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in ^{235}U Using a NaI Crystal

by

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A METHOD TO ESTIMATE THE SPECIFIC FISSIONS
IN ^{235}U USING A NaI CRYSTAL

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Silvio Balestrini

ABSTRACT

A technique is described to assay both the fissions and ^{235}U content in certain test samples used for critical assembly studies. The method essentially compares a pulse height analysis from a NaI well crystal scintillator with an empirical mathematical model. In the case of fissions, the analysis can be made from 6 hours to 50 days after irradiation. The listings and description are included for the computer program ASSAY that was developed to do the computations. The listings and brochure are also included for GPLOT, a general subroutine to plot on film and which is used extensively by ASSAY.



I. INTRODUCTION

This report describes a simple method to estimate the absolute number of fissions in a small sample of ^{235}U . It compares the shape and intensity of the gamma-radiation spectrum from the fission products in the sample by scaling to those predicted by an empirical mathematical model. Any time from 6 hours to 50 days after irradiation can be chosen. The ^{235}U in the sample is similarly assayed by comparing its gamma spectrum with that from a known mass.

The gamma-radiation energy spectra are obtained with a NaI well crystal scintillating counter and stored in a pulse height analyzer. This method takes advantage of the relatively poorer resolution of a NaI crystal compared to that of a Ge(Li) crystal. Fission-product spectrum detail from the NaI crystal is washed out into a simpler, gross picture that changes more slowly in character with time and also which is not too sensitive to the energy spectrum of the fissioning neutron flux.

The specifics of the ASSAY computer program that was developed to solve the problem are treated in a series of Appendices. Appendix A describes

how to structure the problem deck for the computer from data cards. Appendix B describes the ASSAY routine itself and its associated subroutines and contains all but one of the FORTRAN listings. Subroutine GPLOT is treated separately in Appendix C. This is a generally useful subroutine to plot on film. It was developed by the author for his own use, and it found its way naturally into the ASSAY program. It is included in this report for the convenience of the reader; and because of its more general applicability, it is given this special treatment.

II. EXPERIMENTAL

It has been convenient at times in the critical-assembly studies group of this laboratory, when studying neutron activation profiles, to prepare samples of ^{235}U by cutting suitable lengths of standard alloy wire from a supply especially manufactured for the purpose. The wire alloy consists by weight of 90% Al and 10% U that is highly enriched (93%) in ^{235}U . The wire diameter is 0.51 mm.

A sample 381 mm (15 in.) long was spiraled to fit into a small space near the center of the Flat-top critical assembly¹ and then irradiated with a

high-intensity neutron flux. The sample was afterwards cut into three lengths in approximate proportion to 0.3, 1.2, and 13.5 to provide a range of radiating sources from 1 to 50 in strength.

The analyses were performed with a Harshaw type 12SW12-W4 NaI well crystal and photomultiplier unit. The crystal was enclosed by lead shielding more than 10 cm thick. The output was amplified and stored in a Hewlett-Packard 1024 channel pulse height analyzer set to count on real time. After each analysis, the data was read onto paper tape and later converted to computer cards. The channels were calibrated for energy using the 0.662 MeV γ -ray from ^{137}Cs .

The shortest sample piece was analyzed periodically, beginning a few hours after irradiation. The sample position inside the crystal well was fixed by scotch taping the sample to the flat bottom of a plastic crucible of a size and shape to fit snugly in the bottom of the well. When the intensities had decreased sufficiently, the shortest sample piece was analyzed several times alternately by itself and together with the next longer piece to normalize the two spectrum sources. About a week later, a similar normalization was possible also between the two sample pieces and all three. Nearly 50 spectral analyses were made, subtracting the background each time, covering a period of 53 days after irradiation. The time interval between analyses was increased as time went on. The entire set of analyses normalized to the intensity of the complete sample is shown in Fig. 1.

III. THE FISSION SPECTRUM MODEL

In structuring the model, the time dependence of the radiation intensity at a given energy was examined first at each of all values 0.02 MeV apart from 0.1 to 2.0 MeV.

Because of the scatter of counts in those channels near any selected energy, the intensity for each analysis was estimated as follows: Since the gain was inadvertently changed in the course of the work, the counts per channel in some analyses had to be adjusted first to reflect the same intensity in counts per minute per MeV interval for the gain originally set. Then the intensity was estimated as the value of a second degree function adjusted for best fit to the data from the seven adjacent channels centered nearest to that energy.

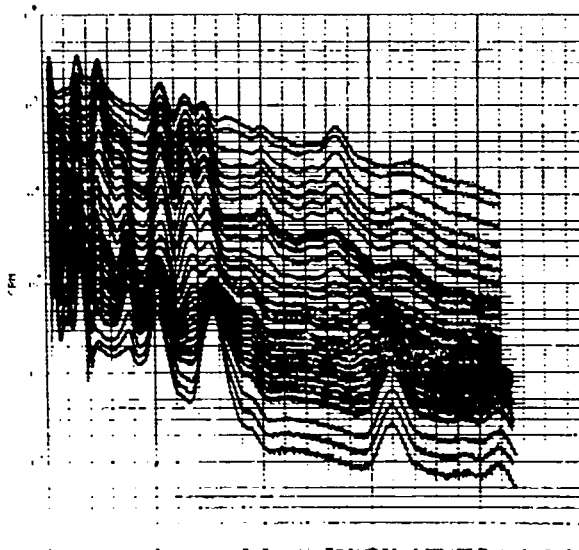


Fig. 1. Synthesis of all the normalized pulse height analyses of the irradiated sample, taken from a few hours to over 50 days after irradiation.

The results at 0.5 MeV are typical and appear in Fig. 2. The intensity estimates are shown as points. The curve results when a smoothing spline is adjusted²⁻³ with ten knots for best fit to the points. It was more convenient for this work to fit the spline to the logarithms of the rates and time lapses after irradiation rather than to the values themselves. The knots are equally spaced on the log-time scale from 5 to 1300 hours.

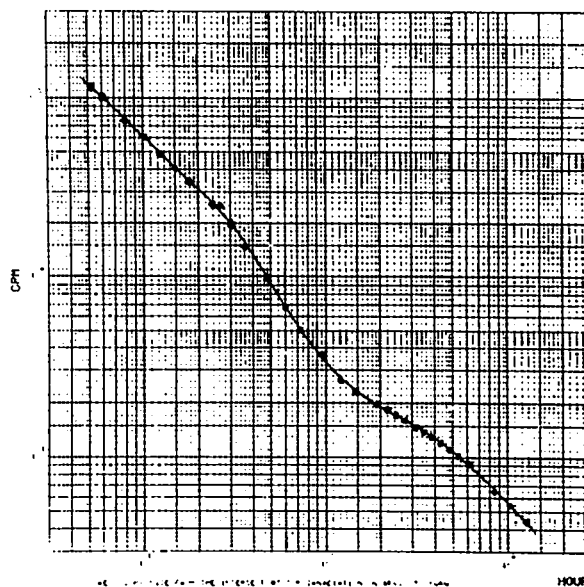


Fig. 2. Time dependence of the radiation intensity at 0.5 MeV.

The shape of the radiation energy spectrum can now be constructed for any time lapse within this time span: A value for the activity is computed from each adjusted spline for the time lapse, and then a new spline is evaluated as a function of energy which passes through these activity values. Figure 3 is a set of 50 spectrum constructions for time lapses increasing in geometric progression from 5 to 1500 hours after irradiation.

The model is formed by choosing only the adjusted splines included by the energy range from 0.45 to 0.9 MeV. When a spectrum construction is to be compared with data for assay, three practical considerations are met in this energy range: The structure is relatively simple and yet distinctive (useful in curve fitting), the intensity is reasonably high, and it is also comparatively free of background from cosmic rays, from the ^{235}U in the sample, and from aluminum activation.

The model was finally calibrated by comparison with radiochemical results: A ^{235}U sample prepared from the supply of standard Al-U(93) wire was irradiated and then analyzed inside the well crystal using an adopted standard geometry. It was afterwards submitted for radiochemical analysis for the number of fissions via a determination of the ^{99}Mo content.

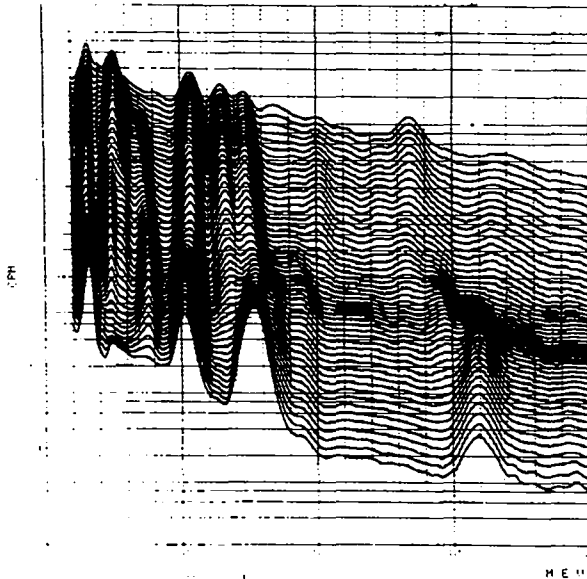


Fig. 3. Fission-product spectrum constructions for time lapses increasing in geometric progression from 5 to 1500 hours after irradiation.

IV. THE ASSAY FOR FISSIONS

A sample is analyzed in the well crystal at some convenient lapsed time T after irradiation, when the radioactivity level has decreased to some satisfactory point. Generally, T is long compared to the durations of both the irradiation and the analysis, so that it can be measured from the time center of one duration to that of the other.

A fission-product spectrum constructed from the model for the time lapse T is a spline function of energy, $S(E)$, which must be related to the data. Let Y_i represent the counts in the i -th channel. The energy is linear with channel number; i.e., for channel i ,

$$E_i = A + B \cdot i \quad (1)$$

where A and B are constants. The spline is fit to the data⁴ by adjusting three parameters A , B , and C so as to minimize the summation

$$\sum P_i [Y_i - C \cdot S(A + B \cdot i)]^2 \quad (2)$$

over all the data. P_i is a weight associated with Y_i and which is set equal either to Y_i if the channel falls within the energy range of the model or to zero if it does not. The number of fissions in the sample is

$$f = K_f \frac{C}{B \cdot t} \quad (3)$$

where t is the duration of the analysis and K_f is the fission calibration factor for the crystal.

An example of a spline from the model when fit to the data from an actual analysis appears in Fig. 4. In this assay, the fissions were evaluated at $(1.541 \pm 0.016) \times 10^9$. The assay was repeated from the same analysis data, but this time using only the counts in those channels between 0.475 and 0.59 MeV (about one-fourth as many channels), and the result was $1.587 \pm 0.019 \times 10^9$ fissions. It is important to understand the reason for this discrepancy. In both cases, the adjusted values for the amplitude parameter C agreed to within less than 0.2%. The discrepancy between the assays resulted almost entirely from the two estimates for B , which is the scaling factor for the energy interval per channel. In the former case, the evaluation for B was

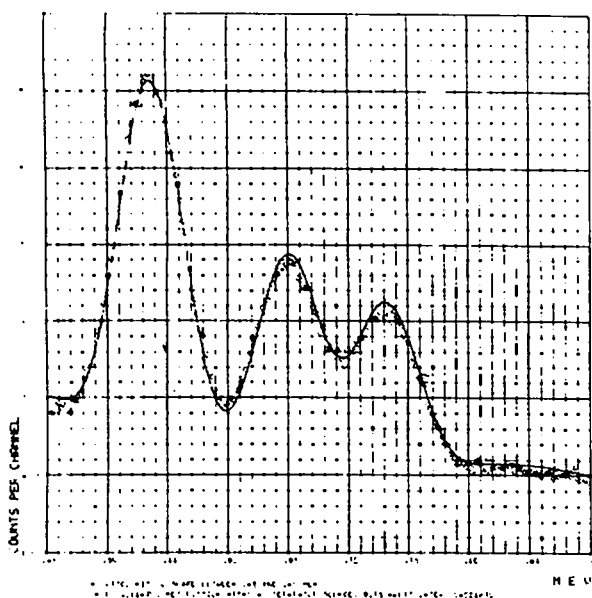


Fig. 4. A fission-product spectrum constructed from the model and then fit by scaling to the data from an analysis.

influenced mostly by the channel locations of the three major spectral peaks. In the latter case, the evaluation was forced to rely only on the width of the one peak, which is less reliable. The two assay error estimates do not reflect the discrepancy since they are based in part on how well the spline function can be scaled to fit both coordinates of the data. The more trustworthy assay is the former, when all the data was used, as will be seen in the discussion below.

V. THE ASSAY FOR ^{235}U

A spectrum model for the radiation from ^{235}U decay was constructed more simply. Since this spectrum is invariant with time, one well crystal analysis of a previously unirradiated sample followed later by a radiochemical assay for the ^{235}U content completed the necessary experimental work. The model was formed directly by a smoothing spline through the analysis data and selecting knots equally spaced 0.01 MeV apart. The energy range of this model spans the values from 0.135 to 0.25 MeV in order to describe the 0.19-MeV line and neighboring lesser lines. The model consists of a value for the intensity and the second derivative for each of a set of energy values.

The mass of ^{235}U in a sample is assayed by matching the model to the data from the well crystal

analysis of the sample before irradiation. As for the case with fissions, see equations (1) to (3); the mass of ^{235}U is

$$U = K_U \frac{C}{B \cdot t} \quad (4)$$

where K_U is the mass calibration factor for the crystal.

VI. STANDARD SAMPLE GEOMETRIES

Since the efficiency of the crystal depends to some extent upon the location of the sample in the well of the crystal, a standard reproducible sample geometry is important.

As a primary standard geometry, the wire sample was first wound in the form of a tight helix roughly 2.3 cm in diameter, using a mandrel, and then inserted into a plastic crucible so as to fit firmly against the crucible sides by spring action. A lid fitting tightly inside the crucible helped to hold the sample fixed and also reduced the risk of contamination in the well. An advantage with this geometry is that the length of a sample up to 40 cm is not critical.

A secondary standard geometry was adopted for convenience. The wire sample was wound in a compact spiral resembling a disc and held firmly against the bottom of the crucible by the crucible lid. Although the crystal is less sensitive to this geometry, the difference is less than 2% for 10 mg and smaller samples of ^{235}U , and sometimes worth the convenience since the equipment to spiral the wire already exists, and at times a sample in the form of a spiraled disk is desirable.

When an assay for ^{235}U was attempted on two 1.27-cm-diameter U(93) foils 25 μm thick and weighing about 60 mg each, the results fell short by about 14% due in part to a bad state of oxidation that affected the apparent weight and in part to self-absorption. The latter was shown to be a contributing cause by assaying the foils flat against each other and then separately. The sum of the assays from each was 7% greater than from the two together. Although the 0.19-MeV radiation from ^{235}U is more likely to be self-absorbed than the higher energy radiation from the fission products, the risk of error by departing to other forms of samples should be borne in mind.

VII. DISCUSSION

A group of 20 samples from a neutron activation profile study of a critical assembly were spiraled and then analyzed for relative activation in the programable, sample cycling beta counter known as the "jukebox."⁵ Each sample was afterwards assayed for fissions using the well crystal, and then they were all assayed for fissions in two groups of ten each by the Los Alamos Scientific Laboratory radio-chemistry group CNC-11.

Table I compares the fission assays from the well crystal with the relative activations from the beta-counter results. These samples were prepared from four identical, long wires that had been placed side by side during the irradiation and afterwards cut into five lengths each. All the samples with the same letter were of the same length and exposed

to the same neutron flux and should therefore have the same activation except for possible small variations in ²³⁵U content. In general, the like-letter groups of results show standard deviations that are percentagewise smaller for the well crystal assays than for the activation ratios from the beta-counter measurements. However, the individual error estimates for the latter, which are based on reproducibility from repeated observations, are smaller. A likely explanation for the discrepancy, although the discrepancy is small, is that the well counter is less sensitive to sample form for small samples than the beta counter of the jukebox. In support of this, one notes from the normalized ratios in the last column of Table I that these tend to be lower for the "A" and "E" groups. And indeed, the length of these wires was 30% shorter than the uniform, 19-cm length for the others.

TABLE I
COMPARISON OF TWENTY RELATIVE ACTIVATIONS DETERMINED BY THE CYCLING BETA COUNTER
WITH THE NUMBER OF FISSIONS ESTIMATED USING THE NaI-CRYSTAL WELL COUNTER

Wire Sample	NaI Crystal Assay, Fissions x 10 ⁻⁹	Relative Activation, Beta Counter Results	Normalized ^a Ratios
1-A	0.8954 ± .0093	0.6550 ± .0029	0.963 ± .011
B	1.441 .015	1.0000 .0054	1.015 .012
C	1.236 .013	0.8602 .0035	1.012 .011
D	0.8185 .0086	0.5750 .0029	1.002 .012
E	0.2214 .0024	0.1559 .0011	1.000 .013
2-A	0.8938 ± .0093	0.6403 ± .0020	0.983 ± .011
B	1.420 .015	0.9916 .0037	1.008 .011
C	1.249 .013	0.8829 .0039	0.996 .011
D	0.8270 .0086	0.5810 .0033	1.002 .012
E	0.2240 .0025	0.1588 .0012	0.993 .013
3-A	0.8849 ± .0092	0.6415 ± .0022	0.971 ± .011
B	1.404 .014	0.9860 .0043	1.003 .011
C	1.228 .013	0.8694 .0041	0.995 .012
D	0.8091 .0084	0.5610 .0032	1.016 .012
E	0.2202 .0025	0.1526 .0012	1.016 .014
4-A	0.8943 ± .0093	0.6385 ± .0024	0.986 ± .011
B	1.404 .015	0.9876 .0044	1.001 .012
C	1.254 .013	0.8594 .0041	1.028 .011
D	0.8207 .0085	0.5569 .0033	1.038 .012
E	0.2254 .0024	0.1579 .0012	1.005 .013

^a Ratio of fission assay to beta counter results multiplied by a factor to normalize the average to unity.

TABLE II
COMPARISON OF FISSION ASSAY RESULTS USING THE NaI-CRYSTAL ASSAY
METHOD WITH THE RADIOCHEMICAL RESULTS FROM CNC-11.

Wire Samples	Sum of NaI Crystal Assays, Fissions	CNC-11 Assay, Fissions
All of Wires 1 & 2	$(9.226 \pm .033) \times 10^9$	9.225×10^9
All of Wires 3 & 4	$(9.143 \pm .033) \times 10^9$	9.065×10^9

The results of the fission assays from the well crystal and radiochemistry are compared in Table II. The elapsed time between irradiation and well crystal assay varied from 6.8 to 11.8 hours. This degree of good agreement has been obtained in other instances when elapsed times were as long as 42 hours.

VIII. ACKNOWLEDGMENTS

The author expresses his gratitude to E. A. Bryant and G. W. Knobeloch of Group CNC-11 for the several radiochemical assays used to calibrate and test the models and also to J. C. Hogterp of Group N-2 for making available his irradiated samples and the results from the jukebox so that a comparison of methods could be made.

IX. REFERENCES

1. W. U. Geer, P. G. Koontz, J. D. Orndoff, and H. C. Paxton, "Safety Analysis for the Los Alamos Critical-Assembly Facility," Los Alamos Scientific Laboratory report LA-4273 (November 1969), p. 7.

2. J. L. Walsh, J. H. Ahlberg, E. N. Nilson, "Best Approximation Properties of the Spline Fit," J. Math. Mech. 11, 225 (1962).
3. T. L. Jordan, "Smoothing and Multivariable Interpolation with Splines," Los Alamos Scientific Laboratory report LA-3137 (March 1965).
4. R. H. Moore and R. K. Zeigler, "The Solution of the General Least Squares Problem with Special Reference to High-Speed Computers," Los Alamos Scientific Laboratory report LA-2367 (March 1960).
5. C. G. Chezem and H. H. Helmick, "100-Foil Sample Changer with Tape-Controlled Sequencing," Nucl-eonics 21, 3, 83 (1963).

APPENDIX A

STRUCTURING THE PROBLEM DECK FOR THE ASSAY ROUTINE

Generally, the experimenter may ask the following three questions concerning a sample of ^{235}U :

1. What is the ^{235}U content?
2. How many fissions occurred in it?
3. What are the specific fissions (fissions per gram of ^{235}U)?

The computer can be directed to answer all or part of these questions by means of entries in a control card, which is read first. An A-deck will refer to a deck of computer cards that contains all

the information concerning a well crystal pulse height analysis. One or two A-decks follow the control card to complete the problem deck. When finished, the computer will read the next control card for the next problem deck. A blank card causes the computer to return.

To solve only for the ^{235}U content or the fissions, the appropriate A-deck follows the control card. But if the specific fissions are desired, three choices exist:

1. The ^{235}U pre-irradiation A-deck is read first followed by the fission A-deck. The solution produces two assay results and the specific fissions together with an estimate of the propagated error in this ratio.

2. Only the fission A-deck is read, and the assay is related to the results of a previous ^{235}U assay of a representative sample that are still in computer memory. After once made, the results from a ^{235}U assay remain available in memory from problem to problem until replaced with new values from a subsequent assay.

3. Only the fission A-deck is read, but the assay is related to an assumed mass of ^{235}U .

A-deck Structure

The A-deck is structured as follows:

1. First Card: Title card containing the analysis description, 10A8 format,
2. A series of data cards follow the title card. The format is 1X, I4, 1X, 10F6.0, 6X, A8. The first entry is the number of a channel and is mandatory. The subsequent entries are the contents of that channel and of the next nine, followed by an identification (ID) for the analysis; entries here are not mandatory. If the card for channel zero is included, it must be the first card. The others can follow in any order.

3. Last Card: Termination for the A-deck, must be blank in spaces 2-5. The remaining 10F6.0 fields are used to record the following information:
Spaces 7-12, count duration in minutes.

Spaces 13-18, analyzer dead time in percent.

Spaces 19-24, estimated channel number for zero energy; the iterating routine requires this estimate to start with.

Spaces 25-30, estimated channel number where the ^{137}Cs , 0.662-MeV gamma-ray peak would be centered for this gain setting; the iterating routine also requires this estimate to start with.

Spaces 31-36, minimum channel to be used.

Spaces 37-42, maximum channel to be used. If no entry, the value 1000 will be substituted by the program.

Control Card

The control card is prepared as follows (obviously, not all entries are always mandatory):

Space 1 entries:

- 0 = No ^{235}U assay is to be made.
- 1 = The deck that follows is from a ^{235}U analysis.
- 2 = Also list the ^{235}U analysis data in the output.
- 3 = Use the ^{235}U results in memory from the earlier assay.

Space 2 entries:

- 0 = No fission assay is to be made. (If both spaces 1 and 2 are zero, the computer returns.)
- 1 = A fission assay is to be made.
- 2 = Also list the fission analysis data in the output.

Space 3 entries:

- 0 = The fission spectrum analysis has not had the background subtracted from it. (The program will correct for it.)
- 1 = The fission spectrum analysis data is corrected for background.

Spaces 7-10, time when irradiation started; 2:38 p.m. is written 1438, and midnight is 2400; I4 format.

Spaces 13-16, duration of the irradiation in minutes; I4 format.

Spaces 19-26, irradiation date, i.e., 10/18/74; A8 format.

Spaces 31-34, time when the well crystal fission analysis started; I4 format.

Spaces 37-44, date when well crystal analysis started; A8 format.

Spaces 46-48, number of calendar days between irradiation date and analysis date, regardless of the times of day; I3 format. (If the dates are 10/18/74 and 10/19/74, this entry is 1.) The computer uses this information and the times of day to compute the time elapsed after irradiation.

Spaces 49-54, optional, default entry for an assumed mass in mg of ^{235}U for the irradiated sample; F6.0 format. (This entry will not affect the value in memory from a previous assay.)

APPENDIX B

ASSAY PROGRAM AND ASSOCIATED SUBROUTINES

The main PROGRAM reads the control card and proceeds according to the entries for the major controls (MC) in spaces 1-3. The main function is to understand the MC directives, conduct the computations through subroutines and print the final results. The principal variables used throughout are defined in this listing.

Subroutine ASSAYZ is a block of data that is structured as a subroutine and called once early from the main program. (As a subroutine, it can be included in one's USERLIB file.) It contains the information for the ^{235}U model and the cosmic-ray background model. Each model is described first by a listing of the model identification, the number of spline points, and several essential parameters. This is followed by listings of the abscissa, the ordinate, and the second derivative for each point for use by spline routines.

Subroutine FSHAPE contains the fission model and constructs the shape of the fission spectrum from it for any time lapse after irradiation. The block of data in this subroutine is headed by a listing of the model identification, six parameters essential to it, the number of knots on the time axis, and the number of points on the energy axis. This is followed by data arrays for 24 splines with 10 knots each, describing the logarithms of the intensity (CPMK) and times (CPMT) and the associated second derivatives (CPMW) for each of the 24 energy values (FX). The subroutine solves for the intensity of the model at the lapsed time for each energy value and then passes a spline through these values.

Subroutine READ HP reads and stores the A-deck contents, lists them if directed, and plots the data on film.

Subroutine BPART. If the fission analysis data has not had a background subtracted from it, this subroutine corrects for it.

Subroutine MATCH adjusts the scaling of the spline function for best fit to the data. It computes an assay from the scaling parameters P and also an estimate of precision from the goodness of fit and the estimated calibration accuracy for the model. It plots the data and the fitted spline on film. This subroutine makes repeated use of the subroutine ASSAYP.

Subroutine ASSAYP is an iterative program that adjusts the three scaling parameters P of a spline function to fit a set of data by the least squares criterion. The arguments IX1 and IX2 are optional entries for indices of parameters to be kept constant during adjustment of the others. This version was adapted for the problem from a more general routine developed for the least squares treatment discussed in Ref. 4 of this report.

Subroutines SPLIN1 and SPLIN2 are old subroutines no longer available except from the archives, and therefore they are listed here for the convenience of the user. The identification label is E202. SPLIN1 solves for the second derivatives of the spline given the coordinates of the points, and SPLIN2 solves for the value of the function for a given argument.

Subroutine GPLOT: See Appendix C.

```

PROGRAM      ASSAY      ( INP, OUT, PUN, FILM,
P          FSET9=OUT, FSET10=INP, FSET11=PUN, FSET12=FILM )
C- VERSN = CURRENT VERSION OF THE ASSAYING CODE
C-UMODEL = LABEL OF THE URANIUM SPECTRUM MODEL USED
C-BMODEL = LABEL OF THE BACKGROUND SPECTRUM MODEL USED (I.E. COSMIC RAYS)
C-FMODEL = LABEL OF THE FISSION SPECTRUM MODEL USED
C- MC = MAJOR CONTROL NUMBERS
C- ID235, IDFISS = A-DECK LABEL CARD CONTENTS
C- ASMG, ASSD = WT AND SD OF THE URANIUM-235 ASSAY
C- UDT = COUNT DURATION FOR THE U-235 ASSAY
C- UWT = WT OF U-235 IF ENTERED WITHOUT ASSAY
C- RATIO = AMPLITUDE RATIO OF DATA TO THE CURVE SHAPE MODEL
C-IRDATE, IRT1, IRT2 = IRRADIATION DATE, START TIME AND DURATION
C-WLDATE, IWLT = WELL COUNT DATE AND START TIME
C- NDAYS = NUMBER OF CALENDAR DAYS WLDATE FOLLOWS THE IRRADIATION
C- UCS = CS-137 CHANNEL NUMBER FOR THE U-235 ASSAY
C- FCS = CS-137 CHANNEL NUMBER FOR THE FISSION ASSAY
C-MINUCH, MAXUCH, MINFCH, MAXFCH = MIN AND MAX CHANNELS FOR ASSAYS
C- NUCH, NFCH = NUMBER OF CHANNELS QUALIFYING FOR U AND FISSION ASSAYS
C- FISS, FISSSD = NUMBER AND SD OF FISSIONS
C- NUK, NFK, NBK - UX, UY, UW - FX, FY, FW - BX, BY, BW -
C          = NUMBER OF SPLINE POINTS, ABSCISSAE, ORDINATES, AND SECOND
C          DERIVATIVES, RESPECTIVELY, FOR U-235, FISSION, AND BACKGROUND
C- FPG, FPGSD = FISSIONS PER GRAM AND SD OF THE ASSAY
C- UPAR, FPAR, I=1,2 = ENERGY LIMITS FOR U AND FISSION SHAPE COMPARISON
C-          3 = MODEL COUNT TIME
C-          4 = MODEL QUANTITY, I.E., MG OF U-235
C-          5 = CS-137 CHANNEL FOR THE MODEL
C-          6 = UNCERTAINTY PLACED ON THE MODEL QUANTITY
C BPAR, I=1, MODEL COUNT TIME
C          2, CS-137 CHANNEL FOR THE MODEL
DIMENSION ID235(10), IDFISS(10), MC(3), JOB(4)
COMMON /DATA/ N, X(1030), Y(1030), DUM(10)
COMMON /MODEL/ UMODEL,FMODEL,BMODEL
COMMON /USPLIN/ NUK, UPAR(6), UX(50), UY(50), UW(50)
COMMON /FSPLIN/ NFK, FPAR(6), FX(50), FY(50), FW(50)
LOGICAL ASSAYU, ASSAYF, OLDWT, ARBWT, NET
DATA VERSN/8HFEB 1974/
DATA ZERO/1.E-6/
2 FORMAT( 3I1,3X,I4, 2X, I4, 2X, A8, 4X, I4, 2X, A8, 1X, I3, F6.0 )
3 FORMAT(1H1////* WELL COUNTER ASSAY SUMMARY, ASSAY ROUTINE VERSION
X*A8/* RUN ON * A8 * AT * A8 *, JOB * A10 * SERIAL* I3 / )
4 FORMAT( *0ORALLOY SAMPLE -*/ 1X10A8 )
5 FORMAT( *0ORALLOY SAMPLE WEIGHT IS CHOSEN AT *1PE10.3* MG U-235*)
6 FORMAT( *0IRRADIATION -*/ 1X10A8 )
7 FORMAT(/6X44(1H* )/ 6X1H*, 19X, 14HVALUE SD, 9X 1H* )
8 FORMAT(6X1H*,42X1H*/6X16H* FISSIONS = , 1PE12.4, E10.2, 5X1H*)
9 FORMAT(6X1H*,42X1H*/6X16H* MG U-235 = , 1PE12.4, E10.2, 5X1H*)
10 FORMAT(6X1H*,42X1H*/6X16H* FISS/GM = , 1PE12.4, E10.2, 5X1H*)
11 FORMAT( / * IRRADIATION STARTED ON *A8* AT *I4*, LASTED*I3
X* MINUTES*/* WELL COUNT STARTED ON *A8* AT *I4*, LASTED*I4* MIN
XUTES*/13X*WITH *I2* PERCENT DEAD TIME,* F7.1* HOURS LATER*/
X12X,I4* CHANNELS WERE USED BETWEEN *I3* AND *I3/
X 13X*WITH THE CS-137 LINE FALLING ON * F7.1 )
12 FORMAT( * FISSION MODEL *A8* WAS USED ON A NET SPECTRUM*)
13 FORMAT( * FISSION MODEL *A8* WAS USED ON A GROSS SPECTRUM*/
X 13X*AFTER CORRECTING IT WITH BACKGROUND MODEL * A8 )
14 FORMAT( / * U-235 WELL COUNT LASTED *I3* MINUTES*/
X12X,I4* CHANNELS WERE USED BETWEEN *I3* AND *I3/
X 13X*WITH THE CS-137 LINE FALLING ON * F7.1 /

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X * URANIUM MODEL * A8 * WAS USED* )
15 FORMAT( 6X1H*, 42X1H*/ 6X, 44(1H* ) )
CALL ASSAYZ
CALL DATE1 ( JOB(1) )
CALL CLOCK1 ( JOB(2) )
CALL JOBNAME( JOB(3) )
JOB(4) = 0
99 ASSAYU = .FALSE.
ASSAYF = .FALSE.
OLDWT = .FALSE.
ARBWT = .FALSE.
NET = .FALSE.
JOB(4) = JOB(4) + 1
READ(10,2) MC, IRT1, IRDT, IRDATE, IWLT, WLDATE, NDAYS, UWT
IF ( MC(1) .EQ. 0 .AND. MC(2) .EQ. 0 ) RETURN
IF ( MC(1) .GT. 0 ) ASSAYU = .TRUE.
IF ( MC(1) .EQ. 3 ) OLDWT = .TRUE.
IF ( MC(2) .GT. 0 ) ASSAYF = .TRUE.
IF ( MC(3) .GT. 0 ) NET = .TRUE.
IF ( OLDWT ) GO TO 200
IF ( ASSAYU ) GO TO 110
IF ( UWT .GT. ZERO ) ARBWT = .TRUE.
GO TO 200
110 CALL READ HP ( ID235, MC(1), JOB )
UDT = DUM(1)
CALL MATCH ( NUCH, NUK, UX, UY, UW, UPAR, ASMG, ASSD, ID235, JOB )
UCS = DUM(4)
MINUCH = DUM(5) + 0.5
MAXUCH = DUM(6) + 0.5
IF ( .NOT. ASSAYF ) GO TO 300
200 CALL READ HP ( IDFISS, MC(2), JOB )
IF ( NET ) GO TO 205
CALL BPART
205 NH = IRT1 / 100
M = IRT1 - NH * 100
T = FLOAT(NH) + ( FLOAT(M)+0.5*FLOAT(IRDT) ) / 60.0
NH = IWLT / 100
M = IWLT - NH * 100
DECAYT = FLOAT(NDAYS)*24.0-T+FLOAT(NH)+FLOAT(M)/60.0+
X DUM(1)/(1.0-DUM(2) *0.01)/120.0
210 CALL FSHAPE ( DECAYT )
CALL MATCH ( NFCH,NFK,FX,FY,FW,FPAR,FISS,FISSSD,IDFISS,JOB )
FCS = DUM(4)
MINFCH = DUM(5) + 0.5
MAXFCH = DUM(6) + 0.5
IF ( ARBWT ) GO TO 220
IF ( .NOT. ASSAYU ) GO TO 300
FPG = FISS / ASMG * 1000.0
FPGSD = FPG*SQRT( (FISSSD/FISS)**2 + (ASSD/ASMG)**2 )
GO TO 300
220 FPG = FISS / UWT * 1000.0
FPGSD = FISSSD/ UWT * 1000.0
300 WRITE(9,3) VERSN, JOB
IF ( ASSAYU .OR. OLDWT ) WRITE(9,4) ID235
IF ( ARBWT ) WRITE(9,5) UWT
IF ( ASSAYF ) WRITE(9,6) IDFISS
WRITE(9,7)
IF ( ASSAYF ) WRITE(9,8) FISS, FISS SD
IF ( ASSAYU ) WRITE(9,9) ASMG, ASSD
IF ( ASSAYF .AND. (ASSAYU.OR.ARBWT) ) WRITE(9,10) FPG, FPGSD
ASSAY061
ASSAY062
ASSAY063
ASSAY064
ASSAY065
ASSAY066
ASSAY067
ASSAY068
ASSAY069
ASSAY070
ASSAY071
ASSAY072
ASSAY073
ASSAY074
ASSAY075
ASSAY076
ASSAY077
ASSAY078
ASSAY079
ASSAY080
ASSAY081
ASSAY082
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ASSAY097
ASSAY098
ASSAY099
ASSAY100
ASSAY101
ASSAY102
ASSAY103
ASSAY104
ASSAY105
ASSAY106
ASSAY107
ASSAY108
ASSAY109
ASSAY110
ASSAY111
ASSAY112
ASSAY113
ASSAY114
ASSAY115
ASSAY116
ASSAY117
ASSAY118
ASSAY119
ASSAY120

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WRITE(9,15)
IF ( .NOT. ASSAYF ) GO TO 310
IT = DUM(1) + 0.5
IP = DUM(2)+ 0.5
WRITE(9,11) IRDATE, IRT1, IRDT, WLDATE, IWLT, IT, IP, DECAYT,
X NFCH, MINFCH, MAXFCH, FCS
IF ( NET ) WRITE(9,12) FMODEL
IF ( .NOT. NET ) WRITE(9,13) FMODEL, BMODEL
310 IF ( .NOT. ASSAYU ) GO TO 99
IT = UDT + 0.5
WRITE(9,14) IT, NUCH, MINUCH, MAXUCH, UCS, UMODEL
GO TO 99
END

```

ASSAY121
ASSAY122
ASSAY123
ASSAY124
ASSAY125
ASSAY126
ASSAY127
ASSAY128
ASSAY129
ASSAY130
ASSAY131
ASSAY132
ASSAY133

```

SUBROUTINE ASSAYZ
BLOCK DATA FOR THE ASSAY CODE ON USERLIB TAPE
COMMON /MODEL/ UMODEL,FMODEL,BMODEL
COMMON /USPLIN/ NUK, UPAR(6), UX(50), UY(50), UW(50)
COMMON /BSPLIN/ NBK, BPAR(2), BX(50), BY(50), BW(50)
URANIUM SPECTRUM SHAPE
DATA UMODEL/8HMAY 1974/,NUK/15/,UPAR/.135,.25,1.,9.8,662.,0.1/
DATA (UX(I),I=1,15) / .12,.13,.14,.15,.16,.17,.18,.19,.2,.21,.22,
X .23,.24,.25,.26/
DATA (UY(I), I = 1, 15 ) / 1.4564E2, 1.0975E2, 1.2200E2,ASAYZ 10
X 1.9492E2, 2.1683E2, 2.1895E2, 3.7618E2, 6.5999E2, 7.2401E2,ASAYZ 11
X 4.6409E2, 1.9829E2, 6.9214E1, 2.5461E1, 1.3728E1, 1.3728E1/ASAYZ 12
DATA (UW(I), I = 1, 15 ) / 3.2945E2, 4.6906E5, 1.0121E6,ASAYZ 13
X -8.7748E5, -5.6306E5, 1.9427E6, 2.0988E6, -2.7432E6, -4.3136E6,ASAYZ 14
X 5.6139E5, 1.7150E6, 7.8270E5, 2.6750E5, 8.0106E4, 0.0 /ASAYZ 15
COSMIC RAY BACKGROUND
DATA BMODEL/8H031270 /, NBK/6/, BPAR/1.,931./
DATA ( BX(I),I = 1, 6 ) / 0.25, 0.5, 0.75, 1.0, 1.5, 2.0 /
DATA (BY(I),I=1,6)/1.1679,.47823,.26427,.17725,.073422,.024707/
DATA (BW(I),I=1,6)/8.9926,8.9926,.70303,.3815,.18919,.18919/
RETURN $ END

```

ASAYZ 01
ASAYZ 02
ASAYZ 03
ASAYZ 04
ASAYZ 05
ASAYZ 06
ASAYZ 07
ASAYZ 08
ASAYZ 09
ASAYZ 10
ASAYZ 11
ASAYZ 12
ASAYZ 13
ASAYZ 14
ASAYZ 15
ASAYZ 16
ASAYZ 17
ASAYZ 18
ASAYZ 19
ASAYZ 20
ASAYZ 21

```

SUBROUTINE FSHAPE ( T )
COMMON /FSPLIN/ NFK, FPAR(6), FX(50), FY(50), FW(50)
COMMON /MODEL/ UMODEL,FMODEL,BMODEL
DIMENSION CPMK(10, 24), CPMW(10, 24), CPMT(10), TEMP(24)
DATA FMODEL/8H040171 /,FPAR/.45,.9,1.,1.499E11,315.5,1.499E9/
DATA KNOTS /10/, NFK /24/
DATA ( CPMT(I), I = 1, 10 ) / 1.609,
X 2.227, 2.845, 3.463, 4.081, 4.699, 5.317, 5.934, 6.552, 7.170/
DATA (FX(I), I = 1, 24 ) / .44,.46,.48,.50,.52,.54,.56,.58,.60,
X .62,.64,.66,.68,.70,.72,.74,.76,.78,.80,.82,.84,.86,.88,.90/
DATA ( CPMK(I), I = 1, 172 ) / 11.480,
X10.664, 9.899, 9.031, 8.109, 7.261, 6.710, 6.156, 5.527, 4.826,
X11.417,10.620, 9.857, 9.005, 8.126, 7.328, 6.801, 6.280, 5.677,
X 4.973,11.458,10.702, 9.996, 9.255, 8.361, 7.635, 7.173, 6.747,
X 6.189, 5.520,11.698,11.100,10.487, 9.828, 8.843, 8.004, 7.541,
X 7.191, 6.682, 6.048,12.031,11.531,10.999,10.332, 9.325, 8.197,
X 7.575, 7.218, 6.715, 6.070,12.109,11.652,11.148,10.394, 9.447,
X 8.223, 7.418, 6.959, 6.371, 5.589,11.882,11.395,10.852, 9.981,

```

FSHPE 01
FSHPE 02
FSHPE 03
FSHPE 04
FSHPE 05
FSHPE 06
FSHPE 07
FSHPE 08
FSHPE 09
FSHPE 10
FSHPE 11
FSHPE 12
FSHPE 13
FSHPE 14
FSHPE 15
FSHPE 16
FSHPE 17
FSHPE 18

```

X 9.036, 7.907, 7.155, 6.638, 5.946, 4.955,11.508,10.882,10.269, FSHPE 19
X 9.322, 8.286, 7.271, 6.676, 6.129, 5.411, 4.425,11.373,10.577, FSHPE 20
X 9.879, 9.033, 7.885, 6.852, 6.254, 5.636, 4.928, 4.087,11.594, FSHPE 21
X10.819,10.164, 9.435, 8.231, 6.994, 6.215, 5.515, 4.770, 3.989, FSHPE 22
X11.801,11.155,10.598, 9.910, 8.778, 7.400, 6.447, 5.598, 4.728, FSHPE 23
X 3.895,11.769,11.214,10.719,10.028, 9.072, 7.724, 6.680, 5.678, FSHPE 24
X 4.660, 3.815,11.560,10.998,10.480, 9.774, 8.949, 7.782, 6.792, FSHPE 25
X 5.734, 4.713, 4.037,11.494,10.892,10.294, 9.567, 8.650, 7.631, FSHPE 26
X 6.749, 5.839, 5.104, 4.677,11.604,11.054,10.466, 9.759, 8.689, FSHPE 27
X 7.554, 6.725, 6.098, 5.661, 5.379,11.612,11.084,10.567, 9.850, FSHPE 28
X 8.870, 7.654, 6.861, 6.395, 6.103, 5.905,11.422,10.844,10.334, FSHPE 29
X 9.598, 3.789, 7.730, 6.996, 6.547, 6.316, 6.173,11.228,10.464/ FSHPE 30
DATA ( CPMK(I), I = 173, 240 ) / FSHPE 31
X 9.840, 9.075, 8.437, 7.638, 7.015, 6.499, 6.259, 6.127,11.188, FSHPE 32
X10.233, 9.400, 8.574, 7.979, 7.430, 6.895, 6.304, 5.945, 5.719, FSHPE 33
X11.259,10.153, 9.218, 8.322, 7.646, 7.200, 6.752, 6.130, 5.562, FSHPE 34
X 5.006,11.302,10.119, 9.177, 8.273, 7.533, 7.037, 6.633, 6.031, FSHPE 35
X 5.282, 4.313,11.280,10.107, 9.148, 8.270, 7.510, 6.948, 6.485, FSHPE 36
X 5.862, 5.028, 3.874,11.209,10.110, 9.161, 8.282, 7.527, 6.878, FSHPE 37
X 6.328, 5.591, 4.702, 3.472,11.132,10.125, 9.197, 8.265, 7.536, FSHPE 38
X 6.872, 6.235, 5.376, 4.425, 3.238/ FSHPE 39
DATA ( CPMW(I), I = 1, 172 ) / FSHPE 40
X .246, -.440, -.105, .012, 1.228, -.273, -.175, -.196, -.196, FSHPE 41
X .185, .185, -.393, -.020, .048, 1.106, -.202, -.207, -.274, FSHPE 42
X -.274, .155, .155, .017, -.767, .635, .870, .036, -.457, FSHPE 43
X -.262, -.262, -.089, -.089, .214,-1.494, .638, 1.242, .297, FSHPE 44
X -.638, -.265, -.265, -.053, -.053, -.242,-1.100, -.699, 1.987, FSHPE 45
X .713, -.673, -.311, -.311, .045, .045, -.959, -.142,-1.495, FSHPE 46
X 1.753, 1.085, -.659, -.480, -.480, .101, .101,-1.404, .368, FSHPE 47
X-1.221, 1.613, .686, -.654, -.812, -.812, .322, .322,-1.417, FSHPE 48
X .103, -.394, 1.791, -.150, -.448, -.751, -.751, .386, .386, FSHPE 49
X -.386,-1.168, .308, 1.749, -.480, -.134, -.394, -.394, .359, FSHPE 50
X .359, .087,-1.859, -.129, 1.861, -.123, -.123, -.090, -.090, FSHPE 51
X .329, .329, -.246,-1.404,-1.111, 1.968, -.063, -.097, .134, FSHPE 52
X .134, .345, .345, -.762, -.383,-1.875, 1.721, -.231, -.148, FSHPE 53
X .577, .577, .307, .307, -.859, .175,-1.702, 1.263, -.586, FSHPE 54
X .024, 1.078, 1.078, .091, .091, -.396, -.532, -.462, .771, FSHPE 55
X -.458, .598, .844, .844, -.101, -.101, -.104,-1.348, -.208, FSHPE 56
X 1.163, .359, .567, .374, .374, .176, .176, -.696, -.549, FSHPE 57
X-1.233, 1.785, .726, .454, .202, .202, .429, .429,-1.079, FSHPE 58
X .344,-1.446, 1.498, .575, .682, .136, .136, .633, .633/ FSHPE 59
DATA ( CPMW(I), I = 173, 240 ) / FSHPE 60
X -.974, 1.033,-1.142, .999, -.094, 1.072, .128, .128, .456, FSHPE 61
X .456, -.349, 1.034, -.139, .222, -.518, .983, .221, .221, FSHPE 62
X .572, .572, -.168, .720, .725, .006, -.788, .422, -.050, FSHPE 63
X -.050, .790, .790, -.172, .501, .740, .379, -.815, -.217, FSHPE 64
X -.646, -.646, .658, .658, .082, .290, .610, .389, -.613, FSHPE 65
X -.448, -.918, -.918, .465, .465, .046, .437, .165, .564, FSHPE 66
X -.852, -.116,-1.051,-1.051, .314, .314, -.319, .890, -.054, FSHPE 67
X .361, -.977, .066, -.751, -.751/ FSHPE 68
125 AA = ALOG( T ) FSHPE 69
DO 130 J = 1, NFK FSHPE 70
CALL _SPLIN2 ( CPMT, CPMK(1,J), KNOTS, CPMW(1,J), AA, TEMP ) FSHPE 71
130 FY(J) = EXP( TEMP(1) ) FSHPE 72
CALL SPLIN1 ( FX, FY, NFK, FW, TEMP, 2, 1.0, 1.0 ) FSHPE 73
RETURN FSHPE 74
END FSHPE 75

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SUBROUTINE READ HP (ID, LST, JOB)	READ	01
COMMON /DATA/ N, X(1030), Y(1030), DUM(10)	READ	02
DIMENSION ID(1), IH(10), IC(10), JOB(1)	READ	03
DATA (IH(I),I=1,10)/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/	READ	04
DATA ZERO/1.E-6/, SPACE/1.E6/, FOLD/9.85E5/	READ	05
LOGICAL LIST	READ	06
1 FORMAT(10A8)	READ	07
2 FORMAT(1X, I4, 1X, 10F6.0, 6X, A8)	READ	08
3 FORMAT(1H1,10A8 // 3X, 4H IND, 8X, 10A10)	READ	09
4 FORMAT(1H)	READ	10
5 FORMAT(1X, I6, 10I10, 4X, A8)	READ	11
6 FORMAT(16X, 10A8 / 86X3A10 * SERIAL* I3)	READ	12
7 FORMAT(/* COUNT TIME * F7.0,6X* DEAD TIME * F7.0	READ	13
X /* ZERO ENERGY AT * F7.0,6X * CHANNEL FOR CS-137 * F7.0	READ	14
X /* MINIMUM CHANNEL * F7.0,6X * MAXIMUM CHANNEL * F7.0)	READ	15
LIST = .FALSE.	READ	16
IF (LST .GT. 1) LIST = .TRUE.	READ	17
READ(10,1) (ID(I), I = 1, 10)	READ	18
IF (LIST) WRITE (9,3) (ID(I), I=1,10), IH	READ	19
N = 0	READ	20
NG = 0	READ	21
IL = 0	READ	22
READ(10,2) II, DUM, IE	READ	23
GO TO 120	READ	24
110 READ(10,2) II, DUM, IE	READ	25
IF (II .LT. 1) GO TO 180	READ	26
120 K2 = (II/10 + 1) * 10 - II	READ	27
DO 130 I = 1, K2	READ	28
JJ = II - 1 + I	READ	29
IF (JJ .GT. 1023 .OR. N .GT. 1024) GO TO 135	READ	30
N = N + 1	READ	31
X(N) = JJ	READ	32
Y(N) = DUM(I)	READ	33
130 IF (DUM(I) .GT. FOLD) Y(N) = DUM(I) - SPACE	READ	34
135 IF (.NOT. LIST) GO TO 110	READ	35
DO 140 I = 1, 10	READ	36
140 IC(I) = DUM(I) + ZERO	READ	37
IF (NG .NE. 5) GO TO 150	READ	38
WRITE(9,3) (ID(I), I=1,10), IH	READ	39
NG = 6	READ	40
150 IF (IL .LT. 10) GO TO 160	READ	41
WRITE(9,4)	READ	42
IL = 0	READ	43
160 WRITE(9,5) II, (IC(I), I = 1, 10), IE	READ	44
IL = IL + 1	READ	45
IF (IL .EQ. 10) NG = NG + 1	READ	46
GO TO 110	READ	47
180 IF (DUM(6) .LE. ZERO) DUM(6) = 1000.0	READ	48
IF (DUM(1) .LE. 0.0) DUM(1) = 1.0	READ	49
IF (LIST) WRITE(9, 7) (DUM(I), I=1,6)	READ	50
NN = N	READ	51
N = 0	READ	52
DO 190 I = 1, NN	READ	53
IF (X(I).LT.DUM(5) .OR. X(I).GT.DUM(6)) GO TO 190	READ	54
N = N + 1	READ	55
X(N) = X(I)	READ	56

	Y(N) = Y(I)	READ 57
190	CONTINUE	READ 58
	CALL GPLOT (1, N, X, Y, 38, 0)	READ 59
	CALL WLCV (60, 910, 18, 18HCOUNTS PER CHANNEL, 1)	READ 60
	CALL WLCH (896, 945, 7, 7HCHANNEL, 1)	READ 61
	CALL LINCNT (60)	READ 62
	WRITE(12,6) (ID(I), I = 1, 10), (JOB(I), I=1,4)	READ 63
	RETURN	READ 64
	END	READ 65

	SUBROUTINE BPART	BPART 01
	COMMON /DATA/ N, X(1030), Y(1030), DUM(10)	BPART 02
	COMMON /BSPLIN/ NBK, BPAR(2), BX(50), BY(50), BW(50)	BPART 03
	DIMENSION TEMP(3)	BPART 04
	SPA = DUM(1) * BPAR(2) / BPAR(1) / (DUM(4)-DUM(3))	BPART 05
	SPB = 0.662 / DUM(4)	BPART 06
	DO 110 I = 1, N	BPART 07
	EE = (X(I) - DUM(3)) * SPB	BPART 08
	CALL SPLIN2 (BX, BY, NBK, BW, EE, TEMP(2))	BPART 09
110	Y(I) = Y(I) - TEMP(1) * SPA	BPART 10
	RETURN	BPART 11
	END	BPART 12

	SUBROUTINE MATCH (NCH, NK, XK, YK, WK, PAR, ASSAY, SDEV, ID, JOB)	MATCH 01
	DIMENSION XX(1032), YY(1032), PAR(1), XK(1), YK(1), WK(1), ID(1), JOB(1)	MATCH 02
	COMMON /PAUX/ P(3), SP(3), BM(3,4), NP, EP(2), XP(50), YP(50), WP(50)	MATCH 03
	COMMON /DATA/ N, X(1030), Y(1030), DUM(10)	MATCH 04
	DIMENSION IND(2)	MATCH 05
	DATA (IND(I), I=1,2) / 9HCONVERGED, 6HFAILED /	MATCH 06
1	FORMAT(16X*ADJUSTED FIT*/ 16X10A8/ 81X2A10, A12* SERIAL* I3)	MATCH 07
2	FORMAT(1H1///1X10A8///4X4HP(1), 8X4HP(2), 8X4HP(3), 5X10HITERATIONS)	MATCH 08
3	FORMAT(/ 2X, 1PE10.2, 2E12.4, I7, 2X, A9)	MATCH 09
4	FORMAT(/4X 39HP(3) * SPLINE(P(2) * (X - P(1))))	MATCH 10
	NP = NK	MATCH 11
	EP(1) = PAR(1)	MATCH 12
	EP(2) = PAR(2)	MATCH 13
	DO 105 I = 1, NK	MATCH 14
	XP(I) = XK(I)	MATCH 15
	YP(I) = YK(I)	MATCH 16
105	WP(I) = WK(I)	MATCH 17
	P(1) = DUM(3)	MATCH 18
	P(2) = 0.662 / (DUM(4) - P(1))	MATCH 19
	P(3) = 1.0	MATCH 20
	WRITE(9,2) (ID(I), I = 1, 10)	MATCH 21
	WRITE(9,3) P	MATCH 22
	CALL ASSAYP (1, 2, IT, II)	MATCH 23
	WRITE(9,3) P, IT, IND(II)	MATCH 24
	CALL ASSAYP (1, 3, IT, II)	MATCH 25
	WRITE(9,3) P, IT, IND(II)	MATCH 26
	CALL ASSAYP (2, 3, IT, II)	MATCH 27

WRITE(9,3) P, IT, IND(II)	MATCH 28
CALL ASSAYP (1, 0, IT, II)	MATCH 29
WRITE(9,3) P, IT, IND(II)	MATCH 30
CALL ASSAYP (0, 0, IT, II)	MATCH 31
WRITE(9,3) P, IT, IND(II)	MATCH 32
WRITE(9,4)	MATCH 33
DUM(4) = 0.662 / P(2) + P(1)	MATCH 34
NCH = 0	MATCH 35
ASSAY = PAR(4)*PAR(3)/DUM(1)*0.662/P(2)*P(3)/PAR(5)	MATCH 36
SDEV = ASSAY*SQRT((1.0/P(2))**2*BM(2,3) + (1.0/P(3))**2*BM(3,4)	MATCH 37
X +1.0/P(2)/P(3)*BM(2,4) + (PAR(6)/PAR(4))**2)	MATCH 38
DO 110 I = 1, N	MATCH 39
X(I) = (X(I) - P(1)) * P(2)	MATCH 40
IF (X(I) .LT. PAR(1) .OR. X(I) .GT. PAR(2)) GO TO 110	MATCH 41
NCH = NCH + 1	MATCH 42
XX(NCH) = X(I)	MATCH 43
YY(NCH) = Y(I)	MATCH 44
110 CONTINUE	MATCH 45
CALL G PLOT (1, NCH, XX, YY, 38, 0)	MATCH 46
XMIN = XX(1)	MATCH 47
XMAX = XX(1)	MATCH 48
DO 120 I = 1, NCH	MATCH 49
120 IF (XX(I) .GT. XMAX) XMAX = XX(I)	MATCH 50
IF (XX(I) .LT. XMIN) XMIN = XX(I)	MATCH 51
DD = (XMAX - XMIN) / 101.0	MATCH 52
XX(1) = XMIN	MATCH 53
DO 125 I = 1, 101	MATCH 54
CALL SPLIN2 (XK, YK, NK, WK, XX(I), YY(I))	MATCH 55
YY(I) = YY(I) * P(3)	MATCH 56
125 XX(I+1) = XX(I) + DD	MATCH 57
CALL G PLOT (20, 101, XX, YY, 48, 1)	MATCH 58
CALL WLCH (896, 945, 7, 7H M E V, 1)	MATCH 59
CALL WLCV (60, 910, 18, 18HCOUNTS PER CHANNEL, 1)	MATCH 60
CALL LINCNT (60)	MATCH 61
WRITE(12,1) (ID(I), I=1, 10), (JOB(I), I=1, 4)	MATCH 62
RETURN	MATCH 63
END	MATCH 64

SUBROUTINE ASSAYP (IX1, IX2, IT, IND)	ASAYP 01
C PARAMETER ADJUSTING SUBROUTINE MODIFIED ESPECIALLY FOR ASSAY	ASAYP 02
COMMON /DATA/ N, X(1030), Y(1030), DUM(10)	ASAYP 03
COMMON /PAUX/ P(3), SP(3), BM(3,4), NP, EP(2), XP(50), YP(50), WP(50)	ASAYP 04
DIMENSION DYDP(3), AN(3), TMP(100), IX(2), W(1030), AM(3,3), DY(1030)	ASAYP 05
LOGICAL NOFIX, DONE, KLT2	ASAYP 06
DATA H/1.0/, TEST/0.000001/	ASAYP 07
C	ASAYP 08
100 DONE=.FALSE.	ASAYP 09
IM = 0	ASAYP 10
IF (IX1 .LT. 1) GO TO 105	ASAYP 11
IM = 1	ASAYP 12
IX(1) = IX1	ASAYP 13
105 IF (IX2 .LT. 1) GO TO 110	ASAYP 14
IM = IM + 1	ASAYP 15
IX(IM) = IX2	ASAYP 16
110 K = 3 - IM	ASAYP 17
NOFIX=IM.LT.1	ASAYP 18

KLT2=K.LT.2	ASAYP 19
IT=0	ASAYP 20
IND = 1	ASAYP 21
KP=K+1	ASAYP 22
150 IT=IT+1	ASAYP 23
DO160 I=1,3	ASAYP 24
DO160 J=1,4	ASAYP 25
IF(J.LT.KP)AM(I,J)=0.0	ASAYP 26
IF(I+1.EQ.J)GOTO155	ASAYP 27
BM(I,J)=0.0	ASAYP 28
GOTO160	ASAYP 29
155 BM(I,J)=1.0	ASAYP 30
160 CONTINUE	ASAYP 31
DUM(5) = EP(1) / P(2) + P(1)	ASAYP 32
DUM(6) = EP(2) / P(2) + P(1)	ASAYP 33
DO 180 I = 1, N	ASAYP 34
W(I) = Y(I)	ASAYP 35
180 IF (X(I).LT.DUM(5) .OR. X(I).GT.DUM(6)) W(I) = 0.0	ASAYP 36
200 DO230 L=1,N	ASAYP 37
ARG = (X(L) - P(1)) * P(2)	ASAYP 38
CALL SPLIN2 (XP, YP, NP, WP, ARG, TMP)	ASAYP 39
DYDP(1) = - TMP(2) * P(2) * P(3)	ASAYP 40
DYDP(2) = TMP(2) * (X(L)-P(1)) * P(3)	ASAYP 41
DYDP(3) = TMP(1)	ASAYP 42
DY(L) = Y(L) - TMP(1) * P(3)	ASAYP 43
J = 0	ASAYP 44
DO215 JUK=1,3	ASAYP 45
IF(NOFIX)GOTO 210	ASAYP 46
DO205 JOKE=1,IM	ASAYP 47
205 IF(JUK.EQ.IX(JOKE))GOTO215	ASAYP 48
210 J = J + 1	ASAYP 49
AN(J) = DYDP(JUK)	ASAYP 50
215 CONTINUE	ASAYP 51
DO225 I=1,K	ASAYP 52
DO 225 J=I,KP	ASAYP 53
IF(J.EQ.KP)GOTO 220	ASAYP 54
AM(I,J)=AM(I,J)+AN(I)*AN(J)*W(L)	ASAYP 55
GO TO 225	ASAYP 56
220 BM(I,1)=BM(I,1)+AN(I)*DY(L)*W(L)	ASAYP 57
225 CONTINUE	ASAYP 58
230 CONTINUE	ASAYP 59
AM(2,1) = AM(1,2)	ASAYP 60
AM(3,1) = AM(1,3)	ASAYP 61
AM(3,2) = AM(2,3)	ASAYP 62
300 IF (KLT2) GO TO 305	ASAYP 63
CALL LSS (K, KP, 3, AM, BM, TMP, DET)	ASAYP 64
GOTO310	ASAYP 65
305 BM(1,1) = BM(1,1)/AM(1,1)	ASAYP 66
BM(1,2) = 1.0/AM(1,1)	ASAYP 67
310 J = 0	ASAYP 68
DO 330 I=1,3	ASAYP 69
IF(NOFIX)GOTO 320	ASAYP 70
DO315 JOKE=1,IM	ASAYP 71
315 IF(I.EQ.IX(JOKE))GOTO330	ASAYP 72
320 J = J + 1	ASAYP 73
IF (ABS (TEST * P(I)) .LT. ABS(BM(J,1))) GO TO 325	ASAYP 74
DONE = .TRUE.	ASAYP 75
325 P(I) = P(I) + H * BM(J,1)	ASAYP 76
330 CONTINUE	ASAYP 77
400 IF (.NOT. DONE .AND. IT .LT. 25) GO TO 150	ASAYP 78

IF (.NOT. DONE) IND = 2	ASAYP 79
IF (IM .GT. 1) GO TO 425	ASAYP 80
VAR = 0.0	ASAYP 81
WVAR = 0.0	ASAYP 82
IF (N .LT. 4) GO TO 410	ASAYP 83
DO 405 L = 1, N	ASAYP 84
405 VAR = VAR + W(L) * DY(L) ** 2	ASAYP 85
WVAR = VAR / FLOAT(N-3)	ASAYP 86
410 DO 420 I = 1,3	ASAYP 87
DO 415 J = 2, 4	ASAYP 88
415 BM(I,J) =BM(I,J) * WVAR	ASAYP 89
420 SP(I) = SQRT (BM(I,I+1))	ASAYP 90
425 RETURN	ASAYP 91
END	ASAYP 92

SUBROUTINE SPLIN1(X,F,N,W,G,IND,XM1,XMN)	SPLN1 1
DIMENSION X(1),F(1),W(1),G(1)	SPLN1 2
GO TO (15,16,200),IND	SPLN1 3
15 W(1) =(X(2)-X(1))/3.	SPLN1 4
G(1) =((F(2)-F(1))/(X(2)-X(1))-XM1)/W(1)	SPLN1 5
NDIC =1	SPLN1 6
GO TO 17	SPLN1 7
16 W(2) =((X(2)-X(1))*(1.+XM1/2.))+X(3)-X(2))/3.	SPLN1 8
G(2) =((F(3)-F(2))/(X(3)-X(2))-(F(2)-F(1))/(X(2)-X(1)))/W(2)	SPLN1 9
NDIC =2	SPLN1 10
GO TO 17	SPLN1 11
200 G(1)=XM1	SPLN1 12
W(1)=1.	SPLN1 13
W(2) =(X(3)-X(1))/3.	SPLN1 14
G(2) =((F(3)-F(2))/(X(3)-X(2))-(F(2)-F(1))/(X(2)-X(1))	SPLN1 15
1-(X(2)-X(1))/6.*G(1))/W(2)	SPLN1 16
NDIC =2	SPLN1 17
17 K =N-NDIC	SPLN1 18
J =NDIC+1	SPLN1 19
30 DO 165 I=J,K	SPLN1 20
W(I) =(X(I+1)-X(I-1))/3.-((X(I)-X(I-1))**2.)/36./W(I-1)	SPLN1 21
165 G(I) =((F(I+1)-F(I))/(X(I+1)-X(I))-(F(I)-F(I-1))/(X(I)-X(I-1))	SPLN1 22
1-(X(I)-X(I-1))/6.*G(I-1))/W(I)	SPLN1 23
GO TO (53,54,55),IND	SPLN1 24
53 W(N) =(X(N)-X(N-1))/3.*(1.-(X(N)-X(N-1))/12./W(N-1))	SPLN1 25
W(N) =(XMN-(F(N)-F(N-1))/(X(N)-X(N-1))-(X(N)-X(N-1))*G(N-1)/6.	SPLN1 26
1)/W(N)	SPLN1 27
GO TO 18	SPLN1 28
54 W(N-1) =((X(N)-X(N-1))*(1.+XMN/2.))+X(N-1)-X(N-2))/3.	SPLN1 29
1-(X(N-1)-X(N-2))/36.*(X(N-1)-X(N-2))/W(N-2)	SPLN1 30
W(N-1) =((F(N)-F(N-1))/(X(N)-X(N-1))-(F(N-1)-F(N-2))/(X(N-1)-X(N-2)	SPLN1 31
1)-(X(N-1)-X(N-2))/6.*G(N-2))/W(N-1)	SPLN1 32
GO TO 18	SPLN1 33
55 IF(NDIC-1)60,60,56	SPLN1 34
56 J =N-1	SPLN1 35
K =N-1	SPLN1 36
NDIC =1	SPLN1 37
GO TO 30	SPLN1 38
60 G(N)=1.	SPLN1 39
W(N)=XMN	SPLN1 40
18 I =N-NDIC	SPLN1 41

19	K=2*NDIC	SPLN1	42
20	DO 156 J=K,N	SPLN1	43
	W(I) =G(I)-(X(I+1)-X(I))/W(I)* W(I+1)/6.	SPLN1	44
156	I=I-1	SPLN1	45
	GO TO(22,52,57),IND	SPLN1	46
57	W(1)=XM1	SPLN1	47
	GO TO 22	SPLN1	48
52	W(1) =XM1*W(2)	SPLN1	49
	W(N) =XMN*W(N-1)	SPLN1	50
22	RETURN	SPLN1	51
	END	SPLN1	52

	SUBROUTINE SPLIN2(X,F,N,W,Y,TAB)	SPLN2	01
	DIMENSION X(N),F(N),W(N),TAB(3)	SPLN2	02
	DATA T/0.333333333/	SPLN2	03
	IF (N .LT. 2) GO TO 80	SPLN2	04
	I = 1	SPLN2	05
	K = N	SPLN2	06
10	J = (I + K) / 2	SPLN2	07
	IF (I .EQ. J) GO TO 70	SPLN2	08
	IF (X(J) .LT. Y) GO TO 20	SPLN2	09
	K = J	SPLN2	10
	GO TO 10	SPLN2	11
20	I = J	SPLN2	12
	GO TO 10	SPLN2	13
70	EL = X(K) - X(I)	SPLN2	14
	DX1 = X(K) - Y	SPLN2	15
	REL = 1.0 / EL	SPLN2	16
	EL = EL * 0.1666666666666667	SPLN2	17
	DX2 = Y - X(I)	SPLN2	18
	F1 = DX1 * W(I) * REL	SPLN2	19
	F2 = DX2 * W(K) * REL	SPLN2	20
	TAB(3) =F1+F2	SPLN2	21
	F3 = -F1 * 0.5 * DX1	SPLN2	22
	F4 = F2 * 0.5 * DX2	SPLN2	23
	F5 = F(I) *REL - EL * W(I)	SPLN2	24
	F6 = F(K) *REL - EL * W(K)	SPLN2	25
	TAB(2)=F3+F4-F5+F6	SPLN2	26
	TAB(1) = (F5 - F3 * T) * DX1 + (F6 + F4 * T) * DX2	SPLN2	27
	RETURN	SPLN2	28
80	TAB(1) = F(1)	SPLN2	29
	TAB(2) = 0.0	SPLN2	30
	TAB(3) = 0.0	SPLN2	31
	RETURN	SPLN2	32
	END	SPLN2	33

APPENDIX C
SUBROUTINE GPLOT

This is a general subroutine developed by the author to plot on film. It became incorporated naturally into the ASSAY program, and therefore a listing and brochure are included for convenience to the reader.

Purpose

The subroutine will draw a suitably scaled rectangular grid and plot N points on film to any combination of log and linear scales. The controlling program can either assign axial boundary values or let the subroutine determine them for optimum use of the plotting space. Several sets of points can be plotted on one grid.

Usage

CALL GPLOT (IOP, N, X, Y, ICHAR, ICON)
where IOP \leq 1 plots linear-linear,
 = 2 plots linear-log,
 = 3 plots log-linear,
 = 4 to 9 plots log-log;
add 10 for new plot with previously used
 boundaries,
 20 to plot another set of points on the
 previous plot;
 = 30 means to find the ranges of coordi-
 nate values;
N = number of points to be plotted;
X and Y are the single-indexed coordinates of
 the points;
ICHR is the decimal integer code for the plot-
 ting symbol;
ICON = 0 means do not connect the points,
 = 1 means connect the points.

General Information

By making appropriate use of IOP, the program-
mer can also plot several sets of points on one
grid, or on separate but identical grids, or plot
points without a grid. A simplified flow chart is
included as a quick guide in Fig. C-1.

The four interdependent task assignments (TA)
for which the subroutine can be employed are indi-
cated by the tens digit of IOP.

TA-1 ($0 \leq$ IOP \leq 9) will advance the film one
frame, adjust boundary values for best use of the
plotting area, draw and scale a grid, and plot N
points. The frame is left in readiness for additio-
nal plots via TA-3, writing on film, etc. See the
template in Fig. C-2. The boundary values will be
determined by the results from TA-4 only if TA-1 is
assigned next after TA-4.

TA-2 ($10 \leq$ IOP \leq 19) differs from TA-1 only in
that the boundary values previously stored in the
subroutine memory will be used. The programmer can
plot various sets of points on several identical
grids by successive re-entry with TA-2 and choosing
the same plotting mode each time.

TA-3 ($20 \leq$ IOP \leq 29) will plot an additional set
of points on the existing frame if it follows TA-1,
-2, or -3, and the units digit of IOP will be ignor-
ed. On entry next after TA-4, the points will be
plotted on a new frame with a grid and scaling sub-
ject to the results from TA-4, and the units digit
of IOP will be observed, as if entered with TA-1.

TA-4 ($30 \leq$ IOP) will select and retain maximum
and minimum coordinate values without plotting. An
unbroken succession of entries with TA-4 for several
sets of points will adjust the values to accomodate
all the sets. These values will be used on first
entry with any other TA and then forgotten.

Whenever a point with a zero or negative coordi-
nate value appears, the subroutine will generally
veto a log scale request and program a linear scale
for that coordinate. An exception can occur with
TA-3 after TA-1, -2, or -3 without the benefit of
results from TA-4, and which would lead to a job
abort.

Points falling outside the outer boundary will
be plotted on that boundary.

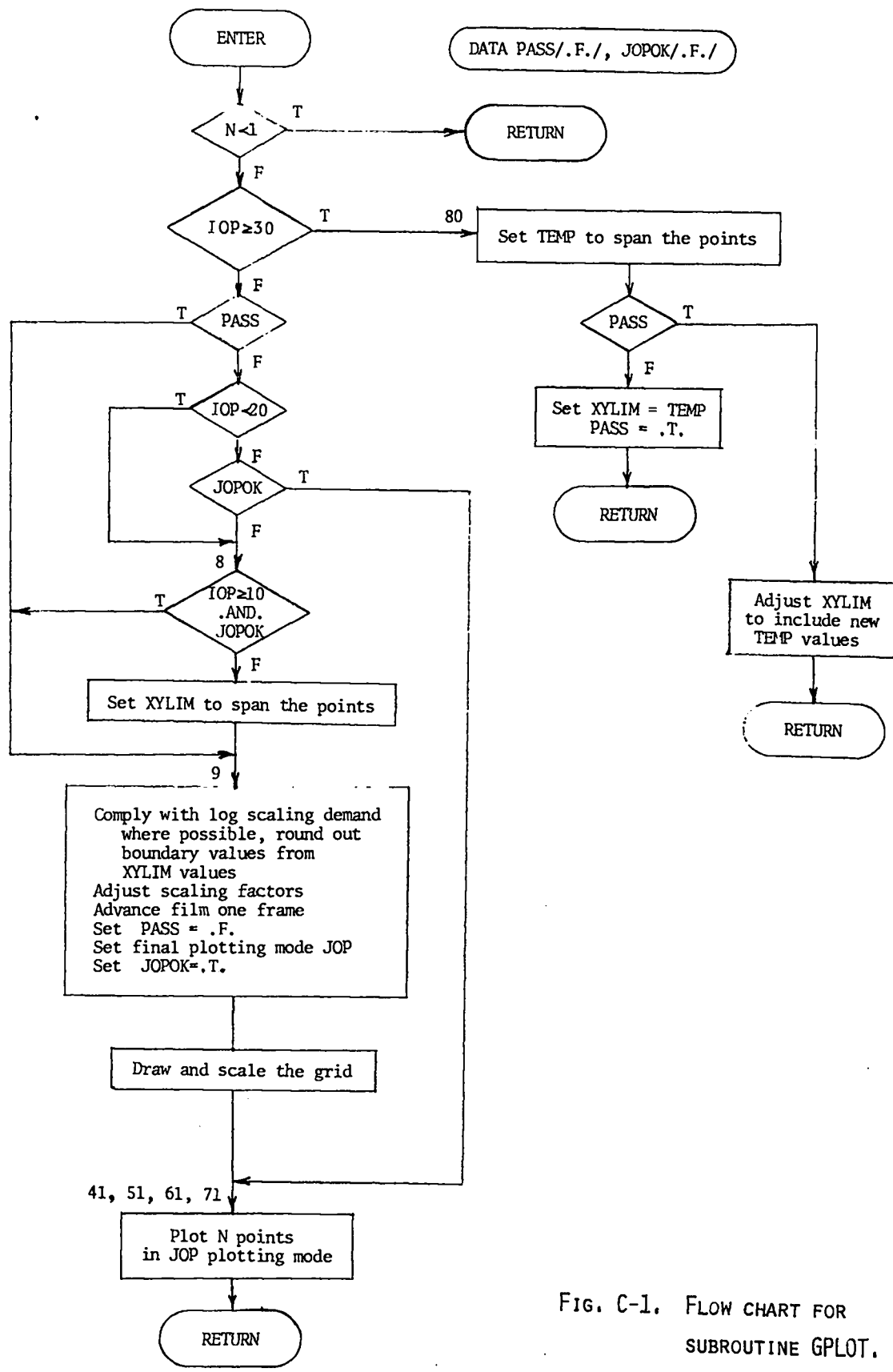


FIG. C-1. FLOW CHART FOR SUBROUTINE GPLOT.

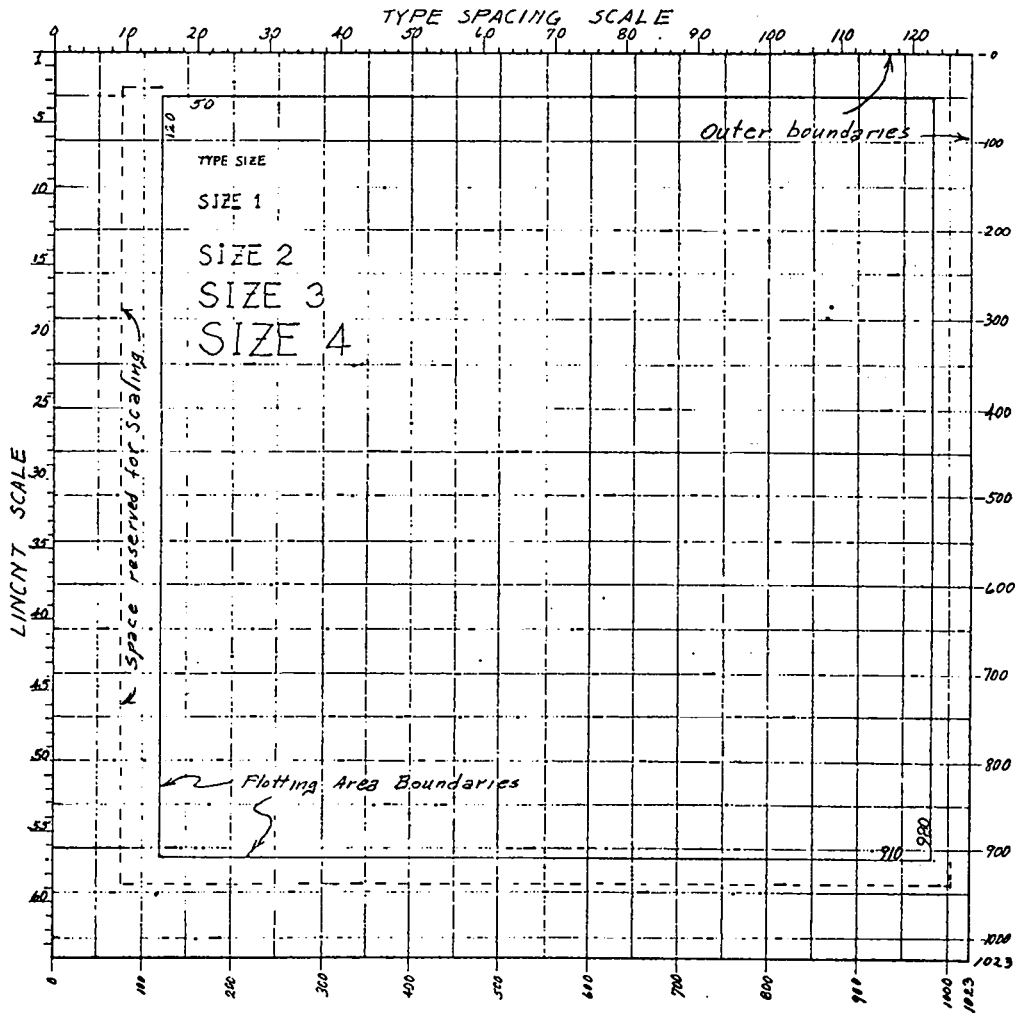


Fig. C-2. Template for additions to a film plot.

```

SUBROUTINE GPLOT ( IOP, N, X, Y, ICHAR, ICON )
GPLOT -- GENERAL PLOTTING SUBROUTINE F4 VERSION DEC. 1, 1966
THE SIX ASSOCIATED SUBROUTINES ARE
1. GPLOTA, FOR MAXIMUM AND MINIMUM VALUES OF COORDINATE
2. GPLOTB, TO ROUND OUT LOGARITHMS OF THE PLOTTING LIMITS
3. GPLOTG, TO ROUND OUT THE LINEAR PLOTTING LIMITS
4. GPLOTD, TO DRAW AND LABEL THE GRID
5. GPLOTE, TO KEEP THE PLOTTING POINT WITHIN THE OUTER FRAME
6. GPLOTF, TO INSCRIBE A LOGARITHMIC SCALING
ALL THE OTHER SUBROUTINES ARE CONTAINED IN THE LA-FLM1 PACKAGE.
DIMENSION X(N), Y(N), XYLIM(4), TEMP(4)
LOGICAL PXLIN, PYLIN, PASS, JOPOK
DATA PASS/.FALSE./, JOPOK/.FALSE./
DATA IXL/120/, IXR/980/, IYT/50/, IYB/910/
IF ( N .LT. 1 ) RETURN
IF ( IOP .GE. 30 ) GO TO 80
IF ( PASS ) GO TO 9
IF ( IOP .LT. 20 ) GO TO 8
IF ( JOPOK ) GO TO ( 41, 51, 61, 71 ), JOP
8 IF ( IOP .GE. 10 .AND. JOPOK ) GO TO 9
CALLGPLOTA(N,X,XYLIM(1),XYLIM(2))
CALLGPLOTA(N,Y,XYLIM(3),XYLIM(4))
9 JOP = IOP - ( IOP/10 ) * 10
10 PXLIN=.TRUE.
PYLIN=.TRUE.
IF(JOP.GT.2)PXLIN=.FALSE.
IF(JOP.EQ.2.OR.JOP.GT.3)PYLIN=.FALSE.
12 IF(PXLIN)GOTO14
IF(XYLIM(1).LE.0.0)GOTO13
CALLGPLOTB(XYLIM(2),XYLIM(1),XR,XL,JX)
GOTO22
13 PXLIN=.TRUE.
14 CALLGPLOTG(XYLIM(2),XYLIM(1),XR,XL,NX,KX,JX)
22 IF(PYLIN)GOTO24
IF(XYLIM(3).LE.0.0)GOTO23
CALLGPLOTB(XYLIM(4),XYLIM(3),YT,YB,JY)
GOTO30
23 PYLIN=.TRUE.
24 CALLGPLOTG(XYLIM(4),XYLIM(3),YT,YB,NY,KY,JY)
30 IF ( JOPOK ) GO TO 32
SPANX = FLOAT( IXR - IXL )
SPANY = FLOAT( IYB - IYT )
BIASX = FLOAT( IXL ) + 0.4995
BIASY = FLOAT( IYT ) + 0.4995
32 AX = SPANX / ( XR - XL )
AY = SPANY / ( YT - YB )
CALLADV(1)
PASS = .FALSE.
JOP=4
IF(PXLIN)JOP=2
IF(PYLIN)JOP=JOP-1
JOPOK = .TRUE.
CALL DGA (IXL,IXR,IYT,IYB,XL,XR,YT,YB )
CALL GPLOTD (IXL,IXR,IYT,IYB,XL,XR,YT,YB,JOP,NX,KX,NY,KY,JX,JY)
GOTO(41,51,61,71),JOP
41 NN = N
IF(ICON.GT.0)NN=1
DO 42 I = 1, NN
IX = BIASX + AX * ( X(I) - XL )
IY = BIASY + AY * ( YT - Y(I) )

```


CALL GPLOTE (IX, IY)	GPLOT061
42 CALL PLT(IX, IY, ICHAR)	GPLOT062
IF (NN .EQ. N) RETURN	GPLOT063
DO 43 I = 2, N	GPLOT064
IIX = IX	GPLOT065
IIY = IY	GPLOT066
IX = BIASX + AX * (X(I) - XL)	GPLOT067
IY = BIASY + AY * (YT - Y(I))	GPLOT068
CALL GPLOTE (IX, IY)	GPLOT069
CALL PLT(IX, IY, ICHAR)	GPLOT070
43 CALL DRV(IIX, IIY, IX, IY)	GPLOT071
RETURN	GPLOT072
51 NN=N	GPLOT073
IF(ICON.GT.0)NN=1	GPLOT074
DO52I=1,NN	GPLOT075
IX = BIASX + AX * (X(I) - XL)	GPLOT076
IY = BIASY + AY * (YT - ALOG10(Y(I)))	GPLOT077
CALL GPLOTE (IX, IY)	GPLOT078
52 CALLPLT(IX,IY,ICHR)	GPLOT079
IF (NN .EQ. N) RETURN	GPLOT080
DO53I=2,N	GPLOT081
IIX=IX	GPLOT082
IIY=IY	GPLOT083
IX = BIASX + AX * (X(I) - XL)	GPLOT084
IY = BIASY + AY * (YT - ALOG10(Y(I)))	GPLOT085
CALL GPLOTE (IX, IY)	GPLOT086
CALLPLT(IX,IY,ICHR)	GPLOT087
53 CALLDRV(IIX,IIY,IX,IY)	GPLOT088
RETURN	GPLOT089
61 NN=N	GPLOT090
IF(ICON.GT.0)NN=1	GPLOT091
DO62I=1,NN	GPLOT092
IX = BIASX + AX * (ALOG10(X(I)) - XL)	GPLOT093
IY = BIASY + AY * (YT - Y(I))	GPLOT094
CALL GPLOTE (IX, IY)	GPLOT095
62 CALLPLT(IX,IY,ICHR)	GPLOT096
IF (NN .EQ. N) RETURN	GPLOT097
DO63I=2,N	GPLOT098
IIX=IX	GPLOT099
IIY=IY	GPLOT100
IX = BIASX + AX * (ALOG10(X(I)) - XL)	GPLOT101
IY = BIASY + AY * (YT - Y(I))	GPLOT102
CALL GPLOTE (IX, IY)	GPLOT103
CALLPLT(IX,IY,ICHR)	GPLOT104
63 CALLDRV(IIX,IIY,IX,IY)	GPLOT105
RETURN	GPLOT106
71 NN=N	GPLOT107
IF(ICON.GT.0)NN=1	GPLOT108
DO72I=1,NN	GPLOT109
IX = BIASX + AX * (ALOG10(X(I)) - XL)	GPLOT110
IY = BIASY + AY * (YT - ALOG10(Y(I)))	GPLOT111
CALL GPLOTE (IX, IY)	GPLOT112
72 CALLPLT(IX,IY,ICHR)	GPLOT113
IF (NN .EQ. N) RETURN	GPLOT114
DO73I=2,N	GPLOT115
IIX=IX	GPLOT116
IIY=IY	GPLOT117
IX = BIASX + AX * (ALOG10(X(I)) - XL)	GPLOT118
IY = BIASY + AY * (YT - ALOG10(Y(I)))	GPLOT119
CALL GPLOTE (IX, IY)	GPLOT120

CALLPLT(IX,IY,ICHR)	GPLOT121
73 CALLDRV(IIX,IY,IX,IY)	GPLOT122
RETURN	GPLOT123
80 CALL GPLOTA (N, X, TEMP(1), TEMP(2))	GPLOT124
CALL GPLOTA (N, Y, TEMP(3), TEMP(4))	GPLOT125
IF (PASS) GO TO 82	GPLOT126
DO 81 I = 1, 4	GPLOT127
81 XYLIM(I) = TEMP(I)	GPLOT128
PASS = .TRUE.	GPLOT129
RETURN	GPLOT130
82 DO 83 I = 1, 3, 2	GPLOT131
IF (TEMP(I) .LT. XYLIM(I)) XYLIM(I) = TEMP(I)	GPLOT132
83 IF (TEMP(I+1) .GT. XYLIM(I+1)) XYLIM(I+1) = TEMP(I+1)	GPLOT133
RETURN	GPLOT134
END	GPLOT135

SUBROUTINE GPLOTA (N, X, XMIN, XMAX)	GPLTA001
DIMENSION X(N)	GPLTA002
XMIN=X(1)	GPLTA003
XMAX=X(1)	GPLTA004
DO2I=1,N	GPLTA005
IF(X(I).GE.XMIN)GOTO1	GPLTA006
XMIN=X(I)	GPLTA007
GOTO2	GPLTA008
1 IF(X(I).GT.XMAX)XMAX=X(I)	GPLTA009
2 CONTINUE	GPLTA010
RETURN	GPLTA011
END	GPLTA012

SUBROUTINE GPLOTB (XRR, XLL, XR, XL, J)	GPLTB001
IF (XRR .LT. XLL) GO TO 4	GPLTB002
1 C = 0.9999	GPLTB003
IF (XRR .LT. 1.0) C = -0.0001	GPLTB004
TR= ALOG10(XRR)	GPLTB005
J = TR+ C	GPLTB006
XR=J	GPLTB007
C = 0.0001	GPLTB008
IF (XLL .LT. 1.0) C = -0.9999	GPLTB009
T = ALOG10(XLL)	GPLTB010
J = T + C	GPLTB011
XL=J	GPLTB012
IF (XR - XL .GT. 4.0) GO TO 3	GPLTB013
IF (XR - TR .LE. 0.522878) GO TO 2	GPLTB014
XR=XR-0.522878	GPLTB015
2 IF(T-XL.LE.0.477121)GOTO3	GPLTB016
XL=XL+0.477121	GPLTB017
3 IF(XR-XL.GT.25.0)XL=XR-25.0	GPLTB018
IF (XR .LT. XL + 0.0001) XR = XL + 0.477122	GPLTB019
RETURN	GPLTB020
4 T=XRR	GPLTB021
XRR=XLL	GPLTB022
XLL=T	GPLTB023
GOTO1	GPLTB024
END	GPLTB025

	SUBROUTINE GPLTC (XRR, XLL, XR, XL, NX, K, J)	GPLTC001
	IF (XRR .LT. XLL*1.001) GO TO 7	GPLTC002
	XR = XRR	GPLTC003
1	XL = XLL	GPLTC004
	KADD = 0	GPLTC005
	T=ALOG(XR-XL)*0.434294	GPLTC006
	IF(T.LE.0.0) KADD = 1	GPLTC007
	J=T-FLOAT(KADD)	GPLTC008
	IF (T .LT. 1.0) KADD = 1	GPLTC009
	TEN=10.0**(-J+1)	GPLTC010
	IR = 0.999999 + XR * TEN	GPLTC011
	IL=XL*TEN+ 0.0000001	GPLTC012
	IF(XL.LT.0.0)GOTO5	GPLTC013
	IL=IL/5	GPLTC014
2	IR=(IR+4)/5	GPLTC015
3	NX=(IR-IL)	GPLTC016
	IF(NX.GT.10)GOTO6	GPLTC017
4	AR=IR*5	GPLTC018
	AL=IL*5	GPLTC019
	XR=AR/TEN	GPLTC020
	XL=AL/TEN	GPLTC021
	A=XR	GPLTC022
	IF(XL+XR.LT.0.0)A=-XL	GPLTC023
	K = KADD	GPLTC024
	IF(J.LE.0)K=-J+KADD	GPLTC025
	C = 0.00001	GPLTC026
	IF (A .LT. 1.0) C = -0.99999	GPLTC027
	J = ALOG10(A) + C	GPLTC028
	IF(J.LT.5.AND.K.LT.5) RETURN	GPLTC029
	K = 10 + K	GPLTC030
	IF (J .LT. 0) K = K + J	GPLTC031
	RETURN	GPLTC032
5	IL=(IL-5)/5	GPLTC033
	IF(XR.GT.0.0)GOTO2	GPLTC034
	IR=IR/5	GPLTC035
	GOTO3	GPLTC036
6	IF ((IL/2)*2 .NE. IL) IL = IL - 1	GPLTC037
	IF ((IR/2)*2 .NE. IR) IR = IR + 1	GPLTC038
	NX = (IR - IL) / 2	GPLTC039
	KADD = 0	GPLTC040
	GOTO4	GPLTC041
7	IF (XRR.LT. XLL) GO TO 9	GPLTC042
8	XR = XLL * 1.001	GPLTC043
	GOTO1	GPLTC044
9	T = XRR	GPLTC045
	XRR = XLL	GPLTC046
	XLL = T	GPLTC047
	IF (XRR .LT. XLL*1.001) GO TO 8	GPLTC048
	GO TW 1	GPLTC049
	END	GPLTC050

	SUBROUTINE GPLOTD (IXL, IXR, IYT, IYB, XL, XR, YT, YB, JOP,	GPLTD001
	X NX, KX, NY, KY, JX, JY)	GPLTD002
	DIMENSION G(80), IG(171), NG1(5), NG2(5)	GPLTD003
	DATA (G(I), I = 1, 16) /	GPLTD004
	X .00000, .07918, .14613, .20412, .25527, .30103, .39794, .47712,	GPLTD005
	X .54407, .60206, .65321, .69897, .77815, .84510, .90309, .95424/	GPLTD006
	DATA (IG(I), I = 1, 27) /	GPLTD007
	X 1,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,	GPLTD008
	X 1,1,6,8,10,12,13,14,15,16/	GPLTD009
	DATA (NG1(i), I = 1, 3) / 1, 18, 1 /	GPLTD010
	DATA (NG2(I), I = 1, 3) / 17, 27, 1 /	GPLTD011
	IF (JOP .GT. 2) GO TO 100	GPLTD012
	CALL EXL	GPLTD013
	R = FLOAT(IXR - IXL) / FLOAT (NX)	GPLTD014
	K2 = NX + 1	GPLTD015
	DO 20 LAP=1,2	GPLTD016
	X = IXL	GPLTD017
	DO 10 I = 1, K2	GPLTD018
	IX = X + 0.4999	GPLTD019
	X = X + R	GPLTD020
10	CALL GYA (IYT, IYB, IX)	GPLTD021
	IF (NX.GE.5) GOTO 30	GPLTD022
	K2 = NX*5 + 1	GPLTD023
20	R = R*0.2	GPLTD024
30	CALL EXH	GPLTD025
	CALL SBLIN (NX, KX)	GPLTD026
	GO TO 200	GPLTD027
100	CYC = XR - XL	GPLTD028
	T = JX	GPLTD029
	R = FLOAT(IXR - IXL) / CYC	GPLTD030
	NL = CYC + 1.9999	GPLTD031
	ING = 1	GPLTD032
	J = 1	GPLTD033
	IY = IYB + 20	GPLTD034
	IF (CYC .GT. 1.9) GO TO 115	GPLTD035
	K1 = NG1(2) + 2	GPLTD036
	K2 = NG2(2)	GPLTD037
	CALL EXH	GPLTD038
	TT = T	GPLTD039
	DO 111 LAP = 1, NL	GPLTD040
	DO 110 I = K1, K2	GPLTD041
	J = J + 1	GPLTD042
	K = IG(I)	GPLTD043
	X = TT+ G(K)	GPLTD044
	IF (X .LT. XL - 0.0001) GO TO 110	GPLTD045
	IF (X .GT. XR + 0.0001) GO TO 115	GPLTD046
	IX = (X - XL) * R + FLOAT(IXL) + 0.4999	GPLTD047
	CALL PLT(IX, IY, J)	GPLTD048
110	CONTINUE	GPLTD049
	J = 1	GPLTD050
111	TT = TT + 1.0	GPLTD051
115	IF (CYC .GT. 1.9) ING = 2	GPLTD052
	IF (CYC .GT. 4.1) ING = 3	GPLTD053
	K1 = NG1(ING)	GPLTD054
	K2 = NG2(ING)	GPLTD055
	DO 135 I = 1, NL	GPLTD056
	IF (T .LT. XL - 0.0001) GO TO 122	GPLTD057
	CALL EXH	GPLTD058
	IX = (T - XL) * R + FLOAT(IXL) + 0.4999	GPLTD059
	CALL GPLOTF (IX, IY, JX, 2)	GPLTD060

122	CALL EXL	GPLTD061
	DO 125 J = K1, K2	GPLTD062
	K = IG(J)	GPLTD063
	X = T + G(K)	GPLTD064
	IF (X .LT. XL - 0.0001) GO TO 125	GPLTD065
	IF (X .GT. XR + 0.0001) GO TO 200	GPLTD066
	IX = (X - XL) * R + FLOAT(IXL) + 0.4999	GPLTD067
	CALL GYA (IYT, IYB, IX)	GPLTD068
125	CONTINUE	GPLTD069
130	JX = JX + 1	GPLTD070
135	T = JX	GPLTD071
200	IF (JOP .EQ. 2 .OR. JOP .GT. 3) GO TO 300	GPLTD072
	CALL EXL	GPLTD073
	R = FLOAT(IYB - IYT) / FLOAT(NY)	GPLTD074
	K2 = NY + 1	GPLTD075
	DO 220 LAP=1,2	GPLTD076
	X = IYB	GPLTD077
	DO 210 I = 1, K2	GPLTD078
	IY = X + 0.4999	GPLTD079
	X = X - R	GPLTD080
210	CALL GXA (IXR, IXL, IY)	GPLTD081
	IF (NY.GE.5) GOTO 230	GPLTD082
	K2 = NY*5 + 1	GPLTD083
220	R = R*0.2	GPLTD084
230	CALL EXH	GPLTD085
	CALL SLLIN (NY, KY)	GPLTD086
	RETURN	GPLTD087
300	CYC = YT - YB	GPLTD088
	T = JY	GPLTD089
	R = FLOAT(IYB - IYT) / CYC	GPLTD090
	NL = CYC + 1.9999	GPLTD091
	ING = 1	GPLTD092
	J = 1	GPLTD093
	IX = IXL - 10	GPLTD094
	IF (CYC .GT. 1.9) GO TO 315	GPLTD095
	K1 = NG1(2) + 2	GPLTD096
	K2 = NG2(2)	GPLTD097
	CALL EXH	GPLTD098
	TT = T	GPLTD099
	DO 311 LAP = 1, NL	GPLTD100
	DO 310 I = K1, K2	GPLTD101
	J = J + 1	GPLTD102
	K = IG(I)	GPLTD103
	X = TT + G(K)	GPLTD104
	IF (X .LT. YB - 0.0001) GO TO 310	GPLTD105
	IF (X .GT. YT + 0.0001) GO TO 315	GPLTD106
	IY = FLOAT(IYB) + 0.4999 - (X - YB) * R	GPLTD107
	CALL PLT(IX, IY, J)	GPLTD108
310	CONTINUE	GPLTD109
	J = 1	GPLTD110
311	TT = TT + 1.0	GPLTD111
315	IF (CYC .GT. 1.9) ING = 2	GPLTD112
	IF (CYC .GT. 4.1) ING = 3	GPLTD113
	K1 = NG1(ING)	GPLTD114
	K2 = NG2(ING)	GPLTD115
	DO 335 I = 1, NL	GPLTD116
	IF (T .LT. YB - 0.0001) GO TO 322	GPLTD117
	CALL EXH	GPLTD118
	IY = FLOAT(IYB) + 0.4999 - (T - YB) * R	GPLTD119
	CALL GPLOTF (IX, IY, JY, 3)	GPLTD120

322	CALL EXL	GPLTD121
	DO 325 J = K1, K2	GPLTD122
	K = IG(J)	GPLTD123
	X = T + G(K)	GPLTD124
	IF (X .LT. YB - 0.0001) GO TO 325	GPLTD125
	IF (X .GT. YT + 0.0001) GO TO 400	GPLTD126
	IY = FLOAT(IYB) + 0.4999 - (X - YB) * R	GPLTD127
	CALL GXA (IXL, IXR, IY)	GPLTD128
325	CONTINUE	GPLTD129
330	JY = JY + 1	GPLTD130
335	T = JY	GPLTD131
400	CALL EXH	GPLTD132
	RETURN	GPLTD133
	END	GPLTD134

	SUBROUTINE GPLOTE (IX, IY)	GPLTE001
	IF (IX .LT. 0) IX = 0	GPLTE002
	IF (IX .GT. 1023) IX = 1023	GPLTE003
	IF (IY .LT. 0) IY = 0	GPLTE004
	IF (IY .GT. 1023) IY = 1023	GPLTE005
	RETURN	GPLTE006
	END	GPLTF001

	SUBROUTINE GPLOTF (IX, IY, J, IS)	GPLTF002
	IYY = IY - 12	GPLTF003
	JJ = J	GPLTF004
	M = 0	GPLTF005
	IF (J .GE. 0) GO TO 1	GPLTF006
	JJ = - J	GPLTF007
	M = 1	GPLTF008
1	K = 1	GPLTF009
	L = 10	GPLTF010
2	IF (JJ .LT. L) GO TO 3	GPLTF011
	L = L * 10	GPLTF012
	K = K + 1	GPLTF013
	GO TO 2	GPLTF014
3	IF (IS - 2) 4, 5, 6	GPLTF015
4	IXX = IX	GPLTF016
	GO TW 7	GPLTF017
5	IXX = IX - (8 + 7 * (K+M)) / 2	GPLTF018
	GO TO 7	GPLTF019
6	IXX = IX - 8 - 7 * (K+M)	GPLTF020
7	CALL TSP (IXX, IY, 2, 2H10)	GPLTF021
	IXX = IXX + 14	GPLTF022
	IF (M .EQ. 0) GO TO 8	GPLTF023
	CALL TSP (IXX, IYY, 1, 1H-)	GPLTF024
	IXX = IXX + 7	GPLTF025
8	DO 9 I = 1, K	GPLTF026
	L = L / 10	GPLTF027
	M = JJ / L	GPLTF028
	CALL PLT (IXX, IYY, M)	GPLTF029
	JJ = JJ - M * L	GPLTF030
9	IXX = IXX + 7	GPLTF031
	RETURN	GPLTF032
	END	GPLTF033

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