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NASA TECH BRIEF

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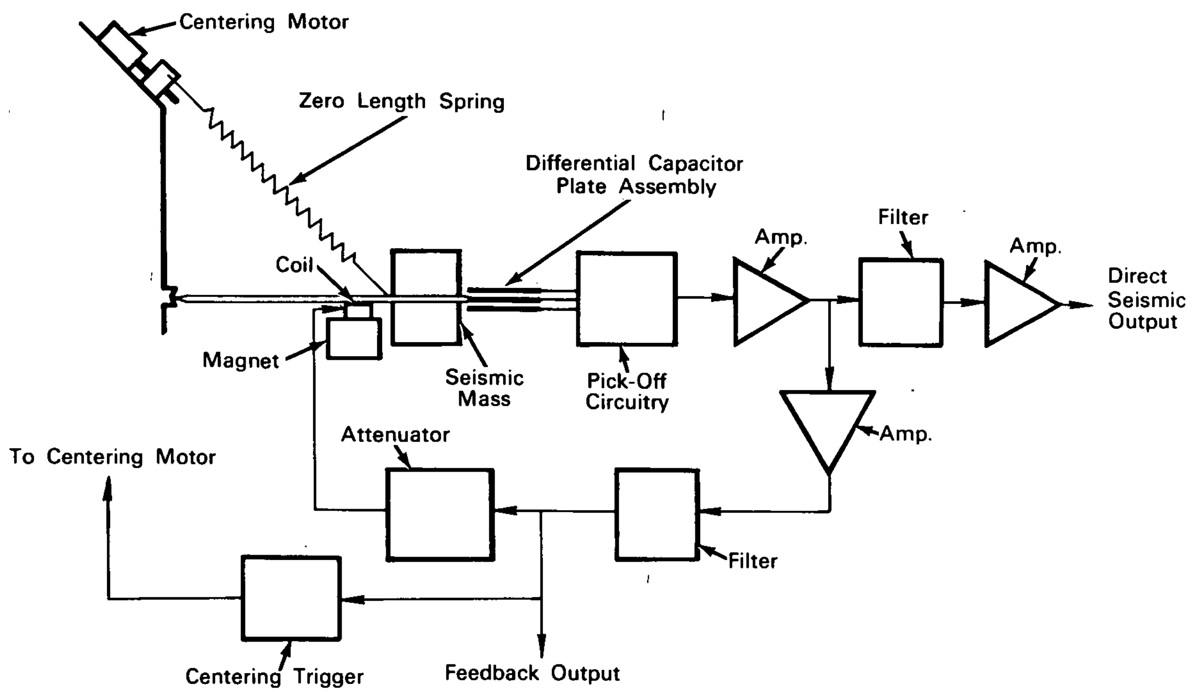
Unmanned Seismometer Levels Self, Corrects Drift Errors



The problem: Detecting and recording earthquake waves where the seismograph must be put in a remote location and is unmanned. Certain kinds of seismic research, as at the ocean bottom or on the surface of the moon, requires a seismograph that has electronic equipment which allows the instrument to be both self-leveling and capable of automatic compensation for long-period drift errors.

Compensation for drift must be provided if the instrument is to remain centered within its operating range for long periods of time. Drift may be due to a combination of the following causes: thermal effects—changes in spring constants or structural dimensions; mechanical fatigue—deformation of the structure with time; barometric pressure—change in density of the surrounding medium; and gravitational effects—changes in zero position of the seismic mass.

The solution: An advanced design of a four-component, three-axis, feedback-controlled seismograph. Electronic circuitry is included for leveling, as well as monitoring the feedback signal required for servocentering. A matched set of three long-period seis-

(continued overleaf)

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mometers sense motion in two orthogonal horizontal directions and one in the vertical. A fourth seismometer, which is a short-period device, is also aligned in the vertical plane.

Automatic circuitry and mechanisms provide coarse initial leveling, fine leveling, viscous damping of the earth-motion signal, compensation of the residual long-term drift, and centering of the seismometers.

How it's done: A package of less than one cubic foot and weighing approximately 24 pounds contains three subsystems: a mechanical, an electronic pick-off and feedback, and a leveling and vertical centering subsystem.

Coarse leveling will allow installation on irregular surfaces or on a uniform surface slope up to 15 degrees. The coarse leveling device consists of three extensible legs mounted in an aluminum plate. All three legs are fully extended initially (3 to 4 inches). The first two legs to contact a surface are forced upward through base-plate bushing until the third leg makes contact. Small upward motion of the third leg clamps all three in place. The fine leveling system consists of a two-axis, motor-driven gimbal, with an accuracy better than ±10 seconds of arc.

Earth motions are detected by means of a seismic mass coupled to a coil-magnet assembly and a differential capacitor plate assembly. The coil-magnet assembly provides viscous damping and serves as a torqueing device for each sensing component. The differential capacitor plate assembly consists of three parallel brass plates—two outer plates fixed to the seismic mass and a center plate fixed rigidly to the frame. There is approximately 1 millimeter spacing between plates.

Feedback control to compensate for residual drift is obtained by feeding a portion of the output signal back through a low-pass filter to the coil of the coil-magnet assembly provided for damping the seismometer.

If drift proceeds to such an extent that feedback current is no longer able to maintain the seismic mass centered within tolerable limits, the threshold of a trigger circuit which monitors feedback signal is exceeded. Firing of the trigger circuit supplies power to the centering motor which adjusts the elastic suspension until the feedback signal again falls below the trigger threshold value.

Centering of each horizontal component is accomplished in the same manner except that the centering motor tilts the instrument base-plate in a direction perpendicular to the plane of the instrument.

The short-period vertical seismometer is also feedback controlled. Signal is provided by a self-generating coil-magnet transducer. The magnet portion of the transducer is suspended elastically by means of copper-beryllium spider springs and hence serves as the seismic mass.

The breadboard system, including electronics, coarse leveler, short-period vertical component, three long-period components, and gimbal assembly, weighs approximately 35 pounds.

Notes:

1. This is a specialized instrument that would be suitable for universities, seismographic research firms, or government-sponsored organizations interested in the detection of elastic waves from earthquakes or powerful explosions and the gathering of such data over long periods of time. Concepts incorporated in this instrument are expected to aid seismic data acquisition by scientific and industrial groups on a world-wide basis.
2. For further information about this innovation inquiries may be directed to:
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   Goddard Space Flight Center
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Patent status: NASA encourages commercial use of this innovation. No patent action is contemplated.

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