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Orbit Changes from Moving Magnets E17 and K15

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AGS Studies Report

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Reported by R. Thern

Subject Orbit Changes from Moving Magnets E17 and K15

1. Introduction

The radial survey of the AGS ring, done in the summers of 1985 and 1986, shows that magnets K15 and E17 have their upstream ends displaced 0.368" inside and 0.277" outside, respectively, from the local average. These displacements are about twice as large as the next largest errors. In this study, these two magnets were moved back to the local average, where the local average is taken as the average of the radial position of the magnet itself and five magnets on each side.

The purpose of the study is to see how well we can predict the change in the orbit from these moves. The ability to calculate the equilibrium orbit due to misaligned magnets is being built into MAD, but the calculations for this report were done with a Symphony spreadsheet, using ray tracing through first-order matrices.

It is not expected that the orbit will actually be improved significantly by moving these two magnets, because there are still many magnets off by nearly half as much as these.

2. Procedure

A reference orbit was taken before moving the magnets. Then K15 was moved, and a difference orbit taken, and then E17 bas moved and a difference orbit taken.

The magnets were moved (by the Survey Group) using dial gauges to measure the motion. The dial gauges were placed approximately in line with the survey sockets, at each end of the magnet. Only the upstream

adjusting screw was turned, but because the downstream pivot point is not below the survey socket, both ends of the magnet moved. The motion used for the orbit calculation was that of the center (the average of the two ends).

The vacuum chambers were repositioned after these large moves to relieve stresses on the bellows and seals.

Magnet Motion

Magnet	Upstream	Downstream	Average
K15	0.368	0.031	0.200"
K17	-0.268	-0.028	-0.148"

3. Results

Figures 1 and 2 show the actual orbits before and after the moves. Figures 3 and 4 show the difference orbits, measured and calculated, with K15 only, and both magnets moved. The agreement in the shapes is very good.

The calculated orbits depend on the tune, which for these conditions is 8.68 (horizontal).

The measured amplitudes appear lower than expected. Actually, there is evidence from previous studies that the PUE system is miscalibrated and shows only about 80% of actual motion. This is strongly supported in this study. Figure 5 shows a scatter plot, one point for each PUE, of the measured vs. predicted orbit change, clearly showing this 80% factor.

4. Radiation Loss Patterns

After moving magnets E17 and K15, the radiation patterns in the ring (RLRM output) have been significantly changed, showing the prominent peak at A14/A16 as seen in Figure 6. Before the realignment, most of the beam losses during acceleration were captured at the E20 beam catcher at the standard position, i.e., at US/DS = 900/900 mils. In order to minimize the loss at A14/A16, the catcher had to be moved to US/DS = 1200/1200 mils, as shown in Figure 6.

(A follow-up study -- see Figure 7 -- shows that the optimum position for the catcher is US/DS = 1075/900 mils, since for US > 1050 mils, the catcher will interfere with the circulating stable beam, causing an extra beam loss.)

5. A Mystery . . . .

The mechanism for adjusting the radial position of the magnets has a bed that slides along two rods, adjusted with a screw, as shown in Figure 8. Over the years, there has been a buildup of things like spray paint, rust, or heavy layers of dust on the rods, which is different on the exposed part and on the part protected in the holes of the traveling bed. Thus, it is often possible to actually see if a magnet has been moved "recently" (within a few years, perhaps).

Both K15 and E17 had very clearly been moved recently, and had spent most of their life closer to the position to which they have now been restored. In a quick check of about ten more magnets, which the survey shows to be greater than 0.1" from their "correct" location, all but two appear to have been purposely moved recently, agreeing with the survey in direction and approximately correct in amount.

We do not know when or why these magnets were moved.

Figures

1. Orbit at 550 msec before moving magnets.
2. Orbit after moving E17 and K15.
3. Difference orbit, calculated and measured, after moving K15.
4. Same after moving both E17 and K15.
5. Scatter p[lot showing, for each PUE, the measured vs. calculated change due to moving the magnets.
6. Radiation loss patterns, before and after the magnet moves, for different E20 beam catcher positions.
7. Loss patterns for different beam catcher positions (after the magnet moves, from a follow-up study on December 19).
8. Magnet radial adjusting mechanism, showing where paint or dirt buildup will show changes in magnet position. (This drawing, done from memory, may not be correct in some details.)

mvh
THERN/STUDY

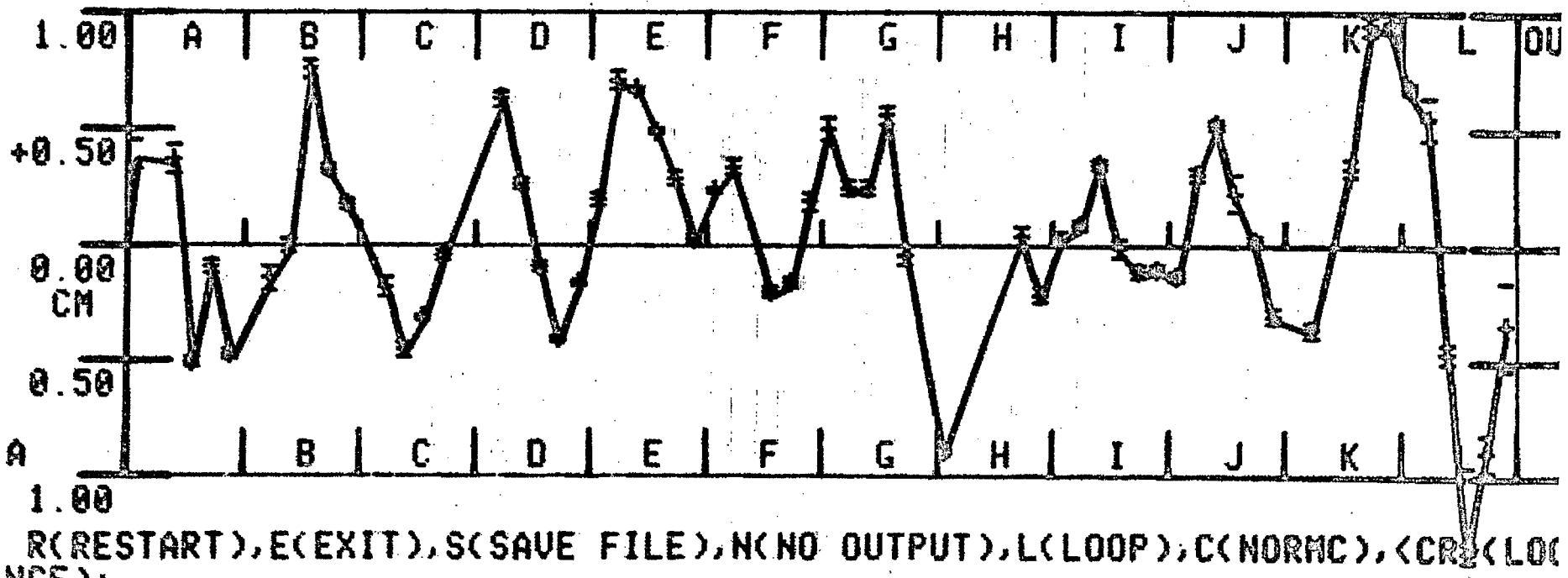
raw orbit before

DATA FROM REFERENCE FILE SV550
11-DEC-86 08:07 HOR. ORBIT @ 550 CMPTR NAVEN 5
NORMALIZED BY L20CT = 277
AVERAGE POS= 0.053

A	0.37		0.35	-0.52	-0.11	-0.49	A
B		-0.16	-0.02	0.74	0.31	0.16	B
C		-0.20	-0.47	-0.33	-0.06		C
D		0.61	0.25	-0.11	-0.42	-0.18	D
E	0.18	0.69	0.65	0.47	0.27	0.01	E
F	0.22	0.32		-0.22	-0.18	0.17	F
G	0.48	0.23	0.23	0.54	-0.06		G
H	-0.91				0.02	-0.23	H
I	0.01	0.07	0.33	-0.03	-0.13	-0.12	I
J	-0.15	0.29	0.50	0.21	0.00	-0.32	J
K		-0.38		0.32	0.93	0.92	K
L	0.66	0.53	-0.48	-1.34	-0.91	-0.36	L

HARMONIC ANALYSIS

	COS	SIN	AMP
1	-0.03	0.08	0.088
2	-0.05	-0.17	0.174
3	-0.05	0.06	0.077
4	0.00	-0.06	0.055
5	-0.16	-0.04	0.166
6	-0.04	0.11	0.120
7	-0.07	-0.03	0.075
8	0.14	0.34	0.369
9	0.09	0.26	0.275
10	-0.00	0.09	0.094
11	0.13	-0.05	0.143
12	-0.01	0.09	0.090

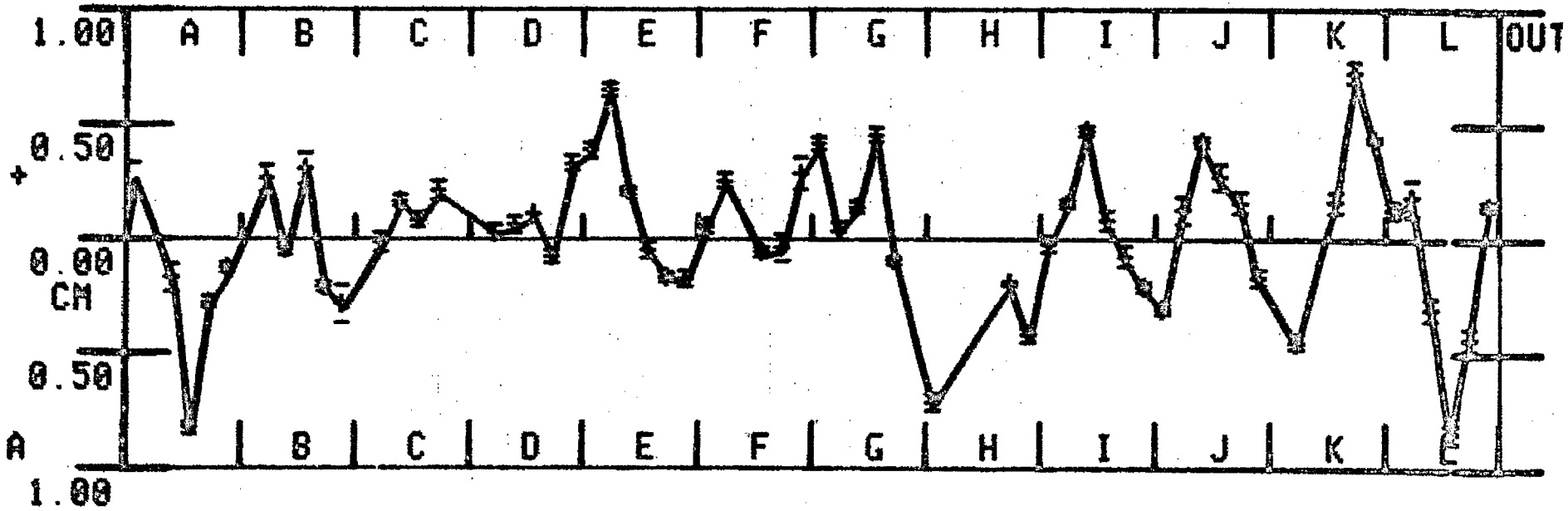


R(RESTART),E(EXIT),S(SAVE FILE),N(NO OUTPUT),L(LOOP),C(NORMC),<CR>(LOO
NCE):

Figure 1

final orbit "K15+E17"

```
11-DEC-86  12:32 HOR. ORBIT @  550 CMPTR NAVE: 5 HARMONIC ANALYSIS
NORMALIZED BY L20CT =  268                          N     COS     SIN     AMP
AVERAGE POS=  0.006                                 1   -0.03    0.08   0.089
A  0.26          -0.19 -0.84 -0.29 -0.15 A          2   -0.06   -0.12   0.135
B         0.24   -0.06  0.29 -0.23 -0.30 B          3   -0.04    0.05   0.065
C        -0.03    0.15  0.06  0.19      C          4    0.08   -0.03   0.082
D         0.01    0.04  0.09 -0.09  0.31 D          5   -0.14   -0.05   0.153
E  0.37   0.63    0.19 -0.07 -0.18 -0.19 E          6    0.03    0.05   0.061
F  0.04   0.24         -0.07 -0.06  0.27 F          7   -0.09   -0.03   0.097
G  0.40   0.02    0.12  0.44 -0.11      G          8    0.01    0.06   0.064
H -0.73                       -0.21 -0.43 H          9    0.19    0.10   0.214
I -0.04   0.13    0.45  0.06 -0.10 -0.23 I         10    0.13    0.07   0.147
J -0.32   0.11    0.41  0.26  0.14 -0.19 J         11    0.12   -0.08   0.145
K        -0.46          0.14  0.71  0.41 K         12   -0.01    0.05   0.055
L  0.11   0.16   -0.32 -0.86 -0.45  0.13 L
```



R(RESTART),E(EXIT),S(SAVE FILE),N(NO OUTPUT),L(LOOP),C(NORMC),<CR>(LOOP
NCE):

Figure 2

FIGURE 3. DIFFERENCE ORBIT, K15 MOVED

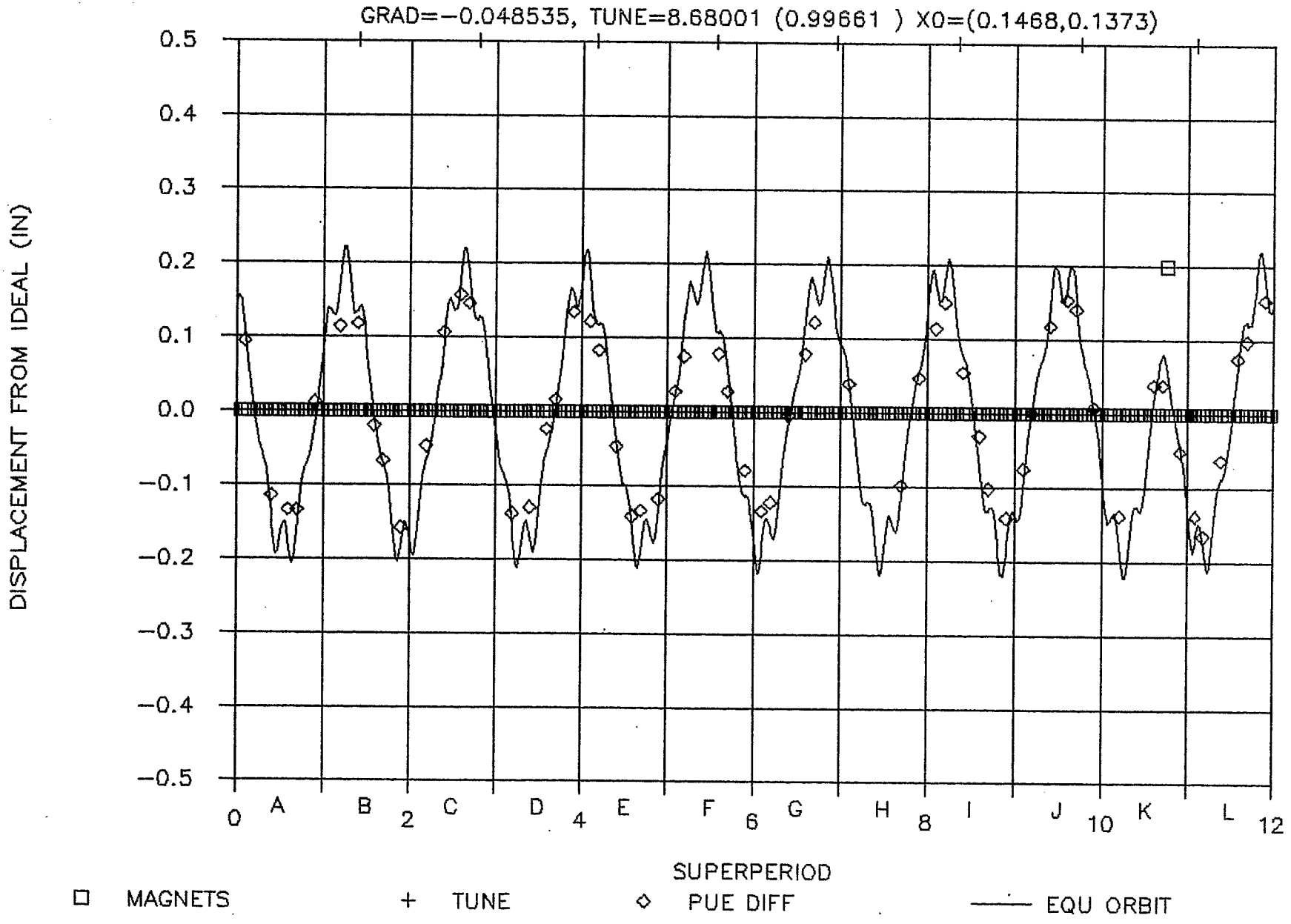
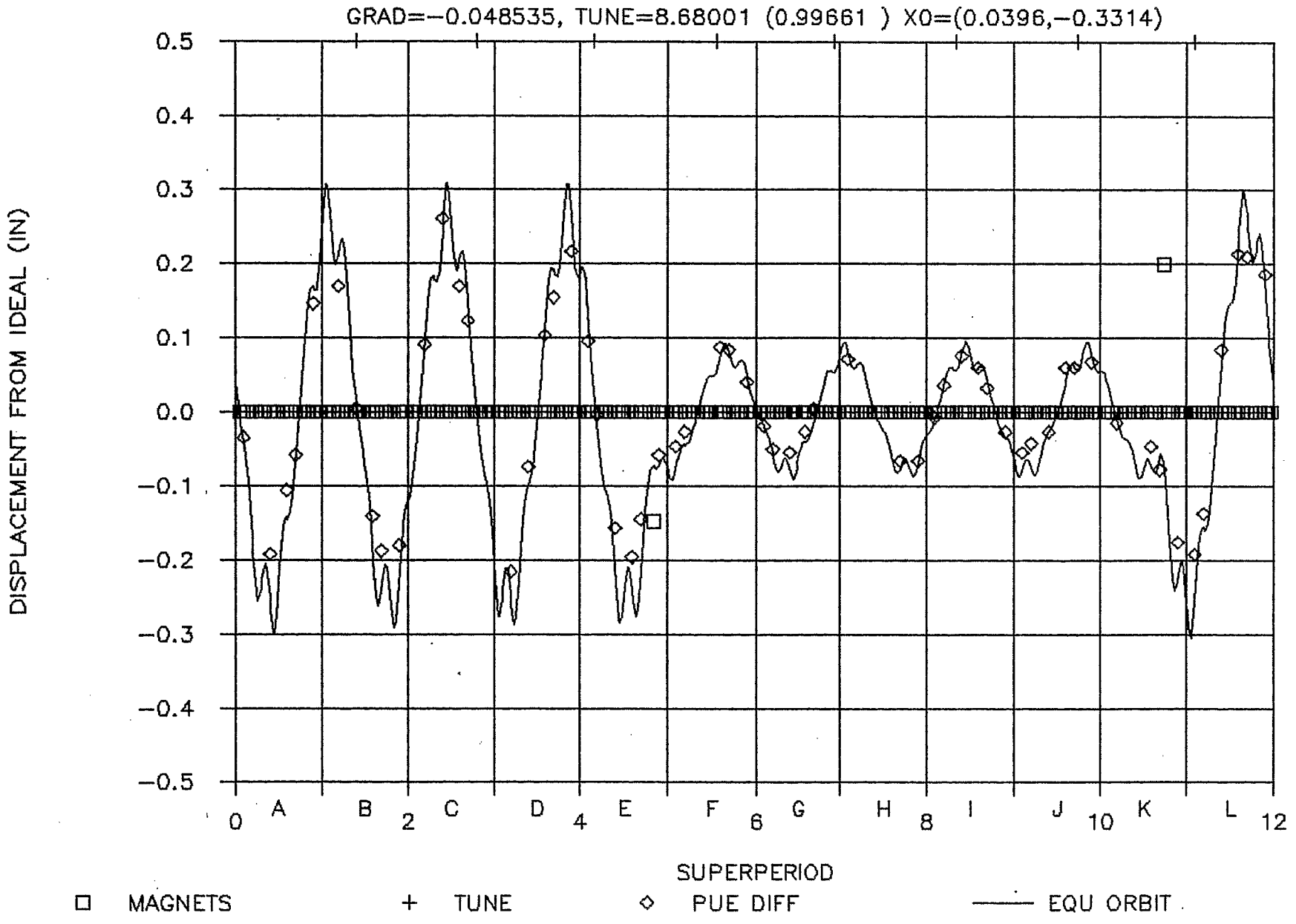


FIGURE 4. DIFFERENCE ORBIT, K15 AND E17 MOVED



GRAPH

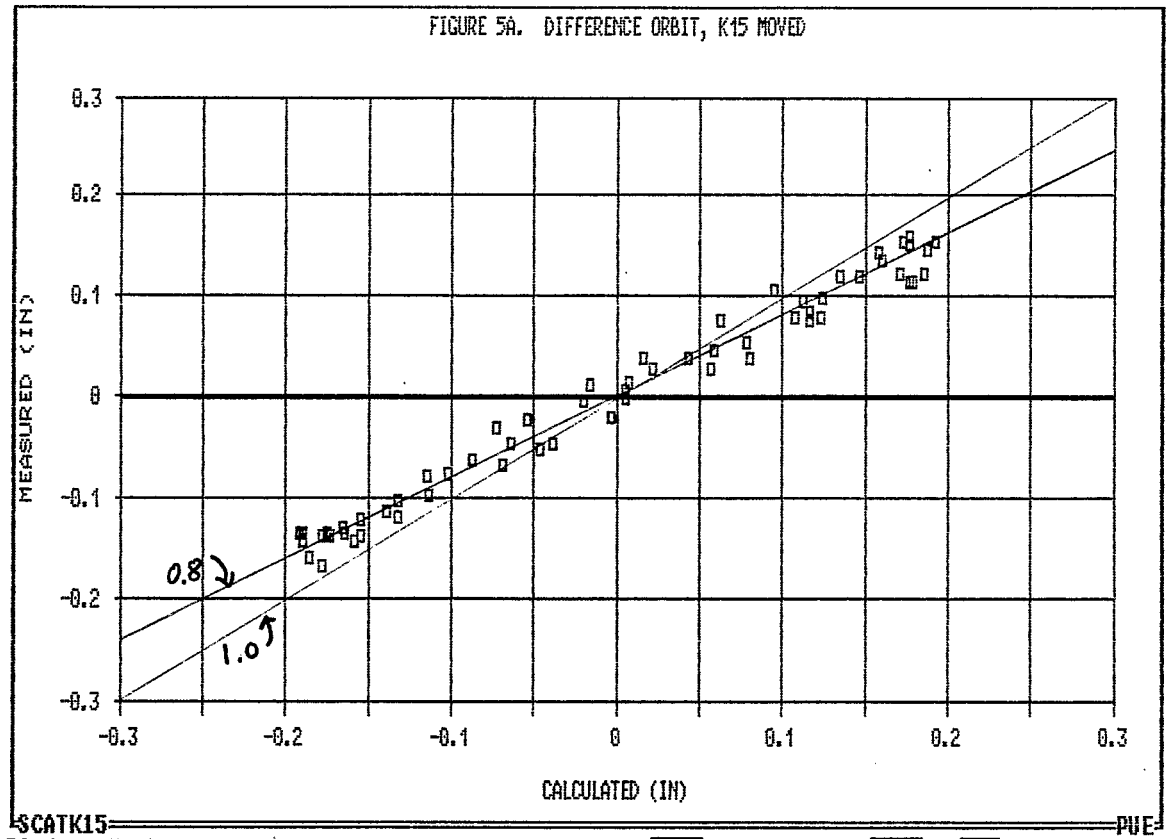


FIGURE 5A. DIFFERENCE ORBIT, K15 MOVED
MEASURED (IN)
CALCULATED (IN)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
0.8
1.0
SCATK15
PUE
06-Jan-87 04:23 PM
Zoom
Calc
Cap

GRAPH

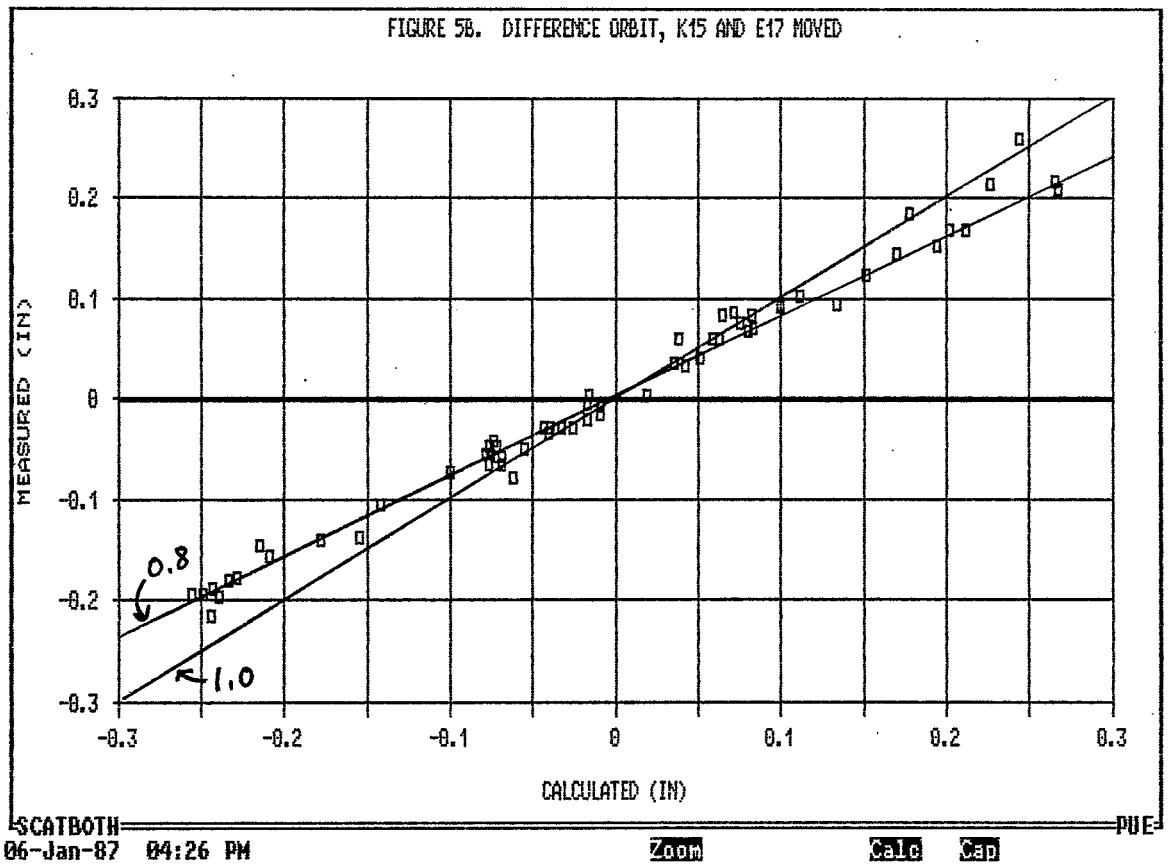


FIGURE 5B. DIFFERENCE ORBIT, K15 AND E17 MOVED
MEASURED (IN)
CALCULATED (IN)
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
0.8
1.0
SCATBOTH
PUE
06-Jan-87 04:26 PM
Zoom
Calc
Cap

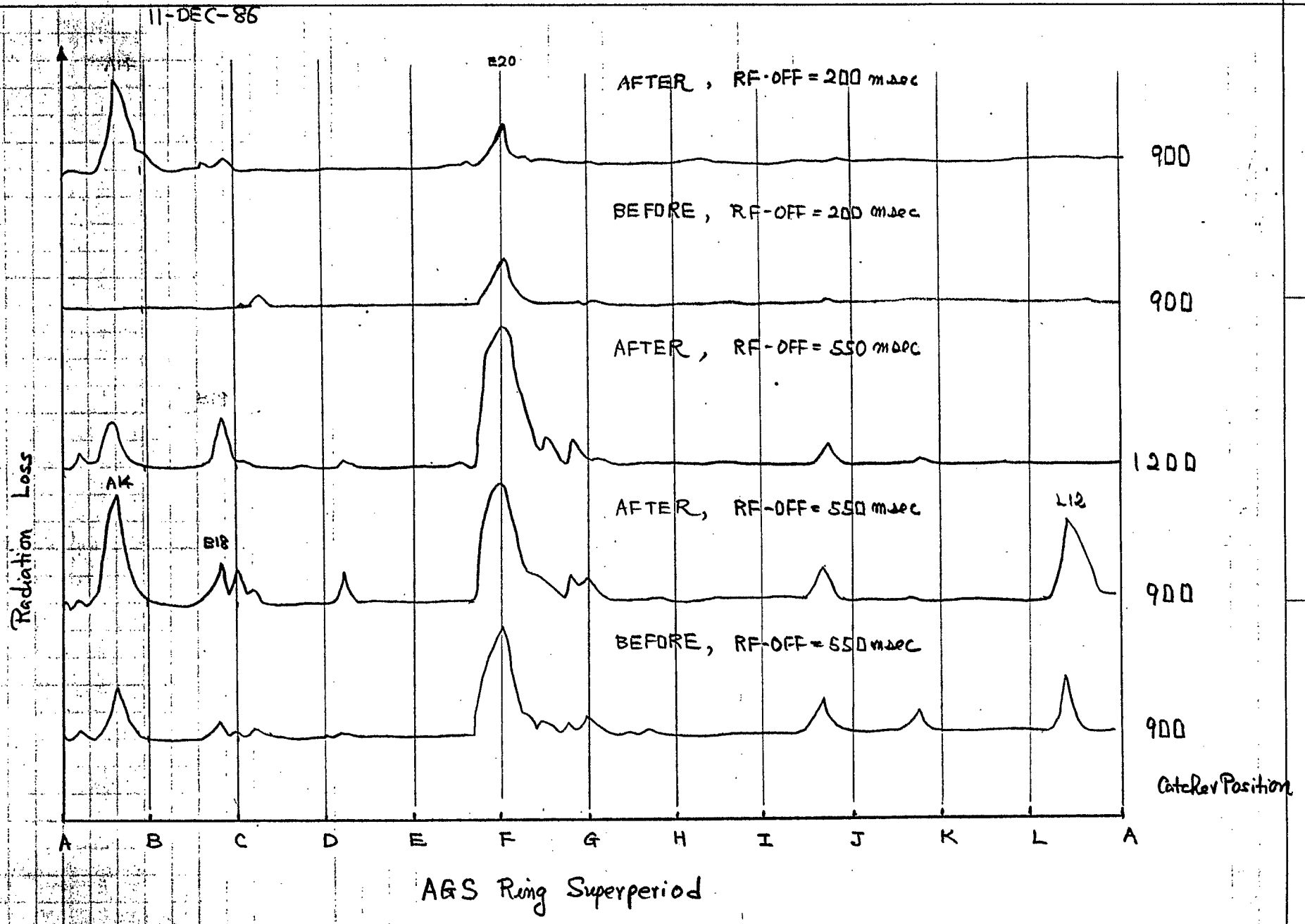


Figure 6

Fig. A

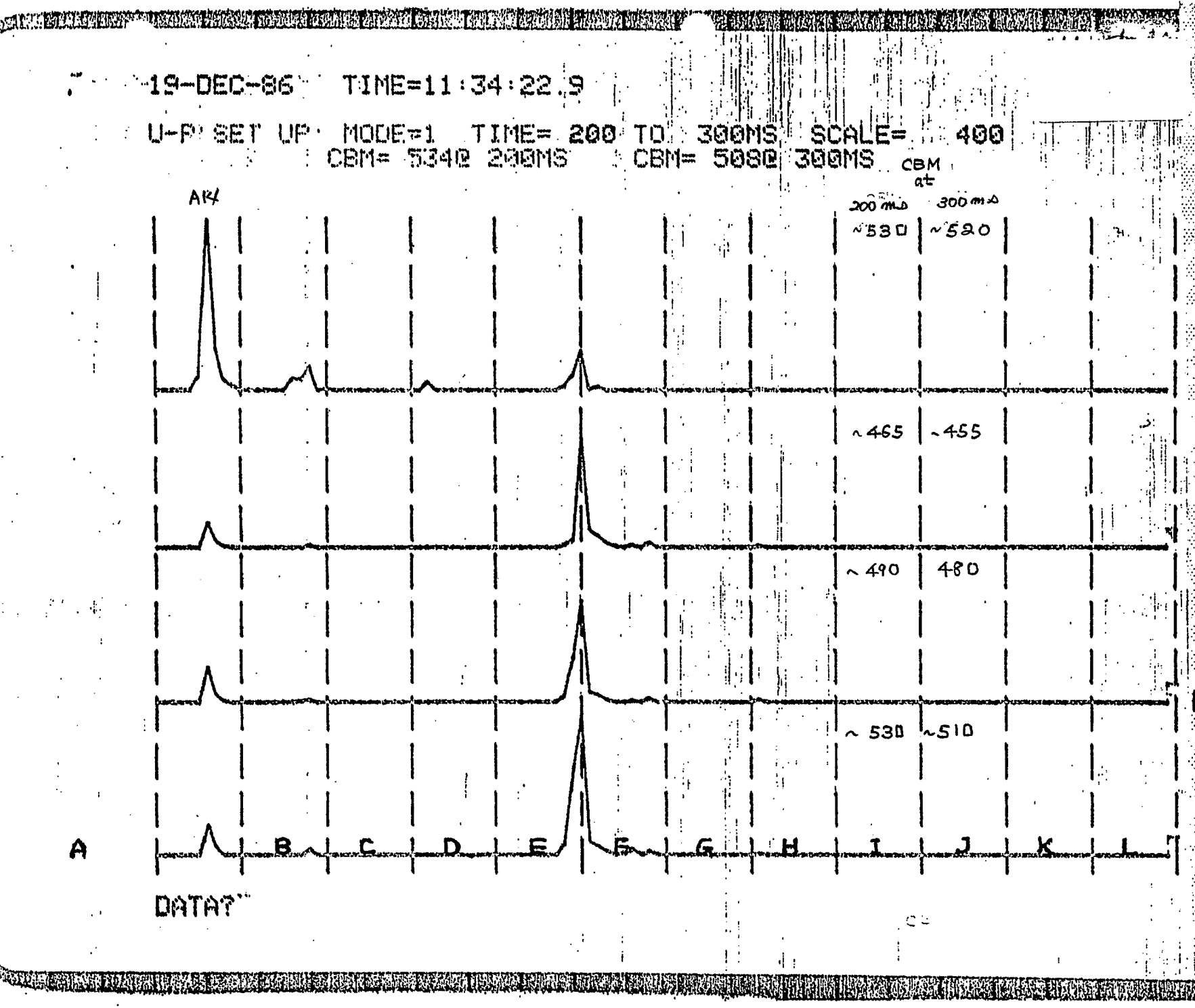


Figure 7

Fig. B

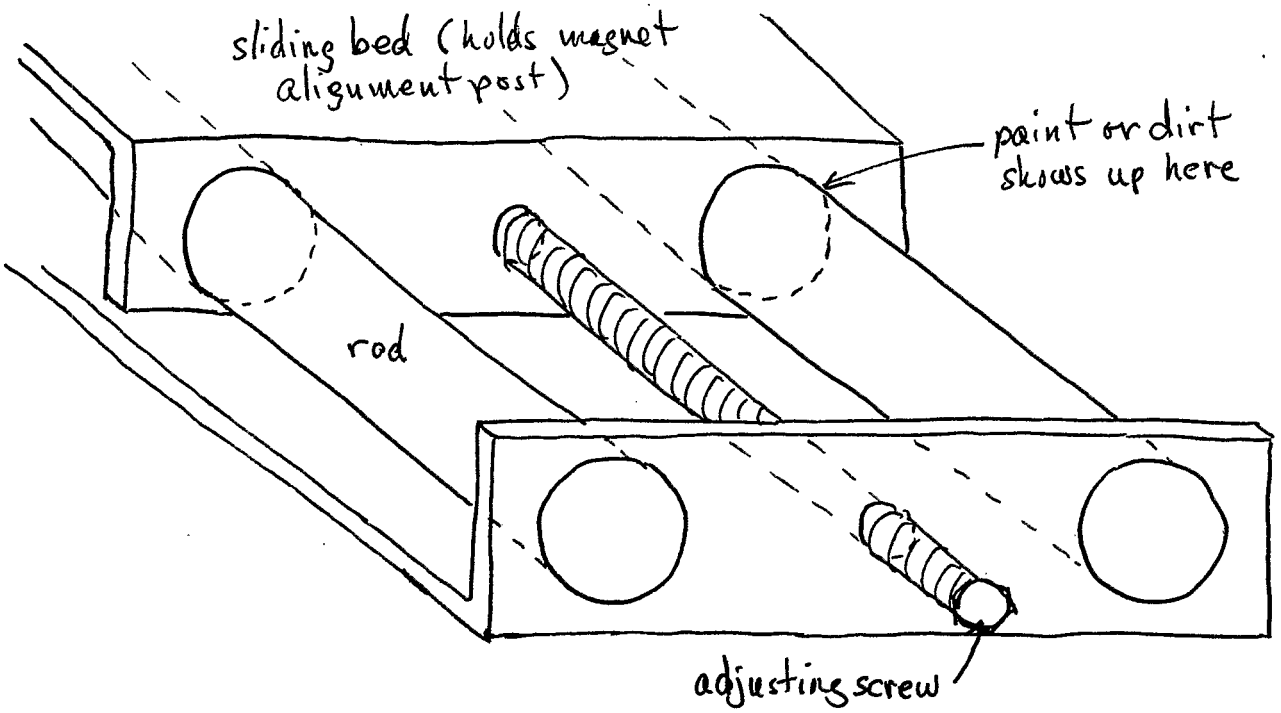

sliding bed (holds magnet alignment post)
paint or dirt shows up here
rod
adjusting screw

Figure 8.