A METHOD FOR INJECTION INTO BETATRON PHASE SPACE

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The standard technique for injection into storage rings involves radial displacement of the beam from the injector by a radiofrequency signal. A limit is reached when the synchrotron phase space is filled and at this time the stacked beam will have an appreciable energy spread which may be as high as 2 or 3%. For some storage-ring experiments this is undesirably high and it might be preferable to use injection techniques that involve filling betatron phase space and that result in no increase in energy spread. This, of course, is the method already used in the multiturn injectors of the Cosmotron and the Bevatron. This paper describes another possible method depending on the simultaneous existence of two equilibrium orbits in the same magnet structure.

The method is illustrated by Fig. 1, which represents a cross section through a bending magnet of a separated-function storage ring. In this

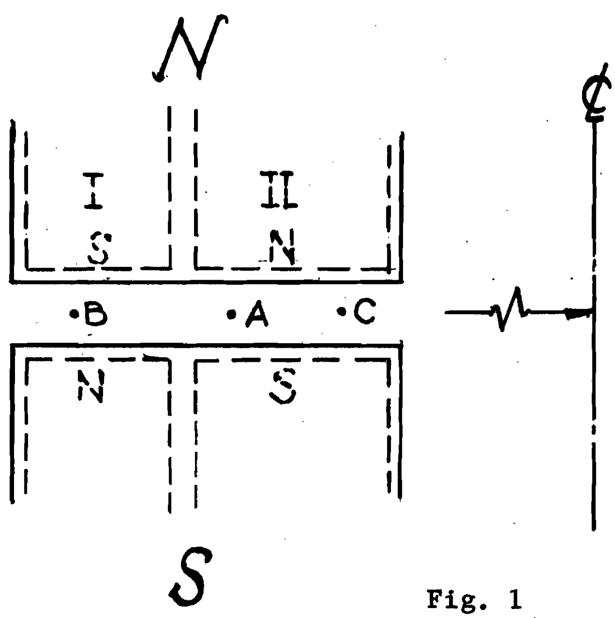

Fig. 1

magnet the equilibrium orbit is at A. Azimuthally displaced from this magnet is a split magnet whose cross section is indicated by dotted lines. The section labelled I weakens the field in the outer region and the section labelled II strengthens the field in the inner part of the magnet. When magnets I and II are turned on to suitable strengths, new equilibrium orbits exist at B and C. Now injection is carried on through the following steps:

a) Magnet I is turned on and a beam is injected on orbit B.

b) Magnet I is turned off and the beam moves to A.

c) Magnet II is turned on and the orbit moves to C.

d) Magnet I is turned on and beam is again injected on orbit B.

e) Magnets I and II are slowly turned off and the beams at B and C coalesce at A.

f) Magnet II is turned on and the beams move to C.

g) Magnet I is turned on and more beam is injected at B, and so forth.

Of course this scheme cannot violate Liouville's theorem and as the stacking process proceeds the maximum betatron-oscillation amplitude will build up. The optimum filling of betatron phase space will probably involve changes in the rates of manipulation of the magnetic fields as a large stack collects at orbit C.

It appears to be possible, in principle, to maintain two equilibrium orbits vertically displaced from one another. The magnet structure necessary to achieve this is, however, rather cumbersome and impractical.

The number of turns that can be injected by this method will have a maximum value given by the ratio:

$$\frac{\text{(Vertical acceptance area)(Horizontal acceptance area)}}{\text{(Vertical beam emittance)(Horizontal beam emittance)}}$$

For a final beam area 6 cm × 1 cm a structure like the AGS has acceptance areas of 19.3 and 0.54 cm-mrad. The emittance area for the AGS beam (6 mm in diameter) is 0.19 cm-mrad in both planes. Hence, in a 1 × 1 cm area we can inject a maximum of

$$\frac{19.3 \times 0.54}{(0.19)^2} = 290 \text{ turns} .$$

If the phase space is not filled with maximum efficiency, the number of turns that can be accepted in this area will be less than 290.

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