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BAND-1 - A DATA REDUCTION PROGRAM FOR THE IBM-704

May 1961

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**BETTIS ATOMIC POWER LABORATORY
PITTSBURGH, PENNSYLVANIA**

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BAND-1
A DATA REDUCTION PROGRAM FOR THE IBM-704

B. L. Anderson
A. P. Hemphill
P. H. Jarvis
R. E. Kettler

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BAND-1 is an IBM-704 program to reduce the experimental data obtained from measurements of the neutron activation distribution within a critical facility. The data reduction consists of correcting the measured data, sorting and ordering it, and calculating the critical buckling parameters by means of a least squares analysis.

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BAND-1
A DATA REDUCTION PROGRAM FOR THE IBM-704

I. INTRODUCTION

A. Purpose

The purpose of the BAND-1 program is to reduce the amount of manual processing of activation distribution data measured in critical assemblies. By setting up a systematic method of processing and analyzing the data, BAND-1 has eliminated much of the tedious and time consuming work of the experimentalist.

B. Experimental Techniques

Measurement of the neutron activation distribution in a critical reactor consists of inserting activating materials (detectors) in the form of wires or foils into plastic or metal holders (wands) and loading the wands into those positions of the critical assembly where measurements are desired. Each wand holds a series of detectors, usually along a straight line through the assembly. After being irradiated, the wands are removed from the reactor, the detectors transferred to individual holders or chips and the chips are loaded into counting units. The loading of the counting units is designed to optimize the use of ten counting units and usually results in the simultaneous counting of detectors from a given wand in more than one counting channel.

The counting system typically consists of ten counting channels using anthracene crystals and photomultiplier tubes to measure the beta emission of the irradiated detectors. The system has been equipped with automatic sample changers for each channel and can be operated either manually or automatically.

Data is automatically punched onto IBM cards at the end of each count cycle and consists of the run number, a serial card number, the time from reactor shutdown at which the sample is counted, and from one to ten counts of six digits each. This deck of cards, either automatically punched or manually punched in the same format, is used as input to BAND-1.

II. GENERAL DESCRIPTION

BAND-1 is divided into two separate sections, which will be referred to as Phase I and Phase II. Each phase may be run as a separate problem or both may be run together, where the output of Phase I serves as input to Phase II.

A. Phase I

Phase I corrects the raw data and reassembles it into wands. Corrections to the raw counts consist of channel normalization, background correction, and, if necessary, decay correction. Following this, the necessary bookkeeping consists of reassembling the wand sections into the original wands or traverses, or creating new traverses, and creating the positional coordinates of the samples.

For each wand, a listing is made containing an identification, the positional coordinates, the raw counts, and the corrected counts. A magnetic tape containing the same information is written and may be used as input to Phase II.

These wands, or any combination of them, may be selected for plotting either by the IBM off-line printer or by decks of cards punched for automatic plotting on the Moseley plotter through an IBM-519 card reader.

B. Phase II

Phase II provides a least squares analysis for positive and negative buckling parameters. The same iterative least-squares method which was used in COFIT (Ref. 1) is used in BAND-1. The equations which may be selected for analysis are:

$$(1) \quad y = Ae^{BX}$$

$$(2) \quad y = A \cos B(x-C)$$

$$(3) \quad y = A \sinh B(x-C)$$

It has been found from experience that many attempts to fit data to the hyperbolic sine function are unsuccessful, therefore a provision has been made in the program to switch from the hyperbolic sine-fit to the exponential-fit if a problem has failed to converge after 25 iterations.

Phase II may be entered immediately following Phase I or at some later time using the magnetic tape containing the wand assemblies as input. By saving the tape and re-entering the program to do Phase II, it is possible for the user to delete or correct any bad counts before attempting to do the curve fitting problems.

Entry to Phase II may also be made by the user's providing all the information which would have been created by Phase I, i.e., a wand name or identification, x-values, y-values, and weighting factors. A tape containing this information is written and may be saved for use at a later time.

An outline of the BAND-1 program is shown in Figure 1 in the appendix.

III. PHASE I

A. Preliminary Calculations

1. Standard Count Ratios

In order to detect drift or a change in counter sensitivity within a channel during a run, a long lived sample is counted as a standard in the same channel throughout the entire run. The ratio of each standard count to the succeeding standard count is printed for each channel.

2. Background Correction

Background counts can be identified in a listing of the data as counts preceded by a minus sign. To correct for background, an average of two successive background counts is taken and added (since the signs are negative) to each sample count between the background counts. It is assumed that if there is a background count in one of the recording channels, there is one in the same position in each of the channels being used.

3. Channel Normalization

The first counting cycle must contain the channel normalization counts. These counts must be preceded and followed by a background-standard-background count set and are obtained by counting a given set of wires on all channels being used. These normalization counts are then summed for each channel and the sums divided into the largest sum, giving a normalization ratio greater than one. All the remaining counts in the channel are multiplied by this ratio. The normalization sums and ratios are printed as part of the Phase I output.

Any number of normalization counts may be taken just so long as the total number of data cards does not exceed 500. It is not necessary to use all of the counting channels; any combination of the ten channels may be used providing the same channels are used throughout a problem.

4. Decay Correction

Two methods used in counting are preset-time and preset-count. Preset-time requires that each sample be counted the same length of time. The activities are corrected for decay loss by multiplying them by a decay correction factor $e^{\lambda t}$, where λ is the decay rate of the material being counted in sec^{-1} , and t is the time in seconds from the reactor shutdown to the counting time. The only restriction imposed is that

$$-88.028 < \lambda t < 88.028 .$$

For preset count, the counting time for each sample increases in proportion to the decay rate of the sample being counted. This procedure is used when the decay rate is not known or is very complex. There is no need to decay correct this data, therefore the decay constant is set equal to zero.

5. Deletion of Bad Counts

It is possible to delete counts from the raw data by indicating the channel number and the card number of the count. The positional coordinate, corresponding to this count, will also be deleted.

B. Bookkeeping and Wand Assembly

The function of the bookkeeping section is to assemble sections of wands into complete wands and to create the positional coordinate, or x-value, for each sample.

A wand section is specified by giving the number of the channel in which it is counted and the card numbers of the initial and final counts. A section may contain background counts, but no standard counts.

A wand may be assembled from any number of sections or parts of sections. The only limit on the number of points is imposed by Phase II which requires that the number of points per wand be ≤ 300 .

The assembled wand is designated by a wand name which is supplied as part of the control data. The wand name is a seven digit coded number of which the first two digits represents a letter, A = 01, ..., Z = 26; the next four digits are arbitrary and the final digit must be zero, one, or two. Zero is used if the wand section is to be listed as the original counting, and one is used if it is to be the repeat counting. Each section of a wand must be specified by listing the wand name, the channel in which it is counted, the card numbers of the initial and final count, the initial x-value, the spacing, Δx , of the wires, and a scale limit J which will be explained in the section dealing with the Moseley plotter. The x-values will be created by assigning to the first count the initial value x and increasing it by Δx for each succeeding count. However, if the spacing, Δx , is to be the same as for the preceding section, a value of (-1) may be used in place of Δx ; and, if the spacing is to continue from the last value of the preceding section, a value of (-1) may be used in place of the initial x-value.

After all wand sections have been specified in the above manner, and if some of these sections are repeat sections, then a wand name representing the averaged wand must be specified. The final digit of the wand name must be a two. The remaining six pieces of data describing the section must all appear as zeros.

Data may be listed under more than one wand name. Up to 100 wands may be created; however, repeat wands and averaged wands count as separate wands in determining this limit.

A listing of the input and the corresponding output may be found in the sample problem appearing in the appendix.

C. Normalization for the Moseley Plotter

Phase I of BAND contains an option to provide a deck of cards containing selected wands for automatic plotting by a Moseley x-y Plotter connected to an IBM-519 card punch. The data is normalized for plotting on K and E, 11" x 16-1/2", 10 by 10 to the 1/2 inch, graph paper.

There are two types of normalization possible for the y-axis:

Type 1 - Five or fewer wands are treated as a group. Each wand is normalized to full scale.

Type 2 - Five or fewer wands are treated as a group. The maximum activity of the group of wands is normalized to full scale and the other wands are normalized proportionally.

The type of normalization and grouping is optional, and the input consists of the wand names and the type of normalization desired. A particular wand may be punched as often and in as many combinations as desired; however, only the original counts may be punched.

The Moseley system can accept x and y values as follows:

$0.000 \leq x \leq 0.999$ in increments of 0.001,

$0.000 \leq y \leq 1.999$ in increments of 0.001.

Since the x and y axes of the data to be plotted may vary depending upon the activity level and the wand length, some system of scaling these curves is necessary to insure that they will fit the required size of graph paper.

For the x-axis there is a single type of normalization determined by an input "scale limit J". The normalization factor K_x is determined as follows:

$$K_x = \frac{0.999}{J} .$$

All of the x-values for the wand are multiplied by this factor.

The y-axis of the graph paper contains 20 major divisions with each further subdivided into 10 units. It is desirable that the normalized y-axis be such that an integer times some power of ten correspond to each major division of the scale. Such an arrangement allows for easier interpolation of the data points. Allowing only the integers 0-9, the worth of each major division of the y-axis and the maximum value of the y-axis are given by the following table:

<u>i</u>	<u>U - Unit Worth</u>	<u>T - Max Value of y-axis</u>
0	0	0
1	10	200
2	20	400
3	30	600
4	40	800
5	50	1000
6	60	1200
7	70	1400
8	80	1600
9	90	1800

The maximum activity of each wand for type 1 normalization and the maximum activity for the group in a type 2 normalization are reduced to a number less than 1800 by dividing by some multiple of ten, i.e.,

$$C = C' \times 10^F$$

where C is the original count,

$$0 \leq C' \leq 1800$$

and F is the y-axis scale factor. The unit worth is determined from the table

such that

$$T_i \leq C_i \leq T_{i+1}.$$

The unit worth used is U_{i+1} . The normalization factor K_y is computed from

$$K_y = \frac{1.999}{T_{i+1}}.$$

All of the activities of the wand or group of wands are multiplied by this factor.

Consider, for example, the following three wands:

	<u>Max. Activity</u>
A	125,763
B	28,943
C	3,254

Normalized as a type 1 plot:

	<u>F</u>	<u>U</u>	<u>K_y</u>
A	2	70	1.999/1400
B	2	20	1.999/400
C	1	20	1.999/400

Normalized as type 2 plot:

	<u>F</u>	<u>U</u>	<u>K_y</u>
A	2	70	1.999/1400
B	2	70	1.999/1400
C	2	70	1.999/1400

The normalized x and y values for each wand in the group are punched by the computer into a deck of IBM cards. Since the unit worth of each axis of each wand in the group may differ, a set of x and y axis points are punched out for each wand following the data points. There are 20 values punched for each y-axis of each wand, starting with 0.000 and increasing by the value of U to 1.999. The x-axis is punched in intervals of two units from 0.000 to 0.999. There is only one set of axes for wands of type 2 normalization and one set for each curve of type 1 normalized wand groups. There is a data deck punched for each group of wands. Each deck contains a group number to identify it with its printed information.

The printed output for the Moseley data consists of the following:

- a) Identifying group number,
- b) Wand name,
- c) y-axis scale factor, F,
- d) y-axis unit worth, U,
- e) y-axis normalization factor, K_y ,
- f) x-axis scale limit, J,
- g) x-axis normalization factor, K_x ,
- h) The unnormalized decimal values corresponding to the punched x and y axis points.

There is also an IBM-407 listing of the data decks.

D. Normalization for the Off-Line Printer Plots

An output option of Phase I is to have any or all wands plotted by an off-line printer. The option is intended to provide immediate information about the relative shape and magnitude of the plots and to show points which are obviously

out of line. These plots may also be used to determine the regions for analysis in Phase II.

Two types of normalization are available for these plots and are the same as for the Moseley plots. For a type 1 normalization each curve has its own set of axes, and for type 2 there is only one set of axes. The grouping of wands is completely optional and any particular wand may be plotted as often and in as many different groupings as desired. Repeat and averaged counts may be plotted.

The only input information necessary is the wand names and the type of normalization desired.

The x-axis is determined as follows:

The subroutine finds a scale increment, D_x , from

$$D_x = \frac{X_{\max} - X_{\min}}{(P_x - 1)/10}$$

where $X_{\max}$ = maximum x-value for a given wand,

$X_{\min}$ = minimum x-value for a given wand,

P_x = the number of points in the wand.

P_x must be in the form $10K + 1$ where $K = 1, 2, 3, \dots$ and it is put into this form by the plotting subroutine. The first value of 1, 2, or 5, times some power of 10 which is not less than D_x is chosen as the increment. The scale values, printed at intervals of 10 grid lines, will be consecutive integral multiples of this increment, the first being that which is nearest and not greater than $X_{\min}$. If, however, this results in a scale value on the last grid line which is less than $X_{\max}$, the next larger value of 1, 2, or 5 times some power of 10 which is not less than D_x is chosen as the increment. If it is possible to place the first grid line at 00.0 and still contain $X_{\min}$ and $X_{\max}$ within the number P_x without changing D_x , the subroutine will do so.

The y-axis is chosen as follows for a type 1 normalization:

The subroutine will examine all corrected counts of a wand and remove all zero or negative counts which may still be present. Then, due to limitations in the subroutine, each corrected count is divided by a scaling factor which is either 100 or 1000. If the maximum count of a wand is less than 500,000, the scale factor is 100, otherwise it is 1000.

The y scale increment, D_y , is determined by

$$D_y = (Y_{\max} - Y_{\min})/10$$

where $Y_{\max}$ and $Y_{\min}$ are the maximum and minimum values of the scaled counts. The first value of 1, 2, or 5 times some power of 10 which is less than D_y is chosen as the increment. The denominator is constant since there are a fixed number of grid lines parallel to the X-axis. If the above value of D_y results in a scale value on the last grid line which is less than $Y_{\max}$, the next larger value of 1, 2, or 5 times some power of 10 which is not less than D_y is chosen as the increment.

For type 2 normalizations the minor changes in the above description are apparent.

Consider as an example a wand which has the following properties:

Number of Points = $N = 84$

$$X_{\max} = 18.411$$

$$X_{\min} = 2.000$$

$$Y_{\max} = 285,527$$

$$Y_{\min} = 32,113$$

The y-axis increment would be

$$D_y = (2855.27 - 321.13)/10 = 253.414$$

where $Y_{\max}$ and $Y_{\min}$ have been scaled by the factor 100.

The increment used for the y-axis will be 500 since it is the smallest of the number 100, 200, or 500 which is larger than 253.414. The y-axis grid lines will be multiples of 500 and the smallest increment, y , which the printer can plot is 50.

The x-axis increment is obtained as follows:

$$D_x = (18.411 - 2.00) / \frac{(91-1)}{10} = \frac{16.411}{9} = 1.823$$

and the increment used for the x-axis will be 2.0 since it is the smallest value of 1, 2, or 5 which is greater than D_x . The smallest increment the printer can plot in the x direction is 0.2.

The value of $P_x = 91$ is obtained from the number of points, $N = 84$, on the wand. N points require $N-1$ mesh intervals and since P_x must be in the form $10K + 1$ where $K = 1, 2, 3, \dots$, K must therefore be 9 and $P_x = 10(9) + 1 = 91$.

As a second example consider the following wand

$$N = 150$$

$$X_{\min} = 1.016$$

$$X_{\max} = 30.887$$

$$Y_{\min} = 26,578$$

$$Y_{\max} = 426,827$$

therefore:

$$D_y = (4268.27 - 265.78) / 10 = 400.249$$

$$P_x = 10(15) + 1 = 151$$

$$D_x = (30.887 - 1.016) / 15.1 = 1.987$$

Therefore, the subroutine would use $D_y = 500$ and $D_x = 2$. However, the smallest x interval would be 0.2 inches and 150 mesh spaces would result in an upper limit of 30.0 inches for the x -axis. Since this would not include $X_{\max} = 30.887$, the next value of 5 would be chosen for D_x .

IV. PHASE II

A. General Description

The second phase of BAND-1 attempts to fit to the observed data, which has been corrected and ordered in Phase I, one of three curves:

$$y = A e^{Bx}$$

$$y = A \cos B(x-C)$$

$$y = A \sinh B(x-C)$$

The method of determining the parameters A , B , C is the iterative least squares method used in the IBM-704 programs, COFIT and EXFIT. The derivation of the solution for the hyperbolic-sine function is essentially the same as for the cosine-fit.

In many cases the hyperbolic-sine problem will not converge in a reasonable number of iterations. If a problem does not converge in 25 iterations, or if for other reasons a solution cannot be obtained by the method applied in the program, an attempt will be made to fit the data to an exponential curve.

In addition to the parameters A , B , C , the standard deviations of the estimates for A , B , C are calculated. Although the calculations are unitless, the results are printed assuming that the units were inches and a conversion is made to centimeters.

The computed value of the buckling B^2 , is corrected for a change in critical height of the reactor, due to the presence of the detecting samples. By supplying as input, a value ΔH which is the difference in the bank height in inches for the critical case with and without samples, the correction may be made as follows:

$$B_c^2 = B^2 \left(\frac{H}{H - \Delta H} \right)^2$$

B. Entry to Phase II

Phase II may be entered directly from Phase I. It will use as data the information on the tape prepared in Phase I. This tape contains a list of wand names and the corresponding values of x , corrected count, raw count, for each wand. By specifying the wand name, the type of weighting factor to be calculated and the choice of curve to be fitted, it is possible to attempt to fit any part of a wand to any of the three curves. Any number of regions may be analyzed by specifying the lower and upper limits on x between which the analysis is to be done.

It is sometimes desirable to be able to look at the results of Phase I before entering Phase II. Provision has been made to enter the program at the Phase II level using the binary data tape created in Phase I. Corrections to the tape may be made at this time by deleting bad counts or replacing the counts by other values. This tape, having the corrections, may be used immediately and saved for further analysis.

Entry may also be made directly into Phase II by providing a wand name and the corresponding values of x , y , w , where w is either a weight associated with y or a number corresponding to the raw count from which the weight is to be computed. A tape is created, identical in form to the tape from Phase I, which may also be saved and used at a later time.

V. PREPARATION OF INPUT

BAND-1 input is of the variable field type, with all words separated by commas. The last word on a card must not be followed by a comma.

A. Phase I

1. Title Card

Columns 1-67, available for problem identification.

Columns 68-72, must contain BAND1.

2. General Control Card

a. Format

1) Card number, 1000.

2) Run number.

3) Total number of recording channels, ≤ 10 .

4) Phase control word

1 = Phase I only.

2 = Phase I and Phase II.

3 = Phase II, using data from Phase I or from a tape previously prepared in Phase II.

4 = Phase II, not using data from Phase I or from a previously prepared tape.

5) Deletion control word

0 = Raw counts will not be deleted in Phase I.

1 = Some raw counts will be deleted in Phase I.

6) Normalization control word

0 = Wands will not be punched for automatic plotter.

1 = Some or all wands will be punched for automatic plotter.

7) Off-line printer flux plot control word

0 = None of the wands are to be plotted.

1 = Some or all of the wands are to be plotted.

8) Preset monitor count, an integer to be used in calculating weighting factors in Phase II.

9) Decay constant, a decimal number, λ , where
 $-88.028 < \lambda t < 88.028$.

10) Percentage, a decimal number to be used in computing weighting factors in Phase II.

11) ΔH , a decimal number to be used in computing a corrected buckling.

12) Convergence criterion for curve fitting, a decimal number.

b. Features and Restrictions

1) Any control word which is not needed for a particular problem must be set to zero; it cannot be omitted.

2) An integer must not have any decimal point or exponent.

3) A decimal number must have a decimal point and/or exponent. For example, 1.234, .1234E1, 123.4E-2 each represent the same decimal number.

3. Channel Control Card

The channel control card denotes which of the recording channels are being used. If all channels are being used, do not use this series.

a. Format

1) Card number, 2000.

2) Channel number,

- 3) Channel number,
etc.

b. Features and Restrictions

- 1) Do not use this series if all channels are being used.
- 2) Channel numbers must be given in integer form.

4. Deletion Control Series

a. Format

- 1) Card number, 3000 series,
 - 2) Count card number,
 - 3) Channel number of count,
 - 4) Count card number,
 - 5) Channel number of count,
etc.
- } This pair of numbers describes
one count to be deleted.

b. Features and Restrictions

- 1) If the deletion control word is zero, do not use this series.
- 2) Information must be in integer form.
- 3) As many cards as necessary may be used, as long as they do
not exceed the 3000 series.

5. Bookkeeping Control Series

These cards specify the raw count data to be associated with each wand.

a. Format

- 1) Card number, 4000 series.
- 2) Wand number, a seven digit integer:

digits 1-2: the numerical equivalent of an alphabetic
character

A = 01, B = 02, ..., Z = 26

digits 3-6: to be used for identification

digit 7: 0 for non-repeat counts

1 for repeat counts

2 for averaged wand

- 3) Channel number: the number of the channel in which the raw counts referred to by this card will appear.
 - 4) First count card number: the number of the count card on which the raw counts mentioned in 3) will start.
 - 5) Last count card number: the number of the count card on which the raw counts mentioned in 3) will end. If the raw counts for a particular section of wand are given in reverse order, then $5) < 4)$.
 - 6) Initial x-value for the particular section of wand referred to by this card: If this wand section is simply a continuation of the section on the preceding card, then specifying the initial x-value as minus one (-1) will cause the code to compute it automatically.
 - 7) Mesh spacing for the particular section of wand referred to by this card: Specifying the mesh space as minus one (-1) causes the code to use the same mesh for this wand section as for the last previous section where the mesh was specified.
 - 8) The scale limit J: used for the normalization of the x-axis data in the punched card plotting of this wand. ($J < 99$)
- b. If repeat sections have been specified, BAND-1 will create averaged raw and averaged corrected counts for each x-value at which repeats were specified. In order that this averaged wand

may be referenced by the program, it is necessary that a dummy card be inserted immediately after the repeat section cards. This dummy card must contain a card number and wand number as described above. The remaining six words on the card must all be zeros. If no repeat sections are specified, the dummy card must not be used.

c. Features and Restrictions

- 1) Except for the dummy card, the initial value of x, mesh spacing, and scale limit must be decimal numbers. All other words on the card must be integers.
- 2) Card number 4000 must not have a minus one (-1) mesh.
- 3) All cards relating to the same wand must be grouped together.
- 4) The first card for each wand must not be a repeat.

6. Normalization Grouping Control Series, 5000 Series

This series specifies the grouping of wands for plotting on a Moseley plotter, and the type of normalization to be used for each group. A set of $n+1$ words ($1 \leq n \leq 5$) must be used to specify each group of n wands. The first n words must be wand numbers, with the seventh digit of each, zero. The $(n+1)^{th}$ word must specify the type of normalization (1 or 2).

- 1 = The peak flux of each wand is normalized to 1.999.
- 2 = The wand with the largest peak flux is selected and that peak is normalized to 1.999. The peak fluxes of the remaining wands are normalized relative to this maximum peak flux.

7. Grouping of Wands for Off-Line Printer Flux Plotting

This series specified which of the wands are to be grouped together for plotting. A set of $n+1$ words ($1 \leq n \leq 4$) must be used to specify each group of n

wands that will be plotted on a given set of axes. The first n words must be wand numbers. The $(n+1)^{th}$ word must indicate whether there is to be a common set of axes or if each curve is to have its own set.

a. Format

1) Card number, 6000 series,

2) Wand number,

•
•
•

(≤ 5) Wand number,

(≤ 6) Axes control

1 = Each curve of the plot is to have its own set
of y-axis units.

2 = Each curve is to have the same set of y-axis units.

B. Phase II

This phase may be entered either as a continuation or restart of Phase I, or it may be entered by providing all the data to be analyzed. In any case, it is necessary that there be a title card and a 1000 series control card, described in Phase I. These two cards must be used in all types of BAND-1 problems.

1. No Restart, 7000 Series

a. Format

1) Card numbers, 7000 series,

2) Wand numbers,

3) x,	}	There are to be two sets of points per card unless the total number of points in the wand is odd, in which case there will be one set on the last card.
4) y,		
5) w,		
6) x,		
7) y,	}	
8) w		

b. Features and Restrictions

- 1) The total number of wands ≤ 100 .
- 2) The total number of points per wand ≤ 300 .
- 3) The number w , may be the actual weight to be used or a number to be used to calculate the weight.
- 4) Values of x , y , w are written as decimal numbers.
- 5) A tape containing these wands will be created and may be saved for use at a later time when it can be corrected and/or reanalyzed.

2. Restart, 8000 Series

It is possible by use of this series of control cards to correct a data tape by deleting or replacing counts.

a. Format

- 1) Card number, 8000 series,
- 2) Wand number,
- 3) x ,
 y ,
 w ,
.
.
.
 x ,
 y ,
 w .

b. Features and Restrictions

- 1) As many sets of deletions and corrections may be put onto a card as will fit in the first 72 columns. If there are more corrections to be made than will fit on one card, more cards may be used, but do not split a set between two cards.
- 2) In listing corrections for a wand, values of x must be in ascending order.

- 3) The tape may be corrected and used any number of times.
It will always contain the latest accumulated corrections.
- 4) This series cannot be used with a phase control type 4 problem.

3. Analysis, 9000 Series

A set of control cards to describe the analysis to be done over various sections of the wands.

a. Format

- 1) Card number, 9000 series,
- 2) Wand number,
- 3) Type of analysis,
 - 1 = exponential
 - 2 = cosine
 - 3 = hyperbolic sine
- 4) Type of weighting factor,
 - 0 = use weights as they are
 - 1 = fixed percent of raw count
 - 2 = fixed percent of corrected count
 - 3 = square root of raw count
 - 4 = $\sqrt{y} \cdot \sqrt{1 + y/M}$, y = corrected count
M = preset monitor count
 - 5 = set weight equal to 1.0
- 5) Print out,
 - 0 = print parameters and errors
 - 1 = print parameters, errors, and the value of the function at each point.

- 6) X_L , lower limit on X for which the analysis is to be done.
- 7) X_U , upper limit on X for which the analysis is to be done.

b. Features and Restrictions

- 1) As many sets of X_L and X_U may be put on one card as will fit into the first 72 columns of the card.
- 2) If the limits on X do not actually exist on the list of X coordinates for a particular wand, the code will pick out a coordinate near the limit.
- 3) If the code attempts to fit a hyperbolic sine to a set of data and fails, it will then attempt to fit to this data an exponential function.

C. General Information Concerning Control Cards

1. Number Systems

- a. Integers must not have decimal points or exponents.
 - b. Decimal numbers must have decimal points and/or exponents.
2. Each word on a control card must be followed by a comma, except for the last word, which must not be followed by a comma.
 3. In case a particular control word does not apply to a problem, use a zero. Do not omit the word.

D. Data Cards

1. Format

Columns

1-2	Run number,
3-5	Serial number,
6-10	Time in seconds, from the termination of the irradiation period to the time at which the sample is being counted.

Columns

11	Blank or an 11 punch,
12-17	Count, channel 1,
18	Blank or an 11 punch,
19-24	Count, channel 2
.	
.	
.	
74	Blank or 11 punch
75-80	Count, channel 10.

2. Features and Restrictions

- a. All data on these cards must be in integer form.
- b. In case a count is a background count, it must be identified as such by having an 11 punch preceding the count in columns 11, 18, 25, etc.
- c. It is assumed that standard counts appear between two background counts.
- d. It is also assumed that the order of counts on the first three cards will be as follows:

background

standard

background

These will be followed by a set of normalization counts. There must be at least one normalization count per channel. No upper limit has been specified. But it has been assumed that there are the same number of normalization counts in all counting channels being used and that none of these counts are to be deleted. There must be a background count following the normalization counts.

- e. The maximum number of data cards is 500.
- f. Since the card has an 80 column format, there must not be a label in columns 73-80.
- g. It is assumed that if a background count appears in the first counting channel for a particular card number, there will be a background count for each channel.
- h. It is assumed that none of the counts in the channel being used are zero.

VI. OUTPUT

A. Phase I

1. The ratio of each standard count to the standard count following it in the same channel will be printed.
2. A list of the sums of the normalization counts and the normalization factors will be printed.
3. There will be a listing of each of the wands.
4. A binary tape is created for Phase II which contains a directory of the wands and the corresponding values of x , corrected counts, and raw counts for each of the wands. This tape may be used as input to Phase II immediately or saved for use at a later time.
5. As an option, the wands may be plotted by the off-line printer.
6. Also as an option, a deck of cards may be punched for use on the Moseley plotter. Each punched card contains information at one point for a group of five or fewer non-repeat wands. Each group of wands will be represented by two sets of punched cards. The first set will contain as many cards as there are points in the largest wand of the group. The first card contains information for the

first point, etc. The format is as follows:

Columns

3	Group number. The groups are consecutively numbered by the code.
4-7	The normalized x-axis value for the 1st, 2nd, ..., 5th wand respectively. The format is: .XXX
18-21	
32-35	
46-49	
60-63	
8-11	The normalized corrected counts at the given y values. The format is: XXXX
22-25	
36-39	
50-53	
64-67	
12-16	The natural logarithm of the unnormalized corrected count at the given value of x. The format is: XX.XX
26-30	
40-44	
54-58	
68-72	

The second set contains the value at each division for the x and y axes of each wand in the group. The lower and upper limits are .000 - .999, and .000 - 1.999 for the x and y axes respectively. The actual number of punched cards in this set will depend upon the number of divisions, and hence upon the scaling specified. In any case, the number of cards will be $n+1$, where n is the largest number of axis scale divisions in the group. The format is as follows:

Columns

3 Group number.

7-10

20-23

33-36

46-49

59-62

The value at a division on the x axis (.000 - .999).

The format is: .XXX

12-16

25-29

38-42

51-55

64-68

The value at a division on the y axis (0.000 - 1.999).

The format is: X.XXX

B. Phase II

1. Identification of each wand, with the type of analysis and the type of weighting factor used will be printed.

2. Parameters A, B, C, H, and B^2 along with the standard deviations of the estimates for the parameters will be printed.

3. As an option, the value of the flux at each point may be printed.

4. The tape which was used as input to Phase II will contain any corrections made to the data. This tape may be saved and used at a later time.

VII. OPERATING INSTRUCTIONS

A. Makeup of Problem

1. From Tape

It is possible to run the entire problem from tape. In this case information must be written onto a BCD tape in the following order:

- a. Control cards to Phase I.
- b. Blank card.
- c. Data cards containing raw counts from as many as 10 counting channels.
- d. Blank card.
- e. Control cards to Phase II.
- f. Blank card.

2. From Cards and Tape

It is also possible to run part of the problem from tape and the rest from cards. In any case, the data cards to Phase I must be written on tape. But control information to Phase I and II may be read from the on-line card reader.

The control cards will then be in the following order:

- a. Control cards to Phase I.
- b. Blank card.
- c. Control cards to Phase II.
- d. Blank card.

3. From Cards

If a problem does not require data cards for Phase I, all information may be read in from cards or tape. In either case the information must be in the following order:

- a. Title card.
- b. General control card.
- c. Blank card.
- d. Control cards to Phase II.
- e. Blank card.

B. Tapes

- #1 Program Tape.
- #2 Blank, or a tape saved from a previous problem.
- #3 Tape containing input data.
- #4 Blank.
- #5 Output.

C. Printer Board: Aerojet (or SHARE)

D. Punch - Ready

E. Procedure

- a. CLEAR, LOAD TAPE.
- b. At completion of problems, or after an error stop, save tape #2.
- c. Print output from tape #5 under Program Control.
- d. The end-of-program stop may be either 77775 or 77776.

APPENDIX A

Figure 1

FIGURE I

APPENDIX B

Sample Problem

IBM-407 LISTING OF CONTROL CARDS

SAMPLE PROBLEM FOR WAPD-TM-216

BAND1

1000,243,10,2,0,0,1,0,7.44551E-5,.01,0,.01

4000,2600380,1,28,48,.0,1.0,60.

4001,2600380,1,52,73,-1,-1,60.

4002,2600381,2,72,52,.0,1.0,60.

4003,2600381,2,48,27,-1,-1,60.

4004,2600382,0,0,0,0,0,0

4005,2600480,3,28,48,.0,1.0,60.

4006,2600480,3,52,73,-1,-1,60.

4007,2600481,4,72,52,.0,1.0,60.

4008,2600481,4,48,27,-1,-1,60.

4009,2600482,0,0,1,0,0,0

6000,2600380,1

6001,2600381,1

6002,2600382,1

6003,2600480,2600481,2600482,1

9000,2600380,2,2,1,7.0,31.0,7.0,29.0,7.0,28.0,8.0,31.0,8.0,29.0,8.0,28.0

IBM-407 LISTING OF DATA CARDS

4300103655-000031-000027-000039-000025-000029-000044-000025-000024-000035-000030
 4300203695 007905 007813 007859 007792 007790 007661 007782 007568 007918 007790
 4300303755-000038-000033-000040-000026-000033-000019-000032-000026-000041-000043
 4300403795 049424 050865 051079 050303 050308 050530 051264 050332 052445 052398
 4300503835 049877 049564 052101 050274 051552 051924 051358 050102 051995 053528
 4300603985 050768 048801 050666 048337 050626 049414 049385 049253 051379 051787
 4300704025 051319 049797 049726 049847 050159 051271 049916 049743 050851 052421
 4300804155 051021 050585 049085 048511 048968 050367 048372 047515 049500 051214
 4300904195 050468 051566 050004 047894 050167 050348 050024 048173 049709 049740
 4301004395 049883 049683 051044 046848 048745 048195 048844 046737 047866 049488
 4301104435 050271 049797 051744 047448 047757 049083 048505 047528 048024 049689
 4301204575 047791 048819 050122 048485 046888 047945 047218 046234 047263 047963
 4301304615 048728 048922 050448 049190 047887 047726 048390 046810 047822 048737
 4301404795 046096 047463 049449 047872 048916 046753 046669 044751 047145 047211
 4301504835 046441 047321 048981 048214 046978 047446 046351 046773 046735 047920
 4301604985 045130 045999 047540 047369 048393 048067 045069 044874 045320 046975
 4301705025 046331 046585 047554 046925 048391 047954 045639 044417 046599 046481
 4301805145 045721 044938 045906 045790 047813 048011 047264 043619 045943 045286
 4301905185 045015 046004 046746 045914 047355 048098 047410 043939 044708 046472
 4302005285 044326 045411 045402 044200 046152 047523 046691 045178 044427 045616
 4302105325 044866 045547 046978 044742 046754 046628 046762 046160 044494 044872
 4302205495 044272 043717 045433 043953 044703 045396 046334 044670 045264 044016
 4302305535 043307 044500 045315 044438 044999 046071 045140 045056 046075 045046
 4302405575-000024-000047-000040-000035-000030-000022-000032-000028-000026-000041
 4302505615 008000 008108 008060 007659 007984 007881 007761 007750 007951 007763
 4302606665-000197-000214-000449-000355-000469-000380-000268-000180-000294-000421
 4302706765 000207 083721 000492 079117 000550 057996 000252 074630 000349 094890
 4302806865 056995 031365 078017 034511 099694 033240 061783 026252 062305 045370
 4302906965 032014 031903 046702 041044 065139 053833 031765 029391 047291 049174
 4303007065 034584 038796 051863 054234 072673 078198 035071 036393 055777 060367
 4303107165 039946 044111 062020 062530 086719 093081 041551 041275 062571 069083
 4303207265 046299 050016 069412 072919 098812 106523 046753 047487 071170 079547
 4303307365 053489 056117 078623 081126 111719 118566 053263 054359 082906 088125
 4303407465 057132 059796 085934 087403 121469 127754 058795 057954 089162 094620
 4303507565 061776 065629 092867 096675 132098 142605 062691 065219 096170 102244
 4303607665 068889 068764 100754 103427 140993 147673 069196 067533 106094 106655
 4303707765-000297-000278-000637-000444-000935-000762-000332-000235-000610-000614
 4303807865 071705 071629 103294 107984 148116 155302 072915 070481 113901 112103
 4303907965 076762 076283 110899 115112 155799 167951 076629 076996 118962 124385
 4304008065 079396 077315 115966 114003 158857 167883 078835 077661 126178 128106
 4304108165 081880 079628 119362 119786 165719 175956 082105 079989 126212 130435
 4304208265 085264 082471 124262 124455 172263 182545 085383 081286 130438 136743
 4304308365 085863 086215 122237 125084 172848 184192 083163 082768 130995 138981

4304408465 086352 089668 125509 126940 178260 190805 084765 086999 134063 142374
 4304508565 087622 086640 134691 124137 187480 185381 087472 086009 131766 141468
 4304608665 085386 087030 134833 125413 187295 184230 086799 087188 129606 139532
 4304708765 083561 087455 138406 129943 186785 184484 084772 089011 119791 139385
 4304808865 086531 086372 130350 124781 182835 180256 089773 086788 133866 136333
 4304908965-000217-000217-000563-000356-000561-000608-000294-000223-000390-000507
 4305009065 023762 023790 024025 023428 023986 023915 023780 023443 023885 023435
 4305109265-000207-000198-000482-000333-000497-000389-000264-000179-000329-000450
 4305209365 082767 083829 124856 121876 172760 176353 085822 083788 129043 130856
 4305309465 082494 079464 126678 127495 174543 178367 085593 078152 130041 115663
 4305409565 080960 079534 120724 122881 171710 176094 083809 079116 128839 122767
 4305509665 078973 080805 118917 121143 170741 172646 081801 077964 128793 123022
 4305609765 081204 078591 119710 110283 171941 162051 080833 074729 127339 122899
 4305709865 077163 077148 114941 105768 164001 154800 076041 072176 122182 118865
 4305809965 072349 075557 113564 106266 159721 151240 073768 073102 119044 117565
 4305910065 068417 071858 107835 099705 151405 145218 071579 068631 112282 110804
 4306010165 066110 067959 101098 095356 143100 135882 068456 065741 107647 109046
 4306110265 064050 065300 100267 090100 140534 132137 066885 062149 102671 101587
 4306210365 059659 060248 093336 083584 128035 123549 060426 058508 092262 095718
 4306310465-000251-000241-000488-000343-000722-000626-000265-000232-000389-000521
 4306410565 055007 055420 086324 078821 118970 114932 056232 054356 084349 086337
 4306510665 052085 049503 079914 071615 113006 105182 054080 048551 080256 076637
 4306610765 046602 045322 070721 064458 099734 096564 047315 044884 072957 070703
 4306710865 042820 041353 064652 058677 090423 086839 042785 040102 066833 064223
 4306810965 037874 035515 057564 051213 080475 074970 037394 034223 059877 055412
 4306911065 033201 030024 048886 044418 069183 065123 031453 029829 051497 047660
 4307011165 028376 025700 041198 037099 057682 053950 027596 025023 043234 041597
 4307111265 022723 023152 030918 032498 038741 047185 021999 022302 035480 034756
 4307211365 022246 040452 025668 053856 023654 071979 019265 043309 031686 045704
 4307311465 058764 000170 057645 000245 040708 000315 054103 000148 065879 000317
 4307411565-000177-000155-000380-000221-000352-000296-000173-000148-000257-000253
 4307511665 023765 023658 023960 023407 023753 023720 023890 023492 023656 023617
 4307611765-000164-000131-000359-000238-000376-000381-000186-000162-000300-000311

RATIO OF A STANDARD COUNT TO PREVIOUS ONE

CHANNEL	1	2	3	4	5	6	7	8	9	10
	.98812	.96362	.97506	1.01737	.97570	.97208	1.00271	.97652	.99585	1.00348
	.33667	.34082	.33546	.32692	.33286	.32954	.32637	.33059	.33289	.33126
	.99987	1.00558	1.00271	1.00090	1.00961	1.00822	.99540	.99791	1.00968	.99229

NORMALIZATION SUMS
NORMALIZATION RATIOS

CHANNEL	1	2	3	4	5	6	7	8	9	10
	1345045	1352010	1379783	1339517	1363687	1371515	1353856	1318671	1348666	1366831
	1.02583	1.02054	1.00000	1.03006	1.01180	1.00603	1.01915	1.04634	1.02307	1.00948

SAMPLE PROBLEM FOR WAPD-TM-216

BAND1

PAGE 2

WAND NUMBER	X	RAW COUNT	CORRECTED	1ST REPEAT RAW COUNT	1ST REPEAT CORRECTED	AVERAGE RAW COUNT	AVERAGE CORRECTED
Z0038	0.000	56995	97053	40452	95744	48724	96398
Z0038	1.000	32014	54735	23152	54189	27583	54462
Z0038	2.000	34584	59605	25700	59758	30142	59682
Z0038	3.000	39946	69428	30024	69373	34985	69401
Z0038	4.000	46299	81141	35515	81536	40907	81338
Z0038	5.000	53489	94510	41353	94310	47421	94410
Z0038	6.000	57132	101732	45322	102639	51227	102185
Z0038	7.000	61776	110859	49503	111317	55640	111088
Z0038	8.000	68889	124599	55420	123752	62155	124175
Z0038	9.000	71705	131638	60248	132540	65977	132089
Z0038	10.000	76762	142009	65300	142628	71031	142319
Z0038	11.000	79396	147996	67959	147354	73678	147675
Z0038	12.000	81880	153782	71858	154680	76869	154231
Z0038	13.000	85264	161354	75557	161460	80411	161407
Z0038	14.000	85863	163706	77148	163647	81506	163676
Z0038	15.000	86352	165871	78591	165480	82472	165676
Z0038	16.000	87622	169576	80805	168892	84214	169234
Z0038	17.000	85386	166471	79534	164995	82460	165733
Z0038	18.000	83561	164119	79464	163627	81513	163873
Z0038	19.000	86531	171241	83829	171359	85180	171300
Z0038	20.000	82767	170039	86372	170064	84570	170051
Z0038	21.000	82494	170743	87455	170925	84975	170834
Z0038	21.000	82494	170743	87455	170925	84975	170834
Z0038	22.000	80960	168612	87030	168830	83995	168821
Z0038	23.000	78973	165887	86640	166825	82807	166356
Z0038	24.000	81204	171862	89668	171391	85436	171627
Z0038	25.000	77163	164506	86215	163550	81689	164028
Z0038	26.000	72349	155365	82471	155267	77410	155316
Z0038	27.000	68417	147992	79628	148787	74023	148389
Z0038	28.000	66110	144054	77315	143380	71713	143717
Z0038	29.000	64350	140592	76283	140410	70167	140501
Z0038	30.000	59559	131897	71629	130838	65644	131368
Z0038	31.000	55007	123431	68764	123733	61886	123582
Z0038	32.000	52085	117722	65629	117196	58857	117459
Z0038	33.000	46502	106065	59796	105949	53199	106007
Z0038	34.000	42320	98145	56117	98666	49469	98406
Z0038	35.000	37374	87400	50016	87240	43945	87320
Z0038	36.000	33201	77127	44111	76319	38656	76723
Z0038	37.000	28376	66338	38796	66574	33586	66456
Z0038	38.000	22723	53418	31903	54265	27313	53841
Z0038	39.000	22246	52677	31365	52947	26806	52812
Z0038	40.000	58764	141035	83721	140973	71243	141004

SAMPLE PROBLEM FOR WAPD-TM-216

BAND1

PAGE 3

WAND NUMBER	X	RAW COUNT	CORRECTED	1ST REPEAT RAW COUNT	1ST REPEAT CORRECTED	AVERAGE RAW COUNT	AVERAGE CORRECTED
Z0048	0.000	78017	129163	53856	128620	65937	128892
Z0048	1.000	46702	77531	32498	76770	39600	77150
Z0048	2.000	51863	86843	37099	87064	44481	86963
Z0048	3.000	62020	104808	44418	103621	53219	104215
Z0048	4.000	69412	118288	51213	118687	60313	118487
Z0048	5.000	78623	135111	58677	135071	68650	135091
Z0048	6.000	85934	148866	64458	147342	75196	148104
Z0048	7.000	92867	162156	71615	162559	82241	162357
Z0048	8.000	100754	177324	78821	177653	89788	177488
Z0048	9.000	103294	184443	83584	185517	93439	184980
Z0048	10.000	110899	199583	90100	198554	100500	199068
Z0048	11.000	115966	210312	95356	208621	105661	209466
Z0048	12.000	119362	218120	99705	216551	109534	217336
Z0048	13.000	124262	228817	106266	229137	115264	228977
Z0048	14.000	122237	226752	105768	226368	114003	226560
Z0048	15.000	125509	234592	110283	234312	117896	234452
Z0048	16.000	134691	253719	121143	255546	127917	254633
Z0048	17.000	134833	255886	122881	257300	128857	256593
Z0048	18.000	138406	264660	127495	265007	132951	264834
Z0048	19.000	130350	251050	121876	251418	126113	251234
Z0048	20.000	124856	249770	124781	247896	124819	248833
Z0048	21.000	126678	255323	129943	256269	128311	255796
Z0048	22.000	120724	245095	125413	245473	123069	245284
Z0048	23.000	118917	243215	124137	241166	121527	242190
Z0048	24.000	119710	246674	126940	244799	123325	245736
Z0048	25.000	114941	238577	125084	239419	120013	238998
Z0048	26.000	113564	237468	124455	236445	119010	236956
Z0048	27.000	107835	227121	119786	225858	113811	226490
Z0048	28.000	101098	214459	114003	213323	107551	213891
Z0048	29.000	100267	214277	115112	213808	107690	214042
Z0048	30.000	93336	200883	107984	199035	100660	199959
Z0048	31.000	66324	188611	103427	187788	94876	188199
Z0048	32.000	79914	175839	96675	174179	88295	175009
Z0048	33.000	70721	156663	87403	156237	79062	156450
Z0048	34.000	64652	144205	81126	143890	72889	144047
Z0048	35.000	57564	129248	72919	128302	65242	128775
Z0048	36.000	48886	110434	62530	109107	55708	109770
Z0048	37.000	41198	93606	54234	93837	47716	93721
Z0048	38.000	30918	70523	41044	70320	35981	70422
Z0048	39.000	25668	58814	34511	58580	30090	58697
Z0048	40.000	57645	134340	79117	134179	68381	134259

(0) 200380

$$(\text{CORRECTED COUNTS})/100 \quad (0)$$

0.00 200.00 400.00 600.00 800.00 1000.00 1200.00 1400.00 1600.00 1800.00 2000.00

INCHES

The scatter plot displays the relationship between the number of hours per week (X-axis) and the number of days per week (Y-axis). The X-axis ranges from 0 to 50 with major grid lines every 10 units. The Y-axis ranges from 0 to 5 with major grid lines every 1 unit. The data points are represented by open circles. The plot shows a positive correlation, with a dense cluster of points between 10 and 20 hours per week and 1 to 2 days per week. There are also several points at higher hours per week (30-40) and higher days per week (3-4).

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(0) Z003E2

(O) Z00480 (H) Z00481 (*) Z00482

WAND Z 380

ANALYSIS - TYPE 2

WEIGHTING FACTOR - TYPE 2

PARAMETER	VALUE(IN.)	ST. DEV. OF EST.	VALUE(CM.)	ST. DEV. OF EST.
A	+17270559+06	+10711400+04		
B	+67235676-01	+10855842-02		
C	+19480267+02	+11422085+00		
B*B	+45206361-02	+14597997-03	+70069442-03	+22626760-04
B*B(CORRECTED)	+45206361-02	+14597997-03	+70069442-03	+22626760-04
H	+46725084+02	+75442107+00	+11868218+03	+19162371+01

RESSQ=+10280434+03

ERROR=+21616948+01

X	Y(INPUT)	Y(COMPUTED)	RESIDUALS
7.00	110859	115388	+40850840+01
8.00	124599	123761	-67304207+00
9.00	131638	131574	-48851018-01
10.00	142009	138793	-22646568+01
11.00	147996	145385	-17644950+01
12.00	153782	151319	-16014065+01
13.00	161354	156570	-29650897+01
14.00	163706	161114	-15834857+01
15.00	165871	164929	-56819974+00
16.00	169576	167999	-93005627+00
17.00	166471	170310	+23060611+01
18.00	164119	171851	+47109178+01
19.00	171241	172616	+80275707+00
20.00	170039	172600	+15060503+01
21.00	170743	171805	+62161648+00
22.00	168812	170233	+84192217+00
23.00	165887	167892	+12084169+01
24.00	171862	164792	-41137161+01
25.00	164506	160948	-21628043+01
26.00	155365	156376	+65106274+00
27.00	147992	151098	+20986904+01
28.00	144054	145137	+75191790+00
29.00	140592	138520	-14740662+01
30.00	131897	131277	-47068255+00
31.00	123431	123440	+79529752-02

WAND Z 380

ANALYSIS - TYPE 2

WEIGHTING FACTOR - TYPE 2

PARAMETER	VALUE(IN.)	ST. DEV. OF EST.	VALUE(CM.)	ST. DEV. OF EST.
A	+17274967+06	+11543500+04		
B	+67409140-01	+14554278-02		
C	+19459695+02	+15712799+00		
B*B	+45439921-02	+19621827-03	+70431459-03	+30413652-04
B*B(CORRECTED)	+45439921-02	+19621827-03	+70431459-03	+30413652-04
H	+46604846+02	+10062432+01	+11837678+03	+25558678+01
RESSQ=+10246819+03		ERROR=+22634949+01		

X	Y (INPUT)	Y (COMPUTED)	RESIDUALS
7.00	110859	115317	+40213991+01
8.00	124599	123719	-70618194+00
9.00	131636	131559	-60005519-01
10.00	142009	138802	-22583742+01
11.00	147996	145414	-17447323+01
12.00	153782	151365	-15714623+01
13.00	161354	156629	-29284577+01
14.00	163706	161182	-15417974+01
15.00	165871	165002	-52400015+00
16.00	169576	168073	-88630169+00
17.00	166471	170381	+23486057+01
18.00	164119	171914	+47493985+01
19.00	171241	172667	+83264917+00
20.00	170039	172635	+15266108+01
21.00	170743	171619	+63013507+00
22.00	168812	170223	+83602966+00
23.00	165887	167854	+11852896+01
24.00	171862	164722	-41547532+01
25.00	164506	160842	-22273715+01
26.00	155365	156231	+55761828+00
27.00	147992	150911	+19722424+01
28.00	144054	144905	+59103339+00
29.00	140592	138241	-16723154+01

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ANALYSIS - TYPE 2

WEIGHTING FACTOR - TYPE 2

PARAMETER	VALUE(IN.)	ST. DEV. OF EST.	VALUE(CM.)	ST. DEV. OF EST.
A	+17287456+06	+11703226+04		
B	+68114848-01	+16370380-02		
C	+19369471+02	+18085271+00		
B*B	+46396325-02	+22301319-03	+71913876-03	+34566839-04
B+B(CORRECTED)	+46396325-02	+22301319-03	+71913876-03	+34566839-04
H	+46121994+02	+11084728+01	+11715033+03	+28155320+01

RESSQ=-98187602+22

ERROR=+22732726+01

X	Y(INPUT)	Y(COMPUTED)	RESIDUALS
7.00	110859	115059	+37888571+01
8.00	124599	123574	-82259513+00
9.00	131638	131516	-93019459-01
10.00	142009	138948	-22261496+01
11.00	147996	145535	-16626328+01
12.00	153782	151548	-14526010+01
13.00	161354	156358	-27866842+01
14.00	163706	161440	-13837729+01
15.00	165871	165274	-35999760+00
16.00	169576	168341	-72806121+00
17.00	166471	170628	+24971830+01
18.00	164119	172123	+48766888+01
19.00	171241	172820	+92204261+00
20.00	170039	172715	+15736806+01
21.00	170743	171809	+62435383+00
22.00	168812	170107	+76722150+00
23.00	165887	167615	+10417164+01
24.00	171862	164347	-43730217+01
25.00	164506	160316	-25471610+01
26.00	155365	155541	+11353078+00
27.00	147992	150045	+13873671+01
28.00	144054	143853	-13896747+00

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ANALYSIS - TYPE 2

WEIGHTING FACTOR - TYPE 2

PARAMETER	VALUE(IN.)	ST. DEV. OF EST.	VALUE(CM.)	ST. DEV. OF EST.
A	+17210640+06	+96647462+03		
B	+65781475-01	+11189231-02		
C	+19371709+02	+11229689+00		
B*B	+43272024-02	+14720883-03	+67071239-03	+22817233-04
B*B(CORRECTED)	+43272024-02	+14720883-03	+67071239-03	+22817233-04
H	+47758014+02	+81234947+00	+12130583+03	+20633758+01
RESSO=+75808465+02		ERROR=+18999808+01		

X	Y (INPUT)	Y (COMPUTED)	RESIDUALS
8.00	124599	126157	+12504093+01
9.00	131638	133580	+14747651+01
10.00	142009	140424	-11158001+01
11.00	147996	146662	-90158992+00
12.00	153782	152264	-98675137+00
13.00	161354	157209	-25693444+01
14.00	163706	161473	-13639584+01
15.00	165871	165039	-50200810+00
16.00	169576	167890	-99397487+00
17.00	166471	170016	+21296741+01
18.00	164119	171406	+44399664+01
19.00	171241	172055	+47538452+00
20.00	170039	171959	+11292463+01
21.00	170743	171120	+22060470+00
22.00	168812	169541	+43168922+00
23.00	165887	167228	+80788165+00
24.00	171862	164191	-44634318+01
25.00	164506	160445	-24686707+01
26.00	155365	156004	+41161224+00
27.00	147992	150889	+19574401+01
28.00	144054	145121	+74084888+00
29.00	140592	138725	-13280611+01
30.00	131897	131729	-12770780+00
31.00	123431	124163	+59362172+00

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ANALYSIS - TYPE 2

WEIGHTING FACTOR - TYPE 2

PARAMETER	VALUE(IN.)	ST. DEV. OF EST.	VALUE(CM.)	ST. DEV. OF EST.
A	+17200693+06	+10541624+04		
B	+65481461-01	+15214044-02		
C	+19397374+02	+14744433+00		
B*B	+42878216-02	+19924757-03	+66+60840-03	+30883189-04
B*B(CORRECTED)	+42878216-02	+19924757-03	+66+60840-03	+30883189-04
H	+47976825+02	+11146995+01	+12-86162+03	+28313480+01
RESSO=+15223760+02		ERROR=+19897601+01		

X	Y (INPUT)	Y (COMPUTED)	RESIDUALS
8.00	124599	126287	+13542870+01
9.00	131638	133658	+15339190+01
10.00	142009	140456	-10938082+01
11.00	147996	146652	-90835874+00
12.00	153782	152219	-10163070+01
13.00	161354	157134	-26156383+01
14.00	163706	161375	-14234783+01
15.00	165871	164925	-57037693+00
16.00	169576	167763	-10661494+01
17.00	166471	169892	+20550399+01
18.00	164119	171287	+43675321+01
19.00	171241	171949	+41333401+00
20.00	170039	171873	+10784308+01
21.00	170743	171061	+18580399+00
22.00	168812	169515	+41661603+00
23.00	165887	167243	+81711113+00
24.00	171862	164254	-44270177+01
25.00	164506	160561	-23981279+01
26.00	155365	156180	+52446166+00
27.00	147992	151129	+21196098+01
28.00	144054	145430	+95575114+00
29.00	140592	139103	-10552611+01

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ANALYSIS - TYPE 2 WEIGHTING FACTOR - TYPE 2

PARAMETER	VALUE(IN.)	ST. DEV. OF EST.	VALUE(CM.)	ST. DEV. OF EST.
A	+17211717+06	+10851108+04		
B	+66025016-01	+17405656-02		
C	+19338611+02	+17101266+00		
B*B	+43593027-02	+22984174-03	+67568790-03	+35625258-04
B*B(CORRECTED)	+43593027-02	+22984174-03	+67568790-03	+35625258-04
H	+47581852+02	+12543630+01	+12085838+03	+31860945+01
RESSQ=+73481039+02		ERROR=+20204653+01		

X	Y(INPUT)	Y(COMPUTED)	RESIDUALS
8.00	124599	126097	+12018372+01
9.00	131638	133551	+14530259+01
10.00	142009	140423	-11164176+01
11.00	147996	146684	-88647654+00
12.00	153782	152305	-96021724+00
13.00	161354	157263	-25357651+01
14.00	163706	161535	-13259149+01
15.00	165871	165104	-46286466+00
16.00	169576	167952	-95741540+00
17.00	166471	170069	+21617591+01
18.00	164119	171445	+44638153+01
19.00	171241	172074	+48659748+00
20.00	170039	171953	+11255155+01
21.00	170743	171083	+19871513+00
22.00	168812	169467	+38801192+00
23.00	165887	167112	+73843271+00
24.00	171862	164030	-45574286+01
25.00	164506	160232	-25978110+01
26.00	155365	155737	+23939645+00
27.00	147992	150562	+17368081+01
28.00	144054	144732	+47088218+00

REFERENCE

1. B. L. Anderson and T. J. Lawton, "COFIT - A Least Squares Cosine Fitting Program for the IBM-704", WAPD-TM-26, October 1956.