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METHOD OF CHECKING ALIGNMENT AND REMOTE RE-ALIGNMENT OF THE TWO-MILE ACCELERATOR DURING NORMAL BEAM OPERATION

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It is recognized that the difficulty in obtaining initial alignment of the two-mile accelerator may be a much less serious question than the maintenance of alignment for prolonged periods in the presence of shifting supporting terrain at the accelerator site. A number of techniques[1] have been proposed to accomplish the initial alignment. These same techniques could, of course, be used for re-alignment when necessary but would require shutting down the machine with consequent loss of beam time. In this note, a method of re-alignment which can be effected without interference with normal operations is described.*

In this method it is first assumed that:

a) the accelerator has been accurately aligned over its entire length by suitable techniques prior to the start of beam operations;

b) a number of degaussing coils serving the simultaneous purpose of steering and degaussing are provided as recommended in Project M Report No. 249 (no steering coils or magnetic shielding material used).

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1. R. B. Neal, M-240; and R. C. Sandkuhle, Section III.J - Project M Source Book (in preparation).

*K. B. Mallory has proposed another method of remote alignment. In his method, two electron beams of different energies are passed through the accelerator. Transmission of both beams is possible only when the correct degaussing fields are established and then only when the accelerator is accurately aligned.

c) the earth's magnetic field is constant with time or its magnitude is monitored and suitable account of variations are taken during the re-alignment procedure described below.

The procedure is then as follows:

1. When the beam is first turned on (and while the accelerator is still "perfectly" aligned) the degaussing coils are adjusted to give maximum beam transmission through the accelerator making use of enroute beam monitors, transverse position indicators, and/or beam detectors in the target area. These degaussing currents would essentially establish zero resultant magnetic fields along the accelerator axis.
2. The magnitudes of the degaussing currents required to accomplish step 1 are recorded for future reference.
3. During subsequent operation of the accelerator, deviations of the optimized degaussing currents from the reference values provide indication of the magnitude, direction, and axial location of the misalignment of the accelerator axis.
4. Application of this method does not require that the earth's magnetic field remain constant in time. At the time of carrying out the re-alignment procedure, the earth's field can be precisely monitored, using well-known nuclear induction techniques, and the reference values of the degaussing currents multiplied by a factor equal to the ratio of the measured earth's field divided by the field which existed when the reference values were originally established.
5. The re-alignment procedure consists of transverse adjustment of the accelerator axis by means of remote control until the degaussing currents, which produce optimum beam transmission, correspond to the reference values (corrected as described in step 4 as necessary).
6. Parenthetically, it should be remarked that if the earth's field along the accelerator axis is sufficiently well mapped (including magnitude and dip angle) it should be possible to establish the reference degaussing currents

entirely by calculation and to carry out the accurate alignment procedure described in step 5 after only crude pre-alignment of the accelerator by other means.

Moreover, the fields along the accelerator axis might be monitored continuously by means of peaking strips or nuclear magnetic resonance techniques during beam operation. In this case, the reference values of degaussing currents could be automatically calculated and the deviations of the actual degaussing currents from the reference values used as information for re-alignment of the accelerator. This procedure would be required in place of the procedure described in step 4 only if there are appreciable deviations in the magnitude of the earth's field variations along the two-mile length of the machine.

Another possibility suggested by K. Brown consists of keeping the degaussing fields continuously set to give zero resultant fields along the axis. Then, the magnitudes of current in a number of strong-focusing (e.g., quadrupole) lenses along the axis required for optimum beam transmission is a measure of accelerator misalignment.