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709 PROGRAM FOR REDUCTION OF EXPONENTIAL PILE DATA

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709 PROGRAM FOR REDUCTION OF EXPONENTIAL PILE DATA

A multi-purpose program for processing exponential data has been prepared for the 709 computer.

USES

The main purpose of the program is to compute the material buckling from raw data (given counts, time, and counter information) or from previously calculated $A_{thermal}$'s. It is also possible to compute only $C_e C_h$ (end and harmonic corrections) for a given B_{11} or series of B_{11}'s, no counting data being entered. In every case, pile measurements must be submitted as input for corrections.

OPTIONS AVAILABLE TO THE USER

When raw data are submitted, A_{th}'s may be calculated by standard method (Eq. 3) or by the cadmium shutter method (Eq. 4). When cadmium shutter method is used, bare counts taken with shutter are entered as cadmium counts.

If the user has available a set of corrections which may be satisfactory, these may be entered as data, eliminating the computation of a trial set of corrections. If no corrections are available, but a B_{11} is estimated, the trial set of corrections will be computed using this B_{11}. If no B_{11} is entered, the program estimates one from pile data. Since this machine estimate is quite reliable for moderately good data, no B_{11} estimate should be made by the user without adequate certainty.

The program will compute one- or two-region harmonic corrections and one- or two-region end corrections. Fast source theory corrections can also be computed. Detectors may be displaced or on the center line. Up to four source positions may be used. It is also at the option of the user to compute with end corrections only (C_e) rather than the usual end and harmonic product (C_eC_h). For unusual dimensions, arrangements of sources or detectors, translation must be made to fit the standard input requirements.

Having computed A_{th}'s and a trial set of corrections, a least squares fit is made with the corrected A_{th}'s, obtaining a buckling and an output B_{11}. The difference between input and output B_{11}'s is examined, as well as the back fit to the least-squares analysis. If the B_{11} difference is unsatisfactory, a new B_{11} is used to compute new corrections. If the back fit is unsatisfactory, combinations of the worst points are dropped. These two tests are repeated according to a set procedure (see Fig. 3) until a fit is found in which the B_{11} difference is less than the specified limit and there are five points having a difference from the line less than the specified limit, data permitting. All intermediate fits will be printed out, and the most satisfactory of these may be chosen. If there are three or more poor points, fits will be made omitting all combinations of the worst three. Should none of these be adequate, it should then be a simple matter to choose a good B_{11} and make a satisfactory fit with those points which the user chooses. Only in extreme cases should this be necessary, as one of the intermediate fits has nearly always proven satisfactory.

MACHINE TIME

The user can expect to be charged with as much as five minutes of machine time only in the case of exceptionally poor data or an unwise choice of B_{11}. A more realistic estimate is one minute per case, plus three minutes loading time.

FORMULATION

(1) $$A_1 = \frac{\Sigma\ (\text{cts} + \text{CL} - \text{BG})\ \text{CF}}{\Sigma\ \text{time}}$$

where A_i is corrected counts/min., and i = bare, cadmium, or background. BG refers to counter background, CF is counter factor, and CL is coincidence loss.

(2) $cts + CL = \frac{Counts}{1 - \mu N_{counted}}$ and $N_{counted} = \frac{Counts}{Time}$

where μ = dead time = 7.6×10^{-6} μ sec. = 1.27×10^{-7} min.

(3) $A_{th} = (A_{bare} - A_{BG}) \left(\frac{\overline{CR} - 1.0}{\overline{CR}}\right)$

where $\overline{CR}$ is the average cadmium ratio, that is, the average $\frac{A_{bare}}{A_{cad}}$.

(4) $A_{th} = (A_{bare,\ no\ shutter} - A_{bare,\ with\ shutter})$ if the cadmium shutter method is used.

(5) $C_e = \left[1 - e^{-2(Z-z)/B_{11}}\right]^{-1}$

(6) $C_h = A_{11} B_{11} F_{11} e^{-z/B_{11}} / \sum_{nm} A_{nm} B_{nm} F_{nm} e^{-z/B_{nm}}$

where n and m are odd integers from 1 to 9. The contribution of all harmonics of order > 9 are negligible and are ignored.

(7) $A_{nm} = 2\left[1 + \mathrm{Coth}\ (z'/B_{nm})\right]^{-1}$

(8) $B_{nm} = \left[\pi^2\left(\frac{n^2}{a^2} + \frac{m^2}{b^2}\right) - B\right]^{-1/2}$

(9) $F_{nm} = \cos\frac{n\pi x'}{a} \cos\frac{m\pi y'}{b} \sum_i \cos\frac{n\pi x_i}{a} \cos\frac{m\pi y_i}{b}$.

When two-region harmonics are used, C_e is formulated as above, but we introduce the notation

(10) $(\gamma_1)^2_{nm} = \left(\frac{n\pi}{a}\right)^2 + \left(\frac{m\pi}{b}\right)^2 - B_{region\ 1}$

where region 1 is the base region, region 2 is the measurement region, and region 3 is the top region. Note that if region 1 is graphite, B_1 now becomes $- 1/L_g^2$. Then

$$(11)\quad C_h = \frac{F_{11}\, P_{11}\, e^{-z(\gamma_2)_{11}}}{\sum_{nm} F_{nm}\, P_{nm}\, e^{-z(\gamma_2)_{nm}}}$$

where

$$(12)\quad P_{nm} = \frac{e^{s(\gamma_2 - \gamma_1)_{nm}}}{(\gamma_1 + \gamma_2)_{nm} \left\{ (1 - D_{nm}) + (1 + D_{nm}) \coth\left[z'(\gamma_1)_{nm} \right] \right\}}$$

$$(13)\quad D_{nm} = \frac{R_{nm} - 1}{R_{nm} + 1}\, e^{-2s(\gamma_1)_{nm}}$$

$$(14)\quad R_{nm} = (\gamma_1)_{nm} / (\gamma_2)_{nm} \; .$$

When two-region end corrections are used, C_h may be computed for one- or two-region corrections as required and

$$(15)\quad C_e = \left\{ 1 + e^{-2(\gamma_2)_{11}(C-z)} \left[\frac{\left(\frac{1-Q}{1+Q}\right) e^{2(\gamma_3)_{11}(Z-C)} - 1}{e^{2(\gamma_3)_{11}(Z-C)} - \left(\frac{1-Q}{1+Q}\right)} \right] \right\}^{-1}$$

where

$$(16)\quad Q = (\gamma_3)_{11} / (\gamma_2)_{11} \; .$$

Fast source theory harmonic corrections, applicable to Sigma pile, are given by

$$(17)\quad C_h = \frac{A_{11}\, B_{11}\, F_{11}\, e^{-z/B_{11}}}{\sum_{nm} A_{nm}\, B_{nm}\, F_{nm}\, J_{nm}\, e^{-z/B_{nm}}}$$

where A_{nm} and F_{nm} are formulated by Equations 7 and 9 respectively, but

$$(18)\quad B_{nm} = \left\{ \frac{1}{L_g^{\,2}} + \pi^2 \left[\left(\frac{\omega_x n}{a}\right)^2 + \left(\frac{\omega_y m}{b}\right)^2 \right] \right\}^{-1/2} \quad \text{and}$$

$$(19)\quad J_{nm} = \sum_{i=1}^{3} F_i \, e^{r_i^2/4L_s^2} \left\{ \left[1 + \mathrm{erf}\left(\frac{z}{r_i} - \frac{r_i}{2B_{nm}} \right) \right] + e^{2z/B_{nm}} \left[1 - \mathrm{erf}\left(\frac{z}{r_i} + \frac{r_i}{2B_{nm}} \right) \right] \right\}.$$

In equations 5-19 above: Z = distance from source plane to effective top of pile, z = distance of measured point from source plane, z' = distance from the effective bottom of pile to source plane, a = effective width, b = effective depth, and B = input buckling (see Fig. 1). In the case of a multi-region pile, s = distance from the source plane to the boundary plane between regions one and two, and C = the distance from the source plane to the boundary plane between regions two and three (see Fig. 2).

INSTRUCTIONS FOR USE OF DATA SHEETS (See sample sheets, pp. 13-14.)

General

A. Each case requires one card of each of these types (card type is found at right on data sheet): 01, 03, 04, 05, 06, and 07. Each case must have four 02-cards. The number or absence of types 08-13 is dictated by data to be entered upon them.

B. Fill in all pertinent information. Extraneous information will be ignored unless it conflicts with the problem's needs as stated in question 5. If question 5.12 is answered "no", data will not be accepted unless the R_i, F_i, ω_a^2, and ω_b^2 fields are blank. Also, if question 9 says there are 5 slots, only the first 5 slots will be used even though "bare" data are entered on page two for 7 slots. If, in the same case, "background" data are entered for only 4 slots, all data for the case will be rejected. "Cadmium" data need not be entered for every slot, of course. The entry of both "bare" data and "$A_{thermal}$" data will also cause the case to be rejected. In short, data checking tries to assure that a sensible case has been entered.

C. Case number is three digits: 021

D. Definition of Terms

1. Question 9 - Number of slots is the number of positions in which measurements are taken. "Bare" data must be entered for each of these.

2. Question 11 - Number of cadmium slots is the number of positions in which "cadmium" measurements are taken. Ordinarily this will equal number of slots.

3. Question 16 - λ is the amount by which the effective a and effective Z will be varied if question 5.15 is answered "yes". It should be blank if 5.15 is answered "no". The effect of answering 5.15 "yes" is that the entire procedure of choosing a good fit (with the right corrections) is executed three times: with the original a and Z; with both incremented by λ; and with both decremented by λ. The effective b will not be varied.

4. Question 21 - ΔB_{11} limit is the value with which ΔB_{11} is compared in order to determine whether another set of harmonic corrections must be computed. ΔB_{11} is the difference between input and output B_{11}'s of the least squares fit. See skeleton flow chart, p. 12.

5. Question 26 - Δ L limit is used to determine which points, if any, are to be discarded in order to make a better fit. It represents the maximum allowable difference between L_n (A_{th}) and the computed value of Y.

6. Questions 37-44 pertain only to fast source theory corrections.

SPECIFIC CARD TYPES

A. Card 01

1. Questions 1-4 - Hollerith information (that is, alphabetic or numeric as desired) limited to the size of the field. When in doubt about field size refer to "starting column" at left on data sheet.

2. Question 5 - All 15 digits must be filled in. If a set of data gives peculiar answers or refuses to run, check here first.
3. Questions 6-11 - Integer information. Question 6 is a one-digit field. Questions 7-11 are two-digit fields and should be answered with 07, 09, 11, etc.

B. Cards 05-07 - fixed-point information only. Never omit the decimal point.

C. Card types 08-10 - fixed-point information except for slot (at right on data sheet) and NMTS, both of which are two-digit integer fields. NMTS, the first field on the sheet, should be the number of measurements this slot. For example, if three lines of "bare" data are entered for slot 07, each of these will have 03 in NMTS. Fill in "counter factor" and "counter background" on every line where "counts" are entered, even though they are "1.0" and "0" respectively.

D. Card type 11 - fixed point information except for slot. If type 11 cards are used, one and only one must be submitted for each slot. Leave blank fields which do not pertain to the case submitted.

E. Card types 12 and 13 are used only for fast source data.

F. Card type 02 - there must be four 02-cards for every case, numbered from 0200-0203. Since no form is specifically provided for these, they may be written in the 08-10-card form or on an attached standard 80-80 data form. These four cards contain identifying material for report headings. Although information may be entered haphazardly in columns 1-65 of these cards, the following information will be helpful in obtaining a neat, readable report heading.

Card	Cols	Placed in Heading Line
0200	1-48	Line 1 (Cols. 49-65 of 0200 are dropped)
0201	1-65	Line 2
0202	1-48	Line 2 (immediately following cols. 1-65 of 0201)
0202	49-65	Line 3
0203	1-65	Line 3 (immediately following cols. 49-65 of 0202).

Columns 1-65 of any or all type 02-cards may be blank.

DD MATSUMOTO:bg

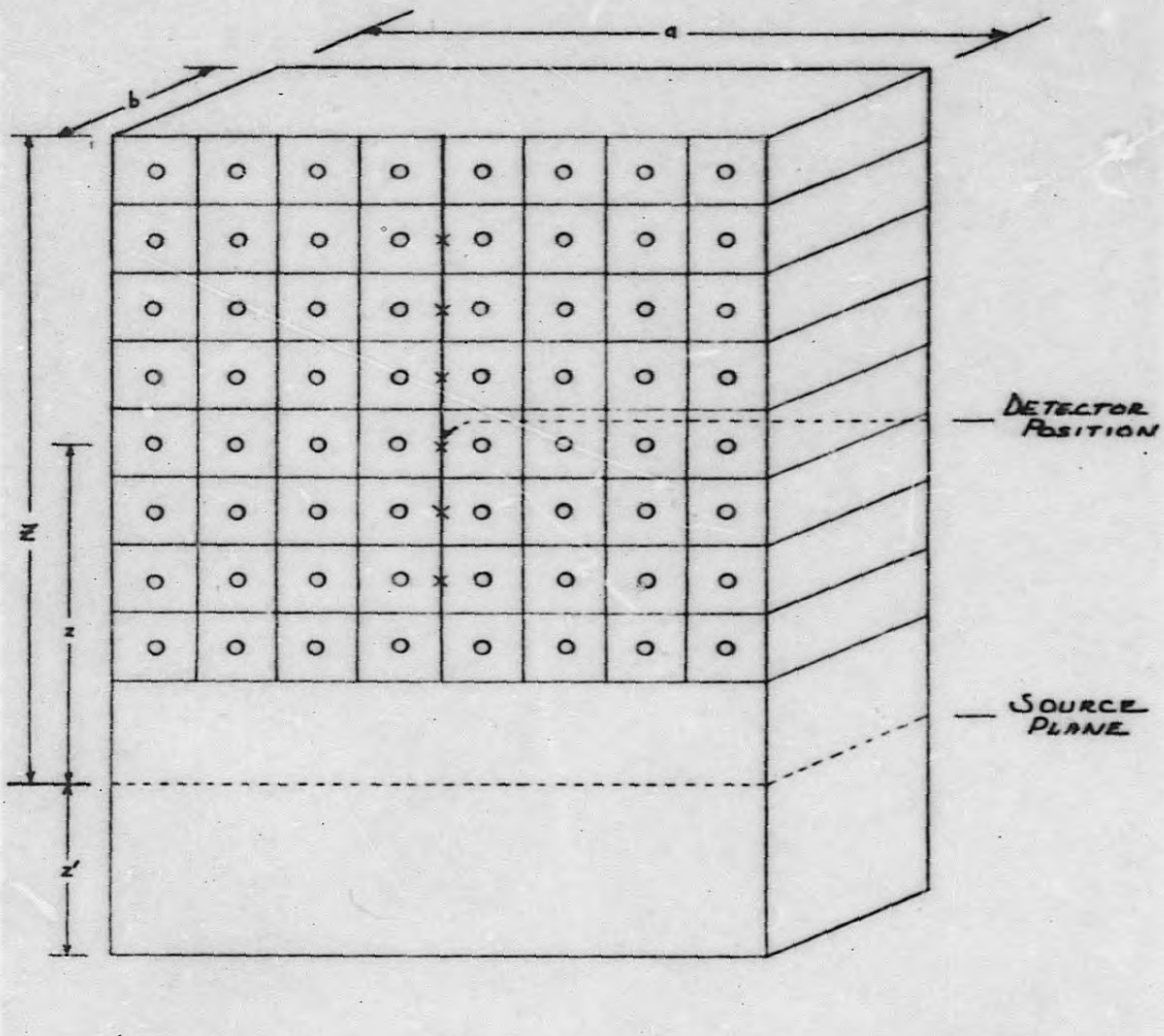


FIGURE 1

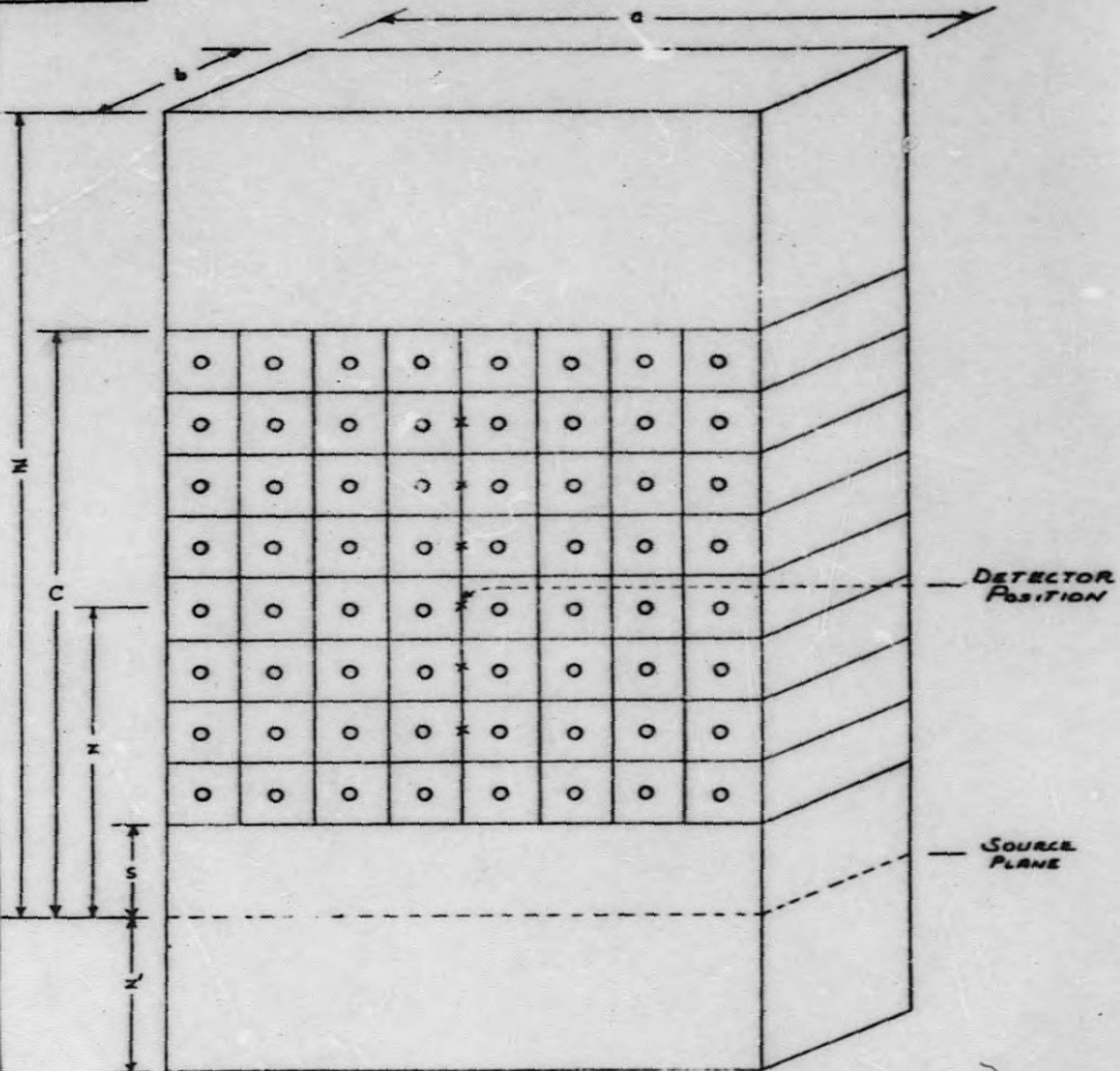
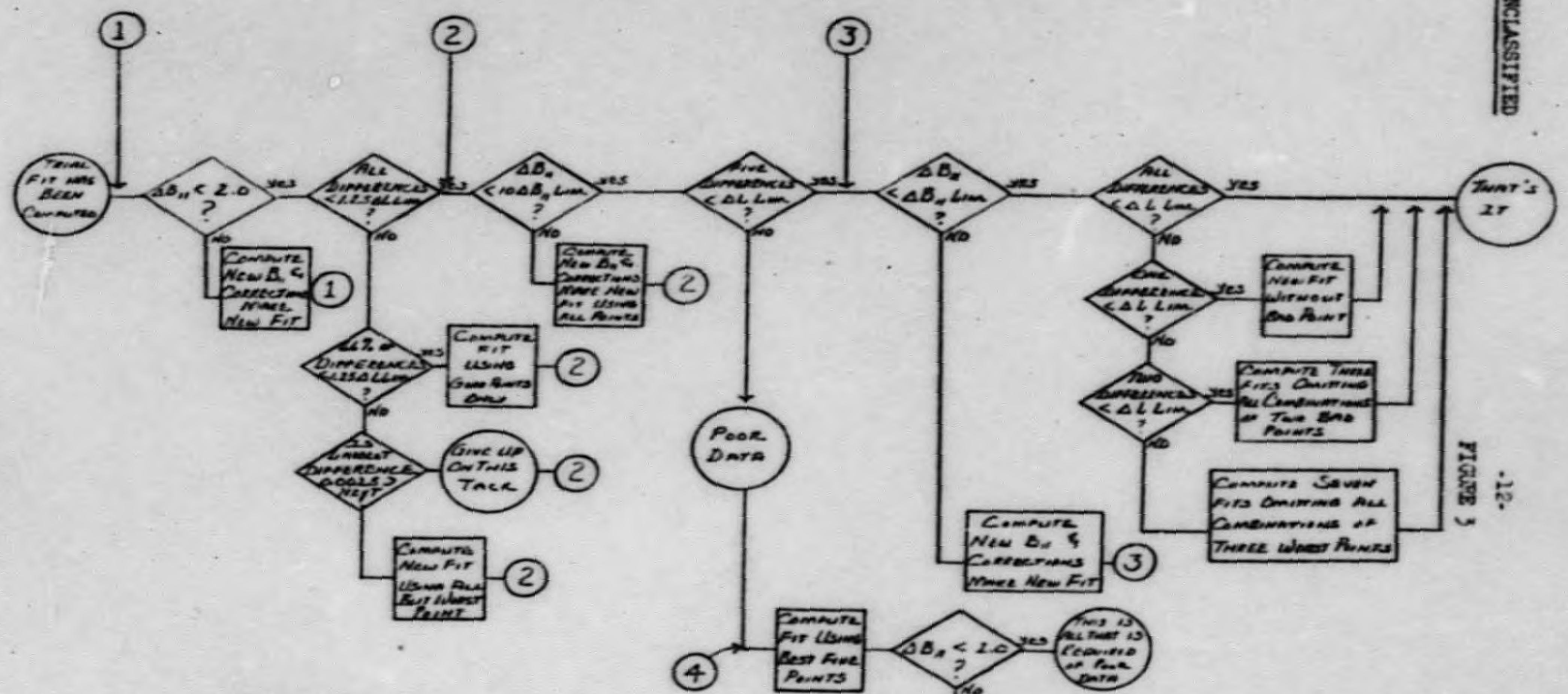


FIGURE 2

Simpli[illegible]ed flow chart illustrating method by which points are chosen to make new least-squares fits



ΔB_{11} = Difference between input and output B_{11}'s.

DDM:j
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FIGURE 3

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CUE 001 CASE ________

Starting Column				Card Type
1	1.	Experiment number	________	
9	2.	Lattice	________	
16	3.	Slug	________	
21	4.	Wet/dry	________	
27	5.	Answer questions 5.01-5.15 below*	________	
42	6.	Number of sources	________	
43	7.	Initial slot	________	
45	8.	Slot increment	________	
47	9.	Number of slots	________	
49	10.	Number of B_{11}'s (if corrections only)	________	
51	11.	Number of cadmium slots		01
1	12.	Effective a	________	
14	13.	Effective b	________	
27	14.	Effective $\bar{c}$	________	
40	15.	z'	________	
53	16.	λ		03
1	17.	Initial z	________	
14	18.	z increment	________	
27	19.	B_{11} (measurement region)	________	
40	20.	B_{11} increment	________	
53	21.	ΔB_{11} Limit		04
1	22.	B_1 (Buckling of region 1 if more than 1 region)	________	
14	23.	B_3 (Buckling of region 3)	________	
27	24.	c' (if 2-region end corrections)	________	
40	25.	s (if more than 1 region)	________	
53	26.	Δ L Limit		05
1	27.	x'	________	
14	28.	x_1	________	
27	29.	x_2	________	
40	30.	x_3	________	
53	31.	x_4		06
1	32.	y'	________	
14	33.	y_1	________	
27	34.	y_2	________	
40	35.	y_3	________	
53	36.	y_4		07
1	37.	ω^2 (if fast source)	________	
14	38.	ω^{*2} (if fast source)	________	
27	39.	F_1 (if fast source)	________	
40	40.	F_2 (if fast source)	________	
53	41.	F_3 (if fast source)		12
1	42.	R_1	________	
14	43.	R_2	________	
27	44.	R_3	________	
40	45.		________	
53	46.			13

* Place answers to the following questions in 5 above (0 = yes, 1 = no):

- 5.01 Must counts/minute be calculated?
- 5.02 Are corrections computed?
- 5.03 Cadmium shutter method?
- 5.04 Is a likely B_{11} suggested?
- 5.05 Calculate corrections only?
- 5.06 Use 2-region harmonics?
- 5.07 Use 2-region end corrections?
- 5.08 Sources placed at ± a/4?
- 5.09 Detector on center line of pile?
- 5.10 Does a = b (effective pile dimensions)?
- 5.11 Use end corrections only (no harmonics)?
- 5.12 Use fast source corrections?
- 5.13 Calculate $A_{thermal}$'s only?
- 5.14 Must background counts/minute be calculated?
- 5.15 Vary extrapolation length?

KEYPUNCH: Punch case number in cols. 66-68; card type in cols. 69-70; 00 in cols. 71-72.

CARD TYPE:
Bare = 08
Cadmium = 09
Backgrnd = 10

CASE ____________

NO. MNTS.	COUNTS	TIME	COUNTER FACTOR	COUNTER BKGRND	CARD TYPE	SLOT (2dig)

$A_{THERMAL}$	A_{BKGRND}	C_eC_h			CARD TYPE	SLOT (2 dig)
					11	
					11	
					11	
					11	
					11	
					11	
					11	
					11	
					11	
					11	

KEYPUNCH: Punch case no. in cols. 66-68, card type in cols 69-70; slot in cols. 71-72.

END