EUR 3469.e

EUROPEAN ATOMIC ENERGY COMMUNITY - EURATOM

COMPUTER PROGRAM FOR ACTIVATION ANALYSIS WITH GERMANIUM LITHIUM DRIFTED DETECTORS

by

G. GUZZI, J. PAULY, F. GIRARDI and B. DORPEMA

1967

Joint Nuclear Research Center
Ispra Establishment - Italy
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Printed by L. Vanmelle N.V.
Brussels, May 1967

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The program has been used routinely since a few months for the determination of radioelements in biological specimens.

The principles on which the program is based are given, and in appendices the necessary instructions for its use and the complete list are added.

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SUMMARY

A computer program especially developed for activation analysis problems is presented. This program is based on the measurement of photopeak surfaces of complex gamma spectra obtained by means of Ge(Li) detectors. Possible interferences from radioisotopes which give photopeaks which can be superimposed to that measured are evaluated, but not corrected.

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The principles on which the program is based are given, and in appendices the necessary instructions for its use and the complete list are added.

Gamma spectra obtained with high resolution Ge-Li drifted detectors require multichannel analyzers with a large memory if a wide range of gamma energies (from 0 to 2 Mev, e.g.) needs to be analyzed without loss of resolution due to the finite width of the channels.

The use of an electronic computer for processing the output data is almost a necessity in this case, particularly when a high number of spectra is obtained in routine applications, such as activation analysis.

Although many computer programs are available for the unscrambling of scintillation gamma spectra, only a few were developed up to now for the Ge-Li drifted spectra (1,2) and none of them was especially developed for activation analysis problems.

We have set up a Fortran program called ANGIR for the IBM 7090 computer, which was especially studied for qualitative and quantitative activation analysis. This program has been used routinely since a few months with satisfactory results.

The gamma spectra are presently obtained with an 18 cc Ge-Li drifted detector, developed in this laboratory, coupled with a 512 channels analyzer, and recorded on punched tape. The range of energies analyzed can be restricted to that of interest for the application done, by means of a threshold amplifier.

The program does not attempt to make a complete qualitative and quantitative analysis of all the peaks in the spectrum, but only determines radioelements and checks for interferences according to the instructions contained in libraries which are especially prepared for the different routine problems of the laboratory. All the libraries are loaded with the reading statements of the program, and the requester simply refers to them by numbers.

Manuscript received on March 7, 1967

TABLE I

Program library for the determination of trace elements in biological materials.

Isotopes (xx)	Analytical peak energy in kev	Specific activity in cpm (°°)	Decay constants (minutes)	Control peaks energy in kev	Ratios
Co	1332	1.130×10^{5}	2.496×10^{-7}		
Cs	796	6.407×10^{4}	5.980×10^{-7}		
Sc*	885	1.490×10^{5}	5.675×10^{-6}		
*Ag	885	2.586×10^{3}	1.850×10^{-6}	1384	0.217
Fe	1098	0.750×10	1.060×10^{-5}		
Rb	1079	8.430×10	3.320×10^{-5}		
Zn**	1114	1.410×10^{2}	1.965×10^{-6}		
**Sc	1119	1.130×10^{5}	5.675×10^{-6}	885	1.320
Sr***	513	5.430×10	7.400×10^{-6}		
***Zn	511	2.637×10	1.965×10^{-6}	1114	5.55

(xx) The elements followed by asterisks are those having peaks not completely free from interferences. The related interfering peaks are preceded by the same number of asterisks.

(°°) This factor is calculated from irradiation of one μgm of element in a thermal flux of 10^{13} neutrons/cm^{2}, at saturation.

Table I shows a typical library for the determination of trace elements giving raise to long lived radioisotopes in biological materials of interest in radioecology. In each library the elements which are called for analysis are listed and for each of them the energy of one or more "analytical peaks" is given. Analytical peaks are chosen as those giving the best sensitivity and the highest chance of being free from interfering activities, within a range of energy which dèpends on the resolution of the detector for that energy, and on the stability of the gamma spectrometer. The range chosen for our spectrometer is 1.5 times the full width at half maximum. The resolution of the detector vs. energy is tabulated as one of the libraries of the program. The actions of the program for each analytical peak are the following:

1) Scan the experimental spectrum and determine all peaks present. For each of them determine the energy and the counting rated. A first selection of possible photopeaks is done by considering a possible maximum in channel n when its content c_n satisfy the following condition:

$$c_{n-2} < c_n - P\sqrt{c_n} > c_{n+2}$$

where P is chosen empirically (presently P = 1).
The minima on both sides of the maxima are chosen as the channels n-k and n+k' for which:

$$c_{n-k-1} \geqslant c_{n-k} - P\sqrt{c_{n-k}}$$

$$c_{n+k'+1} \geqslant c_{n+k'} - P\sqrt{c_{n+k'}}$$

The area S of the photopeak is then determined as:

$$S = \sum_{n=n-k}^{n+k'} c_n - \frac{c_{n-k} + c_{n+k'}}{2} (k + k'+1)$$

and its standard deviation σ_s :

$$\sigma_s = \sqrt{S + \frac{c_{n-k} + c_{n+k'}}{4} \quad n^2}$$

A peak is retained as a true peak if

$$\sigma_s < S/2$$

The energy corresponding to the peak is measured by determining the symmetry axis A of the peak, after subtracting the underlying background, by means of the equation:

$$A = \sum_{k_1}^{k_2} k(c_k) / \sum_{k_1}^{k_2} c_k$$

where the limits k_1 and k_2 are chosen so that the corrected channel contents c_k are all larger than half the channel content of the maximum.

All the preceding operations are performed by the Subroutine PIKAR.

2) Calculate the concentration of the stable element and the associate error, by correcting for decay (Function TDEC), and using auxiliary input data (weight of sample, irradiation data, etc) loaded together with the gamma spectra (Subroutine DETER). This subroutine uses the already described Single Comparator Technique (3).

Those elements which do not have peaks completely free from the danger of interfering radioactivities are marked by asterisks and the possible interferences are listed. Other peaks of the interfering radioisotopes and peaks ratios are also listed as a means of controlling the presence and the amount of the interference.

The program in this case also uses the Subroutine DETER and acts as follows:

1) measure the concentration of the wanted element in the way already indicated, and report it, as if no interference would occur.

2) check for the presence of the control peaks of the interfering element, and measure their counting rate. If control peaks are not found, determine with the Subroutine IPOL the minimum counting rates that would have had a photopeak to be detected over the existing background, and assume this as the counting rate of the control peak.

3) measure, on the bases of photopeak ratios, what is the highest fraction of the analytical peak which could be due to the interfering element, and report it in percent.

4) calculate the corresponding concentration of interfering stable element, and report it in parts per million.

The knowledge of these three figures (ppm in case of no interference, maximum interference possible, corresponding concentration of interfering element) are generally sufficient for the analyst who controls the output of the computer, to decide whether the determined concentration is reliable or if another technique (e.g. chemical separation) must be employed. A further control to see if the program has taken into consideration the correct peaks is the plotting of each spectrum, performed by the Subroutine GRAPH, after the numerical results. It is of course essential to assure that the detector is carefully calibrated. Thus a mixture of radioisotopes with gamma peaks of known energy is measured as the first of a set of spectra, for calibrating the detector. The calibration curve is calculated by the Subroutines KALIP and FITN and it is used to calibrate all the spectra which follow.

The preparation of the libraries for each kind of problems which becomes a routine task of the laboratory is a responsability of the analyst, as the choice of the analytical peaks, possible interferences, and control peaks is fully based on his experience. It is nevertheless true that the selectivity of the detector is such that the cases of interferences are not many. The energy range in which the interfering peaks are searched could perhaps be restricted considerably by using a preamplifier with a high resolving power (preamplifier based on field-effect transistors instead of our present vacuum-tube charge sensitive preamplifier) and by studying more carefully the drifts of the analyzer.

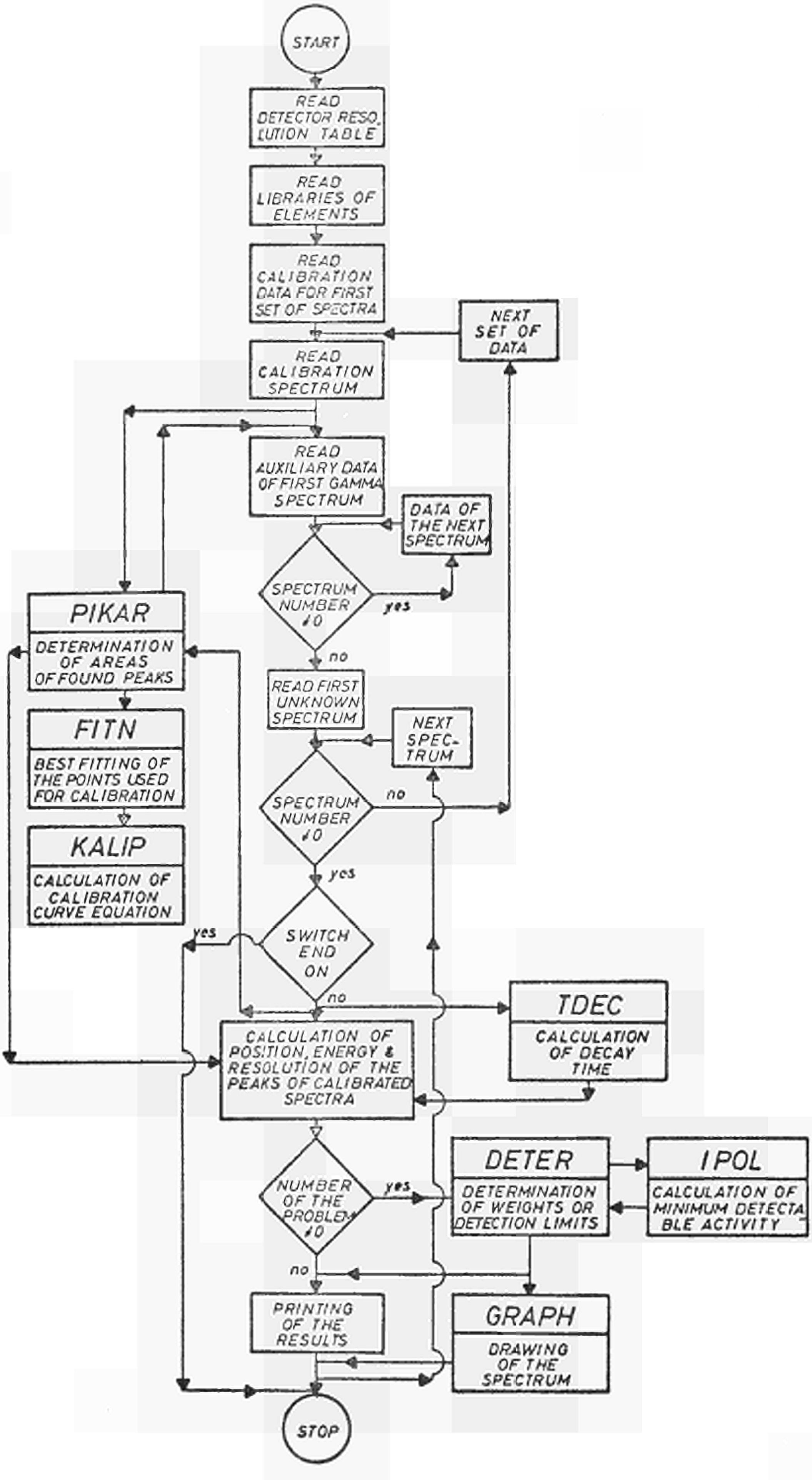

Figure 1. flow sheet of the program ANGIR

The necessary data for the preparation of libraries are taken from a tabulation of gamma emitting radioelements formed by (n, γ) reactions, which is kept up to date for the detector used, by means of another computer program (4). In the tabulation all the possible gamma peaks are reported in order to increase energy, with the indication of the corresponding radioelement, half life, and the specific activity of all its peaks obtained under fixed irradiation conditions and counting geometry. When a new detector is obtained, the new tabulation is prepared by running the program with the new efficiency curves of the detector.

A flow-sheet of the program is reported in Figure 1. The full program listing and the instructions for its use are given in appendices.

REFERENCES:

(1) R.L. Heath, W.W. Black and J.E. Cline, IEEE Trans. Nuclear Science, 455, June 1966.

(2) J.M. Wyckoff, On Line Transformations of High Resolution Spectra, Nat. Bureau of Standards, 1966.

(3) F. Girardi, G. Guzzi and J. Pauly, Anal. Chem. 37, 1085, 1965.

(4) G. Guzzi, J. Pauly, F. Girardi and B. Dorpema, Report EUR 3154.e (1966)

Appendix 1 : Instructions for the use of the computer program : ANGIR

1. IDENTIFICATION

a) ANGIR, a Computer Program System for the Semi-Qualitative and Quantitative Analysis of Trace Elements from Gamma Spectra of Neutron Activated Materials, obtained with Germanium Lithium Drifted Detectors.

b) G. GUZZI - August 1966

c) EURATOM C.C.R. Ispra: Nuclear Chemistry Laboratory

2. INSTRUMENTS COMPUTERS AND CODE

a) Coaxial Ge(Li) detectors with active volume of 18 cc. 512 channels spectrometer (LABEN Milano) with the output of data on tapes punched by a High Speed Tape Punch (TELETYPE Corp.).

b) IBM 7090
IBM 360/30

c) Fortran IV

3. USE AND COMPOSITION OF THE PROGRAM

A) Use of the program:
INPUT consists of:

i) IME: one card for the computation of decay times of the radioisotopes after the irradiation in the reactor.
FORMAT (12I6)

ii) One card with a set of switches which allow the program to read the succeeding cards in a prefixed sequence. Three switches are used at present, i.e. SS, L5 and L6.
FORMAT (12X, 4F6.2, 6I1, 5A6).

iii) NTAB3: the number of elements present in the succeeding cards.
FORMAT (I3).

iv) TAB3: eight cards with the values of the resolution (full width at half maximum) of the Ge(Li) spectrometer in KeV vs. energy from 0 to 5 Mev, in intervals of 50 KeV.
FORMAT (12F6.3)

v) One card with the number of the different libraries (KOMAX) used by the program, and the number of radioelements for each library (NUPIC).

vi) One card for each radioelement in the library. This card contains:

ENE: Energy in KeV either of the analytical peaks or of the interfering peaks of the radioisotope. Values of energy are taken from (4).

ELE: Name of the radioelement.

AAS: Specific activity for a μg sample irradiated in a flux of 10^{13} neutron/sq cm.sec.

XLAM: Decay constant of the isotope in minutes.

KT: Number of control peaks for the interfering radioisotope.

FORMAT (F10.3,A6,2E12.6, I1)

vii) One card for each interfering peak, containing:

ALEN: Energy of the control peak of the interfering isotopes

RAR: Ratio between the area of the control peak and that of the analytical peak.

FORMAT (10F7.3)

viii) One card for each set of spectra with the lower (KLOW) and the higher (KHIGH) channels considered for the scanning of the spectra, the number of the spectra of each set (NSPCT), the number of peaks taken into consideration for the calibration of the spectrometer (KE) and the energies in KeV (E) of the peaks chosen.

FORMAT (2I3,2I6,9F6.2/(12F6.2)).

ix) One card for completion of the preceding one, with the number of peaks (KM) and the number of the channel in which each peak falls (KLA, KLB).

FORMAT (35I2)

x) One card for each measurement made with the spectrometer, with:

KOL: Type of library to be chosen

NIRR: Irradiation number

IRRORA: End of the irradiation stating its hour, minute, day and month

TIRR: Irradiation duration in minutes

NCAMP: Identification number of the sample

PESOC: Weight of the sample in grams

MISORA: hour, minute, day and month of the counting

TIME: Counting time in minutes

IPEC: Number of the spectrum

FLUSSO: Thermal neutron flux during the irradiation

FORMAT (2I4,4I2,F8.3,I4,F11.8,4I2,F8.3,I6,E11.3)

After each set of measurements there is a blank card which allows the program to start the calculations for the spectra belonging to that set.

xi) A magnetic tape obtained by transformation of the punched paper tape by means of the 360/30 computer. This tape contains all the spectra produced by the gamma spectrometer.

OUTPUT consists of:

1) The following input data:

i) DETECTOR RESOLUTION TABLE: A table of 96 values representing the f.w.h.m. in KeV vs. energy, from 0 to 5 MeV.

ii) LIBRARIES: one sheet for each library composed by one line for each radioelement.

iii) The calibration spectrum WHICH MUST BE ALWAYS THE FIRST OF EACH SET.

iv) The peaks found for calibration with their energies, the boundaries of each peak, and the equation of the calibration line.

v) One sheet for each spectrum to be analyzed with the data of the measurement.

2) After each spectrum there is:

i) ELOW and EHIGH, low and high energy boundaries of the spectrum (according to the calibration line).

ii) PHOTOPEAK LIST: list of the photopeaks found with the energy of each peak (and the channel in which its maximum falls). For each peak the left side and the right side minima are given, the area in counts per minute, the associate statistical error (in counts) and finally the resolution (f.w.h.m.) in channels and in KeV.

iii) A sheet with the results of the analysis of each spectrum, with:

ELEMENT: The name of the radioelement found.

TH.ENERGY: the theoretical energy of the analytical peaks, of the interfering peaks and of the control peaks given in library.

EXP.ENERGY: Same energies, but found by the program on the basis of the calibration equation. If a control peak is not found, the minimum detectable activity is calculated and this value is printed out preceded by the word SENSIT.

P.P.M.: part per millions calculated on the bases of the area found and the values in library.

ERROR: Statistical error in part per million.

CONTRIBUTION: percent contribution of the interfering peaks over the analytical peaks.

iv) Three sheets with the drawing of the spectrum divided into three superposed parts (170 channels each part) each plotted with different marks. The channel content of the second and of the third parts are multiplied by factors chosen by the program, to make them comparable with the first part.

B) Composition of the program:

The program is composed of a deck of Fortran Cards and its listing is given in Appendix 2.

- MAIN PROGRAM: Reading and printing of the input data, coordination of the subroutines, printing of the photopeaks list.
- SUBROUTINE RITE: reading of the magnetic tape and transformation of the data in a suitable format, by means of FUNCTION KONV. This subroutine numbers each spectrum and gives sign and corrects eventual invalid characters.

- SUBROUTINE PIKAR: Research of the gamma peaks, evaluation of the photopeak area, and of the associated statistical error. For each peak found, is symmetry axis, its corrected energy and its full width at half maximum is calculated.
- SUBROUTINE KALIP: control that the peaks found are those indicated for the calibration and fit, by means of SUBROUTINE FITN, a polynomial of order N=1 (in our case), to the points used for the calibration.
- FUNCTION TDEC : evaluation of the decay times.
- SUBROUTINE DETER: calculation of the concentration of the stable elements and of the associated errors. For the analytical peaks of the elements not completely free from interfering radioisotopes, this subroutine controls the presence and the amount of the interference. It checks for the presence of control peaks and measures their counting rates. If control peaks are not found, determines by means of the:
- SUBROUTINE IPOL the minimum counting rate, measures, on the bases of photopeak ratios, what is the highest fraction of the analytical peak which could be due to the interfering element, and prints the results.
- SUBROUTINE GRAPH: plotting of the spectra as stated above.

4. RESTRICTIONS

The maximum number of different libraries is 5, for each library 20 elements (analytical and interfering elements) are allowed and each element can have a maximum of 5 control peaks. Each set of spectra (calibration and unknown spectra) is composed by a maximum of 10.

The maximum number of channels of the spectrometer which can be used is 512.

If one wants to give to the program higher possibilities all the dimensions must be changed.

5. TYPICAL RUNNING TIME

For a typical analysis of 10 spectra produced by a Ge(Li) detector (calibration spectrum plus nine unknown) plotting included, the running time (COMP./LOAD AND EXECUTION) is about two minutes.

6. MATERIAL AVAILABLE

The list of the program is given. Upon request, the deck of cards in symbolic code and binary cards are available to scientists working in this field.

Appendix 2 : Listing of the program : ANGIR

```
        ANGIR                                                                      02/15/67
      EXTERNAL FORMULA NUMBER    -    SOURCE STATEMENT    -    INTERNAL FORMULA NUMBER

      DIMENSION
     1 AA(512,10),  XLAM(5,20),  ALEN(5,20,5),  ENGH(80),  ARP(60),
     2 AB(127,15),   ELE(5,20),   RAR(5,20,5),   ENG(80),   SD(60),
     3    NEP(127),   ENE(5,20),   KEV(127,15),  ENGL(80),  NHI(60),
     4   ELEM(127),   AAS(5,20),      Y(200,3),   RES(60),   FE(60),
     5     TP(127),    KT(5,20),     TAB3(100),  KLAS(60),   X(200),
     6      A(512),      B(512),      NUPIC(5),  NLOW(60),  ALFA(5),
     7      T(127),     NE(127)
      DIMENSION
     1 PESOC(25),  IRRORA(4,25),  NIRR(25),  KLS(25),  KLA(60),  FLUSSO(25),
     2 NCAMP(25),  MISORA(4,25),  TIRR(25),  KOL(25),  KLB(60),    IPEC(25),
     3   M128(6),  E(25),RE(60),  TIME(25),  IME(12)
C
      COMMON NP,Y,X,N,RINDA,LOGA,LOGO,IS
      COMMON
     1      ENG,    ENGH,    ENGL,    TDEC,     TIR,    PESO,   FLUSS,   NUPIC,
     2      ENE,     ELE,     AAS,    XLAM,      KT,    ALEN,     RAR,      KO,
     3    EHIGH,    ELOW,     RES,       A,       B,    NLOW,      FE,     NHI,
     4       L1,      L2,      L3,      L4,      L5,      L6,    ELEM,      TP,
     5        T,      NE,     NEP,     KEV,      AB,    KLOW,   KHIGH,    JMAX,
     6     IFIT,    KLAS,     ARP,      SD,    TAB3,     AKK,     BKK,      AA
C
      M128(1)=1                                                                  ,1
      M128(2)=128                                                                ,2
      M128(3)=128*128                                                            ,3
      M128(4)=128*128*128                                                        ,4
      M128(5)=128*128*128*128
C                                                                                ,5
      READ (5,1001) IME                                                          ,6
 1001 FORMAT (12I6)
  100 READ (5,201) PP,QQ,RR,SS,L1,L2,L3,L4,L5,L6,ALFA                            ,9
                                                                                 ,15
      ARMIN=20.0                                                                 ,18
      EKTW=1.2                                                                   ,19
      IF(PP)102,102,104                                                          ,20
  102 PP=1.0                                                                     ,21
  104 IF(QQ)106,106,108                                                          ,22
  106 QQ=1.1                                                                     ,23
  108 IF(RR)110,110,112                                                          ,24
  110 RR=0.5                                                                     ,25
  112 IF(L1)666,666,115
C                                                                                ,26
  666 READ (5,600) NTAB3                                                         ,27
      READ(5,601) (TAB3(I),I=1,NTAB3)                                            ,30
  600 FORMAT (I3)
  601 FORMAT (12F6.3)
      WRITE (6,700) (I,I=1,5)                                                    ,35
      WRITE (6,701) (TAB3(I),I=1,NTAB3)                                          ,40
  700 FORMAT (1H1,25HDETECTOR RESOLUTION TABLE/1H0,6XI1,4(10XI1)/1H0)
  701 FORMAT ((1H0,1P5E11.3))
      READ (5,212) KOMAX,(NUPIC(I),I=1,KOMAX)                                    ,45

  212 FORMAT (35I2)
      DO 1 I=1,KOMAX                                                             ,51
      WRITE (6,702)                                                              ,52
```

```
      NU=NUPIC(I)                                                        ,54
      DO 2 J=1,NU                                                        ,55
      READ (5,214) ENE(I,J),ELE(I,J),AAS(I,J),XLAM(I,J),KT(I,J)          ,56
      WRITE (6,703) ELE(I,J),ENE(I,J),AAS(I,J),XLAM(I,J)                 ,59
  702 FORMAT (1H1,7HLIBRARY///8H ISOTOPE,3X6HENERGY,5X9HSPEC.ACT.,5X,12
     1HDECAY CONST.,3X13HCONTROL PEAKS,5X6HRATIOS///)
  703 FORMAT (1H0,A6,F10.3,5X,1PE9.3,8X,E9.3)
      IF(KT(I,J)-1)2,4,5                                                 ,62
    4 READ (5,215) ALEN(I,J,1),RAR(I,J,1)                                ,63
      WRITE (6,704) ALEN(I,J,1),RAR(I,J,1)                               ,66
  704 FORMAT (1H+,53X,F8.3,7X,F8.3)
      GO TO 2                                                            ,69
    5 KTI=KT(I,J)                                                        ,70
      READ (5,216) (ALEN(I,J,K),RAR(I,J,K),K=1,KTI)                      ,71
      WRITE (6,704) ALEN(I,J,1),RAR(I,J,1)                               ,76
      WRITE (6,710) (ALEN(I,J,K),RAR(I,J,K),K=2,KTI)                     ,79
  710 FORMAT (1H ,53X,F8.3,7X,F8.3)
    2 CONTINUE                                                           ,84
    1 CONTINUE                                                           ,86
  214 FORMAT (F10.3,A6,2E12.6,I2)
  215 FORMAT (2F10.3)
  216 FORMAT (10F7.3)
  115 READ (5,202) KLOW,KHIGH,NSPCT,KE,(E(I),I=1,KE)                     ,88
                                                                         ,94
      READ (5,240) KM,(KLA(I),KLB(I),I=1,KM)                             ,97

      DO 116 I=1,KM                                                      ,103
  116 KLS(I)=16*KLA(I)+KLB(I)                                            ,104
      I=0                                                                ,106
  124 I=I+1                                                              ,107
      READ (5,210) KOL(I),NIRR(I),(IRRORA(L,I),L=1,4),TIRR(I),NCAMP(I),P
     1ESOC(I),(MISORA(L,I),L=1,4),TIME(I),IPEC(I),FLUSSO(I)              ,108
                                                                         ,114
  210 FORMAT (2I4,4I2,F8.3,I4,F11.8,4I2,F8.3,I6,E11.3)
      IF(IPEC(I))122,122,124                                             ,119
  122 MAPX=I-1
C                                                                        ,120
      CALL RITE(KHIGH,NSPCT,AA)
C                                                                        ,121
      DO 117 I=1,KHIGH                                                   ,122
  117 A(I)=AA(I,1)                                                       ,123
      WRITE (6,205) KLOW,EN,PP,KHIGH,KE,QQ,RR,SS                         ,125
      WRITE (6,206) (I,I=1,10)                                           ,128
      IMX=KHIGH/10+1                                                     ,133
      DO 118 I=1,IMX                                                     ,134
      IP=I-1                                                             ,135
      IL=IP*10+1                                                         ,136
      IH=MIN0(I*10,KHIGH)                                                ,137
  118 WRITE (6,207) IP,(A(J),J=IL,IH)
C                                                                        ,138
                                                                         ,144
      WRITE (6,155)                                                      ,145
      CALL PIKAR(PP,QQ,RR,1.0)                                           ,147
      CALL KALIP(EN,FE,E,KE,KLS,KM,RES)                                  ,148
      AKK=B(1)                                                           ,149
      BKK=B(2)                                                           ,150
```

```
      WRITE (6,245) AKK,BKK
C                                                                          ,151
  120 NSPMU=NSPCT-1                                                        ,154
      DO 127 IPC=1,NSPMU                                                   ,155
      DO 121 I=1,KHIGH                                                     ,156
  121 A(I)=AA(I,IPC+1)                                                     ,157
      ITST=IPC+1                                                           ,159
      KO=KOL(IPC)                                                          ,160
      DO 502 I=1,MAPX                                                      ,161
      IF(ITST-IPEC(I))502,503,502                                          ,162
  502 CONTINUE                                                             ,163
      WRITE (6,220) ITST                                                   ,165
      TCON=1.0                                                             ,168
      GO TO 137                                                            ,169
  503 TCON=TIME(I)                                                         ,170
      TIR=TIRR(I)                                                          ,171
      PESO=PESOC(I)                                                        ,172
      FLUSS=FLUSSO(I)                                                      ,173
      TDEC=TDEC1(MISORA(1,I),IRRORA(1,I),IME)                              ,174
  137 WRITE (6,705)                                                        ,175
      WRITE (6,706) KO,ITST,NIRR(I),(IRRORA(L,I),L=1,4),TIR,FLUSS,(MISOR
     1A(L,I),L=1,4),TDEC,TCON,NCAMP(I),PESO                                ,177
                                                                           ,183
  705 FORMAT (1H1,31X,6HIRRORA,35X6HMISORA,34X6HSAMPLE/1H 123HPROBLEM  S
     1PEC.N.  IRR.N. HOUR MIN DAY MONTH  IRR.TIME       FLUX    HOUR MIN D
     2AY MONTH   DECAY TIME    TCON     NUMBER     WEIGHT)
  706 FORMAT (I5,2I9,4I5,F10.3,1PE12.4,I5,2I4,I5,0PF14.3,F9.3,I5,3XF11.7
     1/1H0)
      WRITE (6,206) (I,I=1,10)                                             ,188
      DO 138 I=1,IMX                                                       ,193
      IP=I-1                                                               ,194
      IL=IP*10+1                                                           ,195
      IH=MIN0(I*10,KHIGH)                                                  ,196
  138 WRITE (6,207) IP,(A(J),J=IL,IH)                                      ,197
                                                                           ,203
      CALL PIKAR(PP,CQ,RR,TCON)                                            ,204
      ELOW=FLOAT(KLOW+3)*AKK+BKK                                           ,205
      EHIGH=FLOAT(KHIGH-3)*AKK+BKK                                         ,206
      WRITE (6,151) ELOW,EHIGH                                             ,207
      DO 150 J=1,JMAX                                                      ,210
      ENGL(J)=FLOAT(NLOW(J))*AKK+BKK                                       ,211
      ENGH(J)=FLOAT(NHI(J))*AKK+BKK                                        ,212
      RE(J)=RES(J)*AKK                                                     ,213
  150 ENG(J)=FE(J)*AKK+BKK                                                 ,214
      DO 152 J=1,JMAX                                                      ,216
  152 WRITE (6,153) J,ENGL(J),NLOW(J),ENG(J),FE(J),ENGH(J),NHI(J),ARP(J)
     1,SD(J),RE(J),RES(J)
C                                                                          ,217
  151 FORMAT (1H1,6H ELOW=F9.4/1H0,6HEHIGH=F9.4/
     1          1H0/1H0,10X12HLEFT-MINIMUM ,14X4HPEAK,12X13HRIGHT-MINIMUM
     2,14X4HAREA/1H0)
  155 FORMAT (1H1)
  153 FORMAT (1H0,I2,6XF9.4,2X1H(I3,1H),6XF9.4,2X1H(F6.2,1H),3XF9.4,2X1H
     1(I3,1H),2F10.3,F10.3,2X1H(F6.2,1H))
  201 FORMAT (12X,4F6.2,6I1,5A6)
  202 FORMAT (2I3,2I6,9F6.2/(12F6.2))
```

```
  203 FORMAT ((10F6.0,20X))
  205 FORMAT (1H1,5HKLOW=I4,10X3HEN=F6.1,10X2HP=F6.2/1H ,6HKHIGH=I3,10X3
     1HKE=I3,13X2HQ=F6.2,10X2HR=F6.2,10X2HS=F6.2)
  206 FORMAT (1H0,10(9XI1)/)
  207 FORMAT (1H ,I2,10F10.0)
  211 FORMAT (10F6.0,I6)
  220 FORMAT (1H0,28HWARNING..... SPECTRUM NUMBER I7,7HUNKNOWN/1H0)
  240 FORMAT (35I2)
  245 FORMAT (1H0,22HCALIBRATION LINE    Y=F7.5,3H*X+F9.5)
C
      IF(KO)127,127,500                                         ,221
  500 CALL DETER(TCON)                                          ,222
      NP=3                                                      ,223
      X(1)=1.                                                   ,224
      DX=1.
C                                                               ,225
      DO 2000 I=2,170                                           ,226
 2000 X(I)=X(I-1)+DX                                            ,227
      DO 2001 I=1,170                                           ,229
 2001 Y(I,1)=A(I)+2.0                                           ,230
      B1=A(1)                                                   ,232
      DO 2004 J=2,170                                           ,233
      IF(A(J)-B1)2004,2004,2005                                 ,234
 2005 B1=A(J)                                                   ,235
 2004 CONTINUE                                                  ,236
      B2=A(171)                                                 ,238
      DO 2006 J=172,340                                         ,239
      IF(A(J)-B2)2006,2006,2007                                 ,240
 2007 B2=A(J)                                                   ,241
 2006 CONTINUE                                                  ,242
      B3=A(341)                                                 ,244
      DO 2008 J=342,510                                         ,245
      IF(A(J)-B3)2008,2008,2009                                 ,246
 2009 B3=A(J)                                                   ,247
 2008 CONTINUE                                                  ,248
      DO 2002 I=171,340                                         ,250
      J=I-170                                                   ,251
 2002 Y(J,2)=A(I)*B1/B2                                         ,252
      DO 2003 I=341,510                                         ,254
      J=I-340                                                   ,255
 2003 Y(J,3)=A(I)*B1/B3                                         ,256
      B12=B1/B2                                                 ,258
      B13=B1/B3                                                 ,259
      WRITE (6,2010) B12                                        ,260
      WRITE (6,2011) B13                                        ,263
 2010 FORMAT (41H THE SECOND CURVE HAS BEEN MULTIPLIED BY,E12.4)
 2011 FORMAT (40H THE THIRD CURVE HAS BEEN MULTIPLIED BY,E12.4)
      N=170                                                     ,266
      RINDA=0.                                                  ,267
      IS=0                                                      ,268
      LOGA=-1                                                   ,269
      LOGO=-1                                                   ,270
      CALL GRAPH                                                ,271
  127 CONTINUE                                                  ,272
      GO TO 115                                                 ,274
      END                                                       ,275
```

```
      SUBROUTINE RITE(JSX,MIX,A)
C     THIS RIET ONLY FOR PURE SPECTRA (L=5)
C
      DIMENSION                                                             10
     1  A(512,10),  XLAM(5,20),  ALEN(5,20,5),  ENGH(80),  ARP(60),         11 MODIF
     2 AB(127,15),   ELE(5,20),   RAR(5,20,5),   ENG(80),   SD(60),         12
     3   NEP(127),   ENE(5,20),   KEV(127,15),  ENGL(80),  NHI(60),         13
     4  ELEM(127),   AAS(5,20),      Y(200,3),   RES(60),   FE(60),         14
     5    TP(127),    KT(5,20),     TAB3(100),  KLAS(60),   X(200),         15
     6MODIFA(512),      B(512),      NUPIC(5),  NLOW(60),  ALFA(5),         16 MODIF
     7     T(127),     NE(127),       IN(76)                                17 MODIF
      COMMON NP,Y,X,N,RINDA,LOGA,LOGO,IS                                    22
      COMMON                                                                23
     1     ENG,     ENGH,     ENGL,     TDEC,     TIR,    PESO,    FLUSS,   NUPIC,   24
     2     ENE,      ELE,      AAS,     XLAM,      KT,    ALEN,      RAR,      KO,   25
     3   EHIGH,     ELOW,      RES,   MODIFA,       B,    NLOW,       FE,     NHI,   26 MODIF
     4      L1,       L2,       L3,       L4,      L5,      L6,     ELEM,      TP,   27
     5       T,       NE,      NEP,      KEV,      AB,    KLOW,    KHIGH,    JMAX,   28
     6    IFIT,     KLAS,      ARP,       SD,    TAB3,     AKK,      BKK,       A    29 MODIF
      DATA INC/0776060606060/
  701 JSXME=JSX-1                                                           ,1
      IS=0                                                                  ,2
      J=0                                                                   ,3
  702 J=J+1                                                                 ,4
      IF(J-MIX) 7021,7021,7022                                              ,5
 7022 RETURN                                                                ,6
 7021 JS=0                                                                  ,7
  703 JS=JS+1                                                               ,8
      READ (11,730) L,(IN(I),I=1,5)                                         ,9

      DO 704 I=1,5                                                          ,15
      IF(IN(I).EQ.INC) GO TO 720                                            ,16
  704 CONTINUE                                                              ,19
      IF(L.NE.5) GO TO 710                                                  ,21
      KAN=KONV(IN,1,5)                                                      ,24
      A(JS,J)=KAN                                                           ,25
      IF(IS.EQ.0) GO TO 705                                                 ,26
      A(JS-1,J)=(A(JS-2,J)+A(JS,J))*0.5                                     ,29
      IS=0                                                                  ,30
  705 IF(JS.EQ.1) GO TO 706                                                 ,31
      IF(JS-JSX)703,702,702                                                 ,34
  706 IF(MOD(KAN,16))708,703,708                                            ,35
  708 WRITE (6,731) J,KAN                                                   ,36
      GO TO 703                                                             ,39
  710 IF(L-76)712,712,714                                                   ,40
  712 WRITE (6,732) J,JS,L,(IN(I),I=1,5)                                    ,41

      JS=JS-1                                                               ,47
      GO TO 703                                                             ,48
  714 WRITE(6,736)                                                          ,49
  736 FORMAT(1H0,24HEND OF TAPE WITH SPECTRA)
      IF(JS.NE.1) GO TO 715                                                 ,51
      RETURN                                                                ,54
  715 WRITE (6,733) J,JS                                                    ,55
      RETURN                                                                ,58
```

```
      RITE                                                                02/15/67
 EXTERNAL FORMULA NUMBER    -    SOURCE STATEMENT    -    INTERNAL FORMULA NUMBER
720 IF(L.NE.5) GO TO 712                                                      ,59
    A(JS,J)=0.0                                                               ,62
    IF(IS.EQ.1.OR.JS.EQ.1.OR.JS EQ.JSX) GO TO 724                             ,63
    IS=1                                                                      ,66
    WRITE (6,734) J,JS                                                        ,67
    GO TO 703                                                                 ,70
724 WRITE (6,735) J,JS                                                        ,71
    GO TO 703
C                                                                             ,74
730 FORMAT (I6,5A1)
731 FORMAT (1H0,32HWARNING FIRST CHANNEL NOT =MOD16,8X2HJ=I3,5X4HKAN=I
   15)
732 FORMAT (1H0,30HWARNING INVALID RECORD SKIPPED ,10X2HJ=I3,
   15X4HKAN=I5,5X2HL=I2,5X5A1)
733 FORMAT (1H0,34HWARNING LAST SPECTRUM NOT COMPLETE,6X2HJ=I3,6X3HJS=
   1I5)
734 FORMAT (1H0,37HWARNING INV. REC. SUBSTITUTED BY MEAN,3X2HJ=I3,6X3H
   1JS=I5)
735 FORMAT (1H0,37HWARNING INV. REC. SUBSTITUTED BY ZERO,3X2HJ=I3,6X3H
   1JS=I5)
    END                                                                       ,75
```

```
      KONV                                                                02/15/67
 EXTERNAL FORMULA NUMBER    -    SOURCE STATEMENT    -    INTERNAL FORMULA NUMBER

    FUNCTION KONV(IN,KL,KH)
    DIMENSION IN(80),N(10)
    DATA (N(I),I=1,10)/1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
    KONV=0                                                                    ,1
    DO 20 K=KL,KH                                                             ,2
    DO 10 I=1,10                                                              ,3
 10 IF(IN(K).EQ.N(I)) GO TO 20                                                ,4
    WRITE (6,30) K                                                            ,8
    I=1                                                                       ,11
 20 KONV=KONV*10+I-1                                                          ,12
    RETURN                                                                    ,14
 30 FORMAT (1H0,29HWARNING CONVERSION ERROR   I=I2)
    END                                                                       ,15
```

```
      SUBROUTINE DETER(TCON)
C
      DIMENSION                                                          10
     1 AA(512,10), XLAM(5,20), ALEN(5,20,5), ENGH(80), ARP(60),          11
     2 AB(127,15),  ELE(5,20),  RAR(5,20,5),  ENG(80),  SD(60),          12
     3   NEP(127),  ENE(5,20),  KEV(127,15), ENGL(80), NHI(60),          13
     4  ELEM(127),  AAS(5,20),     Y(200,3),  RES(60),  FE(60),          14
     5    TP(127),   KT(5,20),    TAB3(100), KLAS(60),  X(200),          15
     6     A(512),     B(512),     NUPIC(5), NLOW(60), ALFA(5),          16
     7     T(127),    NE(127)                                            17
C
      COMMON NP,Y,X,N,RINDA,LOGA,LOGO,IS                                 22
      COMMON                                                             23
     1     ENG,     ENGH,    ENGL,    TDEC,    TIR,   PESO,  FLUSS,  NUPIC, 24
     2     ENE,      ELE,     AAS,    XLAM,     KT,   ALEN,    RAR,     KO, 25
     3   EHIGH,     ELOW,     RES,       A,      B,   NLOW,     FE,    NHI, 26
     4      L1,       L2,      L3,      L4,     L5,     L6,   ELEM,     TP, 27
     5       T,       NE,     NEP,     KEV,     AB,   KLOW,  KHIGH,   JMAX, 28
     6    IFIT,     KLAS,     ARP,      SD,   TAB3,    AKK,    BKK,     AA  29
C
      NU=NUPIC(KO)                                                       ,1
      WRITE (6,201)                                                      ,2
      DO 1 J=1,NU                                                        ,4
      DO 4 NPEAK=1,JMAX                                                  ,5
      CFF=4.0                                                            ,6
      KEN=ENE(KO,J)                                                      ,7
      KEL=ENG(NPEAK)-(ENGH(NPEAK)-ENGL(NPEAK))/CFF-0.5                   ,8
      KEH=ENG(NPEAK)+(ENGH(NPEAK)-ENGL(NPEAK))/CFF-0.5                   ,9
      IF(KEL-KEN)3,3,4                                                   ,10
    3 IF(KEH-KEN)4,5,5                                                   ,11
    5 AREAI=ARP(NPEAK)/EXP(-XLAM(KO,J)*TDEC)                             ,12
      AROS=1.E13*AREAI/(1.-EXP(-XLAM(KO,J)*TIR))                         ,13
      PPM=AROS/(AAS(KO,J)*PESO*FLUSS)                                    ,14
      ERR=SD(NPEAK)*PPM/ARP(NPEAK)                                       ,15
      ELES=ELE(KO,J)                                                     ,16
      ENT=ENE(KO,J)                                                      ,17
      ENS=ENG(NPEAK)                                                     ,18
      KI=KT(KO,J)                                                        ,19
      WRITE (6,202) ELES,ENT,ENS,ARP(NPEAK),PPM,ERR                      ,20
      M=0                                                                ,23
      CON=100.                                                           ,24
      IF(KI-1)30,31,32                                                   ,25
   30 CONP=100.                                                          ,26
   50 WRITE (6,101) CONP                                                 ,27
      GO TO 61                                                           ,30
   31 IF(ALEN(KO,J,1)-EHIGH)112,444,444                                  ,31
  112 IF(ALEN(KO,J,1)-ELOW)444,444,113                                   ,32
  444 CONP=100.                                                          ,33
      WRITE (6,203) ALEN(KO,J,1),CONP                                    ,34
      GO TO 61                                                           ,37
  113 M=M+1                                                              ,38
      N=0                                                                ,39
      DO 134 JIF=1,JMAX                                                  ,40
      IF(ALEN(KO,J,1)-ENGL(JIF))134,134,137                              ,41
  137 IF(ALEN(KO,J,1)-ENGH(JIF))138,134,134                              ,42
```

```
 138 CON=100.*ARP(JIF)/(RAR(KO,J,1)*ARP(NPEAK))                       ,43
     WRITE (6,204) ALEN(KO,J,1),ARP(JIF),CON                          ,44
     N=N+1                                                            ,47
 134 CONTINUE                                                         ,48
     IF(N)400,400,61                                                  ,50
 400 AL=ALEN(KO,J,1)                                                  ,51
     CALL IPOL(DET,AL,TCON)                                           ,52
     CON=100.*DET/(RAR(KO,J,1)*ARP(NPEAK))                            ,53
     WRITE (6,205) ALEN(KO,J,1),DET,CON                               ,54
     GO TO 61                                                         ,57
  32 DO 33 K=1,KI                                                     ,58
     IF(ALEN(KO,J,K)-EHIGH)12,35,35                                   ,59
  12 IF(ALEN(KO,J,K)-ELOW)35,35,13                                    ,60
  35 WRITE (6,203) ALEN(KO,J,K),CON                                   ,61
     GO TO 33                                                         ,64
  13 M=M+1                                                            ,65
     N=0                                                              ,66
     DO 34 JIF=1,JMAX                                                 ,67
     IF(ALEN(KO,J,K)-ENGL(JIF))34,34,37                               ,68
  37 IF(ALEN(KO,J,K)-ENGH(JIF))38,34,34                               ,69
  38 CON=100.*ARP(JIF)/(RAR(KO,J,K)*ARP(NPEAK))                       ,70
     N=N+1                                                            ,71
     WRITE (6,204) ALEN(KO,J,K),ARP(JIF),CON                          ,72
  34 CONTINUE                                                         ,75
     IF(N)40,40,41                                                    ,77
  40 AL1=ALEN(KO,J,K)                                                 ,78
     CALL IPOL(DET,AL1,TCON)                                          ,79
     CON=100.*DET/(RAR(KO,J,K)*ARP(NPEAK))                            ,80
     WRITE (6,205) ALEN(KO,J,K),DET,CON                               ,81
  41 CONTINUE                                                         ,84
  33 CONTINUE                                                         ,85
  61 CONTINUE                                                         ,87
   4 CONTINUE                                                         ,88
   1 CONTINUE
C                                                                     ,90
 101 FORMAT (1H+,82X,F7.3)
 201 FORMAT (1H1,92HELEMENT  TH.ENERGY  EXP.ENERGY          AREA CPM
    1       P.P.M.         ERROR       CONTRIBUTION//)
 202 FORMAT (1H0,A7,F11.3,F12.3,6X,F12.3,F16.5,F14.5)
 203 FORMAT (1H0,7X,F11.3,64X,F7.3)
 204 FORMAT (1H0,7X,F11.3,18X,F12.3,34X,F7.3)
 205 FORMAT (1H0,7X,F11.3,12X,6HSENSIT,F12.3,34X,F7.3)
     RETURN                                                           ,92
     END                                                              ,93
```

```
      SUBROUTINE FITN(X,Y,B,N,IX)
C
C     THIS SUBPROGRAM FITS A POLYNOMIAL OF ORDER N TO A SET OF POINTS
C     X(I),Y(I)OUTPUT ARE THE COEFFICIENTS B OF THE POLYNOMIAL (POWERS I
C     N DECREASING ORDER
C
      DIMENSION
     1 UT(20,20), U(20,20), SY(21), SX(40), B(1), Y(1), X(1)
      IF(N-2)12,12,10                                                   ,1
   10 ITER=3                                                            ,2
      GO TO 14                                                          ,3
   12 ITER=2                                                            ,4
   14 NE=N+1                                                            ,5
      NT=N+2                                                            ,6
      NKE=2*N+1                                                         ,7
      DO 16 L=1,NKE                                                     ,8
   16 SX(L)=0.0                                                         ,9
      DO 18 L=1,NE                                                      ,11
   18 SY(L)=0.0                                                         ,12
      DO 22 I=1,IX                                                      ,14
      P=1.0                                                             ,15
      DO 22 L=1,NKE                                                     ,16
      SX(L)=SX(L)+P                                                     ,17
      IF(L-NE)20,20,22                                                  ,18
   20 SY(L)=SY(L)+P*Y(I)                                                ,19
   22 P=P*X(I)                                                          ,20
      DO 26 K=1,NE                                                      ,23
      DO 24 J=1,NE                                                      ,24
      IND=K+J-1                                                         ,25
   24 U(K,J)=SX(IND)                                                    ,26
   26 U(K,NT)=SY(K)                                                     ,28
      U(NT,NT)=-1.0                                                     ,30
      DO 28 J=1,NE                                                      ,31
   28 U(NT,J)=0.0
C                                                                       ,32
      DO 30 I=1,NT                                                      ,34
      DO 30 J=1,NT                                                      ,35
   30 UT(I,J)=U(J,I)                                                    ,36
      DET=1.0                                                           ,39
      DO 90 IL=1,ITER                                                   ,40
      DO 80 I=1,NT                                                      ,41
      C=0.0                                                             ,42
      DO 1 K=1,NT                                                       ,43
    1 C=C+U(I,K)*UT(K,I)                                                ,44
      IF(C)2,99,2                                                       ,46
    2 DET=DET*C                                                         ,47
      DO 3 J=1,NT                                                       ,48
    3 UT(J,I)=UT(J,I)/C                                                 ,49
      DO 80 J=1,NT                                                      ,51
      IF(J-I)4,80,4                                                     ,52
    4 H=0.0                                                             ,53
      DO 5 K=1,NT                                                       ,54
    5 H=H+U(I,K)*UT(K,J)                                                ,55
      DO 6 K=1,NT                                                       ,57
    6 UT(K,J)=UT(K,J)-H*UT(K,I)                                         ,58
```

```
      FITN                                                          02/15/67
  EXTERNAL FORMULA NUMBER   -   SOURCE STATEMENT   -   INTERNAL FORMULA NUMBER(S

80 CONTINUE                                                            ,60
90 CONTINUE                                                            ,63
   DO 7 I=1,NE                                                         ,65
   IND=NE+1-I                                                          ,66
 7 B(IND)=UT(I,NT)                                                     ,67
   RETURN                                                              ,69
99 WRITE(6,98)N,IX,IL                                                  ,70
98 FORMAT (1H0,34HWARNING.....FITTING CANNOT PROCEED,3I4/1H0)
   RETURN                                                              ,73
   END                                                                 ,74
```

```
      TDEC1                                                         02/15/67
  EXTERNAL FORMULA NUMBER   -   SOURCE STATEMENT   -   INTERNAL FORMULA NUMBER(S

   FUNCTION TDEC1(MO,IO,IME)

   DIMENSION MO(4),IO(4),IME(12)
   I1=MO(4)                                                            ,1
   I2=IO(4)                                                            ,2
   TDEC1=((IME(I1)-IME(I2)+MO(3)-IO(3))*24+MO(1)-IO(1))*60+MO(2)-IO(2
  1)                                                                   ,3
   RETURN                                                              ,4
   END                                                                 ,5
```

```
        IPOL                                                                                   02/15/67
    EXTERNAL FORMULA NUMBER    -    SOURCE STATEMENT    -    INTERNAL FORMULA NUMBER(S

      SUBROUTINE IPOL(DET,EN,TE)
C
      DIMENSION                                                                 10
     1 AA(512,10), XLAM(5,20), ALEN(5,20,5), ENGH(80), ARP(60),                 11
     2 AB(127,15),  ELE(5,20),  RAR(5,20,5),  ENG(80),  SD(60),                 12
     3   NEP(127),  ENE(5,20),  KEV(127,15), ENGL(80), NHI(60),                 13
     4  ELEM(127),  AAS(5,20),     Y(200,3),  RES(60),  FE(60),                 14
     5    TP(127),   KT(5,20),    TAB3(100), KLAS(60),  X(200),                 15
     6     A(512),     B(512),     NUPIC(5), NLOW(60), ALFA(5),                 16
     7     T(127),    NE(127)                                                   17
C
      COMMON NP,Y,X,N,RINDA,LOGA,LOGO,IS                                        22
      COMMON                                                                    23
     1     ENG,    ENGH,    ENGL,    TDEC,     TIR,    PESO,  FLUSS,  NUPIC,    24
     2     ENE,     ELE,     AAS,    XLAM,      KT,    ALEN,    RAR,     KO,    25
     3   EHIGH,    ELOW,     RES,       A,       B,    NLOW,     FE,    NHI,    26
     4      L1,      L2,      L3,      L4,      L5,      L6,   ELEM,     TP,    27
     5       T,      NE,     NEP,     KEV,      AB,    KLOW,  KHIGH,   JMAX,    28
     6    IFIT,    KLAS,     ARP,      SD,    TAB3,     AKK,    BKK,     AA     29
C
      FK=3.0                                                                                  ,1
      P=1.3                                                                                   ,2
      VYFT=50.0                                                                               ,3
      KN=(EN-BKK)/AKK+0.5                                                                     ,4
      IND=EN/VYFT+1.C                                                                         ,5
      ED=AMOD(EN,VYFT)                                                                        ,6
      KD=P*0.5*((TAB3(IND+1)-TAB3(IND))*ED/VYFT+TAB3(IND))/AKK+0.5                            ,7
      IL=KN-KD                                                                                ,8
      IH=KN+KD                                                                                ,9
      SUM=0.0                                                                                 ,10
      DO 2 I=IL,IH                                                                            ,11
    2 SUM=SUM+A(I)                                                                            ,12
      DET=FK*FK/(1.66*TE)*(1.0+SQRT(1.0+8.0*SUM/(FK*FK)))                                     ,14
      RETURN                                                                                  ,15
      END                                                                                     ,16
```

```
      SUBROUTINE KALIP(EN,FR,E,KE,KLS,KM,RE)
C
      DIMENSION                                                          10
     1 AA(512,10), XLAM(5,20), ALEN(5,20,5), ENGH(80), ARP(60),          11
     2 AB(127,15),   ELE(5,20),  RAR(5,20,5),   ENG(80),  SD(60),        12
     3   NEP(127),   ENE(5,20),  KEV(127,15), ENGL(80), NHI(60),         13
     4  ELEM(127),   AAS(5,20),     Y(200,3),   RES(60),  FE(60),        14
     5    TP(127),    KT(5,20),    TAB3(100), KLAS(60),  X(200),         15
     6     A(512),      B(512),     NUPIC(5), NLOW(60), ALFA(5),         16
     7     T(127),     NE(127),     LLOW(10),  LHI(10)                   17    MOD
      DIMENSION                                                          18
     1 KLS(25),  FR(25),  FN(25), REI(25),  RE(25),  EG(25),   E(25)     19
C
      COMMON NP,Y,X,N,RINDA,LOGA,LOGO,IS                                 22
      COMMON                                                             23
     1     ENG,    ENGH,    ENGL,    TDEC,     TIR,    PESO,   FLUSS,   NUPIC,   24
     2     ENE,     ELE,     AAS,    XLAM,      KT,    ALEN,     RAR,      KO,   25
     3  EHIGH,    ELOW,     RES,       A,       B,    NLOW,      FE,     NHI,   26
     4      L1,      L2,      L3,      L4,      L5,      L6,    ELEM,      TP,   27
     5       T,      NE,     NEP,     KEV,      AB,    KLOW,   KHIGH,    JMAX,   28
     6    IFIT,    KLAS,     ARP,      SD,    TAB3,     AKK,     BKK,      AA    29
C
   80 DO 82 I=1,KM                                                       ,1
      LLOW(I)=KLS(I)-5                                                   ,2
   82 LHI(I)=KLS(I)+5                                                    ,3
   88 N=1                                                                ,5
      J=1                                                                ,6
      M=1                                                                ,7
      DO 39 I=1,KHIGH                                                    ,8
      KR=FR(J)+0.5                                                       ,9
      IF(I-KR)31,33,31                                                   ,10
   31 IF(I-LHI(M))30,30,32                                               ,11
   32 M=M+1                                                              ,12
      GO TO 30                                                           ,13
   33 IF(I-LHI(M))34,34,36                                               ,14
   34 IF(I-LLOW(M))36,35,35                                              ,15
   35 FI=I                                                               ,16
      FN(N)=FR(J)                                                        ,17
      REI(N)=RE(J)                                                       ,18
      B(N)=A(I)                                                          ,19
      EG(N)=E(M)                                                         ,20
      N=N+1                                                              ,21
      M=M+1                                                              ,22
   36 J=J+1                                                              ,23
   30 IF(J-JMAX)37,37,40                                                 ,24
   37 IF(M-KE)39,39,40                                                   ,25
   39 CONTINUE
C                                                                        ,26
   40 N=N-1                                                              ,28
      WRITE(6,91)N                                                       ,29
      DO 41 I=1,N                                                        ,32
   41 WRITE (6,92) I,E(I),LLOW(I),LHI(I),FN(I),B(I),REI(I)               ,33
      NPE=N+1                                                            ,37
      IF(NPE-KE)42,42,45                                                 ,38
   42 DO 43 I=NPE,KE                                                     ,39
```

```
   43 WRITE(6,92)I,E(I),LLOW(I),LHI(I)                                ,40
   45 CALL FITN (FN,EG,B,I,N)                                         ,44
      RETURN
C                                                                     ,45
   92 FORMAT (1H0,I2,F10.3,2I10,3F10.3)
   91 FORMAT (1H0/1H0,6X23HDATA OF ESTIMATED PEAKS,5X21HPEAKS FOR CALIBR
     1ATION/1H0,5X6HENERGY,7X3HLOW,6X4HHIGH,4X7HCHANNEL,4X6HCOUNTS,6X4HF
     2WHM,10XI2)
      END                                                             ,46
```

```
      SUBROUTINE PIKAR(P,Q,R,TCON)
      DIMENSION                                                             10
     1 AA(512,10), XLAM(5,20), ALEN(5,20,5), ENGH(80), ARP(60),            11
     2 AB(127,15),   ELE(5,20),  RAR(5,20,5),  ENG(80),  SD(60),           12
     3    NEP(127),   ENE(5,20),  KEV(127,15), ENGL(80), NHI(60),          13
     4  ELEM(127),   AAS(5,20),     Y(200,3),  RES(60),  FE(60),           14
     5    TP(127),    KT(5,20),    TAB3(100), KLAS(60), X(200),            15
     6     A(512),      B(512),     NUPIC(5), NLOW(60), ALFA(5),           16
     7     T(127),     NE(127)                                             17
      DIMENSION                                                             18
     1    C(512), REST(512)                                                 19
C
      COMMON NP,Y,X,N,RINDA,LOGA,LOGO,IS                                    22
      COMMON                                                                23
     1     ENG,    ENGH,    ENGL,    TDEC,    TIR,    PESO,   FLUSS,  NUPIC,  24
     2     ENE,     ELE,     AAS,    XLAM,     KT,    ALEN,     RAR,     KO,  25
     3   EHIGH,    ELOW,     RES,       A,      B,    NLOW,      FE,    NHI,  26
     4      L1,      L2,      L3,      L4,     L5,      L6,    ELEM,     TP,  27
     5       T,      NE,     NEP,     KEV,     AB,    KLOW,   KHIGH,   JMAX,  28
     6    IFIT,    KLAS,     ARP,      SD,   TAB3,     AKK,     BKK,     AA   29
C
C
      RL=1.00                                                               ,1
      RR=1.05                                                               ,2
      DO 10 I=KLOW,KHIGH                                                    ,3
   10 C(I)=A(I)+P*SQRT(A(I))                                                ,4
      I=KLOW+2                                                              ,6
      J=0                                                                   ,7
   12 I=I+1                                                                 ,8
      IF(I-KHIGH+3)16,84,84                                                 ,9
   16 IF(A(I)-A(I-1))12,18,18                                               ,10
   18 IF(A(I)-A(I+1))12,12,20                                               ,11
   20 IL=I                                                                  ,12
      KLS=100                                                               ,13
      IF(A(I)-C(I-1))24,24,26                                               ,14
   24 IL=IL-1                                                               ,15
      KLS=200                                                               ,16
   26 IH=I                                                                  ,17
      IF(A(I)-C(I+1))28,28,30                                               ,18
   28 IH=IH+1                                                               ,19
      KLS=KLS+100
C
   30 IF(A(IL-1)-C(IL-2))38,38,36                                           ,20
   36 IF(A(IH+1)-C(IH+2))38,38,42                                           ,21
   38 IF(A(IL)-0.333*Q*RL*(A(IL-1)+A(IL-2)+A(IL-3)))12,12,39               ,22
   39 IF(A(IH)-0.333*Q*RR*(A(IH+1)+A(IH+2)+A(IH+3)))12,12,40               ,23
   40 KLS=KLS+500                                                           ,24
C
   42 IL=IL-1                                                               ,25
      IF(IL-KLOW-3)54,54,44                                                 ,26
   44 IF(A(IL)-A(IL-1))46,42,42                                             ,27
   46 IF(A(IL)-0.333*RL*(A(IL-3)+A(IL-2)+A(IL-1)))54,54,48                 ,28
   48 IF(J-1)52,52,50                                                       ,29
   50 IF(IL-NHI(J-1))54,54,52                                               ,30
   52 KLS=KLS+10                                                            ,31
                                                                            ,32
```

```
         GO TO 42
C                                                                         ,33
     54  IH=IH+1                                                          ,34
         IF(IH-KHIGH+3)56,62,62                                           ,35
     56  IF(A(IH)-A(IH+1))58,54,54                                        ,36
     58  IF(A(IH)-0.333*RR*(A(IH+3)+A(IH+2)+A(IH+1)))62,62,60             ,37
     60  KLS=KLS+1                                                        ,38
         GO TO 54
C                                                                         ,39
     62  ART=0.0                                                          ,40
         DO 64 L=IL,IH                                                    ,41
     64  ART=ART+A(L)                                                     ,42
         FLT=IH-IL+1                                                      ,44
         AP=ART-0.5*FLT*(A(IL)+A(IH))                                     ,45
         SDEV=SQRT(ART+FLT*FLT*(A(IL)+A(IH))*0.25)                        ,46
         IF(AP*R-SDEV)12,12,66                                            ,47
     66  IF(J-60)68,67,67                                                 ,48
     67  WRITE (6,201)                                                    ,49
         GO TO 84                                                         ,51
    201  FORMAT (1H0,26HWARNING JMAX LIMITED TO 60/1H0)
C
     68  J=J+1                                                            ,52
         IMEM=IH                                                          ,53
         DO 90 KLEBS=IL,IH                                                ,54
         FLEBS=KLEBS                                                      ,55
         FIL=IL                                                           ,56
         FIH=IH                                                           ,57
         FLH=(A(IH)-A(IL))/(FIH-FIL)                                      ,58
         FOND=FLH*(FLEBS-FIL)+A(IL)                                       ,59
     90  REST(KLEBS)=A(KLEBS)-FOND                                        ,60
     93  IF(REST(I)-REST(I-1))91,92,92                                    ,62
     91  I=I-1                                                            ,63
         GO TO 93                                                         ,64
     92  IF(REST(I)-REST(I+1))94,95,95                                    ,65
     94  I=I+1                                                            ,66
         GO TO 92                                                         ,67
     95  SUM1=0.                                                          ,68
         SUM2=0.                                                          ,69
         DO 96 KLEB=IL,IH                                                 ,70
         IF(2.*REST(KLEB)-REST(I))96,97,97                                ,71
     97  FLEB=KLEB                                                        ,72
         SUM1=SUM1+FLEB*REST(KLEB)                                        ,73
         SUM2=SUM2+REST(KLEB)                                             ,74
     96  CONTINUE                                                         ,75
         FE(J)=SUM1/SUM2                                                  ,77
         IFE=FE(J)+0.5                                                    ,78
         DIFE=IFE                                                         ,79
         DELTA=FE(J)-DIFE                                                 ,80
         IF(DELTA)70,70,71                                                ,81
     70  XMAS=(1.-DELTA)*REST(IFE)+DELTA*REST(IFE-1)                      ,82
         GO TO 72                                                         ,83
     71  XMAS=(1.-DELTA)*REST(IFE)+DELTA*REST(IFE+1)                      ,84
     72  RES(J)=2.*AP/XMAS*SQRT(0.693/3.14)                               ,85
    103  NHI(J)=IH                                                        ,86
         NLOW(J)=IL                                                       ,87
         KLAS(J)=KLS                                                      ,88
```

```
      ARP(J)=AP/TCON                                              ,89
      SD(J)=SDEV/TCON                                             ,90
      I=IMEM                                                      ,91
      GO TO 12
C                                                                 ,92
   84 JMAX=J                                                      ,93
      RETURN                                                      ,94
      END                                                         ,95
```

```
      SUBROUTINE GRAPH
      DIMENSION Y(200,3),X(200),V(18),E1(6),E2(6),E3(6),Y2(200,3),X2(200
     1),M1(200,3),M2(200),IMIN(3),IMAX(3)
      DIMENSION MM(41),G(41)
C THE FOLLOWING STATEMENT(S) HAVE BEEN MANUFACTURED BY THE TRANSLATOR TO
C   COMPENSATE FOR THE FACT THAT EQUIVALENCE DOES NOT REORDER COMMON---
      COMMON  NP     , Y      , X      , N      , RINDA  , LOGA
      COMMON  LOGO   , IS
C     DIMENSION MM(41),G(41)
C     COMMON NP,Y,X,N,RINDA,LOGA,LOGO,IS
      DO 10 I=1,18                                                      ,1
      DATA Q000HL/6H       /
   10 V(I)=Q000HL                                                       ,2
      DATA Q001HL/6H.      /
      E1(1)=Q001HL                                                      ,4
      DATA Q002HL/6H .     /
      E1(2)=Q002HL                                                      ,5
      DATA Q003HL/6H  .    /
      E1(3)=Q003HL                                                      ,6
      DATA Q004HL/6H   .   /
      E1(4)=Q004HL                                                      ,7
      DATA Q005HL/6H    .  /
      E1(5)=Q005HL                                                      ,8
      DATA Q006HL/6H     ./
      E1(6)=Q006HL                                                      ,9
      DATA Q007HL/6H*      /
      E2(1)=Q007HL                                                      ,10
      DATA Q008HL/6H *     /
      E2(2)=Q008HL                                                      ,11
      DATA Q009HL/6H  *    /
      E2(3)=Q009HL                                                      ,12
      DATA Q010HL/6H   *   /
      E2(4)=Q010HL                                                      ,13
      DATA Q011HL/6H    *  /
      E2(5)=Q011HL                                                      ,14
      DATA Q012HL/6H     */
      E2(6)=Q012HL                                                      ,15
      DATA Q013HL/6H+      /
      E3(1)=Q013HL                                                      ,16
      DATA Q014HL/6H +     /
      E3(2)=Q014HL                                                      ,17
      DATA Q015HL/6H  +    /
      E3(3)=Q015HL                                                      ,18
      DATA Q016HL/6H   +   /
      E3(4)=Q016HL                                                      ,19
      DATA Q017HL/6H    +  /
      E3(5)=Q017HL                                                      ,20
      DATA Q018HL/6H     +/
      E3(6)=Q018HL                                                      ,21
      DO 60 J=1,NP                                                      ,22
      IMIN(J)=1                                                         ,23
      IMAX(J)=1                                                         ,24
      LLL=IMIN(J)                                                       ,25
      MMM=IMAX(J)                                                       ,26
      DO 24 K=2,N                                                       ,27
```

```
          B                                                        02/15/67
     EXTERNAL FORMULA NUMBER   -   SOURCE STATEMENT   -   INTERNAL FORMULA NUMBER(S
       IF(Y(K,J)-Y(LLL,J))23,23,24                                 0580      ,28
  23   IMIN(J)=K                                                   0590      ,29
       LLL=IMIN(J)                                                 0600      ,30
  24   CONTINUE                                                    0610      ,31
       DO 34  K=2,N                                                0620      ,33
       IF(Y(K,J)-Y(MMM,J))34,34,33                                 0630      ,34
  33   IMAX(J)=K                                                   0640      ,35
       MMM=IMAX(J)                                                 0650      ,36
  34   CONTINUE                                                    0660      ,37
  60   CONTINUE                                                    0670      ,39
       IF(NP-1)81,81,80                                            0680      ,41
  80   LMIN=1                                                      0690      ,42
       KMIN=IMIN(1)                                                0700      ,43
       DO 64  J=2,NP                                               0710      ,44
       K=IMIN(J)                                                   0720      ,45
       IF(Y(K,J)-Y(KMIN,LMIN))63,63,64                             0730      ,46
  63   LMIN=J                                                      0740      ,47
       KMIN=K                                                      0750      ,48
  64   CONTINUE                                                    0760      ,49
       LMAX=1                                                      0770      ,51
       KMAX=IMAX(1)                                                0780      ,52
       DO 65  J=2,NP                                               0790      ,53
       K=IMAX(J)                                                   0800      ,54
       IF(Y(K,J)-Y(KMAX,LMAX))65,66,66                             0810      ,55
  66   LMAX=J                                                      0820      ,56
       KMAX=K                                                      0830      ,57
  65   CONTINUE                                                    0840      ,58
       GO TO 149                                                   0850      ,60
  81   LMIN=1                                                      0860      ,61
       KMIN=IMIN(1)                                                0870      ,62
       LMAX=1                                                      0880      ,63
       KMAX=IMAX(1)                                                0890      ,64
 149   IF(IS)150,150,151                                           0900      ,65
 151   IF(Y(KMAX,LMAX))8002,152,8001                               0910      ,66
8002   D1=Y(KMIN,LMIN)/Y(KMAX,LMAX)                                0920      ,67
       GO TO 8015                                                  0930      ,68
8001   D1=Y(KMAX,LMAX)/Y(KMIN,LMIN)                                0940      ,69
8015   IF(D1-10.E+02)152,152,153                                   0950      ,70
 152   LOGO=-1                                                     0960      ,71
       GO TO 8003                                                  0970      ,72
 153   LOGO=+1                                                     0980      ,73
8003   IF(X(N))8012,155,8011                                       0990      ,74
8012   D2=X(1)/X(N)                                                1000      ,75
       GO TO 8016                                                  1010      ,76
8011   D2=X(N)/X(1)                                                1020      ,77
8016   IF(D2-10.E+02)155,155,156                                   1030      ,78
 155   LOGA=-1                                                     1040      ,79
       GO TO 150                                                   1050      ,80
 156   LOGA=+1                                                     1060      ,81
 150   IF(LOGA)43,43,44                                            1070      ,82
  44   DO 45  K=1,N                                                1080      ,83
  45   X2(K)=ALOG(ABS(X(K)))*0.43429*X(K)/ABS(X(K))                1090      ,84
       WRITE (6,1012)                                              1100      ,86
1012   FORMAT (23H  LOG SCALE IN ABSCISSA/)                        1110
       GO TO 47                                                    1120      ,88
  43   DO 46  K=1,N                                                1130      ,89
```

```
               B                                                   02/15/67
       EXTERNAL FORMULA NUMBER    -    SOURCE STATEMENT    -    INTERNAL FORMULA NUMBER(S

  46 X2(K)=X(K)                                                            1140   ,90
     WRITE (6,1008)                                                        1150   ,92
1008 FORMAT (26H  NORMAL SCALE IN ABSCISSA/)                               1160
  47 IF(LOGO)48,48,49                                                      1170   ,94
  49 DO 50 K=1,N                                                           1180   ,95
     DO 50 J=1,NP                                                          1190   ,96
  50 Y2(K,J)=ALOG(ABS(Y(K,J)))*0.43429*Y(K,J)/ABS(Y(K,J))                  1200   ,97
     WRITE (6,1011)                                                        1210   ,100
1011 FORMAT (23H  LOG SCALE IN ORDINATE/)                                  1220
     GO TO 51                                                              1230   ,102
  48 DO 52 K=1,N                                                           1240   ,103
     DO 52 J=1,NP                                                          1250   ,104
  52 Y2(K,J)=Y(K,J)                                                        1260   ,105
     WRITE (6,1009)                                                        1270   ,108
1009 FORMAT(26H  NORMAL SCALE IN ORDINATE/)                                1280
  51 XINTM=X2(2)-X2(1)                                                     1290   ,110
      DO 700 J=3,N                                                         1300   ,111
      XINT=X2(J)-X2(J-1)                                                   1310   ,112
      IF(XINT-XINTM)701,700,700                                            1320   ,113
 701 XINTM=XINT                                                            1330   ,114
 700 CONTINUE                                                              1340   ,115
     DO 53 K=1,N                                                           1350   ,117
      M2(K)=2.5+((X2(K)-X2(1))/XINTM)                                      1360   ,118
     DO 53 J=1,NP                                                          1370   ,119
  53 M1(K,J)=((Y2(K,J)-Y2(KMIN,LMIN))/(Y2(KMAX,LMAX)-Y2(KMIN,LMIN)))*      1380
    1(96.0-(10.0*(FLOAT(NP)-1.0)))+1.5                                     1390   ,120
        IF (RINDA)702,702,703                                              1400   ,123
 703 DO 704 K=1,N                                                          1410   ,124
 704 M2(K)=2.0+(78.0-(10.0*(FLOAT(NP)-1.0)))*RINDA*(X2(K)-X2(1))/(X2(N)    1420
    1-X2(1))+0.5                                                           1430   ,125
 702 AA=Y2(KMAX,LMAX)                                                      1440   ,127
     BB=Y2(KMIN,LMIN)                                                      1450   ,128
     DIF=AA-BB                                                             1460   ,129
     TAC=10.E-35                                                           1470   ,130
     IF(DIF-TAC)73,73,7                                                    1480   ,131
  73 CALL EXIT                                                             1490   ,132
   6 TAC=TAC*10.0                                                          1500   ,133
   7 TEC=TAC*10.0                                                          1510   ,134
     IF(DIF-4.0*TEC)4,4,6                                                  1520   ,135
   4 IF(LOGO)8700,8700,8701                                                1530   ,136
8701 IF(TAC-1.0)8702,8700,8700                                             1540   ,137
8702 TAC=1.0                                                               1550   ,138
8700 BBB=AINT((BB/TAC)*1.00001)*TAC                                        1560   ,139
     AAA=AINT((AA/TAC)*1.00001)*TAC                                        1570   ,140
      IF(ABS((BBB-BB)/BB)-1.E-05)8500,8500,8800                            1580   ,141
8800 IF(BB-BBB)8500,8500,8501                                              1590   ,142
8501 BBB=BBB+TAC                                                           1600   ,143
8500 IF(ABS((AAA-AA)/AA)-1.E-05)8600,8600,8801                             1610   ,144
8801 IF(AA-AAA)8601,8600,8600                                              1620   ,145
8601 AAA=AAA-TAC                                                           1630   ,146
8600 DIFV=AAA-BBB                                                          1640   ,147
     NQP=AINT((DIFV/TAC)*1.00001)+1.0                                      1650   ,148
     DO 18 I=1,NQP                                                         1660   ,149
     P=FLOAT(I)-1.0                                                        1670   ,150
  18 G(I)=BBB+TAC*P                                                        1680   ,151
      IF(ABS(G(1)-BB)-1.E-05)8900,8900,8901                                1690   ,153
```

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          B                                                                     02/15/67
     EXTERNAL FORMULA NUMBER   -   SOURCE STATEMENT   -   INTERNAL FORMULA NUMBER(S

8900 G(1)=BB                                                              1700    ,154
8901 DO 19 J=1,NQP                                                        1710    ,155
  19 MM(J)=((G(J)-BB)/(AA-BB))*(96.0-(10.0*(FLOAT(NP)-1.0)))+1.5          1720    ,156
     IF(LOGO)9001,9001,9002                                               1790    ,158
9002 EBBB=10.0**BBB                                                               ,159
     ETAC=10.0**TAC                                                       1740    ,160
     IF(Y(KMIN,LMIN))8705,8706,8706                                       1750    ,161
8705 ETAC=1.0/ETAC                                                        1760    ,162
     EBBB=-1.0/EBBB                                                       1770    ,163
8706 CONTINUE                                                             1780    ,164
     WRITE (6,999)EBBB,ETAC                                                       ,165
 999 FORMAT (55H  INFORMATIONS ON ORDINATE SCALE - LEFT SCALING POINT =   1810
    11PE12.3,31H-FACTOR BETWEEN SCALING POINTS=1PE12.3)                   1820
     GO TO 8000                                                           1830    ,168
9001 WRITE (6,99)BBB,TAC                                                  1840    ,169
  99 FORMAT (55H  INFORMATIONS ON ORDINATE SCALE - LEFT SCALING POINT =   1850
    11PE12.3,33H-INTERVAL BETWEEN SCALING POINTS=1PE12.3)                 1860
8000 DO 28 J=1,NQP                                                        1870    ,172
     IF(J-1)20,20,21                                                      1880    ,173
  20 KKK=1                                                                1890    ,174
     GO TO 22                                                             1900    ,175
  21 KKK=4                                                                1910    ,176
  22 MIAO=NP*KKK                                                          1920    ,177
     N2=MM(J)/6                                                           1930    ,178
     IF(N2)83,83,84                                                       1940    ,179
  83 N3=MM(J)                                                             1950    ,180
 103 GO TO(6001,6002,6003,6009,6009,6009,6009,6005,6005,6005,6005,6006)   1960
    1,MIAO                                                                1970    ,181
6001 WRITE (6,1015)E1(N3)                                                 1980    ,182
     GO TO 28                                                             1990    ,185
6002 WRITE (6,1025)E1(N3)                                                 2000    ,186
     GO TO 28                                                             2010    ,189
6003 WRITE (6,1035)E1(N3)                                                 2020    ,190
     GO TO 28                                                             2030    ,193
6005 WRITE (6,1205)E1(N3)                                                 2040    ,194
     GO TO 28                                                             2050    ,197
6006 WRITE (6,1305)E1(N3)                                                 2060    ,198
     GO TO 28                                                             2070    ,201
6009 WRITE (6,1105)E1(N3)                                                 2080    ,202
     GO TO 28                                                             2090    ,205
  84 N3=MM(J)-N2*6                                                        2100    ,206
     IF(N3)86,86,87                                                       2110    ,207
  86 N2=N2-1                                                              2120    ,208
     IF(N2)7003,7003,7002                                                 2130    ,209
7003 N3=6                                                                 2140    ,210
        GO TO 103                                                         2150    ,211
7002 N3=6                                                                 2160    ,212
  87 GO TO(6011,6012,6013,6019,6019,6019,6019,6015,6015,6015,6015,6016)   2170
    1,MIAO                                                                2180    ,213
6011 WRITE (6,1015)(V(L),L=1,N2),E1(N3)                                   2190    ,214

     GO TO 28                                                             2200    ,220
6012 WRITE (6,1025)(V(L),L=1,N2),E1(N3)                                   2210    ,221

     GO TO 28                                                             2220    ,227
6013 WRITE (6,1035)(V(L),L=1,N2),E1(N3)                                   2230    ,228
```

```
     GO TO 28                                                        2240    ,234
6015 WRITE (6,1205)(V(L),L=1,N2),E1(N3)                              2250    ,235

     GO TO 28                                                        2260    ,241
6016 WRITE (6,1305)(V(L),L=1,N2),E1(N3)                              2270    ,242

     GO TO 28                                                        2280    ,248
6019 WRITE (6,1105)(V(L),L=1,N2),E1(N3)                              2290    ,249

  28 CONTINUE                                                        2300    ,255
1015 FORMAT (1H0,21X,17A6)                                           2310
1025 FORMAT (1H0,31X,15A6)                                           2320
1035 FORMAT (1H0,41X,14A6)                                           2330
1205 FORMAT (1H+,31X,15A6)                                           2340
1305 FORMAT (1H+,41X,14A6)                                           2350
1105 FORMAT (1H+,21X,17A6)                                           2360
     IF(NP-1)1001,1001,1002                                          2370    ,257
1001 WRITE (6,1005)                                                  2380    ,258
     WRITE (6,3005)                                                  2390    ,260
     GO TO 1010                                                      2400    ,262
1002 IF(NP-2)1006,1006,1007                                          2410    ,263
1006 WRITE (6,1004)                                                  2420    ,264
     WRITE (6,3004)                                                  2430    ,266
     GO TO 1010                                                      2440    ,268
1007 WRITE (6,1003)                                                  2450    ,269
     WRITE (6,3003)                                                  2460    ,271
1005 FORMAT(20H     X          Y(X,1))                               2470
1004 FORMAT(30H     X          Y(X,1)     Y(X,2))                    2480
1003 FORMAT(41H     X          Y(X,1)     Y(X,2)     Y(X,3))         2490
3003 FORMAT(38H                  .          *          +)            2500
3004 FORMAT(27H                  .          *)                       2510
3005 FORMAT(17H                  .)                                  2520
1010 M=0                                                             2530    ,273
     DO 500 K=1,N                                                    2540    ,274
  12 M=M+1                                                           2550    ,275
     IF(M-M2(K))9,40,2000                                            2560    ,276
2000 M=M-1                                                           2570    ,277
     GO TO 500                                                       2580    ,278
   9 WRITE (6,11)                                                    2590    ,279
     GO TO 12                                                        2600    ,281
  40 DO8J=1,NP                                                       2610    ,282
     MIAO=J*NP                                                       2620    ,283
     N2=M1(K,J)/6                                                    2630    ,284
     IF(N2)13,13,14                                                  2640    ,285
  13 N3=M1(K,J)                                                      2650    ,286
 110 GO TO(2001,2002,2003,2005,2005,2006,2006,2006,2009),MIAO        2660    ,287
2001 WRITE (6,15)X(K),(Y(K,L),L=1,NP),E1(N3)                         2670    ,288
                                                                             ,294
     GO TO 8                                                         2680    ,295
2002 WRITE (6,25)X(K),(Y(K,L),L=1,NP),E1(N3)                         2690    ,296
                                                                             ,302
     GO TO 8                                                         2700    ,303
2003 WRITE (6,35)X(K),(Y(K,L),L=1,NP),E1(N3)                         2710    ,304
                                                                             ,310
     GO TO 8                                                         2720    ,311
```

```
      EXTERNAL FORMULA NUMBER   -   SOURCE STATEMENT   -   INTERNAL FORMULA NUMBER(S
2005 WRITE (6,205)X(K),(Y(K,L),L=1,NP),E2(N3)                                2730   ,312
                                                                                    ,318
     GO TO 8                                                                 2740   ,319
2006 WRITE (6,305)X(K),(Y(K,L),L=1,NP),E2(N3)                                2750   ,320
                                                                                    ,326
     GO TO 8                                                                 2760   ,327
2009 WRITE (6,305)X(K),(Y(K,L),L=1,NP),E3(N3)                                2770   ,328
                                                                                    ,334
     GO TO 8                                                                 2780   ,335
  14 N3=M1(K,J)-N2*6                                                         2790   ,336
     IF(N3)16,16,17                                                          2800   ,337
  16 N2=N2-1                                                                 2810   ,338
     IF(N2)3,3,2                                                             2820   ,339
   3 N3=6                                                                    2830   ,340
     GO TO 110                                                               2840   ,341
   2 N3=6                                                                    2850   ,342
  17 GO TO(2011,2012,2013,2015,2015,2016,2016,2016,2019),MIAO                2860   ,343
2011 WRITE (6,15)X(K),(Y(K,L),L=1,NP),(V(L),L=1,N2),E1(N3)                   2870   ,344
                                                                                    ,350
     GO TO 8                                                                 2880   ,354
2012 WRITE (6,25)X(K),(Y(K,L),L=1,NP),(V(L),L=1,N2),E1(N3)                   2890   ,355
                                                                                    ,361
     GO TO 8                                                                 2900   ,365
2013 WRITE (6,35)X(K),(Y(K,L),L=1,NP),(V(L),L=1,N2),E1(N3)                   2910   ,366
                                                                                    ,372
     GO TO 8                                                                 2920   ,376
2015 WRITE (6,205)X(K),(Y(K,L),L=1,NP),(V(L),L=1,N2),E2(N3)                  2930   ,377
                                                                                    ,383
     GO TO 8                                                                 2940   ,387
2016 WRITE (6,305)X(K),(Y(K,L),L=1,NP),(V(L),L=1,N2),E2(N3)                  2950   ,388
                                                                                    ,394
     GO TO 8                                                                 2960   ,398
2019 WRITE (6,305)X(K),(Y(K,L),L=1,NP),(V(L),L=1,N2),E3(N3)                  2970   ,399
                                                                                    ,405
   8 CONTINUE                                                                2980   ,409
 500 CONTINUE                                                                2990   ,411
  11 FORMAT (2H  )                                                           3000
  15 FORMAT (1H ,1P2E10.2,1X,17A6)                                           3010
  25 FORMAT (1H ,1P3E10.2,1X,15A6)                                           3020
  35 FORMAT (1H ,1P4E10.2,1X,14A6)                                           3030
 205 FORMAT (1H+,1P3E10.2,1X,15A6)                                           3040
 305 FORMAT (1H+,1P4E10.2,1X,14A6)                                           3050
     RETURN                                                                  3060   ,413
     END                                                                     3070   ,414
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Alfred Nobel

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