Vibrating Sample Magnetometer

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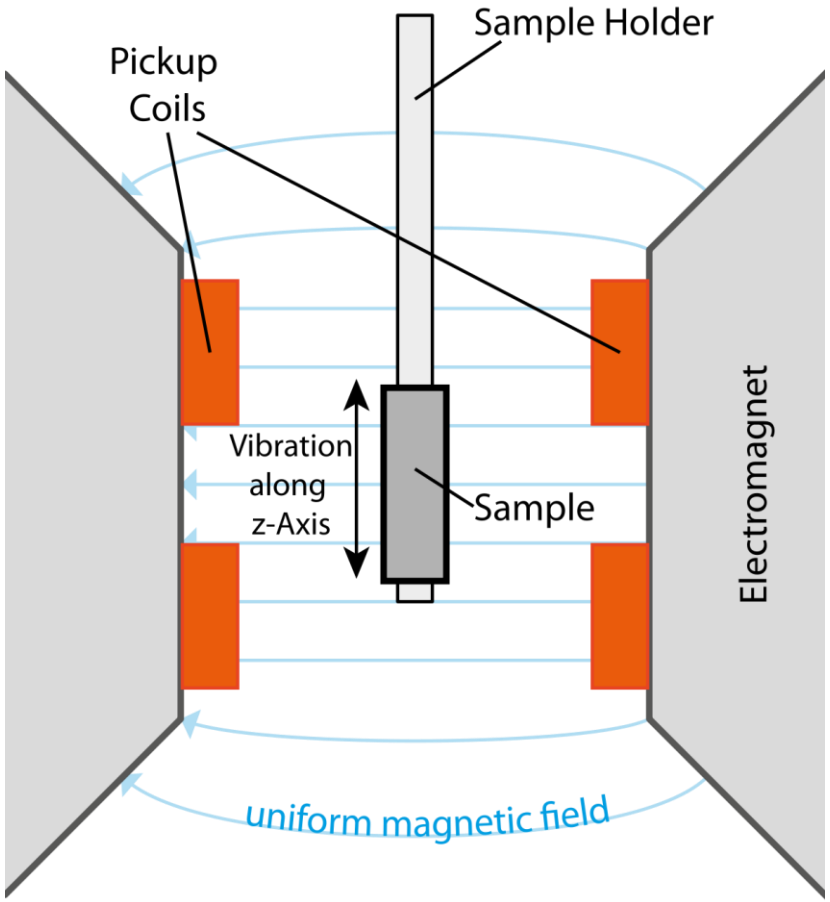
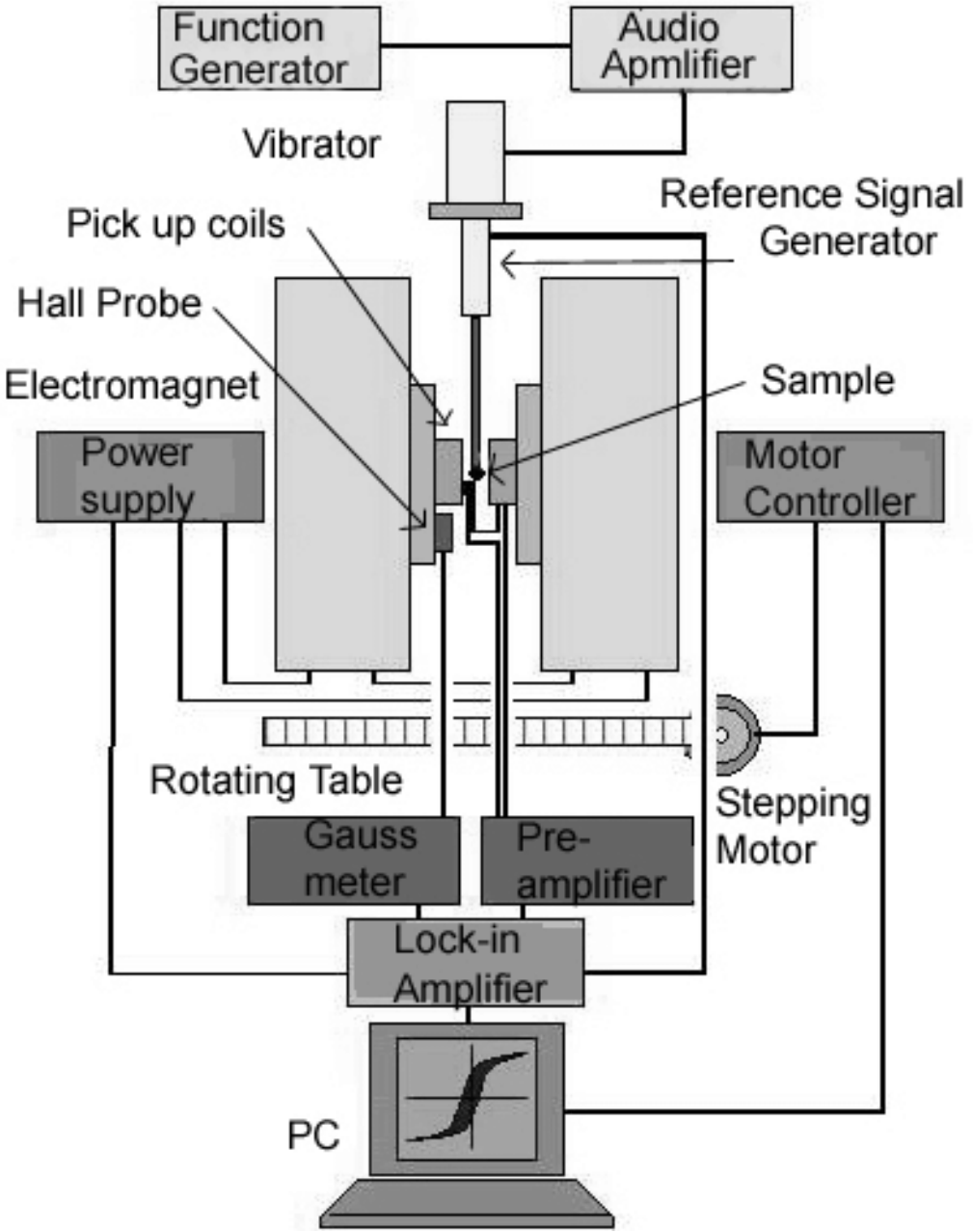
Working principle

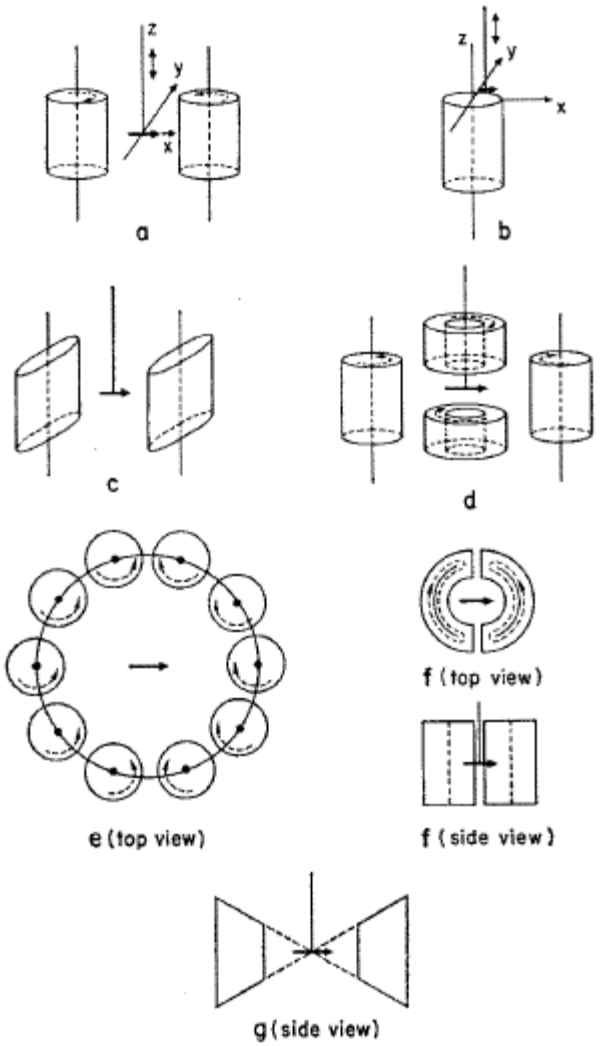
A Vibrating Sample Magnetometer (VSM) is a scientific instrument able to measures magnetic properties of materials in an external magnetic field, invented in 1955 by Simon Foner at Lincoln Laboratory MIT. A VSM converts the dipole field of the sample into an ac electrical signal. The sample is placed inside a uniform magnetic field and then vibrated sinusoidally. That creates a corresponding variation of the magnetic flux in pickup coils placed nearby, inducing a sinusoidal voltage. The amplitude of the ac voltage is proportional to the sample magnetic moment and measured by a lock-in amplifier.



Detailed mechanical features of a vibrating sample magnetometer



Detection coil arrangements in VSM



The coil configuration shown in Fig. (a) has been employed extensively for almost all our magnetic measurements. This arrangement has proved both easy to assemble and most convenient in operation. An arrangement of a single coil, useful when very high fields are required, is shown in Fig. (b). Oval-shaped coils, shown in Fig. (c), have also been used extensively.

In particular, Fig. a) may be modified by the addition of a pair of coils coaxial with the Z axis . With such an arrangement, the magnitude and direction of the magnetic moment vector in space can be determined-the Z component is detected by the coaxial pair, and the component in the *XY* plane is determined by rotating the double coil. Fig. e) shows a multiple-coil arrangement which attempts to intercept a maximum of the sample dipole field, but at the expense of additional thermal noise of the coils. Four coils of this multi-coil array have been used for high-field configurations. An efficient modification of Fig. e) is shown in Fig. (f); this coil geometry, however, is not easily fabricated. Finally, the cross section of a coil geometry which reflects most of the dipole field symmetry properties is shown in Fig. (g).

Electronic circuits in VSM

The functions of the associated electronic circuits are:
(1) to permit accurate calibration of the signal output obtained from the detection coils,
(2) to produce a convenient dc output signal which is directly related to the input and which can be recorded,
(3) to provide sufficient amplification for high sensitivity operation.

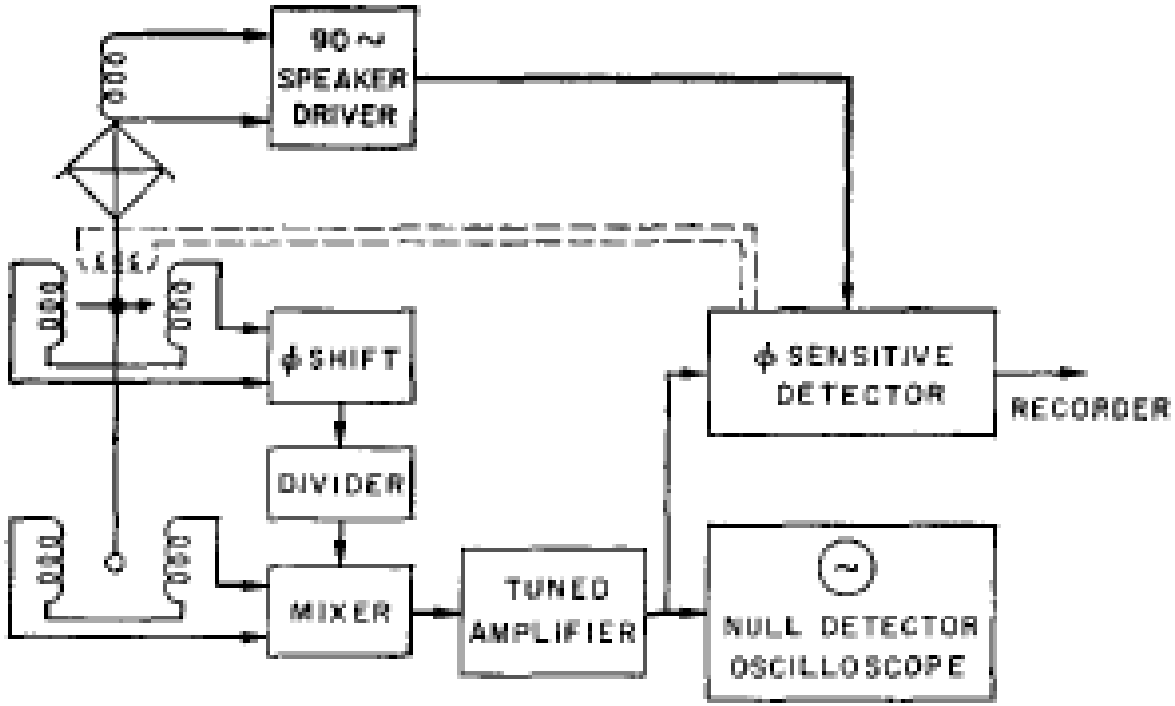


FIG. 9. Block diagram of electronic system for magnetometer. Relevant components of the magnetometer are indicated pictorially.

Applications of vibrating sample magnetometer

A. Magnetic Measurements

1. Low-Conductivity Materials - spherical or approximately ellipsoidal sample shapes are used for magnetic moment versus field measurements of ferri- or ferromagnetic materials, so that accurate corrections for demagnetizing fields can be made. Measurements on single crystals are generally made with spherical samples of constant demagnetizing factor, although thin disks are also satisfactory.

2. High Conductivity Materials - many high-conductivity metals are weakly magnetic and these induced currents will then add large contributions to the magnetic moment. Such effects can be minimized by vibrating the sample in a uniform region of magnetic field.

B. Measurement of Magnetic Field

Extremely small field volumes can be examined by vibrating a small thin flat disk such as a thin film of alloy in this region.


Thank you!