SESSION II. REALIZATION OF REQUIRED FIELD CONFIGURATIONS AND MAGNET MODEL WORK

E. L. Kelly, Chairman

SUMMARY

The work reported in this session is very encouraging. There seem to be rather few problems for which some solution has not been worked out. The diversity of the solutions indicates considerable freedom in the choice of performance specifications and magnet gap geometry. Theoretical analysis of field maps from full-scale and model magnets shows that satisfactory beam dynamics can be achieved with both three- and four-sector contours. The measured amplitudes of the unwanted field harmonics are small and indications are they will not be troublesome. The work at Harwell shows a proton energy of close to 200 Mev can probably be achieved on a four-sector fixed-frequency machine. For higher energy one can use a larger number of sectors as worked out by the Oak Ridge group, or one can use frequency modulation during the latter part of the acceleration cycle as the Harwell group plan to do. The use of frequency modulation results, of course, in considerably reduced beam intensity.

The variable-energy feature greatly complicates the problem of selecting a suitable iron configuration. It should be realized, however, that much of this difficulty would also exist in a conventional cyclotron if it had the variable-energy feature. It seems apparent from the results presented that the difficulties caused by variable saturation as the central field varies can be largely overcome by judicious choice of the surface contour and subsurface voids. One needs to contour the iron surface so that it approaches the magnetic equipotential at the highest field value; then at low fields where the iron surface is actually the equipotential surface the field shape will not be very different from that at high fields. The use of subsurface voids is really an effort to fight saturation with saturation. That is, to make the iron saturation approximately the same amount at all radii at any given field strength. Indications are that with a reasonable amount of model work one might hope to achieve a field that was within 1% of that required for isochronism throughout the entire range of central field variation.

It is apparent that a smaller gap makes it easier to get sufficient flutter. Two of the machines discussed took advantage of this by having minimum gaps of 1 to 1-1/2 inches. To have room for an accelerating system they chose four-fold symmetry and put in two dees, one in each of two opposing valleys. This is a very appealing system although it does restrict the amount of spiral angle one can use. It is also worth noting that one of these, the Hunter's Point machine, is expected to include the variable-energy feature with a maximum proton energy of 80 Mev. A more conventional approach is planned for the Oak Ridge machine. In this case the proton energy is also high (75 Mev), but the minimum gap will be large enough to accommodate the dee system. The spiral angle is not large, and the focusing will be obtained by very deep valleys which will contain powerful coils to enhance the flutter.

Another thing that was quite clear from this session was the enthusiastic approval of poleface windings by all those who had used them. This experience has been on conventional cyclotrons, but there is every reason to think the coils will

be even more useful on the spiral-ridge machines. For a variable-energy machine they seem to be indispensable, and even on a fixed-energy machine they allow a relaxed tolerance on the iron shape which should more than pay for their cost. There is the added safety feature that small changes in the permeability of the iron or errors in the field calculations can be taken care of with these coils. The problem of selecting the proper current values for these poleface windings is still not worked out, but several methods have been suggested for doing this on computing machines. Then, of course, one can always fall back on the knob twiddling method.

The type of measuring gear used seems to depend largely on personal taste; several very adequate types of sensing elements and positioning gear are now available. The positioning gear discussed by Snowden is particularly worthy of notice as it can be used with extremely small gaps.

One area is still uncertain and is likely to remain so until rather complete calculations have been done on beam extraction. It is possible, or even likely, that the shape of the field at and beyond the maximum equilibrium orbit will have a strong influence on beam extraction. If future calculations should indicate that major field changes are needed in this region, then our present field shapes would have to be modified.