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TWO-GROUP MULTIREGION AXIAL WINDOW-

SHADE CALCULATION ON THE

IBM 650

Contract No. AT (11-1) -318

Issued March 29, 1957

ALCO PRODUCTS, INC.

Post Office Box 414

Schenectady, N.Y.

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by

F.B. Fairbanks

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ABSTRACT

This code is a nine-region, two group finite difference calculation in slab geometry for the basic IBM 650 with a 2000 word storage capacity and one Type 533 unit. The code solves the steady-state two-group equation with fast and thermal fission.

A perpendicular buckling must be specified. Also included is the addition of a uniform thermal poison to one section of a reactor to represent the effect of control rods. The program may optionally adjust the insertion of the poison to achieve approximate criticality.

NOTATION

CC	Flux convergence criterion
CC _K	K convergence criterion for rod adjustment
C _j ⁱ	Defined by equations (21) and (22)
C _B ⁱ	Defined by equation (29)
D _j ⁱ	Diffusion coefficient
F	Fast neutron flux
F _n	Fast flux at space point n
g _j ⁱ	Defined by equation (36)
G	Defined by equation (35)
h _j ⁱ	Defined by equation (20)
h _B ⁱ	Defined by equation (28)
I ₁	Calculation Identification No.
I ₈	Card Type 8 Set No.
I ₉	Card Type 9 Set No.
I ₂₁	Card Type 21 Set No.
J ₀	(x) First order Bessel function
k	Effective multiplication
K _j ⁱ	Defined by equations (18) and (19)
K _B ⁱ	Defined by equation (27)
P _j	Resonance escape probability

r Radius of Cylinder
 $\vec{r}$ Arbitrary space location
 RP Control rod insertion
 RP_{max} Maximum control rod insertion
 RP_{min} Minimum control rod insertion
 S Source Function
 S_n Source function at space point n
 S_r Radial reflector savings
 Z Axial dimension
 $\overline{\Delta Z}$ Mesh spacing
 α Iteration acceleration parameter
 α_n^i Defined by equations (33) and (34)
 β_n^i Defined by equations (33) and (34)
 ∇^2 Laplacian operator
 Φ^t Neutron flux
 ϕ Thermal neutron flux
 ϕ_n Thermal neutron flux at space point n
 λ Defined by equation (9)
 ν Fission yield
 ρ Cylinder coordinate
 Σ_f' Fast removal cross-section
 Σ_{aj}^2 Thermal absorption cross-section

$$v \Sigma_{ffj} = K'_j (1 - \rho_j) \Sigma'_j$$

Σ_{ff}^2 Thermal fission cross-section

Superscripts

i Group (number)

m Iteration (number)

Subscripts

B Boundary

j Region (number)

n Mesh point (number)

N Final space point

INTRODUCTION

The program described herein was written initially for the purpose of solving certain non-uniform burnup problems. Consequently, the program is neither as flexible nor as optimum as could be desired. However, the program has been useful in solving numerous problems, and it is being distributed in the hope that it will be of value to others.

1 SOLUTION OF THE TWO-GROUP, MULTI-REGION PROBLEM

1.1 Fundamental Equation

1.1.1. Two-group Equations

From the two-group equations for a steady state reactor

$$-D(\vec{r}) \nabla^2 \Phi'(\vec{r}) + \Sigma'(\vec{r}) \Phi'(\vec{r}) = S(\vec{r}) \quad (1)$$

$$-D(\vec{r}) \nabla^2 \Phi^2(\vec{r}) + \Sigma_a^2(\vec{r}) \Phi^2(\vec{r}) = \rho(\vec{r}) \Sigma'(\vec{r}) \Phi'(\vec{r}) \quad (2)$$

$$S(\vec{r}) = \frac{1}{k} [\nu \Sigma_f'(\vec{r}) \Phi'(\vec{r}) + \nu \Sigma_f^2(\vec{r}) \Phi^2(\vec{r})] \quad (3)$$

The equations for a bare slab reactor can be determined if material properties are a function of Z only by separation of variables:

$$\Phi'(\vec{r}) = \Phi'(r) F(z) \quad (4)$$

$$\Phi^2(\vec{r}) = \Phi^2(r) \phi(z) \quad (5)$$

$$S(\vec{r}) = S(r) S(z) \quad (6)$$

Solutions can be obtained if the radial functions have the form

$$\Phi'(r) = \Phi^2(r) = S(r) = J_0(\lambda r) \quad (7)$$

where λ is the first root of

$$J_0(\lambda r) = 0 \quad (8)$$

Thus

$$\lambda^2 = \left[\frac{2405}{r + S_r} \right]^2 \quad (9)$$

If material constants are invariant over a region j , substitution of equations (4) through (7) into (1) to (3) give

$$-\nabla^2 F(z) + \left[\frac{\sum_j'}{\bar{D}_j'} + \lambda^2 \right] F(z) = \frac{S(z)}{\bar{D}_j'} \quad (10)$$

$$-\nabla^2 \phi(z) + \left[\frac{\sum_j^2}{\bar{D}_j^2} + \lambda^2 \right] \phi(z) = \beta_j \sum_j' F(z) \quad (11)$$

$$S(z) = \frac{1}{K} \left[\nu \sum_{pfj}' F(z) + \nu \sum_{fj}^2 \phi(z) \right] \quad (12)$$

1.1.2 Finite Difference Equations

The finite difference equation can be applied to the point Z corresponding to the mesh point n by the equation

$$\nabla^2 F_n = \frac{F_{n+1} - 2F_n + F_{n-1}}{\Delta Z^2} \quad (13)$$

where

$$F_n \equiv F(z) \quad (14)$$

and

$$F_{n+1} \equiv F(z + \Delta Z) \quad (15)$$

By using equation (13) and a corresponding equation for $\nabla^2 \phi_n$ and substituting in (10) and (11), the result can be written as

$$F_{n+1} = K_j' F_n - h_j' F_{n-1} - C_j' S_n \quad (16)$$

$$\phi_{n+1} = K_j^2 \phi_n - h_j^2 \phi_{n-1} - C_j^2 F_n \quad (17)$$

where

$$K_j' = \left[\frac{\sum_j'}{D_j'} + \lambda^2 \right] \Delta \bar{z}^2 + 2 \quad (18)$$

$$K_j^2 = \left[\frac{\sum_j^2}{D_j^2} + \lambda^2 \right] \Delta \bar{z}^2 + 2 \quad (19)$$

$$h_j^i = 1 \quad (20)$$

$$C_j' = \frac{\Delta \bar{z}^2}{D_j'} \quad (21)$$

$$C_j^2 = \frac{P_j \sum_j'}{D_j^2} \Delta \bar{z}^2 \quad (22)$$

Equations (18) through (22) must be modified at material boundaries.

1.2 Interface Conditions

Continuity of flux and current is assumed. Consider a boundary between regions located at the point $\eta = B$ (see diagram below).

One can determine a flux F_{B+1}^* which would exist if region $j \neq 1$ had the properties of region j .

$$F_{B+1}^* = K_j' F_B - F_{B-1} - C_j' S_B \quad (23)$$

likewise, F_{B-1}^* is computed based on the continuity of region $j \neq 1$,

$$F_{B+1} = K_{j+1}' F_B - F_{B-1}^* - C_{j+1}' S_B \quad (24)$$

Continuity of flux has already been assumed above, in writing F_B .

Continuity of current can be expressed in the form

$$D_{j+1}' (F_{B+1} - F_{B-1}^*) = D_j' (F_{B+1}^* - F_{B-1}) \quad (25)$$

after eliminating F_{B-1}^* and F_{B+1}^* from (23), (24) and (25), the result can be

written as:

$$F_{j+1} = \frac{1}{2} \left(\frac{K_j' D_j' + K_{j+1}' D_{j+1}'}{D_{j+1}'} \right) F_B - \left(\frac{D_j'}{D_{j+1}'} \right) F_{B-1} - \frac{1}{2} \left(\frac{D_j' C_j' + D_{j+1}' C_{j+1}'}{D_{j+1}'} \right) S_B \quad (26)$$

Thus by comparison with equation (16)

$$K_B^i = \frac{1}{2} \left(\frac{D_j^i K_j^i + D_{j+1}^i K_{j+1}^i}{D_{j+1}^i} \right) \quad (27)$$

$$L_B^i = \frac{D_j^i}{D_{j+1}^i} \quad (28)$$

$$C_B^i = \frac{1}{2} \left(\frac{D_j^i C_j^i + D_{j+1}^i C_{j+1}^i}{D_{j+1}^i} \right) \quad (29)$$

1.3 Solution of The Group Diffusion Equation

Several possible methods can be used. One method is to assume solutions in the form

$$F_n = \alpha_n' F_{n+1} + \beta_n' \quad (30)$$

$$\phi_n = \alpha_n^2 \phi_{n+1} + \beta_n^2 \quad (31)$$

If equation (30) is combined with equation (16) to eliminate F_{n+1} the result is:

$$\frac{F_n - \beta_n'}{\alpha_n'} = K_n' F_n - \alpha_{n-1}' F_n - \beta_{n-1}' - C_n' S_n \quad (32)$$

A similar equation for ϕ_n can be found. Since only one solution is needed for (30), a convenient way is to separate terms involving F_n^1 and other terms. Thus we obtain recursion formulas for α_n and β_n

$$\begin{aligned}\alpha'_n &= \frac{1}{K'_j - \alpha'_{n-1}} & n \neq 0, \beta_j \\ \beta'_n &= \alpha'_n (\beta'_{n-1} + C'_n S_n) & n \neq 0, \beta_j\end{aligned}\quad (33)$$

$$\begin{aligned}\alpha_n^2 &= \frac{1}{K^2 - \alpha_{n-1}^2} & n \neq 0, \beta_j \\ \beta_n^2 &= \alpha_n^2 (\beta_{n-1}^2 + C_n^2 F_n) & n \neq 0, \beta_j\end{aligned}\quad (34)$$

1.3.1 Initial Boundary (n = 0)

The condition of no return current is used. It may be expressed by

$$\frac{D'_i \nabla F}{F} = G \quad (35)$$

where G is a constant independent of material properties.

In difference form, equation (35) becomes

$$\frac{F_i - F_{i-1}}{F_0} = g^i \quad \text{when} \quad g^i = \frac{2G}{D_i^i} \quad (36)$$

In diffusion theory, $G = 0.5$.

Using equation (16) for $n = 0$, to eliminate F_1 ,

$$F_0 = \left(\frac{2}{K'_1 + g'_1} \right) F_1 + \left(\frac{C'_0}{K'_1 + g'_1} \right) S_0 \quad (37)$$

and from (30) and (31) the expressions for α'_0 and β'_0 can be obtained.

$$\begin{aligned} \alpha'_0 &= \frac{2}{K'_1 + g'_1} & \alpha_0^2 &= \frac{2}{K_1^2 + g_1^2} \\ \beta'_0 &= \left(\frac{C_0}{K'_1 + g'_1} \right) S_0 & \beta_0^2 &= \left(\frac{C_1^2}{K_1^2 + g_1^2} \right) F_0 \end{aligned} \quad (38)$$

1.3.2 Final Boundary ($n = N$)

Again using the boundary condition of no return current,

$$\frac{F_{N+1} - F_{N-1}}{F_N} = -g'_{10} \quad (39)$$

and combining with equations (16) and (30) in the form

$$F_{N+1} = K'_{10} F_N - F_{N-1} - C'_{10} \phi_N \quad (40)$$

$$F_N = \alpha'_N F_{N+1} + \beta'_N \quad (41)$$

F_{N+1} and F_{N-1} can be eliminated, giving

$$F_N = \frac{2\beta'_N - C'_{10} S_N}{2 - \alpha'_N (K'_{10} - g'_{10})} \quad (42)$$

likewise,

$$\phi_N = \frac{2\beta_N^2 - C_{10}^2 F_N}{2 - \alpha_N^2 (K_{10}^2 - g_{10}^2)} \quad (43)$$

For other points,

$$F_N = \alpha'_N F_{N+1} + \beta'_N \quad (44)$$

$$\phi_N = \alpha_N^2 \phi_{N+1} + \beta_N^2 \quad (45)$$

1.3.3 Inter-region Points

At interface points, it is desired to retain the formula

$$F_n = \alpha'_n F_{n+1} + \beta'_n$$

and equation (16) in the form

$$F_B = K'_1 F_{B-1} - F_{B-2} - C'_1 S_{B-1} \quad (46)$$

$$F_{B+1} = K'_B F_B - h'_B F_{B-1} - C'_B S_B \quad (47)$$

$$F_{B+2} = K'_2 F_{B+1} - F_B - C'_2 S_{B+1} \quad (48)$$

By combining equations (30) and (47), the result is

$$\frac{F_B - \beta'_B}{\alpha'_B} = K'_B F_B - h'_B (\alpha'_{B-1} F_B + \beta'_{B-1} - C'_B S_B) \quad (49)$$

Thus

$$\alpha'_B = \frac{1}{K_B^i - L_B^i \alpha'_{B-1}} \quad (50)$$

and

$$\beta'_B = \alpha'_B (L'_B \beta'_{B-1} + C'_B S_B) \quad (51)$$

$$\beta_B^2 = \alpha_B^2 (L_B^2 \beta_{B-1}^2 + C_B^2 F_B) \quad (52)$$

α and β for non-interface points (including surface points) are given by equations (33) and (34).

1.4 Iterative Solution

1.4.1 Procedure

The fast and slow fluxes are initially assumed flat throughout the reactor, with

$$F_n = \phi_n = 0.005 \quad (53)$$

The source term, which corresponds to the fission power distribution in a reactor, is calculated by the equation

$$S_n = \nu \sum_{fj} F_n + \nu \sum_{fj} \phi_n \quad (54)$$

for non-interface points. At interfaces, S_n is computed by averaging the material constants of the adjoining regions.

$$S_B = \frac{1}{2} \left[\nu \sum'_{f,j} F_{f,j} + \nu \sum'_{f,j+1} F_{f,j+1} \right] F_B + \frac{1}{2} \left[\nu \sum'_{f,j} \phi_{f,j} + \nu \sum'_{f,j+1} \phi_{f,j+1} \right] \phi_B \quad (55)$$

The value of K is calculated by the ~~summation~~

$$K = \sum_{n=0}^N S_n \quad (56)$$

This is used to normalize S_n such that

$$\sum_{n=0}^N S_n = 1 \quad (57)$$

New values for all F_n 's and ϕ_n 's can be calculated, using the method and formulas described previously. After computing the new fluxes, k is again computed by equation (54), and the source again normalized.

Convergence is determined by comparison of the normalized thermal flux at a point with the value at the same point for the previous calculation. The difference in these values is found for each point n , and the maximum absolute difference is used as the convergence criterion.

The calculating process is repeated, using the fluxes from the previous calculation as a trial for the next calculation, until the convergence criterion is less than a selected value.

1.4.2 Accelerated Iteration

An iteration acceleration scheme has been incorporated into

the program. A new power distribution is obtained from the equation

$$S^{m+2} = (1+\alpha)S^{m+1} - \alpha S^m \quad (58)$$

where S^m and S^{m+1} have been normalized by equation (57).

α is revised as the iterations progress in the following manner:

1. Make no changes in α for X_1 times.
2. Increase α and $1+\alpha$ by $\Delta\alpha_1$ for X_2 times.
3. Increase α and $1+\alpha$ by $\Delta\alpha_2$ for X_3 times.
4. Make no further changes in α and $1+\alpha$.

The storage locations and the values used in the program deck furnished are as follows:

<u>Parameter</u>	<u>Location</u>	<u>Value</u>
α	1460	0.0000000000
$1+\alpha$	1278	1.0000000000
X_1	1690	0000000002
X_2	1691	0000000001
X_3	1692	0000000004
$\Delta\alpha_1$	1985	0.2000000000
$\Delta\alpha_2$	1986	0.1000000000

The values indicated have given reasonable acceleration in the cases tested.

2. CONTROL RODS

2.1 Control Rod Representation

Using the "Window Shade" technique, the absorber section of the rod bank is represented by the addition of an equivalent uniform absorption cross-section, Σ_p , to the thermal absorption.

2.2 Rod Bank Position

The initial rod bank position can be selected by specifying the mesh point for the absorber interface. The program adds the value for Σ_p to the appropriate constants in the regions from mesh point 00 to the specified rod bank position. If the specified rod position does not fall on an existing region interface, a new region is created. This new interface is not considered in computing region average power and flux.

When k has converged such that the new value does not differ from the old by more than 0.0005, the control rod position is increased or decreased by one mesh point to bring k toward unity. Once k has passed through unity, the rod position will not change further. The iteration acceleration parameters α and $1/\alpha$ are reset to their original value, and the modification sequence for changing α and $1/\alpha$ is reset.

A switch on the console may be used to cancel the change of rod bank position, either initially or during the operation of the calculation.

2.3 Additional Calculations

Certain cases using the initial input data can be performed without reloading the program or data. The changes which can be made are:

1. Revision of rod bank position mesh point.
2. Selection of automatic rod bank adjustment feature.

The changes in the rod bank position are made from the console switches following the conclusion of the calculation. The console setting is described in Section 3.3.2.

The source guess is taken as the power distribution from the completed calculation. The iteration acceleration parameters α and $1/\alpha$ are reset to their original value. The modification sequence for changing α and $1/\alpha$ is also reset.

3. PROGRAM DETAILS

3.1 Input and Output

3.1.1 Order of Data

	<u>Card Type</u>	<u>Number of Cards</u>	<u>General Contents</u>
<u>Input</u>			
Program 21.1 Deck			
	1	1	Identification and Set Nos.
	8	3	Reactor Data
	9	9	Two-group Parameters
Program 21.2 Deck			
	21	1	Control Rod Data
	22	1	Control Rod Position
<u>Output</u>			
	1	1	Identification and Set Nos.
Iteration		Variable	Iteration Results
31		46	Flux and Power Distribution
6		4	Average Power and Flux

3.1.2 General Arrangement of Data

3.1.2.1 Word 1

The first ten digits of input and output are interpreted as follows:

Program No.	Type No.	Set No. (input types 8,9,21) or Identification No. (output types 31,6)	Card No.
21	06	0301	05

3.1.2.2 Words 2-8

The data indicated is described in Section 3. Each word consists of 10 digits. If no description is given for a word, it is zero.

3.1.3 Card Layout

The input and output formats are indicated in Tables I and II.

3.1.3.1 Program 21.1 Input

Type 1	Identification and Set Numbers		(1 Card)	
<u>Word No.</u>	<u>Contents</u>		<u>Decimal Point</u>	
1		21	0100	0001
2	Identification No.	00	0000	xxxx
3	Set No. for Types 8,9	00	xxxx	xxxx
4	Set No. for Type 21	00	xxxx	0000

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TABLE I INPUT FORMAT

PROGRAM No.	CARD TYPE	CARD No.	1-10	11-20	CARD 21-30	COLUMNS 31-40	41-50	51-60	61-70	71-80
21.4	01	1		I_1	$I_8 I_9$	I_2				
			2101000001	000000XXXX	00XXXXXXXX	00XXXXX0000	0-----0	0-----0	0-----0	0-----0
	08	1	I_8	N_1	N_2	N_3	N_4	N_5	N_6	
			2108XXXX01	00000000XX	00000000XX	00000000XX	00000000XX	00000000XX	00000000XX	0-----0
		2	I_8	N_7	N_8	N_9				
			2108XXXX02	00000000XX	00000000XX	00000000XX	0-----0	0-----0	0-----0	0-----0
		3	I_8					$\Delta \bar{E}$	λ^2	
			2108XXXX03	0-----0	0-----0	0-----0	0-----0	XXXXXXXXXX	XXXXXXXXXX	0-----0
21.2	09	j	I_9 j	D_j^1	D_j^2	τ_j	p_j	K_j^1	K_j^2	Σa_j^2
			2109XXXX0X	XXXX.XXXXXX	XXXX.XXXXXX	XXXX.XXXXXX	X.XXXXXXXX	X.XXXXXXXX	X.XXXXXXXX	XX.XXXXXXXX
	21	1	I_{21}	CC	RP_{min}		$\Sigma p \Delta \bar{E}^2$	RP_{max}		
			2121XXXX01	X.XXXXXXXX	00000000XX	0-----0	XX.XXXXXXXX	00000000XX	0-----0	0-----0
	22	1		RP						
			2122000001	00000000XX	0-----0	0-----0	0-----0	0-----0	0-----0	0-----0

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TABLE II OUTPUT FORMAT

PROGRAM No.	CARD TYPE	CARD No.	1-10	11-20	CARD COLUMNS		41-50	51-60	61-70	71-80
					21-30	31-40				
21.1	NONE									
21.2	01	1		I_1	I_8 I_9	I_{21}				
			21 01 00 00 01	00 00 00 XX XX	00 XX XX XX XX	00 XXXX 00 00	0 ———— 0	0 ———— 0	0 ———— 0	0 ———— 0
	ITER- ATION	C	C	K	$ \phi' - \phi _{\max}$	NOTE 1	RP (NOTE 2)			
			00 00 00 00 XX	XX X.XXX XXXX	X.XXXXX XXXX		00 00 00 00 XX	0 ———— 0	0 ———— 0	0 ———— 0
	31	1	I_1	K	$ \phi' - \phi _{\max}$	NOTE 1	RP			
			21 31 XX XX 01	XXX.XXX XXXX	X.XXX XX XX XX		00 00 00 00 XX	0 ———— 0	0 ———— 0	0 ———— 0
		2	I_1	F_2	F_1	F_2	F_3	F_4	F_5	F_6
			21 31 XXXX 02	X.XXXXX XXXX	X.XXX XX XX XX	X.XXXXX XXXX	X.XXXXX XXXX	X.XXXXX XXXX	X.XXXXX XXXX	X.XXXXX XXXX
		3	I_1	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}	F_{13}
			21 31 XX XX 03	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX
		:	:	:	:	:	:	:	:	:
		16	I_1	F_{98}	F_{99}					
			21 31 XXXX 16	X.XXXXX XXXX	X.XXX XX XX XX	0 ———— 0	0 ———— 0	0 ———— 0	0 ———— 0	0 ———— 0
		17	I_1	ϕ_0	ϕ_1	ϕ_2	ϕ_3	ϕ_4	ϕ_5	ϕ_6
			21 31 XXXX 17	X.XXXXX XXXX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX
		:	:	:	:	:	:	:	:	:
		31	I_1	ϕ_{98}	ϕ_{99}					
			21 31 XXXX 31	X.XXXXX XXXX	X.XXX XX XX XX	0 ———— 0	0 ———— 0	0 ———— 0	0 ———— 0	0 ———— 0
		32	I_1	S_0	S_1	S_2	S_3	S_4	S_5	S_6
			21 31 XXXX 32	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX
		:	:	:	:	:	:	:	:	:
		46	I_1	S_{98}	S_{99}					
			21 31 XXXX 46	X.XXXXX XXXX	X.XXX XX XX XX	0 ———— 0	0 ———— 0	0 ———— 0	0 ———— 0	0 ———— 0
	06	1	I_1	P_1	P_2	P_3	P_4	P_5	P_6	
			21 06 XXXX 01	X.XXXXX XXXX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	0 ———— 0
		2	I_1	P_7	P_8	P_9				
			21 06 XXXX 02	X.XXXXX XXXX	X.XXX XX XX XX	X.XXX XX XX XX	0 ———— 0	0 ———— 0	0 ———— 0	0 ———— 0
		3	I_1	$\bar{\phi}_1$	$\bar{\phi}_2$	$\bar{\phi}_3$	$\bar{\phi}_4$	$\bar{\phi}_5$	$\bar{\phi}_6$	
			21 06 XXXX 03	X.XXXXX XXXX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	X.XXX XX XX XX	0 ———— 0
		4	I_1	$\bar{\phi}_7$	$\bar{\phi}_8$	$\bar{\phi}_9$				
			21 06 XXXX 04	X.XXXXX XXXX	X.XXX XX XX XX	X.XXX XX XX XX	0 ———— 0	0 ———— 0	0 ———— 0	0 ———— 0

Type 8: Reactor Data (3 Cards)

<u>Card No.</u>	<u>Word No.</u>	<u>Contents</u>	<u>Decimal Point</u>
01	2 - 7	Space points in regions 1 - 6	00000000 xx
02	2 - 4	Space points in regions 7 - 9	00000000 xx
03	6	$\overline{\Delta Z}$ (cm)	x.xxxxxxxxxx
	7	λ^2	.xxxxxxxxxx

Type 9: Two-group Parameters (9 Cards)

<u>Card No.</u>	<u>Word No.</u>	<u>Contents</u>	<u>Decimal Point</u>
01	2	D^1 , Region 1	xxx.xxxxxx
	3	D^2 , Region 1	xxx.xxxxxx
	4	τ , Region 1	xxx.xxxxxx
	5	p, Region 1	x.xxxxxxxxxx
	6	K^1 , Region 1	x.xxxxxxxxxx
	7	K^2 , Region 1	x.xxxxxxxxxx
	8	Σa^2 , Region 1	xx.xxxxxxxx
02-09	Identical to 01, except for regions 2-9, respectively.		

Notes for Table II

1. Direction of control rod adjustment (appears only after an automatic change).

Increase 0000000001

Decrease 0000000001 -

2. RP appears on these cards only after an adjustment.

3.1.3.2 Program 21.1 Output

NONE

3.1.3.3 Program 21.2 Input

Type 21: Control Rod Data (1 Card)

<u>Word No.</u>	<u>Contents</u>	<u>Decimal Point</u>
2	Flux Convergence Criterion	x.xxxxxxxxxx
3	Minimum Rod Position	00000000 xx.
4	Reserved	0000000000
5	$\sum_p \Delta \bar{Z}^2$	xx.xxxxxxxxxx
6	Maximum Rod Position	00000000 xx.

Type 22: Control Rod Position (1 Card)

<u>Word No.</u>	<u>Contents</u>	<u>Decimal Point</u>
2	Rod Position	00000000 xx

3.1.3.4 Program 21.2 Output

Type 1: Identification and Set Numbers (1 Card)

See description under 21.1 Input

Iteration Results

<u>Word No.</u>	<u>Contents</u>	<u>Decimal Point</u>
1	Iteration No.	00000 00 xxx.
2	k	xxx.xx xxxxx
3	Flux convergence	x.xxxx xxxxx
4	Direction of control rod adjust.	
	Increase	00000 00001
	Decrease	00000 00001 -
5	Control Rod Position (appears only after adjustment)	00000 00 xx.

Type 31: Flux and Power Distribution (46 Cards)

<u>Card No.</u>	<u>Word No.</u>	<u>Contents</u>	<u>Decimal Point</u>
01	2	k	xxx.xxxxxxx
	3	Flux convergence	x.xxxxxxxx
	4	Direction of rod adjustment	
02-16	5 2-8	Control rod position Fn, successively from n = 0 to n = 99	x.xxxxxxxx
17-31	2-8	ϕ_n , successively from n= 0 to n= 99	x.xxxxxxxx
32-46	2-8	S _n , successively from n= 0 to n= 99	x.xxxxxxxx

Type 6: Average Power and Flux (4 Cards)

Decimal Point Location x.xxxx xxxx

<u>Card No.</u>	<u>Word No.</u>	<u>Contents</u>
01	2 - 7	Power Fraction Regions 1 - 6
02	2 - 4	Power Fraction Regions 7 - 9
03	2 - 7	Average Thermal Flux Regions 1 - 6
04	2 - 4	Average Thermal Flux Regions 7 - 9

3.2 General Requirements

3.2.1 Type 1 Card

The set numbers specified must agree with the set numbers on the type 8, 9, and 21 cards.

3.2.2 Type 8 Cards

There are 9 regions. Each region must contain at least one mesh interval. The total number of mesh intervals in the 9 regions must be 99. The region boundaries must fall on mesh points.

There are 100 mesh points, numbered from 00 to 99. The mesh spacing is the same for all regions.

If nine regions of different properties are not needed, two or more regions will have identical properties. Data for nine regions must be specified.

K_j and $\sum_{aj}^2$ must be region properties without correction for the $\sum_p$ representing control rods.

3.2.3 Type 21 Card

A suitable flux convergence criterion for obtaining k accurate to 5 places is 0.000002000.

The minimum and maximum rod position entries specify limits of adjustment of rod position, if automatic rod position adjustment is used. The positions are specified by mesh point number.

3.2.4 Type 22 Card

The rod position entry specifies initial rod position used by machine. A deck of cards from 00 to 99 is available so that any rod position may be used to specify the mesh point limit of addition of $\sum_p$. The $\sum_p$ is added to the thermal absorption cross-sections of all regions from mesh point 00 to the mesh point specified.

3.3 Operating Instructions

3.3.1 Console Setting

The sign of the console is used to control rod position adjustment. Console - prevents rod change. Console / enables rod position to change, subject to program convergence requirements, until a specified limit is reached or until k changes sign. The sign position is examined just following the punch of the iteration result card. Change of console sign may be made any time during program operation.

If automatic adjustment is used, care should be taken on the selection of initial rod position. As each adjustment of only one mesh interval extends the calculating time by approximately 5 minutes, considerable time can be consumed if excessive adjustment must be made.

The error and overflow switches should be in stop position.

3.3.2 Repeat Cases

If it is desired to repeat a calculation in which only rod position and/or console sign is changed, it is not necessary to reload the program. The final instruction in the program is a program stop, transferring control to 8000.

The following table indicates console settings to be used to make changes

<u>Console</u>	<u>Operation</u>
70 0051 xxxx	Initial setting for program loading
00 00rr 0894	Recalculate, using an initial rod position of rr
70 0051 xxxx	Load program 21 for next calculation

If there is no need to change console sign, the program switch may be set to run, permitting the change to be made when the previous case is finished. The console must not be changed from the read instruction until the entire program has been loaded. The sign of any of the above instructions may be negative if automatic rod bank position adjustment is not desired.

3.3.3 Type 533 Wiring

Load cards - Col. 1.

Read card C - 8 10-digit words

Punch card C - 8 10-digit words

RSU and PSU switches wired.

R+ and P+ not wired.

3.3.4 Special Operations

To change rod position when $|K' - K| > CC_K$, stop at 0421, reset accumulator ($\neq$), return address stop switch to run, and start program.

To finish calculation when $|\phi' - \phi|_{MAX} > CC$, stop at 1258, reset accumulator (0), return address stop switch to run, and start program.

To adjust rod position, stop at 0413. Set console as indicated in table in Section 3.3.2, and take next instruction from console.

3.3.5 Error Stops

A storage selection error is used to indicate certain limits have been exceeded. The number will be in the program and address registers. Rescaling of data or change of region locations may be necessary.

<u>Program</u>	<u>Number</u>	<u>Reason</u>
21.1	9901	Type 1 card incorrect
	9908	Type 8 or 9 card incorrect
21.2	9921	Type 21 or 22 card incorrect
	9950	Number of mesh points not equal to 99
	9951	$K_j^2 \geq 100$
	9952	Not used
	9953	Not used
	9954	$C_n^i \phi_n + \beta_{n-1} \geq 10$ (ϕ_n or F_n)
	9955	$\beta_n^i \geq 10$
	9956	$C_n^i \phi_n \geq 10$ (ϕ_n or F_n)
	9957	$\beta_n^i \geq 10$

<u>Program</u>	<u>Number</u>	<u>Reason</u>
21.2 (cont'd)	9958	$\phi_n \geq 10$ (ϕ_n or F_n)
	9959	K negative
	9960	$K \geq 10$

If a division overflow occurs with either 640061 1179 or 20 0062 1182 in the program register, $K \leq 0.1$. If this happens on the initial normalization, the initial flux guess in 1512 (now set at 0.050000000) should be increased. Likewise, on an initial normalization in which $K \geq 10$ (error stop 9960), the initial flux guess should be decreased.

3.4 Time Requirements

Each iteration requires 90 seconds. The table below indicates the approximate number of iterations required for various flux convergence criteria, with no adjustment of control rod position.

<u>Flux Convergence Criterion</u>	<u>No. Iterations</u>
0.000050000	11 - 16
.000020000	12 - 18
.000010000	13 - 20
.000005000	14 - 22
.000002000	16 - 25

As k differs from unity, the convergence is generally slower. The accuracy of k is usually related fairly closely to the number of iterations, as shown in the table below.

<u>No. Iterations</u>	<u>Convergence of k</u>
10	± 0.0001
13	± 0.00002
16	± 0.000005

The flux usually converges faster for uniform than for non-uniform composition reactors.

Approximately three iterations additional are required for each adjustment of control rod position. For a flux convergence of 0.000002000, the approximate time, T, in minutes for the entire calculation is given by:

$$T = 35 + 5A$$

where A is the number of times the control rod position is adjusted.

3.5 Program Listing

The program decks and two sample calculations are listed on the following pages.

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* PROGRAM	21.1 DECK	*	*	*	*	*	*
6080000053	0000010000	2100000054	6000570055	2119990056	6100588003	1100528003	2006001999
7000013000	6900520051	6900540053	6900560055	6900580057	7000500132	6900560058	2419991999
6900520002	2400500003	6900530004	2419960005	6900540006	2419970007	6900550008	2419980057
2401321996	7000500051	2401331997	6901360140	2401401998	2201360143	2401431999	3500040134
2401341996	1580010144	2401441997	2201480135	2401351998	6501380142	2401421999	1001368002
2401371996	1001410145	2401451997	1580010139	2401391998	1101480146	2401461999	4401470132
2401471996	1080018002	2401361997	2400000137	2401381998	6900528003	2401411999	0000010000
2400500132	6500510133	*	*	*	*	*	*
0000270001	2101000001	*	*	*	*	*	*
0000300005	0000000000	0000000000	0000000000	0000000000	0000000000	*	*
0010560007	7000511057	6500511058	1615061059	4510601061	0000009901	6500521062	2400281063
0010630007	3500021064	1515071065	2000641066	6500531067	2400291068	6980031069	2215061070
0010700007	6580011071	3000021072	1515081073	2015061074	6500541075	2400301076	3000021077
0010770007	1515091078	2000631079	6915101080	2410591056	0000009908	6515111090	6915161108
0010840007	6000561116	6015191127	0000000000	0000000000	0000000000	0000000000	1015128002
0010910007	1115131092	4410931096	1080011094	1015141095	1580018002	6510591097	1515151098
0010980002	2010591099	6515061106	1080011094	1015141095	1580018002	6510591097	1515151098
0011060007	1515151107	2015061056	2415121109	6915171110	2415131082	0000000000	0000000000
0011130007	0000000000	0000000000	0000000000	1980011117	2115561118	6900571119	2415571120
0011200007	6500291121	6980031122	2315061123	6580011124	3500021125	1515181126	2015061096
0011270007	6400541128	1515571129	6080021130	1915561131	1015201132	2115611133	6015561134
0011340007	3000041135	6400521136	2415631137	2015621138	6000521139	6400541140	2015581141
0011410007	6015211142	1100551143	1915581144	6080031145	1900561146	6580031147	3100021148
0011480002	2015641149	6000581156	1915581144	6080031145	1900561146	6580031147	3100021148
0011560007	3000041157	6400531158	3500021159	1515571160	3100021161	6080021162	1915561163
0011630007	3100081164	1515201165	2015651166	6000551167	1915581168	3100041169	6400531170
0011700007	6080021171	1915561172	3100091173	2015661174	6900531175	2415671176	6000571177
0011770007	1900581178	6580031179	3100011180	2015681190	0000000000	0000000000	0000000000
0011840007	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	6015221191
0011910007	1515238003	1115241193	4411941206	1080011195	1015141196	1580018003	0000000000
0011980002	0000000000	0000000000	4411941206	1080011195	1015141196	1580018003	0000000000
0012060007	6015251207	4412080132	1115151209	2115251210	6515231211	1515261212	2015231099
0012130006	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	2015231099
0015060007	2101000001	2131000001	2108000001	2121000001	4510811082	6900528003	2410181091
0015130007	2410231091	0000010000	0000000001	2410241091	2410261091	2109000000	0001000000
0015200007	0200000000	1000000000	6915618002	2405131192	6915688002	0000000008	0000080000
0015270002	0000000000	0000000000	6915618002	2405131192	6915688002	0000000009	0000080000
0000001056	*	*	*	*	*	*	*
* PROGRAM	21.2 DECK	*	*	*	*	*	*
0000000132	*	*	*	*	*	*	*
6905770052	2419020053	6905780054	2419030055	6905790056	2419040057	6905800058	2419050132
6905810052	2419520053	6905820054	2419530055	6905830056	2419540057	6905840058	2419550132
0000770007	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000840001	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0004100003	0000000000	0000000000	0000000000	*	*	*	*
0004130007	6580000414	4612900415	6516340416	1600610417	2416340418	2016280419	6516700420
0004200007	1816280421	4612900422	6500610423	1616710424	4604360425	6500540426	1600560427

NON LOAD

NON LOAD

NON LOAD

NON LOAD

NON LOAD

NON LOAD

NON LOAD

NON LOAD

NON LOAD

NON LOAD

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0004270007	4504281290	1580010429	1515090430	2000540434	6916730432	2404240433	6515090447
0004340007	2000810431	0000000000-	6500540437	1600530438	4504391290	1580010440	1615090441
0004410007	2000540442	2000810443	6916720444	2404240445	6615090447	0000000000-	2000800448
0004480007	6916740449	2409980958	2415650451	6915320452	2415700453	6915710454	2419331912
0004550007	6915720456	2415650457	6915730458	2415700459	6915740460	2419331912	6500770462
0004620007	1604750463	2000770466	6904760465	2400840466	6904770467	2415690468	6904780469
0004690007	2415650470	6904790471	2415700472	6904800473	2419241915	0000000000-	0025000045
0004760007	2402191003	2400831917	6904018003	6904118003	4519250481	2100830484	6904850483
0004830007	2400840484	7100770486	2402251003	6904950487	2415650488	6904960489	2415700490
0004900007	6904970491	2419241912	6904980493	2400841912	2100830587	6905018003	6905118003
0004970003	4519250494	2403191003	2403251003	2400841912	2100830585	6905018003	6905118003
0005100003	0000000000	0000000000	0000000000	*	*	*	*
0005850007	6904990586	2400840587	7100770588	6905920589	2417720590	6905930591	2410921056
0005920007	2017581085	2416061112	2110911106	6902008003	6902998003	7100771934	2400841917
0005990001	4519251928	2416061112	2110911106	6902008003	6902998003	7100771934	2400841917
0008000007	6010180801	1010190802	1010200803	1010210804	1010220805	1010230806	1010240807
0008070007	1010250808	1010260809	1115820810	4508110812	0000009950	6000540813	1515830815
0008140007	4408160870	4608170814	1515088002	1080010818	2116280819	1615830820	2010160866
0008210007	1515840822	2016290823	6915850824	1515860825	1116290826	4408270830	1000018003
0008280007	1115080829	1615080825	6580010831	1615878002	1116280833	1515888002	1515890835
0008350007	6916288002	6510160867	1515900838	2016280839	6515910840	1015928002	1515080842
0008420007	1015938002	1515080842	1115958002	1515080842	1515080842	1615940844	1515080842
0008490007	3500020837	1515080842	4408550862	1116280851	1116660854	1615948002	1080010853
0008560007	0000000000-	0000000000-	0000000000-	0000000000-	0000000000-	0000000000-	6510160880
0008630007	0000000000-	0000000000-	0000000000-	2010170821	1516570868	2016290869	6510160849
0008700007	1615830871	2010170872	2110160873	6916560874	2416290890	2012780876	2114600812
0008770007	6516901685	4516931696	0000000000-	3500020881	1516580882	2016280883	6010160884
0008840007	1916590885	1516600886	2016310950	6916740888	2404131290	0000000000-	6916620891
0008910007	2416280892	6916610893	2416310950	6780000895	3000040896	6900540897	2300540898
0008980007	2300811990	0000000000-	0000000000-	0000000000-	0000000000-	0000000000-	0000000000-
0009050007	0000000000-	0000000000-	0000000000-	0000000000-	0000000000-	0000000000-	0000000000-
0009120007	0000000000-	0000000000-	0000000000-	0000000000-	0000000000-	0000000000-	0000000000-
0009190007	1109440949	7000008000	1009240937	1015000923	1600020925	2409280922	1180030938
0009260007	1500020919	0009260007	1500020919	0009260007	1500020919	0009260007	1500020919
0009330007	0009260007	1500020919	0000000000-	0000000000-	6909400943	4509410945	7109270920
0009400007	0000000007	1080010948	1080018002	2209278002	2409350922	6580010994	7109270921
0009470007	0000000000-	1515000926	4409420946	6516290951	1080010952	1116630953	1116640954
0009540007	4409550960	1080018002	1115080957	1680010953	6908770959	2416840978	6016280961
0009610007	1516318002	1015930963	1515088002	1015930963	1615948002	1015930963	1015930963
0009680007	1115950965	1015930963	4409720980	1015930963	1080010974	1116650970	1116660975
0009750007	1615948002	6916670977	2409920998	6908780979	2419770999	6510170981	3500020982
0009820007	1516670983	2016280984	6509920985	1616280986	4509900976	6509920988	1515200989
0009890007	2009920985	6000550991	3000040992	6410540993	1009920994	1116688003	1016698003
0009960004	0000000987	0000000951	0000001085	6519870875	0000000000	0000000000	0000000000
0010360007	00000009921	7000011038	6500011039	1615101040	4510361041	6900021042	2400541077
0010560007	6905941057	2410991058	6905951059	2415651060	6905961061	2415701062	6905971063
0010630007	2419331064	6905981065	2415691066	6505991067	2419241992	0100008000	1080011922
0010700007	1515708002	2016061059	7100271073	7000511074	6500511075	1600631076	4510361037
0010770007	6015111078	1515128003	1115131080	4410811083	1080011082	1015088003	2101000800
0010840007	2410521057	6010161086	1015141087	2116101088	6010911089	1116101090	4510911093

0010910007	6910061092	2416061112	6510911094	1615158002	1515168002	2116061097	6010911098
0010980003	1015081099	2110911106	6915111101	1615158002	1515168002	2116061097	6010911098
0011060007	6011391107	1015201108	2111391192	2416121124	2416131117	4511151118	6002001139
0011130007	6415171239	6415171138	1115181143	6015191126	3100061135	6516081113	1615251134
0011200007	6013241141	2111421197	2411491231	2116081128	3500041140	2011391193	1011128003
0011270007	6511121119	6016061111	6511121130	1515081131	1011128003	2011491228	2111121421
0011340007	6916080002	1516081114	3500041148	3500041199	1511421147	1910051109	2116081116
0011410007	1011121133	0000000000	2116061127	1511128002	2011121146	6511121217	2016081128
0011480003	2116081211	1910551110	1016121156	1511128002	2011121146	6511121217	2016081128
0011560007	2104011157	6516081158	6416061159	1011561160	1115228003	1115231162	4411631176
0011630007	6010911164	1015081165	2110911166	6011121167	1115241168	2111121169	6011391170
0011700007	1015251171	2111391172	6011561173	1015081174	2111561088	2416001187	2000611230
0011770007	4511801188	6400611179	2000621182	6511391196	2411121225	6003001208	3500011198
0011840007	4413361186	2016271449	2016411349	6016041188	6511421189	2003991121	1515201191
0011910007	2011491112	6511491190	6511491215	6518151774	2116001456	1515201125	6915061213
0011980003	2103001226	1016081123	1901031201	6518151774	2116001456	1515201125	6915061213
0012060007	4412121214	4512191222	1900621183	1916121136	1916131137	6015261131	1080011218
0012130007	2411391243	3100021176	1515201132	2112071224	1615221177	1013248003	1580011227
0012200007	6015238003	2011821236	6515341223	2411821238	2211981245	6915301233	6511821237
0012270007	1515081221	6510911229	1513241234	6015201178	6915271181	6912351238	2410911220
0012340007	2010911088	2211981182	6911981235	1615491207	6911981224	2011421146	0000009959
0012410007	1115481206	0000009960	6915471122	6915401245	6015351246	2016071247	2116081248
0012480003	6516081263	6780021257	6915431251	6915401245	6015351246	2016071247	2116081248
0012560007	6516071258	1616071261	1600521259	4618071260	6516071262	4612651268	1000611269
0012630007	1512668002	1512671271	6516081264	4898000359	0000010000	1580011275	0000001286
0012700007	6012781285	1612741279	1115381273	4412770413	1603991249	2016071265	1580018002
0012770007	1080011285	1000000000	4512821256	0000253198	1015091283	1580011289	2100771284
0012840007	7100771270	1903001195	2100781287	2000791288	6000771281	2016081263	6910061365
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0013060007	3500041315	6910061365	6016151320	2416141292	2416151292	2416161294	2416171292
0013130007	2416181292	2416191328	4413171777	6003001318	3000041326	1916071321	2016241329
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0013270007	6416241299	6512901298	6013321337	2107001356	6013671372	0002000000	1916151334
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0013410007	1513241342	2013161356	2006001308	1916271338	2016081368	6916278003	6916088003
0013480003	1516141319	6013671374	4513511366	1916271338	2016081368	6916278003	6916088003
0013560007	6016061362	4413581345	0000009955	6910021309	1516141369	4513561366	1115091363
0013630007	4513831385	6913431365	2416061322	6015081325	606001360	6113711384	2016231378
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0013840007	1013671347	6016161386	1916141387	6580031395	1916171389	6580031397	6080021399
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0014340007	4414171438	6580031445	0598999918	0000009957	2016431448	6513161424	1516451392
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0015770007	2403251003	2400841861	6903008003	2401001822	2401991822	0000000099	1110170815
0015840007	6910178002	6910268002	2410150828	5900007170	1099890002	0299990002	2410050852
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0015980003	2419520841	0000000000	0180754415	0000070000	0000530001	0000080000	6905818003
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0017060007	1580011776	6015081708	6416161709	1616141710	6080021711	1906991712	1015391713
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0017410007	4499000005	1613241744	3500041748	2017301725	1916301726	4417281724	6517221727
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0018060007	3500011816	6500641809	1615461809	2000771810	6900611811	2400781812	6916071813
0018130007	2400791814	6900541818	1901001944	2101001786	6512851943	2400811819	7100511820
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0018480003	2016131961	6518431856	2017671851	6415171878	2016121846	6502001847	6415171792
0018560007	1513241880	6518461858	1513241881	6115091860	1016061861	4518661872	6518431863
0018630007	1515668002	3100011879	1515688002	2116061862	3100011793	2016121869	6518461863
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0018770007	6415171949	3100011845	1516121868	2018431857	2018461859	2016121883	3500011794
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0019340007	6915590450	1519368002	4100040140	1916121938	3100051939	1516131887	6017961941
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NON LOAD

* PROGRAM	21	TEST	CASE A	INPUT	CONSOLE	700051XXXX-	*	*
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2108030802	0000000008	0000000008	0000000021	0000000021	0000000000	0000000000	0000000000	0000000000
2108030803	0000000000	0000000000	0000000000	0000000000	0000000000	0997857143	0045080000	0000000000
2109030901	0001860980	0000256190	0053556500	0943908169	0000000000	0000000000	0000000000	0004356663
2109030902	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0022685141
2109030903	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0022685141
2109030904	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0022685141
2109030905	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0022685141
2109030906	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0022685141
2109030907	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0022685141
2109030908	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0022685141
2109030909	0001860980	0000256190	0053556500	0943908169	0000000000	0000000000	0004356663	0004356663
2121032101	0000200000	0000000022	0000000000	0008443696	0000000078	0000000000	0000000000	0000000000
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0000000003	0009891225	0002916251	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000004	0010079795	0001293635	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000005	0010170490	0000577240	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000006	0010211135	0000265915	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2131034301	0010227886	0000132090	0000000000	0000000038	0000000000	0000000000	0000000000	0000000000
2131034302	0002634904	0003373248	0004189458	0005102364	0006133036	0007305263	0008646097	0008646097
2131034303	0010186494	0011962002	0014013599	0016388645	0019141951	0022337059	0026047728	0026047728
2131034304	0030359597	0035372187	0041201182	0047981127	0055868514	0065045386	0075723546	0075723546
2131034305	0088149457	0102609913	0122679799	0142487313	0162408311	0182600617	0203147238	0203147238
2131034306	0224106193	0245528039	0267462523	0289953632	0313056040	0336819133	0361292695	0361292695
2131034307	0386521877	0412533811	0439299391	0466622897	0493808348	0520035625	0544930408	0544930408
2131034308	0568305551	0590051981	0610095389	0628379529	0644860883	0659488676	0672238896	0672238896
2131034309	0683078761	0691983758	0698936094	0703924222	0706943242	0707996422	0707076183	0707076183
2131034310	0704202647	0699384936	0692640003	0683990943	0673466461	0661101120	0646936717	0646936717
2131034311	0631004823	0613362057	0594054567	0573135269	0550662160	0526697725	0501308823	0501308823
2131034312	0474567207	0446535686	0417291481	0386893938	0355381766	0322733368	0288770074	0288770074
2131034313	0252914971	0213589103	0183480691	0157607134	0135371258	0116259850	0099831793	0099831793
2131034314	0085707926	0073562249	0063114450	0054123374	0046381510	0039710170	0033955364	0033955364
2131034315	0028984278	0024682167	0020949754	0017700881	0014860558	0012363229	0010151257	0010151257
2131034316	0008173585	0006384575	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2131034317	0000264111	0000678136	0001003540	0001300082	0001600672	0001925236	0002287725	0002287725
2131034318	0002699687	0003172151	0003716603	0004345619	0005073071	0005914184	0006885068	0006885068
2131034319	0008001438	0009275621	0010710043	0012283740	0013924637	0015453261	0016469297	0016469297
2131034320	0016123009	0012656036	0009729752	0009502511	0010223911	0011288442	0012487556	0012487556
2131034321	0013749977	0015050705	0016376844	0017774396	0019202501	0020678056	0022226499	0022226499
2131034322	0023908997	0025893444	0028656606	0033565890	0039141803	0042654063	0045263263	0045263263
2131034323	0047428901	0049330506	0051034808	0052560450	0053898694	0055173424	0056261078	0056261078
2131034324	0057176614	0057924628	0058505305	0058915772	0059148566	0059185319	0059160905	0059160905

2131034325	0058941495	0058546487	0057984367	0057258978	0056371179	0055317482	0054084372
2131034326	0052798359	0051340384	0049731430	0047982584	0046100904	0044091408	0041956793
2131034327	0039694908	0037412599	0035052394	0032699152	0030529720	0028966797	0029055134
2131034328	0033400626	0048522568	0067840187	0075559895	0076321793	0073092904	0067748261
2131034329	0061453090	0054913654	0048541604	0042561238	0037079226	0032129611	0027702508
2131034330	0023762026	0020256952	0017126461	0014302232	0011707521	0009253398	0006831646
2131034331	0004303313	0001481016	0000000000	0000000000	0000000000	0000000000	0000000000
2131034332	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2131034333	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2131034334	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2131034335	0000000000	0002626117	0004467677	0004585097	0005021139	0005574252	0006175269
2131034336	0006800806	0007442930	0008097769	0008781109	0009479778	0010199883	0010950370
2131034337	0011752030	0012661013	0013835704	0015729279	0017841702	0019256365	0020356309
2131034338	0021292883	0022124961	0022874208	0023546454	0024138555	0024691270	0025163562
2131034339	0025560237	0025882748	0026131117	0026304443	0026400335	0026412867	0026386642
2131034340	0026277717	0026092666	0025834512	0025504799	0025104110	0024631643	0024083350
2131034341	0023501230	0022846561	0022126671	0021345694	0020506472	0019611209	0018661402
2131034342	0017656981	0016633694	0015573304	0014504290	0013485230	0012655090	0012356198
2131034343	0013441222	0009021018	0000000000	0000000000	0000000000	0000000000	0000000000
2131034344	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2131034345	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2131034346	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
2106034301	0000000000	0046211590	0088896730	0166661885	0205490370	0205739751	0000000000
2106034302	0170273230	0117114502	0000000000	0000000000	0000000000	0000000000	0000000000
2106034303	0006786495	0012068662	0022913985	0046393261	0057455925	0057526970	0000000000
2106034304	0047611436	0033903143	0037975681	0000000000	0000000000	0000000000	0000000000

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* PROGRAM	21	TEST	CASE B	INPUT	CONSOLE	700051XXXX	*	*
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2108030802	0000000008	0000000008	0000000021	0000000000	0000000000	0000000000	0000000000	0000000000
2108030803	0000000000	0000000000	0000000000	0000000000	0997857143	0045080000	0000000000	0000000000
2109030901	0001860980	0000256190	0053556500	0943908169	0000000000	0000000000	0004356663	0000000000
2109030902	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0000000000
2109030903	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0000000000
2109030904	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0000000000
2109030905	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0000000000
2109030906	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0000000000
2109030907	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0000000000
2109030908	0001405800	0000256190	0053556500	0729485634	1366342750	1459620630	0022685141	0000000000
2109030909	0001860980	0000256190	0053556500	0943908169	0000000000	0000000000	0004356663	0000000000
2121032101	0000002000	0000000022	0000000000	0008443696	0000000078	0000000000	0000000000	0000000000
2122000001	0000000038	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
* PROGRAM	21	TEST	CASE B	OUTPUT	*	*	*	*
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0000000002	0009598739	0007445832	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000003	0009891225	0002916251	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000004	0010079795	0001293635	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000005	0010170490	0000577240	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000006	0010211135	0000265915	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000007	0010227886	0000132090	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000008	0010234232	0000077091	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000009	0010236390	0000048187	0000000000	0000000000	0000000000	0000000000	0000000000	0000000000
0000000010	0010200179	0001175698	0000000001	0000000039	0000000000	0000000000	0000000000	0000000000
0000000011	0010201654	0000189282	0000000001	0000000039	0000000000	0000000000	0000000000	0000000000
0000000012	0010164970	0001285559	0000000001	0000000040	0000000000	0000000000	0000000000	0000000000
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