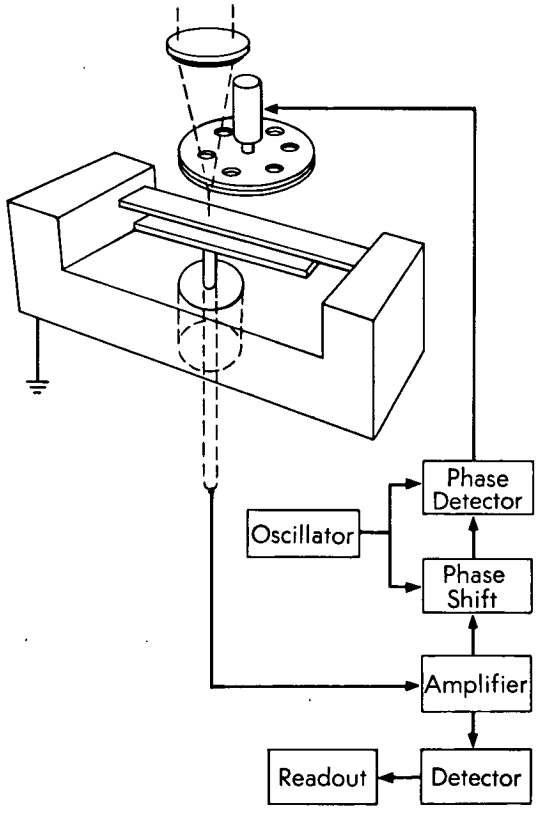
NASA TECH BRIEF
Ames Research Center

Vibrating Ribbon Bolometer — A Concept

Devices for measuring the power of low-intensity electromagnetic radiations ordinarily are based on the principle that heat is developed when the radiation strikes a sensitive element. In the devices which are called bolometers, radiant power is correlated with a change in the value of an electrical element (resistance, capacitance, or inductance); other devices, such as a Golay cell, correlate the pressure of a fixed volume of gas as it is altered by energy absorbed from the incident radiation. The sensitivity of these transducers is limited by electrical noise, stability of structure, inadequate thermal insulation, etc. A new type of bolometer, based on a thermomechanical principle, is described in the following paragraphs. It differs from other bolometers in that a sensitive element is maintained in a state of resonant oscillation by incident pulses of electromagnetic radiation, and the amplitude of the oscillation is correlated with the power of the incident radiation.

As indicated in the diagram, electromagnetic radiation is focused by a lens onto a very thin, conducting ribbon; the ribbon is mounted under tension between opposed arms of a rigid support. The beam of radiation is periodically interrupted by a light-chopping disc driven by a servo motor. A fixed, elongated electrode is aligned with the ribbon but maintained at a small distance so that the electrode and ribbon become the elements of a capacitor which is to be used as a sensor. The fixed electrode is attached to an insulated conductor; the ribbon support structure serves as the contact for the ribbon. The capacitance of the sensor varies as a function of the spacing between these members, and since the periodically interrupted radiation causes a rhythmic heating and cooling of the ribbon, the ribbon expands and contracts; as the ribbon moves toward or away from the fixed electrode, there is a periodic variation in capacitance. The amplitude of the periodically varying capacitance is, of course, relatable to the intensity



of the incident radiation and serves as a sensitive indicator of the power level of the incident radiation.

For maximum sensitivity, the beam of incident energy must be interrupted at the natural resonance frequency of vibration of the ribbon or at a suitable

(continued overleaf)

harmonic of this frequency. To accomplish this, the capacitor formed by the ribbon and the fixed electrode is connected to the input of an AC power amplifier and the output of the amplifier is fed to a phase-shift network which is modulated by a local oscillator tuned to the fundamental resonant frequency of the ribbon (or a harmonic); the alternating phase output of the phase-shift network is then compared in a phase-sensitive detector with a reference signal from the local oscillator and converted to a DC signal.

If the ribbon is vibrating at the resonance frequency (or a harmonic), maximum system response is attained, and the alternating phase shift introduced by the modulated phase shifter causes equal attenuation on both half-cycles of the modulation. As a result, the phase detector does not generate an output. If the frequency of vibration of the ribbon begins to drift away from resonance, an output is generated by the phase detector with a polarity which depends on the direction of drift. Accordingly, the output of the phase detector is used to vary the speed of the disc so that the output is reduced to zero, that is, the rotation of the disc is stabilized at the speed for which the beam is interrupted at the resonance frequency of the ribbon or some harmonic thereof. The output of the AC power amplifier is also fed to a detector which generates a signal that varies directly with the input capacitance and is therefore used to provide indication of the power in the incident radiation.

Notes:

1. As is typical of all bolometers, maximum sensitivities are obtained when the ribbon assembly is in a good vacuum and the entire device is kept at a very low temperature.
2. The new bolometer can be employed with other devices for detecting the motion of the ribbon, e.g., optical strain gages or inductive devices.
3. Requests for further information may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: TSP 72-10170

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,508,053) and royalty-free license rights will be granted for its commercial development. Inquiries about obtaining a license should be addressed to:

Patent Counsel
Mail Code 200-11A
Ames Research Center
Moffett Field, California 94035

Source: John Dimeff
Ames Research Center
(XAC-10768)