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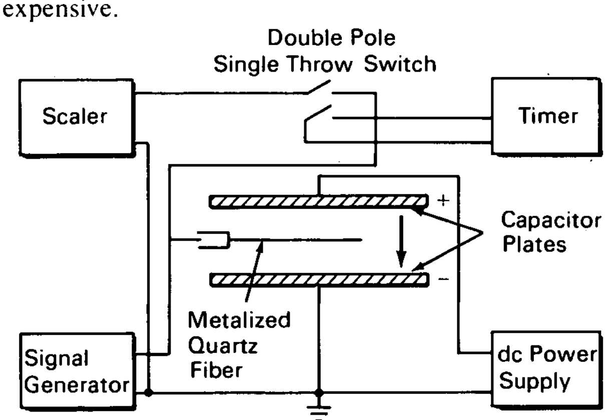
Microbalance Accurately Measures Extremely Small Masses

The problem:

To develop a simple, highly sensitive device for measuring a wide range of masses, particularly extremely small particles. Existing devices, although quite accurate, are not sensitive enough to weigh extremely minute quantities, especially under 10^{-6} gram; also, they require calibration and are usually expensive.



Microbalance Schematic

The solution:

An oscillating fiber microbalance capable of accurately weighing masses as small as 10^{10} gram. This balance, considerably more sensitive than any commercial microbalance, consists of a vibrating quartz fiber used as the balance arm to hold the mass to be weighed. Increasing the weight of the fiber decreases its resonant frequency. The weighing technique is relatively simple, but requires some degree of operator skill.

How it's done:

As shown in the figure, the oscillating fiber microbalance consists of a metalized fiber held rigidly at one end, inserted between two metal plates. The free end of the fiber is viewed through a microscope. An electrical potential is applied to the plates and a sinusoidal signal to the fiber. As the frequency of the signal is varied, the fiber oscillates and displays resonances; the resonant frequencies are dependent upon the physical parameters of the fiber. For greatest sensitivity, the highest easily observed harmonic is selected. The frequency measurement are made with a scaler in conjunction with a timer. When the mass is added to the end of the fiber, the resonant frequency decreases. The magnitude of the shift depends upon the amount of mass added.

Particles are attached to the fiber end by minute quantities of adhesive. The fiber is removed from its holder, and the adhesive carefully applied so that it contributes only a negligible amount of mass with respect to the particle to be weighed. The particle is then brought in contact with the adhesive, adhering to the fiber, and the entire assembly is replaced between the capacitor plates so that a new resonant frequency with the particle can be determined.

Each fiber is calibrated using microspheres of known material, such as aluminum or nickel, whose density, size, and thus mass, are known. Calibration particles are mounted as described and the resonant frequencies are measured. A calibration curve for the fiber can be drawn showing mass added versus frequency. Other means of calibrating are possible, such as electrodepositing material at the end of the fiber.

Aside from using thinner or longer fibers for increased sensitivity, the instrument is designed so that the cavity between the two plates can be evacuated, reducing damping effects. The resonant frequency peaks become sharper and increased in amplitude.

(continued overleaf)

This instrument has the following advantages over conventional balances: 1) a sensitivity of 10^{10} gram; 2) accuracy of 1 or 2%, even at the lowest ranges; 3) a ruggedness to withstand considerable physical abuse; 4) calibration stability at normal room temperatures; 5) a large measurement range, dependent only upon the fiber dimensions; and 6) low cost.

Notes:

1. The greatest sensitivity (10^{-10} gram) has been acquired with a 7-μ diameter, 1-cm long, gold-overcoated quartz fiber.
2. No additional documentation is available. Specific questions, however, may be directed to:

   Technology Utilization Officer
Headquarters
National Aeronautics
and Space Administration
Washington, D.C. 20546
Reference: B70-10607

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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