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EXPERIMENTAL STUDIES OF THE ACOUSTICS OF CLASSIC AND FLAMENCO GUITARS

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To study the behavior of classic and Flamenco guitars particularly in the lower two octaves of their range, we built the experimental enclosure shown in Fig. 1. The ribs or sides are 2.25 inches thick and weigh 11.5 pounds. The soundboard and back plates are glued to 0.5 inch plywood pieces which can be bolted to the sides. The resulting rib height is 3.25 inches, which is shallower than that of most guitars. We thought this would enhance acoustic coupling between the top and back plates.

Figures 5, 6, 7 and 8 show more detailed views of these plates. The wood thicknesses chosen were .062 inch for the top and .064 inch for the back plate. These are about 10% thinner than those we had measured in some Flamenco guitars. This choice made the total stiffness of each plate far more dependent on the strutting than on the plate thickness and therefore more easily modifiable. The strutting from the waist strut to the top of the instrument is significantly stiffer in either plate than that of real instruments in order to shift the resonances of these areas out of the region of interest.

Figure 3 shows our moving coil driver attached to a real instrument on the test stand. The driver was made from an old field coil (electrodynamic) speaker. The speaker cone was replaced by a smaller cone which terminated in a steel stem as shown in Fig. 9. Fig. 10 shows the external suspension spider. The original suspension spider is attached at the joint between the voice coil and the cone and is fastened to the center polepiece of the armature. It is accessible through the holes in the cone. The mass of the voice coil, cone and stem is 5.4 grams. This driver allowed us to obtain frequency response curves from the experimental enclosure, real instruments and top and back plates in the process of construction.

The electronics used consisted of an audio oscillator and amplifier to drive the voice coil and an AC voltmeter to measure the output from the microphone. The amplifier output voltage was held constant. A frequency meter allowed measurements of the oscillator output to 0.1 Hz accuracy (10 sec. gate). All frequency response curves were taken with the driver attached to the center of the bridge. When testing real instruments the mass of the driver plus bridge clamp was 10.75 grams. The microphone was always positioned 20 inches above a point midway between the lower edge of the soundhole and the bridge. Instruments were held in the test stand cradled in foam in a 3 point suspension: 2 points at the lower bout of the instrument and 1 point at the first position underneath the neck. The strings were damped with felt strips.

Our earliest frequency response tests were carried out indoors in conditions that were far from anechoic. The resulting frequency response curves showed mostly room resonances (Fig. 13). Our first driver consisted of an iron slug fastened to the bridge rail and driven by a solenoid coil surrounding it. The second harmonic distortion that resulted from using a permeable slug caused "ghost" peaks at half the frequency of any large peak. Our third instrument was made with redwood back and sides and its third peak, shown in Fig. 13 at 245 Hz, started out at higher frequency and lower amplitude. The change was accomplished by trimming the height of the hip strut after the instrument was finished, that is by lowering the resonant frequency of the lower back plate.

In these early frequency response tests we found that in the lower two octaves of the guitar range the areas in motion were confined to elliptical patches centered on the bridge, and hip and waist struts of the back. The waist strut resonance was often in the 300-350 Hz region for classic instruments and in the 250 Hz region for some Flamenco instruments. Depending on the strength of the back seam cover some of these instruments

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