Ph.D. Quals Question
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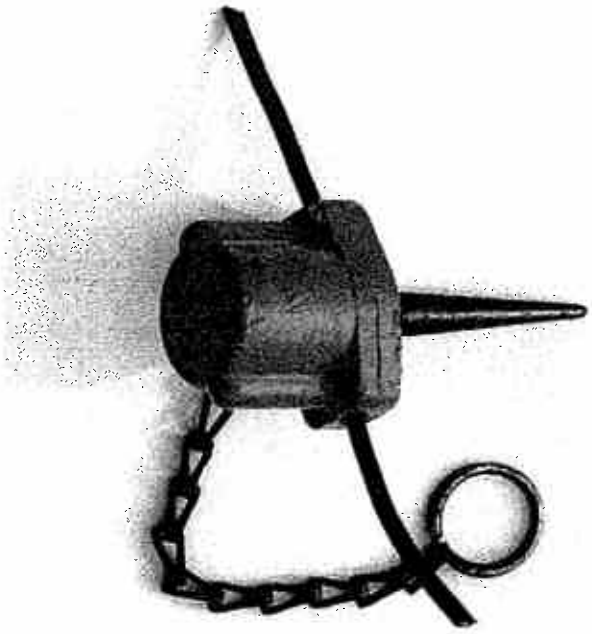
The Geophone

The picture below shows the device that was placed on the table in front of each student being examined. It is a geophone, a device that is used in large numbers by oil companies and other Earth resources companies to prospect for valuable minerals. What it does is measure Earth vibrations, i.e., it converts vibration of the ground into a voltage that can be measured by an appropriate instrument (e.g., a voltmeter) attached to the wires emerging from the device. The picture below doesn't show its scale; the ring on the chain is just large enough to hold a quarter. The student is shown the device, encouraged to shake it (there is clearly something loose inside its body) and asked how they think it works.



A Geophone

Scoring for this question consisted generally of 6 points for a scientifically-valid consideration of the way vibrations of the device are converted to a voltage, with 4 more points for a reasonable discussion of its actual frequency response as compared with what users might consider an ideal response.

A number of students thought the spike sticking out to the right in the picture above was an antenna. This is not an unreasonable assumption but the spike is really just that and it is meant to hold the device firmly in place on the ground (implications for frequency response?). There was no penalty for making the antenna assumption. The device contains a cylindrical magnet suspended by leaf springs and free to move along the device's axis. The magnet is surrounded