NASA TECH BRIEF

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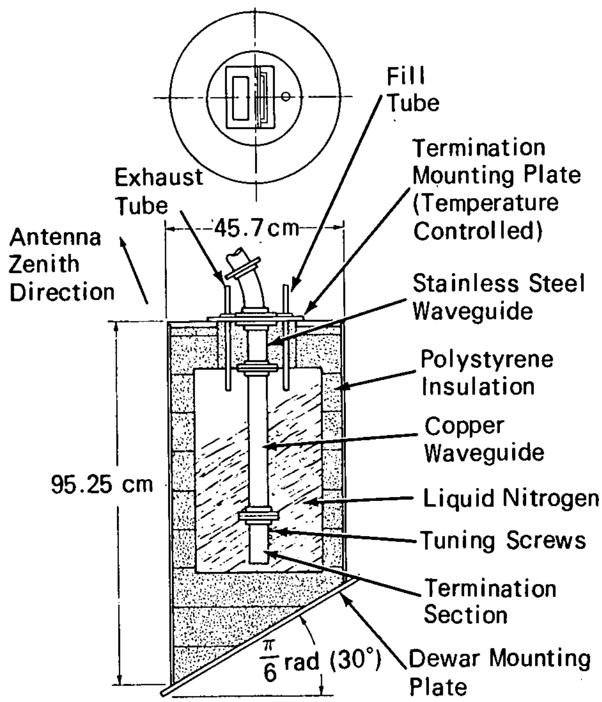
Microwave Cryogenic Thermal-Noise Standards

A field operational, liquid nitrogen cooled, waveguide noise standard with a nominal noise temperature of 78.09 ± 0.12 K has been calibrated with



greater precision than had previously been achieved.

Originally intended for calibrating maser-amplifier units used in large diameter, Cassegrain-feed, deep-space communications antennas, the calibration technique may also be applied to various disciplines such as microwave radiometry, antenna temperature and loss measurement, low-noise amplifier performance evaluation, and low-level CW signal amplitude calibration.

The noise standard (see fig.), constructed using relatively conventional techniques, is shown as it is set up for use in the feed unit of a large-diameter, parabolic antenna. The $\pi/6$ rad (30°) mounting inclination prevents loss of the liquid nitrogen as the antenna sweeps from the zenith to the horizon.

The heavy-wall copper waveguide, the straight section of which is filled with a polystyrene foam block, is used to assure a constant waveguide temperature, independent of liquid nitrogen level. The 15.24 cm (6 in.) section of thin-wall (0.0626 cm) stainless steel waveguide, plated with approximately 330 μm of copper with a 25 μm gold flash, is sealed with polystyrene and foamed in place. The $\pi/6$ rad (30°) waveguide bend is sealed with a 10.6 cm (3 in., or approximately 1/2 wavelength) section of polystyrene, foamed in place. This foam plastic window serves as both a gas and a thermal barrier. The complete waveguide section is filled with polystyrene foam to eliminate gas convection and radiation heating of the termination.

Voltage standing-wave ratio (VSWR) matching is done directly at the termination section with tuning screws. This eliminates the standing waves that occur in the transmission line if the matching is done in the upper waveguide sections. Standing waves in a standard operational thermal noise transmission line invalidate the transmission line calibrations performed under matched conditions.

The top mounting plate is heated with thermostatically controlled power resistors to prevent moisture from condensing around the waveguide during operation.

The temperature distribution along the stainless steel section is measured with chromel-constantan thermocouples referenced to liquid nitrogen. Dissipative and transmission line losses of the various

(continued overleaf)

sections of waveguide are measured using both transmission and cavity resonance techniques. The temperature and loss measurements are used with a computer program (see Note 1) to define the nominal noise temperature at the output of the steel section. Use of the computer is necessary because the assumptions, such as linear temperature and loss distributions, that must be made in analytical solutions are not precisely satisfied. The calibration error that results from such assumptions is greater than 0.1 K. The program, employing iterative techniques, uses higher-order terms in the expansion of the loss and temperature distribution functions, or an exact expression for losses greater than 0.02 dB.

Notes:

1. The computer program is written in FORTRAN IV and is available from COSMIC, Barrow Hall, University of Georgia, Athens, Georgia 30601 (Ref. NPO-10610).
2. Requests for further information may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B71-10139

Patent status:

Inquiries about obtaining rights for the commercial use of the invention may be made to:

Patent Counsel
Mail Code 1
NASA Pasadena Office
4800 Oak Grove Drive
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Source: C. T. Stelzried
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-11424)