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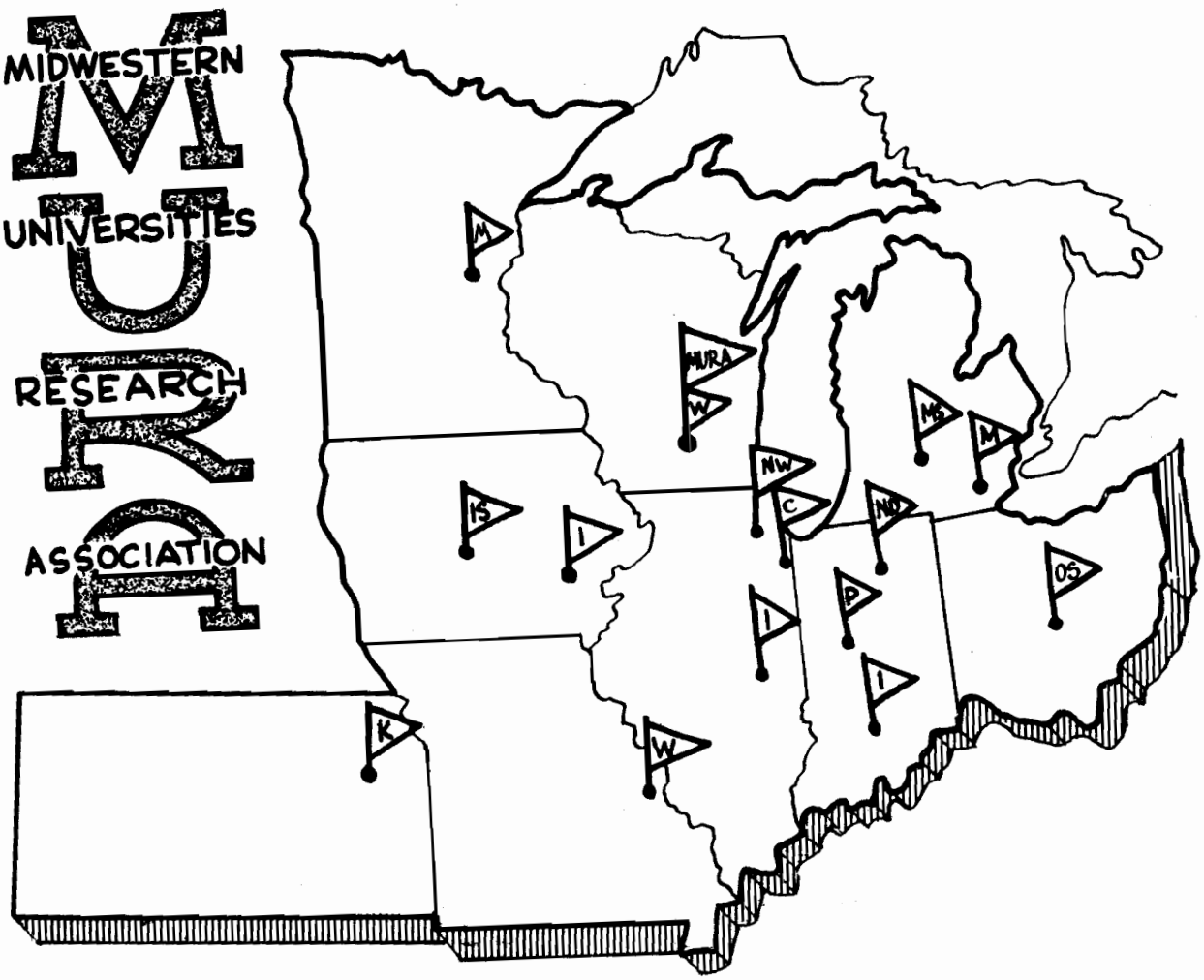


**REPORT**
XMASH
(Program F16)
May, 1960

**NUMBER** 571
Computer Program
(Internal)

# XMASH
(Program F16)

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XMASH, suggested by R. Christian, is a system of programs to study the motion of a particle through a series of magnetic fields. The magnetic fields are described on the median plane by suitable parameters or by experimentally measured values. There is no limit to the number of meshes to be placed in sequence, but the maximum number of field potentials (mesh points) on any one mesh is limited to 2048.

There are currently 7 different programs (methods of calculations) in the XMASH system. More can be added when necessary. The XMASH system is located on tape, and is called for by means of a one-card XMASH LOADER, followed by parameters on data cards.

The first data card selects the method of calculation to be used, and contains the address 10 with the value 1,2,3,...,7 (method number).

## METHOD 1

Fields on the median plane are described by the formula

$$B_y = -(A+x)^k \sum_{m=0}^{31} \left(\mu_m \cos m\phi + \nu_m \sin m\phi\right)$$

where

$$k = \sum_{j=0}^{19} k_j x^j$$

$$\left.\begin{aligned} \mu_m &= \sum_{j=0}^{19} \mu_{m,j} x^j \\ \nu_m &= \sum_{j=0}^{19} \nu_{m,j} x^j \end{aligned}\right\} (m = 0,1,2,\ldots,31)$$

$$\phi = K \ln(A+x) - N\theta$$

$$K = \sum_{j=0}^{19} \left(\frac{1}{W}\right)_j x^j$$

Fields off the median plane are calculated by the formulas

$$H_y = B_y - y^2\left[\frac{1}{2!}\nabla\right] + y^4\left[\frac{1}{4!}\nabla\nabla\right]$$

$$H_x = y\left[\frac{\partial B_y}{\partial x}\right] - y^3\left[\frac{1}{3!}\frac{\partial \nabla}{\partial x}\right]$$

$$H_\theta = y\left[\frac{\partial B_y}{\partial \theta}\right] - y^3\left[\frac{1}{3!}\frac{\partial \nabla}{\partial \theta}\right]$$

where $$\frac{\partial B_y}{\partial x} = \frac{-B_{y_{i+2}} + 8B_{y_{i+1}} - 8B_{y_{i-1}} + B_{y_{i-2}}}{12\,\Delta x}$$

$$\frac{\partial B_y}{\partial \theta} = \frac{-B_{y_{j+2}} + 8B_{y_{j+1}} - 8B_{y_{j-1}} + B_{y_{j-2}}}{12\,\Delta\theta\,(A+x)}$$

$$\frac{1}{2!}\nabla = \frac{B_{y_{i+1,j}} - 2B_{y_{i,j}} + B_{y_{i-1,j}}}{2(\Delta x)^2} + \frac{B_{y_{i+1,j}} - B_{y_{i-1,j}}}{4\Delta x\,(A+x)}$$

$$+ \frac{B_{y_{i,j+1}} - 2B_{y_{i,j}} + B_{y_{i,j-1}}}{2(\Delta\theta)^2(A+x)^2}$$

$$\frac{1}{3!}\frac{\partial \nabla}{\partial x} = \frac{\nabla_{i+1} - \nabla_{i-1}}{12\,\Delta x}$$

$$\frac{1}{3!}\frac{\partial \nabla}{\partial \theta} = \frac{\nabla_{j+1} - \nabla_{j-1}}{12\,\Delta\theta\,(A+x)}$$

$$\frac{1}{4!}\nabla\nabla = \frac{\nabla_{i+1,j} - 2\nabla_{i,j} + \nabla_{i-1,j}}{24(\Delta x)^2} + \frac{\nabla_{i+1,j} - \nabla_{i-1,j}}{48\,\Delta x\,(A+x)}$$

$$+ \frac{\nabla_{i,j+1} - 2\nabla_{i,j} + \nabla_{i,j-1}}{24(\Delta\theta)^2(A+x)^2}$$

NOTE: In the determination of field values on and adjacent to the mesh boundary it is necessary to extend the mesh 2 units in each direction.

The dynamics of the particle through the fields are obtained by the Runge-Kutta process of integration, using the formulas

$$\frac{dx}{d\theta} = (a+x)\frac{p_x}{D}$$

$$\frac{dy}{d\theta} = (a+x)\frac{p_y}{D}$$

$$\frac{dp_x}{d\theta} = D - \lambda(a+x)\left[H_y - \frac{p_x}{D} H_\theta\right]$$

$$\frac{dp_y}{d\theta} = \lambda(a+x)\left[H_x - \frac{p_x}{D} H_\theta\right]$$

$$\text{where } D = \sqrt{P^2 - (p_x^2 + p_y^2)}$$

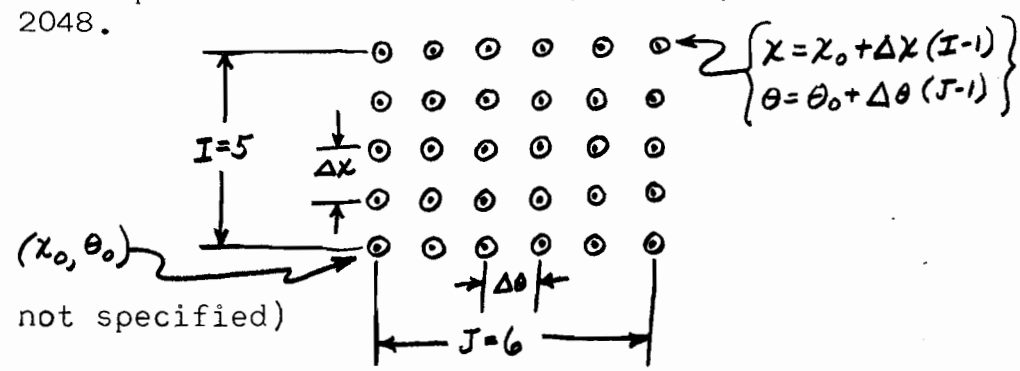
WRITING AGENDA FOR METHOD 1

Using the standard MURA-FORTRAN agendum sheets (see attached sample on last page), the value 1 with address 10 (to select method one) is entered, followed by an asterisk to indicate an END DATA card. (Each group of parameters, to specify a function in the sequence of calculations, is terminated by an END DATA card.)

Field parameters are specified next. Enter only those parameters whose values are not zero, or that change from one mesh to the next. The parameters available, with their addresses are:

1 Mesh identification number (positive integer $<$ 32768)
2 I (number of points in the x-direction)
3 J (number of points in the $\Theta$-direction)
J must be odd. J = 2n + 1, where n is the number of integration steps to be taken across the mesh.
I x J $\leqslant$ 2048.

4 $\Delta X$
5 $\Delta\Theta$
6 $X_0$
7 $\Theta_0$




8 A ( = 1 if not specified)
9 N

| | | |
|---|---|---|
| 11-30 | $k_0, k_1, k_2, \ldots, k_{19}$ | |
| 31-50 | $(1/w)_0, (1/w)_1, \ldots, (1/w)_{19}$ | |
| 51-70 | $\mu_{0,j=0-19}$ | (32 blocks of 20 each) |
| 71-90 | $\mu_{1,0} - \mu_{1,19}$ | |
| 671-690 | $\mu_{31,0} - \mu_{31,19}$ | |
| 691-710 | $\nu_{0,j=0-19}$ | (32 blocks of 20 each) |
| 711-730 | $\nu_{1,0} - \nu_{1,19}$ | |
| 1311-1300 | $\nu_{31,0} - \nu_{31,19}$ | |

Terminate each mesh specification with an END DATA card. When all the meshes necessary for the dynamics have been specified, the controlling address 10 (finished indicator) is entered with a value not zero. (This finished indicator is used throughout XMASH to indicate transfer of control to the next phase or sequence of programs to allow processing of new data.)

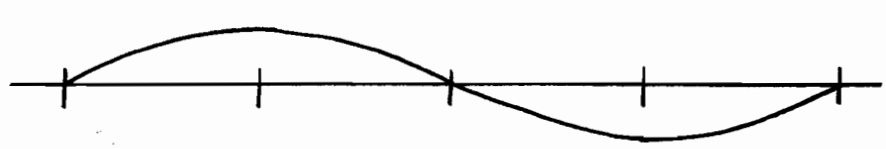
<u>Sector configuration parameters</u> are entered next. A sector is here defined to be one complete period consisting of all the meshes necessary for the dynamics to follow. Meshes other than those previously described on the same agendum can be inserted in the sector, provided they have been previously recorded on the same tape as has just been prepared (see paragraph entitled INTERNAL METHOD below). The four parameters necessary to include a mesh in the sector are:

1. Mesh identification number
2. Type (see diagram below)
3. $(N_\rho)_o$
4. $N_\rho$

where printing of results during dynamics begins after $(N_\rho)_o$ integration steps, and then occurs once every $N_\rho$ steps within the mesh.

There are four available <u>types</u> of particle movement through a mesh. The value 1 = normal (or unchanged)
2 = symmetric
3 = change of sign
4 = anti-symmetric (symmetric with sign change)

Take a case of motion in the median plane field $H_y = \sin N\theta$ of one period across four meshes as an example:



Rather than describing four different meshes, it is possible to describe only the first. Taking the motion across the first to be normal, then that across the second is symmetric; that across the third involves a change of sign; and that across the fourth is anti-symmetric, all with respect to the first.

After terminating the sector configuration specifications (with an END DATA card specified after each mesh entry), the controling address 10 is again entered with a non-zero value.

Dynamics parameters are now entered. Parameters for each run in a series are separated by an END DATA card. The series is terminated with two END DATA cards. Enter only those parameters whose values are not zero (or different from internally specified values), or that change from run to run in the series. The parameters available, with their addresses are:

1. Run identification number (positive integer $<$ 32768)
2. $N_E$ (total number of integration steps per run)
3. $\Theta_o$
4. $X_o$
5. $\rho x_o$
6. $\rho y_o$
7. A
8. P
9. $\lambda$
10. $X_{max}$
11. $\rho x_{max}$
12. $y_{max}$
13. $\rho y_{max}$

( = 1 if not specified)

INTERNAL METHOD

With the XMASH MASTER mounted on tape drive 1, erasable tapes on 3 and 4, and either an erasable, or a previously recorded master of meshes on tape drive 2, the XMASH LOADER card reads the method selector program into core. The set of programs specified by the first data card (address 10 with value 1-8) is transfered from tape 1 to drums.

Mesh specification cards are read. If none are found (another card with address 10 is immediately read), field calculations are by-passed and control is transferred to the sector configuration phase. If a mesh is specified, field potentials are calculated and added to any already on tape 2. It is important here to remark that a user should notify the machine operator or state on his agenda if he wants his meshes on tape 2 saved or a previously recorded tape used. Sector configurations are made solely on mesh ID numbers. Tape 3 is used during field calculations for temporary storage while computing coefficients off the median plane. Both the median plane potentials and these coefficients are packed (7 coefficients per 3 words) on

tape 2 (one record per mesh).

Meshes mentioned in the sector configuration phase are found on tape 2 and copied onto tape 3 in the order mentioned. Tape 3 is duplicated on tape 4.

Dynamics begins at a point in one of the meshes of tape 3 corresponding to the value of $\Theta_0$. As each mesh is needed it is either read from tape or left in core (read from tape only if it has an ID different from the previous mesh). At the end of each sector, tape 3 or 4 is rewound and the next sector is obtained from the other tape. This eliminates time lost by rewinding between sectors.

## PRINTING

Initial conditions are listed for each mesh specification before the field is calculated. The sector configuration is printed before dynamics is begun. Initial conditions are printed for the dynamics phase before the first step is taken. Printing then occurs under control of $(N_\rho)_0$ and $N\rho$ of each mesh. Printing of each integration step is possible by raising sense switch 3.

## SENSE SWITCH SETTINGS

For a normal run, all 6 sense switches are <u>down</u>. The sense switch functions are:

1. Interrupts dynamics, saving core and machine registers on tape 1
2. Skips to the next run (dynamics only)
3. Prints every integration step
4. No action
5. Tune calculation performed
6. Search feature (up = stops after $N_E$ steps are reached in any run, dn = continues with next run)

## ERRORS

Appropriate printing occurs if the following should occur:

1. Sector configuration parameters include an identification number for a mesh that has not been prepared or loaded on tape 2.
2. The number of meshes desired in a sector exceeds 32.
3. One of the maxima $(x, \rho x, y, \rho y)$ has been exceeded
4. $P^2 = (\rho x^2 + \rho y^2) < 0$
5. The value of X lies outside the current mesh.

1 and 2 above cause the calculator to stop. 3,4, and 5 cause the program to skip to the next run.

METHOD 2

Fields on the median plane are described by the expansion

$$B_y = -(A+x)^k \sum_{m=0}^{19} \sum_{n=0}^{19} \Big[\alpha_{m,n} \cos(m\phi)\cos(nM\theta)$$

$$+\beta_{m,n} \cos(m\phi)\sin(nM\theta) + \gamma_{m,n} \sin(m\phi)\cos(nM\theta)$$

$$+\delta_{m,n} \sin(m\phi)\sin(nM\theta)$$

where $\phi = \frac{1}{W} \ln(A+x) - N\theta$

Fields off the median plane and dynamics are calculated as in METHOD 1 above.

WRITING AGENDA FOR METHOD 2

The first data card must have the address 10 and the value 2.

The field parameters have the following addresses:

| | |
|---|---|
| 1 Mesh ID number | 7 $\theta_0$ |
| 2 I | 8 A |
| 3 J | 9 N |
| 4 $\Delta$ X | 11 k |
| 5 $\Delta\theta$ | 12 1/W |
| 6 $X_0$ | 13 M |

(see METHOD 1 above for description of these parameters)

21-40 $\alpha_{0,0} - \alpha_{0,19}$

41-420 $\alpha_{1,0} - \alpha_{19,19}$

421-820 $\beta_{0,0} - \beta_{19,19}$

821-1220 $\gamma_{0,0} - \gamma_{19,19}$

1221-1620 $\delta_{0,0} - \delta_{19,19}$

Sector configuration and dynamics parameters are the same as in METHOD 1 above.

METHOD 3

Method 3 is identical to method 2 with the addition that the coefficients $\alpha, \beta, \gamma$, and $\delta$ of the field description are adjusted to the median plane before use in the field calculation.

If the magnetic field and magnetic potential have the relation

$$B_y(r,\theta,y) = \frac{\partial \psi(\phi,\theta,\eta)}{\partial y} ,$$

and the magnetic potential has the expansion

$$\psi(\phi,\theta,\eta_0) = (A+x)^{k+1} \sum_{m,n} \alpha_{m,n}(\eta_0) \cos m\phi \cos nM\theta$$
$$+ \beta_{m,n}(\eta_0) \cos m\phi \sin nM\theta + \gamma_{m,n}(\eta_0) \sin m\phi \cos nM\theta$$
$$+ \delta_{m,n}(\eta_0) \sin m\phi \sin nM\theta$$

on the plane $\eta_0$, the program computes $\alpha_{m,n,0}$, $\beta_{m,n,0}$, $\gamma_{m,n,0}$ and $\delta_{m,n,0}$ for the median plane ( $\eta$ =0) expansion,

$$\psi(\phi,\theta,\eta) = (A+x)^{k+1} \sum_{K=1}^{K_{max}} [\alpha_{m,n,K} \cos m\phi \cos nM\theta$$
$$+ \beta_{m,n,K} \cos m\phi \sin nM\theta + \gamma_{m,n,K} \sin m\phi \cos nM\theta$$
$$+ \gamma_{m,n,K} \sin m\phi \sin nM\theta] \frac{\eta^{2K+1}}{(2K+1)!} ,$$

using recursion relations,

$$\alpha_{m,n,K+1} = \left[m^2\left(\tfrac{1}{w^2}+N^2\right) - (k-2K)^2 + (nM)^2\right] \alpha_{m,n,K}$$
$$- \left[\tfrac{2m}{w}(k-2K)\right] \gamma_{m,n,K} + \left[2Nmn M\right] \delta_{m,n,K}$$

$$\beta_{m,n,K+1} = \left[m^2\left(\frac{1}{W^2}+N^2\right)-(k-2K)^2+(nM)^2\right]\beta_{m,n,K}$$
$$-\left[2Nmn M\right]\gamma_{m,n,K} - \left[\frac{2m}{W}(k-2K)\right]\delta_{m,n,K}$$

$$\gamma_{m,n,K+1} = \left[\frac{2m}{W}(k-2K)\right]\alpha_{m,n,K} - \left[2Nmn M\right]\beta_{m,n,K}$$
$$+\left[m^2\left(\frac{1}{W^2}+N^2\right)-(k-2K)^2+(nM)^2\right]\gamma_{m,n,K}$$

$$\delta_{m,n,K+1} = \left[2Nmn M\right]\alpha_{m,n,K} + \left[\frac{2m}{W}(k-2K)\right]\beta_{m,n,K}$$
$$+\left[m^2\left(\frac{1}{W^2}+N^2\right)-(k-2K)^2+(nM)^2\right]\delta_{m,n,K}$$

and the equality

$$\alpha_{m,n}(\eta_0) = \sum_{K}^{K_{max}} \left[\alpha_{m,n,K}\frac{\eta_0^{2K+1}}{(2K+1)!}\right] .$$

The values of $\alpha_{m,n,0}$, $\beta_{m,n,0}$, $\gamma_{m,n,0}$, $\delta_{m,n,0}$ so determined are automatically used as input and the program proceeds as in method 2.

METHOD 4

This method is identical with method 3 with the addition that the coefficients $\alpha, \beta, \gamma, \delta$ are printed both before and after the adjustment to the median plane.

WRITING AGENDA FOR METHODS 3 and 4

In addition to the field parameters for method 2, the following are necessary:

14 $\eta_0$

15 $K_{max}$

METHOD 5

Fields on the median plane are described by the formula

$$B_y = \left[1+f(x)\left(d_0+d_1\cos\left[M_1\theta-2\pi L_1\right]+d_2\cos\left[M_2\theta-2\pi L_2\right]\right)\right]C_y$$

$$\text{where } f(x) = Be^{-(x-\bar{x})^2/a^2}\sum_{n=0}^{4} b_n(x-\bar{x})^n$$

$$C_y = (A+x)^k \sum_{m=0}^{31} (\mu_m \cos m\phi + \nu_m \sin m\phi)$$

$$k = \sum_{j=0}^{9} k_j x^j$$

$$\left.\begin{aligned} \mu_m &= \sum_{j=0}^{9} \mu_{m,j} x^j \\ \nu_m &= \sum_{j=0}^{9} \nu_{m,j} x^j \end{aligned}\right\} (m = 0, 1, 2, \ldots, 31)$$

$$\phi = K \ln(A+x) - N\theta$$

$$K = \sum_{j=0}^{9} \left(\frac{1}{W}\right)_j x^j$$

Fields off the median plane and dynamics are calculated as in method 1 above.

WRITING AGENDA FOR METHOD 5

The first data card must have the address 10 and the value 5.

The field parameters have the following addresses:

| | |
|---|---|
| 1 | Mesh ID number |
| 2 | I |
| 3 | J |
| 4 | $\Delta X$ |
| 5 | $NW/2\pi$ $\left(= \frac{N(J-1)\Delta\theta}{2\pi}\right)$ |
| 6 | $X_0$ |
| 7 | $(N\theta/2\pi)_0$ |
| 8 | A |
| 9 | N |
| 11-20 | $k_0 - k_9$ |
| 21-30 | $(\frac{1}{W})_0 - (\frac{1}{W})_9$ |
| 31 | $d_\phi$ |
| 32 | $d_1$ |

| | |
|---|---|
| 33 | $d_2$ |
| 34 | $M_1$ |
| 35 | $M_2$ |
| 36 | $L_1$ |
| 37 | $L_2$ |
| 38 | B |
| 39 | a |
| 40 | $\overline{X}$ |
| 41-45 | $b_o - b_4$ |
| 51-60 | $\mu_{0,0} - \mu_{0,9}$ |
| 61-70 | $\mu_{1,0} - \mu_{1,9}$ |
| ⋮ | |
| 361-370 | $\mu_{31,0} - \mu_{31,9}$ |

(32 blocks of 10 each)

| | |
|---|---|
| 371-380 | $\nu_{0,0} - \nu_{0,9}$ |
| ⋮ | |
| 681-690 | $\nu_{31,0} - \nu_{31,9}$ |

(32 blocks of 10 each)

Sector configuration parameters are identical to method 1 above

The <u>dynamics parameters</u> have the following addresses:

| | | | |
|---|---|---|---|
| 1 | Run ID | 8 | A |
| 2 | $N_E$ | 9 | P |
| 3 | $(N\Theta/2\pi)_o$ | 10 | $\lambda$ |
| 4 | $X_o$ | 11 | $X_{max}$ |
| 5 | $px_o$ | 12 | $px_{max}$ |
| 6 | $y_o$ | 13 | $y_{max}$ |
| 7 | $py_o$ | 14 | $py_{max}$ |
| | | 15 | N |

( =1 if not specified)

METHOD 6

Fields on the median plane are described by the formula.

$$B_y = (A+x)^k \sum_{n=0}^{N_{HH}} a_{n,j} \cos\left[nN\phi - \beta_{n,j}\right]$$

where j = -2, -1, 0, ... , I, I+1, I+2 corresponding to

$$x = x_0 - 2\Delta x,\ x_0 - \Delta x,\ x_0,\ \ldots,\ x_0 + I\Delta x,\ x_0 + (I+1)\Delta x,\ x_0 + (I+2)\Delta x$$

and $\phi = \theta - \frac{1}{NW} \ln(A+x)$

$$\beta_{0,j} \equiv 0, \quad N_{HH} \leq 29, \quad I \leq 31$$

Fields off the median plane and dynamics are claculated as in method 1 above.

WRITING AGENDA FOR METHOD 6

The first data card must have the address 10 and the value 6.

The field parameters have the following addresses:

1 Mesh ID

2 I ( $\leq$ 31)

3 J

4 $\Delta x$

5 Mesh width $\left(\frac{NW}{2\pi}\right)$

6 $x_0$

7 $(N\theta/2\pi)_0$

8 A

9 N

11 k

12 1/W

13 $N_{HH}$ ( $\leq$ 29)

| | | |
|---|---|---|
| 101-135 | $a_{0,0} - a_{0,34}$ | 30 blocks of 35 each |
| 136-170 | $a_{1,0} - a_{1,34}$ | |
| ⋮ | | |
| 1116-1150 | $a_{29,0} - a_{29,34}$ | |
| 1201-1235 | $\beta_{0,0} - \beta_{0,34}$ | 30 blocks of 35 each |
| ⋮ | | |
| 2216-2250 | $\beta_{29,0} - \beta_{29,34}$ | |

Sector configurations and dynamics parameters are identical to those in method 5 above.

METHOD 7

This method differs from method 6 above only in the way input is entered. In addition to the field parameters listed below, method 7 requires an input tape (FRANCIS-PROGRAM F27 prepares such a tape) consisting of 100 word records. Each record contains up to 50 harmonics of the required $a_{m,j}$ and 50 harmonics of the $\beta_{m,j}$. Each record corresponds to a different value of x. By means of the parameter $R_1$ (first record number), the tape is positioned and read into core storage: The $a_{m,j}$ and $\beta_{m,j}$ in the $R_1$th record are used to compute the mesh points at $x = x_0 - 2\Delta x$; those in the next record are used at $x = x_0 - \Delta x$, etc.

FIELD PARAMETERS FOR METHOD 7

| | | | |
|---|---|---|---|
| 1 | Mesh ID | 8 | A |
| 2 | I | 9 | N |
| 3 | J | 11 | k |
| 4 | $\Delta x$ | 12 | 1/W |
| 5 | Mesh width | 13 | $N_{HH}$ |
| 6 | $x_0$ | 14 | $R_1$ (first record number) |
| 7 | $(N\theta/2\pi)_0$ | | |

NOTE: The first data card must have the address 10 and the value 7.

METHOD T (TUNE CALCULATION)

Any of the above methods can be used to provide a mesh of fields for the tune calculation. (method N is obtained by the first data card containing the address 10 and the value N.)

The tune calculation is obtained by setting sense switch 5 up.

The tune parameters are entered following the sector configuration parameters (replacing the dynamics parameters). A program stop will occur after the completion of one tune calculation run. It is therefore impossible to request a series of tune calculation runs.

METHOD T SEQUENCE OF EVENTS

Beginning with the input $x_0$, $(p_x)_0$, $y_0$, $(p_y)_0$, a pass is made through 3 sectors, recording the values of $x$, $p_x$, $y$, $p_y$ after each sector.

The values of $x_f$, $(p_x)_f$, $\cos\sigma_x$, $\sigma_x/2\pi$ are printed.

$$\cos\sigma_x = \frac{1}{2}\left[\frac{x_3 + x_1 - x_0 - x_2}{x_2 - x_1}\right]$$

$$x_f = x_1 + \frac{x_2 + x_0 - 2x_1}{2(1-\cos\sigma_x)}$$

$$(p_x)_f = (p_x)_1 + \frac{(p_x)_2 + (p_x)_0 - 2(p_x)_1}{2(1-\cos\sigma_x)}$$

A test is made for $|x_f - x_0| < \varepsilon_{test}$

If the test is unsuccessful ($|x_f - x_0| \geq \varepsilon_{test}$), another pass is made with the new values $x = x_f$, $p_x = (p_x)_f$, $y_0$, $(p_y)_0$. This is continued until either the test is successful or 10 passes have been completed.

Now starting with $x = x_f + \varepsilon_{tune}$, $p_x = (p_x)_f$, $y = p_y = 0$, a pass is made through 3 sectors.

The values of $x_f$, $(p_x)_f$, $\cos\sigma_x$, $\sigma_x/2\pi$ are printed.

Now starting with $x = x_f$, $p_x = (p_x)_f$, $y = \varepsilon_{tune}$, $p_y = 0$, another pass is made through 3 sectors.

The values of $y_f$, $(p_y)_f$, $\cos\sigma_y$, $\sigma_y/2\pi$ are printed.

An equilibrium orbit run is now made through one sector, starting with $x = x_f$, $p_x = (p_x)_f$, $y = 0$, $p_y = 0$, printing every step.

The value $\bar{x}_0$ is printed.

$$\bar{x}_0 = \frac{1}{N_{RK}}(x_1 + x_2 + x_3 + \cdots + x_{N_{RK}})$$

## WRITING AGENDA FOR METHOD T

Indicate on the agendum sheet(s) that sense switch 5 is to be set up.

The tune parameters have the following addresses:

1. Tune ID
2. $\varepsilon_{tune}$
3. $\varepsilon_{test}$
4. $x_0$
5. $(p_x)_0$
6. $y_0$
7. $(p_y)_0$
8. A
9. P
10. $\lambda$
11. $x_{max}$
12. $p_{x\,max}$
13. $y_{max}$
14. $p_{y\,max}$
15. N

MURA/FORTRAN AGENDUM

PROGRAM NO. _____ SUBMITTER_____

Instructions:

1. Enter program number and submitter's name above.
2. Enter address and value below for parameters desired.
3. Enter sense switch settings: _____ _____ _____ _____ _____ _____

Notes:

1. Decimal points may be omitted only if understood to follow the rightmost digit.
2. Addresses may not contain more than 4 digits.
3. Factors may not contain more than 8 digits.
4. Exponents may not contain more than 2 digits.
5. Exponents may be omitted if zero. If not, they must be signed.

| Address | Value | | Address | Value | | Address | Value | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |