Title

AUTOMATIC, SELF-NULLING, SPECTRAL SCANNING ELLIPSCMETER: SOFTWARE FOR THE LSI-II DATA ACQUISITION SYSTEM

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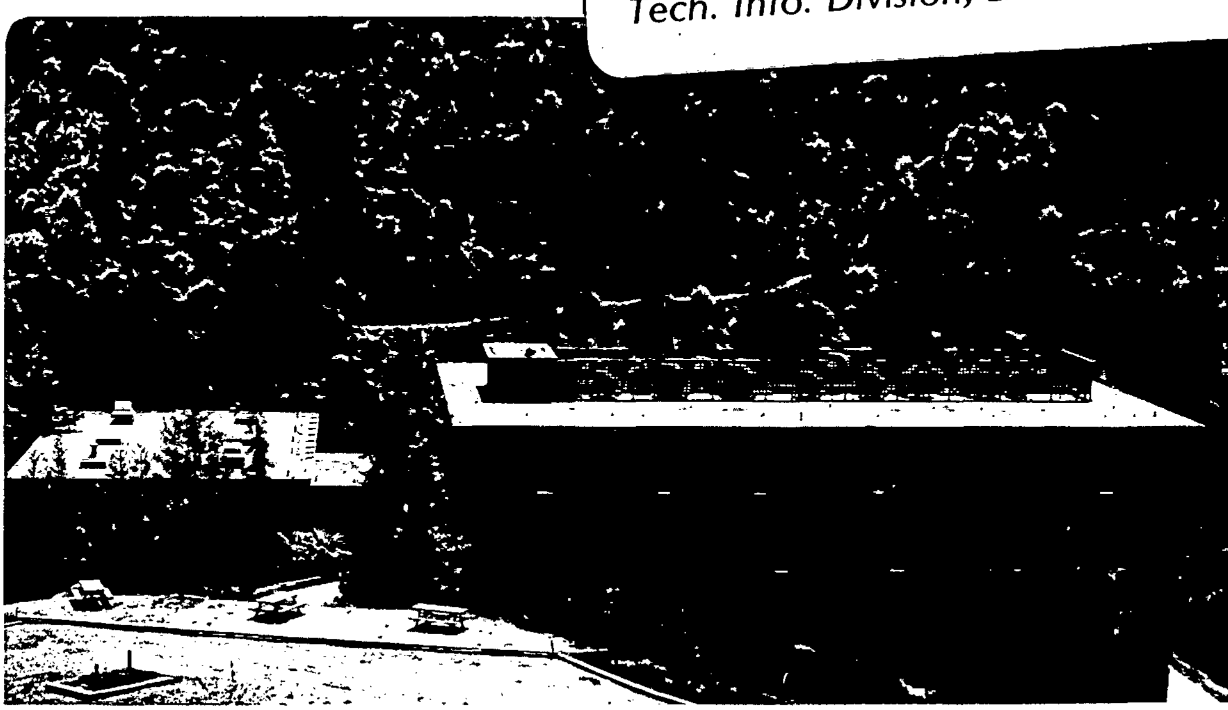

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DISCLAIMER

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AUTOMATIC, SELF-NULLING, SPECTRAL SCANNING ELLIPSOMETER: SOFTWARE FOR THE LSI-11 DATA ACQUISITION SYSTEM

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Abstract

The automatic, magneto-optic ellipsometer reported previously (1) has been given spectral scanning capabilities in the visible-UV, and has been interfaced to an LSI-11/2 for data acquisition.

FORTRAN software is documented for the acquisition of both fixed-wavelength and spectroscopic data from an automatic, self-nulling ellipsometer by a LSI-11 microcomputer. This ellipsometer has resulted from the addition of spectral scanning capabilities over the visible-UV to a previously reported (1) automatic, magneto-optic instrument. Additional programs are presented to aid in the interpretation of the acquired ellipsometry data. Software is categorized as being for either (a) fixed-wavelength data collection; (b) spectroscopic data collection, reduction, and simulation; (c) graphics; or (d) modeling and optimization.

The most basic ellipsometry equations have also been programmed for a Texas Instruments 59 calculator, and are presented because of their proven usefulness, convenience, and popularity.

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Introduction

The automatic, magneto-optic ellipsometer reported previously (1) has been given spectral scanning capabilities in the visible-UV, and has been interfaced to an LSI-11/2 for data acquisition. Computerization allows rapid, efficient treatment of nonlinear responses of the Faraday cells to changes in wavelength; simultaneous recording of wavelength, psi, and delta (as well as electrochemical cell potential and current), and "on the spot" interpretation of spectra in terms of physically significant quantities such as adatom coverages and orientations, substrate refractive indices, and deposit micromorphologies. Applications are discussed in "Effect of Organic Adsorbates on the Initial Stage of Electrolytic Metal Deposition: Development and Use of a Spectroscopic Ellipsometer," the Ph.D. thesis of J. C. Farmer. This documentation serves as an appendix to that dissertation (2).

FORTRAN software (3) was written to make possible acquisition of both fixed-wavelength and spectroscopic data from the automatic, self-nulling ellipsometer by a LSI-11 microcomputer. Additional programs were written to aid in the interpretation of the acquired ellipsometry data. Software is categorized as being for either (a) fixed-wavelength data collection; (b) spectroscopic data collection, reduction, and simulation; (c) graphics; or (d) modeling and optimization. Only main programs are discussed in the text. Both main programs and subroutines are thoroughly documented in the appendices (presented in reference 1) by effective use of comment statements; each listing of software begins with a statement of the software objective. Subroutine listings are presented in the same appendix as the main program calling the subroutine, unless the subroutine listing has been presented in a preceding appendix.

Fixed-wavelength data are synchronized by the internal line clock of the computer and spectroscopic data are synchronized by the digital encoder of the spectral scanner (see Chapter 2 of dissertation). The file length (blocks) for fixed-wavelength data depends upon the duration of the experiment, whereas spectroscopic data files always require 5 blocks; the number of encoder pulses per spectral scan is always constant (400), even when several scans are averaged. Therefore, one double density floppy disk (974 blocks) can store about 190 spectroscopic data files. Spectroscopic data files can contain either raw data, delta and psi, measured substrate refractive indices, or simulated spectroscopic measurements (delta and psi generated by ellipsometry models. However, all these data are written to and read from floppy disk using the same subroutines (OUTPUT and INPUT).

This strategy allows easy manipulation of spectroscopic data. All files can be retrieved from disk and viewed by the user using a single program, RECALL (discussed subsequently). Furthermore, the user can measure delta and psi over the spectral range of the ellipsometer prior to film formation, and subsequently convert these data into complex refractive indices. These refractive indices can then be read by simulation programs, which generate theoretical spectral scan data files comparable to experimental measurements; theoretical and experimental values of delta and psi can be plotted together using the same graphics programs so that visual comparisons can be made. Plotting can be done either on the screen of the VT55 graphics terminal or on the Tektronix 4662 digital interactive plotter. One spectroscopic data file can be easily subtracted from another so that very small changes in delta and psi can be easily seen (second order optical effects) since all files are stored and recalled similarly.

Modeling and simulation programs used to interpret ellipsometry data are based upon either (1) the Bruggeman theory, (2) the Maxwell-Garnett theory, (3) the coherent superposition of reflection coefficients, or (4) a uniaxial anisotropic film model. These basic theories were applied to both single and multilayer film models (see Chapters 5, 6, 7, and 8).

The most basic ellipsometry equations have also been programmed for a Texas Instruments 59 calculator, and are presented because of their proven usefulness, convenience, and popularity. These programs exploit the complex arithmetic capabilities of this particular calculator and require all of the memory.

Fixed-wavelength Data Acquisition

The basic data collection programs used during a fixed-wavelength, potentiodynamic experiment are SCAN, EDR002, DECOD2, TRNSLT, and PLOT01, and will be discussed first (see appendix 1). These programs are demonstrated using a typical data storage disk (see appendix 2).

I. SCAN (appendix 3).

This program, which is actually called as a subroutine, reads the 8-channel A/D converter (4) continuously and displays all channel input levels on the VT55 screen (5). SCAN allows the LSI-11 to serve as an 8-channel digital voltmeter. Channel gains can be either 0, 1, 2, or 3 (1X, 2X, 4X, or 8X, respectively). The digital resolution of the A/D converter is limited by a maximum value of 2047 units (ADCU), which corresponds to an input voltage of 1.2445 volts at a gain of 3 (0.000608 volts per ADCU).

II. EDR002 (appendix 4 through 6).

EDR002 reads the 8-channel A/D converter at intervals specified by the user and stores the data in unformatted form on floppy disk. The user also specifies the channels to be read and their respective gains. The shortest interval between channel sampling is 1/60 seconds (1 tic); longer intervals allow digital filtering of the data (an interval of 10 tics would result in averaging 10 measurements).

Though EDR002 is a general data acquisition program and can be used to monitor any analog electrical signal, the following conventions have been adopted and should be used for monitoring the ellipsometer and potentiostat (appendix 5).

Channel Assignments

Identification	Channel	Gain
Polarizer Faraday Cell	0	3
Analyzer Faraday Cell	1	3
Cell Potential	2	3
Cell Current	3	3
Polarizer Manual Adjustment Flag	4	3
Analyzer Manual Adjustment Flag	5	3

III. DECOD2 (appendix 7).

Since EDR002 stores data in unformatted files, one cannot display these numeric data directly on the VT55 screen with the TYPE command. Data must first be read from the unformatted data file by DECOD2 and then displayed on the VT55 screen.

Values of time are not stored in the data files, but are reconstructed for individual data points on the basis of specified channel sampling intervals; this increases the storage efficiency of each floppy disk. Early software (before optimization) was too slow to allow data collection from all 8 channels at the maximum sampling rate without a loss of data. Such losses caused errors in the reconstructed times displayed with data points. EDR002 has been optimized so that 6 channels can now be monitored simultaneously at the maximum sampling rate without any loss of data.

IV. TRNSLT (appendix 8).

TRNSLT converts the unformatted data files to polarizer azimuth, analyzer azimuth, cell potential, cell current, delta, and psi, respectively. These conversions are based upon parameters read by TRNSLT from the data file TRNSLT.DAT (appendix 9); parameters in this file are defined in the "Demonstration of TRNSLT." In the example shown the "incremental manual adjustments of the polarizer and analyzer" are both 10 degrees. During the experiment, if the Faraday cells had been required to exceed their range, the user could have adjusted the Glan-Thompson polarizers by ±10 degrees to prevent overranging (loss of ellipsometer signal). Inputs to either channel 5 (polarizer) or channel 6 (analyzer) should be set to zero (grounded) during the manual adjustments to alert TRNSLT so than similar corrections can be made in the reduction of data files (conversion of azimuth reading to delta and psi). The open channels will always be read as a value greater than zero, until grounded; the "flag tolerance" is the range of ADCU values which TRNSLT interprets as zero for the two "flag channels." The Faraday cells are calibrated by allowing them to compensate for increments of the Glan-Thompson prism azimuths; this compensation (increased dc Faraday cell current) is monitored with SCAN and recorded in terms of ADCU; polarization rotation is correlated with Faraday cell current level (in ADCU) by linear regression, which gives the "Faraday cell calibration curve equation parameters." Note that the "slope" is the effective Verdet coefficient (with the units of degrees per ADCU).

The converted data are then output to a formatted file called PLTDAT.DAT (appendix 10). The first line of this data file is the experiment identification. The columns of numbers are time (tics), polarizer azimuth (degrees), analyzer azimuth (degrees), cell potential (mV), and cell current (microamps), delta (degrees), and psi (degrees), respectively. The last column currently serves no purpose.

V. PLOT01 (appendix 11).

Any data stored in PLTDAT.DAT can be recalled and plotted on the VT55 screen with PLOT01. Plots are automatically scaled. However, the user can select any scaling desired, superimpose grids on the plot, label the plot, and specify any combination of the x and y axes desired; i.e., any column of PLTDAT.DAT can be plotted against any other column. In the example shown polarizer azimuth (column 1) is plotted against reconstructed time (column 0). Though time is not stored per se in the unformatted data files, it is stored as a column of numbers in PLTDAT.DAT.

Spectroscopic Data Acquisition

The basic data collection programs used during spectral scans are SEV002, RECALL, RISURF, MINUS, and DSCONV (see appendix 12). An additional program, CALFC1, is required for spectroscopic calibration of the Faraday cells (values of Verdet coefficients measured of the spectral range of the instrument). Other programs which have been written to enhance the capabilities of the instrument will also be discussed. The directory of the data storage disk used to illustrate the operation of these programs is shown in appendix 13, along with the spectral scanner calibration file WLCALC.DAT, required as an input data file by all programs discussed in this section.

From the preceding discussion, recall that EDR002 increases disk storage efficiency by storing a single parameter used to reconstruct time values for each stored set of data points. Here, in an analogous fashion, SEV002 increases disk storage efficiency by storing only a few numeric values used to reconstruct wavelengths rather than actually storing wavelength values for each data point. The parameters for wavelength reconstruction are stored in WLCALC.DAT , a single formatted data file common to all spectroscopic data files (for a given spectral scanner calibration). The six numbers in this file are two sets of intercept, slope, and regression coefficient for wavelength calibration of the spectral scanner. Linear regression is used to correlate encoder count with the center of the band-pass wavelength of the spectral scanner rotating circular filter (also called a continuously variable filter, or CVF. Two sets of regression line parameters (one per half-revolution) are necessary since the CVF is symmetric; i.e., the spectral range of the filter is repeated twice per revolution (400 encoder counts; Chapter 2, encoder wavelength calibrations).

The plotting routine (subroutine PLOT) requires the input data file TITLE.DAT shown in appendix 14 for labeling VT55 graphics with alphanumeric characters. Almost all spectroscopic programs, SEV0002, RECALL, etc. call subroutine PLOT.

I. SEV002 (appendix 15).

This is the main spectroscopic data collection program for monitoring variations in Faraday cell current levels via two channels of the A/D converter (preset as channels 0 and 1 at gains of 3). Digital filtering is done by averaging all data collected between encoder pulses. Channels are sampled at the maximum possible speed (limited by the A/D conversion rate). The program reinitializes the pulse counter (5) every revolution after detection of the indexing pulse on a separate channel of the counter interface. Another channel monitors the pulse frequency, used as a measure of the scan rate. The program is capable of averaging multiple scans (data for a single surface can be collected and averaged for hours); this may be necessary for reduction of background noise to an extent necessary to see some spectroscopic features attributable to submonolayer films (see Chapters 6 and 8). The user is also required to store other instrument operational parameters with the data for purposes of thorough experimental documentation.

II. RECALL (appendix 16).

All spectroscopic data files, regardless of their content, are unformatted. RECALL is used to retrieve these data files and can display the information graphically on the VT55 screen or output the information in numeric form on the line printer (Model 43 teletype).

III. FIXPCA (appendix 17).

Mistakes in entering azimuths of the Glan-Thompson polarizers and the Fresnel rhomb with stored data occur. These azimuths are required when the data files are converted to delta and psi by DSCONV (to be discussed). To correct azimuth entries, one uses FIXPCA.

IV. SHIFT (appendix 18).

It is sometimes desired to use data files together (in spectroscopic simulations or subtractions) which were collected at times when different spectral scanner calibrations were in effect (which sometimes results from equipment maintenance). SHIFT allows the unformatted data files to be rearranged so that the simulators can use the same WLCALC.DAT parameters for both files.

V. CALFC1 (appendix 19).

Delta and psi are indirectly measured by the automatic, self-nulling ellipsometer as the dc current levels in the polarizer (POL) and analyzer (ANA) Faraday cells. These current levels are monitored by the microcomputer over two channels (0 and 1) of the 8-channel A/D converter. In order to convert these current levels (recorded as ADCU) to polarizer and analyzer azimuths (delta and psi), proportionality constants (effective Verdet coefficients) must be known; these constants are "current-level independent" but vary in a non-linear manner with wavelength. CALFC1 generates a spectroscopic data file with wavelength dependent effective Verdet coefficients (degrees of rotation per ADCU);

one constant is stored for each encoder pulse (wavelength). CALFC1 requires three spectroscopic data files as input. One spectral scan is required with the ellipsometer nulled (zero Faraday cell dc current levels) at some reference wavelength (say with the spectral scanner azimuth set at M = 120 degrees); another spectral scan is required with the polarizer Glan-Thompson prism azimuth incremented (increment unimportant), and final spectral scan with the analyzer Glan-Thompson prism azimuth incremented (increment unimportant). The effective Verdet coefficients (degrees per ADCU) are calculated by subtraction of the first spectral scan from those with incremented polarizer and analyzer azimuths and division of the resultant values (ADCU) by the increment in azimuth (degrees). These constants are stored in a file 7 blocks in length (rather than the usual 5 blocks); consequently, slightly different input/out subroutines are required for these calibration factors (subroutines INFC and OUTFC). In appendix 19 these factors are referred to as "FC RESPONSE FACTORS" and were stored in a file called "DY1FARADYDAT."

In addition to generating effective Verdet coefficients, CALFC1 also calculates "CROSS-TALK PARAMETERS" which are measures of the degree of cross-modulation existing between the two channels of the Faraday cell controller. Ideally, increments of the polarizer azimuth should only result in changes in the polarizer Faraday cell dc current; however, due to cross-modulation, some response in the analyzer Faraday cell occurs. The analyzer "CROSS-TALK PARAMETER" is the change in analyzer response (ADCU) normalized by the change in polarizer response

(ADCU) when the polarizer Glan-Thompson prism is incremented. Cross-modulation for the polarizer channel is measured in a similar manner. Through careful tuning of the Faraday cell controller (two-channel phase sensitive detector), cross-modulation between channels has been reduced to essentially zero over the entire spectral range.

VI. FCSMTH (appendix 20).

Noise present in the original spectral scans used to generate the Faraday cell calibration file is also present in the effective Verdet coefficients. To prevent propagation of these errors throughout all data converted to delta and psi (by DSCONV), the effective Verdet coefficients are smoothed by approximating the data with an nth degree Lagrangian polynomial. This is done by FCSMTH. Data can be stored in the original data file, or in a new, smoothed data file created by FCSMTH.

VII. FCAVG2 (appendix 21).

This program allows one to average both polarizer and analyzer effective Verdet coefficients, using the result for both Faraday cells.

VIII. DSCONV (appendix 22).

DSCONV recalls spectroscopic data files stored by SEV002 and converts the contents to delta and psi; effective Verdet coefficients stored by CALFC1 are also required. For the ellipsometer configuration having the plane-of-incidence parallel to the optical table, the "rotated azimuth formula option" is selected by the user. This program also allows the user to diplay delta and psi plotted against wavelength on the VT55 screen (by calling subroutine PLOT). The converted data can then be stored in the same file as the original data or in a new file specified by the user.

IX. RISURF (appendix 23).

Measurements of delta and psi for a bare, reflecting surface can be used to calculate the optical constants of the surface (refractive index and extinction coefficient). Files created by DSCONV can be converted to complex refractive indices at different wavelengths by RISURF. The converted data can then be stored in any new or existing spectroscopic data file. Subroutine PLOT is also used by RISURF to generate graphics on the VT55 screen.

X. RISMTH (appendix 24).

This program performs Lagrangian smoothing of spectroscopic complex refractive index data files using subroutine SMOOTH, the same routine as employed by FCSMTH.

XI. RIGEN1 (appendix 25).

Spectroscopic refractive index data files can be generated by linear regression of literature data; use of RIGEN1 requires the assumption of linear optical constants (no absorption bands or edges) over the spectral range of the data.

XII. DYERI (appendix 26).

This program can be used to generate the refractive index data file of an adsorbed dye layer on an electrode surface from (1) absorption spectra measured with the spectral scanning ellipsometer serving as a spectrophotometer and from (2) a data file having a refractive index (real part) believed to be comparable to that of the dye (see Chapter 8).

XIII. MINUS (appendix 27).

This program generates "difference spectra" by subtracting one spectroscopic ellipsometry data file from another. This program is essential for determining very small changes in delta and psi due to formation of single monolayers (see Chapter 6, dye relaxation experiment).

XIV. NORMAL (appendix 28).

This program normalizes one spectroscopic ellipsometry data file by another and is useful when measuring intensity (photomultiplier tube output) rather than polarization (Faraday cell dc current levels).

Simulators are used to predict spectroscopic ellipsometry measurements on the basis of experimentally determined spectroscopic refractive index data files, literature data, and established optical theories.

Spectroscopic Simulators

I. EMASES (appendix 29).

Delta and psi are calculated at different wavelengths based upon the Maxwell-Garnett theory. This routine was used extensively in Chapter 7 to predict spectroscopic ellipsometry measurements of thin, porous Pb electrodeposits on Cu.

II. BRUGMN (appendix 30).

This program is similar to EMASES and calculates values of delta and psi at different wavelengths based upon the Bruggeman theory. This routine was also used extensively in Chapter 7 to predict spectroscopic ellipsometry measurements of thin, porous Pb electrodeposits on Cu. This program is believed to have a more sound theoretical basis than EMASES due to the self-consistancy of the Bruggeman theory.

III. CSMSES (appendix 31).

Delta and psi at different wavelengths are calculated on the basis of the coherent superposition model. When a deposit is distributed as islands on a substrate the weighted average of reflection coefficients for film-covered and for bare surface are used to calculate the overall reflection coefficients, when are then used to calculate delta and psi. See Chapters 5 and 7.

IV. AISPEC (appendix 32).

Delta and psi at different wavelengths are calculated on the basis of a uniaxial anisotropic film model. This simulator reads spectroscopic complex refractive index data files created by DYERI and RISURF to predict spectroscopic ellipsometry measurements of adsorbed dye monolayers on electrodes and was used extensively in Chapter 8.

Single Parameter Modeling Routines

I. EMAFIT (appendix 33).

The current passed during cathodic metal deposition with fixed-wavelength ellipsometry experiments is integrated by this program and values of delta and psi calculated based upon combinations of deposit thickness and porosity consistent with the charge balance. This program uses the Bruggeman theory as the theoretical basis for predicting delta and psi. EMAFIT reads PLTDAT.DAT and creates a formatted data file, EMAFIT.DAT, of the same format as PLTDAT.DAT. The columns of numbers in EMAFIT.DAT are time, calculated delta, calculated psi, the sum-of-squares error between predicted and measured values, the charge determined by integration of the current in PLTDAT.DAT, the film thickness, and the volume fraction of deposit in the composit film. This model has only one adjustable parameter which was optimized by gradually increasing the parameter value until a minimum in the sum-of-squares error was detected (column 4 of EMAFIT.DAT).

II. CSMFIT (appendix 34).

This program is similar to EMAFIT except that the theoretical basis for calculating delta and psi is the coherent superposition model. There is only one adjustable parameter; combinations of island thickness and surface coverage are coupled through the charge balance. Programs for Graphic Output on the Tektronix 4662 Digital Interactive Plotter

Most of the figures presented in this thesis were generated with the Tektronix plotter (7) using four programs, TEK002, TEK003, AXES, and LABMOD (appendix 35). The axes of graphs are drawn and labeled by AXES (appendix 36); the alpha-numeric labeling of the axes is determined by values read from the input data file AXES.DAT (appendix 37). Program LABMOD is used to label graphics with alpha-numeric information (appendix 38). Graphic output generated by AXES from the input AXES.DAT and demonstration labels generated by LABMOD are both shown in appendix 39. TEK002 (appendix 40) plots any spectroscopic ellipsometry file (those 5 blocks in length); scaling of the plot is determined by values read from the input file RANGES.DAT (appendix 41). The graphic output generated by TEK002 is shown in appendix 42. TEK003 (appendix 43) reads the formatted data file PLTDAT.DAT (appendix 44) and draws graphs (appendix 45) identical in size to those drawn by TEK002; scaling of graphs generated by TEK003 is done via the VT55 keyboard.

Multiple Parameter Optimization Routines (appendix 46).

A univariant search program, SEARCH (appendix 47), was written so that multiple parameter ellipsometry models could be optimized. This optimization program has been applied to several multilayer film models and a uniaxial anisotropic film model. SEARCH minimizes any function Y calculated in the objective subroutine ERROR.

I. OHGOGO (appendix 48).

OHGOGO optimizes a two-layer film model (8) where the film closest to the substrate is assumed to be compact and the second film is assumed to be porous. The complex refractive index of the second layer are calculated from the combined optical constants of the solid film material and the incident medium using the Bruggeman theory. After delta and psi are calculated for the substrate covered by the single, compact film, apparent optical constants for this film-covered surface are calculated and used as the substrate optical properties in the delta-psi calculation for the second, porous layer. The program reads the formatted input film OHGOGO.DAT and outputs the optimized model parameters to the line printer.

II. GOGOGO (appendix 49).

GOGOGO is similar to OHGOGO except that the assumed film structure consists of a compact layer closest to the substrate, covered by a second porous layer. Sitting on top of the second porous layer are islands. The Bruggeman theory is used to compute the composite optical properties of the second layer and the coherent superposition model is applied to the third layer, which is composed of islands.

Apparent substrate optical constants are determined after the calculation of delta and psi for each layer, beginning with the inner-most compact film. A film-covered surface is treated as a simple substrate having optical properties corresponding to the values of delta and psi calculated for the film covered surface. This program was used for calculations discussed in both Chapters 5 and 6.

III. WLGOGO (appendix 50).

The multilayer model optimized by this program is identical to that optimized by GOGOGO. WLGOGO and GOGOGO are different in that WLGOGO only optimizes those parameters of the film model which are assumed to be wavelength independent. Values of delta and psi measured at several different wavelengths for a particular surface are all treated as independent observations of that surface. Consequently, model parameter variances can be determined from spectroscopic ellipsometry measurements. See Chapter 7. These variances are measures of the ability of the model to fit the experimental data; they also reflect the models sensitivity to particular parameters. Variability in model parameters from one experiment to another cannot be determined from a single experiment. Furthermore, these values do not account for errors in the alignment of optical components.

IV. AIGOGO (appendix 51).

The optical constants and thickness of a uniaxial film are optimized. This program was used in calculations discussed in Chapter 6 (dye relaxation experiment).

Simple Calculations of Delta and Psi

I. FLMTST (appendix 52).

This program calculates delta and psi for a homogeneous film model.

II. EMATST (appendix 53).

This program calculates delta and psi for a homogeneous, composite film model composed of two components. It is based upon the Bruggeman theory.

III. CSFIT (appendix 54).

This program calculates delta and psi for an island covered surface; the theoretical basis is the coherent superposition model.

IV. PSIDEL (appendix 55).

This program computes delta and psi from polarizer and analyzer azimuths entered from the VT55 keyboard; azimuths in any zone can be converted. Ellipsometry Programs for the Texas Instruments 59 Calculator

Given the angle-of-incidence and measured values of delta and psi for a reflecting surface, the complex refractive index of the surface can be calculated (appendix 56). Values of delta and psi for a homogeneous film model can also be calculated (appendix 57). The complex arithmetic capabilities of this calculator make it attractive for such calculations (9).

Acknowledgements

We wish to thank Joe Katz and Brian Ng for their advice and assistance in implementing the LSI-11 microcomputer.

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References

1. Mathieu, H. J., McClure, D. E., Muller, R. H., "Fast Self-Compensating Ellipsometer," Rev. Sci. Instrum., 45(6), 798 (1974).

2. Farmer, J. C., "Effect of Organic Adsorbates on the Initial Stage of Electrolytic Metal Deposition: Development and Use of a Spectroscopic Ellipsometer," Ph.D. dissertation, Department of Chemical Engineering, UC Berkeley, Lawrence Berkeley Laboratory, LBL-15607, 1982.

3 RT-11 Version 3 and Version 4 Documentation, Digital Equipment Corporation, Maynard, Massachusetts, 1979-1980.

4. Instruction Manual No. 58-12140-35, DATEL Systems, Inc., 11 Cabot Blvd., Mansfield, Massachusetts, 1979.

5. VT55 Programming Manual, AA-4949B-TC, Digital Equipment Corporation, 1980.

6. Model 1604/OPI Optically Isolated Four Channel 16 Bit Binary Input Pulse Counter Instruction Manual, ADAC, Inc., 70 Tower Office Park, Woburn, Massachussetts, 1978.

7. Tektronix 4662 Digital Interactive Plotter Instruction Manual, Tektronix, Beaverton, Oregon, 1981.

8. Mathieu, H. J., "Computer Programs for Ellipsometry II," Lawerence Berkeley Laboratory, Berkeley, CA, LBL-2517, 1973.

9. TI Programmable 58/59 Master Library Manual, Texas Instruments, Inc.,

Appendices

Appendix 1.

Directory of Working Disk DY0:

```
.DIR DY0:
 26-Jan-83
SWAP  .SYS    24 11-Mar-78      DYMNSJ.SYS    63 11-Mar-78
TT    .SYS     2 11-Mar-78      PIP   .SAV    16 11-Mar-78
LIBR  .SAV    18 11-Mar-78      DIR   .SAV    17 11-Mar-78
BATCH .SAV    26 11-Mar-78      FILEX .SAV    18 11-Mar-78
SRCCOM.SAV    11 11-Mar-78      DUMP  .SAV     7 11-Mar-78
PAT   .SAV     7 11-Mar-78      RESORC.SAV    12 11-Mar-78
FORMAT.SAV     6 11-Mar-78      PATCH .SAV     9 11-Mar-78
DUP   .SAV    21 29-Mar-79      NL    .SYS     2 11-Mar-78
BA    .SYS     7 11-Mar-78      EDIT  .SAV    19 11-Mar-78
CREF  .SAV     6 11-Mar-78      DXMNSJ.SYS    63 11-Mar-78
STARTS.COM     1 16-Apr-81      EDR002.SAV    32 13-Feb-81 *
DECOD2.SAV    25 13-Feb-81 *    TRNSLT.SAV    94 13-Feb-81 *
PLOT01.SAV    69 30-Sep-81 *    SCAN  .SAV    18 13-Feb-81 *
RECALL.SAV    83 27-May-82      SEV002.SAV    86 23-Oct-81
RISURF.SAV    80 16-Apr-81      MINUS .SAV    40 17-Jun-81
WLBOND.NEW     1 28-Oct-81      WLCONT.OLD     1 10-Apr-81
DSCONV.SAV    90 27-May-82
 33 Files, 974 Blocks
 0 Free blocks
```

*programs for data acquisition with automatic ellipsometer at a fixed wavelength; general purpose data acquisition and data reduction programs

SCAN - reading A/D converter channels with numeric display on VT55 screen
EDR002 - data acquisition program for data collection over A/D converter channels
DECOD2 - recalling unformatted data files created by EDR002 with numeric display
TRNSLT - conversion of data files to delta, psi, etc. and creation of PLTDAT.DAT
PLOT01 - generation of graphic display on VT55 screen from PLTDAT.DAT data

Appendix 1 (continued).

Directory of Fixed-Wavelength Ellipsometry Data Acquisition Programs Disk

15-Nov-82

EDR002.FOR	5	23-Jun-80	INIT02.FOR	3	23-Jun-80
CLOSE2.FOR	1	23-Jun-80	SETUP2.FOR	8	23-Jun-80
INPUT2.FOR	13	23-Jun-80	TIME02.FOR	10	23-Jun-80
PSIDEL.FOR	8	05-Sep-80	OUTPUT.FOR	11	12-Feb-81
DEFINE.FOR	6	12-Feb-81	FLMMOD.FOR	3	12-Feb-81
CHGTME.FOR	1	12-Feb-81	TRNSLT.FOR	7	12-Feb-81
DECODE.FOR	13	12-Feb-81	CONVRT.FOR	6	13-Feb-81
DELPSI.FOR	9	13-Feb-81	PLOT .FOR	15	13-Feb-81
SCAN .FOR	9	13-Feb-81	DECOD2.FOR	14	13-Feb-81
PLOTER.FOR	4	15-Feb-81	FLMFIT.FOR	14	15-Feb-81
PLOT01.FOR	4	30-Aug-81	SUBPLT.FOR	6	30-Sep-81

22 Files, 170 Blocks
256 Free blocks
15-Nov-82

EXP002.DAT	13	25-Jun-80	FLMDAT.DAT	1	11-Feb-81
PLTDAT.DAT	53	12-Feb-81	TEST .DAT	3	17-Feb-81
TRNSLT.DAT	1	12-Oct-81			

5 Files, 71 Blocks
256 Free blocks
15-Nov-82

SCAN .SAV	18	13-Feb-81	TRNSLT.SAV	94	13-Feb-81
PSIDEL.SAV	24	13-Feb-81	EDR002.SAV	32	13-Feb-81
DECOD2.SAV	25	13-Feb-81	PLOTER.SAV	70	15-Feb-81
FLMFIT.SAV	88	15-Feb-81	PLOT01.SAV	69	30-Sep-81

8 Files, 420 Blocks
256 Free blocks

Appendix 2.

Example Directory of a Data Storage Disk DY1:

```
.DIR
 19-Jan-83
TITLE .DAT     4 17-Jun-81      TRNSLT.514     1 09-Nov-81
TRNSLT.555     1 07-Nov-81      RECALL.DAT     2 13-Apr-81
WLCALC.DAT     1 25-May-82      FARADY.OLD     9 25-May-82
FCCAL1.DAT     5 26-May-82      FCCAL2.DAT     5 26-May-82
FCCAL3.DAT     5 26-May-82      FCCAL4.DAT     5 26-May-82
FARADY.NEW     9 26-May-82      FARADY.DAT     9 26-May-82
CVPBCU.DAT    13 30-Jun-82      POTDEP.DAT    11 02-Jul-82
TEFLON.117     5 12-Jul-82      TEFLON.118     5 12-Jul-82
TEFLON.119     5 12-Jul-82      TEFLON.120     5 12-Jul-82
TEFLON.121     5 12-Jul-82      TEFLON.122     5 12-Jul-82
TEFLON.123     5 12-Jul-82      TEFLON.124     5 12-Jul-82
TEFLON.125     5 12-Jul-82      TEFLON.126     5 13-Jul-82
TEFLON.127     5 13-Jul-82      TEFLON.128     5 13-Jul-82
TEFLON.129     5 13-Jul-82      TEFLON.130     5 13-Jul-82
TEFLON.131     5 13-Jul-82      TEFLON.132     5 13-Jul-82
TEFLON.133     5 13-Jul-82      TEFLON.134     5 13-Jul-82
TEFLON.135     5 13-Jul-82      TEFLON.136     5 13-Jul-82
TEFLON.137     5 13-Jul-82      TEFLON.138     5 13-Jul-82
TEFLON.139     5 13-Jul-82      TEFLON.140     5 13-Jul-82
TEFLON.141     5 13-Jul-82      TEFLON.142     5 13-Jul-82
TEFLON.143     5 13-Jul-82      TEFLON.144     5 13-Jul-82
TEFLON.145     5 13-Jul-82      RESULT.140     5 13-Jul-82


RESULT.141     5 13-Jul-82      RESULT.142     5 13-Jul-82
RESULT.143     5 13-Jul-82      RESULT.144     5 13-Jul-82
RESULT.145     5 13-Jul-82      MINUS .141     5 13-Jul-82
MINUS .142     5 13-Jul-82      MINUS .143     5 13-Jul-82
MINUS .144     5 13-Jul-82      MINUS .145     5 13-Jul-82
TEFLON.146     5 13-Jul-82      TEFLON.147     5 13-Jul-82
TEFLON.148     5 13-Jul-82      RESULT.146     5 13-Jul-82
RESULT.147     5 13-Jul-82      RESULT.148     5 13-Jul-82
MINUS .146     5 13-Jul-82      MINUS .147     5 13-Jul-82
MINUS .148     5 13-Jul-82      TEFLON.149     5 13-Jul-82
TEFLON.150     5 13-Jul-82      TEFLON.151     5 13-Jul-82
TEFLON.152     5 13-Jul-82      TEFLON.153     5 13-Jul-82
TEFLON.154     5 13-Jul-82      TEFLON.155     5 13-Jul-82
TEFLON.156     5 13-Jul-82      TEFLON.157     5 13-Jul-82
TEFLON.158     5 13-Jul-82      RESULT.149     5 15-Jul-82
RESULT.150     5 15-Jul-82      RESULT.151     5 15-Jul-82
RESULT.152     5 15-Jul-82      RESULT.153     5 15-Jul-82
RESULT.154     5 15-Jul-82      RESULT.155     5 15-Jul-82
RESULT.156     5 15-Jul-82      RESULT.157     5 15-Jul-82
RESULT.158     5 15-Jul-82      RESULT.135     5 15-Jul-82
MINUS .149     5 16-Jul-82      MINUS .150     5 16-Jul-82
MINUS .151     5 16-Jul-82      MINUS .152     5 16-Jul-82
MINUS .153     5 16-Jul-82      MINUS .154     5 16-Jul-82
MINUS .155     5 16-Jul-82      MINUS .156     5 16-Jul-82
```

```
MINUS .157     5 16-Jul-82    TEFLON.159     5 16-Jul-82
TEFLON.160     5 16-Jul-82    RESULT.160     5 16-Jul-82
MINUS .160     5 16-Jul-82    TEFLON.161     5 17-Jul-82
TEFLON.162     5 17-Jul-82    TEFLON.163     5 17-Jul-82
TEFLON.164     5 17-Jul-82    TEFLON.165     5 17-Jul-82
TEFLON.166     5 17-Jul-82    TEFLON.167     5 17-Jul-82
TEFLON.168     5 17-Jul-82    TEFLON.169     5 17-Jul-82
TEFLON.170     5 17-Jul-82    TEFLON.171     5 17-Jul-82
TEFLON.172     5 17-Jul-82    TEFLON.173     5 17-Jul-82
TEFLON.174     5 17-Jul-82    TEFLON.175     5 17-Jul-82
TEFLON.176     5 17-Jul-82    TEFLON.177     5 17-Jul-82
RESULT.175     5 17-Jul-82    RESULT.176     5 17-Jul-82
MINUS .175     5 17-Jul-82    TEFLON.178     5 17-Jul-82
TEFLON.179     5 18-Jul-82    TEFLON.180     5 18-Jul-82
TEFLON.181     5 18-Jul-82    TEFLON.182     5 18-Jul-82
TEFLON.183     5 18-Jul-82    TEFLON.184     5 18-Jul-82
TEFLON.185     5 18-Jul-82    TEFLON.186     5 18-Jul-82
TEFLON.187     5 18-Jul-82    TEFLON.188     5 18-Jul-82
TEFLON.189     5 18-Jul-82    TEFLON.190     5 18-Jul-82
TEFLON.191     5 18-Jul-82    TEFLON.192     5 18-Jul-82
TEFLON.193     5 18-Jul-82    TEFLON.194     5 18-Jul-82
TEFLON.195     5 19-Jul-82    TEFLON.196     5 19-Jul-82
TEFLON.197     5 19-Jul-82    TEFLON.198     5 19-Jul-82
TEFLON.199     5 19-Jul-82    TEFLON.200     5 19-Jul-82


TEFLON.185     5 18-Jul-82    TEFLON.186     5 18-Jul-82
TEFLON.187     5 18-Jul-82    TEFLON.188     5 18-Jul-82
TEFLON.189     5 18-Jul-82    TEFLON.190     5 18-Jul-82
TEFLON.191     5 18-Jul-82    TEFLON.192     5 18-Jul-82
TEFLON.193     5 18-Jul-82    TEFLON.194     5 18-Jul-82
TEFLON.195     5 19-Jul-82    TEFLON.196     5 19-Jul-82
TEFLON.197     5 19-Jul-82    TEFLON.198     5 19-Jul-82
TEFLON.199     5 19-Jul-82    TEFLON.200     5 19-Jul-82
TEFLON.201     5 19-Jul-82    TEFLON.202     5 19-Jul-82
TEFLON.203     5 19-Jul-82    TEFLON.204     5 19-Jul-82
TEFLON.205     5 19-Jul-82    RESULT.203     5 19-Jul-82
CVPBAU.000    13 19-Jul-82    CVPBAU.001    13 19-Jul-82
CVPBAU.002    13 19-Jul-82    CVPBAU.003    13 19-Jul-82
CVPBAU.004    13 19-Jul-82    TRNSLT.DAT     1 09-Nov-81
PLTDAT.DAT    58 19-Jul-82    TEFLON.206     5 19-Jul-82
TEFLON.207     5 19-Jul-82    CVPBAU.005    13 19-Jul-82
CVPBAU.006    13 19-Jul-82    GOLD  .186     5 19-Jan-83
GOLD  .183     5 19-Jan-83    MINUS .186     5 19-Jan-83
GOLD  .188     5 19-Jan-83    MINUS .188     5 19-Jan-83
GOLD  .185     5 19-Jan-83    MINUS .185     5 19-Jan-83
 164 Files, 935 Blocks
 39 Free blocks

.
```

Appendix 3.

Demonstration of SCAN

```
152310 ............................system "crashed"
@173000G ..........................command entered from VT55 keyboard to "boot"
RT-11SJ    V03B-00 ................VT55 response to "boot"

.SET TT: SCOPE

.ASSIGN DY1: DK

.DATE 19-JAN-83

.RUN DY0:SCAN ....................running program SCAN
TYPE  1 FOR ONE CHANNEL
      A FOR ALL CHANNELS
      C FOR CONTINOUS OUTPUT
      S FOR SINGLE OUTPUT
      R FOR RETURN
      P FOR STOP
CONTROL=A
   GAIN = 3
 CHAN  0        1        2        3        4        5        6        7
      -53     2047     2047      155     2047     2047     2047      274 ....A/D converter
CONTROL=C                                                                  channels scanned
CONTROL=A                                                                  a single time
   GAIN = 3

                                                         grounded
                                                         input
     2047     2047     2047     2047     2047     2047       -5     -121 ...continuous A/D
     1626     2047     2047     2047     2047     2047       -3     -128    converter scanning
     1727     2047     2047     2047     2047     2047       -4     -254
     1812     2047     2047     2047     2047     2047       -5     -110
     1895     2047     2047     2047     2047     2047       -5      125
     1976     2047     2047     2047     2047     2047       -3      170
     2047     2047     2047     2047     2047     2047       -3      -34
     2047     2047     2047     2047     2047     2047       -2     -231
     2047     2047     2047     2047     2047     2047       -5     -182
     2047     2047     2047     2047     2047     2047       -5       61
     2047     2047     2047     2047     2047     2047       -3      189
     2047     2047     2047     2047     2047     2047       -3       61
     2047     2047     2047     2047     2047     2047       -3     -168
     2047     2047     2047     2047     2047     2047       -5     -220
     2047     2047     2047     2047     2047     2047       -5      -14
     2047     2047     2047     2047     2047     2047       -5      177
     2047     2047     2047     2047     2047     2047       -3      127
     2047     2047     2047     2047     2047     2047       -3     -119
     2047     2047     2047     2047     2047     2047       -4     -250
     2047     2047     2047     2047     2047     2047       -5     -119
     2047     2047     2047     2047     2047     2047       -5      114
     2047     2047     2047     2047     2047     2047       -4      159
     2047     2047     2047     2047     2047     2047       -3      -44
     2047     2047     2047     2047     2047     2047       -4     -248
```

Listing of SCAN

```
      CALL SCAN
      CALL EXIT
      END
      SUBROUTINE SCAN
C*************************************************************************
C     THIS SUBROUTINE SCANS THE A/D CHANNELS CONSTANTLY, AND DISPLAYS
C     VALUES FOUND IN THE REGISTERS ON THE VT55 SCREEN.  THIS SUBROUTINE
C     ALSO ALLOWS ONE TO SELECT THE CHANNEL GAIN USED DURING THE SCAN.
C*************************************************************************
C     DEFINITION OF TERMS:
C          STA = STATUS FOR SCANNING
C                 1  FOR CONTINUS SCANNING
C                 0  FOR SINGLE TIME SCANNING
C          MES = MESSAGE FROM USER.
C          IGAIN= GAIN OF PGA
C**************************************************************************
      COMMON/PRINT/STA,MES,IGAIN
      INTEGER*2 STA,MES
      STA=0
      I=0
C*****TYPE MESSAGE FOR USER**********************************************
100   TYPE 1
1     FORMAT(' TYPE  1 FOR ONE CHANNEL'
     1   ,/,7X,'A FOR ALL CHANNELS'
     2   ,/,7X,'C FOR CONTINOUS OUTPUT'
     3   ,/,7X,'S FOR SINGLE OUTPUT'
     4   ,/,7X,'R FOR RETURN '
     5   ,/,7X,'P FOR STOP')
101   TYPE 3
3     FORMAT('$CONTROL=')
C*****GET MESSAGE FROM USER**********************************************
      ACCEPT 2,MES
2     FORMAT(A1)
      IF(MES.EQ.1H1)CALL SINGLE
      IF(MES.EQ.1HA)CALL ALL
      IF(MES.EQ.1HC)STA=1
      IF(MES.EQ.1HS)STA=0
      IF(MES.EQ.1HR)RETURN
      IF(MES.EQ.1HP)STOP
      GOTO 101
      END
```

```
      SUBROUTINE SINGLE
C*****ITIME AND JTIME ARE TIMING VARIABLES FOR TIME DELAY***************
      COMMON/PRINT/STA,MES,IGAIN
      INTEGER*4 ITIME, JTIME
      INTEGER*2 STA,MES,C
      I=0
C*****SET UP ADC FOR PROGRAM CONTROL, NO INTERUPT***********************
      CALL IPOKE("170400,0)
100   TYPE 1
1     FORMAT(/,'$CHANNEL = ')
      ACCEPT 2,C
2     FORMAT(I2)
C*****GET CODED GAIN****************************************************
      TYPE 4
4     FORMAT('$   GAIN = ')
      ACCEPT 2, IGAIN
C*****RETURN IF INPUT CHANNEL IS NOT VALID******************************
      IF(C.LT.0.OR.C.GT.7)RETURN
C*****SET UP CHANNEL****************************************************
1000  CALL IPOKE("170402,C.OR.(64*IGAIN))
C*****CHECK TO SEE IF ADC IS FINISHED***********************************
1001  IF(.NOT.(IPEEK("170400).AND."100000))GOTO 1001
C*****OUTPUT THE RESULT*************************************************
      TYPE 3,IPEEK("170402)
3     FORMAT(9X,I8,X)
C*****SET UP TIME DELAY FOR NEXT SAMPLE*********************************
      CALL GTIM(ITIME)
      CALL JJCVT(ITIME)
      JTIME=ITIME
500   CALL GTIM(ITIME)
      CALL JJCVT(ITIME)
      IF((ITIME-JTIME).LT.60)GOTO 500
C*****RETURN IF ANY MESSAGE IS COMMING FROM THE KEY BOARD***************
      IF(ITTINR(I).GT.0)RETURN
C*****LOOP FOR NEXT CHANNEL*********************************************
      IF(STA.EQ.0)GOTO 100
C*****IF CONTINUOUS MODE IS USED, SCAN LOOP AGAIN***********************
      GOTO 1000
      END
      SUBROUTINE ALL
      COMMON/PRINT/STA,MES,IGAIN
      INTEGER*2 STA,MES,C(8)
```

```
C*****GET THE CODED GAIN*****************************************************
      TYPE 4
4     FORMAT('$   GAIN = ')
      ACCEPT 3,IGAIN
3     FORMAT(I1)
C*****PRINT HEADING**********************************************************
      TYPE 1
1     FORMAT('  CHAN  0       1       2       3       4       5',
     1     '        6       7')
      CALL IPOKE("170400,5)
C*****SET UP FOR SEQUENTIAL SCAN AND AUTO START ON READING OUTPUT*******
C*****START WITH FIRST CHANNEL**********************************************
100   CALL IPOKE("170402,64*IGAIN)
      DO 1001 I=1,8
C*****CHECK FOR THE END OF CONVERSION ON EACH CHANNEL******************
1000  IF(.NOT.(IPEEK("170400).AND."100000))GOTO 1000
C*****INPUT THE RESULT*******************************************************
      C(I)=IPEEK("170402)
1001  CONTINUE
C*****PRINT THE RESULT*******************************************************
      TYPE 2,(C(I),I=1,8)
2     FORMAT(2X,8I8)
C*****IF IN SINGLE SCAN MODE, RETURN****************************************
      IF(STA.EQ.0)RETURN
C*****IF THE USER TYPES ANY MESSAGE, RETURN*******************************
      IF(ITTINR(I).GT.0)RETURN
C*****LOOP*******************************************************************
      GOTO 100
      END
```

Appendix 4.

Demonstration of EDR002 - setting up channel parameters

```
.RUN DY0:EDR002


     TYPE : 0 FOR GETTING PARAMETERS FROM A DISK FILE.
            1 FOR CHANGING THE INPUT PARAMETERS.
            2 FOR A LISTING OF THE CURRENT PARAMETERS.
            3 FOR START SETTING UP  CURRENT PARAMETER.

     INPUT = 1


    WHAT IS THE DESIRED NUMBER OF CHANNELS (I2)?6

CHANNEL  1    DO YOU WISH TO CHANGE THIS CHANNEL (Y/N)?Y

  LOCATION     (I2)=  0
  GAIN         (I2)=  3
  PERIOD,TIC   (I4)=  60
  RANGE        (I2)=
  UNITS        (A4)=  DEG
  NAME AND COMMENT(A20)=  POLARIZER CURRENT

CHANNEL  2    DO YOU WISH TO CHANGE THIS CHANNEL (Y/N)?Y
```

Appendix 5.

Demonstration of EDR002 - getting parameters from a stored data file

```
CVPBAU.004    13 19-Jul-82      TRNSLT.DAT     1 09-Nov-81
PLTDAT.DAT    58 19-Jul-82      TEFLON.206     5 19-Jul-82
TEFLON.207     5 19-Jul-82      CVPBAU.005    13 19-Jul-82
CVPBAU.006    13 19-Jul-82      GOLD  .186     5 19-Jan-83
GOLD  .183     5 19-Jan-83      MINUS .186     5 19-Jan-83
GOLD  .188     5 19-Jan-83      MINUS .188     5 19-Jan-83
GOLD  .185     5 19-Jan-83      MINUS .185     5 19-Jan-83
 164 Files, 935 Blocks
 39 Free blocks ...............................................end of directory

.RUN DY0:EDR002 ...............................................running EDR002


     TYPE : 0 FOR GETTING PARAMETERS FROM A DISK FILE.
            1 FOR CHANGING THE INPUT PARAMETERS.
            2 FOR A LISTING OF THE CURRENT PARAMETERS.
            3 FOR START SETTING UP  CURRENT PARAMETER.

     INPUT = 0

     NAME OF FILE OF WHICH THE TABLE IS STORED (A12) =  DY1CVPBAU006

     INPUT = 2


     NUMBER OF CHANNELS =  6

     NUMBER  LOC N   GAIN    PERIOD,TIC  RANGE   UNITS   NAME AND COMMENT

       1       0      3        30         0               POL
       2       1      3        30         0               ANA
       3       2      3        30         0               POTENTIAL
       4       3      3        30         0               CURRENT
       5       4      3        30         0               PFLAG
       6       5      3        30         0               AFLAG

     INPUT = 3

     RUN DURATION: "HRS:MIN:SEC:TIC" (4(I2,X)) = 00 00 30 00

     RUN DURATION IS ENTERED AS  0: 0:30: 0

     RUN IDENTIFICATION(A40) = DEMONSTRATION OF PROGRAM "EDR"

     FILE NAME FOR NEW DATA (A12) =  DY1DEMO  DAT

     TYPE "G" FOR START OF RUN: G
```

Appendix 5 (continued).

Listing of EDR002

```
      PROGRAM EDR
C*************************************************************************
C
C     THIS IS THE MAIN PROGRAM OF THE ELLIPSOMETER DATA RECORDER WHICH
C     CALLS VARIOUS SUBROUTINES FOR THEIR SPECIFIC OPERATIONS.
C
C*************************************************************************
      COMMON/WRUBUF/ICHAN,IBLOCK,IFLAG
      COMMON/AREA/IAREA(4)
      IF(IQSET(5).NE.0)STOP 'NOT ENOUGHT FREE SPACE FOR QUEUE ELEMENT'
      IFLAG=1
      CALL FINISH
C*************************************************************************
C     COMPLETION ROUTINE FOR WRITING DATA ONTO DISK.
C*************************************************************************
      CALL INIT02
C*************************************************************************
C     THIS SUBROUTINE INITIALIZES ALL THE STARTING PARAMETERS BEFORE ANY
C     OPERATION IS DONE.
C*************************************************************************
      CALL INPUT2
C*************************************************************************
C     THIS SUBROUTINE COMMUNICATES WITH THE OPERATOR FOR INPUT PARA-
C     METERS TO SETUP THE DATA ACQUISITION PROCESS.
C*************************************************************************
      CALL SETUP2
C*************************************************************************
C       THIS SUBROUTINE SETS UP THE NECESSARY PARAMETERS FOR THE DATA
C       GATHERING PROCESS ON THE BASIS OF THE OPERATOR INPUT.
C*************************************************************************
      CALL TIME02
C*************************************************************************
C       THIS SUBROUTINE KEEPS TRACK OF THE TIMING AND CALLS THE ACTUAL
C       DATA RECORDING ROUTINE TO RECORD DATA AT THE RIGHT TIME.
C       IT ALSO KEEPS TRACK OF THE STATUS OF THE BUFFER AND CALLS THE
C       ROUTINE FOR WRITING DATA ONTO DISK.
C*************************************************************************
      CALL CLOSE2
C*************************************************************************
C       THIS IS THE ROUTINE THAT COMMUNICATES WITH THE OPERATOR TO
C       HANDLE MODIFICATIONS ON THE EXISTING DATA.
C       MORE DATA CAN ALSO BE GATHERED IF DESIRED.
C*************************************************************************
      END
```

```
      SUBROUTINE INIT02
C**************************************************************************
C         ISETUP=SET UP PARAMETERS
C                NUM=NUMBER OF CHANNEL
C                LIS=TABLE FOR HOLDING ALL THE PARAMETERS
C                    LIS(I,J)...J=CHANNEL NUMBER
C                               I=1....PHYSICAL LOCATION OF CHANNEL
C                                 2....GAIN
C                                 3....SAMPLE RATE IN TICS.
C                                 4-5..UNIT
C                                 6....RANGE
C                                 7-16.NAME AND COMMENT
C                ID = IDENTIFICATION FOR THIS RUN
C                LENGTH= LENGTH OF RUN IN TICS
C
C         LIMIT=MAXIMUM LIMIT OF THIS PROGRAM
C                NHAMAX=MAXIMUM NUMBER OF CHANNEL
C                NERMAX =MAXIMUM NUMBER OF DIFFERENT SAMPLE RATE
C**************************************************************************
      COMMON /ISETUP/NUM,LIS(16,16),ID(20),LENGTH(4)
      COMMON /LIMIT/NHAMAX,NERMAX
      NHAMAX=16
      NERMAX=3
      NUM=8
      DO 100 I=1,16
      DO 100 J=1,NHAMAX
      LIS(I,J)=0
100   CONTINUE
      RETURN
      END
```

```
      SUBROUTINE CLOSE2
      COMMON/WRBUF/ICHAN,IBLOCK,IFLAG
C***********************************************************************
C     SEE SUBROUTINE INIT01 FOR DISCRIPTION OF COMMON BLOCK.
C     THIS SUBROUTINE TERMINATES DISC STORAGE.
C***********************************************************************
      CALL CLOSEC(ICHAN)
      CALL IFREEC(ICHAN)
      CALL EXIT
      END
```

```
      SUBROUTINE SETUP2
C***********************************************************************
C     SEE SUBROUTINE INIT01 FOR EXPLANATION OF THE COMMON BLOCKS.
C***********************************************************************
C           IRUND = COMMON BLOCK FOR RUNNING PARAMETER
C           COUNT = COUNT DOWN TO WARDS ANOTHER SAMPLE TIME FOR EACH CHANNEL
C           IBUFF = BUFFER FOR DATA STORAGE
C***********************************************************************
      INTEGER*2 COUNT(16)
      COMMON/ISETUP/NUM,LIS(16,16),ID(20),LENGTH(4)
      COMMON/IRUND/IDUMMY(55),IBUFF(768)
      COMMON/WRBUF/ICHAN,IBLOCK,IFLAG
      REAL*4 DBLK(2),NAME(3)
C***********************************************************************
C     SET UP THE BUFFER FOR DATA INPUT.
C***********************************************************************
      DO 1005 I=1,768
      IBUFF(I)=0
1005  CONTINUE
C***********************************************************************
C     STORE THE SET UP INFORMATION FOR THIS RUN IN THE BUFFER.
C***********************************************************************
      DO 1007 I=1,20
      IBUFF(I)=ID(I)
1007  CONTINUE
      IBUFF(21)=NUM
      IBUFF(22)=LENGTH(1)
      IBUFF(23)=LENGTH(2)
      IBUFF(24)=LENGTH(3)
      IBUFF(25)=LENGTH(4)
C***********************************************************************
C     STORE THE BUFFER CONTENTS ON A DISK.
C***********************************************************************
      TYPE 1
1     FORMAT(/,'$     FILE NAME FOR NEW DATA (A12) =  ')
      ACCEPT 2, (NAME(I),I=1,3)
2     FORMAT(3A4)
      N=IRAD50(12,NAME,DBLK)
      ICHAN=IGETC(0)
      IF(ICHAN.LT.0)STOP 'CANNOT ALLOCATE CHANNEL'
      IERROR=IENTER(ICHAN,DBLK,0)
      IF(IERROR.LT.0)GOTO 9001
      IBLOCK=0
      IFLAG=IFLAG+1
      CALL WRBUFF(IBUFF)
      CALL IWAIT(ICHAN)
```

```
C***********************************************************************
C     RECORD RUN PARAMETERS FOR EACH CHANNEL IN BUFFER.
C***********************************************************************
      DO 1009 I=1,256
      IBUFF(I)=0
1009  CONTINUE
      DO 1010 I=1,NUM
      DO 1010 J=1,16
      IBUFF((I-1)*16+J)=LIS(J,I)
1010  CONTINUE
C***********************************************************************
C     STORE BUFFER CONTENTS ON A DISK.
C***********************************************************************
      IF(IFLAG.GT.0)CALL IWAIT(ICHAN)
      IFLAG=IFLAG+1
      CALL WRBUFF(IBUFF)
      CALL IWAIT(ICHAN)
C***********************************************************************
C     SETUP ADC FOR:
C               NO END-OF-CONVERSION INTERUPT
C               NO AUTO INCREMENT
C               PROGRAM CONTROL A-D CONVERSION
C***********************************************************************
      CALL IPOKE("170400,"000000)
      RETURN
9001  TYPE 3,IERROR
3     FORMAT(X,I5)
      STOP 'ENTER FAIL'
      END
      SUBROUTINE WRBUFF(IBUFF)
      COMMON/WRBUF/ICHAN,IBLOCK,IFLAG
C***********************************************************************
C     WRITES IBUFF INTO FILE ICHAN.
C***********************************************************************
      COMMON/AREA/IAREA(4)
      EXTERNAL FINISH
      IERROR=IWRITF(256,IBUFF,IBLOCK,ICHAN,IAREA,FINISH)
      IF(IERROR.LT.0)GOTO 2000
      IBLOCK=IBLOCK+1
      RETURN
2000  TYPE 1,IERROR
1     FORMAT(/,3X,I2)
      STOP 'FATAL WRITE'
      END
      SUBROUTINE FINISH
      COMMON/WRBUF/ICHAN,IBLOCK,IFLAG
      IFLAG=IFLAG-1
      RETURN
      END
```

```
      SUBROUTINE INPUT2
C*************************************************************************
C     SEE SUBROUTINE INITO1 FOR AN EXPLANATION OF THE COMMON BLOCKS.
C*************************************************************************
      COMMON/ISETUP/NUM,LIS(16,16),ID(20),LENGTH(4)
      COMMON/LIMIT/NHAMAX,NERMAX
      COMMON/IRUND/IDUMMY(55),IBUFF(768)
      REAL*4 NAME(3),BDLK(2)
C*************************************************************************
C     THE REQUIRED OPERATOR RESPONSE IS EXPLAINED AND DISPLAYED ON
C     THE CRT IN CODED FORM FOR REFERENCE.
C*************************************************************************
100   TYPE 1
1     FORMAT(///,6X,'TYPE : 0 FOR GETTING PARAMETERS FROM A DISK FILE.',
     1       /,13X,'1 FOR CHANGING THE INPUT PARAMETERS.',
     2       /,13X,'2 FOR A LISTING OF THE CURRENT PARAMETERS.',
     3       /,13X,'3 FOR START SETTING UP  CURRENT PARAMETER.')
C*************************************************************************
C     THE PROGRAM NOW GETS A RESPONSE FROM THE USER.
C*************************************************************************
200   TYPE 26
26    FORMAT(/,'$',5X,'INPUT = ')
101   ACCEPT 2,J
2     FORMAT(I1)
C*************************************************************************
C     THE USER'S RESPONSE IS NOW CHECKED.
C             100   =   NOT LEGEL RESPONSE, TYPE MESSAGE AGAIN.
C             102   =   PRINT CURRENT PARAMETER TABLE CONTENT
C             103   =   MODIFY CURRENT TABLE OF PARAMETER
C             104   =   ASK FOR RUN IDENTIFICATION
C             105   =   GET TABLE FROM A DISK FILE.
C*************************************************************************
      IF (J.GT.3.OR.J.LT.0) GOTO 100
      GOTO (105,103,102,104) J+1
C*************************************************************************
C     CONTENTS OF THE CURRENT PARAMETER LIST ARE PRINTED.
C*************************************************************************
102   TYPE 3,NUM,(K,(LIS(M,K),M=1,16),K=1,NUM)
3     FORMAT (//,6X,'NUMBER OF CHANNELS = ',I2,//,
     1   6X,'NUMBER',2X,'LOC N',3X,'GAIN',4X,'PERIOD,TIC',2X,'RANGE',
     2   3X,'UNITS',3X,'NAME AND COMMENT',//,
     3   (7X,I2,6X,I2,6X,I2,6X,I4,8X,I2,5X,2A2,6X,10A2))
      GOTO 200
```

```
C***********************************************************************
C     THE CURRENT PARAMETERS ARE NOW CHANGED ONE AT A TIME; SEE
C     SUBROUTINE "INIT01" FOR AN EXPLANATION OF ARRAY "LIS(I,J)".
C***********************************************************************
103   TYPE 4
4     FORMAT(//,'$    WHAT IS THE DESIRED NUMBER OF CHANNELS (I2)?')
      ACCEPT 5, NUM
5     FORMAT (I2)
      DO 1000 J=1,NUM
      TYPE 6,J
6     FORMAT(/,'$','CHANNEL ',I2,4X,'DO YOU WISH TO CHANGE THIS CHANNEL'
     1     ,' (Y/N)?')
      ACCEPT 7,IRES
7     FORMAT(A1)
      IF (IRES.NE.1HY) GOTO 1000
C***********************************************************************
C     CHANNEL LOCATION
C***********************************************************************
      TYPE 8
8     FORMAT(/,'$ LOCATION    (I2)=  ')
      ACCEPT 9,LIS(1,J)
9     FORMAT(I2)
C***********************************************************************
C     GAIN
C***********************************************************************
      TYPE 10
10    FORMAT('$  GAIN        (I2)=  ')
      ACCEPT 9,LIS(2,J)
C***********************************************************************
C     PERIOD
C***********************************************************************
      TYPE 11
11    FORMAT('$  PERIOD,TIC  (I4)=  ')
      ACCEPT 12,LIS(3,J)
12    FORMAT (I4)
C***********************************************************************
C     RANGE
C***********************************************************************
      TYPE 13
13    FORMAT('$  RANGE       (I2)=  ')
      ACCEPT 9,LIS(4,J)
C***********************************************************************
C      UNITS
C***********************************************************************
      TYPE 14
14    FORMAT('$  UNITS       (A4)=  ')
      ACCEPT 15,LIS(5,J),LIS(6,J)
15    FORMAT(2A2)
```

```
C************************************************************************
C     NAME AND COMMENT
C************************************************************************
      TYPE 16
16    FORMAT('$  NAME AND COMMENT(A20)=  ')
      ACCEPT17,(LIS(K,J),K=7,16)
17    FORMAT(10A2)
1000  CONTINUE
      GOTO 200
C************************************************************************
C     PREVIOUSLY STORED INPUT PARAMETERS ARE OBTAINED FROM DISK FILE.
C************************************************************************
105   TYPE 22
22    FORMAT(/,'$',5X,'NAME OF FILE OF WHICH THE TABLE IS STORED ',
     1       '(A12) =  ')
      ACCEPT 23, (NAME(I),I=1,3)
23    FORMAT(3A4)
      N=IRAD50(12,NAME,BDLK)
      ICHAN=IGETC(I)
      IF(ICHAN.LT.0)STOP 'CANNOT ALLOCATE CHANNEL'
      IF(IFETCH(ICHAN).LT.0)STOP 'FETCH FAIL'
      IF(LOOKUP(ICHAN,BDLK).LT.0)STOP 'BAD LOOK'
      IBLOCK=0
      CALL READ(IBUFF,IBLOCK,ICHAN)
      NUM=IBUFF(21)
      CALL READ(IBUFF,IBLOCK,ICHAN)
      DO 1005 I=1,NUM
      DO 1005 J=1,16
      LIS(J,I)=IBUFF((I-1)*16+J)
1005  CONTINUE
      CALL CLOSEC(ICHAN)
      CALL IFREEC(ICHAN)
      GOTO 200
C************************************************************************
C     GET THE DURATION (LENGTH) OF THE RUN.
C************************************************************************
104   TYPE 24
24    FORMAT(/,'$',5X,'RUN DURATION: "HRS:MIN:SEC:TIC" (4(I2,X)) = ')
      ACCEPT 25,(LENGTH(I),I=1,4)
25    FORMAT(4(I2,1X))
      TYPE 27,(LENGTH(I),I=1,4)
27    FORMAT(/,6X,'RUN DURATION IS ENTERED AS ',3(I2,':'),I2)
```

```
C***********************************************************************
C     INPUT COMMENT OR RUN IDENTIFICATION.
C***********************************************************************
      TYPE 20
20    FORMAT(/,'$',5X,'RUN IDENTIFICATION(A40) = ')
      DO 1001 I=1,20
      ID(I)=2H
1001  CONTINUE
      ACCEPT 21,(ID(I),I=1,20)
21    FORMAT (20A2)
      RETURN
      END
      SUBROUTINE READ(IBUFF,IBLOCK,ICHAN)
C***********************************************************************
C     READ FILE ICHAN INTO IBUFF.
C***********************************************************************
      IERROR=IREADW(256,IBUFF,IBLOCK,ICHAN)
      IF(IERROR.LT.0) GOTO 2000
      IBLOCK=IBLOCK+1
      RETURN
2000  STOP 'FATAL READ'
      END
```

```
      SUBROUTINE TIME02
C***********************************************************************
C     SEE SUBROUTINE INIT01 FOR EXPLANATION OF THE COMMON BLOCKS.
C***********************************************************************
      DIMENSION SUM(16)
      INTEGER*2 COUNT(16)
      COMMON/ISETUP/NUM,LIS(16,16),ID(20),LENGTH(4)
      COMMON/IRUND/IDUMMY(55),IBUFF(768)
      COMMON/WRBUF/ICHAN,IBLOCK,IFLAG
C***********************************************************************
C     SETUP THE COUNT-DOWN TABLE AND ZERO THE SUM ARRAY.
C***********************************************************************
      DO 1005 I=1,NUM
      COUNT(I)=LIS(3,I)
      SUM(I)=0
1005  CONTINUE
C***********************************************************************
C     INITIALIZE BUFFER COUNT.
C***********************************************************************
      NBC=1
C***********************************************************************
C     WAIT FOR OPERATOR O.K. BEFORE STARTING DATA RECORDING PROCEDURE.
C***********************************************************************
14    TYPE 15
15    FORMAT(/,'$',5X,'TYPE "G" FOR START OF RUN: ')
      ACCEPT 16,INP
16    FORMAT(A1)
      IF(INP.NE.1HG)GOTO 14
C***********************************************************************
C     OBTAIN THE TIME FROM THE INTERNAL CLOCK AND COMPUTE THE TIME OF
C     EXPERIMENT COMPLETION USING THE "RUN DURATION".
C***********************************************************************
      CALL GTIM(ITIME)
      CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITIC)
      ENDHRS=LENGTH(1)+IHRS
      ENDMIN=LENGTH(2)+IMIN
      ENDSEC=LENGTH(3)+ISEC
      ENDTIC=LENGTH(4)+ITIC
1000  CALL GTIM(ITIME)
      CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITIC)
C***********************************************************************
C     READ ALL CHANNELS FOR DIGITAL SAMPLING.
C***********************************************************************
      DO 2000 I=1,NUM
C***********************************************************************
C     SET ADC FOR NEXT CHANNEL:
C          LIS(1,I)=CHANNEL LOCATION
C          LIS(2,I)=CODED GAIN
C***********************************************************************
      CALL IPOKE("170402,LIS(1,I).OR.(LIS(2,I)*64))
```

```
C***********************************************************************
C     CHECK FOR END OF CONVERSION.
C***********************************************************************
1500  IF(.NOT.(IPEEK("170400).AND."100000))GOTO 1500
C***********************************************************************
C     NOW DO THE SUMMATION FOR DIGITAL FILTERING.
C***********************************************************************
      SUM(I)=SUM(I)+IPEEK("170402)
C***********************************************************************
C     NEXT CHANNEL:
C***********************************************************************
2000  CONTINUE
C***********************************************************************
C     CHECK THE COUNT-DOWN TABLE FOR A "READY" CHANNEL.
C***********************************************************************
      DO 3000 I=1,NUM
      COUNT(I)=COUNT(I)-1
      IF(COUNT(I).GT.0)GOTO 3000
C***********************************************************************
C     WRITE DATA INTO BUFFER.
C***********************************************************************
      L=I-1
      ISUM=SUM(I)/LIS(3,I)
      IF(L.GE.8)L=L.OR."177770
      IBUFF(NBC)=("7777.AND.ISUM.OR.("170000.AND.(L*4096)))
C***********************************************************************
C     CLEAR THE SUM ARRAY AND RESET THE COUNT-DOWN TABLE.
C***********************************************************************
      SUM(I)=0.
      COUNT(I)=LIS(3,I)
C***********************************************************************
C     CHECK TO SEE IF THE BUFFER IS FULL.
C***********************************************************************
      IF(MOD(NBC,256).NE.0) GOTO 2500
      IF(IFLAG.EQ.1)CALL IWAIT(ICHAN)
      IFLAG=IFLAG+1
C***********************************************************************
C     WRITE THE BUFFER ONTO A DISK FILE.
C***********************************************************************
      CALL WRBUFF(IBUFF(((NBC-1)/256)*256+1))
2500  NBC=1+MOD(NBC,768)
3000  CONTINUE
C***********************************************************************
C     CHECK FOR THE END OF THE RUN.
C***********************************************************************
      ENDTIM=ENDTIC+60.*ENDSEC+3600.*ENDMIN+216000.*ENDHRS
      CURTIM=ITIC+60.*ISEC+3600.*IMIN+216000.*IHRS
      IF(CURTIM.LT.ENDTIM)GOTO 1000
C***********************************************************************
C     WRITE THE REMAINING DATA IF THERE ARE ANY.
C***********************************************************************
      IF(IFLAG.GE.1)CALL IWAIT(ICHAN)
      IF(MOD(NBC,256).NE.1)CALL WRBUFF(IBUFF(((NBC-1)/256)*256+1))
      RETURN
      END
```

```
      SUBROUTINE OUTPUT
C***********************************************************************
C     PROGRAM "OUTPUT" CONTROLS (1) THE WRITING OF THE CONVERTED DATA TO
C     "PLTDAT.DAT" VIA SUBROUTINE "LOOP", (2) THE CONVERSION OF THE
C     QUANTATIES READ FROM A/D CONVERTORS TO USEFUL NUMBERS SUCH AS THE
C     POLARIZER AND ANALYZER AZIMUTHS VIA THE CALIBRATION CURVE
C     SUBROUTINE "CONVRT", (3) THE CONVERSION OF POLARIZER AND ANALYZER
C     AZIMUTHS TO THE ELLIPSOMETER PARAMETER "PSI" AND "DELTA".  THE
C     "PSI" AND "DELTA" CONVERSION IS DONE BY ANOTHER SUBROUTINE,
C     "DELPSI", WHICH IS CALLED FROM WITHIN "CONVRT".
C***********************************************************************
      COMMON/JTIME0/JHRS0,JMIN0,JSEC0,JFLAG
      COMMON/DATPLT/TIME(512),PLTDAT(512,7),NDATA
      COMMON/ZAP/JPZAP,JAZAP
      COMMON/EXPDAT/P,A,VOLT,AMPS,POLMAN,ANAMAN
      COMMON/MANSET/POLOAZ,ANAOAZ,ADJPOL,ADJANA,C
      COMMON/CHGAIN/IGP,IGA,IGCP,IGCC,TOL
      COMMON/CALBRT/RESIST,PSLOPE,ASLOPE,PYINT,AYINT,IGPCAL,IGACAL
      COMMON/ELLIPS/D,S
      COMMON/OPTDAT/OPTION,TIMOPT,ANGOPT
      INTEGER*2 OPTION,TIMOPT,ANGOPT
      COMMON/FILDAT/ARRAY(16),T
C***********************************************************************
C     "TICS" ARE CONVERTED TO HOURS, MINUTES AND SECONDS.
C***********************************************************************
      THRS=T
      IHRS=THRS/216000.
      TMIN=THRS-IHRS*216000.
      IMIN=TMIN/3600.
      TSEC=TMIN-IMIN*3600.
      ISEC=TSEC/60.
      TTIC=TSEC-ISEC*60.
      ITIC=TTIC
      IF(JFLAG.NE.1)GOTO 3000
C***********************************************************************
C     THE FLAGS CONTROLLING THE EXPERIMENTAL TIME LAPSE BETWEEN DATA
C     POINTS RECORDED IN "PLTDAT.DAT" ARE INITIALIZED.
C***********************************************************************
      JHRS0=IHRS
      JMIN0=IMIN
      JSEC0=ISEC
 3000 CONTINUE
C***********************************************************************
C     VARIABLES IN THE COMMON BLOCK FOR "CONVRT" ARE ASSIGNED VALUES.
C***********************************************************************
      P=ARRAY(1)
      A=ARRAY(2)
      VOLT=ARRAY(3)
      AMPS=ARRAY(4)
      POLMAN=ARRAY(5)
      ANAMAN=ARRAY(6)
```

```
C*********************************************************************
C     "DELTA" AND "PSI" VALUES ARE RETURNED FROM "CONVRT".
C*********************************************************************
      CALL CONVRT
      ARRAY(1)=P
      ARRAY(2)=A
      ARRAY(3)=VOLT
      ARRAY(4)=AMPS
      ARRAY(5)=D
      ARRAY(6)=S
      ARRAY(7)=0.
      IF(NDATA.GT.1)GOTO 4015
C*********************************************************************
C     DATA IN THE PLOTTING ARRAY IS DISPLAYED ON THE VT55 FOR REVIEW BY
C     THE OPERATOR.
C*********************************************************************
      TYPE 4000
 4000 FORMAT(/19X,'THE DATA AVAILABLE FOR PLOTTING:')
      TYPE 4010
 4010 FORMAT(/8X,'TIME',2X,'POL(DEG)',2X,'ANA(DEG)',1X,'VOLTS(MV)',
     C2X,'AMPS(MA)',2X,'DEL(DEG)',2X,'PSI(DEG)')
 4015 CONTINUE
      TYPE 4020,IHRS,IMIN,ISEC,ITIC,(ARRAY(K),K=1,6)
 4020 FORMAT(1X,3(I2,':'),I2,6(1X,F9.3))
      IF(NDATA.GE.512)GOTO 6000
C*********************************************************************
C     THIS "IF" STATEMENT SCREENS DATA FROM CHANNEL 5 AND 6, WHICH ARE
C     USED TO FLAG DATA DISTURBED WHILE MAKING MANUAL ADJUSTMENTS
C     DURING AN EXPERIMENT.
C*********************************************************************
      IF(ABS(POLMAN).LT.TOL.OR.ABS(ANAMAN).LT.TOL)GOTO 6000
C*********************************************************************
C     THE EXPERIMENTAL TIME LAPSE BETWEEN RECORDED, CONVERTED DATA IS
C     DETERMINED.
C*********************************************************************
      IF(TIMOPT.NE.1)GOTO 5020
      IF(JHRSO-IHRS)5010,6000,6000
 5010 CALL LOOP
      JHRSO=IHRS
 5020 CONTINUE
      IF(TIMOPT.NE.2)GOTO 5040
      IF(JMINO-IMIN)5030,6000,6000
 5030 CALL LOOP
      JMINO=IMIN
 5040 CONTINUE
      IF(TIMOPT.NE.3)GOTO 5060
      IF(JSECO-ISEC)5050,6000,6000
 5050 CALL LOOP
      JSECO=ISEC
 5060 CONTINUE
      IF(TIMOPT.NE.4)GOTO 5080
 5070 CALL LOOP
 5080 NDATA=NDATA+1
 6000 JFLAG=JFLAG+1
      RETURN
      END
```

```
      SUBROUTINE LOOP
C***************************************************************************
C     THIS SUBROUTINE WRITES DATA TO THE FILE "PLTDAT.DAT" AND FILLS THE
C     TWO DIMENSIONAL ARRAY "PLTDAT" FOR DATA POINTS NOT DISTURBED BY
C     MANUAL ADJUSTMENTS, AND HAVING THE DESIRED SPACING IN TIME.
C***************************************************************************
      COMMON/OPTDAT/OPTION,TIMOPT,ANGOPT
      INTEGER*2 OPTION,TIMOPT,ANGOPT
      COMMON/DATPLT/TIME(512),PLTDAT(512,7),NDATA
      COMMON/FILDAT/ARRAY(16),T
      TIME(NDATA)=T
      DO 1 K=1,7
    1 PLTDAT(NDATA,K)=ARRAY(K)
      IF(OPTION.NE.1)GOTO 3
      WRITE(2,2)T,(ARRAY(K),K=1,7)
    2 FORMAT(1X,F9.0,7(1X,F9.3))
    3 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DEFINE
C***********************************************************************
C     SUBROUTINE "DEFINE" IS CALLED FROM THE MAIN PROGRAM "TRNSLT" TO
C     DEFINE INPUT PARAMETERS READ FROM "TRNSLT.DAT" FOR THE OPERATOR.
C***********************************************************************
      COMMON/MANSET/POLOAZ,ANAOAZ,ADJPOL,ADJANA,C
      COMMON/CHGAIN/IGP,IGA,IGCP,IGCC,TOL
      COMMON/CALBRT/RESIST,PSLOPE,ASLOPE,PYINT,AYINT,IGPCAL,IGACAL
      COMMON/OPTDAT/OPTION,TIMOPT,ANGOPT
      INTEGER*2 OPTION,TIMOPT,ANGOPT
      TYPE 10
   10 FORMAT(/,5X,'CALIBRATION CURVE AND MANNUAL SETTING DATA:')
      TYPE 20,RESIST
   20 FORMAT(/,10X,'(1)RESISTOR FOR CELL CURRENT DETERMINATION (KOHM)
     1 = ',F10.4)
      TYPE 30
   30 FORMAT(/,10X,'(2)INITIAL MANUAL AZIMUTH SETTINGS OF POLARIZERS
     1 AND COMPENSATOR:')
      TYPE 40,POLOAZ,ANAOAZ,C
   40 FORMAT(/,15X,'POLARIZER(DEG) = ',F10.4,/,15X,'ANALYZER(DEG)  = ',
     1F10.4,/,15X,'QTR. WAVE(DEG) = ',F10.4)
      TYPE 50
   50 FORMAT(/,10X,'(3)INCREMENTAL MANUAL ADJUSTMENTS OF POLARIZERS
     1 DURING EXPERIMENT:')
      TYPE 60,ADJPOL,ADJANA,TOL
   60 FORMAT(/,15X,'POLARIZER(DEG) = ',F10.4,/,15X,'ANALYZER(DEG)  = ',
     1F10.4,/,15X,'FLAG TOLERANCE = ',F10.4)
      TYPE 70
   70 FORMAT(/,10X,'(4)FARADAY CELL CALIBRATION CURVE EQUATION
     1 PARAMETERS:')
      TYPE 80
   80 FORMAT(/,15X,'POLARIZER-')
      TYPE 90,PSLOPE,PYINT,IGPCAL
   90 FORMAT(/,15X,'SLOPE(DEG/ADCU)        =',F10.4,/,15X,
     1'INTERCEPT(DEG)         =',F10.4,/,15X,'GAIN DURING CALIBRATION=',
     29X,I1)
      TYPE 100
  100 FORMAT(/,15X,'ANALYZER-')
      TYPE 90,ASLOPE,AYINT,IGACAL
      TYPE 110
  110 FORMAT(/,10X,'(5)OUTPUT FILE OPTIONS:')
      TYPE 120,OPTION
  120 FORMAT(/,15X,'OPTION = ',I1)
      TYPE 130
  130 FORMAT(/,15X,'1=FILE CREATED WITH REDUCED DATA',/,15X,
     1'2=NO OUTPUT FILE CREATED')
      TYPE 140,TIMOPT
  140 FORMAT(/,15X,'TIME OPTION = ',I1)
      TYPE 150
  150 FORMAT(/,15X,'1=DATA POINT OUTPUT OR STORED IN PLOTTING ARRAY
     1 FOR EVERY HOUR',/,15X,'2=FOR EVERY MINUTE',/,15X,'3=FOR EVERY
     2 SECOND',/,15X,'4=ALL DATA POINTS OUTPUT OR STORED IN PLOTTING
     3 ARRAY',/,15X,'5=NO DATA POINTS OUTPUT OR STORED IN PLOTTING
     4 ARRAY')
      TYPE 160,ANGOPT
  160 FORMAT(/,15X,'ANGLE CONVERSION OPTION = ',I1)
      TYPE 170
  170 FORMAT(/,15X,'1=AZIMUTH READINGS CONVERTED TO DELTA AND PSI USING
     1 STANDARD FORMULAS',/,15X,'2=USING ROTATED ANGLE FORMULAS')
      RETURN
      END
```

Appendix 6.

Directory of data storage disk showing data file created by EDR002

```
TEFLON.187     5 18-Jul-82        TEFLON.188     5 18-Jul-82
TEFLON.189     5 18-Jul-82        TEFLON.190     5 18-Jul-82
TEFLON.191     5 18-Jul-82        TEFLON.192     5 18-Jul-82
TEFLON.193     5 18-Jul-82        TEFLON.194     5 18-Jul-82
TEFLON.195     5 19-Jul-82        TEFLON.196     5 19-Jul-82
TEFLON.197     5 19-Jul-82        TEFLON.198     5 19-Jul-82
TEFLON.199     5 19-Jul-82        TEFLON.200     5 19-Jul-82
TEFLON.201     5 19-Jul-82        TEFLON.202     5 19-Jul-82
TEFLON.203     5 19-Jul-82        TEFLON.204     5 19-Jul-82
TEFLON.205     5 19-Jul-82        RESULT.203     5 19-Jul-82
CVPBAU.000    13 19-Jul-82        CVPBAU.001    13 19-Jul-82
CVPBAU.002    13 19-Jul-82        CVPBAU.003    13 19-Jul-82
CVPBAU.004    13 19-Jul-82        TRNSLT.DAT     1 09-Nov-81
PLTDAT.DAT    58 19-Jul-82        TEFLON.206     5 19-Jul-82
TEFLON.207     5 19-Jul-82        CVPBAU.005    13 19-Jul-82
CVPBAU.006    13 19-Jul-82        GOLD  .186     5 19-Jan-83
GOLD  .183     5 19-Jan-83        MINUS .186     5 19-Jan-83
GOLD  .188     5 19-Jan-83        MINUS .188     5 19-Jan-83
GOLD  .185     5 19-Jan-83        MINUS .185     5 19-Jan-83
DEMO  .DAT     4 19-Jan-83.......................created data file
 165 Files, 939 Blocks
 35 Free blocks
```

Appendix 7.

Demonstration of DECOD2 - conversion of unformatted data file to formatted output

```
.RUN DY0:DECOD2

   FILE NAME OF DATA = DY1CVPBAU006

   DO YOU WISH TO LIST RUN INFORMATION ? Y

   ID = PB ON AU - 10RHOD-B - -0.6V DC

   DURATION OF RUN *HRS:MIN:SEC:TIC* =  0: 3: 0: 0


   NUMBER OF CHANNELS =  6

   NUMBER  LOC N   GAIN    PERIOD,TIC  RANGE   UNITS   NAME AND COMMENT

     1       0       3         30        0               POL
     2       1       3         30        0               ANA
     3       2       3         30        0               POTENTIAL
     4       3       3         30        0               CURRENT
     5       4       3         30        0               PFLAG
     6       5       3         30        0               AFLAG

   DO YOU WISH TO PRINT OUT DATA ? Y


0: 0: 0:29 C 1= 1382 C 2=  597 C 3= -332 C 4=   -2 C 5=  751 C 6= 2039
           C
0: 0: 0:59 C 1= 1374 C 2=  570 C 3= -332 C 4=   -1 C 5=  268 C 6= 2047
           C
0: 0: 1:29 C 1= 1403 C 2=  596 C 3= -332 C 4=    0 C 5=   48 C 6= 2047
           C
0: 0: 1:59 C 1= 1410 C 2=  613 C 3= -332 C 4=    0 C 5=  -79 C 6= 2047
           C
0: 0: 2:29 C 1= 1387 C 2=  582 C 3= -332 C 4=    0 C 5= -131 C 6= 2047
           C
0: 0: 2:59 C 1= 1355 C 2=  550 C 3= -331 C 4=    0 C 5= -144 C 6= 2047
           C
0: 0: 3:29 C 1= 1417 C 2=  608 C 3= -332 C 4=    0 C 5= -150 C 6= 2047
           C
0: 0: 3:59 C 1= 1391 C 2=  586 C 3= -331 C 4=   -4 C 5= -153 C 6= 2047
           C
0: 0: 4:29 C 1= 1367 C 2=  580 C 3= -332 C 4=    2 C 5= -150 C 6= 2047
           C
0: 0: 4:59 C 1= 1431 C 2=  632 C 3= -332 C 4=    0 C 5= -155 C 6= 2047
           C
0: 0: 5:29 C 1= 1381 C 2=  587 C 3= -332 C 4=    2 C 5= -153 C 6= 2047
           C
0: 0: 5:59 C 1= 1415 C 2=  612 C 3= -331 C 4=   -1 C 5= -149 C 6= 2047
           C
```

Listing of DECOD2

```
      CALL DECODE
      CALL EXIT
      END
      SUBROUTINE DECODE
      COMMON/ISETUP/NUM,LIS(16,16),ID(20),LENGTH(4)
      COMMON/IRUND/COUNT(16),IBUFF(768)
      INTEGER*2 DATA(16),CHANNEL(16),CHAN,RD,INP
      INTEGER*4 NAME(3),BDLK(2)
      DIMENSION TIM(16)
C***********************************************************************
C     GET FILE NAME FROM USER.
C***********************************************************************
      TYPE 1
1     FORMAT(/,'$',4X,'FILE NAME OF DATA = ')
      ACCEPT 2,(NAME(I),I=1,3)
2     FORMAT(3A4)
C***********************************************************************
C     CONVERT THE FILE NAME INTO THE CORRECT FORMAT.
C***********************************************************************
      N=IRAD50(12,NAME,BDLK)
C***********************************************************************
C     OPEN A CHANNEL FOR FILE INPUT.
C***********************************************************************
      ICHAN=IGETC(I)
      IF(ICHAN.LT.0)STOP 'CANNOT ALLOCATE CHANNEL'
      IF(LOOKUP(ICHAN,BDLK).LT.0)STOP 'BAD LOOKUP'
C***********************************************************************
C     READ THE FIRST BLOCK OF DATA.
C***********************************************************************
      IBLOCK=0
      CALL READ(IBUFF,IBLOCK,ICHAN)
C***********************************************************************
C     DECODE THE "ID" OF THE DATA.
C***********************************************************************
      DO 100, I=1,20
      ID(I)=IBUFF(I)
100   CONTINUE
C***********************************************************************
C     DECODE THE NUMBER OF CHANNELS (NUM) AND THE RUN DURATION (LENGTH).
C***********************************************************************
      NUM=IBUFF(21)
      LENGTH(1)=IBUFF(22)
      LENGTH(2)=IBUFF(23)
      LENGTH(3)=IBUFF(24)
      LENGTH(4)=IBUFF(25)
      STOPT=216000.*LENGTH(1)+3600.*LENGTH(2)+60.*LENGTH(3)+LENGTH(4)
```

```
C*********************************************************************
C     READ THE SECOND BLOCK OF DATA; GET SETUP INFO PERTAINING TO DATA.
C*********************************************************************
      CALL READ(IBUFF,IBLOCK,ICHAN)
      DO 200,I=1,NUM
      DO 200 J=1,16
      LIS(J,I)=IBUFF((I-1)*16+J)
200   CONTINUE
C*********************************************************************
C     ASK USER IF A LIST OF RUN INFO IS NEEDED.
C*********************************************************************
1001  TYPE 3
3     FORMAT(/,'$',4X,'DO YOU WISH TO LIST RUN INFORMATION ? ')
      ACCEPT 4,INP
4     FORMAT(A1)
      IF((INP.NE.1HY).AND.(INP.NE.1HN))GOTO 1001
      IF(INP.NE.1HY)GOTO 1002
C*********************************************************************
C     TYPE HEADING OF DATA.
C*********************************************************************
      TYPE 5,(ID(I),I=1,20)
5     FORMAT(/,5X,'ID = ',20A2)
      TYPE 6,(LENGTH(I),I=1,4)
6     FORMAT(/,5X,'DURATION OF RUN "HRS:MIN:SEC:TIC" = ',3(I2,':'),I2)
      TYPE 7,NUM,(K,(LIS(M,K),M=1,16),K=1,NUM)
7     FORMAT (//,5X,'NUMBER OF CHANNELS = ',I2,//,
     1    5X,'NUMBER',2X,'LOC N',3X,'GAIN',4X,'PERIOD,TIC',2X,'RANGE',
     2    3X,'UNITS',3X,'NAME AND COMMENT',//,
     3    (6X,I2,6X,I2,6X,I2,6X,I4,8X,I2,5X,2A2,6X,10A2))
C*********************************************************************
C     ASK IF THE USER WANTS TO PRINT OUT THE COLLECTED DATA.
C*********************************************************************
1002  TYPE 8
8     FORMAT(/,'$',4X,'DO YOU WISH TO PRINT OUT DATA ? ')
      ACCEPT 9,INP
9     FORMAT(A1)
      IF(INP.NE.1HY.AND.INP.NE.1HN)GOTO 1002
C*********************************************************************
C     IF NOT, RETURN CONTROL TO MAIN PROGRAM AND TERMINATE.
C*********************************************************************
      IF(INP.EQ.1HN)GOTO 1003
C*********************************************************************
C     IF YES, PRINT THE DATA.
C*********************************************************************
C     SET UP INITIAL CONDITION
C*********************************************************************
      J=0
      T=0
      DO 400,I=1,NUM
      TIM(I)=-1
400   CONTINUE
```

```
C***********************************************************************
C     READ THE BUFFER.
C***********************************************************************
1004  CALL READ(IBUFF,IBLOCK,ICHAN)
C***********************************************************************
C     DECODE THE BUFFER.
C***********************************************************************
      DO 500,I=1,256
C***********************************************************************
C     DECODE EACH WORD.
C***********************************************************************
      CHAN=((("170000.AND.IBUFF(I))/4096).AND."17)+1
      RD=IBUFF(I).AND."7777
C***********************************************************************
C     EXTEND SIGN BIT FOR BIPOLER SIGNAL.
C***********************************************************************
      IF(RD.AND."4000)RD=RD.OR."170000
C***********************************************************************
C     RECONSTRUCT TIME BY CALCULATION.
C***********************************************************************
      TIM(CHAN)=TIM(CHAN)+LIS(3,CHAN)
C***********************************************************************
C     IF THE TIME HASN'T CHANGED, RECORD THIS DATA AND GO TO THE NEXT POINT.
C***********************************************************************
      IF(TIM(CHAN).LE.T)GOTO 600
      THRS=T
      IHRS=THRS/216000.
      TMIN=THRS-IHRS*216000.
      IMIN=TMIN/3600.
      TSEC=TMIN-IMIN*3600.
      ISEC=TSEC/60.
      TTIC=TSEC-ISEC*60.
      ITIC=TTIC
      IF(T.EQ.0.0)GOTO 300
      TYPE 10,IHRS,IMIN,ISEC,ITIC ,(CHANNEL(K),DATA(K),K=1,J)
10    FORMAT(1X,3(I2,':'),I2,3(6(1X,'C',I2,'=',I5)/,12X))
C***********************************************************************
C     RESET THE PRINTING PARAMETER.
C***********************************************************************
300   J=0
      T=TIM(CHAN)
C***********************************************************************
C    IIIF TIME IS UP, RETURN.
C***********************************************************************
      IF(T.GT.STOPT)GOTO 1003
600   J=J+1
      DATA(J)=RD
      CHANNEL(J)=CHAN
500   CONTINUE
```

```
C**********************************************************************
C     IF TIME IS NOT UP YET, READ THE NEXT BUFFER.
C**********************************************************************
      IF(T.LT.STOPT)GOTO 1004
1003  RETURN
      END
      SUBROUTINE READ(IBUFF,IBLOCK,ICHAN)
      IERROR=IREADW(256,IBUFF,IBLOCK,ICHAN)
      IF(IERROR.LT.0) GOTO 2000
      IBLOCK=IBLOCK+1
      RETURN
2000  STOP 'FATAL READ'
      END
```

Demonstration of TRNSLT - conversion of unformatted data file to delta, psi, etc.

```
.RUN DY0:TRNSLT

 LOAD DISK WITH DATA TO BE DECODED INTO DISK DRIVE "DY1:" AND THEN "RETURN".
          2.0000
         17.0000  125.0000   10.0000   10.0000  135.0000    0.0000
          0.0105    0.0105    0.0000    0.0000         3         3
               1         4         2

 DO YOU WANT THIS INPUT DATA DEFINED (Y/N)?  Y  ........input file TRNSLT.DAT
                                                     parameters defined;
   CALIBRATION CURVE AND MANNUAL SETTING DATA:       see appendix 9.

       (1)RESISTOR FOR CELL CURRENT DETERMINATION (KOHM) =     2.0000

       (2)INITIAL MANUAL AZIMUTH SETTINGS OF POLARIZERS AND COMPENSATOR:

           POLARIZER(DEG) =    17.0000
           ANALYZER(DEG)  =   125.0000
           QTR. WAVE(DEG) =   135.0000

       (3)INCREMENTAL MANUAL ADJUSTMENTS OF POLARIZERS DURING EXPERIMENT:

           POLARIZER(DEG) =    10.0000


           ANALYZER(DEG)  =    10.0000
           FLAG TOLERANCE =     0.0000

       (4)FARADAY CELL CALIBRATION CURVE EQUATION PARAMETERS:

           POLARIZER-

           SLOPE(DEG/ADCU)        =    0.0105
           INTERCEPT(DEG)         =    0.0000
           GAIN DURING CALIBRATION=         3

           ANALYZER-

           SLOPE(DEG/ADCU)        =    0.0105
           INTERCEPT(DEG)         =    0.0000
           GAIN DURING CALIBRATION=         3

       (5)OUTPUT FILE OPTIONS:

           OPTION = 1

           1=FILE CREATED WITH REDUCED DATA
           2=NO OUTPUT FILE CREATED
```

```
        INTERCEPT(DEG)          =     0.0000
        GAIN DURING CALIBRATION=           3

    (5)OUTPUT FILE OPTIONS:

        OPTION = 1

        1=FILE CREATED WITH REDUCED DATA
        2=NO OUTPUT FILE CREATED

        TIME OPTION = 4

        1=DATA POINT OUTPUT OR STORED IN PLOTTING ARRAY FOR EVERY HOUR
        2=FOR EVERY MINUTE
        3=FOR EVERY SECOND
        4=ALL DATA POINTS OUTPUT OR STORED IN PLOTTING ARRAY
        5=NO DATA POINTS OUTPUT OR STORED IN PLOTTING ARRAY

        ANGLE CONVERSION OPTION = 2

        1=AZIMUTH READINGS CONVERTED TO DELTA AND PSI USING STANDARD FORMS
        2=USING ROTATED ANGLE FORMULAS

FILE NAME OF DATA = DY1CVPBAU006  ...........data file converted


DO YOU WISH TO LIST RUN INFORMATION ? Y

ID = PB ON AU - 10RHOD-B - -0.6V OC

DURATION OF RUN "HRS:MIN:SEC:TIC" =  0: 3: 0: 0


NUMBER OF CHANNELS =  6

NUMBER  LOC N   GAIN    PERIOD,TIC  RANGE   UNITS   NAME AND COMMENT

  1       0       3        30         0              POL
  2       1       3        30         0              ANA
  3       2       3        30         0              POTENTIAL
  4       3       3        30         0              CURRENT
  5       4       3        30         0              PFLAG
  6       5       3        30         0              AFLAG

               THE DATA AVAILABLE FOR PLOTTING:  ......creation of formatted output
                                                        data file PLTDAT.DAT
     TIME    POL(DEG)   ANA(DEG) VOLTS(MV)  AMPS(MA)  DEL(DEG)  PSI(DEG)
0: 0: 0:29    31.464   131.248  -202.637    -0.610    27.072    41.248
0: 0: 0:59    31.380   130.966  -202.637    -0.305    27.239    40.966
```

Listing of TRNSLT

```
      PROGRAM TRNSLT
C***********************************************************************
C     THIS IS THE MAIN PROGRAM CONTROLLING THE DATA DECODING AND
C     CONVERSION FROM ON-LINE ELLIPSOMETER EXPERIMENTS.
C***********************************************************************
      COMMON/JTIME0/JHRS0,JMIN0,JSEC0,JFLAG
      COMMON/DATPLT/TIME(512),PLTDAT(512,7),NDATA
      COMMON/ZAP/JPZAP,JAZAP
      COMMON/EXPDAT/P,A,VOLT,AMPS,POLMAN,ANAMAN
      COMMON/MANSET/POLOAZ,ANAOAZ,ADJPOL,ADJANA,C
      COMMON/CHGAIN/IGP,IGA,IGCP,IGCC,TOL
      COMMON/CALBRT/RESIST,PSLOPE,ASLOPE,PYINT,AYINT,IGPCAL,IGACAL
      COMMON/ELLIPS/D,S
      COMMON/OPTDAT/OPTION,TIMOPT,ANGOPT
      INTEGER*2 OPTION,TIMOPT,ANGOPT
      COMMON/FILDAT/ARRAY(16),T
      TYPE 1
    1 FORMAT(/'$ LOAD DISK WITH DATA TO BE DECODED INTO DISK DRIVE
     1 "DY1:" AND THEN "RETURN".')
      ACCEPT 2,NWAIT
    2 FORMAT(I1)
C***********************************************************************
C     THE FILE "TRNSLT.DAT" CONTAINS BASELINE ELLIPSOMETER PARAMETERS
C     AND PARAMETERS RELATED TO THE ELECTROCHEMICAL EXPERIMENT SUCH AS
C     THE MANUAL AZIMUTH SETTINGS, RESISTOR VALUES, ETC.
C***********************************************************************
      OPEN(UNIT=1,NAME='DY1:TRNSLT.DAT',TYPE='OLD')
      READ(1,10)RESIST
      TYPE 10,RESIST
      READ(1,10)POLOAZ,ANAOAZ,ADJPOL,ADJANA,C,TOL
      TYPE 10,POLOAZ,ANAOAZ,ADJPOL,ADJANA,C,TOL
      READ(1,11)PSLOPE,ASLOPE,PYINT,AYINT,IGPCAL,IGACAL
      TYPE 11,PSLOPE,ASLOPE,PYINT,AYINT,IGPCAL,IGACAL
      READ(1,12)OPTION,TIMOPT,ANGOPT
      TYPE 12,OPTION,TIMOPT,ANGOPT
      TYPE 3
    3 FORMAT(/,'$ DO YOU WANT THIS INPUT DATA DEFINED (Y/N)?  ')
      ACCEPT 4,IDEFIN
    4 FORMAT(1A)
      IF(IDEFIN.EQ.1HN)GOTO 5
C***********************************************************************
C     SUBROUTINE "DEFINE" IS CALLED FROM THE MAIN PROGRAM "TRNSLT" TO
C     DEFINE INPUT PARAMETERS READ FROM "TRNSLT.DAT" FOR THE OPERATOR.
C***********************************************************************
      CALL DEFINE
    5 CONTINUE
      IF(OPTION.NE.1)GOTO 6
```

```
C*************************************************************************
C     THE FILE "PLTDAT.DAT" IS USED FOR WRITING THE CONVERTED DATA.
C*************************************************************************
      OPEN(UNIT=2,NAME='DY1:PLTDAT.DAT',TYPE='UNKNOWN',INITIALSIZE=100)
    6 CONTINUE
   10 FORMAT(10X,6(F10.4))
   11 FORMAT(10X,4(F10.4),2(9X,I1))
   12 FORMAT(10X,4(9X,I1))
      NDATA=1
      JFLAG=1
      JPZAP=0
      JAZAP=0
C*************************************************************************
C     SUBROUTINE "DECODE" IS USED TO ACTUALLY DECODE THE ORIGINAL
C     UNFORMATED DATA FILE FOR A GIVEN EXPERIMENT.  VARIOUS DATA
C     REDUCTION SUBROUTINES ARE ACCESSED FROM THIS SUBROUTINE.  THE
C     OUTPUT FILE "PLTDAT.DAT" IS CREATED BY A SUBROUTINE ("OUTPUT")
C     CALLED FROM "DECODE".
C*************************************************************************
      CALL DECODE
C*************************************************************************
C     SUBROUTINE "PLOT" IS CALLED AND IS A GENERAL PURPOSE PLOTTING
C     SUBROUTINE WRITTEN FOR THE VT-55 GRAPHICS TERMINAL AND ALLOWS
C     VARIOUS COMBINATIONS OF EXPERIMENTAL PARAMETERS TO BE PLOTTED
C     AGAINST ONE ANOTHER.
C*************************************************************************
      CALL PLOT
      STOP
      END
```

```
      SUBROUTINE CHGTME(TIME1,IHRS,IMIN,ISEC,ITIC)
C***********************************************************************
C     THIS SUBROUTINE CONVERTS THE TIME IN "TICS" TO HOURS, MINUTES,
C     SECONDS, AND TICS.
C***********************************************************************
      THRS=TIME1
      IHRS=THRS/216000.
      TMIN=THRS-IHRS*216000.
      IMIN=TMIN/3600.
      TSEC=TMIN-IMIN*3600.
      ISEC=TSEC/60.
      TTIC=TSEC-ISEC*60.
      ITIC=TTIC
      RETURN
      END
```

```
      SUBROUTINE DECODE
C***************************************************************************
C     SUBROUTINE "DECODE" IS A VARIATION OF THE MAIN DATA DECODING
C     PROGRAM "DECODE".  THE PURPOSE OF THIS SUBROUTINE IS TO CONVERT
C     THE UNFORMATTED EXPERIMENTAL DATA FILES INTO A STANDARD FORM
C     MORE EASILY USED BY AUXILIARY FORTRAN DATA REDUCTION SUBROUTINES.
C     SEVERAL OF THESE AUXILIARY SUBROUTINES ARE THEN CALLED FROM
C     "DECODE".
C***************************************************************************
      COMMON/JTIME0/JHRS0,JMIN0,JSEC0,JFLAG
      COMMON/DATPLT/TIME(512),PLTDAT(512,7),NDATA
      COMMON/ZAP/JPZAP,JAZAP
      COMMON/EXPDAT/P,A,VOLT,AMPS,POLMAN,ANAMAN
      COMMON/MANSET/POLOAZ,ANAOAZ,ADJPOL,ADJANA,C
      COMMON/CHGAIN/IGP,IGA,IGCP,IGCC,TOL
      COMMON/CALBRT/RESIST,PSLOPE,ASLOPE,PYINT,AYINT,IGPCAL,IGACAL
      COMMON/ELLIPS/D,S
      COMMON/OPTDAT/OPTION,TIMOPT,ANGOPT
      INTEGER*2 OPTION,TIMOPT,ANGOPT
      COMMON/FILDAT/ARRAY(16),T
      COMMON/ISETUP/NUM,LIS(16,16),ID(20),LENGTH(4)
      COMMON/IRUND/COUNT(16),IBUFF(768)
      INTEGER*2 DATA(16),CHANNEL(16),CHAN,RD,INP
      INTEGER*4 NAME(3),BDLK(2)
      DIMENSION TIM(16)
C*****GET FILE NAME FROM USER**********************************************
      TYPE 1
1     FORMAT(/,'$',4X,'FILE NAME OF DATA = ')
      ACCEPT 2,(NAME(I),I=1,3)
2     FORMAT(3A4)
C*****CONVERT THE FILE NAME INTO THE CORRECT FORMAT*********************
      N=IRAD50(12,NAME,BDLK)
C*****OPEN A CHANNEL FOR FILE INPUT***************************************
      ICHAN=IGETC(I)
      IF(ICHAN.LT.0)STOP 'CANNOT ALLOCATE CHANNEL'
      IF(LOOKUP(ICHAN,BDLK).LT.0)STOP 'BAD LOOKUP'
C*****READ THE FIRST BLOCK OF DATA****************************************
      IBLOCK=0
      CALL READ(IBUFF,IBLOCK,ICHAN)
C*****DECODE THE "ID" OF THE DATA*****************************************
      DO 100, I=1,20
      ID(I)=IBUFF(I)
100   CONTINUE
C*****DECODE THE NUMBER OF CHANNELS (NUM) AND THE RUN DURATION (LENGTH)*
      NUM=IBUFF(21)
      LENGTH(1)=IBUFF(22)
      LENGTH(2)=IBUFF(23)
      LENGTH(3)=IBUFF(24)
      LENGTH(4)=IBUFF(25)
      STOPT=216000.*LENGTH(1)+3600.*LENGTH(2)+60.*LENGTH(3)+LENGTH(4)
```

```
C*****READ SECOND BLOCK OF DATA; GET SETUP INFO PERTAINING TO DATA******
      CALL READ(IBUFF,IBLOCK,ICHAN)
      DO 200,I=1,NUM
      DO 200 J=1,16
      LIS(J,I)=IBUFF((I-1)*16+J)
200   CONTINUE
C*****ASK USER IF A LIST OF RUN INFO IS NEEDED**************************
1001  TYPE 3
3     FORMAT(/,'$',4X,'DO YOU WISH TO LIST RUN INFORMATION ? ')
      ACCEPT 4,INP
4     FORMAT(A1)
      IF((INP.NE.1HY).AND.(INP.NE.1HN))GOTO 1001
      IF(INP.NE.1HY)GOTO 1002
C*****TYPE HEADING OF THE DATA******************************************
      TYPE 5,(ID(I),I=1,20)
5     FORMAT(/,5X,'ID = ',20A2)
      TYPE 6,(LENGTH(I),I=1,4)
6     FORMAT(/,5X,'DURATION OF RUN "HRS:MIN:SEC:TIC" = ',3(I2,':'),I2)
      TYPE 7,NUM,(K,(LIS(M,K),M=1,16),K=1,NUM)
7     FORMAT (//,5X,'NUMBER OF CHANNELS = ',I2,//,
     1    5X,'NUMBER',2X,'LOC N',3X,'GAIN',4X,'PERIOD,TIC',2X,'RANGE',
     2    3X,'UNITS',3X,'NAME AND COMMENT',//,
     3    (6X,I2,6X,I2,6X,I2,6X,I4,8X,I2,5X,2A2,6X,10A2))
C*****ASK IF THE USER WANTS TO PRINT OUT THE COLLECTED DATA*************
1002  CONTINUE
C*****SET UP THE INITIAL CONDITION**************************************
      IF(OPTION.NE.1)GOTO 1005
      WRITE(2,8)(ID(I),I=1,20)
8     FORMAT(/,5X,20A2)
1005  CONTINUE
      J=0
      T=0
      DO 400,I=1,NUM
      TIM(I)=-1
400   CONTINUE
C*****READ THE BUFFER***************************************************
1004  CALL READ(IBUFF,IBLOCK,ICHAN)
C*****DECODE THE BUFFER*************************************************
      DO 500,I=1,256
C*****DECODE EACH WORD**************************************************
      CHAN=((("170000.AND.IBUFF(I))/4096).AND."17)+1
      RD=IBUFF(I).AND."7777
C*****EXTEND THE SIGN BIT FOR BIPOLAR SIGNAL****************************
      IF(RD.AND."4000)RD=RD.OR."170000
C*****RECONSTRUCT THE TIME BY CALCULATION*******************************
      TIM(CHAN)=TIM(CHAN)+LIS(3,CHAN)
```

```
C*****IF THE TIME  HASN'T CHANGED, RECORD THIS DATA AND GO TO NEXT PT.**
      IF(TIM(CHAN).LE.T)GOTO 600
C***********************************************************************
C     THE TIME IN "TICS" IS CONVERTED TO HOURS, MINUTES, SECONDS, AND
C     TICS.  NOTE THAT A TIC IS DEFINED AS 1/60 TH OF A SECOND.
C***********************************************************************
      THRS=T
      IHRS=THRS/216000.
      TMIN=THRS-IHRS*216000.
      IMIN=TMIN/3600.
      TSEC=TMIN-IMIN*3600.
      ISEC=TSEC/60.
      TTIC=TSEC-ISEC*60.
      ITIC=TTIC
      IF(T.EQ.0.0)GOTO 300
      IGP=LIS(2,1)
      IGA=LIS(2,2)
      IGCP=LIS(2,3)
      IGCC=LIS(2,4)
      DO 700 IJK=1,6
700   ARRAY(IJK)=DATA(IJK)
      CALL OUTPUT
C***********************************************************************
C     SUBROUTINE "OUTPUT" IS CALLED.  THIS SUBROUTINE ACTUALLY CONTROLS
C     (1) THE WRITING OF THE CONVERTED DATA TO "PLTDAT.DAT" VIA SUBROU-
C     TINE "LOOF", (2) THE CONVERSION OF THE QUANTITIES READ FROM A/D
C     CONVERTORS TO USEFUL NUMBERS SUCH AS THE POLARIZER AND ANALYZER
C     AZIMUTHS VIA THE "CALIBRATION CURVE" SUBROUTINE "CONVRT", (3) THE
C     CONVERSION OF POLARIZER AND ANALYZER AZIMUTHS TO THE ELLIPSOMETER
C     PARAMETERS "PSI" AND "DELTA".  THE "PSI" AND "DELTA" CONVERSION IS
C     DONE BY ANOTHER SUBROUTINE, "DELPSI", WHICH IS CALLED FROM WITHIN
C     SUBROUTINE "CONVRT".
C***********************************************************************
C*****RESET THE PRINTING PARAMETER**************************************
300   J=0
      T=TIM(CHAN)
C*****IF THE TIME IS UP, RETURN*****************************************
      IF(T.GT.STOPT)GOTO 1003
600   J=J+1
      DATA(J)=RD
      CHANNEL(J)=CHAN
500   CONTINUE
C*****IF THE TIME IS NOT UP, READ THE NEXT BUFFER***********************
      IF(T.LT.STOPT)GOTO 1004
1003  RETURN
      END
      SUBROUTINE READ(IBUFF,IBLOCK,ICHAN)
      IERROR=IREADW(256,IBUFF,IBLOCK,ICHAN)
      IF(IERROR.LT.0) GOTO 2000
      IBLOCK=IBLOCK+1
      RETURN
2000  STOP 'FATAL READ'
      END
```

```
      SUBROUTINE CONVRT
C************************************************************************
C     THIS SUBROUTINE USES CALIBRATION CURVE DATA FOR THE ELLIPSOMETER
C     FARADAY CELLS TO CONVERT A/D READINGS CORRESPONDING TO FARADAY
C     CELL CURRENT TO AZIMUTHS OF ROTATION.  THE CELL POTENTIAL AND
C     CELL CURRENTS ARE ALSO COMPUTED IN MILLIVOLTS AND MILLIAMPS.
C     THESE CALIBRATION CURVES TAKE INTO ACCOUNT VARIABLE CHANNEL GAIN
C     BETWEEN THE CALIBRATION RUNS AND EXPERIMENTS.
C************************************************************************
      COMMON/ZAP/JPZAP,JAZAP
      COMMON/EXPDAT/P,A,VOLT,AMPS,POLMAN,ANAMAN
      COMMON/MANSET/POLOAZ,ANAOAZ,ADJPOL,ADJANA,C
      COMMON/CHGAIN/IGP,IGA,IGCP,IGCC,TOL
      COMMON/CALBRT/RESIST,PSLOPE,ASLOPE,PYINT,AYINT,IGPCAL,IGACAL
      COMMON/ELLIPS/D,S
      COMMON/OPTDAT/OPTION,TIMOPT,ANGOPT
      INTEGER*2 OPTION,TIMOPT,ANGOPT
      IF(POLMAN.GT.-TOL.AND.POLMAN.LT.TOL)GOTO 1000
      IF(ANAMAN.GT.-TOL.AND.ANAMAN.LT.TOL)GOTO 1100
C************************************************************************
C     THESE ARE THE LINEAR EQUATIONS FOR THE CONVERSION.
C************************************************************************
      P=(PSLOPE*P+PYINT)*(2**IGP/2**IGPCAL)+POLOAZ
      A=(ASLOPE*A+AYINT)*(2**IGA/2**IGACAL)+ANAOAZ
      VOLT=((VOLT*10.)/(2048.*(2**IGCP)))*1000.
      AMPS=(AMPS*10.)/(RESIST*2.048*(2**IGCC))
      JPZAP=0
      JAZAP=0
C************************************************************************
C     SUBROUTINE "DELPSI" IS A SPECIAL SUBROUTINE THAT, GIVEN THE
C     QUARTER WAVE PLATE, POLARIZER, AND ANALYZER AZIMUTH ANGLES,
C     COMPUTES "PSI" AND "DELTA" USING THE CONVERSION FORMULAS FOR THE
C     APPROPRIATE ZONE.
C************************************************************************
      CALL DELPSI
      GOTO 2000
 1000 JPZAP=JPZAP+1
C************************************************************************
C     THIS "SCREENING" STEP INCREMENTS THE MANUAL POLARIZER AND ANALYZER
C     AZIMUTHS WHEN IT DETECTS THAT MANUAL ADJUSTMENTS HAVE BEEN MADE TO
C     KEEP THE SIGNAL IN THE RANGE OF THE FARADAY CELLS.  RECALL THAT
C     CHANNELS 5 AND 6 ARE USED TO FLAG THE DATA DURING SUCH ADJUSTMENTS.
C************************************************************************
      IF(JPZAP.NE.1)GOTO 1200
      POLOAZ=POLOAZ+ADJPOL
      GOTO 1200
 1100 JAZAP=JAZAP+1
      IF(JAZAP.NE.1)GOTO 1200
      ANAOAZ=ANAOAZ+ADJANA
 1200 P=0.
      A=0.
      VOLT=0.
      AMPS=0.
      POLMAN=0.
      ANAMAN=0.
      D=0.
      S=0.
 2000 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE DELPSI
C***********************************************************************
C     THIS PROGRAM, GIVEN THE POLARIZER, QUARTER WAVE PLATE, AND
C     ANALYZER AZIMUTH ANGLES COMPUTES "PSI" AND "DELTA" USING THE
C     APPROPRIATE ZONE CONVERSION FORMULAS.
C***********************************************************************
      INTEGER*2 PFLAG,AFLAG,CFLAG,FLAG
      COMMON/EXPDAT/P,A,VOLT,AMPS,POLMAN,ANAMAN
      COMMON/MANSET/POLOAZ,ANAOAZ,ADJPOL,ADJANA,C
      COMMON/ELLIPS/D,S
      COMMON/OPTDAT/OPTION,TIMOPT,ANGOPT
      INTEGER*2 OPTION,TIMOPT,ANGOPT
      D=0.
      S=0.
      PFLAG=0
      GOTO 6
    5 P=P+180.
    6 CONTINUE
      IF(P.LE.180.)PFLAG=400
      IF(P.LE.135.)PFLAG=300
      IF(P.LE. 90.)PFLAG=200
      IF(P.LE. 45.)PFLAG=100
      IF(P.LE.  0.)GOTO 5
      AFLAG=0
      GOTO 8
    7 A=A+180.
    8 CONTINUE
      IF(A.LE.180.)AFLAG=20
      IF(A.LE. 90.)AFLAG=10
      IF(A.LT.  0.)GOTO 7
      CFLAG=0
      IF(C.EQ.45.)CFLAG=1
      IF(C.EQ.135.)CFLAG=2
      FLAG=PFLAG+AFLAG+CFLAG
      IF(ANGOPT.NE.2)GOTO 180
      IF(FLAG.NE.312)GOTO 10
      D=270.-2.*P
      S=90.-A
   10 CONTINUE
      IF(FLAG.NE.411)GOTO 20
      D=2.*P-270.
      S=90.-A
   20 CONTINUE
      IF(FLAG.NE.122)GOTO 30
      D=90.-2.*P
      S=A-90.
   30 CONTINUE
      IF(FLAG.NE.221)GOTO 40
      D=2.*P-90.
      S=A-90.
```

```
 40 CONTINUE
    IF(FLAG.NE.321)GOTO 50
    D=2.*P-90.
    S=A-90.
 50 CONTINUE
    IF(FLAG.NE.422)GOTO 60
    D=450.-2.*P
    S=A-90.
 60 CONTINUE
    IF(FLAG.NE.111)GOTO 70
    D=2.*P-90.
    S=90.-A
 70 CONTINUE
    IF(FLAG.NE.212)GOTO 80
    D=270.-2.*P
    S=90.-A
 80 CONTINUE
    IF(FLAG.NE.322)GOTO 90
    D=450.-2.*P
    S=A-90.
 90 CONTINUE
    IF(FLAG.NE.421)GOTO 100
    D=2.*P-90.
    S=A-90.
100 CONTINUE
    IF(FLAG.NE.112)GOTO 110
    D=270.-2.*P
    S=90.-A
110 CONTINUE
    IF(FLAG.NE.211)GOTO 120
    D=2.*P+90.
    S=90.-A
120 CONTINUE
    IF(FLAG.NE.311)GOTO 130
    D=2.*P+90.
    S=90.-A
130 CONTINUE
    IF(FLAG.NE.412)GOTO 140
    D=630.-2.*P
    S=90.-A
140 CONTINUE
    IF(FLAG.NE.121)GOTO 150
    D=2.*P+270.
    S=A-90.
150 CONTINUE
    IF(FLAG.NE.222)GOTO 160
    D=450.-2.*P
    S=A-90.
160 CONTINUE
    IF(D.EQ.0.0.AND.S.EQ.0.0)TYPE 170
    IF(D.EQ.0.0.AND.S.EQ.0.0)STOP
170 FORMAT(/,1X,'*PROBABLE ELLIPSOMETER ANGLE CONVERSION ERROR IN
   C SUBROUTINE "PSIDEL" DETECTED;',/,' EXECUTION TERMINATED*')
    GOTO 1180
```

```
 180 CONTINUE
     IF(ANGOPT.NE.1)GOTO 1180
     IF(FLAG.NE.121)GOTO 1010
     D=90.-2.*P
     S=180.-A
1010 CONTINUE
     IF(FLAG.NE.222)GOTO 1020
     D=2.*P-90.
     S=180.-A
1020 CONTINUE
     IF(FLAG.NE.311)GOTO 1030
     D=270.-2.*P
     S=A
1030 CONTINUE
     IF(FLAG.NE.412)GOTO 1040
     D=2.*P-270.
     S=A
1040 CONTINUE
     IF(FLAG.NE.112)GOTO 1050
     D=90.+2.*P
     S=A
1050 CONTINUE
     IF(FLAG.NE.211)GOTO 1060
     D=270.-2.*P
     S=A
1060 CONTINUE
     IF(FLAG.NE.322)GOTO 1070
     D=2.*P-90.
     S=180.-A
1070 CONTINUE
     IF(FLAG.NE.421)GOTO 1080
     D=450.-2.*P
     S=180.-A
1080 CONTINUE
     IF(FLAG.NE.111)GOTO 1090
     D=270.-2.*P
     S=A
1090 CONTINUE
     IF(FLAG.NE.212)GOTO 1100
     D=2.*P+90.
     S=A
1100 CONTINUE
     IF(FLAG.NE.321)GOTO 1110
     D=450.-2.*P
     S=180.-A
1110 CONTINUE
     IF(FLAG.NE.422)GOTO 1120
     D=2.*P-90.
     S=180.-A
1120 CONTINUE
     IF(FLAG.NE.122)GOTO 1130
     D=2.*P+270.
     S=180.-A
```

```
1130 CONTINUE
     IF(FLAG.NE.221)GOTO 1140
     D=450.-2.*P
     S=180.-A
1140 CONTINUE
     IF(FLAG.NE.312)GOTO 1150
     D=2.*P+90.
     S=A
1150 CONTINUE
     IF(FLAG.NE.411)GOTO 1160
     D=630.-2.*P
     S=A
1160 CONTINUE
     IF(D.EQ.0.0.AND.S.EQ.0.0)TYPE 170
     IF(D.EQ.0.0.AND.S.EQ.0.0)STOP
1180 CONTINUE
     IF(ANGOPT.EQ.1.OR.ANGOPT.EQ.2)GOTO 2010
     TYPE 2000
2000 FORMAT(/,1X,'*INCORRECT OPTION CODE SPECIFIED IN SUBROUTINE
    C "PSIDEL" SO EXECUTION WAS TERMINATED*')
2010 CONTINUE
     RETURN
     END
```

```
      PROGRAM PLOTER
C***********************************************************************
C     THE PURPOSE OF "PLOTER" IS TO ACCESS SUBROUTINE "PLOT" AND THE
C     DATA FILE "PLTDAT.DAT" SO THAT THE DATA CAN BE PLOTTED ON THE
C     VT-55 SCREEN.  A HARD COPY OF THE DATA IN THAT FILE CAN ALSO
C     BE OBTAINED THROUGH EXECUTION OF PLOTER.
C***********************************************************************
      COMMON/DATPLT/TIME(512),PLTDAT(512,7),NDATA
      DIMENSION ID(20)
      TYPE 1
    1 FORMAT(/'$ LOAD DISK WITH DATA TO BE PLOTTED INTO DISK DRIVE
     C "DY1:" AND "RETURN".')
      ACCEPT 2,NWAIT
    2 FORMAT(I1)
      OPEN(UNIT=1,NAME='DY1:PLTDAT.DAT',TYPE='OLD')
      TYPE 3
    3 FORMAT(/,'$ AT WHAT INDEX IS THE READING TO BE STARTED (I5)? ')
      ACCEPT 4,NSTART
    4 FORMAT(I5)
      TYPE 5
    5 FORMAT(/,'$ HOW MANY DATA POINTS ARE TO BE READ (I5)? ')
      ACCEPT 6,NDATA
    6 FORMAT(I5)
      TYPE 7
    7 FORMAT(/,'$ WOULD YOU LIKE A "HARDCOPY" OF DATA TO BE
     C PLOTTED (Y/N)?')
      ACCEPT 8,IHDCPY
    8 FORMAT(1A)
      READ(1,9)(ID(I),I=1,20)
    9 FORMAT(/,5X,20A2)
      IF(IHDCPY.NE.1HY)GOTO 1000
      PRINT   9,(ID(I),I=1,20)
 1000 CONTINUE
      IF(NSTART.EQ.1)GOTO 1500
      DO 100 I=1,NSTART-1
  100 READ(1,10)TIME(I),(PLTDAT(I,J),J=1,7)
   10 FORMAT(1X,F9.0,7(1X,F9.3))
 1500 CONTINUE
      DO 200 I=1,NDATA
      READ(1,10)TIME(I),(PLTDAT(I,J),J=1,7)
      IF(IHDCPY.NE.1HY)GOTO 2000
      PRINT  10,TIME(I),(PLTDAT(I,J),J=1,7)
 2000 CONTINUE
  200 CONTINUE
      CALL PLOT
      STOP
      END
```

```
      SUBROUTINE PLOT
C***********************************************************************
C     THIS IS A GENERAL PURPOSE PLOTTING ROUTINE WRITTEN FOR THE VT55
C     GRAPHICS TERMINAL.
C***********************************************************************
      COMMON/STATUS/ISTAT(16)
      DIMENSION ALPHA(512)
      DIMENSION IX(512),IY(235)
      COMMON/DATPLT/TIME(512),PLTDAT(512,7),NDATA
      LOGICAL*1 IYLABL(24)
C***********************************************************************
C     INITIALIZATION OF STATUS WORDS FOR THE "PLOT55" SUBROUTINE.
C***********************************************************************
      IFLAG=0
      DO 1000 I=1,16
 1000 ISTAT(I)=0
      CALL WIPE01
      MAXDAT=NDATA
      DO 1100 I=1,MAXDAT
 1100 ALPHA(I)=TIME(I)
C***********************************************************************
C     THE OPERATOR IS CONSULTED TO DETERMINE EXACTLY WHAT GRAPHICS ARE
C     WANTED.  THERE ARE TWO TYPES OF PLOTS AVAILABLE: (1) CHANNEL VS
C     CHANNEL, OR (2) CHANNEL VS TIME.  CHANNELS FOR THE "TRNSLT" MAIN
C     PROGRAM HAVE BEEN ASSIGNED AS:
C          CH1 = POLARIZER       (DEGREES)
C          CH2 = ANALYZER        (DEGREES)
C          CH3 = CELL POTENTIAL  (MV)
C          CH4 = CELL CURRENT    (MA)
C          CH5 = MEASURED DELTA  (DEGREES)
C          CH6 = MEASURED PSI    (DEGREES)
C     ALTERNATIVELY, THE MAIN PROGRAM "FLMFIT" ASSIGNS CHANNELS FOR
C     THE PLOTTING ROUTINE AS:
C          CH1 = FILM THICKNESS  (ANGSTROMS)
C          CH2 = COMPOSITE ERROR (DEGREES)
C          CH3 = CELL POTENTIAL  (MV)
C          CH4 = CELL CURRENT    (MA)
C          CH5 = CALCULATED DELTA(DEGREES)
C          CH6 = CALCULATED PSI  (DEGREES)
C***********************************************************************
      TYPE 41
   41 FORMAT(/'$ ARE ANY CHANNEL-CHANNEL PLOTS WANTED (Y/N)?  ')
      ACCEPT 42,MANYCC
   42 FORMAT(1A)
      IF(MANYCC.EQ.1HY)GOTO 1500
      GOTO 315
 1600 IFLAG=1
      DO 1200 I=1,MAXDAT
 1200 TIME(I)=ALPHA(I)
      TYPE 43
   43 FORMAT(/,2X,'THE X-AXIS NOW CORRESPONDS TO TIME.')
      GOTO 1700
```

```
 1500 TYPE 50
   50 FORMAT(/'$ WHAT CHANNEL CORRESPONDS TO THE X-AXIS?  ')
      ACCEPT 60,NCHX
   60 FORMAT(I2)
 1700 TYPE 70
   70 FORMAT(/'$ WHAT CHANNEL CORRESPONDS TO THE Y-AXIS?  ')
      ACCEPT 80,NCHY
   80 FORMAT(I2)
      TYPE 90
   90 FORMAT(/'$ AT WHAT DATA INDEX SHOULD THE PLOT BE STARTED?  ')
      ACCEPT 100,NMIN
  100 FORMAT(I4)
      NMIN=NMIN-1
  109 TYPE 110
  110 FORMAT(/'$ HOW MANY POINTS ARE TO BE PLOTTED?  ')
      ACCEPT 120,NMAX
  120 FORMAT(I4)
      IF(NMAX.GT.512)GOTO 109
      TYPE 130
  130 FORMAT(/'$ WHAT IS THE X-OFFSET?  ')
      ACCEPT 140,XOFFST
  140 FORMAT(F10.0)
      TYPE 150
  150 FORMAT(/'$ WHAT IS THE Y-OFFSET?  ')
      ACCEPT 160,YOFFST
  160 FORMAT(F10.0)
      TYPE 170
  170 FORMAT(/'$ WHAT IS THE NORMALIZATION FACTOR FOR X-VALUES?  ')
      ACCEPT 180,XNORM
  180 FORMAT(F10.0)
      TYPE 190
  190 FORMAT(/'$ WHAT IS THE NORMALIZATION FACTOR FOR Y-VALUES?  ')
      ACCEPT 191,YNORM
  191 FORMAT(F10.0)
      TYPE 192
  192 FORMAT(/'$ ARE THE SCALES OF THE AXES TO BE PRINTED (Y/N)? ')
      ACCEPT 193,IORIGN
  193 FORMAT(A1)
C*************************************************************************
C     NORMALIZATION OF THE DATA TO FIT IT ONTO THE CRT SCREEN.
C*************************************************************************
      X0=-XOFFST*50.
      Y0=-YOFFST*50.
      XDIV=50.*XNORM
      YDIV=50.*YNORM
      DO 210 I=1,NMAX
      IF(IFLAG.NE.0)GOTO 201
      IX(I)=(XOFFST+PLTDAT(I+NMIN,NCHX))/XNORM
      GOTO 202
  201 IX(I)=(XOFFST+TIME(I+NMIN))/XNORM
  202 IY(I)=(YOFFST+PLTDAT(I+NMIN,NCHY))/YNORM
  210 TYPE 220,IX(I),IY(I)
  220 FORMAT(2(15X,10I))
      TYPE 240
  240 FORMAT(/'$ ARE DATA POINTS TO BE CONNECTED BY LINES (Y/N)?  ')
      ACCEPT 250,ILINE
  250 FORMAT(A1)
```

```
C***********************************************************************
C     THIS SERIES OF SUBROUTINES CREATES THE GRAPH DESIRED, USING
C     VARIATIONS OF "PLOT55".  THE SUBROUTINE FUNCTIONS ARE:
C          "GRAF01" - PLOTS DATA POINTS ON SCREEN
C          "LINE01" - DRAWS LINES (INTERPOLATES) BETWEEN POINTS
C          "LABEL " - LABELS AXES (NOT USED CURRENTLY)
C          "WIPE01" - CLEARS THE CRT SCREEN
C          "GRID01" - PRODUCES A RECTANGULAR GRID AS BACKGROUND FOR THE
C                     GRAPHS PLOTTED
C          "PLOT55" - SOFTWARE "HEART" OF THE VT55 GRAPHICS............
C                     COMMERCIAL SOFTWARE ONLY AVAILABLE AS AN OBJECTIVE
C                     SUBROUTINE FOR LINKING
C***********************************************************************
      DO 1800 I=1,16
 1800 ISTAT(I)=0
      CALL WIPE01
      CALL PLOT55(2,1+2+4+32+64+512,,ISTAT)
      CALL GRID01
      CALL LABEL('','')
      IF(IORIGN.NE.1HY)GOTO 1920
      TYPE 1900,X0,Y0
 1900 FORMAT(40X,'GRAPH ORIGIN:   X = ',F8.2,'  Y = ',F8.2)
      TYPE 1910,XDIV,YDIV
 1910 FORMAT(40X,'SCALE DIVISION: X = ',F8.2,'  Y = ',F8.2)
 1920 CONTINUE
      CALL GRAF01(NMAX,IX,IY)
      IF(ILINE.NE.1HY)GOTO 2000
      CALL LINE01(NMAX,IX,IY)
 2000 READ(5,2010) KR
 2010 FORMAT(I2)
      DO 3000 I=1,16
 3000 ISTAT(I)=0
      CALL WIPE01
      IF(IFLAG.EQ.1)GOTO 3400
      TYPE 300
  300 FORMAT(/'$ ARE MORE CHANNEL-CHANNEL PLOTS WANTED (Y/N)?  ')
      ACCEPT 310,MORPLOT
  310 FORMAT(A1)
      CALL WIPE01
 3400 CONTINUE
      IF(IFLAG.EQ.1)GOTO 3500
      IF(MORPLOT.EQ.1HY)GOTO 1500
 3500 DO 4000 I=1,16
 4000 ISTAT(I)=0
      CALL WIPE01
  315 TYPE 320
  320 FORMAT(/'$ IS A TIME-CHANNEL PLOT WANTED (Y/N)?  ')
      ACCEPT 330,MORTCP
  330 FORMAT(A1)
      IF(MORTCP.EQ.1HY)GOTO 1600
      RETURN
      END
```

```
      SUBROUTINE GRAF01(NMAX,IX,IY)
      DIMENSION IX(512),IY(235)
      COMMON/STATUS/ISTAT(16)
      CALL PLOT55(7,0,0,ISTAT)
      CALL PLOT55(1,0,,ISTAT)
      DO 1 I=1,NMAX
      MX0=IX(I)
      MY0=IY(I)
    1 CALL PLOT55(3,MX0,MY0,ISTAT)
      RETURN
      END
      SUBROUTINE LINE01(NMAX,IX,IY)
      DIMENSION IX(512),IY(235)
      COMMON/STATUS/ISTAT(16)
      DO 1 I=2,NMAX
      LOX=IX(I-1)
      LOY=IY(I-1)
      LFX=IX(I)
      LFY=IY(I)
      CALL PLOT55(7,LOX,LOY,ISTAT)
    1 CALL PLOT55(8,LFX,LFY,ISTAT)
      RETURN
      END
      SUBROUTINE LABEL(IXLABL,IYLABL)
      COMMON/STATUS/ISTAT(16)
      LOGICAL*1 IYLABL(24)
      CALL PLOT55(9,0,23,ISTAT)
      CALL PLOT55(12,,IXLABL,ISTAT)
      DO 3 I=1,24
      IF(IYLABL(I).EQ.0)GOTO 4
      CALL PLOT55(9,0,I-1,ISTAT)
    3 CALL PLOT55(12,1,IYLABL(I),ISTAT)
    4 CALL PLOT55(9,0,23,ISTAT)
      CALL PLOT55(13,91,,ISTAT)
      CALL PLOT55(13,92,,ISTAT)
      RETURN
      END
      SUBROUTINE WIPE01
      COMMON/STATUS/ISTAT(16)
      CALL PLOT55(13,72,,ISTAT)
      CALL PLOT55(13,74,,ISTAT)
      CALL PLOT55(2,1+512,,ISTAT)
      RETURN
      END
      SUBROUTINE GRID01
      COMMON/STATUS/ISTAT(16)
      CALL PLOT55(5,0,1,ISTAT)
      DO 1 I=50,500,50
    1 CALL PLOT55(5,I,1,ISTAT)
      DO 2 I=50,200,50
    2 CALL PLOT55(4,1,I,ISTAT)
      RETURN
      END
```

Appendix 9.

Input Data File TRNSLT.DAT

```
39 Free blocks   ......end of directory

.TYPE TRNSLT.*   ......to view all data files on DY1: called TRNSLT
 Files copied:
DK:TRNSLT.514  to TT:  .......stored data file TRNSLT.514 with Verdet coefficients
           2.0              for a wavelength of 514.5 nm
          17.00    125.00     10.00     10.00    135.00      0.00
       0.010466  0.010466  0.000000  0.000000         3         3
              1         4         2

DK:TRNSLT.555  to TT:  .......stored data file TRNSLT.555 with Verdet coefficients
           2.0              for a wavelength of 555.0 nm
          17.00    125.00     10.00     10.00    135.00      0.00
       0.008705  0.008705  0.000000  0.000000         3         3
              1         4         2

DK:TRNSLT.DAT  to TT: ........stored data file TRNSLT.DAT actually read by TRNSLT.SAV
           2.0
          17.00    125.00     10.00     10.00    135.00      0.00
       0.010466  0.010466  0.000000  0.000000         3         3
              1         4         2
```

Appendix 10.

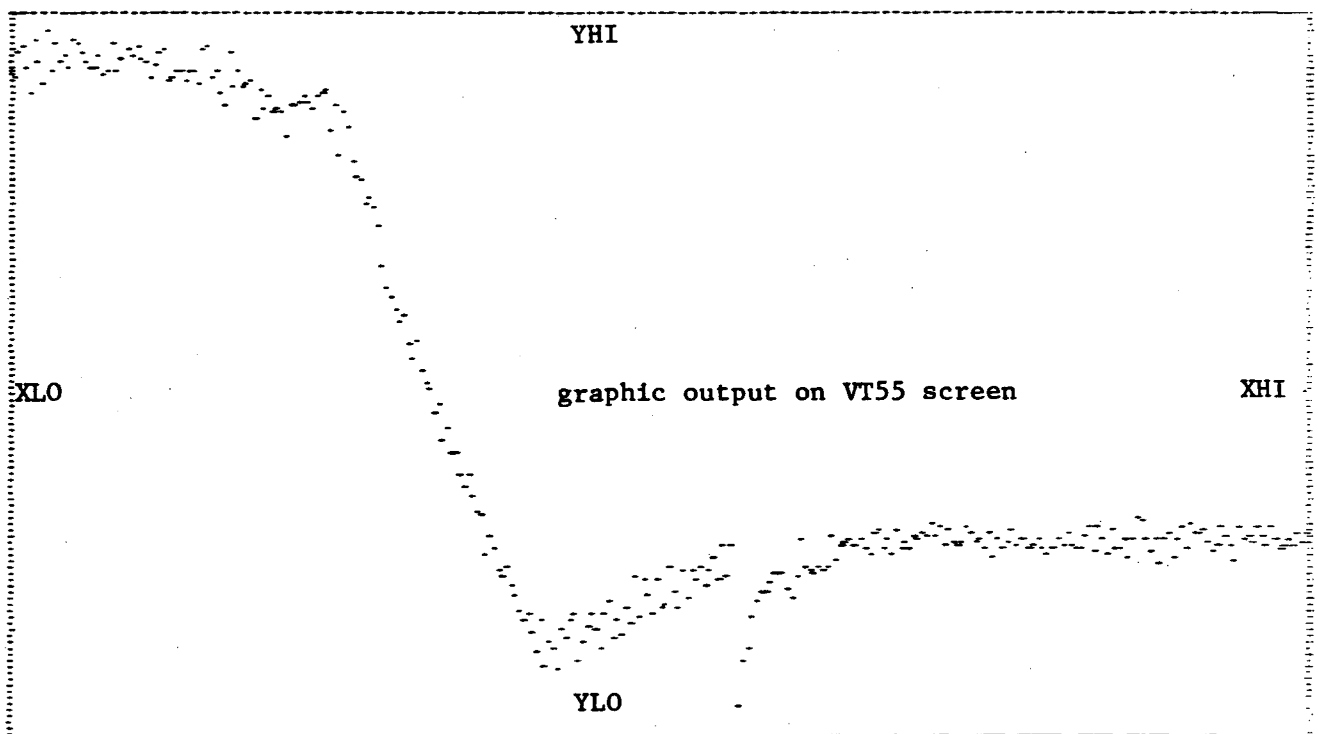
Output Data File PLTDAT.DAT

```
.TYPE PLTDAT.DAT

  PB ON AU - 10RHDD-B - -0.6V DC
    29.     31.464   131.248  -202.637     -0.610     27.072     41.248     0.000
    59.     31.380   130.966  -202.637     -0.305     27.239     40.966     0.000
    89.     31.684   131.238  -202.637      0.000     26.632     41.238     0.000
   119.     31.757   131.416  -202.637      0.000     26.486     41.416     0.000
   149.     31.516   131.091  -202.637      0.000     26.967     41.091     0.000
   179.     31.181   130.756  -202.026      0.000     27.637     40.756     0.000
   209.     31.830   131.363  -202.637      0.000     26.339     41.363     0.000
   239.     31.558   131.133  -202.026     -1.221     26.884     41.133     0.000
   269.     31.307   131.070  -202.637      0.610     27.386     41.070     0.000
   299.     31.977   131.615  -202.637      0.000     26.046     41.615     0.000
   329.     31.454   131.144  -202.637      0.610     27.093     41.144     0.000
   359.     31.809   131.405  -202.026     -0.305     26.381     41.405     0.000
   389.     31.558   131.342  -202.637      0.000     26.884     41.342     0.000
   419.     31.642   131.164  -202.637      0.000     26.716     41.164     0.000
   449.     31.506   131.269  -202.637     -0.305     26.988     41.269     0.000
   479.     31.851   131.353  -202.637     -1.221     26.297     41.353     0.000
   509.     31.809   131.374  -202.637      0.000     26.381     41.374     0.000
   539.     31.684   131.206  -202.637      0.000     26.632     41.206     0.000
   569.     31.569   131.133  -202.637      0.305     26.863     41.133     0.000
   599.     31.506   131.133  -202.637      0.916     26.988     41.133     0.000


   629.     31.485   130.997  -202.026     -0.916     27.030     40.997     0.000
   659.     31.652   131.070  -202.637      0.610     26.695     41.070     0.000
   689.     31.412   130.955  -202.637      0.000     27.177     40.955     0.000
   719.     31.454   131.039  -202.637     -0.610     27.093     41.039     0.000
   749.     31.799   131.290  -202.637     -0.610     26.402     41.290     0.000
   779.     31.474   131.290  -202.637     -0.305     27.051     41.290     0.000
   809.     31.631   131.018  -202.026     -0.916     26.737     41.018     0.000
   839.     32.176   131.803  -191.650     -1.526     25.649     41.803     0.000
   869.     31.715   131.196  -178.833     -0.610     26.570     41.196     0.000
   899.     31.663   130.997  -164.795      0.305     26.674     40.997     0.000
   929.     31.768   131.573  -151.978      0.610     26.465     41.573     0.000
   959.     31.621   131.363  -138.550     -0.610     26.758     41.363     0.000
   989.     31.579   131.301  -125.122     -0.610     26.842     41.301     0.000
  1019.     31.401   131.007  -112.305      0.000     27.198     41.007     0.000
  1049.     31.548   130.819   -99.487      0.000     26.905     40.819     0.000
  1079.     31.705   131.206   -86.670     -1.221     26.591     41.206     0.000
  1109.     31.736   131.384   -73.853     -0.305     26.528     41.384     0.000
  1139.     31.359   131.112   -59.814     -1.526     27.281     41.112     0.000
  1169.     31.380   131.164   -46.387     -1.221     27.239     41.164     0.000
  1199.     31.464   131.531   -33.569     -0.916     27.072     41.531     0.000
  1229.     31.474   131.144   -19.531     -1.526     27.051     41.144     0.000
  1259.     31.349   130.913    -6.714     -2.441     27.302     40.913     0.000
  1289.     31.464   131.175     5.493     -0.610     27.072     41.175     0.000
  1319.     31.464   131.217    18.921     -2.136     27.072     41.217     0.000
```

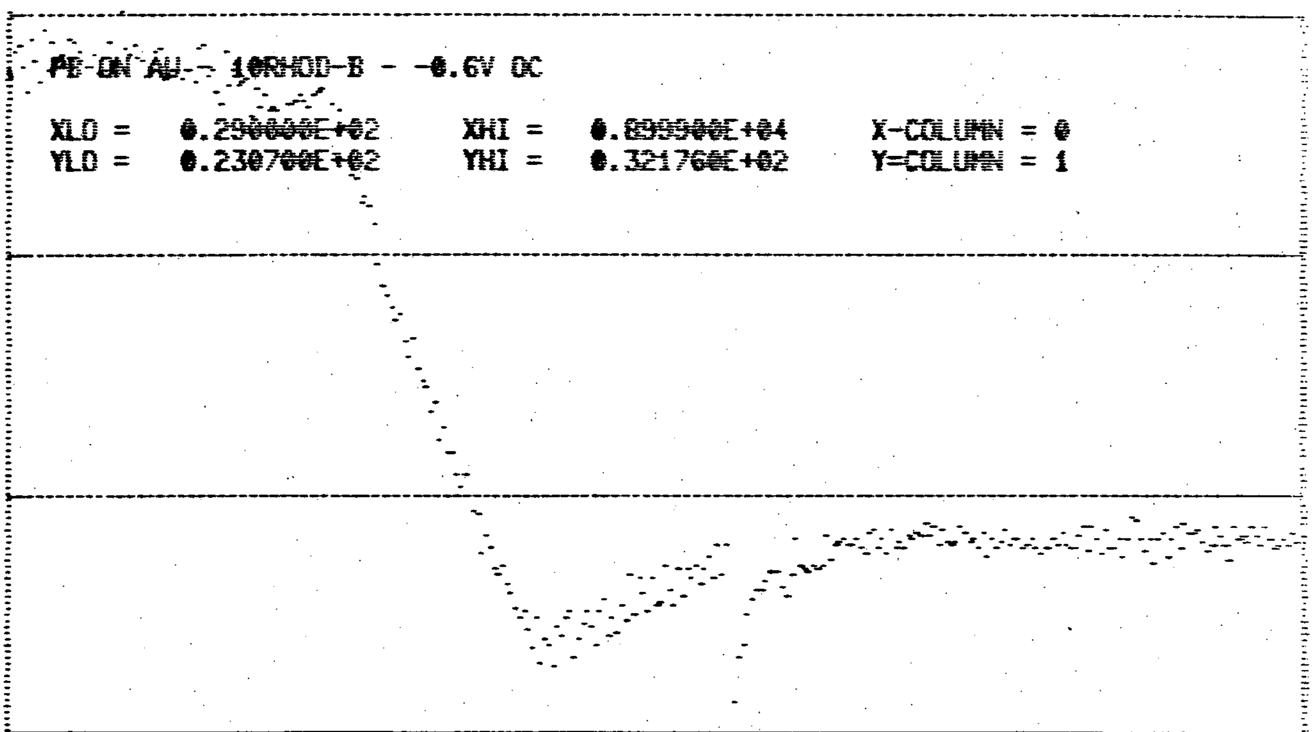
Appendix 11.

Demonstration of PLOT01 - plotting data file PLTDAT.DAT

```
39 Free blocks ...........end of directory after DIR command

.RUN DY0:PLOT01 ...........running plotting program PLOT01

LOAD DISK WITH DATA TO BE PLOTTED INTO DISK DRIVE "DY1:" AND "RETURN".

AT WHAT INDEX IS THE READING TO BE STARTED (I5)? 1

HOW MANY DATA POINTS ARE TO BE READ (I5)? 300

X-COLUMN = 0

Y-COLUMN = 1

   XLO =    0.290000E+02     XHI =    0.899900E+04     X-COLUMN = 0
   YLO =    0.230700E+02     YHI =    0.321760E+02     Y=COLUMN = 1

DO YOU WANT TO CHANGE THESE(Y/N)? N

IS THE GRAPH TO BE LABELED(Y/N)? N

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE X-AXIS? 1

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE Y-AXIS? 1
```



```
MORE PLOTS(Y/N)? Y

X-COLUMN = 0

Y-COLUMN = 1

   XLO =    0.290000E+02     XHI =    0.899900E+04     X-COLUMN = 0
   YLO =    0.230700E+02     YHI =    0.321760E+02     Y=COLUMN = 1

DO YOU WANT TO CHANGE THESE(Y/N)? N

IS THE GRAPH TO BE LABELED(Y/N)? Y

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE X-AXIS? 1

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE Y-AXIS? 3
```



Appendix 11 (continued).

Listing of PLOT01

```
      PROGRAM PLOT01
C***********************************************************************
C     THE PURPOSE OF "PLOT01" IS TO ACCESS SUBROUTINE "PLOT" AND THE
C     DATA FILE "PLTDAT.DAT" SO THAT THE DATA CAN BE PLOTTED ON THE
C     VT-55 SCREEN.  A HARD COPY OF THE DATA IN THAT FILE CAN ALSO
C     BE OBTAINED THROUGH EXECUTION OF PLOTER.
C***********************************************************************
      DIMENSION Z(512,8)
      COMMON/ARRAY/ID(20),IX,IY,INDEX,X(512),Y(512)
      COMMON/LIMITS/ILIMX,ILIMY,IGRIDX,IGRIDY,IDELX,IDELY
      COMMON/STATUS/ISTAT(16)
      TYPE 1
    1 FORMAT(/'$ LOAD DISK WITH DATA TO BE PLOTTED INTO DISK DRIVE
     C "DY1:" AND "RETURN".')
      ACCEPT 2,NWAIT
    2 FORMAT(I1)
      OPEN(UNIT=1,NAME='DY1:PLTDAT.DAT',TYPE='OLD')
      TYPE 3
    3 FORMAT(/,'$ AT WHAT INDEX IS THE READING TO BE STARTED (I5)? ')
      ACCEPT 4,NSTART
    4 FORMAT(I5)
      TYPE 5
    5 FORMAT(/,'$ HOW MANY DATA POINTS ARE TO BE READ (I5)? ')
      ACCEPT 6,NDATA
    6 FORMAT(I5)
      INDEX=NDATA
      READ(1,8)(ID(I),I=1,20)
    8 FORMAT(/,5X,20A2)
      IF(NSTART.EQ.1)GOTO 1000
      DO 100 I=1,NSTART-1
  100 READ(1,10)(Z(I,J),J=1,8)
   10 FORMAT(1X,F9.0,7(1X,F9.3))
 1000 CONTINUE
      DO 200 I=1,NDATA
      READ(1,10)(Z(I,J),J=1,8)
  200 CONTINUE
 2000 CONTINUE
      TYPE 11
   11 FORMAT(/,'$ X-COLUMN = ')
      ACCEPT 2,IX
      IX=IX+1
      TYPE 12
   12 FORMAT(/,'$ Y-COLUMN = ')
      ACCEPT 2,IY
      IY=IY+1
      DO 300 I=1,NDATA
      X(I)=Z(I,IX)
  300 Y(I)=Z(I,IY)
      CALL SUBPLT
      TYPE 13
   13 FORMAT(/,'$ MORE PLOTS(Y/N)? ')
      ACCEPT 14,MORPLT
   14 FORMAT(A1)
      IF(MORPLT.EQ.1HY)GOTO 2000
      STOP
      END
```

```
      SUBROUTINE SUBPLT
      COMMON/ARRAY/ID(20),IX,IY,INDEX,X(512),Y(512)
      COMMON/LIMITS/ILIMX,ILIMY,IGRIDX,IGRIDY,IDELX,IDELY
      COMMON/STATUS/ISTAT(16)
      XLO=X(1)
      XHI=X(1)
      YLO=Y(1)
      YHI=Y(1)
      IX=IX-1
      IY=IY-1
      DO 10 I=2,INDEX
      IF(XLO.GT.X(I))XLO=X(I)
      IF(XHI.LT.X(I))XHI=X(I)
      IF(YLO.GT.Y(I))YLO=Y(I)
      IF(YHI.LT.Y(I))YHI=Y(I)
   10 CONTINUE
      TYPE 1000,XLO,XHI,IX,YLO,YHI,IY
 1000 FORMAT(/,5X,'XLO = ',E14.6,5X,'XHI = ',E14.6,5X,'X-COLUMN = ',I1,
     1       /,5X,'YLO = ',E14.6,5X,'YHI = ',E14.6,5X,'Y=COLUMN = ',I1)
   20 TYPE 1001
 1001 FORMAT(/,'$ DO YOU WANT TO CHANGE THESE(Y/N)? ')
      ACCEPT 1002,IF1
 1002 FORMAT(A1)
      IF(IF1.NE.1HY.AND.IF1.NE.1HN)GOTO 20
      IF(IF1.EQ.1HN)GOTO 30
      TYPE 1003
 1003 FORMAT(/,'$ XLO = ')
      ACCEPT 1004,XLO
 1004 FORMAT(F10.3)
      TYPE 1005
 1005 FORMAT(/,'$ XHI = ')
      ACCEPT 1004,XHI
      TYPE 1006
 1006 FORMAT(/,'$ YLO = ')
      ACCEPT 1004,YLO
      TYPE 1007
 1007 FORMAT(/,'$ YHI = ')
      ACCEPT 1004,YHI
   30 TYPE 1008
 1008 FORMAT(/,'$ IS THE GRAPH TO BE LABELED(Y/N)? ')
      ACCEPT 1002,IF2
      IF(IF2.NE.1HY.AND.IF2.NE.1HN)GOTO 30
```

```
      DO 40 I=1,INDEX
      X(I)=(X(I)-XLO)/(XHI-XLO)
   40 Y(I)=(Y(I)-YLO)/(YHI-YLO)
      TYPE 1009
 1009 FORMAT(/,'$ HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE
     1 X-AXIS? ')
      ACCEPT 1010,IGRIDX
 1010 FORMAT(I2)
      TYPE 1011
 1011 FORMAT(/,'$ HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE
     1 Y-AXIS? ')
      ACCEPT 1010,IGRIDY
      CALL WIPE
      CALL PLOT55(2,2+4+32+64,,ISTAT)
      ILIMX=511
      ILIMY=235
      IDELX=ILIMX/IGRIDX
      IDELY=ILIMY/IGRIDY
      CALL GRID
      M=INDEX/2
      DO 50 I=1,M
      I1=(I-1)*2+1
      MX=X(I1)*ILIMX
      MY=Y(I1)*ILIMY
      CALL PLOT55(1,0,,ISTAT)
      CALL PLOT55(3,MX,MY,ISTAT)
      I2=I*2
      MX=X(I2)*ILIMX
      MY=Y(I2)*ILIMY
      CALL PLOT55(2,0,,ISTAT)
      CALL PLOT55(3,MX,MY,ISTAT)
   50 CONTINUE
      IF(IF2.NE.1HY)GOTO 60
      TYPE 1012,(ID(I),I=1,20)
 1012 FORMAT(/,5X,20A2)
      TYPE 1000,XLO,XHI,IX,YLO,YHI,IY
   60 CONTINUE
      ACCEPT 1013,IWAIT
 1013 FORMAT(A1)
      CALL WIPE
      RETURN
      END
```

```
      SUBROUTINE WIPE
      COMMON/STATUS/ISTAT(16)
      DO 1 I=1,16
    1 ISTAT(I)=0
      CALL PLOT55(13,72,,ISTAT)
      CALL PLOT55(13,74,,ISTAT)
      CALL PLOT55(2,1+512,,ISTAT)
      RETURN
      END

      SUBROUTINE GRID
      COMMON/STATUS/ISTAT(16)
      COMMON/LIMITS/ILIMX,ILIMY,IGRIDX,IGRIDY,IDELX,IDELY
      CALL PLOT55(5,0,1,ISTAT)
      CALL PLOT55(4,1,0,ISTAT)
      DO 1 I=IDELX,ILIMX,IDELX
    1 CALL PLOT55(5,I,1,ISTAT)
      DO 2 I=IDELY,ILIMY,IDELY
    2 CALL PLOT55(4,1,I,ISTAT)
      RETURN
      END
```

Appendix 12.

Directory of Working Disk DY0:

```
.DIR DY0:
 19-Jan-83
SWAP  .SYS    24 11-Mar-78        DYMNSJ.SYS    63 11-Mar-78
TT    .SYS     2 11-Mar-78        PIP   .SAV    16 11-Mar-78
LIBR  .SAV    18 11-Mar-78        DIR   .SAV    17 11-Mar-78
BATCH .SAV    26 11-Mar-78        FILEX .SAV    18 11-Mar-78
SRCCOM.SAV    11 11-Mar-78        DUMP  .SAV     7 11-Mar-78
PAT   .SAV     7 11-Mar-78        RESORC.SAV    12 11-Mar-78
FORMAT.SAV     6 11-Mar-78        PATCH .SAV     9 11-Mar-78
DUP   .SAV    21 29-Mar-79        NL    .SYS     2 11-Mar-78
BA    .SYS     7 11-Mar-78        EDIT  .SAV    19 11-Mar-78
CREF  .SAV     6 11-Mar-78        DXMNSJ.SYS    63 11-Mar-78
STARTS.COM     1 16-Apr-81        EDR002.SAV    32 13-Feb-81
DECOD2.SAV    25 13-Feb-81        TRNSLT.SAV    94 13-Feb-81
PLOT01.SAV    69 30-Sep-81        SCAN  .SAV    18 13-Feb-81
RECALL.SAV    83 27-May-82**      SEV002.SAV    86 23-Oct-81**
RISURF.SAV    80 16-Apr-81**      MINUS .SAV    40 17-Jun-81**
WLBOND.NEW     1 28-Oct-81        WLCONT.OLD     1 10-Apr-81
DSCONV.SAV    90 27-May-82**
 33 Files, 974 Blocks
 0 Free blocks
```

**programs for data acquisition with automatic ellipsometer functioning as a spectroscopic ellipsometer; related data reduction programs

SEV002 - data collection
RECALL - recalling stored spectroscopic ellipsometer data for plotting and output
RISURF - conversion of spectroscopic data file created by DSCONV to refractive indices
MINUS - subtration of one data file from another to generate "difference spectra"
DSCONV - conversion of spectroscopic data file generated by SEV002 to delta and psi

Appendix 12 (continued).

Directory of Spectral Scanning Programs Disk A

```
 21-Nov-82
NEWSET.FOR      5  07-Apr-81     RESET .FOR      7  07-Apr-81
INOUT .FOR     13  07-Apr-81     P1INFO.FOR      6  07-Apr-81
T1INFO.FOR      6  07-Apr-81     P1TIME.FOR      2  07-Apr-81
T1TIME.FOR      2  07-Apr-81     FCSET1.FOR      7  07-Apr-81
FCPRNT.FOR      6  07-Apr-81     FCTYPE.FOR      6  07-Apr-81
FCIO  .FOR     13  07-Apr-81     DELPSI.FOR      9  07-Apr-81
WLTEST.FOR      1  07-Apr-81     FCCAL .FOR      5  07-Apr-81
WLCALC.FOR      6  10-Apr-81     SEV001.FOR     27  11-Apr-81
RISURF.FOR     12  11-Apr-81     PLOT  .FOR     26  17-Jun-81
DSCONV.FOR     14  15-Apr-81     RECALL.FOR     14  16-Apr-81
FCSPEC.FOR      3  16-Apr-81     OUTPUT.FOR      7  14-Jun-81
INPUT .FOR      7  14-Jun-81     OUTFC .FOR      7  14-Jun-81
INFC  .FOR      7  14-Jun-81     FCPLOT.FOR     10  17-Jun-81
CALFC1.FOR     12  16-Jun-81     MINUS .FOR      3  17-Jun-81
SEV002.FOR     18  23-Oct-81     EDATA .FOR      3  23-Oct-81
 30 Files, 264 Blocks
 7 Free blocks
 21-Nov-82
CALFC1.DAT      5  18-Mar-81     CALFC2.DAT      5  18-Mar-81
CALFC3.DAT      5  18-Mar-81     WAVE01.DAT      5  26-Mar-81
WAVE02.DAT      5  26-Mar-81     WAVE03.DAT      5  26-Mar-81
WAVE04.DAT      5  26-Mar-81     WAVE05.DAT      5  26-Mar-81
RISURF.DAT      5  30-Mar-81     WLBOND.DAT      1  28-Oct-81
WLCONT.DAT      1  25-May-82     WLCALC.DAT      1  28-Oct-81
FARADY.DAT      9  02-Nov-81     TITLE .DAT      4  17-Jun-81
RECALL.DAT      2  13-Apr-81
 15 Files, 63 Blocks
 7 Free blocks
 21-Nov-82
DSCONV.SAV     90  15-Apr-81     RECALL.SAV     83  16-Apr-81
SEV001.SAV     87  16-Apr-81     RISURF.SAV     80  16-Apr-81
FCPLOT.SAV     83  17-Jun-81     CALFC1.SAV     89  16-Jun-81
MINUS .SAV     40  17-Jun-81     SEV002.SAV     86  23-Oct-81
 8 Files, 638 Blocks
 7 Free blocks
```

Appendix 12 (continued).

Directory of Spectral Scanning Programs Disk B

```
 21-Nov-82
NEWSET.FOR     5  07-Apr-81      RESET .FOR     7  07-Apr-81
INOUT .FOR    13  07-Apr-81      P1INFO.FOR     6  07-Apr-81
T1INFO.FOR     6  07-Apr-81      P1TIME.FOR     2  07-Apr-81
T1TIME.FOR     2  07-Apr-81      FCSET1.FOR     7  07-Apr-81
FCPRNT.FOR     6  07-Apr-81      FCTYPE.FOR     6  07-Apr-81
FCIO  .FOR    13  07-Apr-81      DELPSI.FOR     9  07-Apr-81
WLTEST.FOR     1  07-Apr-81      FCCAL .FOR     5  07-Apr-81
WLCALC.FOR     6  10-Apr-81      SEV001.FOR    27  11-Apr-81
RISURF.FOR    12  11-Apr-81      PLOT  .FOR    26  17-Jun-81
RECALL.FOR    14  16-Apr-81      FCSPEC.FOR     3  16-Apr-81
OUTPUT.FOR     7  14-Jun-81      INPUT .FOR     7  14-Jun-81
OUTFC .FOR     7  14-Jun-81      INFC  .FOR     7  14-Jun-81
FCPLOT.FOR    10  17-Jun-81      CALFC1.FOR    12  16-Jun-81
MINUS .FOR     3  17-Jun-81      EDATA .FOR     3  23-Oct-81
SEV002.FOR    18  23-Oct-81      RUNTST.FOR     2  23-Oct-81
EDATA2.FOR     3  22-Oct-81      PLOTXX.FOR     5  23-Oct-81
FCAVG1.FOR     5  02-Nov-81      FCAVG2.FOR     6  02-Nov-81
FCSMTH.FOR     4  02-Nov-81      SMOOTH.FOR     6  02-Nov-81
FCREAD.FOR     4  07-Dec-81      DSCON1.FOR    11  07-Dec-81
RISMTH.FOR     4  13-Dec-81      RIGEN1.FOR     6  13-Dec-81
RILINE.FOR     4  13-Dec-81      FILM  .FOR     3  14-Dec-81
EMASES.FOR    11  18-Jan-82      CSMSES.FOR    10  12-Jan-82
FILM02.FOR     5  20-Jan-82      CSMFIT.FOR    11  12-Jan-82
EMAFIT.FOR    12  21-Jan-82      NORMAL.FOR     4  18-Feb-82
 48 Files, 366 Blocks
 23 Free blocks
 21-Nov-82
CALFC1.DAT     5  18-Mar-81      CALFC2.DAT     5  18-Mar-81
CALFC3.DAT     5  18-Mar-81      WLCALC.DAT     1  28-Oct-81
WAVE01.DAT     5  26-Mar-81      WAVE02.DAT     5  26-Mar-81
WAVE03.DAT     5  26-Mar-81      WAVE04.DAT     5  26-Mar-81
WAVE05.DAT     5  26-Mar-81      RECALL.DAT     2  13-Apr-81
TITLE .DAT     4  17-Jun-81      FARADY.DAT     9  02-Nov-81
 12 Files, 56 Blocks
 23 Free blocks
 21-Nov-82
DSCON1.SAV    90  07-Dec-81      RISMTH.SAV    63  13-Dec-81
RIGEN1.SAV    49  13-Dec-81      EMASES.SAV    83  18-Jan-82
CSMFIT.SAV    46  12-Jan-82      CSMSES.SAV    93  12-Jan-82
EMAFIT.SAV    43  21-Jan-82      NORMAL.SAV    41  18-Feb-82
 8 Files, 508 Blocks
 23 Free blocks
```

Appendix 12 (continued).

Directory of Spectral Scanning Programs Disk C

```
 21-Nov-82
FCSMTH.FOR     4  02-Nov-81      SMOOTH.FOR     6  02-Nov-81
WLCALC.FOR     6  10-Apr-81      INFC   .FOR    7  14-Jun-81
OUTFC .FOR     7  14-Jun-81      FCAVG2.FOR     6  02-Nov-81
DSCONV.FOR    11  07-Dec-81      INPUT .FOR     7  14-Jun-81
OUTPUT.FOR     7  14-Jun-81      PLOT  .FOR    26  17-Jun-81
P1INFO.FOR     6  07-Apr-81      T1INFO.FOR     6  07-Apr-81
P1TIME.FOR     2  07-Apr-81      T1TIME.FOR     2  07-Apr-81
FCREAD.FOR     4  26-May-82      DELPSI.FOR     9  27-May-82
RECALL.FOR    14  27-May-82      FIXPCA.FOR     3  05-Jul-82
 18 Files, 133 Blocks
 138 Free blocks
 21-Nov-82
WLBOND.DAT     1  28-Oct-81      WLCONT.DAT     1  25-May-82
WLCALC.DAT     1  25-May-82      TITLE .DAT     4  17-Jun-81
 4 Files, 7 Blocks
 138 Free blocks
 21-Nov-82
FCSMTH.SAV    65  23-May-82      FCAVG2.SAV    59  25-May-82
DSCONV.SAV    90  27-May-82      RECALL.SAV    83  27-May-82
FIXPCA.SAV    37  05-Jul-82
 5 Files, 334 Blocks
 138 Free blocks
```

Appendix 12 (continued).

Directory of Spectral Scanning Programs Disk D

21-Nov-82

NEWSET.FOR	5	07-Apr-81	RESET .FOR	7	07-Apr-81
INOUT .FOR	13	07-Apr-81	P1INFO.FOR	6	07-Apr-81
T1INFO.FOR	6	07-Apr-81	P1TIME.FOR	2	07-Apr-81
T1TIME.FOR	2	07-Apr-81	FCSET1.FOR	7	07-Apr-81
FCPRNT.FOR	6	07-Apr-81	FCTYPE.FOR	6	07-Apr-81
FCIO .FOR	13	07-Apr-81	DELPSI.FOR	9	07-Apr-81
WLTEST.FOR	1	07-Apr-81	FCCAL .FOR	5	07-Apr-81
WLCALC.FOR	6	10-Apr-81	SEV001.FOR	27	11-Apr-81
RISURF.FOR	12	11-Apr-81	PLOT .FOR	26	17-Jun-81
RECALL.FOR	14	16-Apr-81	FCSPEC.FOR	3	16-Apr-81
OUTPUT.FOR	7	14-Jun-81	INPUT .FOR	7	14-Jun-81
OUTFC .FOR	7	14-Jun-81	INFC .FOR	7	14-Jun-81
FCPLOT.FOR	10	17-Jun-81	CALFC1.FOR	12	16-Jun-81
MINUS .FOR	3	17-Jun-81	EDATA .FOR	3	23-Oct-81
SEV002.FOR	18	23-Oct-81	RUNTST.FOR	2	23-Oct-81
EDATA2.FOR	3	22-Oct-81	PLOTXX.FOR	5	23-Oct-81
FCAVG1.FOR	5	02-Nov-81	FCAVG2.FOR	6	02-Nov-81
FCSMTH.FOR	4	02-Nov-81	SMOOTH.FOR	6	02-Nov-81
FCREAD.FOR	4	07-Dec-81	DSCON1.FOR	11	07-Dec-81
RISMTH.FOR	4	13-Dec-81	RIGEN1.FOR	6	13-Dec-81
RILINE.FOR	4	13-Dec-81	FILM .FOR	3	14-Dec-81
EMASES.FOR	11	18-Jan-82	CSMSES.FOR	10	12-Jan-82
FILM02.FOR	5	20-Jan-82	CSMFIT.FOR	11	12-Jan-82
EMAFIT.FOR	12	21-Jan-82	NORMAL.FOR	4	18-Feb-82
PROEMA.FOR	13	01-Sep-82	BRUGMN.FOR	19	03-Sep-82
AIFILM.FOR	3	30-May-81	AISPEC.FOR	12	01-Sep-82
DYEMTB.FOR	15	04-Sep-82	DYERI .FOR	4	04-Sep-82
SHIFT .FOR	4	05-Sep-82			

55 Files, 436 Blocks
65 Free blocks
21-Nov-82

RECALL.DAT	2	13-Apr-81	TITLE .DAT	4	17-Jun-81
FARADY.DAT	9	02-Nov-81	RHODB .DAT	5	31-Aug-82
COPPER.DAT	5	27-Jul-82	SOLN .DAT	5	27-Jul-82
WLCALC.DAT	1	25-May-82	RHODBO.DAT	5	05-Sep-82

8 Files, 36 Blocks
65 Free blocks
21-Nov-82

BRUGMN.SAV	95	03-Sep-82	AISPEC.SAV	87	01-Sep-82
DYEMTB.SAV	91	04-Sep-82	DYERI .SAV	40	04-Sep-82
SHIFT .SAV	43	05-Sep-82			

5 Files, 356 Blocks
65 Free blocks

Appendix 13.

Input Data File WLCALC.DAT

```
TEFLON.193     5 18-Jul-82     TEFLON.194     5 18-Jul-82
TEFLON.195     5 19-Jul-82     TEFLON.196     5 19-Jul-82
TEFLON.197     5 19-Jul-82     TEFLON.198     5 19-Jul-82
TEFLON.199     5 19-Jul-82     TEFLON.200     5 19-Jul-82
TEFLON.201     5 19-Jul-82     TEFLON.202     5 19-Jul-82
TEFLON.203     5 19-Jul-82     TEFLON.204     5 19-Jul-82
TEFLON.205     5 19-Jul-82     RESULT.203     5 19-Jul-82
CVPBAU.000    13 19-Jul-82     CVPBAU.001    13 19-Jul-82
CVPBAU.002    13 19-Jul-82     CVPBAU.003    13 19-Jul-82
CVPBAU.004    13 19-Jul-82     TRNSLT.DAT     1 09-Nov-81
PLTDAT.DAT    58 19-Jul-82     TEFLON.206     5 19-Jul-82
TEFLON.207     5 19-Jul-82     CVPBAU.005    13 19-Jul-82
CVPBAU.006    13 19-Jul-82     GOLD  .186     5 19-Jan-83
GOLD  .183     5 19-Jan-83     MINUS .186     5 19-Jan-83
GOLD  .188     5 19-Jan-83     MINUS .188     5 19-Jan-83
GOLD  .185     5 19-Jan-83     MINUS .185     5 19-Jan-83
 164 Files, 935 Blocks
 39 Free blocks ..............end of directory of DY1:

.TYPE WLCALC.DAT  ............display of WLCALC.DAT on VT55 screen
 121 321  18.7332  5137.13 0.9996 -18.8188  9668.07 0.9999 .....regression parameters
123456789/123456789/123456789/123456789/123456789/123456789/ ...dummy line to aid in
                                                                formatting data file
```

Appendix 14.

Input Data File TITLE.DAT

```
.TYPE TITLE.DAT
POLARIZER CURRENT(ADCU,Y-AXIS) VS ENCODER COUNT(X-AXIS)
ANALYZER CURRENT(ADCU,Y-AXIS) VS ENCODER COUNT(X-AXIS)
POLARIZER CURRENT(ADCU,Y-AXIS) VS WAVELENGTH(X-AXIS)
ANALYZER CURRENT(ADCU,Y-AXIS) VS WAVELENGTH(X-AXIS)
ANALYZER CURRENT(Y-AXIS) VS POLARIZER CURRENT(X-AXIS)
POLARIZER CURRENT
ANALYZER CURRENT
1 1.
DELTA(Y-AXIS) VS ENCODER COUNT(X-AXIS)
PSI(Y-AXIS) VS ENCODER COUNT(X-AXIS)
DELTA(Y-AXIS) VS WAVELENGTH(X-AXIS)
PSI(Y-AXIS) VS WAVELENGTH(X-AXIS)
PSI(Y-AXIS) VS DELTA(X-AXIS)
DELTA(DEGREES)
PSI(DEGREES)
2 100.
REAL REFRACTIVE INDEX(Y-AXIS) VS ENCODER COUNT(X-AXIS)
IMAG REFRACTIVE INDEX(Y-AXIS) VS ENCODER COUNT(X-AXIS)
REAL REFRACTIVE INDEX(Y-AXIS) VS WAVELENGTH(X-AXIS)
IMAG REFRACTIVE INDEX(Y-AXIS) VS WAVELENGTH(X-AXIS)
IMAG R.I.(Y-AXIS) VS REAL R.I.(X-AXIS)
REAL REFRACTIVE INDEX
IMAG REFRACTIVE INDEX


IMAG R.I.(Y-AXIS) VS REAL R.I.(X-AXIS)
REAL REFRACTIVE INDEX
IMAG REFRACTIVE INDEX
3 1000.
POL VERDET COEF(1000X, DEG/ADCU) VS ENCODER COUNT(X-AXIS)
ANA VERDET COEF(1000X, DEG/ADCU) VS ENCODER COUNT(X-AXIS)
POL VERDET COEF(1000X, DEG/ADCU) VS WAVELENGTH(X-AXIS)
ANA VERDET COEF(1000X, DEG/ADCU) VS WAVELENGTH(X-AXIS)
ANA VERDET COEF(Y-AXIS) VS POL VERDET COEF(X-AXIS)
POL VERDET COEF X1000
ANA VERDET COEF X1000
4 100.
POL CROSS-TALK PARAMETER(100X) VS ENCODER COUNT(X-AXIS)
ANA CROSS-TALK PARAMETER(100X) VS ENCODER COUNT(X-AXIS)
POL CROSS-TALK PARAMETER(100X) VS WAVELENGTH(X-AXIS)
ANA CROSS-TALK PARAMETER(100X) VS WAVELENGTH(X-AXIS)
ANA CROSS-TALK PARAMETER VS POL CROSS TALK PARAMETER(X-AXIS)
POL CROSS-TALK(X100)
ANA CROSS-TALK(X100)
5 1.
123456789/123456789/123456789/123456789/123456789/123456789/
```

Appendix 15.

Demonstration of SEV002 - collection of spectroscopic ellipsometry data

```
.RUN DY0:SEV002

DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? Y

        DIGITAL ENCODER PRESETS:

        CALIBRATION CURVE SEGMENT NUMBER 1:
             SLOPE =     10.7332
             INTERCEPT =     5137.13
             CORRELATION COEFFICIENT =      0.9996

        CALIBRATION CURVE SEGMENT NUMBER 2:
             SLOPE =    -10.8188
             INTERCEPT =     9668.07
             CORRELATION COEFFICIENT =      0.9999

        LIMITS OF APPLICATION:
             UPPER =    321
             LOWER =    121

DO YOU WANT TO CHANGE THESE(Y/N)? N

INSERT DATA STORAGE DISK, THEN "RETURN".


DO YOU WANT TO ADJUST THE SCAN RATE(Y/N)? N

STEADY SCAN RATE ESTABLISHED.  SCAN RATE =      0 .....spectral scanner not rotating

IS SETUP INFO TO BE (A)ENTERED FROM KEYBOARD OR (B)READ FROM OLD DATA FILE? B

NAME OF SPECTRA FILE TO BE RETRIEVED = DY1TEFLON183

NAME(A40) = JOSEPH COLLIN FARMER

DATE(I2-A3-I2/DAY-MONTH-YEAR) = 19-JAN-83

LAMP OPERATIONAL LIFE(I5/HOURS) = 1000

EXPERIMENT IDENTIFICATION(A40) = DEMONSTRATION OF PROGRAM "SEV002"

HAVE MANUAL AZIMUTHS BEEN CHANGED(Y/N)? N

ANALOG/DIGITAL CONVERTOR PRESET PARAMETERS: ........assumes Faraday cells monitored
 POL. INPUT CH. = 0                                 over channels 0 and 1; PMT out-
 ANA. INPUT CH. = 1                                 put can be monitored by changing
 ADC GAIN       = 3                                 input channels; only gains of 0,
                                                    1, 2, and 3 are allowed.
DO YOU WANT TO CHANGE THESE(Y/N)? N
```

```
NAME(A40) = JOSEPH COLLIN FARMER

DATE(I2-A3-I2/DAY-MONTH-YEAR) = 19-JAN-83

LAMP OPERATIONAL LIFE(I5/HOURS) = 1000

EXPERIMENT IDENTIFICATION(A40) = DEMONSTRATION OF PROGRAM "SEV002"

HAVE MANUAL AZIMUTHS BEEN CHANGED(Y/N)? N

ANALOG/DIGITAL CONVERTOR PRESET PARAMETERS:
POL. INPUT CH. = 0
ANA. INPUT CH. = 1
ADC GAIN       = 3

DO YOU WANT TO CHANGE THESE(Y/N)? N

HOW MANY SPECTRAL SCANS ARE TO BE AVERAGED(I5)? 3

IS SETUP INFORMATION TO BE OUTPUT (A)TO CRT, (B)TO PRINTER, OR (C)NOT AT ALL? C

ENTER "G" AND "RETURN" FOR SPECTRA COLLECTION. G

SPECTRA BEING COLLECTED..........
```

Listing of SEV002

```
      PROGRAM SEV002
C***********************************************************************
C     OBJECTIVE: TO COORDINATE THE ACTUAL DATA ACQUISITION DURING AN
C                ELLIPSOMETRIC SPECTRAL SCAN WITH OPERATOR REVIEW OF
C                THE RAW DATA.  THIS IS THE MAIN DATA COLLECTION
C                ROUTINE.
C
C     PROGRAM WRITTEN BY JOSEPH C. FARMER IN SPRING 1981 LBL-MMRD
C
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/O/NPASS
      COMMON/STATUS/ISTAT(16)
      COMMON/TITLE/NTITLE(5,30),NWORD(2,21)
      COMMON/MODE/MODE0,MODE1,FACTOR
      NPASS=1
C*****THE ENCODER COUNT IS CONVERTED TO WAVELENGTH.*********************
      CALL WLCALC
C*****THE GRAPHICS TITLES ARE READ FROM "DY1:TITLE.DAT".****************
      MODE0=1
      CALL TITLE
      TYPE 10
   10 FORMAT(/,'$ INSERT DATA STORAGE DISK, THEN "RETURN".')
      ACCEPT 20,NWAIT
   20 FORMAT(A1)
C*****THE FOURTH CHANNEL OF THE ADAC MODEL 1604/OPI COUNTER CARD IS ***
C     READ AT VARIOUS TIMES TO ASSURE THAT THE RATE OF ROTATION OF
C     THE FILTER DISC(SPECTRAL SCANNING RATE) IS CONSTANT.  PROGRAM
C     EXECUTION IS DELAYED UNTIL A SPECIFIED STABILITY CRITERIA IS
C     MET.  CHANNEL 4 OF THIS COUNTER CARD IS WIRE WRAPPED TO
C     OPERATE IN THE FREQUENCY MODE; THE FREQUENCY OF THE ENCODER
C*****GENERATED PULSES IS MEASURED BY THIS CHANNEL.*********************
   30 CALL RATE
      NSAVE=NRATE
```

```
C*****SETUP INFORMATION IS EITHER READ FROM A PREVIOUS EXPERIMENTAL ****
C     DATA FILE OR INPUT FROM THE VT55 KEYBOARD BY THE OPERATOR,
C     DEPENDING UPON THE OPERATOR'S RESPONSE AT THIS POINT.
  100 TYPE 110
  110 FORMAT(/,'$ IS SETUP INFO TO BE (A)ENTERED FROM KEYBOARD
    C OR (B)READ FROM OLD DATA FILE? ')
      ACCEPT 20,IF1
      IF(IF1.NE.1HA.AND.IF1.NE.1HB)GOTO 100
      IF(IF1.NE.1HA)GOTO 120
C*****THIS SUBROUTINE ALLOWS THE OPERATOR TO INPUT THE SETUP **********
C     INFORMATION FROM THE KEYBOARD.
      CALL NEWSET
      GOTO 130
  120 CONTINUE
C*****THIS SUBROUTINE ACCESSES AN OLD DATA FILE SPECIFIED BY THE ******
C     OPERATOR TO REASSIGN OLD SETUP VALUES TO THE CURRENT
C     EXPERIMENT.
      CALL INPUT
      NRATE=NSAVE
  130 CONTINUE
C*****SOME PARAMETERS MUST BE ENTERED FROM THE KEYBOARD SINCE *********
C     THEY WILL PROBABLY BE CHANGED FROM ONE SPECTRAL SCAN TO
C     ANOTHER(FOR EXAMPLE MANUAL AZIMUTH SETTINGS).  SUBROUTINE
C     "RESET" ALLOWS FOR THIS.
      CALL RESET
C*****THE OPERATOR CAN SPECIFY THE TYPE OF OUTPUT DESIRED FOR *********
C     THE SETUP INFORMATION.
  200 TYPE 210
  210 FORMAT(/,'$ IS SETUP INFORMATION TO BE OUTPUT (A)TO CRT,
    C (B)TO PRINTER, OR (C)NOT AT ALL? ')
      ACCEPT 20,IF2
      IF(IF2.NE.1HA.AND.IF2.NE.1HB.AND.IF2.NE.1HC)GOTO 200
      IF(IF2.EQ.1HC)GOTO 230
      IF(IF2.EQ.1HC)GOTO 230
      IF(IF2.NE.1HA)GOTO 220
C*****SETUP INFORMATION IS DISPLAYED ON THE CRT.**********************
      CALL T1INFO
      GOTO 230
  220 CONTINUE
C*****SETUP INFORMATION IS SENT TO THE LINE PRINTER.******************
      CALL P1INFO
  230 CONTINUE
  400 TYPE 410
  410 FORMAT(/,'$ ENTER "G" AND "RETURN" FOR SPECTRA COLLECTION. ')
      ACCEPT 20,IF3
      IF(IF3.NE.1HG)GOTO 400
      TYPE 411
  411 FORMAT(/,'  SPECTRA BEING COLLECTED...........')
      CALL EDATA
```

```
C*****THE REQUIRED DATA ACQUISITION TIME FOR THE SPECTRAL SCAN IS *****
C     EITHER DISPLAYED ON THE CRT OR OUTPUT ON THE LINE PRINTER.
      IF(IF2.EQ.1HC)GOTO 630
      IF(IF2.NE.1HA)GOTO 620
      CALL T1TIME
      GOTO 630
  620 CONTINUE
      CALL P1TIME
  630 CONTINUE
C*****IF DESIRED, THE SPECTRAL SCAN IS DISPLAYED ON THE VT55 **********
C     TERMINAL IN GRAPHICAL FORM.
  700 TYPE 710
  710 FORMAT(/,'$ DO YOU WANT TO PLOT SPECTRA(Y/N)? ')
      ACCEPT 20,IF4
      IF(IF4.NE.1HY.AND.IF4.NE.1HN)GOTO 700
      IF(IF4.EQ.1HN)GOTO 720
      CALL PLOT
  720 CONTINUE
C*****IF DESIRED, THE SPECTRAL SCAN IS STORED ON A FLOPPY DISK*********
C     FOR SUBSEQUENT RETRIEVAL AND ANALYSIS.
  800 TYPE 810
  810 FORMAT(/,'$ ARE THE SPECTRA TO BE STORED ON FLOPPY DISK(Y/N)? ')
      ACCEPT 20,IF5
      IF(IF5.NE.1HY.AND.IF5.NE.1HN)GOTO 800
      IF(IF5.EQ.1HN)GOTO 820
      CALL OUTPUT
  820 CONTINUE
C*****DEPENDING ON THE OPERATOR'S RESPONSE, VARIOUS COMBINATIONS ******
C     OF NUMERICAL OUTPUT CAN BE GENERATED(EITHER CRT DISPLAY OR
C     HARDCOPY FROM THE LINE PRINTER.
      TYPE 890
  890 FORMAT(/,'$ IS ANY NUMERIC OUTPUT DESIRED(Y/N)? ')
      ACCEPT 20,IF6
      IF(IF6.NE.1HY.AND.IF6.NE.1HN)GOTO 820
      IF(IF6.EQ.1HN)GOTO 960
  900 TYPE 910
  910 FORMAT(/,5X,'NUMERIC OUTPUT MENU:',
     C        /,10X,'(A)HARDCOPY OF SETUP INFO. ONLY',
     C        /,10X,'(B)HARDCOPY OF SETUP INFO. AND PLOTTED DATA PTS.',
     C        /,10X,'(C)CRT DISPLAY OF SETUP INFO. ONLY',
     C        /,10X,'(D)CRT DISPLAY OF SETUP INFO. AND PLOTTED DATA
     C PTS.', /,10X,'(E)NONE OF THE ABOVE')
      TYPE 920
  920 FORMAT(/,'$    YOUR CHOICE IS: ')
      ACCEPT 20,IF6
      IF(IF6.NE.1HA.AND.IF6.NE.1HB.AND.IF6.NE.1HC.AND.IF6.NE.1HD
     C.AND.IF6.NE.1HE)GOTO 900
      IF(IF6.EQ.1HE)GOTO 960
      IF(IF6.NE.1HA)GOTO 930
      CALL P1INFO
      CALL P1TIME
```

```
 930 CONTINUE
     IF(IF6.NE.1HB)GOTO 940
     CALL P1INFO
     CALL P1TIME
     DO 934 IPAGE=1,4
     PRINT 931,IPAGE
 931 FORMAT(///,5X,'DATA(ADCU) FROM POLARIZER AND ANALYZER CHANNELS
    C AS A FUNCTION OF WAVELENGTH(ANGSTROMS)...PAGE ',I1,
    C       ///,2(5X,'INDEX',5X,'WL',3X,'NAVG',7X,'POL',7X,'ANA'))
     DO 932 I=1,50
     I1=(IPAGE-1)*100+I
     I2=I1+50
 932 PRINT 933,I1,IWAVE(I1),NAVG(I1),POL(I1),ANA(I1),I2,IWAVE(I2),
    CNAVG(I2),POL(I2),ANA(I2)
 933 FORMAT(2(5X,I5,2X,I5,2X,I5,3X,F7.0,3X,F7.0))
 934 PRINT 935
 935 FORMAT(////////)
 940 CONTINUE
     IF(IF6.NE.1HC)GOTO 950
     CALL T1INFO
     CALL T1TIME
 950 CONTINUE
     IF(IF6.NE.1HD)GOTO 960
     CALL T1INFO
     CALL T1TIME
     TYPE 951
 951 FORMAT(//,5X,'RAW DATA FROM SPECTRAL SCAN',//)
     DO 952 I=1,400
 952 TYPE 953,I,IWAVE(I),NAVG(I),POL(I),ANA(I)
 953 FORMAT(5X,'I = ',I3,5X,'WL = ',I5,5X,'NAVG = ',I3,5X,'POL = ',
    CF7.0,5X,'ANA = ',F7.0)
 960 CONTINUE
C*****THE OPERATOR HAS THE OPTION OF REPEATING PROGRAM EXECUTION.******
1000 TYPE 1010
1010 FORMAT(/,'$ IS THE PROGRAM TO BE EXECUTED AGAIN(Y/N)? ')
     ACCEPT 20,IF7
     IF(IF7.NE.1HY.AND.IF7.NE.1HN)GOTO 1000
     NPASS=NPASS+1
     IF(IF7.EQ.1HY)GOTO 30
     STOP
     END
```

```
      SUBROUTINE WLCALC
C*********************************************************************
C     OBJECTIVE: TO CONVERT ENCODER COUNTS INTO WAVELENGTH USING
C                PREDETERMINED CALIBRATION CURVE PARAMETERS.
C*********************************************************************
      COMMON/M/IWAVE(400)
      OPEN(UNIT=2,NAME='DY1:WLCALC.DAT',TYPE='OLD')
      READ(2,996)IU,IL,A1,B1,R1,A2,B2,R2
  996 FORMAT(2(1X,I3),2(1X,F8.4,1X,F8.2,1X,F6.4))
      CLOSE(UNIT=2,DISPOSE='SAVE')
  997 TYPE 998
  998 FORMAT(/,'$ DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION
     C PARAMETERS(Y/N)? ')
      ACCEPT 999,IF0
      IF(IF0.NE.1HY.AND.IF0.NE.1HN)GOTO 997
      IF(IF0.EQ.1HN)GOTO 3
  999 FORMAT(A1)
      TYPE 1000
 1000 FORMAT(//,10X,'DIGITAL ENCODER PRESETS:')
    1 TYPE 1001,A1,B1,R1
 1001 FORMAT(/,10X,'CALIBRATION CURVE SEGMENT NUMBER 1:',
     C       /,15X,'SLOPE = ',F10.4,
     C       /,15X,'INTERCEPT = ',F10.2,
     C       /,15X,'CORRELATION COEFFICIENT = ',F10.4)
      TYPE 1002,A2,B2,R2
 1002 FORMAT(/,10X,'CALIBRATION CURVE SEGMENT NUMBER 2:',
     C       /,15X,'SLOPE = ',F10.4,
     C       /,15X,'INTERCEPT = ',F10.2,
     C       /,15X,'CORRELATION COEFFICIENT = ',F10.4)
      TYPE 1003,IL,IU
 1003 FORMAT(/,10X,'LIMITS OF APPLICATION:',
     C       /,15X,'UPPER = ',I6,
     C       /,15X,'LOWER = ',I6)
    2 TYPE 1004
 1004 FORMAT(/,'$ DO YOU WANT TO CHANGE THESE(Y/N)? ')
      ACCEPT 1005,IF1
 1005 FORMAT(A1)
      IF(IF1.NE.1HY.AND.IF1.NE.1HN)GOTO 2
      IF(IF1.EQ.1HN)GOTO 3
      TYPE 1006
 1006 FORMAT(/,2X,'SEGMENT 1:')
```

```
      TYPE 1007
1007  FORMAT(/,'$ SLOPE(F10.4/ANGSTROMS PER COUNT) = ')
      ACCEPT 1008,A1
1008  FORMAT(F10.4)
      TYPE 1009
1009  FORMAT(/,'$ INTERCEPT(F10.2/ANGSTROMS)       = ')
      ACCEPT 1010,B1
1010  FORMAT(F10.2)
      TYPE 1011
1011  FORMAT(/,'$ CORRELATION COEFFICIENT(F10.4)   = ')
      ACCEPT 1012,R1
1012  FORMAT(F10.4)
      TYPE 1013
1013  FORMAT(/,2X,'SEGMENT 2:')
      TYPE 1007
      ACCEPT 1008,A2
      TYPE 1009
      ACCEPT 1010,B2
      TYPE 1011
      ACCEPT 1012,R2
      TYPE 1014
1014  FORMAT(/,'$ UPPER LIMIT OF APPLICATION(I6) = ')
      ACCEPT 1015,IL
1015  FORMAT(I6)
      TYPE 1016
1016  FORMAT(/,'$ LOWER LIMIT OF APPLICATION(I6) = ')
      ACCEPT 1015,IU
      GOTO 1
   3  CONTINUE
      DO 40 I=1,400
      IF(I.LE.IL.AND.I.GE.IU)GOTO 10
      IF(I.GT.IL)GOTO 20
      COUNT=I
      WL=A1*COUNT+B1
      GOTO 30
  10  COUNT=I
      WL=A2*COUNT+B2
      GOTO 30
  20  COUNT=I-400
      WL=A1*COUNT+B1
  30  CONTINUE
  40  IWAVE(I)=WL
      RETURN
      END
```

```
      SUBROUTINE RATE
C*************************************************************************
C     OBJECTIVE: MAKE TWO "AVERAGED" DETERMINATIONS OF THE ROTATION
C                RATE OF THE FILTER DISK(SPECTRAL SCAN RATE) VIA
C                CHANNEL 4 OF THE ADAC 1604/OPI COUNTER CARD WHICH
C                IS WIRE WRAPPED IN THE FREQUENCY MODE.  THESE TWO
C                RATES OF ROTATION ARE MADE AT A TIME INTERVAL
C                DETERMINED BY THE SUBROUTINE "DELAY"(15 SECONDS).
C                IF THE TWO RATES ARE IDENTICAL, THE SCAN RATE IS
C                DETERMINED TO BE STABLE(FREE OF "CHATTER", ETC.)
C                AND PROGRAM CONTROL IS RETURNED TO THE MAIN
C                PROGRAM "SEV001".
C*************************************************************************
      COMMON/B/NRATE,NSCAN,IPOL,IANA
   10 TYPE 20
   20 FORMAT(/,'$ DO YOU WANT TO ADJUST THE SCAN RATE(Y/N)? ')
      ACCEPT 30,MRATE
   30 FORMAT(A1)
      IF(MRATE.NE.1HY.AND.MRATE.NE.1HN)GOTO 10
      IF(MRATE.NE.1HY)GOTO 85
      TYPE 40
   40 FORMAT(/,'$ ADJUST THE SPECTRAL SCANNER SPEED, THEN "RETURN".')
      ACCEPT 50,IWAIT
   50 FORMAT(A1)
   60 ISUM0=0
      DO 70 I=1,3
   70 ISUM0=ISUM0+IPEEK("164406)
      CALL DELAY
      ISUM1=0
      DO 80 I=1,3
   80 ISUM1=ISUM1+IPEEK("164406)
      IF(ISUM0.NE.ISUM1)GO TO 60
   85 NRATE=IPEEK("164406)
      TYPE 90,NRATE
   90 FORMAT(/,'  STEADY SCAN RATE ESTABLISHED.  SCAN RATE = ',I5)
      RETURN
      END
```

```
      SUBROUTINE DELAY
C***********************************************************************
C     OBJECTIVE: TO GENERATE A 15 SECOND TIME DELAY FOR SUBROUTINE
C                "RATE".
C***********************************************************************
      INTEGER*4 ITIME
   10 CALL GTIM(ITIME)
      CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITIC)
      ISECO=ISEC
      IF(ISECO.GT.44)GOTO 10
   20 CALL GTIM(ITIME)
      CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITIC)
      ISECF=ISEC
      IF(ISECF.EQ.ISECO+15)RETURN
      GOTO 20
      END
```

```
      SUBROUTINE RATE
C***********************************************************************
C     OBJECTIVE: MAKE TWO "AVERAGED" DETERMINATIONS OF THE ROTATION
C                RATE OF THE FILTER DISK(SPECTRAL SCAN RATE) VIA
C                CHANNEL 4 OF THE ADAC 1604/OPI COUNTER CARD WHICH
C                IS WIRE WRAPPED IN THE FREQUENCY MODE.  THESE TWO
C                RATES OF ROTATION ARE MADE AT A TIME INTERVAL
C                DETERMINED BY THE SUBROUTINE "DELAY"(15 SECONDS).
C                IF THE TWO RATES ARE IDENTICAL, THE SCAN RATE IS
C                DETERMINED TO BE STABLE(FREE OF "CHATTER", ETC.)
C                AND PROGRAM CONTROL IS RETURNED TO THE MAIN
C                PROGRAM "SEV001".
C***********************************************************************
      COMMON/B/NRATE,NSCAN,IPOL,IANA
   10 TYPE 20
   20 FORMAT(/,'$ DO YOU WANT TO ADJUST THE SCAN RATE(Y/N)? ')
      ACCEPT 30,MRATE
   30 FORMAT(A1)
      IF(MRATE.NE.1HY.AND.MRATE.NE.1HN)GOTO 10
      IF(MRATE.NE.1HY)GOTO 85
      TYPE 40
   40 FORMAT(/,'$ ADJUST THE SPECTRAL SCANNER SPEED, THEN "RETURN".')
      ACCEPT 50,IWAIT
   50 FORMAT(A1)
   60 ISUM0=0
      DO 70 I=1,3
   70 ISUM0=ISUM0+IPEEK("164406)
      CALL DELAY
      ISUM1=0
      DO 80 I=1,3
   80 ISUM1=ISUM1+IPEEK("164406)
      IF(ISUM0.NE.ISUM1)GO TO 60
   85 NRATE=IPEEK("164406)
      TYPE 90,NRATE
   90 FORMAT(/,'  STEADY SCAN RATE ESTABLISHED.  SCAN RATE = ',I5)
      RETURN
      END
```

```
      SUBROUTINE DELAY
C***********************************************************************
C     OBJECTIVE: TO GENERATE A 15 SECOND TIME DELAY FOR SUBROUTINE
C                "RATE".
C***********************************************************************
      INTEGER*4 ITIME
   10 CALL GTIM(ITIME)
      CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITIC)
      ISECO=ISEC
      IF(ISECO.GT.44)GOTO 10
   20 CALL GTIM(ITIME)
      CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITIC)
      ISECF=ISEC
      IF(ISECF.EQ.ISECO+15)RETURN
      GOTO 20
      END
```

```
      SUBROUTINE RATE
C***********************************************************************
C     OBJECTIVE: MAKE TWO "AVERAGED" DETERMINATIONS OF THE ROTATION
C                RATE OF THE FILTER DISK(SPECTRAL SCAN RATE) VIA
C                CHANNEL 4 OF THE ADAC 1604/OPI COUNTER CARD WHICH
C                IS WIRE WRAPPED IN THE FREQUENCY MODE.  THESE TWO
C                RATES OF ROTATION ARE MADE AT A TIME INTERVAL
C                DETERMINED BY THE SUBROUTINE "DELAY"(15 SECONDS).
C                IF THE TWO RATES ARE IDENTICAL, THE SCAN RATE IS
C                DETERMINED TO BE STABLE(FREE OF "CHATTER", ETC.)
C                AND PROGRAM CONTROL IS RETURNED TO THE MAIN
C                PROGRAM "SEV001".
C***********************************************************************
      COMMON/B/NRATE,NSCAN,IPOL,IANA
   10 TYPE 20
   20 FORMAT(/,'$ DO YOU WANT TO ADJUST THE SCAN RATE(Y/N)? ')
      ACCEPT 30,MRATE
   30 FORMAT(A1)
      IF(MRATE.NE.1HY.AND.MRATE.NE.1HN)GOTO 10
      IF(MRATE.NE.1HY)GOTO 85
      TYPE 40
   40 FORMAT(/,'$ ADJUST THE SPECTRAL SCANNER SPEED, THEN "RETURN".')
      ACCEPT 50,IWAIT
   50 FORMAT(A1)
   60 ISUM0=0
      DO 70 I=1,3
   70 ISUM0=ISUM0+IPEEK("164406)
      CALL DELAY
      ISUM1=0
      DO 80 I=1,3
   80 ISUM1=ISUM1+IPEEK("164406)
      IF(ISUM0.NE.ISUM1)GO TO 60
   85 NRATE=IPEEK("164406)
      TYPE 90,NRATE
   90 FORMAT(/,'  STEADY SCAN RATE ESTABLISHED.  SCAN RATE = ',I5)
      RETURN
      END

      SUBROUTINE DELAY
C***********************************************************************
C     OBJECTIVE: TO GENERATE A 15 SECOND TIME DELAY FOR SUBROUTINE
C                "RATE".
C***********************************************************************
      INTEGER*4 ITIME
   10 CALL GTIM(ITIME)
      CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITIC)
      ISEC0=ISEC
      IF(ISEC0.GT.44)GOTO 10
   20 CALL GTIM(ITIME)
      CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITIC)
      ISECF=ISEC
      IF(ISECF.EQ.ISEC0+15)RETURN
      GOTO 20
      END
```

```
      SUBROUTINE NEWSET
C***********************************************************************
C     OBJECTIVE: TO ALLOW THE OPERATOR TO COMPLETELY INITIALIZE ALL
C                THE SETUP PARAMETERS FROM THE VT55 KEYBOARD.
C***********************************************************************
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      TYPE 140
  140 FORMAT(/,' LAMP PARAMETERS:')
      TYPE 141
  141 FORMAT('$ TYPE(A2/XE,ETC.) = ')
      ACCEPT 142,LMPTYP
  142 FORMAT(A2)
      TYPE 143
  143 FORMAT('$ SERIAL NO.(A18) = ')
      ACCEPT 144,(LMPSER(I),I=1,9)
  144 FORMAT(9A2)
      TYPE 145
  145 FORMAT('$ LAMP VOLTAGE(I3/VOLTS) = ')
      ACCEPT 146,LMPVLT
  146 FORMAT(I4)
      TYPE 147
  147 FORMAT('$ LAMP CURRENT(I2/AMPS) = ')
      ACCEPT 148,LMPAMP
  148 FORMAT(I3)
      TYPE 150
  150 FORMAT(/,' PHOTOMULTIPLIER PARAMETERS:')
      TYPE 151
  151 FORMAT('$ MODEL(A20) = ')
      ACCEPT 152,(IPMTYP(I),I=1,10)
  152 FORMAT(10A2)
      TYPE 153
  153 FORMAT('$ DYNODE VOLTAGE(I4/VOLTS) = ')
      ACCEPT 154,IPMTDV
  154 FORMAT(I5)
      TYPE 160
  160 FORMAT(/,' FARADAY CELL CONTROLLER PARAMETERS:')
      TYPE 161
  161 FORMAT(/,' POLARIZER CHANNEL')
      TYPE 162
  162 FORMAT('$ PHASE(I3/POT SETTING) = ')
      ACCEPT 163,IPHASP
  163 FORMAT(I4)
```

```
    TYPE 164
164 FORMAT('$ GAIN(I3/POT SETTING) = ')
    ACCEPT 163,IGAINP
    TYPE 165
165 FORMAT('$ AMPLITUDE(I3/POT SETTING) = ')
    ACCEPT 163,IAMPLP
    TYPE 166
166 FORMAT('$ TIME CONSTANT(I3/MILLISECONDS) = ')
    ACCEPT 163,ITIMEP
    TYPE 167
167 FORMAT(/,' ANALYZER CHANNEL')
    TYPE 162
    ACCEPT 163,IPHASA
    TYPE 164
    ACCEPT 163,IGAINA
    TYPE 165
    ACCEPT 163,IAMPLA
    TYPE 166
    ACCEPT 163,ITIMEA
    TYPE 170
170 FORMAT(/,' GALVANOMETER AMPLIFIER PARAMETERS:')
    TYPE 171
171 FORMAT(/,' POLARIZER CHANNEL')
    TYPE 172
172 FORMAT('$ GAIN(I5) = ')
    ACCEPT 173,IGAGP
173 FORMAT(I6)
    TYPE 174
174 FORMAT('$ TIME CONSTANT(I5/MILLISECONDS) = ')
    ACCEPT 173,IGATP
    TYPE 175
175 FORMAT(/,' ANALYZER CHANNEL')
    TYPE 172
    ACCEPT 173,IGAGA
    TYPE 174
    ACCEPT 173,IGATA
    RETURN
    END
```

```
      SUBROUTINE INPUT
C***********************************************************************
C     OBJECTIVE: TO READ THE SETUP INFORMATION AND SPECTRAL SCAN DATA
C                FROM ANY FLOPPY DISK FILE SPECIFIED BY THE OPERATOR
C                AND CREATED BY SUBROUTINE "OUTPUT".
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      REAL*4 BDLK(2),NAME(20)
      IBLOCK=0
      TYPE 100
  100 FORMAT(/,'$ NAME OF SPECTRA FILE TO BE RETRIEVED = ')
      ACCEPT 200,(NAME(I),I=1,3)
  200 FORMAT(3A4)
      N=IRAD50(12,NAME,BDLK)
      ICHAN=IGETC(I)
      IF(ICHAN.LT.0)STOP 'CANNOT ALLOCATE CHANNEL'
      IF(IFETCH(ICHAN).LT.0)STOP 'FETCH FAIL'
      IF(LOOKUP(ICHAN,BDLK).LT.0)STOP 'BAD LOOKUP'
      DO 10 I=1,256
   10 IBUFF(I)=0
      CALL READ
      DO 20 I=1,20
      NAMEOP(I)=IBUFF(I)
   20 ID(I)=IBUFF(20+I)
      LMPTYP=IBUFF(41)
      DO 30 I=1,9
   30 LMPSER(I)=IBUFF(41+I)
```

```
      LMPVLT=IBUFF(51)
      LMPAMP=IBUFF(52)
      IPHASP=IBUFF(54)
      IGAINP=IBUFF(55)
      IAMPLP=IBUFF(56)
      ITIMEP=IBUFF(57)
      IPHASA=IBUFF(58)
      IGAINA=IBUFF(59)
      IAMPLA=IBUFF(60)
      ITIMEA=IBUFF(61)
      IGAGP =IBUFF(62)
      IGATP =IBUFF(63)
      IGAGA =IBUFF(64)
      IGATA =IBUFF(65)
      NRATE =IBUFF(66)
      NSCAN =IBUFF(67)
      IPOL  =IBUFF(68)
      IANA  =IBUFF(69)
      NWL   =IBUFF(70)
      NPOL  =IBUFF(71)
      NCMP  =IBUFF(72)
      NANA  =IBUFF(73)
      IHRSO =IBUFF(74)
      IHRSF =IBUFF(75)
      IMINO =IBUFF(76)
      IMINF =IBUFF(77)
      ISECO =IBUFF(78)
      ISECF =IBUFF(79)
      ITICO =IBUFF(80)
      ITICF =IBUFF(81)
      IDAY  =IBUFF(82)
      IYRS  =IBUFF(83)
      LMPHRS=IBUFF(84)
      IMON(1)=IBUFF(85)
      IMON(2)=IBUFF(86)
      IMON(3)=IBUFF(87)
      DO 35 I=1,10
   35 IPMTYP(I)-IBUFF(87+I)
      IPMTDV=IBUFF(98)
      CALL READ
      DO 40 I=1,200
   40 POL(I)=IBUFF(I)
      CALL READ
      DO 50 I=1,200
   50 ANA(I)=IBUFF(I)
      CALL READ
      DO 60 I=1,200
   60 POL(I+200)=IBUFF(I)
      CALL READ
      DO 70 I=1,200
   70 ANA(I+200)=IBUFF(I)
      CALL CLOSEC(ICHAN)
      CALL IFREEC(ICHAN)
      RETURN
      END

      SUBROUTINE READ
C**********************************************************************
C     OBJECTIVE: TO ACTUALLY READ THE DATA STORED ON THE FLOPPY DISK
C                INTO BUFFER MEMORY.
C**********************************************************************
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      IERROR=IREADW(256,IBUFF,IBLOCK,ICHAN)
      IF(IERROR.LT.0)STOP 'FATAL READ'
      IBLOCK=IBLOCK+1
      RETURN
      END
```

```
      SUBROUTINE RESET
C***********************************************************************
C     OBJECTIVE: TO ALLOW THE OPERATOR TO CHANGE ONLY THOSE SETUP
C                PARAMETERS WHICH ARE TYPICALLY CHANGED FROM ONE
C                SPECTRAL SCAN TO ANOTHER.  THIS MODIFYS SETUP
C                INFORMATION READ FROM OLD DATA FILES TO MAKE IT
C                APPLICABLE TO THE CURRENT SPECTRAL SCAN OR
C                COMPLETES THE INITIALIZATION OF SETUP
C                INFORMATION STARTED WITH "NEWSET".
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/O/NPASS
      IF(NPASS.GT.1)GOTO 106
      TYPE 100
  100 FORMAT(/,'$ NAME(A40) = ')
      ACCEPT 101,(NAMEOP(I),I=1,20)
  101 FORMAT(20A2)
      TYPE 102
  102 FORMAT(/,'$ DATE(I2-A3-I2/DAY-MONTH-YEAR) = ')
      ACCEPT 103,IDAY,(IMON(I),I=1,3),IYRS
  103 FORMAT(I2,1X,3A1,1X,I2)
      TYPE 104
  104 FORMAT(/,'$ LAMP OPERATIONAL LIFE(I5/HOURS) = ')
      ACCEPT 105,LMPHRS
  105 FORMAT(I5)
  106 CONTINUE
      TYPE 107
  107 FORMAT(/,'$ EXPERIMENT IDENTIFICATION(A40) = ')
      ACCEPT 101,(ID(I),I=1,20)
  108 TYPE 109
  109 FORMAT(/,'$ HAVE MANUAL AZIMUTHS BEEN CHANGED(Y/N)? ')
      ACCEPT 110,MANAZ
  110 FORMAT(A1)
      IF(MANAZ.NE.1HY.AND.MANAZ.NE.1HN)GOTO 108
      IF(MANAZ.NE.1HY)GOTO 119
      TYPE 112
  112 FORMAT(/,' MANUAL AZIMUTH SETTINGS(DEG):')
      TYPE 113
  113 FORMAT('$ POLARIZER(F7.2)    = ')
      ACCEPT 114,P
  114 FORMAT(F7.2)
```

```
      NPOL=P*100.
      TYPE 115
  115 FORMAT('$ ANALYZER(F7.2)    = ')
      ACCEPT 114,A
      NANA=A*100.
  116 TYPE 117
  117 FORMAT('$ COMPENSATOR(F7.2) = ')
      ACCEPT 114,C
      IF(C.NE.135.0.AND.C.NE.45.0)GOTO 116
      NCMP=C*100.
      TYPE 118
  118 FORMAT('$ MONOCHROMATOR SETTING AT NULL(F7.2) = ')
      ACCEPT 114,WL
      NWL=WL*100.
  119 CONTINUE
      IGAIN=3
      NCHP=0
      NCHA=1
  120 TYPE 121
  121 FORMAT(/,' ANALOG/DIGITAL CONVERTOR PRESET PARAMETERS:')
  122 TYPE 123,NCHP
  123 FORMAT('  POL. INPUT CH. = ',I1)
      TYPE 124,NCHA
  124 FORMAT('  ANA. INPUT CH. = ',I1)
      TYPE 125,IGAIN
  125 FORMAT('  ADC GAIN       = ',I1)
      TYPE 126
  126 FORMAT(/,'$ DO YOU WANT TO CHANGE THESE(Y/N)? ')
      ACCEPT 110,NADC
      IF(NADC.NE.1HY.AND.NADC.NE.1HN)GOTO 120
      IF(NADC.EQ.1HN)GOTO 131
      TYPE 127
  127 FORMAT('$ POL. INPUT CH.(I1) = ')
      ACCEPT 128,NCHP
  128 FORMAT(I1)
      TYPE 129
  129 FORMAT('$ ANA. INPUT CH.(I1) = ')
      ACCEPT 128,NCHA
      TYPE 130
  130 FORMAT('$ ADC GAIN(I1)       = ')
      ACCEPT 128,IGAIN
      GOTO 120
  131 CONTINUE
      IPOL=IGAIN*64+NCHP
      IANA=IGAIN*64+NCHA
      TYPE 132
  132 FORMAT(/,'$ HOW MANY SPECTRAL SCANS ARE TO BE AVERAGED(I5)? ')
      ACCEPT 133,NSCAN
  133 FORMAT(I5)
      DO 140 I=1,400
      POL(I)=0.
      ANA(I)=0.
  140 NAVG(I)=0
      NPASS=NPASS+1
      RETURN
      END
```

```
      SUBROUTINE T1INFO
C************************************************************************
C     OBJECTIVE: DISPLAYS ALL THE SETUP INFORMATION FOR A GIVEN
C                SPECTRAL SCAN ON THE VT55 GRAPHICS TERMINAL SCREEN,
C                EXCEPT FOR THE DATA ACQUISTION TIME.
C************************************************************************
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      TYPE 100,IDAY,(IMON(I),I=1,3),IYRS
  100 FORMAT(/10X,I2,'-',3A1,'-',I2)
      TYPE 101,(NAMEOP(I),I=1,20)
  101 FORMAT(10X,10A2)
      TYPE 102,(ID(I),I=1,20)
  102 FORMAT(10X,20A2)
      TYPE 110
  110 FORMAT(/10X,'MANUAL AZIMUTHS(DEG):')
      P=NPOL/100.
      A=NANA/100.
      C=NCMP/100.
      WL=NWL/100.
      TYPE 111,P,A,C,WL
  111 FORMAT(/12X,'P = ',F7.2,
     C       /12X,'A = ',F7.2,
     C       /12X,'C = ',F7.2,
     C       /12X,'WL= ',F7.2)
      TYPE 120
  120 FORMAT(/10X,'LAMP:')
      TYPE 121,LMPTYP
  121 FORMAT(/12X,'TYPE       = ',A2)
      TYPE 122,(LMPSER(I),I=1,9)
  122 FORMAT(12X,'SERIAL NO. = ',9A2)
      TYPE 123,LMPVLT
  123 FORMAT(12X,'LAMP VOLTAGE(VOLTS) = ',I4)
      TYPE 124,LMPAMP
  124 FORMAT(12X,'LAMP CURRENT(AMPS)  = ',I3)
```

```
      TYPE 125,LMPHRS
  125 FORMAT(12X,'LAMP OPERATIONAL LIFE(HOURS) = ',I5)
      TYPE 130
  130 FORMAT(/10X,'PHOTOMULTIPLIER:')
      TYPE 131,(IPMTYP(I),I=1,10)
  131 FORMAT(/12X,'MODEL = ',10A2)
      TYPE 132,IPMTDV
  132 FORMAT(12X,'DYNODE VOLTAGE(VOLTS) = ',I5)
      TYPE 140
  140 FORMAT(/10X,'FARADAY CELL CONTROLLER:')
      TYPE 141
  141 FORMAT(/12X,'POLARIZER')
      TYPE 142,IPHASP,IGAINP,IAMPLP,ITIMEP
  142 FORMAT(/12X,'PHASE             = ',I4,
     C       /12X,'GAIN              = ',I4,
     C       /12X,'AMPLITUDE         = ',I4,
     C       /12X,'TIME CONSTANT(MS) = ',I4)
      TYPE 143
  143 FORMAT(/12X,'ANALYZER')
      TYPE 142,IPHASA,IGAINA,IAMPLA,ITIMEA
      TYPE 150
  150 FORMAT(/10X,'GALVANOMETER AMPLIFIER:')
      TYPE 141
      TYPE 151,IGAGP,IGATP
  151 FORMAT(/12X,'GAIN              = ',I6,
     C       /12X,'TIME CONSTANT(MS) = ',I6)
      TYPE 143
      TYPE 151,IGAGA,IGATA
      IGAIN=IPOL/64
      NCHP=IPOL-IGAIN*64
      NCHA=IANA-IGAIN*64
      TYPE 160
  160 FORMAT(/10X,'ANALOG/DIGITAL CONVERTOR:')
      TYPE 161,NCHP,NCHA,IGAIN
  161 FORMAT(/12X,'POL. INPUT CH. = ',I1,
     C       /12X,'ANA. INPUT CH. = ',I1,
     C       /12X,'ADC GAIN       = ',I1)
      RETURN
      END
```

```
      SUBROUTINE T1TIME
C***************************************************************************
C     OBJECTIVE: DISPLAYS THE DATA ACQUISITION TIME FOR THE GIVEN
C                SPECTRAL SCAN ON THE CRT SCREEN.
C***************************************************************************
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      TYPE 100,NSCAN
  100 FORMAT(/,10X,'THE NUMBER OF SPECTRA AVERAGED = ',I5)
      TYPE 110,NRATE
  110 FORMAT(10X,'MEASURED SCAN RATE VIA COUNTER = ',I5)
      TYPE 120,IHRS0,IMIN0,ISEC0,ITIC0
  120 FORMAT(/10X,'DATA COLLECTION INITIATED AT: ',3(I2,':'),I2)
      TYPE 130,IHRSF,IMINF,ISECF,ITICF
  130 FORMAT(10X,'DATA COLLECTION FINISHED  AT: ',3(I2,':'),I2)
      RETURN
      END
```

```
      SUBROUTINE P1INFO
C***********************************************************************
C     OBJECTIVE: OUTPUTS ALL THE SETUP INFORMATION FOR A SPECTRAL SCAN
C                TO THE LINE PRINTER, EXCEPT FOR THE DATA ACQUISITION
C                TIME.
C***********************************************************************
      COMMON/B/NRATE,NSCAN,IFOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      PRINT 100,IDAY,(IMON(I),I=1,3),IYRS
  100 FORMAT(/10X,I2,'-',3A1,'-',I2)
      PRINT 101,(NAMEOP(I),I=1,20)
  101 FORMAT(10X,20A2)
      PRINT 102,(ID(I),I=1,20)
  102 FORMAT(10X,20A2)
      PRINT 110
  110 FORMAT(/10X,'MANUAL AZIMUTHS(DEG):')
      P=NPOL/100.
      A=NANA/100.
      C=NCMP/100.
      WL=NWL/100.
      PRINT 111,P,A,C,WL
  111 FORMAT(/12X,'P = ',F7.2,
     C       /12X,'A = ',F7.2,
     C       /12X,'C = ',F7.2,
     C       /12X,'WL= ',F7.2)
      PRINT 120
  120 FORMAT(/10X,'LAMP:')
      PRINT 121,LMPTYP
  121 FORMAT(/12X,'TYPE       = ',A2)
      PRINT 122,(LMPSER(I),I=1,9)
  122 FORMAT(12X,'SERIAL NO. = ',9A2)
      PRINT 123,LMPVLT
  123 FORMAT(12X,'LAMP VOLTAGE(VOLTS) = ',I4)
      PRINT 124,LMPAMP
  124 FORMAT(12X,'LAMP CURRENT(AMPS)  = ',I3)
```

```
      PRINT 125,LMPHRS
  125 FORMAT(12X,'LAMP OPERATIONAL LIFE(HOURS) = ',I5)
      PRINT 130
  130 FORMAT(/10X,'PHOTOMULTIPLIER:')
      PRINT 131,(IPMTYP(I),I=1,10)
  131 FORMAT(/12X,'MODEL = ',10A2)
      PRINT 132,IPMTDV
  132 FORMAT(12X,'DYNODE VOLTAGE(VOLTS) = ',I5)
      PRINT 140
  140 FORMAT(/10X,'FARADAY CELL CONTROLLER:')
      PRINT 141
  141 FORMAT(/12X,'POLARIZER')
      PRINT 142,IPHASP,IGAINP,IAMPLP,ITIMEP
  142 FORMAT(/12X,'PHASE              = ',I4,
     C        /12X,'GAIN               = ',I4,
     C        /12X,'AMPLITUDE          = ',I4,
     C        /12X,'TIME CONSTANT(MS) = ',I4)
      PRINT 143
  143 FORMAT(/12X,'ANALYZER')
      PRINT 142,IPHASA,IGAINA,IAMPLA,ITIMEA
      PRINT 150
  150 FORMAT(/10X,'GALVANOMETER AMPLIFIER:')
      PRINT 141
      PRINT 151,IGAGP,IGATP
  151 FORMAT(/12X,'GAIN               = ',I6,
     C        /12X,'TIME CONSTANT(MS) = ',I6)
      PRINT 143
      PRINT 151,IGAGA,IGATA
      IGAIN=IPOL/64
      NCHP=IPOL-IGAIN*64
      NCHA=IANA-IGAIN*64
      PRINT 160
  160 FORMAT(/10X,'ANALOG/DIGITAL CONVERTOR:')
      PRINT 161,NCHP,NCHA,IGAIN
  161 FORMAT(/12X,'POL. INPUT CH. = ',I1,
     C        /12X,'ANA. INPUT CH. = ',I1,
     C        /12X,'ADC GAIN       = ',I1)
      RETURN
      END
```

```
      SUBROUTINE P1TIME
C*************************************************************************
C     OBJECTIVE: OUTPUTS THE DATA ACQUISITION FOR THE GIVEN SPECTRAL
C                SCAN TO THE LINE PRINTER.
C*************************************************************************
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      PRINT 100,NSCAN
  100 FORMAT(/,10X,'THE NUMBER OF SPECTRA AVERAGED = ',I5)
      PRINT 110,NRATE
  110 FORMAT(10X,'MEASURED SCAN RATE VIA COUNTER = ',I5)
      PRINT 120,IHRSO,IMINO,ISECO,ITICO
  120 FORMAT(/10X,'DATA COLLECTION INITIATED AT: ',3(I2,':'),I2)
      PRINT 130,IHRSF,IMINF,ISECF,ITICF
  130 FORMAT(10X,'DATA COLLECTION FINISHED  AT: ',3(I2,':'),I2)
      RETURN
      END
```

```
      SUBROUTINE EDATA
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      INTEGER*4 ITIME0,ITIMEF
      CALL IPOKE("170400,0)
      IGAIN=3
      JGAIN=IGAIN*64
      N=1
      DO 100 I=1,400
      POL(I)=0.
      ANA(I)=0.
      NAVG(I)=0
  100 CONTINUE
      CALL GTIM(TIMEF)
      CALL IPOKE("164400,0)
 1000 IF(IPEEK("164400).LE.0)GOTO 1000
      CALL IPOKE("164404,1)
 2000 I0=IPEEK("164404)
 2500 CONTINUE
      CALL IPOKE("170402,IPOL.OR.(JGAIN))
 3000 IF(.NOT.(IPEEK("170400).AND."100000))GOTO 3000
      POL(N)=POL(N)+IPEEK("170402)
      CALL IPOKE("170402,IANA.OR.(JGAIN))
 4000 IF(.NOT.(IPEEK("170400).AND."100000))GOTO 4000
      ANA(N)=ANA(N)+IPEEK("170402)
      NAVG(N)=NAVG(N)+1
      IF(IPEEK("164404).EQ.I0)GOTO 2500
      N=N+1
      IF(N.LE.399)GOTO 2000
      N=1
 4500 IF(IPEEK("164400).EQ.I1)GOTO 4500
      I1=IPEEK("164400)
      IF(I1.LE.NSCAN)GOTO 2000
      CALL GTIM(TIMEF)
      CALL CVTTIM(TIME0,IHRS0,IMIN0,ISEC0,ITIC0)
      CALL CVTTIM(TIMEF,IHRSF,IMINF,ISECF,ITICF)
      DO 6000 I=1,399
      IF(NAVG(I).EQ.0)GOTO 5000
      POL(I)=POL(I)/NAVG(I)
      ANA(I)=ANA(I)/NAVG(I)
      GOTO 6000
 5000 POL(I)=0.
      ANA(I)=0.
 6000 CONTINUE
      SUM=0.
      DO 7000 I=1,399
 7000 SUM=SUM+NAVG(I)
      SUM=I1*(SUM/399.)
      TYPE 8000,SUM
 8000 FORMAT(/,'  EACH POINT AN AVERAGE OF: ',F5.0,' CHANNEL SCANS')
      RETURN
      END
```

```
      SUBROUTINE EDATA
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      INTEGER*4 ITIME0,ITIMEF
      CALL IPOKE("170400,0)
      IGAIN=3
      JGAIN=IGAIN*64
      N=1
      DO 100 I=1,400
      POL(I)=0.
      ANA(I)=0.
      NAVG(I)=0
  100 CONTINUE
      CALL GTIM(TIMEF)
      CALL IPOKE("164400,0)
 1000 IF(IPEEK("164400).LE.0)GOTO 1000
      CALL IPOKE("164404,1)
 2000 I0=IPEEK("164404)
 2500 CONTINUE
      CALL IPOKE("170402,IPOL.OR.(JGAIN))
 3000 IF(.NOT.(IPEEK("170400).AND."100000))GOTO 3000
      POL(N)=POL(N)+IPEEK("170402)
      CALL IPOKE("170402,IANA.OR.(JGAIN))
 4000 IF(.NOT.(IPEEK("170400).AND."100000))GOTO 4000
      ANA(N)=ANA(N)+IPEEK("170402)
      NAVG(N)=NAVG(N)+1
      IF(IPEEK("164404).EQ.I0)GOTO 2500
      N=N+1
      IF(N.LE.399)GOTO 2000
      N=1
 4500 IF(IPEEK("164400).EQ.I1)GOTO 4500
      I1=IPEEK("164400)
      IF(I1.LE.NSCAN)GOTO 2000
      CALL GTIM(TIMEF)
      CALL CVTTIM(TIME0,IHRS0,IMIN0,ISEC0,ITIC0)
      CALL CVTTIM(TIMEF,IHRSF,IMINF,ISECF,ITICF)
      DO 6000 I=1,399
      IF(NAVG(I).EQ.0)GOTO 5000
      POL(I)=POL(I)/NAVG(I)
      ANA(I)=ANA(I)/NAVG(I)
      GOTO 6000
 5000 POL(I)=0.
      ANA(I)=0.
 6000 CONTINUE
      SUM=0.
      DO 7000 I=1,399
 7000 SUM=SUM+NAVG(I)
      SUM=I1*(SUM/399.)
      TYPE 8000,SUM
 8000 FORMAT(/,'  EACH POINT AN AVERAGE OF: ',F5.0,' CHANNEL SCANS')
      RETURN
      END
```

```
      SUBROUTINE EDATA
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      INTEGER*4 ITIMEO,ITIMEF
      CALL IPOKE("170400,0)
      IGAIN=3
      JGAIN=IGAIN*64
      N=1
      DO 100 I=1,400
      POL(I)=0.
      ANA(I)=0.
      NAVG(I)=0
  100 CONTINUE
      CALL GTIM(TIMEF)
      CALL IPOKE("164400,0)
 1000 IF(IPEEK("164400).LE.0)GOTO 1000
      CALL IPOKE("164404,1)
 2000 IO=IPEEK("164404)
 2500 CONTINUE
      CALL IPOKE("170402,IPOL.OR.(JGAIN))
 3000 IF(.NOT.(IPEEK("170400).AND."100000))GOTO 3000
      POL(N)=POL(N)+IPEEK("170402)
      CALL IPOKE("170402,IANA.OR.(JGAIN))
 4000 IF(.NOT.(IPEEK("170400).AND."100000))GOTO 4000
      ANA(N)=ANA(N)+IPEEK("170402)
      NAVG(N)=NAVG(N)+1
      IF(IPEEK("164404).EQ.IO)GOTO 2500
      N=N+1
      IF(N.LE.399)GOTO 2000
      N=1
 4500 IF(IPEEK("164400).EQ.I1)GOTO 4500
      I1=IPEEK("164400)
      IF(I1.LE.NSCAN)GOTO 2000
      CALL GTIM(TIMEF)
      CALL CVTTIM(TIMEO,IHRSO,IMINO,ISECO,ITICO)
      CALL CVTTIM(TIMEF,IHRSF,IMINF,ISECF,ITICF)
      DO 6000 I=1,399
      IF(NAVG(I).EQ.0)GOTO 5000
      POL(I)=POL(I)/NAVG(I)
      ANA(I)=ANA(I)/NAVG(I)
      GOTO 6000
 5000 POL(I)=0.
      ANA(I)=0.
 6000 CONTINUE
      SUM=0.
      DO 7000 I=1,399
 7000 SUM=SUM+NAVG(I)
      SUM=I1*(SUM/399.)
      TYPE 8000,SUM
 8000 FORMAT(/,'  EACH POINT AN AVERAGE OF: ',F5.0,' CHANNEL SCANS')
      RETURN
      END
```

```
      SUBROUTINE PLOT
C***********************************************************************
C     OBJECTIVE: TO PREPARE PLOTS OF SPECTROSCOPIC ELLIPSOMETRIC DATA
C                USING VARIOUS COMBINATIONS OF ARRAYS FOR THE X AND Y
C                COORDINATES.
C
C     PROGRAM WRITTEN BY JOSEPH C. FARMER IN SPRING 1981 AT LBL-MMRD
C
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/M/IWAVE(400)
      COMMON/STATUS/ISTAT(16)
      COMMON/LIMITS/ILIMX,ILIMY,IGRIDX,IGRIDY,IDELX,IDELY
      COMMON/MAXMIN/MAXP,MINP,MAXA,MINA,MAXWL,MINWL,XHI,XLO,YHI,YLO
      COMMON/XYCONV/NOPT,INDEX,MX,MY
      COMMON/VECTOR/LOX,LOY,LFX,LFY
      COMMON/TITLE/NTITLE(5,30),NWORD(2,21)
      COMMON/MODE/MODE0,MODE1,FACTOR
  100 CONTINUE
C*****THE MAXIMUM AND MINIMUM VALUES OF DATA ARRAYS ARE FOUND SO ******
C     THAT THE SCALE PARAMETERS FOR GRAPHS CAN BE SPECIFIED.
      CALL MAXMIN
      PMAX=MAXP/FACTOR
      PMIN=MINP/FACTOR
      AMAX=MAXA/FACTOR
      AMIN=MINA/FACTOR
 1000 TYPE 1010,MAXWL,MINWL,(NWORD(1,J),J=1,21),PMAX,PMIN
     C                    ,(NWORD(2,J),J=1,21),AMAX,AMIN
 1010 FORMAT( /10X,'RANGES OF DATA TO BE PLOTTED:',
     C        /15X,'MAXIMUM WAVELENGTH(ANGSTROMS) = ',5X,I5,
     C        /15X,'MINIMUM                       = ',5X,I5,
     C        /15X,'MAXIMUM ',21A1,             ' = ',F10.3,
     C        /15X,'MINIMUM                       = ',F10.3,
     C        /15X,'MAXIMUM ',21A1,             ' = ',F10.3,
     C        /15X,'MINIMUM                       = ',F10.3)
 1020 TYPE 1030
 1030 FORMAT(/,'$ DO YOU WANT TO CHANGE THESE(Y/N)? ')
      ACCEPT 1040,IFO
 1040 FORMAT(A1)
      IF(IFO.NE.1HY.AND.IFO.NE.1HN)GOTO 1020
      IF(IFO.EQ.1HN)GOTO 1060
      TYPE 1050
 1050 FORMAT(/,'$ MAXIMUM WAVELENGTH(I5/ANGSTROMS)     = ')
      ACCEPT 1051,MAXWL
 1051 FORMAT(I5)
```

```
      TYPE 1052
 1052 FORMAT(  '$ MINIMUM                                  = ')
      ACCEPT 1051,MINWL
      TYPE 1053,(NWORD(1,J),J=1,21)
 1053 FORMAT(/,'$ MAXIMUM ',21A1,              '(F10.3) = ')
      ACCEPT 1054,PMAX
 1054 FORMAT(F10.3)
      TYPE 1055
 1055 FORMAT(  '$ MINIMUM                                  = ')
      ACCEPT 1054,PMIN
      TYPE 1056,(NWORD(2,J),J=1,21)
 1056 FORMAT(/,'$ MAXIMUM ',21A1,              '(F10.3) = ')
      ACCEPT 1054,AMAX
      TYPE 1057
 1057 FORMAT(  '$ MINIMUM                                  = ')
      ACCEPT 1054,AMIN
      MAXP=PMAX*FACTOR
      MINP=PMIN*FACTOR
      MAXA=AMAX*FACTOR
      MINA=AMIN*FACTOR
      GOTO 1000
 1060 CONTINUE
      FLAG1=MAXP-MINP
      FLAG2=MAXA-MINA
      FLAG3=MAXWL-MINWL
      IF(FLAG1.EQ.0.0.OR.FLAG2.EQ.0.0.OR.FLAG3.EQ.0.0)GOTO 1070
      GOTO 1080
 1070 TYPE 1071
 1071 FORMAT(/,'  BEWARE: POTENTIAL NORMALIZATION ERROR IN PLOTTER!!!')
      GOTO 1000
 1080 CONTINUE
C*****THE COMBINATION OF THE DATA ARRAYS TO BE USED AS X AND Y ********
C     COORDINATES ARE SPECIFIED BY THE OPERATOR.
      TYPE 2000,((NTITLE(I,J),J=1,30),I=1,5)
 2000 FORMAT( /10X,'PLOTTING MENU FOR REFRACTIVE INDEX DATA:',
     C        /15X,'(1) ',30A2,
     C        /15X,'(2) ',30A2,
     C        /15X,'(3) ',30A2,
     C        /15X,'(4) ',30A2,
     C        /15X,'(5) ',30A2)
 2010 TYPE 2020
 2020 FORMAT(/'$ YOUR CHOICE(1,2,3,4,OR 5)? ')
      ACCEPT 2030,NOPT
 2030 FORMAT(I1)
      IF(NOPT.GT.5.OR.NOPT.LT.1)GOTO 2010
C*****THE GRAPH IS PLOTTED ON THE VT55 GRAPHICS TERMINAL SCREEN.*******
      CALL GRAPH
C*****IF THE OPERATOR DESIRES, PROGRAM EXECUTION IS REPEATED.**********
 4000 TYPE 4001
 4001 FORMAT(/,'$ ARE ANY ADDITIONAL PLOTS WANTED(Y/N)? ')
      ACCEPT 4002,IF1
 4002 FORMAT(A1)
      IF(IF1.NE.1HY.AND.IF1.NE.1HN)GOTO 4000
      IF(IF1.EQ.1HY)GOTO 100
      RETURN
      END
```

```
      SUBROUTINE GRAPH
C***********************************************************************
C     OBJECTIVE: TO PLOT GRAPHS OF INPUT DATA AT VARIOUS SCALE
C                EXPANSIONS.
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/E/NAMEOP(400),ID(400)
      COMMON/M/IWAVE(400)
      COMMON/STATUS/ISTAT(16)
      COMMON/LIMITS/ILIMX,ILIMY,IGRIDX,IGRIDY,IDELX,IDELY
      COMMON/MAXMIN/MAXP,MINP.MAXA,MINA,MAXWL,MINWL,XHI,XLO,YHI,YLO
      COMMON/XYCONV/NOPT,INDEX,MX,MY
      COMMON/TITLE/NTITLE(5,30)
C*****THE SCALE EXPANSION IS REQUESTED FROM THE OPERATOR.**************
      TYPE 1
    1 FORMAT(/,'$ HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE
     C X-COORDINATE(I2)? ')
      ACCEPT 2,IGRIDX
    2 FORMAT(I2)
      TYPE 3
    3 FORMAT(/,'$ HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE
     C Y-COORDINATE(I2)? ')
      ACCEPT 2,IGRIDY
C*****THE OPERATOR DETERMINES IF THE GRAPH IS TO BE LABELED.***********
    4 TYPE 5
    5 FORMAT(/,'$ IS THE GRAPH TO BE LABELED(Y/N)? ')
      ACCEPT 6,ILABEL
    6 FORMAT(A1)
      IF(ILABEL.NE.1HY.AND.ILABEL.NE.1HN)GOTO 4
C*****THE VT55 GRAPHICS TERMINAL SCREEN IS CLEARED OF ALL GRAPHICS,ETC.
      CALL WIPE
C*****THE DESIRED PLOT55 FUNCTIONS ARE ENABLED; I.E., VERTICAL AND ****
C     HORIZONTAL LINES, POINT PLOTTING, AND FIGURES 1 AND 2.
      CALL PLOT55(2,2+4+32+64,,ISTAT)
C*****SCREEN LIMITS ARRE SET AND PARAMETERS CONTROLLING GRID MESH *****
C     SIZE COMPUTED IN ACCORDANCE WITH OPERATOR INPUT.
      ILIMX=511
      ILIMY=235
      IDELX=ILIMX/IGRIDX
      IDELY=ILIMY/IGRIDY
C*****THE GRID IS DISPLAYED ON THE SCREEN.*****************************
      CALL GRID
C*****IF DESIRED BY THE OPERATOR, THE GRAPH IS LABELED.****************
      IF(ILABEL.EQ.1HN)GOTO 10
      INDEX=1
      CALL XYCONV
      CALL LABEL
   10 CONTINUE
```

```
C*****POINTS ARE PLOTTED ON THE SCREEN AS FIGURES 1 AND 2. THIS *******
C     IS NECESSARY SINCE ONLY ONE Y-VALUE CAN BE PLOTTED FOR A
C     GIVEN X-VALUE ON A GIVEN FIGURE.  TO PROVIDE FOR THE CASE
C     WHERE ONE X-VALUE MIGHT HAVE TWO Y-VALUES ASSOCIATED WITH
C     IT(FOR EXAMPLE PSI-DELTA PLOTS) IT IS NECESSARY TO DISTRIBUTE
C*****THE DATA POINTS BETWEEN FIGURES 1 AND 2.************************
      DO 21 I=1,200
      INDEX=(I-1)*2+1
      CALL XYCONV
      IF(MX.GT.ILIMX.OR.MY.GT.ILIMY)GOTO 20
      IF(MX.LT.0.OR.MY.LT.0)GOTO 20
      CALL PLOT55(1,0,,ISTAT)
      CALL PLOT55(3,MX,MY,ISTAT)
   20 CONTINUE
      INDEX=I*2
      CALL XYCONV
      IF(MX.GT.ILIMX.OR.MY.GT.ILIMY)GOTO 21
      IF(MX.LT.0.OR.MY.LT.0)GOTO 21
      CALL PLOT55(2,0,,ISTAT)
      CALL PLOT55(3,MX,MY,ISTAT)
   21 CONTINUE
C*****THE GRAPH IS DISPLAYED ON THE VT55 SCREEN UNTIL THE OPERATOR ****
C     DEPRESSES THE "RETURN" KEY.
      ACCEPT 30,IWAIT
   30 FORMAT(A1)
C*****THE VT55 SCREEN IS AGAIN CLEARED OF ALL GRAPHICS AND CHARACTERS *
      CALL WIPE
      RETURN
      END
```

```
      SUBROUTINE XYCONV
C*****************************************************************
C     OBJECTIVE: TO SCALE(NORMALIZE) DATA POINTS FOR DISPLAY ON GRAPH.
C*****************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/M/IWAVE(400)
      COMMON/LIMITS/ILIMX,ILIMY,IGRIDX,IGRIDY,IDELX,IDELY
      COMMON/MAXMIN/MAXP,MINP,MAXA,MINA,MAXWL,MINWL,XHI,XLO,YHI,YLO
      COMMON/XYCONV/NOPT,INDEX,MX,MY
      COMMON/MODE/MODE0,MODE1,FACTOR
      IF(NOPT.EQ.1)GOTO 1
      IF(NOPT.EQ.2)GOTO 2
      IF(NOPT.EQ.3)GOTO 3
      IF(NOPT.EQ.4)GOTO 4
      IF(NOPT.EQ.5)GOTO 5
      GOTO 6
    1 XLO=0.
      XHI=400.
      YLO=MINP/FACTOR
      YHI=MAXP/FACTOR
      X=INDEX
      Y=POL(INDEX)/FACTOR
      GOTO 6
    2 XLO=0.
      XHI=400.
      YLO=MINA/FACTOR
      YHI=MAXA/FACTOR
      X=INDEX
      Y=ANA(INDEX)/FACTOR
      GOTO 6
    3 XLO=MINWL
      XHI=MAXWL
      YLO=MINP/FACTOR
      YHI=MAXP/FACTOR
      X=IWAVE(INDEX)
      Y=POL(INDEX)/FACTOR
      GOTO 6
    4 XLO=MINWL
      XHI=MAXWL
      YLO=MINA/FACTOR
      YHI=MAXA/FACTOR
      X=IWAVE(INDEX)
      Y=ANA(INDEX)/FACTOR
      GOTO 6
    5 XLO=MINP/FACTOR
      XHI=MAXP/FACTOR
      YLO=MINA/FACTOR
      YHI=MAXA/FACTOR
      X=POL(INDEX)/FACTOR
      Y=ANA(INDEX)/FACTOR
    6 CONTINUE
      X=(X-XLO)/(XHI-XLO)
      Y=(Y-YLO)/(YHI-YLO)
      MX=X*ILIMX
      MY=Y*ILIMY
      RETURN
      END
```

```
      SUBROUTINE TITLE
C***********************************************************************
C     OBJECTIVE: TO READ THE TITLES USED TO LABEL THE GRAPHICS
C                GENERATED BY SUBROUTINE "PLOT"; THE INFORMATION
C                READ HERE IS ACTUALLY USED IN "PLOT" AND "LABEL".
C                THE FILE READ IS "DY1:TITLE.DAT".  IN ADDITION
C                TO THE GRAPHICS TITLES, A GRAPHICS MODE FLAG
C                "MODE1" AND A DATA NORMALIZATION FACTOR "FACTOR"
C                ARE READ.
C***********************************************************************
      COMMON/TITLE/NTITLE(5,30),NWORD(2,21)
      COMMON/MODE/MODE0,MODE1,FACTOR
C*****TITLES FOR GRAPHS TO BE PLOTTED ARE READ FROM "DY1:TITLE.DAT"****
      OPEN(UNIT=1,NAME='DY1:TITLE.DAT',TYPE='OLD')
      DO 6 IMODE=1,5
      DO 1 I=1,5
    1 READ(1,2)(NTITLE(I,J),J=1,30)
    2 FORMAT(30A2)
      DO 3 I=1,2
    3 READ(1,4)(NWORD(I,J),J=1,21)
    4 FORMAT(21A1)
      READ(1,5)MODE1,FACTOR
    5 FORMAT(I1,1X,F4.0)
      IF(MODE1.EQ.MODE0)GOTO 100
    6 CONTINUE
  100 CONTINUE
      CLOSE(UNIT=1,DISPOSE='SAVE')
      RETURN
      END
```

```
      SUBROUTINE WIPE
C***********************************************************************
C     OBJECTIVE: TO CLEAR ALL GRAPHICS AND CHARACTERS FROM THE VT55
C                GRAPHICS TERMINAL SCREEN.
C***********************************************************************
      COMMON/STATUS/ISTAT(16)
      DO 1 I=1,16
    1 ISTAT(I)=0
      CALL PLOT55(13,72,,ISTAT)
      CALL PLOT55(13,74,,ISTAT)
      CALL PLOT55(2,1+512,,ISTAT)
      RETURN
      END
```

```
      SUBROUTINE GRID
C***********************************************************************
C     OBJECTIVE: DISPLAY A GRID AS BACKGROUND FOR THE GRAPHIC DISPLAY
C                OF PLOTTED ELLIPSOMETER DATA ON THE VT55 SCREEN.
C***********************************************************************
      COMMON/STATUS/ISTAT(16)
      COMMON/LIMITS/ILIMX,ILIMY,IGRIDX,IGRIDY,IDELX,IDELY
      CALL PLOT55(5,0,1,ISTAT)
      CALL PLOT55(4,1,0,ISTAT)
      DO 1 I=IDELX,ILIMX,IDELX
    1 CALL PLOT55(5,I,1,ISTAT)
      DO 2 I=IDELY,ILIMY,IDELY
    2 CALL PLOT55(4,1,I,ISTAT)
      RETURN
      END
```

```
      SUBROUTINE LABEL
C***********************************************************************
C     OBJECTIVE: TO LABEL THE GRAPH WITH A TITLE, EXPERIMENTAL INFOR-
C                MATION, THE COORDINATES OF THE ORIGIN, AND THE SCALE
C                ALONG THE X AND Y AXES.
C***********************************************************************
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/STATUS/ISTAT(16)
      COMMON/LIMITS/ILIMX,ILIMY,IGRIDX,IGRIDY,IDELX,IDELY
      COMMON/MAXMIN/MAXP,MINP,MAXA,MINA,MAXWL,MINWL,XHI,XLO,YHI,YLO
      COMMON/XYCONV/NOPT,INDEX,MX,MY
      COMMON/TITLE/NTITLE(5,30)
      TYPE 1,(NTITLE(NOPT,I),I=1,30)
    1 FORMAT(12X,30A2)
      TYPE 2,(NAMEOP(I),I=1,20)
      TYPE 2,(ID(I),I=1,20)
    2 FORMAT(/40X,20A2)
      TYPE 3,XLO,YLO
    3 FORMAT(/40X,'ORIGIN: X = ',F9.3,4X,'Y = ',F9.3)
      XDIV=(XHI-XLO)/IGRIDX
      YDIV=(YHI-YLO)/IGRIDY
      TYPE 4,XDIV,YDIV
    4 FORMAT( 40X,'SCALE:  X = ',F9.3,4X,'Y = ',F9.3)
      RETURN
      END
```

```
      SUBROUTINE LINE
C***********************************************************************
C     OBJECTIVE: DISPLAY A VECTOR ON THE VT55 SCREEN WITH ITS TAIL AT
C                THE POINT (LOX,LOY) AND ITS TIP AT THE POINT (LFX,LFY).
C***********************************************************************
      COMMON/STATUS/ISTAT(16)
      COMMON/VECTOR/LOX,LOY,LFX,LFY
      CALL PLOT55(7,LOX,LOY,ISTAT)
      CALL PLOT55(8,LFX,LFY,ISTAT)
      RETURN
      END
```

```
      SUBROUTINE MAXMIN
C***********************************************************************
C     OBJECTIVE: TO DETERMINE THE MAXIMUM AND MINIMUM VALUES OF THE
C                ARRAYS TO BE PLOTTED SO THAT THE SCALES CAN BE SET
C                AUTOMATICALLY BY THE SOFTWARE.  HOWEVER, THE OPERA-
C                TOR HAS THE OPTION OF CHANGING THESE AUTOMATICALLY
C                SET VALUES.
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/M/IWAVE(400)
      COMMON/MAXMIN/MAXP,MINP,MAXA,MINA,MAXWL,MINWL,XHI,XLO,YHI,YLO
      MAXWL=IWAVE(1)
      MINWL=IWAVE(1)
      MAXP =POL(1)
      MINP =POL(1)
      MAXA =ANA(1)
      MINA =ANA(1)
      DO 1 I=2,400
      IF(MAXWL.LT.IWAVE(I))MAXWL=IWAVE(I)
      IF(MINWL.GT.IWAVE(I))MINWL=IWAVE(I)
      IF(MAXP.LT.POL(I))MAXP=POL(I)
      IF(MINP.GT.POL(I))MINP=POL(I)
      IF(MAXA.LT.ANA(I))MAXA=ANA(I)
      IF(MINA.GT.ANA(I))MINA=ANA(I)
    1 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PLOT
      COMMON/ARRAY/X(400),Y(400),INDEX
      COMMON/LIMITS/ILIMX,ILIMY,IGRIDX,IGRIDY,IDELX,IDELY
      COMMON/STATUS/ISTAT(16)
      XLO=X(1)
      XHI=X(1)
      YLO=Y(1)
      YHI=Y(1)
      DO 10 I=2,INDEX
      IF(XLO.GT.X(I))XLO=X(I)
      IF(XHI.LT.X(I))XHI=X(I)
      IF(YLO.GT.Y(I))YLO=Y(I)
      IF(YHI.LT.Y(I))YHI=Y(I)
   10 CONTINUE
      TYPE 1000,XLO,XHI,YLO,YHI
 1000 FORMAT(/,5X,'XLO = ',E14.6,5X,'XHI = ',E14.6,
     1       /,5X,'YLO = ',E14.6,5X,'YHI = ',E14.6)
   20 TYPE 1001
 1001 FORMAT(/,'$ DO YOU WANT TO CHANGE THESE(Y/N)? ')
      ACCEPT 1002,IF1
 1002 FORMAT(A1)
      IF(IF1.NE.1HY.AND.IF1.NE.1HN)GOTO 20
      IF(IF1.EQ.1HN)GOTO 30
      TYPE 1003
 1003 FORMAT(/,'$ XLO = ')
      ACCEPT 1004,XLO
 1004 FORMAT(F10.3)
      TYPE 1005
 1005 FORMAT(/,'$ XHI = ')
      ACCEPT 1004,XHI
      TYPE 1006
 1006 FORMAT(/,'$ YLO = ')
      ACCEPT 1004,YLO
      TYPE 1007
 1007 FORMAT(/,'$ YHI = ')
      ACCEPT 1004,YHI
   30 CONTINUE
      DO 40 I=1,INDEX
      X(I)=(X(I)-XLO)/(XHI-XLO)
   40 Y(I)=(Y(I)-YLO)/(YHI-YLO)
      TYPE 1008
 1008 FORMAT(/,'$ HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE
     1 X-AXIS? ')
      ACCEPT 1009,IGRIDX
 1009 FORMAT(I2)
      TYPE 1010
 1010 FORMAT(/,'$ HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE
     1 Y-AXIS? ')
      ACCEPT 1009,IGRIDY
```

```
      CALL WIPE
      CALL PLOT55(2,2+4+32+64,,ISTAT)
      ILIMX=511
      ILIMY=235
      IDELX=ILIMX/IGRIDX
      IDELY=ILIMY/IGRIDY
      CALL GRID
      M=INDEX/2
      DO 50 I=1,M
      I1=(I-1)*2+1
      MX=X(I1)*ILIMX
      MY=Y(I1)*ILIMY
      CALL PLOT55(1,0,,ISTAT)
      CALL PLOT55(3,MX,MY,ISTAT)
      I2=I*2
      MX=X(I2)*ILIMX
      MY=Y(I2)*ILIMY
      CALL PLOT55(2,0,,ISTAT)
      CALL PLOT55(3,MX,MY,ISTAT)
   50 CONTINUE
      TYPE 1000,XLO,XHI,YLO,YHI
      ACCEPT 1011,IWAIT
 1011 FORMAT(A1)
      CALL WIPE
      RETURN
      END

      SUBROUTINE WIPE
      COMMON/STATUS/ISTAT(16)
      DO 1 I=1,16
    1 ISTAT(I)=0
      CALL PLOT55(13,72,,ISTAT)
      CALL PLOT55(13,74,,ISTAT)
      CALL PLOT55(2,1+512,,ISTAT)
      RETURN
      END

      SUBROUTINE GRID
      COMMON/STATUS/ISTAT(16)
      COMMON/LIMITS/ILIMX,ILIMY,IGRIDX,IGRIDY,IDELX,IDELY
      CALL PLOT55(5,0,1,ISTAT)
      CALL PLOT55(4,1,0,ISTAT)
      DO 1 I=IDELX,ILIMX,IDELX
    1 CALL PLOT55(5,I,1,ISTAT)
      DO 2 I=IDELY,ILIMY,IDELY
    2 CALL PLOT55(4,1,I,ISTAT)
      RETURN
      END
```

```
      SUBROUTINE OUTPUT
C***********************************************************************
C     OBJECTIVE: TO WRITE THE SETUP INFORMATION AND DATA FROM THE
C                SPECTRAL SCAN INTO ANY FLOPPY DISK FILE SPECIFIED
C                BY THE OPERATOR.
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      REAL*4 DBLK(2),NAME(20)
      IBLOCK=0
      TYPE 100
  100 FORMAT(/,'$ FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = ')
      ACCEPT 200,(NAME(I),I=1,3)
  200 FORMAT(3A4)
      N=IRAD50(12,NAME,DBLK)
      ICHAN=IGETC(0)
      IF(ICHAN.LT.0)STOP 'CANNOT ALLOCATE CHANNEL'
      IERROR=IENTER(ICHAN,DBLK,0)
      IF(IERROR.LT.0)STOP 'ENTER FAILURE'
      DO 10 I=1,256
   10 IBUFF(I)=0
      DO 20 I=1,20
      IBUFF(I)=NAMEOP(I)
   20 IBUFF(20+I)=ID(I)
      IBUFF(41)=LMPTYP
      DO 30 I=1,9
   30 IBUFF(41+I)=LMPSER(I)
```

```
      IBUFF(51)=LMPVLT
      IBUFF(52)=LMPAMP
      IBUFF(54)=IPHASP
      IBUFF(55)=IGAINP
      IBUFF(56)=IAMPLP
      IBUFF(57)=ITIMEP
      IBUFF(58)=IPHASA
      IBUFF(59)=IGAINA
      IBUFF(60)=IAMPLA
      IBUFF(61)=ITIMEA
      IBUFF(62)=IGAGP
      IBUFF(63)=IGATP
      IBUFF(64)=IGAGA
      IBUFF(65)=IGATA
      IBUFF(66)=NRATE
      IBUFF(67)=NSCAN
      IBUFF(68)=IPOL
      IBUFF(69)=IANA
      IBUFF(70)=NWL
      IBUFF(71)=NPOL
      IBUFF(72)=NCMP
      IBUFF(73)=NANA
      IBUFF(74)=IHRSO
      IBUFF(75)=IHRSF
      IBUFF(76)=IMINO
      IBUFF(77)=IMINF
      IBUFF(78)=ISECO
      IBUFF(79)=ISECF
      IBUFF(80)=ITICO
      IBUFF(81)=ITICF
      IBUFF(82)=IDAY
      IBUFF(83)=IYRS
      IBUFF(84)=LMPHRS
      IBUFF(85)=IMON(1)
      IBUFF(86)=IMON(2)
      IBUFF(87)=IMON(3)
      DO 35 I=1,10
   35 IBUFF(87+I)=IPMTYP(I)
      IBUFF(98)=IPMTDV
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 40 I=1,200
   40 IBUFF(I)=POL(I)
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 50 I=1,200
   50 IBUFF(I)=ANA(I)
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 60 I=1,200
   60 IBUFF(I)=POL(I+200)
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 70 I=1,200
   70 IBUFF(I)=ANA(I+200)
      CALL WRITE
      CALL IWAIT(ICHAN)
      CALL CLOSEC(ICHAN)
      CALL IFREEC(ICHAN)
      RETURN
      END
```

```
      SUBROUTINE WRITE
C*************************************************************************
C     OBJECTIVE: THIS SUBROUTINE ACTUALLY WRITES THE DATA STORED IN THE
C                BUFFER MEMORY TO THE SPECIFIED DISK FILE.
C*************************************************************************
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      EXTERNAL FINISH
      IERROR=IWRITF(256,IBUFF,IBLOCK,ICHAN,IAREA,FINISH)
      IF(IERROR.LT.0)STOP 'FATAL WRITE'
      IBLOCK=IBLOCK+1
      RETURN
      END



      SUBROUTINE FINISH
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      IFLAG=IFLAG-1
      RETURN
      END
```

Appendix 16.

Demonstration of RECALL - recalling spectroscopic ellipsometry data file

```
PLOT01.SAV    69 30-Sep-81     SCAN  .SAV    18 13-Feb-81
RECALL.SAV    83 27-May-82     SEV002.SAV    86 23-Oct-81
RISURF.SAV    80 16-Apr-81     MINUS .SAV    40 17-Jun-81
WLBOND.NEW     1 28-Oct-81     WLCONT.OLD     1 10-Apr-81
DSCONV.SAV    90 27-May-82
 33 Files, 974 Blocks
 0 Free blocks
```

........end of directory of DY0: after DIR DY0: command

```
.RUN DY0:RECALL
```

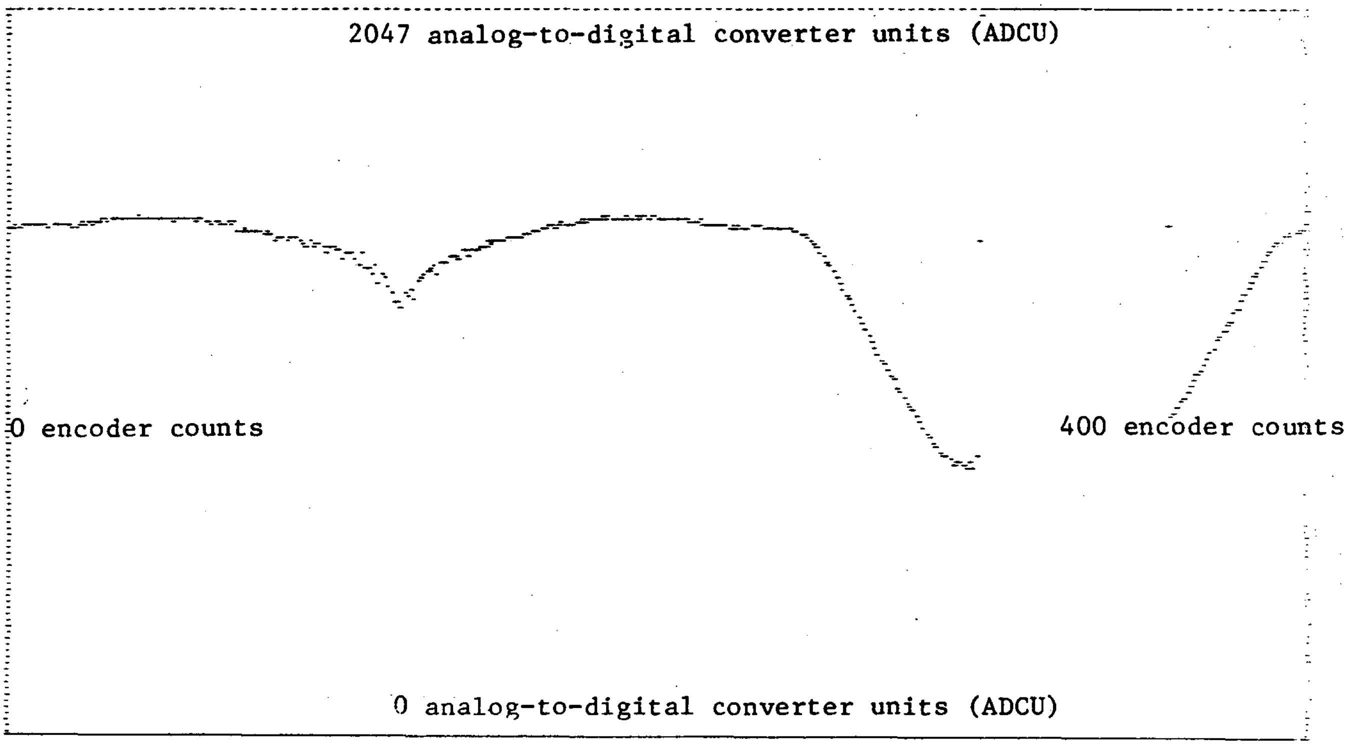
........running RECALL

```
 DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

 OUTPUT MODE: (1)RAW DATA
              (2)PSI/DELTA
              (3)COMPLEX REFRACTIVE INDEX
              (4)VERDET COEFFICIENTS

 YOUR CHOICE: 1

 INSERT THE DISK WITH THE DATA TO BE OUTPUT, THEN 'RETURN'.

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1TEFLON183

 DO YOU WANT TO PLOT THE DATA(Y/N)? Y


        RANGES OF DATA TO BE PLOTTED:
             MAXIMUM WAVELENGTH(ANGSTROMS) =        7390
             MINIMUM                       =        3627
             MAXIMUM POLARIZER CURRENT     =    2047.000
             MINIMUM                       =       0.000
             MAXIMUM ANALYZER CURRENT      =    2047.000
             MINIMUM                       =       0.000

 DO YOU WANT TO CHANGE THESE(Y/N)? N

        PLOTTING MENU FOR REFRACTIVE INDEX DATA:
             (1) POLARIZER CURRENT(ADCU,Y-AXIS) VS ENCODER COUNT(X-AXIS)
             (2) ANALYZER CURRENT(ADCU,Y-AXIS) VS ENCODER COUNT(X-AXIS)
             (3) POLARIZER CURRENT(ADCU,Y-AXIS) VS WAVELENGTH(X-AXIS)
             (4) ANALYZER CURRENT(ADCU,Y-AXIS) VS WAVELENGTH(X-AXIS)
             (5) ANALYZER CURRENT(Y-AXIS) VS POLARIZER CURRENT(X-AXIS)

 YOUR CHOICE(1,2,3,4,OR 5)? 1

 HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE X-COORDINATE(I2)? 1

 HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE Y-COORDINATE(I2)? 1

 IS THE GRAPH TO BE LABELED(Y/N)? N
```

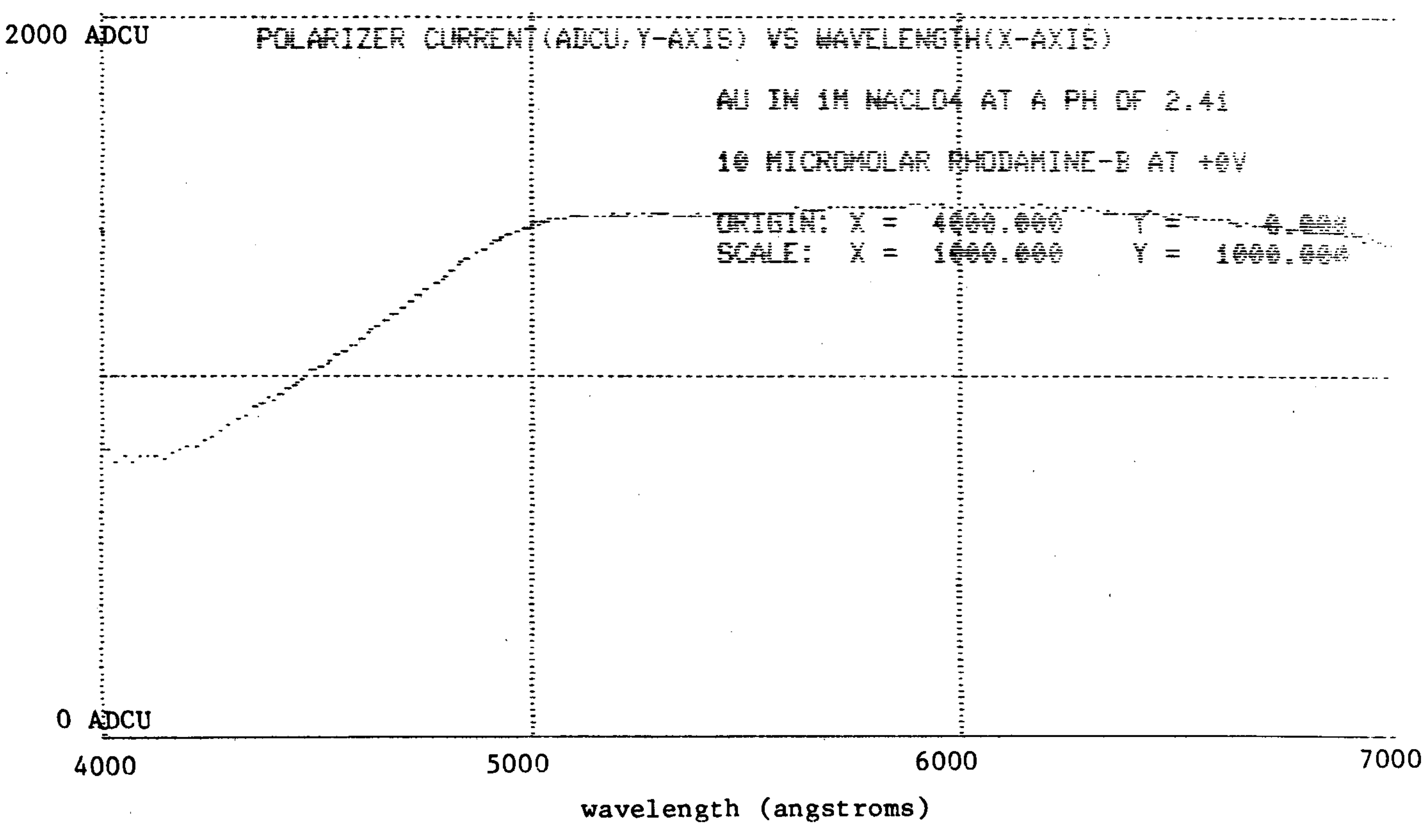
Appendix 16 (continued).

```
DO YOU WANT TO CHANGE THESE(Y/N)? Y

MAXIMUM WAVELENGTH(I5/ANGSTROMS)        = 7000
MINIMUM                                 = 4000

MAXIMUM POLARIZER CURRENT      (F10.3) = 2000.
MINIMUM                                 = 0.

MAXIMUM ANALYZER CURRENT       (F10.3) = 2000.
MINIMUM                                 = 0.

        RANGES OF DATA TO BE PLOTTED:
             MAXIMUM WAVELENGTH(ANGSTROMS) =        7000
             MINIMUM                       =        4000
             MAXIMUM POLARIZER CURRENT     =    2000.000
             MINIMUM                       =       0.000
             MAXIMUM ANALYZER CURRENT      =    2000.000
             MINIMUM                       =       0.000

DO YOU WANT TO CHANGE THESE(Y/N)? N

        PLOTTING MENU FOR REFRACTIVE INDEX DATA:
             (1) POLARIZER CURRENT(ADCU,Y-AXIS) VS ENCODER COUNT(X-AXIS)
```

```
RANGES OF DATA TO BE PLOTTED:
     MAXIMUM WAVELENGTH(ANGSTROMS) =       7390
     MINIMUM                       =       3627
     MAXIMUM POLARIZER CURRENT     =   2047.000
     MINIMUM                       =      0.000
     MAXIMUM ANALYZER CURRENT      =   2047.000
     MINIMUM                       =      0.000

DO YOU WANT TO CHANGE THESE(Y/N)? N

       PLOTTING MENU FOR REFRACTIVE INDEX DATA:
     (1) POLARIZER CURRENT(ADCU,Y-AXIS) VS ENCODER COUNT(X-AXIS)
     (2) ANALYZER CURRENT(ADCU,Y-AXIS) VS ENCODER COUNT(X-AXIS)
     (3) POLARIZER CURRENT(ADCU,Y-AXIS) VS WAVELENGTH(X-AXIS)
     (4) ANALYZER CURRENT(ADCU,Y-AXIS) VS WAVELENGTH(X-AXIS)
     (5) ANALYZER CURRENT(Y-AXIS) VS POLARIZER CURRENT(X-AXIS)

YOUR CHOICE(1,2,3,4,OR 5)? 1

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE X-COORDINATE(I2)? 1

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE Y-COORDINATE(I2)? 1

IS THE GRAPH TO BE LABELED(Y/N)? N
```



```
RANGES OF DATA TO BE PLOTTED:
     MAXIMUM WAVELENGTH(ANGSTROMS) =        7000
     MINIMUM                       =        4000
     MAXIMUM POLARIZER CURRENT     =    2000.000
     MINIMUM                       =       0.000
     MAXIMUM ANALYZER CURRENT      =    2000.000
     MINIMUM                       =       0.000

DO YOU WANT TO CHANGE THESE(Y/N)? N

     PLOTTING MENU FOR REFRACTIVE INDEX DATA:
          (1) POLARIZER CURRENT(ADCU,Y-AXIS) VS ENCODER COUNT(X-AXIS)
          (2) ANALYZER CURRENT(ADCU,Y-AXIS) VS ENCODER COUNT(X-AXIS)
          (3) POLARIZER CURRENT(ADCU,Y-AXIS) VS WAVELENGTH(X-AXIS)
          (4) ANALYZER CURRENT(ADCU,Y-AXIS) VS WAVELENGTH(X-AXIS)
          (5) ANALYZER CURRENT(Y-AXIS) VS POLARIZER CURRENT(X-AXIS)

YOUR CHOICE(1,2,3,4,OR 5)? 3

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE X-COORDINATE(I2)? 3

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE Y-COORDINATE(I2)? 2

IS THE GRAPH TO BE LABELED(Y/N)? Y
```



```
ARE ANY ADDITIONAL PLOTS WANTED(Y/N)? N

OUTPUT MENU:  (A) HARDCOPY
              (B) CRT DISPLAY
              (C) NEITHER

YOUR CHOICE: B

       18-JUL-82
       AU IN 1M NACLO4 AT A
        PH OF 2.41
       10 MICROMOLAR RHODAMINE-B AT +0V

       MANUAL AZIMUTHS(DEG):

         P =   85.00
         A =   38.00
         C =  135.00
         WL=  120.00

       LAMP:

         TYPE        = XE


         SERIAL NO. = XE-W75 B12-17
         LAMP VOLTAGE(VOLTS) =   15
         LAMP CURRENT(AMPS)  =   6
         LAMP OPERATIONAL LIFE(HOURS) =    10

       PHOTOMULTIPLIER:

         MODEL = HAMAMATSU R928
         DYNODE VOLTAGE(VOLTS) =  1100

       FARADAY CELL CONTROLLER:

         POLARIZER

         PHASE              =  908
         GAIN               =  200
         AMPLITUDE          =   -2
         TIME CONSTANT(MS)  =    1

         ANALYZER

         PHASE              =  830
         GAIN               = 1000
         AMPLITUDE          =    0
```

Appendix 16 (continued).

TIME CONSTANT(MS) = 1

GALVANOMETER AMPLIFIER:

POLARIZER

GAIN = 10
TIME CONSTANT(MS) = 1

ANALYZER

GAIN = 10
TIME CONSTANT(MS) = 1

ANALOG/DIGITAL CONVERTOR:

POL. INPUT CH. = 0
ANA. INPUT CH. = 1
ADC GAIN = 3

THE NUMBER OF SPECTRA AVERAGED = 1
MEASURED SCAN RATE VIA COUNTER = 147

DATA COLLECTION INITIATED AT: 0: 0: 0: 0

DATA COLLECTION FINISHED AT: 1:16:12:41

POLARIZER AND ANALYZER CURRENT(ADCU) AS A FUNCTION OF WAVELENGTH

I = 1	WL = 5155	POLARIZER = 1441.0000	ANALYZER = 741.0000
I = 2	WL = 5174	POLARIZER = 1442.0000	ANALYZER = 748.0000
I = 3	WL = 5193	POLARIZER = 1448.0000	ANALYZER = 745.0000
I = 4	WL = 5212	POLARIZER = 1444.0000	ANALYZER = 754.0000
I = 5	WL = 5230	POLARIZER = 1449.0000	ANALYZER = 761.0000
I = 6	WL = 5249	POLARIZER = 1446.0000	ANALYZER = 764.0000
I = 7	WL = 5268	POLARIZER = 1448.0000	ANALYZER = 771.0000
I = 8	WL = 5286	POLARIZER = 1449.0000	ANALYZER = 784.0000
I = 9	WL = 5305	POLARIZER = 1447.0000	ANALYZER = 788.0000
I = 10	WL = 5324	POLARIZER = 1447.0000	ANALYZER = 797.0000
I = 11	WL = 5343	POLARIZER = 1447.0000	ANALYZER = 807.0000
I = 12	WL = 5361	POLARIZER = 1446.0000	ANALYZER = 810.0000
I = 13	WL = 5380	POLARIZER = 1445.0000	ANALYZER = 817.0000
I = 14	WL = 5399	POLARIZER = 1445.0000	ANALYZER = 839.0000
I = 15	WL = 5418	POLARIZER = 1448.0000	ANALYZER = 846.0000
I = 16	WL = 5436	POLARIZER = 1447.0000	ANALYZER = 857.0000
I = 17	WL = 5455	POLARIZER = 1449.0000	ANALYZER = 875.0000
I = 18	WL = 5474	POLARIZER = 1450.0000	ANALYZER = 890.0000
I = 19	WL = 5493	POLARIZER = 1451.0000	ANALYZER = 899.0000

Appendix 16 (continued).

Listing of RECALL

```
      PROGRAM RECALL
C***********************************************************************
C     OBJECTIVE: TO RECALL ANY DATA FILE(SPECTRA) AND OUTPUT THE
C                INFORMATION IN NUMERIC AND/OR GRAPHIC FORM.
C
C     PROGRAM WRITTEN BY JOSEPH C. FARMER IN SPRING 1981 AT LBL-MMRD
C
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOF(20),ID(20)
      COMMON/F/LMPTTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/QBRIEF/ASLOPE(400),PSLOPE(400)
      COMMON/TITLE/NTITLE(5,30),NWORD(2,21)
      COMMON/MODE/MODEO,MODE1,FACTOR
      DIMENSION ALPHA(35),PWORD(5),AWORD(5)
      NPASS=1
C*****THE ENCODER COUNT IS CONVERTED TO TO WAVELENGTH BY "WLCALC".*****
      CALL WLCALC
C*****THE OUTPUT MODE FOR "RECALL" IS SELECTED BY THE OPERATOR.********
      TYPE 1002
    1 TYPE 1003
      ACCEPT 1004,MODEO
      IF(MODEO.LT.1.OR.MODEO.GT.4)GOTO 1
C*****TITLES FOR LABELING GRAPHICS ARE READ FROM "DY1:TITLE.DAT".******
      CALL TITLE
C*****THE NUMERIC OUTPUT COLUMN HEADINGS ARE READ FROM "DY1.RECALL.DAT"
      OPEN(UNIT=1,NAME='DY1:RECALL.DAT',TYPE='OLD')
      DO 2 J=1,4
      READ(1,1005)(ALPHA(I),I=1,35)
      READ(1,1006)(PWORD(JP),JP=1,5),(AWORD(JA),JA=1,5)
      READ(1,1007)MODE1
      IF(MODE1.EQ.MODEO)GOTO 100
    2 CONTINUE
  100 CONTINUE
      CLOSE(UNIT=1,DISPOSE='SAVE')
  200 CONTINUE
      IF(NPASS.EQ.1)GOTO 220
      TYPE 1002
  210 TYPE 1003
      ACCEPT 1004,MODEO
  220 CONTINUE
      IF(MODEO.LT.1.OR.MODEO.GT.4)GOTO 210
      IF(MODEO.NE.4)GOTO 3
```

```
C*****THE FARADAY CELL CALIBRATION DATA IS OBTAINED.*******************
      TYPE 1000
      TYPE 1008
      ACCEPT 1001,IWAIT
      CALL FCREAD
      DO 300 I=1,400
      POL(I)=PSLOPE(I)
  300 ANA(I)=ASLOPE(I)
      GOTO 4
C*****RAW SPECTRAL SCAN DATA IS OBTAINED FROM THE FLOPPY DISK.*********
    3 TYPE 1009
      ACCEPT 1001,IWAIT
      CALL INPUT
    4 CONTINUE
C*****IF DESIRED BY THE OPERATOR, THE DATA IS PLOTTED.*****************
   10 TYPE 1011
      ACCEPT 1001,IF1
      IF(IF1.NE.1HY.AND.IF1.NE.1HN)GOTO 10
      IF(IF1.EQ.1HN)GOTO 20
      CALL PLOT
   20 CONTINUE
      DO 40 I=1,400
      POL(I)=POL(I)/FACTOR
   40 ANA(I)=ANA(I)/FACTOR
C*****THE NUMERICAL OUTPUT MODE IS SELECTED.***************************
      TYPE 1012
   50 TYPE 1013
      ACCEPT 1001,IF4
      IF(IF4.NE.1HA.AND.IF4.NE.1HB.AND.IF4.NE.1HC)GOTO 50
      IF(IF4.EQ.1HC)GOTO 70
      IF(IF4.NE.1HA)GOTO 60
C*****NUMERICAL DATA IS PRINTED ON THE MODEL 41 TELETYPE.**************
      TYPE 1020
      ACCEPT 1001,IWAIT
      CALL P1INFO
      CALL P1TIME
      DO 56 IPAGE=1,4
      J=IPAGE-1
      PRINT 1014,(ALPHA(ICHAR),ICHAR=1,35),IPAGE
      PRINT 1015,(PWORD(JP),JP=1,5),(AWORD(JA),JA=1,5)
     C           ,(PWORD(JP),JP=1,5),(AWORD(JA),JA=1,5)
      DO 55 I=1,50
      I1=J*100+I
      I2=I1+50
   55 PRINT 1016,I1,IWAVE(I1),POL(I1),ANA(I1),I2,IWAVE(I2),POL(I2),
     CANA(I2)
   56 PRINT 1021
   60 CONTINUE
      IF(IF4.NE.1HB)GOTO 70
```

```
C*****NUMERICAL DATA IS DISPLAYED ON THE VT55 TERMINAL SCREEN.*********
      CALL T1INFO
      CALL T1TIME
      TYPE 1017,(ALPHA(ICHAR),ICHAR=1,35)
      DO 65 I=1,400
   65 TYPE 1018,I,IWAVE(I),(PWORD(JP),JP=1,5),POL(I)
     C,(AWORD(JA),JA=1,5),ANA(I)
   70 CONTINUE
C*****DEPENDING UPON OPERATOR RESPONSE, THE PROGRAM IS REPEATED.*******
   80 TYPE 1019
      ACCEPT 1001,IF3
      IF(IF3.NE.1HY.AND.IF3.NE.1HN)GOTO 80
      NPASS=NPASS+1
      IF(IF3.EQ.1HY)GOTO 200
      TYPE 1020
      ACCEPT 1001,IWAIT
 1000 FORMAT(/,'  FOR RT-11, V.4  : DATA DISK READ VIA "DY0:"',/,
     C         '  FOR RT-11, V.3.B: DATA DISK READ VIA "DY1:"')
 1001 FORMAT(A1)
 1002 FORMAT(/,'  OUTPUT MODE: (1)RAW DATA',
     C       /,'               (2)PSI/DELTA',
     C       /,'               (3)COMPLEX REFRACTIVE INDEX',
     C       /,'               (4)VERDET COEFFICIENTS')
 1003 FORMAT(/,'$ YOUR CHOICE: ')
 1004 FORMAT(I1)
 1005 FORMAT(35A2)
 1006 FORMAT(2(5A2,1X))
 1007 FORMAT(I1)
 1008 FORMAT(/,'$ INSERT THE DISK WITH THE FARADAY CELL CALIBRATION
     C DATA, THEN "RETURN".')
 1009 FORMAT(/,'$ INSERT THE DISK WITH THE DATA TO BE OUTPUT,
     C THEN "RETURN".')
 1011 FORMAT(/,'$ DO YOU WANT TO PLOT THE DATA(Y/N)? ')
 1012 FORMAT(/,'  OUTPUT MENU:  (A) HARDCOPY',
     C       /,'                (B) CRT DISPLAY',
     C       /,'                (C) NEITHER')
 1013 FORMAT(/,'$ YOUR CHOICE: ')
 1014 FORMAT(///,10X,35A2,1X,'PAGE ',I1)
 1015 FORMAT(///,5X,2(3X,'INDEX',6X,'WL',3X,5A2,3X,5A2))
 1016 FORMAT(5X,2(5X,I3,3X,I5,3X,F10.4,3X,F10.4))
 1017 FORMAT(//,5X,35A2,/)
 1018 FORMAT(1X,'I = ',I3,5X,'WL = ',I5,5X,5A2,' = ',F10.4,5X,
     C5A2,' = ',F10.4)
 1019 FORMAT(/,'$ IS THE PROGRAM TO BE EXECUTED AGAIN(Y/N)? ')
 1020 FORMAT(/,'$ BE SURE THAT THE SYSTEM VOLUME IS IN "DY0:",
     C THEN "RETURN".')
 1021 FORMAT(///////)
      STOP
      END
```

Appendix 17.

Demonstration of FIXPCA - correction of manual azimuth input parameters

```
RECALL.SAV     83 27-May-82      FIXPCA.FOR      3 05-Jul-82
FIXPCA.OBJ      7 05-Jul-82      FIXPCA.SAV     37 05-Jul-82
 48 Files, 836 Blocks
 138 Free blocks    ...........end of directory of DY0:

.RUN FIXPCA ..................running FIXPCA

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1TEFLON183  ....data file being corrected

 POLARIZER AZIMUTH(DEGREES) = 70.

 ANALYZER  AZIMUTH(DEGREES) = 45.

 RETARDER  AZIMUTH(DEGREES) = 135.

 CVF NULL  AZIMUTH(DEGREES) = 120.

 FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1FIXPCADEM  ....corrected data file

 DO YOU WANT TO CORRECT OTHER SPECTRA(Y/N)? N

STOP --

.


TEFLON.187      5 18-Jul-82      TEFLON.188      5 18-Jul-82
TEFLON.189      5 18-Jul-82      TEFLON.190      5 18-Jul-82
TEFLON.191      5 18-Jul-82      TEFLON.192      5 18-Jul-82
TEFLON.193      5 18-Jul-82      TEFLON.194      5 18-Jul-82
TEFLON.195      5 19-Jul-82      TEFLON.196      5 19-Jul-82
TEFLON.197      5 19-Jul-82      TEFLON.198      5 19-Jul-82
TEFLON.199      5 19-Jul-82      TEFLON.200      5 19-Jul-82
TEFLON.201      5 19-Jul-82      TEFLON.202      5 19-Jul-82
TEFLON.203      5 19-Jul-82      TEFLON.204      5 19-Jul-82
TEFLON.205      5 19-Jul-82      RESULT.203      5 19-Jul-82
CVPBAU.000     13 19-Jul-82      CVPBAU.001     13 19-Jul-82
CVPBAU.002     13 19-Jul-82      CVPBAU.003     13 19-Jul-82
CVPBAU.004     13 19-Jul-82      TRNSLT.DAT      1 09-Nov-81
PLTDAT.DAT     58 19-Jul-82      TEFLON.206      5 19-Jul-82
TEFLON.207      5 19-Jul-82      CVPBAU.005     13 19-Jul-82
CVPBAU.006     13 19-Jul-82      GOLD  .186      5 19-Jan-83
GOLD  .183      5 19-Jan-83      MINUS .186      5 19-Jan-83
GOLD  .188      5 19-Jan-83      MINUS .188      5 19-Jan-83
GOLD  .185      5 19-Jan-83      MINUS .185      5 19-Jan-83
FIXPCA.DEM      5 21-Jan-83
 165 Files, 940 Blocks
 34 Free blocks  ................end of directory of DY1: showing corrected data file
```

Appendix 17 (continued).

Listing of FIXPCA

```
      PROGRAM FIXPCA
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      REAL*4 DBLK(2),NAME(20)
 1000 CALL INPUT
      TYPE 1
    1 FORMAT(/,'$ POLARIZER AZIMUTH(DEGREES) = ')
      ACCEPT 100,XPOL
      TYPE 2
    2 FORMAT(/,'$ ANALYZER  AZIMUTH(DEGREES) = ')
      ACCEPT 100,XANA
      TYPE 3
    3 FORMAT(/,'$ RETARDER  AZIMUTH(DEGREES) = ')
      ACCEPT 100,XCMP
      TYPE 4
    4 FORMAT(/,'$ CVF NULL  AZIMUTH(DEGREES) = ')
      ACCEPT 100,XWL
      NPOL=XPOL*100.
      NANA=XANA*100.
      NCMP=XCMP*100.
      NWL =XWL *100.
      CALL OUTPUT
 2000 TYPE 5
    5 FORMAT(/,'$ DO YOU WANT TO CORRECT OTHER SPECTRA(Y/N)? ')
      ACCEPT 200,IFLAG
      IF(IFLAG.NE.1HY.AND.IFLAG.NE.1HN)GOTO 2000
      IF(IFLAG.EQ.1HY)GOTO 1000
      IF(IFLAG.EQ.1HN)STOP
  100 FORMAT(F10.4)
  200 FORMAT(A1)
      END
```

Appendix 18.

Demonstration of SHIFT - shifting measurements to different encoder counts

```
.RUN DY1:SHIFT

 INSERT DATA DISK - "RETURN".

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1GOLD  183

 JSHIFT = 185
  1        6671.0000        4344.0000        6671.0000        4344.0000
  2        6700.0000        4344.0000        6700.0000        4344.0000
  3        6718.0000        4355.0000        6718.0000        4355.0000
  4        6759.0000        4354.0000        6759.0000        4354.0000
  5        6774.0000        4353.0000        6774.0000        4353.0000
  6        6813.0000        4358.0000        6813.0000        4358.0000
  7        6837.0000        4358.0000        6837.0000        4358.0000
  8        6864.0000        4351.0000        6864.0000        4351.0000
  9        6894.0000        4354.0000        6894.0000        4354.0000
 10        6923.0000        4352.0000        6923.0000        4352.0000
 11        6952.0000        4350.0000        6952.0000        4350.0000
 12        6980.0000        4354.0000        6980.0000        4354.0000
 13        7008.0000        4354.0000        7008.0000        4354.0000
 14        7034.0000        4339.0000        7034.0000        4339.0000
 15        7057.0000        4340.0000        7057.0000        4340.0000
 16        7082.0000        4336.0000        7082.0000        4336.0000
 17        7104.0000        4325.0000        7104.0000        4325.0000


392        6443.0000        4259.0000        7448.0000        4291.0000
393        6447.0000        4263.0000        7429.0000        4294.0000
394        6477.0000        4282.0000        7402.0000        4298.0000
395        6494.0000        4294.0000        7386.0000        4294.0000
396        6519.0000        4303.0000        7371.0000        4299.0000
397        6556.0000        4319.0000        7360.0000        4301.0000
398        6568.0000        4323.0000        7338.0000        4303.0000
399        6598.0000        4333.0000        7311.0000        4300.0000
400       10000.0000        5200.0000        7280.0000        4301.0000

 IS THE SPECTRA TO BE STORED(Y/N)? N

 INSERT DATA DISK - "RETURN".

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1GOLD  185

 JSHIFT = 170
  1        6412.0000        4455.0000        6412.0000        4455.0000
  2        6469.0000        4482.0000        6469.0000        4482.0000
  3        6485.0000        4482.0000        6485.0000        4482.0000
  4        6544.0000        4470.0000        6544.0000        4470.0000
  5        6571.0000        4487.0000        6571.0000        4487.0000
  6        6605.0000        4463.0000        6605.0000        4463.0000
  7        6636.0000        4468.0000        6636.0000        4468.0000
```

Listing of SHIFT

```
      PROGRAM SHIFT
C*************************************************************************
C      OBJECTIVE: TO SHIFT ENCODER CALIBRATION OF SPECTRA BY "JSHIFT"
C
C     BY JOSEPH C. FARMER, DECEMBER 13,1981, LBL-MMRD, UCB.
C
C*************************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      REAL*4 DBLK(2),NAME(20)
      DIMENSION POLO(400),ANAO(400)
    1 FORMAT(I1)
    2 FORMAT(F10.4)
   10 TYPE 100
  100 FORMAT(/,'$ INSERT DATA DISK - "RETURN".')
      ACCEPT 1, IWAIT
      CALL INPUT
      TYPE 150
  150 FORMAT(/,'$ JSHIFT = ')
      ACCEPT 151,JSHIFT
  151 FORMAT(I3)
      DO 200 J=1,400
      POLO(J)=POL(J)
  200 ANAO(J)=ANA(J)
      DO 300 J=1,400
      JTOTAL=J+JSHIFT
      IF(JTOTAL.LE.0  )GOTO 298
      IF(JTOTAL.GT.400)GOTO 299
      ANA(JTOTAL)=ANAO(J)
      POL(JTOTAL)=POLO(J)
      GOTO 300
  298 ANA(JTOTAL+400)=ANAO(J)
      POL(JTOTAL+400)=POLO(J)
      GOTO 300
  299 ANA(JTOTAL-400)=ANAO(J)
      POL(JTOTAL-400)=POLO(J)
  300 TYPE 9999,J,POLO(J),ANAO(J),POL(J),ANA(J)
 9999 FORMAT(1X,I3,4(1X,F15.4))
  700 TYPE 701
  701 FORMAT(/,'$ IS THE SPECTRA TO BE STORED(Y/N)? ')
      ACCEPT 702,IFLAG
  702 FORMAT(A1)
      IF(IFLAG.NE.1HY.AND.IFLAG.NE.1HN)GOTO 700
      IF(IFLAG.NE.1HY)GOTO 10
      CALL OUTPUT
      STOP
      END
```

Appendix 19.

Demonstration of CALFC1 - calibration of Faraday cells at different wavelengths

```
.RUN DY1:CALFC1

 DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? Y


          DIGITAL ENCODER PRESETS:

          CALIBRATION CURVE SEGMENT NUMBER 1:
               SLOPE =     18.0000
               INTERCEPT =     5690.00
               CORRELATION COEFFICIENT =      1.0000

          CALIBRATION CURVE SEGMENT NUMBER 2:
               SLOPE =   -18.0000
               INTERCEPT =     8695.00
               CORRELATION COEFFICIENT =      1.0000

          LIMITS OF APPLICATION:
               UPPER =    282
               LOWER =     78

 DO YOU WANT TO CHANGE THESE(Y/N)? N

 DATA REJECTION LIMIT(ADCU AT SATURATION) = 2000.


 INPUT SPECTRA FOR NULL AT "M=120".

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1CALFC1DAT

 INPUT SPECTRA FOR NULL WITH INCREMENTED POLARIZER AZIMUTH.

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1CALFC2DAT

 INPUT SPECTRA FOR NULL WITH INCREMENTED ANALYZER AZIMUTH.

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1CALFC3DAT

 DO YOU WANT CRT DISPLAY OF THE NUMERIC DATA(Y/N)? N

 "RETURN" FOR PROGRAM CONTINUATION.

          18-MAR-81
          CALIBRATION BY: JOE FARMER
          MIRROR/FC CALIBRATION/ANA. ADJ.

          LAMP:

            TYPE        = XE
            SERIAL NO. = 1A7-19
```

```
 LAMP VOLTAGE(VOLTS) =   15
 LAMP CURRENT(AMPS)  =   6
 LAMP OPERATIONAL LIFE(HOURS) =    17

PHOTOMULTIPLIER:

 MODEL = HAMAMATSU R928
 DYNODE VOLTAGE(VOLTS) =   800

FARADAY CELL CONTROLLER:

 POLARIZER

 PHASE              =  606
 GAIN               =   10
 AMPLITUDE          =  500
 TIME CONSTANT(MS)  =    5

 ANALYZER

 PHASE              =  800
 GAIN               =   10
 AMPLITUDE          =  500
 TIME CONSTANT(MS)  =    5


 PHASE              =  800
 GAIN               =   10
 AMPLITUDE          =  500
 TIME CONSTANT(MS)  =    5

GALVANOMETER AMPLIFIER:

 POLARIZER

 GAIN               =     10
 TIME CONSTANT(MS)  =      1

 ANALYZER

 GAIN               =     10
 TIME CONSTANT(MS)  =      1

ANALOG/DIGITAL CONVERTOR:

 POL. INPUT CH. = 0
 ANA. INPUT CH. = 1
 ADC GAIN       = 3

DO YOU WANT TO CHANGE ANY INFORMATION TO BE OUTPUT WITH FACTORS(Y/N)? N
```

```
      GAIN                =     10
      TIME CONSTANT(MS) =      1

      ANALYZER

      GAIN                =     10
      TIME CONSTANT(MS) =      1

    ANALOG/DIGITAL CONVERTOR:

      POL. INPUT CH. = 0
      ANA. INPUT CH. = 1
      ADC GAIN       = 3

 DO YOU WANT TO CHANGE ANY INFORMATION TO BE OUTPUT WITH FACTORS(Y/N)? N

 DO YOU WANT TO OUTPUT THE RESPONSE FACTORS TO A DISK FILE(Y/N)? Y

 FILE NAME FOR THE NEW FC RESPONSE FACTORS (A12) = DY1FARADYDAT

STOP -- FATAL WRITE ...........not enough storage space on DY1: for DY1FARADYDAT
```

Appendix 19 (continued).

Listing of CALFC1

```
      PROGRAM CALFC1
C***********************************************************************
C     OBJECTIVE: TO RECALL THE THREE OUTPUT FILES GENERATED BY "SEV001"
C                FOR FARADAY CELL CALIBRATION, TO USE THIS INFORMATION
C                TO COMPUTE APPARANT VERDET COEFFICIENTS FOR EACH
C                FARADAY CELL AND QUANTIFY THE DEGREE OF "CROSS-TALK"
C                BETWEEN THE FARADAY CELLS DURING CALIBRATION, TO
C                DISPLAY THIS INFORMATION ON THE CRT SCREEN
C                NUMERICALLY, AND TO STORE THE INFORMATION ON
C                A FLOPPY DISK FOR ACCESS BY "DSCONV" AND "FCPLOT".
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/O/NPASS
      COMMON/P/CNULL0,PNULL0,PNULL1,ANULL0,ANULL1
      COMMON/Q/ASLOPE(400),PSLOPE(400),AINTER(400),PINTER(400)
      COMMON/R/P0(400),A0(400),P1(400),A1(400),PA(400),AP(400)
      COMMON/MODE/MODE0,MODE1,FACTOR
      NPASS=1
C*****ENCODER COUNTS(DATA INDICES) ARE CONVERTED TO WAVELENGTHS.*******
      CALL WLCALC
C*****THE TOLERANCE FOR DETECTING DATA IN WAVELENGTH REGIONS **********
C     OUT-OF-RANGE OF THE FARADAY CELLS IS INPUT.
      TYPE 1001
      ACCEPT 1002,TOL
C*****THE SPECTRAL SCAN FOR THE NULL AT A STATIC ROTATING FILTER ******
C     AZIMUTH OF 120 DEGREES(M=120) IS READ FROM A DISK FILE.
      TYPE 1003
      CALL INPUT
      DO 10 I=1,400
      P0(I)=POL(I)
   10 A0(I)=ANA(I)
      PNULL0=NPOL
      PNULL0=PNULL0/100.
      ANULL0=NANA
      ANULL0=ANULL0/100.
      CNULL0=NCMP
      CNULL0=CNULL0/100.
```

```
C*****THE SPECTRAL SCAN FOR THE NULL AT M=120 WITH THE MANUAL *********
C     POLARIZER INCREMENTED IS READ.
      TYPE 1004
      CALL INPUT
      DO 20 I=1,400
      P1(I)=POL(I)
   20 AP(I)=ANA(I)
      PNULL1=NPOL
      PNULL1=PNULL1/100.
C*****THE SPECTRAL SCAN FOR THE NULL AT M=120 WITH THE MANUAL *********
C     ANALYZER AZIMUTH INCREMENTED IS READ.
      TYPE 1005
      CALL INPUT
      DO 30 I=1,400
      PA(I)=POL(I)
   30 A1(I)=ANA(I)
      ANULL1=NANA
      ANULL1=ANULL1/100.
C*****THE DIFFERENCES IN THE ANALYZER AND POLARIZER NULL AZIMUTHS *****
C     ARE COMPUTED.
      PNULL=ABS(PNULL1-PNULL0)
      ANULL=ABS(ANULL1-ANULL0)
      PSUM=0.
      ASUM=0.
      SUM=0.
      DO 50 I=1,400
C*****THE OUT-OF-RANGE DATA POINTS ARE DETECTED AND NO VERDET *********
C     COEFFICIENTS COMPUTED FOR THESE ANGULAR POSITIONS OF
C     THE ROTATING FILTER(WAVELENGTHS).
      IF(ABS(P0(I)).GT.TOL.OR.ABS(P1(I)).GT.TOL)GOTO 40
      IF(ABS(A0(I)).GT.TOL.OR.ABS(A1(I)).GT.TOL)GOTO 40
      PDENOM=ABS(P1(I)-P0(I))
      ADENOM=ABS(A1(I)-A0(I))
C*****THIS STEP PREVENTS "DIVISION BY ZERO" ERRORS.*******************
      IF(PDENOM.EQ.0.0.OR.ADENOM.EQ.0.0)GOTO 40
C*****THE VERDET COEFFICIENTS ARE COMPUTED FOR EACH ROTATING FILTER ***
C     ANGULAR POSITION(WAVELENGTH).
      PSLOPE(I)=PNULL/PDENOM
      ASLOPE(I)=ANULL/ADENOM
      IF(PSLOPE(I).GT.0.32767.OR.ASLOPE(I).GT.0.32767)GOTO 40
C*****THE "CROSS-TALK" OR INTERACTION PARAMETER IS COMPUTED FOR EACH **
C     INDEX.
      PINTER(I)=ABS(PA(I)-P0(I))/ADENOM
      AINTER(I)=ABS(AP(I)-A0(I))/PDENOM
      IF(PINTER(I).GT.327.67.OR.AINTER(I).GT.327.67)GOTO 40
      PSUM=PSUM+ABS(PINTER(I))
      ASUM=ASUM+ABS(AINTER(I))
      SUM=SUM+1.
```

```
      GOTO 50
   40 PSLOPE(I)=0.
      ASLOPE(I)=0.
      PINTER(I)=0.
      AINTER(I)=0.
   50 CONTINUE
      PSUM=PSUM/SUM
      ASUM=ASUM/SUM
C*****NUMERIC DATA IS DISPLAYED ON THE VT55 SCREEN.*******************
   60 TYPE 1006
      ACCEPT 1000,IF4
      IF(IF4.NE.1HY.AND.IF4.NE.1HN)GOTO 60
      IF(IF4.NE.1HY)GOTO 140
  100 CALL FCTYPE
      DO 110 I=1,400
  110 TYPE 1007,I,IWAVE(I),PSLOPE(I),ASLOPE(I),PINTER(I),AINTER(I)
      TYPE 1008,PSUM,ASUM
  140 CONTINUE
      TYPE 1011
      ACCEPT 1000,IWAIT
C*****FARADAY CELL SETUP CALIBRATION INFO IS INPUT FROM VT55.**********
  150 CALL FCTYPE
  160 TYPE 1009
      ACCEPT 1000,IF5
      IF(IF5.NE.1HY.AND.IF5.NE.1HN)GOTO 160
      IF(IF5.NE.1HY)GOTO 170
      CALL FCSET1
      GOTO 150
  170 CONTINUE
C*****VERDET COEFFICIENTS ARE OUTPUT TO A DISK FILE.******************
  180 TYPE 1010
      ACCEPT 1000,IF6
      IF(IF6.NE.1HY.AND.IF5.NE.1HN)GOTO 180
      IF(IF6.NE.1HY)GOTO 190
      CALL OUTFC
  190 CONTINUE
```

```
1000 FORMAT(A1)
1001 FORMAT(/,'$ DATA REJECTION LIMIT(ADCU AT SATURATION) = ')
1002 FORMAT(F10.0)
1003 FORMAT(/,'  INPUT SPECTRA FOR NULL AT "M=120".')
1004 FORMAT(/,'  INPUT SPECTRA FOR NULL WITH INCREMENTED POLARIZER
    C AZIMUTH.')
1005 FORMAT(/,'  INPUT SPECTRA FOR NULL WITH INCREMENTED ANALYZER
    C AZIMUTH.')
1006 FORMAT(/,'$ DO YOU WANT CRT DISPLAY OF THE NUMERIC DATA(Y/N)? ')
1007 FORMAT(/,1X,'I = ',I3,3X,'WL = ',I5,3X,'POL. RESPONSE  = ',E10.4,
    C3X,'ANA. RESPONSE  = ',E10.4,/,24X,'POL. INTERACT. = ',E10.4,
    C3X,'ANA. INTERACT. = ',E10.4)
1008 FORMAT(///,5X,'AVERAGE CROSS-TALK PARAMETERS(INTERACTIONS):',
    C          /,5X,'POLARIZER = ',E14.6,
    C          /,5X,'ANALYZER  = ',E14.6)
1009 FORMAT(/,'$ DO YOU WANT TO CHANGE ANY INFORMATION TO BE
    C OUTPUT WITH FACTORS(Y/N)? ')
1010 FORMAT(/,'$ DO YOU WANT TO OUTPUT THE RESPONSE FACTORS TO A
    C DISK FILE(Y/N)? ')
1011 FORMAT(/,'$ "RETURN" FOR PROGRAM CONTINUATION.')
     STOP
     END
```

```
      SUBROUTINE FCTYPE
C***********************************************************************
C     OBJECTIVE: TO DISPLAY THE SETUP INFORMATION RELEVENT TO THE
C                FARADAY CELL CALIBRATION ON THE CRT SCREEN.
C***********************************************************************
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/O/NPASS
      COMMON/P/CNULL0,PNULL0,PNULL1,ANULL0,ANULL1
      COMMON/Q/ASLOPE(400),PSLOPE(400),AINTER(400),PINTER(400)
      TYPE 100,IDAY,(IMON(I),I=1,3),IYRS
  100 FORMAT(/10X,I2,'-',3A1,'-',I2)
      TYPE 101,(NAMEOP(I),I=1,20)
  101 FORMAT(10X,'CALIBRATION BY: ',20A2)
      TYPE 102,(ID(I),I=1,20)
  102 FORMAT(10X,20A2)
      IF(NPASS.EQ.1)GOTO 112
      TYPE 110
  110 FORMAT(/10X,'MANUAL AZIMUTHS(DEG) AT NULL:')
      P=PNULL0
      A=ANULL0
      C=CNULL0
      WL=120.
      TYPE 111,P,A,C,WL
  111 FORMAT(/12X,'P = ',F7.2,
     C       /12X,'A = ',F7.2,
     C       /12X,'C = ',F7.2,
     C       /12X,'WL= ',F7.2)
  112 CONTINUE
      TYPE 120
  120 FORMAT(/10X,'LAMP:')
      TYPE 121,LMPTYP
  121 FORMAT(/12X,'TYPE       = ',A2)
      TYPE 122,(LMPSER(I),I=1,9)
  122 FORMAT(12X,'SERIAL NO. = ',9A2)
      TYPE 123,LMPVLT
  123 FORMAT(12X,'LAMP VOLTAGE(VOLTS) = ',I4)
```

```
      TYPE 124,LMPAMP
  124 FORMAT(12X,'LAMP CURRENT(AMPS)  = ',I3)
      TYPE 125,LMPHRS
  125 FORMAT(12X,'LAMP OPERATIONAL LIFE(HOURS) = ',I5)
      TYPE 130
  130 FORMAT(/10X,'PHOTOMULTIPLIER:')
      TYPE 131,(IPMTYP(I),I=1,10)
  131 FORMAT(/12X,'MODEL = ',10A2)
      TYPE 132,IPMTDV
  132 FORMAT(12X,'DYNODE VOLTAGE(VOLTS) = ',I5)
      TYPE 140
  140 FORMAT(/10X,'FARADAY CELL CONTROLLER:')
      TYPE 141
  141 FORMAT(/12X,'POLARIZER')
      TYPE 142,IPHASP,IGAINP,IAMPLP,ITIMEP
  142 FORMAT(/12X,'PHASE                = ',I4,
     C       /12X,'GAIN                 = ',I4,
     C       /12X,'AMPLITUDE            = ',I4,
     C       /12X,'TIME CONSTANT(MS) = ',I4)
      TYPE 143
  143 FORMAT(/12X,'ANALYZER')
      TYPE 142,IPHASA,IGAINA,IAMPLA,ITIMEA
      TYPE 150
  150 FORMAT(/10X,'GALVANOMETER AMPLIFIER:')
      TYPE 141
      TYPE 151,IGAGP,IGATP
  151 FORMAT(/12X,'GAIN                 = ',I6,
     C       /12X,'TIME CONSTANT(MS) = ',I6)
      TYPE 143
      TYPE 151,IGAGA,IGATA
      IGAIN=IPOL/64
      NCHP=IPOL-IGAIN*64
      NCHA=IANA-IGAIN*64
      TYPE 160
  160 FORMAT(/10X,'ANALOG/DIGITAL CONVERTOR:')
      TYPE 161,NCHP,NCHA,IGAIN
  161 FORMAT(/12X,'POL. INPUT CH. = ',I1,
     C       /12X,'ANA. INPUT CH. = ',I1,
     C       /12X,'ADC GAIN       = ',I1)
      RETURN
      END
```

```
      SUBROUTINE FCPRNT
C***********************************************************************
C     OBJECTIVE: TO OUTPUT THE SETUP INFORMATION RELEVENT TO THE
C                FARADAY CELL CALIBRATION TO THE LINE PRINTER.
C***********************************************************************
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/O/NPASS
      COMMON/P/CNULLO,PNULLO,PNULL1,ANULLO,ANULL1
      COMMON/Q/ASLOPE(400),PSLOPE(400),AINTER(400),PINTER(400)
      PRINT 100,IDAY,(IMON(I),I=1,3),IYRS
  100 FORMAT(/10X,I2,'-',3A1,'-',I2)
      PRINT 101,(NAMEOP(I),I=1,20)
  101 FORMAT(10X,'CALIBRATION BY: ',20A2)
      PRINT 102,(ID(I),I=1,20)
  102 FORMAT(10X,20A2)
      IF(NPASS.EQ.1)GOTO 112
      PRINT 110
  110 FORMAT(/10X,'MANUAL AZIMUTHS(DEG) AT NULL:')
      P=PNULLO
      A=ANULLO
      C=CNULLO
      WL=120.
      PRINT 111,P,A,C,WL
  111 FORMAT(/12X,'P = ',F7.2,
     C       /12X,'A = ',F7.2,
     C       /12X,'C = ',F7.2,
     C       /12X,'WL= ',F7.2)
  112 CONTINUE
      PRINT 120
  120 FORMAT(/10X,'LAMP:')
      PRINT 121,LMPTYP
  121 FORMAT(/12X,'TYPE        = ',A2)
      PRINT 122,(LMPSER(I),I=1,9)
  122 FORMAT(12X,'SERIAL NO. = ',9A2)
      PRINT 123,LMPVLT
  123 FORMAT(12X,'LAMP VOLTAGE(VOLTS) = ',I4)
```

```
      PRINT 124,LMPAMP
  124 FORMAT(12X,'LAMP CURRENT(AMPS)  = ',I3)
      PRINT 125,LMPHRS
  125 FORMAT(12X,'LAMP OPERATIONAL LIFE(HOURS) = ',I5)
      PRINT 130
  130 FORMAT(/10X,'PHOTOMULTIPLIER:')
      PRINT 131,(IPMTYP(I),I=1,10)
  131 FORMAT(/12X,'MODEL = ',10A2)
      PRINT 132,IPMTDV
  132 FORMAT(12X,'DYNODE VOLTAGE(VOLTS) = ',I5)
      PRINT 140
  140 FORMAT(/10X,'FARADAY CELL CONTROLLER:')
      PRINT 141
  141 FORMAT(/12X,'POLARIZER')
      PRINT 142,IPHASP,IGAINP,IAMPLP,ITIMEP
  142 FORMAT(/12X,'PHASE             = ',I4,
     C       /12X,'GAIN              = ',I4,
     C       /12X,'AMPLITUDE         = ',I4,
     C       /12X,'TIME CONSTANT(MS) = ',I4)
      PRINT 143
  143 FORMAT(/12X,'ANALYZER')
      PRINT 142,IPHASA,IGAINA,IAMPLA,ITIMEA
      PRINT 150
  150 FORMAT(/10X,'GALVANOMETER AMPLIFIER:')
      PRINT 141
      PRINT 151,IGAGP,IGATP
  151 FORMAT(/12X,'GAIN              = ',I6,
     C       /12X,'TIME CONSTANT(MS) = ',I6)
      PRINT 143
      PRINT 151,IGAGA,IGATA
      IGAIN=IPOL/64
      NCHP=IPOL-IGAIN*64
      NCHA=IANA-IGAIN*64
      PRINT 160
  160 FORMAT(/10X,'ANALOG/DIGITAL CONVERTOR:')
      PRINT 161,NCHP,NCHA,IGAIN
  161 FORMAT(/12X,'POL. INPUT CH. = ',I1,
     C       /12X,'ANA. INPUT CH. = ',I1,
     C       /12X,'ADC GAIN       = ',I1)
      RETURN
      END
```

```
      SUBROUTINE FCSET1
C***********************************************************************
C     OBJECTIVE: TO ALLOW THE OPERATOR TO INPUT SETUP INFORMATION
C                REGARDING THE FARADAY CELL CALIBRATION.
C***********************************************************************
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      TYPE 100
  100 FORMAT(/,'$ NAME(A40) = ')
      ACCEPT 110,(NAMEOP(I),I=1,20)
      TYPE 101
  101 FORMAT(/,'$ DATE(I2-A3-I2/DAY-MONTH-YEAR) = ')
      ACCEPT 102,IDAY,(IMON(I),I=1,3),IYRS
  102 FORMAT(I2,1X,3A1,1X,I2)
  110 FORMAT(20A2)
      TYPE 120
  120 FORMAT(/,'$ IDENTIFCATION OF FC CALIBRATION(A40) = ')
      ACCEPT 130,(ID(I),I=1,20)
  130 FORMAT(20A2)
      TYPE 140
  140 FORMAT(/,' LAMP PARAMETERS:')
      TYPE 141
  141 FORMAT('$ TYPE(A2/XE,ETC.) = ')
      ACCEPT 142,LMPTYP
  142 FORMAT(A2)
      TYPE 143
  143 FORMAT('$ SERIAL NO.(A18) = ')
      ACCEPT 144,(LMPSER(I),I=1,9)
  144 FORMAT(9A2)
      TYPE 145
  145 FORMAT('$ LAMP VOLTAGE(I3/VOLTS) = ')
      ACCEPT 146,LMPVLT
  146 FORMAT(I4)
      TYPE 147
  147 FORMAT('$ LAMP CURRENT(I2/AMPS) = ')
      ACCEPT 148,LMPAMP
  148 FORMAT(I3)
      TYPE 149
  149 FORMAT('$ LAMP OPERATIONAL LIFE(I4/HOURS) = ')
      ACCEPT 146,LMPHRS
```

```
    TYPE 150
150 FORMAT(/,' PHOTOMULTIPLIER PARAMETERS:')
    TYPE 151
151 FORMAT('$ MODEL(A20) = ')
    ACCEPT 152,(IPMTYP(I),I=1,10)
152 FORMAT(10A2)
    TYPE 153
153 FORMAT('$ DYNODE VOLTAGE(I4/VOLTS) = ')
    ACCEPT 154,IPMTDV
154 FORMAT(I5)
    TYPE 160
160 FORMAT(/,' FARADAY CELL CONTROLLER PARAMETERS:')
    TYPE 161
161 FORMAT(/,' POLARIZER CHANNEL')
    TYPE 162
162 FORMAT('$ PHASE(I3/POT SETTING) = ')
    ACCEPT 163,IPHASP
163 FORMAT(I4)
    TYPE 164
164 FORMAT('$ GAIN(I3/POT SETTING) = ')
    ACCEPT 163,IGAINP
    TYPE 165
165 FORMAT('$ AMPLITUDE(I3/POT SETTING) = ')
    ACCEPT 163,IAMPLP
    TYPE 166
166 FORMAT('$ TIME CONSTANT(I3/MILLISECONDS) = ')
    ACCEPT 163,ITIMEP
    TYPE 167
167 FORMAT(/,' ANALYZER CHANNEL')
    TYPE 162
    ACCEPT 163,IPHASA
    TYPE 164
    ACCEPT 163,IGAINA
    TYPE 165
    ACCEPT 163,IAMPLA
    TYPE 166
    ACCEPT 163,ITIMEA
    TYPE 170
170 FORMAT(/,' GALVANOMETER AMPLIFIER PARAMETERS:')
    TYPE 171
171 FORMAT(/,' POLARIZER CHANNEL')
    TYPE 172
172 FORMAT('$ GAIN(I5) = ')
    ACCEPT 173,IGAGP
173 FORMAT(I6)
```

Appendix 19 (continued).

```
      TYPE 174
174   FORMAT('$ TIME CONSTANT(I5/MILLISECONDS) = ')
      ACCEPT 173,IGATP
      TYPE 175
175   FORMAT(/,' ANALYZER CHANNEL')
      TYPE 172
      ACCEPT 173,IGAGA
      TYPE 174
      ACCEPT 173,IGATA
      IGAIN=IPOL/64
      NCHP=IPOL-IGAIN*64
      NCHA=IANA-IGAIN*64
180   TYPE 181
181   FORMAT(/,' ANALOG/DIGITAL CONVERTOR PRESET PARAMETERS:')
182   TYPE 183,NCHP
183   FORMAT('  POL. INPUT CH. = ',I1)
      TYPE 184,NCHA
184   FORMAT('  ANA. INPUT CH. = ',I1)
      TYPE 185,IGAIN
185   FORMAT('  ADC GAIN       = ',I1)
      RETURN
      END
```

```
      SUBROUTINE OUTFC
C***********************************************************************
C     OBJECTIVE: TO WRITE THE FARADAY CELL CALIBRATION DATA ONTO THE
C                FLOPPY DISK; I.E., VERDET COEFFICIENTS, ETC.
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/P/CNULLO,PNULLO,PNULL1,ANULLO,ANULL1
      COMMON/Q/ASLOPE(400),PSLOPE(400),AINTER(400),PINTER(400)
      REAL*4 DBLK(2),NAME(20)
      IBLOCK=0
      FACT01=1.E05
      FACT02=1.E02
      TYPE 1
    1 FORMAT(/,'$ FILE NAME FOR THE NEW FC RESPONSE FACTORS (A12) = ')
      ACCEPT 2,(NAME(I),I=1,3)
    2 FORMAT(3A4)
      N=IRAD50(12,NAME,DBLK)
      ICHAN=IGETC(0)
      IF(ICHAN.LT.0)STOP 'CANNOT ALLOCATE CHANNEL'
      IERROR=IENTER(ICHAN,DBLK,0)
      IF(IERROR.LT.0)STOP 'ENTER FAILURE'
      DO 10 I=1,256
   10 IBUFF(I)=0
      DO 20 I=1,20
      IBUFF(I)=NAMEOP(I)
   20 IBUFF(20+I)=ID(I)
      IBUFF(41)=LMPTYP
      DO 30 I=1,9
   30 IBUFF(41+I)=LMPSER(I)
```

```
      IBUFF(51)=LMPVLT
      IBUFF(52)=LMPAMP
      IBUFF(54)=IPHASP
      IBUFF(55)=IGAINP
      IBUFF(56)=IAMPLP
      IBUFF(57)=ITIMEP
      IBUFF(58)=IPHASA
      IBUFF(59)=IGAINA
      IBUFF(60)=IAMPLA
      IBUFF(61)=ITIMEA
      IBUFF(62)=IGAGP
      IBUFF(63)=IGATP
      IBUFF(64)=IGAGA
      IBUFF(65)=IGATA
      IBUFF(66)=NRATE
      IBUFF(67)=NSCAN
      IBUFF(68)=IPOL
      IBUFF(69)=IANA
      IBUFF(70)=IDAY
      IBUFF(71)=IYRS
      IBUFF(72)=LMPHRS
      IBUFF(73)=IMON(1)
      IBUFF(74)=IMON(2)
      IBUFF(75)=IMON(3)
      DO 35 I=1,10
   35 IBUFF(75+I)=IPMTYP(I)
      IBUFF(86)=IPMTDV
      IBUFF(87)=CNULL0*100.
      IBUFF(88)=PNULL0*100.
      IBUFF(89)=PNULL1*100.
      IBUFF(90)=ANULL0*100.
      IBUFF(91)=ANULL1*100.
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 40 I=1,200
   40 IBUFF(I)=PSLOPE(I)*FACT01
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 50 I=1,200
   50 IBUFF(I)=ASLOPE(I)*FACT01
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 60 I=1,200
   60 IBUFF(I)=PSLOPE(I+200)*FACT01
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 70 I=1,200
   70 IBUFF(I)=ASLOPE(I+200)*FACT01
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 80 I=1,200
   80 IBUFF(I)=PINTER(I)*FACT02
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 90 I=1,200
   90 IBUFF(I)=AINTER(I)*FACT02
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 100 I=1,200
  100 IBUFF(I)=PINTER(I+200)*FACT02
      CALL WRITE
      CALL IWAIT(ICHAN)
      DO 110 I=1,200
  110 IBUFF(I)=AINTER(I+200)*FACT02
      CALL WRITE
      CALL IWAIT(ICHAN)
      CALL CLOSEC(ICHAN)
      CALL IFREEC(ICHAN)
      RETURN
      END
```

```
SUBROUTINE WRITE
COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
EXTERNAL FINISH
IERROR=IWRITF(256,IBUFF,IBLOCK,ICHAN,IAREA,FINISH)
IF(IERROR.LT.0)STOP 'FATAL WRITE'
IBLOCK=IBLOCK+1
RETURN
END
```

```
SUBROUTINE FINISH
COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
IFLAG=IFLAG-1
RETURN
END
```

Appendix 20.

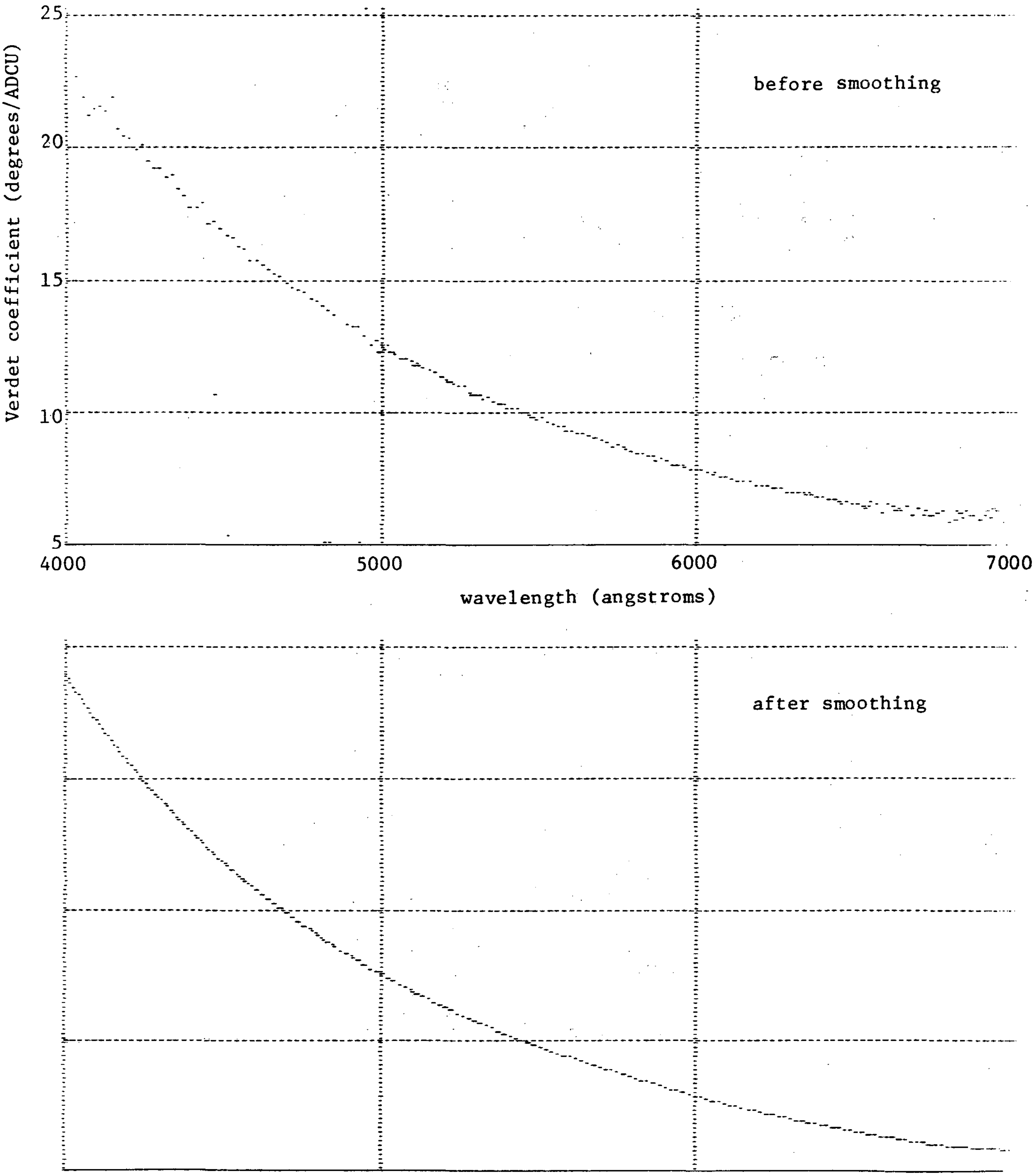
Demonstration of FCSMTH - Langrangian smoothing of Verdet coefficients at different wavelengths

```
.RUN DY1:FCSMTH

 INSERT DISK WITH WAVELENGTH CALIBRATION - 'RETURN'.

 DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

 INSERT DISK WITH VERDET COEF FILE TO BE SMOOTHED - 'RETURN'.

 FC RESPONSE FACTOR FILE TO BE RETRIEVED = DY1FARADYNEW .....file to be smoothed;
                                                              created by CALFC1
 LOWER ENCODER INDEX FOR SMOOTHING POLYNOMIAL = 140

 UPPER ENCODER INDEX FOR SMOOTHING POLYNOMIAL = 300

 POWER OF LAGRANGIAN SMOOTHING POLYNOMIAL     = 5
 WL =  5155     POL VERDET COEF =  0.125E-01     ANA VERDET COEF =  0.117E-01
 WL =  5174     POL VERDET COEF =  0.123E-01     ANA VERDET COEF =  0.115E-01
 WL =  5193     POL VERDET COEF =  0.122E-01     ANA VERDET COEF =  0.114E-01
 WL =  5212     POL VERDET COEF =  0.120E-01     ANA VERDET COEF =  0.113E-01
 WL =  5230     POL VERDET COEF =  0.119E-01     ANA VERDET COEF =  0.111E-01
 WL =  5249     POL VERDET COEF =  0.117E-01     ANA VERDET COEF =  0.110E-01
 WL =  5268     POL VERDET COEF =  0.116E-01     ANA VERDET COEF =  0.109E-01
 WL =  5286     POL VERDET COEF =  0.115E-01     ANA VERDET COEF =  0.107E-01
 WL =  5305     POL VERDET COEF =  0.113E-01     ANA VERDET COEF =  0.106E-01


 WL =  4799     POL VERDET COEF =  0.142E-01     ANA VERDET COEF =  0.132E-01
 WL =  4818     POL VERDET COEF =  0.142E-01     ANA VERDET COEF =  0.132E-01
 WL =  4837     POL VERDET COEF =  0.141E-01     ANA VERDET COEF =  0.132E-01
 WL =  4856     POL VERDET COEF =  0.141E-01     ANA VERDET COEF =  0.131E-01
 WL =  4874     POL VERDET COEF =  0.140E-01     ANA VERDET COEF =  0.131E-01
 WL =  4893     POL VERDET COEF =  0.140E-01     ANA VERDET COEF =  0.130E-01
 WL =  4912     POL VERDET COEF =  0.139E-01     ANA VERDET COEF =  0.130E-01
 WL =  4931     POL VERDET COEF =  0.138E-01     ANA VERDET COEF =  0.129E-01
 WL =  4949     POL VERDET COEF =  0.137E-01     ANA VERDET COEF =  0.128E-01
 WL =  4968     POL VERDET COEF =  0.136E-01     ANA VERDET COEF =  0.127E-01
 WL =  4987     POL VERDET COEF =  0.135E-01     ANA VERDET COEF =  0.127E-01
 WL =  5005     POL VERDET COEF =  0.134E-01     ANA VERDET COEF =  0.126E-01
 WL =  5024     POL VERDET COEF =  0.133E-01     ANA VERDET COEF =  0.125E-01
 WL =  5043     POL VERDET COEF =  0.132E-01     ANA VERDET COEF =  0.124E-01
 WL =  5062     POL VERDET COEF =  0.131E-01     ANA VERDET COEF =  0.122E-01
 WL =  5080     POL VERDET COEF =  0.130E-01     ANA VERDET COEF =  0.121E-01
 WL =  5099     POL VERDET COEF =  0.128E-01     ANA VERDET COEF =  0.120E-01
 WL =  5118     POL VERDET COEF =  0.127E-01     ANA VERDET COEF =  0.119E-01
 WL =  5137     POL VERDET COEF =  0.126E-01     ANA VERDET COEF =  0.118E-01


 PERROR =   0.65E-02     AERROR =   0.79E-02

 INSERT THE DISK FOR SMOOTHED VERDET COEF DATA - 'RETURN'.
```

```
WL =  4949    POL VERDET COEF =  0.137E-01    ANA VERDET COEF =  0.128E-01
WL =  4968    POL VERDET COEF =  0.136E-01    ANA VERDET COEF =  0.127E-01
WL =  4987    POL VERDET COEF =  0.135E-01    ANA VERDET COEF =  0.127E-01
WL =  5005    POL VERDET COEF =  0.134E-01    ANA VERDET COEF =  0.126E-01
WL =  5024    POL VERDET COEF =  0.133E-01    ANA VERDET COEF =  0.125E-01
WL =  5043    POL VERDET COEF =  0.132E-01    ANA VERDET COEF =  0.124E-01
WL =  5062    POL VERDET COEF =  0.131E-01    ANA VERDET COEF =  0.122E-01
WL =  5080    POL VERDET COEF =  0.130E-01    ANA VERDET COEF =  0.121E-01
WL =  5099    POL VERDET COEF =  0.128E-01    ANA VERDET COEF =  0.120E-01
WL =  5118    POL VERDET COEF =  0.127E-01    ANA VERDET COEF =  0.119E-01
WL =  5137    POL VERDET COEF =  0.126E-01    ANA VERDET COEF =  0.118E-01

PERROR =   0.65E-02     AERROR =   0.79E-02

INSERT THE DISK FOR SMOOTHED VERDET COEF DATA - "RETURN".

FILE NAME FOR THE NEW FC RESPONSE FACTORS (A12) = DY1FCSMTHDEM....smoothed
                                                                   Faraday cell
ARE OTHER FILES TO BE SMOOTHED(Y/N)? N                             calibration
                                                                   file
STOP --


TEFLON.189     5 18-Jul-82      TEFLON.190     5 18-Jul-82
TEFLON.191     5 18-Jul-82      TEFLON.192     5 18-Jul-82
TEFLON.193     5 18-Jul-82      TEFLON.194     5 18-Jul-82
TEFLON.195     5 19-Jul-82      TEFLON.196     5 19-Jul-82
TEFLON.197     5 19-Jul-82      TEFLON.198     5 19-Jul-82
TEFLON.199     5 19-Jul-82      TEFLON.200     5 19-Jul-82
TEFLON.201     5 19-Jul-82      TEFLON.202     5 19-Jul-82
TEFLON.203     5 19-Jul-82      TEFLON.204     5 19-Jul-82
TEFLON.205     5 19-Jul-82      RESULT.203     5 19-Jul-82
CVPBAU.000    13 19-Jul-82      CVPBAU.001    13 19-Jul-82
CVPBAU.002    13 19-Jul-82      CVPBAU.003    13 19-Jul-82
CVPBAU.004    13 19-Jul-82      TRNSLT.DAT     1 09-Nov-81
PLTDAT.DAT    58 19-Jul-82      TEFLON.206     5 19-Jul-82
TEFLON.207     5 19-Jul-82      CVPBAU.005    13 19-Jul-82
CVPBAU.006    13 19-Jul-82      GOLD  .186     5 19-Jan-83
GOLD  .183     5 19-Jan-83      MINUS .186     5 19-Jan-83
GOLD  .188     5 19-Jan-83      MINUS .188     5 19-Jan-83
GOLD  .185     5 19-Jan-83      MINUS .185     5 19-Jan-83
DEMOAU.DAT     5 19-Jan-83      RIAU01.DAT     5 19-Jan-83
MINUS .DEM     5 19-Jan-83      FCSMTH.DEM     9 21-Jan-83......smoothed data file
 108 Files, 959 Blocks
 15 Free blocks
```

Appendix 20 (continued).

Verdet coefficients before and after smoothing



Appendix 20 (continued).

Listing of FCSMTH

```
      PROGRAM FCSMTH
C***********************************************************************
C      OBJECTIVE:  TO CONTROL I/O AND SMOOTHING OF VERDET COEFFICIENT
C                  CALIBRATION FILES.
C
C      WRITTEN BY JOSEPH C. FARMER ON OCTOBER 30, 1981, LBL-MMRD, UCB.
C
C***********************************************************************
      COMMON/A/NAVG(400),POL(400).ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOF(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/P/CNULLO,PNULLO,PNULL1,ANULLO,ANULL1
      COMMON/Q/ASLOPE(400),PSLOPE(400),AINTER(400),PINTER(400)
 1000 CONTINUE
  100 FORMAT(A1)
      TYPE 1
    1 FORMAT(/,'$ INSERT DISK WITH WAVELENGTH CALIBRATION - "RETURN".')
      ACCEPT 100,IWAIT
      CALL WLCALC
      TYPE 2
    2 FORMAT(/,'$ INSERT DISK WITH VERDET COEF FILE TO BE SMOOTHED
     C - "RETURN".')
      ACCEPT 100,IWAIT
      CALL INFC
      CALL SMOOTH
      TYPE 3
    3 FORMAT(/,'$ INSERT THE DISK FOR SMOOTHED VERDET COEF DATA
     C - "RETURN".')
      ACCEPT 100,IWAIT
      CALL OUTFC
    4 CONTINUE
      TYPE 5
    5 FORMAT(/,'$ ARE OTHER FILES TO BE SMOOTHED(Y/N)? ')
      ACCEPT 100,IWAIT
      IF(IWAIT.NE.1HY.AND.IWAIT.NE.1HN)GOTO 4
      IF(IWAIT.EQ.1HY)GOTO 1000
      STOP
      END
```

Appendix 20 (continued).

```
      SUBROUTINE INFC
C***********************************************************************
C     OBJECTIVE: TO READ THE FARADAY CELL CALIBRATION DATA FROM THE
C                FLOPPY DISK; I.E., VERDET COEFFICIENTS, ETC.
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOF(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/P/CNULLO,PNULLO,PNULL1,ANULLO,ANULL1
      COMMON/Q/ASLOPE(400),PSLOPE(400),AINTER(400),PINTER(400)
      REAL*4 BDLK(2),NAME(20)
      IBLOCK=0
      FACT01=1.E05
      FACT02=1.E02
      TYPE 1
    1 FORMAT(/,'$ FC RESPONSE FACTOR FILE TO BE RETRIEVED = ')
      ACCEPT 2,(NAME(I),I=1,3)
    2 FORMAT(3A4)
      N=IRAD50(12,NAME,BDLK)
      ICHAN=IGETC(I)
      IF(ICHAN.LT.0)STOP 'CANNOT ALLOCATE CHANNEL'
      IF(IFETCH(ICHAN).LT.0)STOP 'FETCH FAIL'
      IF(LOOKUP(ICHAN,BDLK).LT.0)STOP 'BAD LOOKUP'
      DO 10 I=1,256
   10 IBUFF(I)=0
      CALL READ
      DO 20 I=1,20
      NAMEOF(I)=IBUFF(I)
   20 ID(I)=IBUFF(20+I)
      LMPTYP=IBUFF(41)
      DO 30 I=1,9
   30 LMPSER(I)=IBUFF(41+I)
```

```
      LMPVLT=IBUFF(51)
      LMPAMP=IBUFF(52)
      IPHASP=IBUFF(54)
      IGAINP=IBUFF(55)
      IAMPLP=IBUFF(56)
      ITIMEP=IBUFF(57)
      IPHASA=IBUFF(58)
      IGAINA=IBUFF(59)
      IAMPLA=IBUFF(60)
      ITIMEA=IBUFF(61)
      IGAGP =IBUFF(62)
      IGATP =IBUFF(63)
      IGAGA =IBUFF(64)
      IGATA =IBUFF(65)
      NRATE =IBUFF(66)
      NSCAN =IBUFF(67)
      IPOL  =IBUFF(68)
      IANA  =IBUFF(69)
      IDAY  =IBUFF(70)
      IYRS  =IBUFF(71)
      LMPHRS=IBUFF(72)
      IMON(1)=IBUFF(73)
      IMON(2)=IBUFF(74)
      IMON(3)=IBUFF(75)
      DO 35 I=1,10
   35 IPMTYP(I)=IBUFF(75+I)
      IPMTDV=IBUFF(86)
      CNULL0=IBUFF(87)/100.
      PNULL0=IBUFF(88)/100.
      PNULL1=IBUFF(89)/100.
      ANULL0=IBUFF(90)/100.
      ANULL1=IBUFF(91)/100.
      CALL READ
      DO 40 I=1,200
   40 PSLOPE(I)=IBUFF(I)/FACT01
      CALL READ
      DO 50 I=1,200
   50 ASLOPE(I)=IBUFF(I)/FACT01
      CALL READ
      DO 60 I=1,200
   60 PSLOPE(I+200)=IBUFF(I)/FACT01
      CALL READ
      DO 70 I=1,200
   70 ASLOPE(I+200)=IBUFF(I)/FACT01
      CALL READ
      DO 80 I=1,200
   80 PINTER(I)=IBUFF(I)/FACT02
      CALL READ
      DO 90 I=1,200
   90 AINTER(I)=IBUFF(I)/FACT02
      CALL READ
      DO 100 I=1,200
  100 PINTER(I+200)=IBUFF(I)/FACT02
      CALL READ
      DO 110 I=1,200
  110 AINTER(I+200)=IBUFF(I)/FACT02
      CALL CLOSEC(ICHAN)
      CALL IFREEC(ICHAN)
      RETURN
      END

      SUBROUTINE READ
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      IERROR=IREADW(256,IBUFF,IBLOCK,ICHAN)
      IF(IERROR.LT.0)STOP 'FATAL READ'
      IBLOCK=IBLOCK+1
      RETURN
      END
```

```
      SUBROUTINE SMOOTH
C***********************************************************************
C     OBJECTIVE:  TO REMOVE NOISE FROM VERDET COEFFICIENT CALIBRATION
C                 FILES USING AN NTH DEGREE LAGRANGIAN INTERPOLATING
C                 POLYNOMIAL WHERE THE USER SPECIFIES "N".  THE USER
C                 ALSO SPECIFIES THE RANGE OF ENCODER INDICES TO BE
C                 USED IN COEFFICIENT ESTIMATION, THOUGH THE FUNCTION
C                 CAN BE USED OUTSIDE OF THE RANGE SPECIFIED.  THIS
C                 PERMITS EXCLUSION OF DATA COLLECTED IN REGIONS OF
C                 "SIGNAL DROP-OUT",ETC.  SUCH SMOOTHING PREVENTS
C                 ERROR PROPAGATION FROM FARADAY CELL CALIBRATION
C                 FILE NOISE.

C     WRITTEN BY JOSEPH C. FARMER ON OCTOBER 30, 1981 OF LBL-MMRD, UCB.

C***********************************************************************
      DIMENSION POLY(400)
      COMMON/M/IWAVE(400)
      COMMON/Q/ASLOPE(400),PSLOPE(400),AINTER(400),PINTER(400)
 1000 FORMAT(I3)
      TYPE 1001
 1001 FORMAT(/,'$ LOWER ENCODER INDEX FOR SMOOTHING POLYNOMIAL = ')
      ACCEPT 1000,IL
      TYPE 1002
 1002 FORMAT(/,'$ UPPER ENCODER INDEX FOR SMOOTHING POLYNOMIAL = ')
      ACCEPT 1000,IH
      TYPE 1003
 1003 FORMAT(/,'$ POWER OF LAGRANGIAN SMOOTHING POLYNOMIAL      = ')
      ACCEPT 1000,N
      RANGE=(IH-IL)/(N-1)
      DO 4000 INDEX=1,400
      SUM=0.
      DO 3000 I=1,N
      RI=IL+(I-1)*RANGE
      II=RI
      PROD=1.
      DO 2000 J=1,N
      IF(I.EQ.J)GOTO 2000
      RJ=IL+(J-1)*RANGE
      JJ=RJ
      PROD=PROD*(IWAVE(INDEX)-IWAVE(JJ))/(IWAVE(II)-IWAVE(JJ))
 2000 CONTINUE
 3000 SUM=SUM+PROD*PSLOPE(II)
 4000 POLY(INDEX)=SUM
```

```
      PERR=0.
      DO 5000 INDEX=1,400
      PERR=PERR+(POLY(INDEX)-PSLOPE(INDEX))*(POLY(INDEX)-PSLOPE(INDEX))
 5000 PSLOPE(INDEX)=POLY(INDEX)
      DO 8000 INDEX=1,400
      SUM=0.
      DO 7000 I=1,N
      RI=IL+(I-1)*RANGE
      II=RI
      PROD=1.
      DO 6000 J=1,N
      IF(I.EQ.J)GOTO 6000
      RJ=IL+(J-1)*RANGE
      JJ=RJ
      PROD=PROD*(IWAVE(INDEX)-IWAVE(JJ))/(IWAVE(II)-IWAVE(JJ))
 6000 CONTINUE
 7000 SUM=SUM+PROD*ASLOPE(II)
 8000 POLY(INDEX)=SUM
      AERR=0.
      DO 9000 INDEX=1,400
      AERR=AERR+(POLY(INDEX)-ASLOPE(INDEX))*(POLY(INDEX)-ASLOPE(INDEX))
 9000 ASLOPE(INDEX)=POLY(INDEX)
      PERR=SQRT(PERR/400.)
      AERR=SQRT(AERR/400.)
      DO 10000 I=1,400
10000 TYPE 10001,IWAVE(I),PSLOPE(I),ASLOPE(I)
10001 FORMAT(2X,'WL = ',I5,5X,'POL VERDET COEF = ',E10.3,5X,
     C                        'ANA VERDET COEF = ',E10.3)
      TYPE 10002,PERR,AERR
10002 FORMAT(//,2X,'PERROR = ',E10.2,5X,'AERROR = ',E10.2)
      RETURN
      END
```

Appendix 21.

Demonstration of FCAVG2 - averaging polarizer and analyzer Verdet coefficients

```
.RUN DY1:FCAVG2

 INSERT DISK WITH WAVELENGTH CALIBRATION - "RETURN".

 DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

 INSERT DISK WITH VERDET COEF FILE TO BE AVERAGED OR INTERCHANGED - "RETURN".

 FC RESPONSE FACTOR FILE TO BE RETRIEVED = DY1FARADYNEW

 POL COEF ONLY(P), ANA COEF ONLY(A), OR AVG(M)? M

 SIGNAL LOSS - LOWER WL LIMIT = 4000

 SIGNAL LOSS - UPPER WL LIMIT = 7000

 INSERT THE DISK FOR VERDET COEF DATA STORAGE - "RETURN".

 FILE NAME FOR THE NEW FC RESPONSE FACTORS (A12) = DY1FCAVG2DEM

 ARE OTHER FILES TO BE AVERAGED OR INTERCHANGED(Y/N)? N

STOP --


TEFLON.187     5 18-Jul-82       TEFLON.188     5 18-Jul-82
TEFLON.189     5 18-Jul-82       TEFLON.190     5 18-Jul-82
TEFLON.191     5 18-Jul-82       TEFLON.192     5 18-Jul-82
TEFLON.193     5 18-Jul-82       TEFLON.194     5 18-Jul-82
TEFLON.195     5 19-Jul-82       TEFLON.196     5 19-Jul-82
TEFLON.197     5 19-Jul-82       TEFLON.198     5 19-Jul-82
TEFLON.199     5 19-Jul-82       TEFLON.200     5 19-Jul-82
TEFLON.201     5 19-Jul-82       TEFLON.202     5 19-Jul-82
TEFLON.203     5 19-Jul-82       TEFLON.204     5 19-Jul-82
TEFLON.205     5 19-Jul-82       RESULT.203     5 19-Jul-82
CVPBAU.000    13 19-Jul-82       CVPBAU.001    13 19-Jul-82
CVPBAU.002    13 19-Jul-82       CVPBAU.003    13 19-Jul-82
CVPBAU.004    13 19-Jul-82       TRNSLT.DAT     1 09-Nov-81
PLTDAT.DAT    58 19-Jul-82       TEFLON.206     5 19-Jul-82
TEFLON.207     5 19-Jul-82       CVPBAU.005    13 19-Jul-82
CVPBAU.006    13 19-Jul-82       GOLD  .186     5 19-Jan-83
GOLD  .183     5 19-Jan-83       MINUS .186     5 19-Jan-83
GOLD  .188     5 19-Jan-83       MINUS .188     5 19-Jan-83
GOLD  .185     5 19-Jan-83       MINUS .185     5 19-Jan-83
FCAVG2.DEM     9 21-Jan-83 ..................................averaged file
 165 Files, 944 Blocks
 30 Free blocks

.
```

Appendix 21 (continued).

Listing of FCAVG2

```
      PROGRAM FCAVG
C*************************************************************************
C     OBJECTIVE:  TO FACILITATE USE OF EITHER POLARIZER OR ANALYZER
C                 VERDET COEFFICIENT FILES, OR AN AVERAGE OF THE TWO
C                 FOR BOTH CHANNELS(POL & ANA).
C
C     WRITTEN BY JOSEPH C. FARMER ON OCTOBER 30, 1981, LBL-MMRD, UCB.
C
C*************************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/P/CNULLO,PNULLO,PNULL1,ANULLO,ANULL1
      COMMON/Q/ASLOPE(400),PSLOPE(400),AINTER(400),PINTER(400)
  100 FORMAT(A1)
  200 FORMAT(I5)
 1000 CONTINUE
      TYPE 1
    1 FORMAT(/,'$ INSERT DISK WITH WAVELENGTH CALIBRATION - "RETURN".')
      ACCEPT 100,IWAIT
      CALL WLCALC
      TYPE 2
    2 FORMAT(/,'$ INSERT DISK WITH VERDET COEF FILE TO BE AVERAGED
     C OR INTERCHANGED - "RETURN".')
      ACCEPT 100,IWAIT
      CALL INFC
 2000 TYPE 3
    3 FORMAT(/,'$ POL COEF ONLY(P), ANA COEF ONLY(A), OR AVG(M)? ')
      ACCEPT 100,IOPT
      IF(IOPT.NE.1HP.AND.IOPT.NE.1HA.AND.IOPT.NE.1HM)GOTO 2000
      TYPE 4
    4 FORMAT(/,'$ SIGNAL LOSS - LOWER WL LIMIT = ')
      ACCEPT 200,ILOWER
      TYPE 5
    5 FORMAT(/,'$ SIGNAL LOSS - UPPER WL LIMIT = ')
      ACCEPT 200,IUPPER
      IF(IOPT.NE.1HP)GOTO 2002
```

```
      DO 2001 I=1,400
 2001 ASLOPE(I)=PSLOPE(I)
      GOTO 2006
 2002 CONTINUE
      IF(IOPT.NE.1HA)GOTO 2004
      DO 2003 I=1,400
 2003 PSLOPE(I)=ASLOPE(I)
      GOTO 2006
 2004 CONTINUE
      IF(IOPT.NE.1HM)GOTO 2006
      DO 2005 I=1,400
      AVG=(PSLOPE(I)+ASLOPE(I))/2.
      PSLOPE(I)=AVG
 2005 ASLOPE(I)=AVG
 2006 CONTINUE
      DO 2007 I=1,400
      IF(IWAVE(I).LT.IUPPER.AND.IWAVE(I).GT.ILOWER)GOTO 2007
      PSLOPE(I)=0.
      ASLOPE(I)=0.
 2007 CONTINUE
      TYPE 6
    6 FORMAT(/,'$ INSERT THE DISK FOR VERDET COEF DATA STORAGE
     C - "RETURN".')
      ACCEPT 100,IWAIT
      CALL OUTFC
 2008 CONTINUE
      TYPE 7
    7 FORMAT(/,'$ ARE OTHER FILES TO BE AVERAGED OR INTERCHANGED
     C(Y/N)? ')
      ACCEPT 100,IWAIT
      IF(IWAIT.NE.1HY.AND.IWAIT.NE.1HN)GOTO 2007
      IF(IWAIT.EQ.1HY)GOTO 1000
      STOP
      END
```

Appendix 22.

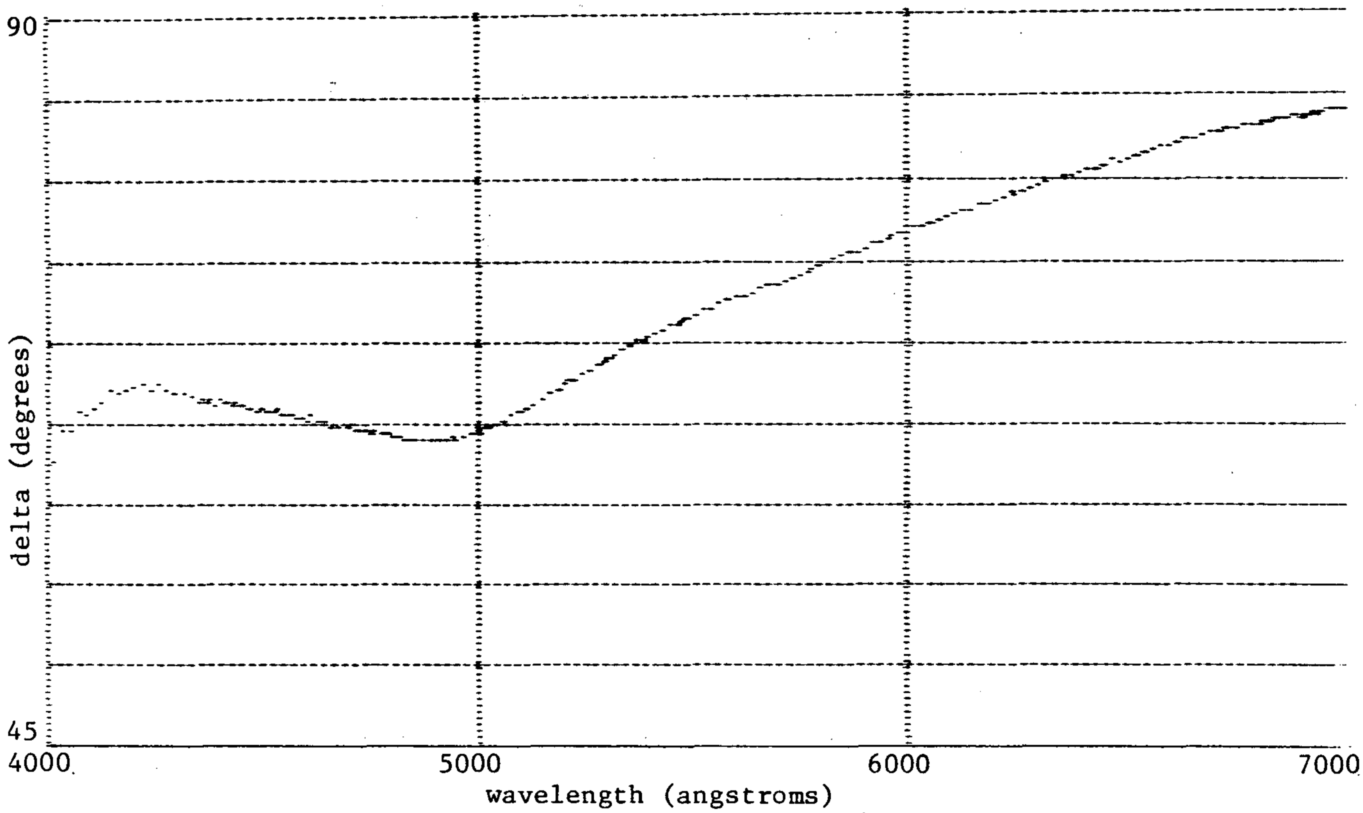
Demonstration of DSCONV - conversion of spectroscopic measurements to delta and psi

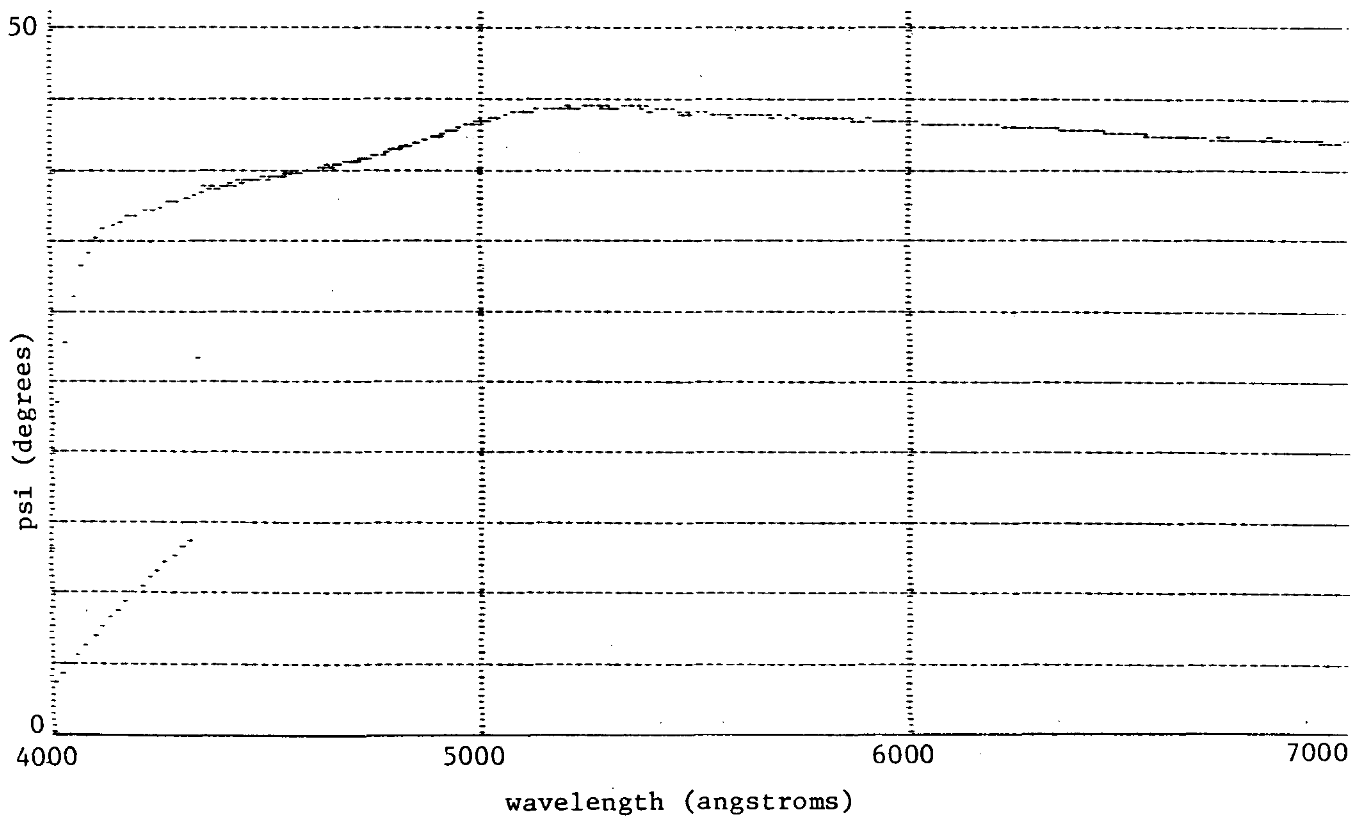
```
.RUN DY0:DSCONV

DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? Y

        DIGITAL ENCODER PRESETS:

        CALIBRATION CURVE SEGMENT NUMBER 1:
             SLOPE =    18.7332
             INTERCEPT =    5137.13
             CORRELATION COEFFICIENT =      0.9996

        CALIBRATION CURVE SEGMENT NUMBER 2:
             SLOPE =   -18.8188
             INTERCEPT =    9668.07
             CORRELATION COEFFICIENT =      0.9999

        LIMITS OF APPLICATION:
             UPPER =    321
             LOWER =    121

DO YOU WANT TO CHANGE THESE(Y/N)? N

FOR RT-11 V.4  : DATA DISK READ VIA "DY0:"

FOR RT-11 V.3.B: DATA DISK READ VIA "DY1:"

INSERT THE DISK WITH THE FARADAY CELL CALIBRATION DATA, THEN "RETURN".

VERDET COEFFICIENT FILE TO BE RETRIEVED = DY1FARADYDAT

INSERT THE DISK WITH THE DATA TO BE CONVERTED TO PSI AND DELTA, THEN "RETURN".

NAME OF SPECTRA FILE TO BE RETRIEVED = DY1TEFLON183 .......spectral scan of Au

ARE STANDARD(1) OR ROTATED(2) AZIMUTH CONVERSION FORMULAS TO BE USED(I1)? 2

CONVERSION IN PROGRESS.................

DO YOU WANT TO PLOT DELTA OR PSI AGAINST WAVELENGTH(Y/N)? Y

        RANGES OF DATA TO BE PLOTTED:
             MAXIMUM WAVELENGTH(ANGSTROMS) =       7390
             MINIMUM                       =       3627
             MAXIMUM DELTA(DEGREES)        =    175.520
             MINIMUM                       =     -3.700
             MAXIMUM PSI(DEGREES)          =     52.000
             MINIMUM                       =      0.140
```

```
DO YOU WANT TO CHANGE THESE(Y/N)? Y

MAXIMUM WAVELENGTH(I5/ANGSTROMS)      = 7000
MINIMUM                               = 4000

MAXIMUM DELTA(DEGREES)        (F10.3) = 90.
MINIMUM                               = 45.

MAXIMUM PSI(DEGREES)          (F10.3) = 50.
MINIMUM                               = 0.

        RANGES OF DATA TO BE PLOTTED:
             MAXIMUM WAVELENGTH(ANGSTROMS) =       7000
             MINIMUM                       =       4000
             MAXIMUM DELTA(DEGREES)        =     90.000
             MINIMUM                       =     45.000
             MAXIMUM PSI(DEGREES)          =     50.000
             MINIMUM                       =      0.000

DO YOU WANT TO CHANGE THESE(Y/N)? N

        PLOTTING MENU FOR REFRACTIVE INDEX DATA:
             (1) DELTA(Y-AXIS) VS ENCODER COUNT(X-AXIS)
             (2) PSI(Y-AXIS) VS ENCODER COUNT(X-AXIS)


        RANGES OF DATA TO BE PLOTTED:
             MAXIMUM WAVELENGTH(ANGSTROMS) =       7000
             MINIMUM                       =       4000
             MAXIMUM DELTA(DEGREES)        =     90.000
             MINIMUM                       =     45.000
             MAXIMUM PSI(DEGREES)          =     50.000
             MINIMUM                       =      0.000

DO YOU WANT TO CHANGE THESE(Y/N)? N

        PLOTTING MENU FOR REFRACTIVE INDEX DATA:
             (1) DELTA(Y-AXIS) VS ENCODER COUNT(X-AXIS)
             (2) PSI(Y-AXIS) VS ENCODER COUNT(X-AXIS)
             (3) DELTA(Y-AXIS) VS WAVELENGTH(X-AXIS)
             (4) PSI(Y-AXIS) VS WAVELENGTH(X-AXIS)
             (5) PSI(Y-AXIS) VS DELTA(X-AXIS)

YOUR CHOICE(1,2,3,4,OR 5)? 3

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE X-COORDINATE(I2)? 3

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE Y-COORDINATE(I2)? 9

IS THE GRAPH TO BE LABELED(Y/N)? N
```

Appendix 22 (continued).

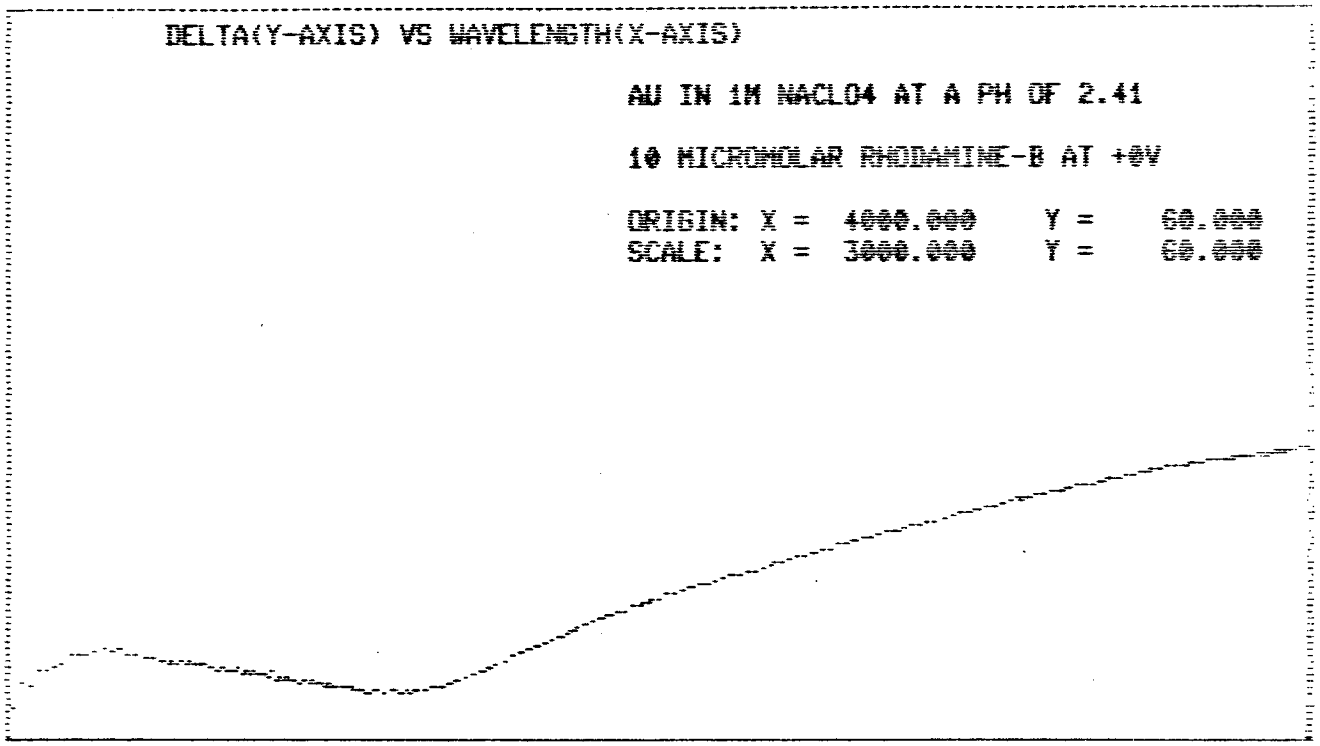
Au in 1 M $NaClO_4$ at pH 2.4

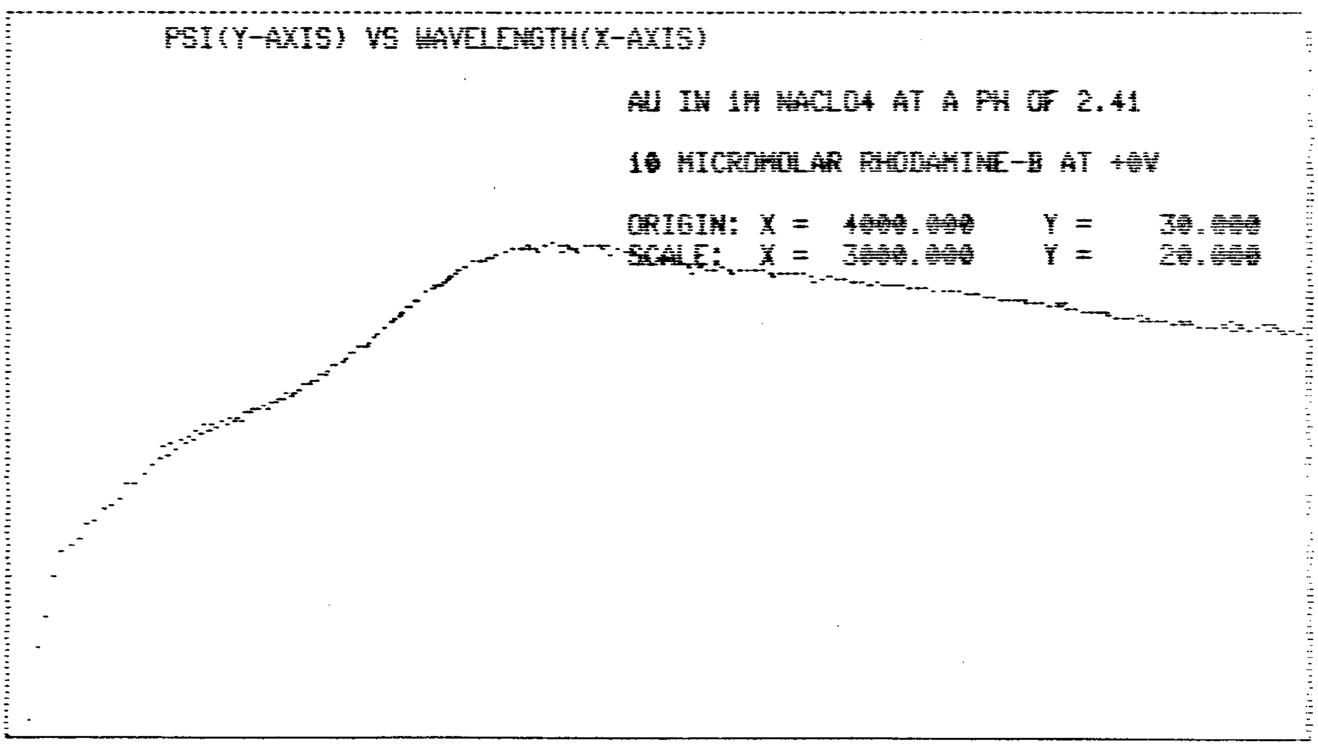




Appendix 22 (continued).

Au in 1 M $NaClO_4$ at pH 2.4





```
ARE ANY ADDITIONAL PLOTS WANTED(Y/N)? N

DO YOU WANT TO STORE THE CONVERTED DATA(Y/N)? Y

FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1DEMOAUDAT

OUTPUT MENU:  (A) HARDCOPY
              (B) CRT DISPLAY
              (C) NEITHER

YOUR RESPONSE: B
```

```
     THE NUMBER OF SPECTRA AVERAGED =      1
     MEASURED SCAN RATE VIA COUNTER =    147

     DATA COLLECTION INITIATED AT:  0: 0: 0: 0
     DATA COLLECTION FINISHED  AT:  1:16:12:41
```

.....time from "booting" measured by line clock

DELTA(DEG) AND PSI(DEG) AS A FUNCTION OF WAVELENGTH(ANGSTROMS)

I = 1	WL = 5155	DELTA = 66.71	PSI = 43.44
I = 2	WL = 5174	DELTA = 67.01	PSI = 43.44
I = 3	WL = 5193	DELTA = 67.19	PSI = 43.56
I = 4	WL = 5212	DELTA = 67.60	PSI = 43.54
I = 5	WL = 5230	DELTA = 67.75	PSI = 43.53
I = 6	WL = 5249	DELTA = 68.13	PSI = 43.58
I = 7	WL = 5268	DELTA = 68.38	PSI = 43.58
I = 8	WL = 5286	DELTA = 68.64	PSI = 43.52
I = 9	WL = 5305	DELTA = 68.95	PSI = 43.54
I = 10	WL = 5324	DELTA = 69.24	PSI = 43.53
I = 11	WL = 5343	DELTA = 69.53	PSI = 43.50
I = 12	WL = 5361	DELTA = 69.81	PSI = 43.54
I = 13	WL = 5380	DELTA = 70.09	PSI = 43.54
I = 14	WL = 5399	DELTA = 70.35	PSI = 43.39
I = 15	WL = 5418	DELTA = 70.58	PSI = 43.40

Appendix 22 (continued).

```
.DIR
 19-Jan-83
TITLE .DAT      4 17-Jun-81    TRNSLT.514      1 09-Nov-81
TRNSLT.555      1 07-Nov-81    RECALL.DAT      2 13-Apr-81
WLCALC.DAT      1 25-May-82    FARADY.OLD      9 25-May-82
FCCAL1.DAT      5 26-May-82    FCCAL2.DAT      5 26-May-82
FCCAL3.DAT      5 26-May-82    FCCAL4.DAT      5 26-May-82
FARADY.NEW      9 26-May-82    FARADY.DAT      9 26-May-82
CVPBCU.DAT     13 30-Jun-82    POTDEP.DAT     11 02-Jul-82
TEFLON.117      5 12-Jul-82    TEFLON.118      5 12-Jul-82
TEFLON.119      5 12-Jul-82    TEFLON.120      5 12-Jul-82
TEFLON.121      5 12-Jul-82    TEFLON.122      5 12-Jul-82
TEFLON.123      5 12-Jul-82    TEFLON.124      5 12-Jul-82
TEFLON.125      5 12-Jul-82    TEFLON.126      5 13-Jul-82
TEFLON.127      5 13-Jul-82    TEFLON.128      5 13-Jul-82
TEFLON.129      5 13-Jul-82    TEFLON.130      5 13-Jul-82
TEFLON.131      5 13-Jul-82    TEFLON.132      5 13-Jul-82
TEFLON.133      5 13-Jul-82    TEFLON.134      5 13-Jul-82
TEFLON.135      5 13-Jul-82    TEFLON.136      5 13-Jul-82
TEFLON.137      5 13-Jul-82    TEFLON.138      5 13-Jul-82
TEFLON.139      5 13-Jul-82    TEFLON.140      5 13-Jul-82
TEFLON.141      5 13-Jul-82    TEFLON.142      5 13-Jul-82
TEFLON.143      5 13-Jul-82    TEFLON.144      5 13-Jul-82


TEFLON.187      5 18-Jul-82    TEFLON.188      5 18-Jul-82
TEFLON.189      5 18-Jul-82    TEFLON.190      5 18-Jul-82
TEFLON.191      5 18-Jul-82    TEFLON.192      5 18-Jul-82
TEFLON.193      5 18-Jul-82    TEFLON.194      5 18-Jul-82
TEFLON.195      5 19-Jul-82    TEFLON.196      5 19-Jul-82
TEFLON.197      5 19-Jul-82    TEFLON.198      5 19-Jul-82
TEFLON.199      5 19-Jul-82    TEFLON.200      5 19-Jul-82
TEFLON.201      5 19-Jul-82    TEFLON.202      5 19-Jul-82
TEFLON.203      5 19-Jul-82    TEFLON.204      5 19-Jul-82
TEFLON.205      5 19-Jul-82    RESULT.203      5 19-Jul-82
CVPBAU.000     13 19-Jul-82    CVPBAU.001     13 19-Jul-82
CVPBAU.002     13 19-Jul-82    CVPBAU.003     13 19-Jul-82
CVPBAU.004     13 19-Jul-82    TRNSLT.DAT      1 09-Nov-81
PLTDAT.DAT     58 19-Jul-82    TEFLON.206      5 19-Jul-82
TEFLON.207      5 19-Jul-82    CVPBAU.005     13 19-Jul-82
CVPBAU.006     13 19-Jul-82    GOLD  .186      5 19-Jan-83
GOLD  .183      5 19-Jan-83    MINUS .186      5 19-Jan-83
GOLD  .188      5 19-Jan-83    MINUS .188      5 19-Jan-83
GOLD  .185      5 19-Jan-83    MINUS .185      5 19-Jan-83
DEMOAU.DAT      5 19-Jan-83.................................data file created by
 165 Files, 940 Blocks                                      program DSCONV
 34 Free blocks
```

Listing of DSCONV

```
      PROGRAM DSCONV
C**********************************************************************
C     OBJECTIVE: TO CONVERT RAW DATA FROM ELLIPSOMETER SPECTRAL SCAN
C                INTO PSI, DELTA, AND WAVELENGTH.
C
C     PROGRAM WRITTEN BY JOSEPH C. FARMER IN SPRING 1981 AT LBL-MMRD
C
C**********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/O/NPASS
      COMMON/QBRIEF/ASLOPE(400),PSLOPE(400)
      COMMON/TITLE/NTITLE(5,30),NWORD(2,21)
      COMMON/MODE/MODE0,MODE1,FACTOR
      INTEGER*2 ANGOPT
      NPASS=1
C*****THE ENCODER COUNT IS CONVERTED TO TO WAVELENGTH BY "WLCALC".*****
      CALL WLCALC
C*****TITLES FOR LABELING GRAPHICS ARE READ FROM "DY1:TITLE.DAT".******
      MODE0=2
      CALL TITLE
C*****THE FARADAY CELL CALIBRATION DATA IS OBTAINED.*******************
      TYPE 999
      TYPE 1000
      ACCEPT 1003,IWAIT
      CALL FCREAD
C*****RAW SPECTRAL SCAN DATA IS OBTAINED FROM THE FLOPPY DISK.*********
    1 TYPE 1001
      ACCEPT 1003,IWAIT
      CALL INPUT
```

```
C*****THE OPERATOR SELECTS THE AZIMUTH CONVERION FORMULAS TO BE USED.**
    2 TYPE 1013
      ACCEPT 1014, ANGOPT
      IF(ANGOPT.NE.1.AND.ANGOPT.NE.2)GOTO 2
      TYPE 1015
      DO 5 I=1,400
      P=NPOL/100.+POL(I)*PSLOPE(I)
      A=NANA/100.+ANA(I)*ASLOPE(I)
      C=NCMP/100.
      CALL DELPSI(P,C,A,D,S,ANGOPT)
      IF(D.LT.180.)GOTO 3
      POL(I)=(D-360.)*100.
      GOTO 4
    3 CONTINUE
      POL(I)=D*100.
    4 ANA(I)=S*100.
    5 CONTINUE
C*****IF DESIRED BY THE OPERATOR, THE CONVERTED DATA IS PLOTTED.*******
   10 TYPE 1002
      ACCEPT 1003,IF1
      IF(IF1.NE.1HY.AND.IF1.NE.1HN)GOTO 10
      IF(IF1.EQ.1HN)GOTO 20
      CALL PLOT
   20 CONTINUE
C*****IF DESIRED, THE CONVERTED DATA IS STORED IN A DISK FILE *********
C     (AZIMUTHS STORED AS HUNDRETHS OF A DEGREE).
   30 TYPE 1004
      ACCEPT 1003,IF2
      IF(IF2.NE.1HY.AND.IF2.NE.1HN)GOTO 30
      IF(IF2.EQ.1HN)GOTO 40
      CALL OUTPUT
   40 CONTINUE
      DO 41 I=1,400
      POL(I)=POL(I)/100.
   41 ANA(I)=ANA(I)/100.
C*****THE NUMERICAL OUTPUT MODE IS SELECTED.****************************
      TYPE 1006
   50 TYPE 1007
      ACCEPT 1003,IF4
      IF(IF4.NE.1HA.AND.IF4.NE.1HB.AND.IF4.NE.1HC)GOTO 50
      IF(IF4.EQ.1HC)GOTO 70
      IF(IF4.NE.1HA)GOTO 60
C*****NUMERICAL DATA IS PRINTED ON THE MODEL 41 TELETYPE.**************
      TYPE 1016
      ACCEPT 1003,IWAIT
      CALL P1INFO
      CALL P1TIME
```

```
      DO 56 IPAGE=1,4
      J=IPAGE-1
      PRINT 1008, IPAGE
      PRINT 1009
      DO 55 I=1,50
      I1=J*100+I
      I2=I1+50
   55 PRINT 1010,I1,IWAVE(I1),POL(I1),ANA(I1),I2,IWAVE(I2),POL(I2),
     CANA(I2)
   56 PRINT 1017
   60 CONTINUE
      IF(IF4.NE.1HB)GOTO 70
C*****NUMERICAL DATA IS DISPLAYED ON THE VT55 TERMINAL SCREEN.*********
      CALL T1INFO
      CALL T1TIME
      TYPE 1011
      DO 65 I=1,400
   65 TYPE 1012,I,IWAVE(I),POL(I),ANA(I)
   70 CONTINUE
C*****DEPENDING UPON OPERATOR RESPONSE, THE PROGRAM IS REPEATED.*******
   80 TYPE 1005
      ACCEPT 1003,IF3
      IF(IF3.NE.1HY.AND.IF3.NE.1HN)GOTO 80
      NPASS=NPASS+1
      IF(IF3.EQ.1HY)GOTO 1
      TYPE 1016
      ACCEPT 1003,IWAIT
```

```
 999 FORMAT(/,'  FOR RT-11 V.4  : DATA DISK READ VIA "DY0:"',/,
    C          '  FOR RT-11 V.3.B: DATA DISK READ VIA "DY1:"')
1000 FORMAT(/,'$ INSERT THE DISK WITH THE FARADAY CELL CALIBRATION
    C DATA, THEN "RETURN".')
1001 FORMAT(/,'$ INSERT THE DISK WITH THE DATA TO BE CONVERTED
    C TO PSI AND DELTA, THEN "RETURN".')
1002 FORMAT(/,'$ DO YOU WANT TO PLOT DELTA OR PSI AGAINST WAVELENGTH
    C(Y/N)? ')
1003 FORMAT(A1)
1004 FORMAT(/,'$ DO YOU WANT TO STORE THE CONVERTED DATA(Y/N)? ')
1005 FORMAT(/,'$ IS THE PROGRAM TO BE EXECUTED AGAIN(Y/N)? ')
1006 FORMAT(/,'  OUTPUT MENU:  (A) HARDCOPY',
    C        /,'                (B) CRT DISPLAY',
    C        /,'                (C) NEITHER')
1007 FORMAT(/,'$ YOUR RESPONSE: ')
1008 FORMAT(///,10X,'DELTA(DEG) AND PSI(DEG) AS A FUNCTION OF
    C WAVELENGTH(ANGSTROMS)',9X,'PAGE ',I1)
1009 FORMAT(///,1X,2(9X,'INDEX',5X,'WL',6X,'DELTA',8X,'PSI'))
1010 FORMAT(1X,2(11X,I3,2X,I5,4X,F7.2,4X,F7.2))
1011 FORMAT(//,5X,'DELTA(DEG) AND PSI(DEG) AS A FUNCTION OF
    C WAVELENGTH(ANGSTROMS)',/)
1012 FORMAT(5X,'I = ',I3,5X,'WL = ',I5,5X,'DELTA = ',F7.2,5X,
    C'PSI = ',F7.2)
1013 FORMAT(/,'$ ARE STANDARD(1) OR ROTATED(2) AZIMUTH
    C CONVERSION FORMULAS TO BE USED(I1)? ')
1014 FORMAT(I1)
1015 FORMAT(/,'  CONVERSION IN PROGRESS.................')
1016 FORMAT(/,'$ BE SURE THAT THE SYSTEM VOLUME IS IN "DY0",
    C THEN "RETURN".')
1017 FORMAT(////////)
     STOP
     END
```

```
      SUBROUTINE FCREAD
C*************************************************************************
C     OBJECTIVE: TO RETRIEVE ONLY THE VERDET COEFFICIENTS STORED BY
C                THE FARADAY CELL CALIBRATION ROUTINE "CALFC1",
C                DISREGARDING OTHER INFORMATION STORED ON THE
C                DISK WITH THE VERDET COEFFICIENTS.  THIS
C                INFORMATION IS USED BY "DSCONV" TO CONVERT
C                A/D CONVERTOR READINGS TO POLARIZER AND
C                ANALYZER AZIMUTHS PRIOR TO CALLING
C                SUBROUTINE "DELPSI" FOR AZIMUTH
C                CONVERSION TO PSI AND DELTA.
C*************************************************************************
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/QBRIEF/ASLOPE(400),PSLOPE(400)
      REAL*4 FCBDLK(2),NAME(20)
      IBLOCK=0
      FACT01=1.
      TYPE 1
    1 FORMAT(/,'$ VERDET COEFFICIENT FILE TO BE RETRIEVED = ')
      ACCEPT 2,(NAME(I),I=1,3)
    2 FORMAT(3A4)
      N=IRAD50(12,NAME,FCBDLK)
      ICHAN=IGETC(I)
      IF(ICHAN.LT.0)STOP 'CANNOT ALLOCATE CHANNEL'
      IF(IFETCH(ICHAN).LT.0)STOP 'FETCH FAIL'
      IF(LOOKUP(ICHAN,FCBDLK).LT.0)STOP 'BAD LOOKUP'
      CALL READ
      CALL READ
      DO 40 I=1,200
   40 PSLOPE(I)=IBUFF(I)/FACT01
      CALL READ
      DO 50 I=1,200
   50 ASLOPE(I)=IBUFF(I)/FACT01
      CALL READ
      DO 60 I=1,200
   60 PSLOPE(I+200)=IBUFF(I)/FACT01
      CALL READ
      DO 70 I=1,200
   70 ASLOPE(I+200)=IBUFF(I)/FACT01
      CALL CLOSEC(ICHAN)
      CALL IFREEC(ICHAN)
      RETURN
      END
```

```
      SUBROUTINE READ
C***********************************************************************
C     OBJECTIVE: TO ACTUALLY READ THE DATA STORED ON THE FLOPPY DISK
C                INTO BUFFER MEMORY.
C***********************************************************************
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      IERROR=IREADW(256,IBUFF,IBLOCK,ICHAN)
      IF(IERROR.LT.0)STOP 'FATAL READ'
      IBLOCK=IBLOCK+1
      RETURN
      END
```

```
      SUBROUTINE DELPSI(P,C,A,D,S,ANGOPT)
C***********************************************************************
C     OBJECTIVE: THIS SUBROUTINE, GIVEN THE POLARIZER, COMPENSATOR, AND
C                ANALYZER AZIMUTH COMPUTES THE CORRESPONDING PSI AND
C                DELTA ELLIPSOMETER ANGLES USING EITHER STANDARD OR
C                ROTATED CONVERSION FORMULAS(DEPENDING UPON THE
C                VALUE OF "ANGOPT".  IF ANGOPT=1 STANDARD FORMULAS
C                ARE USED; IF ANGOPT=2 ROTATED FORMULAS ARE USED.
C***********************************************************************
      INTEGER*2 PFLAG,AFLAG,CFLAG,FLAG,ANGOPT
      D=0.
      S=0.
      PFLAG=0
      GOTO 6
    5 P=P+180.
    6 CONTINUE
      IF(P.LE.180.)PFLAG=400
      IF(P.LE.135.)PFLAG=300
      IF(P.LE. 90.)PFLAG=200
      IF(P.LE. 45.)PFLAG=100
      IF(P.LE.  0.)GOTO 5
      AFLAG=0
      GOTO 8
    7 A=A+180.
    8 CONTINUE
      IF(A.LE.180.)AFLAG=20
      IF(A.LE. 90.)AFLAG=10
      IF(A.LT.  0.)GOTO 7
      CFLAG=0
      IF(C.EQ.45.)CFLAG=1
      IF(C.EQ.135.)CFLAG=2
      FLAG=PFLAG+AFLAG+CFLAG
      IF(ANGOPT.NE.2)GOTO 180
      IF(FLAG.NE.312)GOTO 10
      D=270.-2.*P
      S=90.-A
   10 CONTINUE
      IF(FLAG.NE.411)GOTO 20
      D=2.*P-270.
      S=90.-A
   20 CONTINUE
      IF(FLAG.NE.122)GOTO 30
      D=90.-2.*P
      S=A-90.
```

```
 30 CONTINUE
    IF(FLAG.NE.221)GOTO 40
    D=2.*P-90.
    S=A-90.
 40 CONTINUE
    IF(FLAG.NE.321)GOTO 50
    D=2.*P-90.
    S=A-90.
 50 CONTINUE
    IF(FLAG.NE.422)GOTO 60
    D=450.-2.*P
    S=A-90.
 60 CONTINUE
    IF(FLAG.NE.111)GOTO 70
    D=2.*P-90.
    S=90.-A
 70 CONTINUE
    IF(FLAG.NE.212)GOTO 80
    D=270.-2.*P
    S=90.-A
 80 CONTINUE
    IF(FLAG.NE.322)GOTO 90
    D=450.-2.*P
    S=A-90.
 90 CONTINUE
    IF(FLAG.NE.421)GOTO 100
    D=2.*P-90.
    S=A-90.
100 CONTINUE
    IF(FLAG.NE.112)GOTO 110
    D=270.-2.*P
    S=90.-A
110 CONTINUE
    IF(FLAG.NE.211)GOTO 120
    D=2.*P+90.
    S=90.-A
120 CONTINUE
    IF(FLAG.NE.311)GOTO 130
    D=2.*P+90.
    S=90.-A
130 CONTINUE
    IF(FLAG.NE.412)GOTO 140
    D=630.-2.*P
    S=90.-A
```

```
 140 CONTINUE
     IF(FLAG.NE.121)GOTO 150
     D=2.*P+270.
     S=A-90.
 150 CONTINUE
     IF(FLAG.NE.222)GOTO 160
     D=450.-2.*P
     S=A-90.
 160 CONTINUE
     IF(D.EQ.0.0.AND.S.EQ.0.0)TYPE 170
     IF(D.EQ.0.0.AND.S.EQ.0.0)STOP
 170 FORMAT(/,1X,'*PROBABLE ELLIPSOMETER ANGLE CONVERSION ERROR IN
    C SUBROUTINE "PSIDEL" DETECTED;',/,' EXECUTION TERMINATED*')
     GOTO 1180
 180 CONTINUE
     IF(ANGOPT.NE.1)GOTO 1180
     IF(FLAG.NE.121)GOTO 1010
     D=90.-2.*P
     S=180.-A
1010 CONTINUE
     IF(FLAG.NE.222)GOTO 1020
     D=2.*P-90.
     S=180.-A
1020 CONTINUE
     IF(FLAG.NE.311)GOTO 1030
     D=270.-2.*P
     S=A
1030 CONTINUE
     IF(FLAG.NE.412)GOTO 1040
     D=2.*P-270.
     S=A
1040 CONTINUE
     IF(FLAG.NE.112)GOTO 1050
     D=90.+2.*P
     S=A
1050 CONTINUE
     IF(FLAG.NE.211)GOTO 1060
     D=270.-2.*P
     S=A
1060 CONTINUE
     IF(FLAG.NE.322)GOTO 1070
     D=2.*P-90.
     S=180.-A
```

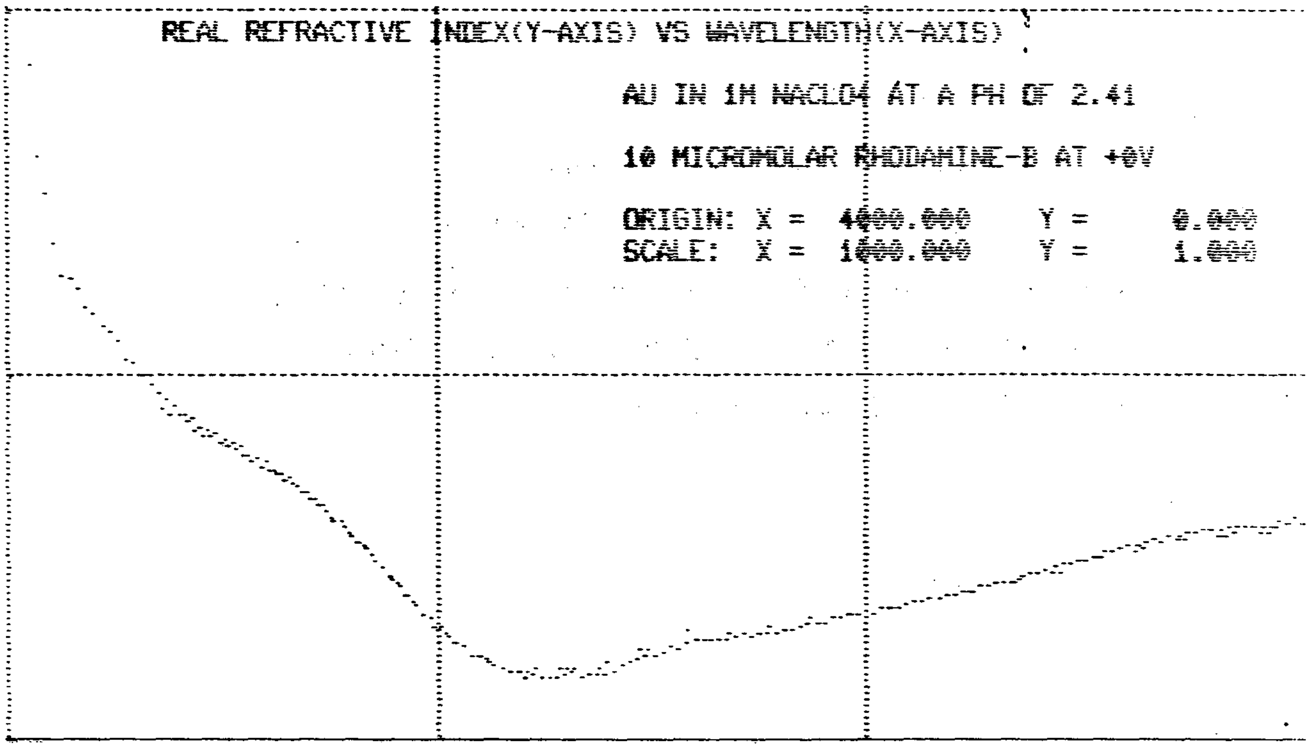
```
1070 CONTINUE
     IF(FLAG.NE.421)GOTO 1080
     D=450.-2.*P
     S=180.-A
1080 CONTINUE
     IF(FLAG.NE.111)GOTO 1090
     D=270.-2.*P
     S=A
1090 CONTINUE
     IF(FLAG.NE.212)GOTO 1100
     D=2.*P+90.
     S=A
1100 CONTINUE
     IF(FLAG.NE.321)GOTO 1110
     D=450.-2.*P
     S=180.-A
1110 CONTINUE
     IF(FLAG.NE.422)GOTO 1120
     D=2.*P-90.
     S=180.-A
1120 CONTINUE
     IF(FLAG.NE.122)GOTO 1130
     D=2.*P+270.
     S=180.-A
1130 CONTINUE
     IF(FLAG.NE.221)GOTO 1140
     D=450.-2.*P
     S=180.-A
1140 CONTINUE
     IF(FLAG.NE.312)GOTO 1150
     D=2.*P+90.
     S=A
1150 CONTINUE
     IF(FLAG.NE.411)GOTO 1160
     D=630.-2.*P
     S=A
1160 CONTINUE
     IF(D.EQ.0.0.AND.S.EQ.0.0)TYPE 170
     IF(D.EQ.0.0.AND.S.EQ.0.0)STOP
1180 CONTINUE
     IF(ANGOPT.EQ.1.OR.ANGOPT.EQ.2)GOTO 2010
     TYPE 2000
2000 FORMAT(/,1X,'*INCORRECT OPTION CODE SPECIFIED IN SUBROUTINE
    C "PSIDEL" SO EXECUTION WAS TERMINATED*')
2010 CONTINUE
     RETURN
     END
```

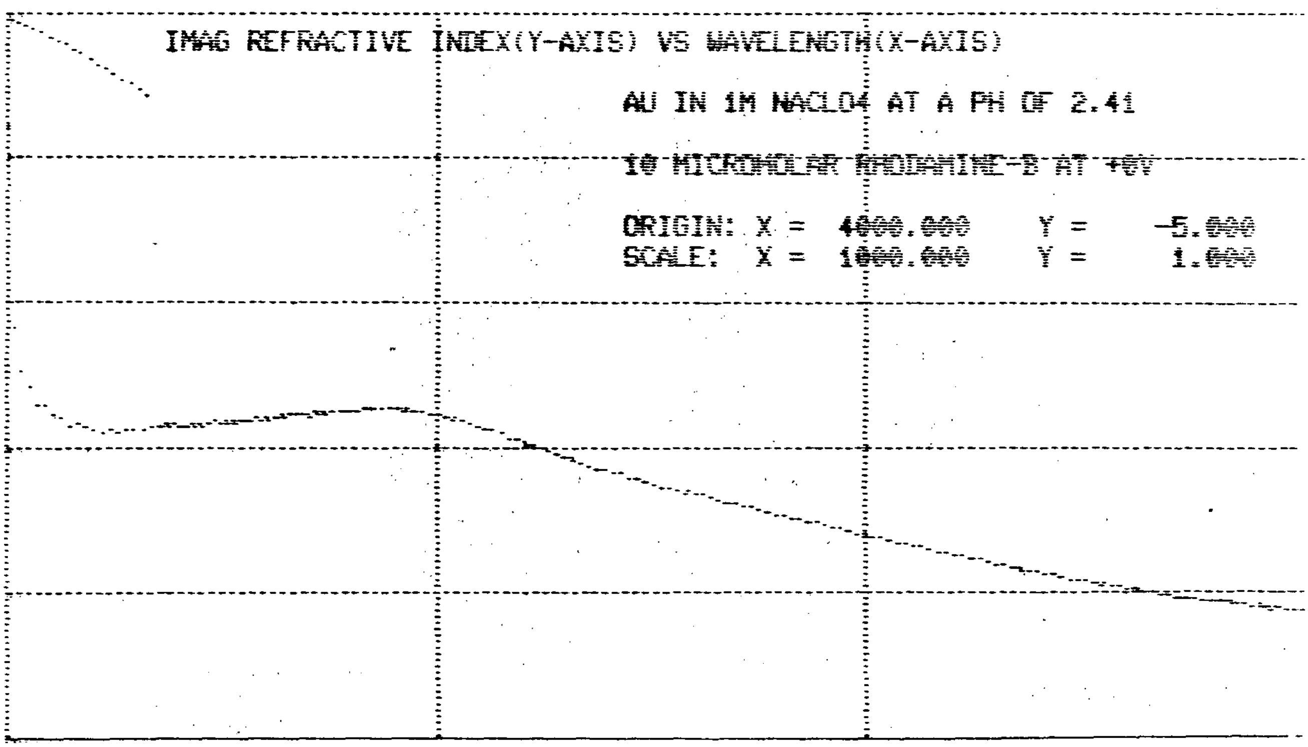
Appendix 23.

Demonstration of RISURF - complex refractive indices of surface computed from files created by program DSCONV

```
TEFLON.199     5 19-Jul-82      TEFLON.200     5 19-Jul-82
TEFLON.201     5 19-Jul-82      TEFLON.202     5 19-Jul-82
TEFLON.203     5 19-Jul-82      TEFLON.204     5 19-Jul-82
TEFLON.205     5 19-Jul-82      RESULT.203     5 19-Jul-82
CVPBAU.000    13 19-Jul-82      CVPBAU.001    13 19-Jul-82
CVPBAU.002    13 19-Jul-82      CVPBAU.003    13 19-Jul-82
CVPBAU.004    13 19-Jul-82      TRNSLT.DAT     1 09-Nov-81
PLTDAT.DAT    58 19-Jul-82      TEFLON.206     5 19-Jul-82
TEFLON.207     5 19-Jul-82      CVPBAU.005    13 19-Jul-82
CVPBAU.006    13 19-Jul-82      GOLD  .186     5 19-Jan-83
GOLD  .183     5 19-Jan-83      MINUS .186     5 19-Jan-83
GOLD  .188     5 19-Jan-83      MINUS .188     5 19-Jan-83
GOLD  .185     5 19-Jan-83      MINUS .185     5 19-Jan-83
DEMOAU.DAT     5 19-Jan-83 ...................file to be used for calculation;
 165 Files, 940 Blocks                        Au in 1 M NaClO4 at pH 2.4
 34 Free blocks

.RUN DY0:RISURF ............running program

 DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

 INSERT THE STORAGE DISK WITH SUBSTRATE DELTA/PSI DATA, THEN "RETURN".

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1DEMOAUDAT


 THE ASSUMED ANGLE OF INCIDENCE(DEG) =  75.00

 SHOULD THIS VALUE BE CHANGED(Y/N)? N

 THE ASSUMED INCIDENT MEDIUM REFRATIVE INDEX =  1.0000

 DO YOU WANT TO CHANGE THIS VALUE(Y/N)? Y

 INCIDENT MEDIUM REFRACTIVE INDEX(F7.4) = 1.34

 THE ASSUMED INCIDENT MEDIUM REFRATIVE INDEX =  1.3400

 DO YOU WANT TO CHANGE THIS VALUE(Y/N)? N

 COMPUTATION IN PROGRESS...................

 DO YOU WANT TO PLOT THE REFRACTIVE INDEX DATA AGAINST WAVELENGTH(Y/N)? Y

         RANGES OF DATA TO BE PLOTTED:
              MAXIMUM WAVELENGTH(ANGSTROMS) =       7390
              MINIMUM                       =       3627
              MAXIMUM REAL REFRACTIVE INDEX =      7.117
              MINIMUM                       =     -1.442
```

```
          MAXIMUM IMAG REFRACTIVE INDEX =      0.005
          MINIMUM                       =     -5.407

DO YOU WANT TO CHANGE THESE(Y/N)? Y

MAXIMUM WAVELENGTH(I5/ANGSTROMS)     = 7000
MINIMUM                              = 4000

MAXIMUM REAL REFRACTIVE INDEX(F10.3) = 2.
MINIMUM                              = 0.

MAXIMUM IMAG REFRACTIVE INDEX(F10.3) = 0.
MINIMUM                              = -4.

       RANGES OF DATA TO BE PLOTTED:
          MAXIMUM WAVELENGTH(ANGSTROMS) =       7000
          MINIMUM                       =       4000
          MAXIMUM REAL REFRACTIVE INDEX =      2.000
          MINIMUM                       =      0.000
          MAXIMUM IMAG REFRACTIVE INDEX =      0.000
          MINIMUM                       =     -4.000

DO YOU WANT TO CHANGE THESE(Y/N)? N

       PLOTTING MENU FOR REFRACTIVE INDEX DATA:
          (1) REAL REFRACTIVE INDEX(Y-AXIS) VS ENCODER COUNT(X-AXIS)
          (2) IMAG REFRACTIVE INDEX(Y-AXIS) VS ENCODER COUNT(X-AXIS)
          (3) REAL REFRACTIVE INDEX(Y-AXIS) VS WAVELENGTH(X-AXIS)
          (4) IMAG REFRACTIVE INDEX(Y-AXIS) VS WAVELENGTH(X-AXIS)
          (5) IMAG R.I.(Y-AXIS) VS REAL R.I.(X-AXIS)

YOUR CHOICE(1,2,3,4,OR 5)? 3

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE X-COORDINATE(I2)? 3

HOW MANY SCALE DIVISIONS DO YOU WANT FOR THE Y-COORDINATE(I2)? 2

IS THE GRAPH TO BE LABELED(Y/N)? Y
```


REAL REFRACTIVE INDEX(Y-AXIS) VS WAVELENGTH(X-AXIS)
AU IN 1M NACLO4 AT A PH OF 2.41
10 MICROMOLAR RHODAMINE-B AT +0V
ORIGIN: X = 4000.000 Y = 0.000
SCALE: X = 1000.000 Y = 1.000


IMAG REFRACTIVE INDEX(Y-AXIS) VS WAVELENGTH(X-AXIS)
AU IN 1M NACLO4 AT A PH OF 2.41
10 MICROMOLAR RHODAMINE-B AT +0V
ORIGIN: X = 4000.000 Y = -5.000
SCALE: X = 1000.000 Y = 1.000

```
ARE ANY ADDITIONAL PLOTS WANTED(Y/N)? N

DO YOU WANT THE COMPLEX REFRACTIVE INDEX STORED(Y/N)? Y

FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1RIAU01DAT

DO YOU WANT TO DISPLAY THE COMPLEX REFRACTIVE INDEX ON THE CRT(Y/N)? N

DO YOU WANT A HARDCOPY OF THE REFRACTIVE INDEX DATA(Y/N)? N

DO YOU WANT TO EXECUTE THE PROGRAM AGAIN(Y/N)? N

STOP --

.
```

```
TEFLON.187      5 18-Jul-82      TEFLON.188      5 18-Jul-82
TEFLON.189      5 18-Jul-82      TEFLON.190      5 18-Jul-82
TEFLON.191      5 18-Jul-82      TEFLON.192      5 18-Jul-82
TEFLON.193      5 18-Jul-82      TEFLON.194      5 18-Jul-82
TEFLON.195      5 19-Jul-82      TEFLON.196      5 19-Jul-82
TEFLON.197      5 19-Jul-82      TEFLON.198      5 19-Jul-82
TEFLON.199      5 19-Jul-82      TEFLON.200      5 19-Jul-82
TEFLON.201      5 19-Jul-82      TEFLON.202      5 19-Jul-82
TEFLON.203      5 19-Jul-82      TEFLON.204      5 19-Jul-82
TEFLON.205      5 19-Jul-82      RESULT.203      5 19-Jul-82
CVPBAU.000     13 19-Jul-82      CVPBAU.001     13 19-Jul-82
CVPBAU.002     13 19-Jul-82      CVPBAU.003     13 19-Jul-82
CVPBAU.004     13 19-Jul-82      TRNSLT.DAT      1 09-Nov-81
PLTDAT.DAT     58 19-Jul-82      TEFLON.206      5 19-Jul-82
TEFLON.207      5 19-Jul-82      CVPBAU.005     13 19-Jul-82
CVPBAU.006     13 19-Jul-82      GOLD  .186      5 19-Jan-83
GOLD  .183      5 19-Jan-83      MINUS .186      5 19-Jan-83
GOLD  .188      5 19-Jan-83      MINUS .188      5 19-Jan-83
GOLD  .185      5 19-Jan-83      MINUS .185      5 19-Jan-83
DEMOAU.DAT      5 19-Jan-83      RIAU01.DAT      5 19-Jan-83 .....data file
 166 Files, 945 Blocks                                           created by
 29 Free blocks                                                  RISURF

.
```

```
      PROGRAM RISURF
C*************************************************************************
C     OBJECTIVE: COMPUTATION OF COMPLEX REFRACTIVE INDEX OF A BARE
C                SUBSTRATE AS A FUNCTION OF WAVELENGTH FROM AN
C                ELLIPSOMETRIC SPECTRAL SCAN.
C
C     PROGRAM WRITTEN BY JOSEPH C. FARMER IN SPRING 1981 AT LBL-MMRD
C
C*************************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/O/NPASS
      COMMON/TITLE/NTITLE(5,30),NWORD(2,21)
      COMMON/MODE/MODE0,MODE1,FACTOR
      NPASS=1
C*****CALIBRATE THE DIGITAL ENCODER FOR WAVELENGTH*********************
      CALL WLCALC
C*****TITLES FOR LABELING GRAPHICS ARE READ FROM "DY1:TITLE.DAT".******
      MODE0=3
      CALL TITLE
C*****INPUT STORED DELTA/PSI DATA FOR SUBSTRATE FROM FLOPPY DISK********
    1 TYPE 2018
      ACCEPT 2019,WAIT
      CALL INPUT
```

```
C*****ACCEPT INCIDENT MEDIUM REFRACTIVE INDEX AND ANGLE OF INCIDENCE****
      PHID=75.
    2 TYPE 2008,PHID
      TYPE 2009
      ACCEPT 2010,IF0
      IF(IF0.NE.1HY.AND.IF0.NE.1HN)GOTO 2
      IF(IF0.EQ.1HN)GOTO 3
      TYPE 2011
      ACCEPT 2012,PHID
      GOTO 2
    3 CONTINUE
      TNO=1.0
    4 TYPE 2013,TNO
      TYPE 2014
      ACCEPT 2015,IF0
      IF(IF0.NE.1HY.AND.IF0.NE.1HN)GOTO 4
      IF(IF0.EQ.1HN)GOTO 5
      TYPE 2016
      ACCEPT 2017,TNO
      GOTO 4
    5 CONTINUE
C*****PERFORM REFRACTIVE INDEX COMPUTATION USING SUBROUTINE "REFIND"****
      TYPE 2024
      DO 10 I=1,400
      DELD=POL(I)/100.
      PSID=ANA(I)/100.
      CALL REFIND(PHID,DELD,PSID,TNO,TN,TK)
      POL(I)=TN*1000.
      ANA(I)=TK*1000.
   10 CONTINUE
C*****PLOT THE RESULTS ON VT55 GRAPHICS TERMINAL************************
  100 TYPE 2006
      ACCEPT 2000,IF4
      IF(IF4.NE.1HY.AND.IF4.NE.1HN)GOTO 100
      IF(IF4.EQ.1HN)GOTO 110
      CALL PLOT
  110 CONTINUE
C*****STORE THE COMPLEX REFRACTIVE INDEX SPECTRA ON THE FLOPPY DISK*****
  200 TYPE 2001
      ACCEPT 2000,IF1
      IF(IF1.NE.1HY.AND.IF1.NE.1HN)GOTO 200
      IF(IF1.EQ.1HN)GOTO 300
      CALL OUTPUT
  300 CONTINUE
      DO 310 I=1,400
      POL(I)=POL(I)/1000.
  310 ANA(I)=ANA(I)/1000.
```

```
C*****DISPLAY THE NUMERICAL RESULTS ON THE VT55 CRT SCREEN*************
  400 TYPE 2002
      ACCEPT 2000,IF2
      IF(IF2.NE.1HY.AND.IF2.NE.1HN)GOTO 400
      IF(IF2.EQ.1HN)GOTO 600
      CALL T1INFO
      CALL T1TIME
      TYPE 2003
      DO 500 I=1,400
  500 TYPE 2004,I,IWAVE(I),POL(I),ANA(I)
C*****PRODUCE A HARDCOPY OF REFRACTIVE INDEX DATA ON LINE PRINTER*******
  600 TYPE 2005
      ACCEPT 2000,IF3
      IF(IF3.NE.1HY.AND.IF3.NE.1HN)GOTO 600
      IF(IF3.EQ.1HN)GOTO 800
      CALL P1INFO
      CALL P1TIME
      DO 710 IPAGE=1,4
      J=IPAGE-1
      PRINT 2020,IPAGE
      PRINT 2021
      DO 700 I=1,50
      I1=J*100+I
      I2=I1+50
  700 PRINT 2022,I1,IWAVE(I1),POL(I1),ANA(I1),I2,IWAVE(I2),POL(I2)
     C,ANA(I2)
  710 PRINT 2023
  800 CONTINUE
C*****EXECUTE "RISURF" AGAIN IF DESIRED*******************************
 1000 TYPE 2007
      ACCEPT 2000,IF5
      IF(IF5.NE.1HY.AND.IF5.NE.1HN)GOTO 1000
      IF(IF5.NE.1HY)STOP
      NPASS=NPASS+1
      GOTO 1
```

```
2000 FORMAT(A1)
2001 FORMAT(/,'$ DO YOU WANT THE COMPLEX REFRACTIVE INDEX STORED
    C(Y/N)? ')
2002 FORMAT(/,'$ DO YOU WANT TO DISPLAY THE COMPLEX REFRACTIVE
    C INDEX ON THE CRT(Y/N)? ')
2003 FORMAT(//,5X,'COMPLEX REFRACTIVE INDEX AS A FUNCTION OF
    C WAVELENGTH',/)
2004 FORMAT(5X,'I = ',I3,5X,'WL = ',I5,5X,'N = ',F7.4,5X,'K = ',F7.4)
2005 FORMAT(/,'$ DO YOU WANT A HARDCOPY OF THE REFRACTIVE
    C INDEX DATA(Y/N)? ')
2006 FORMAT(/,'$ DO YOU WANT TO PLOT THE REFRACTIVE INDEX DATA
    C AGAINST WAVELENGTH(Y/N)? ')
2007 FORMAT(/,'$ DO YOU WANT TO EXECUTE THE PROGRAM AGAIN(Y/N)? ')
2008 FORMAT(/,'  THE ASSUMED ANGLE OF INCIDENCE(DEG) = ',F6.2)
2009 FORMAT(/,'$ SHOULD THIS VALUE BE CHANGED(Y/N)? ')
2010 FORMAT(A1)
2011 FORMAT(/,'$ PHID(F6.2/DEG) = ')
2012 FORMAT(F6.2)
2013 FORMAT(/,'  THE ASSUMED INCIDENT MEDIUM REFRATIVE INDEX = ',
    CF7.4)
2014 FORMAT(/,'$ DO YOU WANT TO CHANGE THIS VALUE(Y/N)? ')
2015 FORMAT(A1)
2016 FORMAT(/,'$ INCIDENT MEDIUM REFRACTIVE INDEX(F7.4) = ')
2017 FORMAT(F7.4)
2018 FORMAT(/,'$ INSERT THE STORAGE DISK WITH SUBSTRATE DELTA/PSI
    C DATA, THEN "RETURN".')
2019 FORMAT(A1)
2020 FORMAT(///,10X,'COMPLEX REFRACTIVE INDEX DATA AS A FUNCTION OF
    C WAVELENGTH             PAGE ',I1)
2021 FORMAT(///,1X,2(9X,'INDEX',3X,'WL',7X,'REAL',4X,'IMAGINARY'))
2022 FORMAT(2(11X,I3,2X,I5,4X,F7.4,4X,F7.4))
2023 FORMAT(/////////)
2024 FORMAT(/,'  COMPUTATION IN PROGRESS....................')
     END
```

```
      SUBROUTINE REFIND(PHID,DELD,PSID,TNO,TN,TK)
C***********************************************************************
C       OBJECTIVE: TO COMPUTE THE COMPLEX REFRACTIVE INDEX OF A BARE
C                  SURFACE FOR A SINGLE SET OF VALUES OF DELTA, PSI,
C                  WAVELENGTH, AND INCIDENT MEDIUM REFRACTIVE INDEX.
C***********************************************************************
      COMPLEX RHO,T2,S2,TNC,I
      ALPHA=0.01745329252
      PHI=PHID*ALPHA
      PSI=PSID*ALPHA
      DEL=DELD*ALPHA
      I=CMPLX(0.0,1.0)
      RHO=(SIN(PSI)/COS(PSI))*CEXP(I*DEL)
      S1=SIN(PHI)
      T1=SIN(PHI)/COS(PHI)
      T2=(1.0+RHO)/((1.0-RHO)*T1)
      S2=T2/CSQRT(1.0+T2*T2)
      TNC=(TNO*S1)/S2
      TN=REAL(TNC)
      TK=AIMAG(TNC)
      RETURN
      END
```

Appendix 24.

Demonstration of RISMTH - Langrangian smoothing of complex refractive index spectra

```
.RUN DY1:RISMTH

 INSERT DISK WITH WAVELENGTH CALIBRATION - 'RETURN'.

 DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

 INSERT DISK WITH RI SPECTRA FILE TO BE SMOOTHED - 'RETURN'.

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1LEAD  DAT

 LOWER ENCODER INDEX FOR SMOOTHING POLYNOMIAL = 140

 UPPER ENCODER INDEX FOR SMOOTHING POLYNOMIAL = 300

 POWER OF LAGRANGIAN SMOOTHING POLYNOMIAL     = 2
 WL =  5155     POL VERDET COEF = -0.319E+04     ANA VERDET COEF = -0.197E+04
 WL =  5174     POL VERDET COEF = -0.314E+04     ANA VERDET COEF = -0.199E+04
 WL =  5193     POL VERDET COEF = -0.310E+04     ANA VERDET COEF = -0.200E+04
 WL =  5212     POL VERDET COEF = -0.305E+04     ANA VERDET COEF = -0.202E+04
 WL =  5230     POL VERDET COEF = -0.300E+04     ANA VERDET COEF = -0.203E+04
 WL =  5249     POL VERDET COEF = -0.296E+04     ANA VERDET COEF = -0.204E+04
 WL =  5268     POL VERDET COEF = -0.291E+04     ANA VERDET COEF = -0.206E+04
 WL =  5286     POL VERDET COEF = -0.286E+04     ANA VERDET COEF = -0.207E+04
 WL =  5305     POL VERDET COEF = -0.281E+04     ANA VERDET COEF = -0.209E+04


 WL =  4949     POL VERDET COEF = -0.371E+04     ANA VERDET COEF = -0.182E+04
 WL =  4968     POL VERDET COEF = -0.366E+04     ANA VERDET COEF = -0.183E+04
 WL =  4987     POL VERDET COEF = -0.362E+04     ANA VERDET COEF = -0.185E+04
 WL =  5005     POL VERDET COEF = -0.357E+04     ANA VERDET COEF = -0.186E+04
 WL =  5024     POL VERDET COEF = -0.352E+04     ANA VERDET COEF = -0.187E+04
 WL =  5043     POL VERDET COEF = -0.347E+04     ANA VERDET COEF = -0.189E+04
 WL =  5062     POL VERDET COEF = -0.343E+04     ANA VERDET COEF = -0.190E+04
 WL =  5080     POL VERDET COEF = -0.338E+04     ANA VERDET COEF = -0.192E+04
 WL =  5099     POL VERDET COEF = -0.333E+04     ANA VERDET COEF = -0.193E+04
 WL =  5118     POL VERDET COEF = -0.329E+04     ANA VERDET COEF = -0.195E+04
 WL =  5137     POL VERDET COEF = -0.324E+04     ANA VERDET COEF = -0.196E+04
```

Note: POL VERDET COEF and ANA VERDET COEF are n and k, respectively, both multiplied by 100

```
 PERROR =  0.44E+04      AERROR =    0.14E+04

 INSERT THE DISK FOR SMOOTHED RI SPECTRA - 'RETURN'.

 FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1SMOOTHPB1

 ARE OTHER FILES TO BE SMOOTHED(Y/N)? N

STOP --

.
```

Listing of RISMTH

```
      PROGRAM RISMTH
C************************************************************************
C      OBJECTIVE:  TO CONTROL I/O AND SMOOTHING OF RI SPECTRA.
C
C      WRITTEN BY JOSEPH C. FARMER ON OCTOBER 30, 1981, LBL-MMRD, UCB.
C
C************************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOF(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/Q/ASLOPE(400),PSLOPE(400),AINTER(400),PINTER(400)
 1000 CONTINUE
  100 FORMAT(A1)
      TYPE 1
    1 FORMAT(/,'$ INSERT DISK WITH WAVELENGTH CALIBRATION - "RETURN".')
      ACCEPT 100,IWAIT
      CALL WLCALC
      TYPE 2
    2 FORMAT(/,'$ INSERT DISK WITH RI SPECTRA FILE TO BE SMOOTHED
     C - "RETURN".')
      ACCEPT 100,IWAIT
      CALL INPUT
      DO 2000 I=1,400
      PSLOPE(I)=POL(I)
 2000 ASLOPE(I)=ANA(I)
      CALL SMOOTH
      DO 3000 I=1,400
      POL(I)=PSLOPE(I)
 3000 ANA(I)=ASLOPE(I)
      TYPE 3
    3 FORMAT(/,'$ INSERT THE DISK FOR SMOOTHED RI SPECTRA
     C - "RETURN".')
      ACCEPT 100,IWAIT
      CALL OUTPUT
    4 CONTINUE
      TYPE 5
    5 FORMAT(/,'$ ARE OTHER FILES TO BE SMOOTHED(Y/N)? ')
      ACCEPT 100,IWAIT
      IF(IWAIT.NE.1HY.AND.IWAIT.NE.1HN)GOTO 4
      IF(IWAIT.EQ.1HY)GOTO 1000
      STOP
      END
```

Appendix 25.

Demonstration of RIGEN1 - generation of spectroscopic refractive index data file by linear regression of literature data; assumes no absorption bands over spectral range of data

```
.RUN DY1:RIGEN1

 INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE DIGITAL ENCODER AND "RETURN".

 DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

 NUMBER OF POINTS TO BE REGRESSED = 3

 CORRECTION(Y/N)? N


 WAVELENGTH(F10.0) = 7000.

 N(F10.3) = 2.5

 K(F10.3) = 5.0

 CORRECTION(Y/N)? N


 WAVELENGTH(F10.0) = 5500.

 N(F10.3) = 2.4


 K(F10.3) = 3.0

 CORRECTION(Y/N)? N


 WAVELENGTH(F10.0) = 4000.

 N(F10.3) = 2.3

 K(F10.3) = 1.0

 CORRECTION(Y/N)? N


M1 =    0.6667E-04       B1 =    0.2033E+01       R1 =    0.1000E+01
M2 =    0.1333E-02       B2 =   -0.4333E+01       R2 =    0.1000E+01

 IS SYNTHETIC RI SPECTRA TO BE STORED(Y/N)? Y

 INSERT DISK FOR SYNTHETIC RI SPECTRA AND "RETURN".

 NAME(20A2) = JOSEPH COLLIN FARMER
```

```
ID(20A2) = SYNTHETIC SPECTROSCOPIC RI FOR DEMO

CORRECTION(Y/N)? N

FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1RIGEN1DEM

IS PROGRAM TO BE EXECUTED AGAIN(Y/N)? Y

INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE DIGITAL ENCODER AND "RETURN".

DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? Y


        DIGITAL ENCODER PRESETS:

        CALIBRATION CURVE SEGMENT NUMBER 1:
             SLOPE =     18.0000
             INTERCEPT =     5690.00
             CORRELATION COEFFICIENT =      1.0000

        CALIBRATION CURVE SEGMENT NUMBER 2:
             SLOPE =    -18.0000
             INTERCEPT =     8695.00
             CORRELATION COEFFICIENT =      1.0000
```

```
INFC  .FOR     7 14-Jun-81       FCPLOT.FOR    10 17-Jun-81
CALFC1.FOR    12 16-Jun-81       MINUS .FOR     3 17-Jun-81
EDATA .FOR     3 23-Oct-81       SEV002.FOR    18 23-Oct-81
RUNTST.FOR     2 23-Oct-81       EDATA2.FOR     3 22-Oct-81
PLOTXX.FOR     5 23-Oct-81       WLCALC.NEW     1 28-Oct-81
FCAVG1.FOR     5 02-Nov-81       FCAVG2.FOR     6 02-Nov-81
FCSMTH.FOR     4 02-Nov-81       SMOOTH.FOR     6 02-Nov-81
TITLE .DAT     4 17-Jun-81       FARADY.DAT     9 02-Nov-81
FCREAD.FOR     4 07-Dec-81       DSCON1.FOR    11 07-Dec-81
DSCON1.SAV    90 07-Dec-81       RISMTH.FOR     4 13-Dec-81
RISMTH.SAV    63 13-Dec-81       RIGEN1.FOR     6 13-Dec-81
RIGEN1.SAV    49 13-Dec-81       RILINE.FOR     4 13-Dec-81
FILM  .FOR     3 14-Dec-81       EMASES.FOR    11 18-Jan-82
EMASES.SAV    83 18-Jan-82       CSMSES.FOR    10 12-Jan-82
FILM02.FOR     5 20-Jan-82       CSMFIT.FOR    11 12-Jan-82
CSMFIT.SAV    46 12-Jan-82       CSMSES.SAV    93 12-Jan-82
EMAFIT.FOR    12 21-Jan-82       EMAFIT.SAV    43 21-Jan-82
NORMAL.FOR     4 18-Feb-82       NORMAL.SAV    41 18-Feb-82
FCSMTH.OBJ     7 23-May-82       SMOOTH.OBJ    12 23-May-82
RIGEN1.DEM     5 21-Jan-83 ..................................generated data file
 73 Files, 956 Blocks                                          in directory of DY1:
 18 Free blocks
```

Listing of RIGEN1

```
      PROGRAM RIGEN1
C***********************************************************************
C     OBJECTIVE:  TO USE A LINEAR REGRESSION ROUTINE TO CREATE A
C                 SIMULATED RI SPECTRA THAT VARIES LINEARLY WITH
C                 WAVELENGTH.  REGRESSION IS DONE ON REFRACTIVE INDEX
C                 DATA ENTERED FROM THE KEYBOARD BY THE OPERATOR.
C
C     BY JOSEPH C. FARMER, DECEMBER 13, 1981, LBL-MMRD, UCB.
C
C***********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      REAL*4 DBLK(2),NAME(20)
      REAL*4 M1,M2
    1 CONTINUE
      TYPE 10
   10 FORMAT(/,'$ INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE
     C DIGITAL ENCODER AND "RETURN".')
      ACCEPT 11,IWAIT
   11 FORMAT(I1)
      CALL WLCALC
      CALL RILINE(M1,M2,B1,B2,R1,R2)
      DO 1000 I=1,400
      POL(I)=(M1*IWAVE(I)+B1)*1000.
 1000 ANA(I)=(M2*IWAVE(I)+B2)*1000.
   12 TYPE 13
   13 FORMAT(/,'$ IS SYNTHETIC RI SPECTRA TO BE STORED(Y/N)? ')
      ACCEPT 14,IFLAG1
   14 FORMAT(A1)
      IF(IFLAG1.NE.1HY.AND.IFLAG1.NE.1HN)GOTO 12
      IF(IFLAG1.EQ.1HN)GOTO 40
      DO 2000 I=1,10
      LMPSER(I)=1HX
 2000 IPMTYP(I)=1HX
      DO 3000 I=1,3
 3000 IMON(I)=1HX
```

```
LMPVLT=0
LMPAMP=0
IPHASP=0
IGAINP=0
IAMPLP=0
ITIMEP=0
IPHASA=0
IGAINA=0
IAMPLA=0
ITIMEA=0
IGAGP=0
IGATP=0
IGAGA=0
IGATA=0
NRATE=0
NSCAN=0
IPOL=0
IANA=0
NWL=0
NPOL=0
NCMP=0
NANA=0
IHRSO=0
IMINO=0
ISECO=0
ITICO=0
IHRSF=0
IMINF=0
ISECF=0
ITICF=0
```

```
      TYPE 20
   20 FORMAT(/,'$ INSERT DISK FOR SYNTHETIC RI SPECTRA AND "RETURN".')
      ACCEPT 21,IWAIT
   21 FORMAT(I1)
   30 TYPE 31
   31 FORMAT(/,'$ NAME(20A2) = ')
      ACCEPT 32,(NAMEOP(I),I=1,20)
   32 FORMAT(20A2)
      TYPE 33
   33 FORMAT(/,'$ ID(20A2) = ')
      ACCEPT 32,(ID(I),I=1,20)
      TYPE 34
   34 FORMAT(/,'$ CORRECTION(Y/N)? ')
      ACCEPT 35,IFLAG2
   35 FORMAT(A1)
      IF(IFLAG2.NE.1HN.AND.IFLAG2.NE.1HY)GOTO 30
      CALL OUTPUT
   40 CONTINUE
   41 TYPE 42
   42 FORMAT(/,'$ IS PROGRAM TO BE EXECUTED AGAIN(Y/N)? ')
      ACCEPT 43,IFLAG3
   43 FORMAT(A1)
      IF(IFLAG3.NE.1HY.AND.IFLAG3.NE.1HN)GOTO 41
      IF(IFLAG3.EQ.1HY)GOTO 1
      STOP
      END
```

Appendix 26.

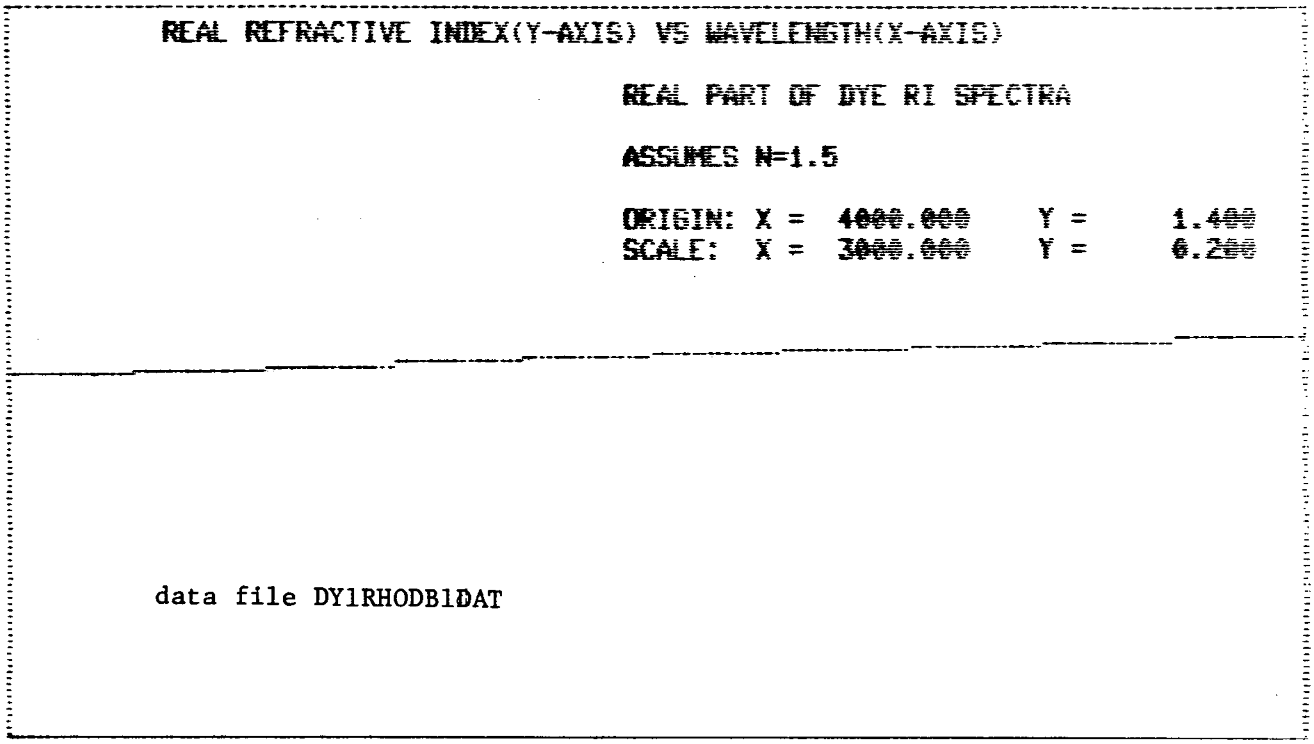
Demonstration of DYERI - simulation of dye adsorbate refractive index data file from absorption spectra measured with the spectral scanning ellipsometer serving as spectrophotometer

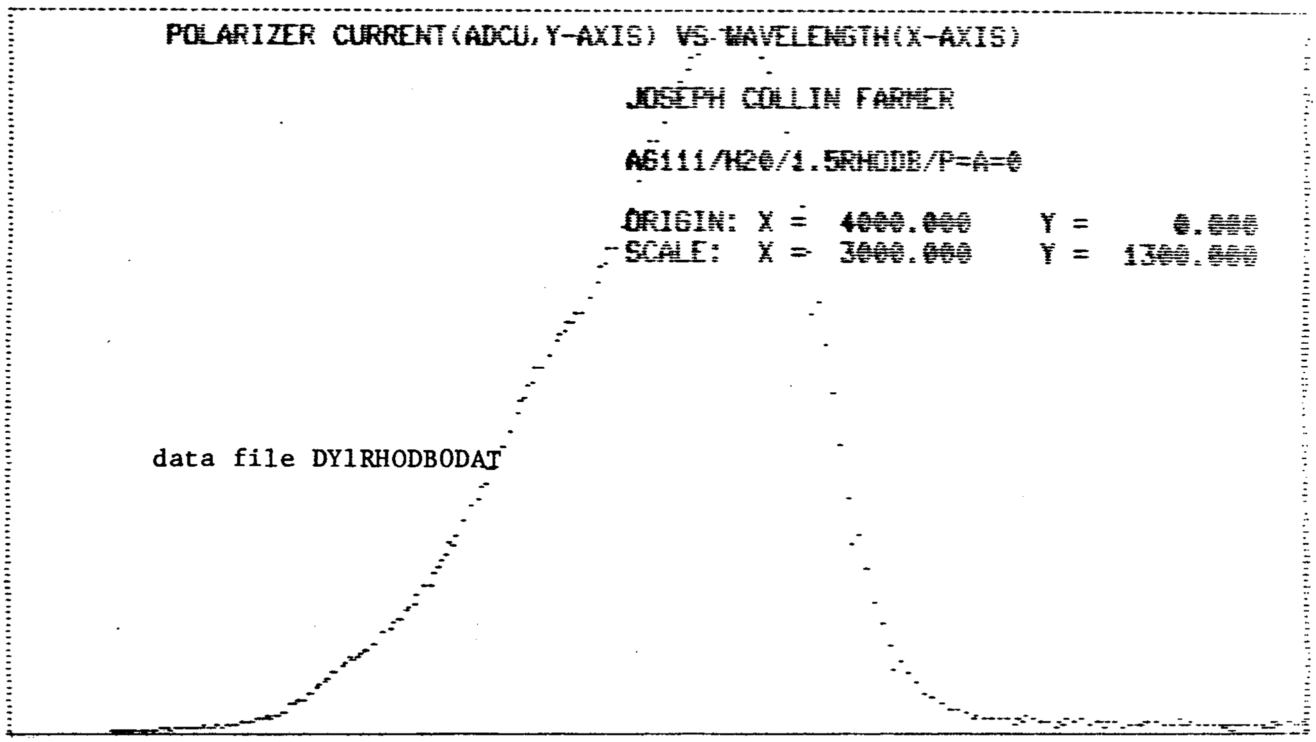
```
.RUN DY1:DYERI

 INSERT REAL RI COMPONENT DISK - "RETURN".

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1RHODB1DAT

 INSERT IMAG RI COMPONENT DISK - "RETURN".

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1RHODB0DAT

 EXTINCTION COEFFICIENT MAXIMUM = 1.7

 FILE MAXIMUM VALUE             = 1274.

 IS THE DYE RI SPECTRA TO BE STORED(Y/N)? Y

 FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1DYERI DEM

STOP --

.

.

SUB001.DAT     5 07-Sep-82      SUB002.DAT     5 07-Sep-82
INOUT .FOR    13 07-Apr-81      MINMOD.SAV    40 07-Sep-82
MINMOD.FOR     3 07-Sep-82      INOUT .OBJ    34 07-Sep-82
SUB003.DAT     5 07-Sep-82      SUB004.DAT     5 07-Sep-82
PLTNUM.DAT     5 07-Sep-82      SILVER.DAT     5 07-Sep-82
LEAD  .DAT     5 07-Sep-82      SPEC05.DAT     5 07-Sep-82
SPEC06.DAT     5 07-Sep-82      SPEC07.DAT     5 07-Sep-82
SPEC08.DAT     5 07-Sep-82      SPEC09.DAT     5 07-Sep-82
SUB006.DAT     5 07-Sep-82      SUB007.DAT     5 07-Sep-82
SUB008.DAT     5 07-Sep-82      SUB009.DAT     5 07-Sep-82
SPEC10.DAT     5 07-Sep-82      SPEC11.DAT     5 07-Sep-82
SPEC12.DAT     5 07-Sep-82      SPEC13.DAT     5 07-Sep-82
SPEC14.DAT     5 07-Sep-82      SUB011.DAT     5 07-Sep-82
SUB012.DAT     5 07-Sep-82      SUB013.DAT     5 07-Sep-82
SUB014.DAT     5 07-Sep-82      SPEC16.DAT     5 10-Sep-82
SPEC18.DAT     5 10-Sep-82      SPEC19.DAT     5 10-Sep-82
SPEC15.DAT     5 10-Sep-82      SUB016.DAT     5 10-Sep-82
SUB018.DAT     5 10-Sep-82      SUB019.DAT     5 10-Sep-82
SPEC17.DAT     5 10-Sep-82      SUB017.DAT     5 10-Sep-82
DYERI .DEM     5 21-Jan-83
 63 Files, 844 Blocks
 130 Free blocks
```

DYERI .DEM .... generated data file in directory of DY1:

Appendix 26 (continued).

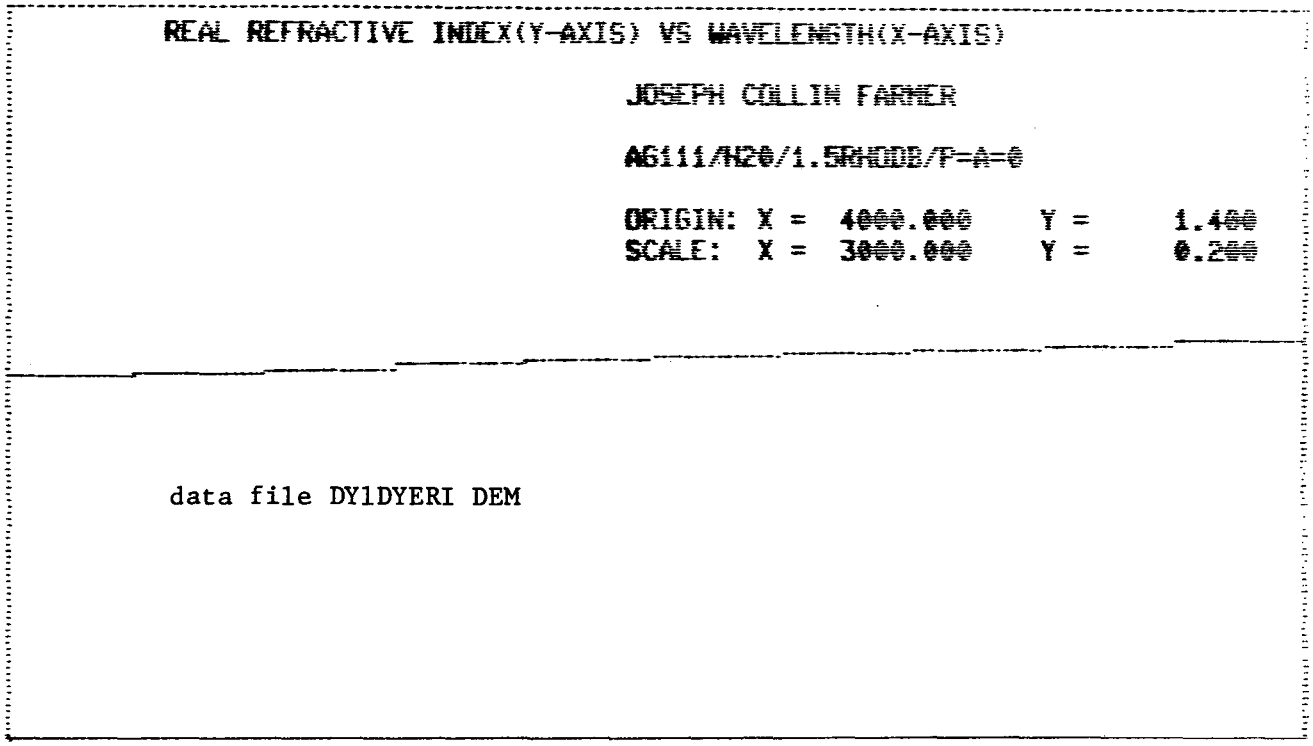
Simulated rhodamine-B complex refractive index spectra: required input data

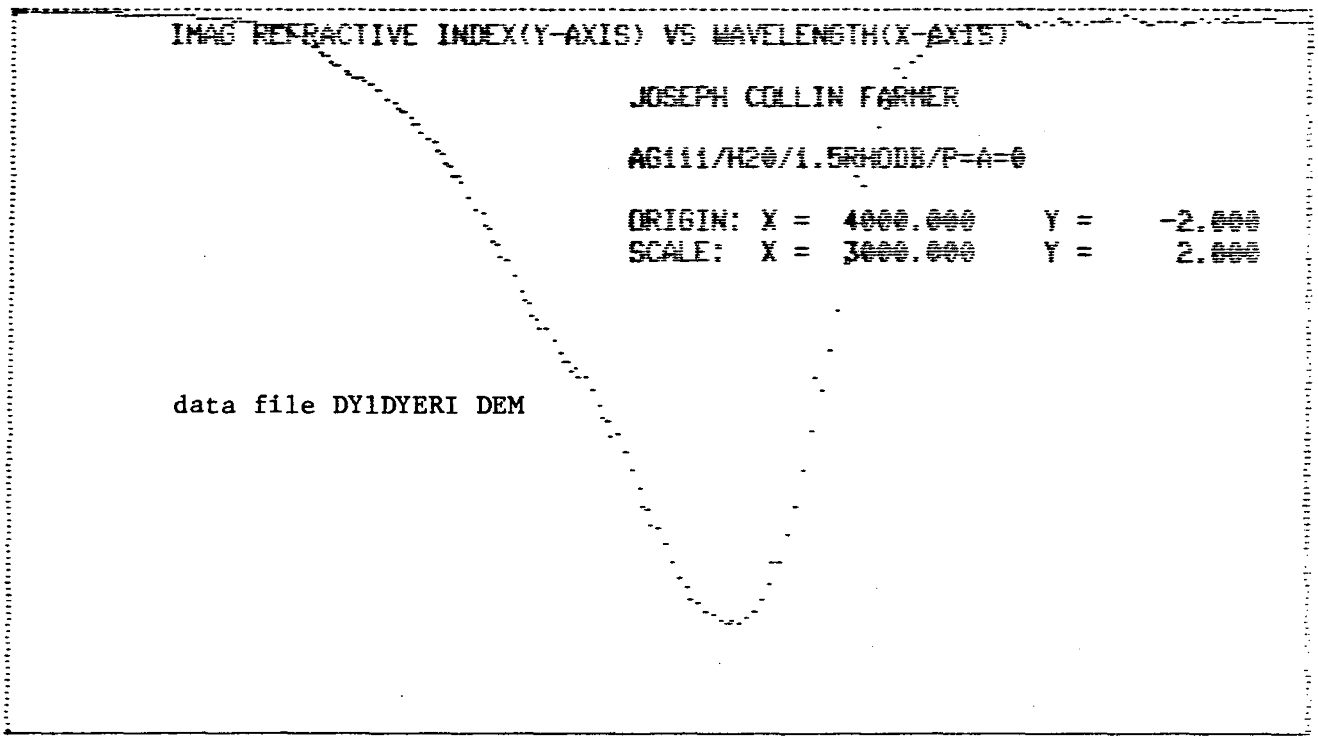




Appendix 26 (continued).

Simulated rhodamine-B complex refractive index spectra:
data output by DYERI





Listing of DYERI

```
      PROGRAM DYERI
C***************************************************************************
C     OBJECTIVE: TO GENERATE RI SPECTRA FOR DYE SOLUTIONS FROM ABSORBANCE
C                SPECTRA MEASURED WITH THE ELLIPSOMETER.
C
C     BY JOSEPH C. FARMER, DECEMBER 13,1981, LBL-MMRD, UCB.
C
C***************************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      REAL*4 DBLK(2),NAME(20)
      DIMENSION DN(400)
    1 FORMAT(I1)
    2 FORMAT(F10.4)
   10 TYPE 100
  100 FORMAT(/,'$ INSERT REAL RI COMPONENT DISK - "RETURN".')
      ACCEPT 1, IWAIT
      CALL INPUT
      DO 200 J=1,400
  200 DN(J)=POL(J)
      TYPE 300
  300 FORMAT(/,'$ INSERT IMAG RI COMPONENT DISK - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      TYPE 400
  400 FORMAT(/,'$ EXTINCTION COEFFICIENT MAXIMUM = ')
      ACCEPT 2,DKMAX
      TYPE 500
  500 FORMAT(/,'$ FILE MAXIMUM VALUE             = ')
      ACCEPT 2,FILMAX
      DO 600 J=1,400
      ANA(J)=(ANA(J)*DKMAX/FILMAX)*1000.
  600 POL(J)=DN(J)
  700 TYPE 701
  701 FORMAT(/,'$ IS THE DYE RI SPECTRA TO BE STORED(Y/N)? ')
      ACCEPT 702,IFLAG
  702 FORMAT(A1)
      IF(IFLAG.NE.1HY.AND.IFLAG.NE.1HN)GOTO 700
      IF(IFLAG.NE.1HY)GOTO 10
      CALL OUTPUT
      STOP
      END
```

Appendix 27.

Demonstration of MINUS - subtraction of spectroscopic ellipsometer data files

```
DECOD2.SAV    25 13-Feb-81      TRNSLT.SAV    94 13-Feb-81
PLOT01.SAV    69 30-Sep-81      SCAN  .SAV    18 13-Feb-81
RECALL.SAV    83 27-May-82      SEV002.SAV    86 23-Oct-81
RISURF.SAV    80 16-Apr-81      MINUS .SAV    40 17-Jun-81
WLBOND.NEW     1 28-Oct-81      WLCONT.OLD     1 10-Apr-81
DSCONV.SAV    90 27-May-82
 33 Files, 974 Blocks
 0 Free blocks  ..................................end of directory of DY0:

.RUN DY0:MINUS ...................................running MINUS

 INPUT SPECTRA TO BE USED AS BASELINE:

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1GOLD  183

 INPUT SPECTRA TO BE SUBTRACTED:

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1GOLD  185

 FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1MINUS DEM

STOP --

.

TEFLON.189     5 18-Jul-82      TEFLON.190     5 18-Jul-82
TEFLON.191     5 18-Jul-82      TEFLON.192     5 18-Jul-82
TEFLON.193     5 18-Jul-82      TEFLON.194     5 18-Jul-82
TEFLON.195     5 19-Jul-82      TEFLON.196     5 19-Jul-82
TEFLON.197     5 19-Jul-82      TEFLON.198     5 19-Jul-82
TEFLON.199     5 19-Jul-82      TEFLON.200     5 19-Jul-82
TEFLON.201     5 19-Jul-82      TEFLON.202     5 19-Jul-82
TEFLON.203     5 19-Jul-82      TEFLON.204     5 19-Jul-82
TEFLON.205     5 19-Jul-82      RESULT.203     5 19-Jul-82
CVPBAU.000    13 19-Jul-82      CVPBAU.001    13 19-Jul-82
CVPBAU.002    13 19-Jul-82      CVPBAU.003    13 19-Jul-82
CVPBAU.004    13 19-Jul-82      TRNSLT.DAT     1 09-Nov-81
PLTDAT.DAT    58 19-Jul-82      TEFLON.206     5 19-Jul-82
TEFLON.207     5 19-Jul-82      CVPBAU.005    13 19-Jul-82
CVPBAU.006    13 19-Jul-82      GOLD  .186     5 19-Jan-83
GOLD  .183     5 19-Jan-83      MINUS .186     5 19-Jan-83
GOLD  .188     5 19-Jan-83      MINUS .188     5 19-Jan-83
GOLD  .185     5 19-Jan-83      MINUS .185     5 19-Jan-83
DEMOAU.DAT     5 19-Jan-83      RIAU01.DAT     5 19-Jan-83
MINUS .DEM     5 19-Jan-83..................................data file created by
 167 Files, 950 Blocks                                      MINUS on DY1:
 24 Free blocks

.
```

Appendix 27 (continued).

Listing of MINUS

```
      PROGRAM MINUS
C*************************************************************************
C
C     OBJECTIVE: TO PROVIDE "SUBTRACTED" ELLIPSOMETRIC SPECTRA.
C
C     PROGRAM BY JOSEPH C. FARMER IN SPRING 1981 AT LBL MMRD
C
C*************************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      DIMENSION P0(400),A0(400)
      TYPE 10
   10 FORMAT(/,'  INPUT SPECTRA TO BE USED AS BASELINE:')
      CALL INPUT
      DO 15 I=1,400
      P0(I)=POL(I)
   15 A0(I)=ANA(I)
      TYPE 20
   20 FORMAT(/,'  INPUT SPECTRA TO BE SUBTRACTED:')
      CALL INPUT
      DO 25 I=1,400
      POL(I)=POL(I)-P0(I)
   25 ANA(I)=ANA(I)-A0(I)
      CALL OUTPUT
      STOP
      END
```

Appendix 28.

Demonstration of NORMAL - normalization of spectroscopic ellipsometer data files

```
CVPBAU.006    13 19-Jul-82      GOLD  .186     5 19-Jan-83
GOLD  .183     5 19-Jan-83      MINUS .186     5 19-Jan-83
GOLD  .188     5 19-Jan-83      MINUS .188     5 19-Jan-83
GOLD  .185     5 19-Jan-83      MINUS .185     5 19-Jan-83
 164 Files, 935 Blocks
 39 Free blocks
```
....end of directory of DY1:

```
.RUN DY1:NORMAL
```
...........................running NORMAL

```
 INPUT SPECTRA TO BE USED AS NORMALIZATION BASIS:

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1GOLD  183

 INPUT SPECTRA TO BE NORMALIZED:

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1GOLD  185

 FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1NORMALDEM

 IS THE PROGRAM TO BE EXECUTED AGAIN(Y/N)? N

STOP --

.


TEFLON.187     5 18-Jul-82      TEFLON.188     5 18-Jul-82
TEFLON.189     5 18-Jul-82      TEFLON.190     5 18-Jul-82
TEFLON.191     5 18-Jul-82      TEFLON.192     5 18-Jul-82
TEFLON.193     5 18-Jul-82      TEFLON.194     5 18-Jul-82
TEFLON.195     5 19-Jul-82      TEFLON.196     5 19-Jul-82
TEFLON.197     5 19-Jul-82      TEFLON.198     5 19-Jul-82
TEFLON.199     5 19-Jul-82      TEFLON.200     5 19-Jul-82
TEFLON.201     5 19-Jul-82      TEFLON.202     5 19-Jul-82
TEFLON.203     5 19-Jul-82      TEFLON.204     5 19-Jul-82
TEFLON.205     5 19-Jul-82      RESULT.203     5 19-Jul-82
CVPBAU.000    13 19-Jul-82      CVPBAU.001    13 19-Jul-82
CVPBAU.002    13 19-Jul-82      CVPBAU.003    13 19-Jul-82
CVPBAU.004    13 19-Jul-82      TRNSLT.DAT     1 09-Nov-81
PLTDAT.DAT    58 19-Jul-82      TEFLON.206     5 19-Jul-82
TEFLON.207     5 19-Jul-82      CVPBAU.005    13 19-Jul-82
CVPBAU.006    13 19-Jul-82      GOLD  .186     5 19-Jan-83
GOLD  .183     5 19-Jan-83      MINUS .186     5 19-Jan-83
GOLD  .188     5 19-Jan-83      MINUS .188     5 19-Jan-83
GOLD  .185     5 19-Jan-83      MINUS .185     5 19-Jan-83
NORMAL.DEM     5 21-Jan-83
```
...............................data file created by NORMAL on DY1:

```
 165 Files, 940 Blocks
 34 Free blocks

.
```

Appendix 28 (continued).

Listing of NORMAL

```
      PROGRAM NORMAL
C*********************************************************************
C
C     OBJECTIVE: TO PROVIDE "SUBTRACTED" ELLIPSOMETRIC SPECTRA.
C
C     PROGRAM BY JOSEPH C. FARMER IN SPRING 1981 AT LBL MMRD
C
C*********************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      DIMENSION P0(400),A0(400)
    1 TYPE 10
   10 FORMAT(/,'  INPUT SPECTRA TO BE USED AS NORMALIZATION BASIS:')
      CALL INPUT
      DO 15 I=1,400
      P0(I)=POL(I)
   15 A0(I)=ANA(I)
      TYPE 20
   20 FORMAT(/,'  INPUT SPECTRA TO BE NORMALIZED:')
      CALL INPUT
      DO 25 I=1,400
      IF(POL(I).EQ.P0(I))GOTO 21
      IF(P0(I).EQ.0.)GOTO 22
      POL(I)=POL(I)/P0(I)
      GOTO 25
   21 POL(I)=1.
      GOTO 25
   22 POL(I)=0.
   25 POL(I)=2047.*POL(I)
      DO 35 I=1,400
      IF(ANA(I).EQ.A0(I))GOTO 31
      IF(A0(I).EQ.0.)GOTO 32
      ANA(I)=ANA(I)/A0(I)
      GOTO 35
   31 ANA(I)=1.
      GOTO 35
   32 ANA(I)=0.
   35 ANA(I)=2047.*ANA(I)
      CALL OUTPUT
   40 TYPE 45
   45 FORMAT(/,'$ IS THE PROGRAM TO BE EXECUTED AGAIN(Y/N)? ')
      ACCEPT 50,IFLAG
   50 FORMAT(A1)
      IF(IFLAG.NE.1HY.AND.IFLAG.NE.1HN)GOTO 40
      IF(IFLAG.EQ.1HN)STOP
      GOTO 1
      END
```

Appendix 29.

Demonstration of EMASES - simulation of spectroscopic ellipsometer measurements based upon the Maxwell-Garnett theory

```
RUN DY1:EMASES

INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE DIGITAL ENCODER - 'RETURN'.

DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

INSERT HOST MEDIUM RI DATA DISK - 'RETURN'.

NAME OF SPECTRA FILE TO BE RETRIEVED = DY1SOLN  DAT

NUMBER OF FILM COMPONENTS = 1

INSERT COMPONENT 'I' RI DATA DISK - 'RETURN'.

COMPONENT VOLUME FRACTION = 0.3

DO YOU WANT TO CORRECT ENTRY(Y/N)? N

NAME OF SPECTRA FILE TO BE RETRIEVED = DY1LEAD  DAT

DO YOU WANT APPARANT FILM RI STORED(Y/N)? Y

IDENTIFICATION(20A2) = REFRACTIVE INDICES OF 70% POROUS PB DEPOSIT


FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1FILM70DAT

INSERT SUBSTRATE RI DATA DISK - 'RETURN'.

NAME OF SPECTRA FILE TO BE RETRIEVED = DY1COPPERDAT

ANGLE OF INCIDENCE(DEG,F10.4) = 75.

FILM THICKNESS(ANG,F10.0)     = 1000.

PHI =    75.0000            T =      1000.           THETA =     0.7000

CORRECTIONS(Y/N)? N

DO YOU WANT TO STORE THE SIMULATED SPECTRA(Y/N)? Y

IDENTIFICATION(20A2) = SIMULATION FOR 30 NM COMPACT DEPOSIT, 70% POROUS

FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1EMASES070

DO YOU WANT TO EXECUTE THE PROGRAM AGAIN(Y/N)? N

STOP --
```

Listing of EMASES

```
      PROGRAM EMASES
C*************************************************************************
C     OBJECTIVE:  TO GENERATE SIMULATED ELLIPSOMETER SPECTRA BASED UPON
C                 EXPERIMENTALLY DETERMINED OR GENERATED REFRACTIVE INDEX
C                 SPECTRA, AND OPERATOR INPUT FILM THICKNESSES AND VOID
C                 FRACTIONS.  THE THEORETICAL BASIS IS THE MAXWELL-
C                 GARNETT THEORY AND ALLOWS ONE TO TAKE INTO
C                 ACCOUNT MICROPOROSITY AND INCLUSIONS LESS THAN THE
C                 WAVELENGTH OF THE LIGHT.
C
C     BY JOSEPH C. FARMER, DECEMBER 13,1981, LBL-MMRD, UCB.
C
C*************************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMPLEX TN2,TN3,CPHI2,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      COMPLEX EH(400),E(400),SUM(400)
      REAL*4 DBLK(2),NAME(20)
      DIMENSION X(10)
    1 FORMAT(I1)
    2 FORMAT(A1)
C*****WAVELENGTH CALIBRATION OF DIGITAL ENCODER
      TYPE 3
    3 FORMAT(/,'$ INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE
     C DIGITAL ENCODER - "RETURN".')
      ACCEPT 1,IWAIT
      CALL WLCALC
C*****HOST MEDIUM RI SPECTRA INPUT FROM FLOPPY DISK
  100 TYPE 4
    4 FORMAT(/,'$ INSERT HOST MEDIUM RI DATA DISK - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 1000 J=1,400
      POL(J)=POL(J)/1000.
      ANA(J)=ANA(J)/1000.
      EH(J)=CMPLX(POL(J),ANA(J))
      EH(J)=EH(J)*EH(J)
 1000 SUM(J)=0.
```

```
C*****FILM COMPONENTS' RI SPECTRA INPUT FROM FLOPPY DISK
      TYPE 5
    5 FORMAT(/,'$ NUMBER OF FILM COMPONENTS = ')
      ACCEPT 20,NCOMP
   20 FORMAT(I5)
      THETA=1.
      DO 3000 I=1,NCOMP
      TYPE 6
    6 FORMAT(/,'$ INSERT COMPONENT "I" RI DATA DISK - "RETURN".')
      ACCEPT 1,IWAIT
  100 TYPE 7
    7 FORMAT(/,'$ COMPONENT VOLUME FRACTION = ')
      ACCEPT 21,X(I)
   21 FORMAT(F5.3)
      TYPE 8
    8 FORMAT(/,'$ DO YOU WANT TO CORRECT ENTRY(Y/N)? ')
      ACCEPT 2,IFLAG
      IF(IFLAG.NE.1HN)GOTO 100
      CALL INPUT
C*****APPARANT FILM RI SPECTRA COMPUTED FROM COMPONENT SPECTRA
      DO 2000 J=1,400
      POL(J)=POL(J)/1000.
      ANA(J)=ANA(J)/1000.
      E(J)=CMPLX(POL(J),ANA(J))
      E(J)=E(J)*E(J)
 2000 SUM(J)=SUM(J)+X(I)*(E(J)-EH(J))/(E(J)+2.*EH(J))
 3000 THETA=THETA-X(I)
      DO 4000 J=1,400
      E(J)=EH(J)*(1.+2.*SUM(J))/(1.-SUM(J))
      E(J)=CSQRT(E(J))
      POL(J)=REAL(E(J))
      ANA(J)=AIMAG(E(J))
      POL(J)=POL(J)*1000.
      ANA(J)=ANA(J)*1000.
 4000 CONTINUE
C*****THE APPARANT FILM RI SPECTRA IS STORED ON DISK
  120 TYPE 9
    9 FORMAT(/,'$ DO YOU WANT APPARANT FILM RI STORED(Y/N)? ')
      ACCEPT 2,IFLAG
      IF(IFLAG.NE.1HY.AND.IFLAG.NE.1HN)GOTO 120
      IF(IFLAG.EQ.1HN)GOTO 130
      TYPE 16
      ACCEPT 24,(ID(I),I=1,20)
      CALL OUTPUT
  130 CONTINUE
C*****SUBSTRATE RI SPECTRA INPUT FROM FLOPPY DISK
      TYPE 10
   10 FORMAT(/,'$ INSERT SUBSTRATE RI DATA DISK - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 5000 J=1,400
      POL(J)=POL(J)/1000.
      ANA(J)=ANA(J)/1000.
 5000 SUM(J)=CMPLX(POL(J),ANA(J))
```

```
C*****ANGLE OF INCIDENCE AND FILM THICKNESS INPUT FROM CRT
  140 TYPE 11
   11 FORMAT(/,'$ ANGLE OF INCIDENCE(DEG,F10.4) = ')
      ACCEPT 22,PHI1
   22 FORMAT(F10.4)
  145 TYPE 12
   12 FORMAT(/,'$ FILM THICKNESS(ANG,F10.0)     = ')
      ACCEPT 23,T
   23 FORMAT(F10.0)
      TYPE 13,PHI1,T,THETA
   13 FORMAT(/,'  PHI = ',F10.4,10X,' T = ',F10.0,10X,'THETA = ',F10.4)
  150 TYPE 14
   14 FORMAT(/,'$ CORRECTIONS(Y/N)? ')
      ACCEPT 2,IF0
      IF(IF0.NE.1HN.AND.IF0.NE.1HY)GOTO 150
      IF(IF0.EQ.1HY)GOTO 140
C*****THE PSI-DELTA SPECTRA IS COMPUTED FROM INPUT SPECTRA
      DO 6000 J=1,400
      EH(J)=CSQRT(EH(J))
      TNA=REAL(EH(J))
      TNKA=-AIMAG(EH(J))
      TNF=REAL(E(J))
      TNKF=-AIMAG(E(J))
      TNS=REAL(SUM(J))
      TNKS=-AIMAG(SUM(J))
      WL=IWAVE(J)
      CALL FILM
      IF(DELC.GT.180.)GOTO 160
      POL(J)=DELC*100.
      GOTO 170
  160 POL(J)=(DELC-360.)*100.
  170 ANA(J)=PSIC*100.
 6000 CONTINUE
C*****THE COMPUTED PSI-DELTA SPECTRA IS STORED ON DISK
  180 TYPE 15
   15 FORMAT(/,'$ DO YOU WANT TO STORE THE SIMULATED SPECTRA(Y/N)? ')
      ACCEPT 2,IF1
      IF(IF1.NE.1HN.AND.IF1.NE.1HY)GOTO 180
      IF(IF1.EQ.1HN)GOTO 190
      TYPE 16
   16 FORMAT(/,'$ IDENTIFICATION(20A2) = ')
      ACCEPT 24,(ID(I),I=1,20)
   24 FORMAT(20A2)
      CALL OUTPUT
C*****OPERATOR CAN EXECUTE PROGRAM AGAIN WITHOUT LOADING BUFFER
  190 TYPE 17
   17 FORMAT(/,'$ DO YOU WANT TO EXECUTE THE PROGRAM AGAIN(Y/N)? ')
      ACCEPT 2,IF2
      IF(IF2.NE.1HN.AND.IF2.NE.1HY)GOTO 190
      IF(IF2.EQ.1HN)STOP
  200 TYPE 18
```

```
18 FORMAT(/,'$ DO YOU WANT TO CHANGE RI DATA(A) OR
  C FILM THICKNESS(B)? ')
   ACCEPT 2,IF3
   IF(IF3.NE.1HA.AND.IF3.NE.1HB)GOTO 200
   IF(IF3.EQ.1HA)GOTO 100
   IF(IF3.EQ.1HB)GOTO 145
   STOP
   END
```

```
      SUBROUTINE FILM
C***********************************************************************
C     THIS SUBROUTINE COMPUTES "PSI" AND "DELTA" FOR A SIMPLE HOMO-
C     GENEOUS FILM ON A SUBSTRATE GIVEN (1) THE REFRACTIVE INDICES OF
C     THE SUBSTRATE, FILM, AND INCIDENT MEDIUM; (2) THE FILM THICKNESS;
C     (3) THE WAVELENGTH OF THE SOURCE; AND (4) THE ANGLE OF INCIDENCE.
C***********************************************************************
      COMMON/FLMDAT/TN1,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMPLEX TN2,TN3,CPHI2,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      PHI=0.01745329252*PHI1
      CP=DCOS(PHI)
      SP=DSIN(PHI)
      TN3=CMPLX(TNS,-TNKS)
      CPHI3=CSQRT(1.0-TN1**2*SP**2/(TN3**2))
      TN2=CMPLX(TNF,-TNKF)
      CPHI2=CSQRT(1.0-TN1**2*SP**2/(TN2**2))
      R1S=(TN1*CP-TN2*CPHI2)/(TN1*CP+TN2*CPHI2)
      R1P=-(TN1*CPHI2-TN2*CP)/(TN1*CPHI2+TN2*CP)
      R2S=(TN2*CPHI2-TN3*CPHI3)/(TN2*CPHI2+TN3*CPHI3)
      R2P=-(TN2*CPHI3-TN3*CPHI2)/(TN2*CPHI3+TN3*CPHI2)
      Z=(0.0,1.0)*(4.0*3.1415927*T/WL)*TN2*CPHI2
      RS=(R1S+R2S*CEXP(-Z))/(1.0+R1S*R2S*CEXP(-Z))
      RP=(R1P+R2P*CEXP(-Z))/(1.0+R1P*R2P*CEXP(-Z))
      RHO=RP/RS
      PSIC=DATAN(CABS(RHO))/0.01745329252
      DELC=DATAN2(AIMAG(RHO),REAL(RHO))/0.01745329252
      RETURN
      END
```

Demonstration of BRUGMN - simulation of spectroscopic ellipsometer measurements based upon the Bruggeman theory

```
.RUN DY1:BRUGMN

 INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE DIGITAL ENCODER - "RETURN".

 DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

 INSERT AMBIENT MEDIUM RI DATA DISK - "RETURN".

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1SOLN  DAT

 INSERT COMPONENT "I" RI DATA DISK - "RETURN".

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1LEAD  DAT

 INSERT COMPONENT "I" RI DATA DISK - "RETURN".

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1SOLN  DAT

 INSERT SUBSTRATE RI DATA DISK - "RETURN".

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1COPPERDAT

 ANGLE OF INCIDENCE(DEG,F10.4) = 75.


 FILM THICKNESS(ANG,F10.0)     = 620.

 COMPONENT #1 VOLUME FRACTION  = 0.5

 PHI =    75.0000            T =       620.          THETA =     0.5000

 CORRECTIONS(Y/N)? N

 DO YOU WANT TO STORE THE SIMULATED SPECTRA(Y/N)? Y

 IDENTIFICATION(20A2) = SIMULATION BASED UPON BRUGGEMAN MIXING RULE

 FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1BRUGMN050

CALCULATION OF SUBSTRATE RI FOR NEXT INCREMENT....

 DO YOU WANT TO EXECUTE THE PROGRAM AGAIN(Y/N)? N

 IS A COMPOSITE FILM RI WANTED(Y/N)? N

STOP --

.
```

Listing of BRUGMN

```
      PROGRAM BRUGMN
C*****************************************************************************
C     OBJECTIVE:  TO GENERATE SIMULATED ELLIPSOMETER SPECTRA BASED UPON
C                 EXPERIMENTALLY DETERMINED OR GENERATED REFRACTIVE INDEX
C                 SPECTRA, AND OPERATOR INPUT FILM THICKNESSES AND VOID
C                 FRACTIONS.  THE THEORETICAL BASIS IS THE BRUGGEMAN
C                 EFFECTIVE MEDIA APPROXIMATION, ALLOWING ONE TO TAKE INTO
C                 ACCOUNT MICROPOROSITY AND INCLUSIONS LESS THAN THE
C                 WAVELENGTH.
C
C     BY JOSEPH C. FARMER, DECEMBER 13,1981, LBL-MMRD, UCB.
C
C****************************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRSO,IMINO,ISECO,ITICO,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMPLEX TN2,TN3,CPHI2,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      DIMENSION FN(3,400),FK(3,400),AN(400),AK(400)
      COMMON/THETA/THETA
      REAL*4 DBLK(2),NAME(20)
    1 FORMAT(I1)
    2 FORMAT(A1)
C*****WAVELENGTH CALIBRATION OF DIGITAL ENCODER
      TYPE 3
    3 FORMAT(/,'$ INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE
     C DIGITAL ENCODER - "RETURN".')
      ACCEPT 1,IWAIT
      CALL WLCALC
C*****AMBIENT MEDIUM RI SPECTRA INPUT FROM FLOPPY DISK
  100 TYPE 4
    4 FORMAT(/,'$ INSERT AMBIENT MEDIUM RI DATA DISK - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 1000 J=1,400
      AN(J)=POL(J)/1000.
 1000 AK(J)=ANA(J)/1000.
```

```
C*****FILM COMPONENTS' RI SPECTRA INPUT FROM FLOPPY DISK
      DO 3000 I=1,2
      TYPE 6
    6 FORMAT(/,'$ INSERT COMPONENT "I" RI DATA DISK - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 2000 J=1,400
      FN(I,J)=POL(J)/1000.
 2000 FK(I,J)=ANA(J)/1000.
 3000 CONTINUE
C*****SUBSTRATE RI SPECTRA INPUT FROM FLOPPY DISK
      TYPE 10
   10 FORMAT(/,'$ INSERT SUBSTRATE RI DATA DISK - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 5000 J=1,400
      POL(J)=POL(J)/1000.
 5000 ANA(J)=ANA(J)/1000.
C*****ANGLE OF INCIDENCE AND FILM THICKNESS INPUT FROM CRT
  140 TYPE 11
   11 FORMAT(/,'$ ANGLE OF INCIDENCE(DEG,F10.4) = ')
      ACCEPT 22,PHI1
   22 FORMAT(F10.4)
  145 TYPE 12
   12 FORMAT(/,'$ FILM THICKNESS(ANG,F10.0)     = ')
      ACCEPT 23,T
   23 FORMAT(F10.0)
      TYPE 7
    7 FORMAT(/,'$ COMPONENT #1 VOLUME FRACTION  = ')
      ACCEPT 21,THETA
   21 FORMAT(F5.3)
      TYPE 13,PHI1,T,THETA
   13 FORMAT(/,'  PHI = ',F10.4,10X,' T = ',F10.0,10X,'THETA = ',F10.4)
  150 TYPE 14
   14 FORMAT(/,'$ CORRECTIONS(Y/N)? ')
      ACCEPT 2,IFO
      IF(IFO.NE.1HN.AND.IFO.NE.1HY)GOTO 150
      IF(IFO.EQ.1HY)GOTO 140
C*****APPARANT FILM RI SPECTRA COMPUTED FROM COMPONENT SPECTRA
      DO 4000 J=1,400
      TNF=FN(1,J)
      TNKF=-FK(1,J)
      TNA=FN(2,J)
      TNKA=-FK(2,J)
      CALL EMA
      FN(3,J)=TNF
 4000 FK(3,J)=-TNKF
```

```
C*****THE PSI-DELTA SPECTRA IS COMPUTED FROM INPUT SPECTRA
      DO 6000 J=1,400
      TNA=AN(J)
      TNKA=-AK(J)
      TNF=FN(3,J)
      TNKF=-FK(3,J)
      TNS=POL(J)
      TNKS=-ANA(J)
      WL=IWAVE(J)
      CALL FILM
      IF(DELC.GT.180.)GOTO 160
      POL(J)=DELC*100.
      GOTO 170
  160 POL(J)=(DELC-360.)*100.
  170 ANA(J)=PSIC*100.
 6000 CONTINUE
C*****THE COMPUTED PSI-DELTA SPECTRA IS STORED ON DISK
  180 TYPE 15
   15 FORMAT(/,'$ DO YOU WANT TO STORE THE SIMULATED SPECTRA(Y/N)? ')
      ACCEPT 2,IF1
      IF(IF1.NE.1HN.AND.IF1.NE.1HY)GOTO 180
      IF(IF1.EQ.1HN)GOTO 189
      TYPE 16
   16 FORMAT(/,'$ IDENTIFICATION(20A2) = ')
      ACCEPT 24,(ID(I),I=1,20)
   24 FORMAT(20A2)
      CALL OUTPUT
  189 CONTINUE
C*****AN APPARANT SUBSTRATE RI SPECTRA OF FILM COVERED SURFACE COMPUTED
C     BEFORE NEXT FILM LEVEL INCREMENT
      TYPE 6999
 6999 FORMAT(/,' CALCULATION OF SUBSTRATE RI FOR NEXT INCREMENT....')
      DO 7000 J=1,400
      DELC=POL(J)/100.
      PSIC=ANA(J)/100.
      CALL REFIND
      POL(J)=TNS
 7000 ANA(J)=-TNKS
C*****OPERATOR CAN EXECUTE PROGRAM AGAIN WITHOUT LOADING BUFFER
  190 TYPE 17
   17 FORMAT(/,'$ DO YOU WANT TO EXECUTE THE PROGRAM AGAIN(Y/N)? ')
      ACCEPT 2,IF2
      IF(IF2.NE.1HN.AND.IF2.NE.1HY)GOTO 190
      IF(IF2.EQ.1HN)GOTO 9999
  200 TYPE 18
   18 FORMAT(/,'$ DO YOU WANT TO CHANGE RI DATA(A) OR
     C INCREMENT FILM(B)? ')
      ACCEPT 2,IF3
      IF(IF3.NE.1HA.AND.IF3.NE.1HB)GOTO 200
      IF(IF3.EQ.1HA)GOTO 100
      IF(IF3.EQ.1HB)GOTO 145
```

```
C*****A COMPOSITE FILM RI SPECTRA IS COMPUTED IF DESIRED
 9999 TYPE  9998
 9998 FORMAT(/,'$ IS A COMPOSITE FILM RI WANTED(Y/N)? ')
      ACCEPT 2,IFLAG
      IF(IFLAG.NE.1HY.AND.IFLAG.NE.1HN)GOTO 9999
      IF(IFLAG.EQ.1HN)STOP
 9997 TYPE 9996
 9996 FORMAT(/,'$ COMPONENT #1 VOLUME FRACTION  = ')
      ACCEPT 21,THETA
 9995 TYPE 9994
 9994 FORMAT(/,'$ CORRECTIONS(Y/N)? ')
      ACCEPT 2, IFLAG
      IF(IFLAG.NE.1HY.AND.IFLAG.NE.1HN)GOTO 9995
      IF(IFLAG.EQ.1HY)GOTO 9997
      DO 9993 J=1,400
      TNF=FN(1,J)
      TNKF=-FK(1,J)
      TNA=FN(2,J)
      TNKA=-FK(2,J)
      CALL EMA
      FN(3,J)=TNF
      FK(3,J)=-TNKF
      POL(J)=TNF*1000.
 9993 ANA(J)=-TNKF*1000.
      TYPE 16
      ACCEPT 24,(ID(I),I=1,20)
      CALL OUTPUT
      GOTO 9999
      STOP
      END
```

```
      SUBROUTINE EMA
C*****************************************************************************
C     OBJECTIVE: TO COMPUTE THE EFFECTIVE MEDIA REFRACTIVE INDEX VIA
C                THE BRUGGEMAN MIXING RULE FOR A BINARY COMPONENT FILM.
C*****************************************************************************
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/THETA/THETA
      COMPLEX TN2,TN3,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      COMPLEX E,E1,E2,A,B,ROOT1,ROOT2
      SFLAG=0.
      E1=CMPLX(TNF,-TNKF)
      E2=CMPLX(TNA,-TNKA)
      E1=E1*E1
      E2=E2*E2
      X1=THETA
      X2=1.-THETA
      A=0.5*(E1*(X2-2.*X1)+E2*(X1-2.*X2))
      B=-0.5*(E1*E2)
      ROOT1=0.5*(-A+CSQRT(A*A-4.*B))
      RMAG1=CABS(ROOT1)
      ROOT2=0.5*(-A-CSQRT(A*A-4.*B))
      RMAG2=CABS(ROOT2)
      IF(RMAG2.GT.RMAG1)GOTO 98
      E=ROOT1
      RFLAG=1.
      GOTO 99
   98 E=ROOT2
      RFLAG=2.
   99 CONTINUE
      TN2=CSQRT(E)
      TNF=REAL(TN2)
      TNKF=-AIMAG(TN2)
      IF(TNF.GE.0.0.AND.TNKF.GE.0.0) GOTO 102
      SFLAG=SFLAG+1.
      IF(SFLAG.GT.1.)STOP
      IF(RFLAG.EQ.1.)GOTO 101
      E=ROOT1
      GOTO 99
  101 CONTINUE
      E=ROOT2
      GOTO 99
  102 CONTINUE
      RETURN
      END
```

Demonstration of CSMSES - simulation of spectroscopic ellipsometer measurements based upon the coherent superposition model

```
.RUN DY1:CSMSES

INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE DIGITAL ENCODER - "RETURN".

DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

INSERT DISK WITH INCIDENT MEDIA RI SPECTRA - "RETURN".

NAME OF SPECTRA FILE TO BE RETRIEVED = DY1SOLN  DAT

INSERT DISK WITH FILM COMPONENT #1 RI SPECTRA - "RETURN".

NAME OF SPECTRA FILE TO BE RETRIEVED = DY1LEAD  DAT

INSERT DISK WITH FILM COMPONENT #2 RI SPECTRA - "RETURN".

NAME OF SPECTRA FILE TO BE RETRIEVED = DY1SOLN  DAT

INSERT DISK WITH SUBSTRATE RI SPECTRA - "RETURN".

NAME OF SPECTRA FILE TO BE RETRIEVED = DY1COPPERDAT

ANGLE OF INCIDENCE(DEG,F10.4) = 75.


FILM THICKNESS(ANG,F10.0)      = 1000.

FRACTION OF SURFACE COVERED BY FILM #1(F10.4) = 0.3

PHI =    75.0000            T =      1000.          THETA =     0.3000

CORRECTIONS(Y/N)? N

DO YOU WANT TO STORE THE SIMULATED SPECTRA(Y/N)? Y

IDENTIFICATION(20A2) = CU COVERED BY PB ISLANDS, 30% SURFACE COVERAGE

FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1CSMSES030

DO YOU WANT TO EXECUTE THE PROGRAM AGAIN(Y/N)? N

STOP --

.

.

.
```

Listing of CSMSES

```
      PROGRAM CSMSES
C***************************************************************************
C     OBJECTIVE:  TO GENERATE SIMULATED ELLIPSOMETER SPECTRA BASED UPON
C                 EXPERIMENTALLY DETERMINED OR GENERATED REFRACTIVE INDEX
C                 SPECTRA, AND OPERATOR INPUT FILM THICKNESSES AND VOID
C                 FRACTIONS.  THE THEORETICAL BASIS IS THE COHERENT
C                 SUPERPOSITION MODEL, ALLOWING ONE TO TAKE INTO
C                 ACCOUNT ISLAND FORMATION.  THIS MODEL IS APPLICABLE
C                 WHEN THE ISLANDS ARE SMALLER THAN THE COHERENCE LENGTH.
C
C     BY JOSEPH C. FARMER, DECEMBER 13,1981, LBL-MMRD, UCB.
C
C**************************************************************************
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/CSMDAT/TNF1,TNKF1,TNF2,TNKF2,THETA
      COMPLEX TN2,TN3,CPHI2,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      REAL*4 DBLK(2),NAME(20),N(4,400),K(4,400)
    1 FORMAT(I1)
C*****WAVELENGTH CALIBRATION OF DIGITAL ENCODER
      TYPE 2
    2 FORMAT(/,'$ INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE
     C DIGITAL ENCODER - "RETURN".')
      ACCEPT 1,IWAIT
      CALL WLCALC
C*****RI SPECTRA OF INCIDENT MEDIA INPUT FROM FLOPPY DISK
    9 TYPE 10
   10 FORMAT(/,'$ INSERT DISK WITH INCIDENT MEDIA RI SPECTRA
     C - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 11 I=1,400
      N(1,I)=POL(I)/1000.
   11 K(1,I)=ANA(I)/1000.
C*****RI SPECTRA OF FILM COMPONENT #1 INPUT FROM FLOPPY DISK
      TYPE 20
   20 FORMAT(/,'$ INSERT DISK WITH FILM COMPONENT #1 RI SPECTRA
     C - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 21 I=1,400
      N(2,I)=POL(I)/1000.
   21 K(2,I)=ANA(I)/1000.
```

```
C*****RI SPECTRA OF FILM COMPONENT #2 INPUT FROM FLOPPY DISK
      TYPE 30
   30 FORMAT(/,'$ INSERT DISK WITH FILM COMPONENT #2 RI SPECTRA
     C - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 31 I=1,400
      N(3,I)=POL(I)/1000.
   31 K(3,I)=ANA(I)/1000.
C*****RI SPECTRA OF SUBSTRATE INPUT FROM FLOPPY DISK
      TYPE 40
   40 FORMAT(/,'$ INSERT DISK WITH SUBSTRATE RI SPECTRA
     C - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 41 I=1,400
      N(4,I)=POL(I)/1000.
   41 K(4,I)=ANA(I)/1000.
C*****OPERATOR INPUTS ANGLE OF INCIDENCE, FILM THICKNESS, ETC.
 1000 TYPE 1001
 1001 FORMAT(/,'$ ANGLE OF INCIDENCE(DEG,F10.4) = ')
      ACCEPT 1002,PHI1
 1002 FORMAT(F10.4)
      TYPE 1003
 1003 FORMAT(/,'$ FILM THICKNESS(ANG,F10.0)     = ')
      ACCEPT 1004,T
 1004 FORMAT(F10.0)
      TYPE 1005
 1005 FORMAT(/,'$ FRACTION OF SURFACE COVERED BY FILM #1(F10.4) = ')
      ACCEPT 1006,THETA
 1006 FORMAT(F10.4)
      TYPE 1007,PHI1,T,THETA
 1007 FORMAT(/,'  PHI = ',F10.4,10X,' T = ',F10.0,10X,'THETA = ',F10.4)
 1008 TYPE 1009
 1009 FORMAT(/,'$ CORRECTIONS(Y/N)? ')
      ACCEPT 1010,IFO
 1010 FORMAT(A1)
      IF(IFO.NE.1HN.AND.IFO.NE.1HY)GOTO 1008
      IF(IFO.EQ.1HY)GOTO 1000
```

```
C*****THE PSI-DELTA SPECTRA IS COMPUTED
      DO 2000 I=1,400
      TNA=N(1,I)
      TNKA=-K(1,I)
      TNF1=N(2,I)
      TNF2=N(3,I)
      TNKF1=-K(2,I)
      TNKF2=-K(3,I)
      TNS=N(4,I)
      TNKS=-K(4,I)
      WL=IWAVE(I)
      CALL FILM02
      IF(DELC.GT.180.)GOTO 100
      POL(I)=DELC*100.
      GOTO 200
  100 POL(I)=(DELC-360.)*100.
  200 ANA(I)=PSIC*100.
 2000 CONTINUE
C*****THE PSI-DELTA SPECTRA IS STORED
   50 TYPE 51
   51 FORMAT(/,'$ DO YOU WANT TO STORE THE SIMULATED SPECTRA(Y/N)? ')
      ACCEPT 52,IF1
   52 FORMAT(A1)
      IF(IF1.EQ.1HN)GOTO 60
      IF(IF1.NE.1HN.AND.IF1.NE.1HY)GOTO 50
      TYPE 53
   53 FORMAT(/,'$ IDENTIFICATION(20A2) = ')
      ACCEPT 54,(ID(I),I=1,20)
   54 FORMAT(20A2)
      CALL OUTPUT
C*****THE OPERATOR EXECUTES THE PROGRAM AGAIN IF DESIRED
   60 TYPE 61
   61 FORMAT(/,'$ DO YOU WANT TO EXECUTE THE PROGRAM AGAIN(Y/N)? ')
      ACCEPT 62,IF2
   62 FORMAT(A1)
      IF(IF2.NE.1HN.AND.IF2.NE.1HY)GOTO 60
      IF(IF2.EQ.1HN)STOP
   70 TYPE 71
   71 FORMAT(/,'$ DO YOU WANT TO CHANGE RI DATA(A) OR
     C FILM THICKNESS(B)? ')
      ACCEPT 72,IF3
   72 FORMAT(A1)
      IF(IF3.NE.1HA.AND.IF3.NE.1HB)GOTO 70
      IF(IF3.EQ.1HA)GOTO 9
      IF(IF3.EQ.1HB)GOTO 1000
      STOP
      END
```

```
SUBROUTINE FILM02
COMMON/FLMDAT/TN1,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
COMMON/THETA/THETA
COMPLEX TN2,TN3,CPHI2,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
COMPLEX RSX,RPX,RSY,RPY
TNF0=TNF
TNKF0=TNKF
PHI=0.01745329252*PHI1
CP=DCOS(PHI)
SP=DSIN(PHI)
TN3=CMPLX(TNS,-TNKS)
CPHI3=CSQRT(1.0-TN1**2*SP**2/(TN3**2))
TN2=CMPLX(TNF,-TNKF)
CPHI2=CSQRT(1.0-TN1**2*SP**2/(TN2**2))
R1S=(TN1*CP-TN2*CPHI2)/(TN1*CP+TN2*CPHI2)
R1P=-(TN1*CPHI2-TN2*CP)/(TN1*CPHI2+TN2*CP)
R2S=(TN2*CPHI2-TN3*CPHI3)/(TN2*CPHI2+TN3*CPHI3)
R2P=-(TN2*CPHI3-TN3*CPHI2)/(TN2*CPHI3+TN3*CPHI2)
Z=(0.0,1.0)*(4.0*3.1415927*T/WL)*TN2*CPHI2
RS=(R1S+R2S*CEXP(-Z))/(1.0+R1S*R2S*CEXP(-Z))
RP=(R1P+R2P*CEXP(-Z))/(1.0+R1P*R2P*CEXP(-Z))
RSX=THETA*RS
RPX=THETA*RP
TNF=TN1
TNKF=0.
TN2=CMPLX(TNF,-TNKF)
CPHI2=CSQRT(1.0-TN1**2*SP**2/(TN2**2))
R1S=(TN1*CP-TN2*CPHI2)/(TN1*CP+TN2*CPHI2)
R1P=-(TN1*CPHI2-TN2*CP)/(TN1*CPHI2+TN2*CP)
R2S=(TN2*CPHI2-TN3*CPHI3)/(TN2*CPHI2+TN3*CPHI3)
R2P=-(TN2*CPHI3-TN3*CPHI2)/(TN2*CPHI3+TN3*CPHI2)
Z=(0.0,1.0)*(4.0*3.1415927*T/WL)*TN2*CPHI2
RS=(R1S+R2S*CEXP(-Z))/(1.0+R1S*R2S*CEXP(-Z))
RP=(R1P+R2P*CEXP(-Z))/(1.0+R1P*R2P*CEXP(-Z))
RSY=(1.-THETA)*RS
RPY=(1.-THETA)*RP
RS=RSX+RSY
RP=RPX+RPY
TNF=TNF0
TNKF=TNKF0
RHO=RP/RS
PSIC=DATAN(CABS(RHO))/0.01745329252
DELC=DATAN2(AIMAG(RHO),REAL(RHO))/0.01745329252
RETURN
END
```

Appendix 32.

Demonstration of AISPEC - simulation of spectroscopic ellipsometer measurements based upon the uniaxial anisotropic film model

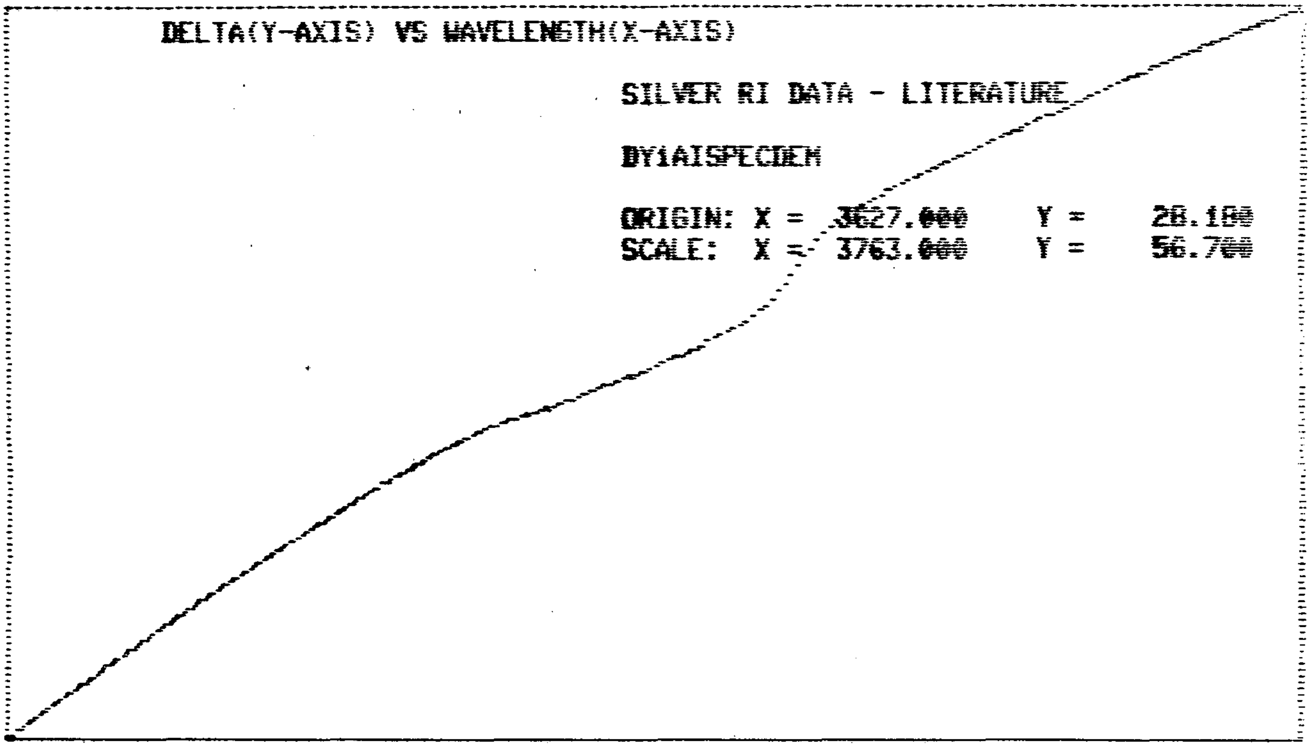
```
.RUN DY1:AISPEC

 INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE DIGITAL ENCODER - 'RETURN'.

 DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

 INSERT AMBIENT MEDIUM RI DATA DISK - 'RETURN'.

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1SOLN  DAT

 INSERT RI SPECTRA DISK FOR Z-AXIS - 'RETURN'.

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1HIDYE DAT

 INSERT RI SPECTRA DISK FOR X/Y-PLANE - 'RETURN'.

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1RHODB1DAT

 INSERT SUBSTRATE RI DATA DISK - 'RETURN'.

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1SILVERDAT

 ANGLE OF INCIDENCE(DEG,F10.4) = 75.



 FILM THICKNESS(ANG,F10.0)      = 32.

 PHI =     75.0000              T =         32.

 CORRECTIONS(Y/N)? N

 DO YOU WANT TO STORE THE SIMULATED SPECTRA(Y/N)? Y

 IDENTIFICATION(20A2) = DY1AISPECDEM

 FILE NAME FOR THE NEW SPECTRAL SCAN (A12) = DY1AISPECDEM

 DO YOU WANT TO EXECUTE THE PROGRAM AGAIN(Y/N)? N

STOP --
```

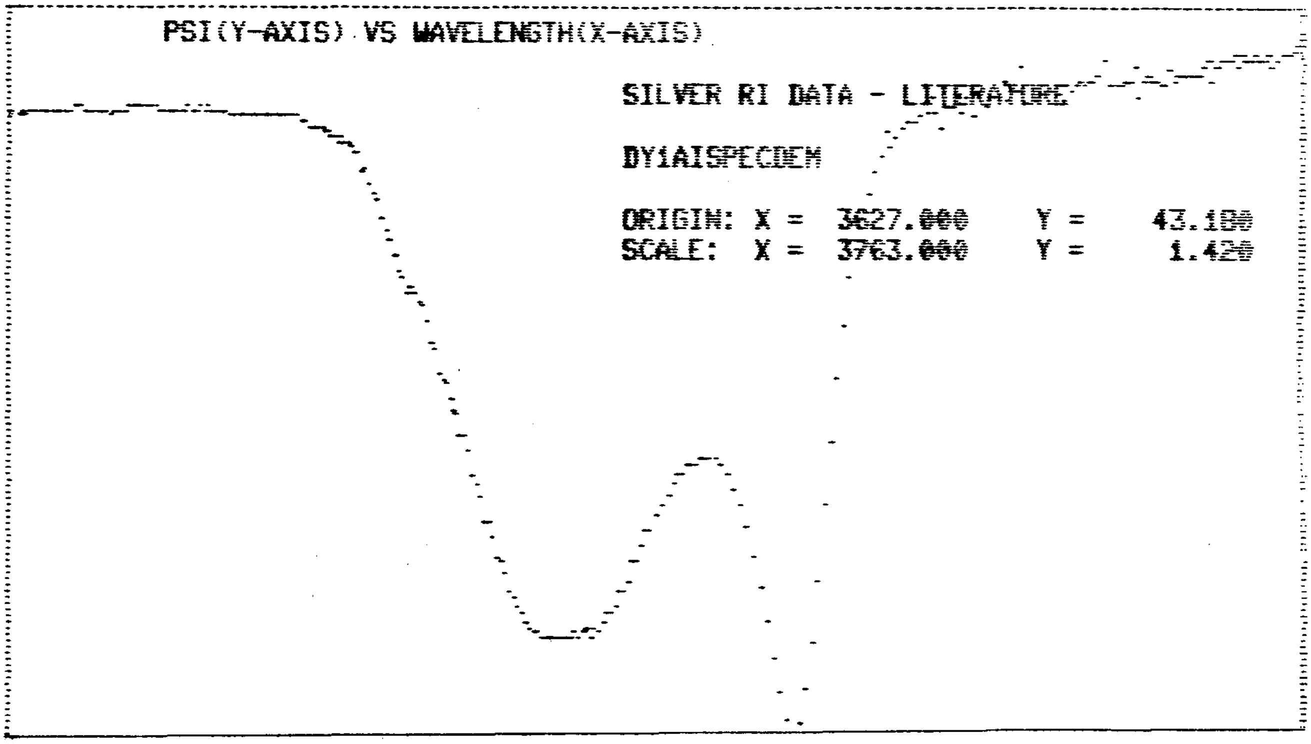
Recalling simulated spectroscopic data file

```
SPEC18.DAT      5 10-Sep-82       SPEC19.DAT      5 10-Sep-82
SPEC15.DAT      5 10-Sep-82       SUB016.DAT      5 10-Sep-82
SUB018.DAT      5 10-Sep-82       SUB019.DAT      5 10-Sep-82
SPEC17.DAT      5 10-Sep-82       SUB017.DAT      5 10-Sep-82
DYERI .DEM      5 21-Jan-83       AISPEC.DEM      5 21-Jan-83
 64 Files, 849 Blocks
 125 Free blocks

.R RECALL

 DO YOU WANT TO REVIEW ENCODER WAVELENGTH CALIBRATION PARAMETERS(Y/N)? N

 OUTPUT MODE: (1)RAW DATA
              (2)PSI/DELTA
              (3)COMPLEX REFRACTIVE INDEX
              (4)VERDET COEFFICIENTS

 YOUR CHOICE: 2

 INSERT THE DISK WITH THE DATA TO BE OUTPUT, THEN 'RETURN'.

 NAME OF SPECTRA FILE TO BE RETRIEVED = DY1AISPECDEM

 DO YOU WANT TO PLOT THE DATA(Y/N)? Y
```

Appendix 32 (continued).

Recalling simulated spectroscopic data file





Listing of AISPEC

```
      PROGRAM AISPEC
C***************************************************************************
C     OBJECTIVE:  TO GENERATE SIMULATED ELLIPSOMETER SPECTRA BASED UPON
C                 EXPERIMENTALLY DETERMINED OR GENERATED REFRACTIVE INDEX
C                 SPECTRA, AND OPERATOR INPUT FILM THICKNESSES AND VOID
C                 FRACTIONS.  THE THEORETICAL BASIS IS THE ANISOTROPIC
C                 FILM MODEL FOR A UNIAXIAL ANISOTROPIC, HOMOGENEOUS
C                 OVERLAYER.
C
C     BY JOSEPH C. FARMER, DECEMBER 13,1981, LBL-MMRD, UCB.
C
C**************************************************************************
      COMMON/AI1/N0,N1ER,N1EI,N10R,N10I,N2R,N2I,WL,PHI,D,PSI,DEL
      COMMON/AI2/R01PP,R12PP,R01SS,R12SS,RPP,RSS,RHO,N2,N1E,N10
      COMMON/A/NAVG(400),POL(400),ANA(400)
      COMMON/B/NRATE,NSCAN,IPOL,IANA
      COMMON/E/NAMEOP(20),ID(20)
      COMMON/F/LMPTYP,LMPSER(10),LMPVLT,LMPAMP
      COMMON/G/IPMTYP(10),IPMTDV
      COMMON/H/IPHASP,IPHASA,IGAINP,IGAINA,IAMPLP,IAMPLA,ITIMEP,ITIMEA
      COMMON/I/IGAGP,IGAGA,IGATP,IGATA
      COMMON/J/NWL,NPOL,NCMP,NANA
      COMMON/K/IHRS0,IMIN0,ISEC0,ITIC0,IHRSF,IMINF,ISECF,ITICF
      COMMON/L/IDAY,IMON(3),IYRS,LMPHRS
      COMMON/M/IWAVE(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      COMPLEX SPHI2,CPHI2,EX0,EX2,OR0,OR2,BETAP,BETAS
      COMPLEX R01PP,R12PP,R01SS,R12SS,RPP,RSS,RHO,N2,N1E,N10
      REAL N0,N2R,N2I,N1ER,N1EI,N10R,N10I
      DIMENSION FN(3,400),FK(3,400),AN(400),AK(400)
      REAL*4 DBLK(2),NAME(20)
    1 FORMAT(I1)
    2 FORMAT(A1)
C*****WAVELENGTH CALIBRATION OF DIGITAL ENCODER
      TYPE 3
    3 FORMAT(/,'$ INSERT DISK WITH WAVELENGTH CALIBRATION FOR THE
     C DIGITAL ENCODER - "RETURN".')
      ACCEPT 1,IWAIT
      CALL WLCALC
C*****AMBIENT MEDIUM RI SPECTRA INPUT FROM FLOPPY DISK
  100 TYPE 4
    4 FORMAT(/,'$ INSERT AMBIENT MEDIUM RI DATA DISK - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 1000 J=1,400
      AN(J)=POL(J)/1000.
 1000 AK(J)=ANA(J)/1000.
```

```
C*****FILM COMPONENTS' RI SPECTRA INPUT FROM FLOPPY DISK
      TYPE 2001
 2001 FORMAT(/,'$ INSERT RI SPECTRA DISK FOR Z-AXIS - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 2002 J=1,400
      FN(1,J)=POL(J)/1000.
 2002 FK(1,J)=ANA(J)/1000.
      TYPE 3001
 3001 FORMAT(/,'$ INSERT RI SPECTRA DISK FOR X/Y-PLANE - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 3002 J=1,400
      FN(2,J)=POL(J)/1000.
 3002 FK(2,J)=ANA(J)/1000.
C*****SUBSTRATE RI SPECTRA INPUT FROM FLOPPY DISK
      TYPE 10
   10 FORMAT(/,'$ INSERT SUBSTRATE RI DATA DISK - "RETURN".')
      ACCEPT 1,IWAIT
      CALL INPUT
      DO 5000 J=1,400
      POL(J)=POL(J)/1000.
 5000 ANA(J)=ANA(J)/1000.
C*****ANGLE OF INCIDENCE AND FILM THICKNESS INPUT FROM CRT
  140 TYPE 11
   11 FORMAT(/,'$ ANGLE OF INCIDENCE(DEG,F10.4) = ')
      ACCEPT 22,PHI1
   22 FORMAT(F10.4)
  145 TYPE 12
   12 FORMAT(/,'$ FILM THICKNESS(ANG,F10.0)      = ')
      ACCEPT 23,T
   23 FORMAT(F10.0)
      TYPE 13,PHI1,T
   13 FORMAT(/,'  PHI = ',F10.4,10X,' T = ',F10.0)
  150 TYPE 14
   14 FORMAT(/,'$ CORRECTIONS(Y/N)? ')
      ACCEPT 2,IFO
      IF(IFO.NE.1HN.AND.IFO.NE.1HY)GOTO 150
      IF(IFO.EQ.1HY)GOTO 140
```

```
C*****THE PSI-DELTA SPECTRA IS COMPUTED FROM INPUT SPECTRA
      DO 6000 J=1,400
      N0=AN(J)
      N1ER=FN(1,J)
      N1EI=FK(1,J)
      N1OR=FN(2,J)
      N1OI=FK(2,J)
      N2R=POL(J)
      N2I=ANA(J)
      PHI=PHI1
      D=T
      WL=IWAVE(J)
      CALL AIFILM
      POL(J)=DEL*100.
      ANA(J)=PSI*100.
      IF(DEL.LE.180.)GOTO 6000
      POL(J)=(DEL-360.)*100.
 6000 CONTINUE
C*****THE COMPUTED PSI-DELTA SPECTRA IS STORED ON DISK
  180 TYPE 15
   15 FORMAT(/,'$ DO YOU WANT TO STORE THE SIMULATED SPECTRA(Y/N)? ')
      ACCEPT 2,IF1
      IF(IF1.NE.1HN.AND.IF1.NE.1HY)GOTO 180
      IF(IF1.EQ.1HN)GOTO 190
      TYPE 16
   16 FORMAT(/,'$ IDENTIFICATION(20A2) = ')
      ACCEPT 24,(ID(I),I=1,20)
   24 FORMAT(20A2)
      CALL OUTPUT
C*****OPERATOR CAN EXECUTE PROGRAM AGAIN WITHOUT LOADING BUFFER
  190 TYPE 17
   17 FORMAT(/,'$ DO YOU WANT TO EXECUTE THE PROGRAM AGAIN(Y/N)? ')
      ACCEPT 2,IF2
      IF(IF2.NE.1HN.AND.IF2.NE.1HY)GOTO 190
      IF(IF2.EQ.1HN)STOP
      GOTO 100
      STOP
      END
```

```
      SUBROUTINE AIFILM
C***********************************************************************
C     OBJECTIVE: TO COMPUTE DELTA AND PSI FOR A UNIAXIALLY ANISOTROPIC
C                FILM
C***********************************************************************
      COMMON/AI1/NO,N1ER,N1EI,N1OR,N1OI,N2R,N2I,WL,PHI,D,PSI,DEL
      COMMON/AI2/R01PP,R12PP,R01SS,R12SS,RPP,RSS,RHO,N2,N1E,N1O
      COMPLEX SPHI2,CPHI2,EX0,EX2,OR0,OR2,BETAP,BETAS
      COMPLEX R01PP,R12PP,R01SS,R12SS,RPP,RSS,RHO,N2,N1E,N1O
      REAL NO,N2R,N2I,N1ER,N1EI,N1OR,N1OI
      N1E=CMPLX(N1ER,N1EI)
      N1O=CMPLX(N1OR,N1OI)
      N2=CMPLX(N2R,N2I)
      PI=3.1415927
      PHIO=PHI*0.01745329252
      SPHIO=SIN(PHIO)
      SPHI2=NO*SIN(PHIO)/N2
      CPHIO=COS(PHIO)
      CPHI2=CSQRT(1.-SPHI2*SPHI2)
      EX0=CSQRT(N1E*N1E-NO*NO*SPHIO*SPHIO)
      EX2=CSQRT(N1E*N1E-N2*N2*SPHI2*SPHI2)
      OR0=CSQRT(N1O*N1O-NO*NO*SPHIO*SPHIO)
      OR2=CSQRT(N1O*N1O-N2*N2*SPHI2*SPHI2)
      R01PP=( N1O*N1E*CPHIO-NO*EX0)/(N1O*N1E*CPHIO+NO*EX0)
      R12PP=(-N1O*N1E*CPHI2+N2*EX2)/(N1O*N1E*CPHI2+N2*EX2)
      R01SS=( NO*CPHIO-OR0)/(NO*CPHIO+OR0)
      R12SS=(-N2*CPHI2-OR2)/(N2*CPHI2+OR2)
      BETAP=(0.0,1.0)*4.0*PI*(N1O/N1E)*EX0*(D/WL)
      BETAS=(0.0,1.0)*4.0*PI*OR0*(D/WL)
      RPP=(R01PP+R12PP*CEXP(-BETAP))/(1.+R01PP*R12PP*CEXP(-BETAP))
      RSS=(R01SS+R12SS*CEXP(-BETAS))/(1.+R01SS*R12SS*CEXP(-BETAS))
      RHO=RPP/RSS
      PSI=DATAN(CABS(RHO))/0.01745329252
      DEL=DATAN2(AIMAG(RHO),REAL(RHO))/0.01745329252
      RETURN
      END
```

Appendix 33.

Demonstration of EMAFIT

```
.RUN DY1:EMAFIT

 INSERT DATA DISK - 'RETURN'.

 TNA   = 1.34

 INPUT =      1.3400

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

-TNKA  = 0.

 INPUT =      0.0000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

 TNF   = 2.

 INPUT =      2.0000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

-TNKF  = 3.

 INPUT =      3.0000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

 TNS   = 0.2

 INPUT =      0.2000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

-TNKS  = 2.5

 INPUT =      2.5000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

 PHI1  = 75.

 INPUT =     75.0000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

 WL    = 5145.
```

```
WL    = 5145.

INPUT =  5145.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

DEPOSIT MW               = 207.

INPUT =   207.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

DEPOSIT DENSITY(GM/CM3) = 11.

INPUT =    11.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

DEPOSIT VALENCE          = 2.

INPUT =     2.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

ELECTRODE AREA(CM2)      = 3.

INPUT =     3.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

TSTART = 29.

INPUT =    29.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

TFINAL = 119.

INPUT =   119.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

NITER  = 4

INPUT =      4

DO YOU WANT TO CHANGE ENTRY(Y/N)? N
    119.     60.492    43.330     7.992    -0.000     0.982     0.000
STOP --
```

Appendix 33 (continued).

Data file created by EMAFIT from PLTDAT

```
.DIR
 22-Jan-83
PBCU57.DAT     16 24-Nov-81     PBAG11.DAT     16 25-Nov-81
PBCU58.DAT     16 25-Nov-81     PBAG12.DAT     16 27-Nov-81
PBCU59.DAT     16 29-Nov-81     PBCU60.DAT     15 29-Nov-81
PBCU61.DAT     15 29-Nov-81     PBCU62.DAT     15 29-Nov-81
PBCU63.DAT     16 30-Nov-81     PBCU64.DAT     16 30-Nov-81
PBCU65.DAT     16 30-Nov-81     PBCU66.DAT     15 30-Nov-81
PBCU67.DAT     15 30-Nov-81     PBCU68.DAT     15 30-Nov-81
PBCU69.DAT     20 30-Nov-81     PBCU70.DAT     19 01-Dec-81
PBCU71.DAT     20 01-Dec-81     PBCU72.DAT     19 01-Dec-81
PBCU73.DAT     20 01-Dec-81     TRNSLT.514      1 09-Nov-81
TRNSLT.555      1 07-Nov-81     TRNSLT.DAT      1 08-Jan-82
PLTDAT.070     82 08-Jan-82     CSMFIT.070     47 24-Jan-82
EMAFIT.070     47 24-Jan-82     PLTDAT.073     82 08-Jan-82
CSMFIT.073     68 26-Jan-82     PLTDAT.072     82 28-Jan-82
CSMFIT.072     47 28-Jan-82     EMAFIT.072     47 28-Jan-82
PLTDAT.DAT     82 08-Jan-82     EMAFIT.DAT      1 22-Jan-83 ....created file
 32 Files, 904 Blocks
 70 Free blocks
```

Listing of EMAFIT

```
      PROGRAM EMAFIT
C***********************************************************************
C     OBJECTIVE:  TO INTEGRATE THE CURRENT PASSED DURING A FIXED
C                 WAVELENGTH EXPERIMENT AND COMPUTE A DEPOSIT THICKNESS
C                 AND FILM MICRO-POROSITY CONSISTENT WITH ELLIPSOMETER
C                 MEASUREMENTS USING THE COHERENT SUPERPOSITION MODEL
C                 AS A BASIS.
C
C     BY JOSEPH C. FARMER, LBL-MMRD, UCB, 1-20-82
C
C***********************************************************************
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMPLEX TN2,TN3,CPHI2,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      COMPLEX E,EH,EF,SUM
      DIMENSION ID(20)
      TYPE 100
  100 FORMAT(/,'$ INSERT DATA DISK - "RETURN".')
      ACCEPT 101,IWAIT
  101 FORMAT(I1)
      OPEN(UNIT=1,NAME='DY1:PLTDAT.DAT',TYPE='OLD')
      OPEN(UNIT=2,NAME='DY1:EMAFIT.DAT',TYPE='NEW')
    1 FORMAT(F10.4)
    2 FORMAT(I5)
    3 FORMAT(/,5X,20A2)
    4 FORMAT(1X,F9.0,7(1X,F9.3))
    5 FORMAT(/,'  INPUT = ',F10.4)
    6 FORMAT(/,'$ DO YOU WANT TO CHANGE ENTRY(Y/N)? ')
    7 FORMAT(A1)
    8 FORMAT(/,'  INPUT = ',I5)
C*****THE REFRACTIVE INDICES OF THE SYSTEM ARE INPUT BY OPERATOR
  110 TYPE 10
   10 FORMAT(/,'$ TNA   = ')
      ACCEPT 1,TNA
      TYPE 5,TNA
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 110
  111 TYPE 11
   11 FORMAT(/,'$-TNKA  = ')
      ACCEPT 1,TNKA
      TYPE 5,TNKA
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 111
  112 TYPE 12
   12 FORMAT(/,'$ TNF   = ')
      ACCEPT 1,TNF
      TYPE 5,TNF
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 112
```

```
  113 TYPE 13
   13 FORMAT(/,'$-TNKF  = ')
      ACCEPT 1,TNKF
      TYPE 5,TNKF
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 113
  116 TYPE 16
   16 FORMAT(/,'$ TNS   = ')
      ACCEPT 1,TNS
      TYPE 5,TNS
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 116
  117 TYPE 17
   17 FORMAT(/,'$-TNKS  = ')
      ACCEPT 1,TNKS
      TYPE 5,TNKS
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 117
C*****THE ANGLE OF INCIDENCE AND WAVELENGTH ARE INPUT
  118 TYPE 18
   18 FORMAT(/,'$ PHI1  = ')
      ACCEPT 1,PHI1
      TYPE 5,PHI1
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 118
  119 TYPE 19
   19 FORMAT(/,'$ WL    = ')
      ACCEPT 1,WL
      TYPE 5,WL
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 119
C*****THE PHYSICAL PROPERTIES OF THE DEPOSIT ARE INPUT
  120 TYPE 20
   20 FORMAT(/,'$ DEPOSIT MW                 = ')
      ACCEPT 1,DEPMW
      TYPE 5,DEPMW
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 120
  121 TYPE 21
   21 FORMAT(/,'$ DEPOSIT DENSITY(GM/CM3) = ')
      ACCEPT 1,DEPRHO
      TYPE 5,DEPRHO
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 121
```

```
  122 TYPE 22
   22 FORMAT(/,'$ DEPOSIT VALENCE         = ')
      ACCEPT 1,DEPVAL
      TYPE 5,DEPVAL
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 122
  123 TYPE 23
   23 FORMAT(/,'$ ELECTRODE AREA(CM2)     = ')
      ACCEPT 1,AREA
      TYPE 5,AREA
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 123
C*****THE LIMITS OF CURRENT INTEGRATION ARE SET
  124 TYPE 24
   24 FORMAT(/,'$ TSTART = ')
      ACCEPT 1,TSTART
      TYPE 5,TSTART
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 124
  125 TYPE 25
   25 FORMAT(/,'$ TFINAL = ')
      ACCEPT 1,TFINAL
      TYPE 5,TFINAL
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 125
C*****THE NUMBER OF ITERATIONS OF THE "POROSITY" ARE SPECIFIED
  126 TYPE 26
   26 FORMAT(/,'$ NITER  = ')
      ACCEPT 2,NITER
      TYPE 8,NITER
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 126
      READ(1,3)(ID(I),I=1,20)
      WRITE(2,3)(ID(I),I=1,20)
  200 READ(1,4)TIME1,POL,ANA,POT,CUR,DELM,PSIM
      IF(TIME1.LT.TSTART)GOTO 200
      TIME0=TIME1
      CUR0=0.
      Q=0.
      ERRFIT=1.E06
      DTHETA=1./NITER
C*****DIELECTRIC CONSTANTS ARE COMPUTED FROM REFRACTIVE INDICES
      EH=CMPLX(TNA,-TNKA)
      EF=CMPLX(TNF,-TNKF)
      EH=EH*EH
      EF=EF*EF
      SUM=(EF-EH)/(EF+2.*EH)
```

```
C*****THE DATA TO BE FIT IS INPUT FROM "PLTDAT.DAT"
  300 READ(1,4)TIME1,POL,ANA,POT,CUR,DELM,PSIM
C*****THE TOTAL SPECIFIC CHARGE PASSED (MICROCOULOMBS/CM2) AND THE
C     COMPACT FILM THICKNESS BASED ON THIS CHARGE BALANCE (ANGSTROMS)
C     ARE COMPUTED BY INTEGRATION
      Q=Q+(TIME1-TIME0)*(CUR+CUR0)/(1.2E02*AREA)
      T0=(-Q*DEPMW)/(9.64846E04*DEPVAL*DEPRHO)
      T0=T0*100.
C*****THE FILM MICRO POROSITY IS VARIED GIVING AN APPARANT FILM OPTICAL
C     PROPERTIES MINIMIZING THE COMPOSITE ERROR BETWEEN MEASURED AND
C     PREDICTED VALUES OF PSI AND DELTA.  PREDICTED VALUES ARE BASED
C     ON BRUGGEMAN'S EFFECTIVE MEDIA APPROXIMATION (EMA)
      THETA=-DTHETA
      DO 1000 J=1,NITER
      THETA=THETA+DTHETA
      T=T0/(1.-THETA)
      E=SUM*(1.-THETA)
      E=EH*(1.+2.*E)/(1.-E)
      E=CSQRT(E)
      TNF=REAL(E)
      TNKF=-AIMAG(E)
      CALL FILM
      ERROR=ABS(DELC-DELM)+ABS(PSIC-PSIM)
      IF(ERROR.GT.ERRFIT)GOTO 1000
      QFIT=Q/1.E06
      TFIT=T
      THETAF=THETA
      DELFIT=DELC
      PSIFIT=PSIC
      ERRFIT=ERROR
 1000 CONTINUE
C*****THE CALCULATED FILM PROPERTIES ARE OUTPUT TO "EMAFIT.DAT"
      TYPE 4,TIME1,DELFIT,PSIFIT,ERRFIT,QFIT,TFIT,THETAF
      WRITE(2,4)TIME1,DELFIT,PSIFIT,ERRFIT,QFIT,TFIT,THETAF
      TIME0=TIME1
      CUR0=CUR
      ERRFIT=1.E06
      IF(TIME1.GE.TFINAL)STOP
      GOTO 300
      END
```

Appendix 34.

Demonstration of CSMFIT

```
.RUN DY1:CSMFIT

 INSERT DATA DISK - 'RETURN'.

 TNA   = 1.34

 INPUT =      1.3400

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

-TNKA  = 0.

 INPUT =      0.0000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

 TNF1  = 2.

 INPUT =      2.0000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

-TNKF1 = 3.


 INPUT =      3.0000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

 TNF2  = 1.34

 INPUT =      1.3400

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

-TNKF2 = 0.

 INPUT =      0.0000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

 TNS   = 0.2

 INPUT =      0.2000

 DO YOU WANT TO CHANGE ENTRY(Y/N)? N

-TNKS  = 2.5
```

```
INPUT =     2.5000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

PHI1  = 75.

INPUT =    75.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

WL    = 5145.

INPUT =  5145.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

DEPOSIT MW               = 207.

INPUT =   207.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

DEPOSIT DENSITY(GM/CM3) = 11.
INPUT =    11.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

DEPOSIT VALENCE          = 2.

INPUT =     2.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

ELECTRODE AREA(CM2)      = 3.

INPUT =     3.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

TSTART = 29.

INPUT =    29.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

TFINAL = 119.


INPUT =   119.0000

DO YOU WANT TO CHANGE ENTRY(Y/N)? N

NITER  = 4

INPUT =     4

DO YOU WANT TO CHANGE ENTRY(Y/N)? N
   119.    60.493    43.140    7.000    -0.000    3.928    0.750
STOP --
```

Appendix 34 (continued).

Data file created by CSMFIT from PLTDAT

```
.DIR
 22-Jan-83
PBCU57.DAT     16 24-Nov-81       PBAG11.DAT     16 25-Nov-81
PBCU58.DAT     16 25-Nov-81       PBAG12.DAT     16 27-Nov-81
PBCU59.DAT     16 29-Nov-81       PBCU60.DAT     15 29-Nov-81
PBCU61.DAT     15 29-Nov-81       PBCU62.DAT     15 29-Nov-81
PBCU63.DAT     16 30-Nov-81       PBCU64.DAT     16 30-Nov-81
PBCU65.DAT     16 30-Nov-81       PBCU66.DAT     15 30-Nov-81
PBCU67.DAT     15 30-Nov-81       PBCU68.DAT     15 30-Nov-81
PBCU69.DAT     20 30-Nov-81       PBCU70.DAT     19 01-Dec-81
PBCU71.DAT     20 01-Dec-81       PBCU72.DAT     19 01-Dec-81
PBCU73.DAT     20 01-Dec-81       TRNSLT.514      1 09-Nov-81
TRNSLT.555      1 07-Nov-81       TRNSLT.DAT      1 08-Jan-82
PLTDAT.070     82 08-Jan-82       CSMFIT.070     47 24-Jan-82
EMAFIT.070     47 24-Jan-82       PLTDAT.073     82 08-Jan-82
CSMFIT.073     68 26-Jan-82       PLTDAT.072     82 28-Jan-82
CSMFIT.072     47 28-Jan-82       EMAFIT.072     47 28-Jan-82
PLTDAT.DAT     82 08-Jan-82       EMAFIT.DAT      1 22-Jan-83
CSMFIT.DAT      1 22-Jan-83...................................created file
 33 Files, 905 Blocks
 69 Free blocks
```

Appendix 34 (continued).

Listing of CSMFIT

```
      PROGRAM CSMFIT
C************************************************************************
C     OBJECTIVE:  TO INTEGRATE THE CURRENT PASSED DURING A FIXED
C                 WAVELENGTH EXPERIMENT AND COMPUTE A DEPOSIT THICKNESS
C                 AND SURFACE COVERAGE CONSISTENT WITH ELLIPSOMETER
C                 MEASUREMENTS USING THE COHERENT SUPERPOSITION MODEL
C                 AS A BASIS.
C
C     BY JOSEPH C. FARMER, LBL-MMRD, UCB, 1-20-82
C
C************************************************************************
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/CSMDAT/TNF1,TNKF1,TNF2,TNKF2,THETA
      COMPLEX TN2,TN3,CPHI2,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      DIMENSION ID(20)
      TYPE 100
  100 FORMAT(/,'$ INSERT DATA DISK - "RETURN".')
      ACCEPT 101,IWAIT
  101 FORMAT(I1)
      OPEN(UNIT=1,NAME='DY1:PLTDAT.DAT',TYPE='OLD')
      OPEN(UNIT=2,NAME='DY1:CSMFIT.DAT',TYPE='NEW')
    1 FORMAT(F10.4)
    2 FORMAT(I5)
    3 FORMAT(/,5X,20A2)
    4 FORMAT(1X,F9.0,7(1X,F9.3))
    5 FORMAT(/,'  INPUT = ',F10.4)
    6 FORMAT(/,'$ DO YOU WANT TO CHANGE ENTRY(Y/N)? ')
    7 FORMAT(A1)
    8 FORMAT(/,'  INPUT = ',I5)
C*****THE REFRACTIVE INDICES OF THE SYSTEM ARE INPUT BY OPERATOR
  110 TYPE 10
   10 FORMAT(/,'$ TNA   = ')
      ACCEPT 1,TNA
      TYPE 5,TNA
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 110
  111 TYPE 11
   11 FORMAT(/,'$-TNKA  = ')
      ACCEPT 1,TNKA
      TYPE 5,TNKA
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 111
```

```
112 TYPE 12
 12 FORMAT(/,'$ TNF1  = ')
    ACCEPT 1,TNF1
    TYPE 5,TNF1
    TYPE 6
    ACCEPT 7,IFLAG
    IF(IFLAG.NE.1HN)GOTO 112
113 TYPE 13
 13 FORMAT(/,'$-TNKF1 = ')
    ACCEPT 1,TNKF1
    TYPE 5,TNKF1
    TYPE 6
    ACCEPT 7,IFLAG
    IF(IFLAG.NE.1HN)GOTO 113
114 TYPE 14
 14 FORMAT(/,'$ TNF2  = ')
    ACCEPT 1,TNF2
    TYPE 5,TNF2
    TYPE 6
    ACCEPT 7,IFLAG
    IF(IFLAG.NE.1HN)GOTO 114
115 TYPE 15
 15 FORMAT(/,'$-TNKF2 = ')
    ACCEPT 1,TNKF2
    TYPE 5,TNKF2
    TYPE 6
    ACCEPT 7,IFLAG
    IF(IFLAG.NE.1HN)GOTO 115
116 TYPE 16
 16 FORMAT(/,'$ TNS   = ')
    ACCEPT 1,TNS
    TYPE 5,TNS
    TYPE 6
    ACCEPT 7,IFLAG
    IF(IFLAG.NE.1HN)GOTO 116
117 TYPE 17
 17 FORMAT(/,'$-TNKS  = ')
    ACCEPT 1,TNKS
    TYPE 5,TNKS
    TYPE 6
    ACCEPT 7,IFLAG
    IF(IFLAG.NE.1HN)GOTO 117
```

```
C*****THE ANGLE OF INCIDENCE AND WAVELENGTH ARE INPUT
  118 TYPE 18
   18 FORMAT(/,'$ PHI1  = ')
      ACCEPT 1,PHI1
      TYPE 5,PHI1
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 118
  119 TYPE 19
   19 FORMAT(/,'$ WL    = ')
      ACCEPT 1,WL
      TYPE 5,WL
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 119
C*****THE PHYSICAL PROPERTIES OF THE DEPOSIT ARE INPUT
  120 TYPE 20
   20 FORMAT(/,'$ DEPOSIT MW                = ')
      ACCEPT 1,DEPMW
      TYPE 5,DEPMW
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 120
  121 TYPE 21
   21 FORMAT(/,'$ DEPOSIT DENSITY(GM/CM3) = ')
      ACCEPT 1,DEPRHO
      TYPE 5,DEPRHO
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 121
  122 TYPE 22
   22 FORMAT(/,'$ DEPOSIT VALENCE           = ')
      ACCEPT 1,DEPVAL
      TYPE 5,DEPVAL
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 122
  123 TYPE 23
   23 FORMAT(/,'$ ELECTRODE AREA(CM2)       = ')
      ACCEPT 1,AREA
      TYPE 5,AREA
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 123
```

```
C*****THE LIMITS OF CURRENT INTEGRATION ARE SET
  124 TYPE 24
   24 FORMAT(/,'$ TSTART = ')
      ACCEPT 1,TSTART
      TYPE 5,TSTART
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 124
  125 TYPE 25
   25 FORMAT(/,'$ TFINAL = ')
      ACCEPT 1,TFINAL
      TYPE 5,TFINAL
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 125
C*****THE NUMBER OF ITERATIONS OF THE "COVERAGE" ARE SPECIFIED
  126 TYPE 26
   26 FORMAT(/,'$ NITER  = ')
      ACCEPT 2,NITER
      TYPE 8,NITER
      TYPE 6
      ACCEPT 7,IFLAG
      IF(IFLAG.NE.1HN)GOTO 126
      READ(1,3)(ID(I),I=1,20)
      WRITE(2,3)(ID(I),I=1,20)
  200 READ(1,4)TIME1,POL,ANA,POT,CUR,DELM,PSIM
      IF(TIME1.LT.TSTART)GOTO 200
      TIME0=TIME1
      CUR0=0.
      Q=0.
      ERRFIT=1.E06
      DTHETA=1./NITER
C*****THE TOTAL CHARGE PASSED (MICRO COULOMBS) AND THE FILM THICKNESS
C     BASED ON THIS CHARGE BALANCE (ANGSTROMS) ARE COMPUTED
  300 READ(1,4)TIME1,POL,ANA,POT,CUR,DELM,PSIM
      THETA=-DTHETA
      Q=Q+(TIME1-TIME0)*(CUR+CUR0)/(1.2E02*AREA)
      DO 1000 J=1,NITER
      THETA=THETA+DTHETA
      T=(-Q*DEPMW)/(9.64846E04*DEPVAL*DEPRHO*(1.-THETA))
      T=T*100.
```

```
C*****PSI AND DELTA ARE PREDICTED BASED ON CSM MODEL FOR COMPARISON
C     WITH EXPERIMENTALLY DETERMINED VALUES...THE COVERAGE MINIMIZING
C     THE COMPOSITE ERROR IS SELECTED AS THE CORRECT VALUE FOR THIS
C     SINGLE ADJUSTABLE PARAMETER
      CALL FILM02
      ERROR=ABS(DELC-DELM)+ABS(PSIC-PSIM)
      IF(ERROR.GT.ERRFIT)GOTO 1000
      QFIT=Q/1.E06
      TFIT=T
      THETAF=THETA
      DELFIT=DELC
      PSIFIT=PSIC
      ERRFIT=ERROR
 1000 CONTINUE
      TYPE 4,TIME1,DELFIT,PSIFIT,ERRFIT,QFIT,TFIT,THETAF
      WRITE(2,4)TIME1,DELFIT,PSIFIT,ERRFIT,QFIT,TFIT,THETAF
      TIME0=TIME1
      CUR0=CUR
      ERRFIT=1.E06
      IF(TIME1.GE.TFINAL)STOP
      GOTO 300
      END
```

Appendix 35.

Directory of Tektronix 4662 Interactive Plotter Software Disk DY1:

```
 22-Jan-83
PL1OLB.OBJ   304  23-Mar-80    TEKPLT.SAV    25  05-May-82
INPUT .FOR     3  06-May-82    SPCTRA.TST     5  11-Mar-82
WLCALC.OLD     1  06-May-82    WLCALC.FOR     2  06-May-82
IOTEST.SAV    35  06-May-82    SPCTRA.DAT     5  06-May-82
IOTEST.FOR     2  06-May-82    TEK001.FOR     1  06-May-82
TEKPLT.FOR     2  06-May-82    TEK001.SAV    52  06-May-82
RANGES.FOR     1  06-May-82    LABEL .SAV    50  08-May-82
SCALE .FOR     1  06-May-82    LABEL .FOR     2  08-May-82
TEST  .SAV    19  09-May-82    TEST  .FOR     2  09-May-82
AXIOLD.FOR     5  10-May-82    AXIOLD.SAV    53  10-May-82
TEK002.FOR     5  10-May-82    TEK002.SAV    60  10-May-82
TEK003.FOR     6  11-May-82    TEK003.SAV    41  11-May-82
RANGES.001     1  11-May-82    AXES02.001     2  11-May-82
AXES03.001     2  12-May-82    WLCALC.NEW     1  23-Jul-82
RANGES.002     1  01-Aug-82    RANGES.003     1  03-Aug-82
AXES02.002     1  03-Aug-82    AXES02.003     1  03-Aug-82
AXES02.004     1  03-Aug-82    RANGES.004     1  03-Aug-82
RANGES.005     1  03-Aug-82    AXES02.005     1  03-Aug-82
RANGES.006     1  03-Aug-82    AXES02.006     1  03-Aug-82
LABMOD.FOR     3  17-Aug-82    LABMOD.OBJ     7  17-Aug-82
LABMOD.SAV    50  17-Aug-82    AXINEW.FOR     6  17-Aug-82
AXINEW.OBJ    18  17-Aug-82    AXINEW.SAV    54  17-Aug-82
AXINEW.LST    15  17-Aug-82    AXES  .SAV    54  17-Aug-82
RANGES.007     1  20-Aug-82    AXES02.007     1  20-Aug-82
RANGES.008     1  20-Aug-82    AXES02.008     1  20-Aug-82
AXES03.002     1  22-Aug-82    AXES03.003     1  24-Aug-82
AXES03.004     1  24-Aug-82    RANGES.009     1  08-Sep-82
RANGES.09A     1  08-Sep-82    AXES02.009     1  10-Sep-82
AXES03.05A     1  26-Sep-82    AXES03.005     2  26-Sep-82
AXES03.006     2  30-Sep-82    AXES03.06A     2  30-Sep-82
AXES02.010     1  08-Jan-83    RANGES.010     1  08-Jan-83
AXES02.011     1  08-Jan-83    RANGES.011     1  08-Jan-83
RANGES.012     1  08-Jan-83    AXES02.012     1  08-Jan-83
RANGES.013     1  08-Jan-83    AXES02.013     1  08-Jan-83
WLCALC.DAT     1  23-Jul-82    RANGES.DAT     1  12-Jan-83
AXES  .DAT     2  12-Jan-83
 71 Files, 934 Blocks
 40 Free blocks
```

Appendix 36.

Demonstration of AXES and LABMOD - labeling axes and positions on graph

```
.RUN AXES   ........running AXES
 OPTION(I2) = 1
 DO YOU WANT TO CHANGE THE ORIGIN(Y/N)? N
.RUN LABMOD    .........running LABMOD
 X-POSITION(I4): 400
 Y-POSITION(I4): 400
 ROTATION ANGLE: 45.
 LABELING(30A1): JOE FARMER
 X-SIZE(I3)     : 30
 Y-SIZE(I3)     : 45
 MORE LABELS(Y/N)? Y
 X-POSITION(I4): 300
 Y-POSITION(I4): 200
 ROTATION ANGLE: 0.
 LABELING(30A1): DEMONSTRATION OF AXES & LABMOD
 X-SIZE(I3)     : 45
 Y-SIZE(I3)     : 60
 MORE LABELS(Y/N)? N
.
```

Listing of AXES

```
      PROGRAM AXES
      COMMON/TEKTYP/IX,IY,ISX,ISY,NCHAR,ANGLE,IARRAY(30)
      DIMENSION LABELX(30),LABELY(30),NX(4,10),NY(2,10)
      TYPE 1
    1 FORMAT(/,'$ OPTION(I2) = ')
      ACCEPT 2,MOPT
    2 FORMAT(I2)
      OPEN(UNIT=1,NAME='DY1:AXES.DAT',TYPE='OLD')
 1000 READ(1,1001)NOPT
      READ(1,1002)(LABELY(I),I=1,30)
      READ(1,1002)(LABELX(I),I=1,30)
      READ(1,1001)NTICY
      DO 100 III=1,NTICY
  100 READ(1,1003)(NY(II,III),II=1,2)
      READ(1,1001)NTICX
      DO 200 III=1,NTICX
  200 READ(1,1004)(NX(II,III),II=1,4)
      IF(NOPT.NE.MOPT)GOTO 1000
 1001 FORMAT(1X,I2)
 1002 FORMAT(1X,30A1)
 1003 FORMAT(1X,2A1)
 1004 FORMAT(1X,4A1)
      CLOSE(UNIT=1,DISPOSE='SAVE')
      CALL INITT(120)
      CALL TERM(1,1)
      CALL PLINIT(1)
      CALL PLON
      IDX=0
      IDY=0
  300 IX=IDX+50
      IY=IDY+50
      CALL MOVABS(IX,IY)
  310 TYPE 320
  320 FORMAT(/,'$ DO YOU WANT TO CHANGE THE ORIGIN(Y/N)? ')
      ACCEPT 330,IFLAG
  330 FORMAT(A1)
      IF(IFLAG.NE.1HY.AND.IFLAG.NE.1HN)GOTO 310
      IF(IFLAG.EQ.1HN)GOTO 370
      TYPE 340
  340 FORMAT(/,'$ IDX = ')
      ACCEPT 360,IDX
      TYPE 350
  350 FORMAT(/,'$ IDY = ')
      ACCEPT 360,IDY
  360 FORMAT(I5)
      GOTO 300
  370 CONTINUE
```

```
      CALL DRWREL(600,0)
      CALL DRWREL(0,400)
      CALL DRWREL(-600,0)
      CALL DRWREL(0,-400)
      IX=IDX+15
      IY=IDY+150
      ISX=50
      ISY=75
      NCHAR=30
      ANGLE=90.
      DO 2000 I=1,NCHAR
 2000 IARRAY(I)=LABELY(I)
      CALL TEKTYP
      IX=IDX+25
      IY=IDY+450
      ISX=45
      ISY=60
      NCHAR=2
      ANGLE=0.
      DO 4000 III=1,NTICY
      DO 3000 II=1,NCHAR
 3000 IARRAY(II)=NY(II,III)
      CALL TEKTYP
      ISTOP1=450+IDY
      ISTOP2=50+IDY
      IF(IY.GE.ISTOP1.OR.IY.LE.ISTOP2)GOTO 3500
      IIX=50+IDX
      CALL MOVABS(IIX,IY)
      CALL DRWREL(10,0)
      IIX=640+IDX
      CALL MOVABS(IIX,IY)
      CALL DRWREL(10,0)
 3500 IY=IY-(400./(NTICY-1))
 4000 CONTINUE
      IX=IDX+225
      IY=IDY+10
      ISX=50
      ISY=75
      NCHAR=30
      ANGLE=0.
      DO 5000 I=1,NCHAR
 5000 IARRAY(I)=LABELX(I)
      CALL TEKTYP
      IX=IDX+650
      IY=IDY+35
      ISX=45
      ISY=60
      NCHAR=4
      ANGLE=0.
```

```
      DO 7000 III=1,NTICX
      DO 6000 II=1,NCHAR
6000  IARRAY(II)=NX(II,III)
      CALL TEKTYP
      ISTOP3=650+IDX
      ISTOP4=50+IDX
      IF(IX.GE.ISTOP3.OR.IX.LE.ISTOP4)GOTO 6500
      IIY=50+IDY
      CALL MOVABS(IX,IIY)
      CALL DRWREL(0,10)
      IIY=440+IDY
      CALL MOVABS(IX,IIY)
      CALL DRWREL(0,10)
6500  IX=IX-(600./(NTICX-1))
7000  CONTINUE
      CALL HOME
      CALL EXIT
      STOP
      END
```

Appendix 37.

Input Data File AXES.DAT

```
01
  DELTA(DEGREES)
   WAVELENGTH(NM)
05
75
70
65
60
55
04
700
600
500
400
02
  PSI(DEGREES)
   WAVELENGTH(NM)
04
40
38
36
34
04
700
600
500
400
```

```
03
 DELTA(DEGREES)
  WAVELENGTH(NM)
04
80
70
60
50
04
700
600
500
400
04
 PSI(DEGREES)
  WAVELENGTH(NM)
04
50
40
30
20
04
700
600
500
400
```

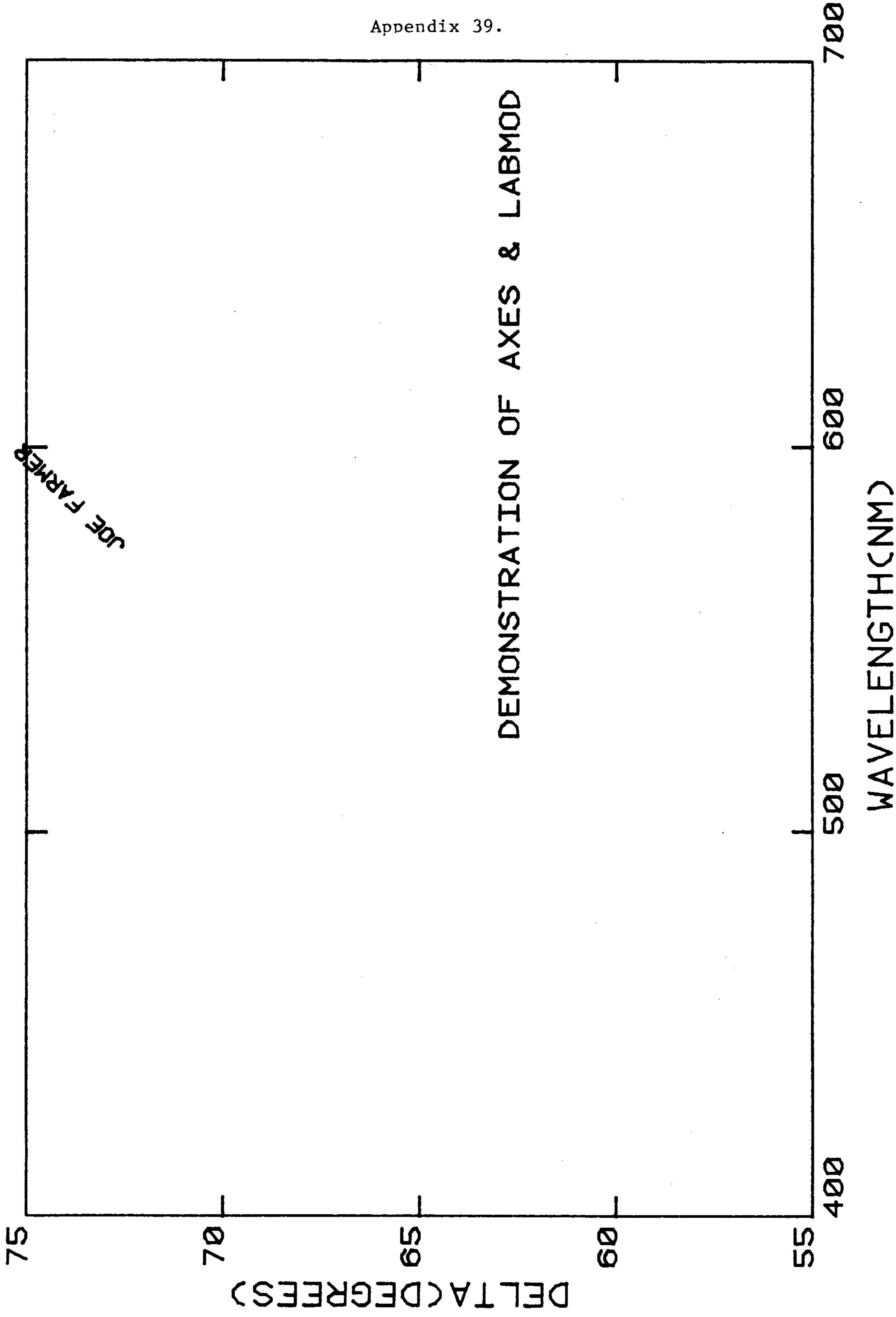
```
05
REFRACTIVE INDEX - N
   WAVELENGTH(NM)
05
 4
 3
 2
 1
 0
04
700
600
500
400
06
EXTINCTION COEF - K
  WAVELENGTH(NM)
06
 0
-1
-2
-3
-4
-5
04
700
600
500
400
```

Appendix 38

Listing of LABMOD

```
      PROGRAM LABEL
      DIMENSION IARRAY(30)
      CALL INITT(120)
      CALL TERM(1,1)
      CALL PLINIT(1)
      CALL PLON
   10 CONTINUE
      TYPE 20
   20 FORMAT(/,'$ X-POSITION(I4): ')
      ACCEPT 30,IX
   30 FORMAT(I4)
      TYPE 40
   40 FORMAT(/,'$ Y-POSITION(I4): ')
      ACCEPT 50,IY
   50 FORMAT(I4)
      CALL MOVABS(IX,IY)
      TYPE 60
   60 FORMAT(/,'$ ROTATION ANGLE: ')
      ACCEPT 70,ANGLE
   70 FORMAT(F10.2)
      TYPE 80
   80 FORMAT(/,'$ LABELING(30A1): ')
      ACCEPT 90,(IARRAY(I),I=1,30)
   90 FORMAT(30A1)
      TYPE 100
  100 FORMAT(/,'$ X-SIZE(I3)      : ')
      ACCEPT 110,ISX
  110 FORMAT(I3)
      TYPE 120
  120 FORMAT(/,'$ Y-SIZE(I3)      : ')
      ACCEPT 130,ISY
  130 FORMAT(I3)
      CALL LINROT(ANGLE)
      CALL PLCHAR(ISX,ISY)
      CALL A1OUT(30,IARRAY)
  135 TYPE 140
  140 FORMAT(/,'$ MORE LABELS(Y/N)? ')
      ACCEPT 150, IFLAG
  150 FORMAT(A1)
      IF(IFLAG.NE.1HY.AND.IFLAG.NE.1HN)GOTO 135
  160 IF(IFLAG.EQ.1HY)GOTO 10
      CALL HOME
      CALL EXIT
      END
```

Appendix 39.


DEMONSTRATION OF AXES & LABMOD
JOE FARMER
WAVELENGTH(NM)
400
500
600
700
DELTA(DEGREES)
75
70
65
60
55

Appendix 40.

Demonstration of TEK002 - plotting spectroscopic ellipsometer data files

```
.RUN TEK002

LOAD DISK & TYPE SPECTRA FILE NAME: DY1RESULTZ42

P/WL PLOT(A), A/WL PLOT(B), OR A/P PLOT(C)? A

DOTTED(A) OR CONTINUOUS(B) LINES? B

MORE PLOTTED SPECTRA(Y/N)? N

.RUN LABMOD

X-POSITION(I4): 200

Y-POSITION(I4): 200

ROTATION ANGLE: 0.

LABELING(30A1): EXAMPLE EXECUTION OF TEK002

X-SIZE(I3)     : 60

Y-SIZE(I3)     : 75


MORE LABELS(Y/N)? N
```

Appendix 40 (continued).

Listing of TEK002

```
      PROGRAM TEK002
      COMMON/A/POL(400),ANA(400)
      COMMON/B/WL(400)
      COMMON/C/WLMAX,WLMIN,PMAX,PMIN,PSCALE,AMAX,AMIN,ASCALE
      COMMON/TEKPLT/X(400),Y(400)
      CALL RANGES
      CALL WLCALC
      DO 100 I=1,399
  100 WL(I)=((WL(I)-WLMIN)/(WLMAX-WLMIN))*600
  200 CALL INPUT
      DO 300 I=1,399
      POL(I)=(POL(I)/PSCALE-PMIN)*400./(PMAX-PMIN)
  300 ANA(I)=(ANA(I)/ASCALE-AMIN)*400./(AMAX-AMIN)
  400 TYPE 500
  500 FORMAT(/,'$ P/WL PLOT(A), A/WL PLOT(B), OR A/P PLOT(C)? ')
      ACCEPT 600,FLAG1
  600 FORMAT(A1)
      IF(FLAG1.NE.1HA.AND.FLAG1.NE.1HB.AND.FLAG1.NE.1HC)GOTO 400
      IF(FLAG1.NE.1HA)GOTO 800
      DO 700 I=1,399
      X(I)=WL(I)
  700 Y(I)=POL(I)
      GOTO 1200
  800 CONTINUE
      IF(FLAG1.NE.1HB)GOTO 1000
      DO 900 I=1,399
      X(I)=WL(I)
  900 Y(I)=ANA(I)
      GOTO 1200
 1000 CONTINUE
      IF(FLAG1.NE.1HC)GOTO 400
      DO 1100 I=1,399
      X(I)=POL(I)
 1100 Y(I)=ANA(I)
 1200 CONTINUE
      CALL TEKPLT
 1250 TYPE 1300
 1300 FORMAT(/,'$ MORE PLOTTED SPECTRA(Y/N)? ')
      ACCEPT 1400,FLAG2
 1400 FORMAT(A1)
      IF(FLAG2.NE.1HY.AND.FLAG2.NE.1HN)GOTO 1250
      IF(FLAG2.EQ.1HY)GOTO 200
      CALL EXIT
      STOP
      END
```

```
      SUBROUTINE TEKPLT
      COMMON/TEKPLT/X(400),Y(400)
      CALL INITT(120)
      CALL TERM(1,1)
      CALL PLINIT(1)
      CALL PLON
  100 TYPE 200
  200 FORMAT(/,'$ DOTTED(A) OR CONTINUOUS(B) LINES? ')
      ACCEPT 300,FLAG
  300 FORMAT(A1)
      IF(FLAG.NE.1HA.AND.FLAG.NE.1HB)GOTO 100
      CALL MOVABS(50,50)
      CALL DRWREL(600,0)
      CALL DRWREL(0,400)
      CALL DRWREL(-600,0)
      CALL DRWREL(0,-400)
      IF(FLAG.EQ.1HB)GOTO 500
      IF(FLAG.NE.1HA)GOTO 100
      DO 400 I=1,399
      IX=X(I)+50.
      IY=Y(I)+50.
      IF(IX.GT.650.OR.IX.LT.50)GOTO 400
      IF(IY.GT.450.OR.IY.LT.50)GOTO 400
      CALL PNTABS(IX,IY)
  400 CONTINUE
      GOTO 700
  500 CONTINUE
      DO 600 I=2,399
      IX=X(I-1)+50
      IY=Y(I-1)+50
      IF(IX.GT.650.OR.IX.LT.50)GOTO 600
      IF(IY.GT.450.OR.IY.LT.50)GOTO 600
      CALL MOVABS(IX,IY)
      IX=X(I)-X(I-1)
      IY=Y(I)-Y(I-1)
      CALL DRWREL(IX,IY)
  600 CONTINUE
  700 CALL HOME
      RETURN
      END
```

```
      SUBROUTINE RANGES
      COMMON/C/WLMAX,WLMIN,PMAX,PMIN,PSCALE,AMAX,AMIN,ASCALE
      OPEN(UNIT=1,NAME='DY1:RANGES.DAT',TYPE='OLD')
      READ(1,100)WLMAX,WLMIN,PMAX,PMIN,PSCALE,AMAX,AMIN,ASCALE
  100 FORMAT(8(1X,F6.0))
      CLOSE(UNIT=1,DISPOSE='SAVE')
      RETURN
      END
```

```
      SUBROUTINE WLCALC
      COMMON/B/WL(400)
      OPEN(UNIT=1,NAME='DY1:WLCALC.DAT',TYPE='OLD')
      READ(1,100)IU,IL,A1,B1,R1,A2,B2,R2
  100 FORMAT(2(1X,I3),2(1X,F8.4,1X,F8.2,1X,F6.4))
      CLOSE(UNIT=1,DISPOSE='SAVE')
      DO 30 I=1,400
      IF(I.LE.IL.AND.I.GE.IU)GOTO 10
      IF(I.GT.IL)GOTO 20
      COUNT=I
      WL(I)=A1*COUNT+B1
      GOTO 30
   10 COUNT=I
      WL(I)=A2*COUNT+B2
      GOTO 30
   20 COUNT=I-400
      WL(I)=A1*COUNT+B1
   30 CONTINUE
      RETURN
      END
```

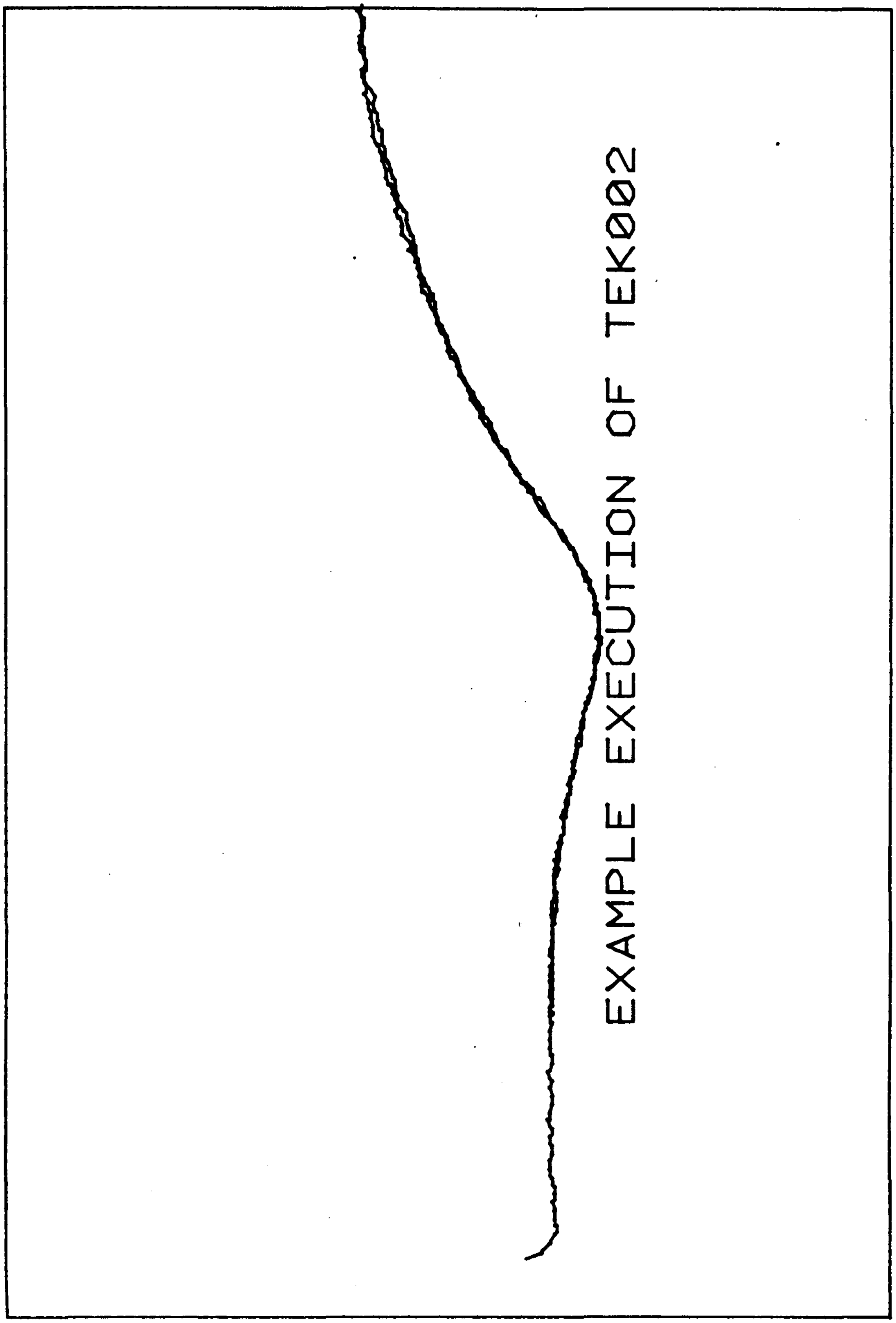
```
      SUBROUTINE TEKTYP
      COMMON/TEKTYP/IX,IY,ISX,ISY,NCHAR,ANGLE,IARRAY(30)
      CALL MOVABS(IX,IY)
      CALL LINROT(ANGLE)
      CALL PLCHAR(ISX,ISY)
      CALL A1OUT(NCHAR,IARRAY)
      RETURN
      END
```

```
      SUBROUTINE INPUT
      REAL*4 BDLK(2),NAME(20)
      COMMON/A/POL(400),ANA(400)
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      TYPE 100
  100 FORMAT(/,'$ LOAD DISK & TYPE SPECTRA FILE NAME: ')
      ACCEPT 200,(NAME(I),I=1,3)
  200 FORMAT(3A4)
      N=IRAD50(12,NAME,BDLK)
      ICHAN=IGETC(I)
      IF(ICHAN.LT.0)STOP 'CANNOT ALLOCATE CHANNEL'
      IF(IFETCH(ICHAN).LT.0)STOP 'FETCH FAIL'
      IF(LOOKUP(ICHAN,BDLK).LT.0)STOP 'BAD LOOKUP'
      IBLOCK=1
      DO 300 I=1,256
  300 IBUFF(I)=0
      CALL READ
      DO 1000 I=1,200
 1000 POL(I)=IBUFF(I)
      CALL READ
      DO 1010 I=1,200
 1010 ANA(I)=IBUFF(I)
      CALL READ
      DO 1020 I=1,200
 1020 POL(I+200)=IBUFF(I)
      CALL READ
      DO 1030 I=1,200
 1030 ANA(I+200)=IBUFF(I)
      CALL CLOSEC(ICHAN)
      CALL IFREEC(ICHAN)
      RETURN
      END

      SUBROUTINE READ
      COMMON/N/ICHAN,IBLOCK,IFLAG,IBUFF(256)
      IERROR=IREADW(256,IBUFF,IBLOCK,ICHAN)
      IF(IERROR.LT.0)STOP 'FATAL READ'
      IBLOCK=IBLOCK+1
      RETURN
      END
```

Appendix 41.

Input Data File RANGES.DAT

```
  7000.  4000.    95.    45.   100.    50.     20.   100.
/123456/123456/123456/123456/123456/123456/123456/123456/123456/
```


EXAMPLE EXECUTION OF TEKØØ2

Appendix 43 (continued).

Listing of TEK003

```
      PROGRAM TEK003
      DIMENSION ARRAY(8),ID(20)
      TYPE 10
      ACCEPT 1,IWAIT
  999 OPEN(UNIT=1,NAME='DY1:PLTDAT.DAT',TYPE='OLD')
      READ(1,5)(ID(I),I=1,20)
      TYPE 5,(ID(I),I=1,20)
 1000 TYPE 20
      ACCEPT 1,ICHANX
      TYPE 30
      ACCEPT 2,XMAX
      TYPE 40
      ACCEPT 2,XMIN
      TYPE 50
      ACCEPT 1,ICHANY
      TYPE 60
      ACCEPT 2,YMAX
      TYPE 70
      ACCEPT 2,YMIN
      TYPE 80
      ACCEPT 2,TSTART
      TYPE 90
      ACCEPT 2,TFINAL
 2000 TYPE 100
      ACCEPT 3,FLAG
      IF(FLAG.EQ.1HY)GOTO 1000
      IF(FLAG.NE.1HY.AND.FLAG.NE.1HN)GOTO 2000
 3000 TYPE 200
      ACCEPT 3,FLAG
      IF(FLAG.NE.1HA.AND.FLAG.NE.1HB)GOTO 3000
      CALL INITT(120)
      CALL TERM(1,1)
      CALL PLINIT(1)
      CALL PLON
      CALL MOVABS(50,50)
      CALL DRWREL(600,0)
      CALL DRWREL(0,400)
      CALL DRWREL(-600,0)
      CALL DRWREL(0,-400)
      IF(FLAG.EQ.1HB)GOTO 5000
 4000 CONTINUE
      READ(1,4)(ARRAY(I),I=1,8)
      IF(ARRAY(1).GE.TFINAL)GOTO 7000
      IF(ARRAY(1).LE.TSTART)GOTO 4001
      IX=(ARRAY(ICHANX)-XMIN)*600./(XMAX-XMIN)+50
      IY=(ARRAY(ICHANY)-YMIN)*400./(YMAX-YMIN)+50
      IF(IX.GT.650.OR.IX.LT.50)GOTO 4001
      IF(IY.GT.450.OR.IY.LT.50)GOTO 4001
      CALL PNTABS(IX,IY)
```

```
4001 CONTINUE
     GOTO 4000
5000 CONTINUE
     READ(1,4)(ARRAY(I),I=1,8)
     IF(ARRAY(1).LE.TSTART)GOTO 5000
     READ(1,4)(ARRAY(I),I=1,8)
     X0=(ARRAY(ICHANX)-XMIN)*600./(XMAX-XMIN)
     Y0=(ARRAY(ICHANY)-YMIN)*400./(YMAX-YMIN)
6000 IX=X0+50
     IY=Y0+50
     IF(IX.GT.650.OR.IX.LT.50)GOTO 6001
     IF(IY.GT.450.OR.IY.LT.50)GOTO 6001
     CALL MOVABS(IX,IY)
     READ(1,4)(ARRAY(I),I=1,8)
     IF(ARRAY(1).GE.TFINAL)GOTO 7000
     IF(ARRAY(1).LE.TSTART)GOTO 6001
     X=(ARRAY(ICHANX)-XMIN)*600./(XMAX-XMIN)
     Y=(ARRAY(ICHANY)-YMIN)*400./(YMAX-YMIN)
     IX=X-X0
     IY=Y-Y0
     X0=X
     Y0=Y
     CALL DRWREL(IX,IY)
6001 CONTINUE
     GOTO 6000
7000 CALL HOME
8000 TYPE 300
     ACCEPT 3,FLAG
     IF(FLAG.NE.1HY.AND.FLAG.NE.1HN)GOTO 8000
     CLOSE(UNIT=1,DISPOSE='SAVE')
     IF(FLAG.EQ.1HY)GOTO 999
   1 FORMAT(I1)
   2 FORMAT(F10.0)
   3 FORMAT(A1)
   4 FORMAT(1X,F9.0,7(1X,F9.3))
   5 FORMAT(/,5X,20A2)
  10 FORMAT(/,'$ INSERT DATA DISK & RETURN. ')
  20 FORMAT(/,'$ ICHANX(I1)  = ')
  30 FORMAT(/,'$ XMAX(F10.0) = ')
  40 FORMAT(/,'$ XMIN(F10.0) = ')
  50 FORMAT(/,'$ ICHANY(I1)  = ')
  60 FORMAT(/,'$ YMAX(F10.0) = ')
  70 FORMAT(/,'$ YMIN(F10.0) = ')
  80 FORMAT(/,'$ TSTART      = ')
  90 FORMAT(/,'$ TFINAL      = ')
 100 FORMAT(/,'$ CORRECTIONS(Y/N)? ')
 200 FORMAT(/,'$ DOTTED(A) OR CONTINUOUS(B) LINES? ')
 300 FORMAT(/,'$ MORE PLOTS(Y/N)? ')
     STOP
     END
```

Appendix 43.

Demonstration of TEK003 - plotting information in data file PLTDAT.DAT

```
.RUN TEK003
 INSERT DATA DISK & RETURN.
   CU(111)#4/5E-3PB/1M NACLO4/10MIN/NO DYE
ICHANX(I1)  = 1
XMAX(F10.0) = 30599.
XMIN(F10.0) = 59.
ICHANY(I1)  = 6
YMAX(F10.0) = 80.
YMIN(F10.0) = 50.
TSTART      = 59.
TFINAL      = 30599.
CORRECTIONS(Y/N)? N
```

Appendix 44.

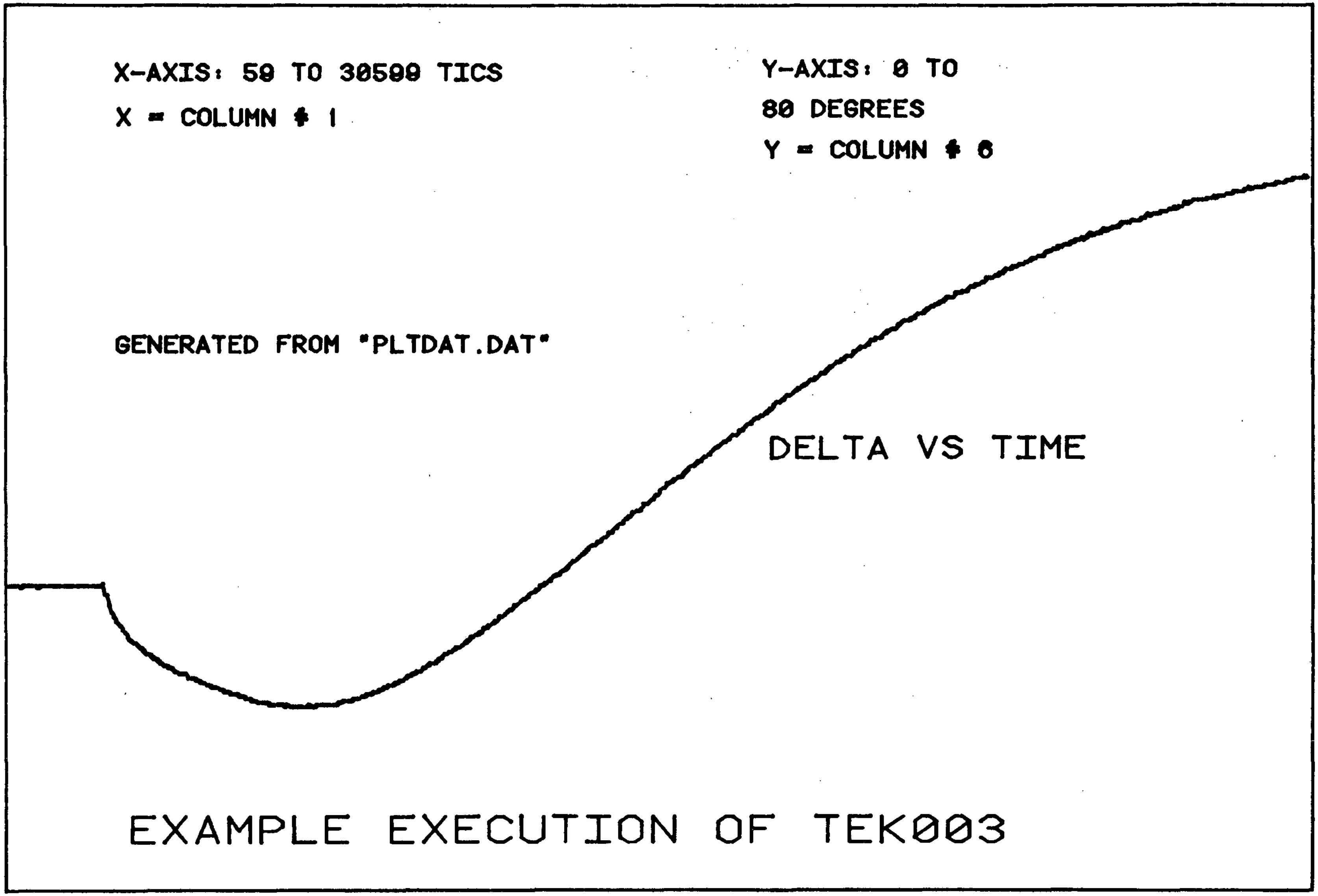
A Portion of the Input Data File PLTDAT.DAT

CU(111)#4/5E-3PB/1M NACLO4/10MIN/NO DYE

59.	104.814	52.063	-601.196	-202.433	60.372	37.937	0.000
119.	104.814	52.063	-600.586	-202.433	60.372	37.937	0.000
179.	104.814	52.063	-600.586	-201.416	60.372	37.937	0.000
239.	104.804	52.074	-600.586	-201.416	60.393	37.926	0.000
299.	104.825	52.063	-600.586	-201.416	60.351	37.937	0.000
359.	104.825	52.074	-600.586	-201.416	60.351	37.926	0.000
419.	104.835	52.074	-600.586	-201.416	60.330	37.926	0.000
479.	104.814	52.074	-599.976	-201.416	60.372	37.926	0.000
539.	104.814	52.053	-599.976	-201.416	60.372	37.947	0.000
599.	104.814	52.074	-599.976	-200.399	60.372	37.926	0.000
659.	104.825	52.063	-599.976	-200.399	60.351	37.937	0.000
719.	104.814	52.084	-599.976	-200.399	60.372	37.916	0.000
779.	104.825	52.063	-599.976	-201.416	60.351	37.937	0.000
839.	104.835	52.074	-599.976	-201.416	60.330	37.926	0.000
899.	104.804	52.053	-599.976	-200.399	60.393	37.947	0.000
959.	104.825	52.063	-599.976	-200.399	60.351	37.937	0.000
1019.	104.825	52.074	-599.976	-200.399	60.351	37.926	0.000
1079.	104.814	52.063	-599.976	-200.399	60.372	37.937	0.000

Definition of numeric values:

Column 1. time, tics (1/60 second units)
Column 2. polarizer azimuth, degrees
Column 3. analyzer azimuth, degrees
Column 4. cell potential, millivolts (with respect to reference electrode).
Column 5. cell current, microamps
Column 6. delta, degrees
Column 7. psi, degrees
Column 8. zeros, due only to length of format statement in TRNSLT


X-AXIS: 59 TO 30599 TICS
X = COLUMN # 1
Y-AXIS: 0 TO
80 DEGREES
Y = COLUMN # 6
GENERATED FROM "PLTDAT.DAT"
DELTA VS TIME
EXAMPLE EXECUTION OF TEK003

Appendix 46.

Directory of Model Optimization Programs Disk DY1:

```
 21-Nov-82
FILM01.FOR     6  27-May-81     AIFILM.FOR     3  30-May-81
PLOT  .FOR     5  28-Aug-81     CSFILM.FOR     3  28-Aug-81
FILM02.FOR     4  28-Aug-81     CSPLOT.FOR     5  28-Aug-81
EMA   .FOR     2  01-Aug-81     EMAFIT.FOR     6  01-Aug-81
EMATIM.FOR     5  27-Oct-81     MULTIF.FOR     5  01-Sep-82
FLMTST.FOR     2  01-Sep-82     REFIND.FOR     2  01-Sep-82
PROEMA.FOR    13  01-Sep-82     PROLIN.FOR    13  02-Sep-82
MODEL1.FOR    13  06-Sep-82     MODEL2.FOR    15  12-Sep-82
MODEL3.FOR    14  12-Sep-82     CSFIT .FOR     6  29-Sep-82
CSMTST.FOR     4  29-Sep-82     FILM  .FOR     3  14-Dec-81
GOGOGO.FOR    19  19-Nov-82     AIGOGO.FOR    11  12-Nov-82
WLGOGO.FOR    18  13-Nov-82     OHGOGO.FOR    15  19-Nov-82
EMATST.FOR     6  20-Nov-82     BRUGMN.FOR     6  20-Nov-82
 26 Files, 204 Blocks
 80 Free blocks
```

```
      PROGRAM SEARCH
      DIMENSION B(20),T(20),D(20),EN(20)
      COMMON Y,X(20)
      OPEN(UNIT=1,NAME='DY1:SEARCH.DAT',TYPE='OLD')
      READ(1,1)NVAR,NF,EF
      TYPE 1,NVAR,NF,EF
      READ(1,2)(B(I),I=1,NVAR)
      TYPE 3,(B(I),I=1,NVAR)
      READ(1,2)(D(I),I=1,NVAR)
      TYPE 4,(D(I),I=1,NVAR)
      NT=0
   50 CONTINUE
      DO 300 I=1,NVAR
      DO 100 J=1,NVAR
  100 X(J)=B(J)
      CALL ERROR
      E0=Y
      X(I)=B(I)-D(I)
      CALL ERROR
      E1=Y
      X(I)=B(I)+D(I)
      CALL ERROR
      E2=Y
      IF(E0.LT.E1.AND.E0.LT.E2)GOTO 200
      IF(E1.LT.E0.AND.E1.LT.E2)GOTO 201
      IF(E2.LT.E0.AND.E2.LT.E1)GOTO 202
  200 T(I)=B(I)
      EN(I)=E0
      GOTO 300
  201 T(I)=B(I)-D(I)
      EN(I)=E1
      GOTO 300
  202 T(I)=B(I)+D(I)
      EN(I)=E2
  300 CONTINUE
      DO 350 J=1,NVAR
      B(J)=T(J)
  350 X(J)=T(J)
      CALL ERROR
      ET=Y
      NT=NT+1
      IF(ET.GT.E0)GOTO 998
      IF(NT.EQ.NF)GOTO 999
      IF(ET.LE.EF)GOTO 1000
      GOTO 50
  998 TYPE 5
      GOTO 1000
  999 TYPE 6
 1000 TYPE 7,(X(I),I=1,NVAR)
      TYPE 8,ET
    1 FORMAT(5X,I5,5X,I5,1X,F9.3)
    2 FORMAT(3(1X,F9.3))
    3 FORMAT(/,' STARTING VALUES: ',3(1X,F9.3,';'))
    4 FORMAT(/,' INCREMENTS      : ',3(1X,F9.3,';'))
    5 FORMAT(/,' NO CONVERGENCE : ')
    6 FORMAT(/,' NOT FINISHED   : ')
    7 FORMAT(/,' FINAL VALUES   : ',3(1X,F9.3,';'))
    8 FORMAT(/,' FINAL ERROR    : ',1X,F9.3)
      STOP
      END
```

Objective subroutine optimized:

```
      SUBROUTINE ERROR
      COMMON Y,X(20)
      Y=1.+X(1)*X(2)*X(3)-X(1)*X(1)+X(2)*X(2)-15.*X(3)
      RETURN
      END
```

Appendix 48.

Listing of OHGOGO

```
      PROGRAM OHGOGO
      COMMON/SEARCH/Y,X(20),Y0(20)
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/THETA/THETA
      COMPLEX TN2,TN3,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      COMPLEX E,E1,E2,A,B,ROOT1,ROOT2
      DIMENSION B1(20),B0(20),D(20),EN(20),EN1(20)
      OPEN(UNIT=1,NAME='DY1:OHGOGO.DAT',TYPE='OLD')
 3000 TYPE 11
      ACCEPT 12,FLAG
      IF(FLAG.NE.1HY.AND.FLAG.NE.1HN)GOTO 3000
 2000 READ(1,1)NVAR,NERR,NF,EF,ALPHA
      IF(NVAR.EQ.999)STOP
      IF(FLAG.NE.1HY)GOTO 3001
      PRINT 1,NVAR,NERR,NF,EF,ALPHA
 3001 TYPE 1,NVAR,NERR,NF,EF,ALPHA
      READ(1,2)(Y0(I),I=1,NERR)
      READ(1,2)(B0(I),I=1,NVAR)
      IF(FLAG.NE.1HY)GOTO 3002
      PRINT 3,(B0(I),I=1,NVAR)
 3002 TYPE 3,(B0(I),I=1,NVAR)
      READ(1,2)(D(I),I=1,NVAR)
      IF(FLAG.NE.1HY)GOTO 3003
      PRINT 4,(D(I),I=1,NVAR)
 3003 TYPE 4,(D(I),I=1,NVAR)
      ET0=1.E09
      NT=0
   50 CONTINUE
      DO 300 I=1,NVAR
      E00=0.0
      E10=0.0
      E20=0.0
      IF(D(I).EQ.0.0)GOTO 200
      DO 100 J=1,NVAR
  100 X(J)=B0(J)
      CALL ERROR
      E00=Y
      X(I)=B0(I)-D(I)
      CALL ERROR
      E10=Y
      X(I)=B0(I)+D(I)
      CALL ERROR
      E20=Y
```

```
      IF(E00.LT.E10.AND.E00.LT.E20)GOTO 200
      IF(E10.LT.E00.AND.E10.LT.E20)GOTO 201
      IF(E20.LT.E00.AND.E20.LT.E10)GOTO 202
  200 B1(I)=B0(I)
      GOTO 300
  201 B1(I)=B0(I)-D(I)
      GOTO 300
  202 B1(I)=B0(I)+D(I)
  300 EN(I)=0.5*(E10+E20)-E00
      DO 350 J=1,NVAR
      B0(J)=B1(J)
  350 X(J)=B0(J)
      CALL ERROR
      ET=Y
      DO 357 I=1,NVAR
      IF(D(I).NE.0.0)GOTO 355
      EN(I)=0.000
      EN1(I)=0.000
      GOTO 357
  355 EN(I)=EN(I)/(D(I)*D(I))
      IF(EN(I).NE.0.0)GOTO 356
      EN1(I)=0.
      GOTO 357
  356 EN1(I)=ET/EN(I)
  357 CONTINUE
      NT=NT+1
      IF(ET.GT.ET0)GOTO 998
      IF(NT.EQ.NF)GOTO 999
      IF(ET.LE.EF)GOTO 1000
      DO 360 J=1,NVAR
  360 D(J)=ALPHA*D(J)
      ET0=ET
      GOTO 50
  998 TYPE 5
      IF(FLAG.NE.1HY)GOTO 3004
      PRINT 5
 3004 CONTINUE
      GOTO 1000
  999 TYPE 6
      IF(FLAG.NE.1HY)GOTO 3005
      PRINT 6
 3005 CONTINUE
```

```
1000 TYPE 7,(X(I),I=1,NVAR)
     TYPE 13,(EN(I),I=1,NVAR)
     TYPE 14,(EN1(I),I=1,NVAR)
     TYPE 8,ET
     TYPE 9,(Y0(I),I=1,NERR)
     TYPE 10,(Y0(I),I=1+NERR,NERR+NERR)
     IF(FLAG.NE.1HY)GOTO 3006
     PRINT 7,(X(I),I=1,NVAR)
     PRINT 13,(EN(I),I=1,NVAR)
     PRINT 14,(EN1(I),I=1,NVAR)
     PRINT 8,ET
     PRINT 9,(Y0(I),I=1,NERR)
     PRINT 10,(Y0(I),I=1+NERR,NERR+NERR)
3006 CONTINUE
   1 FORMAT(3(5X,I5),2(1X,F9.3))
   2 FORMAT(3(1X,F9.3))
   3 FORMAT(/,' STARTING VALUES: ',5(1X,F9.3,';'))
   4 FORMAT(/,' INCREMENTS      : ',5(1X,F9.3,';'))
   5 FORMAT(/,' NO CONVERGENCE : ')
   6 FORMAT(/,' NOT FINISHED    : ')
   7 FORMAT(/,' FINAL VALUES    : ',5(1X,F9.3,';'))
   8 FORMAT(/,' FINAL ERROR     : ',1X,F9.3)
   9 FORMAT(/,' MEASURED VALUES: ',5(1X,F9.3,';'))
  10 FORMAT(/,' CALCULATED      : ',5(1X,F9.3,';'))
  11 FORMAT(/,'$ PRINTER IN SYSTEM(Y/N)? ')
  12 FORMAT(A1)
  13 FORMAT(/,' VARIANCE COEF 1: ',5(1X,E9.2,';'))
  14 FORMAT(/,' VARIANCE COEF 2: ',5(1X,E9.2,';'))
     GOTO 2000
     STOP
     END
```

Appendix 48 (continued).

Objective subroutine optimized by OHGOGO

```
      SUBROUTINE ERROR
      COMMON/SEARCH/Y,X(20),Y0(20)
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/THETA/THETA
      COMPLEX TN2,TN3,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      COMPLEX E,E1,E2,A,B,ROOT1,ROOT2
      TNA=X(1)
      TNKA=X(2)
      TNF=X(3)
      TNKF=X(4)
      TNS=X(5)
      TNKS=X(6)
      WL=X(7)
      PHI1=X(8)
      T=X(9)
      IF(T.LE.0.0)GOTO 10
      CALL FILM
      CALL REFIND
   10 CONTINUE
      TNF=X(10)
      TNKF=X(11)
      T=X(12)
      THETA=X(13)
      DELM=Y0(1)
      PSIM=Y0(2)
      IF(T.LE.0.0)GOTO 20
      CALL EMA
      CALL FILM
   20 CONTINUE
      Y0(3)=DELC
      Y0(4)=PSIC
      Y=(DELC-DELM)**2+(PSIC-PSIM)**2
      Y=SQRT(Y)
      RETURN
      END
```

Appendix 48 (continued).

Input Data File OHGOGO.DAT

```
       13         2       200     0.001     0.975
   72.060    43.270
    1.340     0.000     1.270
    4.230     0.176     3.219
 5145.000    75.000     5.450
    2.000     3.000     0.000
    1.000     0.000     0.000
    0.000     0.000     0.005
    0.005     0.000     0.000
    0.000     0.000     0.010
    0.000     0.000     0.000
    0.000     0.000     0.000
      999       999       999     0.000     0.000
123456789/123456789/123456789/123456789/123456789/123456789/
```

Numeric values defined:

Line 1. total number of input parameters which can be optimized, number of terms involved in sum-of-squares calculation (delta and psi), maximum number of iterations, desired tolerance for optimization, contraction factor.
Line 2. measured value of delta, measured value of psi.
Line 3. n of incident medium, k of incident medium, n of film closest to substrate.
Line 4. k of film, n of substrate, k of substrate.
Line 5. wavelength, angle-of-incidence, thickness of film closest to substrate.
Line 6. n of second porous film, k of second film, thickness of second film.
Line 7. volume fraction of deposit in second film, value read but not used, value read but not used.
Line 8. increments (step size) of values listed in line 3 used in search.
Line 9. increments (step size) of values listed in line 4 used in search.
Line 10. increments (step size) of values listed in line 5 used in search.
Line 11. increments (step size) of values listed in line 6 used in search.
Line 12. increments (step size) of values listed in line 7 used in search.
Line 13. terminates reading of input data file (reading stops when 999 is read).

Notes:

If a value listed in lines 3 through 7 has its respective step size listed in lines 8 through 9 set to zero, this value is taken as a constant in the optimization; it is not optimizied and retains its starting (original) value.

Delta, psi, and the angle-of-incidence are given in degrees; thickness and wavelength are given in angstroms; and extinction coefficients (k) are entered as positive values.

This example is for optimization of a single compact film model (second film thickness set to zero and not varied).

Appendix 48 (continued).

OHGOGO output to line printer

```
     13         2       200     0.010     0.975

STARTING VALUES:      1.340;      0.000;      1.270;      4.230;      0.176;
     3.219;  5145.000;    75.000;     5.450;     2.000;
     3.000;     0.000;     1.000;

INCREMENTS     :      0.000;      0.000;      0.005;      0.005;      0.000;
     0.000;     0.000;     0.000;     0.010;     0.000;
     0.000;     0.000;     0.000;

FINAL VALUES   :      1.340;      0.000;      1.293;      4.267;      0.176;
     3.219;  5145.000;    75.000;     5.523;     2.000;
     3.000;     0.000;     1.000;

VARIANCE COEF 1:   0.00E+00;  0.00E+00;  0.85E+01;  0.39E+01;  0.00E+00;
  0.00E+00;  0.00E+00;  0.00E+00; -0.11E-02;  0.00E+00;
  0.00E+00;  0.00E+00;  0.00E+00;

VARIANCE COEF 2:   0.00E+00;  0.00E+00;  0.81E-03;  0.18E-02;  0.00E+00;
  0.00E+00;  0.00E+00;  0.00E+00; -0.62E+01;  0.00E+00;
  0.00E+00;  0.00E+00;  0.00E+00;

FINAL ERROR    :      0.007

MEASURED VALUES:     72.060;    43.270;

CALCULATED     :     72.054;    43.274;
```

Numeric values defined:

First line .... same as line 1 in OHGOGO.DAT

Starting values .... same input values in the same order as in lines 3 through 7 of OHGOGO.DAT.

Increments .... same initial step sizes in the same order as in lines 8 through 12 of OHGOGO.DAT.

Final values .... values of parameters after optimization listed in the same order as in lines 3 through 7 of OHGOGO.DAT.

Variance coef 1 .... numeric estimates of the partial derivative defined by equation 26 of chapter 5 for each optimized parameter.

Variance coef 2 .... numeric estimates of the variances defined by equation 23 of chapter 5 for each optimized parameter assuming df=1.

Final error .... sum-of-squares error after optimization of parameters in ellipsometer model .

Measured values .... measured values of delta and psi, respectively.

Calculated values .... calculated values of delta and psi, respectively; values predicted with optimized parameters.

Appendix 49.

Listing of GOGOGO

```
      PROGRAM GOGOGO
      COMMON/SEARCH/Y,X(20),Y0(20)
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/THETA/THETA
      COMPLEX TN2,TN3,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      COMPLEX E,E1,E2,A,B,ROOT1,ROOT2
      DIMENSION B1(20),B0(20),D(20),EN(20),EN1(20)
      OPEN(UNIT=1,NAME='DY1:GOGOGO.DAT',TYPE='OLD')
 3000 TYPE 11
      ACCEPT 12,FLAG
      IF(FLAG.NE.1HY.AND.FLAG.NE.1HN)GOTO 3000
 2000 READ(1,1)NVAR,NERR,NF,EF,ALPHA
      IF(NVAR.EQ.999)STOP
      IF(FLAG.NE.1HY)GOTO 3001
      PRINT 1,NVAR,NERR,NF,EF,ALPHA
 3001 TYPE 1,NVAR,NERR,NF,EF,ALPHA
      READ(1,2)(Y0(I),I=1,NERR)
      READ(1,2)(B0(I),I=1,NVAR)
      IF(FLAG.NE.1HY)GOTO 3002
      PRINT 3,(B0(I),I=1,NVAR)
 3002 TYPE 3,(B0(I),I=1,NVAR)
      READ(1,2)(D(I),I=1,NVAR)
      IF(FLAG.NE.1HY)GOTO 3003
      PRINT 4,(D(I),I=1,NVAR)
 3003 TYPE 4,(D(I),I=1,NVAR)
      NT=0
   50 CONTINUE
      DO 300 I=1,NVAR
      E00=0.0
      E10=0.0
      E20=0.0
      IF(D(I).EQ.0.0)GOTO 200
      DO 100 J=1,NVAR
  100 X(J)=B0(J)
      CALL ERROR
      E00=Y
      X(I)=B0(I)-D(I)
      CALL ERROR
      E10=Y
      X(I)=B0(I)+D(I)
      CALL ERROR
      E20=Y
```

```
      IF(E00.LT.E10.AND.E00.LT.E20)GOTO 200
      IF(E10.LT.E00.AND.E10.LT.E20)GOTO 201
      IF(E20.LT.E00.AND.E20.LT.E10)GOTO 202
  200 B1(I)=B0(I)
      GOTO 300
  201 B1(I)=B0(I)-D(I)
      GOTO 300
  202 B1(I)=B0(I)+D(I)
  300 EN(I)=0.5*(E10+E20)-E00
      DO 350 J=1,NVAR
      B0(J)=B1(J)
  350 X(J)=B0(J)
      CALL ERROR
      ET=Y
      DO 357 I=1,NVAR
      IF(D(I).NE.0.0)GOTO 355
      EN(I)=0.000
      EN1(I)=0.000
      GOTO 357
  355 EN(I)=EN(I)/(D(I)*D(I))
      IF(EN(I).NE.0.0)GOTO 356
      EN1(I)=0.
      GOTO 357
  356 EN1(I)=ET/EN(I)
  357 CONTINUE
      NT=NT+1
      IF(ET.GT.E00)GOTO 998
      IF(NT.EQ.NF)GOTO 999
      IF(ET.LE.EF)GOTO 1000
      DO 360 J=1,NVAR
  360 D(J)=ALPHA*D(J)
      GOTO 50
  998 TYPE 5
      IF(FLAG.NE.1HY)GOTO 3004
      PRINT 5
 3004 CONTINUE
      GOTO 1000
  999 TYPE 6
      IF(FLAG.NE.1HY)GOTO 3005
      PRINT 6
 3005 CONTINUE
```

```
1000 TYPE 7,(X(I),I=1,NVAR)
     TYPE 13,(EN(I),I=1,NVAR)
     TYPE 14,(EN1(I),I=1,NVAR)
     TYPE 8,ET
     TYPE 9,(Y0(I),I=1,NERR)
     TYPE 10,(Y0(I),I=1+NERR,NERR+NERR)
     IF(FLAG.NE.1HY)GOTO 3006
     PRINT 7,(X(I),I=1,NVAR)
     PRINT 13,(EN(I),I=1,NVAR)
     PRINT 14,(EN1(I),I=1,NVAR)
     PRINT 8,ET
     PRINT 9,(Y0(I),I=1,NERR)
     PRINT 10,(Y0(I),I=1+NERR,NERR+NERR)
3006 CONTINUE
   1 FORMAT(3(5X,I5),2(1X,F9.3))
   2 FORMAT(3(1X,F9.3))
   3 FORMAT(/,' STARTING VALUES: ',5(1X,F9.3,';'))
   4 FORMAT(/,' INCREMENTS      : ',5(1X,F9.3,';'))
   5 FORMAT(/,' NO CONVERGENCE : ')
   6 FORMAT(/,' NOT FINISHED   : ')
   7 FORMAT(/,' FINAL VALUES    : ',5(1X,F9.3,';'))
   8 FORMAT(/,' FINAL ERROR     : ',1X,F9.3)
   9 FORMAT(/,' MEASURED VALUES: ',5(1X,F9.3,';'))
  10 FORMAT(/,' CALCULATED      : ',5(1X,F9.3,';'))
  11 FORMAT(/,'$ PRINTER IN SYSTEM(Y/N)? ')
  12 FORMAT(A1)
  13 FORMAT(/,' VARIANCE COEF 1: ',5(1X,E9.2,';'))
  14 FORMAT(/,' VARIANCE COEF 2: ',5(1X,E9.2,';'))
     GOTO 2000
     STOP
     END
```

Objective subroutine optimized by GOGOGO

```
      SUBROUTINE ERROR
      COMMON/SEARCH/Y,X(20),Y0(20)
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/THETA/THETA
      COMPLEX TN2,TN3,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      COMPLEX E,E1,E2,A,B,ROOT1,ROOT2
      TNA=X(1)
      TNKA=0.
      TNF=X(2)
      TNKF=X(3)
      TNS=X(4)
      TNKS=X(5)
      WL=X(6)
      PHI1=X(7)
      T=X(8)
      CALL FILM
      CALL REFIND
      TNF=X(9)
      TNKF=X(10)
      T=X(11)
      THETA=X(12)
      IF(T.EQ.0.)GOTO 10
      CALL EMA
      CALL FILM
      CALL REFIND
      TNF=X(13)
      TNKF=X(14)
      T=X(15)
      THETA=X(16)
      IF(T.EQ.0.)GOTO 10
      CALL CSFILM
   10 CONTINUE
      DELM=Y0(1)
      PSIM=Y0(2)
      Y0(3)=DELC
      Y0(4)=PSIC
      Y=(DELC-DELM)**2+(PSIC-PSIM)**2
      Y=SQRT(Y)
      RETURN
      END
```

Appendix 49 (continued).

Modified version of FILM02 required by GOGOGO

```
SUBROUTINE CSFILM
COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
COMMON/THETA/THETA
COMPLEX TN2,TN3,CPHI2,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
COMPLEX RSX,RPX,RSY,RPY
TN1=TNA
TNF0=TNF
TNKF0=TNKF
PHI=0.01745329252*PHI1
CP=DCOS(PHI)
SP=DSIN(PHI)
TN3=CMPLX(TNS,-TNKS)
CPHI3=CSQRT(1.0-TN1**2*SP**2/(TN3**2))
TN2=CMPLX(TNF,-TNKF)
CPHI2=CSQRT(1.0-TN1**2*SP**2/(TN2**2))
R1S=(TN1*CP-TN2*CPHI2)/(TN1*CP+TN2*CPHI2)
R1P=-(TN1*CPHI2-TN2*CP)/(TN1*CPHI2+TN2*CP)
R2S=(TN2*CPHI2-TN3*CPHI3)/(TN2*CPHI2+TN3*CPHI3)
R2P=-(TN2*CPHI3-TN3*CPHI2)/(TN2*CPHI3+TN3*CPHI2)
Z=(0.0,1.0)*(4.0*3.1415927*T/WL)*TN2*CPHI2
RS=(R1S+R2S*CEXP(-Z))/(1.0+R1S*R2S*CEXP(-Z))
RP=(R1P+R2P*CEXP(-Z))/(1.0+R1P*R2P*CEXP(-Z))
RSX=THETA*RS
RPX=THETA*RP
TNF=TN1
TNKF=0.
TN2=CMPLX(TNF,-TNKF)
CPHI2=CSQRT(1.0-TN1**2*SP**2/(TN2**2))
R1S=(TN1*CP-TN2*CPHI2)/(TN1*CP+TN2*CPHI2)
R1P=-(TN1*CPHI2-TN2*CP)/(TN1*CPHI2+TN2*CP)
R2S=(TN2*CPHI2-TN3*CPHI3)/(TN2*CPHI2+TN3*CPHI3)
R2P=-(TN2*CPHI3-TN3*CPHI2)/(TN2*CPHI3+TN3*CPHI2)
Z=(0.0,1.0)*(4.0*3.1415927*T/WL)*TN2*CPHI2
RS=(R1S+R2S*CEXP(-Z))/(1.0+R1S*R2S*CEXP(-Z))
RP=(R1P+R2P*CEXP(-Z))/(1.0+R1P*R2P*CEXP(-Z))
RSY=(1.-THETA)*RS
RPY=(1.-THETA)*RP
RS=RSX+RSY
RP=RPX+RPY
TNF=TNF0
TNKF=TNKF0
RHO=RP/RS
PSIC=DATAN(CABS(RHO))/0.01745329252
DELC=DATAN2(AIMAG(RHO),REAL(RHO))/0.01745329252
RETURN
END
```

Input Data File GOGOGO.DAT

```
         17         2       100     0.050     1.00
     65.000    38.000
      1.340     0.000     1.293
      4.267     0.176     3.219
   5145.000    75.000     5.523
      2.000     3.000   300.000
      0.500     2.000     3.000
  10000.000     0.200     0.000
      0.000     0.000     0.000
      0.000     0.000     0.000
      0.000     0.000     0.000
      0.000     0.000     0.000
      0.000     0.000     0.000
    100.000     0.010     0.000
        999       999       999     0.000     0.000
123456789/123456789/123456789/123456789/123456789/123456789/123456789/
```

Numeric values defined:

Line 1. total number of input parameters which can be optimized, number of terms involved in sum-of-squares calculation (delta and psi), maximum number of iterations, desired tolerance for optimization, contraction factor.
Line 2. measured value of delta, measured value of psi
Line 3. n of incident medium, k of incident medium, n of film closest to substrate.
Line 4. k of film closest to substrate, n of substrate, k of substrate.
Line 5. wavelength, angle-of-incidence, thickness of film closest to substrate.
Line 6. n of second porous film, k of second porous film, thickness of second porous film.
Line 7. volume fraction of deposit in second film, n of islands, k of islands.
Line 8. thickness of islands, fraction of surface covered by islands, value read but not used
Line 9. increments (step sizes) of values listed in line 3 used in search.
Line 10. increments (step sizes) of values listed in line 4 used in search.
Line 11. increments (step sizes) of values listed in line 5 used in search.
Line 12. increments (step sizes) of values listed in line 6 used in search.
Line 13. increments (step sizes) of values listed in line 7 used in search.
Line 14. increments (step sizes) of values listed in line 8 used in search.
Line 15. terminates reading of data file (reading stops when 999 is read).

Notes:

If a value listed in lines 3 through 8 has its respective step size listed in lines 9 through 14 set to zer, this value is taken as a constant in the optimization; it is not optimizied and retains its starting (original) value.

Delta, psi, and the angle-of-incidence are given in degrees; thickness and wavelength are given in angstroms; and extinction coefficients (k) are entered as positive values.

Any film structure which can be simulated by OHGOGO can also be simulated by GOGOGO (by assuming island thickness to be zero); however, the converse is not true.

This example is for optimization of a layer of islands sitting on a two-layer film. The two layer film consists of a compact layer (5.523 angstroms thick) covered by a more porous layer (300 angstroms thick, 50% porosity). Parameters specific to these first two layers are not varied in this example.

Appendix 49 (continued).

GOGOGO output to line printer

```
       17          2        100      0.050      1.000

STARTING VALUES:        1.340;      0.000;      1.293;      4.267;      0.176;
    3.219;  5145.000;    75.000;      5.523;      2.000;
    3.000;   300.000;     0.500;      2.000;      3.000;
10000.000;     0.200;

INCREMENTS     :        0.000;      0.000;      0.000;      0.000;      0.000;
    0.000;     0.000;     0.000;      0.000;      0.000;
    0.000;     0.000;     0.000;      0.000;      0.000;
  100.000;     0.010;

NOT FINISHED   :

FINAL VALUES   :        1.340;      0.000;      1.293;      4.267;      0.176;
    3.219;  5145.000;    75.000;      5.523;      2.000;
    3.000;   300.000;     0.500;      2.000;      3.000;
 5400.000;     0.530;

VARIANCE COEF 1:   0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;
 0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;
 0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;
 0.51E-04;  0.30E+04;

VARIANCE COEF 2:   0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;
 0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;
 0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;
 0.33E+04;  0.57E-04;

FINAL ERROR    :        0.168

MEASURED VALUES:      65.000;     38.000;

CALCULATED     :      64.923;     38.149;
```

Numeric values defined:

First line .... same as line 1 in GOGOGO.DAT.

Starting values .... same input values in the same order as in lines 3 through 8 of GOGOGO.DAT.

Increments .... values of parameters after optimization listed in the same order as in lines 9 through 14 of GOGOGO.DAT.

Final values .... values of parameters after optimization listed in the same order as in lines 3 through 8 of GOGOGO.DAT.

Variance coef 1 .... numeric estimates of the partial derivative defined by equation 26 of chapter 5 for each optimized parameter.

Variance coef 2 .... numeric estimates of the variances defined by equation 23 of chapter 5 for each optimized parameter assuming df=1.

Final error .... sum-of-squares error after optimization of parameters in ellipsometer model.

Measured values .... measured values of delta and psi, respectively

Calculated values .... calculated values of delta and psi, respectively; values predicted with optimized parameters.

Appendix 50.

Listing of WLGOGO

```
      PROGRAM WLGOGO
      COMMON/SEARCH/Y,X(20),YO(20,40),NDAT
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/THETA/THETA
      COMPLEX TN2,TN3,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      COMPLEX E,E1,E2,A,B,ROOT1,ROOT2
      DIMENSION B1(20),BO(20),D(20),EN(20),EN1(20)
      OPEN(UNIT=1,NAME='DY1:WLGOGO.DAT',TYPE='OLD')
 3000 TYPE 11
      ACCEPT 12,FLAG
      IF(FLAG.NE.1HY.AND.FLAG.NE.1HN)GOTO 3000
 2000 READ(1,1)NVAR,NYO,NF,EF,ALPHA
      IF(NVAR.EQ.999)STOP
      IF(FLAG.NE.1HY)GOTO 3001
      PRINT 1,NVAR,NYO,NF,EF,ALPHA
 3001 TYPE 1,NVAR,NYO,NF,EF,ALPHA
      READ(1,2)(BO(I),I=1,NVAR)
      IF(FLAG.NE.1HY)GOTO 3002
      PRINT 3,(BO(I),I=1,NVAR)
 3002 TYPE 3,(BO(I),I=1,NVAR)
      READ(1,2)(D(I),I=1,NVAR)
      IF(FLAG.NE.1HY)GOTO 3003
      PRINT 4,(D(I),I=1,NVAR)
 3003 TYPE 4,(D(I),I=1,NVAR)
   30 READ(1,15)NDAT
      IF(NDAT.EQ.9999)GOTO 40
      READ(1,2)YO(1,NDAT),YO(2,NDAT),(YO(I,NDAT),I=5,NYO)
      IF(FLAG.NE.1HY)GOTO 3007
      PRINT 16,YO(1,NDAT),YO(2,NDAT),(YO(I,NDAT),I=5,NYO)
 3007 TYPE 16,YO(1,NDAT),YO(2,NDAT),(YO(I,NDAT),I=5,NYO)
      NDAT1=NDAT
      GOTO 30
   40 NDAT=NDAT1
      ETO=1.E09
      NT=0
   50 CONTINUE
      DO 300 I=1,NVAR
      E00=0.0
      E10=0.0
      E20=0.0
      IF(D(I).EQ.0.0)GOTO 200
      DO 100 J=1,NVAR
  100 X(J)=BO(J)
```

```
      CALL ERROR
      E00=Y
      X(I)=B0(I)-D(I)
      CALL ERROR
      E10=Y
      X(I)=B0(I)+D(I)
      CALL ERROR
      E20=Y
      IF(E00.LT.E10.AND.E00.LT.E20)GOTO 200
      IF(E10.LT.E00.AND.E10.LT.E20)GOTO 201
      IF(E20.LT.E00.AND.E20.LT.E10)GOTO 202
  200 B1(I)=B0(I)
      GOTO 300
  201 B1(I)=B0(I)-D(I)
      GOTO 300
  202 B1(I)=B0(I)+D(I)
  300 EN(I)=0.5*(E10+E20)-E00
      DO 350 J=1,NVAR
      B0(J)=B1(J)
  350 X(J)=B0(J)
      CALL ERROR
      ET=Y
      DO 357 I=1,NVAR
      IF(D(I).NE.0.0)GOTO 355
      EN(I)=0.000
      EN1(I)=0.000
      GOTO 357
  355 EN(I)=EN(I)/(D(I)*D(I))
      IF(EN(I).NE.0.0)GOTO 356
      EN1(I)=0.
      GOTO 357
  356 EN1(I)=ET/(EN(I)*(2.*NDAT-NVAR))
  357 CONTINUE
      NT=NT+1
      IF(ET.GT.ET0)GOTO 998
      IF(NT.EQ.NF)GOTO 999
      IF(ET.LE.EF)GOTO 1000
      DO 360 J=1,NVAR
  360 D(J)=ALPHA*D(J)
      ET0=ET
      GOTO 50
  998 TYPE 5
      IF(FLAG.NE.1HY)GOTO 3004
      PRINT 5
 3004 CONTINUE
      GOTO 1000
  999 TYPE 6
      IF(FLAG.NE.1HY)GOTO 3005
      PRINT 6
 3005 CONTINUE
```

```
1000 TYPE 7,(X(I),I=1,NVAR)
     TYPE 13,(EN(I),I=1,NVAR)
     TYPE 14,(EN1(I),I=1,NVAR)
     TYPE 8,ET
     DO 7000 J=1,NDAT
     TYPE 9,(YO(I,J),I=1,2)
7000 TYPE 10,(YO(I,J),I=3,4)
     IF(FLAG.NE.1HY)GOTO 3006
     PRINT 7,(X(I),I=1,NVAR)
     PRINT 13,(EN(I),I=1,NVAR)
     PRINT 14,(EN1(I),I=1,NVAR)
     PRINT 8,ET
     DO 7001 J=1,NDAT
     PRINT 9,(YO(I,J),I=1,2)
7001 PRINT 10,(YO(I,J),I=3,4)
3006 CONTINUE
   1 FORMAT(3(5X,I5),2(1X,F9.3))
   2 FORMAT(7(1X,F9.3))
   3 FORMAT(/,' STARTING VALUES: ',5(1X,F9.3,';'))
   4 FORMAT(/,' INCREMENTS      : ',5(1X,F9.3,';'))
   5 FORMAT(/,' NO CONVERGENCE : ')
   6 FORMAT(/,' NOT FINISHED    : ')
   7 FORMAT(/,' FINAL VALUES    : ',5(1X,F9.3,';'))
   8 FORMAT(/,' FINAL ERROR     : ',1X,F9.3)
   9 FORMAT(/,' MEASURED VALUES: ',5(1X,F9.3,';'))
  10 FORMAT(/,' CALCULATED      : ',5(1X,F9.3,';'))
  11 FORMAT(/,'$ PRINTER IN SYSTEM(Y/N)? ')
  12 FORMAT(A1)
  13 FORMAT(/,' VARIANCE COEF 1: ',5(1X,E9.2,';'))
  14 FORMAT(/,' VARIANCE COEF 2: ',5(1X,E9.2,';'))
  15 FORMAT(5X,I5)
  16 FORMAT(/,' KNOWN PARAMETERS:',5(1X,F9.3,';'))
     GOTO 2000
     STOP
     END
```

Objective subroutine optimized by WLGOGO

```
      SUBROUTINE ERROR
      COMMON/SEARCH/Y,X(20),Y0(20,40),NDAT
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/THETA/THETA
      COMPLEX TN2,TN3,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      COMPLEX E,E1,E2,A,B,ROOT1,ROOT2
      Y=0.
      DO 100 J=1,NDAT
      DELM=Y0(1,J)
      PSIM=Y0(2,J)
      TNA =Y0(5,J)
      TNKA=Y0(6,J)
      TNF =Y0(7,J)
      TNKF=Y0(8,J)
      TNS =Y0(9,J)
      TNKS=Y0(10,J)
      WL  =Y0(11,J)
      PHI1=Y0(12,J)
      T   =X(1)
      IF(T.EQ.0.0)GOTO 10
      CALL FILM
      CALL REFIND
   10 CONTINUE
      TNA  =Y0(13,J)
      TNKA =Y0(14,J)
      TNF  =Y0(15,J)
      TNKF =Y0(16,J)
      THETA=X(2)
      CALL EMA
      TNA  =Y0(5,J)
      TNKA =Y0(6,J)
      T    =X(3)
      IF(T.EQ.0.0)GOTO 20
      CALL FILM
      CALL REFIND
   20 CONTINUE
      TNF  =X(4)
      TNKF =X(5)
      THETA=X(6)
      T    =X(7)*10000.
      IF(T.EQ.0.0)GOTO 30
      CALL CSFILM
   30 CONTINUE
      Y0(3,J)=DELC
      Y0(4,J)=PSIC
      Y=Y+(DELM-DELC)**2+(PSIM-PSIC)**2
  100 CONTINUE
      Y=SQRT(Y)
      RETURN
      END
```

Input Data File WLGOGO.DAT

```
       7        16       100     5.000     1.000
  82.000     0.530   260.000     1.000     0.000     0.000     0.000
   0.500     0.005     1.000     0.100     0.100     0.000     0.000
       1
  58.690    32.990     1.352     0.000     2.811     4.438     0.645
   2.766  4248.000    75.000     1.352     0.000     2.811     4.438
       2
  50.070    31.730     1.344     0.000     2.490     3.588     0.612
   2.610  5586.000    75.000     1.344     0.000     2.490     3.588
       3
  53.450    38.110     1.335     0.000     1.644     3.377     0.100
   3.560  6991.000    75.000     1.335     0.000     1.644     3.377
       4
  52.730    30.990     1.347     0.000     2.466     3.707     0.880
   2.725  5155.000    75.000     1.347     0.000     2.466     3.707
       5
  49.970    33.580     1.341     0.000     2.447     3.480     0.190
   2.980  5998.000    75.000     1.341     0.000     2.447     3.480
       6
  51.030    34.470     1.340     0.000     2.373     3.409     0.133
   3.201  6242.000    75.000     1.340     0.000     2.373     3.409
       7
  51.850    35.350     1.338     0.000     2.228     3.357     0.098
   3.359  6504.000    75.000     1.338     0.000     2.228     3.357
       8
  52.870    36.390     1.337     0.000     2.049     3.351     0.050
   3.484  6748.000    75.000     1.337     0.000     2.049     3.351
       9
  57.240    31.120     1.351     0.000     2.225     4.152     0.845
   2.762  4492.000    75.000     1.351     0.000     2.225     4.152
      10
  55.480    30.880     1.349     0.000     2.391     3.920     0.912
   2.759  4756.000    75.000     1.349     0.000     2.391     3.920
    9999
```

Appendix 50 (continued).

Numeric values of WLGOGO.DAT defined

Line 1. total number of input parameters (wavelength independent) which can be optimized, number of terms involved in sum-of-squares calculation (delta and psi), maximum number of iterations, desired tolerance for optimization, contraction factor.

Line 2. wavelength independent model parameters which can be optimized
- a) thickness of first compact layer, angstroms.
- b) volume fraction of component #1 in second composite layer.
- c) thickness of second composite layer, angstroms.
- d) effective refractive index of islands.
- e) effective extinction coefficient of islands.
- f) effective surface coverage by islands.
- g) effective island thickness, microns.

Line 3. increments (step sizes) of values listed in line 2 used in search; listed in same order as corresponding parameter values in line 2.

Line 4. data point number

Line 5. measured delta, measured psi, incident medium refractive index, incident medium extinction coefficient, refractive index of film closest to substrate, extinction coefficient of film closest to substrate, refractive index of substrate.

Line 6. extinction coefficient of substrate, wavelength, angle-of-incidence, component #2 refractive index (second composite layer), component #2 extinction coefficient, component #1 refractive index, component #1 extinction coefficient.

Line 7. see line 4.

Line 8. see line 5.

Line 9. see line 6.

Line 34. reading of data file terminated when "999" values is read.

Notes:

Input values for 10 different data points, each corresponding to a different wavelength, are given in WLGOGO.DAT. More data points could have been included.

The refractive indices of the islands are assumed to be wavelength independent, which is a reasonable assumption if optical constants are linear and do not change appreciably over the spectral range of the measurements.

Appendix 50 (continued).

WLGOGO output to line printer

```
      7         16        100      5.000      1.000

STARTING VALUES:    82.000;     0.530;   260.000;     1.000;     0.000;
    0.000;     0.000;

INCREMENTS      :    0.500;     0.005;     1.000;     0.100;     0.100;
    0.000;     0.000;

KNOWN PARAMETERS:   58.690;    32.990;     1.352;     0.000;     2.811;
    4.438;     0.645;     2.766;  4248.000;    75.000;
    1.352;     0.000;     2.811;     4.438;

KNOWN PARAMETERS:   50.070;    31.730;     1.344;     0.000;     2.490;
    3.588;     0.612;     2.610;  5586.000;    75.000;
    1.344;     0.000;     2.490;     3.588;

KNOWN PARAMETERS:   53.450;    38.110;     1.335;     0.000;     1.644;
    3.377;     0.100;     3.560;  6991.000;    75.000;
    1.335;     0.000;     1.644;     3.377;

KNOWN PARAMETERS:   52.730;    30.990;     1.347;     0.000;     2.466;
    3.707;     0.880;     2.725;  5155.000;    75.000;
    1.347;     0.000;     2.466;     3.707;

KNOWN PARAMETERS:   49.970;    33.580;     1.341;     0.000;     2.447;
    3.480;     0.190;     2.980;  5998.000;    75.000;
    1.341;     0.000;     2.447;     3.480;

KNOWN PARAMETERS:   51.030;    34.470;     1.340;     0.000;     2.373;
    3.409;     0.133;     3.201;  6242.000;    75.000;
    1.340;     0.000;     2.373;     3.409;

KNOWN PARAMETERS:   51.850;    35.350;     1.338;     0.000;     2.228;
    3.357;     0.098;     3.359;  6504.000;    75.000;
    1.338;     0.000;     2.228;     3.357;

KNOWN PARAMETERS:   52.870;    36.390;     1.337;     0.000;     2.049;
    3.351;     0.050;     3.484;  6748.000;    75.000;
    1.337;     0.000;     2.049;     3.351;

KNOWN PARAMETERS:   57.240;    31.120;     1.351;     0.000;     2.225;
    4.152;     0.845;     2.762;  4492.000;    75.000;
    1.351;     0.000;     2.225;     4.152;

KNOWN PARAMETERS:   55.480;    30.880;     1.349;     0.000;     2.391;
    3.920;     0.912;     2.759;  4756.000;    75.000;
    1.349;     0.000;     2.391;     3.920;
```

```
NOT FINISHED   :

FINAL VALUES   :    71.000;     0.540;   256.000;     1.000;     0.000;
    0.000;     0.000;

VARIANCE COEF 1:   0.12E-02;  0.38E+04;  0.13E-02;  0.00E+00;  0.00E+00;
  0.00E+00;  0.00E+00;

VARIANCE COEF 2:   0.33E+03;  0.10E-03;  0.32E+03;  0.00E+00;  0.00E+00;
  0.00E+00;  0.00E+00;

 FINAL ERROR    :      5.235

 MEASURED VALUES:     58.690;    32.990; ...........delta and psi,
                                                    respectively
 CALCULATED     :     58.637;    29.783;

 MEASURED VALUES:     50.070;    31.730;

 CALCULATED     :     50.733;    31.327;

 MEASURED VALUES:     53.450;    38.110;

 CALCULATED     :     55.139;    36.288;

 MEASURED VALUES:     52.730;    30.990;

 CALCULATED     :     52.391;    31.098;

 MEASURED VALUES:     49.970;    33.580;

 CALCULATED     :     50.455;    32.889;

 MEASURED VALUES:     51.030;    34.470;

 CALCULATED     :     51.215;    33.701;

 MEASURED VALUES:     51.850;    35.350;

 CALCULATED     :     52.322;    34.545;

 MEASURED VALUES:     52.870;    36.390;

 CALCULATED     :     53.607;    35.308;

 MEASURED VALUES:     57.240;    31.120;

 CALCULATED     :     55.464;    32.003;

 MEASURED VALUES:     55.480;    30.880;

 CALCULATED     :     54.003;    31.304;
```

Numeric values in WLGOGO output defined

First line	same as line 1 of WLGOGO.DAT
Starting values	same as line 2 of WLGOGO.DAT
Increments	same as line 3 of WLGOGO.DAT
Known parameters	same as lines 5 and 6 of WLGOGO.DAT, etc.
Final values	optimized model parameters corresponding to the starting values given in line 2 of WLGOGO.DAT; listed in the same order.
Variance coef 1	numeric estimates of the partial derivative defined by equation 26 of chapter 5 for each model parameter; a measure of the model sensitivity to each parameter; larger values are indicative of greater sensitivity.
Variance coef 2	numeric estimates of the variances of model parameters (the number of degrees-of-freedom is determined by the number of wavelength independent adjustable parameters and the total number of data points); these values can be used directly (with corresponding value of t-statistic) to estimate the confidence intervals of model parameters.
Final error	total sum-of-squares error between model predictions and measured values of delta and psi for all data points read.
Measured values	measured values of delta and psi, respectively.
Calculated values	calculated values of delta and psi, respectively; based upon optimized values of model parameters.

Appendix 51.

Listing of AIGOGO

```
      PROGRAM AIGOGO
      COMMON/AIMOD1/N0,N1ER,N1EI,N1OR,N1OI,N2R,N2I,WL,PHI,T,PSI,DEL
      COMMON/AIMOD2/R01PP,R12PP,R01SS,R12SS,RPP,RSS,RHO,N2,N1E,N1O
      COMPLEX SPHI2,CPHI2,EX0,EX2,OR0,OR2,BETAP,BETAS
      COMPLEX R01PP,R12PP,R01SS,R12SS,RPP,RSS,RHO,N2,N1E,N1O
      REAL N0,N2R,N2I,N1ER,N1EI,N1OR,N1OI
      COMMON/SEARCH/Y,X(20),Y0(20)
      DIMENSION B1(20),B0(20),D(20),EN(20),EN1(20)
      OPEN(UNIT=1,NAME='DY1:AIGOGO.DAT',TYPE='OLD')
 3000 TYPE 11
      ACCEPT 12,FLAG
      IF(FLAG.NE.1HY.AND.FLAG.NE.1HN)GOTO 3000
 2000 READ(1,1)NVAR,NERR,NF,EF,ALPHA
      IF(NVAR.EQ.999)STOP
      IF(FLAG.NE.1HY)GOTO 3001
      PRINT 1,NVAR,NERR,NF,EF,ALPHA
 3001 TYPE 1,NVAR,NERR,NF,EF,ALPHA
      READ(1,2)(Y0(I),I=1,NERR)
      READ(1,2)(B0(I),I=1,NVAR)
      IF(FLAG.NE.1HY)GOTO 3002
      PRINT 3,(B0(I),I=1,NVAR)
 3002 TYPE 3,(B0(I),I=1,NVAR)
      READ(1,2)(D(I),I=1,NVAR)
      IF(FLAG.NE.1HY)GOTO 3003
      PRINT 4,(D(I),I=1,NVAR)
 3003 TYPE 4,(D(I),I=1,NVAR)
      NT=0
   50 CONTINUE
      DO 300 I=1,NVAR
      E00=0.0
      E10=0.0
      E20=0.0
      IF(D(I).EQ.0.0)GOTO 200
      DO 100 J=1,NVAR
  100 X(J)=B0(J)
      CALL ERROR
      E00=Y
      X(I)=B0(I)-D(I)
      CALL ERROR
      E10=Y
      X(I)=B0(I)+D(I)
      CALL ERROR
      E20=Y
```

Variation:

```
      ET0=1.E09
      NT=0
   50 CONTINUE
```

```
      IF(E00.LT.E10.AND.E00.LT.E20)GOTO 200
      IF(E10.LT.E00.AND.E10.LT.E20)GOTO 201
      IF(E20.LT.E00.AND.E20.LT.E10)GOTO 202
  200 B1(I)=B0(I)
      GOTO 300
  201 B1(I)=B0(I)-D(I)
      GOTO 300
  202 B1(I)=B0(I)+D(I)
  300 EN(I)=0.5*(E10+E20)-E00
      DO 350 J=1,NVAR
      B0(J)=B1(J)
  350 X(J)=B0(J)
      CALL ERROR
      ET=Y
      DO 357 I=1,NVAR
      IF(D(I).NE.0.0)GOTO 355
      EN(I)=0.000
      EN1(I)=0.000
      GOTO 357
  355 EN(I)=EN(I)/(D(I)*D(I))
      IF(EN(I).NE.0.0)GOTO 356
      EN1(I)=0.
      GOTO 357
  356 EN1(I)=ET/EN(I)
  357 CONTINUE
      NT=NT+1
      IF(ET.GT.E00)GOTO 998
      IF(NT.EQ.NF)GOTO 999
      IF(ET.LE.EF)GOTO 1000
      DO 360 J=1,NVAR
  360 D(J)=ALFHA*D(J)
      GOTO 50
  998 TYPE 5
      IF(FLAG.NE.1HY)GOTO 3004
      PRINT 5
 3004 CONTINUE
      GOTO 1000
  999 TYPE 6
      IF(FLAG.NE.1HY)GOTO 3005
      PRINT 6
 3005 CONTINUE
```

```
1000 TYPE 7,(X(I),I=1,NVAR)
     TYPE 13,(EN(I),I=1,NVAR)
     TYPE 14,(EN1(I),I=1,NVAR)
     TYPE 8,ET
     TYPE 9,(Y0(I),I=1,NERR)
     TYPE 10,(Y0(I),I=1+NERR,NERR+NERR)
     IF(FLAG.NE.1HY)GOTO 3006
     PRINT 7,(X(I),I=1,NVAR)
     PRINT 13,(EN(I),I=1,NVAR)
     PRINT 14,(EN1(I),I=1,NVAR)
     PRINT 8,ET
     PRINT 9,(Y0(I),I=1,NERR)
     PRINT 10,(Y0(I),I=1+NERR,NERR+NERR)
3006 CONTINUE
   1 FORMAT(3(5X,I5),2(1X,F9.3))
   2 FORMAT(3(1X,F9.3))
   3 FORMAT(/,' STARTING VALUES: ',5(1X,F9.3,';'))
   4 FORMAT(/,' INCREMENTS      : ',5(1X,F9.3,';'))
   5 FORMAT(/,' NO CONVERGENCE : ')
   6 FORMAT(/,' NOT FINISHED   : ')
   7 FORMAT(/,' FINAL VALUES   : ',5(1X,F9.3,';'))
   8 FORMAT(/,' FINAL ERROR    : ',1X,F9.3)
   9 FORMAT(/,' MEASURED VALUES: ',5(1X,F9.3,';'))
  10 FORMAT(/,' CALCULATED     : ',5(1X,F9.3,';'))
  11 FORMAT(/,'$ PRINTER IN SYSTEM(Y/N)? ')
  12 FORMAT(A1)
  13 FORMAT(/,' VARIANCE COEF 1: ',5(1X,E9.2,';'))
  14 FORMAT(/,' VARIANCE COEF 2: ',5(1X,E9.2,';'))
     GOTO 2000
     STOP
     END
```

Objective subroutine optimized by AIGOGO

```
SUBROUTINE ERROR
COMMON/SEARCH/Y,X(20),YO(20)
COMMON/AIMOD1/NO,N1ER,N1EI,N1OR,N1OI,N2R,N2I,WL,PHI,T,PSI,DEL
COMMON/AIMOD2/R01PP,R12PP,R01SS,R12SS,RPP,RSS,RHO,N2,N1E,N1O
COMPLEX SPHI2,CPHI2,EX0,EX2,OR0,OR2,BETAP,BETAS
COMPLEX R01PP,R12PP,R01SS,R12SS,RPP,RSS,RHO,N2,N1E,N1O
REAL NO,N2R,N2I,N1ER,N1EI,N1OR,N1OI
NO=X(1)
N1ER=X(2)
N1EI=X(3)
N1OR=X(4)
N1OI=X(5)
N2R=X(6)
N2I=X(7)
WL=X(8)
PHI=X(9)
T=0.
CALL AIFILM
DELO=DEL
PSIO=PSI
T=X(10)
CALL AIFILM
DELM=YO(1)
PSIM=YO(2)
DELC=DEL-DELO
PSIC=PSI-PSIO
YO(3)=DELC
YO(4)=PSIC
Y=(DELC-DELM)**2+(PSIC-PSIM)**2
Y=SQRT(Y)
RETURN
END
```

Appendix 51 (continued).

Input Data File AIGOGO.DAT

```
      10         2       100     0.100     1.000
   1.580    -3.550
   1.340     2.000     2.000
   2.000     2.000     0.830
   2.780  4460.000    75.000
  25.000     0.000     0.000
   0.000     0.010     0.020
   0.010     0.020     0.000
   0.000     0.000     0.000
   0.250     0.000     0.000
      10         2       100     0.100     1.000
   1.520    -3.370
   1.340     2.000     2.000
   2.000     2.000     0.830
   2.780  4460.000    75.000
  25.000     0.000     0.000
   0.000     0.010     0.020
   0.010     0.020     0.000
   0.000     0.000     0.000
   0.250     0.000     0.000
```

Numeric values defined:

Line 1. total number of input parameters which can be optimized, number of terms involved in sum-of-squares calculation (delta and psi), maximum number of iterations, desired tolerance for optimization, contraction factor.
Line 2. delta and psi, respectively; given as "differences" from initial measured values.
Line 3. incident medium refractive index, extrodinary refractive index of film, extrodinary extinction coefficient of film.
Line 4. ordinary refractive index of film, ordinary extinction coefficient of film, substrate refractive index.
Line 5. extinction coefficient of substrate, wavelength, angle-of-incidence.
Line 6. thickness of film, value read but not used, value read but not used.
Line 7. increments (step sizes) of parameters listed in line 3 used in search.
Line 8. increments of parameters listed in line 4.
Line 9. increments of parameters listed in line 5.
Line 10. increments of parameters listed in line 6.

Notes:

Two sets of data for optimization are given, lines 1 through 10 and lines 11 through 20, respectively. Reading of data file terminated by "999" value.

Appendix 51 (continued).

Numeric values in AIGOGO output defined

First line	same as line 1 in AIGOGO.DAT.
Starting values	same input values in the same order as in lines 3 through 6 of AIGOGO.DAT.
Increments	same initial step sizes in the same order as in lines 7 through 10 of AIGOGO.DAT.
Final values	values of parameters after optimization listed in the same order as in lines 3 through 6 of AIGOGO.DAT.
Variance coef 1	numeric estimates of the partial derivative defined by equation 26 of chapter 5 for each optimized parameter.
Variance coef 2	numeric estimates of the variances defined by equation 23 of chapter 5 for each optimized parameter assuming df=1.
Final error	sum-of-squares error after optimization of parameters in ellipsometer model.
Measured values	measured values of delta and psi, respectively.
Calculated values	calculated values of delta and psi, respectively; values predicted with optimized parameters.

Notes:

This program was written to interpret second order optical effects (birefringent monolayer) and uses "differences" in delta and psi, instead of absolute values.

Appendix 51 (continued).

AIGOGO output to line printer

```
      10          2        100      0.100      1.000

STARTING VALUES:       1.340;     2.000;     2.000;     2.000;     2.000;
    0.830;     2.780;  4460.000;    75.000;    25.000;

INCREMENTS     :       0.000;     0.010;     0.020;     0.010;     0.020;
    0.000;     0.000;     0.000;     0.000;     0.250;

FINAL VALUES   :       1.340;     2.140;     1.180;     2.070;     2.840;
    0.830;     2.780;  4460.000;    75.000;    33.750;

VARIANCE COEF 1:    0.00E+00;  0.62E+00;  0.66E+01;  0.76E+01;  0.10E+03;
 0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;  0.35E-01;

VARIANCE COEF 2:    0.00E+00;  0.89E-01;  0.83E-02;  0.72E-02;  0.53E-03;
 0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;  0.16E+01;

FINAL ERROR    :       0.055

MEASURED VALUES:       1.580;    -3.550;

CALCULATED     :       1.603;    -3.500;
      10          2        100      0.100      1.000

STARTING VALUES:       1.340;     2.000;     2.000;     2.000;     2.000;
    0.830;     2.780;  4460.000;    75.000;    25.000;

INCREMENTS     :       0.000;     0.010;     0.020;     0.010;     0.020;
    0.000;     0.000;     0.000;     0.000;     0.250;

FINAL VALUES   :       1.340;     2.170;     1.180;     2.040;     2.820;
    0.830;     2.780;  4460.000;    75.000;    32.750;

VARIANCE COEF 1:    0.00E+00;  0.81E+00;  0.55E+01;  0.11E+02;  0.91E+02;
 0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;  0.25E-01;

VARIANCE COEF 2:    0.00E+00;  0.82E-01;  0.12E-01;  0.60E-02;  0.73E-03;
 0.00E+00;  0.00E+00;  0.00E+00;  0.00E+00;  0.27E+01;

FINAL ERROR    :       0.066

MEASURED VALUES:       1.520;    -3.370;

CALCULATED     :       1.532;    -3.305;
```

Appendix 52.

Listing of FLMTST

```
      PROGRAM FLMTST
      COMMON/FLMDAT/TN1,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMPLEX TN2,TN3,CPHI2,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      TYPE 1
    1 FORMAT(/,'$ TN1 = ')
      ACCEPT 10,TN1
      TYPE 2
    2 FORMAT(/,'$ TNF = ')
      ACCEPT 10,TNF
      TYPE 3
    3 FORMAT(/,'$ TNKF= ')
      ACCEPT 10,TNKF
      TYPE 4
    4 FORMAT(/,'$ TNS = ')
      ACCEPT 10,TNS
      TYPE 5
    5 FORMAT(/,'$ TNKS= ')
      ACCEPT 10,TNKS
      TYPE 6
    6 FORMAT(/,'$ WL  = ')
      ACCEPT 10,WL
      TYPE 7
    7 FORMAT(/,'$ PHI1= ')
      ACCEPT 10,PHI1
  100 TYPE 8
    8 FORMAT(/,'$ T   = ')
      ACCEPT 10,T
      CALL FILM
      TYPE 9,DELC,PSIC
    9 FORMAT(/,1X,'DELTA = ',F10.4,10X,'PSI = ',F10.4)
   10 FORMAT(F10.4)
      GOTO 100
      STOP
      END
```

Appendix 52 (continued).

Demonstration of FLMTST

```
TNI = 1.    ....... incident medium refractive index
TNF = 1.38  ...... film refractive index
TNKF= 0.    ........ film extinction coefficient
TNS = 0.93  ...... substrate refractive index
TNKS= 2.39  ...... substrate extinction coefficient
WL  = 5461. ..... wavelength, angstroms
PHI1= 75.   ...... angle-of-incidence, degrees
T   = 400.  ...... film thickness, angstroms
DELTA =    55.7827          PSI =    41.1170
T   = 200.  ...... another film thickness, angstroms
DELTA =    61.1009          PSI =    38.8784
T   = 100.  ...... etc.
```

Appendix 53.

Listing of EMATST

```
      PROGRAM EMATST
      COMMON/FLMDAT/TNA,TNKA,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/THETA/THETA
    1 TYPE 2
    2 FORMAT(/,'$ IS THERE A PRINTER IN THE SYSTEM(Y/N)? ')
      ACCEPT 3,FLAG
    3 FORMAT(A1)
      IF(FLAG.NE.1HY.AND.FLAG.NE.1HN)GOTO 1
    4 TYPE 5
    5 FORMAT(/,'$ ARE DELTA AND PSI TO BE COMPUTED(Y/N)? ')
      ACCEPT 3,FLAG1
      IF(FLAG1.NE.1HY.AND.FLAG1.NE.1HN)GOTO 4
      TYPE 10
   10 FORMAT(/,'$ N2 = ')
      ACCEPT 100,TNA0
      TYPE 15
   15 FORMAT(/,'$ K2 = ')
      ACCEPT 100,TNKA0
      TYPE 20
   20 FORMAT(/,'$ N1 = ')
      ACCEPT 100,TNF0
      TYPE 30
   30 FORMAT(/,'$ K1 = ')
      ACCEPT 100,TNKF0
      TYPE 40
   40 FORMAT(/,'$ X1 = ')
      ACCEPT 100,THETA
      TNA=TNA0
      TNKA=TNKA0
      TNF=TNF0
      TNKF=TNKF0
      CALL EMA
      TYPE 200,TNF0,TNKF0
      TYPE 205,TNA0,TNKA0
      TYPE 210,TNF,TNKF,THETA
      IF(FLAG.NE.1HY)GOTO 45
      PRINT 200,TNF0,TNKF0
      PRINT 205,TNA0,TNKA0
      PRINT 210,TNF,TNKF,THETA
   45 CONTINUE
```

```
      IF(FLAG1.NE.1HY)STOP
      TYPE 50
   50 FORMAT(/,'$ NA = ')
      ACCEPT 100,TNA1
      TYPE 55
   55 FORMAT(/,'$ NS = ')
      ACCEPT 100,TNS
      TYPE 60
   60 FORMAT(/,'$ KS = ')
      ACCEPT 100,TNKS
      TYPE 65
   65 FORMAT(/,'$ WL = ')
      ACCEPT 100,WL
      TYPE 70
   70 FORMAT(/,'$ PHI= ')
      ACCEPT 100,PHI1
      TYPE 75
   75 FORMAT(/,'$ T    = ')
      ACCEPT 100,T
      TNA=TNA1
      TNKA=0.
      CALL FILM
      TYPE 215,TNS,TNKS,TNA
      TYPE 220,WL,PHI1
      TYPE 225,T,DELC,PSIC
      IF(FLAG.NE.1HY)GOTO 80
      PRINT 215,TNS,TNKS,TNA
      PRINT 220,WL,PHI1
      PRINT 225,T,DELC,PSIC
   80 CONTINUE
    6 TYPE 7
    7 FORMAT(/,'$ ARE MULTIPLE CALCULATIONS TO BE DONE(Y/N)? ')
      ACCEPT 3,FLAG2
      IF(FLAG2.NE.1HY.AND.FLAG2.NE.1HN)GOTO 6
      IF(FLAG2.NE.1HY)STOP
      IF(FLAG.NE.1HY)GOTO 85
      PRINT 230
   85 CONTINUE
   90 TYPE 40
      ACCEPT 100,THETA
      TYPE 75
      ACCEPT 100,T
```

```
      TNF=TNF0
      TNKF=TNKF0
      TNA=TNA0
      TNKA=TNKA0
      CALL EMA
      TNA=TNA1
      TNKA=0.
      CALL FILM
      TYPE 230
      TYPE 235,T,THETA,TNF,TNKF,DELC,PSIC
      IF(FLAG.NE.1HY)GOTO 95
      PRINT 235,T,THETA,TNF,TNKF,DELC,PSIC
   95 CONTINUE
      GOTO 90
  100 FORMAT(F10.4)
  200 FORMAT(/,' N1 = ',F6.3,' - ',F6.3,'I')
  205 FORMAT(/,' N2 = ',F6.3,' - ',F6.3,'I')
  210 FORMAT(/,' N  = ',F6.3,' - ',F6.3,'I',5X,'X1 = ',F6.3)
  215 FORMAT(/,' NS = ',F6.3,' - ',F6.3,'I',5X,'NA = ',F6.3)
  220 FORMAT(/,' WL = ',F10.0,5X,'PHI  = ',F10.4)
  225 FORMAT(/,' T  = ',F10.0,5X,'DELC = ',F10.4,5X,'PSIC = ',F10.4)
  230 FORMAT(/,5X,'T',9X,'X1',8X'NF',8X,'KF',5X,'DELTA',5X,'PSI')
  235 FORMAT(/,7(1X,F9.3))
      RETURN
      END
```

Appendix 53 (continued).

EMATST output to line printer

```
N1 =  1.301 -  4.271I

N2 =  1.340 -  0.000I

N  =  1.340 -  0.000I      X1 =  0.000

NS =  0.176 -  3.219I      NA =  1.340

WL =      5145.     PHI  =    75.0000

T  =          6.    DELC =    71.4059     PSIC =    43.7224
```

T	X1	NF	KF	DELTA	PSI
5.532	0.250	1.824	0.831	70.653	43.464
5.532	0.410	1.617	1.442	70.611	43.385
5.532	0.860	1.185	3.718	71.668	43.360
5.532	1.000	1.301	4.271	72.057	43.270
5.532	0.500	1.423	1.794	70.660	43.394
5.532	0.100	1.677	0.151	70.959	43.664
5.532	0.200	1.841	0.616	70.704	43.517
5.532	0.300	1.780	1.030	70.624	43.426
5.532	0.400	1.636	1.405	70.610	43.387
5.532	0.600	1.169	2.297	70.838	43.440
5.532	0.700	1.083	2.922	71.172	43.443
5.532	0.800	1.138	3.447	71.491	43.396
5.532	0.900	1.218	3.886	71.782	43.335

Definition of numeric values:

N1 ...... complex refractive index of film component #1.
N2 ...... complex rerractive index of film component #2.
N ...... apparent complex refractive index of composite film at X1.
X1 ...... volume fraction of component #1 in film.
NS ...... complex refractive index of substrate.
WL ...... wavelength
PHI ..... angle-of-incidence

T .... thickness of composite film, angstroms
DELC .... calculated values of delta, also given as DELTA
PSIC .... calculated values of psi, also given as PSI
NF ...... real part of the composite film complex refractive index calculated from N1, N2, and X1.
KF ...... imaginary part of the composite film complex refractive index calculated from N1, N2, and X1.

Notes:

This example is taken from the work discussed in chapter 5 regarding the Bruggeman model of the Pb underpotential monolayer on Ag(111).

Optical properties of the underpotential layer were estimated at full coverage by OHGOGO; the substrate refractive index was measured at zero coverage.

Appendix 54.

Listing of CSFIT

```
      PROGRAM CSFIT
      COMMON/FLMDAT/TN1,TNF,TNKF,TNS,TNKS,WL,PHI1,T,DELC,PSIC
      COMMON/THETA/THETA
      COMPLEX TN2,TN3,CPHI2,CPHI3,R1S,R1P,R2S,R2P,Z,RS,RP,RHO
      COMPLEX RSX,RPX,RSY,RPY
   97 FORMAT(I3)
   98 FORMAT(A1)
   99 FORMAT(F10.4)
      TYPE 1
    1 FORMAT(/,'$ PHI = ')
      ACCEPT 99,PHI1
      TYPE 2
    2 FORMAT(/,'$ WL  = ')
      ACCEPT 99,WL
      TYPE 10
   10 FORMAT(/,'$ NO = ')
      ACCEPT 99,TN1
      TYPE 20
   20 FORMAT(/,'$ NF = ')
      ACCEPT 99,TNF
      TYPE 25
   25 FORMAT(/,'$ KF = ')
      ACCEPT 99,TNKF
      TYPE 30
   30 FORMAT(/,'$ NS = ')
      ACCEPT 99,TNS
      TYPE 35
   35 FORMAT(/,'$ KS = ')
      ACCEPT 99,TNKS
  100 CONTINUE
      TYPE 40
   40 FORMAT(/,'$ DELM = ')
      ACCEPT 99,DELM
      TYPE 45
   45 FORMAT(/,'$ PSIM = ')
      ACCEPT 99,PSIM
      TYPE 50
   50 FORMAT(/,'$ THICKNESS = ')
      ACCEPT 99,T
      TYPE 55
   55 FORMAT(/,'$ THETA     = ')
      ACCEPT 99,THETA
      CALL FILM02
      ERROR=SQRT((DELM-DELC)**2+(PSIM-PSIC)**2)
```

```
      PRINT 250,PHI1,WL,TN1,TNF,TNKF,TNS,TNKS,DELM,DELC,PSIM,PSIC
     C,ERROR,T,THETA
  250 FORMAT(//,' ANGLE OF INCIDENCE = ',F3.0,5X,'WAVELENGTH = ',F5.0,
     C       //,' AMBIENT   REFRACTIVE INDEX = ',F5.2,
     C        /,' FILM      REFRACTIVE INDEX = ',F5.2,' - ',F5.2,'I',
     C        /,' SUBSTRATE REFRACTIVE INDEX = ',F5.2,' - ',F5.2,'I',
     C       //,' MEASURED VALUE OF DELTA    = ',F7.2,' CALCULATED....'
     C,F7.2,
     C        /,' MEASURED VALUE OF PSI      = ',F7.2,' CALCULATED....'
     C,F7.2,
     C        /,' ERROR BY SUM OF SQUARES    = ',F7.2,
     C        /,' CORRESPONDING THICKNESS    = ',F6.0,
     C        /,' APPARANT SURFACE COVERAGE  = ',F8.4)
      TYPE 300
  300 FORMAT(/,'$ MORE CALCULATIONS? ')
      ACCEPT 98,ANSWER
      IF(ANSWER.EQ.1HY)GOTO 100
      STOP
      END
```

Appendix 54 (continued).

CSFIT output to line printer

```
ANGLE OF INCIDENCE = 75.     WAVELENGTH = 5145.

AMBIENT   REFRACTIVE INDEX =  1.34
FILM      REFRACTIVE INDEX =  1.29 -  4.08I
SUBSTRATE REFRACTIVE INDEX =  0.17 -  3.22I

MEASURED VALUE OF DELTA    =    0.00 CALCULATED....  71.46
MEASURED VALUE OF PSI      =    0.00 CALCULATED....  43.73
ERROR BY SUM OF SQUARES    =   83.78
CORRESPONDING THICKNESS    =     5.
APPARANT SURFACE COVERAGE  =   0.1000


ANGLE OF INCIDENCE = 75.     WAVELENGTH = 5145.

AMBIENT   REFRACTIVE INDEX =  1.34
FILM      REFRACTIVE INDEX =  1.29 -  4.08I
SUBSTRATE REFRACTIVE INDEX =  0.17 -  3.22I

MEASURED VALUE OF DELTA    =    0.00 CALCULATED....  71.51
MEASURED VALUE OF PSI      =    0.00 CALCULATED....  43.69
ERROR BY SUM OF SQUARES    =   83.80
CORRESPONDING THICKNESS    =     5.
APPARANT SURFACE COVERAGE  =   0.2000
```

Notes:

This example is taken from the work discussed in chapter 5 regarding the coherent superposition model of the Pb underpotential monolayer on Ag(111).

Optical properties of the underpotential layer were estimated at full coverage by OHGOGO; the substrate refractive index was measured at zero coverage.

Appendix 55.

Listing of PSIDEL

```
      PROGRAM PSIDEL
      INTEGER PFLAG,AFLAG,CFLAG,FLAG,OPTION
      TYPE 95
   95 FORMAT(/,'$',1X,'STANDARD(1) OR ROTATED(2) AXIMUTH ANGLES (I1)? ')
      ACCEPT 96,OPTION
   96 FORMAT(I1)
      TYPE 97
   97 FORMAT(/,2X,'ENTER THE POLARIZER, ANALYZER, AND COMPENSATOR
     C ANGLES (3(1X,F6.2)):')
      ACCEPT 98,P,A,C
   98 FORMAT(3(1X,F6.2))
      D=0.
      S=0.
      PFLAG=0
      IF(P.LE.180.)PFLAG=400
      IF(P.LE.135.)PFLAG=300
      IF(P.LE. 90.)PFLAG=200
      IF(P.LE. 45.)PFLAG=100
      AFLAG=0
      IF(A.LE.180.)AFLAG=20
      IF(A.LE. 90.)AFLAG=10
      CFLAG=0
      IF(C.EQ.45.)CFLAG=1
      IF(C.EQ.135.)CFLAG=2
      FLAG=PFLAG+AFLAG+CFLAG
      TYPE 99,P,A,C,FLAG
   99 FORMAT(/,2X,'P=',F6.2,2X,'A=',F6.2,2X,'C=',F6.2,2X,'FLAG=',I3)
      IF(OPTION.NE.2)GOTO 180
      IF(FLAG.NE.312)GOTO 10
      D=270.-2.*P
      S=90.-A
   10 CONTINUE
      IF(FLAG.NE.411)GOTO 20
      D=2.*P-270.
      S=90.-A
   20 CONTINUE
      IF(FLAG.NE.122)GOTO 30
      D=90.-2.*P
      S=A-90.
   30 CONTINUE
      IF(FLAG.NE.221)GOTO 40
      D=2.*P-90.
      S=A-90.
   40 CONTINUE
      IF(FLAG.NE.321)GOTO 50
      D=2.*P-90.
      S=A-90.
```

```
 50 CONTINUE
    IF(FLAG.NE.422)GOTO 60
    D=450.-2.*P
    S=A-90.
 60 CONTINUE
    IF(FLAG.NE.111)GOTO 70
    D=2.*P-90.
    S=90.-A
 70 CONTINUE
    IF(FLAG.NE.212)GOTO 80
    D=270.-2.*P
    S=90.-A
 80 CONTINUE
    IF(FLAG.NE.322)GOTO 90
    D=450.-2.*P
    S=A-90.
 90 CONTINUE
    IF(FLAG.NE.421)GOTO 100
    D=2.*P-90.
    S=A-90.
100 CONTINUE
    IF(FLAG.NE.112)GOTO 110
    D=270.-2.*P
    S=90.-A
110 CONTINUE
    IF(FLAG.NE.211)GOTO 120
    D=2.*P+90.
    S=90.-A
120 CONTINUE
    IF(FLAG.NE.311)GOTO 130
    D=2.*P+90.
    S=90.-A
130 CONTINUE
    IF(FLAG.NE.412)GOTO 140
    D=630.-2.*P
    S=90.-A
140 CONTINUE
    IF(FLAG.NE.121)GOTO 150
    D=2.*P+270.
    S=A-90.
150 CONTINUE
    IF(FLAG.NE.222)GOTO 160
    D=450.-2.*P
    S=A-90.
160 CONTINUE
    IF(D.EQ.0.0.AND.S.EQ.0.0)TYPE 170
    IF(D.EQ.0.0.AND.S.EQ.0.0)STOP
170 FORMAT(/,1X,'*PROBABLE ELLIPSOMETER ANGLE CONVERSION ERROR IN
   C SUBROUTINE "PSIDEL" DETECTED;',/,'EXECUTION TERMINATED*')
```

```
      GOTO 1180
  180 CONTINUE
      IF(OPTION.NE.1)GOTO 1180
      IF(FLAG.NE.121)GOTO 1010
      D=90.-2.*P
      S=180.-A
 1010 CONTINUE
      IF(FLAG.NE.222)GOTO 1020
      D=2.*P-90.
      S=180.-A
 1020 CONTINUE
      IF(FLAG.NE.311)GOTO 1030
      D=270.-2.*P
      S=A
 1030 CONTINUE
      IF(FLAG.NE.412)GOTO 1040
      D=2.*P-270.
      S=A
 1040 CONTINUE
      IF(FLAG.NE.112)GOTO 1050
      D=90.+2.*P
      S=A
 1050 CONTINUE
      IF(FLAG.NE.211)GOTO 1060
      D=270.-2.*P
      S=A
 1060 CONTINUE
      IF(FLAG.NE.322)GOTO 1070
      D=2.*P-90.
      S=180.-A
 1070 CONTINUE
      IF(FLAG.NE.421)GOTO 1080
      D=450.-2.*P
      S=180.-A
 1080 CONTINUE
      IF(FLAG.NE.111)GOTO 1090
      D=270.-2.*P
      S=A
 1090 CONTINUE
      IF(FLAG.NE.212)GOTO 1100
      D=2.*P+90.
      S=A
 1100 CONTINUE
      IF(FLAG.NE.321)GOTO 1110
      D=450.-2.*P
      S=180.-A
 1110 CONTINUE
      IF(FLAG.NE.422)GOTO 1120
      D=2.*P-90.
      S=180.-A
```

```
1120 CONTINUE
     IF(FLAG.NE.122)GOTO 1130
     D=2.*P+270.
     S=180.-A
1130 CONTINUE
     IF(FLAG.NE.221)GOTO 1140
     D=450.-2.*P
     S=180.-A
1140 CONTINUE
     IF(FLAG.NE.312)GOTO 1150
     D=2.*P+90.
     S=A
1150 CONTINUE
     IF(FLAG.NE.411)GOTO 1160
     D=630.-2.*P
     S=A
1160 CONTINUE
     IF(D.EQ.0.0.AND.S.EQ.0.0)TYPE 170
     IF(D.EQ.0.0.AND.S.EQ.0.0)STOP
1180 CONTINUE
     IF(OPTION.EQ.1.OR.OPTION.EQ.2)GOTO 2010
     TYPE 2000
2000 FORMAT(/,1X,'*INCORRECT OPION CODE SPECIFIED IN SUBROUTINE
    C "PSIDEL" SO EXECUTION WAS TERMINATED*')
2010 CONTINUE
     TYPE 3000,D,S
3000 FORMAT(/,2X,'DELTA=',F6.2,2X,'PSI=',F6.2)
     STOP
     END
```

Demonstration of PSIDEL

```
.RUN DY1:PSIDEL

 STANDARD(1) OR ROTATED(2) AXIMUTH ANGLES (I1)? 2

 ENTER THE POLARIZER, ANALYZER, AND COMPENSATOR ANGLES (3(1X,F6.2)):
015.00 060.00 045.00

 P= 15.00  A= 60.00  C= 45.00  FLAG=111

 DELTA=-60.00  PSI= 30.00
STOP --
```

Appendix 56.

Substrate refractive index calculation for Texas Instruments 59 Calculator

000	76	LBL
001	11	A
002	42	STO
003	10	10
004	91	R/S
005	76	LBL
006	12	B
007	42	STO
008	11	11
009	91	R/S
010	76	LBL
011	13	C
012	42	STO
013	12	12
014	91	R/S
015	76	LBL
016	14	D
017	42	STO
018	13	13
019	91	R/S
020	76	LBL
021	15	E
022	60	DEG
023	43	RCL
024	11	11
025	38	SIN
026	42	STO
027	14	14
028	43	RCL
029	11	11
030	30	TAN
031	42	STO
032	15	15
033	43	RCL
034	13	13
035	30	TAN
036	42	STO
037	16	16
038	43	RCL
039	12	12
040	65	×
041	02	2
042	65	×
043	89	π
044	55	÷
045	03	3
046	06	6
047	00	0
048	95	=
049	42	STO
050	17	17
051	42	STO
052	02	02
053	00	0
054	42	STO
055	01	01
056	36	PGM
057	05	05
058	17	B'
059	43	RCL
060	01	01
061	65	×
062	43	RCL
063	16	16
064	95	=
065	42	STO
066	18	18
067	43	RCL
068	02	02
069	65	×
070	43	RCL
071	16	16
072	95	=
073	42	STO
074	19	19
075	43	RCL
076	18	18
077	85	+
078	01	1
079	95	=
080	42	STO
081	01	01
082	43	RCL
083	19	19
084	42	STO
085	02	02
086	43	RCL
087	18	18
088	94	+/-
089	85	+
090	01	1
091	95	=
092	42	STO
093	03	03
094	43	RCL
095	19	19
096	94	+/-
097	42	STO
098	04	04

Appendix 56 (continued).

099	36	PGM
100	04	04
101	18	C'
102	43	RCL
103	01	01
104	55	÷
105	43	RCL
106	15	15
107	95	=
108	42	STO
109	21	21
110	43	RCL
111	02	02
112	55	÷
113	43	RCL
114	15	15
115	95	=
116	42	STO
117	22	22
118	43	RCL
119	21	21
120	42	STO
121	01	01
122	43	RCL
123	22	22
124	42	STO
125	02	02
126	36	PGM
127	05	05
128	13	C
129	43	RCL
130	01	01
131	85	+
132	01	1
133	95	=
134	42	STO
135	01	01
136	36	PGM
137	05	05
138	14	D
139	36	PGM
140	05	05
141	15	E
142	43	RCL
143	21	21
144	42	STO
145	03	03
146	43	RCL
147	22	22
148	42	STO
149	04	04
150	36	PGM
151	04	04
152	13	C
153	36	PGM
154	05	05
155	15	E
156	43	RCL
157	01	01
158	65	×
159	43	RCL
160	10	10
161	65	×
162	43	RCL
163	14	14
164	95	=
165	42	STO
166	01	01
167	43	RCL
168	02	02
169	65	×
170	43	RCL
171	10	10
172	65	×
173	43	RCL
174	14	14
175	95	=
176	42	STO
177	02	02
178	91	R/S
179	00	0
180	00	0
181	00	0
182	00	0
183	00	0
184	00	0
185	00	0
186	00	0
187	00	0
188	00	0
189	00	0
190	00	0
191	00	0
192	00	0
193	00	0
194	00	0
195	00	0
196	00	0

Appendix 56 (continued).

A Guide to Using the TI-59 Substrate Refractive Index Calculation Program

1. Load the program from the two card tracks (1 and 2).:

   1, "load track 1"
   2, "load track 2"

2. Enter necessary values. For example, given

   incident medium refractive index = 1.00
   angle-of-incidence = 75 degrees
   delta = 65 degrees
   psi = 38 degrees

   the key sequence would be:

   1, A
   75, B
   65, C
   38, D, E

   the display will show the substrate extinction coefficient:

   -2.049199888

   the substrate refractive index is recalled with the key sequence:

   RCL, 01

   the display will show the substrate refractive index:

   0.6785396928

   the substrate extinction coefficient is recalled with the key sequence:

   RCL, 02

   new values of delta and psi can be entered:

   69, C, 44, D, E .... -2.280649787 ..... RCL, 01 ....
   0.1005854271

Appendix 57.

Simple homogeneous, isotropic film calculation for Texas Instruments 59 Calculator

000	76	LBL
001	11	A
002	99	PRT
003	42	STD
004	00	00
005	70	RAD
006	43	RCL
007	05	05
008	65	×
009	89	π
010	55	÷
011	01	1
012	08	8
013	00	0
014	95	=
015	39	COS
016	42	STD
017	18	18
018	43	RCL
019	05	05
020	65	×
021	89	π
022	55	÷
023	01	1
024	08	8
025	00	0
026	95	=
027	38	SIN
028	42	STD
029	19	19
030	53	(
031	43	RCL
032	07	07
033	33	X²
034	54	)
035	65	×
036	53	(
037	43	RCL
038	19	19
039	33	X²
040	54	)
041	95	=
042	42	STD
043	26	26
044	43	RCL
045	08	08
046	42	STD
047	01	01
048	43	RCL
049	09	09
050	42	STD
051	02	02
052	71	SBR
053	33	X²
054	43	RCL
055	01	01
056	98	ADV
057	99	PRT
058	42	STD
059	12	12
060	43	RCL
061	02	02
062	99	PRT
063	42	STD
064	13	13
065	71	SBR
066	44	SUM
067	43	RCL
068	10	10
069	42	STD
070	01	01
071	43	RCL
072	11	11
073	42	STD
074	02	02
075	71	SBR
076	33	X²
077	43	RCL
078	01	01
079	98	ADV
080	99	PRT
081	42	STD
082	14	14
083	43	RCL
084	02	02
085	99	PRT
086	42	STD
087	15	15
088	43	RCL
089	07	07
090	65	×
091	43	RCL
092	18	18
093	95	=
094	42	STD
095	26	26
096	00	0
097	93	.
098	42	STD

Appendix 57 (continued).

```
099  27  27
100  43  RCL
101  08  08
102  42  STO
103  01  01
104  43  RCL
105  09  09
106  42  STO
107  02  02
108  43  RCL
109  12  12
110  42  STO
111  03  03
112  43  RCL
113  13  13
114  42  STO
115  04  04
116  71  SBR
117  45  YX
118  71  SBR
119  34  ΓX
120  43  RCL
121  01  01
122  98  ADV
123  99  PRT
124  42  STO
125  16  16
126  43  RCL
127  02  02
128  99  PRT
129  42  STO
130  17  17
131  43  RCL
132  07  07
133  42  STO
134  01  01
135  00  0
136  93  .
137  42  STO
138  02  02
139  43  RCL
140  12  12
141  42  STO
142  03  03
143  43  RCL
144  13  13
145  42  STO
146  04  04
147  71  SBR
148  23  LNX
```

```
149  43  RCL
150  08  08
151  42  STO
152  01  01
153  43  RCL
154  09  09
155  42  STO
156  02  02
157  43  RCL
158  18  18
159  42  STO
160  03  03
161  00  0
162  93  .
163  42  STO
164  04  04
165  71  SBR
166  45  YX
167  71  SBR
168  34  ΓX
169  43  RCL
170  01  01
171  94  +/-
172  98  ADV
173  99  PRT
174  42  STO
175  22  22
176  43  RCL
177  02  02
178  94  +/-
179  99  PRT
180  42  STO
181  23  23
182  43  RCL
183  08  08
184  42  STO
185  01  01
186  43  RCL
187  09  09
188  42  STO
189  02  02
190  43  RCL
191  12  12
192  42  STO
193  03  03
194  43  RCL
195  13  13
196  42  STO
197  04  04
198  71  SBR
```

Appendix 57 (continued).

```
199  23 LNX
200  43 RCL
201  10  10
202  42 STO
203  01  01
204  43 RCL
205  11  11
206  42 STO
207  02  02
208  43 RCL
209  14  14
210  42 STO
211  03  03
212  43 RCL
213  15  15
214  42 STO
215  04  04
216  71 SBR
217  45 YX
218  71 SBR
219  34 √X
220  43 RCL
221  01  01
222  98 ADV
223  99 PRT
224  42 STO
225  18  18
226  43 RCL
227  02  02
228  99 PRT
229  42 STO
230  19  19
231  43 RCL
232  08  08
233  42 STO
234  01  01
235  43 RCL
236  09  09
237  42 STO
238  02  02
239  43 RCL
240  14  14
241  42 STO
242  03  03
243  43 RCL
244  15  15
245  42 STO
246  04  04
247  71 SBR
248  23 LNX
249  43 RCL
250  10  10
251  42 STO
252  01  01
253  43 RCL
254  11  11
255  42 STO
256  02  02
257  43 RCL
258  12  12
259  42 STO
260  03  03
261  43 RCL
262  13  13
263  42 STO
264  04  04
265  71 SBR
266  45 YX
267  71 SBR
268  34 √X
269  43 RCL
270  01  01
271  94 +/-
272  98 ADV
273  99 PRT
274  42 STO
275  24  24
276  43 RCL
277  02  02
278  94 +/-
279  99 PRT
280  42 STO
281  25  25
282  43 RCL
283  16  16
284  42 STO
285  26  26
286  43 RCL
287  17  17
288  42 STO
289  27  27
290  43 RCL
291  18  18
292  42 STO
293  28  28
294  43 RCL
295  19  19
296  42 STO
297  29  29
298  71 SBR
```

Appendix 57 (continued).

299	43	RCL
300	43	RCL
301	01	01
302	98	ADV
303	99	PRT
304	42	STO
305	12	12
306	43	RCL
307	02	02
308	99	PRT
309	42	STO
310	13	13
311	43	RCL
312	22	22
313	42	STO
314	26	26
315	43	RCL
316	23	23
317	42	STO
318	27	27
319	43	RCL
320	24	24
321	42	STO
322	28	28
323	43	RCL
324	25	25
325	42	STO
326	29	29
327	71	SBR
328	43	RCL
329	43	RCL
330	01	01
331	98	ADV
332	99	PRT
333	42	STO
334	14	14
335	43	RCL
336	02	02
337	99	PRT
338	42	STO
339	15	15
340	43	RCL
341	12	12
342	42	STO
343	03	03
344	43	RCL
345	13	13
346	42	STO
347	04	04
348	36	PGM
349	04	04
350	18	C'
351	43	RCL
352	01	01
353	98	ADV
354	99	PRT
355	42	STO
356	16	16
357	43	RCL
358	02	02
359	99	PRT
360	42	STO
361	17	17
362	53	(
363	43	RCL
364	01	01
365	65	×
366	43	RCL
367	01	01
368	54	)
369	85	+
370	53	(
371	43	RCL
372	02	02
373	65	×
374	43	RCL
375	02	02
376	54	)
377	95	=
378	34	√X
379	22	INV
380	30	TAN
381	65	×
382	01	1
383	08	8
384	00	0
385	55	÷
386	89	π
387	95	=
388	98	ADV
389	99	PRT
390	42	STO
391	18	18
392	43	RCL
393	02	02
394	55	÷
395	43	RCL
396	01	01
397	95	=
398	22	INV

Appendix 57 (continued).

399	30	TAN
400	65	×
401	01	1
402	08	8
403	00	0
404	55	÷
405	89	π
406	95	=
407	99	PRT
408	42	STO
409	19	19
410	91	R/S
411	76	LBL
412	33	X²
413	36	PGM
414	05	05
415	13	C
416	43	RCL
417	01	01
418	42	STO
419	27	27
420	43	RCL
421	02	02
422	42	STO
423	28	28
424	43	RCL
425	26	26
426	42	STO
427	01	01
428	00	0
429	93	.
430	42	STO
431	02	02
432	43	RCL
433	27	27
434	42	STO
435	03	03
436	43	RCL
437	28	28
438	42	STO
439	04	04
440	36	PGM
441	04	04
442	18	C'
443	43	RCL
444	01	01
445	42	STO
446	27	27
447	43	RCL
448	02	02
449	42	STO
450	28	28
451	01	1
452	93	.
453	00	0
454	42	STO
455	01	01
456	00	0
457	93	.
458	00	0
459	42	STO
460	02	02
461	43	RCL
462	27	27
463	42	STO
464	03	03
465	43	RCL
466	28	28
467	42	STO
468	04	04
469	36	PGM
470	04	04
471	17	B'
472	36	PGM
473	05	05
474	14	D
475	92	RTN
476	76	LBL
477	34	√X
478	71	SBR
479	35	1/X
480	36	PGM
481	04	04
482	12	B
483	43	RCL
484	01	01
485	42	STO
486	24	24
487	43	RCL
488	02	02
489	42	STO
490	25	25
491	71	SBR
492	35	1/X
493	36	PGM
494	04	04
495	17	B'
496	43	RCL
497	24	24
498	42	STO

499	03	03
500	43	RCL
501	25	25
502	42	STD
503	04	04
504	36	PGM
505	04	04
506	18	C'
507	92	RTN
508	76	LBL
509	35	1/X
510	43	RCL
511	26	26
512	42	STD
513	01	01
514	43	RCL
515	27	27
516	42	STD
517	02	02
518	43	RCL
519	28	28
520	42	STD
521	03	03
522	43	RCL
523	29	29
524	42	STD
525	04	04
526	92	RTN
527	76	LBL
528	23	LNX
529	36	PGM
530	04	04
531	13	C
532	43	RCL
533	01	01
534	42	STD
535	26	26
536	43	RCL
537	02	02
538	42	STD
539	27	27
540	92	RTN
541	76	LBL
542	45	YX
543	36	PGM
544	04	04
545	13	C
546	43	RCL
547	01	01
548	42	STD
549	28	28
550	43	RCL
551	02	02
552	42	STD
553	29	29
554	92	RTN
555	76	LBL
556	44	SUM
557	00	0
558	93	.
559	00	0
560	42	STD
561	01	01
562	04	4
563	93	.
564	65	×
565	89	π
566	65	×
567	43	RCL
568	00	00
569	55	÷
570	43	RCL
571	06	06
572	95	=
573	42	STD
574	02	02
575	43	RCL
576	08	08
577	42	STD
578	03	03
579	43	RCL
580	09	09
581	42	STD
582	04	04
583	36	PGM
584	04	04
585	13	C
586	43	RCL
587	12	12
588	42	STD
589	03	03
590	43	RCL
591	13	13
592	42	STD
593	04	04
594	36	PGM
595	04	04
596	13	C

Appendix 57 (continued).

597	43	RCL
598	01	01
599	94	+/-
600	42	STO
601	01	01
602	43	RCL
603	02	02
604	94	+/-
605	42	STO
606	02	02
607	36	PGM
608	05	05
609	17	B'
610	43	RCL
611	01	01
612	42	STO
613	20	20
614	43	RCL
615	02	02
616	42	STO
617	21	21
618	92	RTN
619	76	LBL
620	43	RCL
621	43	RCL
622	20	20
623	42	STO
624	01	01
625	43	RCL
626	21	21
627	42	STO
628	02	02
629	43	RCL
630	26	26
631	42	STO
632	03	03
633	43	RCL
634	27	27
635	42	STO
636	04	04
637	36	PGM
638	04	04
639	13	C
640	43	RCL
641	28	28
642	42	STO
643	03	03
644	43	RCL
645	29	29
646	42	STO
647	04	04
648	36	PGM
649	04	04
650	13	C
651	01	1
652	93	.
653	42	STO
654	03	03
655	00	0
656	93	.
657	42	STO
658	04	04
659	36	PGM
660	04	04
661	12	B
662	43	RCL
663	01	01
664	42	STO
665	14	14
666	43	RCL
667	02	02
668	42	STO
669	15	15
670	43	RCL
671	20	20
672	42	STO
673	01	01
674	43	RCL
675	21	21
676	42	STO
677	02	02
678	43	RCL
679	28	28
680	42	STO
681	03	03
682	43	RCL
683	29	29
684	42	STO
685	04	04
686	36	PGM
687	04	04
688	13	C
689	43	RCL
690	26	26
691	42	STO
692	03	03
693	43	RCL
694	27	27

Appendix 57 (continued).

695	42	STO
696	04	04
697	36	PGM
698	04	04
699	12	B
700	43	RCL
701	14	14
702	42	STO
703	03	03
704	43	RCL
705	15	15
706	42	STO
707	04	04
708	36	PGM
709	04	04
710	18	C'
711	92	RTN
712	00	0
713	00	0
714	00	0
715	00	0
716	00	0
717	00	0
718	00	0
719	00	0

A Guide to Using the TI-59 Film Calculation Program

1. Partition calculator memory with the following key sequence:

   3, 2nd, Op, 17, RST

   the display will show 719.29

2. Load the program from the four card tracks (1, 2, 3, and 4):

   1, "load first card, track 1"
   2, "load first card, track 2"
   3, "load second card, track 3"
   4, "load second card, track 4"

3. Store model parameter values into registers. For example, given

   angle-of-incidence = 75°
   wavelength = 5461 angstroms
   incident medium refractive index = 1.00
   film refractive index = 1.38
   film extinction coefficient = 0.00
   substrate refractive index = 0.93
   substrate extinction coefficient = -2.39

   the key sequence would be:

   75, STO, 05
   5461, STO, 06
   1, STO, 07
   1.38, STO, 08
   0, STO, 09
   0.93, STO, 10
   -2.39, STO, 11

   Then, assuming a film thickness of 400 angstroms:

   RST, 400, A

   after several seconds, the display will show delta ...... 55.78°

   One obtains psi by recalling it from memory:

   RCL, 18

   the display will show ...... 41.12°

   One obtains delta again:

   RCL, 19

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