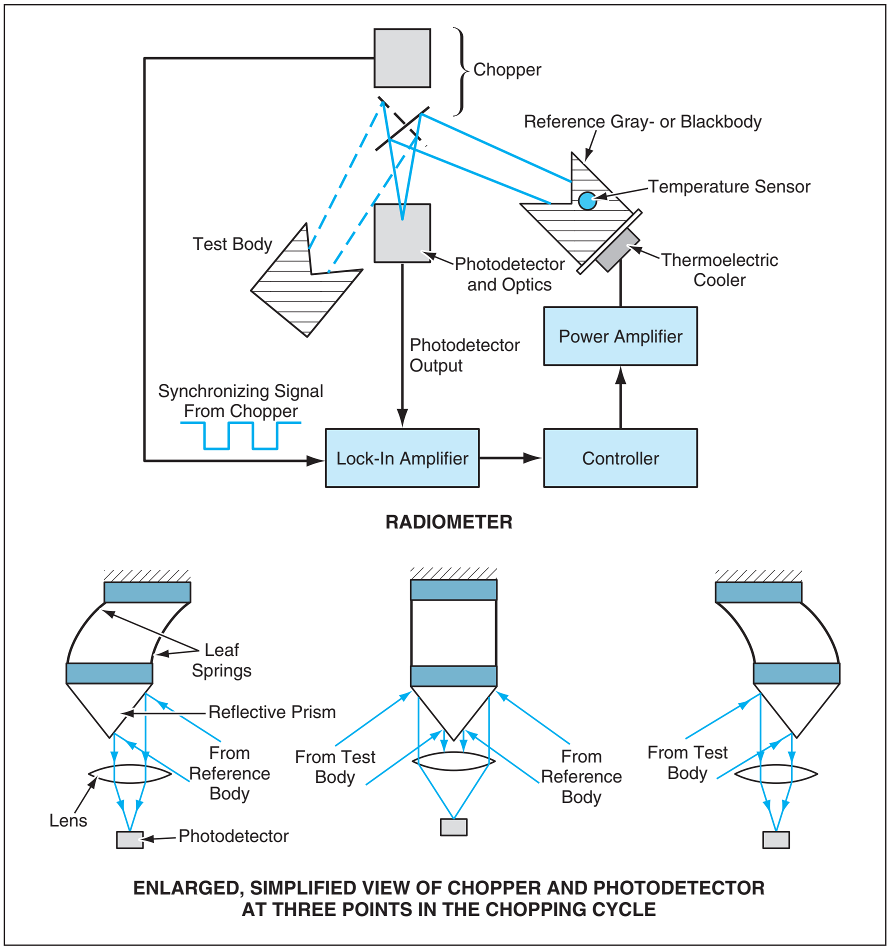
Nulling Infrared Radiometer for Measuring Temperature

A microwave-radiometer self-calibration principle would be adapted to measurement of infrared.

Stennis Space Center, Mississippi

A nulling, self-calibrating infrared radiometer is being developed for use in noncontact measurement of temperature in any of a variety of industrial and scientific applications. This instrument is expected to be especially well-suited to measurement of ambient or near-ambient temperature and, even more specifically, for measuring the surface temperature of a natural body of water. Although this radiometer would utilize the long-wavelength infrared (LWIR) portion of the spectrum (wavelengths of 8 to 12 μm), its basic principle of operation could also be applied to other spectral bands (corresponding to other temperature ranges) in which the atmosphere is transparent and in which design requirements for sensitivity and temperature-measurement accuracy could be satisfied.

The underlying principle of nulling and self-calibration is the same as that of a typical microwave radiometer, but because of differences between the characteristics of signals in the infrared and microwave spectral regions, the principle must be implemented in a different way. The instrument (see figure) would include an infrared photodetector equipped with focusing input optics [e.g., lens(es) and/or mirrors] and an input LWIR band-pass filter. An optomechanical device would periodically chop the input to the photodetector between a reference gray body (ideally, a blackbody) and a test body (the temperature of which one seeks to measure). The reference body would be mounted on or in a heater, a thermoelectric cooler, or other temperature-control device suited to the particular application. If needed, a band-pass LWIR filter could be placed in front of the photodetector.



This **Infrared Radiometer** would exploit a nulling, self-calibrating principle that, heretofore, has been the basis of design and operation of many microwave radiometers. The leaf-spring resonator design of the chopper would be an important element of the overall design of the instrument.

The AC component of the photodetector output would be fed to a lock-in amplifier. The reference or synchronization signal for the lock-in amplifier would be derived from a device that monitored the motion of the chopper. The output of the lock-in amplifier would be a rectified signal approximately proportional to the difference between the radiances of the test body and the reference body. This signal would be used as an error signal in a feedback control loop, which would adjust the power supplied to the temperature-control device and thereby adjust the temperature of the reference body in an effort to reduce the error to zero. The temperature of the reference body would be measured by any of a variety of commercially available contact temperature sensors, which can routinely afford accuracy and long-term stability within 0.1 K. Hence, as long as the error voltage remained at zero and assuming that the emissivities and other radiant properties of the test and reference bodies were sufficiently similar, it could be assumed that the measured reference-body temperature was a close approximation of the test-body temperature.

Initial development efforts have been concentrated on the chopper, which is a major innovative feature of the instrument design. The desired characteristics of the chopper include pure chopping, low power consumption (a few milliwatts), high reliability (millions of cycles), and a chopping frequency of several hertz. "Pure chopping" signifies that at any given instant of time, the infrared radiation incident on the photodetector would be that from the test body and/or the reference body and not from the chopper itself and that, moreover, during one designated portion of the chopping cycle, the photodetector would "see" only the test body while during another designated portion of the cycle it would "see" only the reference body.

The chopper design under consideration at the time of reporting the information for this article calls for an electromechanical resonator comprising two permanent magnets and a reflective prism mounted on leaf springs. Each permanent magnet would interact with one of two electromagnet coils. One electromagnet coil would be driven by amplifier to excite vibrations. The other electromagnet coil would serve as a pickup coil, providing feedback to the amplifier to set up oscillations at the mechanical resonance frequency.

This work was done by Robert Ryan of Lockheed Martin Corp. for **Stennis Space Center**.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Intellectual Property Manager, Stennis Space Center; (228) 688-1929. Refer to SSC-00124.

The Ames Power Monitoring System

Power demand can be managed to reduce cost.

Ames Research Center, Moffett Field, California

The Ames Power Monitoring System (APMS) is a centralized system of power meters, computer hardware, and special-purpose software that collects and stores electrical power data by various facilities at Ames Research Center (ARC). This system is needed because of the large and varying nature of the overall ARC power demand, which has been observed to range from 20 to 200 MW. Large portions of peak demand can be attributed to only three wind tunnels (60, 180, and 100 MW, respectively). The APMS helps ARC avoid or minimize costly demand charges by enabling wind-tunnel operators, test engineers, and the power manager to monitor total demand for center in real time. These persons receive the information they need to manage and schedule energy-intensive research in advance and to adjust loads in real time to ensure that the overall maximum allowable demand is not exceeded.

The APMS (see figure) includes a server computer running the Windows NT operating system and can, in principle, include an unlimited number of power meters and client computers. As configured at the time of reporting the information for this article, the APMS includes more than 40 power meters monitoring all the major research facilities, plus 15 Windows-based client personal computers that display real-time and historical data to users via graphical user interfaces (GUIs). The power meters and client computers communicate with the server using Transmission Control Protocol/Internet Protocol (TCP/IP) on Ethernet networks, variously, through dedicated fiber-optic cables or through the pre-existing ARC local-area network (ARCLAN).

The APMS has enabled ARC to achieve significant savings ($1.2 million in 2001) in the cost of power and electric energy by helping personnel to maintain total demand below monthly allowable levels, to manage the overall power factor to avoid low power factor penalties, and to use historical system data to identify opportunities for additional energy savings. The APMS also provides power engineers and electricians with the information they need to plan modifications in advance and perform day-to-day maintenance of the ARC electric-power distribution system.

This work was done by Leonid Osetinsky of Jacobs/Sverdrup Technology and David Wong of **Ames Research Center**. *For further information, please contact:*

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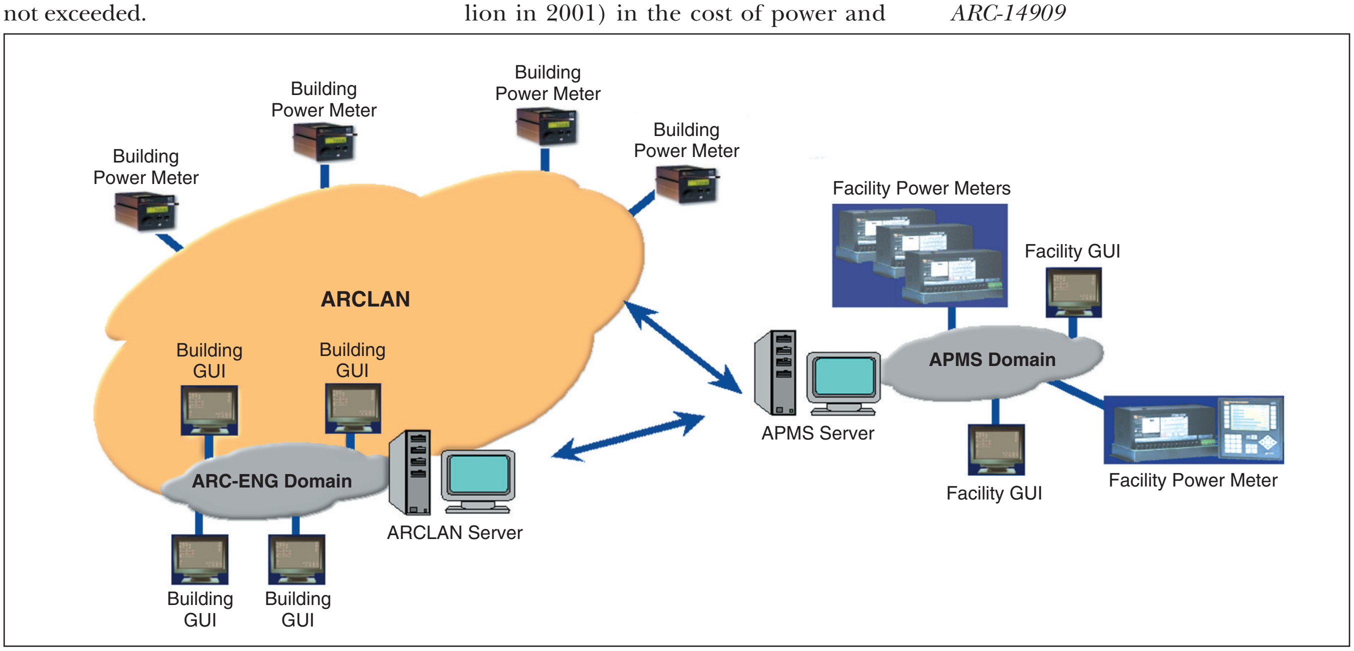

The **APMS** collects, stores, and displays data on the consumption of electric power in major subsystems of the ARC power-distribution system.