connected with the rate of this escape has been the reason for not pursuing this particular design any further. It is by no means clear, however, that such a design could not be successful.

In later sessions a more detailed discussion will be given of the several designs. Here I should like to mention a few general difficulties and to discuss the way and extent to which these difficulties have been overcome.

SINGLE PARTICLE CONFINEMENT

One may consider the plasma from the point of view of the individual charged particles in a fixed field. The first and simplest question is whether or not a field of magnetic lines can retain ions on their orbits for a sufficiently long time. Since the ions slowly drift in a direction perpendicular to the magnetic lines of force and to the gradient of these magnetic lines, it is not clear that an effective confinement is actually possible. In a simple torus with longitudinal magnetic field, the charged particles spiral around closed magnetic lines of force. The inhomogeneity of the field causes them to wander off steadily to the walls.

In the stellarator the lines get twisted, with the result that a line no longer closes but instead returns, after a circuit, into the neighborhood of its starting point. If many circuits are executed, a single magnetic line will have closely covered a toroidal surface. Now an ionized particle in following this more complicated line of force will be subject to displacements due to the inhomogeneity of the magnetic field. One can show, however, that these displacements will average to zero in good approximation.

In the mirror machine an ion spiraling around a magnetic line of force performs a quasi-periodic motion due to oscillations between reflecting points. The periodicity of the orbit is not strict because it drifts to neighboring lines of force, as has been mentioned above. In a cylindrically symmetric case it is evident that the drift perpendicular to the line of force will map out a suface of cylindrical symmetry. But it is not evident where the particles will drift if there exists a nonsymmetric perturbation. The following consideration shows, however, that despite such a perturbation the particles do return to their original line of force with a high degree of precision.

During the periodic motion in a static magnetic field, the energy will be strictly conserved. Two "adiabatic invariants" are also very accurately preserved, even through they vary to a small extent. These are the magnetic moment of the spiraling particle in a direction along the magnetic line and the action $\int p_{\parallel} dq$. Here $p_{\parallel}$ is the momentum of the ion (or the electron) along the magnetic line of force and dq is an element along the magnetic line on which the guiding center of the spiraling particle happens to move. The essential character of the orbit of a particle is determined if its energy and magnetic moment are known. From this the action $\int p_{\parallel} dq$ follows uniquely. If now the particle were to shift to an arbitrary neighboring line of force, conserving its energy and magnetic moment, the action $\int p_{\parallel} dq$ would in general be different. However, the action $\int p_{\parallel} dq$ must be conserved also. Therefore, a shift is not possible to an arbitrary neighboring line, but the guiding center of the particle must remain on a sheet consisting of a single continuous set of

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