SINGLE PASS COLLIDER MEMO

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TITLE: SLC INTERGIRDER QUAD VIBRATIONS

This report concerns recent measurements of the x, y and z vibrational motion of the quadrupole focusing magnets mounted between 40' girder assemblies in Sector 5. The amplitudes of their vibration were of particular concern, and these were measured in the presence of the following disturbances:

- Background vibrations (coolant water flow, ground vibrations, etc.)
- A moderate blow, with a closed fist, to the center of the light pipe (x and y directions)
- A similar blow to the end of the light pipe (x and y directions)
- A light blow with the fist or palm to the quadrupole magnet itself (x, y, and z directions).

The motions were sensed with velocity transducers, mounted on the magnets so as to respond to displacements in the x, y, or z directions. Their output was monitored with the Nicolet 660 FFT Analyzer*, set so as to display signal amplitude (velocity, in this case) versus time. The peak values of velocity in a given cycle and the times of the peaks' occurrence were read from the display, and these numbers were used to calculate the peak-to-peak displacement via the following relations:

$$V_{pp} = A_h - A_l$$

 V_{pp} = Peak-to-peak velocity A_h = Amplitude of highest peak A_l = Amplitude of lowest peak

$$T = 2|t_h - t_l|$$

 T = Period of cycle t_h = Time at highest peak t_l = Time at lowest peak

$$D_{pp} = \frac{V_{pp}}{2\pi}$$

 D_{pp} = Peak-to-peak displacement

An important feature of this computation scheme is that it eliminates the influence at a D-C offset in the FFT analyzer's voltage scale. (Amplitudes are read off the instrument as voltages.)

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*This equipment was also used for the vibration measurements described in Single Pass Collider Note #CN-266.

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The following tables present the quantitative results:

Table 1

Disturbance	Peak-to-Peak Displacement (microns)					
	Quadrupole at 5-2			Quadrupole at 5-4		
	x	y	z	x	y	z
Background	4.2	1	44	6.9	2.4	
Moderate Blow to Center of Light Pipe						
Direction: x	14	5	+60	6.2	1.4 7	+150
y	7	4 29	270	10	3 17	+18
Moderate Blow End of Light Pipe						
Direction: x	18	2.8	71	22.3	1.6	1
y		16	+85	9.2	6.3	8 57
Light Blow to Magnet						
Direction: x	21	30	27	57	5.8 14	140
y	12	36	210	26	10 14	370
z	21 34	56	*500	16	31	*410

| A bar alongside a pair of numbers indicates transient (upper) and resonant (lower) amplitudes

* Denotes a light bump with the palm

+ Indicates that the measurement is of the maximum resonant - as opposed to transient - amplitude observed

Table 2

Disturbance	Frequency (cps)					
	Quadrupole at 5-2			Quadrupole at 5-4		
	x	y	z	x	y	z
Background	30	128	8	49	61	
Moderate Blow to Center of Light Pipe						
Direction: x	38	91	+8.5	82	182 7.6	+8
y	64	106 7.8	8	71	98 7.6	+7.8
Moderate Blow End of Light Pipe						
Direction: x	46	107	7.8	51	107	64
y		53	8	53	91	64 7
Light Blow to Quadrupole						
Direction: x	53	8	58	71	57 8.4	13
y	58	7.5	7.6	64	47 6.7	7
z	46 8	7.9	7.8	7.1	7.4	7.8

+ Indicates that the measurement is of the maximum resonant - as opposed to transient - amplitude observed

| A bar alongside a pair of numbers indicates transient (upper) and resonant (lower) amplitudes

It is important to note some differences between the low- and high-frequency motions. The slow 7-8 Hz oscillations were steady, and relatively long-lived. But, the faster oscillations died out quickly, and their amplitudes were fairly unsteady. Nor were their frequencies particularly constant. So, the higher frequencies in Table 2 should not be looked upon as descriptive of a uniform, oscillatory motion. Also remember that the frequencies, high and low, were determined in order to compute the displacements. In this role, their basic function is to characterize a time interval over which a certain velocity was attained, and the values in Table 2 do that quite accurately.

Use of the FFT analyzer in the signal vs. time mode made some interesting phenomena visible. Perhaps most significant was the z response of the magnet to background disturbance. The motion had a non-uniform, "noisy" appearance most of the time. But occasionally, regular sinusoidal oscillations arose and continued for about 10-15 seconds. Their amplitude was sometimes constant, and sometimes rose to a maximum and then gradually fell off back into noise. The resonant frequency was 8 Hz. This is about the same frequency that characterized the other resonant motions observed. A rough calculation of the resonant frequency of the I-beam support for the magnet assembly yields a value of 7.7 Hz. In this connection, it is interesting to note that the resonant frequency of a Linac 40' girder assembly is 8 Hz in the vertical (y) and 7.35 Hz in the horizontal (x) direction. Also note that after a bump to the light pipe's center in the x or y direction, an increase in amplitude of the magnet's oscillations was accompanied by a shift of frequency into the 7-8 Hz region. It seems likely that the magnet was being driven at its resonant frequency by the vibration of the girder assembly.

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