THE ARGONNE 12.5 GEV PROTON SYNCHROTRON

E. A. CROSBIE. M. I. FERENTZ, M. H. FOSS, M. H. HAMERMESH,
J. J. LIVINGOOD, J. H. MARTIN, L. C. TENG

Argonne National Laboratory, Lemont (Ill.)

(presented by J. J. Livingood)

The proton synchrotron now being designed at Argonne National Laboratory under authorization of the U.S.A.E.C. will employ a pulsed ring magnet of eight sectors with zero radial field gradient, vertical stability being obtained from wedge focusing action at the magnets' ends. Symmetry of the magnetic field will be aided by a magnet of "window frame" cross-section, without poles, the windings being placed at the outside and inside edges of the vacuum chamber.

This structure is appealing since it is reasonable to expect that significantly higher final fields can be obtained than in conventional designs. Although some reduction in the width of the zero gradient region is to be expected at high fields, adiabatic damping will reduce the width of the beam envelope to a sufficiently small value to fit within the good field region. Model magnets are under construction to establish the maximum field at which this condition will hold.

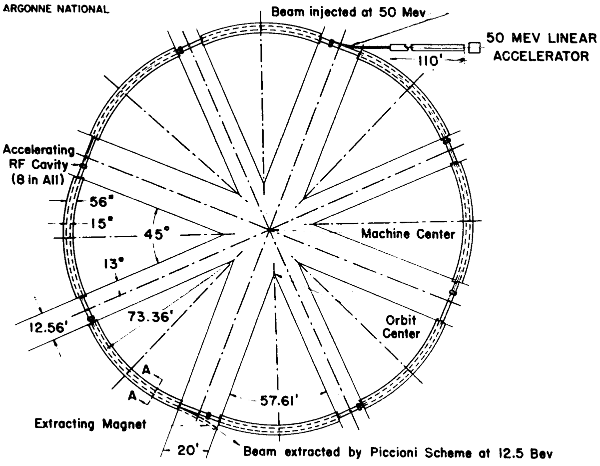

Fig. 1. Plan view of the Argonne 12.5 Bev zero gradient proton synchrotron.

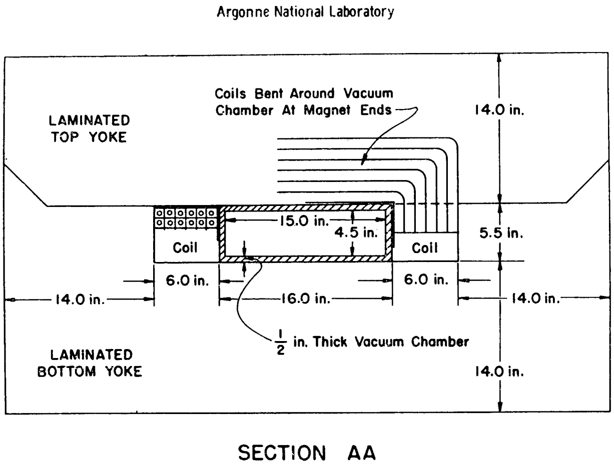

Fig. 2. Cross-section of the magnet.

Injection from a 50 Mev linear accelerator has been chosen in order to bring gas scattering losses to what appears to be a reasonable amount, as computed from existing theories, incomplete as they are. This injection energy also keeps the R.F. frequency range within the manageable limits of 3.2 to 1, and permits a large injected charge before the space charge limit is reached.

Such a weak focusing, low momentum content magnet offers the possibility of multi-turn injection and a greater possibility for beam extraction by the Piccioni method than appears feasible with A.G. magnets.

Injection will occur above the median plane from the outside edge of the vacuum chamber; the chosen values of the radial and vertical betatron oscillations per revolution, $\nu_x = .75$ and $\nu_z = .875$, ideally will cause the beam to miss the end of the inflector for 8 turns, during which time the rising magnetic field will shrink the orbits away from the inflector. Injection will continue for 100 turns; approximate calculations indicate that perhaps $^1/_5$ of the total of injected ions will miss the inflector and about $^1/_2$ of these will be captured in phase stable orbits. The assumed quality of the beam from the linear accelerator has been taken as ± 0.4 inch milliradian, (half angle, half dimension) and the chamber's inside dimensions of 4.5 by 15 inches have been fixed with due regard to betatron and synchrotron oscillation amplitudes.

The rate of rise of field will be low during injection and increased thereafter, to give a total acceleration time of 1 second; the possibility of using a saturable inductance in series with the magnet to effect this schedule is being studied. The initial acceleration will be 1.7 Kev/turn, with an average value throughout the acceleration of 8 Kev/turn. Eight, low Q, ferrite-tunned accelerating cavities are planned, at present, operating on the 8th harmonic of the revolution frequency.

Important parameters of the machine are listed in table I.

A plan view of the proton synchrotron is shown in fig. 1; a cross-section of the magnet in fig. 2.

TABLE I

Parameters

Magnet	
Weight of Iron	1500 tons
Weight of Coils	50 tons
Average Power	3 MW
Peak Power Input	40 MW
Energy Storage System	Flywheel
Radius of orbit	2230 cm.
Mean Radius	2865 cm.
No. of Straight Sectors	8
Pole Tip Width	41 cm.
Gap Height	14 cm.
Useful Width of gap	38 cm.
Useful Height of gap	11 cm.
Magnetic field at injection	463 gauss
Magnetic field at ejection	20 K gauss
Rise time of field	1 sec.
Rate of rise of field	
at injection	3.8 K gauss/sec
average	20 K gauss/sec

Pulse repetition frequency	15 a minute
Type of focusing	Zero gradient, wedge
Injection System	
Type of pre-accelerator	Linac
Energy of pre-accelerator	50 Mev
Proton Current Output	5 mA
Type of Inflection System	Electrostatic
R.F. System	
Harmonic number	8
No. of accelerating cavities	8
Max. R.F. Power per cavity	7 KW
Peak R.F. Volts per cavity	2 KV
Frequency Range	4.2 to 13.3 Mc/s
Beam Data	
Max. Energy of protons	12.5 Gev
Proton Intensity Accepted	5×10^{11} per pulse