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Davis December 18, 2009 BY MAIL

Meade Instruments Corporation
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Re: Meade field tripod design improvement

To Whom It May Concern:

I recently became the owner of a Meade brand telescope, a used 8" LX-10. I am generally happy with the quality of the telescope, and the value it provides. Being from an engineering background however I could not help but muse over different ways to improve the performance of the stock Meade hardware. In particular I was not satisfied with the stability of the stock Meade field tripod (Figure 1). The absence of a spreader on this particular model of tripod detracts from its stability, but another big contributor to the shakiness is the construction of the legs. After some tinkering I have come up with a cheap and effective solution for improving the stability of the tripod.

Figure 1 Meade LX10 field tripod

From what I can discern the legs are hollow chromed steel tubes (OD 51mm) with an estimated wall thickness of 1mm and tube length of 850mm. Attached at either end is a heavy aluminum casting, one for the tripod base clevis and one for the foot of the leg. With the leg attached to the tripod base and resting on the ground, the leg is set up as a pinned-pinned beam element, with its fundamental frequency defined by the equation:

$$\omega_1 = \pi^2 \text{sqrt}(EI/ml^4)$$

For the dimensions and properties I've assumed above, this works out to 1234 Hz, a pleasant bell-like tone if you were to rap on the leg. Adding the leg spreader would raise this frequency, but only to something around 2000 Hz. The construction and manner in which each leg is connected provides almost no damping of vibrations other than natural dissipation within the material of the leg. If something could be done to dampen the vibration of the leg, the shakiness of the tripod would be much improved.

To confirm my calculations of leg vibratory response I mounted a piezoelectric sensor midway along the length of the leg and measured the response with a computer based data acquisition system as I rapped on the leg. Figure 2 is a picture of the mounted piezoelectric sensor, a less expensive alternative to a proper accelerometer but suitable for determining modal responses. The resulting vibratory response is shown in Figure 3, which is the result of performing an FFT on the recorded time history data from the sensor. The red curve is the data from the leg being rapped, and the blue curve is a record of the background noise (no rap) for comparison. The horizontal axis on the plot is in Hz. The predicted natural frequency of 1234Hz stands out very clearly in the plot, as well as the associated harmonics at higher frequencies. Also visible in the plot is a spike at 60Hz and its corresponding harmonics, which the background sample (blue curve) show to be electrical noise, a drawback of my inexpensive measurement system. Note that the sample length (in seconds) from the rap was short, so the resolution and accuracy of the plot below 60 Hz is poor.

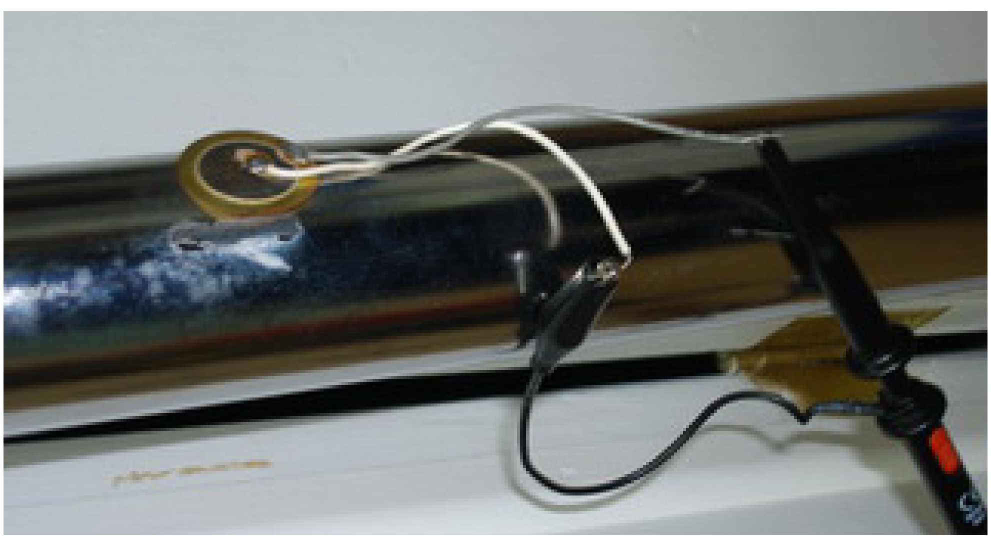

Figure 2 Piezoelectric sensor attached to leg

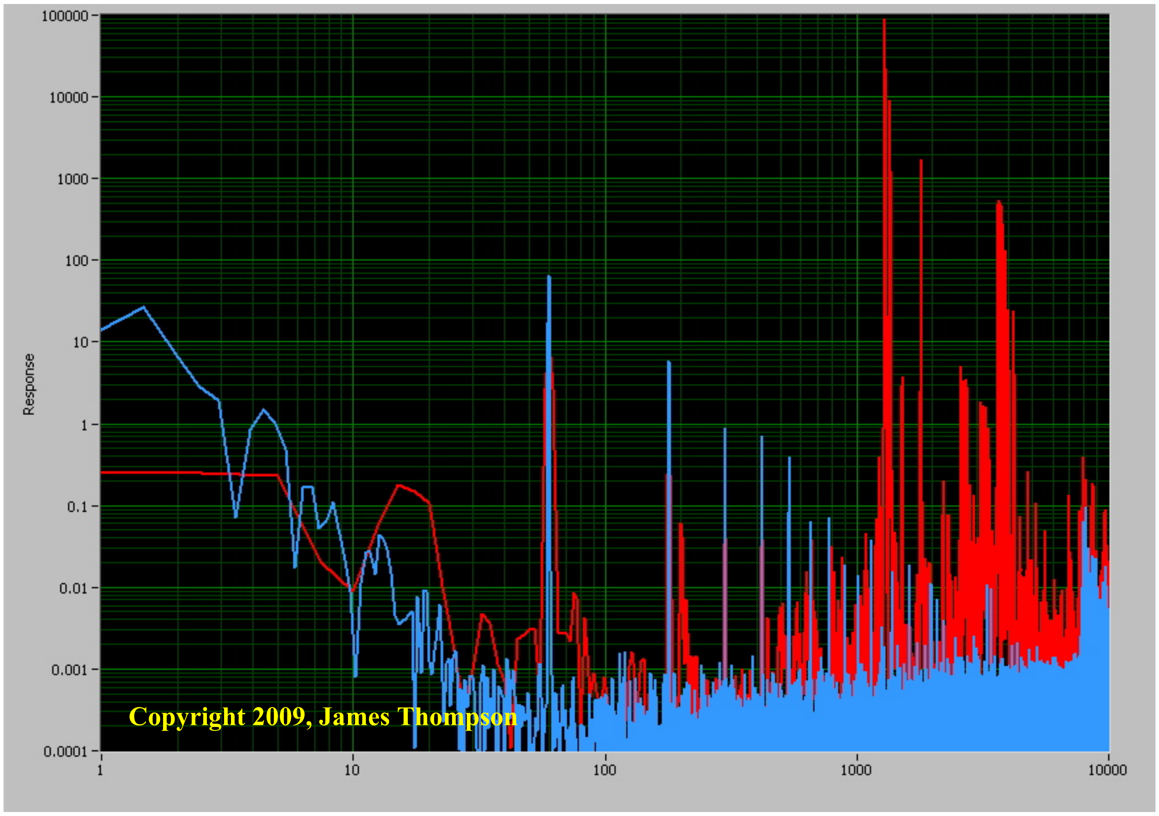

Figure 3 FFT of empty leg rap data

In an attempt to provide some level of damping to the leg, I decided to fill it with something light weight and rigid: polyurethane foam. Specifically I used the single component spray foam that is available in hardware stores for filling cracks around windows and doors. I drilled a hole in either end of the leg (Figure 4), and sprayed the foam in from one end.

Figure 4 Holes drilled in either end of leg

I repeated the rap test again, both immediately after filling the leg with foam, and then again 12 hours later when the foam was cured. The result of the final cured foam rap is presented in Figure 5. Note that the sample length was even shorter now than before, so the resolution is very poor below about 200Hz. The plot shows clearly that the magnitude of the vibration response in the leg is much reduced.

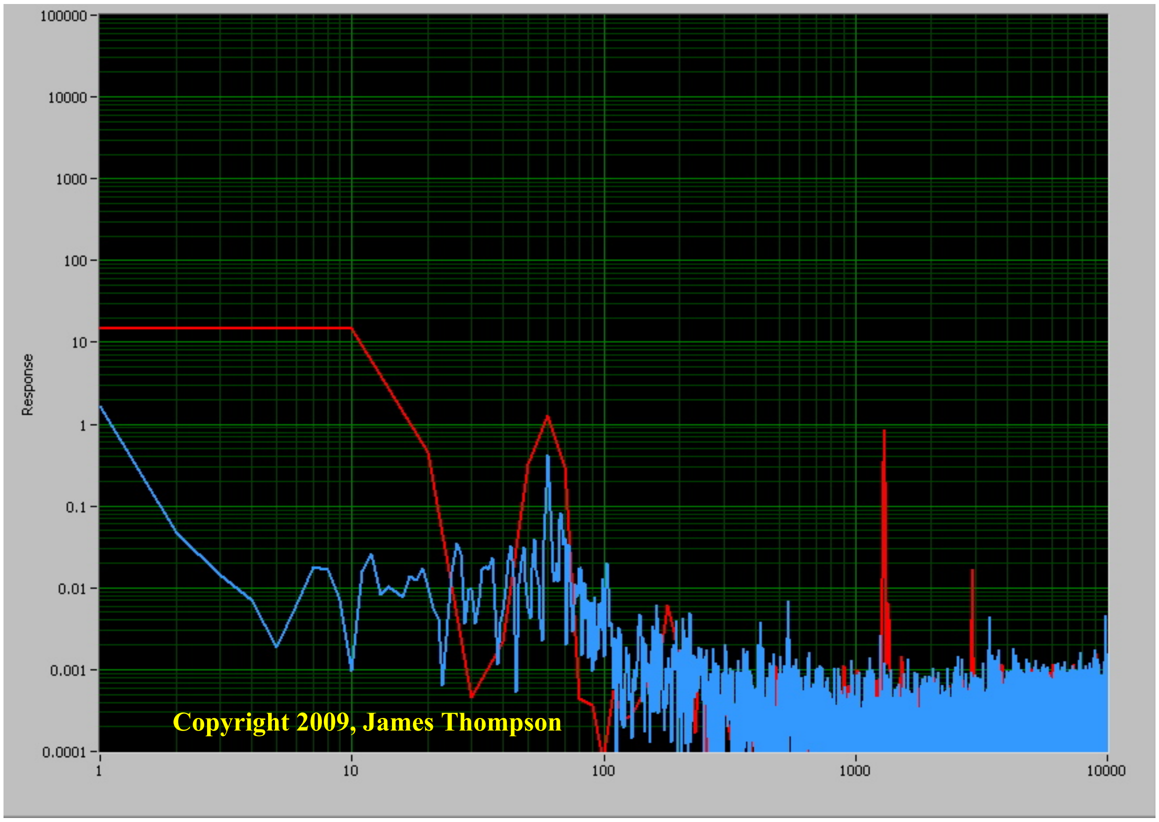

Figure 5 FFT of cured foam filled leg rap data

To further confirm that the addition of polyurethane foam was effective in damping vibrations, I plotted the time history data from the before and after raps (Figure 6). It is very clear from the measured data that for the same strength rap, the foam filled leg's vibration is much more quickly damped than the empty leg. The use of foam in the leg results in vibration damping out about 16 times faster than for the stock empty leg.

From the results of my little experiment I believe that my idea was a success. For a minimal additional weight (~60 to 100g per leg) and very small cost (~$1 per leg) I have greatly improved the ability of the tripod legs to dampen out vibration. My only suggestion for improvement would be to use a 2-component spray foam instead of the 1-component foam. I had difficulty getting the 1-component foam to cure inside the center of the leg, and eventually had to use a messy process of adding water into the leg to assist the curing process. The 2-component foam cures by a chemical reaction, and is ideally suited to this application.

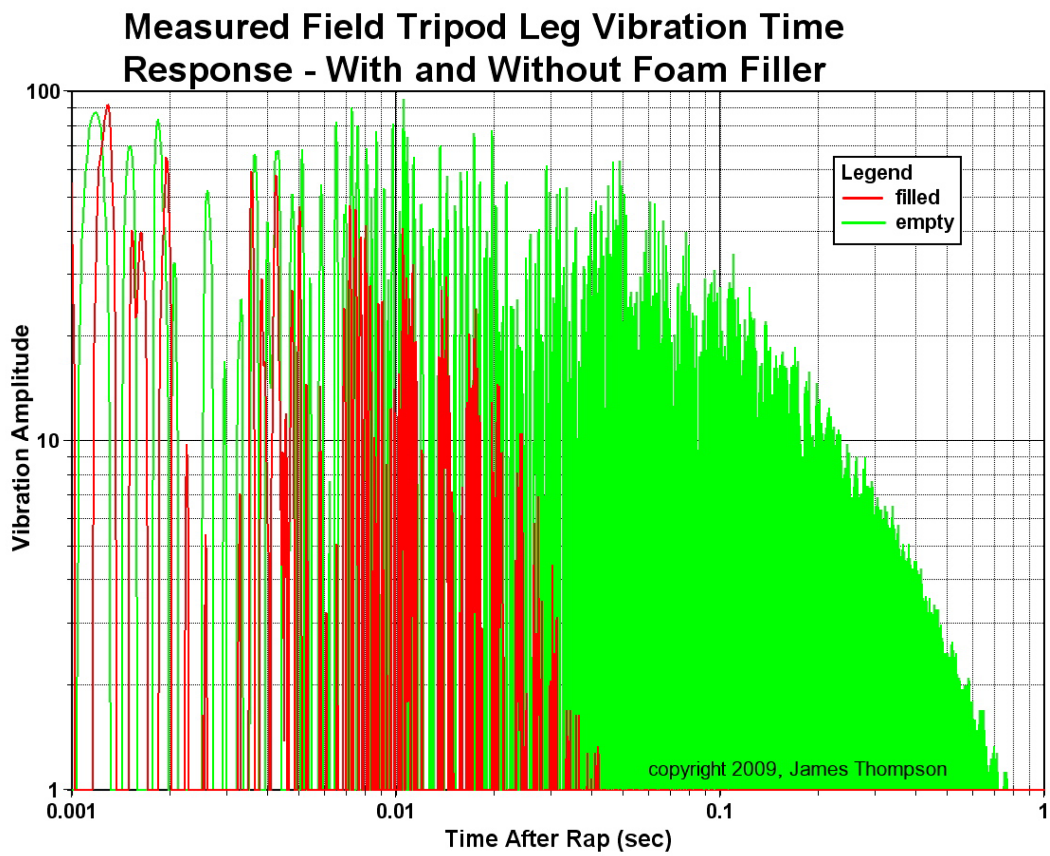

Figure 6 Leg vibration time history, with & without foam

I don't know if your engineering/design group has already considered this idea in your tripod designs. If not, please let me know your opinion of the idea, and whether or not it has any commercial merit. Feel free to contact me if you have any additional questions.

Best Regards,

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