Time_found$,"=") + 1
24630    Tyme$(Graph%) = MID$(Time_found$,Position%)
24640  END DO
24650  EXIT TO,160
24660 END DO
24900 RETURN,160
25000 REM
25210 DO
25220  DIRECTORY("\RES",0,Graph%,Error%)
25230  IF Error% <> 0 THEN EXIT TO,160
25235  RUNTYPE(Graph%,1)
25240 END DO
25250 DO
25260  CLEARSCREEN(2)
25270  SET CURSOR 13,6 : COLOR 2,0,0
25280  INPUT "Enter the Current Bias (mA).",Dummy$
25281  Bias_sought! = VAL(Dummy$)
25282  SET CURSOR 15,6 : COLOR 2,0,0
25283  INPUT "Enter the 4-pt. Correction Factor(CF;pg.31 of Sze).",Dummy$
25284  CF = VAL(Dummy$)
25286  SET CURSOR 17,6 : COLOR 2,0,0
25287  INPUT "Enter the Sample thickness.",Dummy$
25288  Thick! = VAL(Dummy$)
25290 END DO
25500 FOR N% = 1 TO 2
25510  IF INSTR(Directory$(Graph%,N%),"NO") <> 0 THEN EXIT 1 LEVELS
25512  DATAPRINT
25515  IF N% = 2 THEN Max_graph_points%(Graph%) = Max_graph_points%(Graph%) + 1
25520  ID% = 4
25530  DATARETRIEVAL(ID%,Graph%,N%,Error%,0)
25540  IF Error% = 1 THEN EXIT TO,25210
25550 NEXT N%
25700 DO
25720  DELTAMULTIPLY(Graph%,2,CF*Thick!/(.001*Bias_sought!))
25730  Ytitle$ = "Resistivity in ohm*cms"
25735  Graph_name$(1,6) = "Resistivity vs."
25740 END DO
25800 DO
25810  Position% = INSTR(Bias_found$,"=") + 1
25820  Bias$(Graph%) = MID$(Bias_found$,Position%)
25830  DO
25840    IF INSTR(Temp_type$(Graph%),"T") <> 0 THEN EXIT 1 LEVELS
25850    Xtitle$ = "Temperature in Kelvin"
25860    Graph_name$(1,Graph_chosen%) = Graph_name$(1,Graph_chosen%) + "Temperature"
25870    EXIT 2 LEVELS
25880  REPEAT
25890  DO
```

Vita

Phillip Johnson is a prince of a man. A true giant in Lilliput. There never has been or will be another man like him (barring people in towers with rifles). But I regress, how can you judge a man without knowing his background? Phil was born and did lots of boring stuff then he got a drivers license and then things really got interesting. Yes a true AMERICAN with a '69 Camaro Super Sport with a 396 cid engine and Mag wheels. Life began at this point and probably almost ended. Stories are probably still being told around the mighty metropolis of Arlington. We were thinking of entering some of his exploits in "stupid people tricks". Then his life changed for the better he entered VPI&SU. Life just doesn't get any better than this. He decided to devote his life to more philosophical pursuits, bike riding, beer drinking, and aluminum can avoiding. This was the height of his life. After this he did more boring things like got meaningful employment, got married, had lots of children and named them after Doonesbury characters. Bye!!! - Chris Turman

p.s. I had nothing to do with this vita.



Phillip Johnson