two-dimensional configuration of which is dictated by the need to match the rectangular duct cross section.

The flow into and out of the venturi passages is guided by the airfoil surfaces. There are two half airfoils at the top and bottom of the inlet, and there are five full airfoils between them. A plenum downstream of the trailing edges allows the flow to even out prior to entering the screens and flow straighteners. To enable measurement of pressure in all six throats, tubes in three of the airfoils are connected to a manifold, and narrow holes connecting the tubes with the throats are drilled in these airfoils. The pressures sensed at the six throat measurement locations become averaged together in the manifold, which is connected to one side of a sensitive differential-pressure transducer. The other side of the transducer is exposed to the pressure just upstream of the inlet. It has been found that the speed-vs.-pressure calibration curve is highly repeatable, enabling measurement of flow speed to within an error of ±0.2 cm/s.

This work was done by Frank Quinn and Kevin Magee of ZIN Technologies, Inc. for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18021-1.

Measuring Thermal Conductivity of a Small Insulation Sample

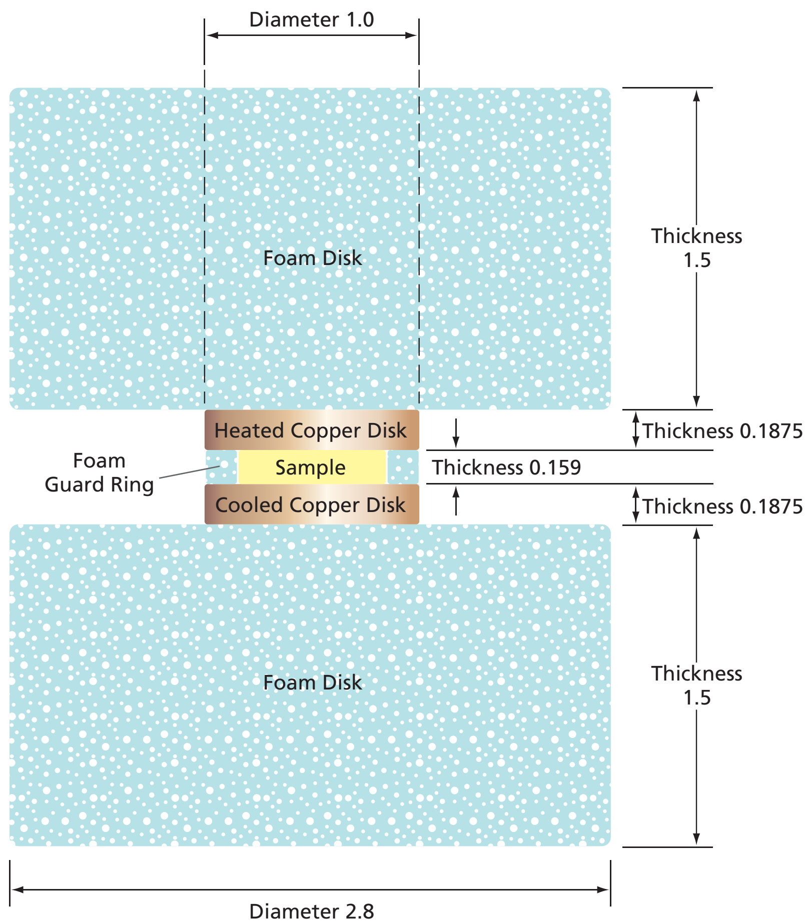
Heat leakage is accounted for in design, operation, and calculation.

John H. Glenn Research Center, Cleveland, Ohio

An instrumentation system for direct measurement of the thermal conductivity of a small sample of a highly insulating material has been devised. As used here, (1) "small" signifies having dimensions of the order of two centimeters — significantly less than the sizes of specimens for which prior devices for direct measurement of thermal conductivity have been designed; and (2) "highly insulating" signifies having thermal conductivity of the order of that of air.

The heart of the system is an assembly that includes two copper disks — one electrically heated, the other cooled with chilled water. The disks are separated by a guard ring made of strong, thermally insulating polymethacrylamide foam. The sample fits between the copper disks and within the ring (see figure). Matched thermocouples are used to measure the temperatures of the heated and cooled disks. The heated and cooled disks are affixed to larger foam disks, and the essentially still air in the gap between the larger disks insulates the sides of the specimen. This air gap region can be further divided by extending the foam ring into the gap region. The entire assembly as described thus far is lightly clamped together by means of nylon threaded rods and is placed inside a cylindrical chamber wherein the temperature is maintained at a set value (typically, 25 °C).

The electric power supplied to the heated disk is adjusted to maintain the temperature of this disk at a fixed value (for example, 35 °C) that exceeds the temperature in the chamber by a fixed amount. Similarly, the supply of chilled water to the cooled disk is regulated to maintain the temperature in this disk at a



This Assembly is Mounted in a constant-temperature chamber. The heated and cooled disks are maintained at temperatures $\Delta T/2$ above and $\Delta T/2$ below, respectively, the chamber temperature. The thermal conductivity of the sample is determined from the heater power needed to maintain the $\Delta T/2$ temperature differential of the heated disk. (Note: The dimensions are in inches.)

value (in the present example, 15 °C) below the chamber temperature by the same fixed amount. Modeling shows that the resulting symmetry in the temperature differential, in combination with the geometric symmetry of the apparatus, serves to ensure that heat escaping from the edge of the heated disk flows through the air-gap region and, for the most part, returns to the edge of the cooled disk. It also ensures that the heat escaping from the half of the guard ring that is positioned toward the heated disk flows to the half of the guard ring positioned towards the cooled disk. This helps to assure one-dimensional heat flow through the sample, thereby minimizing the measurement errors. The time-averaged heater power needed to maintain the specified constant temperature of the heated disk in the steady state is what is measured.

The following description of the theory of operation and the calculation of thermal conductivity from measurement data is somewhat simplified for the sake of brevity. The heater power is nominally given by

$$Q = kA\Delta T/l + Q_L,$$

where k is the thermal conductivity of the sample material under test, A is the cross-sectional area of the sample (nominally, the area of the circle enclosed by the guard ring), ΔT is the specified difference between the temperatures of the heated and cooled disks, l is the thickness of the sample, and Q_L is the rate of leakage of heat along all paths other than that of direct one-dimensional thermal conduction through the thickness of the sample.

Modeling shows that the combination of temperature-differential and geometric symmetry and the one-dimensional heat flow through the sample ensures that the heat-leakage power is essentially independent of the sample material. Hence, it is possible to determine the value of Q_L as a function of the heated disk, cooled disk, and chamber wall temperatures from calibration measurements on one or more specimens having known thermal conductivities. Modeling also shows that the device may be calibrated using air as the reference standard material. Thereafter, one can use the value of Q_L as thus determined to calculate values of k from measured values of Q.

This work was done by Robert A Miller and Maria A Kuczmarski of Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18356-1.

Alignment Jig for the Precise Measurement of THz Radiation

This device can be used by optometrists to measure aberrations in lenses, and by head-mount display manufacturers.

NASA's Jet Propulsion Laboratory, Pasadena, California

An alignment jig (see figure) places a THz horn and power detector at the proper locations with respect to the focal points of a conic reflector in order to couple total power of the THz source radiating out of its horn into the power detector for precise measurement of its power. A visible laser beam locates focal points of the conic reflector. Measuring total diverging power from a THz point source is not an easy task. THz radiation has a wavelength range of between 0.1 and 1 mm. The power levels range from a few tens of nW to 100 mW. These power levels are low, and low temperatures (in the range of –173 °C) are typically used to house the THz power source. Because of the small target, the power emitter and the power detectors must be located in exact positions in order to fully capture the radiated energy. At these low powers, there are three common commercial power meters: a bolometer detector, a Golay Cell, and a Keating Meter. These three power meters have specific power ranges where they excel, and they must be calibrated at their overlapped power ranges. Because of the low THz power being measured, conical reflectors are used to send all of the radiated power to the detectors.

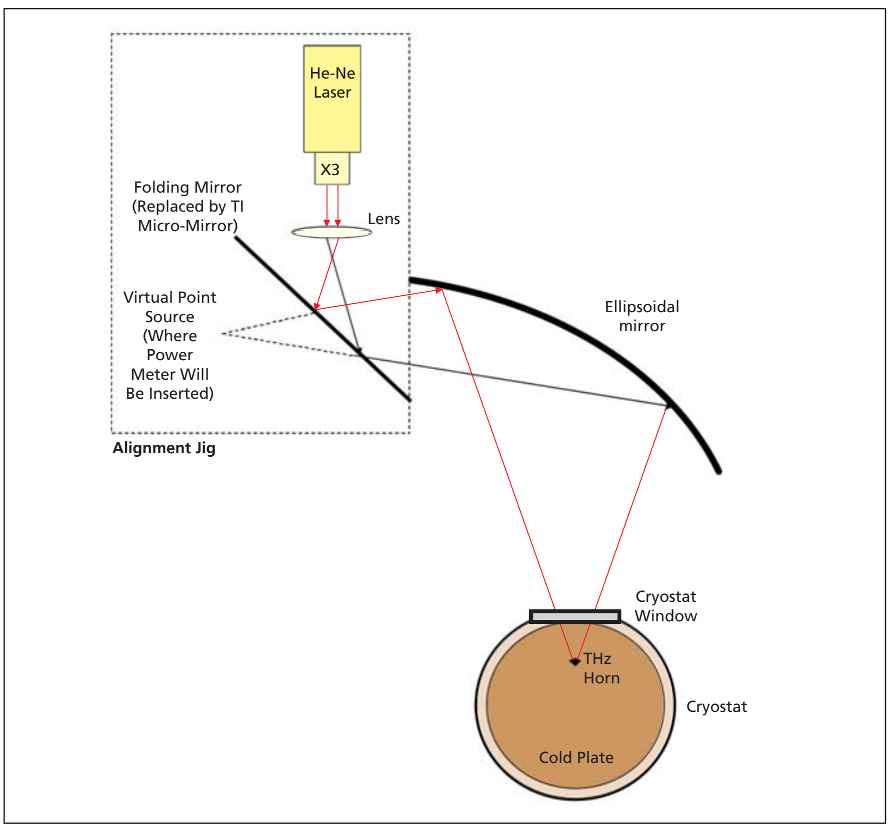


Figure 1. The **Alignment Jig** for measurement of THz power employs an ellipsoidal mirror with a THz horn at one focal point and the power meter at the second focal point.