KERNFORSCHUNGSANLAGE JÜLICH GmbH
Zentralabteilung Forschungsreaktoren

COMPUTER CODES FOR THE OPERATIONAL CONTROL OF THE RESEARCH REACTORS

by

K. J. Kalker, R. Nabbi and H. J. Bormann

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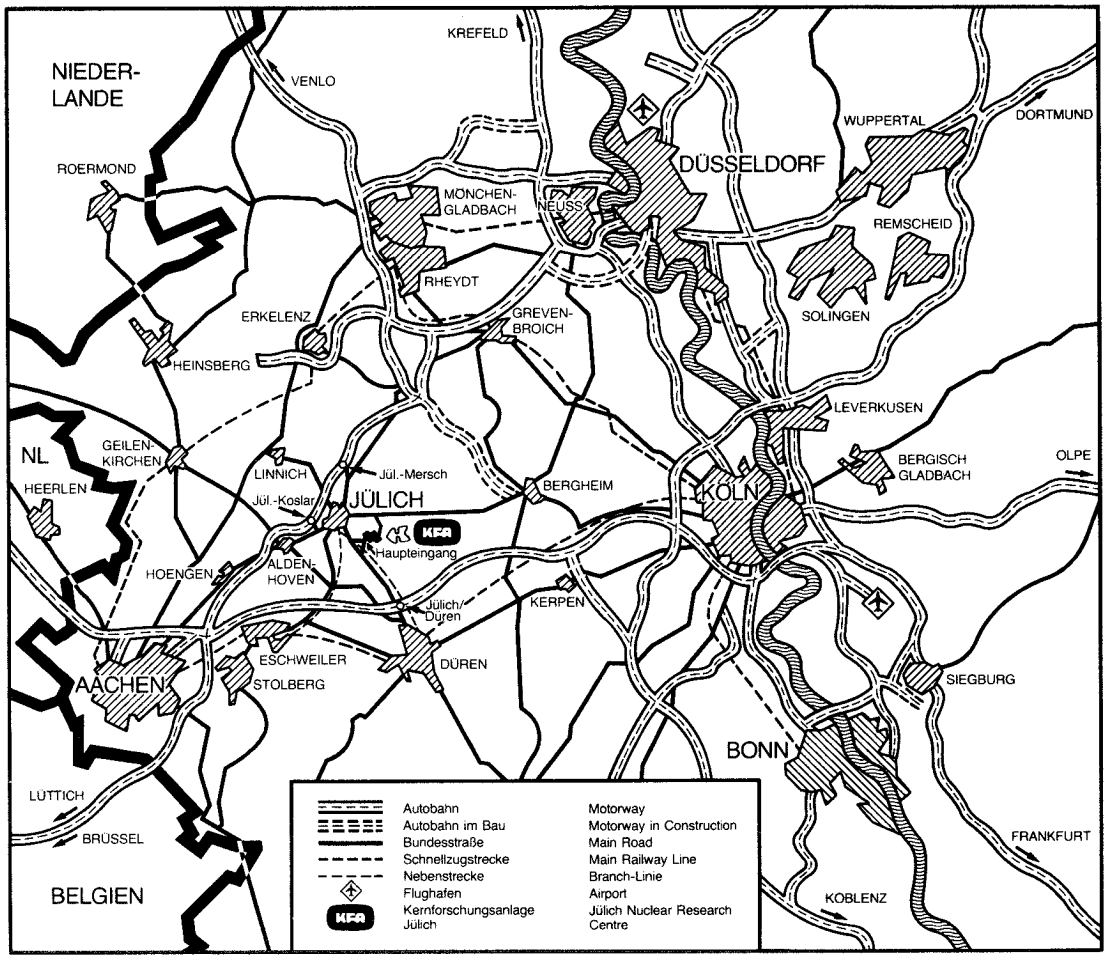

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Abstract

Four small computer codes developed by ZFR are presented, which have been used for several years during operation of the research reactors FRJ-1, FRJ-2, AVR (all in Jülich) and DR-2 (Riso, Denmark). Because of interest coming from the other reactor stations the codes are documented within the frame work of the IAEA Research Contract No. 3634/FG.

The zero-dimensional burnup program CREMAT is used for reactor cores in which flux measurements at each individual fuel element are carried out during operation. The program yields burnup data for each fuel element and for the whole core. On the basis of these data, fuel reloading is prepared for the next operational period under consideration of the permitted minimum shut down reactivity of the system.

The program BURNY calculates burnup for fuel elements inaccesible for flux measurements, but for which 'position weighting factors' have been measured/calculated during zero power operation of the core, and which are assumed to be constant in all operational situations.

The code CURIAX calculates post-irradiation data for discharged fuel elements needed in their manipulation and transport.

These three programs have been written for highly enriched fuel and take into account U-235 only. The modification of CREMAT for LEU Cores and its combination with ORIGEN is in preparation. KINIK is an inverse kinetic code and widely used for absorber rod calibration at the abovementioned research reactors. It includes a special polynomial subroutine which can easily be used in other codes.

Kernforschungsanlage
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COMPUTER PROGRAMME FÜR DIE BETRIEBSKONTROLLE VON FORSCHUNGSREAKTOREN

von

K. J. Kalker, R. Nabbi und H. J. Bormann

Kurzfassung

Vier kleinere, in der ZFR entwickelte Rechenprogramme werden vorgestellt, die seit vielen Jahren an den Forschungsreaktoren FRJ-1, FRJ-2, AVR (alle in Jülich) und am DR-2 in Riso (Dänemark) benutzt werden. Das Interesse anderer Reaktorstationen an diesen Programmen führte im Rahmen des IAEA-Projekts Nr. 3634/FG zu vorliegender Dokumentation.

Der nulldimensionale Abbrandcode CREMAT setzt die Möglichkeit voraus, in jedem einzelnen Brennelement eines Cores Flußmessungen während des Reaktorbetriebs durchführen zu können. Die damit für jedes Brennelement und das Core berechneten Abbranddaten ermöglichen die Planung der Brennelement-Konfiguration für das nächste Betriebscore unter Berücksichtigung der mindestreaktivität für die Reaktorabschaltung. minimalen Abschaltreaktivität des Systems.

Das Programm BURNY leistet das Gleiche für Brennelemente, deren Konstruktion keine Flußmessungen zuläßt, für die aber in der Anfahrphase des Reaktors bei Null-Leistung 'Positions-Gewichts- Faktoren' bestimmt werden, die dann als konstant für alle Betriebszustände angenommen werden.

Der Code CURIAX berechnet Werte für Restleistung und -Aktivität abgebrannter Brennelemente, die bei deren Manipulation und Transport bekannt sein müssen.

Diese drei Programme sind für hoch angereicherten Brennstoff geschrieben und berücksichtigen daher nur U-235. Eine Erweiterung von CREMAT für LEU-Brennstoff sowie dessen Kopplung mit ORIGEN ist in Arbeit.

Der inverskinetische Code KINIK wird häufig für die Kalibrierung von Steuerabsorbern an den oben genannten Reaktoren benutzt; er enthält ein spezielles Unterprogramm für Polynom- Approximation, das als Modul leicht in andere Programme übernommen werden kann.

Development of Software for Small Computers for Research Reactor Operation: IAEA-Research Contract-No. 3634/FG

CONTENTS

1) Introduction

Since 1962 the research reactor division of the Nuclear Research Center Jülich has two power research reactors:

- FRJ-1: Light-Water Cooled with a power of 10 MW (finally shut down on March 22, 1985)
- FRJ-2: Heavy Water Reactor of the DIDO type with a power of 23 MW

To solve some operating tasks of the reactors a series of simple computer codes has been developed. They allow information to be rapidly acquired about the state and behaviour of the reactors. Growing experience with the systems and ample experimental investigations during the last few years have made modifications and fitting of the codes necessary. In this period of time the reliability of the codes was verified by extensive calculations carried out with complicated computer programs required for the HEU-LEU conversion of the cores. For this work computer codes such as ANISN, ORIGEN and the packages of nuclear codes RSYST and AMPX-II have been widely used.

The codes presented here work on the following subjects:

- Burnup calculations including the balance of the fuel material
- Neutron flux densities and power distribution
- Calculation of the reactivity equivalence of control rods using kinetic measurements
- Determination of the decay heat and activity of the fuel elements

In the following sections the physical formalism and model of each program, its structure and the input are described.

Some remarks about CREMAT and KINIK: Input data for these codes are gained by measurements developed by many series of experiments over several years. A lot of parameters leading to faulty results have been found and eliminated. Without knowledge of these parameters concerning characteristics of measuring apparatus and recording devices the applicability of these codes is certainly limited. For this reason it is urgently recommended to became acquainted with the the said conditions in cooperation with ZFR.

For the conversion from HEU to LEU a suitable coupling of CREMAT and ORIGEN is in preparation, after which CURIAX will also become obsol te. The increasing capability of small computers allows utilization of relatively big codes and so the coupled burnup-package will be of interest for the current project too.

Codes are written in FORTRAN IV. Ample information and comments about input and program philosophy are implemented in the source programs to also enable use without the description given in this paper.

CREMAT, BURNY, CURIAX and KINIK have been implemented on a VAX System by ZEL, the Central Division for Electronics of KFA. Especially input and

output subroutines have been rewritten in FORTRAN-77 and adjusted to interactive use of Terminal/VAX Computer.

There are two other programs in use at ZFR which should be mentioned. The first is KUEBEL,[1] The first is KUEBEL, which is a FORTRAN-Program for the calculation of cooling-agent distribution within reactor fuel elements or zones therein. They may be assembled of max. 40 cooling channels with laminar up to turbulent type of flow (respecting Reynold's coefficients up to 2.0E+6) at equal pressure loss. Flow velocity, dynamic flow, concentration and friction losses can be calculated for each channel and for the total zone.

Other calculations will present mean heating-up of cooling-agent, mean outlet temperature of the core, boiling temperature and absolute pressure at flow outlet. All characteristic coolant values,including the factor of safety for flow instability of the most loaded cooling gap, are computed by KUEBEL too. Absolute pressure at flow outlet or IS factor may be alternatively defined as dependent or independent variables of the program. In the latter case 3 variations of solution will be available; adapted flow of coolant, inlet-temperature of the core and thermal power.

All calculations can be done alternatively with variation of parameters: Flow of cooling, inlet temperature of core and thermal power, which are managed by the program itself.

KUEBEL has options for light and heavy water with different flow directions, fuel elements with parallel rectangular or concentric cylindrical gap shape. Required material specifics are generated by the program. Segments of fuel elements or unconnected gaps can also be simulated by interposition of 'phantom channels'.

The second program LEMACA evaluates measurements concerning leakage measurements of reactor containments or similar. A portable equipment of measuring devices is used, which presents 4 pressure-, 18 temperature, 4 humidity and some system data in form of voltages by printer and tape output. For off-line calculation a PL-1 program LEMACA (Version 5) evaluates the physical values measured al accodingly and their mean errors, the linear regression of the reduced pressure in the containment and ultimately the leakage value at different confidence levels.

Both the measuring device as well as the program are flexible for extensions and offer a number of utilities (e.g. an optimizing routine defines automatically the representative start and end of the leakage test by minimizing the probable mean error of the linear degression, by which a considerable amount of reactor shut down time is saved).

For data transfer and preparation for the main program a routine,DANA, has been written, which includes plausibility checks of measured data. DANA is at the moment only executable on ZFR's process computer SIEMENS 330.

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[1] H. Inhoven: KUEBEL Ein Fortran-Programm zur Berechnung der Kühlmittel- Verteilung in Brennelementen/ Jül-1965, Dezember 1984

2) Computer programs

2.1 CREMAT

2.1.1 Description of the Physical Model

For a reactor operating at full power the burnup of the fission materials is one of the fundamental parameters during each operating cycle. It influences the excess reactivity of the core, the absorption of the control rods, fuel element load and safety aspects. Moreover from the aspect of cost optimization a detailed knowledge of the burnup distribution in the different core positions is necessary and this is also calculated by CREMAT.

The code determines optimum polynomials for neutron flux distributions in the individual fuel elements using counting rates of Co-wires, which have been irradiated at distant (7) points of their central axis near the end of a reactor running period.

The equivalent power of the fuel elements is calculated at the beginning (BOC) and at the end (EOC) of each operating cycle, which results in minimum waiting times for discharging fuel elements to be changed when preparing the next core configuration.

"Weighting factors" for the fuel elements are calculated, which represent the reactivity equivalence of the individual fuel element position for the present core configuration. With this data recharging of the new mixed core can be calculated beforehand in order to gain optimum reactivity reserve for the coming period within the reactivity safety margins set by supervising authorities.

The calculation procedure is based on the solution of the burnup equations for a reactor operating at constant power level as opposed to the model assuming constant average neutron flux.

At this moment only the burnup of U-235 is taken into account because only HEU is in use, but for the coming LEU fuel this has to be extended to U-238, the Pu-isotopes etc., which is the reason for the abovementioned intended coupling of CREMAT and ORIGEN.

The temporal change of the fuel due to fission and conversion of the type (n,γ) is described by the following differential equation:

$$dM/dt = -\sigma_c M(t)\phi(t) \qquad (1)$$

Where

M = mass of fissionable materials inserted in the core
σ_c = $(\sigma_f+\sigma_a)$
= effective total cross section for capture
$\phi(t)$ = thermal neutron flux averaged spatially

For the core with one fissionable material the power is given according to the expression:

$$P(t) = \varepsilon_f N_L M(t) \sigma_f \phi(t) / A \qquad (2)$$

The constants are defined as follows:

ε_f = energy per fission
N_L = Avogadro's number
A = atomic weight of fission material
σ_f = effective cross section for fission

With help of the initial values for the power and neutron flux the following relation results for the flux at the time t:

$$\phi(t) = P(t)/\{P_0/\phi_0 - \sigma_c \int P(t)dt\} \qquad (3)$$

Assuming a constant power level one gets

$$\phi(t) = \phi_0 / \{1-\sigma_c \phi_0 t\} \qquad (4)$$

The general solution of the eq.(1) has the form

$$M(t) = M_0 \exp(-\sigma_c \int \phi(\tau) d\tau\} \qquad (5)$$

and gives the temporal change of the total content of fissionable materials at constant power level

$$M(t) = M_0\{1-\sigma_c \phi_0 t\} \qquad (6)$$

By analogy with (5) the following expression is achieved for the amount of fissionable material of a single fuel element of No. ν :

$$m_\nu(t) = m_\nu(0) \exp\{-\sigma_c \int \phi_\nu(\tau) d\tau\} \qquad (7)$$

where $\phi_\nu(\tau)$ is the momentary value of the neutron flux averaged over the fuel element ν.

With the factor g_ν defined as the ratio of the neutron flux of fuel element ν to that of the core, one gets for (7):

$$m_\nu(t) = m_\nu(0)(1-\sigma_c \phi_0 t)^{g_\nu} \qquad (8)$$

where g_ν is commonly obtained from the measurements of the flux distributions in the reactor core.

CREMAT determines the relative mean flux over the whole core from the relative flux densities (counting rates) measured in each fuel element. The corresponding relation is described by the following expression:

$$\phi = \{\Sigma_{\nu=1}^{N} \phi_\nu m_\nu\} / M$$

where N is the quantity of the fuel elements positioned in the core.

The relative core flux is then fitted to the mean flux of the core calculated from the power relation (3), which represents an absolute value.

The program CREMAT needs input-data for the following parameters:

- The mass of U-235 at the beginning of the core cycle (BOC) for each fuel element
- The reactor power (commonly measured as the mean energy during the reactor cycle)
- Time length of the operating cycle
- Distribution of flux densities in the fuel elements, calculated with the respective optimum polynomial over the measured counting rates of irradiated Co wires, which are the primary input to the program.

A run of CREMAT results in the following output:

- Whole-core burnup of U-235 expressed in (g) and (%) respectively
- U-235 burnup of each fuel element in (g) and (%) respectively

- Distributions of the neutron-flux densities in the fuel elements and mean flux in the core

- Maximum power of the fuel elements at BOC and EOC including the 'waiting time' resulting from a defined residual heat production allowed at discharge

CREMAT evaluates 'waiting times' with Untermyer's empirical formula for residual heat using the operating power of each individual fuel element.[2] This formula is corrected once again by the experimental measurement. It is valid for an effective residual heat of 1.8 KW and 'waiting time' ranging from 1 to 3 days. For reactors other than FRJ-2 it naturally has to be modified with regard to the actual condition resulting from the maximum allowed residual power of the fuel element when being moved in transport containers or similar facilities. If irradiated fuel elements are deposited in the pool-water, this 'waiting time' is naturally unimportant.

---

[2] Etherington: Nuclear Engineering Handbook pp. 7-15

2.1.2 Input for CREMAT

CARD 1	TITLE FORMAT (72A1)

CARD 2	TPER,PCORE,LELM,MESP,KPOL,NJOB,LIST,NPGF,NW7 FORMAT (2E12.5,10I4)
TPER	Time length of the reactor cycle (sec)
PCORE	Reactor power averaged over the cycle (Watt)
LELM	Number of the fuel elements (FE)
MESP	Number of flux-measuring position per FE (at present 7 positions)
KPOL	>2: Output of polynomial parameters and flux values calculated in the subroutine POLYN
NJOB	>1: NJOB cases will be subsequently run
LIST	Number of final burnup lists
NPWF	Defines further treatment of the position- weighting-factors for each FE
NW7	Controls output of the intermediate results during the calculations

---

CARD 3	NEL,EL,ELN1,ENL2,U5O,U5B FORMAT (I4,2X,A2,2X,2A4,1X,2F8.2)
NEL	Running number of FE
EL	Position of the FE on the grid plate according to the arrangement in the DATA-routine of DATA EPOS (SEE PROGRAM)
ELN1 & ELN2	8 alphanumerical digits identifying fuel elements
U5O	Original mass of U-235 in the fresh fuel element
U5B	Mass of U-235 in the fuel element at BOC

CARD 3 HAS TO BE REPEATED FOR EACH FUEL ELEMENT (LELM-TIMES)

CARD 4	NEL,EL,NZREL FORMAT (I4,2X,A2,2X,7I6)
NEL	Running number of FE (1 to LELM)
EL	Position of the FE on the grid plate
NZREL	Counting rates at the axial flux-measuring positions

Card 4 has to be repeated for each fuel element (LELM-times)
****

For NJOB > 1 the cards 1 to 4 have to be repeated NJOB-times
****

Attention:

a) NEL have to be in increasing order

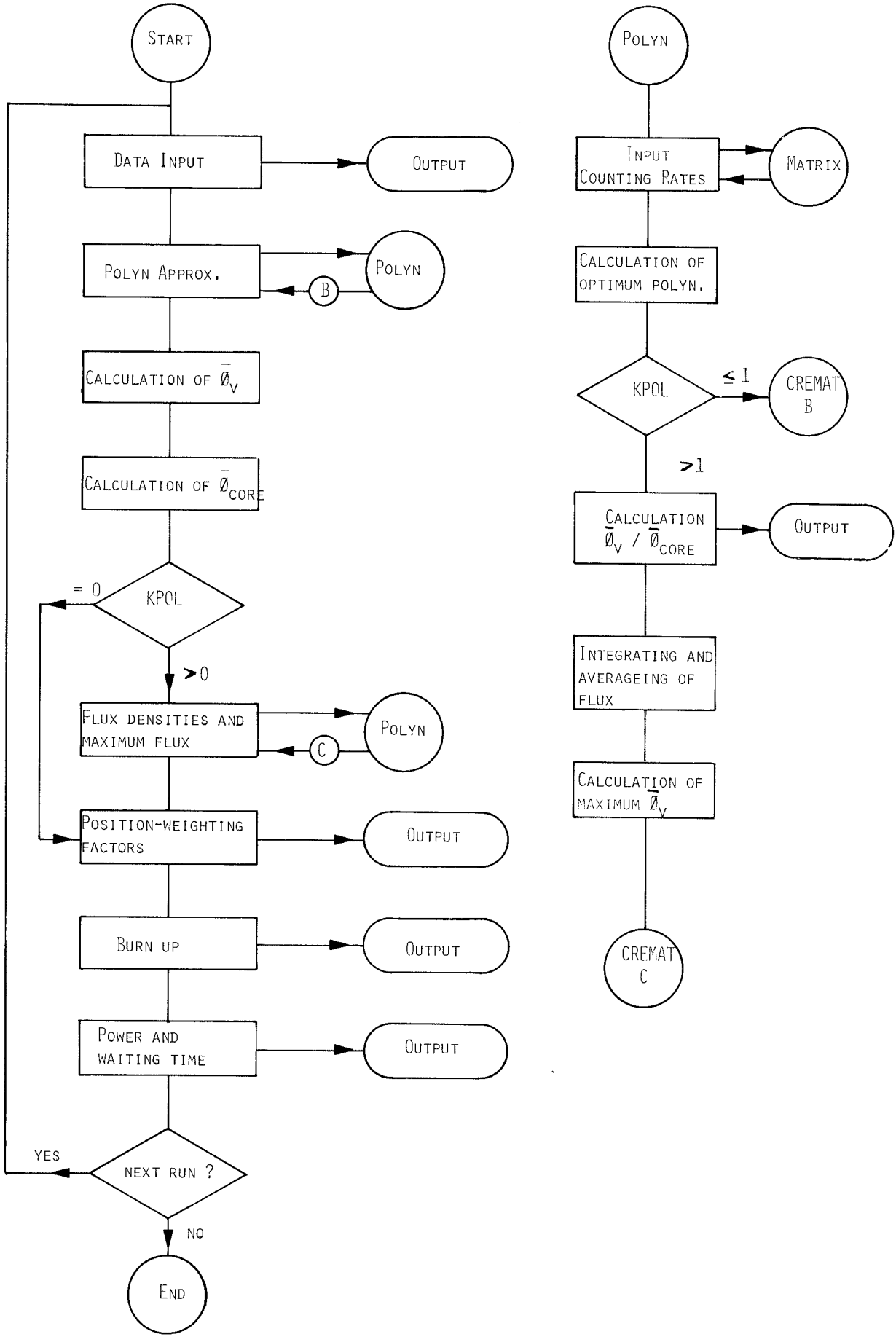
b) Grid-position input EL for the FE must accord with the NEL-th value in program's DATA-block ELPOS.

During the input procedure the program verifies a) and b). In case of error input is terminated, a corresponding error message printed out.

2.1.3 A typical input-examples for CREMAT at FRJ-2/DIDO

```
3.1 ABBRANDRECHNUNG FRJ-2 PERIODE 11/84   V.3.12.84-25.1.85 14.00 H
  1.8189E+06  2.0421E+07  25   7   1   1  15   0   0
   1  A1  ESRB 401   170.32  170.32
   2  A2  4.13.294   167.69  113.02
   3  A3  4.13.293   167.71  114.36
   4  A4  4.13.295   167.72  167.72
   5  B1  ESRB 402   170.12  170.12
   6  B2  4.13.291   167.45  109.36
   7  B3  4.16.304   147.97  147.97
   8  B4  ESRA 516   149.94  149.94
   9  B5  4.13.296   168.08  107.49
  10  B6  4.13.300   168.41  115.32
  11  C1  ESRB 398   170.25  134.99
  12  C2  ESRA 507   149.96  112.47
  13  C3  ESRA 513   149.95  108.90
  14  C4  ESRA 514   149.98  110.88
  15  C5  ESRB 399   169.86  132.70
  16  D1  ESRB 403   169.96  169.96
  17  D2  ESRA 518   150.06  150.06
  18  D3  ESRA 515   149.69  110.54
  19  D4  ESR20 01   199.78  109.30
  20  D5  4.13.297   167.99  102.52
  21  D6  ESRB 395   169.72  169.72
  22  E1  4.13.292   167.80  114.14
  23  E2  ESRB 397   169.63  131.81
  24  E3  ESRB 396   169.97  132.81
  25  E4  ESRB 400   170.19  170.19
   1  A1  33773 36582 41279 47143 49221 44117 41649
   2  A2  37525 40647 45865 52381 54690 49019 46277
   3  A3  33000 37697 46545 52920 51552 46627 43656
   4  A4  31350 35812 44218 50274 48974 44296 41473
   5  B1  28958 32179 38742 42095 42643 38676 38232
   6  B2  38106 43625 52375 58722 58518 52661 49098
   7  B3  48693 53326 57180 65045 64286 58789 52915
   8  B4  49308 49063 56839 62357 61596 55952 52795
   9  B5  40070 43137 49101 52793 58641 57960 54656
  10  B6  29767 34371 45711 47635 47119 41627 39072
  11  C1  37497 42346 52828 56318 59556 51095 48513
  12  C2  49593 55995 63516 71769 71790 66448 60153
  13  C3  59420 60710 71048 78937 76906 69762 64820
  14  C4  55108 55283 63771 70651 67223 62147 57149
  15  C5  45418 45247 51381 59196 57103 52447 49089
  16  D1  30098 32841 39526 43947 43242 40086 38741
  17  D2  42627 46000 54001 58280 59027 54253 51916
  18  D3  56116 57517 67100 69149 74140 66139 63332
  19  D4  52356 55246 65117 68173 68647 63345 61371
  20  D5  49707 48451 57160 60692 61571 55818 54022
  21  D6  39592 35882 41363 45113 44668 42208 41576
  22  E1  36093 39611 48695 59037 55422 49811 47162
  23  E2  46690 45534 53147 58246 56172 54409 57839
  24  E3  46498 45466 52735 57818 58225 53433 52609
  25  E4  36093 39611 48695 59037 55422 49811 47162
```

2.1.4 FLUX DIAGRAM FOR CREMAT



2.2 BURNY

2.2.1 Basis of the program

The program BURNY, originally developed for the light water cooled reactor FRJ-1 (MERLIN), has a burnup routine similar to CREMAT. In contrast to CREMAT no routine measurements of flux distributions in FE are provided for because of the complexity and even impossibility of such measurements in plate-fuel elements. Instead of this FE position, weighting factors for the neutron fluxes are used as input in form of a data block. These weighting factors have to be provided for by separate nuclear calculations or by measurements carried out for specified reactor cores operating at zero-energy.

BURNY is therefore more flexible for reactors requiring frequent variation of core configurations. BURNY input is only the energy produced in MWd and the number of standard and 'effective' fuel elements in the core. 'Effective' fuel elements have fewer plates than the standard form and are represented by a matching fraction. If in opposition to the standard element with 22 fuel plates the special fuel element (containing control-absorber or experimental devices) has only 11 plates, it will be treated 'effectively' as a 0.5 normal element. Similarly to CREMAT, BURNY naturally needs the mass of U-235 for each fuel element at BOC.

Two different output lists are generated:

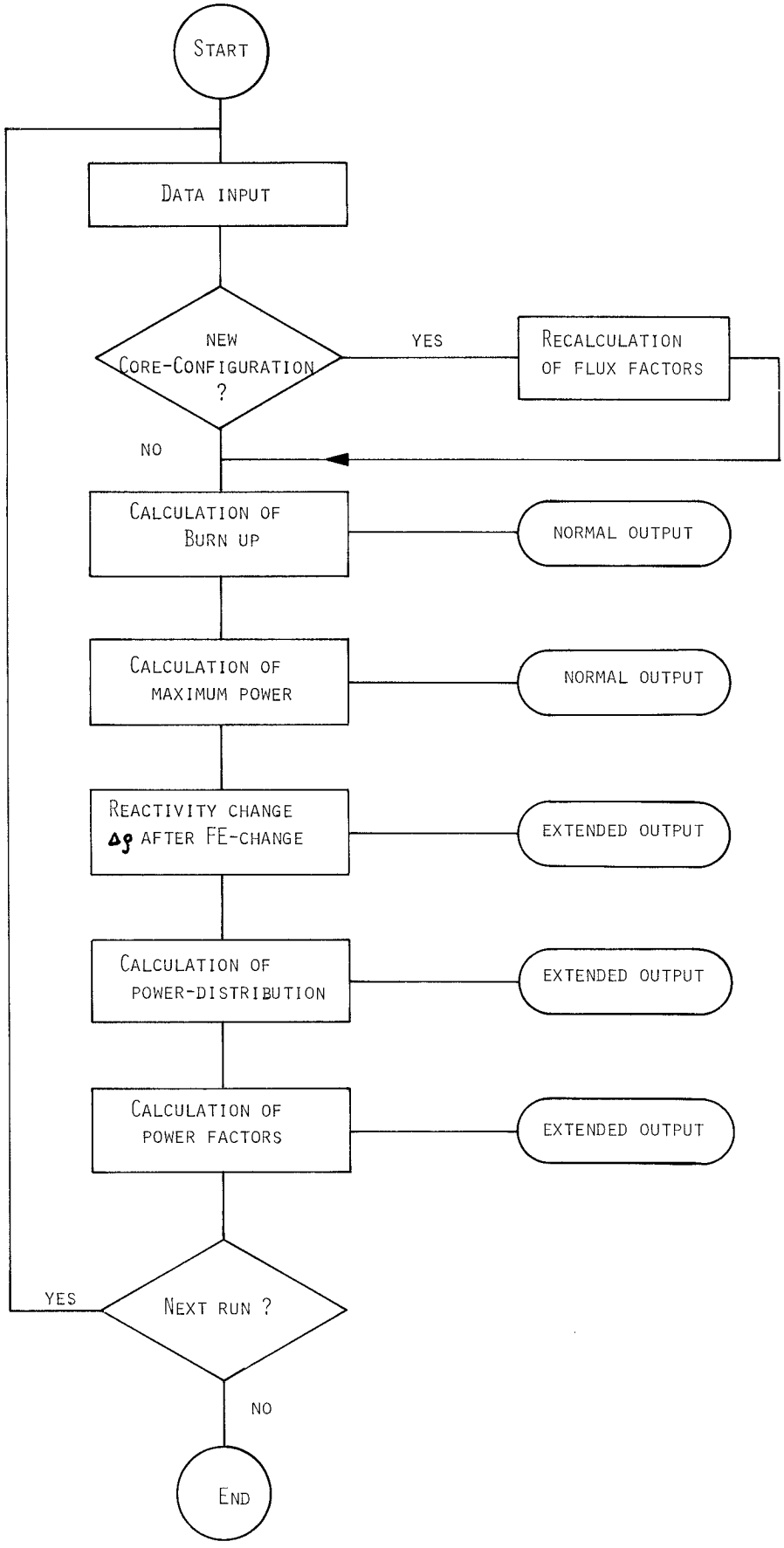
- Small output with positional number of the FE, BOC and EOC mass of U-235 for each fuel element and the whole core, U-235 burnup in g and % in the cycle in question again for each FE and the core, maximum power in the core and indication of the respective fuel element position.

- Extended output representing the reactivity change due to the fuel change, a list of the FE power, core power and flux factors. The extended data are approximated values because of their dependence on the neutron fluxes and position weighting factors of the reactivity.

2.2.2 Input for BURNY

Card	Parameter	Column	Format	Remarks
1	TITLE	1-72	72A1	Header text of output
2.1	XMWD	1- 8	F8.3	Integrated power in MWd of whole operation period
2.2	L	9-11	I3	Number of FE in the core
2.3	XL	12-18	F7.3	Number of 'effective' FE
2.4	P	19-26	F7.3	Mean reactor power in MW
2.5	RO	27-33	E8.2	Mean specific reactivity in %Δk/k per gram of fissionable material
3.1/10	GWF	1-70	10F7.4	Neutron-flux distribution (relative + normalized) in the FE
4.1/10	GWR	1-70	10F7.4	Reactivity distribution (relative + normalized) in the FE
5.1	XMO	1- 6	F6.2	Original mass of U-235 in the fresh FE
5.2	AN	13-16	A4	FE identifier (number)
5.3	ELEM	17-18	A2	Position of FE (gridplate)
6.1	XM	2-11	E12.5	BOC mass U-235 in the FE
CARDS 3 TO 6 ARE REPEATED FOR EACH FUEL ELEMENT (L TIMES)				
7.1	NB	1-3	I3	Number of small lists
7.2	NBG	4-6	I3	Same for extended output

2.2.3 FLUX DIAGRAM FOR BURNY



2.3 CURIAX

2.3.1 Description of physics and program

After a sufficient cooling time irradiated fuel elements are discharged and transported to the end site of a reprocessing plant. Transport in special containers for possibly large distances necessitates precise data on the residual decay heat and radioactivity of the fuel in question.

The program CURIAX calculates:

- The decay heat from β and γ radiation of the fission products.
- The residual activity at the actual transport time.

The residual heat power results in a good approximation from the empirical expression given by Wigner-Way:[3]

$$P(t) = 0.0565\ P_0\ (t_w^{-0.2} - (t_B + t_w)^{-0.2})$$

Where

$P(t)$ = the residual (β+γ) power in (watt)
P_0 = the mean reactor operating power in (watt)
t_B = the total operating time for the FE in (s)
t_w = the cooling time between the end of reactor operation and the start of transport in (s)

Usually the cooling time t_w is relatively long (>3 months). After this period energy of γ-radiation is approximately 800 kev. Using this value the activity resulting from residual power P(t) can then be approximated as:

$$A(t) = (2.09E+2)P(t) \quad (Ci)$$

The mean operating power P_0 is calculated from the input of U-235 burnup in grams and reactor operation time in days.

If transport of the FE cannot be carried out at the time intended, 'waiting times' for the FE are automatically changed in the program by the input of a time correction.

---

[3] Rockwell: Reactor Shielding Design Manual 1956, p. 58

Output of CURIAX includes the following parameters:

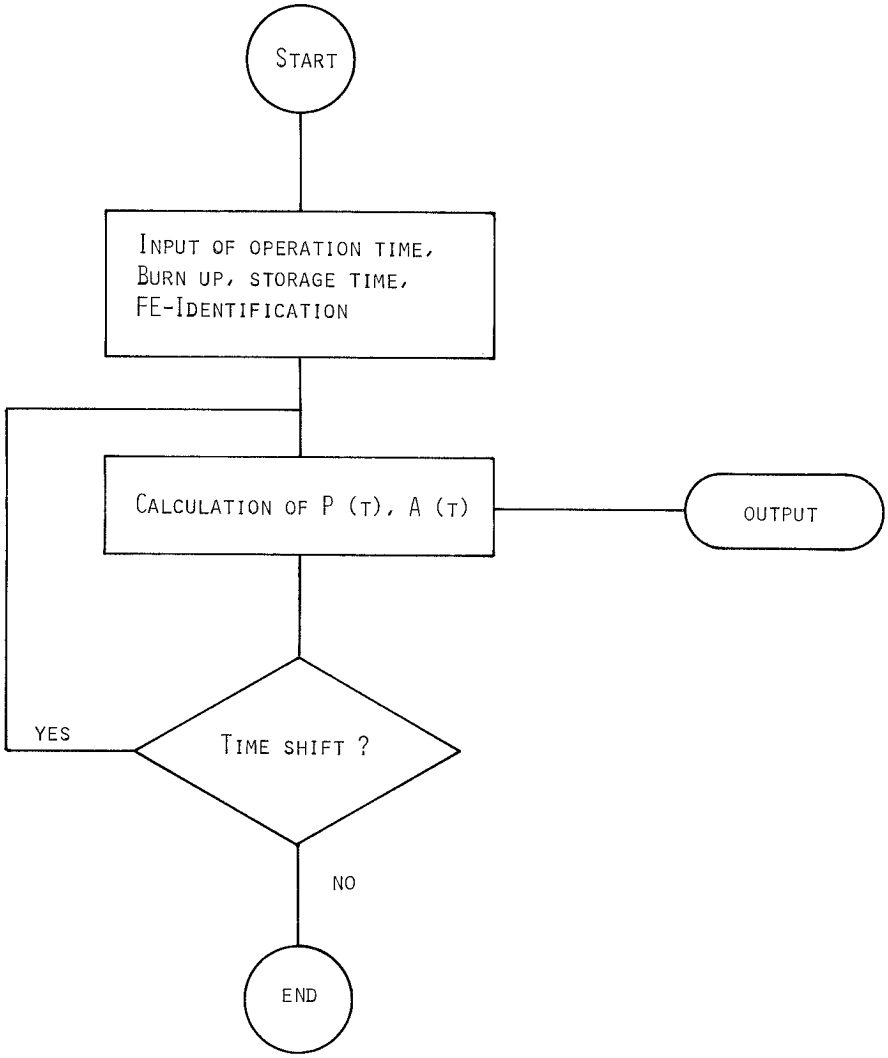
- Element number
- Burnup of U-235 in (g)
- Reactor operating time in (d)
- Waiting time in (d)
- Reactor operating power in (Watt)
- Residual power in (Watt)
- Residual activity in (Ci)

2.3.2 Input for CURIAX

Cards	Parameter	Column	Format	Remarks
1	TITLE	1-40	10A4	Header text of output
2.1	KBE	1- 5	I5	Number of FE
2.2	NCOP	6-10	I5	Number of output lists (default = 3)
2.3	TKW	11-20	F10.3	Time correction in days (earlier -;later +)
3.1	BESIGN	1-10	10A1	FE identifier
3.2	XMA	11-20	F10.3	Burnup of U-235 (g)
3.3	TB	21-30	F10.3	Irradiation time (d)
3.4	TW	31-40	F10.3	Waiting time (d)
	Card 3 has to be repeated for each FE (KBE-times)			

```
TRANSPORT MUENCHEN/JUELICH 30.11.1979 (15 BE / 8. TRANSPORT SAVANNA )
   15    3
 ESRA 8377      68.56      56.72      395.
 ESRA 8379      66.41      50.48      488.
 ESRA 8391      71.42      56.72      395.
 ESRA 8392      62.45      46.53      585.
 ESRA 8393      63.85      68.07      306.
 ESRA 8394      62.43      46.53      585.
 ESRA 8395      62.43      46.53      585.
 ESRA 8396      73.43      56.72      395.
 ESRA 8397      60.19      46.53      585.
 ESRA 8398      67.76      49.54      522.
 ESRA 8399      65.56      50.48      488.
 ESRA 8400      51.33      49.54      522.
 ESRA 8401      70.77      88.20      243.
 ESRA 8402      62.86      50.48      488.
 ESRA 8403      63.90      50.48      488.
```

2,3,3 FLUX DIAGRAM FOR CURIAX



2.4 K I N I K

2.4.1 Description of physical model

The point model of reactor kinetics

The formalism of the program is based on the well known kinetics equations (1,2) in the source-free form, here normalised to the initial conditions.

$$dN/dt=[(\rho-\beta_e)\cdot N + \Sigma\gamma_i\beta_i C_i]/l^* \qquad (1)$$

$$dC/dt=\lambda_i\cdot(N-C_i) \qquad (2)$$

i = 1- 6 for H_2O and graphite

i = 7-15 for D_2O and/or Be-9 reflector in addition

$$N = n/n_0 \qquad C_{i0}=(\gamma_i\beta_i n_0)/\lambda_i l^* \qquad C_i=c_i/c_{i0}$$

$$\beta_e=\Sigma\gamma_i\beta_i \qquad l^*=l/k_e$$

where

n = neutron density (cm^{-3})

n_o = initial neutron density (cm^{-3})

N = neutron density, normalised to 1.0

c_i = concentration of the i-th group of delayed neutron precursors and/or γ-emitter

c_{io} = initial values of the precursors c_i (cm^{-3})

C_i = precursor/emitter concentration, normalised to 1.0

l = neutron generation time (sec)

l^* = effective neutron generation time l/k_e (sec)

k_e = effective multiplication factor

β_i = fraction of i-th delayed neutron group

β = total fraction of delayed neutrons $\Sigma\beta_i$

β_e = effective total fraction $\Sigma\gamma_i\beta_i$

γ_i = system-dependent effectivity factor of i-th group

λ_i = decay constant of i-th group (sec^{-1})

ρ = $(k_e - 1)/k_e$ = reactivity (% $\Delta k/k$)

$\rho_d = \rho/\beta_e$ reactivity ($)

Reactivity ρ, neutron generation time l^* and effective total fraction of delayed neutrons β_e are mean values over the whole system of core, moderator and reflector.

The effectivity factors λ_i represent importance functions and take into account that delayed neutrons are emitted with much lower kine tic energies than prompt neutrons.

The λ_i and β_i used here for the delayed neutrons are taken from /1/ and printed on the first page of the input description 2.4.3 together with the γ_i for two systems (FRJ-1/H2O and FRJ-2/D2O).

Rearranging of Eq. (1) for the reactivity ρ defines the 'inverse kinetic' problem, to find reactivity-time function for a given power-time function.

$$\rho = [l^* dN/dt - \Sigma\gamma_i\beta_i C_i]/N + \beta_e \qquad (3)$$

$$dC/dt = \lambda_i \cdot (N - C_i) \qquad (4)$$

KINIK solves Equations 3 and 4 by a Runge-Kutta procedure; automatic optimization of the step width (e.g. 1/10 of the steepest gradient) leads to very short CPU-times. The program has been used since 1965 for absorber calibration at FRJ-1, FRJ-2 and the pebble-bed reactor AVR here at KFA/Jülich and at DR-2 in Risoe (Denmark).

For the measurement the critical reactor is shut down by drop or steady incore movement of the absorber to be calibrated; the critical power should not be too low. The resulting power data are measured with the highest possible resolution in time and amplitude and analysed with KINIK, which results in the reactivity-time behaviour of the absorber.

If the position-time behaviour of the absorber is known a suitable folding of the two functions gives the position-dependent reactivity with only one kinetic measurement, otherwise in addition to the y- reactivity-time behaviour it only gives the absolute reactivity absorption of the absorber in question in its critical position before shut down.

But if one uses the descending part of Xenon poisoning after shut- down from high power, measurement of the reactivity values for several absorber positions is possible. The reactor is made critical as often as possible and shut down by the absorber in question, the resulting power-time data are then analyzed with KINIK as before; this option will be named 'Xenon Ride' in the program.

As mentioned in the introduction, the flux-measurements are not without difficulties concerning the measuring device and its positioning in the system etc. From this reason precautions have to be taken to avoid faulty results because of

- Unknown behaviour of transients
- Concerning the measuring device such as ionisation chambers etc.
  - different shadowing by absorbers etc. within their movement time
  - position too near to the core to see a nearly 'point-like' reacto r
  - unknown sensitivity to gamma radiation, thus faulty signals and camouflage of the real neutron behaviour
- Concerning signal channel
  - too low resolution of amplitude, which should at least allow amplitude resolution by signal channel. It should at least have three decades
  - very noisy signals etc. etc.

The examination of the said error sources and the use of KINIK for different reactor systems are discussed in a Jül-Report.[4]

The program presented here contains no long-time influences on reactivity as Xenon or Samarium poisoning or temperature effects. They are realized together with selectable 'forward' and 'inverse' kinetics in a bigger program form of KINIK.

---

[4] K.J.Kalker, Inverskinetische Messungen an Kernreaktoren, Jül-780-RE, August 1971

2.4.2.General description of KINIK/SAGAPO

As said, before detailed information concerning variables and procedures are contained in the input description for the cards given hereafter and in the source program itself too, so the following general description can be short.

The main routine of the program deals with

- Input of reactor-typical data of delayed neutron weighting factors, neutron lifetime etc. Two fixed sets of data are implemented, one for FRJ-1 (H2O, NPILE=1), the second for FRJ-2 (D2O, NPILE=2). A third option allows for free input (NPILE=3) on Cards 5-8.
- Input of control integers, some with built-in defaults which have been proved as being adequate for nearly all cases on Cards 3 and 4,
- Step width definitions and others for the Runge-Kutta cycles, which are partially defaulted too, on Card 9,
- Input of reactor power(s) at start of absorber movement(s) and the appropriate time(s) on power and shut-down periods between experiments of a Xenon Ride on Cards 10 and 11,
- Cyclic preparation of data for the Runge-Kutta cycles with automatic recalculation of optimum step width after each R.K-cycle,
- Plausibility controls of intermediate results and
- Paper output of intermediate (if triggered) and final results, optionally on tape or plotter.

As said before the program offers two options concerning the analysis of kinetic measurements:

- A) Only one absorber drop or -movement has to be analyzed (NCASE=1),
- B) Or several consecutive experiments of a Xenon-Ride (NCASE>1)

In case A) only the reactor power and the time on power is needed as input; if the time on operation is sufficiently long, delayed neutron concentrations are assumed as being in equilibrium.

In case B) it is assumed that by waiting times after shut down for s Xenon built-up and/or between two experiments, or too short times on s power before absorber movements the delayed neutron concentrations may not be in equilibrium, so the respective operation times, the powers themselves and the waiting times between the absorber experiments are expected as input on cards 10 and 11.

The little sketch before the description to Card 10 explains this simple context which is more essential in the big program because of the longtime effects on reactivity caused by Xenon, Samarium and the temperature.

SAGAPO calculates optimum polynomials up to the order 10 for given functions of maximum 2000 values with an approximated interval of maximum 400 inner points. SAGAPO is programmed as a freely usable subroutine and can be used separately (NANF.LT.0) without KINIK and integrated into other FORTRAN programs without any difficulty; it has a lot of useful options explained in the card input description.

SAGAPO handles the measured power data in connection with KINIK in various manners. Since the start of measurements in 1965 a variety of fission and

ionisation chambers, different chains of measuring, amplifying and recording devices etc. have been used.

So the program expanded with each new complete chain or part of it in order to cope with new requirements; some program features connected with this are listed here.

- Input of power data in normal or logarithmic form (e.g. output of period meters)
- Input data are screened for faulty values which are discarded; useful in case of obvious stray data and if before start of absorber movement too many constant data have been registered.
- Noisy data can be smoothed in different ways without losing information,
- Optimum polynomial is calculated by the method of root mean square up to the 10th order, dependent on MODPOL/MOD(KW):

  - 1) Over the whole 'big interval' of NPWP input points (max 400) or

  - 2) Over a 'small interval' of preselectable NPI(KW) inner points (max 400 of max NPWP=2000), which 'glides' within the 'big interval' of NPWP points during calculation like a 'magnifying glass'. The direction of this 'gliding' is preselectable and variable during calculations.

    Since the centre of the 'gliding interval' is the best approximated part, finally only a small 'inner interval' of NIN(KW) central points of the 'gliding interval' is used for calculations in KINIK; if the boundaries of this 'inner interval' are reached by Runge-Kutta steps, a new search for the optimum polynomial in SAGAPO is triggered over a new 'gliding interval', the boundaries of which are shifted within the 'big interval' of NPWP points by the NIN(KW) points of the 'inner interval' just used for the last Runge-Kutta step.

2.4.3 Input Description for KINIK/SAGAPO

```
                Group constants of delayed neutrons
                     (Keepin-Whimmet 1972)
 ------------------------------------------------------------
  1- 6 Group constants of delayed neutrons from fission products
  7-15 Group constants of delayed photoneutrons in D2O
 15-24 Group constants of delayed photoneutrons in Beryllium

       First time-constants TCON, then yield fractions BETAI
 ------------------------------------------------------------

 DATA TCON/3.872D 00,1.397D 00,3.108D-01,1.155D-01,3.174D-02,
1          1.272D-02,
2          2.772D-01,1.691D-02,4.813D-03,1.500D-03,4.278D-04,
3          1.167D-04,4.376D-05,3.633D-06,6.098D-07,
4          2.265D-02,8.886D-03,3.610D-03,7.453D-04,2.674D-04,
5          6.191D-05,1.591D-05,2.478D-06,6.098D-07,
6          6*0.0/
 DATA BETAI/1.677D-04,8.256D-04,2.625D-03,1.213D-03,1.374D-03,

1           2.451D-04,
2           6.510D-04,2.040D-04,7.000D-05,3.360D-05,2.070D-05,
3           2.340D-05,3.230D-06,1.030D-06,5.000D-07,
4           2.070D-05,3.660D-05,1.850D-05,3.680D-05,3.660D-06,
5           3.200D-05,2.600D-06,3.800D-07,5.700D-07,
6           6*0.0/


 ------------------------------------------------------------

       Input-Cards are labelled (OPTIONAL), if
    1) they are only triggered for special cases, and/or
    2) their data are normally overridden by DEFAULTs

       Input-cards are labelled "NN A, NN B" etc, if
       they are logically at the same place in the input
       queue, but job-dependent different in data and format.

       INPUT-FORMATS are generally
       for integers                      16G5
       for real numbers                   8G10.3
       for pairs of real numbers        4(2G10.3)
       for text                          20A4
```

C A R D 1

```
READ (MIP,5000,END=9999,ERR=9999) NPILE,NCASE
```

EXPLANATIONS FOR C A R D 1

1.1 NPILE defines fixed sets of delayed-neutron-data etc. for different reactors or forces individual input

=1 fixed set of data for six groups of del. neutrons for H2O- or graphite-moderated systems

=2 fixed set of data for 15 groups of del. neutrons including photoneutrons of D2O

=3 overrides said fixed data and forces input of all relevant neutron data

1.2 NCASE =1 only one absorber-movement or -drop has to be analysed

GT.1 NCASE consecutive absorber-movements or -drops are analysed, e.g. a Xenon-ride

---

C A R D 2

```
READ (MIP,5020,END=9999,ERR=9999) TITLE
```

C A R D 3

```
READ (MIP,5000) MOVAB,NANF,NRE,NREAD,LENLT,NRC,
1               NGAM,NGAFAC,NREFL
```

EXPLANATIONS FOR C A R D 3

3.1 MOVAB defines whether analysis is done for only one absorber-movement (if NCASE.EQ.1) or with ascending numbers up to NCASE consecutive analyses, e.g. of a Xenon-ride.

MOVAB = 1

a) if NCASE.EQ.1, only one absorber-movement has been done and will be analized.

if NANF.EQ.1 reactor power and the concentrations of the delayed neutrons are supposed to be in equilibrium before absorber-movement; no input with cards 10 and 11.

if NANF.EQ.2 power and delayed neutrons have not been in equilibrium before absorber-movement; cards 10-11 are needed for calculation of start-concentrations of the delayed neutrons. possibly with PREPOW=0.0,TSHUT0=0.0 and TBETWN=0.0, but POW.GT.0.0 and TPOW.GT.0.0.
(see the following EXPLANATIONS for b)

MOVAB = 1

b) if NCASE >1, the first experiment of a "Xenon-ride" will be under work.

In this case NANF.EQ.2 and input cards 10 and 11 are awaited for. It is assumed, that in preparing the Xenon-ride the reactor has been a longer time on high power PREPOW and than shut-down for reaching the Xenon-peak. Then the reactor was again brought to criticality on power POW(1) at high Xenon-level. The time between shut-down from PREPOW and being critical with POW(1) is TSHUT0. PREPOW and TSHUT0 are awaited for on card 10.

For MOVAB = 1 TBETWN(1) (card 11) is meaningless and set to 0.0, because TSHUT0 represents this data for the first absorber-movement of a Xenon-ride. Input of POW(1) and TPOW(1) is instead obviously needed.

MOVAB > 1 up to NCASE numbers of the consecutive absorber-movements of the Xenon-ride. No input on card 10, data on card 11 are

```
TBETWN(MOVAB) = the time between two absorber-movements,
POW(MOVAB)    = the reactor-power before this MOVAB.-th
                absorber-movement and
TPOW(MOVAB)   = the time the reactor has been on power
                POW(MOVAB)
```

3.2 NANF flag of initial conditions of reactor-power and concen-

trations of delayed neutrons before absorber movements

DEFAULT = 1

= 1 delayed neutrons and ractor-power in equilibrium after a considerable time on power (time different for H2O- and D2O-systems, in addition if reflected by Boron). No input of cards 10 and 11 needed.

= 2 delayed neutrons and reactor-power not in equlibrium; even possible if only one experiment is analysed, but certainly true for a sequence of experiments of a Xenon-ride. Input cards 10 and 11 with data of power and times are awaited for, see also EXPLANATIONS for MOVAB.

= 3 very rarely used. In addition to cards 10 and 11 optional starting concentrations CIA for the delayed neutrons can be read in with card 12. Only purpose is discussion of their influence on reactivity calculations.

< 0 only optimal polynomial for any given X-Y data are calculated in SAGAPO and results written out, but
N O I N V E R S E - K I N E T I C S

3.3 NRE =0 or 1 reactivity is calculated in % Δk/k

=2 reactivity is calculated in Dollar ($)
DEFAULT=1

3.4 NREAD =0 DEFAULTs are used for

INPRT,NCYC,NCYC1,NVCYC,KPLOT,NPLOT and
H1,H2,FH,HTM,PIO,REO,REIO

=1 values are read in for

INPRT,NCYC,NCYC1,NVCYC,KPLOT,NPLOT on card 4

DEFAULTs are used for

H1,H2,FH,HTM,PIO,REO,REIO

=2 values are read in for

INPRT,NCYC,NCYC1,NVCYC,KPLOT,NPLOT and on card 4
H1,H2,FH,HTM,PIO,REO,REIO on card 9
DEFAULT=0

3.5 LENLT GT.0 = neutron-lifetime has to be read in on card 5
DEFAULT=0

3.6 NRC GT.0 = in case of high cable-capacity between ionisation chamber and amplifier NRC*10E-3 sec will be used for eliminating the time-lag of power-signal.
DEFAULT=0 with signal being supposed as being prompt

3.7 NGAM GT.0 = factor used for weighting coefficients GAMBET(I)

of delayed Beryllium-photoneutrons
DEFAULT=0

3.8 NGAFAC =1 to 6 defines fixed factors alike NGAM
DEFAULT=0

3.9 NREFL =1 includes neutron data for Beryllium, supposed to be reflector-material
DEFAULT=0

KINIK C A R D 4 (OPTIONAL)

```
-------------------------------------------------------------
      NREAD.LT.1 overrides input of following variables
-------------------------------------------------------------
INPRT =1
NCYC  =0
NCYC1 =0
NVCYC =0
KPLOT =0
LPLOT =0

-------------------------------------------------------------

C A R D  4  (OPTIONAL)
----------------------------
If (NREAD.GE.1) READ (MIP,5000)
1               INPRT,NCYC,NCYC1,NVCYC,KPLOT,LPLOT
```

EXPLANATIONS FOR C A R D 4 (OPTIONAL)

4.1 INPRT GT.0 all 'IN'put data are printed as well as the inital values resulting from preparing input data
DEFAULT=1

4.2 NCYC GT.0 after NCYC Runge-Kutta-cycles of each 2*H calculated results of T0,RE,FRE1,FRE2,REAB,REI,PR,PI,TD,TDI are written out before time TNCYC1=2*NCYC1*H1 is reached

4.3 NCYC1 GT.0 same as before for time GT.TNCYC1

4.4 NVCYC GT.0 same as before for concentrations and other data of delayed neutrons

****
If used recommended values NCYC=1, NCYC1=2, NVCYC=5000;
use NCYC,NCYC1 and NVCYC only for debugging, it gives a
L O T O F O U T P U T
DEFAULT=3*0
****

4.5 KPLOT and LPLOT control constants for plot-routine (not used)
DEFAULT=2*0

```
      GO TO (10,20,30) NPILE
      ****************************************
      Weighting factors GAMBET(1-6) for
      H2O-moderated FRJ1-MERLIN (5*6-core)
      ****************************************

   10 GAMBET(1)=1.220
      GAMBET(2)=1.230
      GAMBET(3)=1.228
      GAMBET(4)=1.235
      GAMBET(5)=1.214
      GAMBET(6)=1.244

      BETSUM/LSTAR measured in FRJ-1-MERLIN
      -------------------------------------
      BDVL=108.0

      ********************************
      Weighting factors GAMBET(1-15)
      for D2O-moderated FRJ2-DIDO
      ********************************

   20 GAMBET(1)=1.012
      GAMBET(2)=1.012
      GAMBET(3)=1.010
      GAMBET(4)=1.012
      GAMBET(5)=1.010
      GAMBET(6)=1.019
      GAMBET(7)=0.3687
      GAMBET(8)=0.4283
      GAMBET(9)=0.4068
      GAMBET(10)=0.3920
      GAMBET(11)=0.4068
      GAMBET(12)=0.4082
      GAMBET(13)=0.3921
      GAMBET(14)=0.3921
      GAMBET(15)=0.3921

      BETSUM/LSTAR measured in FRJ2-DIDO
      ----------------------------------
      BDVL=12.1

      ********************************
       Read neutron lifetime LSTAR
      ********************************
      C  A  R  D   5     (OPTIONAL)
      ----------------------------
      IF(LENLT.GT.0) READ (MIP,5010) ENLT
```

Read in a complete set of neutron data

C A R D S 5 - 8

```
30 READ (MIP,5010) NV,ENLT
   READ (MIP,5010) (TCON(M),M=1,NV)
   READ (MIP,5010) (BETAI(M),M=1,NV)
   READ (MIP,5010) (GAMBET(M),M=1,NV)
   NVMAX=NV
```

EXPLANATIONS FOR C A R D S 5-8

5.1	NV	groups of delayed neutrons	I10
5.2	ENLT	neutron lifetime (sec)	E10.3
6	TCON	time-constants of delayed neutrons (sec-1)	8E10.3
7	BETAI	yield fractions of delayed neutrons	8E10.3
8	GAMBET	weighting factors for delayed neutrons	8E10.3

As weighting values GAMBET(I) of Beryllium-groups mean value of the NV groups is multiplied by 0.05*NGAM with DEFAULT = 0.05*10, which assumes Be9-neutrons having normally 50 % of this mean importance.

KINIK C A R D 9 (OPTIONAL)

IF NREAD.LT.2 following DEFAULTs are valid

```
H1= 5.E-3
H2= 5.E-3
FH= 1.E-2
HTM= 0.0
PI0= 0.0
RE0= 0.0
REI0=0.0
```

```
C A R D 9 (OPTIONAL)
-----------------------------
IF (NREAD.EQ.2) READ(MIP,5010) H1,H2,FH,HTM,PI0,RE0,REI0

TNCYC1=2*NCYC1*H1
N1PLOT=1
N5PLOT=0
NRHO= 1
```

EXPLANATION FOR C A R D 9 (OPTIONAL)

9.1 H1 stepwidth for Runge-Kutta integration, used from start H=H1

DEFAULT=5.0E-3

9.2 H2 stepwidth for Runge-Kutta integration; if H2.NE.H1, the optimum stepwidth is recalculated after each full 2*H Runge-Kutta calculation. The program looks for the steepest gradient of prompt/delayed neutrons and other functions, its time-constant is multiplied by FH and H=TCON*FH is held between limits H1 and H2.

for H=TCON*FH.GT.H2, H=H2;
for H=TCON*FH.LT.H1, H=H1.

DEFAULT for H2=5.0E-3

9.3 FH factor as defined before

DEFAULT=1.0E-2

9.4 HTM is the midpoint of the first interval to be worked on, in most cases 0.0.

DEFAULT=0.0

9.5 PI0 is the starting value of the time-integral of the power P(t)

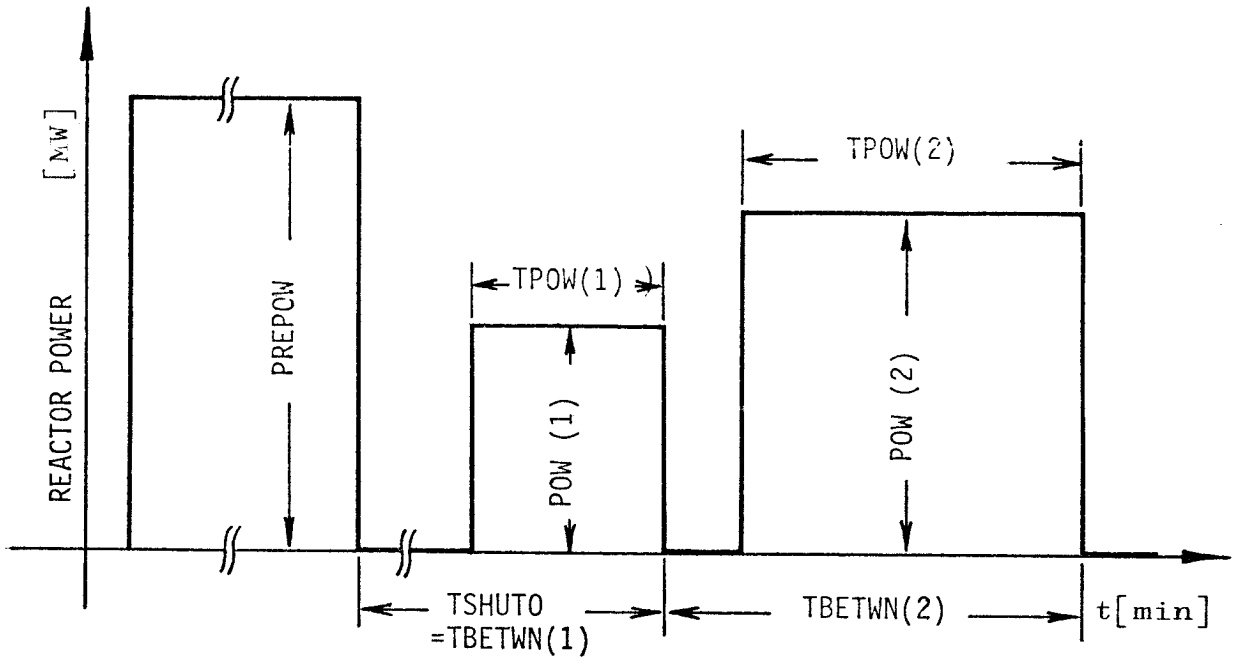
DEFAULT=0.0

9.6 RE0 is the starting value of the reactivity

DEFAULT=0.0

9.7 REIO is the starting value of the time-integral of the reactivity

DEFAULT=0.0



C A R D 10 (only if MOVAB.EQ.1)

```
READ (MIP,5010) PREPOW,TSHUT0
```

R E M E M B E R

MOVAB defines whether analysis is done for only one absorber-movement or a sequence of those, e.g. a Xenon-ride.

MOVAB = 1

a) If NCASE.EQ.1, only one absorber-movement has been done and will be analised.

If NANF.EQ.1 reactor power and the concentrations of the delayed neutrons are supposed to be in equilibrium before absorber-movement; no input with cards 10 and 11.

If NANF.EQ.2 power and delayed neutrons have not been in equlibrium before absorber-movement; cards 10-11 are needed for calculation of start-concentrations of the delayed neutrons. Possibly with PREPOW=0.0, TSHUT0=0.0 and TBETWN=0.0, but POW.GT.0.0 and TPOW.GT.0.0.
(see the following EXPLANATIONS for b)

MOVAB = 1

b) if NCASE >1, the first experiment of a "Xenon-ride" will be under work.

In this case NANF.EQ.2 and input cards 10 and 11 are awaited for. It is assumed, that in preparing the Xenon-ride the reactor has been a sufficient time on high power PREPOW and than shut-down for reaching the Xenon-peak. Then the reactor was again brought to criticality on power POW(1) at high Xenon-level. The time between shut-down from PREPOW and being critical with POW(1) is TSHUT0. PREPOW and TSHUT0 are awaited for on card 10.

For MOVAB = 1 TBETWN(1) (card 11) is meaningless and set to 0.0, because TSHUT0 represents this data for the first absorber-movement of a Xenon-ride. Input of POW(1) and TPOW(1) is obviously needed.

EXPLANATIONS FOR C A R D 10

only for MOVAB=1

10.1 PREPOW is the said high POWer PREParing Xenon build-up

10.2 TSHUT0 is the time between shut-down from PREPOW and reaching again high power in preparation of the absorber-movement under analysis, which may be a single experiment or the first of a Xenon-ride.

C A R D 11 (IF MOVAB.GE.1)

```
READ (MIP,5010) TBETWN(MOVAB),TPOW(MOVAB),POW(MOVAB)
```

R E M E M B E R

MOVAB > 1 up to NCASE numbers of the consecutive absorber-movements of the Xenon-ride. No input on card 10.

EXPLANATIONS FOR C A R D 11

FOR MOVAB.GE.1

11.1 TBETWN is the time BETWeen the shut-down of the reactor with the (MOVAB-1) experiment and the start of the new criticality with power POW(MOVAB).

***** TBETWN(1)=0.0, because TSHUT0 represents this time
***** for MOVAB=1.

11.2 TPOW is the time the reactor has been on power POW(MOVAB) before shutdown by this MOVAB.-th absorber-experiment

11.3 POW is the before-said power POW(MOVAB)

times have to be in minutes, power in MW

C A R D 12 (OPTIONAL, very rare)

```
READ (MIP,5010) (CIA(M),M=1,NV)
```

EXPLANATION FOR C A R D 12 (OPTIONAL)

If reactor is instable at start of absorber, or influence of del. neutrons is discussed, their start concentrations are read in. (very rare)

Input for SAGAPO(MADAM)

General Informations

Program handles various forms of X-Y input with smoothing routines for noisy signals and calculates polynomials up to the 10.th order, searching the optimum polynomial by least sqares method.

Program calc. also derivatives and integrals of the optimum polynomial over the momental "inner small" interval or the whole region of NPWP input-abscissae.

For kinetics/inverskinetics time or geometrical coordinate may be the independent, reactivity or power the dependent variable; in other cases definitions are arbitrarely.

Numbers of input-cards start with 1 assuming use of SAGAPO alone, card-numbers in brackets are follower cards if KINIK is used.

Input-cards are labelled (OPTIONAL), if
1) they are only triggered for special cases and/or
2) their data are normally overridden by DEFAULTs

Input-cards are labelled "NN A, NN B" etc, if they are logically on the same place in the input queue, but job-dependent different in data and format

---

IVAR= independent variable XW = time for kinetics/inverse-kinetics
otherwise ad libitum
DVAR= dependent variable YW = function of time, X-dimension etc.

M A X 2 0 0 0 XW/YW INPUT-V A L U E S A L L O W E D
MAX 400 FOR APPROXIMATION BY ONE POLYNOMIAL

With exception of KRECO=5 or 10 there are read in only the function-values YW(KW,I), (e.g. the measured reactor power) and n o t the independent variable XW(KW,I) (e.g. time); these IVAR-values are calculated with the data NXWZZ which have to be read in after statement 200 (in SAGAPO).

```
-------------------------------------------------------------
DEFAULTs (without KRECO and NPWP) for variables of CARD 1 (13)
-------------------------------------------------------------
KIP=20
KW=1
KWA=1
KWE=1
NREAD=0
NSORT=0
NGLATT=0
KREFAC=0
NORDAT=0

FV=1.E-30
W2FV=SQRT(1./FV)
FAC1=0.0
FAC2=0.0

-----------------------------------------------------------------
C A R D 1 (13)
--------------------
READ (MIP,5010) KRECO,NPWP,MODPOL,NORDAT,NREAD,
1               NSORT,NGLATT,KREFAC

KW=1
KWA=1
KWE=1
NPW(KW)=NPWP
MOD(KW)=MODPOL
```

EXPLANATIONS FOR C A R D 1 (13)

1.1 KRECO=1 declog YW-values are read in, FORMAT 16I5

=2 linear YW-values are read in, FORMAT 16I5

=3 declog YW-values are read in, FORMAT 8E10.3

=4 linear YW-values are read in, FORMAT 8E10.3

=5 optional pairs of data XW/YW FORMAT 4(2*E10.3)

>5 for 6-10 alike KRECO=1-5, but input by tape with DD-number FT20F001; after preparation of these input-data is set KRECO = KRECO-5.

1.2 NPWP quantity of input-function-values YW, in the program NPW(KW) takes over this value.

1.3 MODPOL the "mode" of the polynomial to be searched upon and the information, whether KINIK is also used or only SAGAPO. MOD(KW) takes over this value in the program

MOD(KW) =1 Approx. over only a partial "small inner" interval of the whole read-in region of NPWP values, which is the "big outer" interval.
The "small" interval contains NPI(KW) IVAR-values, starts with the mostleft IVAR-group and "glides" in the course of calculation/approximation over the whole "big" region.

=2 Approx. interval is the "big" IVAR-region of NPWP points

=3 Same procedure as MOD=1, but only calculation of polynomials in SAGAPO and n o k i n e t i c s

=4 Same procedure as MOD=2, but only calculation of polynomials in SAGAPO and n o k i n e t i c s

=5-8 Same as before with MOD(KW)=1-4, but negative function-values YW(KW) are thought to be incorrect and deleted together with their IVAR-values XW(KW).
After this procedure is set MOD(KW)=MOD(KW)-4

1.4 NORDAT=0 The original input-data YW(KW) are used

=1 Input-data YW(KW) are normalized to 100.0

In both cases dec.log.-input-data YW(KW,I) have been delog. into their numeri

DEFAULT=0

1.5 NREAD=0 no input of CARD 2 (14), setting of DEFAULTs

DEFAULT=0

1.6 NSORT>0 the first NSORT YW-values are perused for straying data which are debugged by the smoothing option

DEFAULT=0

1.7 NGLATT Smoothing of input-data YW. This is an important auxiliary means in case of noisy signals, and for inverse kinetics, whenever in the lower power decades signal resolution is poor.

=1 Smoothing starts at IVAR-point XW(KW,N), for which for the 3. time applies YW(KW,N-1)-YW(KW,N).NE.0. Successive YW with a difference of 0.0 are replaced by one pair of IVAR/DVAR, NPW(KW) is lowered by 1.

In case of kinetics this procedure avoids long periods of constant power/reactivity in measured values before starting rod drop.

=2 Smoothing starts, whenever function-values YW have passed the first decade and within the 2. decade the difference

between successive values YW is for the 3. time < 2.5 %. This procedure avoids smoothing of power data during rod drop within the first decade, because these values are in most cases not noisy.

>2 Smoothing starts 6 points after IVAR=XW(KW,NGLATT)

DEFAULT=0

1.8 KREFAC>0 input of factors FAC1 and FAC2 are awaited for; aim is improving faulty signals of measuring lines etc.
It is clear, that this formalism (stmnts 445-451) has to be fitted to the channel, amplifier etc. in question.

DEFAULT=0

SAGAPO C A R D 2 (14) (OPTIONAL)

```
-------------------------------------
DEFAULTs for variables on CARD 2 (14)
-------------------------------------

NPA(KW)=1
NPI(KW)=10
NIN(KW)=2
JOA(KW)=1
JOE(KW)=8

NAV(KW)=2
LON(KW)=1
NTD(KW)=2

NPR(KW)=2
NUN(KW)=20
NEX(KW)=0

C A R D  2 (14)  (OPTIONAL)
--------------------------------
IF (NREAD.NE.0) READ (MIP,5010)
1               NPA(KW),NPI(KW),NIN(KW),JOA(KW),JOE(KW),
2               NAV(KW),LON(KW),NTD(KW),
3               NPR(KW),NUN(KW),NEX(KW)
```

EXPLANATIONS FOR C A R D 2 (14) (OPTIONAL)

2.1 NPA(KW) If MOD=1 or 3 this is the number of the first left IVAR-boundary XW of the "gliding" interval to be approximated; must not be XW(KW,1).

If MOD=2 or 4 the number of the fixed left IVAR-boundary XW of the "total" interval to be approximated and must even not be XW(KW,1).

DEFAULT=1

2.2 NPI(KW) quantity of the inner IVAR-points of interval; the number of the respective right IVAR-boundary of the interval is NPE(KW) = NPA(KW) + NPI(KW).
Maximum value of NPI is 400, otherwise changing of concerning dimensions is afforded.

DEFAULT=10

2.3 NIN(KW) quantity of inner IVAR-points XW, by which in the case of "gliding" interval the left boundary has to be shifted to the right, if during calculation the right boundary of the interval has been reached. the number of the new left boundary is then NPA(KW) + NIN(KW).

DEFAULT=2

2.4 JOA(KW) lowest order (min=2) of polynomial to begin with test for optimisation minus 1.

DEFAULT=1

2.5 JOE(KW) highest order (max 10) of polynomial to end test for optimisation

DEFAULT=8

2.6 NAV(KW) defines meaning of dependent variable YW(KW,I)

=1,4 DVAR=reactivity (kinetics/inverskin., with jump to main)
=2,5 DVAR=flux or power (inverskinetics, with jump to main)

=3,6 prechoosable cycles of: X-Y-data input, calculation of optimum polynomial, output of results, kinetics-calculations etc.
=3 o n l y c y c l e s i n S A G A P O
=6 jump to main and back included

DEFAULT=2

2.7 LON(KW) significant only for kinetic calculations

=0 non-logarithmic DVAR-values YW(KW) are approximated by polynomials and used in the diff.-eqns., even if declog-data has been input-data. (declog-data are all the same de-logarithmised after input and before calculations.)

=1 nat-logarithmic DVAR-values YW(KW) are approximated by polynomials and used in the diff.-eqns.; in this case and for kinetics-calculations the first derivative of the appr. polynomial is the doubling-time of the reactor.

DEFAULT=1, because program is at the moment generally used for inverse-kinetics.

2.8 NTD(KW) significant if LON(KW).EQ.1.; NTD defines meaning of and comment to the (printed) output of derivative values.

=1 doubling time (sec) (YW = reactor power)

=2 inverse doubling time (1/sec) (YW = reactor power)

=3 1. derivative of nat.log. of the input-values

DEFAULT=2

2.9 NPR(KW) triggers output of coefficients etc. of approx. polynomials and the YW-data calculated with them.
DEFAULT 2 should only be changed, if only SAGAPO is used for calculating polynomials without using main program.

****
WARNING! =10 MEANS A LOT OF OUTPUT! WARNING!
****

GT.2 output of all significant data of the momentally calculated o p t i m u m polynomial

= 4 including data of the derivatives of opt. polynomial, if NPR(KW) = 5 also the first order integral.

= 10 alike 5 but for e a c h calculated polynomial, not only for the optimum. A l o t o f o u t p u t!

DEFAULT=2

2.10 NUN(KW) output of provisional results only for each NUN.-th value of the IVAR XW(KW)

DEFAULT=20

2.11 NEX(KW) IF GT.0, DVAR-values YW(KW) for NEX(KW) IVAR-points beyond the right XW(KW)-boundary are calculated, using coefficients of the resp. polynomial, which has been calculated for the inner interval.

DEFAULT=0

C A R D 3 (15)

```
READ (MIP,5010) NXW00,NXW10,NXW20,NXW50,NXW100,NXW200,NXW250,
1               NXW500,NXWSEC,NXW02S,NXW05S,NXW10S,NXW20S,NXW50S
```

EXPLANATIONS FOR C A R D 3 (15)

NXW-data are the quantities of IVAR-values forming "small" intervals in multiples of 10**-3 (thus for the time in ms) in units of 10,20,50,100,200,250,500,1000,2000,5000,10000,20000 and 50000-fold (NXW10,NXW20,.....NXW500,.....NXW10S,.....NXW50S)

Thus NXW50=6 means, that a "big" interval is divided into six small intervals of value 50*10**-3 each.

STMNTS 200 to 464 form with these data the consecutive intervals of IVAR XW(KW). NXW-data of non-used units are set to 0. In case only one NXW-value.GT.0, all "small" intervals have the same width defined by the multiple of 10**-3 given with this NXW.

NXW00 is the starting value of IVAR XW(KW). NXW00 is interpreted in the FORMAT (I2,I3). The first two numbers (from 1-13) means one of the beforesaid multiples of 10,20...to 100000-folds of 10**-3, the last 3 numbers mean the quantity of these multiples.

Thus NXW00=10235 means, that the starting value for IVAR XW(KW) is 235*(5000*10**-3), thus for IVAR=time start is at 1.175e+3 sec.

For KRECO = 1-4 and 6-9 the IVAR XW(KW) will be calculated with the NXW-values just read in, beforehand as integer numbers.

Multiplication with 1.E-3 gives msec, if MOD(KW) = 1 or 2 it is for kinetics; for other cases the user defines the meaning of the independent variable.

```
SAGAPO   C  A  R  D  S   4/5  A-C  (16/17 A-C)

        EXPLANATIONS FOR  C  A  R  D  4 A-C  (16 A-C)  (OBLIGATORY)
                 and for  C  A  R  D  5 A-C  (17 A-C)  (OPTIONAL)
        ------------------------------------------------------------
        With CARD 4 function values YW(KW,I) are read in, Input-FORMAT
        is controlled by KRECO.

        With card 5 (OPTIONAL) two factors can be read in for debug-
        ging faulty signals of instruments recording YW(KW,I).
        Debugging function has to be fitted in program SAGAPO accor-
        ding to this resp. apparatus.
      ------------------------------------------------------------------

      GO TO (410,410,420,420,430,410,410,420,420,430), KRECO

      ------------------------------------------------
            ENTRY for KRECO = 1,2,6 or 7
        Read in integer DVAR-values NYW(I)  16I5
      ------------------------------------------------
      for KRECO=1 or 6 input of dec-log-data
      for KRECO=2 or 7 input of linear  data
      for KRECO=1 or 2 from normal input-file MIP (5)
      for KRECO=6 or 7 from tape file KIP (FT20F001)
      ------------------------------------------------

      C  A  R  D    4 A  (16 A)
      -------------------------
  410 IF(KRECO.EQ.1.OR.KRECO.EQ.2) READ (MIP,5010) (NYW(I),I=1,NPWP)
      IF(KRECO.EQ.6.OR.KRECO.EQ.7) READ (KIP,5010) (NYW(I),I=1,NPWP)

      C  A  R  D    5 A  (17 A)  (OPTIONAL)
      ------------------------------------
      IF(KREFAC.EQ.1) READ (MIP,5020) FAC1,FAC2
      IF(KRECO.GT.5)  KRECO=KRECO-5



      ------------------------------------------------
            ENTRY for KRECO=3,4,8 or 9
        READ in DVAR-values YW(KW,I)    8E10.3
      ------------------------------------------------
      for KRECO=3 or 8 input of dec-log-data
      for KRECO=4 or 9 input of linear data
      for KRECO=3 or 4 from normal input-file MIP (5)
      for KRECO=8 or 9 from tape file KIP (FT20F001)
      ------------------------------------------------

      C  A  R  D    4 B  (16 B)
      -------------------------
  420 IF(KRECO.EQ.3.OR.KRECO.EQ.4) READ (MIP,5020) (YW(KW,I),I=1,NPWP)
      IF(KRECO.EQ.8.OR.KRECO.EQ.9) READ (KIP,5020) (YW(KW,I),I=1,NPWP)

      C  A  R  D    5 B  (17 B)   (OPTIONAL)
      ------------------------------------
      IF(KREFAC.EQ.1) READ (MIP,5020) FAC1,FAC2
      IF(KRECO.GT.5)  KRECO=KRECO-5
```

```
      ------------------------------------------
             ENTRY for KRECO=5 or 10
      IVAR XW(KW,I) and DVAR YW(KW,I) are read
      in as pairs of real numbers 4(2E10.3).
      correct sequence of XW(KW,I) is controlled,
      in case of error program is finished after
      output of resp. comment.
      for KRECO = 5 from normal input-file MIP  (5)
      for KRECO =10 from tape file KIP (FT20F001)
      ------------------------------------------

      C  A  R  D    4 C  (16 C)
      ------------------------
  430 IF(KRECO.EQ.5)  READ (MIP,5030) (XW(KW,N),YW(KW,N),N=1,NPWP)
      IF(KRECO.EQ.10) READ (KIP,5030) (XW(KW,N),YW(KW,N),N=1,NPWP)

      C  A  R  D    5 C  (17 C)  (OPTIONAL)
      -------------------------------------
      IF(KREFAC.EQ.1) READ (MIP,5020) FAC1,FAC2
      IF(KRECO.GT.5)  KRECO=KRECO-5
```

SAGAPO C A R D 6 (18) (OPTIONAL)

****

SMOOTHING OF INPUT-DATA YW(KW,I)

****

This is an auxiliary means in case of noisy signals, and for inverse kinetics, whenever in the lower power decades signal-resolution is poor. NGLATT has been read in on CARD 1 (13).

R E M E M B E R

NGLATT=1 smoothing starts at IVAR-point XW(KW,N), to which for the 3. time applies YW(KW,N-1)-YW(KW,N).NE.0. Successive YW with a difference of 0.0 are replaced by one pair of this IVAR/DVAR-values, NPW(KW) is lowered by 1. In case of kinetics this procedure avoids long periods of constant power/reactivity in measured values before starting rod drop.

NGLATT=2 smoothing starts, whenever function-values YW have passed the first decade and within the 2. decade the difference between successive values YW is for the 3. time < 2.5 %. This procedure avoids smoothing of power data during rod drop within the first decade, because these values are in most cases not noisy.

NGLATT>2 smoothing starts 6 points after IVAR=XW(KW,NGLATT)

DEFAULT=0

Smoothing is done in intervals of odd numbers of the IVAR-abcsissae XW(KW,I). Beginning with the leftmost interval the resp. central abscissae XW(KW,I) are coordinated new YW(KW,I), the values of which depend on the variable KGLATT. New function values are

IF KGLATT=1 New YW(KW,I)= (YW(KW,I-N)+YW(KW,I+N))*0.5,
IF KGLATT=2 New YW(KW,I)= the algebraic mean of the interval from YW(KW,I-N) to YW(KW,I+N), with N going from 1 (for N3) to 6 (for N13)

This interval is shifted each time by NIN(KW) abscissae up to the rightmost value XFIN(KW)=XW(KW,NPWP) of actual region and repeated from left to right with the same "small" intervals as often as the values of N3,N5...N13 prescribe. Procedure starts with intervals of three XW(KW,I) triggered by N3 and goes on up to those with 5,7,....13 abscissae according to the values of N5,N7.....N13.

This procedure flattens noisy signals beginning with "short wave"-noise (N3) and going to rather "long wave"-noise (N13). It is clear, that smoothing in this way affords close knowledge of the function under work in order to keep the essential information of signals.

C A R D 6 (18) (OPTIONAL)

```
READ (MIP,5010) N3,N5,N7,N9,N11,N13,KGLATT,LGLATT
```

EXPLANATIONS FOR C A R D 6 (18) (OPTIONAL)

6.1 N3>0 To the resp. central abscissa XW(KW,I) is coordinated a new function-value YW(KW,I) of the form

IF KGLATT=1 (YW(KW,I-1)+YW(KW,I+1))*0.5,
IF KGLATT=2 the algebraic mean of the sum from YW(KW,I-1) to YW(KW,I+1)

THIS HAPPENS WITHIN THE BIG INTERVAL OF NPWP ABSCISSAE N3-TIMES FROM LEFT TO RIGHT BOUNDARY

6.2 N5>0 N5 -time coordination of (YW(KW,I-2)+YW(KW,I+2))*0.5 or algebr. mean of interval YW(KW,I-2) to YW(KW,I+2)

6.3 N7>0 N7 -time coordination of (YW(KW,I-3)+YW(KW,I+3))*0.5 or algebr. mean of interval YW(KW,I-3) to YW(KW,I+3)

6.6 N13>0 N13-time coordination of (YW(KW,I-6)+YW(KW,I+6))*0.5 or algebr. mean of interval YW(KW,I-6) to YW(KW,I+6)

6.7 KGLATT defines form of smoothing

6.8 LGLATT > 0 printed output of smoothed XW/YW-values

****

2.4.4. Some typical input data for FRJ-2 (DIDO)

```
   2    1
D 120883 DROP 6 GSA FROM 13.26 DEGREE, START OF PERIOD
   1    2    1    1    0    0    0    0    0
   1    0    0    0    0    0
     0.00      0.00
     0.00     79.00     20.00
   2   45    1    1    0    0    0    0
   0   20    5    4   15    0    0    0    0    0    0    0    0    0
 909  906  900  884  861  824  777  718  651  580  508  439  376  321  275  236
 206  181  160  144  131  109   93   81   72   64   53   54   58   60   55   53
  53   51   50   49   48   47   46   45   45   44   43   43   42
*****************************************************************************
   2    1
D-040185 DROP 6 GSA 11.93 DG, SMOOTHING, NANF=2, TAUF=10.0, POW=2.0
   1    2    1    1    0    0    0    0    0
   1    0    0    0    0    0
     0.00      0.00
     0.00     10.00      2.00
   2   45    1    1    0    0    1    0
   0   20    5    4   15    0    0    0    0    0    0    0    0    0
 852  851  849  844  838  825  807  781  749  709  664  611  557  501  446  392
 344  299  262  229  203  161  132  111   96   85   66   59   57   59   57   56
  53   52   51   50   49   48   48   47   45   45   45   44   43
   1    1    0    0    0    0    1    1
*****************************************************************************
   2    1
D-040185 DRP GSA 11.93DG  NO SMOOTHING, NANF=2, TAUF=10.0, POW=2.0
   1    2    1    1    0    0    0    0    0
   1    0    0    0    0    0
     0.00      0.00
     0.00     10.00      2.00
   2   45    1    1    0    0    0    0
   0   20    5    4   15    0    0    0    0    0    0    0    0    0
 852  851  849  844  838  825  807  781  749  709  664  611  557  501  446  392
 344  299  262  229  203  161  132  111   96   85   66   59   57   59   57   56
  53   52   51   50   49   48   48   47   45   45   45   44   43
*****************************************************************************
   2    1
D-040185 DROP 6GSA 11.93DG, SMOOTHING, NANF=1, TAUF=0.0, POW=0.0
   1    1    1    1    0    0    0    0    0
   1    0    0    0    0    0
   2   45    1    1    0    0    1    0
   0   20    5    4   15    0    0    0    0    0    0    0    0    0
 852  851  849  844  838  825  807  781  749  709  664  611  557  501  446  392
 344  299  262  229  203  161  132  111   96   85   66   59   57   59   57   56
  53   52   51   50   49   48   48   47   45   45   45   44   43
   1    1    0    0    0    0    1    1
*****************************************************************************
```

EXAMPLE OF 4 INVERSE-KINETIC MEASUREMENTS IN A XENON-RIDE

```
   2    4
D 260885, MESSUNG 1, AW GSA 13.27 WG
   1    2    1    1    0    0    0    0    0
   1    0    0    0    0    0
     0.00      0.00
0.000E 00 1.000E 01 2.000E 00
   2   45    1    1    0    0    0    0
   0   20    5    4   15    0    0    0    0    0    0    0    0    0
 914  913  912  908  898  881  853  816  767  711  646  580  511  448  387  335
 288  251  219  194  171  140  116  100   87   78   61   53   53   55   54   51
  51   49   49   47   46   45   44   44   43   42   42   41   41
D 260885, MESSUNG 2, AW SAS1
   2    2    1    1    0    0    0    0    0
2.800E 01 1.000E 01 2.000E 00
   2   45    1    1    0    0    0    0
   0   20    5    4   15    0    0    0    0    0    0    0    0    0
 919  916  914  907  894  874  842  795  736  667  596  534  483  447  422  404
 393  384  379  374  372  366  363  359  357  355  350  345  342  338  333  328
 323  319  315  310  308  304  300  296  294  291  288  285  281
D 260885, MESSUNG 3, AW SAS2
   3    2    1    1    0    0    0    0    0
1.700E 01 1.000E 01 2.000E 00
   2   45    1    1    0    0    0    0
   0   20    5    4   15    0    0    0    0    0    0    0    0    0
 943  940  934  927  912  893  869  836  799  757  714  674  641  615  596  582
 572  565  558  554  551  545  539  535  531  528  522  516  512  509  501  496
 489  484  481  476  470  467  464  458  456  452  448  445  441
D 260885, MESSUNG 4, AW SAS3
   4    2    1    1    0    0    0    0    0
1.500E 01 1.000E 01 2.000E 00
   3   45    1
  20    5    4   15
 926  925  923  920  915  905  891  869  840  802  760  713  668  628  595  568
 551  534  526  516  512  503  498  494  490  488  483  478  473  469  461  454
 449  445  439  435  431  426  422  418  414  411  407  403  401
**********************************************************************************
   2    1
D 280985 AW GSA 19.40 WG, MEASUREMENT AT THE END OF PERIOD
   1    1    1    1    0    0    0    0    0
   1    0    0    0    0    0
   2   45    1    1    0    0    0    0
   0   20    5    4   15    0    0    0    0    0    0    0    0    0
 916  914  910  902  888  864  835  794  747  692  632  569  508  446  392  341
 298  262  231  204  184  151  126  108   93   81   61   49   41   41   43   41
  40   38   38   37   36   35   35   34   34   33   32   33   32
**********************************************************************************
```

PROGRAM LISTING CREMAT

```
C*****************************************************************
C**                        CREMAT                                **
C**  BURNUP-PROGRAM (ONLY U-235) FOR FRJ-2/KFA/JUELICH/FRG  **
C*****************************************************************
C
      DIMENSION U5O(30),U5B(30),U5E(30),
     1          BUG(30),BUGT(30),BU$(30),BU$T(30),
     2          QBMAX(30),QEMAX(30),QUAD(30),PFAC(30),
     3          PMEL(30),TWAIT(30),XRVMAX(30),ZRVMAX(30),
     4          ZRELM(30),NZREL(30,7),ZREL(30,7),
     5          ELN1(30),ELN2(30),TITEL(72)
      INTEGER*2 ELPOS(30)
      COMMON/ELDAT/ELN1,ELN2,ELPOS,TITEL,NPAG
C
      COMMON/CODAT/NTAG,MONAT,JAHR,NUHR,MIN
C
      MIP=5
      MOP=6
      KJOB=0
C
C     ***************************************************************
C                  EXPLANATION OF VARIABLE-NAMES
C                  *****************************
C     BOC    = BEGIN OF CORELIFE, CORE AT BEGIN OF REACTOR PERIOD
C     EOC    = END OF CORELIFE, CORE AT END OF REACTOR PERIOD
C     F.E.   = FUEL ELEMENT
C     ---------------------------------------------------------
C     TPER   = TIME OF REACTOR-PERIOD ON POWER IN SEC
C     PCORE  = MEAN REACTOR-POWER AVERAGED OVER THE WHOLE PERIOD,
C              TAKEN FROM: MEASURED INTEGRAL OF REACTOR POWER XMWH
C              (REACTOR-INSTRUMENTATION) DIVIDED BY TPER
C     LELM   = NUMBER OF FUEL-ELEMENTS (MAX AND FOR FRJ-2 25)
C     KORE   = LELM+1, DATA(KORE) = DATA CONCERNING THE WHOLE CORE
C     MESP   = NUMBER OF FLUX-MEASURING POINTS PER F.E. (MAX 7)
C     KPOL   = DEFINES OUTPUT OF APPROX.-RESULTS BY SUBROUTINE POLYN
C     NJOB     IF GT.1 NJOB JOBS RUN ONE AFTER ANOTHER
C     LIST   = NUMBER OF FINAL OUTPUT-LISTS OF BURNUP-RESULTS
C
C     ELN1/2= MAX 8-POSITIONED ALPHA-NUM. IDENTITY NAME OF F.E.
C     U5O    = ORIGINAL CONTENT OF U-235 (GRM) OF FRESH F.E.
C     U5B    = BOC-CONTENT OF U-235 (GRM) IN F.E.; IF NOT U5O, IT IS THE
C              EOC-CONTENT U5E OF THE FORMER CREMAT-BURNUP-CALCULATION
C     U5E    = EOC-CONTENT OF U-235 (GRM) IN F.E. AFTER THIS MOMENTARY
C              CREMAT-BURNUP-CALCULATION
C
C     NZREL = COUNTING RATES OF MATERIAL IRRADIATED IN MESP POSITIONS
C              OF EACH F.E. DURING FLUX-MEASUREMENTS; 0 CM = UPPER END,
C              60 CM BOTTOM END OF F.E.'S ACTIVE ZONE
C
C     ---------------------------------------------------------------
C     NPWF     DECIDES FURTHER TREATMENT OF CALCULATED VALUES OF
C              (P)OSITION-(W)EIGHTING-(F)ACTORS PFAC(I) FOR EACH F.E.
C              CONCERNING THE FORM OF 'PFAC(KORE)' FOR THE WHOLE CORE
C     NPWF =0 PFAC(I) ARE NOT NORMALIZED TO PFAC(KORE)=1.0, NEVERTHE-
C              LESS PROGRAM SETS PFAC(KORE) = 1.0
C     NPWF =1 PFAC(I) ARE NOT NORMALIZED TO PFAC(KORE)=1.0, THE PROGRAM
C              SETS PFAC(KORE)=(PFACSUM/25) WHICH IS NORMALLY > 1.0
```

```
C     NPWF =2 PFAC(I) ARE NORMALIZED TO PFAC(KORE)=1.0
C     ------------------------------------------------------------------
C     NW7  =1 CONTROL-OUTPUT OF INTERMEDIATE RESULTS DURING CALCULATION
C     ******************************************************************
C
   50 READ (MIP,5000) (TITEL(I),I=1,72)
      READ (MIP,5010) TPER,PCORE,LELM,MESP,KPOL,NJOB,LIST,NPWF,NW7
      XMWH=TPER*PCORE/3.6E+09
      KORE=LELM+1
      IF(NJOB.EQ.0) NJOB=1
      NPAG=0
C
      DO 100 I=1,LELM
      READ (MIP,5020) NEL,EL,ELN1(I),ELN2(I),U5O(I),U5B(I)
      IF (NEL.NE.I) GO TO 110
  100 CONTINUE
      GO TO 120
C
  110 WRITE(MOP,7582) I,ELPOS(I),NEL
      GO TO 2700
C
  120 DO 150 I=1,LELM
      READ (MIP,5040) NEL,EL,(NZREL(I,J),J=1,MESP)
      IF (NEL.NE.I) GO TO 110
  150 CONTINUE
C
C     ************************************************************
C        CALCULATION OF TOTAL CORE-CONTENT (GRM) OF U-235
C     A) U5O(KORE) FOR A (FIKTIVE) CORE WITH FRESH F.E.
C     B) U5B(KORE) FOR THE PRESENT BEGIN OF PERIOD  (BOC)
C     ************************************************************
C
      U5O(KORE)=0.
      U5B(KORE)=0.
      DO 200 I=1,LELM
      U5O(KORE)=U5O(KORE)+U5O(I)
  200 U5B(KORE)=U5B(KORE)+U5B(I)
C
      WRITE(MOP,6000) TITEL
      WRITE(MOP,6010)
      WRITE(MOP,6020) TPER,PCORE,LELM,MESP,KPOL,NJOB,LIST,NPWF,NW7
      WRITE(MOP,6030)
      DO 210 I=1,KORE,2
      I1=I+1
  210 WRITE(MOP,6040)  I,ELPOS(I),ELN1(I),ELN2(I),U5B(I),
     1                 I1,ELPOS(I1),ELN1(I1),ELN2(I1),U5B(I1)
      WRITE(MOP,6050)
      DO 220 I=1,KORE,2
      I1=I+1
  220 WRITE(MOP,6040)  I,ELPOS(I),ELN1(I),ELN2(I),U5O(I),
     1                 I1,ELPOS(I1),ELN1(I1),ELN2(I1),U5O(I1)
C
      WRITE(MOP,6000) TITEL
      WRITE(MOP,6055) MESP
      DO 250 I=1,LELM
  250 WRITE(MOP,6060) I,ELPOS(I),ELN1(I),ELN2(I),(NZREL(I,J),J=1,MESP)
C
```

```
C     ************************************************************
C     CALCULATION OF A 'FLUX-FACTOR' FO RELATED TO THE MEAN
C     REACTOR POWER PCORE DURING PERIOD; FO WILL BE DEFINED
C     "PER ONE GRAMATOM U-235", BECAUSE AT THE MOMENT ONLY
C     HEU-FUEL AND FISSION OF U-235 IS CONSIDERED.
C     FO AND THE BOC-CONTENT OF U-235 DEFINES THE MEAN FLUX
C     FLXMB AT BEGIN OF PERIOD, WITH THE EOC-CONTENT U-235
C     THE MEAN FLUX FLXME AT END OF PERIOD.
C
C     SIGABS = SIGMA-ABSORPTION
C     SIGFIS = SIGMA-FISSION
C     ************************************************************
C
C     DATA FOR U-235
C
      SIGABS=0.67000E-21
      SIGFIS=0.58200E-21
      FO=PCORE*235./(0.31040E-10*SIGFIS*0.60225E+24)
C
C     DATA FOR U-233
C
C     SIGABS=0.57800E-21
C     SIGFIS=0.52500E-21
C     FO=PCORE*233./(0.30560E-10*SIGFIS*0.60225E+24)
C
C     DATA FOR PU-239
C
C     SIGABS=1.06100E-21
C     SIGFIS=0.74600E-21
C     FO=PCORE*239./(0.32160E-10*SIGFIS*0.60225E+24)
C
C     ************************************************************
C     FLXMB IS THE MEAN BOC-FLUX OF THE CORE AND IS RELATED TO
C     THE TOTAL CONTENT U5B(KORE) OF U-235.
C     FO IS THE BEFORESAID 'FLUX-FACTOR' FOR U-235.
C     ************************************************************
C
      FLXMB=FO/U5B(KORE)
C
      DO 260 I=1,LELM
      DO 260 J=1,MESP
  260 ZREL(I,J)=NZREL(I,J)
CW7
      IF(NW7.EQ.0) GO TO 300
      WRITE(MOP,6990)
      WRITE(MOP,7520)
      DO 261 I=1,LELM
  261 WRITE(MOP,7010) (ZREL(I,J),J=1,MESP)
C
C     ************************************************************
C     POLYNOMIAL APPROXIMATION IN SUBROUTINE POLYN OF
C     THE COUNTING-RATES OF THE LELM F.E.; WITH THESE
C     CALCULATION OF THE INTEGRATED COUNTING-RATES XINT
C     AND ZRELM(LI) FOR EACH FUEL ELEMENT RESP.
C     ************************************************************
C
  300 DO 350 LI=1,LELM
```

```
      CALL POLYN(MESP,ZREL,KPOL,XINT,LI,XNMAX,YNMAX)
  350 ZRELM(LI)=XINT
C
C     ************************************************************
C     CALCULATION OF THE AVERAGE COUNTING RATE ZRCORM FOR THE CORE
C     THE CORE FROM THE CALCULATED MEAN FE-COUNTING RATES
C     ZRELM(I), WEIGHTED BY THE BOC-MASS OF THE FE ON U-235
C     U5B(I) AND THE TOTAL MASS OF U-235 IN THE CORE
C     ************************************************************
C
      SUMZR=0.
      DO 400 I=1,LELM
  400 SUMZR=SUMZR+ZRELM(I)*U5B(I)
      ZRCORM=SUMZR/U5B(KORE)
      ZRELM(KORE)=ZRCORM
C
      WRITE(MOP,7530)
      DO 420 I=1,KORE,2
      I1=I+1
  420 WRITE(MOP,6040)  I,ELPOS(I),ELN1(I),ELN2(I),ZRELM(I),
     1                 I1,ELPOS(I1),ELN1(I1),ELN2(I1),ZRELM(I1)
      WRITE(MOP,7540) SUMZR,U5B(KORE)
C
      IF(KPOL.EQ.0) GO TO 600
C
C     ************************************************************************
C     FOR KPOL.GT.0 THE FE-COUNTING RATES ZREL(I,J) ARE DIVIDED
C     BY THE MEAN COUNTING RATE OF THE CORE. THEY ARE APPROX. PRO-
C     PORTIONAL TO THE RATIO OF THE NEUTRON FLUX OF THE FE OVER
C     THE CORE FLUX. THE SUBROUTINE POLY SEARCHES AN OPTIMUM POLYNOMIAL
C     FOR THESE RATIOS, WHICH THEN CALCULATSES THE RATIOS OF THE
C     FLUX AT EQUIDISTANT FE-POINTS TO THE MEAN CORE FLUX.
C     THE VALUES OF THE ZRVMAX(I)=YMAX ARE THE MAXIMUM VALUES
C     OF THE RATIOS ZRB/MZRC AND NOT THE MAXIMUM OF THE FLUXES.
C
C     IN SUBROUTINE POLYN THE FOLLOWING PARAMETERS ARE CALCULATED
C     AND PARTIALY PUT OUT
C     - POLYNOMIAL-PARAMETERS
C     - ZRB/MZRC IN AXIAL DIRECTION AND THEIR MAXIMA
C     ************************************************************************
C
      DO 450 I=1,LELM
      DO 450 J=1,MESP
  450 ZREL(I,J)=ZREL(I,J)/ZRCORM
CW7
      IF(NW7.EQ.0) GO TO 460
      WRITE(MOP,7550)
      DO 451 I=1,LELM
  451 WRITE(MOP,7010) (ZREL(I,J),J=1,MESP)
C
  460 KPOL=2
      DO 500 LI=1,LELM
      CALL POLYN(MESP,ZREL,KPOL,XINT,LI,XNMAX,YNMAX)
      XRVMAX(LI)=XNMAX
  500 ZRVMAX(LI)=YNMAX
C
      WRITE(MOP,7560)
```

```
      DO 550 I=1,LELM,2
      I1=I+1
  550 WRITE(MOP,6045)  I,ELPOS(I),ELN1(I),ELN2(I),XRVMAX(I),ZRVMAX(I),
     1            I1,ELPOS(I1),ELN1(I1),ELN2(I1),XRVMAX(I1),ZRVMAX(I1)
C
C     ********************************************************************
C     CALCULATION OF THE POSITION-WEIGHTING-FACTORS PFAC(I) FROM
C     THE AVERAGED ZRELM(I) DIVIDED TO THE MEAN CORE COUNTING RATE
C     ZRCORM.
C     BRENNELEMENTE AUS IHREN EBEN BERECHNETEN MITTLEREN ZAEHLRATEN
C     ZRELM(I) DIVIDIERT DURCH DIE MITTL. CORE-ZAEHLRATE ZRCORM.
C
C     NPWF DECIDES ABOUT THE ADDITIONAL USE OF THE POS.WEIGH.FACT.
C     ------------------------------------------------------------
C     NPWF=0 THEY ARE NOT NORMALIZED TO PFAC(CORE)=1.0 BUT IT IS
C             TO 1.0
C     NPWF=1 THEY ARE NOT NORMALIZED TO PFAC(CORE)=1.0 BUT IT IS
C              BUT PFAC(KORE) IS SET EQUAL TO (PFACSUM/25)
C     NPWF =2 PFAC(I) ARE NORMALIZED TO PFAC(KORE)=1.0
C     ********************************************************************
C
  600 DO 650 I=1,LELM
  650 PFAC(I)=ZRELM(I)/ZRCORM
      FACSUM=0.0
      DO 700 I=1,LELM
  700 FACSUM=FACSUM+PFAC(I)
      XLELM=LELM
      FACP=FACSUM/XLELM
      IF(NPWF.GT.0) GO TO 750
      PFAC(KORE)=1.0
      GO TO 950
C
  750 PFAC(KORE)=FACP
      IF(NPWF.EQ.1) GO TO 950
      DO 800 I=1,KORE
  800 PFAC(I)=PFAC(I)/FACP
      FACSUM=0.0
      DO 900 I=1,LELM
  900 FACSUM=FACSUM+PFAC(I)
C
C     ************************************************
C     CALCULATION OF THE MEAN FE-POWERS PMEL
C           PMEL=PCORE/LELM*PFAC(I)
C     FOR THE ADDITIONAL USE IN THE CODE ORIGEN
C     ************************************************
C
  950 PMELO=PCORE/LELM
      DO 1000 I=1,LELM
 1000 PMEL(I)=PMELO*PFAC(I)
      PMCORE=0.0
      DO 1050 I=1,LELM
 1050 PMCORE=PMCORE+PMEL(I)
CW7
      IF(NW7.EQ.0) GO TO 1080
      WRITE(MOP,6000) TITEL
      WRITE(MOP,7561) NPWF
      WRITE(MOP,7570)
```

```
      DO 1060 I=1,KORE,2
      I1=I+1
 1060 WRITE(MOP,6040) I,ELPOS(I),ELN1(I),ELN2(I),PFAC(I),
     1                I1,ELPOS(I1),ELN1(I1),ELN2(I1),PFAC(I1)
      WRITE(MOP,7571) LELM,FACSUM
      WRITE(MOP,7580) PMELO
      DO 1070 I=1,LELM,2
      I1=I+1
 1070 WRITE(MOP,6040) I,ELPOS(I),ELN1(I),ELN2(I),PMEL(I),
     1                I1,ELPOS(I1),ELN1(I1),ELN2(I1),PMEL(I1)
      WRITE(MOP,7581) PMCORE,PCORE
C
C     ************************************
C     CALCULATION OF
C     QUAD(I)=PFAC(I)*PFAC(I)
C     ************************************
C
 1080 SUMQ=0.
      DO 1090 I=1,LELM
      QUAD(I)=PFAC(I)*PFAC(I)
 1090 SUMQ=SUMQ+QUAD(I)
      XLELM=LELM
      QUAD(KORE)=SUMQ/XLELM
      FAC=QUAD(KORE)
      DO 1100 I=1,KORE
 1100 QUAD(I)=QUAD(I)/FAC
C
      WRITE(MOP,6000) TITEL
      WRITE(MOP,6200)
      DO 1110 I=1,KORE,2
 1110 WRITE(MOP,6210) ELPOS(I),PFAC(I),QUAD(I),
     1                ELPOS(I+1),PFAC(I+1),QUAD(I+1)
C
C     ************************************************************************
C     BURNUP CALCULATION SFOR U-235 AT EACH FE AND FOE THE CORE WITH
C     THE INDEX OF KORE USING PEAK FACTORS PFAC(I)
C
C     U5E(I)  EOC-RESIDUAL MASS OF U-235 (GRM) OF THE FE (ANALYTICAL)
C     U5ESUM  SUM OF U5E(I), EOC-RESIDUAL MASS OF U-235 (GRM) OF CORE
C             SHOULD BE APPROX. EQUAL TO U5E(KORE)
C     BUG(I)  U-235-BURNUP (GRM) OF THE FE DURIN THE CYCLE
C     BU$(I)  U-235-BURNUP OF THE FE DURING THE CYCLE (%)
C     BUGSUM  SUM OF BUG(I), TOTAL BURNUP OF THE CORE(GRM)
C     BUGT(I) U-235-BURNUP OF THE FE (GRM) WITH RESPECT TO FRESH ELEMENT
C     BU$T(I) AS BEFORE BUT IN %
C     SUBUGT  SUM OF BUGT(I), COREBURNUP (GRM) WITH RESPECT TO FRESH ELE
C     BU$TKE  SUM OF BU$T(I)/LELM =AVERGE PERCENTAGEBURNUP OF THE CORE
CCC
C     FLXMB   MEAN-CORE FLUX AT THE BEGINNING OF THE OPERATION CYCLECC
C     FLXME   MEAN-CORE FLUX AT THE END OF THE OPERATION CYCLE
C     ************************************************************************
C
      A1=SIGABS*FLXMB*TPER
      A2=1.-A1
      FLXME=FLXMB/A2
      U5ESUM=0.0
      BUGSUM=0.0
```

```
      SUBUGT=0.0
      BU$TKE=0.0
C
      DO 1250 I=1,KORE
      U5E(I)=U5B(I)*A2**PFAC(I)
      BUG(I)=U5B(I)-U5E(I)
      BUGT(I)=U5O(I)-U5E(I)
      IF (U5O(I)) 1200,1150,1200
 1150 BU$(I)=0.0
      BU$T(I)=0.0
      GO TO 1250
 1200 BU$(I)=BUG(I)*100./U5O(I)
      BU$T(I)=BUGT(I)*100./U5O(I)
      BU$TKE=BU$TKE+BU$T(I)
 1250 CONTINUE
      BU$TKE=BU$TKE/25.
C
      DO 1300 I=1,LELM
      U5ESUM=U5ESUM+U5E(I)
      BUGSUM=BUGSUM+BUG(I)
 1300 SUBUGT=SUBUGT+BUGT(I)
C
      WRITE(MOP,6000) TITEL
      WRITE(MOP,6220)
      WRITE(MOP,6280) FLXMB,FLXME
      WRITE(MOP,6300)
C
      DO 1800 I=1,KORE
      IF (I.EQ. 5) WRITE(MOP,6470)
      IF (I.EQ.11) WRITE(MOP,6470)
      IF (I.EQ.16) WRITE(MOP,6470)
      IF (I.EQ.22) WRITE(MOP,6470)
      IF (I.EQ.26) WRITE(MOP,6470)
 1800 WRITE(MOP,6360) ELPOS(I),U5E(I),BUG(I),BUGT(I),BU$(I),BU$T(I)
      WRITE(MOP,6380)
      WRITE(MOP,6400) U5O(KORE),U5B(KORE),U5E(KORE),U5ESUM,
     1                BUGSUM,SUBUGT,BU$TKE
C
C     ***************************************************************************
C          CALCULATION OF THE MAXIMUM OF THE FE-POWER
C        -----------------------------------------------------
C
C     QBMAX(I) AVERAGE FE-POWER AT BOC IN (W)
C     QEMAX(I) AVERAGE FE-POWER AT EOC IN (W)
C     PMAX     MAXIMUM OF THE FE POWER
C              QBMAX(I) (BOC) AND QEMAX(I) (EOC)           IN W
C     LLL      REFERENCE NO. OF THE FE WITH THE PMAX POWER
C
C     FLXMB   MEAN-CORE FLUX AT THE BEGINNING OF THE OPERATION CYCLECC
C     FLXME   MEAN-CORE FLUX AT THE END OF THE OPERATION CYCLE
C     ***************************************************************************
C
      IF(KPOL.GT.0) GO TO 1950
      DO 1900 I=1,LELM
      XRVMAX(I)=0.
 1900 ZRVMAX(I)=0.
C
```

```
 1950 C=PCORE/FO
      DO 2000 I=1,LELM
      QBMAX(I)=C*U5B(I)*FLXMB*PFAC(I)
 2000 QEMAX(I)=C*U5E(I)*FLXME*PFAC(I)
      PMAX=QBMAX(1)
      LLL=1
      DO 2100 I=1,LELM
      IF(QBMAX(I)-PMAX) 2100,2100,2050
 2050 PMAX=QBMAX(I)
      LLL=I
 2100 CONTINUE
      DO 2200 I=1,LELM
      IF(QEMAX(I)-PMAX) 2200,2200,2150
 2150 PMAX=QEMAX(I)
      LLL=I
 2200 CONTINUE
C
      SQBMAX=0.0
      SQEMAX=0.0
      DO 2210 I=1,LELM
      SQBMAX=SQBMAX+QBMAX(I)
 2210 SQEMAX=SQEMAX+QEMAX(I)
C
C     ***************************************************
C     CALCULATION OF THE WAITING TIME FOR THE DISCHARGE TWAIT(IJ)
C     PBMIT AVERAGE FE POWER AT BOC
C     ABGES TOTAL BURNUP OF U-235 WITH REFERENCE TO FRESH ELEMENT
C     ***************************************************
C
      DO 2250 IJ=1,LELM
      PBMIT=QEMAX(IJ)
      ABGES=BUGT(IJ)
      F1=36000./PBMIT
      F2=((ABGES*6.912E10)/PBMIT)**(-0.2)
      F3=0.87*((ABGES*6.912E10)/PBMIT+2.E7)**(-0.2)
      F4=0.0384
 2250 TWAIT(IJ)=(F1+F2-F3+F4)**(-5.)/3600
C
      DO 2350 KK=1,3
      WRITE(MOP,6000) TITEL
      WRITE(MOP,6420)
      WRITE(MOP,6440)
      DO 2300 I=1,LELM
      IF (I.EQ. 5) WRITE(MOP,6470)
      IF (I.EQ.11) WRITE(MOP,6470)
      IF (I.EQ.16) WRITE(MOP,6470)
      IF (I.EQ.22) WRITE(MOP,6470)
      IF (I.EQ.26) WRITE(MOP,6470)
 2300 WRITE(MOP,6460) I,ELPOS(I),ELN1(I),ELN2(I),
     1                ZRVMAX(I),QBMAX(I),QEMAX(I),TWAIT(I)
 2350 WRITE(MOP,6480)
C
C     ************************
C     CONVERSION OF PMAX  TO KW
C     CONVERSION OF PCORE TO MW
C     ************************
C
```

```
      PMAX=PMAX*1.0E-03
      PCORE=PCORE*1.0E-06
      IF(LIST.LE.0) GO TO 2700
C
      CALL ZEITK
      DO 2650 IK=1,LIST
      WRITE(MOP,6620)
      WRITE(MOP,6640)
      WRITE(MOP,6005) (TITEL(I),I=1,59)
      WRITE(MOP,6006) (TITEL(I),I=60,72)
      WRITE(MOP,6700)
      WRITE(MOP,6720)
      DO  2600 I=1,LELM
      IF (I.EQ. 5) WRITE(MOP,6470)
      IF (I.EQ.11) WRITE(MOP,6470)
      IF (I.EQ.16) WRITE(MOP,6470)
      IF (I.EQ.22) WRITE(MOP,6470)
      IF (I.EQ.26) WRITE(MOP,6470)
 2600 WRITE(MOP,6740) ELPOS(I),ELN1(I),ELN2(I),U5O(I),U5E(I),
     1                BUGT(I),BU$T(I)
      WRITE(MOP,6780) XMWH
      WRITE(MOP,6790) PCORE
      WRITE(MOP,6800) ELPOS(LLL),PMAX
      WRITE(MOP,6820) U5B(KORE)
      WRITE(MOP,6840) U5ESUM
      WRITE(MOP,6860) BUGSUM
      WRITE(MOP,6880) NTAG,MONAT,JAHR
 2650 CONTINUE
      WRITE(MOP,6900)
      XNPWF=NPWF
      WRITE(MOP,7000) XNPWF,SQBMAX,SQEMAX,PMCORE,PCORE
C
      KJOB=KJOB+1
      IF(NJOB.GT.KJOB) GO TO 50
C
 2700 STOP
C
C     OUTPUT FORMATS
C
 5000 FORMAT(72A1)
 5010 FORMAT(2E12.5,10I4)
 5020 FORMAT(I4,2X,A2,2X,2A4,1X,2F8.2)
 5040 FORMAT(I4,2X,A2,2X,7I6)
C
C     OUTPUT FORMATS
C
 6000 FORMAT('1',72A1/70('*'))
 6005 FORMAT(T2,59A1)
 6006 FORMAT(T25,13A1/)
 6010 FORMAT(//T7,'PER.TIME(S)    POWER(W)   ELEM MESP KPOL NJOB ',
     1            'LIST NPWF  NW7'/)
 6020 FORMAT(T5,1P2E13.5,7I5)
 6030 FORMAT(/T14,'BOC-MASSES OF FUEL ELEMENTS  IN GRAM  U-235'/,
     1       T14,43('-')/)
 6040 FORMAT(T2,2(I6,2X,A2,2X,2A4,1PE13.5))
 6045 FORMAT(T3,2(I4,2X,A2,2X,2A4,F8.2,F7.3))
 6050 FORMAT(/T9,'ORIGINAL MASS OF THE  FRESH FUEL ELEMENTS  IN ',
```

```
     1           'GRAM    U-235'/,
     2        T9,56('-')/)
6055 FORMAT(/T14,'COUNTING RATE OF FE  ON',I2,' AXIAL POSITION'/,
     1        T9,'WITH 0.0 CM=TOP, 60.0 CM=BOTTOM OF THE CORE ',
     2           'ZONE'/T9,56('-')//,
     3        T4,'NO POS  FE-LABEL   0.0    10.0   20.0   30.0   40.0',
     4             '   50.0   60.0'/)
6060 FORMAT(T4,I2,2X,A2,2X,2A4,7I7)
6200 FORMAT(////'    POS  POSWEIFACT   NORM.SQUAR.',
     1            '   POS  POSWEIFACT   NORM.SQUAR.'/)
6210 FORMAT(/1X,2(4X,A2,1P2E13.5))
6220 FORMAT(//T24,'BURNUP DATA FOR U-235',
     1        /T24,23('-'))
6280 FORMAT(/T3,'AVERGE FLUX AT THE  BOC =',1PE11.4,
     1           ', EOC =',E11.4,' N*CM-2*SEC-1')
6300 FORMAT(/'  POS.  RESID. U235(G)  BUR.PER.(G)  BUR.TOT.(G)',
     1       '  BUR.PER.(%)  BUR.TOT.(%)'/)
6360 FORMAT(T4,A2,2X,1P5E13.5)
6380 FORMAT(/T10,'VALUES KE CALCULATED WITH BOC-TOTAL MASS ON U-235'/
     1        T10,44('-'))
6400 FORMAT(//
     1    T3,'A) TOLAL MASS OF THE FRESH FUEL ELEMENTS     =',1PE12.5,
     2             ' GRAM U-235'/
     3    T3,'B) TOTAL MASS AT THE BOC                     =',E12.5,
     4             ' GRAM U-235'/
     5    T3,'C) TOTAL MASS AT THE EOC (ANALYTICAL)        =',E12.5,
     6             ' GRAM U-235'/
     7    T3,'D) SUM OF THE U-235 MASSES AT THE EOC        =',E12.5,
     8             ' GRAM U-235'/
     9    T3,'E) BURNUP DURING BOC-EOC (B-D)               =',E12.5,
     A             ' GRAM U-235'/
     B    T3,'F) TOT. BURN. EOC REFER. TO FRESH CORE (A-D) =',E12.5,
     C             ' GRAM U-235'/
     D    T3,'G) AVERAGE BURNUP(PERCENT.) OF CORE (100*F/A)=',E12.5,
     E             ' %')
6420 FORMAT(T5,'MAXIMUM RATIOS OF THE COUNTING RATES CALCULATED ',
     1          'ZRB AT THE FE'/,
     2       T5,'TO THE MEAN COUNT. RATE MZRC OF CORE, MEAN   ',
     3          'POWERS '/,
     4       T5,'BOC AND  EOC OF THE PERIOD IN W, DISCHARGE',
     5          '-WAITING TIMES IN H'/,
     5       T5,65('-')/)
6440 FORMAT(T4,'NO POS. FE-LABEL  MAX ZRB/MZRC  POWER  BOC  ',
     1       'POWER  EOC   WAITINGTIME')
6460 FORMAT(/T4,I2,2X,A2,2X,2A4,2X,1P5E12.4)
6470 FORMAT(/)
6480 FORMAT(/T7,' MAXIMUM RATIOS OF THE ZRB/MZRC, NOT CALCULATED')
6620 FORMAT(1H1//)
6640 FORMAT(' DEP. FOR RESEARCH REACTORS'/' REACTOR CONTROL'//)
6700 FORMAT('  POS.   FE-NO.     MORG(G)    MEND(G)   BURN(G)',
     1       '  BURN(%)' )
6720 FORMAT(/T2,59('-'))
6740 FORMAT('  ',A2,4X,2A4,5X,F6.2,5X,F6.2,4X,F6.2,4X,F6.2)
6780 FORMAT(//T6,'LINTEGRAL POWER OVER THE PERIOD   ',F10.2,' MWH')
6790 FORMAT(T6,'MEAN REACTOR POWER AT THE PERIOD',F9.2,' MW')
6800 FORMAT(T6,'MAXIMUM POWER AT POSITION ',A2,4X,F12.2,' KW'//)
6820 FORMAT(T6,'U-235 CONTENT AT THE BOC:',F10.2,' GRAM')
```

```
 6840 FORMAT(T6,'U-235 CONTENT AT THE EOC  :',F10.2,' GRAM')
 6860 FORMAT(T6,'U-235 CONSUMPTION BOC TO EOC :',F10.2,' GRAM'//)
 6880 FORMAT(T6,'JUELICH,',I2,'.',I2,'.19',I2)
 6900 FORMAT(1H1)
 6990 FORMAT(//)
 7000 FORMAT(1P5E13.5)
 7010 FORMAT(1P7E13.5)
 7500 FORMAT(/T4,'CORE MASS OF U-235 BOC AND FOR FRESH  FE'/)
 7520 FORMAT(/T4,'COUNTING RATES AS REAL VALUES'/)
 7530 FORMAT(/T12,'MEAN TOTAL COUNTING RATES AT FE AND  CORE (KE)',
     1       /T12,49('-')//)
 7531 FORMAT(T4,I2,2X,A2,2X,2A4,1PE13.5)
 7540 FORMAT(/T4,'C.-RATE IN CORE (KE) AVERGED OVER THE BOC-BE-',
     1            'CONTENTS ON U-235',
     2       /T4,'SUM OF WEIGHTED C.-RATES OF THE FE  SUMZR  =',
     3            1PE13.5,
     4       /T4,'TOTAL MASS OF U-235 IN THE CORE AT BOC  U5B(CORE)  =',
     5            1PE13.5/)
 7550 FORMAT(/T4,'COUNTING RATES OF THE FE DIVIDED TO THE ',/,
     1        T4,'AVERGE COUNTING RATE OF THE CORE ZRCORM,',/,
     2        T4,'FOR WHICH AN OPTIMUM POLYNOMIAL IS DETERMINED',/,
     3        T4,'. THEN THE ZRB/MZRC FOR 24 POINTS OF THE FE ARE ',/,
     4        T4,'CALCULATED'/)
 7560 FORMAT(/T12,'POSITIONS AT THE FE IN CM AND MAXIMUM ZRB/MZRC'/,
     1        T12,47('-')//)
 7561 FORMAT(/T14,'NPWF DEFINES THE FORM OF POS.WEI.FACTORS',//
     1        T14,'NPWF=0 THEY ARE NOT NORMALIZED TO 1.0,'/,
     2        T14,'       BUT PFAC(CORE) IS SET TO 1.0'/,
     3        T14,'NPWF=1 THEY ARE NOT NORMALIZED,'/,
     4        T14,'       PFAC(CORE)=(PFACSUM/LELM)'/,
     5        T14,'NPWF=2 THEY ARE NOMALIZED TO 1.0   '/,
     6        T14,'       PFAC(CORE)=(PFACSUM/LELM).EQ.1.0'//,
     7        T19,'  FOR THIS CALCULATION IS NPWF = ',I1/,
     8        T19,'  --------------------------------')
 7570 FORMAT(/T18,'POS.-WEI.-FACTORS OF THE FE AND OF THE CORE',
     1       /T18,39('-')/)
 7571 FORMAT(/T6,'SUM PFACSUM OF POS.-WEI.-FACTORS OF',I3,' FE  =',
     1            1PE13.5//T4,66('*')/)
 7580 FORMAT(/T5,'MEAN POWER PMEL(I) OF THE FE IN W CALCULATED AS ',
     1            'THE PRODUCT OF THE',
     2       /T10,'POS.WEI.FACTORS PFAC(I) OF TH EFE WITH ',
     2            'VALUE',/
     3       /T12,'(AVERGE CORE POWER/LELM) = PMELO =',1PE12.5,' W',/,
     5       /T5,64('-')/)
 7581 FORMAT(/T6,'PMCORE =  SUM OF THE MEAN FE-POWERS PMEL(I) =',
     1            1PE12.5,
     2       /T6,'PCORE  =  AVERAGE POWER OF THE CORE AS INPUT    =',
     3            1PE12.5)
 7582 FORMAT(/T10,'DAS ',I2,'. ELEMENT MIT COREPOSITION ',A2,' IST ',
     1            'FALSCH ALS ',I2,'. EINGEORDNET',/,
     1        T20,'  DATA INPUT IS INTERRUPTED         ',/,
     2        T10,66('*'))
      END
            SUBROUTINE POLYN(N,Z,KPOL,XINT,LI,XNMAX,YNMAX)
C           ***************************************************
      REAL*8    A(7,8),B(7)
      DIMENSION X(7),Q(7),D(7),XN(30),YN(30),Y(7),Z(30,7)
```

```
      DIMENSION G(7,7),C(10,7)
      DIMENSION ELN1(30),ELN2(30),TITEL(72)
      INTEGER*2 ELPOS(30)
      COMMON/ELDAT/ELN1,ELN2,ELPOS,TITEL,NPAG
C
      MIP=5
      MOP=6
C
C     ************************************************************************
C     POLYN.FITTING FOR THE MESP-COUNTING RATES MEASURED AT EACH FE
C     IN THE SEARCHING FOR THE OPTIMUM POLYNOMIAL THE METHOD OF
C     ROOT MEAN SQUARE IS USED
C     ************************************************************************
C
      DO 10 I=1,7
   10 Q(I)=0.
      NORD1=2
      LORD=1
      NTEILG=24
      XN(1)=N-1
      DO 50 I=1,N
      XI=I
   50 X(I)=(XI-1.)*60./XN(1)
      DO 60 I=1,N
   60 Y(I)=Z(LI,I)
      DO 100 I=1,N
  100 G(1,I)=1.
      NORD=NORD1
      GO TO 120
  110 NORD=NORD+1
  120 DO 200 J=2,NORD
      J1=J-1
      DO 200 I=1,N
  200 G(J,I)=X(I)**J1
      DO 300 M=1,NORD
      DO 303 K=1,NORD
      A(M,K)=0.
      DO 306 I=1,N
      A(M,K)=A(M,K)+G(M,I)*G(K,I)
  306 CONTINUE
  303 CONTINUE
  300 CONTINUE
      DO 400 M=1,NORD
      L=NORD+1
      A(M,L)=0.
      DO 403 I=1,N
      A(M,L)=A(M,L)+Y(I)*G(M,I)
  403 CONTINUE
  400 CONTINUE
      CALL MATRIX (A,NORD,B)
      DO 500 L=1,NORD
      C(L,NORD)=B(L)
  500 CONTINUE
      Q(NORD)=0.
      XN2=N-NORD
      DO 600 I=1,N
      D(I)=0.
```

```
      DO 700 J=1,NORD
  700 D(I)=D(I)+C(J,NORD)*G(J,I)
  600 Q(NORD)=Q(NORD)+(D(I)-Y(I))**2
      Q(NORD)=Q(NORD)/XN2
      Q(NORD)=SQRT(Q(NORD))
      N7=N-1
      IF (NORD-N7)110,620,620
  620 QMIN=Q(NORD1)
      L1=NORD1
      N1=NORD1+1
      DO 800 L=N1,NORD
      IF (Q(L)-QMIN)820,800,800
  820 QMIN=Q(L)
      L1=L
  800 CONTINUE
      IF(KPOL.EQ.2) GO TO 3000
C
C     ******************************************************
C     ONLY FOR FIRST CALL OF THE POLYN
C
C     FROM THE INTEGRATED COUNTING RATES THEIR AVERGES
C     ZRELM(I) ARE CALCULATED, FROM WHICH FIRST THE
C     CORE-AVERAGED COUNTING RATE AND THEN POS.WEI.FACTORS
C     PFAC(I) ARE DETERMINED.
C     ******************************************************
C
      XINTO=0.
      XINTU=0.
      DO 2000 L=1,L1
      XL=L
      XINTO=XINTO+C(L,L1)*(X(N)**L)/XL
 2000 XINTU=XINTU+C(L,L1)*(X(1)**L)/XL
      XINT=XINTO-XINTU
      XINT=XINT/(X(N)-X(1))
      RETURN
C
C     ********************************************************
C     AT THE SECOND RECALL OF POLY  KPOL IS SET EQUAL
C     TO 2 (IF KPOL.GT.0) BY THE MAIN PROGRAM RESULTING
C     TO THE FOLLOWING STEPS:
C     - PRINTOUT OF THE POLYNOMIAL PARAMETERS
C     - CALCULATION AND PRINTOUT OF ZRB/MZRC
C     - CALCULATION OF THEIR MAIMUMS WITH TRANSFER TO THE MAIN
C     ********************************************************
C
 3000 IF(NPAG.NE.0) GO TO 3500
      WRITE(MOP,6000) TITEL
      NPAG=2
 3500 WRITE(MOP,6100) ELPOS(LI),LI,ELN1(LI),ELN2(LI)
      LJ=L1-1
      WRITE(MOP,6140) LJ
      DO 910 L=1,L1,5
      IA=L
      IE=L+4
      IF((L1-L).LT.5) IE=L1
  910 WRITE(MOP,6160) (K,C(K,L1),K=IA,IE)
      DO 930 L=NORD1,NORD,5
```

```
      L2=L+1
      L3=L+2
      L4=L+3
      L5=L+4
      WRITE(MOP,6180)
  930 WRITE(MOP,6200)L,Q(L),L2,Q(L2),L3,Q(L3),L4,Q(L4),L5,Q(L5)
C
C     ************************************************
C     CALCULATION OF AXIAL VALUES FOR ZRB/MZRC OF
C                  EACH FUEL ELEMENT
C     ************************************************
C
      XNT=NTEILG
      DELH=(X(N)-X(1))/XNT
      NT1=NTEILG+1
      XN(1)=X(1)
      DO 1000 I=2,NT1
 1000 XN(I)=XN(I-1)+DELH
      L=L1
      DO 1100 I=1,NT1
      YN(I)=0.
      IF (XN(I))1150,1160,1150
 1160 YN(I)=C(1,L)
      GO TO 1100
 1150 DO 1170 J=1,L
      J1=J-1
 1170 YN(I)=YN(I)+(XN(I)**J1)*C(J,L)
 1100 CONTINUE
C
      L7=L-1
      WRITE(MOP,6220)
      WRITE(MOP,6240)
      DO 1200 I=1,NT1,4
      LA=I
      LE=I+3
      IF((NT1-I).LT.4) LE=NT1
 1200 WRITE(MOP,6260) (XN(L),YN(L),L=LA,LE)
      KI=LI/2
      NI=KI*2
      IF(LI.NE.NI) WRITE(MOP,6270)
C
C     ********************************************************
C     DETERMINATION OF THE MAXIMUM VALUES OF ZRB/MZRC
C     AS YMAX AND THEIR POSITIONS XNMAX AT THE FE
C     ********************************************************
C
      YNMAX=YN(1)
      DO 1220 K=1,NT1
      IF (YN(K)-YNMAX)1220,1220,1210
 1210 XNMAX=XN(K)
      YNMAX=YN(K)
 1220 CONTINUE
      NPAG=NPAG-1
      RETURN
C
C     PRINTOUT FORMATS
C
```

```
 6000 FORMAT('1',72A1/72('*'))
 6100 FORMAT(/T10,'VALUES FOR CORE POSITION ',A2,' ELEMENT',I3,4X,2A4/,
     1        T10,50('*')/)
 6140 FORMAT(T13,'COEFFICIENTS OF OPTIMUM POLYNOMIAL OF DEGREE',I2/,
     1       T13,45('-')/)
 6160 FORMAT(5(I3,1PE11.3))
 6180 FORMAT(/T13,'MEAN SQUARE ERROR OF THE POLYNOM.DEGREE 2 UP 6'/,
     1        T13,46('-')/)
 6200 FORMAT(5(I3,1PE11.3))
 6220 FORMAT(//T11,'RATIO OF CALCULATED COUNT. RATES AT FUEL ELEMENT'/,
     1       T11,'TO THE AVERAGE OF COUT. RATE IN THE CORE (AXIAL)'/,
     2       T11,'0.0 CM = UPPER, 60.0 CM = LOWER EDGE OF THE CORE'/,
     3       T11,48('_')/)
 6240 FORMAT(T2,4(3X,' CM  ZRB/MZRC')/)
 6260 FORMAT(4(F9.2,F7.3))
 6270 FORMAT(/70('*')/)
      END
                          SUBROUTINE MATRIX(A,N,X)
C                         ************************
C
C     ***********************************
C     DIAGONALIZATION OF THE MATRIXS
C     ***********************************
C
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION X(7),A(7,8)
C
      KZA=0
      KD=2
      M1=N+1
      IF(N.LT.2) GO TO 100
      N1=N-1
      GO TO 200
  100 N1=N
  200 DO 800 NN=1,N1
      DO 500 I=NN,N
      P=DABS(A(NN,NN))
      Q=DABS(A(I,NN))
      IF (P-Q) 300,500,500
  300 KZA=KZA+1
      DO 400 K=NN,M1
      AA=A(NN,K)
      A(NN,K)=A(I,K)
  400 A(I,K)=AA
  500 CONTINUE
      L=NN+1
      K1=NN+1
      DO 700 I=L,N
      A(I,NN)=A(I,NN)/A(NN,NN)
      DO 600 KK=K1,M1
  600 A(I,KK)=A(I,KK)-A(I,NN)*A(NN,KK)
  700 CONTINUE
  800 CONTINUE
      SUM=0.
      DO 1000 I=1,N
      II=N+1-I
      X(II)=(A(II,M1)-SUM)/A(II,II)
```

```
      IF (N.EQ.I) GO TO 1100
      SUM=0.
      DO 900 K=1,I
      III=N-I
      K2=M1-K
  900 SUM=A(III,K2)*X(K2)+SUM
 1000 CONTINUE
 1100 D=A(1,1)
      GO TO (1200,1400),KD
 1200 DO 1300 I=2,N
 1300 D=D*A(I,I)
      KZA=(-1)**KZA
      ZKA=KZA
      D=D*ZKA
 1400 RETURN
      END
      BLOCK DATA
      DIMENSION ELN1(30),ELN2(30),TITEL(72)
      INTEGER*2 ELPOS(30)
      COMMON/ELDAT/ELN1,ELN2,ELPOS,TITEL,NPAG
      DATA ELPOS/'A1','A2','A3','A4','B1','B2','B3','B4','B5','B6',
     1           'C1','C2','C3','C4','C5','D1','D2','D3','D4','D5',
     2           'D6','E1','E2','E3','E4','KE','NN','NN','NN','NN'/
      END
                          SUBROUTINE ZEITK
C                         ****************
      DIMENSION MON(12),MONS(12)
      DATA MON /31,59,90,120,151,181,212,243,273,304,334,365/
      DATA MONS /31,60,91,121,152,182,213,244,274,305,335,366/
C
      COMMON/CODAT/NTAG,MONAT,JAHR,NUHR,MIN
C
      A=ZEIT(0.)
      NS=IFIX(A)
      MIN=NS/60
      NUHR=MIN/60
      MIN=MOD(MIN,60)
      CALL DATUM (JAHR,ITAG)
      IF ((MOD(JAHR,4)).EQ.0) GO TO  100
      DO 1                    I=1,12
      M=I
      IF (ITAG-MON(I))        110,110,1
    1 CONTINUE
  100 DO 10                   I=1,12
      M=I
      IF (ITAG-MONS(I))       120,120,10
   10 CONTINUE
  110 IF (M.EQ.1)             NTAG=ITAG
      IF (M.NE.1)             NTAG=ITAG-MON(M-1)
      GO TO                   200
  120 IF (M.EQ.1)             NTAG=ITAG
      IF (M.NE.1)             NTAG=ITAG-MONS(M-1)
  200 MONAT=M
      RETURN
      END
```

PROGRAM LISTING BURNY

```
C*****************************************************************
C**  BURNUP-PROGRAM (ONLY U-235) FOR FRJ-2/KFA/JUELICH/FRG  **
C**       DRAFT 24.01.1985:KFA/ZFR/A3,TEL 5468              **
C*****************************************************************
C
      DIMENSION U5O(30),U5B(30),U5E(30),
     1          BUG(30),BUGT(30),BU$(30),BU$T(30),
     2          QBMAX(30),QEMAX(30),QUAD(30),PFAC(30),
     3          PMEL(30),TWAIT(30),XRVMAX(30),ZRVMAX(30),
     4          ZRELM(30),NZREL(30,7),ZREL(30,7),
     5          ELN1(30),ELN2(30),TITEL(72)
      INTEGER*2 ELPOS(30)
      COMMON/ELDAT/ELN1,ELN2,ELPOS,TITEL,NPAG
C
      COMMON/CODAT/NTAG,MONAT,JAHR,NUHR,MIN
C
      MIP=5
      MOP=6
      KJOB=0
C
C     ***************************************************************************
C                  EXPLANATION OF VARIABLE-NAMES
C                  *****************************
C     BOC    = BEGIN OF CORELIFE, CORE AT BEGIN OF REACTOR PERIOD
C     EOC    = END OF CORELIFE, CORE AT END OF REACTOR PERIOD
C     F.E.   = FUEL ELEMENT
C     ---------------------------------------------------------------
C     TPER   = TIME OF REACTOR-PERIOD ON POWER IN SEC
C     PCORE  = MEAN REACTOR-POWER AVERAGED OVER THE WHOLE PERIOD,
C              TAKEN FROM: MEASURED INTEGRAL OF REACTOR POWER XMWH
C              (REACTOR-INSTRUMENTATION) DIVIDED BY TPER
C     LELM   = NUMBER OF FUEL-ELEMENTS (MAX AND FOR FRJ-2 25)
C     KORE   = LELM+1, DATA(KORE) = DATA CONCERNING THE WHOLE CORE
C     MESP   = NUMBER OF FLUX-MEASURING POINTS PER F.E. (MAX 7)
C     KPOL   = DEFINES OUTPUT OF APPROX.-RESULTS BY SUBROUTINE POLYN
C     NJOB     IF GT.1 NJOB JOBS RUN ONE AFTER ANOTHER
C     LIST   = NUMBER OF FINAL OUTPUT-LISTS OF BURNUP-RESULTS
C
C     ELN1/2= MAX 8-POSITIONED ALPHA-NUM. IDENTITY NAME OF F.E.
C     U5O    = ORIGINAL CONTENT OF U-235 (GRM) OF FRESH F.E.
C     U5B    = BOC-CONTENT OF U-235 (GRM) IN F.E.; IF NOT U5O, IT IS THE
C              EOC-CONTENT U5E OF THE FORMER CREMAT-BURNUP-CALCULATION
C     U5E    = EOC-CONTENT OF U-235 (GRM) IN F.E. AFTER THIS MOMENTARY
C              CREMAT-BURNUP-CALCULATION
C
C     NZREL  = COUNTING RATES OF MATERIAL IRRADIATED IN MESP POSITIONS
C              OF EACH F.E. DURING FLUX-MEASUREMENTS; 0 CM = UPPER END,
C              60 CM BOTTOM END OF F.E.'S ACTIVE ZONE
C
C     ---------------------------------------------------------------
C     NPWF     DECIDES FURTHER TREATMENT OF CALCULATED VALUES OF
C              (P)OSITION-(W)EIGHTING-(F)ACTORS PFAC(I) FOR EACH F.E.
C              CONCERNING THE FORM OF 'PFAC(KORE)' FOR THE WHOLE CORE
C     NPWF =0  PFAC(I) ARE NOT NORMALIZED TO PFAC(KORE)=1.0, NEVERTHE-
C              LESS PROGRAM SETS PFAC(KORE) = 1.0
C     NPWF =1  PFAC(I) ARE NOT NORMALIZED TO PFAC(KORE)=1.0, THE PROGRAM
C              SETS PFAC(KORE)=(PFACSUM/25) WHICH IS NORMALLY > 1.0
```

```
C     NPWF =2 PFAC(I) ARE NORMALIZED TO PFAC(KORE)=1.0
C     ------------------------------------------------------------------
C     NW7  =1 CONTROL-OUTPUT OF INTERMEDIATE RESULTS DURING CALCULATION
C     ******************************************************************
C
   50 READ (MIP,5000) (TITEL(I),I=1,72)
      READ (MIP,5010) TPER,PCORE,LELM,MESP,KPOL,NJOB,LIST,NPWF,NW7
      XMWH=TPER*PCORE/3.6E+09
      KORE=LELM+1
      IF(NJOB.EQ.0) NJOB=1
      NPAG=0
C
      DO 100 I=1,LELM
      READ (MIP,5020) NEL,EL,ELN1(I),ELN2(I),U5O(I),U5B(I)
      IF (NEL.NE.I) GO TO 110
  100 CONTINUE
      GO TO 120
C
  110 WRITE(MOP,7582) I,ELPOS(I),NEL
      GO TO 2700
C
  120 DO 150 I=1,LELM
      READ (MIP,5040) NEL,EL,(NZREL(I,J),J=1,MESP)
      IF (NEL.NE.I) GO TO 110
  150 CONTINUE
C
C     ********************************************************
C        CALCULATION OF TOTAL CORE-CONTENT (GRM) OF U-235
C     A) U5O(KORE) FOR A (FIKTIVE) CORE WITH FRESH F.E.
C     B) U5B(KORE) FOR THE PRESENT BEGIN OF PERIOD  (BOC)
C     ********************************************************
C
      U5O(KORE)=0.
      U5B(KORE)=0.
      DO 200 I=1,LELM
      U5O(KORE)=U5O(KORE)+U5O(I)
  200 U5B(KORE)=U5B(KORE)+U5B(I)
C
      WRITE(MOP,6000) TITEL
      WRITE(MOP,6010)
      WRITE(MOP,6020) TPER,PCORE,LELM,MESP,KPOL,NJOB,LIST,NPWF,NW7
      WRITE(MOP,6030)
      DO 210 I=1,KORE,2
      I1=I+1
  210 WRITE(MOP,6040)  I,ELPOS(I),ELN1(I),ELN2(I),U5B(I),
     1                 I1,ELPOS(I1),ELN1(I1),ELN2(I1),U5B(I1)
      WRITE(MOP,6050)
      DO 220 I=1,KORE,2
      I1=I+1
  220 WRITE(MOP,6040)  I,ELPOS(I),ELN1(I),ELN2(I),U5O(I),
     1                 I1,ELPOS(I1),ELN1(I1),ELN2(I1),U5O(I1)
C
      WRITE(MOP,6000) TITEL
      WRITE(MOP,6055) MESP
      DO 250 I=1,LELM
  250 WRITE(MOP,6060) I,ELPOS(I),ELN1(I),ELN2(I),(NZREL(I,J),J=1,MESP)
C
```

```
C     ***************************************************************
C     CALCULATION OF A 'FLUX-FACTOR' FO RELATED TO THE MEAN
C     REACTOR POWER PCORE DURING PERIOD; FO WILL BE DEFINED
C     "PER ONE GRAMATOM U-235", BECAUSE AT THE MOMENT ONLY
C     HEU-FUEL AND FISSION OF U-235 IS CONSIDERED.
C     FO AND THE BOC-CONTENT OF U-235 DEFINES THE MEAN FLUX
C     FLXMB AT BEGIN OF PERIOD, WITH THE EOC-CONTENT U-235
C     THE MEAN FLUX FLXME AT END OF PERIOD.
C
C     SIGABS = SIGMA-ABSORPTION
C     SIGFIS = SIGMA-FISSION
C     ***************************************************************
C
C     DATA FOR U-235
C
      SIGABS=0.67000E-21
      SIGFIS=0.58200E-21
      FO=PCORE*235./(0.31040E-10*SIGFIS*0.60225E+24)
C
C     DATA FOR U-233
C
C     SIGABS=0.57800E-21
C     SIGFIS=0.52500E-21
C     FO=PCORE*233./(0.30560E-10*SIGFIS*0.60225E+24)
C
C     DATA FOR PU-239
C
C     SIGABS=1.06100E-21
C     SIGFIS=0.74600E-21
C     FO=PCORE*239./(0.32160E-10*SIGFIS*0.60225E+24)
C
C     ***************************************************************
C     FLXMB IS THE MEAN BOC-FLUX OF THE CORE AND IS RELATED TO
C     THE TOTAL CONTENT U5B(KORE) OF U-235.
C     FO IS THE BEFORESAID 'FLUX-FACTOR' FOR U-235.
C     ***************************************************************
C
      FLXMB=FO/U5B(KORE)
C
      DO 260 I=1,LELM
      DO 260 J=1,MESP
  260 ZREL(I,J)=NZREL(I,J)
CW7
      IF(NW7.EQ.0) GO TO 300
      WRITE(MOP,6990)
      WRITE(MOP,7520)
      DO 261 I=1,LELM
  261 WRITE(MOP,7010) (ZREL(I,J),J=1,MESP)
C
C     ***************************************************
C     POLYNOMIAL APPROXIMATION IN SUBROUTINE POLYN OF
C     THE COUNTING-RATES OF THE LELM F.E.; WITH THESE
C     CALCULATION OF THE INTEGRATED COUNTING-RATES XINT
C     AND ZRELM(LI) FOR EACH FUEL ELEMENT RESP.
C     ***************************************************
C
  300 DO 350 LI=1,LELM
```

```
      CALL POLYN(MESP,ZREL,KPOL,XINT,LI,XNMAX,YNMAX)
  350 ZRELM(LI)=XINT
C
C     ****************************************************************
C     BERECHNUNG DER MITTLEREN ZAEHLRATE ZRCORM FUER DAS CORE
C     AUS DEN EBEN BERECHNETEN MITTLEREN BE-ZAEHLRATEN
C     ZRELM(I), GEWICHTET MIT DEN ZU BOC EINGESETZTEN MASSEN
C     U5B(I) AN U-235 FUER DIE BE UND DEREN SUMME U5B(KORE).
C     ****************************************************************
C
      SUMZR=0.
      DO 400 I=1,LELM
  400 SUMZR=SUMZR+ZRELM(I)*U5B(I)
      ZRCORM=SUMZR/U5B(KORE)
      ZRELM(KORE)=ZRCORM
C
      WRITE(MOP,7530)
      DO 420 I=1,KORE,2
      I1=I+1
  420 WRITE(MOP,6040)  I,ELPOS(I),ELN1(I),ELN2(I),ZRELM(I),
     1                 I1,ELPOS(I1),ELN1(I1),ELN2(I1),ZRELM(I1)
      WRITE(MOP,7540) SUMZR,U5B(KORE)
C
      IF(KPOL.EQ.0) GO TO 600
C
C     ****************************************************************************
C     BEI KPOL.GT.0 WERDEN DIE ZAEHLRATEN IN DEN BE ZREL(I,J) DURCH
C     DIE MITTLERE ZAEHLRATE IM CORE ZRCORM DIVIDIERT. SIE SIND
C     DAHER IN ETWA EIN MASS FUER DAS VERHAELTNIS DER FLUESSE IN
C     DEN BRENNELEMENTEN ZUM MITTLEREN FLUSS IM CORE. IN POLYN WER-
C     DEN FUER DIESE VERAENDERTEN ZAEHLRATEN ZREL OPTIMALPOLYNOME GE-
C     SUCHT, AUS DIESEN DANN FUER AXIALE AEQUIDISTANTE PUNKTE DER
C     BE WERTE FUER 'ZR(BE)/ZR-MITTEL IM CORE' BERECHNET. DIE AUS
C     POLYN UEBERNOMMENEN ZRVMAX(I)=YNMAX SIND DANN DIE MAXIMALWERTE
C     DIESER VERHAELTNISSE ZRB/MZRC, UND  K E I N E  'MAXIMALFLUESSE'.
C
C     IN SUBROUTINE POLYN WERDEN BERECHNET UND TEILWEISE AUSGEGEBEN
C     - POLYNOM-PARAMETER
C     - ZRB/MZRC IN AXIALER RICHTUNG UND DEREN MAXIMA
C     ****************************************************************************
C
      DO 450 I=1,LELM
      DO 450 J=1,MESP
  450 ZREL(I,J)=ZREL(I,J)/ZRCORM
CW7
      IF(NW7.EQ.0) GO TO 460
      WRITE(MOP,7550)
      DO 451 I=1,LELM
  451 WRITE(MOP,7010) (ZREL(I,J),J=1,MESP)
C
  460 KPOL=2
      DO 500 LI=1,LELM
      CALL POLYN(MESP,ZREL,KPOL,XINT,LI,XNMAX,YNMAX)
      XRVMAX(LI)=XNMAX
  500 ZRVMAX(LI)=YNMAX
C
      WRITE(MOP,7560)
```

```
      DO 550 I=1,LELM,2
      I1=I+1
  550 WRITE(MOP,6045)  I,ELPOS(I),ELN1(I),ELN2(I),XRVMAX(I),ZRVMAX(I),
     1            I1,ELPOS(I1),ELN1(I1),ELN2(I1),XRVMAX(I1),ZRVMAX(I1)
C
C     ********************************************************************
C     BERECHNUNG DER POSITIONS-GEWICHTSFAKTOREN PFAC(I) FUER DIE
C     BRENNELEMENTE AUS IHREN EBEN BERECHNETEN MITTLEREN ZAEHLRATEN
C     ZRELM(I) DIVIDIERT DURCH DIE MITTL. CORE-ZAEHLRATE ZRCORM.
C
C     NPWF ENTSCHEIDET UEBER DIE WEITERE BEARBEITUNG DER POS.GEW.FAKT.
C     ----------------------------------------------------------------
C     NPWF=0 WERDEN SIE WIE FRUEHER NICHT AUF PFAC(CORE)=1.0 NORMIERT,
C             TROTZDEM PFAC(KORE) = 1.0 GESETZT,
C     NPWF=1 WERDEN SIE WIE FRUEHER NICHT AUF PFAC(CORE)=1.0 NORMIERT,
C             ABER PFAC(KORE) = (PFACSUM/25).GT.1.0 GESETZT,
C     NPWF=2 WERDEN SIE AUF PFAC(CORE)=PFACSUM/LELM=1.0 NORMIERT.
C     ********************************************************************
C
  600 DO 650 I=1,LELM
  650 PFAC(I)=ZRELM(I)/ZRCORM
      FACSUM=0.0
      DO 700 I=1,LELM
  700 FACSUM=FACSUM+PFAC(I)
      XLELM=LELM
      FACP=FACSUM/XLELM
      IF(NPWF.GT.0) GO TO 750
      PFAC(KORE)=1.0
      GO TO 950
C
  750 PFAC(KORE)=FACP
      IF(NPWF.EQ.1) GO TO 950
      DO 800 I=1,KORE
  800 PFAC(I)=PFAC(I)/FACP
      FACSUM=0.0
      DO 900 I=1,LELM
  900 FACSUM=FACSUM+PFAC(I)
C
C     ************************************************
C     BERECHNUNG DER MITTLEREN BE-LEISTUNGEN PMEL
C     DURCH MULTIPLIKATION VON PCORE/LELM = PMELO
C     MIT DEN POS.GEW.-FAKTOREN PFAC(I) DER BE
C     ALS VORBEREITUNG ZUR UEBERGABE AN ORIGEN
C     ************************************************
C
  950 PMELO=PCORE/LELM
      DO 1000 I=1,LELM
 1000 PMEL(I)=PMELO*PFAC(I)
      PMCORE=0.0
      DO 1050 I=1,LELM
 1050 PMCORE=PMCORE+PMEL(I)
CW7
      IF(NW7.EQ.0) GO TO 1080
      WRITE(MOP,6000) TITEL
      WRITE(MOP,7561) NPWF
      WRITE(MOP,7570)
      DO 1060 I=1,KORE,2
```

```
      I1=I+1
 1060 WRITE(MOP,6040) I,ELPOS(I),ELN1(I),ELN2(I),PFAC(I),
     1                I1,ELPOS(I1),ELN1(I1),ELN2(I1),PFAC(I1)
      WRITE(MOP,7571) LELM,FACSUM
      WRITE(MOP,7580) PMELO
      DO 1070 I=1,LELM,2
      I1=I+1
 1070 WRITE(MOP,6040) I,ELPOS(I),ELN1(I),ELN2(I),PMEL(I),
     1                I1,ELPOS(I1),ELN1(I1),ELN2(I1),PMEL(I1)
      WRITE(MOP,7581) PMCORE,PCORE
C
C     ************************************
C     BERECHNUNG DER NORMIERTEN QUADRATE
C     QUAD(I) DER PEAKFAKTOREN PFAC(I)
C     ************************************
C
 1080 SUMQ=0.
      DO 1090 I=1,LELM
      QUAD(I)=PFAC(I)*PFAC(I)
 1090 SUMQ=SUMQ+QUAD(I)
      XLELM=LELM
      QUAD(KORE)=SUMQ/XLELM
      FAC=QUAD(KORE)
      DO 1100 I=1,KORE
 1100 QUAD(I)=QUAD(I)/FAC
C
      WRITE(MOP,6000) TITEL
      WRITE(MOP,6200)
      DO 1110 I=1,KORE,2
 1110 WRITE(MOP,6210) ELPOS(I),PFAC(I),QUAD(I),
     1                ELPOS(I+1),PFAC(I+1),QUAD(I+1)
C
C     ************************************************************************
C     BERECHNUNG ABBRAND VON U-235 IN DEN EINZELNEN BRENNELEMENTEN
C     UND FUER DAS CORE (DATENINDEX KORE) UNTER BENUTZUNG DER EBEN
C     BERECHNETEN PEAKFAKTOREN PFAC(I).
C
C     U5E(I)  EOC-RESTMASSE U-235 (GRM) DER BE AUS ANAL. LOESUNG
C     U5ESUM  SUMME U5E(I), EOC-RESTMASSE U-235 (GRM) DES CORES,
C             SOLLTE NAHE BEI U5E(KORE) AUS ANAL. LOESUNG LIEGEN
C     BUG(I)  U-235-ABBRAENDE (GRM) DER BE IN DER PERIODE
C     BU$(I)  %-TUALE U-235-ABBRAENDE DER BE IN DER PERIODE
C     BUGSUM  SUMME BUG(I), PERIODENABBRAND (GRM) U-235 DES GESAMTCORES
C     BUGT(I) U-235-ABBRAENDE (GRM) DER BE BZGL. FRISCHER BE U5O(I)
C     BU$T(I) %-TUALE U-235-ABBRAENDE DER BE BZGL. FRISCHER BE U5O(I)
C     SUBUGT  SUMME BUGT(I), COREABBRAND (GRM) BZGL. FRISCHER BE U5O(I)
C     BU$TKE  SUMME BU$T(I)/LELM = MITTL. PROZ. ABBRAND DES GESAMTCORES
C
C     FLXMB   MITTLERER CORE-FLUSS AM ANFANG DER BETRIEBSPERIODE
C     FLXME   MITTLERER CORE-FLUSS AM ENDE DER BETRIEBSPERIODE
C     ************************************************************************
C
      A1=SIGABS*FLXMB*TPER
      A2=1.-A1
      FLXME=FLXMB/A2
      U5ESUM=0.0
      BUGSUM=0.0
```

```
      SUBUGT=0.0
      BU$TKE=0.0
C
      DO 1250 I=1,KORE
      U5E(I)=U5B(I)*A2**PFAC(I)
      BUG(I)=U5B(I)-U5E(I)
      BUGT(I)=U5O(I)-U5E(I)
      IF (U5O(I)) 1200,1150,1200
 1150 BU$(I)=0.0
      BU$T(I)=0.0
      GO TO 1250
 1200 BU$(I)=BUG(I)*100./U5O(I)
      BU$T(I)=BUGT(I)*100./U5O(I)
      BU$TKE=BU$TKE+BU$T(I)
 1250 CONTINUE
      BU$TKE=BU$TKE/25.
C
      DO 1300 I=1,LELM
      U5ESUM=U5ESUM+U5E(I)
      BUGSUM=BUGSUM+BUG(I)
 1300 SUBUGT=SUBUGT+BUGT(I)
C
      WRITE(MOP,6000) TITEL
      WRITE(MOP,6220)
      WRITE(MOP,6280) FLXMB,FLXME
      WRITE(MOP,6300)
C
      DO 1800 I=1,KORE
      IF (I.EQ. 5) WRITE(MOP,6470)
      IF (I.EQ.11) WRITE(MOP,6470)
      IF (I.EQ.16) WRITE(MOP,6470)
      IF (I.EQ.22) WRITE(MOP,6470)
      IF (I.EQ.26) WRITE(MOP,6470)
 1800 WRITE(MOP,6360) ELPOS(I),U5E(I),BUG(I),BUGT(I),BU$(I),BU$T(I)
      WRITE(MOP,6380)
      WRITE(MOP,6400) U5O(KORE),U5B(KORE),U5E(KORE),U5ESUM,
     1                BUGSUM,SUBUGT,BU$TKE
C
C     ***************************************************************************
C        BERECHNUNG DES MAXIMUMS DER MITTLEREN BE-LEISTUNG IN W
C        ------------------------------------------------------
C
C     QBMAX(I) MITTLERE BE-LEISTUNG AM PERIODEN-BEGINN BOC IN W
C     QEMAX(I) MITTLERE BE-LEISTUNG AM PERIODEN-ENDE   EOC IN W
C     PMAX     MAXIMUM ALLER MITTLEREN BE-LEISTUNGEN
C              QBMAX(I) (BOC) UND QEMAX(I) (EOC)           IN W
C     LLL      KENNZAHL DES MIT PMAX BELASTETEN BE
C
C     FLXMB    MITTLERER CORE-FLUSS AM PERIODEN-BEGINN BOC CM-2*S-1
C     FLXME    MITTLERER CORE-FLUSS AM PERIODEN-ENDE   EOC CM-2*S-1
C     ***************************************************************************
C
      IF(KPOL.GT.0) GO TO 1950
      DO 1900 I=1,LELM
      XRVMAX(I)=0.
 1900 ZRVMAX(I)=0.
C
```

```
 1950 C=PCORE/FO
      DO 2000 I=1,LELM
      QBMAX(I)=C*U5B(I)*FLXMB*PFAC(I)
 2000 QEMAX(I)=C*U5E(I)*FLXME*PFAC(I)
      PMAX=QBMAX(1)
      LLL=1
      DO 2100 I=1,LELM
      IF(QBMAX(I)-PMAX) 2100,2100,2050
 2050 PMAX=QBMAX(I)
      LLL=I
 2100 CONTINUE
      DO 2200 I=1,LELM
      IF(QEMAX(I)-PMAX) 2200,2200,2150
 2150 PMAX=QEMAX(I)
      LLL=I
 2200 CONTINUE
C
      SQBMAX=0.0
      SQEMAX=0.0
      DO 2210 I=1,LELM
      SQBMAX=SQBMAX+QBMAX(I)
 2210 SQEMAX=SQEMAX+QEMAX(I)
C
C     ************************************************
C     BERECHNUNG DER ENTLADEWARTEZEIT TWAIT(IJ)
C     PBMIT MITTLERE BE-LEISTUNG ZU PERIODENENDE
C     ABGES GESAMTER AUF DAS FRISCHE BRENNELEMENT
C           BEZOGENER ABBRAND AN U-235
C     ************************************************
C
      DO 2250 IJ=1,LELM
      PBMIT=QEMAX(IJ)
      ABGES=BUGT(IJ)
      F1=36000./PBMIT
      F2=((ABGES*6.912E10)/PBMIT)**(-0.2)
      F3=0.87*((ABGES*6.912E10)/PBMIT+2.E7)**(-0.2)
      F4=0.0384
 2250 TWAIT(IJ)=(F1+F2-F3+F4)**(-5.)/3600
C
      DO 2350 KK=1,3
      WRITE(MOP,6000) TITEL
      WRITE(MOP,6420)
      WRITE(MOP,6440)
      DO 2300 I=1,LELM
      IF (I.EQ. 5) WRITE(MOP,6470)
      IF (I.EQ.11) WRITE(MOP,6470)
      IF (I.EQ.16) WRITE(MOP,6470)
      IF (I.EQ.22) WRITE(MOP,6470)
      IF (I.EQ.26) WRITE(MOP,6470)
 2300 WRITE(MOP,6460) I,ELPOS(I),ELN1(I),ELN2(I),
     1                ZRVMAX(I),QBMAX(I),QEMAX(I),TWAIT(I)
 2350 WRITE(MOP,6480)
C
C     ************************
C     UMWANDLUNG PMAX  IN KW
C     UMWANDLUNG PCORE IN MW
```

```
C     ************************
C
      PMAX=PMAX*1.0E-03
      PCORE=PCORE*1.0E-06
      IF(LIST.LE.0) GO TO 2700
C
      CALL ZEITK
      DO 2650 IK=1,LIST
      WRITE(MOP,6620)
      WRITE(MOP,6640)
      WRITE(MOP,6005) (TITEL(I),I=1,59)
      WRITE(MOP,6006) (TITEL(I),I=60,72)
      WRITE(MOP,6700)
      WRITE(MOP,6720)
      DO  2600 I=1,LELM
      IF (I.EQ. 5) WRITE(MOP,6470)
      IF (I.EQ.11) WRITE(MOP,6470)
      IF (I.EQ.16) WRITE(MOP,6470)
      IF (I.EQ.22) WRITE(MOP,6470)
      IF (I.EQ.26) WRITE(MOP,6470)
 2600 WRITE(MOP,6740) ELPOS(I),ELN1(I),ELN2(I),U5O(I),U5E(I),
     1                BUGT(I),BU$T(I)
      WRITE(MOP,6780) XMWH
      WRITE(MOP,6790) PCORE
      WRITE(MOP,6800) ELPOS(LLL),PMAX
      WRITE(MOP,6820) U5B(KORE)
      WRITE(MOP,6840) U5ESUM
      WRITE(MOP,6860) BUGSUM
      WRITE(MOP,6880) NTAG,MONAT,JAHR
 2650 CONTINUE
      WRITE(MOP,6900)
      XNPWF=NPWF
      WRITE(MOP,7000) XNPWF,SQBMAX,SQEMAX,PMCORE,PCORE
C
      KJOB=KJOB+1
      IF(NJOB.GT.KJOB) GO TO 50
C
 2700 STOP
C
C     EINGABE-FORMATE
C
 5000 FORMAT(72A1)
 5010 FORMAT(2E12.5,10I4)
 5020 FORMAT(I4,2X,A2,2X,2A4,1X,2F8.2)
 5040 FORMAT(I4,2X,A2,2X,7I6)
C
C     AUSGABE-FORMATE
C
 6000 FORMAT('1',72A1/70('*'))
 6005 FORMAT(T2,59A1)
 6006 FORMAT(T25,13A1/)
 6010 FORMAT(//T7,'PER.ZEIT(S)   LEISTG(W)   ELEM MESP KPOL NJOB ',
     1             'LIST NPWF  NW7'/)
 6020 FORMAT(T5,1P2E13.5,7I5)
 6030 FORMAT(/T14,'BOC-MASSEN DER BRENNELEMENTE IN GRAMM U-235'/,
     1        T14,43('-')/)
 6040 FORMAT(T2,2(I6,2X,A2,2X,2A4,1PE13.5))
```

```
6045 FORMAT(T3,2(I4,2X,A2,2X,2A4,F8.2,F7.3))
6050 FORMAT(/T9,'ORIGINALMASSEN DER FRISCHEN BRENNELEMENTE IN ',
    1           'GRAMM U-235'/,
    2        T9,56('-')/)
6055 FORMAT(/T14,'ZAEHLRATEN JE ELEMENT AN',I2,' AXIALEN MESSPUNKTEN'/,
    1        T9,'MIT 0.0 CM=OBERES, 60.0 CM=UNTERES ENDE DER AKTIVEN ',
    2           'ZONE'/T9,56('-')//,
    3        T4,'NR POS  BE-LABEL   0.0    10.0   20.0   30.0   40.0',
    4             '   50.0   60.0'/)
6060 FORMAT(T4,I2,2X,A2,2X,2A4,7I7)
6200 FORMAT(////'    POS  POSGEWFAKT   NORM.QUADR.',
    1             '   POS  POSGEWFAKT   NORM.QUADR.'/)
6210 FORMAT(/1X,2(4X,A2,1P2E13.5))
6220 FORMAT(//T24,'ABBRANDDATEN FUER U-235',
    1        /T24,23('-'))
6280 FORMAT(/T3,'MITTL. PERIODENFLUESSE BOC =',1PE11.4,
    1           ', EOC =',E11.4,' N*CM-2*SEC-1')
6300 FORMAT(/'  POS   REST U235(G)  ABB.PER.(G)  ABB.GES.(G)',
    1        '  ABB.PER.(%)  ABB.GES.(%)'/)
6360 FORMAT(T4,A2,2X,1P5E13.5)
6380 FORMAT(/T10,'WERTE KE GERECHNET MIT BOC-GESAMTMASSE U-235'/
    1        T10,44('-'))
6400 FORMAT(//
    1    T3,'A) GES.-MASSE FRISCHER BRENNELEMENTE         =',1PE12.5,
    2             ' GRAMM U-235'/
    3    T3,'B) BOC-GES.-MASSE ZU PERIODENBEGINN          =',E12.5,
    4             ' GRAMM U-235'/
    5    T3,'C) EOC-GES.-MASSE ZU PERIODENENDE (AN.LSNG.) =',E12.5,
    6             ' GRAMM U-235'/
    7    T3,'D) EOC-GES.-MASSE ZU PERIODENENDE (SUMME BE) =',E12.5,
    8             ' GRAMM U-235'/
    9    T3,'E) PERIODEN-ABBRAND BOC-EOC (B-D)            =',E12.5,
    A             ' GRAMM U-235'/
    B    T3,'F) GES. ABBR. EOC BZGL. FR. CORE (A-D)       =',E12.5,
    C             ' GRAMM U-235'/
    D    T3,'G) MITTL. PROZ. ABBRAND DES CORES (100*F/A)  =',E12.5,
    E             ' %')
6420 FORMAT(T5,'MAXIMA DER VERHAELTNISSE DER BERECHNETEN ZAEHLRATEN ',
    1          'ZRB IN DEN BE'/,
    2       T5,'ZU DER MITTL. ZAEHLRATE MZRC IM CORE, MITTL. ',
    3          'LEISTUNGEN ZU ANFANG'/,
    4       T5,'(BOC) UND ENDE (EOC) DER PERIODE IN W, ENTLADE-',
    5          'WARTEZEITEN IN H'/,
    5       T5,65('-')/)
6440 FORMAT(T4,'NR POS  BE-LABEL  MAX ZRB/MZRC  LEISTG BOC  ',
    1       'LEISTG EOC   WARTEZEIT')
6460 FORMAT(/T4,I2,2X,A2,2X,2A4,2X,1P5E12.4)
6470 FORMAT(/)
6480 FORMAT(/T7,' NICHT BERECHNETE VERHAELTNISSE MAX ZRB/MZRC = 0.0',
    1           ' GESETZT')
6620 FORMAT(1H1//)
6640 FORMAT(' ZABT.FORSCHUNGSREAKTOREN '/' REAKTORUEBERWACHUNG'//)
6700 FORMAT('  POS.   BE-NR.      MORG(G)    MEND(G)  ABBR.(G)',
    1       '  ABBR.(%)' )
6720 FORMAT(/T2,59('-'))
6740 FORMAT('  ',A2,4X,2A4,5X,F6.2,5X,F6.2,4X,F6.2,4X,F6.2)
6780 FORMAT(//T6,'LEISTUNGSINTEGRAL UEBER DIE PERIODE   ',F10.2,' MWH')
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6790 FORMAT(T6,'MITTLERE REAKTORLEISTUNG IN DER PERIODE',F9.2,' MW')
6800 FORMAT(T6,'MAXIMALE LEISTUNG IN POSITION ',A2,4X,F12.2,' KW'//)
6820 FORMAT(T6,'U-235-INHALT BEI PERIODENBEGINN BOC:',F10.2,' GRAMM')
6840 FORMAT(T6,'U-235-INHALT BEI PERIODENENDE EOC  :',F10.2,' GRAMM')
6860 FORMAT(T6,'U-235-VERBRAUCH IN DER PERIODE     :',F10.2,' GRAMM'//)
6880 FORMAT(T6,'JUELICH, DEN 'I2,'.',I2,'.19',I2,
    1       T39,'GEZ. BORMANN/KALKER')
6900 FORMAT(1H1)
6990 FORMAT(//)
7000 FORMAT(1P5E13.5)
7010 FORMAT(1P7E13.5)
7500 FORMAT(/T4,'COREMASSE U-235 BOC UND FUER FRISCHE BE'/)
7520 FORMAT(/T4,'ZAEHLRATEN ALS REALZAHLEN'/)
7530 FORMAT(/T12,'MITTLERE INTEGRALE ZAEHLRATEN IN BE UND CORE (KE)',
    1       /T12,49('-')/)
7531 FORMAT(T4,I2,2X,A2,2X,2A4,1PE13.5)
7540 FORMAT(/T4,'Z.-RATE IM CORE (KE) GEMITTELT UEBER DIE BOC-BE-',
    1           'INHALTE AN U-235',
    2       /T4,'SUMME DER GEW. MITTL. ZAEHLRATEN IN DEN BE SUMZR  =',
    3            1PE13.5,
    4       /T4,'BOC-GESAMTINHALT DES CORES AN U-235 U5B(CORE)     =',
    5            1PE13.5/)
7550 FORMAT(/T4,'DURCH DIE MITTLERE ZAEHLRATE IM CORE ZRCORM',/,
    1        T4,'DIVIDIERTE ZAEHLRATEN IN DEN BE. FUER SIE',/,
    2        T4,'WERDEN OPT.-POL. GESUCHT, DANN FUER 24 PKTE.',/,
    3        T4,'IN DEN BE DIE WERTE ZRB/MZRC BERECHNET.'/)
7560 FORMAT(/T12,'ORT VON BE-OBERKANTE IN CM UND MAXIMUM ZRB/MZRC'/,
    1        T12,47('-')//)
7561 FORMAT(/T14,'NPWF BESTIMMT DIE FORM DER POS.GEW.FAKTOREN',//
    1        T14,'NPWF=0 WERDEN SIE NICHT AUF 1.0 NORMIERT,'/,
    2        T14,'       PFAC(CORE)=1.0 GESETZT'/,
    3        T14,'NPWF=1 WERDEN SIE NICHT AUF 1.0 NORMIERT,'/,
    4        T14,'       PFAC(CORE)=(PFACSUM/LELM).NE.1.0'/,
    5        T14,'NPWF=2 WERDEN SIE AUF 1.0 NORMIERT '/,
    6        T14,'       PFAC(CORE)=(PFACSUM/LELM).EQ.1.0'//,
    7        T19,'  FUER DIESE RECHNUNG IST NPWF = ',I1/,
    8        T19,'  --------------------------------')
7570 FORMAT(/T18,'POS.-GEW.-FAKTOREN DER BE UND DES CORES',
    1       /T18,39('-')/)
7571 FORMAT(/T6,'SUMME PFACSUM DER POS.-GEW.-FAKTOREN DER',I3,' BE  =',
    1            1PE13.5//T4,66('*')/)
7580 FORMAT(/T5,'MITTL. LEISTUNG PMEL(I) DER BE IN W GEBILDET ALS ',
    1           'PRODUKT AUS DEN',
    2       /T10,'POSITIONSGEWICHTSFAKTOREN PFAC(I) DER BE MIT DEM ',
    2           'WERT',/
    3       /T12,'(MITTL. CORELEISTUNG/LELM) = PMELO =',1PE12.5,' W',/,
    5       /T5,64('-')/)
7581 FORMAT(/T6,'PMCORE =  SUMME DER MITTL. BE-LEISTUNGEN PMEL(I) =',
    1            1PE12.5,
    2       /T6,'PCORE  =  DIE MITTL. EINGEGEBENE CORELEISTUNG    =',
    3            1PE12.5)
7582 FORMAT(/T10,'DAS ',I2,'. ELEMENT MIT COREPOSITION ',A2,' IST ',
    1           'FALSCH ALS ',I2,'. EINGEORDNET',/,
    1        T20,'       EINLESEN WIRD ABGEBROCHEN         ',/,
    2        T10,66('*'))
     END
```

```
      SUBROUTINE POLYN(N,Z,KPOL,XINT,LI,XNMAX,YNMAX)
C     ***********************************************
      REAL*8    A(7,8),B(7)
      DIMENSION X(7),Q(7),D(7),XN(30),YN(30),Y(7),Z(30,7)
      DIMENSION G(7,7),C(10,7)
      DIMENSION ELN1(30),ELN2(30),TITEL(72)
      INTEGER*2 ELPOS(30)
      COMMON/ELDAT/ELN1,ELN2,ELPOS,TITEL,NPAG
C
      MIP=5
      MOP=6
C
C     ***************************************************************************
C     POLYNOM-ANPASSUNG DER MESP ZAEHLRATEN  FUER JEDES BRENNELEMENT
C     ES WIRD UEBER DIE METHODE DER KLEINSTEN FEHLERQUADRATE FUER
C     JEDES BRENNELEMENT DAS OPTIMALE ANPASSUNGSPOLYNOM GESUCHT.
C     ***************************************************************************
C
      DO 10 I=1,7
   10 Q(I)=0.
      NORD1=2
      LORD=1
      NTEILG=24
      XN(1)=N-1
      DO 50 I=1,N
      XI=I
   50 X(I)=(XI-1.)*60./XN(1)
      DO 60 I=1,N
   60 Y(I)=Z(LI,I)
      DO 100 I=1,N
  100 G(1,I)=1.
      NORD=NORD1
      GO TO 120
  110 NORD=NORD+1
  120 DO 200 J=2,NORD
      J1=J-1
      DO 200 I=1,N
  200 G(J,I)=X(I)**J1
      DO 300 M=1,NORD
      DO 303 K=1,NORD
      A(M,K)=0.
      DO 306 I=1,N
      A(M,K)=A(M,K)+G(M,I)*G(K,I)
  306 CONTINUE
  303 CONTINUE
  300 CONTINUE
      DO 400 M=1,NORD
      L=NORD+1
      A(M,L)=0.
      DO 403 I=1,N
      A(M,L)=A(M,L)+Y(I)*G(M,I)
  403 CONTINUE
  400 CONTINUE
      CALL MATRIX (A,NORD,B)
      DO 500 L=1,NORD
      C(L,NORD)=B(L)
  500 CONTINUE
```

```
      Q(NORD)=0.
      XN2=N-NORD
      DO 600 I=1,N
      D(I)=0.
      DO 700 J=1,NORD
  700 D(I)=D(I)+C(J,NORD)*G(J,I)
  600 Q(NORD)=Q(NORD)+(D(I)-Y(I))**2
      Q(NORD)=Q(NORD)/XN2
      Q(NORD)=SQRT(Q(NORD))
      N7=N-1
      IF (NORD-N7)110,620,620
  620 QMIN=Q(NORD1)
      L1=NORD1
      N1=NORD1+1
      DO 800 L=N1,NORD
      IF (Q(L)-QMIN)820,800,800
  820 QMIN=Q(L)
      L1=L
  800 CONTINUE
      IF(KPOL.EQ.2) GO TO 3000
C
C     ************************************************************
C     NUR BEI ERSTEM CALL POLYN
C
C     AUS INTEGRIERTEN ZAEHLRATEN WERDEN IHRE MITTEL-
C     WERTE ZRELM(I) FUER DIE BE BESTIMMT, MIT DENEN
C     DIE GEMITTELTE ZAEHLRATE ZRCORM FUER DAS CORE
C     UND ANSCHLIESSEND DIE POSITIONS-GEWICHTSFAKTOREN
C     PFAC(I) FUER DIE BRENNELEMENTE BESTIMMT WERDEN.
C     ************************************************************
C
      XINTO=0.
      XINTU=0.
      DO 2000 L=1,L1
      XL=L
      XINTO=XINTO+C(L,L1)*(X(N)**L)/XL
 2000 XINTU=XINTU+C(L,L1)*(X(1)**L)/XL
      XINT=XINTO-XINTU
      XINT=XINT/(X(N)-X(1))
      RETURN
C
C     ************************************************************
C     BEIM ZWEITEN CALL POLYN WENN KPOL.GT.0; IN DIESEM
C     FALL WIRD IM HAUPTPROGRAMM AUTOMATISCH KPOL = 2
C     GESETZT. DIE ZAEHLRATEN Z SIND DANN SCHON DURCH
C     DIE MITTLERE ZAEHLRATE ZRCORM IM CORE DIVIDIERT,
C     D.H., DIE POLYNOM-ANPASSUNG ERFOLGTE FUER DIESE
C     'GEMITTELTEN' ZAEHLRATEN, DENEN DANN AUCH DIE
C     POLYNOMWERTE YN(I) ENTSPRECHEN. NUR IM SINNE DIE-
C     SER AUS DEN POLYNOMEN GEWONNENEN, DURCH ZRCOM DI-
C     VIDIERTEN ZAEHLRATEN KANN VON PHI(BE)/PHI-MITTEL
C     IM CORE (WIE FRUEHER GESCHEHEN) GESPROCHEN WERDEN!
C     DAS GLEICHE GILT FUER DIE 'MAXIMALEN FLUESSE' YNMAX,
C     DIE NICHTS ANDERES DARSTELLEN ALS DAS MAXIMUM DER
C     AUS DEN POLYNOMEN BERECHNETEN YN(I) UND MIT DER
C     UNZUTREFFENDEN BEZEICHNUNG PHI(BE)/PHI-MITTEL AXIAL
C     FRUEHER AUSGEGEBEN WURDEN.
```

```
C
C     BEI KPOL=2
C     - AUSSCHREIBEN DER POLYNOM-PARAMETER
C     - BERECHNUNG UND AUSSCHREIBEN DER ZRB/MZRC
C     - BERECHNUNG DER MAXIMA DER ZRB/MZRC UND UEBERGABE
C     ***************************************************
C
 3000 IF(NPAG.NE.0) GO TO 3500
      WRITE(MOP,6000) TITEL
      NPAG=2
 3500 WRITE(MOP,6100) ELPOS(LI),LI,ELN1(LI),ELN2(LI)
      LJ=L1-1
      WRITE(MOP,6140) LJ
      DO 910 L=1,L1,5
      IA=L
      IE=L+4
      IF((L1-L).LT.5) IE=L1
  910 WRITE(MOP,6160) (K,C(K,L1),K=IA,IE)
      DO 930 L=NORD1,NORD,5
      L2=L+1
      L3=L+2
      L4=L+3
      L5=L+4
      WRITE(MOP,6180)
  930 WRITE(MOP,6200)L,Q(L),L2,Q(L2),L3,Q(L3),L4,Q(L4),L5,Q(L5)
C
C     ***********************************************
C     BERECHNUNG DER AXIALEN ZRB/MZRC PRO ELEMENT
C     ACHTUNG, SIEHE BEMERKUNGEN IM VORIGEN BLOCK.
C     ***********************************************
C
      XNT=NTEILG
      DELH=(X(N)-X(1))/XNT
      NT1=NTEILG+1
      XN(1)=X(1)
      DO 1000 I=2,NT1
 1000 XN(I)=XN(I-1)+DELH
      L=L1
      DO 1100 I=1,NT1
      YN(I)=0.
      IF (XN(I))1150,1160,1150
 1160 YN(I)=C(1,L)
      GO TO 1100
 1150 DO 1170 J=1,L
      J1=J-1
 1170 YN(I)=YN(I)+(XN(I)**J1)*C(J,L)
 1100 CONTINUE
C
      L7=L-1
      WRITE(MOP,6220)
      WRITE(MOP,6240)
      DO 1200 I=1,NT1,4
      LA=I
      LE=I+3
      IF((NT1-I).LT.4) LE=NT1
 1200 WRITE(MOP,6260) (XN(L),YN(L),L=LA,LE)
      KI=LI/2
```

```
      NI=KI*2
      IF(LI.NE.NI) WRITE(MOP,6270)
C
C     ***********************************************
C     BESTIMMUNG DER MAXIMA YNMAX DER ZRB/MZRC
C     UND IHRER POSITION XNMAX IM BRENNELEMENT
C     ***********************************************
C
      YNMAX=YN(1)
      DO 1220 K=1,NT1
      IF (YN(K)-YNMAX)1220,1220,1210
 1210 XNMAX=XN(K)
      YNMAX=YN(K)
 1220 CONTINUE
      NPAG=NPAG-1
      RETURN
C
C     AUSGABE-FORMATE
C
 6000 FORMAT('1',72A1/72('*'))
 6100 FORMAT(/T10,'WERTE FUER CORE-POSITION ',A2,' ELEMENT',I3,4X,2A4/,
     1        T10,50('*')/)
 6140 FORMAT(T13,'KOEFFIZIENTEN DES OPTIMAL-POLYNOMS VOM GRAD',I2/,
     1       T13,45('-')/)
 6160 FORMAT(5(I3,1PE11.3))
 6180 FORMAT(/T13,'MITTL. QUADR. FEHLER DER POLYNOME GRAD 2 BIS 6'/,
     1        T13,46('-')/)
 6200 FORMAT(5(I3,1PE11.3))
 6220 FORMAT(//T11,'VERH. DER BERECHNETEN ZAEHLRATEN IM BRENNELEMENT'/,
     1       T11,'ZUR MITTLEREN ZAEHLRATE IM GESAMTEN CORE (AXIAL)'/,
     2       T11,'0.0 CM = OBERE, 60.0 CM = UNTERE KANTE AKTIVTEIL'/,
     3       T11,48('_')/)
 6240 FORMAT(T2,4(3X,' CM  ZRB/MZRC')/)
 6260 FORMAT(4(F9.2,F7.3))
 6270 FORMAT(/70('*')/)
      END
                          SUBROUTINE MATRIX(A,N,X)
C                         ************************
C
C     ***********************************************************
C     DETERMINATENBERECHNUNG DURCH DREIECKSZERLEGUNG
C     ***********************************************************
C
      IMPLICIT REAL*8(A-H,O-Z)
      DIMENSION X(7),A(7,8)
C
      KZA=0
      KD=2
      M1=N+1
      IF(N.LT.2) GO TO 100
      N1=N-1
      GO TO 200
  100 N1=N
  200 DO 800 NN=1,N1
      DO 500 I=NN,N
      P=DABS(A(NN,NN))
      Q=DABS(A(I,NN))
```

```
      IF (P-Q) 300,500,500
  300 KZA=KZA+1
      DO 400 K=NN,M1
      AA=A(NN,K)
      A(NN,K)=A(I,K)
  400 A(I,K)=AA
  500 CONTINUE
      L=NN+1
      K1=NN+1
      DO 700 I=L,N
      A(I,NN)=A(I,NN)/A(NN,NN)
      DO 600 KK=K1,M1
  600 A(I,KK)=A(I,KK)-A(I,NN)*A(NN,KK)
  700 CONTINUE
  800 CONTINUE
      SUM=0.
      DO 1000 I=1,N
      II=N+1-I
      X(II)=(A(II,M1)-SUM)/A(II,II)
      IF (N.EQ.I) GO TO 1100
      SUM=0.
      DO 900 K=1,I
      III=N-I
      K2=M1-K
  900 SUM=A(III,K2)*X(K2)+SUM
 1000 CONTINUE
 1100 D=A(1,1)
      GO TO (1200,1400),KD
 1200 DO 1300 I=2,N
 1300 D=D*A(I,I)
      KZA=(-1)**KZA
      ZKA=KZA
      D=D*ZKA
 1400 RETURN
      END
      BLOCK DATA
      DIMENSION ELN1(30),ELN2(30),TITEL(72)
      INTEGER*2 ELPOS(30)
      COMMON/ELDAT/ELN1,ELN2,ELPOS,TITEL,NPAG
      DATA ELPOS/'A1','A2','A3','A4','B1','B2','B3','B4','B5','B6',
     1           'C1','C2','C3','C4','C5','D1','D2','D3','D4','D5',
     2           'D6','E1','E2','E3','E4','KE','NN','NN','NN','NN'/
      END
                          SUBROUTINE ZEITK
C                         ****************
      DIMENSION MON(12),MONS(12)
      DATA MON /31,59,90,120,151,181,212,243,273,304,334,365/
      DATA MONS /31,60,91,121,152,182,213,244,274,305,335,366/
C
      COMMON/CODAT/NTAG,MONAT,JAHR,NUHR,MIN
C
      A=ZEIT(0.)
      NS=IFIX(A)
      MIN=NS/60
      NUHR=MIN/60
      MIN=MOD(MIN,60)
      CALL DATUM (JAHR,ITAG)
```

```
      IF ((MOD(JAHR,4)).EQ.0) GO TO  100
      DO 1                    I=1,12
      M=I
      IF (ITAG-MON(I))        110,110,1
    1 CONTINUE
  100 DO 10                   I=1,12
      M=I
      IF (ITAG-MONS(I))       120,120,10
   10 CONTINUE
  110 IF (M.EQ.1)             NTAG=ITAG
      IF (M.NE.1)             NTAG=ITAG-MON(M-1)
      GO TO                   200
  120 IF (M.EQ.1)             NTAG=ITAG
      IF (M.NE.1)             NTAG=ITAG-MONS(M-1)
  200 MONAT=M
      RETURN
      END
```

PROGRAM LISTING CURIAX

```
C*********************************************************************
C***              ZFR/KFA/JUELICH/FRG                              ***
C***  CALCULATION OF RESIDUAL HEAT AND ACTIVITIES OF               ***
C***              FUEL ELEMENTS BURNED UP                          ***
C*********************************************************************
C
      DIMENSION BESIGN(100,10),CI(100),P0(100),PG(100),
     1          TB(100),TB1(100),TW(100),TW1(100),XMA(100),
     2          TWE(100),TITEL(20)
C
C
      MIP=5
      MOP=6
C
      READ (MIP,5000) TITEL
      READ (MIP,5010) KBE,NCOP,TKW
      IF(NCOP.EQ.0) NCOP=3
C
      DO 200 I=1,KBE
      READ (MIP,5020) (BESIGN(I,J),J=1,10),XMA(I),TB(I),TW(I)
      TWE(I)=TW(I)+TKW
      TW1(I)=TWE(I)*8.64E+04
      TB1(I)=TB(I)*8.64E+04
      P0(I)=XMA(I)/(1.26*TB(I))*1.0E+06
      A=-0.2
      PG(I)=0.0565*P0(I)*(TW1(I)**A-(TW1(I)+TB1(I))**A)
      CI(I)=PG(I)*2.09E+02
  200 CONTINUE
C
      DO 400 II=1,NCOP
      WRITE(MOP,6000)
      WRITE(MOP,6010) TITEL
      WRITE(MOP,6020)
      DO 300 I=1,KBE
  300 WRITE(MOP,6030) (BESIGN(I,J),J=1,10),XMA(I),TB(I),TWE(I),
     1                P0(I),PG(I),CI(I)
      WRITE(MOP,6040)
  400 CONTINUE
      STOP
C
C       INPUT AND OUTPUT FORMATS
C
 5000 FORMAT(20A4)
 5010 FORMAT(2I5,F10.3)
 5020 FORMAT(10A1,3F10.3)
C
 6000 FORMAT('1',///T15,'RESTLEISTUNG UND AKTIVITAET ABGEBRANNTER ',
     1           'BRENNELEMENTE'/)
 6010 FORMAT(T4,20A4/T4,82('*')//)
 6020 FORMAT(T4,'F-ELEMENT   BURNUP(G)  TB (DAYS)   TW (DAYS)',
     1          '   P-OPER.(W)  P-GAMMA(W)  ACTIV.(CI)'/)
 6030 FORMAT(T3,10A1,1X,1P6E12.4)
 6040 FORMAT(//T4,'FINAKT 79 BORMANN/KALKER'//)
      END
```

PROGRAM LISTING KINIK

```
C     ***************************************************************

C     LISTING OF THE INVERSE-KINETIC CODE KINIK WITH POINT-MODEL

C     ***************************************************************
C
C
      REAL*8     A10,BETAF,BETDOL,BETSUM,BL2,B3,B5,B6,DLNE,ELMA,ENLT,
     1           FRE1,FRE2,H,HI,PI,PI0,PR,P0,P1,P2,P3,RE,REAB,
     2           REA2,REA3,REI,REI0,RE0,RE1,RE2,RE3,SUMBET,SUMCI0,
     3           TD,TDI,TD1,TD2,XR,YR,ZW
      REAL*8     BET(30),BETORG(30),CIA(30),CIT(30),CI0(30),
     1           DCI(30),DCI1(30),DCI2(30),DCI3(30),HN(21),
     2           HNI(21),TCONH(30)
      REAL*8     CO(21),COP(6,11),COPA(6,11),COPI(6,11),EL(11,12)
      REAL*8     BETANT(30,40),BETF(40),BET1(30),
     1           POW(40),TSHD(40),TPOW(40),TBETWN(40)
      REAL*8     GAM,TCSHD,TCPOW,TSHUT0,TOTSHD
      REAL*4     SCAL(6),TDV(30),TDV1(30),TDV2(30),UVA(6),UVE(6),XFIN(6)
      REAL*4     GAMBET(30),QS(2,21),XW(2,2000),YW(2,2000)
      REAL*4     RHO(5),RHOMAX(10),RHOMIN(10),
     1           TRO(5),TROMAX(10),TROMIN(10),
     2           XPLOT(2000,2),YPLOT(2000,2)
      INTEGER    JOA(6),JOE(6),LK(21),LON(6),LOP(6),LOPA(6),LOPI(6),
     1           MOD(6),NAV(6),NEX(6),NIN(6),NPA(6),NPE(6),
     2           NPI(6),NPU(6),NPW(6),NP2(6),NTD(6),NUN(6),NPR(6)
      COMMON/C1/A10,BETAF,BETDOL,BETSUM,BL2,B3,B5,B6,DLNE,ELMA,ENLT,
     1          FRE1,FRE2,H,HI,PI,PI0,PR,P0,P1,P2,P3,RE,REAB,
     2          REA2,REA3,REI,REI0,RE0,RE1,RE2,RE3,SUMBET,SUMCI0,
     3          TD,TDI,TD1,TD2,XR,YR,ZW
      COMMON/C2/BET,BETORG,CIA,CIT,CI0,DCI,DCI1,DCI2,DCI3,HN,
     1          HNI,TCONH
      COMMON/C3/CO,COP,COPA,COPI,EL
      COMMON/C4/SCAL,UVA,UVE,XFIN,TDV,TDV1,TDV2,FV
      COMMON/C5/GAMBET,QS,XW,YW,XPLOT,YPLOT
      COMMON/C6/JOA,JOE,KW,KWA,KWE,LK,LON,LOP,LOPA,LOPI,MOD,
     1          NAV,NEX,NIN,NPA,NPE,NPI,NPU,NPW,NP2,NTD,
     2          NUN,NPR,NPILE,NERROR,LCASE,NCASE
      COMMON/TI/TITLE(20),MIP,MOP,NPAGE,INPRT,KPLOT,LPLOT
C
      REAL*8     TCON(30),BETAI(30)
C
C                ORIGINAL GROUP CONSTANTS OF DELAYED NEUTRONS
C                         KEEPIN-WHIMMET 1972
C     ------------------------------------------------------------
C      1- 6 GROUP CONSTANTS OF DELAYED NEUTRONS FROM FISSION PRODUCTS
C      7-15 GROUP CONSTANTS OF DELAYED PHOTONEUTRONS IN D2O
C     15-24 GROUP CONSTANTS OF DELAYED PHOTONEUTRONS IN BERYLLIUM
C
C           FIRST TIME-CONSTANTS TCON, THEN YIELD FRACTIONS BETAI
C     ------------------------------------------------------------
C
      DATA TCON/3.872D 00,1.397D 00,3.108D-01,1.155D-01,3.174D-02,
     1          1.272D-02,
     2          2.772D-01,1.691D-02,4.813D-03,1.500D-03,4.278D-04,
     3          1.167D-04,4.376D-05,3.633D-06,6.098D-07,
     4          2.265D-02,8.886D-03,3.610D-03,7.453D-04,2.674D-04,
```

```
     5           6.191D-05,1.591D-05,2.478D-06,6.098D-07,
     6           6*0.0/
      DATA BETAI/1.677D-04,8.256D-04,2.625D-03,1.213D-03,1.374D-03,
     1            2.451D-04,
     2            6.510D-04,2.040D-04,7.000D-05,3.360D-05,2.070D-05,
     3            2.340D-05,3.230D-06,1.030D-06,5.000D-07,
     4            2.070D-05,3.660D-05,1.850D-05,3.680D-05,3.660D-06,
     5            3.200D-05,2.600D-06,3.800D-07,5.700D-07,
     6            6*0.0/
C
      MIP=5
      MOP=6
C
C     ------------------------------------------------------------
C           INPUT-CARDS ARE LABELLED (OPTIONAL), IF
C        1) THEY ARE ONLY TRIGGERED FOR SPECIAL CASES AND/OR
C        2) FOR THEIR DATA EXIST BUILT-IN DEFAULTS
C
C           INPUT-CARDS ARE LABELLED "NN A, NN B" ETC, IF
C           THEY ARE LOGICALLY ON THE SAME PLACE IN THE INPUT
C           QUEUE, BUT JOB-DEPENDENT DIFFERENT IN DATA AND FORMAT
C     ------------------------------------------------------------
C           INPUT-FORMATS ARE GENERALLY
C           FOR INTEGERS                          16G5
C           FOR REAL NUMBERS                       8G10.3
C           FOR PAIRS OF REAL NUMBERS            4(2G10.3)
C           FOR TEXT                              20A4
C     ------------------------------------------------------------
C     C  A  R  D    1
C     --------------
      READ (MIP,5000,END=9999,ERR=9999) NPILE,NCASE
      IF (NCASE.EQ.0) NCASE=1
      LCASE=0
C                    EXPLANATIONS FOR  C  A  R  D  1
C                    -------------------------------
C 1.1 NPILE      DEFINES FIXED SETS OF DELAYED-NEUTRON-DATA ETC. FOR
C                DIFFERENT REACTORS OR FORCES INDIVIDUAL INPUT
C
C              =1 FIXED SET OF DATA FOR SIX GROUPS OF DEL. NEUTRONS
C                 FOR H2O- OR GRAPHITE-MODERATED SYSTEMS
C
C              =2 FIXED SET OF DATA FOR 15 GROUPS OF DEL. NEUTRONS
C                 INCLUDING PHOTONEUTRONS OF D2O
C
C              =3 OVERRIDES SAID FIXED DATA AND FORCES INPUT OF ALL
C                 RELEVANT NEUTRON DATA
C
C 1.2 NCASE   =1 ONLY ONE ABSOBER-MOVEMENT OR -DROP HAS TO BE ANALYSED
C
C           GT.1 NCASE CONSECUTIVE ABSOBER-MOVEMENTS OR -DROPS ARE
C                ANALYSED, E.G. A XENON-RIDE
C     ------------------------------------------------------------
C
C
    1 ANFANG=ZEIT(0)
      NERROR=0
      NPAGE =0
```

```
      LCASE =LCASE+1
      IF(LCASE.GT.NCASE) GO TO 9999
      CALL FRIST(ENDE)
      ENDE1=ENDE
C
C     C  A  R  D    2
C     ---------------
      READ (MIP,5020,END=9999,ERR=9999) TITLE
C
C     ------------------------------------------------------------------
C
C     C  A  R  D    3
C     ---------------
      READ (MIP,5000) MOVAB,NANF,NRE,NREAD,LENLT,NRC,
     1                NGAM,NGAFAC,NREFL
C
C                    EXPLANATIONS FOR  C  A  R  D   3
C                    --------------------------------
C 3.1 MOVAB  DEFINES (1) WHETHER ANALYSIS IS DONE FOR ONLY ONE ABSORBER-
C            MOVEMENT (IF NCASE.EQ.1) OR THE ASCENDING NUMBER OF UP TO
C            NCASE CONSECUTIVE ANALYSES, E.G. OF A XENON-RIDE.
C     ------------------------------------------------------------------
C
C  MOVAB = 1
C
C          A) IF NCASE.EQ.1, ONLY ONE ABSORBER-MOVEMENT HAS BEEN
C             DONE AND WILL BE ANALIZED.
C
C             IF NANF.EQ.1 REACTOR POWER AND THE CONCENTRATIONS OF
C             THE DELAYED NEUTRONS ARE SUPPOSED TO BE IN EQUILIBRIUM
C             BEFORE ABSORBER-MOVEMENT; NO INPUT WITH CARDS 10 AND 11.
C
C             IF NANF.EQ.2 POWER AND DELAYED NEUTRONS HAVE NOT BEEN
C             IN EQULIBRIUM BEFORE ABSORBER-MOVEMENT; CARDS 10-11 ARE
C             NEEDED FOR CALCULATION OF START-CONCENTRATIONS OF THE
C             DELAYED NEUTRONS. POSSIBLY WITH PREPOW=0.0,TSHUT0=0.0
C             AND TBETWN=0.0, BUT POW.GT.0.0 AND TPOW.GT.0.0.
C             (SEE THE FOLLOWING EXPLANATIONS FOR CASE B)
C
C  MOVAB = 1
C
C          B) IF NCASE >1, THE FIRST EXPERIMENT OF A "XENON-RIDE" WILL
C             BE UNDER WORK.
C
C             IN THIS CASE NANF.EQ.2 AND INPUT CARDS 10 AND 11 ARE
C             AWAITED FOR. IT IS ASSUMED, THAT IN PREPARING THE XENON-
C             RIDE THE REACTOR HAS BEEN A LONGER TIME ON HIGH POWER
C             PREPOW AND THAN SHUT-DOWN FOR REACHING THE XENON-PEAK.
C             THEN THE REACTOR WAS AGAIN BROUGHT TO CRITICALITY
C             ON POWER POW(1) AT HIGH XENON-LEVEL. THE TIME BETWEEN
C             SHUT-DOWN FROM PREPOW AND BEING CRITICAL WITH POW(1)
C             IS TSHUT0. PREPOW AND TSHUT0 ARE AWAITED FOR ON CARD 10.
C
C             FOR MOVAB = 1 TBETWN(1) (CARD 11) IS MEANINGLESS AND SET
C             TO 0.0, BECAUSE TSHUT0 REPRESENTS THIS DATA FOR THE FIRST
C             ABSORBER-MOVEMENT OF A XENON-RIDE. INPUT OF POW(1) AND
C             TPOW(1) IS OBVIOUSLY NEEDED.
```

```
C
C  MOVAB > 1 UP TO NCASE NUMBERS OF THE CONSECUTIVE ABSORBER-MOVEMENTS
C            OF THE XENON-RIDE. NO INPUT ON CARD 10, ON CARD 11 IS
C            TBETWN(MOVAB) = THE TIME BETWEEN TWO ABSORBER-MOVEMENTS,
C            POW(MOVAB)    = THE REACTOR-POWER BEFORE THIS MOVAB.-TH
C                            ABSORBER-MOVEMENT AND
C            TPOW(MOVAB)   = THE TIME THE REACTOR HAS BEEN ON POWER
C                            POW(MOVAB)
C            ------------------------------------------------------
C 3.2 NANF   FLAG OF INITIAL CONDITIONS OF REACTOR-POWER AND CONCEN-
C            TRATIONS OF DELAYED NEUTRONS BEFORE ABSORBER MOVEMENTS
C
C            DEFAULT = 1
C
C        = 1 DELAYED NEUTRONS AND REACTOR-POWER IN EQUILIBRIUM AFTER
C            A CONSIDERABLE TIME ON POWER (TIME DIFFERENT FOR H2O-
C            AND D2O-SYSTEMS, IN ADDITION IF REFLECTED BY BORON).
C            NO INPUT OF CARDS 10 AND 11 NEEDED.
C
C        = 2 DELAYED NEUTRONS AND REACTOR-POWER NOT IN EQULIBRIUM; EVEN
C            POSSIBLE IF ONLY ONE EXPERIMENT IS ANALYZED, BUT CERTAINLY
C            TRUE FOR A SEQUENCE OF EXPERIMENTS OF A XENON-RIDE.
C            INPUT CARDS 10 AND 11 WITH DATA OF POWER AND TIMES ARE
C            AWAITED FOR, SEE ALSO EXPLANATIONS FOR MOVAB.
C
C        = 3 VERY RARELY USED. IN ADDITION TO CARDS 10 AND 11 OPTIONAL
C            STARTING CONCENTRATIONS CIA FOR THE DELAYED NEUTRONS CAN
C            BE READ IN WITH CARD 12. ONLY PURPOSE IS DISCUSSION OF
C            THEIR INFLUENCE ON RACTIVITY CALCULATIONS.
C
C        < 0 ONLY OPTIMAL POLYNOMIAL FOR ANY GIVEN X-Y DATA ARE
C            CALCULATED IN SAGAPO AND RESULTS WRITTEN OUT, BUT
C                    N O   I N V E R S E - K I N E T I C S
C            ------------------------------------------------------
C 3.3 NRE    =0 OR 1  REACTIVITY IS CALCULATED IN % DK/K
C
C            =2 REACTIVITY IS CALCULATED IN DOLLAR ($)
C            DEFAULT=1
C
C 3.4 NREAD  =0 DEFAULTS ARE USED FOR
C            INPRT,NCYC,NCYC1,NVCYC,KPLOT,NPLOT  AND
C            H1,H2,FH,HTM,PIO,REO,REIO
C
C            =1 VALUES ARE READ IN FOR
C            INPRT,NCYC,NCYC1,NVCYC,KPLOT,NPLOT          ON CARD 4
C               DEFAULTS ARE USED FOR
C            H1,H2,FH,HTM,PIO,REO,REIO
C
C            =2 VALUES ARE READ IN FOR
C            INPRT,NCYC,NCYC1,NVCYC,KPLOT,NPLOT  AND     ON CARD 4
C            H1,H2,FH,HTM,PIO,REO,REIO                   ON CARD 9
C            DEFAULT=0
C
C 3.5 LENLT  GT.0 = NEUTRON-LIFETIME HAS TO BE READ IN   ON CARD 5
C            DEFAULT=0
C
C 3.6 NRC    GT.0 = IN CASE OF HIGH CABLE-CAPACITY BETWEEN IONISA-
```

```
C             TION CHAMBER AND AMPLIFIER NRC*10E-3 SEC WILL BE USED
C             FOR ELIMINATING THE TIME-LAG OF POWER-SIGNAL.
C             DEFAULT=0 AND SIGNAL IS SUPPOSED AS BEING PROMPT
C
C 3.7 NGAM    GT.0 = FACTOR USED FOR WEIGHTING COEFFICIENTS GAMBET(I)
C             OF DELAYED BE-PHOTONEUTRONS
C             DEFAULT=0
C
C 3.8 NGAFAC =1 TO 6 DEFINES FIXED FACTORS ALIKE NGAM
C             DEFAULT=0
C
C 3.9 NREFL  =1 INCLUDES NEUTRON DATA FOR BERYLLIUM, SUPPOSED TO
C             BE REFLECTOR-MATERIAL
C             DEFAULT=0
C     ------------------------------------------------------------------
C
      IF (NANF.LT.0)  CALL SAGAPO(1)
      IF (NANF.EQ.0)  NANF=1
      IF (NRE.EQ.0)   NRE=1
      IF (NPILE.EQ.6) NRE=2
C
C     ------------------------------------------------------------------
C                     DEFAULTS IF NREAD.LE.0
C     ------------------------------------------------------------------
      INPRT =1
      NCYC  =0
      NCYC1 =0
      NVCYC =0
      KPLOT =0
      LPLOT =0
C
C     C  A  R  D    4    (OPTIONAL)
C     ----------------------------
      IF (NREAD.GE.1) READ (MIP,5000)
     1                INPRT,NCYC,NCYC1,NVCYC,KPLOT,LPLOT
C
C ------------------------------------------------------------------
C                EXPLANATIONS FOR  C  A  R  D  4    (OPTIONAL)
C                ------------------------------------------
C 4.1 INPRT  GT.0  ALL 'IN'PUT DATA ARE PRINTED AS WELL AS THE INITAL
C             VALUES RESULTING FROM PREPARING INPUT DATA
C             DEFAULT=1
C
C             IF USED RECOMMENDED VALUES NCYC=1, NCYC1=2, NVCYC=5000
C             USE NCYC,NCYC1 AND NVCYC ONLY FOR DEBUGGING, IT GIVES A
C             LOT OF OUTPUT
C             DEFAULT=3*0
C             IF USED RECOMMENDED VALUES NCYC=1, NCYC1=2, NVCYC=5000
C             ********************************************************************
C 4.2 NCYC   GT.0 AFTER NCYC RUNGE-KUTTA-CYCLES OF EACH 2*H CALCULATED
C             RESULTS OF TO,RE,FRE1,FRE2,REAB,REI,PR,PI,TD,TDI ARE
C             WRITTEN OUT BEFORE TIME TNCYC1=2*NCYC1*H1 IS REACHED
C
C 4.3 NCYC1  GT.0 SAME AS BEFORE FOR TIME GT.TNCYC1
C
C 4.4 NVCYC  GT.0 SAME AS BEFORE FOR CONC. AND OTHER DATA OF DELAYED
C             NEUTRONS
```

```
C     ------------------------------------------------------------------
C 4.5 KPLOT  AND LPLOT CONTROL CONSTANTS FOR PLOT-ROUTINE (NOT USED)
C            DEFAULT=2*0
C     ------------------------------------------------------------------
C
      GO TO (10,20,30),NPILE
C
C     ****************************************
C     WEIGHTING FACTORS GAMBET(1-6) FOR
C     H2O-MODERATED FRJ1-MERLIN (5*6-CORE)
C     ****************************************
C
   10 GAMBET(1)=1.220
      GAMBET(2)=1.230
      GAMBET(3)=1.228
      GAMBET(4)=1.235
      GAMBET(5)=1.214
      GAMBET(6)=1.244
      NV=6
      NVMAX=6
C
C     -------------------------------------
C     BETSUM/LSTAR MEASURED IN FRJ-1-MERLIN
C     ENLT = EFFECTIVE NEUTRON LIFETIME
C     -------------------------------------
C
      BDVL=1.08E2
      ENLT=0.D0
      GO TO 25
C
C     ********************************
C     WEIGHTING FACTORS GAMBET(1-15)
C     FOR D2O-MODERATED FRJ2-DIDO
C     ------------------------------
C
   20 GAMBET(1)=1.012
      GAMBET(2)=1.012
      GAMBET(3)=1.010
      GAMBET(4)=1.012
      GAMBET(5)=1.010
      GAMBET(6)=1.019
      GAMBET(7)=0.3687
      GAMBET(8)=0.4283
      GAMBET(9)=0.4068
      GAMBET(10)=0.3920
      GAMBET(11)=0.4068
      GAMBET(12)=0.4082
      GAMBET(13)=0.3921
      GAMBET(14)=0.3921
      GAMBET(15)=0.3921
      NV=15
      NVMAX=15
C
C     ---------------------------------
C     BETSUM/LSTAR MEASURED IN FRJ2-DIDO
C     ---------------------------------
C
```

```
      BDVL=1.21E1
      ENLT=0.D0
C
C     ------------------------------
C     READ IN NEUTRON LIFETIME LSTAR
C     ------------------------------
C     C  A  R  D   5      (OPTIONAL)
C     ------------------------------
   25 IF(LENLT.GT.0) READ (MIP,5010) ENLT
      IF (NREFL.EQ.0) GO TO 150
      GO TO 140
C
C           ------------------------------------------------
C                READ IN A COMPLETE SET OF NEUTRON DATA
C                 IF NONE OF THE TWO DATASETS ACCORDS
C           ------------------------------------------------
C
C     C  A  R  D  S   5 - 8
C     ---------------------
   30 READ (MIP,5010) NV,ENLT
      READ (MIP,5010) (TCON(M),M=1,NV)
      READ (MIP,5010) (BETAI(M),M=1,NV)
      READ (MIP,5010) (GAMBET(M),M=1,NV)
      NVMAX=NV
      GO TO 150
C           ------------------------------------------------
C                   EXPLANATIONS FOR  C  A  R  D   5-8
C           ------------------------------------------------
C
C 5.1 NV      GROUPS OF DELAYED NEUTRONS                   I10
C
C 5.2 ENLT    NEUTRON LIFETIME (SEC)                       E10.3
C
C 6   TCON    TIME-CONSTANTS OF DELAYED NEUTRONS (SEC-1) 8E10.3
C
C 7   BETAI   YIELD FRACTIONS OF DELAYED NEUTRONS        8E10.3
C
C 8   GAMBET  WEIGHTING FACTORS FOR DELAYED NEUTRONS     8E10.3
C
C     ------------------------------------------------
C
C
C     ------------------------------------------------------
C     AS WEIGHTING VALUES GAMBET(I) OF BERYLLIUM-GROUPS MEAN
C     VALUE OF THE NV GROUPS IS MULTIPLIED BY 0.05*NGAM WITH
C     DEFAULT = 0.05*10, WHICH ASSUMES BE9-NEUTRONS HAVING
C     NORMALLY 50 % OF THIS MEAN IMPORTANCE.
C     ------------------------------------------------------
C
  140 GAM=0.0D0
      DO 141 M=1,NV
  141 GAM=GAM+GAMBET(M)
      ZW=1./NV
      GAM=GAM*ZW
      IF(NGAM.EQ.0) NGAM=10
      GAM=NGAM*0.05*GAM
C
```

```
      DO 142 M=1,9
      N=NV+M
  142 GAMBET(N)=GAM
C
      IF(NV.GT.6) GO TO 144
C
      DO 143 M=1,9
      N=NV+M
      NN=N+9
      TCON(N)=TCON(NN)
  143 BETAI(N)=BETAI(NN)
C
  144 NV=NV+9
      NVMAX=NV
C
C     ------------------------------------
C     IN CASE OF GREAT TIME-CONSTANT DUE TO
C     HIGH CAPACITY OF CONNECTING CABLES
C     BETWEEN IONISATION CHAMBER AND AMPLF.
C     ------------------------------------
  150 ZKNRC=1.E-3*NRC
C
C             NREAD.EQ.2 FORCES INPUT OF FOLLOWING DATA
C             -----------------------------------------
C      DEFAULTS
C      --------
      H1=  5.E-3
      H2=  5.E-3
      FH=  1.E-2
      HTM= 0.0
      PIO= 0.0
      REO= 0.0
      REIO=0.0
C
C     C  A  R  D    9     (OPTIONAL)
C     ------------------------------
      IF(NREAD.EQ.2) READ(MIP,5010) H1,H2,FH,HTM,PIO,REO,REIO
C
C ---------------------------------------------------------------------
C             EXPLANATION FOR  C  A  R  D   9   (OPTIONAL)
C             -------------------------------------------
C 9.1 H1   STEPWIDTH FOR RUNGE-KUTTA INTEGRATION, USED FROM START H=H1
C          DEFAULT=5.0E-3
C
C 9.2 H2   STEPWIDTH FOR RUNGE-KUTTA INTEGRATION, IF NE.H1,
C          THE OPTIMUM STEPWIDTH IS RECALCULATED AFTER EACH FULL 2*H
C          RUNGE-KUTTA CALCULATION. THE PROGRAM LOOKS FOR THE STEEPEST
C          GRADIENT OF PROMPT AND DELAYED NEUTRON CONCENTRATIONS, ITS
C          TIME-CONSTANT IS MULTIPLIED BY FH AND H=TCON*FH IS HELD
C          BETWEEN LIMITS H1 AND H2.
C
C          FOR H=TCON*FH.GT.H2, H=H2;
C          FOR H=TCON*FH.LT.H1, H=H1.
C          DEFAULT FOR H2=5.0E-3
C
C 9.3 FH   FACTOR AS DEFINED BEFORE
C          DEFAULT=1.0E-2
```

```
C
C 9.4 HTM  IS THE MIDPOINT OF THE FIRST INTERVAL TO BE WORKED ON,
C          IN MOST CASES 0.0.
C          DEFAULT=0.0
C
C 9.5 PIO  IS THE STARTING VALUE OF THE TIME-INTEGRAL OF THE POWER P(T)
C          DEFAULT=0.0
C
C 9.6 REO  IS THE STARTING VALUE OF THE REACTIVITY
C          DEFAULT=0.0
C
C 9.7 REIO IS THE STARTING VALUE OF THE TIME-INTEGRAL OF THE REACTIVITY
C          DEFAULT=0.0
C
C-----------------------------------------------------------------------
C
C
      TNCYC1=2*NCYC1*H1



C
C     ---------------------------------------------------
C     ATTENTION: PROGRAM USES WEIGHTED BETAI OF STMT 160;
C     BETORG ARE THE ORIGINAL, POSSIBLY READ-IN VALUES OF BETAI
C     ---------------------------------------------------
C
      DO 160 M=1,NVMAX
      BETORG(M)=BETAI(M)
  160 BETAI(M)=BETAI(M)*GAMBET(M)
C
      IF(NCASE.EQ.1.AND.NANF.EQ.1) GO TO 280
      IF(NCASE.EQ.1.AND.NANF.EQ.2) GO TO 165
      IF(NCASE.GT.1) NANF=2
      IF(MOVAB.EQ.1) GO TO 165
      IF(MOVAB.GT.1) GO TO 190
C
C     ---------------------------------------------------------------
C
C                     R  E  M  E  M  B  E  R
C
C     MOVAB  DEFINES WHETHER ANALYSIS IS DONE FOR ONLY ONE ABSORBER-
C            MOVEMENT OR A SEQUENCE OF THOSE, E.G. A XENON-RIDE.
C     ---------------------------------------------------------------
C
C  MOVAB = 1
C
C         A) IF NCASE.EQ.1, ONLY ONE ABSORBER-MOVEMENT HAS BEEN
C            DONE AND WILL BE ANALISED.
C
C            IF NANF.EQ.1 REACTOR POWER AND THE CONCENTRATIONS OF
C            THE DELAYED NEUTRONS ARE SUPPOSED TO BE IN EQUILIBRIUM
C            BEFORE ABSORBER-MOVEMENT; NO INPUT WITH CARDS 10 AND 11.
C
C            IF NANF.EQ.2 POWER AND DELAYED NEUTRONS HAVE NOT BEEN
C            IN EQULIBRIUM BEFORE ABSORBER-MOVEMENT; CARDS 10-11 ARE
C            NEEDED FOR CALCULATION OF START-CONCENTRATIONS OF THE
```

```
C            DELAYED NEUTRONS. POSSIBLY WITH PREPOW=0.0, TSHUT0=0.0
C            AND TBETWN=0.0, BUT POW.GT.0.0 AND TPOW.GT.0.0.
C            (SEE THE FOLLOWING EXPLANATIONS FOR B)
C
C  MOVAB = 1
C
C         B) IF NCASE >1, THE FIRST EXPERIMENT OF A "XENON-RIDE" WILL
C            BE UNDER WORK.
C
C            IN THIS CASE NANF.EQ.2 AND INPUT CARDS 10 AND 11 ARE
C            AWAITED FOR. IT IS ASSUMED, THAT IN PREPARING THE XENON-
C            RIDE THE REACTOR HAS BEEN A SUFFICIENT TIME ON HIGH POWER
C            PREPOW AND THAN SHUT-DOWN FOR REACHING THE XENON-PEAK.
C            THEN THE REACTOR WAS AGAIN BROUGHT TO CRITICALITY
C            ON POWER POW(1) AT HIGH XENON-LEVEL. THE TIME BETWEEN
C            SHUT-DOWN FROM PREPOW AND BEING CRITICAL WITH POW(1)
C            IS TSHUT0. PREPOW AND TSHUT0 ARE AWAITED FOR ON CARD 10.
C
C            FOR MOVAB = 1 TBETWN(1) (CARD 11) IS MEANINGLESS AND SET
C            TO 0.0, BECAUSE TSHUT0 REPRESENTS THIS DATA FOR THE FIRST
C            ABSORBER-MOVEMENT OF A XENON-RIDE. INPUT OF POW(1) AND
C            TPOW(1) IS OBVIOUSLY NEEDED.
C
C     ------------------------------------------------------------
C                  EXPLANATIONS FOR  C  A  R  D   10
C                  ---------------------------------
C
C                ONLY FOR MOVAB=1
C                ----------------
C 10.1  PREPOW   IS THE SAID HIGH POWER PREPARING XENON BUILD-UP
C
C 10.2  TSHUT0   IS THE TIME BETWEEN SHUT-DOWN FROM PREPOW AND
C                REACHING AGAIN HIGH POWER IN PREPARATION OF THE ABSORBER-
C                MOVEMENT UNDER ANALYSIS, WHICH MAY BE A SINGLE EXPERI-
C                MENT OR THE FIRST OF A XENON-RIDE.
C
C
C     C  A  R  D   10
C     --------------
  165 READ (MIP,5010) PREPOW,TSHUT0
      BETAF=PREPOW
      IF(PREPOW.EQ.0.) BETAF=1.D0
      TSHUT0=TSHUT0*60.D0
      TOTSHD=0.D0
C
      DO 170 I=1,NVMAX
      TCSHD=TCON(I)*TSHUT0
      IF(TCSHD.GT.100.D0) TCSHD=100.D0
  170 BET1(I)=BETAI(I)*(1.D0-DEXP(-TCSHD))
      DO 180 I=1,40
  180 TSHD(I)=0.D0
C
C  ------------------------------------------------------------------
C                      R  E  M  E  M  B  E  R
C
C  MOVAB > 1 UP TO NCASE NUMBERS OF THE CONSECUTIVE ABSORBER-MOVEMENTS
C            OF THE XENON-RIDE. NO INPUT ON CARD 10.
```

```
C
C  ---------------------------------------------------------------
C                  EXPLANATIONS FOR  C  A  R  D   11
C                  ----------------------------------
C
C                FOR MOVAB.GE.1
C                --------------
C 11.1 TBETWN    IS THE TIME BETWEEN THE SHUT-DOWN OF THE REACTOR
C                WITH THE (MOVAB-1) EXPERIMENT AND THE START OF THE
C                NEW CRITICALITY WITH POWER POW(MOVAB).
C
C          ***** TBETWN(1)=0.0, BECAUSE TSHUTO REPRESENTS THIS TIME
C          ***** FOR MOVAB=1.
C
C 11.2 TPOW      IS THE TIME THE REACTOR HAS BEEN ON POWER POW(MOVAB)
C                BEFORE SHUTDOWN BY THIS MOVAB.-TH ABSORBER-EXPERIMENT
C
C 11.3 POW       IS THE BEFORE-SAID POWER POW(MOVAB)
C
C                TIMES HAVE TO BE IN MINUTES, POWER IN MW
C
C     ---------------------------------------------------------------
C
C     C  A  R  D   11
C     --------------
  190 READ (MIP,5010) TBETWN(MOVAB),TPOW(MOVAB),POW(MOVAB)
      BETF(MOVAB)=POW(MOVAB)
      IF(POW(MOVAB).EQ.0.) BETF(MOVAB)=1.D0
      BEFF=BETF(MOVAB)
      BETAF=BETAF/BEFF
      DO 200 I=1,MOVAB
  200 BETF(I)=BETF(I)/BEFF
      TBETWN(MOVAB)=TBETWN(MOVAB)*60.D0
      TPOW(MOVAB)=TPOW(MOVAB)*60.D0
      IF(MOVAB.LT.3) GO TO 220
      MOVAB1=MOVAB-1
      MOVAB2=MOVAB-2
      TOTSHD=TOTSHD+TSHD(MOVAB1)
      TSHD(MOVAB1)=TBETWN(MOVAB)
      DO 210 I=1,MOVAB2
  210 TSHD(I)=TSHD(I)+TSHD(MOVAB1)
      GO TO 240
C
  220 IF(MOVAB.EQ.2) GO TO 230
      TOTSHD=TBETWN(1)
      GO TO 240
  230 TSHD(1)=TBETWN(2)
      TOTSHD=TOTSHD+TSHD(1)
C
  240 DO 260 I=1,NVMAX
      TCSHD=TOTSHD*TCON(I)
      IF(TCSHD.GT.100.D0) TCSHD=100.D0
      BETANT(I,1)=BET1(I)*DEXP(-TCSHD)*BETAF
      BET(I)=BETANT(I,1)
C
      DO 260 J=1,MOVAB
      K=J+1
```

```
      TCSHD=TSHD(J)*TCON(I)
      TCPOW=TPOW(J)*TCON(I)
      IF(TCSHD.GT.100.D0) TCSHD=100.D0
      IF(TCPOW.GT.100.D0) TCPOW=100.D0
      BETANT(I,K)=BETAI(I)*(1.D0-DEXP(-TCPOW))*DEXP(-TCSHD)*BETF(J)
  260 BET(I)=BET(I)+BETANT(I,K)
      BETAF=BETAF*BEFF
C
      DO 270 I=1,MOVAB
  270 BETF(I)=BETF(I)*BEFF
C
C     ----------------------
C     END OF DATA PREPARATION
C     ----------------------
C
      GO TO 300
C
C     ---------------------------------
C       IF MOVAB.EQ.1.AND.NANF.EQ.1
C     REACTOR AND THEREWITH CONC. OF DE-
C     LAYED NEUTRONS BET(I) ARE ASSUMED
C     AS BEING IN EQUILIBRIUM BEFORE AB-
C     SORBER MOVEMENT.
C
C     GO TO 280 FOLLOWS STMNT 160
C     ---------------------------------
C
  280 DO 290 I=1,NV
  290 BET(I)=BETAI(I)
C
  300 SUMBET=0.D0
      DO 310 I=1,NV
  310 SUMBET=SUMBET+BET(I)
      IF(SNGL(ENLT).GT.0.) GO TO 320
      ENLT=SUMBET/BDVL
      GO TO 330
  320 BDVL=SUMBET/ENLT
  330 BETSUM=SUMBET*100.D0
      BETDOL=1.D0/BETSUM
C
C     -------------------------
C     DEFINE SOME CONSTANTS AND
C     INITALIZE START PARAMETERS
C     -------------------------
C
      BL2=DLOG(2.D0)
      BL2FH=SNGL(BL2)*FH
      FV=1.E-70
      TDVU=SNGL(BL2)/FV
      W2FV=SQRT(1./FV)
      FHI=1./FH
      XFIN(KW)=HTM
C
      IROMIN=1
      IROMAX=1
      DO 340 I=1,10
      RHOMAX(I)=0.
```

```
      RHOMIN(I)=0.
      TROMAX(I)=0.
  340 TROMIN(I)=0.
C
C     --------------
      CALL SAGAPO(1)
C     --------------
C
      IF(NERROR.NE.0) GO TO 1
C
      M=NPW(KW)/2
      TAN=XW(KW,M)
      T0=UVA(KW)
      TMAX=UVE(KW)
      PINV=1./P0
      XPLOT(N1PLOT,1)=T0
      XPLOT(N1PLOT,2)=T0
      YPLOT(N1PLOT,1)=RE0
      YPLOT(N1PLOT,2)=P0
      IF (NANF.EQ.3)  GO TO 370
C
C     ------------------------------------------
C     CONCENTRATIONS OF DELAYED NEUTRONS CIA(I)=P0
C     STABLE REACTOR AT START OF CALCULATION
C     ------------------------------------------
C
      DO 360 M=1,NV
  360 CIA(M)=P0
      GO TO 380
C
C     ------------------------------------------------
C     EXPLANATION FOR  C  A  R  D   12  (OPTIONAL)
C     IF REACTOR IS INSTABLE AT START OF ABSORBER, OR
C     INFLUENCE OF DEL. NEUTRONS IS DISCUSSED, THEIR
C     START CONCENTRATIONS ARE READ IN. (VERY RARE)
C     ------------------------------------------------
C     C  A  R  D   12
C     ---------------
  370 READ (MIP,5010) (CIA(M),M=1,NV)
C
  380 DO 390 M=1,NV
  390 CI0(M)=CIA(M)
C
      IF (INPRT.EQ.0) GO TO 405
C
      NPAGE=NPAGE+1
      WRITE(MOP,6010) TITLE,NPAGE
      WRITE(MOP,6020) MOVAB,NANF,NRE,NREAD,LENLT,NRC,NGAM,NGAFAC,NREFL,
     1                INPRT,NCYC,NCYC1,NVCYC,KPLOT,NPLOT,N1PLOT,N5PLOT
      WRITE(MOP,6030) TAN,TMAX,TNCYC1,H1,H2,FV,TDVU,FH,HTM
      WRITE(MOP,6040) BDVL,SUMBET,ENLT
      WRITE(MOP,6050)
      WRITE(MOP,6060) (M,TCON(M),BETORG(M),BET(M),M=1,NV)
      WRITE(MOP,6070) GAM,(M,GAMBET(M),M=1,NV)
      IF(MOVAB.EQ.0)  GO TO 440
C
      NPAGE=NPAGE+1
```

```
      WRITE(MOP,6010) TITLE,NPAGE
  400 WRITE(MOP,6080) MOVAB,TSHUTO,TOTSHD,
     1                TBETWN(MOVAB),TPOW(MOVAB),TSHD(MOVAB)
C
  405 IF(MOVAB.EQ.0) GO TO 440
C
      MOVAB1=MOVAB+1
      XR=TSHD(1)
      DO 410 I=2,MOVAB1
      YR=TSHD(I)
      TSHD(I)=XR
  410 XR=YR
      TSHD(1)=TOTSHD
C
      IF (INPRT.EQ.0) GO TO 425
C
      WRITE(MOP,6090) (I,TSHD(I),I=1,MOVAB1)
      WRITE(MOP,6663)
      WRITE(MOP,6100) BETAF,(BETF(I),I=1,MOVAB)
      WRITE(MOP,6663)
      WRITE(MOP,6110)
      DO 420 I=1,NV
  420 WRITE(MOP,6082) I,(J,BETANT(I,J),J=1,MOVAB1)
C
  425 DO 430 I=1,MOVAB
      K=I+1
  430 TSHD(I)=TSHD(K)
      TSHD(MOVAB1)=0.D0
C
C     ---------------------------
C     INITIALIZING SOME VARIABLES
C     ---------------------------
C
  440 B5=  1.D0/6.D0
      B6=  1.D0/3.D0
      DLNE=1.D0/ENLT
      PI=  PI0
      PR=  P0
      REI= REI0
      RE1= 0.0
      RE2= 0.0
      RE3= 0.0
      REA2=0.0
      REA3=0.0
      RE=  RE0
      TD2= 0.0
      SUMCI0=0.0
      TDMINH=0.0
      NZ=   0
      NVZ=  0
      NHOUT=1
      NZEIL=0
      NRHO= 1
C
      IF(TMAX.LE.5.) GO TO 450
      XMAX=TMAX/H1*1000.
      IF(XMAX.LE.1.) GO TO 450
      NCYC1=2*IFIX(XMAX)
```

```
  450 TNCYC1=2*NCYC1*H2
      N1PLOT=1
      N5PLOT=0
C     ------------------------------------------------
C     VARIABLES DEPENDING ON INTEGRATION STEP-WIDTH H
C     ------------------------------------------------
      NH=1
      IF(H1.NE.H2) NH=2
      H=H1
      HI=1./SNGL(H)
      DO 490 M=1,NV
  490 TCONH(M)=TCON(M)*H
      A10=100.D0*ENLT
      B2=0.5*SNGL(H)
      B3=B6*H
      IF(NH.EQ.1)       GO TO 580
C     ------------------------------------------------
C     IF(NH.EQ.2) = IF(H1.NE.H2) CALC. OF OPTIMUM
C     STEP-WIDTH H AFTER EACH 2 RUNGE-KUTTA-STEPS
C     ------------------------------------------------
  500 IF(T0.LT.TAN)     GO TO 580
      IF(TDMINH.GT.H1)  GO TO 510
      H=H1
      GO TO 560
  510 IF(TDMINH.GT.H2)  GO TO 550
      H=TDMINH*FHI
      MH=0
  520 IF(SNGL(H).GT.1.) GO TO 530
      MH=MH-1
      H=SNGL(H)*10.
      GO TO 520
  530 H=AINT(SNGL(H))
      IF(MH.LT.0) GO TO 540
      H=SNGL(H)*FH
      GO TO 560
  540 H=SNGL(H)*FH*(10.**MH)
      GO TO 560
  550 H=H2
  560 DO 570 M=1,NV
  570 TCONH(M)=TCON(M)*H
      HI=1./SNGL(H)
      B2=0.5*SNGL(H)
      B3=B6*H
C
C     ----------------------------------------
C     CYCLIC PREPARING OF DATA FOR THE NEXT
C     RUNGE-KUTTA-STEP STARTING STATEMENT 1140
C     ----------------------------------------
  580 NZYCL=1
C
  750 IF(T0.GE.XFIN(KW)) GO TO 1440
C
  760 IF (NZYCL-2) 770,800,850
  770 P1=PR
      TRO1=T0
      RHO1=SNGL(RE)
      LOGP=LON(KW)
```

```
      IF(LOGP.EQ.1) GO TO 780
      TD1=DLOG(PR)
  780 IF(SNGL(RE).GT.SNGL(BETSUM)) GO TO 790
      RE1=0.D0
      GO TO 1140
  790 RE1=RE
      GO TO 1140
C
  800 P2=PR
      RHO2=SNGL(RE)
      TRO2=T0
      REA2=RE
      IF(LOGP.EQ.1) GO TO 810
      TD1=DLOG(PR)
  810 IF(NH.EQ.1) GO TO 830
      DO 820 M=1,NV
  820 TDV1(M)=ALOG(SNGL(CI0(M)))
  830 IF(SNGL(RE).GT.SNGL(BETSUM)) GO TO 840
      RE2=0.D0
      GO TO 1140
C
  840 RE2=RE
      GO TO 1140
C
  850 P3=PR
      TRO3=T0
      RHO3=SNGL(RE)
      REA3=RE
      IF(ABS(SNGL(TD2)).GT.FV) GO TO 860
      TD=SIGN(TDVU,SNGL(TD2))
      GO TO 870
  860 TD=BL2/TD2
  870 IF(NH.EQ.1) GO TO 890
      TDMAX=ABS(SNGL(TD2))
      DO 880 M=1,NV
      TDV2(M)=ABS((ALOG(SNGL(CI0(M)))-TDV1(M))*SNGL(HI))
      IF(TDV2(M).GT.FV) GO TO 880
      TDV2(M)=FV
  880 TDMAX=AMAX1(TDMAX,TDV2(M))
      TDMINH=BL2FH/TDMAX
  890 IF(SNGL(RE).GT.SNGL(BETSUM)) GO TO 900
      RE3=0.D0
      GO TO 910
  900 RE3=RE
  910 PI=(P1+4.D0*P2+P3)*B3+PI
      REI=(RE1+4.D0*RE2+RE3)*B3+REI
      REAB=(REA3-REA2)*HI
      REAB=100.D0*RE/(100.D0-RE)
      REI=RE*BETDOL
      TDI=1.D0/TD
      NZ=NZ+1
C
      IF(NRHO.GT.1) GO TO 920
      RHO(1)=RHO1
      RHO(2)=RHO2
      RHO(3)=RHO3
      TRO(1)=TRO1
```

```
      TRO(2)=TRO2
      TRO(3)=TRO3
      NRHO=2
      GO TO 1060
C
  920 IF(NRHO.EQ.3) GO TO 940
  930 RHO(4)=RHO2
      RHO(5)=RHO3
      TRO(4)=TRO2
      TRO(5)=TRO3
      NRHO=3
      GO TO 960
  940 DO 950 I=1,3
      RHO(I)=RHO(I+2)
  950 TRO(I)=TRO(I+2)
      GO TO 930
C
  960 IF(TO.LT.TAN)      GO TO 1060
      IF(IROMAX.GT.10)   GO TO 1060
      IF(IROMIN.GT.10)   GO TO 970
C
      RHO1=AMIN1(RHO(1),RHO(2),RHO(3),RHO(4),RHO(5))
      IF(ABS(RHO1).LT.1.E-2) GO TO 1060
      IF((RHO1.EQ.RHO(1)).OR.(RHO1.EQ.RHO(5)))GO TO 970
      GO TO 980
C
  970 RHO1=AMAX1(RHO(1),RHO(2),RHO(3),RHO(4),RHO(5))
      IF(ABS(RHO1).LT.1.E-2) GO TO 1060
      GO TO 1020
C
  980 DO 990 I=2,4
      IF(RHO1.NE.RHO(I)) GO TO 990
      II=I
      GO TO 1000
  990 CONTINUE
      GO TO 1060
C
 1000 IF(IROMIN.EQ.1)GO TO 1010
      M=IROMIN-1
      IF((TROMIN(M).EQ.TRO(II)).OR.(RHOMIN(M).EQ.RHO1))GO TO 1060
      IF((TROMAX(M).EQ.TRO(II)).OR.(RHOMAX(M).EQ.RHO1))GO TO 1060
 1010 TROMIN(IROMIN)=TRO(II)
      RHOMIN(IROMIN)=RHO1
      IROMIN=IROMIN+1
      GO TO 1060
C
 1020 DO 1030 I=2,4
      IF(RHO1.NE.RHO(I)) GO TO 1030
      II=I
      GO TO 1040
 1030 CONTINUE
      GO TO 1060
 1040 IF(IROMAX.EQ.1)GO TO 1050
      M=IROMAX-1
      IF((TROMAX(M).EQ.TRO(II)).OR.(RHOMAX(M).EQ.RHO1))GO TO 1060
      IF((TROMIN(M).EQ.TRO(II)).OR.(RHOMIN(M).EQ.RHO1))GO TO 1060
 1050 TROMAX(IROMAX)=TRO(II)
```

```
      RHOMAX(IROMAX)=RHO1
      IROMAX=IROMAX+1
C
 1060 IF(NCYC.EQ.0) GO TO 1125
C
C     ------------------------------------------------------
C       ATTENTION, IT'S A LOT OF OUTPUT FOR NCYC/NCY1.GT.0
C       ------------------------------------------------
C     NCYC.LE.2   PRINT RESULTS AFTER EACH INTEGRATION STEP (2*H)
C     NCYC.GT.2   PRINT RESULTS AFTER NCYC INTEGRATION STEPS
C     ------------------------------------------------------
C
      IF(T0.GT.TNCYC1) GO TO 1070
      NCYC=NCYC
      GO TO 1080
 1070 NCYC=NCYC1
 1080 IF (NZ.LT.NCYC) GO TO 1125
 1090 IF (NZEIL.GT.0) GO TO 1095
      NPAGE=NPAGE+1
      WRITE(MOP,6010) TITLE,NPAGE
      WRITE(MOP,6120)
      WRITE(MOP,6130)
C
C     ------------------------------------------
C     FOR NH.EQ.2 STEPWIDTH H CHANGES POSSIBLY EACH
C     RUNGE-KUTTA-CYCLE. THEREFORE DOUBLING TIME TD
C     AND STEP WIDTH H ARE PRINTED OUT IN TURN,
C     TRIGGERED BY NHOUT.
C     HEADING ARB.V=ARBITRARY DIMENSION RESP. NONE
C     ------------------------------------------
C
 1095 IF(NH.EQ.2) GO TO 1100
C
      WRITE(MOP,6135) T0,RE,FRE1,FRE2,REAB,REI,PR,PI,TD,TDI
      GO TO 1120
C
 1100 IF(NHOUT.EQ.2) GO TO 1110
      WRITE(MOP,6135) T0,RE,FRE1,FRE2,REAB,REI,PR,PI,TD,TDI
      NHOUT=2
      GO TO 1120
 1110 WRITE(MOP,6135) T0,RE,FRE1,FRE2,REAB,REI,PR,PI,H,TDI
      NHOUT=1
C
 1120 NZEIL=NZEIL+1
      IF (NZEIL.EQ.55) NZEIL=0
      NZ=0
C
 1125 IF(NVCYC.EQ.0)   GO TO 1135
C
C     ------------------------------------------------
C     NVZ.EQ.NVCYC INCLUDING CONC. OF DELAYED NEUTRONS ETC.
C     ------------------------------------------------
C
      NVZ=NVZ+1
      IF(NVZ.LT.NVCYC) GO TO 1135
C
      NPAGE=NPAGE+1
```

```
      WRITE(MOP,6010) TITLE,NPAGE
      WRITE(MOP,6220) T0,(M,CI0(M),M=1,NV)
      NVZ=0
C
C     ------------------------------
C     OUTPUT OF INTERIM DATA FINISHED
C     ------------------------------
C
 1135 IF(NH.EQ.1) GO TO 580
      IF(NH.GE.2) GO TO 500
C
C     ----------------------------------------
C     START NEXT STEP OF RUNGE-KUTTA CALCULATIONS
C     ----------------------------------------
C
 1140 TI=T0
      DO 1150 M=1,NV
 1150 CIT(M)=CI0(M)
      IT=1
      GO TO 1220
C
 1160 TI=T0+B2
      DO 1170 M=1,NV
      DCI1(M)=DCI(M)
 1170 CIT(M)=CI0(M)+DCI1(M)*0.5D0
      IT=2
      GO TO 1220
C
 1180 DO 1190 M=1,NV
      DCI2(M)=DCI(M)
 1190 CIT(M)=CI0(M)+DCI2(M)*0.5D0
      IT=3
      GO TO 1330
C
 1200 TI=T0+SNGL(H)
      DO 1210 M=1,NV
      DCI3(M)=DCI(M)
 1210 CIT(M)=CI0(M)+DCI3(M)
      IT=4
C
 1220 YR=0.D0
      LO=LOP(KW)
      LOGP=LON(KW)
      XR=TI*SCAL(KW)
      IF(TI.NE.0.) GO TO 1230
      YR=COP(KW,1)
      GO TO 1250
C
 1230 DO 1240 N=1,LO
 1240 YR=YR+COP(KW,N)*(XR**(N-1))
 1250 IF(LOGP.GT.1) GO TO 1260
      PR=DEXP(YR)
      GO TO 1270
 1260 PR=YR
C
C     ------------------------------------
C     FITTING OF MEASURED POWER RESP. FLUX
```

```
C     IN CASE OF HIGH TIME-CONSTANT OF
C     CABLE-CONNECTIONS.
C     ----------------------------------
C
 1270 IF(ZKNCR.EQ.0.) GO TO 1330
      YR=0.D0
      LOA=LOPA(KW)
      XR=TI*SCAL(KW)
      IF(XR.EQ.0.)  GO TO 1290
      DO 1280 N=1,LOA
 1280 YR=YR+COPA(KW,N)*(XR**(N-1))
      GO TO 1300
 1290 YR=0.D0
 1300 YR=YR*SCAL(KW)
      IF(LOGP.GT.1) GO TO 1310
      PR=PR+ZKNRC*DEXP(YR)
      GO TO 1320
 1310 PR=PR+ZKNRC*YR
 1320 YR=YR*PR
C
C     ENDE ANPASSUNG ZEITKONSTANTE
C
 1330 DO 1340 M=1,NV
 1340 DCI(M)=TCONH(M)*(PR-CIT(M))
C
      GO TO(1160,1180,1200,1350),IT
 1350 DO 1360 M=1,NV
      DCI(M)=(DCI(M)+DCI1(M)+(DCI2(M)+DCI3(M))*2.D0)*B5
 1360 CI0(M)=CI0(M)+DCI(M)
      NZYCL=NZYCL+1
      T0=T0+SNGL(H)
      LOA=LOPA(KW)
      LOGP=LON(KW)
      IF(LOGP.LT.2) GO TO 1370
      TD2=(DLOG(PR)-TD1)*HI
      GO TO 1390
 1370 YR=0.D0
      XR=TI*SCAL(KW)
      DO 1380 N=1,LOA
 1380 YR=YR+COPA(KW,N)*(XR**(N-1))
      TD2=YR*SCAL(KW)
 1390 FRE1=A10*TD2
      SUMCI0=0.D0
      DO 1410 M=1,NV
 1410 SUMCI0=BET(M)*CI0(M)+SUMCI0
      FRE2=100.D0*SUMCI0/PR
      RE=FRE1-FRE2+BETSUM
      IF(NRE.EQ.2) RE=RE*BETDOL
C
C     -------------------------
      IF(T0.GE.TMAX) GO TO 1470
C     -------------------------
C
      IF(TMAX.LE.5.) GO TO 1430
      N5PLOT=N5PLOT+1
      IF(N5PLOT.LT.NCYC1) GO TO 750
 1430 N1PLOT=N1PLOT+1
```

```
      IF(N1PLOT.GT.2000) GO TO 750
      XPLOT(N1PLOT,1)=T0
      XPLOT(N1PLOT,2)=T0
      YPLOT(N1PLOT,1)=SNGL(RE)
      YPLOT(N1PLOT,2)=PR
      N5PLOT=0
      GO TO 750
C
C     ------------------------------------------------
C     DEFINE NEW 'WORKING INTERVAL' OF WIDTH NPI BETWEEN
C     NEW LEFT POINT NPA+NIN AND RIGHT POINT NPA+NPI FOR
C     THE NEXT POLYNOMIAL CALCULATION IN SAGAPO
C     ------------------------------------------------
C
 1440 IF(MOD(KW).EQ.2) GO TO 1450
      NPA(KW)=NPA(KW)+NIN(KW)
      NPEP=NPA(KW)+NPI(KW)
      NPWP=NPW(KW)
      IF(NPEP.LE.NPWP) GO TO 1460
C
      NPE(KW)=NPW(KW)
      NPA(KW)=NPE(KW)-NPI(KW)
      GO TO 1460
C
 1450 IF(T0.GE.TMAX) GO TO 1470
C     --------------
 1460 CALL SAGAPO(2)
C     --------------
      GO TO 750
C
C                ************************
C                START OF FINAL OUTPUT
C                ************************
C
 1470 IF(KPLOT.EQ.0) GO TO 1480
C
C     --------------------------------------
C     PLOTROUTINE BYPASSED, MAY BE ACTIVATED
C     FOR EACH INDIVIDUAL INSTALLATION WITH
C     APPROPRIATE PLOT-COMMANDS
C     --------------------------------------
C
C     M1=-N1PLOT
C     CALL KURV$1(LPLOT,1,1,1,M1,0,0,0,0,XPLOT,YPLOT)
C
 1480 NPAGE=NPAGE+1
      WRITE(MOP,6010) TITLE,NPAGE
      WRITE(MOP,6170) (K,XPLOT(K,2),YPLOT(K,2),K=1,N1PLOT,2)
      NPAGE=NPAGE+1
      WRITE(MOP,6010) TITLE,NPAGE
C
      IF(NRE.EQ.2) GO TO 1490
      WRITE(MOP,6180) (K,XPLOT(K,1),YPLOT(K,1),K=1,N1PLOT,2)
      GO TO 1500
C
 1490 WRITE(MOP,6190) (K,XPLOT(K,1),YPLOT(K,1),K=1,N1PLOT,2)
 1500 N1PLOT=0
```

```
      KPLOT=0
C
C     ------------------------------------------------
C     TROMIN/TROMAX = TIMES AT WHICH REACTIVITY-EXTREMA
C     RHOMIN/RHOMAX OCCURRED
C     EXTRAT RATIOS OF SUCCESSIVE EXTREMA
C     ALMEAN ALGEBRAIC MEANS OF THE EXTREMA
C     GEMEAN GEOMETRICAL MEANS OF EXTREMA
C     ------------------------------------------------
C
      WRITE(MOP,6140) (TROMIN(I),I=1,10),(RHOMIN(I),I=1,10),
     1                (TROMAX(I),I=1,10),(RHOMAX(I),I=1,10)
      DO 1510 I=1,19,2
      J=I/2+1
      TDV(I)   =RHOMIN(J)
      TDV(I+1) =RHOMAX(J)
      TDV1(I)  =0.
 1510 TDV1(I+1)=0.
C
C     ---------------------------------------------
C     ARITHM. AND GEOM. MEANS OF REACTIVITY-EXTREMA
C     ---------------------------------------------
C
      DO 1520 I=1,19,2
      IF((TDV(I).EQ.0.).OR.(TDV(I+1).EQ.0.)) GO TO 1530
      J=I/2+1
 1520 TDV1(J)  =TDV(I)/TDV(I+1)
 1530 TDV2(1)  =0.
C
      DO 1540 K=1,J
 1540 TDV2(1)  =TDV2(1)+TDV1(K)
      TDV2(1)  =TDV2(1)/J
      TDV1(10) =TDV2(1)
      WRITE(MOP,6150) (TDV1(K),K=1,10)
      TDV1(20) =0.
      TDV2(20) =0.
C
      II=0
      DO 1550 I=1,19
      IF((TDV(I).EQ.0.).OR.(TDV(I+1).EQ.0.)) GO TO 1560
      TDV1(I)   =(TDV(I)+TDV(I+1))*0.5
      TDV1(20)  =TDV1(20)+TDV1(I)
      TDV2(I)   =SQRT(ABS(TDV(I)*TDV(I+1)))
      TDV2(20)  =TDV2(20)+TDV2(I)
      II=I
 1550 CONTINUE
C
 1560 IF(II.EQ.19) GO TO 1580
      III=II+1
      DO 1570 K=III,19
      TDV1(K)=0.
 1570 TDV2(K)=0.
      IF(II.EQ.0) II=1
C
 1580 TDV1(20)=TDV1(20)/II
      TDV2(20)=TDV2(20)/II
```

```
      WRITE(MOP,6160) (TDV1(K),K=1,20),(TDV2(K),K=1,20)
C
C     ------------------------------------------
C     PROBLEM FINISHED, CALCULATE CPU-TIMES ETC AND
C     GO TO 1 (READ IN DATA FOR A NEW CASE IF ANY)
C     ------------------------------------------
C
      WRITE(MOP,6663)
      DAUER=ZEIT(ANFANG)
      CALL FRIST(ENDE)
      CPUT=ENDE1-ENDE
      WRITE(MOP,6200) CPUT,DAUER
      WRITE(MOP,6666)
      CALL ZEITK
      GO TO 1
C
 9999 STOP
C
C     -------------
C     INPUT-FORMATS
C     -------------
C
 5000 FORMAT(16G5)
 5010 FORMAT(8G10.6)
 5020 FORMAT(20A4)
C
C     --------------
C     OUTPUT-FORMATS
C     --------------
C
 6010 FORMAT('1',T15,20A4,5X,'PAGE ',I4/T15,99('-')///)
 6020 FORMAT(/T30,
     1' MOVAB   NANF   NRE   NREAD  LENLT   NRC   NGAM  NGAFAC  NREFL',/
     2        T30,I4,8I7,/T30,
     3' INPRT   NCYC  NCYC1  NVCYC  KPLOT  NPLOT N1PLOT N5PLOT ',/
     4        T30,I4,7I7//)
 6030 FORMAT(/T20,'TAN       TMAX       TCYC1       H1          H2',
     1          9X,'FV         TDVU         FH         HTM'/,
     2         14X,1P9E11.2///)
 6040 FORMAT(1H0,40X,4HBDVL,9X,6HSUMBET,11X,4HENLT/33X,1P3E15.5///)
 6050 FORMAT (1H0,17X,2(5X,1HI,7X,5HZK(I),9X,7HBETA(I),7X,7HBETR(I)))
 6060 FORMAT (1H ,17X,I6,1P3E14.5,I6,1P3E14.5)
 6070 FORMAT(//T20,'GAM =',F10.3///T60,'GAMBET(I)'//(17X,6(I6,F10.3)))
 6080 FORMAT(T20,'MOVAB =',I3,'  TSHUT0 =',1PE10.3,'  TOTSHD =',E10.3,
     1     '    TBETWN =',E10.3,'  TAUF =',E10.3,'  TABK =',E10.3)
 6082 FORMAT(T60,'DEL. GROUPS ',I3/(10X,6(I5,1PE11.3)))
 6090 FORMAT(T60,'TSHD(I)'/(10X,6(I5,1PE11.3)))
 6100 FORMAT(T5,'BETAF =',1PE11.2//(T5,'BETFI =',8E11.2))
 6110 FORMAT(T60,'BETANT(I,J)')
 6120 FORMAT(/7X,'T',9X,'RHO',8X,'FRE1',8X,'FRE2',7X,'RHO*K',5X,
     1       'RHO/BETA',6X,'PHI',11X,'IPHI',7X,'TDT/H',7X,'TDTINV')
 6130 FORMAT(5X,'(SEC)     (% DELTK)  (% DELTK)    (% DELTK)    (% DELTK)',
     1       '   (DOLLAR)      (ARB.V)     (ARB.V*SEC)     (SEC)',
     2       '      (SEC-1)'//)
 6135 FORMAT(10(1PE12.4))
 6140 FORMAT(///T15,'1',T26,'2',T37,'3',T48,'4',T59,'5',T70,'6',
     1          T81,'7',T92,'8',T103,'9',T113,'10'//
```

```
     2          T2,'TROMIN',10(1X,1PE10.3)/T2,'RHOMIN',10(1X,1PE10.3)//
     3          T2,'TROMAX',10(1X,1PE10.3)/T2,'RHOMAX',10(1X,1PE10.3))
 6150 FORMAT(//T2,'EXTRAT',10(1X,1PE10.3))
 6160 FORMAT(//T2,'ALMEAN',10(1X,1PE10.3)/T8,10(1X,1PE10.3)//
     1         T2,'GEMEAN',10(1X,1PE10.3)/T8,10(1X,1PE10.3))
 6170 FORMAT(T18,'NORM. POWER VERSUS TIME : POINTNR./TIME(SEC)/',
     1           'VALUES BY OPT. POLYNOMIAL)'///(1X,5(I4,1P2E11.3)))
 6180 FORMAT(T25,'REACTIVITY VERSUS TIME  : POINTNR./TIME(SEC)/'
     1          ,'REACTIVITY IN %DK/K'///(1X,5(I4,1P2E11.3)))
 6190 FORMAT(T25,'REACTIVITY VERSUS TIME  : POINTNR./TIME(SEC)/'
     1          ,'REACTIVITY IN DOLLAR'///(1X,5(I4,1P2E11.3)))
 6200 FORMAT(T20,'CPU-TIME =',1PE11.3,' MSEC',
     1       T60,'JOB-TIME =',E11.3,' SEC')
 6220 FORMAT (1H0,31X,'CONCENTRATIONS OF DELAYED NEUTRONS AT TIME T =',
     1                 1PE10.3,4H SEC//(6(I6,1PE15.5)))
 6663 FORMAT (///)
 6666 FORMAT('1')
      END
                        SUBROUTINE SAGAPO(MADAM)
C                       ************************
C     ------------------------------------------------------------------
C     PROGRAM HANDLES VARIOUS FORMS OF X-Y INPUT WITH SMOOTHING ROUTINES
C     FOR NOISY SIGNALS AND CALCULATES POLYNOMIALS UP TO THE 10.TH ORDER,
C     SEARCHING THE OPTIMUM POLYNOMIAL BY LEAST SQARES METHOD.
C
C     PROGRAM CALC. ALSO DERIVATIVES AND INTEGRALS OF THE OPTIMUM POLYNO-
C     MIAL OVER THE MOMENTAL "INNER SMALL" INTERVAL OR THE WHOLE REGION
C     OF NPWP INPUT-ABSCISSAE.
C
C     FOR KINETICS/INVERSKINETICS TIME OR GEOMETRICAL COORDINATE MAY BE
C     THE INDEPENDENT, REACTIVITY OR POWER THE DEPENDENT VARIABLE;
C     IN OTHER CASES DEFINITIONS ARE ARBITRARELY.
C     ------------------------------------------------------------------
C
      REAL*8     A10,BETAF,BETDOL,BETSUM,BL2,B3,B5,B6,DLNE,ELMA,ENLT,
     1           FRE1,FRE2,H,HI,PI,PI0,PR,P0,P1,P2,P3,RE,REAB,
     2           REA2,REA3,REI,REI0,RE0,RE1,RE2,RE3,SUMBET,SUMCI0,
     3           TD,TDI,TD1,TD2,XR,YR,ZW
      REAL*8     BET(30),BETORG(30),CIA(30),CIT(30),CI0(30),
     1           DCI(30),DCI1(30),DCI2(30),DCI3(30),HN(21),
     2           HNI(21),TCONH(30)
      REAL*8     CO(21),COP(6,11),COPA(6,11),COPI(6,11),EL(11,12)
      REAL*8     BETANT(30,40),BETF(40),BET1(30),
     1           POW(40),TSHD(40),TPOW(40),TBETWN(40)
      REAL*8     GAM,TCSHD,TCPOW,TSHUT0,TOTSHD
      REAL*4     SCAL(6),TDV(30),TDV1(30),TDV2(30),UVA(6),UVE(6),XFIN(6)
      REAL*4     GAMBET(30),QS(2,21),XW(2,2000),YW(2,2000)
      REAL*4     RHO(5),RHOMAX(10),RHOMIN(10),
     1           TRO(5),TROMAX(10),TROMIN(10),
     2           XPLOT(2000,2),YPLOT(2000,2)
      INTEGER    JOA(6),JOE(6),LK(21),LON(6),LOP(6),LOPA(6),LOPI(6),
     1           MOD(6),NAV(6),NEX(6),NIN(6),NPA(6),NPE(6),
     2           NPI(6),NPU(6),NPW(6),NP2(6),NTD(6),NUN(6),NPR(6)
      COMMON/C1/A10,BETAF,BETDOL,BETSUM,BL2,B3,B5,B6,DLNE,ELMA,ENLT,
     1           FRE1,FRE2,H,HI,PI,PI0,PR,P0,P1,P2,P3,RE,REAB,
     2           REA2,REA3,REI,REI0,RE0,RE1,RE2,RE3,SUMBET,SUMCI0,
     3           TD,TDI,TD1,TD2,XR,YR,ZW
```

```
      COMMON/C2/BET,BETORG,CIA,CIT,CIO,DCI,DCI1,DCI2,DCI3,HN,
     1          HNI,TCONH
      COMMON/C3/CO,COP,COPA,COPI,EL
      COMMON/C4/SCAL,UVA,UVE,XFIN,TDV,TDV1,TDV2,FV
      COMMON/C5/GAMBET,QS,XW,YW,XPLOT,YPLOT
      COMMON/C6/JOA,JOE,KW,KWA,KWE,LK,LON,LOP,LOPA,LOPI,MOD,
     1          NAV,NEX,NIN,NPA,NPE,NPI,NPU,NPW,NP2,NTD,
     2          NUN,NPR,NPILE,NERROR,LCASE,NCASE
      COMMON/TI/TITLE(20),MIP,MOP,NPAGE,INPRT,KPLOT,LPLOT
C
C
      INTEGER   NXW(2000), NYW(2000)
      REAL*8    XP(11,400),X(400),Y(400)
C
C     ------------------------------------------------------
C     DEFAULTS (WITHOUT KRECO AND NPWP) FOR DATA OF CARD 1 (13)
C     ------------------------------------------------------
C
      KIP=20
      KW=1
      KWA=1
      KWE=1
      NREAD=0
      NSORT=0
      NGLATT=0
      KREFAC=0
      NORDAT=0
C
      FV=1.E-70
      W2FV=SQRT(1./FV)
      FAC1=0.0
      FAC2=0.0
C
C     ---------------------------
      GO TO (100,1680,1680), MADAM
C     ---------------------------
C     ACTIVATE THIS INPUT IN CASE (UP TO KW=6) FUNCTIONS YW(KW) SHALL
C     BE APPROXIMATED IN PARALLEL IN THE JOB. UP TO 6 CAN BE COMBINED
C     IN THE PROGRAM. KWA IS THEN THE LOWEST, KWE THE HIGHEST NUMBER.
C
C 100 READ (MIP,5010,END=9999,ERR=9999) KW,KWA,KWE
C     READ (MIP,5010) KRECO,NPWP,MODPOL,NORDAT,NREAD,NSORT,NGLATT,KREFAC
C
C               ************************************************************
C               NUMBERS OF INPUT-CARDS START WITH 1 ASSUMING USE
C               OF SAGAPO ALONE, CARD-NUMBERS IN BRACKETS ARE
C               FOLLOWER CARD-NUMBERS IF KINIK IS USED.
C
C               INPUT-CARDS ARE LABELLED (OPTIONAL), IF
C            1) THEY ARE ONLY TRIGGERED FOR SPECIAL CASES AND/OR
C            2) FOR THEIR DATA EXIST BUILT-IN DEFAULTS
C
C               INPUT-CARDS ARE LABELLED "NN A,NN B" ETC, IF
C               THEY ARE LOGICALLY ON THE SAME PLACE IN THE INPUT
C               QUEUE, BUT JOB-DEPENDENT DIFFERENT IN DATA AND FORMAT
C               ************************************************************
C
```

```
C     C  A  R  D    1 (13)
C     -------------------
  100 READ (MIP,5010) KRECO,NPWP,MODPOL,NORDAT,NREAD,NSORT,NGLATT,KREFAC
      KW=1
      KWA=1
      KWE=1
      NPW(KW)=NPWP
      MOD(KW)=MODPOL
C
C     ------------------------------------------------------------------
C     IVAR= INDEPENDENT VARIABLE XW = TIME FOR KINETICS/INVERSE-KINETICS
C           OTHERWISE AD LIBITUM
C     DVAR= DEPENDENT   VARIABLE YW = FUNCTION OF TIME, X-DIMENSION ETC.
C     ------------------------------------------------------------------
C         M A X   2 0 0 0  INPUT-V A L U E S   A L L O W E D
C              MAX 400 FOR POLYNOMIAL-APPROXIMATION
C           ---------------------------------------------
C     WITH EXCEPTION OF KRECO=5 OR 10 THERE ARE READ IN ONLY THE
C     FUNCTION-VALUES YW(KW,I), (E.G. THE MEASURED REACTOR POWER)
C     AND  N  O  T  THE INDEPENDENT VARIABLE XW(KW,I) (E.G. TIME),
C     IVAR-VALUES ARE CALCULATED WITH THE DATA NXWZZ WHICH HAVE
C     TO BE READ IN AFTER STATEMENT 200.
C     ------------------------------------------------------------------
C
C
C                EXPLANATIONS FOR  C  A  R  D   1  (13)
C                -------------------------------------
C
C 1.1 KRECO=1  DECLOG YW-VALUES ARE READ IN, FORMAT 16I5
C
C           =2  LINEAR YW-VALUES ARE READ IN, FORMAT 16I5
C
C           =3  DECLOG YW-VALUES ARE READ IN, FORMAT  8E10.3
C
C           =4  LINEAR YW-VALUES ARE READ IN, FORMAT  8E10.3
C
C           =5  OPTIONAL PAIRS OF DATA XW/YW  FORMAT  4(2*E10.3)
C
C           >5  FOR 6-10 ALIKE KRECO=1-5, BUT INPUT BY TAPE WITH
C               DD-NUMBER FT20F001; AFTER PREPARATION OF THESE
C               INPUT-DATA IS SET KRECO = KRECO-5.
C     ------------------------------------------------------------------
C
C 1.2 NPWP     QUANTITY OF INPUT-FUNCTION-VALUES YW, IN THE PROGRAM
C              NPW(KW) TAKES OVER THIS VALUE.
C
C     ------------------------------------------------------------------
C 1.3 MODPOL   THE "MODE" OF THE POLYNOMIAL TO BE SEARCHED UPON AND THE
C              INFORMATION, WHETHER KINIK IS ALSO USED OR ONLY SAGAPO.
C              MOD(KW) TAKES OVER THIS VALUE IN THE PROGRAM
C
C MOD(KW)  =1  APPROX. OVER ONLY A PARTIAL "SMALL INNER" INTERVAL OF
C              THE WHOLE READ-IN REGION OF NPWP VALUES, WHICH IS THE
C              "BIG OUTER" INTERVAL.
C              THE "SMALL" INTERVAL CONTAINS NPI(KW) IVAR-VALUES, STARTS
C              WITH THE MOSTLEFT IVAR-GROUP AND "GLIDES" IN THE COURSE OF
C              CALCULATION/APPROXIMATION OVER THE WHOLE "BIG" REGION.
```

```
C
C          =2  APPROX. INTERVAL IS THE "BIG" IVAR-REGION OF NPWP POINTS
C
C          =3  SAME PROCEDURE AS MOD=1, BUT ONLY CALCULATION OF POLY-
C              NOMIALS IN SAGAPO AND   N O    K I N E T I C S
C
C          =4  SAME PROCEDURE AS MOD=2, BUT ONLY CALCULATION OF POLY-
C              NOMIALS IN SAGAPO AND   N O    K I N E T I C S
C
C
C        =5-8  SAME AS BEFORE WITH MOD(KW)=1-4, BUT NEGATIVE FUNCTION-
C              VALUES YW(KW) ARE THOUGHT TO BE INCORRECT AND DELETED
C              TOGETHER WITH THEIR IVAR-VALUES XW(KW).
C              AFTER THIS PROCEDURE IS SET MOD(KW)=MOD(KW)-4
C
C     ------------------------------------------------------------------
C 1.4 NORDAT=0 THE ORIGINAL INPUT-DATA YW(KW) ARE USED
C
C           =1 INPUT-DATA YW(KW) ARE NORMALIZED TO 100.0
C
C              IN BOTH CASES DEC.LOG.-INPUT-DATA YW(KW,I)
C              HAVE BEEN DELOG. INTO THEIR NUMERI
C
C              DEFAULT=0
C     ------------------------------------------------------------------
C 1.5 NREAD=0  NO INPUT OF CARD 2  (14), SETTING OF DEFAULTS
C
C              DEFAULT=0
C
C 1.6 NSORT>0  THE FIRST NSORT YW-VALUES ARE PERUSED FOR STRAYING
C              DATA WHICH ARE DEBUGGED BY THE SMOOTHING OPTION
C
C              DEFAULT=0
C
C 1.7 NGLATT   SMOOTHING OF INPUT-DATA YW. THIS IS AN IMPORTANT AUXILI-
C              ARY MEANS IN CASE OF NOISY SIGNALS, AND FOR INVERSE KIN-
C              ETICS, WHENEVER IN THE LOWER POWER DECADES SIGNAL RESO-
C              LUTION IS POOR.
C
C          =1  SMOOTHING STARTS AT IVAR-POINT XW(KW,N), FOR WHICH FOR
C              THE 3. TIME APPLIES YW(KW,N-1)-YW(KW,N).NE.0. SUCCESSIVE
C              YW WITH A DIFFERENCE OF 0.0 ARE REPLACED BY ONE PAIR
C              OF IVAR/DVAR, NPW(KW) IS LOWERED BY 1.
C
C              IN CASE OF KINETICS THIS PROCEDURE AVOIDS LONG PERIODS
C              OF CONSTANT POWER/REACTIVITY IN MEASURED VALUES BEFORE
C              STARTING ROD DROP.
C
C          =2  SMOOTHING STARTS, WHENEVER FUNCTION-VALUES YW HAVE PASSED
C              THE FIRST DECADE AND WITHIN THE 2. DECADE THE DIFFERENCE
C              BETWEEN SUCCESSIVE VALUES YW IS FOR THE 3. TIME < 2.5 %.
C              THIS PROCEDURE AVOIDS SMOOTHING OF POWER DATA DURING ROD
C              DROP WITHIN THE FIRST DECADE, BECAUSE THESE VALUES ARE
C              IN MOST CASES NOT NOISY.
C
C          >2  SMOOTHING STARTS 6 POINTS AFTER IVAR=XW(KW,NGLATT)
C
```

```
C               DEFAULT=0
C
C 1.8 KREFAC>0 INPUT OF FACTORS FAC1 AND FAC2 ARE AWAITED FOR; AIM IS
C               IMPROVING FAULTY SIGNALS OF MEASURING LINES ETC.
C               IT IS CLEAR, THAT THIS FORMALISM (STMNTS 445-451) HAS TO
C               BE FITTED TO THE CHANNEL, AMPLIFIER ETC. IN QUESTION.
C
C               DEFAULT=0
C
C     ------------------------------------
C     DEFAULTS FOR VARIABLES ON CARD 2(14)
C     ------------------------------------
C
      NPA(KW)=1
      NPI(KW)=10
      NIN(KW)=2
      JOA(KW)=1
      JOE(KW)=8
C
      NAV(KW)=2
      LON(KW)=1
      NTD(KW)=2
C
      NPR(KW)=2
      NUN(KW)=20
      NEX(KW)=0
C
C     -------------------
C     END OF INPUT-BYPASS
C     -------------------
C
C
C     ---------------------------------------------------------------
C                 EXPLANATIONS FOR  C  A  R  D   2  (14)  (OPTIONAL)
C                 -------------------------------------------------
C
C 2.1 NPA(KW)   IF MOD=1 OR 3 THIS IS THE NUMBER OF THE FIRST LEFT IVAR-
C               BOUNDARY XW OF THE "GLIDING" INTERVAL TO BE APPROXIMATED;
C               MUST NOT BE XW(KW,1).
C
C               IF MOD=2 OR 4 THE NUMBER OF THE FIXED LEFT IVAR-BOUNDARY
C               XW OF THE "TOTAL" INTERVAL TO BE APPROXIMATED AND MUST
C               EVEN NOT BE XW(KW,1).
C
C               DEFAULT=1
C
C 2.2 NPI(KW)   QUANTITY OF THE INNER IVAR-POINTS OF INTERVAL; THE NUMBER
C               OF THE RESPECTIVE RIGHT IVAR-BOUNDARY OF THE INTERVAL IS
C               NPE(KW) = NPA(KW) + NPI(KW).
C               MAXIMUM VALUE OF NPI IS 400, CTHERWISE CHANGING OF CON-
C               CERNING DIMENSIONS IS AFFORDED.
C
C
C               DEFAULT=10
C
C 2.3 NIN(KW)   QUANTITY OF INNER IVAR-POINTS XW, BY WHICH IN THE CASE OF
C               "GLIDING" INTERVAL THE LEFT BOUNDARY HAS TO BE SHIFTED
```

```
C              TO THE RIGHT, IF DURING CALCULATION THE RIGHT BOUNDARY
C              OF THE INTERVAL HAS BEEN REACHED. THE NUMBER OF THE NEW
C              LEFT BOUNDARY IS THEN NPA(KW) + NIN(KW).
C
C              DEFAULT=2
C
C 2.4 JOA(KW)  LOWEST ORDER (MIN=2) OF POLYNOMIAL TO BEGIN WITH TEST
C              FOR OPTIMISATION MINUS 1.
C
C              DEFAULT=1
C
C 2.5 JOE(KW)  HIGHEST ORDER (MAX 10) OF POLYNOMIAL TO END TEST FOR
C              OPTIMISATION
C
C              DEFAULT=8
C     ------------------------------------------------------------
C
C 2.6 NAV(KW)  DEFINES MEANING OF DEPENDENT VARIABLE YW(KW,I)
C
C        =1,4  DVAR=REACTIVITY (KINETICS/INVERSKIN., WITH JUMP TO MAIN)
C        =2,5  DVAR=FLUX OR POWER (INVERSKINETICS, WITH JUMP TO MAIN)
C
C        =3,6  PRECHOOSABLE CYCLES OF: X-Y-DATA INPUT, CALCULATION
C              OF OPTIMUM POLYNOMIAL, OUTPUT OF RESULTS, KINETICS-
C              CALCULATIONS ETC.
C        =3    O N L Y   C Y C L E S   I N   S A G A P O
C        =6    JUMP TO MAIN AND BACK INCLUDED
C
C              DEFAULT=2
C     ------------------------------------------------------------
C 2.7 LON(KW)  SIGNIFICANT ONLY FOR KINETIC CALCULATIONS
C
C          =0  NON-LOGARITHMIC DVAR-VALUES YW(KW) ARE APPROXIMATED BY
C              POLYNOMIALS AND USED IN THE DIFF.-EQNS., EVEN IF DECLOG-
C              DATA HAS BEEN INPUT-DATA. (DECLOG-DATA ARE ALL THE SAME
C              DE-LOGARITHMISED AFTER INPUT AND BEFORE CALCULATIONS.)
C
C          =1  NAT-LOGARITHMIC DVAR-VALUES YW(KW) ARE APPROXIMATED BY
C              POLYNOMIALS AND USED IN THE DIFF.-EQNS.; IN THIS CASE
C              AND FOR KINETICS-CALCULATIONS THE FIRST DERIVATIVE OF
C              THE APPR. POLYNOMIAL IS THE DOUBLING-TIME OF THE REACTOR.
C
C              DEFAULT=1, BECAUSE PROGRAM IS AT THE MOMENT GENERALLY
C              USED FOR INVERSE-KINETICS.
C
C     ------------------------------------------------------------
C 2.8 NTD(KW)  SIGNIFICANT IF LON(KW).EQ.1.; NTD DEFINES MEANING OF AND
C              COMMENT TO THE (PRINTED) OUTPUT OF DERIVATIVE VALUES.
C
C          =1  DOUBLING TIME (SEC)              (YW = REACTOR POWER)
C
C          =2  INVERSE DOUBLING TIME (1/SEC)    (YW = REACTOR POWER)
C
C          =3  1. DERIVATIVE OF NAT.LOG. OF THE INPUT-VALUES
C
C              DEFAULT=2
C
```

```
C     ------------------------------------------------------------
C 2.9 NPR(KW)  TRIGGERS OUTPUT OF COEFFICIENTS ETC. OF APPROX. POLYNO-
C              MIALS AND THE YW-DATA CALCULATED WITH THEM.
C              DEFAULT 2 SHOULD ONLY BE CHANGED, IF ONLY SAGAPO IS USED
C              FOR CALCULATING POLYNOMIALS WITHOUT USING MAIN PROGRAM.
C              ************************************************************
C              WARNING!      =10  MEANS A LOT OF OUTPUT!       WARNING!
C              ************************************************************
C
C        GT.2  OUTPUT OF ALL SIGNIFICANT DATA OF THE MOMENTALLY CALCU-
C              LATED  O P T I M U M   POLYNOMIAL
C
C        =  4  INCLUDING DATA OF THE DERIVATIVES OF OPT. POLYNOMIAL,
C              IF NPR(KW) = 5 ALSO THE FIRST ORDER INTEGRAL.
C
C        = 10  ALIKE 5 BUT FOR  E  A  C  H  CALCULATED POLYNOMIAL, NOT
C              ONLY FOR THE OPTIMUM.   A   L O T   O F  O U T P U T!
C
C              DEFAULT=2
C     ------------------------------------------------------------
C 2.10 NUN(KW) OUTPUT OF PROVISIONAL RESULTS ONLY FOR EACH NUN.-TH
C              VALUE OF THE IVAR XW(KW)
C
C              DEFAULT=20
C     ------------------------------------------------------------
C 2.11 NEX(KW) IF GT.0, DVAR-VALUES YW(KW) FOR NEX(KW) IVAR-POINTS
C              BEYOND THE RIGHT XW(KW)-BOUNDARY ARE CALCULATED, USING
C              COEFFICIENTS OF THE RESP. POLYNOMIAL, WHICH HAS BEEN
C              CALCULATED FOR THE INNER INTERVAL.
C
C              DEFAULT=0
C     --------------------------------
C     C  A  R  D    2 (14)  (OPTIONAL)
C     --------------------------------
      IF (NREAD.NE.0) READ (MIP,5010)
     1                NPA(KW),NPI(KW),NIN(KW),JOA(KW),JOE(KW),
     2                NAV(KW),LON(KW),NTD(KW),
     3                NPR(KW),NUN(KW),NEX(KW)
C
      IF(KRECO.EQ.5.OR.KRECO.EQ.10)  GO TO 430
C
C     ------------------------------------------------------------
C                EXPLANATIONS FOR  C  A  R  D  3  (15)
C                ------------------------------------
C
C     NXW-DATA ARE THE QUANTITIES OF IVAR-VALUES FORMING "SMALL" INTER-
C     VALS IN MULTIPLES OF 10**-3 (THUS FOR THE TIME IN MS) IN UNITS OF
C     10,20,50,100,200,250,500,1000,2000,5000,10000,20000 AND 50000-FOLD
C     (NXW10,NXW20,.....NXW500,.............NXW10S,.........NXW50S)
C
C     THUS NXW50=6 MEANS, THAT A "BIG" INTERVAL IS DIVIDED INTO SIX SMALL
C     INTERVALS OF VALUE 50*10**-3 EACH.
C
C     STMNTS 200 TO 464 FORM WITH THESE DATA THE CONSECUTIVE INTERVALS
C     OF IVAR XW(KW). NXW-DATA OF NON-USED UNITS ARE SET TO 0. IN CASE
C     ONLY ONE NXW-VALUE.GT.0, ALL "SMALL" INTERVALS HAVE THE SAME WIDTH
C     DEFINED BY THE MULTIPLE OF 10**-3 GIVEN WITH THIS NXW.
```

```
C
C     NXW00 IS THE STARTING VALUE OF IVAR XW(KW). NXW00 IS INTERPRETED
C     IN THE FORMAT (I2,I3). THE FIRST TWO NUMBERS (FROM 1-13) MEANS ONE
C     OF THE BEFORESAID MULTIPLES OF 10,20...TO 100000-FOLDS OF 10**-3,
C     THE LAST 3 NUMBERS MEAN THE QUANTITY OF THESE MULTIPLES.
C
C     THUS NXW00=10235 MEANS, THAT THE STARTING VALUE FOR IVAR XW(KW)
C     IS 235*(5000*10**-3), THUS FOR IVAR=TIME START IS AT 1.175E+3 SEC.
C
C     FOR KRECO = 1-4 AND 6-9 THE IVAR XW(KW) WILL BE CALCULATED WITH
C     THE NXW-VALUES JUST READ IN, BEFOREHAND AS INTEGER NUMBERS.
C
C     MULTIPLICATION WITH 1.E-3 GIVES MSEC, IF MOD(KW) = 1 OR 2  IT
C     IS FOR KINETICS; FOR OTHER CASES THE USER DEFINES THE MEANING
C     OF THE INDEPENDENT VARIABLE.
C     ------------------------------------------------------------
C
C     C  A  R  D    3 (15)
C     --------------------
      READ (MIP,5010) NXW00,NXW10,NXW20,NXW50,NXW100,NXW200,NXW250,
     1                NXW500,NXWSEC,NXW02S,NXW05S,NXW10S,NXW20S,NXW50S
C
      KZW=NXW00/1000
C
      IF (KZW.EQ.0)   NZW=    0
      IF (KZW.EQ.1)   NZW=   10
      IF (KZW.EQ.2)   NZW=   20
      IF (KZW.EQ.3)   NZW=   50
      IF (KZW.EQ.4)   NZW=  100
      IF (KZW.EQ.5)   NZW=  200
      IF (KZW.EQ.6)   NZW=  250
      IF (KZW.EQ.7)   NZW=  500
      IF (KZW.EQ.8)   NZW= 1000
      IF (KZW.EQ.9)   NZW= 2000
      IF (KZW.EQ.10)  NZW= 5000
      IF (KZW.EQ.11)  NZW=10000
      IF (KZW.EQ.12)  NZW=20000
      IF (KZW.EQ.13)  NZW=50000
C
      NXW00=(NXW00-KZW*1000)*NZW
C
C     ------------------------------------------------------
C     FOR KRECO = 1-4 AND 6-9 THE IVAR XW(KW) WILL BE CAL-
C     CULATED WITH THE NXW-VALUES JUST READ IN, BEFOREHAND
C     AS INTEGER NUMBERS.
C
C     MULTIPLICATION WITH 1.E-3 GIVES MSEC IF MOD(KW) = 1
C     OR 2, WHICH MEANS FOR KINETICS; FOR OTHER CASES THE
C     USER DEFINES THE MEANING OF THE INDEPENDENT VARIABLE.
C     ------------------------------------------------------
C
      DO 130 I=1,400
  130 NXW(I)=0
      NXW(1)=NXW00
C
      NXEND1=NXW10+1
      NXEND2=NXEND1+NXW20
```

```
      NXEND3=NXEND2+NXW50
      NXEND4=NXEND3+NXW100
      NXEND5=NXEND4+NXW200
      NXEND6=NXEND5+NXW250
      NXEND7=NXEND6+NXW500
      NXEND8=NXEND7+NXWSEC
      NXEND9=NXEND8+NXW02S
      NXED10=NXEND9+NXW05S
      NXED11=NXED10+NXW10S
      NXED12=NXED11+NXW20S
      NXED13=NXED12+NXW50S
      IF(NPWP.NE.NXED13) GO TO 9998
C
      IF(NXEND1.EQ.1) GO TO 150
      DO 140 I=2,NXEND1
  140 NXW(I)=NXW(I-1) + 10
  150 IF(NXEND1.EQ.NXEND2) GO TO 170
      NXEND1=NXEND1+1
      DO 160 I=NXEND1,NXEND2
  160 NXW(I)=NXW(I-1)+20
  170 IF(NXEND2.EQ.NXEND3) GO TO 190
      NXEND2=NXEND2+1
      DO 180 I=NXEND2,NXEND3
  180 NXW(I)=NXW(I-1)+50
  190 IF(NXEND3.EQ.NXEND4) GO TO 210
      NXEND3=NXEND3+1
      DO 200 I=NXEND3,NXEND4
  200 NXW(I)=NXW(I-1)+100
  210 IF(NXEND4.EQ.NXEND5) GO TO 230
      NXEND4=NXEND4+1
      DO 220 I=NXEND4,NXEND5
  220 NXW(I)=NXW(I-1)+200
  230 IF(NXEND5.EQ.NXEND6) GO TO 250
      NXEND5=NXEND5+1
      DO 240 I=NXEND5,NXEND6
  240 NXW(I)=NXW(I-1)+250
  250 IF(NXEND6.EQ.NXEND7) GO TO 270
      NXEND6=NXEND6+1
      DO 260 I=NXEND6,NXEND7
  260 NXW(I)=NXW(I-1)+500
  270 IF(NXEND7.EQ.NXEND8) GO TO 290
      NXEND7=NXEND7+1
      DO 280 I=NXEND7,NXEND8
  280 NXW(I)=NXW(I-1)+1000
  290 IF(NXEND8.EQ.NXEND9) GO TO 310
      NXEND8=NXEND8+1
      DO 300 I=NXEND8,NXEND9
  300 NXW(I)=NXW(I-1)+2000
  310 IF(NXEND9.EQ.NXED10) GO TO 330
      NXEND9=NXEND9+1
      DO 320 I=NXEND9,NXED10
  320 NXW(I)=NXW(I-1)+5000
  330 IF(NXED10.EQ.NXED11) GO TO 350
      NXED10=NXED10+1
      DO 340 I=NXED10,NXED11
  340 NXW(I)=NXW(I-1)+10000
  350 IF(NXED11.EQ.NXED12) GO TO 370
```

```
      NXED11=NXED11+1
      DO 360 I=NXED11,NXED12
  360 NXW(I)=NXW(I-1)+20000
  370 IF(NXED12.EQ.NXED13) GO TO 390
      NXED12=NXED12+1
      DO 380 I=NXED12,NXED13
  380 NXW(I)=NXW(I-1)+50000
C
  390 DO 400 I=1,NPWP
  400 XW(KW,I)=NXW(I)*1.E-3
C
C     ------------------------------------------------
C     END OF FORMING INTERVALS FOR THE INDEPENDENT VARIABLE
C     ------------------------------------------------
C
C       ********************************************************************
C       EXPLANATIONS FOR  C  A  R  D  4 A-C  (16 A-C)  (OBLIGATORY)
C                AND FOR  C  A  R  D  5 A-C  (17 A-C)  (OPTIONAL)
C       ------------------------------------------------------------
C       CARD 4 (16) CONTAINS FUNCTION VALUES YW(KW,I), INPUT-FORMAT
C       IS CONTROLLED BY KRECO.
C
C       CARD 5 (17) (OPTIONAL) CONTAINS TWO FACTORS FOR DEBUG-
C       GING FAULTY SIGNALS OF E.G. INSTRUMENTS RECORDING YW(KW,I).
C       DEBUGGING FUNCTIONS HAVE TO BE FITTED IN PROGRAM SAGAPO ACCOR-
C       DING TO THIS RESP. APPARATUS.
C     ------------------------------------------------------------------
C
      GO TO (410,410,420,420,430,410,410,420,420,430), KRECO
C
C     ------------------------------------------
C             ENTRY FOR KRECO = 1,2,6 OR 7
C       READ IN INTEGER DVAR-VALUES NYW(I)  16I5
C     ------------------------------------------
C     FOR KRECO=1 OR 6 INPUT OF DEC-LOG-DATA
C     FOR KRECO=2 OR 7 INPUT OF LINEAR  DATA
C     FOR KRECO=1 OR 2 FROM NORMAL FILE MIP (5)
C     FOR KRECO=6 OR 7 FROM TAPE FILE FT20F001
C     ------------------------------------------
C
C     C  A  R  D    4 A  (16 A)
C     ------------------------
  410 IF(KRECO.EQ.1.OR.KRECO.EQ.2) READ (MIP,5010) (NYW(I),I=1,NPWP)
      IF(KRECO.EQ.6.OR.KRECO.EQ.7) READ (KIP,5010) (NYW(I),I=1,NPWP)
C
C     C  A  R  D    5 A  (17 A)  (OPTIONAL)
C     -------------------------------------
      IF(KREFAC.EQ.1) READ (MIP,5020) FAC1,FAC2
      IF(KRECO.GT.5)  KRECO=KRECO-5
C
      NPAGE=NPAGE+1
      WRITE(MOP,6000) TITLE,NPAGE
      WRITE(MOP,6001) KW,KRECO,(I,NYW(I),I=1,NPWP)
C
      IF(KREFAC.EQ.1) WRITE(MOP,6009) FAC1,FAC2
      WRITE(MOP,6920)
```

```
      GO TO 440
C
C
C     ------------------------------------------
C           ENTRY FOR KRECO=3,4,8 OR 9
C       READ IN DVAR-VALUES YW(KW,I)    8E10.3
C     ------------------------------------------
C     FOR KRECO=3 OR 8 INPUT OF DEC-LOG-DATA
C     FOR KRECO=4 OR 9 INPUT OF LINEAR DATA
C     FOR KRECO=3 OR 4 FROM NORMAL FILE MIP (5)
C     FOR KRECO=8 OR 9 FROM TAPE FILE FT20F001
C     ------------------------------------------
C
C     C  A  R  D    4 B  (16 B)
C     -------------------------
  420 IF(KRECO.EQ.3.OR.KRECO.EQ.4) READ (MIP,5020) (YW(KW,I),I=1,NPWP)
      IF(KRECO.EQ.8.OR.KRECO.EQ.9) READ (KIP,5020) (YW(KW,I),I=1,NPWP)
C
C     C  A  R  D    5 B  (17 B)   (OPTIONAL)
C     ------------------------------------
      IF(KREFAC.EQ.1) READ (MIP,5020) FAC1,FAC2
      IF(KRECO.GT.5)  KRECO=KRECO-5
C
      NPAGE=NPAGE+1
      WRITE(MOP,6000) TITLE,NPAGE
      WRITE(MOP,6002) KW,KRECO,(I,YW(KW,I),I=1,NPWP)
C
      IF(KREFAC.EQ.1) WRITE(MOP,6009) FAC1,FAC2
      WRITE(MOP,6920)
      GO TO 440
C
C
C     ------------------------------------------
C           ENTRY FOR KRECO=5 OR 10
C     IVAR XW(KW,I) AND DVAR YW(KW,I) ARE READ
C     IN AS PAIRS OF REAL NUMBERS 4(2E10.3).
C     CORRECT SEQUENCE OF XW(KW,I) IS CONTROLLED,
C     IN CASE OF ERROR PROGRAM IS FINISHED AFTER
C     OUTPUT OF RESP. COMMENT.
C     FOR KRECO = 5 FROM NORMAL FILE MIP  (5)
C     FOR KRECO =10 FROM TAPE FILE FT20F001
C     ------------------------------------------
C
C     C  A  R  D    4 C  (16 C)
C     -------------------------
  430 IF(KRECO.EQ.5)  READ (MIP,5030) (XW(KW,N),YW(KW,N),N=1,NPWP)
      IF(KRECO.EQ.10) READ (KIP,5030) (XW(KW,N),YW(KW,N),N=1,NPWP)
C
C     C  A  R  D    5 C  (17 C)  (OPTIONAL)
C     -------------------------------------
      IF(KREFAC.EQ.1) READ (MIP,5020) FAC1,FAC2
      IF(KRECO.GT.5)  KRECO=KRECO-5
C
      NPAGE=NPAGE+1
      WRITE(MOP,6000) TITLE,NPAGE
      WRITE(MOP,6003) KW,KRECO,(I,XW(KW,I),YW(KW,I),I=1,NPWP)
```

```
      IF(KREFAC.EQ.1) WRITE(MOP,6009) FAC1,FAC2
C
      DO 435 I=2,NPWP
      J=I-1
      ZW=(XW(KW,I)-XW(KW,J))
      IF(ZW.LE.0.) GO TO 9998
  435 CONTINUE
C
  440 IF(KREFAC.EQ.0) GO TO 455
C
      GO TO (445,450), KREFAC
C
C     ------------------------------------------------------------
C     FITTING OF AMPLITUDES IN CASE OF DIGITALISING DATA E.G.
C     FROM ANALOG-GRAPHED SIGNALS BY HAND (KREFAC=1). AX1 TO AX3
C     HAVE TO BE ADJUSTED AT THE APPARATUS IN QUESTION.
C
C     THE SAME APPLIES FOR THE CORRECTION OF DECLOG INPUT-DATA.
C     (KREFAC=2).
C
C     FOR KREFAC=3 ONLY DECLOG INPUT-DATA ARE DE-LOGARITHMISED.
C     ------------------------------------------------------------
C
  445 AX1=1.085E04/1.7E01
      AX2=AX1**2
      AX3=1.E04/8.5E0
      ZW=NYW(1)
      ZW=100./ZW
      DO 446 I=1,NPWP
      YW(KW,I)=NYW(I)
      YW(KW,I)=YW(KW,I)*ZW
  446 YW(KW,I)=AX1-SQRT(AX2-AX3*YW(KW,I))
      GO TO 460
C
C     ---------------------------------
C     FITTING OF DECLOG-INPUT CONCERNING
C     APPARATUS FOR GRAPHIC REGISTRATION
C     ---------------------------------
C
  450 ZW=ALOG(10.)/FAC2
      DO 451 I=1,NPWP
      ZLOGY=(YW(KW,I)-FAC1)*ZW
  451 YW(KW,I)=EXP(ZLOGY)
C
C     -------------------
C     END OF DATA-FITTING
C     -------------------
C
  455 GO TO (460,470,465,470,470),KRECO
C
C     ----------------------------------------
C     DECLOG INPUT DATA YW(KW) ARE PRINCIPALLY
C     DE-LOGARITHMISED INTO THEIR NUMERI.
C     ----------------------------------------
C
  460 DO 461 I=1,NPWP
      ZLOGY=NYW(I)
```

```
  461 YW(KW,I)=EXP(ZLOGY)
      GO TO 470
C
  465 DO 466 I=1,NPWP
      ZLOGY=YW(KW,I)
  466 YW(KW,I)=EXP(ZLOGY)
C
C
C     ------------------------------------------------------
C     NORDAT=0 THE ORIGINAL INPUT-DATA YW(KW,I) WILL BE USED IN
C              CALCULATION (DECLOG-DATA DE-LOGM. TO NUMERI)
C     NORDAT=1 INPUT-DATA YW(KW,I) WILL BE NORMALISED TO 100.0
C              BEFORE USE IN CALCULATION.
C     ------------------------------------------------------
C
  470 IF(NORDAT.EQ.0) GO TO 490
      IF(KRECO.GT.2) GO TO 480
C
      ZW=NYW(1)
      ZW=100./ZW
      DO 475 I=1,NPWP
  475 YW(KW,I)=NYW(I)*ZW
      YW100=1./ZW
      GO TO 490
C
  480 ZW=100./YW(KW,1)
      DO 485 I=1,NPWP
  485 YW(KW,I)=YW(KW,I)*ZW
      YW100=1./ZW
C
C     ----------------------------------------
C     OUTPUT OF INPUT-DATA NORMALISED TO 100.0
C     ----------------------------------------
C
  490 KANF=0
      KEND=0
  495 NPAGE=NPAGE+1
      KANF=KEND+1
      KEND=KEND+280
      IF(KEND.GE.NPWP) KEND=NPWP
      IF (NPWP.GT.100) WRITE(MOP,6000) TITLE,NPAGE
      WRITE(MOP,6010) KW,(I,XW(KW,I),YW(KW,I),I=KANF,KEND)
      IF(KEND.LT.NPWP) GO TO 495
C
      IF(MOD(KW).LT.5) GO TO 537
C
C     ------------------------------------------------
C     FOR MOD(KW).GT.4 NEGATIVE DVAR-VALUES YW(KW) ARE
C     ASSUMED AS BEING ERRORS AND ARE DISTINGUISHED;
C     CORRECT INTERVAL-STRUCTUR IS KEPT.
C     ------------------------------------------------
C
      MOD(KW)=MOD(KW)-4
  533 DO 535 I=2,NPWP
      IF(YW(KW,I).GT.0.) GO TO 535
      NZW=NPWP-1
      DO 534 K=I,NZW
```

```
  534 YW(KW,I)=YW(KW,I+1)
      GO TO 536
  535 CONTINUE
      GO TO 537
  536 NPWP=NZW
      GO TO 533
C
  537 IF(NSORT.EQ.0) GO TO 562
C
C     ------------------------------------------------------
C     THE FOLLOWING PREPARING OF YW(KW) IS SIGNIFICANT, IF
C     THE MEASURED POWER-DATA ARE VERY NOISY OR CONSTANT IN
C     VALUE BEFORE THE START OF THE ABSORBER. THIS PROCEDURE
C     STARTS INVERSKINETIC ANALYSIS AS NEAR AS POSSIBLE AT
C     THE BEGIN OF ABSORBER MOVEMENT.
C     ------------------------------------------------------
C
      I1=0
      I2=0
      DO 548 I=3,NPWP
      ZW=YW(KW,I-2)-YW(KW,I)
      IF(ZW.LE.0.) GO TO 548
      IF(I2.GT.0) GO TO 542
      I2=I
      I1=I1+1
      GO TO 548
  542 IF(I2.NE.(I-1)) GO TO 544
      IF(I1.EQ.4) GO TO 546
      I1=I1+1
      I2=I
      GO TO 548
  544 I1=0
      I2=0
      GO TO 548
  546 NZW=I-8
      IF(NZW.LE.0) NZW=1
      GO TO 550
  548 CONTINUE
  550 ZW=0.
      DO 552 I=1,NZW
  552 ZW=ZW+YW(KW,I)
      YW(KW,NZW)=ZW/NZW
      NZW=NZW-1
      NPWP=NPWP-NZW
      DO 554 I=1,NPWP
  554 YW(KW,I)=YW(KW,NZW+I)
  556 IF(YW(KW,1).LE.YW(KW,2)) GO TO 558
      GO TO 562
  558 NPWP=NPWP-1
      DO 560 I=1,NPWP
  560 YW(KW,I)=YW(KW,I+1)
      GO TO 556
C
  562 IF(NGLATT.EQ.0) GO TO 1220
C
C     ********************************************************************************
C                        SMOOTHING OF INPUT-DATA YW(KW,I)
```

```
C     ************************************************************************
C     THIS IS AN AUXILIARY MEANS IN CASE OF NOISY SIGNALS, AND FOR
C     INVERSE KINETICS, WHENEVER IN THE LOWER POWER DECADES SIGNAL-
C     RESOLUTION IS POOR. NGLATT HAS BEEN READ IN ON CARD 1 (13).
C
C                     R  E  M  E  M  B  E  R
C
C     NGLATT=1 SMOOTHING STARTS AT IVAR-POINT XW(KW,N), TO WHICH FOR
C              THE 3. TIME APPLIES YW(KW,N-1)-YW(KW,N).NE.0. SUCCESSIVE
C              YW WITH A DIFFERENCE OF 0.0 ARE REPLACED BY ONE PAIR
C              OF THIS IVAR/DVAR-VALUES, NPW(KW) IS LOWERED BY 1.
C              IN CASE OF KINETICS THIS PROCEDURE AVOIDS LONG PERIODS
C              OF CONSTANT POWER/REACTIVITY IN MEASURED VALUES BEFORE
C              STARTING ROD DROP.
C
C     NGLATT=2 SMOOTHING STARTS, WHENEVER FUNCTION-VALUES YW HAVE PASSED
C              THE FIRST DECADE AND WITHIN THE 2. DECADE THE DIFFERENCE
C              BETWEEN SUCCESSIVE VALUES YW IS FOR THE 3. TIME < 2.5 %.
C              THIS PROCEDURE AVOIDS SMOOTHING OF POWER DATA DURING ROD
C              DROP WITHIN THE FIRST DECADE, BECAUSE THESE VALUES ARE
C              IN MOST CASES NOT NOISY.
C
C     NGLATT>2 SMOOTHING STARTS 6 POINTS AFTER IVAR=XW(KW,NGLATT)
C
C              DEFAULT=0
C
C          SMOOTHING IS DONE IN INTERVALS OF ODD NUMBERS OF THE
C          IVAR-ABCSISSAE XW(KW,I). BEGINNING WITH THE LEFTMOST
C          INTERVAL THE RESP. CENTRAL ABSCISSAE XW(KW,I) ARE COOR-
C          DINATED NEW YW(KW,I), THE VALUES OF WHICH DEPEND ON THE
C          VARIABLE KGLATT. NEW FUNCTION VALUES ARE
C
C          IF KGLATT=1  NEW YW(KW,I)= (YW(KW,I-N)+YW(KW,I+N))*0.5,
C          IF KGLATT=2  NEW YW(KW,I)= THE ALGEBRAIC MEAN OF THE
C                       INTERVAL FROM YW(KW,I-N) TO YW(KW,I+N),
C                       WITH N GOING FROM 1 (FOR N3) TO 6 (FOR N13)
C
C          THIS INTERVAL IS SHIFTED EACH TIME BY NIN(KW) ABSCISSAE UP
C          TO THE RIGHTMOST VALUE XFIN(KW)=XW(KW,NPWP) OF ACTUAL REGION
C          AND REPEATED FROM LEFT TO RIGHT WITH THE SAME "SMALL" IN-
C          TERVALS AS OFTEN AS THE VALUES OF N3,N5...N13 PRESCRIBE.
C          PROCEDURE STARTS WITH INTERVALS OF THREE XW(KW,I) TRIG-
C          GERED BY N3 AND GOES ON UP TO THOSE WITH 5,7,....13 AB-
C          SCISSAE ACCORDING TO THE VALUES OF N5,N7.....N13.
C
C          THIS PROCEDURE FLATTENS NOISY SIGNALS BEGINNING WITH
C          "SHORT WAVE"-NOISE (N3) AND GOING TO RATHER "LONG WAVE"-
C          NOISE (N13). IT IS CLEAR, THAT SMOOTHING IN THIS WAY
C          AFFORDS CLOSE KNOWLEDGE OF THE FUNCTION UNDER WORK IN
C          ORDER TO KEEP THE ESSENTIAL INFORMATION OF SIGNALS.
C
C          ------------------------------------------------
C          EXPLANATIONS FOR  C  A  R  D  6  (18)  (OPTIONAL)
C          ------------------------------------------------
C
C     6.1  N3>0 TO THE RESP. CENTRAL ABSCISSA XW(KW,I) IS COORDINATED
C               A NEW FUNCTION-VALUE YW(KW,I) OF THE FORM
```

```
C
C  IF KGLATT=1  (YW(KW,I-1)+YW(KW,I+1))*0.5,
C  IF KGLATT=2  THE ALGEBRAIC MEAN OF THE SUM
C               FROM YW(KW,I-1) TO YW(KW,I+1)
C
C     THIS HAPPENS WITHIN THE BIG INTERVAL OF NPWP ABSCISSAE N3-TIMES
C                      FROM LEFT TO RIGHT BOUNDARY
C     ------------------------------------------------------------
C
C     6.2  N5>0 N5 -TIME COORDINATION OF (YW(KW,I-2)+YW(KW,I+2))*0.5 OR
C               ALGEBR. MEAN OF INTERVAL YW(KW,I-2) TO YW(KW,I+2)
C
C     6.3  N7>0 N7 -TIME COORDINATION OF (YW(KW,I-3)+YW(KW,I+3))*0.5 OR
C               ALGEBR. MEAN OF INTERVAL YW(KW,I-3) TO YW(KW,I+3)
C     6.6 N13>0 N13-TIME COORDINATION OF (YW(KW,I-6)+YW(KW,I+6))*0.5 OR
C               ALGEBR. MEAN OF INTERVAL YW(KW,I-6) TO YW(KW,I+6)
C
C     6.7 KGLATT DEFINES FORM OF SMOOTHING
C
C     6.8 LGLATT > 0 PRINTED OUTPUT OF SMOOTHED XW/YW-VALUES
C     ********************************************************************************C
C     ---------------------------------
C     C  A  R  D    6  (18)  (OPTIONAL)
C     ---------------------------------
      READ (MIP,5010) N3,N5,N7,N9,N11,N13,KGLATT,LGLATT
C
      NSUMIT=0
      DO 564 I=1,11
      DO 564 J=1,400
  564 XP(I,J)=0.
      DO 566 J=1,2
      DO 566 I=1,2000
      XPLOT(I,J)=0.
  566 YPLOT(I,J)=0.
C
      IF(NGLATT.EQ.1) GO TO 568
      IF(NGLATT.EQ.2) GO TO 574
C
      NBEG=NGLATT
      GO TO 578
C
  568 I1=0
      NZW=NPWP
      NNN=NPWP
      DO 572 I=2,NNN
      ZW=YW(KW,I-1)-YW(KW,I)
      IF(ZW.GT.0.) GO TO 572
      IF(ZW.LT.0.) GO TO 570
      DO 569 K=I,NNN
  569 YW(KW,K-1)=YW(KW,K)
      NZW=NZW-1
  570 IF(I1.EQ.2) GO TO 571
      I1=I1+1
      GO TO 572
  571 NBEG=I-(NPWP-NZW)
      NPWP=NZW
      GO TO 578
```

```
  572 CONTINUE
      NGLATT=12
C
  574 DO 576 I=1,NPWP
      IF(YW(KW,I).GT.10.) GO TO 576
      XR=YW(KW,I-1)/YW(KW,I)
      YR=YW(KW,I-2)/YW(KW,I-1)
      IF((XR+YR).GT.2.05) GO TO 576
      NBEG=I-2
      GO TO 578
  576 CONTINUE
      NGLATT=120
      GO TO 1030
C
  578 IF(N13.EQ.0) GO TO 580
      NBEG=NBEG+6
      GO TO 590
C
  580 IF(N11.EQ.0) GO TO 582
      NBEG=NBEG+5
      GO TO 590
C
  582 IF(N9.EQ.0) GO TO 584
      NBEG=NBEG+4
      GO TO 590
C
  584 IF(N7.EQ.0) GO TO 586
      NBEG=NBEG+3
      GO TO 590
C
  586 IF(N5.EQ.0) GO TO 588
      NBEG=NBEG+2
      GO TO 590
C
  588 NBEG=NBEG+1
C
  590 DO 700 I=1,NPWP
  700 YPLOT(I,1)=YW(KW,I)
      NPW(KW)=NPWP
      KXP=0
      IF(N3.EQ.0) GO TO 720
      KMIT=N3
      NMIT=0
      KPUV=1
      GO TO 820
C
  720 IF(N5.EQ.0) GO TO 740
      KMIT=N5
      NMIT=0
      KPUV=2
      GO TO 820
C
  740 IF(N7.EQ.0) GO TO 760
      KMIT=N7
      NMIT=0
      KPUV=3
```

```
      GO TO 820
C
  760 IF(N9.EQ.0) GO TO 780
      KMIT=N9
      NMIT=0
      KPUV=4
      GO TO 820
C
  780 IF(N11.EQ.0) GO TO 800
      KMIT=N11
      NMIT=0
      KPUV=5
      GO TO 820
C
  800 IF(N13.EQ.0) GO TO 1030
      KMIT=N13
      NMIT=0
      KPUV=6
C
  820 NEND=NPW(KW)-KPUV
      DO 840 J=1,2
      DO 840 I=1,NBEG
  840 XPLOT(I,J)=YPLOT(I,1)
      NXPLOT=1
      K=NEND
      ZWI1=2*KPUV+1
      ZWI1=1./ZWI1
C
  860 DO 890 I=NBEG,NEND
      IMK=I-KPUV
      IPK=I+KPUV
      IF (KGLATT.EQ.2) GO TO 870
C
      XPLOT(I,NXPLOT)=(YPLOT(IMK,1)+YPLOT(IPK,1))*0.5
      GO TO 890
C
  870 ZWI2=0.0
      DO 880 KMK=IMK,IPK
  880 ZWI2=ZWI2+YPLOT(KMK,1)
      ZWI2=ZWI2*ZWI1
      XPLOT(I,NXPLOT)=ZWI2
  890 CONTINUE
C
  900 DO 920 I=1,KPUV
      IP0=K+I-1
      IF(K.EQ.NBEG) IP0=K-I+1
      IP1=IP0+1
      IM1=IP0-1
  920 XPLOT(IP0,NXPLOT)=(YPLOT(IM1,1)+YPLOT(IP1,1))*0.5
      IF(K.EQ.NBEG) GO TO 960
      XPLOT(IP1,NXPLOT)=YPLOT(IP1,1)
C
      DO 940 I=1,KPUV
      K=NBEG-I+1
  940 YPLOT(K,1)=XPLOT(K,NXPLOT)
      K=NBEG
```

```
      GO TO 900
C
  960 IF(NXPLOT.EQ.2) GO TO 1000
      K=NPW(KW)
      DO 980 I=1,K
  980 YPLOT(I,1)=XPLOT(I,1)
      NXPLOT=2
      K=NEND
      GO TO 860
C
 1000 J=NPW(KW)
      KXP=KXP+1
      DO 1020 I=1,J
      XP(KXP,I)=(XPLOT(I,1)+XPLOT(I,2))*0.5
 1020 YPLOT(I,1)=XP(KXP,I)
C
      NMIT=NMIT+1
      NSUMIT=NSUMIT+1
      IF((KMIT.GT.NMIT).AND.(NSUMIT.LT.11)) GO TO 820
C
      GO TO(720,740,760,780,800),KPUV
C
C     ------------------------------------------
C               SMOOTHING FINISHED
C     LGLATT=0: NO WRITTEN OUTPUT OF SMOOTHED DATA
C     ------------------------------------------
C
 1030 IF(LGLATT.EQ.0) GO TO 1060
      KANF=1
      KEND=45
 1040 NPAGE=NPAGE+1
      WRITE(MOP,6000) TITLE,NPAGE
      WRITE(MOP,6020) N3,N5,N7,N9,N11,N13,NBEG
      WRITE(MOP,6030) (J,XW(KW,J),YW(KW,J),
     1                (XP(I,J),I=1,11),J=KANF,KEND)
      IF(KEND.EQ.NPWP) GO TO 1060
      KANF=KEND+1
      KEND=KEND+45
      IF(KEND.GT.NPWP) KEND=NPWP
      GO TO 1040
C
 1060 NPWP=NPW(KW)
      DO 1080 I=1,NPWP
 1080 YW(KW,I)=XP(KXP,I)
C
C     ------------------------------------------------------
C     IN ORDER TO GUARANTEE THE OPTIMUM OF THE SMALL WORKING
C     INTERVAL FROM THE BEGINNING OF THE FUNCTION, THERE ARE
C     ADDED NPI/2 IVAR-POINTS TO THE LEFT OF THE ZERO-POINT,
C     CHOOSING IVAR-DISTANCES SYMMETRICAL TO THE ZERO-POINT;
C     COORDINATED TO ALL THESE IVAR IS AS A CONSTANT VALUE
C     YW(KW,1), THE FIRST DVAR-VALUE, SO THAT THE FUNCTION
C     PASSES THE ZERO-POINT WITH A 0.0-GRADIENT.
C     ------------------------------------------------------
C
 1220 M=NPI(KW)/2
      UVA(KW)=XW(KW,1)
```

```
      P0=100.
      DO 1240 I=1,NPWP
      XPLOT(I,1)=XW(KW,I)
 1240 YPLOT(I,1)=YW(KW,I)
      ZZZ=100./YW(KW,1)
      DO 1260 I=1,NPWP
      XW(KW,I+M)=XPLOT(I,1)
 1260 YW(KW,I+M)=YPLOT(I,1)*ZZZ
      NPWP=NPWP+M
      JK=M+1
      J=M+2
      K=2*M+1
      M=0
      DO 1280 I=J,K
      M=M+2
      N=I-M
      XW(KW,N)=2*XW(KW,JK)-XW(KW,I)
 1280 YW(KW,N)=YW(KW,JK)
C
C     ----------------------------------------
C     HERE OUPUT OF ALL PREPROCESSED INPUT-DATA
C     ----------------------------------------
C
      UVE(KW)=XW(KW,NPWP)
      NPW(KW)=NPWP
      MODPOL=MOD(KW)
      IF(MODPOL.EQ.2.OR.MODPOL.EQ.4) NPI(KW)=NPW(KW)-NPA(KW)
      M=NPWP/2
      ZW=XW(KW,M)
      LOGP=LON(KW)
C
      NPAGE=NPAGE+1
      WRITE(MOP,6000) TITLE,NPAGE
C
      WRITE(MOP,6040)     KW ,NPW(KW),NPA(KW),NPI(KW),NIN(KW),
     1                JOA(KW),JOE(KW),LON(KW),NTD(KW),NAV(KW),
     2                NPR(KW),NUN(KW),NEX(KW),UVA(KW),UVE(KW)
      IF((NGLATT.GT.0).AND.(LGLATT.EQ.0))
     1                WRITE(MOP,6020) N3,N5,N7,N9,N11,N13,NBEG
C
      IF(MODPOL.EQ.2.OR.MODPOL.EQ.4) GO TO 1420
C
      WRITE(MOP,6050)
      GO TO 1440
 1420 WRITE(MOP,6060)
 1440 IF(KRECO.GT.3) GO TO 1500
C
      KANF=0
      KEND=0
      GO TO 1444
 1442 NPAGE=NPAGE+1
      WRITE(MOP,6000) TITLE,NPAGE
 1444 KANF=KEND+1
      KEND=KEND+230
      IF(KEND.GT.NPWP) KEND=NPWP
      WRITE(MOP,6010) KW,(I,XW(KW,I),YW(KW,I),I=KANF,KEND)
```

```
      IF(KEND.LT.NPWP) GO TO 1442
C
 1500 IF(LOGP.NE.1) GO TO 1560
C
C     ------------------------------------------
C                 IF LOGP.GT.0
C     FUNCTION-VALUES ARE CHANGED INTO NAT-LOG;
C     FOR KINETICS THEN THE FIRST DERIVATIVE OF THE
C     APPROXIMATING POLYNOMIAL IS THE DOUBLING-TIME
C     ------------------------------------------
C
      DO 1540 I=1,NPWP
 1540 YW(KW,I)=ALOG(YW(KW,I))
 1560 IF(KW.GT.KWA) GO TO 1620
      DO 1600 I=1,21
      HN(I)=I
      HNI(I)=1.D0/HN(I)
 1600 LK(I)=I-1
      NR=1
 1620 NP2(KW)=NPI(KW)/2
      NPU(KW)=NPA(KW)
C
      IF(NPR(KW).GT.2) GO TO 1680
      IF(MOD(KW).LT.3) RETURN
C
C     -------------------------------------
C     ENTRY FROM START OF SAGAPO IF
C     MADAM.EQ.2.OR.3 AND IF
C     MADAM.EQ.1.AND.NPR(KW).GT.2 BUT NE.10
C     -------------------------------------
C
 1680 NPE(KW)=NPA(KW)+NPI(KW)
      NPWP=NPW(KW)
      NPAP=NPA(KW)
      NPEP=NPE(KW)
      NPIP=NPI(KW)+1
      JOA1=JOA(KW)+1
      JOE0=JOE(KW)
      JOE1=JOE(KW)+1
      JOE2=JOE(KW)+2
      MODPOL=MOD(KW)
      LOGP=LON(KW)
      NPRA=NPR(KW)
      NTDA=NTD(KW)
      NINA=NIN(KW)
      NP2P=NP2(KW)
      XA=XW(KW,NPAP)
      XE=XW(KW,NPEP)
C
C     ----------------------------
      GO TO (1700,1700,2560),MADAM
C     ----------------------------
C
C     ------------------------------------------------------
C     FORMING MATRIX-ELEMENTS WITH XW(KW,NPAP) TO XW(KW,NPEP);
C     CALCULATING POLYNOMIAL-COEFFICIENTS ORDER JOA1 TO JOE1
```

```
C     ------------------------------------------------------
C
 1700 XWMAX=ABS(XW(KW,NPAP))
      DO 1720 I=NPAP,NPEP
 1720 XWMAX=AMAX1(XWMAX,ABS(XW(KW,I)))
      MSCAL=0
 1740 IF(XWMAX.LE.1.) GO TO 1780
      MSCAL=MSCAL-1
      XWMAX=XWMAX/10.
      GO TO 1740
 1780 SCAL(KW)=10.**MSCAL
      DO 1800 I=1,NPWP
 1800 XP(1,I)=1.D0
      DO 1820 N=2,JOE1
      M=0
      DO 1820 I=NPAP,NPEP
      XR=XW(KW,I)*SCAL(KW)
      M=M+1
 1820 XP(N,M)=XR**(N-1)
      DO 1840 K=1,JOE1
 1840 QS(KW,K)=0.
      DO 1860 M=1,JOE1
      DO 1860 N=1,JOE1
      EL(M,N)=0.D0
      DO 1860 I=1,NPIP
 1860 EL(M,N)=EL(M,N)+XP(M,I)*XP(N,I)
      DO 1880 N=1,JOE1
      EL(N,JOE2)=0.D0
      M=0
      DO 1880 I=NPAP,NPEP
      YR=YW(KW,I)
      M=M+1
 1880 EL(N,JOE2)=EL(N,JOE2)+YR*XP(N,M)
      NNN=JOE1
      DO 2000 M=1,NNN
      ZW=ABS(SNGL(EL(M,M)))-FV
      IF(ZW.GE.0.) GO TO 1940
      DO 1920 N=1,JOE0
 1920 EL(N,JOE1)=EL(N,JOE2)
      JOE1=M-1
      JOE2=M
      GO TO 2020
 1940 ELMA=1.D0/EL(M,M)
      DO 1960 N=M,JOE2
 1960 EL(M,N)=EL(M,N)*ELMA
      NL=M+1
      IF(NL.GE.JOE2) GO TO 2020
      DO 2000 K=NL,JOE1
      ELMA=EL(K,M)
      DO 2000 L=M,JOE2
 2000 EL(K,L)=EL(K,L)-EL(M,L)*ELMA
C
C     ---------------------------
C     DEFINING OPTIMUM POLYNOMIAL
C     BY METHOD OF LEAST SQUARES
C     ---------------------------
C
```

```
 2020 DO 2400 NO=JOA1,JOE1
      CO(NO)=EL(NO,JOE2)
      K=NO
 2040 ZW=0.DO
      DO 2060 L=K,NO
 2060 ZW=ZW+EL(K-1,L)*CO(L)
      K=K-1
      CO(K)=EL(K,JOE2)-ZW
      IF(K.GT.1) GO TO 2040
      QS(KW,NO)=0.
      XD=NPI(KW)-NO+1
      M=0
C
      DO 2140 I=NPAP,NPEP
      YR=0.DO
      M=M+1
      DO 2120 N=1,NO
 2120 YR=YR+CO(N)*XP(N,M)
      DIFY=ABS(SNGL(YR)-YW(KW,I))
      IF(DIFY.GT.W2FV) GO TO 2160
 2140 QS(KW,NO)=QS(KW,NO)+DIFY**2
      QS(KW,NO)=SQRT(QS(KW,NO)/XD)
      GO TO 2180
C
 2160 QS(KW,NO)=W2FV
 2180 IF(NPR(KW).EQ.10)  GO TO 2280
      IF(NO.GT.JOA1)     GO TO 2220
      QSM=QS(KW,JOA1)
      GO TO 2280
C
 2220 ZW=QS(KW,NO)-QSM
      IF(ZW.GT.0.)       GO TO 2400
      QSM=QS(KW,NO)
C
 2280 LO=NO
      LOA=NO-1
      LOI=NO
      DO 2320 N=1,LO
      COP(KW,N)=CO(N)
      COPI(KW,N)=CO(N)*HNI(N)
      IF(N.GT.LOA)       GO TO 2320
      COPA(KW,N)=CO(N+1)*HN(N)
 2320 CONTINUE
C
      IF(NPR(KW).EQ.10)  GO TO 2420
C
 2400 CONTINUE
C
C     ------------------------------------------------
C               OPTIMUM POLYNOMIAL IS FOUND
C     LOP(KW)   ORDER OF THIS POLYNOMIAL
C     LOPA(KW)  ORDER OF ITS 1. DERIVATIVE
C     LOP1(KW)  ORDER OF ITS 1. INTEGRAL TAKEN OVER THE
C               (POSSIBLY GLIDING) INTERVAL UNDER WORK
C     ------------------------------------------------
C
 2420 LOP(KW)=LO
```

```
      LOPA(KW)=LOA
      LOPI(KW)=LOI
C
C     ---------------------------------------------------------------
C     XFIN IS ONLY SIGNIFICANT, IF KINIK IS USED. IN KINIK CALCULATION
C     GOES ON UNTIL THE RIGHTHAND IVAR OF THE "INTERVAL UNDER WORK",
C     XFIN(KW) IS REACHED, WHERE XFIN(KW) DEPENDS ON THE "MODE" OF
C     POLYNOMIAL APPROXIMATION.
C
C     IF MODPOL=2: POLYNOMIAL APPROXIMATION HAS BEEN DONE OVER THE WHOLE
C                  NPWP INPUT-VALUES AND SO THIS APPROXIMATION IS USED
C                  IN KINIK FOR THE WHOLE CALCULATION; THIS MEANS THAT
C                  IT IS ALWAYS XFIN(KW)=XW(KW,NPWP).
C
C     IF MODPOL=1: XFIN(KW) IS ALWAYS THE (NPI/2 + 1)-TH XW(KW)-VALUE
C                  FROM THE LEFTMOST IVAR IN THE "SMALL GLIDING" INTER-
C                  VAL OF NPI(KW) VALUES, FOR WHICH APPROXIMATION HAS
C                  BEEN DONE. OPTIMUM POLYNOMIAL FOR THE NEW "SMALL"
C                  INTERVAL IS FOUND AND THE NEW XFIN(KW) HAS TO BE
C                  DEFINED BEFORE RETURN TO KINIK.
C
C     ---------------------------------------------------------------
C                        R  E  M  E  M  B  E  R
C                        ---------------------
C     NPR(KW)  TRIGGERS OUTPUT OF COEFFICIENTS ETC. OF APPROX. POLYNO-
C              MIALS AND THE YW-DATA CALCULATED WITH THEM.
C              DEFAULT 2 SHOULD ONLY BE CHANGED, IF ONLY SAGAPO IS USED
C              FOR CALCULATING POLYNOMIALS WITHOUT USING MAIN PROGRAM.
C              ***************************************************************
C              WARNING!       =10  MEANS A LOT OF OUTPUT!        WARNING!
C              ***************************************************************
C
C        GT.2  OUTPUT OF ALL SIGNIFICANT DATA OF THE MOMENTALLY CALCU-
C              LATED  O P T I M U M-POLYNOMIAL
C
C        =  4  INCLUDING DATA OF THE DERIVATIVES OF OPT. POLYNOMIAL,
C              IF NPR(KW) = 5 ALSO THE FIRST ORDER INTEGRAL.
C
C        = 10  ALIKE 5 BUT FOR  E  A  C  H  CALCULATED POLYNOMIAL, NOT
C              ONLY FOR THE OPTIMUM.
C     ---------------------------------------------------------------
C
      IF(NPEP.GE.NPWP.AND.MODPOL.EQ.1) MODPOL=2
      IF(NPEP.GE.NPWP.AND.MODPOL.EQ.3) MODPOL=4
      IF(MODPOL.EQ.2.OR.MODPOL.EQ.4) GO TO 2500
      NA2=NP2P+NPAP+1
      XFIN(KW)=XW(KW,NA2)
      GO TO 2520
C
 2500 XFIN(KW)=XW(KW,NPWP)
 2520 IF(NPR(KW).GT.2) GO TO 2560
      IF(MOD(KW).LT.3) RETURN
C
C     ------------------------------
C     START OUTPUT OF POLYNOMIAL-DATA
C     ------------------------------
C
```

```
 2560 LOA=LOPA(KW)
      LOI=LOPI(KW)
      IF(NPR(KW).NE.10) GO TO 2580
      IF((LOA/2).EQ.NPAGE) GO TO 2580
C
      NPAGE=NPAGE+1
      WRITE(MOP,6000) TITLE,NPAGE
 2580 WRITE(MOP,6090) KW,XA,XE,LOA,(LK(N),COP(KW,N),N=1,LOI)
      IF(NPR(KW).NE.10) GO TO 2600
      NZW=JOA1
      JOA1=JOA(KW)+1
 2600 WRITE(MOP,6100) (LK(N),QS(KW,N),N=JOA1,JOE1)
      IF(NPR(KW).NE.10) GO TO 2620
      JOA1=NZW
C
 2620 XT=NUN(KW)
      XD=((XE-XA)/XT)*SCAL(KW)
      NT=NUN(KW)+NEX(KW)+1
      X(1)=XW(KW,NPAP)*SCAL(KW)
      DO 2660 I=2,NT
      X(I)=0.D0
 2660 X(I)=SNGL(X(I-1))+XD
      LOPR=LOP(KW)
      DO 2680 N=1,LOPR
 2680 CO(N)=COP(KW,N)
C
 2700 DO 2780 I=1,NT
      Y(I)=0.D0
      IF(SNGL(X(I)).NE.0.) GO TO 2740
      Y(I)=CO(1)
      GO TO 2780
 2740 DO 2760 N=1,LOPR
 2760 Y(I)=Y(I)+CO(N)*(X(I)**(N-1))
 2780 CONTINUE
C
      IF(LOP(KW).GT.LOPR) GO TO 2940
      IF(LOGP.GT.1)       GO TO 2860
      DO 2840 I=1,NT
 2840 Y(I)=DEXP(Y(I))
C
 2860 WRITE(MOP,6920)
      WRITE(MOP,6110) KW,LOPA(KW),XT
      MAUS=1
      GO TO 3280
C
C     ------------------------------------------------
C     IF NPR(KW).GT.3 ADDITIONAL OUTPUT OF DERIVATIVES
C     OF THE POLYNOMIAL APPROXIMATING THE INPUT-FUNCTION
C
C     IF LON(KW).EQ.1 A NATLOG-FUNCTION HAS BEEN DERIVED;
C     THEN NTDA DEFINES THE MEANING OF THE OUTPUT
C
C     NTDA = 1 NATLOG-FUNCTION IS REACTOR POWER;
C              OUTPUT IS THE DOUBLING-TIME (SEC)
C
C     NTDA = 2 SAME AS BEFORE, OUTPUT IS THE
C              INVERSE DOUBLING TIME (1/SEC)
```

```
C
C     NTDA = 3 MEANING OF DERIVATIVE IS DEFINED BY USER
C     ------------------------------------------------
C
 2880 IF(NPR(KW).LT.4) GO TO 3160
      LOPR=LOPA(KW)
      DO 2920 N=1,LOPR
 2920 CO(N)=COPA(KW,N)
      GO TO 2700
C
 2940 IF(SCAL(KW).EQ.1.) GO TO 3000
      DO 2980 I=1,NT
 2980 Y(I)=Y(I)*SCAL(KW)
 3000 IF(LOGP.GT.1) GO TO 3140
C
      GO TO(3040,3080,3120),NTDA
C
 3040 DO 3060 I=1,NT
 3060 Y(I)=BL2/Y(I)
      WRITE(MOP,6120) KW
      MAUS=2
      GO TO 3280
C
 3080 BL2I=1./SNGL(BL2)
      DO 3100 I=1,NT
 3100 Y(I)=BL2I*Y(I)
      WRITE(MOP,6130) KW
      MAUS=2
      GO TO 3280
C
 3120 WRITE(MOP,6140) KW
      MAUS=2
      GO TO 3280
C
 3140 WRITE(MOP,6920)
      WRITE(MOP,6150) KW
      MAUS=2
      GO TO 3280
C
C     ------------------------------------------------
C     IF NPR(KW).GT.4 OUTPUT OF THE SIMPLE INTEGRAL
C
C     MODPOL=1 OVER THE MOMENTARY "SMALL GLIDING" INTERVAL
C              UNDER WORK
C     MODPOL=2 OVER THE WHOLE INPUT-REGION OF NPWP POINTS
C
C     IF LON(KW)=1 THE INTEGRAND Y WAS NATLOG, AND FOR
C     THIS CASE INTEGRATION LEADS TO (Y*LN(Y)-Y)
C     ------------------------------------------------
C
 3160 IF(NPR(KW).LT.5) GO TO 3420
      LOPR=LOPI(KW)
      DO 3200 N=1,LOPR
 3200 CO(N)=COPI(KW,N)
      DO 3260 I=1,NT
      Y(I)=0.D0
      IF(SNGL(X(I)).EQ.1.) GO TO 3260
```

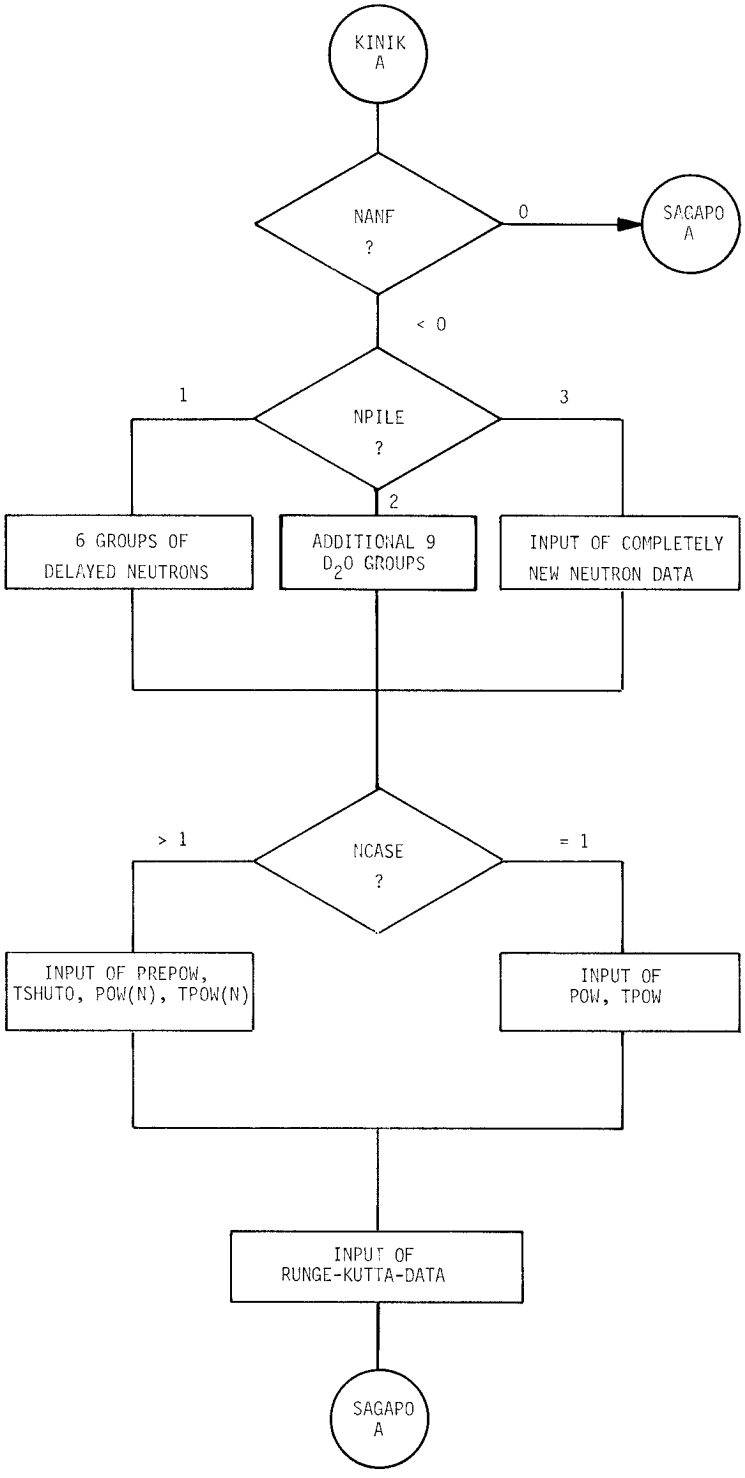
```
      DO 3240 N=1,LOPR
 3240 Y(I)=Y(I)+CO(N)*(X(I)**N)
 3260 CONTINUE
      MAUS=3
      WRITE(MOP,6160) KW
C
C     ------------------------------------------------
C     DIVISION BY SCAL(KW) HAD BROUGHT THE IVAR XW(KW,I)
C     INTO THE INTERVAL >0.0,1.0< ; FOR OUTPUT THEY ARE
C     CHANGED HERE TO THEIR ORIGINAL VALUES, BEFORE FUR-
C     THER CALCULATION AGAIN DIVIDED BY SCAL(KW).
C
C     NT=NUN(KW)+NEX(KW)+1, I.E. IF NEX(KW).GT.0 THE PO-
C     YNOMIAL HAS BEEN USED FOR CALCULATION OF NEX(KW)
C     FUNCTION-VALUES YW(KW) OUTSIDE THE RIGHTMOST IVAR
C     OF THE APPROXIMATED INTERVAL.
C     ------------------------------------------------
C
 3280 IF(SCAL(KW).EQ.1.) GO TO 3340
      DO 3320 I=1,NT
 3320 X(I)=X(I)/SCAL(KW)
 3340 WRITE(MOP,6170) (I,X(I),Y(I),I=1,NT)
      WRITE(MOP,6920)
      IF(SCAL(KW).EQ.1.) GO TO 3400
      DO 3380 I=1,NT
 3380 X(I)=X(I)*SCAL(KW)
C     -------------------------
 3400 GO TO(2880,3160,3420),MAUS
C     -------------------------
 3420 IF(NPR(KW).EQ.10) GO TO 3720
      IF(MOD(KW).LT.3)  GO TO 3440
      IF(NAV(KW)-3)     3440,3460,3580
 3440 RETURN
C
C     ------------------------------------------
C     IF NAV(KW).EQ.3 AND MOD(KW).EQ.3 GO TO 1680
C     ALL OPTIMUM POLYNOMIALS FOR "SMALL GLIDING"
C     INTERVALS OF THE INPUT-FUNCTION(S) ARE CAL-
C     CULATED AND PRINTED OUT.
C       ******************************************
C       WARNING! MAY BE A LOT OF OUTPUT! WARNING!
C       ******************************************
C
 3460 IF(MODPOL.EQ.4)   GO TO 3520
      IF(NPEP.GE.NPWP)  GO TO 3520
 3500 NPA(KW)=NPA(KW)+1
      GO TO 1680
C
C     ------------------------------------------
C     AS MENTIONED BEFORE THE OPTIMUM-DATA FOR UP TO
C     SIX FUNCTIONS YW(KW) WITH DIFFERENT ABSCISSAE
C     XW(KW) CAN BE PROCESSED IN PARALLEL. BUT THIS
C     MAKES SENSE ONLY IF THEY ARE COUPLED WITH A
C     SPECIAL ROUTINE NOT INCLUDED IN THIS PROGRAM.
C     ------------------------------------------
C
 3520 IF(KW.GT.5) GO TO 3560
```

```
      KW=KW+1
      GO TO 100
C     ------------------------------------
C     HE (SHE) WHO IS STILL NOT FED UP CAN
C     POLYNOMIZE FURTHER FUNCTIONS IN SAGAPO
C     ------------------------------------
 3560 KW=1
      GO TO 100
C
 3580 IF(MODPOL.GT.1) GO TO 3640
      IF(NPEP.GE.NPWP) GO TO 3500
      NAV(KW)=NAV(KW)-3
      NPA(KW)=NPU(KW)
      IF(NAV(KW).GT.2) GO TO 100
C
 3640 IF(NPR(KW).LT.10) RETURN
C
C     ------------------------------------
C     AS BEFORE CHANGING OF ABSCISSAE WITHIN
C     WORKING INTERVAL >0.0,1.0< INTO THEIR
C     ORIGINAL DATA FOR OUPUT
C     ------------------------------------
C
      IF(SCAL(KW).EQ.1.) GO TO 3680
      FSCAL=1./SCAL(KW)
      DO 3660 M=1,NT
      XW(KW,M)=X(M)*FSCAL
 3660 YW(KW,M)=Y(M)
      RETURN
C
 3680 DO 3700 M=1,NT
      XW(KW,M)=X(M)
 3700 YW(KW,M)=Y(M)
      RETURN
C
 3720 IF(JOA1.EQ.JOE1) GO TO 3560
      JOA1=JOA1+1
C
C     ------------------------------------------------
C                  IF NPR(KW).EQ.10
C                  ---------------
C     AFTER PRINTING DATA OF THE MOMENTARY POLYNOMIAL
C     THE POLYNOMIAL OF THE NEXT HIGHER ORDER IS CAL-
C     CULATED STARTING AT STMNT 2020, THEREAFTER AGAIN
C     PRINTING OF THE POLYNOMIAL DATA ETC UNTIL THE
C     GIVEN MAXIMUM ORDER JOE1 HAS BEEN REACHED.
C
C     WARNING!       A LOT OF OUTPUT!         WARNING!
C     ------------------------------------------------
C
      GO TO 2020
C
C
C     ------------------------------------
C     PRINTED WARNING IN CASE OF INPUT ERORS
C                THEN STOP
```

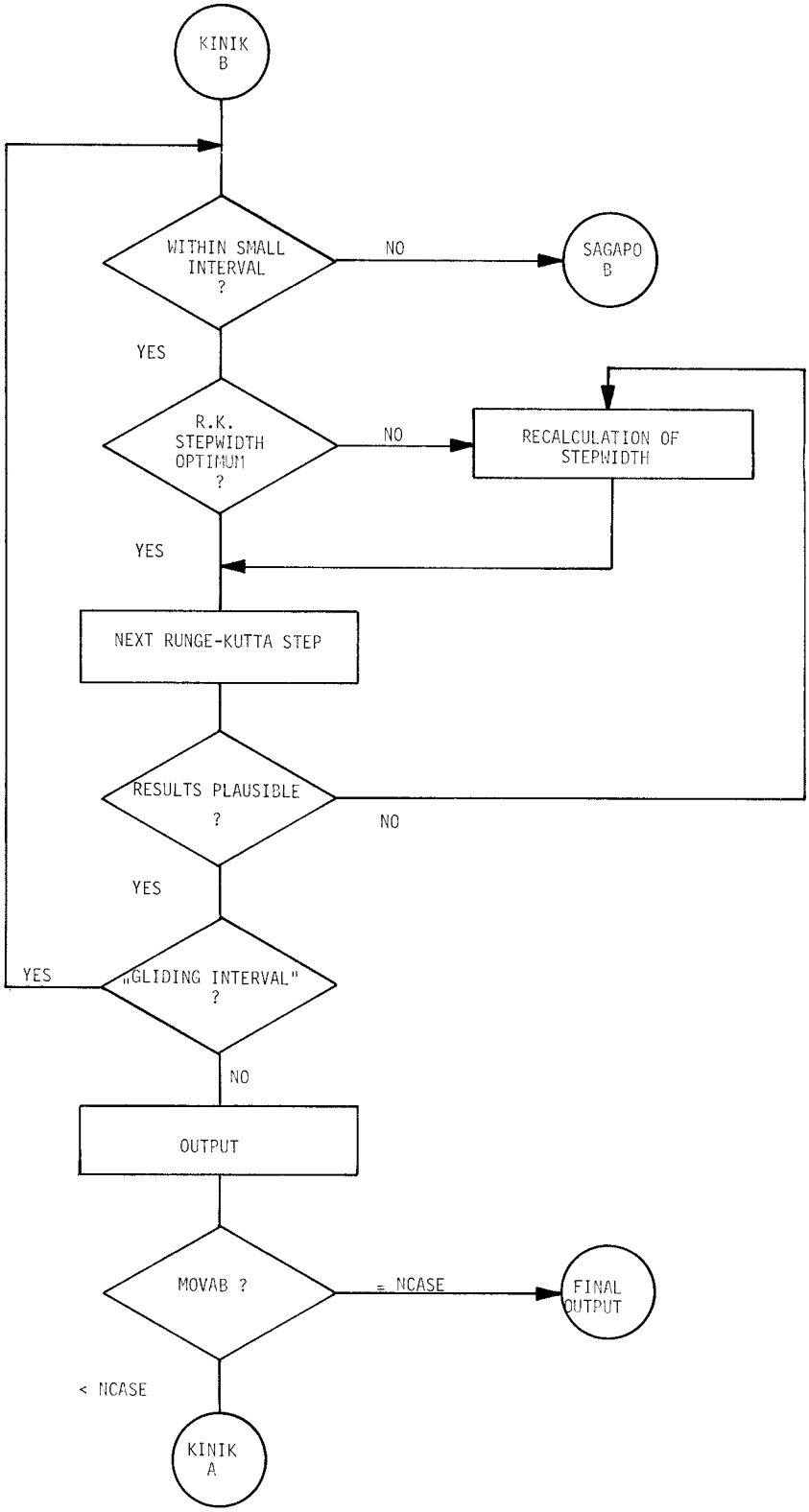
```
C     ------------------------------------
C
 9998 WRITE(MOP,6070) KW,J
      WRITE(MOP,6080)
      IF(MOD(KW).GT.2) GO TO 100
 9999 STOP
C     -------------
C     INPUT-FORMATS
C     -------------
C
 5010 FORMAT(16G5)
 5020 FORMAT(8G10.3)
 5030 FORMAT(4(2G10.3))
C
C     --------------
C     OUTPUT-FORMATS
C     --------------
C
 6000 FORMAT('1',T15,20A4,5X,'PAGE ',I4/T15,99('-')///)
 6001 FORMAT(38X,'INPUT DATA OF FUNCTION KW =',I2,',  KRECO =',I2////
     1      (8(I8,I6)))
 6002 FORMAT(38X,'INPUT DATA OF FUNCTION KW =',I2,',  KRECO =',I2////
     1      (8(I5,1PE11.3)))
 6003 FORMAT(38X,'INPUT DATA OF FUNCTION KW =',I2,',  KRECO =',I2////
     1      (5(I4,1P2E11.3)))
 6009 FORMAT(///20X,'FAC1 =',1PE10.3,'   FAC2 =',1PE10.3)
 6010 FORMAT (38X,'NORMALIZED INPUT DATA OF FUNCTION KW =',I2////
     1      (5(I4,1P2E11.3)))
 6020 FORMAT(T10,I3,'-TIMES AVERAGEING MOD 1<2>03'/
     1       T10,I3,'-TIMES AVERAGEING MOD 1<3>05'/
     2       T10,I3,'-TIMES AVERAGEING MOD 1<4>07'/
     3       T10,I3,'-TIMES AVERAGEING MOD 1<5>09'/
     4       T10,I3,'-TIMES AVERAGEING MOD 1<6>11'/
     5       T10,I3,'-TIMES AVERAGEING MOD 1<7>13'/T15,'NBEG = ',I3///)
 6030 FORMAT(T5,'PNT  TIME/S  ORIGIN  MEAN01  MEAN02  MEAN03  MEAN04',
     1             '  MEAN05  MEAN06  MEAN07  MEAN08  MEAN09  MEAN10',
     2             '  MEAN11'//(T5,I3,T8,13F8.2))
 6040 FORMAT(15X,' KW  NPW  NPA  NPI  NIN  JOA  JOE  LON  NTD  NAV  ',
     1           'NPR  NUN  NEX     UVA          UVE  '/,
     2       13X,13I5,1P2E12.3//)
 6050 FORMAT (18X,'APPROXIMATION BY OPTIMUM POLYNOMIAL OVER A PARTIAL ',
     1            '"GLIDING" IVAR-INTERVAL FOR THE')
 6060 FORMAT (18X,'APPROXIMATION BY OPTIMUM POLYNOMIAL OVER THE WHOLE ',
     1           'INPUT IVAR-REGION FOR THE')
 6070 FORMAT (1HK,20X,'SEQUENCE-ERROR IN ABSCISSAE-INPUT FOR KW =',
     1            I2,' AT XW(KW)-NUMBER',I4)
 6080 FORMAT (1HK,20X,'RUNNING JOB STOPPED, NEXT SET OF CARDS IF ANY ',
     1               'READ IN OVER MAIN-PROGRAM')
 6090 FORMAT (///23X,'FCT. KW =',I2,' PA =',1PE12.3,' PE =',1PE12.3,
     1               ' OPT. ORDER =',I3,' WITH COEFFICENTS'//
     2              (6(I6,1PE15.5)))
 6100 FORMAT (///40X,'ORDER AND ERROR SQUARES OF ALL CALCULATED ',
     1               'POLYNOMIALS'//
     2              (6(I6,1PE15.5)))
 6110 FORMAT (1HK,20X,'VALUES OF FUNCTION KW =',I2,
     1               ' CALCULATED WITH OPT. POLYN. OF ORDER',I3,
     2               ' IVAR-INTERVAL DIVIDED',F7.2,'-TIMES'//)
```

```
 6120 FORMAT (1HK,38X,'DOUBLING-TIME (SEC) FOR FUNCTION KW =',I2//)
 6130 FORMAT (1HK,38X,'INV. DOUBL.-TIME (1/SEC) FOR FUNCTION KW =',I2/)
 6140 FORMAT (1HK,38X,'1. DERIVATIVE OF LOGNAT-FUNCTION KW =',I2//)
 6150 FORMAT (1HK,38X,'1. DERIVATIVE OF FUNCTION KW =',I2//)
 6160 FORMAT (1HK,38X,'1. INTEGRAL OF FUNCTION KW = ',I2/
     1           38X,'FOR LOGAR. FUNCTION = Y*LOG(Y)-Y'//)
 6170 FORMAT (5(I4,1P2E11.3))
 6920 FORMAT(//)
      END
                        SUBROUTINE ZEITK
C                       ******************
C
      DIMENSION MON(12),MONS(12)
      INTEGER *4 TAG,T,UHR
      DATA MON /31,59,90,120,151,181,212,243,273,304,334,365/
      DATA MONS /31,60,91,121,152,182,213,244,274,305,335,366/
      A=ZEIT(0.)
      NSEC=IFIX(A)
      MIN=NSEC/60
      UHR=MIN/60
      MIN=MOD(MIN,60)
      CALL DATUM (JAHR,TAG)
      IF ((MOD(JAHR,4)) .EQ. 0)     GO TO  100
      DO 1                      I=1,12
      M=I
      IF (TAG-MON(I))           110,110,1
 1    CONTINUE
 100  DO 10                     I=1,12
      M=I
      IF (TAG-MONS(I))          120,120,10
 10   CONTINUE
 110  IF (M .EQ. 1)             T=TAG
      IF (M .NE. 1)             T=TAG-MON(M-1)
      GO TO                     200
 120  IF (M .EQ. 1)             T=TAG
      IF (M .NE. 1)             T=TAG-MONS(M-1)
 200  WRITE (6,500) T,M,JAHR,UHR,MIN
 500  FORMAT(//30X,'DATUM:    ',I2,'.',I2,'.19',I2,5X,I2,' UHR',I5,' MIN
     1UTEN'/30X,44('-'))
      RETURN
      END
/*
//G.SYSIN DD *
    2    1
 D-040185 AW GSA 11.93WG  MIT GLAETTEN, NANF=2, TAUF=10.0, POW=2.0
    1    2    1    1    0    0    0    0    0
    1    0    0    0    0    0
      0.00       0.00
      0.00      10.00       2.00
    2   45    1    1    0    0    1    0
    0   20    5    4   15    0    0    0    0    0    0    0    0    0
  852  851  849  844  838  825  807  781  749  709  664  611  557  501  446  392
  344  299  262  229  203  161  132  111   96   85   66   59   57   59   57   56
   53   52   51   50   49   48   48   47   45   45   45   44   43
    1    1    0    0    0    0    1    1
/*
```

2.4.5.1 FLOW CHART KINIK (A)



2.4.5.2 FLOW CHART KINIK (B)



2.4.5.3 FLOW CHART SAGAPO