Subject BOOSTER MAGNET GRADIENT TOLERANCE.

A simple Fortran computer program (GRADERRB on the GE Mark 11) has been used to study the effect of the n shape of the booster magnet design. Input to the program consists of two sets of polynomial coefficients relating n with radial displacement for the two types of magnet. Particles of various initial amplitudes are then tracked through the lattice in small steps and the motion analysed to find the tune.

The design field shapes for the proposed magnets were supplied by S. Snowdon and are shown in Figure 1. For the computations these were fitted successively by linear, quadratic and cubic functions. See for instance Figure 2 which shows this for the F magnet.

The variation in tune is shown in Figure 3 for each of the functions, in terms of the beam radius in the mid-F straight section.

By comparing figures 2 and 3 various effects can be detected. The linear cases correspond to the sextupole component which has been designed into the magnetic field shape to make the tunes independent of momentum. Consequently, these effects partly cancel so that for a peak amplitude of 70mms corresponding to a peak $\delta n/n = 1.6\%$ the tune shift is only $\delta\nu/\nu = 0.5\%$. For the quadratic fit, the effects again partly cancel and for a peak amplitude of 70mms the peak gradient error of $\delta n/n = 1\%$ gives a tune shift of $\delta\nu/\nu = 1.4\%$.

The cubic curves, which best represent the finite pole width effect give a tune shift at 70mms of $\delta\nu/\nu = 4\%$ for a peak $\delta n/n = 2.7\%$. In this case the effects seem to reinforce, particularly when one allows for the fact that in sinusoidal motion the average displacement is only $2/\pi$ times the peak value.

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To check this effect the change in tune was computed for $\delta n/n = 1\%$ applied uniformly in each magnet of the same sign as the cubic term. (ie k increased in the F magnet and $|k|$ decreased in the D magnet.) These 1% changes in the n values gave a tune shift $\delta\nu/\nu = 3.24\%$. This 'magnification' together with the fact that particles spend more time at large displacements than close to the axis explains why the fractional tune shift is about twice the peak fractional error in n.

In order to examine the adequacy of the pole width we choose the amplitude which corresponds to a tune shift of $\delta\nu = 0.1$ ie x = 54mms. This amplitude includes half of the F magnet sagitta which is 8.5mms. Thus the acceptance based on $\delta\nu = 0.1$ is 63π mm mrads., whereas for the same field shapes, applying the previous criterion of $\delta n/n = 0.5\%$ gave an acceptance of 90π mm mrads.. Thus if $\delta\nu = 0.1$ is taken as the criterion, the pole widths are adequate but only just so.

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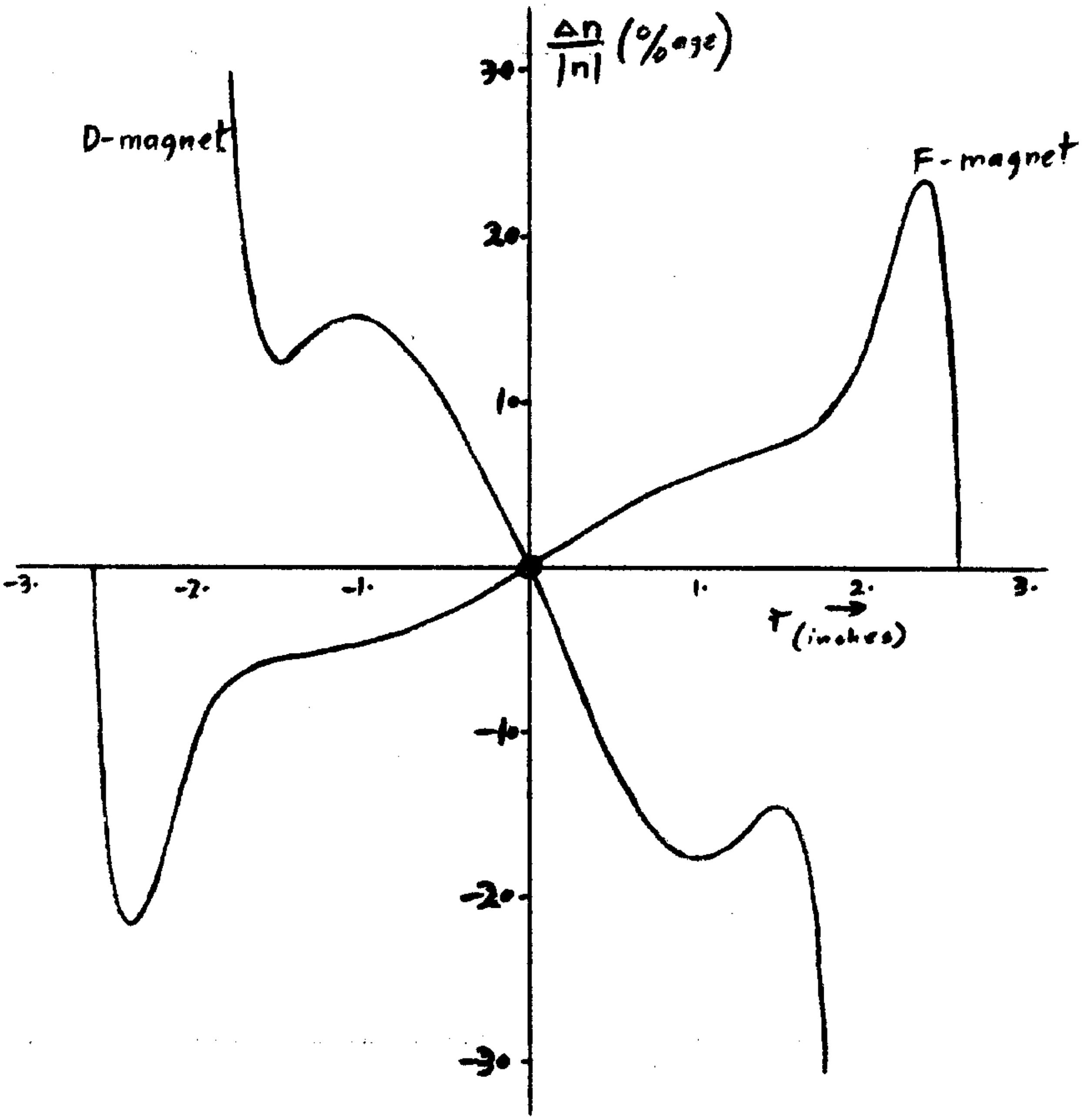

Figure 1

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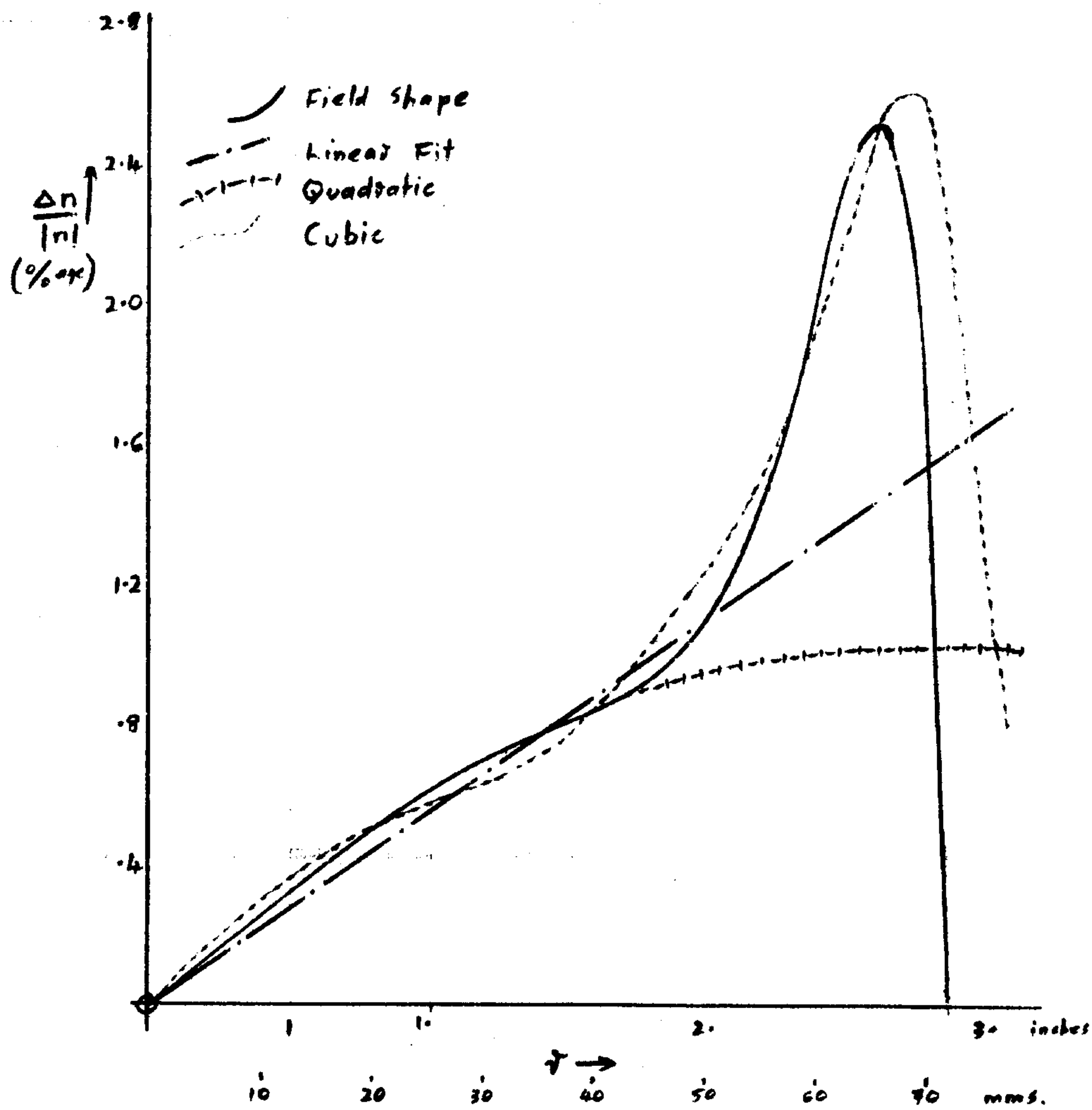
Figure 2



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