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A SYNCHROTRON WITH A DOUBLE VACUUM CHAMBER

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1. The Harwell group [1] has studied the possibility of making a double synchrotron in which the magnet has two different apertures. The first aperture is larger, and in it the particles are only accelerated to low energy. The particles are then made to pass into a second aperture, which is adjacent and concentric and smaller, and they are here accelerated to full energy.

As pointed out by T.G. Pickavance, we also proposed a similar type of machine in a note to Nuovo Cimento [2], and the reason of my discussion paper is to refer on some further study we made on the subject. In fig. 1 are reported the schematic cross sections of two of the possible alternatives we considered in our note [3]. The possible distribution of the current conductors is indicated in the same note. With this distribution we should create a magnetic field with a constant and proper n-value in both the apertures A, B and in the region between the two gaps.

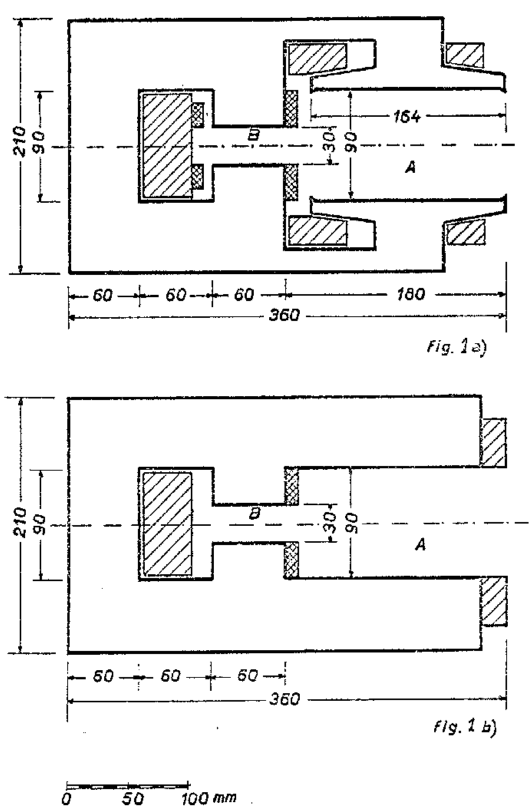

FIG. 1

The numerical dimensions of fig. 1 are only an example, and refer to an electron synchrotron of 1000 Mev.

2. The main problem in a nuclear machine of the type described here is associated with the field matching at cross-over from the aperture A to the aperture B, and the corresponding acceleration programme. We made a first exploration of the cross-over problem by measuring the magnetic field in an iron model excited by d.c. current, whose section is given in fig. 2. This is a convenient variant of the proposal of fig 1*b*). The model was of cast iron and the purpose of the measurements was to check if it was possible to obtain a uniform magnetic field along the median plane m — m′, by providing a convenient set of currents in the coil II. Of course the problem is immediately resolvable in theory, by disposing a thin sheet of currents of uniform density from M to N. In practice the currents in coil II have to be rather large, and we had to check if the right magnetic field could be obtained even with thick coils which are necessarily far from the iron.

The disposition of the current turns was as follows:

Coil I : 24 turns, antiparallel to the turns of the coils II, III.

Coil II : 16 turns.

Coil III : 8 turns.

All these turns were in series. Around coil II there was a layer of 11 correcting coils, whose reason was to correct the field in the transition region from A to B. These correcting coils are indicated by dots in fig. 2. We realized a field of 500 gauss in the gap A, with the direct current in coils I, II, III. We adjusted by successive approximations the currents in the 11 correcting coils in order to get the best uniformity in the region m — m′.

The result was encouraging, for we observed that it was easy to control the shape of the field, by choosing only 3 different values of the currents in the correcting coils around coil II. It was possible to realize a uniform magnetic

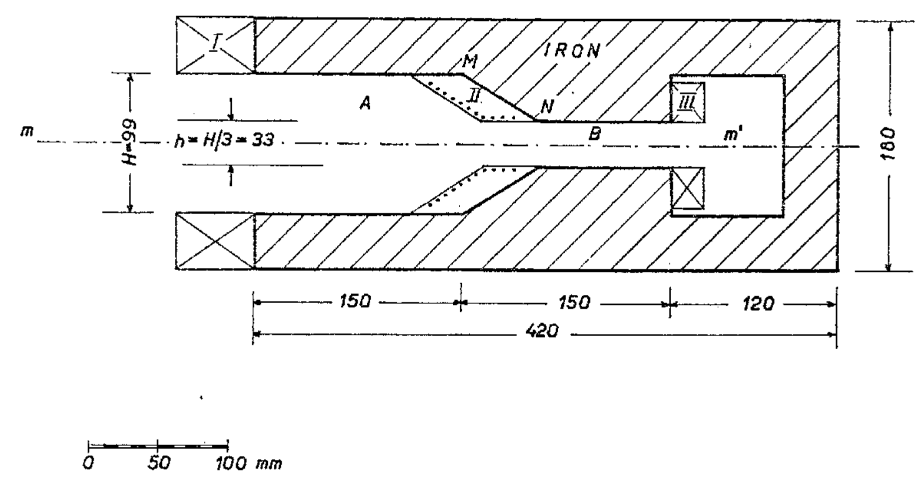

FIG. 2

field in m — m′ (see fig. 2) inside the limits of the fluxmeter (Pye Scalamp, precision 1 %), and the general conclusion was that the final limit to the precision of the field in the region between A and B is mainly or only given by the precise control of the currents in coils I, II, III and in the correcting coils[3]. The problem of realizing with the due precision the real a.c. excitation may be hard, and has not been completely examined as yet.

3. In the near future we will measure with our Dike fluxmeter the n-value of the field not only along m — m′, but also outside of the median plane. The following observation may throw some light on this point.

In the course of our project of an electron synchrotron of 1000 Mev with a constant gradient, we have studied the possibility of enlarging the field at injection by use of coils (enlarging coils) placed near the corners of the polar faces. This study is reported in one section of this Symposium[4]. The problem was studied in detail and for the case of many currents with the electronic computer of the University of Rome, but at the end the result was quite simple, as indicated in fig. 1 of the quoted report [4].

In fact it has been computed and experimentally verified that with one current in I_1, plus two small currents in i_6, i_8 (see fig. 1 of the quoted report[4]), it is possible to compensate the end effect of the poles on the magnetic field, and enlarge the region of space where n has the right value, not only along the median plane but also outside. The result is also shown in fig. 4 of the quoted report[4].

This result, which was actually obtained for different purposes than the study of the double synchrotron, is in our opinion a definite indication that it is possible with a few coils in the right position to control the magnetic field between the two chambers and make the cross over possible.

In our opinion the transition from one aperture to the other should happen in many turns, while the RF is properly frequency modulated.*

4. Finally, I would like to emphasize the following point, which probably may give some confidence in such a machine; the cross over would happen when the induction field B has an "ideal" intensity : under these conditions the effects of the eddy currents and of the remanence may be disregarded, the iron poles are real equipotentials, and all the problems of the cross over may be well defined and foreseen.

LIST OF REFERENCES

1. Dunn, P. D. et al. Accelerator studies at A.E.R.E. Harwell. See p. 9.
2. Salvini, G. Proposal of a synchrotron with a double vacuum chamber. Nuov. Cim., *11*, p. 555-8, 1954.
3. Sanna, G. Thesis : University of Pisa. 1954.
4. Salvini, G. and Sanna, G. On the use of electric currents to increase the radial extent of the focusing region in the INFN electron synchrotron. See p. 458.

* I am indebted to Dr. M. Sands for a discussion on this point.