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Ring 2

INVESTIGATION OF CLOSED ORBITS FOR THE LOW-β ACCELERATION WORKING LINE

Summary

In order to investigate problems of closed orbit corrections on the AC working line, several sets of orbits were measured at 26.5 and 29.5 GeV/c by C. Fischer. A careful off-line analysis using the correct α_p-values* for the $\Delta p/p$ corresponding to the orbit revealed substantial differences when compared to the ARGUS on-line method of analysis (the ARGUS database contains only the CL values for α_p). The orbits from the off-line analysis look quite normal and it should be possible to correct these orbits. It appears that the conjecture for strong quadrupole field error, based on the on-line ARGUS orbit representation, is in fact a product of the data treatment. This problem can be avoided by introducing an addition to the low-β database for injection.

Introduction

For some time problems concerning the correction of closed orbits in ring 2 on the low-β acceleration working line were reported. It seemed that the orbit at the top of a stack could not be corrected without destroying the orbit at injection and vice versa. Such behaviour might be explained by a misadjustment in one le the low-β quadrupoles, and therefore, it was decided to check this hypothesis with orbit measurements on the machine.

* Here α_p is defined as (undistorted orbit position/momentum error).

Method of displaying orbits

Before discussing the measurements it seems worthwhile to look at the method of treatment by the ARGUS of the raw orbit measurement data coming from the pick-ups.

Let x_i be the measured orbit at the i^{th} P.U.,

α_{p_i} be the momentum compaction,

$\Delta p/p$ be the momentum error,

d_i be the true distortion.

The orbit calculations with PUSO are done according to the following formulae :

$$\frac{\Delta p}{p} = \frac{\Sigma\, x_i \alpha_i}{\Sigma\, \alpha_i^2} \qquad (1)$$

The values for α_i are linearly interpolated from values at +40 mm and at centre line. (1) corresponds to a least squares fit of the measured orbit to the undistorted orbit $\alpha_p(\Delta p/p)$.

The difference

$$x_i - \alpha_{p_i} \frac{\Delta p}{p} = d_i \qquad (2)$$

corresponds to the orbit distortion and is displayed on the screen when measuring an orbit.. A major difficulty in the analysis of the measured orbits was to get the correct α_p-values for the AG working line on injection orbits, as AGS refuses to find orbits for negative $\Delta p/p$. By using a special routine by A. Verdier it was finally possible to get results, however, the α_p-values were so different from the centre line values that we disbeleaved them. As pointed out by A. Verdier the precision of the AGS computation at injection orbits could be increased by cutting the main bending units into several pieces. This was subsequently done and the dependence of two extreme α_p-values on the number of pieces per block is shown in fig. 1. The values for 8 pieces per block are thought to be sufficiently precise for our purpose.

Measurements

From all measurements made we shall only present the ones at 26 GeV/c in some detail and resume the outcome of the remaining ones. The closed orbit was measured at injection, centre line and top. Figure 2 shows the orbits as obtained by PUSO according to (1) and (2) on the ARGUS. A careful comparison between the top and the injection orbits reveals some quite important differences e.g. around PU 348 or PU 432, where the two orbits are actually of opposite phase.

Figure 3 shows the three orbits again, but this time the correct α_p-values were used for the calculations. By looking at the general shape, one can see two things :

- the three orbits at injection, CL and top belong obviously to the same family. The resemblance is particularly strong between injection and top. The distortion is in phase.
- these orbits, although obtained from the same raw data as the ones depicted in Figure 2 are quite different from the previous ones, especially at injection.

These results lead us to the following conclusions :

- It is of primordial importance to use the correct α_p-values for the calculation of the closed orbit distortion from the raw data. In fact, several cases were found where the use of the CL α_p-values for an injection orbit could completely alter the shape of the orbit distortion.
- Using the described method yields comparable in phase orbits at injection and at top. There is no reason why these orbits could not be corrected. As the error of the actual α_p-values is biggest at injection, it is recommended to correct the orbits near the top (this practice is also recommended for other reasons, cf. Memorandum of 13.11.1975 "Operating procedures for the low-β insertion").
- Further measurements were made with small changes in one of the low-β quadrupoles (2 LBQ8)*. There is no evidence that the residual difference

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* As the μ_h varies slowly through the low-β insertion, the distortions produced by the low-β quadrupoles are all very similar. However, LBQ8 was chosen for this test since he gives the biggest effect for the smallest change in current.

in orbit distortions between injection and top is in any way related to the effect of this quadrupole. Such a correlation is seen, however, when comparing the on-line orbits from ARGUS, but this is believed to be an effect arising from the use of centre line α_p-values on the injection orbit and such comparisons should be avoided.

- Measurements at 29.5 GeV/c show roughly the same behaviour ; however, the correlation between the injection and top orbit becomes less obvious. This is due to saturation effects mainly in the main units and has nothing to do with the focalisation of the machine, as the latter remains constant during acceleration.
- The correct values for α_p at injection could be included in the database at the expense of an additional file. Of course, corresponding modifications would be needed in PUSO, COCO and probably other programs.

K. Brand

Dependence of α_p on $\Delta p/p$.

B2AC

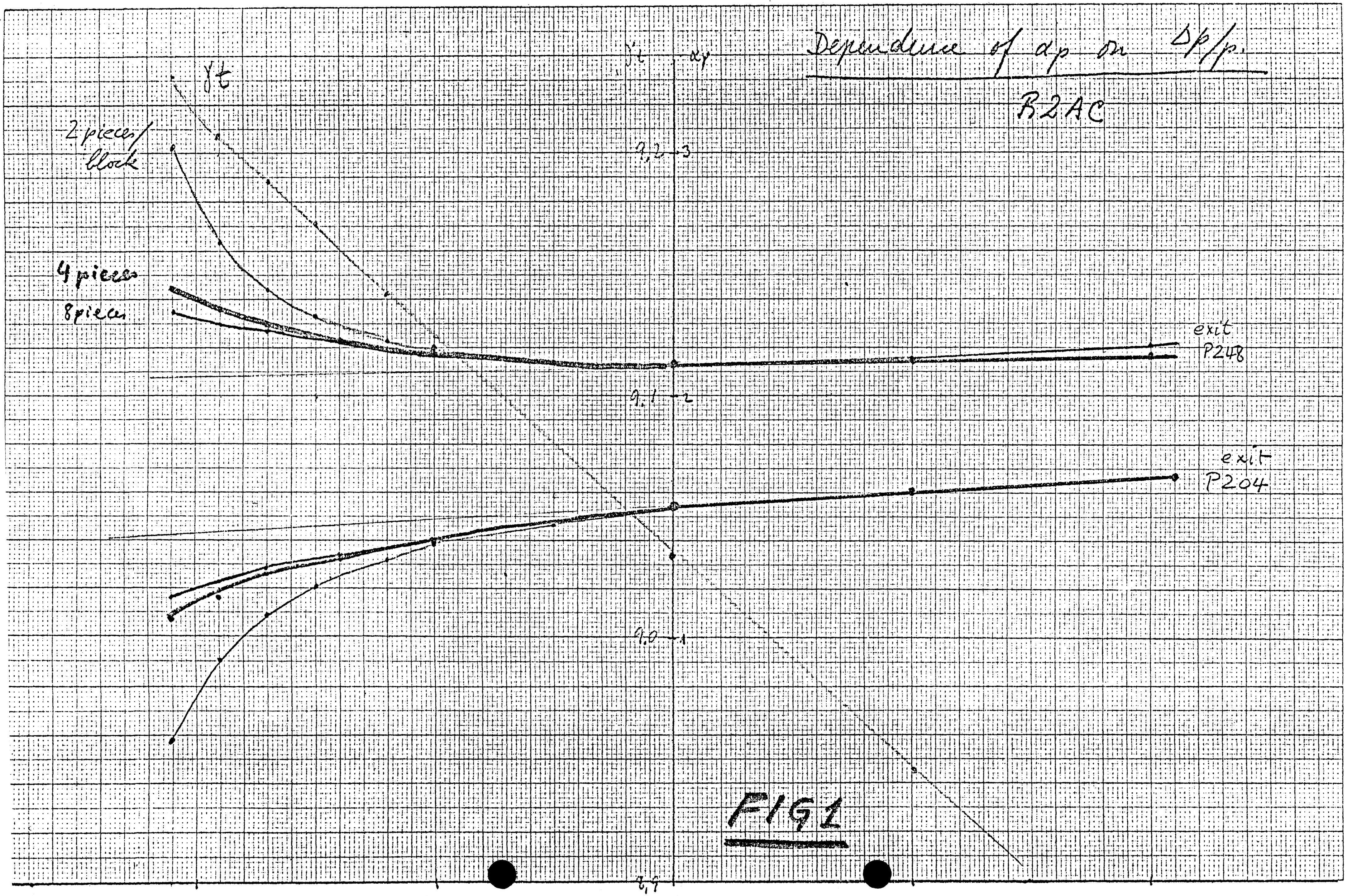

FIG 1

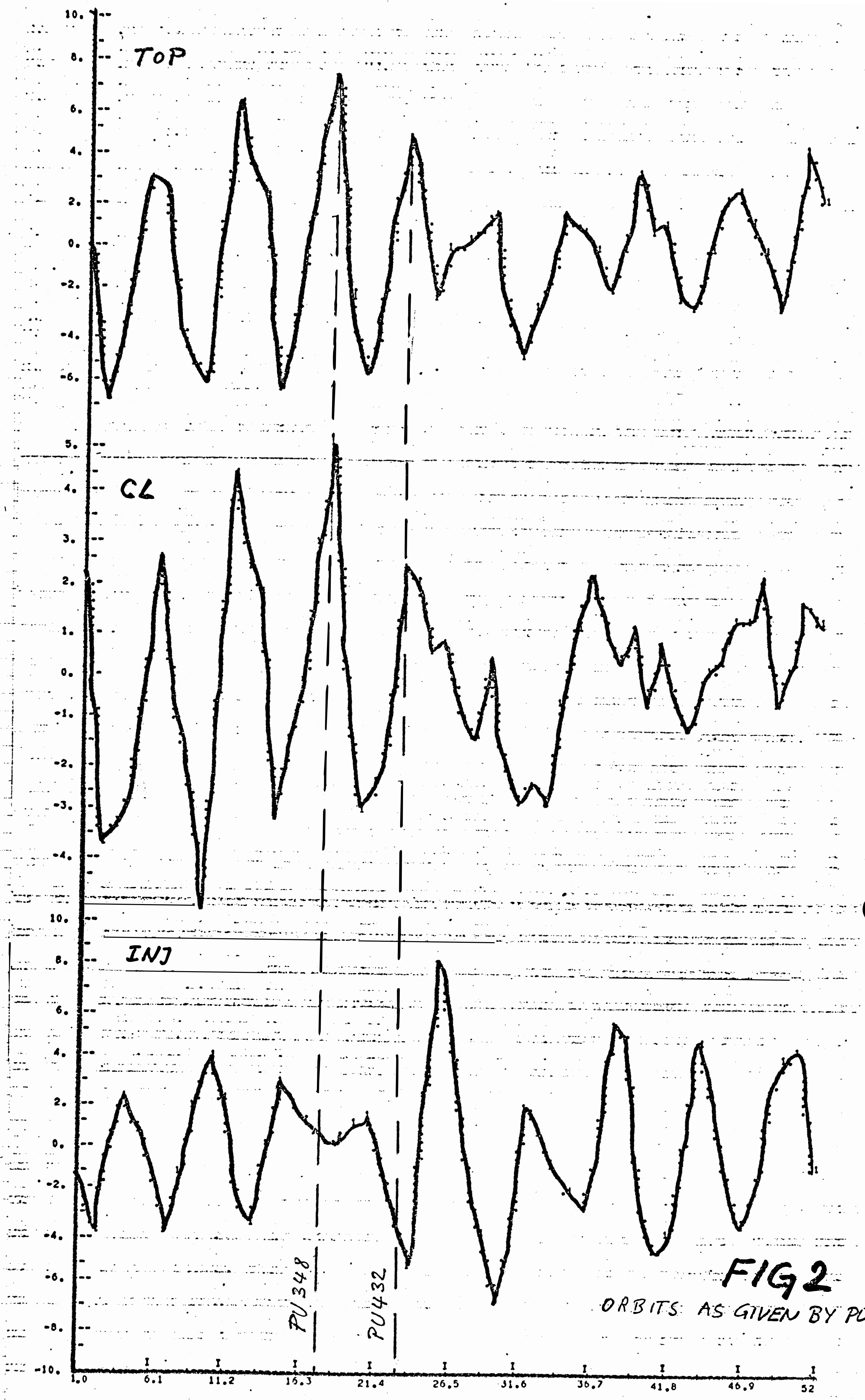

FIG 2

ORBITS AS GIVEN BY PU50

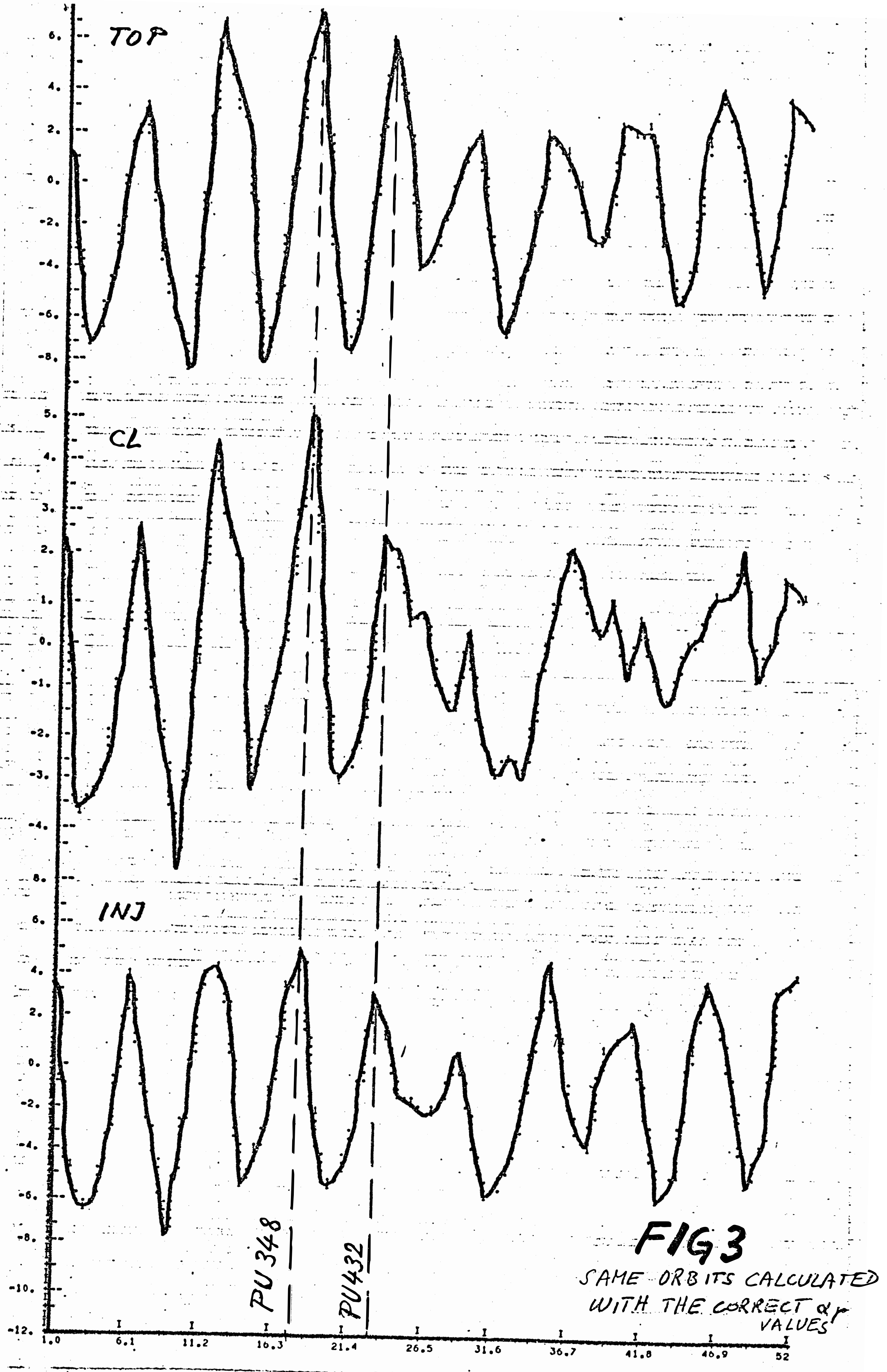

FIG3
SAME ORBITS CALCULATED WITH THE CORRECT q_r VALUES