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Improvement of seismometer for moonquake observation on LUNAR-A mission

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The LUNAR-A mission will send two penetrators to the Moon to study its internal structure. Each penetrator has two seismometers which detect horizontal and vertical ground motion respectively. The seismometers are designed to be approximately 10 times more sensitive than either the Apollo short period the long period seismometer. In the course of precise investigation to characterize the seismometer, we found significant hysteresis of the neutral position of the moving coil. From our analysis of the calibration data, the hysteresis is estimated up to 40 micronmeters. One possibility is that it is caused by the effect of frictional force which disturbs the coil movement. If the frictional force is applied to the coil movement, it is not be possible to detect minute seismic waves. We examine the coil motion using a laser sensor for measuring displacement with precision of 0.5 micrometers. As a result of this experiment, we found the frictional effect is not the cause because the continuous change of displacement was observed with gradual increment of the current load. From our further experiments, we found that two factors might be the caused for the nonlinear behavior of the moving coil. One is the unstable motion of flat shaped diaphragm springs, and the other is magnetic hysteresis of the components of the seismometer. Especially, two small pieces of pure iron which are used for adjustment of the frequency response lead to the large hysteresis. In order to fix the above hysteresis behavior, we adopt a pre-bent diaphragm spring to eliminate unstable position mechanically, and the pure iron pieces were replaced by 78 permalloy pieces to minimize magnetic hysterisis as much as possible. These changes of the seismometer components reduced significantly the hysteresis of the coil movement. This may be caused by the small hysterisis of other components of the seismometer. In order to check the overall function of the lunar seismometers, in situ observation of ground motion was carried out at Inuyama Seismic Observation using our improved sensor and Mark L4 seismometer at the same time. The comparison of the wave forms obtained by the two seismometers shows the improved lunar seismometer is correctly responding to the ground motion.