HIGH-Tc SUPERCONDUCTING ACCELEROMETER

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Abstract

Ultra-high resolution accelerometer is required in completing the high precision airplane inertial navigation system employing a gravity gradiometer which compensates the geodetic induced error and is also required in micro-g environment in space. The resolution of the conventional accelerometer is limited in the order of $10^{-6}g_E$. On the contrary, superconducting accelerometer has the potential of $10^{-12}g_E$. In National Aerospace Laboratory (NAL), a principle model of a high-Tc superconducting accelerometer operated at the liquid nitrogen temperature (77K) was designed, manufactured and evaluated and some of the characteristics are described in this paper.

1. Introduction

Ultra-high resolution accelerometers are required in the field of aerospace for detecting micro-g environment. An accelerometer consists of a proof mass and elastic coils. Superconducting accelerometer also has the same construction. Paik[1] has developed superconducting accelerometers and pointed out that the potential sensitivity is estimated with an order of $10^{-12}g_E/Hz^{1/2}$ (where g_E=9.8ms^{-2} Earth gravity) under 50Hz frequency range and Hoffman[2] has proposed superconducting fluxgradient accelerometer whose sensitivity is expected to be $9\times10^{-20}(\Box f)^{-1/2}$m, where $\Box f$ is the bandwidth of the amplifier. The sensitivity capability is almost the same as that of Paik.

A principle model of a high-Tc superconducting accelerometer operated at the liquid nitrogen temperature(77K) is developed and preliminary results are obtained.

2. Experimental Model

NAL has studied a high-Tc superconducting accelerometer for aerospace application. Fig.1 shows the constitution of the trial manufactured superconducting accelerometer. They are permanent magnet(instead of superconducting coil for easy construction) for magnetic flux supply, superconducting proof mass(inertia mass) which is fixed to the inertial frame, SQUID(Super-conducting Quantum Interference Device) magnetometer for detecting the magnetic flux variation and superconducting magnetic shield vessel. The material of this superconductor is YBCO($YBa_2Cu_3O_{7-y}$) with 92K critical temperature. Proof mass and permanent magnet are arranged and cooled in a liquid nitrogen filled vessel which shields the external magnetic fluxes. If an acceleration(□g) acts on this accelerometer, the distance(x) between the proof mass supported with a hinge and permanent magnet is deviated from its normal position with a small distance(□x), which causes a small flux change(□□) induced by the permanent magnet. □□ is detected by the SQUID magnetometer and converted to the output voltage(□v).

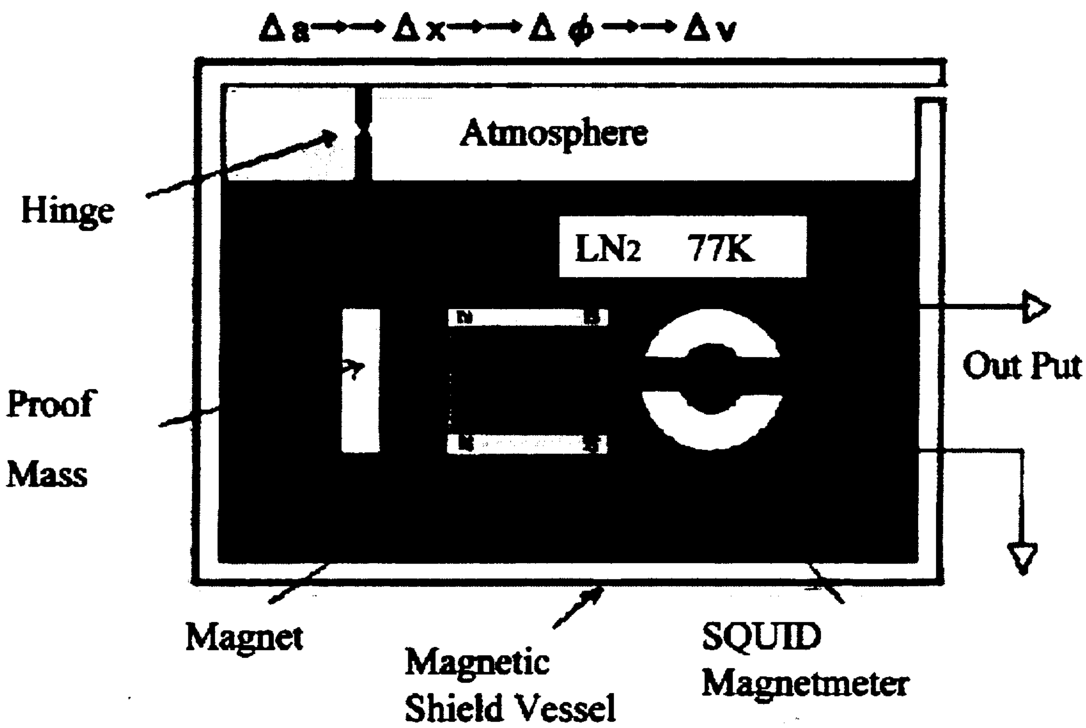
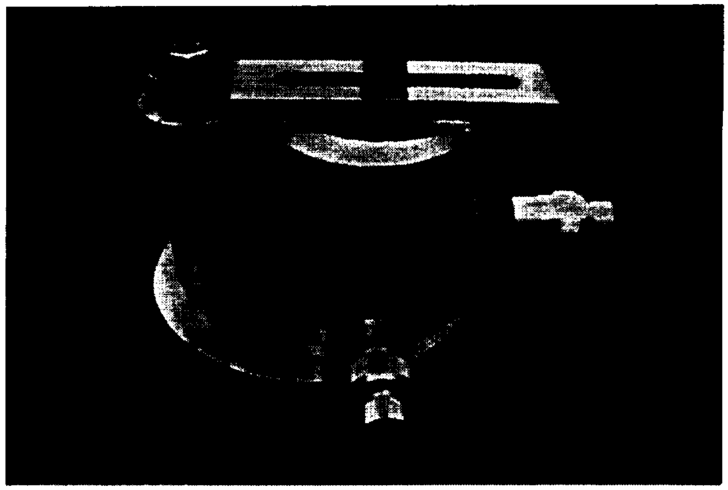


Fig. 1 Conceptual Model of experimental high-Tc superconducting accelerometer



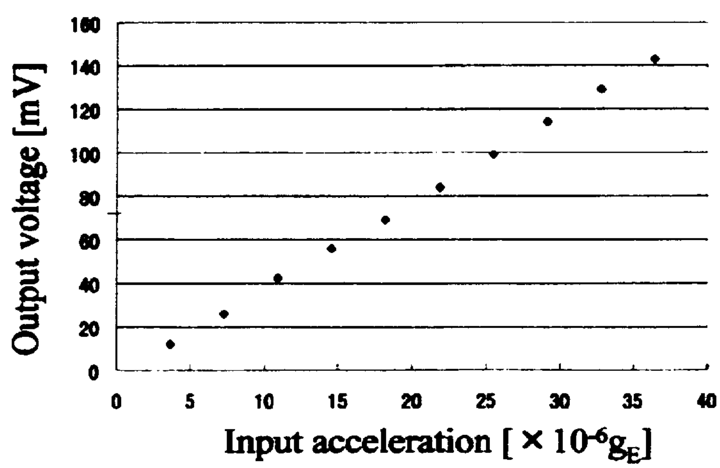
160 dia. × 225 mm
Dimension of the accelerometer

Fig.2 Trial-manufactured Experimental Model

The manufactured model is shown in Fig.2. The proof mass is supported by the left-side pole and the distance between the proof mass and permanent magnet is positioned by adjusting the two micrometers shown in this figure for the determination of the high sensitivity position

3. Preliminary Experimental Data

Fig.3 shows the measured output voltage versus input acceleration. The linearity



Typical output data of the accelerometer

Fig. 3 Measured Acceleration Linearity

is obtained in the range of $10^{-6}g_E$ order. The measurement under this level is limited by the accelerator itself at this time. The sensitivity $10^{-7}g_E$ order will be expected by the improvements of the measured system.

4. Concluding Remarks

High-Tc superconducting accelerometer was designed and manufactured for aerospace applications. From the evaluations of the principle model, the potential capability for detecting low-level acceleration by applying the high-Tc superconductors was confirmed. Magnetic flux analysis is ongoing for the improvement of sensitivity and the optimization of the mechanical arrangement. Miniaturization of the system is necessary for practical use in aerospace applications.

References

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[2] A.W Hoffman et.al.:Fluxgradient accelerometer;Test on a working model. Rev.Sci.Instrum. Vol.47, No.12, pp1441-1444, 1976