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INFLECTOR SYSTEMS FOR NINA

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February, 1964.

INFLECTION SYSTEMS FOR NINA

In order to inject the electrons along the correct closed orbit path, it is necessary to change their transverse momentum the correct amount at the point of injection. This change of trans erse momentum will be made by the application of a pulsed axial magnetic field. The alternative use of a transverse electrostatic field would require unacceptably high field strengths. The magnetic field must be constant during the time it takes an electron to make one orbit, and then fall, in as short a time as possible, to a negligible level, so as not to perturb the subsequent orbits.

Both C.E.A. and D.E.S.Y. obtain the required magnetic field by circulating a current round a multi-turn loop. The rapid fall in field at the end of the injection period is obtained by effectively short-circuiting the loop, by means of a hydrogen thyratron, through a damping resistor.

With the magnet configuration used for NINA, there are two positions where the inflection could take place, in a long straight or in a short straight. The original design, Fig. 1, called for inflection in a long straight, and this requires an inflection angle of at least 5° if the injection path is to avoid passing through the fringe field of the preceeding magnet where it causes excessive defocussing in the horizontal plane. The large angle requires a high magnetic field in the inflector.

The main difficulty with this system lies not with the high magnetic field, but with the close tolerance on this field, and the low value to which it must fall.

It is planned to accelerate positrons in the synchrotron, and in order to obtain a reasonable positron current, it will be necessary to use the full aperture of the magnet system. Therefore, since a perturbation causing even 1 milliradian deflection of the orbit would lead to a loss of over 10% of the particles, the magnetic field in the inflector must be constant and uniform to better than 1% during the injection period, 0.7 μs, and must become, and remain, less than 1% of its maximum amplitude in a small fraction of a microsecond.

In order to try to overcome the necessity for such a tight tolerance on the pulse shape, the possibility of inflecting in a short straight is being investigated. In such a system, the injected beam would still enter the magnet system in the long straight, but at a smaller angle to the central orbit, and would pass through the fringe field of a D-magnet, before reaching the inflector in the short straight following. Fig. 2. In this case the inflection angle could be as small as 20 milliradians, so that the tolerances on pulse flatness and remenant effect could be relaxed by a factor of five. However, the free length available in a short straight is only about 25 cm, and it may be difficult to obtain a sufficiently uniform magnetic field from an inflector in which the aperture is of the same order as the length. Other problems, due to the defocussing effect of the D-magnet, are being investigated.

It can be seen that there are difficulties with either scheme, and a decision has not yet been made as to which shall be used. The first scheme is preferable if the necessary tolerances on the pulse shape can be achieved, and so an investigation into this is proposed. For the purpose of this investigation, a tentative design for the inflector is required.

A design similar to that used at C.E.A. or D.E.S.Y. is not practicable, since a larger deflection angle and a larger aperture are required, and the injection energy will be higher. The scale-up necessary would result in an unacceptable increase in the time constant.

The proposed design uses a strip transmission line along which a suitably shaped pulse is passed. The transmission line has a matched termination and is loaded with shunt capacitance to reduce its surge impedance. A ferrite frame round the transmission line is used to improve the uniformity of the field, and reduce the current required. The following parameters apply:-

Maximum beam width at inflector	10 cm
Maximum beam height at inflector	6 cm
Deflection angle	0.1 radian
Length of Inflector	1 m.
Magnetic field needed (for ~~60~~ 75 MeV Positrons)	~~200~~ 250 gauss.

Thus the minimum aperture in the ferrite is 15 cm x 6 cm.

If it is assumed that the return path in the ferrite is equivalent to 1 cm of air, the current needed for ~~200~~ 250 gauss

$$I = \frac{0.025 \times 0.07}{4\pi \times 10^{-7}} = 1350 \text{ A.}$$

The inductance of the transmission line is approximately

$$4\pi \times 10^{-7} \times \frac{15}{6} = 3.1 \times 10^{-6} \text{ H/m.}$$

The orbital period is 0.735 μs and the inflector switch-off time should be short compared with this, say 0.1μs. The transit time of the transmission line should not be greater than about half this. Assume τ = 50 ns/m

$$\text{From this, } Z_o = \frac{3.1 \times 10^{-6}}{50 \times 10^{-9}} = 62 \text{ ohms.}$$

If it proves impracticable to produce the pulse waveform to the required tolerance, it may be possible to use the short inflector, the scheme shown in Fig.2. The angle of deflection would be 20 milliradian, and the length of inflector 20 cm, so the magnetic field would need to be the same as above - 290 gauss. The width of the aperture could be reduced to 11 cm, giving an inductance of about 2.3×10^{-6} H/m. Keeping the same velocity of propagation, the surge impedance would be 11.5 ohms, so that a pulse voltage of 15.5 kV, and a capacitive loading of 174 p F/cm would be required.

The pulse requirement would then be modified to 1350 A at 15.5 kV, constant to better than 5% during the last 0.7 µs of the pulse, falling to less than 67 A in about 0.05 µs.

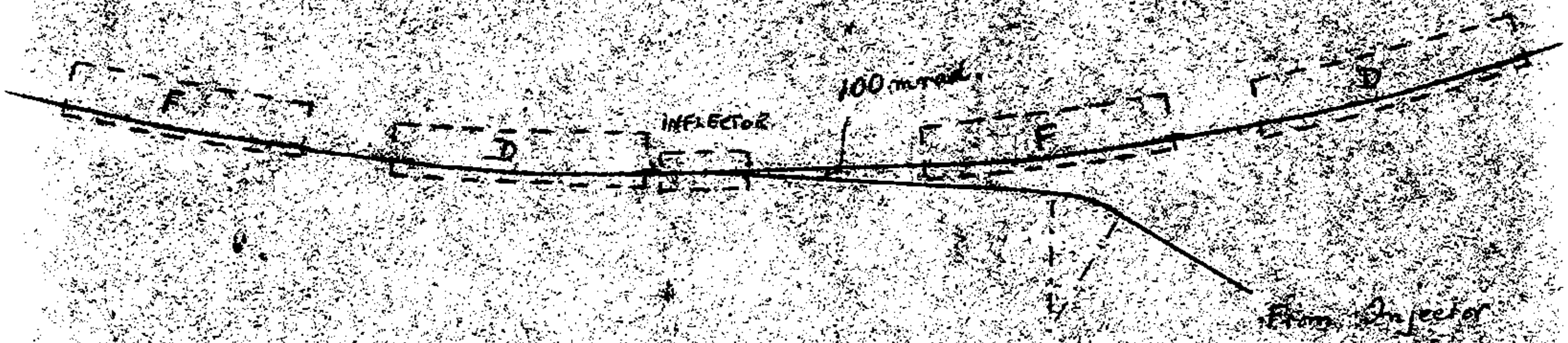
F
D
INFLECTOR
100 mrad.
F
D
From Injector

Fig 1


INFLECTOR
F
D
20 mrad.
F
D
From Injector.

Fig 2.