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M. Bassetti and R. M. Buonanni: COMPUTATION OF THE EFFECTS OF ERRORS OF A MAGNETIC CHANNEL ON THE FINAL BEAM PARAMETERS. -

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Section 1

In this note we will compute the correlation between the beam parameters at the output of a magnetic channel and the errors due to the channel assembling and to the variations of current supply.

In other words we will compute the effects of a displacement of any element on the final beam features.

Mathematically speaking this computation is equivalent to a computation of derivatives of certain quantities with respect to some parameters.

For each of the two phase planes we will consider the following final beam parameters:

a) - center coordinates of the ellypse that envelopes the beam, Y, Y';
b) - R, X defined as: R = a/b; X = c/b (see fig. 1);
c) - absolute maximum values of the displacement and the inclination, for a non centered ellypse, defined as:

$$Y_{max} = \sqrt{E(R+X^2/R)} + |Y|$$

(1)

$$Y'_{max} = \sqrt{E/R} + |Y'|$$

where E = ab is the emittance.

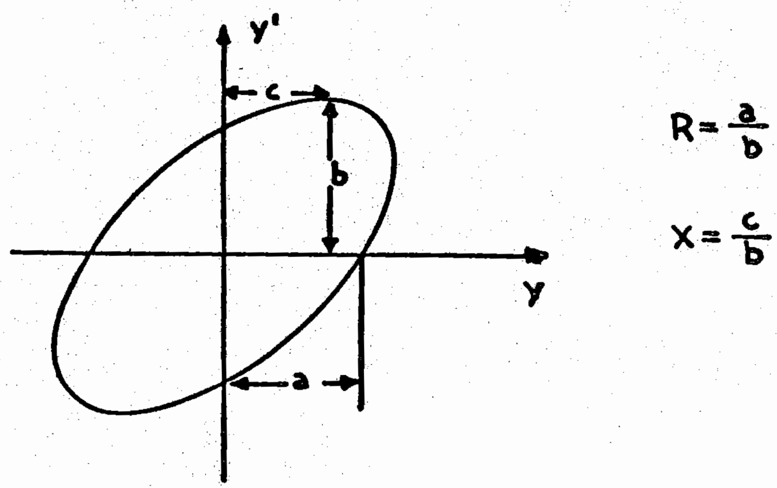

FIG. 1

Likewise the parameters variations we consider are:

d) - variations of the drift spaces lengths;
e) - variations of the quadrupole lenses or bending magnets current supplies;
f) - rigid displacements of the quadrupoles or magnets, that we will subdivide into translations and rotations.

To compute the effects of the above mentioned errors we will proceed in the following way:

making use of the well-known matrix method(1) the channel is first traced assuming magnetic elements without errors so that we can obtain the theoretical values of the variables defined in a), b), c).

Successively the channel is traced many times, every time introducing a small but finite variation (such as in d), e), f)) for the single element.

Such variations are obtained by suitably modifiyng the computation corresponding to the element we are considering.

In such a way we obtain the varied final parameters, which together with the theoretical ones allow us to compute the derivatives of the final parameters with respect to the varied parameters (properly speaking such derivatives are "incremental ratios").

The method we will use to treat the rigid displacements is too rigorous and not consistent with the first order treatment of the channel, but we have adopted it for two reasons:

a) - It is easier to draw a rigorous formula than a good approximation;

b) - The formulae we have deduced are true also if the analytical treatment of the channel is computed in a higher approximation.

Section 2

The computation of the effects caused by the variations we mentioned in e), d) is easily performed because it involves only the change of the magnetic element matrix.

Thus the variation of a drift space length only produces in the corresponding matrix the simple change:

$$\begin{vmatrix} 1 & \ell \\ 0 & 1 \end{vmatrix} \longrightarrow \begin{vmatrix} 1 & \ell + \Delta\ell \\ 0 & 1 \end{vmatrix}$$

A variation of the current supply of a magnetic element is equivalent for relativistic particles, to a percentual variation of the particle energy (because of the Lorentz force) and in this case the matrices are easily modified.

Properly speaking if the current supply i goes into $i(1+\Delta i/i)$ the constant k of the quadrupole matrix becomes $k(1+\Delta i/i)$ because it is proportional to the magnetic field; whereas in the third-order bending matrices, one must introduce a $\Delta p/p = \Delta i/i$.

Section 3

On the contrary the computation of the effects caused by rigid displacements of magnetic elements, is more difficult.

To define such displacements we shall assume a right-handed reference system solidary with the element. We shall also assume that the origin of the systems is coincident, for quadrupole, with its central point. For a bending magnet the origin of the reference is taken at the central point of the principal orbit. The reference axes are oriented as in fig. 2.

As shown in fig. 2 we call T_1 the reference placed at the input face of the element; T_2 the central reference, and T_3 the one placed at the output face of the element.

For what follows it is useful to compute the coordinates of the origin and of the unit vectors of T_1 (T_3) with respect to T_2.

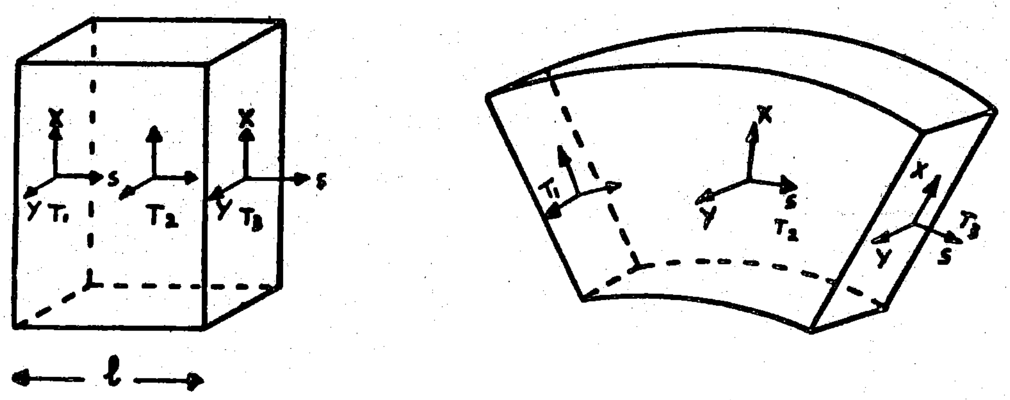

FIG. 2

We thus obtain for each kind of element (see fig. 3):

1) - Quadrupole - (We indicate the element lenght with ℓ)

(2)

$$x_A = 0. \qquad x_B = 1.$$
$$y_A = 0. \qquad y_B = 0.$$
$$s_A = -.5\cdot\ell \qquad s_B = -.5\cdot\ell$$

$$x_C = 0. \qquad x_D = 0.$$
$$y_C = 1. \qquad y_D = 0.$$
$$s_C = -.5\cdot\ell \qquad s_D = -.5\cdot\ell + 1$$

2) - Magnet - (We indicate the deflection angle with α and the radius of curvature with r)

(2')

$$x_A = -r\left(1 - \cos\frac{\alpha}{2}\right) \qquad x_B = -r\left(1 - \cos\frac{\alpha}{2}\right) + \cos\frac{\alpha}{2}$$
$$y_A = 0. \qquad y_B = 0.$$
$$s_A = -r \operatorname{sen}\frac{\alpha}{2} \qquad s_B = -r \operatorname{sen}\frac{\alpha}{2} - \operatorname{sen}\frac{\alpha}{2}$$

$$x_C = -r\left(1 - \cos\frac{\alpha}{2}\right) \qquad x_D = -r\left(1 - \cos\frac{\alpha}{2}\right) + \operatorname{sen}\frac{\alpha}{2}$$
$$y_C = 1. \qquad y_D = 0.$$
$$s_C = -r \operatorname{sen}\frac{\alpha}{2} \qquad s_D = -r \operatorname{sen}\frac{\alpha}{2} + \cos\frac{\alpha}{2}$$

To obtain the coordinates of the same points with respect to system T_3 it is sufficient to change, for the quadrupoles, the sign of ℓ, and, for the bending magnets the sign of α.

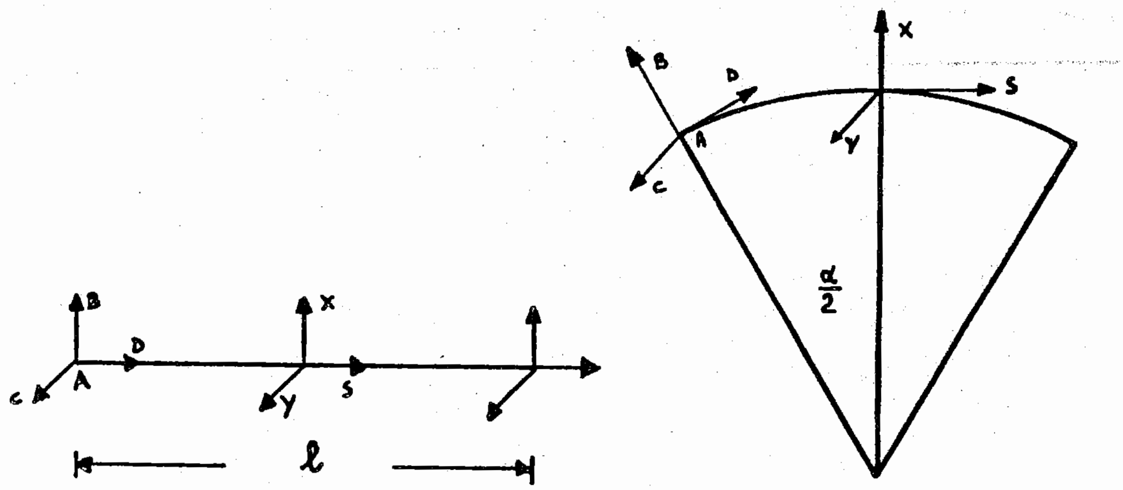

FIG. 3

Section 4

With $\overline{T}_1$, $\overline{T}_2$, $\overline{T}_3$ we indicate the coordinate systems of the displaced elements.

We define the displacement of the generic element giving the τ transformation of the displacement of $\overline{T}_2$ with respect to T_2, i.e. giving three translation parameters p_*, q_*, t_*, along the three axes, and nine direction cosines forming the rotation matrix:

$$R = \begin{vmatrix} \vartheta_1 & \vartheta_2 & \vartheta_3 \\ \delta_1 & \delta_2 & \delta_3 \\ \varphi_1 & \varphi_2 & \varphi_3 \end{vmatrix}$$

Such parameters have the following meaning:

p_* q_* t_* center coordinates of $\overline{T}_2$ with respect to T_2

ϑ_1 ϑ_2 ϑ_3 projections of the three unitary vectors of $\overline{T}_2$ onto the x axis of T_2

δ_1 δ_2 δ_3 projections of the three unitary vectors of $\overline{T}_2$ onto the axis of T_2

$\varphi_1 \quad \varphi_2 \quad \varphi_3$ projections of the three unitary vectors of $\overline{T}_2$ onto the z axis of T_2

We will consider the following kinds of displacements of $\overline{T}_2$ with respect to T_2:

A) - Rotations

In this case one always has

$$p_* = 0 \qquad q_* = 0 \qquad t_* = 0$$

and also:

1) rotation through an angle φ_x about the x axis:

$$R = \begin{vmatrix} 1 & 0 & 0 \\ 0 & \cos \varphi_x & -\mathrm{sen}\ \varphi_x \\ 0 & \mathrm{sen}\ \varphi_y & \cos \varphi_y \end{vmatrix}$$

2) rotation through an angle φ_y about the y axis:

$$R = \begin{vmatrix} \cos \varphi_y & 0 & \mathrm{sen}\ \varphi_y \\ 0 & 1 & 0 \\ -\mathrm{sen}\ \varphi_y & 0 & \cos \varphi_y \end{vmatrix}$$

3) rotation through an angle φ_s about the s axis:

$$R = \begin{vmatrix} \cos \varphi_s & -\mathrm{sen}\ \varphi_s & 0 \\ \mathrm{sen}\ \varphi_s & \cos \varphi_s & 0 \\ 0 & 0 & 1 \end{vmatrix}$$

B) - Translation

one always has

$$R = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{vmatrix}$$

and also:

4) translation through a lenght Δx along x axis

$$p_* = \Delta x \qquad q_* = 0 \qquad t_* = 0$$

5) translation through a lenght Δy along y axis

$$p_* = 0 \qquad q_* = \Delta y \qquad t_* = 0$$

6) translation through a lenght Δs along s axis

$$p_* = 0 \qquad q_* = 0 \qquad t_* = \Delta s$$

Section 5

Since we are dealing with rigid displacements, when the parameters defining the displacement of T_2 have been assigned the ones $\overline{T}_1$; $\overline{T}_3$ are also defined.

In the present section we will calculate the transformation law between the initial systems T_1 and $\overline{T}_1$.

From the above considerations it is clear that when the element considered is displaced, the four points A, B, C, D go into the four points A', B', C', D' whose coordinates with respect to T_2 can be calculated by the $\mathcal{T}$ transformation defined in section 4.

If, for example, we apply $\mathcal{T}$ to A we have:

$$
\begin{aligned}
x_{A'} &= p_* + \vartheta_1 x_A + \vartheta_2 y_A + \vartheta_3 s_A \\
y_{A'} &= q_* + \delta_1 x_A + \delta_2 y_A + \delta_3 s_A \\
s_{A'} &= t_* + \varphi_1 x_A + \varphi_2 y_A + \varphi_3 s_A
\end{aligned}
\tag{3}
$$

Likewise for B', C', D'.

Let us consider now the points A, B, C, D, A', B', C', D', ... as vectors whose components are $x_A\ y_A\ s_A$; $x_B\ y_B\ s_B$...; $x_{A'}\ y_{A'}\ s_{A'}$... and let us write them as $\vec{A}\ \vec{B}\ \vec{C}\ \vec{A'}\ \vec{B'}\ \vec{C}$.........

By means of suitable differences we obtain the following vectors:

(4)

$(\vec{B} - \vec{A})$ unitary vector of T_1 x axis

$(\vec{C} - \vec{A})$ " " " " y "

$(\vec{D} - \vec{A})$ " " " " s "

$(\vec{A'} - \vec{A})$ difference between the $\overline{T}_1$ and T_1 origins

$(\vec{B'} - \vec{A'})$ unitary vector of x axis of $\overline{T}_1$

$(\vec{C'} - \vec{A'})$ " " " y " " "

$(\vec{D'} - \vec{A'})$ " " " s " " "

Let us now consider as un-known terms the parameters of the transformation $\mathcal{F}$ that makes us pass from the coordinates $\bar{x}$, $\bar{y}$, $\bar{s}$ of $\bar{T}_1$ to the coordinates x, y, s of T_1 of a point P.

$$
\text{(5)} \qquad
\begin{aligned}
x &= x_* + \alpha_1 \bar{x} + \beta_1 \bar{y} + \gamma_1 \bar{s} \\
y &= y_* + \alpha_2 \bar{x} + \beta_2 \bar{y} + \gamma_2 \bar{s} \\
s &= s_* + \alpha_3 \bar{x} + \beta_3 \bar{y} + \gamma_3 \bar{s}
\end{aligned}
$$

keeping in mind the meaning of (5) and the above given definitions (4), we obtain:

$$
\begin{aligned}
x_* &= (\vec{A}' - \vec{A})\cdot(\vec{B} - \vec{A}) & \alpha_1 &= (\vec{B}' - \vec{A}')\cdot(\vec{B} - \vec{A}) \\
y_* &= (\vec{A}' - \vec{A})\cdot(\vec{C} - \vec{A}) & \alpha_2 &= (\vec{B}' - \vec{A}')\cdot(\vec{C} - \vec{A}) \\
s_* &= (\vec{A}' - \vec{A})\cdot(\vec{D} - \vec{A}) & \alpha_3 &= (\vec{B}' - \vec{A}')\cdot(\vec{D} - \vec{A})
\end{aligned}
$$

$$
\begin{aligned}
\beta_1 &= (\vec{C}' - \vec{A}')\cdot(\vec{B} - \vec{A}) & \gamma_1 &= (\vec{D}' - \vec{A}')\cdot(\vec{B} - \vec{A}) \\
\beta_2 &= (\vec{C}' - \vec{A}')\cdot(\vec{C} - \vec{A}) & \gamma_2 &= (\vec{D}' - \vec{A}')\cdot(\vec{C} - \vec{A}) \\
\beta_3 &= (\vec{C}' - \vec{A}')\cdot(\vec{D} - \vec{A}) & \gamma_3 &= (\vec{D}' - \vec{A}')\cdot(\vec{D} - \vec{A})
\end{aligned}
$$

The indicated inner products can easily be computed in the T_2 system using the coordinates as in (2) (2') (3').

Let us remark that the $\mathcal{T}$ transformation connects the coordinates of two different points A, A' referred to the same frame T_2; the $\mathcal{F}$ transformation connects the coordinates of a same point P referred to two different frames (T_1, $\bar{T}_1$).

Section 6

In this section our task is to calculate the parameters of the generic particle at the input face of the displaced element in reference T_1.

The particle before entering a magnetic element follows a straight path (assuming the rectangular model, as we do) and thus we can write the trajectory equation in T_1 as:

$$
\text{(6)} \qquad
\begin{aligned}
x &= x_o + x'_o s \\
y &= y_o + y'_o s
\end{aligned}
$$

where (x_o, x'_o, y_o, y'_o) are the four trajectory parameters and s is the curvilinear abscissa.

If the center of reference $\overline{T}_1$ is displaced with respect to T_1 by a vector whose components are $x_* \; y_* \; s_*$ and if $\gamma_1, \gamma_2, \gamma_3$ are the direction cosines of the ξ, η plane in T_1 the equation of this plane in T_1 is

$$\gamma_1 (x - x_*) + \gamma_2 (y - y_*) + \gamma_3 (s - s_*) = 0 \tag{7}$$

the intersection of the straight line (6) with the plane (7) gives us the coordinates (referred to T_1) of the particle input in the displaced element.

Neverthless in order to calculate the slopes of the tangents to the path in the displaced element it is more useful for us to write the intersection of (6) with a plane parallel to the $\xi \; \eta$ one, at a distance ζ, and that has equation:

$$\gamma_1 (x - x_*) + \gamma_2 (y - y_*) + \gamma_3 (s - s_*) = \zeta \tag{7'}$$

we thus obtain:

$$x = \frac{x_o(\gamma_3 + \gamma_2 y'_o) - y_o \gamma_2 x'_o + x'_o(\gamma_1 x_* + \gamma_2 y_* + \gamma_3 s_* + \zeta)}{\gamma_1 x'_o + \gamma_2 y'_o + \gamma_3}$$

$$y = \frac{y_o(\gamma_3 + \gamma_1 x'_o) - x_o \gamma_1 y'_o + y'_o(\gamma_1 x_* + \gamma_2 y_* + \gamma_3 s_* + \zeta)}{\gamma_1 x'_o + \gamma_2 y'_o + \gamma_3} \tag{8}$$

$$s = \frac{\gamma_1 x_* + \gamma_2 y_* + \gamma_3 s_* + \zeta - \gamma_1 x_o - \gamma_2 y_o}{\gamma_1 x'_o + \gamma_2 y'_o + \gamma_3}$$

Let us now specify exactly the displacement we are considering.

Keeping in mind that the direction cosines of the unitary vectors of $\overline{T}_1$ have been labelled $\alpha_1, \alpha_2, \alpha_3, \beta_1, \beta_2, \beta_3, \gamma_1, \gamma_2, \gamma_3$, in order to obtain the input coordinates $\xi \; \eta$ respect to $\overline{T}_1$ we must perform the inner product of vector $\vec{i}(x-x_*) + \vec{j}(y-y_*) + \vec{k}(s-s_*)$ (i.e. vectorial distance between the computed intersection and the origin of $\overline{T}_1$ with the unitary vector of the ξ axis of $\overline{T}_1$ $(\vec{i}\,\alpha_1 + \vec{j}\,\alpha_2 + \vec{k}\,\alpha_3)$, and with the unitary vector of the η axis of $\overline{T}_1$ $(\vec{i}\,\beta_1+\vec{j}\,\beta_2+\vec{k}\,\beta_3)$ respectively.

We thus have:

$$\xi = \alpha_1(x - x_*) + \alpha_2(y - y_*) + \alpha_3(s - s_*)$$

$$\eta = \beta_1(x - x_*) + \beta_2(y - y_*) + \beta_3(s - s_*)$$

In order to compute the derivatives ξ' η' we must derive the eq. (9) with respect to ζ.

So doing we have:

$$\xi' = \frac{\alpha_1 x'_o + \alpha_2 y'_o + \alpha_3}{\gamma_1 x'_o + \gamma_2 y'_o + \gamma_3}$$

(10)

$$\eta' = \frac{\beta_1 x'_o + \beta_2 y'_o + \beta_3}{\gamma_1 x'_o + \gamma_2 y'_o + \gamma_3}$$

The formula (10) gives directly the slopes in the input face of the displaced element whereas to obtain ξ η we must introduce in formula (9) the x, y, s values given by (8) assuming a vanishing ζ.

Section 7

It is now interesting to compute the jacobian of the transformation corresponding to the input face of the displaced magnetic element.

$$\xi = \xi(x_o, y_o, x'_o, y'_o)$$

$$\eta = \eta(x_o, y_o, x'_o, y'_o)$$

$$\xi' = \xi'(x_o, y_o, x'_o, y'_o)$$

$$\eta' = \eta'(x_o, y_o, x'_o, y'_o)$$

We can thus compute by how much the jacobian differs from unity. Let us remark that the transformations (8), (9), (10) are non-linear.

Consider the usual expression:

$$J = \begin{vmatrix} \xi_{x_o} & \xi_{y_o} & \xi_{x'_o} & \xi_{y'_o} \\ \eta_{x_o} & \eta_{y_o} & \eta_{x'_o} & \eta_{y'_o} \\ \xi'_{x_o} & \xi'_{y_o} & \xi'_{x'_o} & \xi'_{y'_o} \\ \eta'_{x_o} & \eta'_{y_o} & \eta'_{x'_o} & \eta'_{y'_o} \end{vmatrix}$$

Where with the subscript we indicate the derivative. From (10) we deduce that the derivatives ξ' η' with respect to x_o, y_o are zero, and we can write:

$$J = (\xi_{x_o} \eta_{y_o} - \eta_{x_o} \xi_{y_o})(\xi'_{x'_o} \eta'_{y'_o} - \eta'_{x'_o} \xi'_{y'_o})$$

After a rather cumbersome computation we have:

$$(\xi_{x_o} \eta_{y_o} - \eta_{x_o} \xi_{y_o}) = \frac{1}{(\gamma_3 + \gamma_2 y'_o + \gamma_1 x'_o)}$$

$$(\xi'_{x'_o} \eta'_{y'_o} - \eta'_{x'_o} \xi'_{y'_o}) = \frac{1}{(\gamma_3 + \gamma_2 y'_o + \gamma_1 x'_o)^3}$$

follows:

(11)
$$J = \frac{1}{(\gamma_3 + \gamma_2 y'_o + \gamma_1 x'_o)^3}$$

Analogous formulae hold for the output face of the element.

Let us note that if in (11) we consider the amplitudes of the rotation angles as first order infinitesimals (like y'_o and x'_o in first order approximation) it follows that J, neglecting the second order terms, is equal to one consixently with the linear treatment of the channel.

Would actually be contradictory to take into consideration the second order infinitesimals at the input and at the output of the displaced elements and then to assume the determinants of the transfer matrices of such elements to be equal to one.

In any case the effect of (11) is negligible for a magnetic chan nel if the particles go through the element only once.

Let us now remark that such a development is not applicable to the circular machines if one considers the second order terms.

It remains to be noted that the result (11) gives, is not generally speaking in contraddiction with Liouville's theorem which deals with the whole phase space.

The problem becomes more interesting if we are dealing with a circular machine and if the effect caused by the errors is due to an arbitrary configuration of the magnetic field.

For example this case arises in the FFAG machines where the magnetic field, as compared to that of a traditional machine, is folded along spirals.

It is clear that in such case one is in need of a different mathematical procedure.

Two recent works[2,3] should be useful in this respect, the first concerning Liouville's theorem and the general problem of the stability, the second the motion of a charged particle in a magnetic field.

Section 8

In the last section we have computed the values of the particle-parameters at the input face of the displaced element.

Applying now the well known matrix-method we obtain the particle parameters at the output face of the element.

To apply the matrix of the subsequent drift space to the displaced magnetic element we must compute the particle path parameters in a P point of the x, y face of T_3 (see fig. 4).

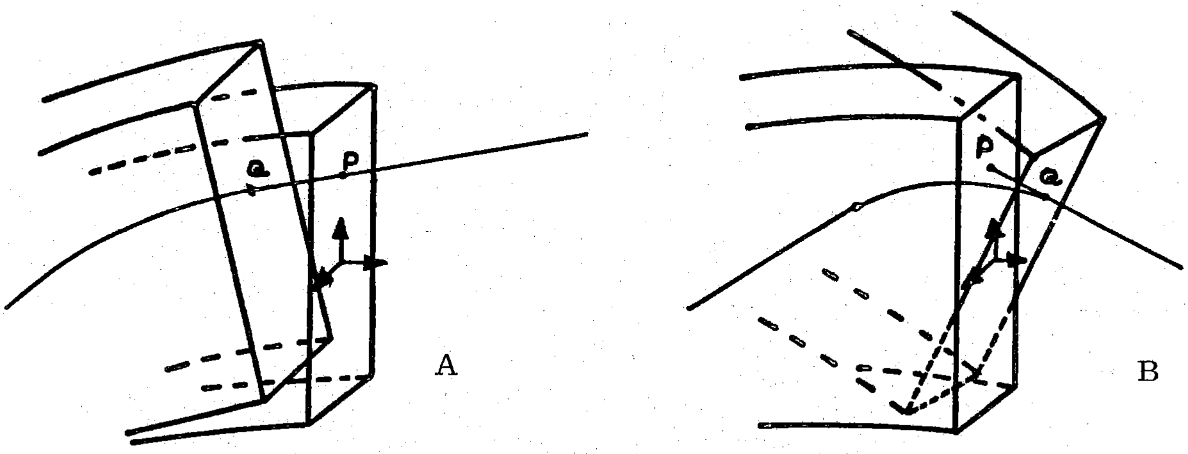

FIG. 4

As shown in fig. 4A and 4B it is clear that, in general, the point P of the x, y face of T_3 is not a point of the path; nevertheless P is always the intersection of the tangent to the trajectory at point Q of the displaced element, with the xy face of T_3.

The same is true for the input face of the element, although the latter case looks easier. But such a difference is only apparent since reversing the direction of the particle on the trajectory the two cases are interchanged.

According to what we said the computation is very similar to the one of section 2 - 3.

More exactly to obtain the transformation that connects $\overline{T}_3$ to T_3 one must do all the computations of section 2 (as seen ealier it is enough to change the sign of ℓ for the quadrupoles and of α for the bending magnets).

Then one must compute the inverse transformation, i.e. the transformation that connects the coordinates $\overline{x}$, $\overline{y}$, $\overline{s}$ of $\overline{T}_3$ to the x, y, s of T_3.

One obtains:

$$
\begin{aligned}
x &= p_* + \alpha_1 x + \alpha_2 y + \alpha_3 s \\
y &= q_* + \beta_1 x + \beta_2 y + \beta_3 s \\
s &= t_* + \gamma_1 x + \gamma_2 y + \gamma_3 s
\end{aligned}
\qquad (5')
$$

where the rotation matrix is the transpose of the rotation matrix that appears in (5), and:

$$
\begin{aligned}
p_* &= -\alpha_1 x_* - \alpha_2 y_* - \alpha_3 s_* \\
q_* &= -\beta_1 x_* - \beta_2 y_* - \beta_3 s_* \\
t_* &= -\gamma_1 x_* - \gamma_2 y_* - \gamma_3 s_*
\end{aligned}
\qquad (12)
$$

To obtain the particle parameters at the input of the following drift space it is now enough to apply the formulae of section 3 changing the vector (x_o, x'_o, y_o, y'_o) with $(\xi_f, \xi'_f, \eta_f, \eta'_f)$ and the transformation (5) with the transformation (5').

Section 9

On each of the two dimensional phase-spaces the beam can be described by the parameters of the enveloping ellypse.

That is, one assumes that in the four-dimensional phase space (x, z, x', z') the whole envelope is the product of two indipendent functions whose arguments are respectively (x, x'), (z, z').

Assuming for example, that in the two phase planes, the ellypses are as shown in fig. 5 the beam, in actual space, has a non continous external envelope, whose intersection with the xz plane is a rectangular surface from every point of which ∞^2 paths, contained within a solid angle with rectangular cross section, start (see fig. 6).

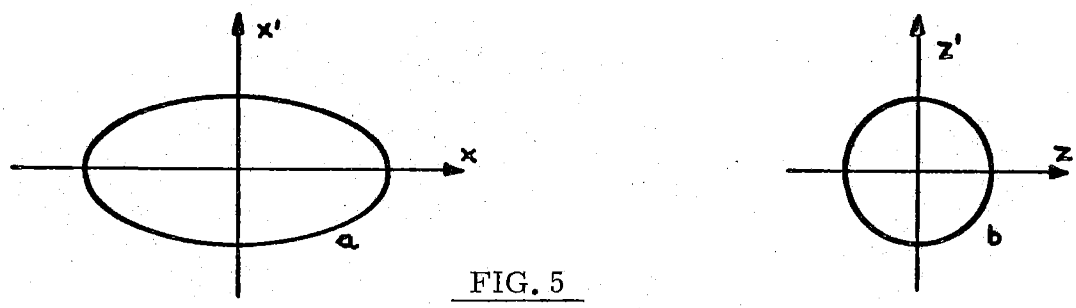

FIG. 5

Such a solid angle vanishes for the outer particles.

For a clear undestanding of how the situation develops from one section to the next let us first of all consider the trajectory of each particle.

As long as the channel is errorless, the final position of a particle in the xx' plane only depends upon the projection, onto this plane, of its initial position; the same is true for the vertical plane. All this still holds in presence of translation errors, or lenght variations of drift spaces or energy variations. But when there are errors due to rotations, the two phase planes are no longer independent.

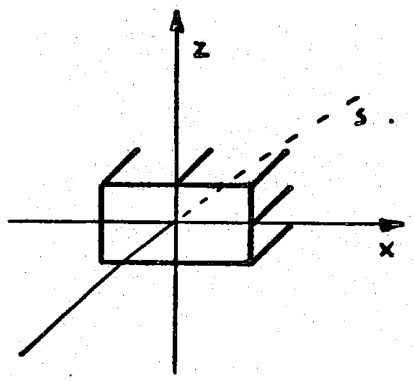

FIG. 6

That is to say (see section 3) that the trajectory of a particle depends upon all four initial coordinates, in both phase planes.

Considering again the ellyptic envelopes, as a consequence of what we said before, it is clear that:

1) - the developments of the initial ellypse (in each of the two phase planes) depend upon the initial conditions that one assumes on the other plane.

2) - Since the transformations of section 3 are non linear, an ellypse does not remain one as a geometrical locus.

Referring to point 1) we note that initial points, internal to the envelope, are transformed into internal ones and external points into external ones in the whole phase space (since the transformations between initial and final points are continous). Therefore in order to see how much the final envelope is changed, it is sufficient to study only points (of the initial envelope) that satisfy the equations:

$$f(x, x') = 0$$
$$g(z, z') = 0$$

Considering only envelope points, the initial conditions to be examined reduce from ∞^4 to ∞^3. Besides such conditions reduce again to ∞^2 since the initial envelope is the product of the two independent functions f and g.

Given the philosophy of our computation it is useful to group the initial conditions into ∞^1 ellypses; i.e. the ellypse $f(x, x') = 0$ together with the ∞^1 points which satisfy the equation $g(z, z') = 0$ and, viceversa, the ellypse $g(z, z') = 0$ together with the ∞^1 points which satisfy the equations $f(x, x') = 0$.

We furthermore note that the effect mentioned under point 2) can be neglected since, a posteriori, the variations of the final ellypse parameters, due to channel errors, give small effects and therefore an accurate quantitative evalutation of the change in the shape of the ellypse is not justified in view of the difficulty of the computation.

However, even though we neglect point 2) the computation of the effects of the errors of a magnetic channel on the final ellypse parameters is very complicated.

We have therefore chosen to start the computation with a finite set of points on the ellypse at the channel input and to then reconstruct the ellypse by means of the transformed points at the channel output.

Section 10

In this section we will describe the practical method we used. For each initial ellypse we chose the 8 intersections, of the ellypse with the axes and with their bisectrices.

In the four dimensional phase space we have considered the 64 points obtained relating the 8-point sets to each other among themselves.

Let us indicate each point with a two figure number, the first figure indicating the point (in two dimension) of the first ellypse (see fig. 7) and the second one the point of the second ellypse.

At the channel output we have considered the following 8-point transformed set:

11	21	31	....	81
12	22	32	....	82
....				
18	28	38	....	88

to obtain the ellypses of the horizontal plane, and the following 8-point set:

11	12	13	....	18
21	22	23	....	28
....				
81	82	83	....	88

to obtain the ellypses of the vertical plane.

Since we, (according to what said before), neglect the change of shape of the ellypse, 8 points are sufficient to describe such a geometrical locus. We have used such points in the following manner (see fig. 7).

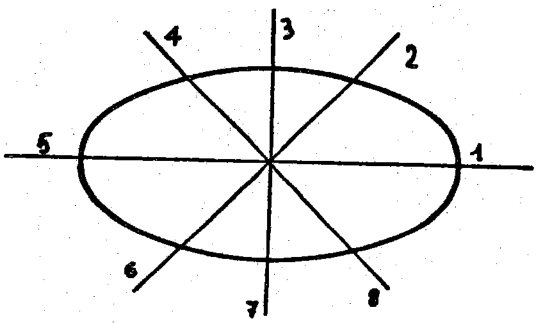

FIG. 7

For each set of 8 points we have defined the center P_o of the ellypse by the weighted average of points 1, 2, 3, 4, 5, 6, 7, 8, then we calculated the centered ellypse through the points:

$$Q_1 = \frac{\vec{P}_1 - \vec{P}_5}{2} \qquad Q_2 = \frac{\vec{P}_2 - \vec{P}_6}{2} \qquad Q_3 = \frac{\vec{P}_3 - \vec{P}_7}{2}$$

Now to obtain the equation $f(x, x')$ of the ellypse it is sufficient to compute the determinant:

$$\begin{vmatrix} x^2 & x\,x' & x'^2 & 1 \\ x_1^2 & x_1x_1' & x_1'^2 & 1 \\ x_2^2 & x_2x_2' & x_2'^2 & 1 \\ x_3^2 & x_3x_3' & x_3'^2 & 1 \end{vmatrix} = 0$$

To compute the effects of the channel errors we have used the following procedure.

The channel has been first traced with errorless elements, computing the trajectory of the 8 points.

At the channel output, (as we said before), we define:

a) - the center coordinates of the ellypse
b) - the R and X parameters
c) - maximum half-displacement and maximum half-inclination.

For each kind of element error the channel is traced following the 64-point paths and the parameters a), b), c) are redefined as said before. Such parameters will present small variations compared with the ones obtained for the errorless channel. This enables us to compute the incremental ratios that we will consider as derivatives.

Let us now remark that the computed derivatives should also be used to shift the beam at the channel output as much as one wishes.

Section 11

In this section we will give some remarks about the subroutines used by the program.

1) - DM
2) - QM
3) - MH
4) - MV

The subprograms transform the vectors at the input face into vectors at the output face applying the element matrices of drift spaces, quadrupoles and bending magnet.

They are used in the block diagram at points marked 1, 2, 3, 4, 5, 6.

5) - SILVA

The subprogram calculates eight bi-dimensional vectors by means of the E, R, X ellypse parameters as said in section 9. It is used, in the block diagram at point 7 both for the initial horizontal ellypse and for the vertical one.

6) - ELLI

The subroutine computes the ellypse parameters (Y, Y', R, X) from a set of eight points using section 10 formulae.

This program is used at point 8 of the block diagram.

7) - FORVE

This subprogram, making use of the two sets of eight bi-dimensional vectors produces 64 quadri-dimensional vectors as said before (section 10). This subprogram is also used at point 7 of the block diagram. All of the following subroutines are used at points 5 and 6.

8) - DEF

This subprogram, according KEK values, defines the three translation (KEK=4, 5, 6) and rotation (KEK=1, 2, 3) parameters of the displaced element (as said in section 4 for the $\mathcal{T}$ transformation). On the contrary for KEK=7 this subroutine introduces the quantity $\Delta i/i \neq 0$ for the purposes have mentioned in section 2.

9) - COOR

The subprogram computes the initial and final coordinates referred to $\overline{T}_1$ and T_3 for bending magnets and quadrupoles. According to what said in the second part of section 3.

10) - CALCO

This subprogram computes the parameters of coordinate transformation $\mathcal{F}$ of $T_1(T_3)$ into $\overline{T}_1(\overline{T}_3)$ by means of section 4 formulae.

11) - SPOST

Such a subroutine computes the vectors at the input (output) of displaced element making use of section 6 formulae.

12) - RICO

Given the transformation that trasforms a system A into a system B, the subprogram RICO computes the transformation that trasforms the system B into A, according to formulae 5'), 12) of section 8.

Section 12

We will now present a sample program output.

The example refers to the transport channel which transfers the electrons (positrons) from the Linac to the machine "Adone". The channel consists of 7 bending magnets, 14 quadrupole lenses, and 20 drift spaces.

The elements constituting the channel are first described row by row as they are geometrically placed into the channel.

On each row the following parameters are written:

a) - for magnets:
field index, radius of curvature, tangent of the slope at the input face, and at the output face, geometrical deflection angle (degrees)

b) - quadrupoles:
strenght (which in tin lens approximation coincides with the a_{21} matrix element), lenght of quadrupole

c) - for drift spaces:
lenght of the drift space.

The final errorless parameters of the beam are typed next. Another set of rows is written after this.

In each row the values of the derivatives of the two center coordinates, the R, X quantities and the two maximum displacements, with respect to varied parameter are typed.

We have defined the latter six quantities in section 1.

On the right of each row there are:

a) - the order number of the channel element

b) - the type of variation:

RX, RY, RZ	rotations
TX, TY, TZ	translations
VE	variation of the current supply
VL	lenght variation.

c) - the channel element type:

MG	bending magnet
TD	drift space
QP	quadrupole

d) - the phase plane

O	horizontal
V	vertical.

Section 13

By now analyzing the numerical results we deduce that:

1) - the variations of the dimensions of the final ellypses are negligible; this may be deduced by comparing the first and 5^{th} column with the second and 6^{th}.

One sees that either the differences are small or, in case the results of the first and the second column vanish, the results of the 5^{th} and 6^{th} columns are negligible in absolute value.

This may be interpreted by saying that the displacement of one element is equivalent to the addition (subtraction) at the element input (at the element output) of a vector which has little dependence from the input conditions.

2) - However, in case one wants, to take into account the ellypse deformations, we list below the cases for which the deformation is more relevant.

For the quadrupoles RZ, VE and TZ are effective (notice that VE and TZ do not shift the ellypse center).

For the magnets RZ and TX are irrelevant.

3) - About the center shift:

For the quadrupoles only TX and TY produce relevant effects. TZ and VE, are indeed ineffective, RZ has only a small effect (though non zero, as we are in phase-space), while finally RX and RY give opposite effects at the element extremes.

For the magnets TX and TY whose effects however, are smaller than for the quadrupoles (because of the low field indices are important. VE and RZ have little importance.

From the data reported below one can observe for istance that a 1 mm x-displacement of element 37 (quadrupole with $a_{21} \simeq -1$) produces a horizontal displacement of about 5 mm of the ellypse center.

On the other hand a similar Y-displacement of element 21 (quadrupole with $a_{21} \simeq 0.77$) shifts the ellypse center vertically of about 9,35 mm.

As far as the slopes are conserved we call attention on element 23 (quadrupole with $a_{21} \simeq 0.74$) that, with a 1 mm x-translation, shifts the center of 2.19 mrad, and on element 21 that with a 1 mm y-translation shifts the center of 3.2 mrad.

The effects we have reported are the largest in absolute value.

4) - One element is particularly sensitive to the VL variation (the 36th drift space 70 cm long).

In this case a 1 cm variation produces variations in the ellypse dimensions of 0.24 and 0.1 mrad (horizontally) and 0.4 and 0.23 mrad (vertically).

In conclusion one must be careful with translations perpendicular to the channel for quadrupoles and for bending magnets.

For magnets there are also small variations of RZ in horizontal and VE in vertical that produce relevant effects.

The authors are much indebted to F. Amman for his helpfull criticism.

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(2) - J. Fronteau: "Le théorème de Liouville et le problème géneral de la stabilité" CERN 65/38 (1965).
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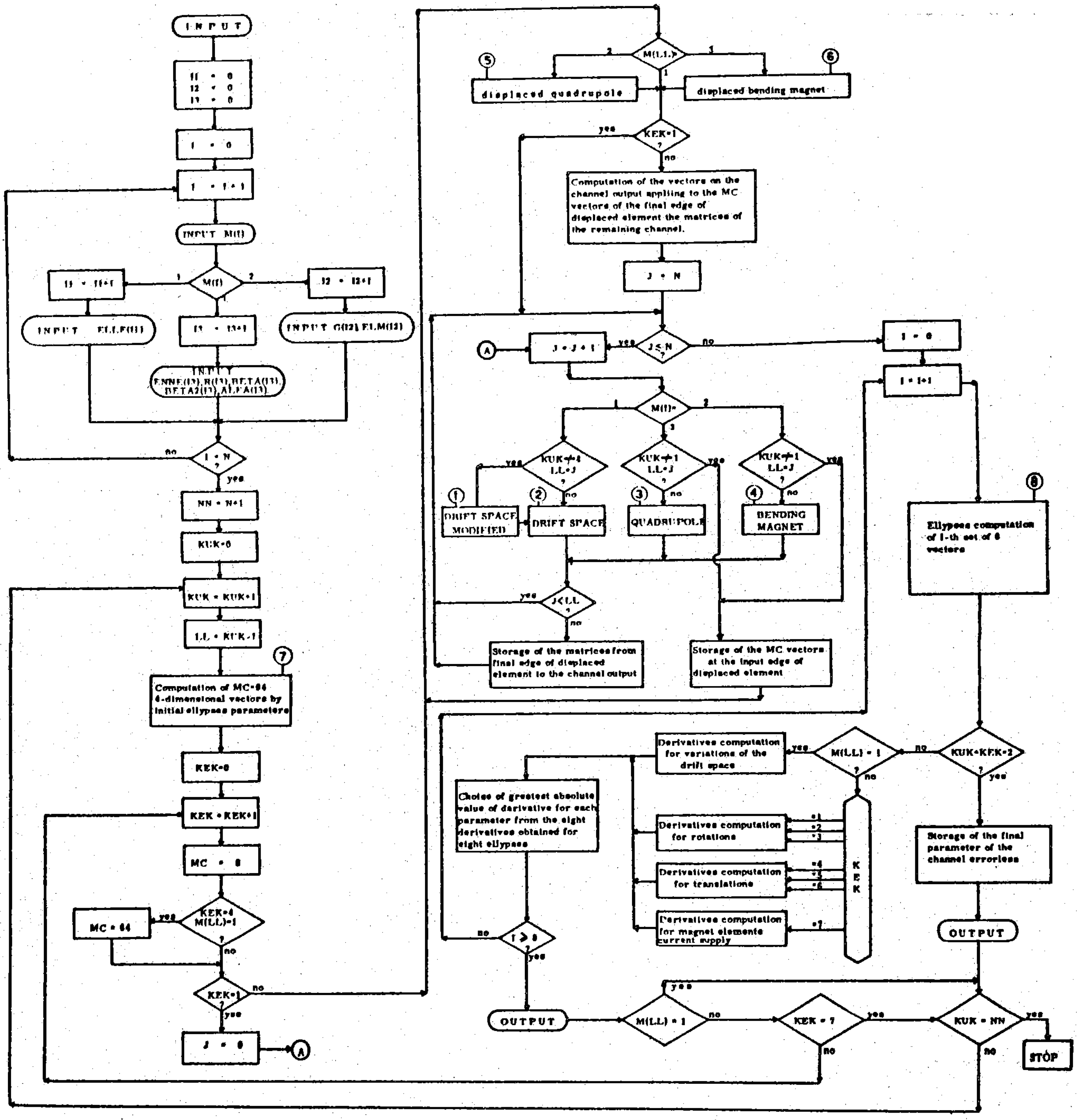
INPUT
INPUT M(I)
M(I)
INPUT ELLE(I1)
INPUT G(I2),ELM(I2)
INPUT ENNE(I3),R(I3),BETA(I3), BETA2(I3),ALFA(I3)
NN = N+1
KUK=0
KUK = KUK+1
LL = KUK-1
Computation of MC=64 4-dimensional vectors by initial ellypses parameters
KEK=0
KEK = KEK+1
MC = 8
KEK=4 M(LL)=1
MC = 64
KEK=1
J = 0
M(LL)
displaced quadrupole
displaced bending magnet
KEK=1
Computation of the vectors on the channel output appling to the MC vectors of the final edge of displaced element the matrices of the remaining channel.
J = N
J = J + 1
J ≤ N
M(J)=
DRIFT SPACE MODIFIED
DRIFT SPACE
QUADRUPOLE
BENDING MAGNET
J<LL
Storage of the matrices from final edge of displaced element to the channel output
Storage of the MC vectors at the input edge of displaced element
I = 0
I = I+1
Ellypses computation of I-th set of 8 vectors
Derivatives computation for variations of the drift space
M(LL) = 1
KUK=KEK=2
Choice of greatest absolute value of derivative for each parameter from the eight derivatives obtained for eight ellypses
Derivatives computation for rotations
Derivatives computation for translations
Derivatives computation for magnet elements current supply
KEK
Storage of the final parameter of the channel errorless
OUTPUT
I ≥ 8
OUTPUT
M(LL) = 1
KEK = 7
KUK = NN
STOP
yes
no

CHANNEL COMPOSITION

****

1	MAGNET	.....	0.	0.51110D 01	0.	0.10500D 00	0.60000D 01
2	DRIFT SPACE	.....	0.25383D 01				
3	QUADRUPOLE	.....	0.29928D 00	0.12000D 00			
4	DRIFT SPACE	.....	0.35000D 00				
5	MAGNET	.....	-0.17000D 01	0.12710D 01	0.	0.	0.24000D 02
6	DRIFT SPACE	.....	0.40000D 00				
7	QUADRUPOLE	.....	0.53310D 00	0.21000D 00			
8	DRIFT SPACE	.....	0.24557D 01				
9	QUADRUPOLE	.....	-0.63701D 00	0.32000D 00			
10	DRIFT SPACE	.....	0.24557D 01				
11	QUADRUPOLE	.....	0.47860D 00	0.21000D 00			
12	DRIFT SPACE	.....	0.40000D 00				
13	MAGNET	.....	-0.17000D 01	0.14020D 01	0.	0.	0.30000D 02
14	DRIFT SPACE	.....	0.40000D 00				
15	QUADRUPOLE	.....	0.50435D 00	0.21000D 00			
16	DRIFT SPACE	.....	0.12750D 01				
17	QUADRUPOLE	.....	0.16880D 00	0.12000D 00			
18	DRIFT SPACE	.....	0.54500D 01				
19	QUADRUPOLE	.....	-0.25084D 00	0.12000D 00			
20	DRIFT SPACE	.....	0.39500D 01				
21	QUADRUPOLE	.....	0.77035D 00	0.32000D 00			
22	DRIFT SPACE	.....	0.75000D 00				
23	QUADRUPOLE	.....	-0.74101D 00	0.32000D 00			
24	DRIFT SPACE	.....	0.22201D 01				
25	MAGNET	.....	0.	0.12710D 01	0.	0.	0.26250D 02
26	DRIFT SPACE	.....	0.35000D 00				
27	QUADRUPOLE	.....	0.25000D 00	0.12000D 00			
28	DRIFT SPACE	.....	0.16434D 01				
29	QUADRUPOLE	.....	-0.95435D 00	0.39000D 00			
30	DRIFT SPACE	.....	0.16434D 01				
31	QUADRUPOLE	.....	0.19486D 00	0.12000D 00			
32	DRIFT SPACE	.....	0.35000D 00				
33	MAGNET	.....	0.	0.14630D 01	0.	0.	0.26250D 02
34	DRIFT SPACE	.....	0.17967D 01				
35	QUADRUPOLE	.....	0.86865D 00	0.39000D 00			
36	DRIFT SPACE	.....	0.70000D 00				
37	QUADRUPOLE	.....	-0.95800D 00	0.39000D 00			
38	DRIFT SPACE	.....	0.40000D 01				
39	MAGNET	.....	0.	0.13751D 02	0.	0.	0.37500D 01
40	DRIFT SPACE	.....	0.70000D-01				
41	MAGNET	.....	0.	0.13751D 02	0.	0.	0.37500D 01

XC	XCP	R	X	XMAX	XPMAX	
0.	0.	0.86953D 00	0.65385D 00	0.36894D-02	0.29488D-02	O
0.	0.	0.14760D 01	0.90035D 00	0.45003D-02	0.38419D-02	V

DXC	DXCP	DR	DX	DXMAX	DXPMAX	N			
-0.33548D-03	0.33923D-03	-0.12069D-03	-0.70305D-04	0.33508D-03	0.33981D-03	1	RX	MG	O
-0.27066D-02	-0.13111D-01	-0.53375D-05	0.39276D-05	0.27066D-02	0.13111D-01	1	RX	MG	V
-0.13200D-01	0.39489D-02	0.20772D-05	0.59061D-05	0.13200D-01	0.39489D-02	1	RY	MG	O
0.20329D-14	-0.21684D-14	0.56031D-03	0.86559D-03	0.15642D-05	0.72921D-06	1	RY	MG	V
-0.52152D-03	0.12200D-03	0.67052D-04	0.83901D-04	0.52173D-03	0.12211D-03	1	RZ	MG	O
-0.51058D-01	-0.24746D 00	-0.11352D-04	0.74776D-05	0.51058D-01	0.24746D 00	1	RZ	MG	V
0.15391D-02	0.18191D-02	-0.44577D-02	-0.79926D-02	0.15202D-02	0.18115D-02	1	TX	MG	O
0.11520D-15	-0.16263D-15	-0.13117D-01	0.78388D-02	0.14737D-05	-0.17071D-04	1	TX	MG	V
0.43368D-15	0.47434D-15	-0.45253D-08	-0.18427D-07	-0.40221D-10	-0.76722D-11	1	TY	MG	O
-0.75493D-02	-0.47837D-01	0.28586D-07	-0.54905D-07	0.75493D-02	0.47837D-01	1	TY	MG	V
0.30313D-01	0.34449D-01	0.43555D-03	0.85323D-03	0.30315D-01	0.34450D-01	1	TZ	MG	O
0.11520D-15	0.	0.33693D-01	0.50416D-01	0.91842D-04	0.43849D-04	1	TZ	MG	V
-0.24804D 00	0.80048D-01	-0.45242D-09	-0.18424D-08	0.24804D 00	0.80048D-01	1	VE	MG	O
0.19651D-16	-0.10842D-16	0.28587D-08	-0.54904D-08	-0.54475D-11	0.37205D-11	1	VE	MG	V
0.54210D-17	-0.81315D-17	-0.42837D-01	-0.76756D-01	-0.18167D-03	-0.72639D-04	2	VL	TD	O
0.10842D-16	0.	-0.14214D 00	0.49660D-01	-0.31789D-04	-0.18501D-03	2	VL	TD	V
0.54210D-15	-0.16263D-14	-0.91531D-02	0.18287D-01	0.26686D-04	-0.19672D-04	3	RX	QP	O
0.12505D-03	0.16135D-03	-0.10797D-03	0.13437D-04	0.12499D-03	0.16121D-03	3	RX	QP	V
-0.27551D-03	-0.13003D-03	-0.65810D-05	0.70659D-04	0.27565D-03	0.13002D-03	3	RY	QP	O
0.24395D-14	0.10842D-14	-0.22688D-01	0.16089D-01	-0.27331D-05	-0.35428D-04	3	RY	QP	V
0.18008D-01	-0.92974D-03	-0.26201D-04	0.28092D-03	0.18009D-01	0.92970D-03	3	RZ	QP	O
0.46652D-02	-0.11560D-01	-0.43452D-03	0.54045D-04	0.46649D-02	0.11559D-01	3	RZ	QP	V
0.95572D 00	0.49362D-01	-0.18763D-10	-0.19762D-10	0.95572D 00	0.49362D-01	3	TX	QP	O
0.18974D-15	0.54210D-16	-0.58842D-10	-0.51403D-10	-0.11102D-12	-0.76328D-13	3	TX	QP	V
0.	-0.54210D-16	-0.20872D-10	-0.23315D-10	-0.59848D-13	-0.35562D-13	3	TY	QP	O
0.23314D 00	-0.57778D 00	-0.58398D-10	-0.51847D-10	0.23314D 00	0.57778D 00	3	TY	QP	V
0.	-0.67763D-16	0.61583D 00	-0.96418D 00	-0.16011D-02	0.10441D-02	3	TZ	QP	O
0.10164D-15	0.	-0.10839D 01	0.10191D 01	0.62613D-03	-0.14108D-02	3	TZ	QP	V
0.	-0.20329D-16	-0.26336D 00	0.28269D 01	0.56562D-02	-0.44673D-03	3	VE	QP	O
0.10164D-16	0.16263D-16	-0.42455D 01	0.49307D 00	-0.22602D-02	-0.55452D-02	3	VE	QP	V
-0.54210D-17	-0.54210D-17	-0.65667D 00	0.88597D 00	0.14325D-02	-0.11145D-02	4	VL	TD	O
0.54210D-17	0.	0.93920D 00	-0.97536D 00	-0.65803D-03	0.12213D-02	4	VL	TD	V
-0.21472D-02	-0.81028D-03	0.10098D-01	-0.26559D-01	0.21210D-02	0.83382D-03	5	RX	MG	O
-0.13073D-01	-0.65288D-02	0.10339D-03	-0.34050D-06	0.13073D-01	0.65289D-02	5	RX	MG	V
-0.98089D-02	0.55734D-02	-0.23089D-01	-0.90565D-01	0.96107D-02	0.55342D-02	5	RY	MG	O
0.10842D-14	-0.21684D-14	0.20245D-01	-0.82637D-01	-0.79594D-04	0.38320D-04	5	RY	MG	V
-0.41567D-01	-0.42160D-02	0.20358D-02	-0.13363D-01	0.41589D-01	0.42126D-02	5	RZ	MG	O
0.41082D 00	-0.66990D 00	0.68535D-03	0.67381D-05	0.41082D 00	0.66990D 00	5	RZ	MG	V
-0.31777D 01	-0.32279D 00	-0.10057D 00	0.10448D 01	0.31797D 01	0.32262D 00	5	TX	MG	O
0.54210D-16	-0.10842D-15	0.27884D 00	-0.44919D-01	0.13367D-03	0.36288D-03	5	TX	MG	V
-0.23419D-13	0.13146D-13	-0.95912D-07	0.30684D-06	0.56892D-09	-0.16262D-09	5	TY	MG	O
-0.54032D 00	0.88097D 00	0.40285D-06	-0.33904D-06	0.54032D 00	0.88097D 00	5	TY	MG	V
-0.15741D 00	0.89150D-01	-0.81476D 00	-0.31798D 01	0.15045D 00	0.87769D-01	5	TZ	MG	O
0.	0.54210D-16	0.52982D 00	-0.16869D 01	-0.19156D-02	0.68949D-03	5	TZ	MG	V
-0.15292D 01	-0.15535D 00	-0.95916D-08	0.30683D-07	0.15292D 01	0.15535D 00	5	VE	MG	O
0.	0.54210D-17	0.40284D-07	-0.33904D-07	-0.17849D-10	0.52427D-10	5	VE	MG	V

0.54210D-17	-0.67763D-17	0.17487D 00	0.41402D 01	0.86161D-02	0.29644D-03	6	VL	TD	O
0.10842D-16	0.	0.40000D 00	0.75464D 00	0.13020D-02	0.52040D-03	6	VL	TD	V
-0.54210D-15	-0.17618D-14	-0.22748D-02	0.43691D-01	0.96165D-04	-0.33831D-05	7	RX	QP	O
0.77687D-03	0.53370D-03	-0.17607D-03	-0.34156D-04	0.77670D-03	0.53347D-03	7	RX	QP	V
0.25109D-02	-0.32909D-03	-0.23712D-04	0.70934D-04	0.25110D-02	0.32905D-03	7	RY	QP	O
0.25411D-14	-0.21684D-14	-0.24613D-01	-0.22173D-01	-0.38296D-04	-0.24409D-04	7	RY	QP	V
-0.23862D-01	-0.39910D-02	-0.93530D-04	0.27874D-03	0.23863D-01	0.39909D-02	7	RZ	QP	O
0.11020D-01	0.12398D-01	-0.71800D-03	-0.13930D-03	0.11020D-01	0.12397D-01	7	RZ	QP	V
0.14129D 01	0.23638D 00	-0.14322D-10	-0.22982D-10	0.14129D 01	0.23638D 00	7	TX	QP	O
0.10164D-15	-0.10842D-15	-0.46407D-10	-0.76938D-10	-0.13618D-12	-0.60282D-13	7	TX	QP	V
0.	-0.81315D-16	-0.13878D-10	-0.23093D-10	-0.55511D-13	-0.23419D-13	7	TY	QP	O
0.74332D 00	-0.83539D 00	-0.39968D-10	-0.83156D-10	0.74332D 00	0.83539D 00	7	TY	QP	V
0.	-0.54210D-16	-0.21132D 00	0.35965D 01	0.72133D-02	-0.35833D-03	7	TZ	QP	O
0.17618D-15	0.10842D-15	-0.81101D 00	0.14155D 01	0.13541D-02	-0.10555D-02	7	TZ	QP	V
-0.10842D-16	0.13553D-17	-0.96069D 00	0.28726D 01	0.53709D-02	-0.16312D-02	7	VE	QP	O
0.16941D-16	0.	-0.67915D 01	-0.13853D 01	-0.66109D-02	-0.88902D-02	7	VE	QP	V
-0.54210D-17	-0.54210D-17	0.38642D 00	0.54140D 00	0.13303D-02	0.65487D-03	8	VL	TD	O
0.10842D-16	0.	0.12102D 01	-0.66744D 00	-0.52976D-04	0.15733D-02	8	VL	TD	V
0.54210D-15	-0.17618D-14	0.63643D-02	0.20439D-02	0.51844D-05	0.73945D-05	9	RX	QP	O
-0.26621D-02	-0.37957D-02	-0.52898D-05	0.31314D-04	0.26621D-02	0.37957D-02	9	RX	QP	V
-0.52436D-02	-0.35539D-03	0.12762D-04	0.12328D-04	0.52437D-02	0.35541D-03	9	RY	QP	O
0.10842D-14	0.16263D-14	0.10457D-01	0.34195D-02	0.13753D-04	-0.17802D-04	9	RY	QP	V
0.51874D-02	-0.51225D-02	0.50902D-04	0.51098D-04	0.51875D-02	0.51226D-02	9	RZ	QP	O
0.67516D-02	0.37322D-03	-0.22453D-04	0.12100D-03	0.67518D-02	0.37319D-03	9	RZ	QP	V
-0.70974D 00	-0.70023D 00	-0.18985D-10	-0.18208D-10	0.70974D 00	0.70023D 00	9	TX	QP	O
0.54210D-16	-0.54210D-16	0.11990D-10	-0.49960D-11	0.17347D-14	0.16046D-13	9	TX	QP	V
0.	-0.27105D-16	-0.18763D-10	-0.19429D-10	-0.50307D-13	-0.32092D-13	9	TY	QP	O
-0.96407D 00	-0.54607D-01	0.13767D-10	-0.54401D-11	0.96407D 00	0.54607D-01	9	TY	QP	V
0.10842D-15	-0.81315D-16	0.11273D 01	-0.38623D 00	-0.12214D-03	0.19111D-02	9	TZ	QP	O
0.10842D-15	0.10842D-15	0.18999D 01	0.42880D 00	0.19067D-02	0.24722D-02	9	TZ	QP	V
0.10842D-16	-0.13553D-16	0.47888D 00	0.47775D 00	0.12548D-02	0.81145D-03	9	VE	QP	O
0.	-0.54210D-17	-0.22865D 00	0.12911D 01	0.15967D-02	-0.29763D-03	9	VE	QP	V
-0.54210D-17	-0.81315D-17	-0.73884D 00	0.92593D 00	0.14678D-02	-0.12541D-02	10	VL	TD	O
0.10842D-16	0.	-0.69302D 00	-0.10860D 01	-0.19559D-02	-0.90245D-03	10	VL	TD	V
-0.10842D-14	-0.13553D-14	0.67868D-02	0.40250D-01	0.70726D-04	0.17358D-04	11	RX	QP	O
0.12444D-03	0.52640D-03	0.14259D-03	0.37043D-04	0.12459D-03	0.52659D-03	11	RX	QP	V
0.31280D-02	0.67465D-03	0.53266D-05	0.54589D-04	0.31282D-02	0.67466D-03	11	RY	QP	O
0.	-0.21684D-14	0.23467D-01	0.93088D-02	0.81583D-05	0.23902D-04	11	RY	QP	V
-0.16559D-01	-0.96529D-03	0.20624D-04	0.21440D-03	0.16559D-01	0.96532D-03	11	RZ	QP	O
0.26081D-01	-0.12780D-01	0.57922D-03	0.15078D-03	0.26082D-01	0.12780D-01	11	RZ	QP	V
-0.99275D 00	0.57884D-01	-0.19318D-10	-0.26645D-10	0.99275D 00	0.57884D-01	11	TX	QP	O
0.	-0.54210D-16	0.10658D-10	-0.66613D-11	-0.17347D-14	0.14311D-13	11	TX	QP	V
0.	-0.81315D-16	-0.18097D-10	-0.25979D-10	-0.64185D-13	-0.30358D-13	11	TY	QP	O
0.18220D 01	0.89246D 00	0.75495D-11	-0.65503D-11	0.18220D 01	0.89246D 00	11	TY	QP	V
0.	-0.94868D-16	0.53585D 00	-0.32162D 01	-0.62320D-02	0.90853D-03	11	TZ	QP	O
0.	-0.54210D-16	-0.37163D 00	-0.15319D 01	-0.23353D-02	-0.48367D-03	11	TZ	QP	V
0.	-0.81315D-17	0.21410D 00	0.22080D 01	0.46444D-02	0.36291D-03	11	VE	QP	O
0.	-0.10842D-16	0.56131D 01	0.15347D 01	0.59895D-02	0.72707D-02	11	VE	QP	V

0.	-0.81315D-17	-0.12697D 01	0.41281D 01	0.78273D-02	-0.21569D-02	12	VL	TD	O
0.16263D-16	0.	-0.31794D 00	0.44194D 00	0.37865D-03	-0.41389D-03	12	VL	TD	V
0.21357D-02	0.98266D-03	0.15911D-01	-0.18959D-01	0.21136D-02	0.10164D-02	13	RX	MG	O
-0.12953D-01	-0.21475D-01	-0.37630D-04	0.28992D-04	0.12953D-01	0.21475D-01	13	RX	MG	V
-0.33261D-01	-0.16284D-01	-0.83296D-01	0.12226D 00	0.33461D-01	0.16143D-01	13	RY	MG	O
0.	0.	0.60947D-01	0.18277D 00	0.31473D-03	0.10022D-03	13	RY	MG	V
0.41123D-01	0.17504D-02	0.18841D-02	-0.18739D-01	0.41156D-01	0.17479D-02	13	RZ	MG	O
0.18322D 01	0.10078D 01	-0.50881D-03	-0.21272D-03	0.18322D 01	0.10078D 01	13	RZ	MG	V
0.33059D 01	0.13984D 00	-0.20943D 00	0.14801D 01	0.33088D 01	0.13949D 00	13	TX	MG	O
0.	0.	-0.42282D 00	-0.48218D 00	-0.94857D-03	-0.55029D-03	13	TX	MG	V
-0.10072D-12	-0.49304D-13	-0.69660D-06	-0.28593D-05	-0.62378D-08	-0.11811D-08	13	TY	MG	O
-0.22188D 01	-0.12204D 01	0.72242D-05	0.75597D-05	0.22188D 01	0.12204D 01	13	TY	MG	V
-0.30049D 00	-0.14712D 00	-0.16837D 01	0.24766D 01	0.30456D 00	0.14427D 00	13	TZ	MG	O
0.	0.	0.96080D 00	0.26553D 01	0.42700D-02	0.12503D-02	13	TZ	MG	V
0.17771D 01	0.75189D-01	-0.69661D-07	-0.28593D-06	0.17771D 01	0.75189D-01	13	VE	MG	O
0.	0.	0.72242D-06	0.75597D-06	0.15287D-08	0.94017D-09	13	VE	MG	V
-0.54210D-17	-0.27105D-17	0.46827D 00	0.15783D 01	0.34961D-02	0.79348D-03	14	VL	TD	O
0.54210D-17	0.	-0.13316D 01	-0.22894D 01	-0.40328D-02	-0.17349D-02	14	VL	TD	V
-0.54210D-15	-0.23039D-14	-0.71888D-02	0.25551D-01	0.64787D-04	-0.18983D-04	15	RX	QP	O
0.59475D-03	0.80543D-03	0.18433D-03	0.13326D-03	0.59506D-03	0.80567D-03	15	RX	QP	V
-0.68045D-03	0.54877D-03	-0.20153D-04	0.95391D-04	0.68063D-03	0.54873D-03	15	RY	QP	O
0.	0.10842D-14	0.28364D-01	0.44489D-01	0.90171D-04	0.45520D-04	15	RY	QP	V
-0.27720D-01	-0.30968D-02	-0.79528D-04	0.37492D-03	0.27721D-01	0.30967D-02	15	RZ	QP	O
0.37763D-01	-0.22826D-01	0.74960D-03	0.54262D-03	0.37764D-01	0.22827D-01	15	RZ	QP	V
-0.15185D 01	-0.16960D 00	-0.17542D-10	-0.19096D-10	0.15185D 01	0.16960D 00	15	TX	QP	O
0.	0.	0.11102D-11	-0.36637D-11	-0.34694D-14	0.17347D-14	15	TX	QP	V
-0.54210D-16	-0.18974D-15	-0.16653D-10	-0.16431D-10	-0.43368D-13	-0.27756D-13	15	TY	QP	O
0.21192D 01	0.12811D 01	-0.39968D-11	0.14433D-11	0.21192D 01	0.12811D 01	15	TY	QP	V
0.54210D-16	-0.81315D-16	0.55922D 00	0.16674D 01	0.37280D-02	0.94814D-03	15	TZ	QP	O
0.	0.	-0.97032D 00	-0.25050D 01	-0.40719D-02	-0.12629D-02	15	TZ	QP	V
0.	-0.17618D-16	-0.81559D 00	0.38573D 01	0.74999D-02	-0.13845D-02	15	VE	QP	O
0.	-0.10842D-16	0.71639D 01	0.54528D 01	0.12309D-01	0.92675D-02	15	VE	QP	V
0.	-0.67763D-17	-0.91995D-01	-0.90658D-01	-0.23899D-03	-0.15601D-03	16	VL	TD	O
0.10842D-16	0.	-0.34632D 00	0.20065D 00	0.30988D-04	-0.45084D-03	16	VL	TD	V
0.10842D-14	-0.23039D-14	-0.68133D-02	0.61030D-02	0.64645D-05	-0.13251D-04	17	RX	QP	O
-0.20810D-03	-0.81295D-04	0.35886D-04	0.42420D-04	0.20819D-03	0.81341D-04	17	RX	QP	V
0.13723D-03	0.92052D-04	-0.17545D-04	0.33944D-04	0.13729D-03	0.92822D-04	17	RY	QP	O
0.	-0.10842D-14	0.14940D-01	0.72620D-02	0.16810D-04	0.16493D-04	17	RY	QP	V
-0.83796D-02	-0.19808D-02	-0.69954D-04	0.13531D-03	0.83798D-02	0.19807D-02	17	RZ	QP	O
0.10093D-01	0.70049D-02	0.14399D-03	0.17025D-03	0.10093D-01	0.70051D-02	17	RZ	QP	V
-0.58478D 00	-0.13825D 00	-0.15654D-10	-0.26312D-10	0.58478D 00	0.13825D 00	17	TX	QP	O
0.	0.	0.30420D-10	-0.30087D-10	-0.19949D-13	0.39899D-13	17	TX	QP	V
0.	-0.16263D-15	-0.14877D-10	-0.26867D-10	-0.64185D-13	-0.25153D-13	17	TY	QP	O
0.56046D 00	0.38879D 00	0.48850D-10	-0.49072D-10	0.56046D 00	0.38899D 00	17	TY	QP	V
0.	-0.54210D-16	0.48020D 00	-0.28735D 00	-0.30255D-03	0.81410D-03	17	TZ	QP	O
0.	-0.10842D-15	0.10039D 01	0.41824D 00	0.12672D-02	0.13064D-02	17	TZ	QP	V
0.	-0.10842D-16	-0.69864D 00	0.13531D 01	0.23703D-02	-0.11858D-02	17	VE	QP	O
0.	0.	0.14155D 01	0.16961D 01	0.32831D-02	0.18400D-02	17	VE	QP	V

0.	-0.81315D-17	-0.57089D 00	0.19695D 00	0.68270D-04	-0.96880D-03	18	VL	TD	O
0.10842D-16	0.	-0.13480D 01	-0.21316D 00	-0.12288D-02	-0.17563D-02	18	VL	TD	V
-0.10842D-14	-0.18974D-14	0.40642D-01	-0.37578D-01	-0.56432D-04	0.65894D-04	19	RX	QP	O
0.53370D-03	0.22160D-03	-0.52328D-04	0.39372D-04	0.53372D-03	0.22153D-03	19	RX	QP	V
0.39551D-04	-0.25747D-04	0.25213D-03	-0.19032D-03	0.39312D-04	0.26174D-04	19	RY	QP	O
0.	0.	0.65778D-01	0.24180D-01	-0.23426D-04	-0.94347D-04	19	RY	QP	V
-0.36799D-01	-0.15335D-01	0.10135D-02	-0.76506D-03	0.36798D-01	0.15337D-01	19	RZ	QP	O
0.34336D-01	0.88986D-02	-0.20828D-03	0.15669D-03	0.34337D-01	0.88984D-02	19	RZ	QP	V
0.21850D 01	0.91054D 00	-0.32419D-10	-0.54068D-10	0.21850D 01	0.91054D 00	19	TX	QP	O
0.	0.	0.17542D-10	-0.16986D-10	-0.10408D-13	0.22985D-13	19	TX	QP	V
0.	0.	-0.19096D-10	-0.29976D-10	-0.72858D-13	-0.32092D-13	19	TY	QP	O
0.94833D 00	0.24577D 00	-0.68834D-11	0.87708D-11	0.94833D 00	0.24577D 00	19	TY	QP	V
0.	0.	0.78278D-01	-0.60293D 00	-0.11825D-02	0.13273D-03	19	TZ	QP	O
0.	0.	0.23738D 01	-0.85371D 00	0.50095D-03	0.30887D-02	19	TZ	QP	V
0.	0.	0.10392D 02	-0.76068D 01	-0.76750D-02	0.17365D-01	19	VE	QP	O
0.	0.	-0.20830D 01	0.15729D 01	0.70912D-03	-0.27157D-02	19	VE	QP	V
-0.54210D-17	-0.12197D-16	-0.64854D 00	0.79839D 00	0.12572D-02	-0.11007D-02	20	VL	TD	O
0.10842D-16	0.	-0.36960D 01	0.65227D 00	-0.16638D-02	-0.48253D-02	20	VL	TD	V
-0.10842D-14	-0.20329D-14	-0.11827D 00	0.18585D-01	0.14556D-03	-0.23112D-03	21	RX	QP	O
0.16354D-01	0.50302D-02	0.20698D-02	-0.66229D-03	0.16354D-01	0.50329D-02	21	RX	QP	V
0.24349D-02	0.29198D-02	-0.19006D-03	0.67530D-04	0.24349D-02	0.29195D-02	21	RY	QP	O
0.	0.	0.53606D 00	-0.20276D 00	0.83048D-04	0.68387D-03	21	RY	QP	V
0.17125D 00	0.90794D-01	-0.72995D-03	0.25904D-03	0.17125D 00	0.90793D-01	21	RZ	QP	O
-0.17284D 00	-0.59147D-01	0.85979D-02	-0.27514D-02	0.17284D 00	0.59158D-01	21	RZ	QP	V
-0.31856D 01	-0.16893D 01	-0.26867D-10	-0.33640D-10	0.31856D 01	0.16893D 01	21	TX	QP	O
0.	0.	0.14122D-09	-0.10192D-09	-0.39899D-13	0.18388D-12	21	TX	QP	V
0.	0.	-0.27089D-10	-0.30753D-10	-0.78930D-13	-0.45970D-13	21	TY	QP	O
-0.93538D 01	-0.32009D 01	0.70388D-10	-0.30753D-10	0.93538D 01	0.32009D 01	21	TY	QP	V
0.	0.	0.18887D 01	0.81151D 00	0.27660D-02	0.32017D-02	21	TZ	QP	O
0.	0.	0.31109D 02	-0.12130D 02	0.56213D-02	0.40380D-01	21	TZ	QP	V
0.	0.	-0.76761D 01	0.28637D 01	0.19218D-02	-0.13163D-01	21	VE	QP	O
0.	0.	0.93362D 02	-0.18664D 02	0.54533D-01	0.11317D 00	21	VE	QP	V
0.	-0.94868D-17	-0.25207D 01	0.83328D-02	-0.14402D-02	-0.42897D-02	22	VL	TD	O
0.16263D-16	0.	-0.32189D 02	0.13344D 02	0.22342D-03	-0.43101D-01	22	VL	TD	V
-0.54210D-15	-0.20329D-14	0.13647D 00	-0.28782D-02	0.98225D-04	0.24989D-03	23	RX	QP	O
-0.26442D-01	-0.83990D-02	-0.72993D-03	0.20785D-03	0.26442D-01	0.83980D-02	23	RX	QP	V
-0.20398D-03	-0.13197D-02	0.32751D-03	-0.82677D-04	0.20400D-03	0.13202D-02	23	RY	QP	O
0.	0.	-0.62556D 00	0.22127D 00	-0.11634D-03	-0.79692D-03	23	RY	QP	V
-0.13085D 00	-0.73902D-01	0.13589D-02	-0.34312D-03	0.13085D 00	0.73904D-01	23	RZ	QP	O
0.13623D 00	0.47720D-01	-0.28158D-02	0.80162D-03	0.13623D 00	0.47717D-01	23	RZ	QP	V
0.38810D 01	0.21926D 01	0.20539D-10	-0.20095D-10	0.38810D 01	0.21926D 01	23	TX	QP	O
0.	0.	-0.14211D-10	0.37748D-11	-0.43368D-14	-0.18648D-13	23	TX	QP	V
0.	0.	0.13767D-10	-0.32196D-10	-0.57246D-13	0.23419D-13	23	TY	QP	O
0.56457D 01	0.19776D 01	-0.21538D-10	0.10880D-10	0.56457D 01	0.19776D 01	23	TY	QP	V
0.	0.	-0.48154D 00	-0.11554D 01	-0.26384D-02	-0.81657D-03	23	TZ	QP	O
0.	0.	-0.33145D 02	0.11923D 02	-0.65722D-02	-0.43257D-01	23	TZ	QP	V
0.	0.	0.13087D 02	-0.29000D 01	0.29670D-02	0.21788D-01	23	VE	QP	O
0.	0.	-0.28542D 02	0.92799D 01	-0.43769D-02	-0.38089D-01	23	VE	QP	V

0.54210D-17	-0.54210D-17	-0.20411D 01	0.11458D 01	0.11889D-02	-0.34711D-02	24	VL	TD	O
0.16263D-16	0.	-0.12355D 01	0.95126D 00	0.43828D-03	-0.16096D-02	24	VL	TD	V
0.64527D-02	0.25918D-02	-0.57265D-02	-0.21967D-02	0.64605D-02	0.26014D-02	25	RX	MG	O
-0.21004D-01	-0.66710D-02	-0.41415D-04	0.17678D-04	0.21004D-01	0.66710D-02	25	RX	MG	V
0.31271D-01	0.16070D-01	0.24396D-01	0.11762D-01	0.31309D-01	0.16111D-01	25	RY	MG	O
0.	0.10842D-14	-0.34903D-02	0.10319D-02	-0.99072D-06	-0.28211D-05	25	RY	MG	V
0.18329D-02	0.23005D-02	0.73565D-02	-0.42966D-02	0.18345D-02	0.22966D-02	25	RZ	MG	O
-0.16690D 01	-0.74042D 00	-0.20870D-03	0.82476D-05	0.16690D 01	0.74042D 00	25	RZ	MG	V
0.21829D 00	0.27999D 00	-0.11008D 01	0.43983D 00	0.21854D 00	0.27813D 00	25	TX	MG	O
0.	-0.10842D-15	-0.56266D 00	0.43233D 00	0.19367D-03	-0.73229D-03	25	TX	MG	V
0.23896D-12	0.12289D-12	-0.26369D-05	-0.66255D-06	-0.29030D-08	-0.44711D-08	25	TY	MG	O
-0.11926D-14	-0.43368D-15	-0.35324D-05	0.16586D-05	-0.21635D-09	-0.45972D-08	25	TY	MG	V
0.91727D 00	0.47142D 00	0.71594D 00	0.34550D 00	0.91840D 00	0.47263D 00	25	TZ	MG	O
0.	0.	-0.35320D-05	0.16582D-05	-0.21650D-09	-0.45966D-08	25	TZ	MG	V
0.28478D 00	0.36536D 00	-0.26369D-06	-0.66255D-07	0.28478D 00	0.36536D 00	25	VE	MG	O
0.	0.	-0.35324D-06	0.16586D-06	-0.21635D-10	-0.45972D-09	25	VE	MG	V
0.	-0.12197D-16	-0.27655D 01	0.80145D 00	0.70554D-04	-0.47081D-02	26	VL	TD	O
0.16263D-16	0.	-0.12355D 01	0.95126D 00	0.43828D-03	-0.16096D-02	26	VL	TD	V
-0.10842D-14	-0.17618D-14	0.30618D-02	0.59145D-02	0.74187D-05	0.74563D-05	27	RX	QP	O
0.54139D-03	0.16227D-03	0.37824D-04	0.12371D-04	0.54144D-03	0.16232D-03	27	RX	QP	V
-0.66540D-03	-0.35171D-03	0.50981D-06	0.37588D-05	0.66541D-03	0.35171D-03	27	RY	QP	O
0.	0.10842D-14	0.13428D-01	0.23137D-02	0.98228D-05	0.16246D-04	27	RY	QP	V
0.21877D-02	-0.18959D-03	0.20012D-05	0.14951D-04	0.21878D-02	0.18959D-03	27	RZ	QP	O
0.35323D-02	0.17938D-02	0.15196D-03	0.49733D-04	0.35325D-02	0.17940D-02	27	RZ	QP	V
0.18431D 00	-0.15697D-01	-0.17764D-11	0.44409D-12	0.18431D 00	0.15697D-01	27	TX	QP	O
0.	0.10842D-15	-0.26645D-11	-0.16764D-10	-0.24286D-13	-0.34694D-14	27	TX	QP	V
0.54210D-16	-0.94868D-16	-0.24425D-11	-0.66613D-12	-0.26021D-14	-0.43368D-14	27	TY	QP	O
-0.67983D 00	-0.34508D 00	-0.17319D-10	-0.61062D-11	0.67983D 00	0.34508D 00	27	TY	QP	V
0.	-0.27105D-16	0.35784D 00	-0.59477D 00	-0.10010D-02	0.60672D-03	27	TZ	QP	O
0.	0.	0.19266D 01	-0.14115D 00	0.11534D-02	0.25070D-02	27	TZ	QP	V
0.	-0.14908D-16	0.20259D-01	0.15027D 00	0.31827D-03	0.34343D-04	27	VE	QP	O
0.	0.	0.14994D 01	0.49646D 00	0.17180D-02	0.19489D-02	27	VE	QP	V
-0.54210D-17	-0.27105D-17	-0.31136D 01	0.13915D 01	0.11121D-02	-0.53034D-02	28	VL	TD	O
0.16263D-16	0.	-0.31442D 01	0.10999D 01	-0.66843D-03	-0.41029D-02	28	VL	TD	V
0.10842D-14	-0.21684D-14	0.49236D-01	-0.44641D-01	-0.66367D-04	0.80843D-04	29	RX	QP	O
-0.29487D-01	-0.71571D-02	0.15128D-04	0.22291D-04	0.29487D-01	0.71571D-02	29	RX	QP	V
0.34528D-02	0.41844D-02	0.24172D-03	-0.19037D-03	0.34526D-02	0.41848D-02	29	RY	QP	O
0.	-0.54210D-15	0.75716D-02	0.60591D-01	0.57875D-04	0.25766D-04	29	RY	QP	V
-0.18453D-01	-0.75701D-02	0.10212D-02	-0.80699D-03	0.18452D-01	0.75719D-02	29	RZ	QP	O
0.14014D-01	-0.38135D-02	0.48203D-04	0.81396D-04	0.14014D-01	0.38136D-02	29	RZ	QP	V
-0.40812D 01	-0.16677D 01	0.62172D-11	0.30309D-10	0.40812D 01	0.16677D 01	29	TX	QP	O
0.	0.	0.12434D-10	-0.20206D-10	-0.18215D-13	0.16480D-13	29	TX	QP	V
0.	0.	-0.88818D-11	0.27756D-11	0.	-0.14745D-13	29	TY	QP	O
-0.77992D 00	0.21214D 00	0.13323D-10	-0.22071D-10	0.77992D 00	0.21214D 00	29	TY	QP	V
0.	0.	-0.18942D 01	-0.48924D 00	-0.21123D-02	-0.32127D-02	29	TZ	QP	O
0.	-0.54210D-16	0.52170D 00	-0.44057D 01	-0.56010D-02	0.67893D-03	29	TZ	QP	V
0.	0.	0.93835D 01	-0.72050D 01	-0.76953D-02	0.15702D-01	29	VE	QP	O
0.	0.54210D-17	0.59478D 00	0.91574D 00	0.16558D-02	0.77367D-03	29	VE	QP	V

-0.54210D-17	-0.16263D-16	-0.12475D 01	0.18699D 01	0.31317D-02	-0.21192D-02	30	VL	TD	O
0.16263D-16	0.	-0.36527D 01	0.54703D 01	0.50778D-02	-0.47685D-02	30	VL	TD	V
0.54210D-15	-0.18974D-14	-0.13684D-01	0.76714D-02	-0.12307D-04	-0.19429D-04	31	RX	QP	O
0.55954D-03	0.10934D-03	0.44434D-04	-0.11664D-03	0.55941D-03	0.10940D-03	31	RX	QP	V
0.37528D-03	0.92617D-04	-0.84903D-05	0.62783D-06	0.37527D-03	0.92603D-04	31	RY	QP	O
0.	-0.10842D-14	0.16738D-01	-0.34232D-01	-0.32994D-04	0.23258D-04	31	RY	QP	V
0.83692D-02	-0.52681D-02	-0.33855D-04	0.25065D-05	0.83692D-02	0.52681D-02	31	RZ	QP	O
-0.86311D-02	-0.96703D-03	0.17842D-03	-0.46843D-03	0.86306D-02	0.96726D-03	31	RZ	QP	V
0.32115D 00	0.20210D 00	-0.10658D-10	-0.24425D-11	0.32115D 00	0.20210D 00	31	TX	QP	O
0.	0.10842D-15	0.10214D-10	-0.17653D-10	-0.16480D-13	0.13444D-13	31	TX	QP	V
0.	-0.54210D-16	-0.94369D-11	-0.34417D-11	-0.13010D-13	-0.16480D-13	31	TY	QP	O
0.10768D 01	0.12067D 00	0.14877D-10	-0.22427D-10	0.10768D 01	0.12067D 00	31	TY	QP	V
0.	0.	-0.60340D 00	0.38494D 00	0.42975D-03	-0.10232D-02	31	TZ	QP	O
0.	-0.10842D-15	-0.19810D 01	0.35928D 01	0.34957D-02	-0.25786D-02	31	TZ	QP	V
0.	0.	-0.33907D 00	0.25413D-01	-0.14729D-03	-0.57521D-03	31	VE	QP	O
0.	0.	0.17695D 01	-0.46379D 01	-0.49431D-02	0.22995D-02	31	VE	QP	V
0.54210D-17	0.	-0.64867D 00	0.14876D 01	0.26757D-02	-0.11009D-02	32	VL	TD	O
0.10842D-16	0.	-0.16972D 01	0.19004D 01	0.14233D-02	-0.22119D-02	32	VL	TD	V
-0.12376D-01	-0.46385D-02	-0.90474D-02	0.19486D-02	0.12385D-01	0.46538D-02	33	RX	MG	O
-0.33100D-01	-0.60044D-02	0.96652D-04	-0.14653D-03	0.33100D-01	0.60045D-02	33	RX	MG	V
-0.27474D-01	-0.75653D-02	0.21839D-01	0.30997D-02	0.27493D-01	0.76023D-02	33	RY	MG	O
0.	0.	0.40332D-02	-0.62006D-02	-0.38625D-05	0.67243D-05	33	RY	MG	V
-0.29527D-02	-0.38640D-02	-0.86110D-02	0.10242D-01	0.29721D-02	0.38571D-02	33	RZ	MG	O
0.30973D 01	0.40329D 00	-0.77868D-04	0.33432D-03	0.30973D 01	0.40329D 00	33	RZ	MG	V
-0.18960D 00	-0.24322D 00	-0.42522D 00	0.65827D 00	0.19069D 00	0.24250D 00	33	TX	MG	O
0.	0.	-0.77380D 00	0.86463D 00	0.63273D-03	-0.10071D-02	33	TX	MG	V
-0.21294D-12	-0.58601D-13	-0.24928D-05	-0.17449D-06	-0.18235D-08	-0.42269D-08	33	TY	MG	O
0.86736D-15	0.21684D-15	0.99541D-05	-0.11940D-04	-0.92390D-08	0.12955D-07	33	TY	MG	V
-0.70011D 00	-0.19281D 00	0.55703D 00	0.79224D-01	0.70060D 00	0.19376D 00	33	TZ	MG	O
0.	0.	0.99547D-05	-0.11941D-04	-0.92395D-08	0.12955D-07	33	TZ	MG	V
-0.28475D 00	-0.36535D 00	-0.24928D-06	-0.17448D-07	0.28475D 00	0.36535D 00	33	VE	MG	O
0.	0.	0.99541D-06	-0.11940D-05	-0.92390D-09	0.12955D-08	33	VE	MG	V
-0.54210D-17	-0.20329D-16	-0.12164D 01	0.14057D 01	0.21878D-02	-0.20661D-02	34	VL	TD	O
0.10842D-16	0.	-0.16972D 01	0.19004D 01	0.14233D-02	-0.22119D-02	34	VL	TD	V
-0.10842D-14	-0.13553D-14	-0.16365D 00	0.45352D 00	0.79045D-03	-0.30750D-03	35	RX	QP	O
-0.29236D-01	-0.35656D-02	0.95628D-03	-0.16083D-02	0.29235D-01	0.35669D-02	35	RX	QP	V
0.31396D-01	0.75488D-02	-0.36885D-04	0.15887D-03	0.31397D-01	0.75488D-02	35	RY	QP	O
0.	0.	0.50520D 00	-0.91134D 00	-0.90002D-03	0.64272D-03	35	RY	QP	V
-0.12234D 00	-0.14781D-01	-0.14114D-03	0.59323D-03	0.12234D 00	0.14781D-01	35	RZ	QP	O
0.15538D 00	0.24787D-01	0.40179D-02	-0.67664D-02	0.15537D 00	0.24792D-01	35	RZ	QP	V
-0.26186D 01	-0.31737D 00	-0.88818D-11	-0.20983D-10	0.26186D 01	0.31737D 00	35	TX	QP	O
0.	0.	-0.26645D-11	0.81046D-11	0.86736D-14	-0.34694D-14	35	TX	QP	V
0.	0.	0.22871D-10	0.20872D-10	0.55511D-13	0.39031D-13	35	TY	QP	O
0.88156D 01	0.14054D 01	-0.55955D-10	0.57288D-10	0.88156D 01	0.14054D 01	35	TY	QP	V
0.	-0.54210D-16	0.43495D 01	-0.11660D 02	-0.21060D-01	0.73705D-02	35	TZ	QP	O
0.	0.	0.16583D 02	-0.32606D 02	-0.31999D-01	0.21551D-01	35	TZ	QP	V
0.	0.	-0.15452D 01	0.66019D 01	0.12907D-01	-0.26258D-02	35	VE	QP	O
0.	0.	0.39383D 02	-0.63671D 02	-0.33929D-01	0.49650D-01	35	VE	QP	V

-0.54210D-17	-0.54210D-17	-0.54341D 01	0.12865D 02	0.24912D-01	-0.92873D-02	36	VL	TD	O
0.10842D-16	0.	-0.17422D 02	0.33525D 02	0.40186D-01	-0.23019D-01	36	VL	TD	V
0.10842D-14	-0.17618D-14	0.18947D 00	-0.47497D 00	-0.83120D-03	0.34147D-03	37	RX	QP	O
0.46663D-01	0.59380D-02	-0.36967D-03	0.56893D-03	0.46664D-01	0.59375D-02	37	RX	QP	V
-0.20601D-01	-0.55429D-02	0.19389D-03	-0.59235D-03	0.20600D-01	0.55433D-02	37	RY	QP	O
0.	0.10842D-14	-0.48950D 00	0.87961D 00	0.88390D-03	-0.60878D-03	37	RY	QP	V
0.15003D 00	-0.24465D-01	0.82086D-03	-0.25204D-02	0.15002D 00	0.24467D-01	37	RZ	QP	O
-0.18353D 00	-0.31314D-01	-0.14025D-02	0.21490D-02	0.18353D 00	0.31312D-01	37	RZ	QP	V
0.52485D 01	0.85726D 00	0.11102D-11	-0.88018D-12	0.52485D 01	0.85726D 00	37	TX	QP	O
0.	0.10842D-15	-0.64393D-11	0.67724D-11	0.43368D-14	-0.82399D-14	37	TX	QP	V
0.	-0.40658D-16	0.10325D-10	0.18208D-10	0.42501D-13	0.17347D-13	37	TY	QP	O
-0.59743D 01	-0.10188D 01	-0.12879D-10	0.14766D-10	0.59743D 01	0.10188D 01	37	TY	QP	V
0.	-0.40658D-16	-0.55663D 01	0.12039D 02	0.21435D-01	-0.94459D-02	37	TZ	QP	O
0.	0.10842D-15	-0.18134D 02	0.33334D 02	0.33215D-01	-0.23637D-01	37	TZ	QP	V
0.	-0.81315D-17	0.75089D 01	-0.22733D 02	-0.36813D-01	0.12598D-01	37	VE	QP	O
0.	-0.10842D-16	-0.15255D 02	0.23825D 02	0.25642D-01	-0.20116D-01	37	VE	QP	V
-0.54210D-17	-0.67763D-17	0.16461D-01	0.99462D 00	0.20416D-02	0.27912D-04	38	VL	TD	O
0.54210D-17	0.	-0.44409D-12	0.10000D 01	0.13582D-02	-0.56379D-15	38	VL	TD	V
0.29294D-03	0.16408D-03	-0.31678D-04	0.25288D-04	0.29292D-03	0.16408D-03	39	RX	MG	O
0.50994D-03	-0.21493D-03	-0.31582D-06	0.22717D-06	0.50994D-03	0.21493D-03	39	RX	MG	V
0.47941D-03	-0.34523D-05	0.59679D-04	-0.53763D-04	0.47933D-03	0.35535D-05	39	RY	MG	O
0.10842D-14	-0.10842D-14	-0.12879D-09	0.96004D-05	0.13013D-07	-0.16914D-12	39	RY	MG	V
0.23692D-04	0.16113D-04	-0.11276D-03	0.24766D-03	0.23697D-04	0.16114D-04	39	RZ	MG	O
0.92947D-01	0.65456D-01	-0.48668D-07	-0.16104D-06	0.92947D-01	0.65456D-01	39	RZ	MG	V
0.67428D-02	0.47318D-02	0.80939D-03	0.65324D-01	0.68764D-02	0.47331D-02	39	TX	MG	O
0.10842D-15	0.	-0.57732D-11	0.65438D-01	0.88697D-04	-0.73726D-14	39	TX	MG	V
-0.54210D-16	-0.81315D-16	-0.71038D-07	0.31684D-07	0.22742D-10	-0.12045D-09	39	TY	MG	O
0.16263D-15	0.	-0.91038D-11	0.21370D-07	0.28960D-10	-0.11709D-13	39	TY	MG	V
0.65077D-01	-0.46614D-03	0.81765D-02	-0.73399D-02	0.65067D-01	0.48001D-03	39	TZ	MG	O
0.	0.	-0.64393D-11	0.21360D-07	0.28947D-10	-0.82399D-14	39	TZ	MG	V
0.92768D-01	0.65101D-01	-0.71040D-08	0.31681D-08	0.92768D-01	0.65101D-01	39	VE	MG	O
0.10842D-16	0.	-0.68834D-12	0.21369D-08	0.28960D-11	-0.86736D-15	39	VE	MG	V
0.	-0.94868D-17	0.82797D-02	0.10019D 01	0.20519D-02	0.14039D-04	40	VL	TD	O
0.16263D-16	0.	-0.22204D-12	0.10000D 01	0.13582D-02	-0.26021D-15	40	VL	TD	V
0.29227D-03	0.16370D-03	-0.32200D-04	0.11561D-04	0.29231D-03	0.16369D-03	41	RX	MG	O
0.51031D-03	-0.21499D-03	-0.31654D-06	-0.18162D-06	0.51031D-03	0.21499D-03	41	RX	MG	V
0.48155D-03	-0.11497D-05	0.60200D-04	0.14137D-04	0.48162D-03	0.12518D-05	41	RY	MG	O
0.17618D-14	-0.10842D-14	-0.13323D-09	-0.60518D-05	-0.82028D-08	-0.17347D-12	41	RY	MG	V
0.89383D-05	0.20602D-04	-0.11246D-03	0.24758D-03	0.96137D-05	0.20602D-04	41	RZ	MG	O
0.29454D-01	0.65452D-01	0.63183D-06	-0.67967D-06	0.29454D-01	0.65452D-01	41	RZ	MG	V
0.21400D-02	0.47537D-02	0.27082D-03	0.65501D-01	0.22737D-02	0.47542D-02	41	TX	MG	O
0.12875D-15	0.	-0.64393D-11	0.65438D-01	0.88697D-04	-0.82399D-14	41	TX	MG	V
0.	-0.10842D-15	-0.71462D-07	-0.82887D-08	-0.58978D-10	-0.12117D-09	41	TY	MG	O
0.14908D-15	0.	-0.77716D-11	-0.18513D-07	-0.25098D-10	-0.99747D-14	41	TY	MG	V
0.65368D-01	-0.15562D-03	0.82749D-02	0.19228D-02	0.65377D-01	0.16965D-03	41	TZ	MG	O
0.81315D-16	0.	-0.53291D-11	-0.18522D-07	-0.25109D-10	-0.65052D-14	41	TZ	MG	V
0.29442D-01	0.65403D-01	-0.71466D-08	-0.82940D-09	0.29442D-01	0.65403D-01	41	VE	MG	O
0.74539D-17	0.	-0.68834D-12	-0.18513D-08	-0.25097D-11	-0.86736D-15	41	VE	MG	V

END-OF-DATA ENCOUNTERED ON SYSTEM INPUT FILE.