INTRODUCTORY COMMENTS

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The topic for this session clearly implies that the required field configuration has been established. Of course, in practice, there must be some give and take between what the theorist would like and what is reasonable to expect from an iron magnet. Consequently, there must be some overlap in solving the problems of this session and those of the previous session. In fact, most of the main variables of cyclotron design are closely coupled with each other and many compromises are required.

If we start the work of this session by getting a magnet to work with, we need some magnet specifications. Some of the points to consider when specifying a magnet are the following. The minimum gap must be determined which, in turn, requires a choice of dee aperture, dee structure, pole liner thickness, poleface windings, and perhaps a few other things. The maximum field, averaged azimuthally, must be chosen; this requires an analysis of cost, saturation effects, and required flutter. The maximum radius of the pole is needed. Then there is the question of optimizing, on a cost basis, the ratio of return path area in the yoke to the poleface area, the main coil dimensions and location, and the coil current density. The choice must be made of how many ridges to have. Perhaps it is an overstatement to say that we are all agreed on either 3 or 4, but in the energy range most of us are talking about 3 or 4 would seem a good choice.

I don't propose to go into these details but merely to point out that they must be settled before either a full-size magnet or a scale model can be built to use in developing the required magnetic field shape.

On the question of whether to build a model magnet or not, there are a number of rather difficult things to assess. If your requirements for the magnetic field are particularly difficult, then you probably will want a model. If the requirements are not difficult, then it may turn out that you would rather work with the full-scale magnet. This brings up the question of the time scale that you are working on and also the relative cost. If you are clever enough, you can get the proper iron, poleface windings, etc., with a few trials on a full-size magnet, and this might be cheaper than going through the model stage.

Let's assume that these particular points have been settled. Then comes the main problem of this session, which is how to design the iron shape on the pole pieces to get the desired field. There are, as has been mentioned previously, two approaches to this. One is to take the theoretical value for the field shape and try to reach this with an iron shape; the other is to take what looks like an easy iron shape to produce and then see whether this will give a field that is suitable. Of course, there are all grades of compromise between these approaches. Probably the best is somewhere between the two. In deciding what the first iron shape should be, one can either use approximate calculations (for which the P. F. Smith report is very useful, and the Stahelin report has similar information) or one can try to do a very detailed calculation by using a machine code or a nearly exact analytical expression.

Having, by some means, arrived at an iron shape, the next thing that is required is to measure the field produced by this shape. In measuring this field there are several points to keep in mind. There is the accuracy required, which is colored somewhat by the faith you place in poleface windings and whether you plan to have only circular poleface windings or also flutter-correction windings. You may decide that for the iron alone 1 or 2% accuracy is adequate on the radial profile, averaged azimuthally, and that you will make any further corrections with poleface windings. You might feel a little safer, actually, to put the coils on the model and see if the isochronous condition is within the range of the coils. This is again something that would depend upon the particular case.

To measure the magnetic field the use of rotating coils, search coils, bismuth wire, or Hall plates is usual; each has strong advocates. The choice probably depends largely on the user's past experience with them. The positioning gear is equally important and involves a choice of grid size and grid type; probably a polar grid is preferable. The type of data read-out varies; some use punched cards, some read meters, and some use a chart recorder. Here the choice depends largely on available equipment.

The analysis of the data can be done either approximately or as accurately as desired. For the first go-around a very approximate analysis of the data will probably show that the field is not near enough to the desired field to warrant spending much time on accurate calculations, at least as far as the axial focusing and the isochronous condition are concerned. Finally, after you get this information, what do you do to the magnet to get closer than you were the first time?

If I seem to be reaising questions rather than answering them, it is deliberate. I have been trying to point out the main problems and points of interest. Perhaps in some small measure this will help you assess the state of the art as the various speakers present their work.

There are eight speakers scheduled for this session. I have tried to correlate their order of speaking with the type of machine to be discussed. The first two speakers, Allen and Snowden, will report on the conversion of existing machines, a low energy cyclotron and a high energy cyclotron. The next two speakers, Hudson and Dols, will talk about new machines of medium energy. Two of the remaining four speakers, Howe and Wright, will describe work on medium energy machines with very small minimum magnet gaps. Blosser will consider the problem of choosing the proper current values for poleface coils. The last speaker, Lafferty, will describe a novel and interesting electron model using poles with protruding iron rods to achieve the desired field shape.