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ELECTRONIC ALIGNMENT OF SPOOL PIECES

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In Energy Saver Correction Coil magnets (also referred to as Spool Pieces) one of the early problems was the relative alignment of the upstream and downstream coil packages. The long spool piece assemblies contain two coil packages. Each coil package consists of three concentric coil assemblies which are manufactured separately and assembled into a unit later. During this assembly it is essential to ensure that the magnetic fields of the upstream coil package are aligned to those of the downstream coil package. This is referred to as relative alignment. It is also necessary to ensure that the absolute orientation of the magnetic fields with respect to the outside of the spool piece box is also preserved.

The initial attempts to achieve these alignments relied upon mechanical means that depended on knowing where the quadrupole coil within a package was with respect to certain marks on the outside frame of the coil package. This method was found to be inadequate to align the coils within the tolerances demanded by the machine. Instead an electronic method for aligning the coils was proposed and implemented with satisfactory results. It is the purpose of this note to describe this technique.

THE ELECTRONIC ALIGNMENT TECHNIQUE

Since each of the coil packages contains a quadrupole coil, it was decided to use a quadrupole Morgan Coil[1] as the probe of the magnetic field direction. The output from the quadrupole Morgan Coil is of the form $A\cos(2\theta)$. By finding the null point of the coil with the probe, it is possible to determine the field direction very accurately. The setup to do this is shown in Figure 1. The quadrupole coil of the upstream package is first excited by an 11Hz wave form generated by a Kepko power supply driven by a signal generator. The output from the Morgan Coil probe is fed into a linear amplifier and is displayed on an oscilloscope. The Morgan Coil shaft has on it 2 sets of

bubbles. The first set encode the true vertical for a normal quadrupole coil. The second set are offset by 45 degrees from the first set and encode the null point for a skew quadrupole coil. (the downstream coil package may contain a normal or skew quadrupole coil.).

The method of alignment consists of first securing the upstream coil package to the beam pipe by means of shims and rotating the assembly until a null is indicated on the scope. At this point, a flange encoding the absolute orientation of the upstream coil is welded on to the beam pipe. This is used for the subsequent building of the rest of the spool piece for absolute orientation. The downstream coil is now slipped on to its place and its orientation is adjusted till a null is reached with the Morgan Coil in the appropriate bubble position. It is then secured to the beam pipe.

RESULTS

Figure 2 shows the results of the magnetic measurements performed on Spool Pieces fabricated using the above technique. The full histogram is the distribution of the absolute orientation of the upstream quadrupole coil. The arrows indicate the desired tolerance. The X's are the orientations of spool pieces fabricated using mechanical orientation methods.

Figure 3 shows the relative orientation of the upstream and downstream packages fabricated using the electronic alignment technique. The X's again denote the results of mechanical alignment. It is seen that the electronic alignment technique described here gives results that are within the tolerances demanded by the machine optics.

REFERENCES

1) "Stationary coil for measuring the harmonics in Pulsed Transport magnets" G.H.Morgan, Proceedings of the 1962 Magnet Conference at Brookhaven National Laboratory.

FIGURE CAPTIONS

Figure 1. Electronic setup.

Figure 2. Absolute alignment of the upstream quadrupole. The full curve is for spools made using the electronic alignment technique. the X's are for those using mechanical alignment.

Figure 3. Relative alignment of upstream and downstream quadrupole coils. Again the X's are for spools fabricated using the mechanical alignment technique.

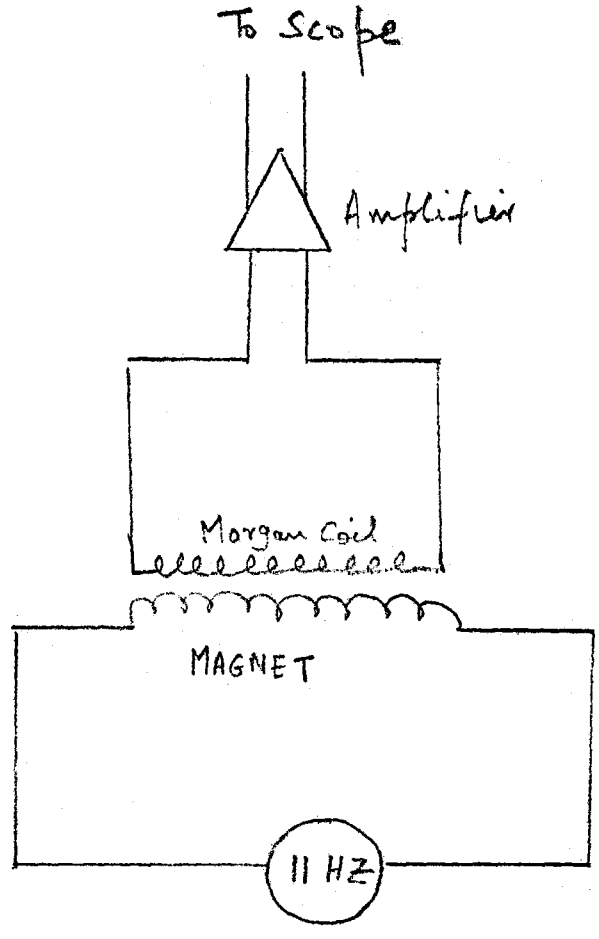

Figure 1

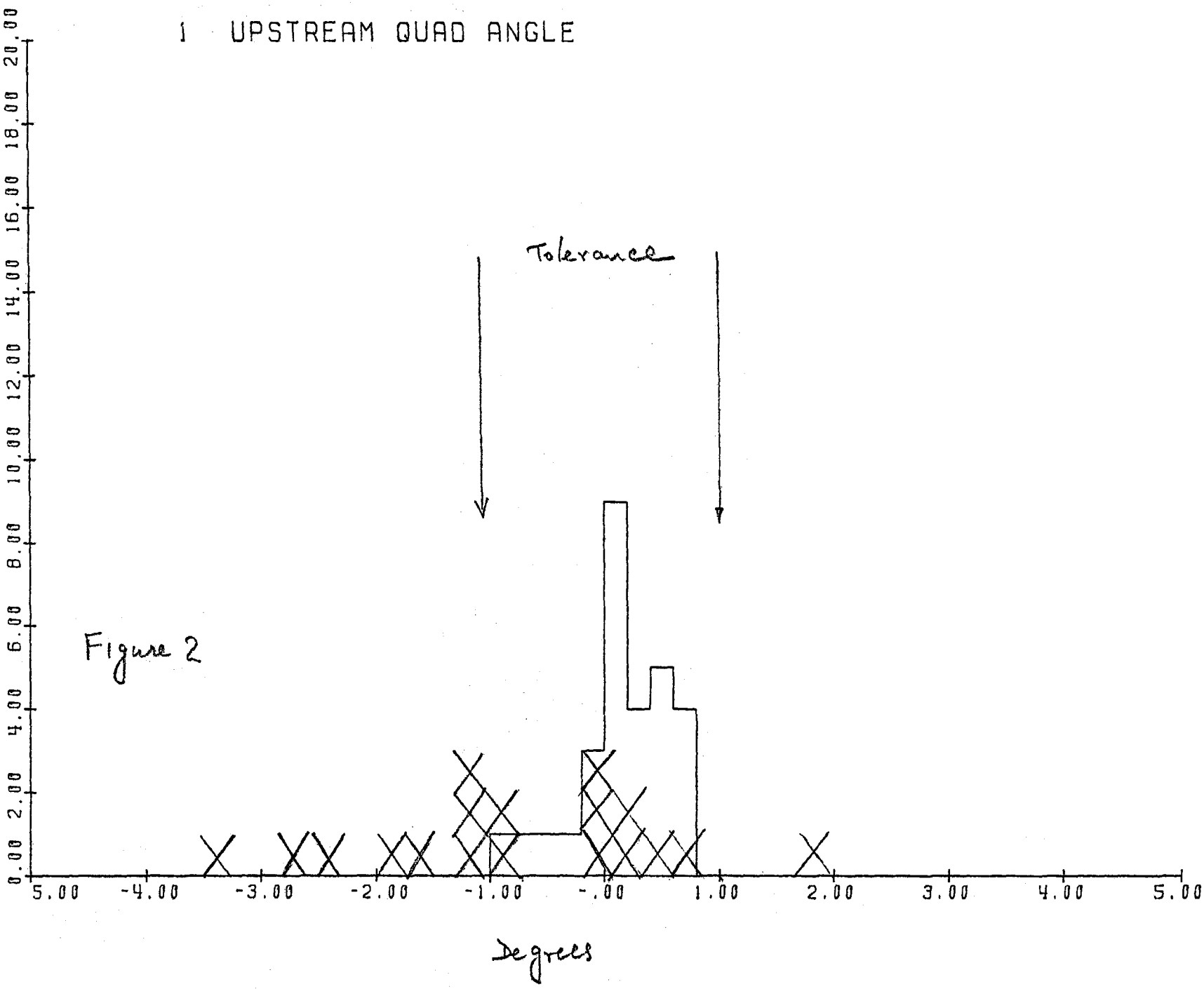
1 UPSTREAM QUAD ANGLE
Tolerance
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
5.00
-4.00
-3.00
-2.00
-1.00
-.00
1.00
2.00
3.00
4.00
5.00
Degrees

Figure 2

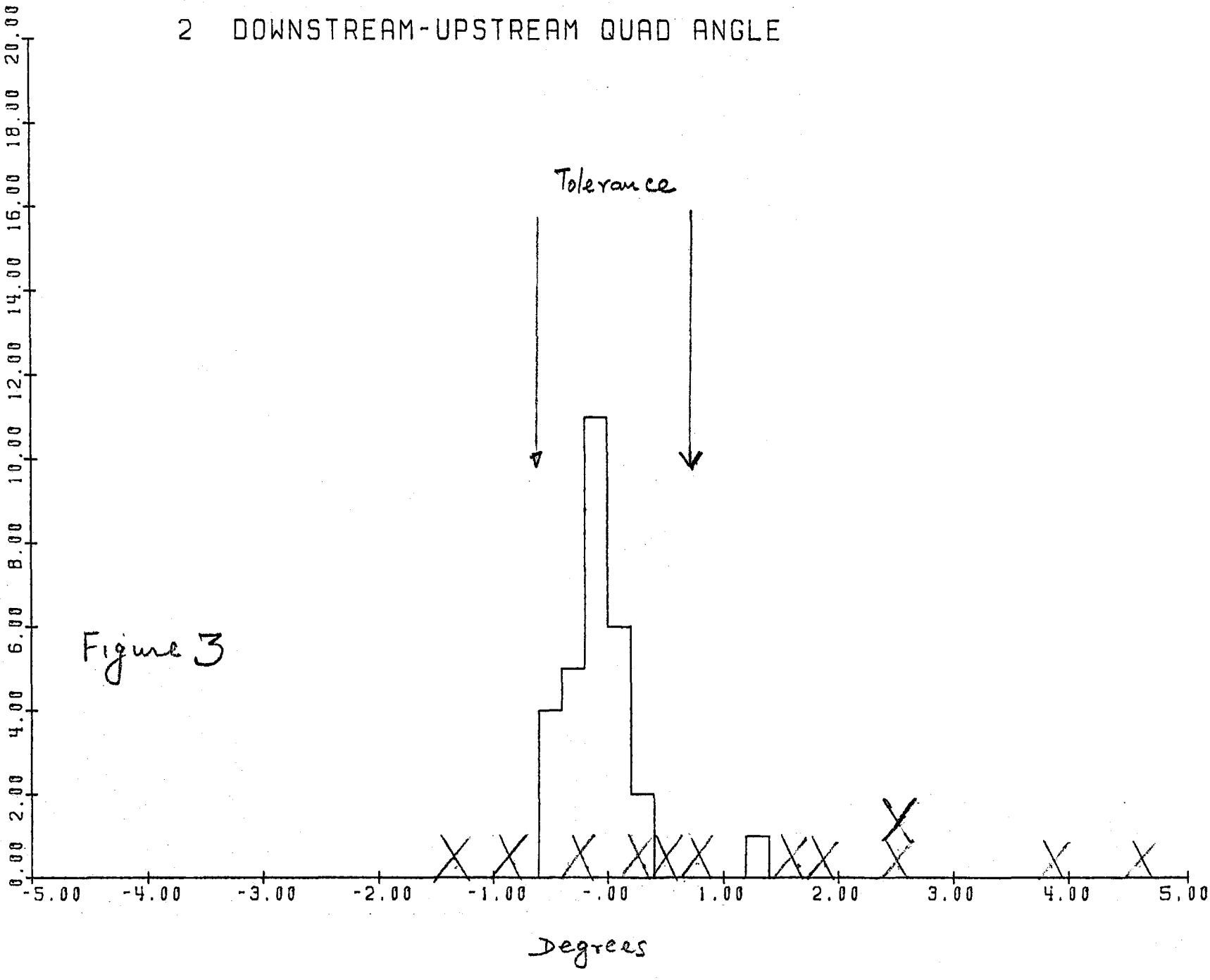
2 DOWNSTREAM-UPSTREAM QUAD ANGLE
Tolerance
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
-5.00
-4.00
-3.00
-2.00
-1.00
-.00
1.00
2.00
3.00
4.00
5.00
Degrees

Figure 3