ANTENNA TECHNOLOGY — MATERIALS FOR ANTENNA PROTECTIVE COATINGS

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MATERIALS FOR ANTENNA PROTECTIVE COATINGS

OBJECTIVE: SELECT MATERIALS HAVING SUITABLE THERMAL AND DIELECTRIC PROPERTIES TO COVER FLUSH MOUNTED ANTENNAS ON THE SPACE SHUTTLE VEHICLE

APPROACH:

- SELECT CANDIDATE MATERIALS
- MEASURE DIELECTRIC PROPERTIES OF CANDIDATE MATERIALS
  - AT ROOM TEMPERATURE
  - AS A FUNCTION OF TEMPERATURE UP TO 2000° F
  - DURING TEMPERATURE RECYCLING TESTS (GEORGIA TECH)
- EVALUATE CANDIDATE MATERIALS DURING EXPOSURE TO SPACE SHUTTLE HEATING RATES IN ARC TUNNEL
- INVESTIGATE MATERIAL BREAKDOWN DURING SIMULTANEOUS EXPOSURE TO HIGH SURFACE TEMPERATURES AND HIGH RF POWER LEVELS (STANFORD RESEARCH INSTITUTE)

CANDIDATE ANTENNA WINDOW MATERIALS FOR THERMAL PROTECTION

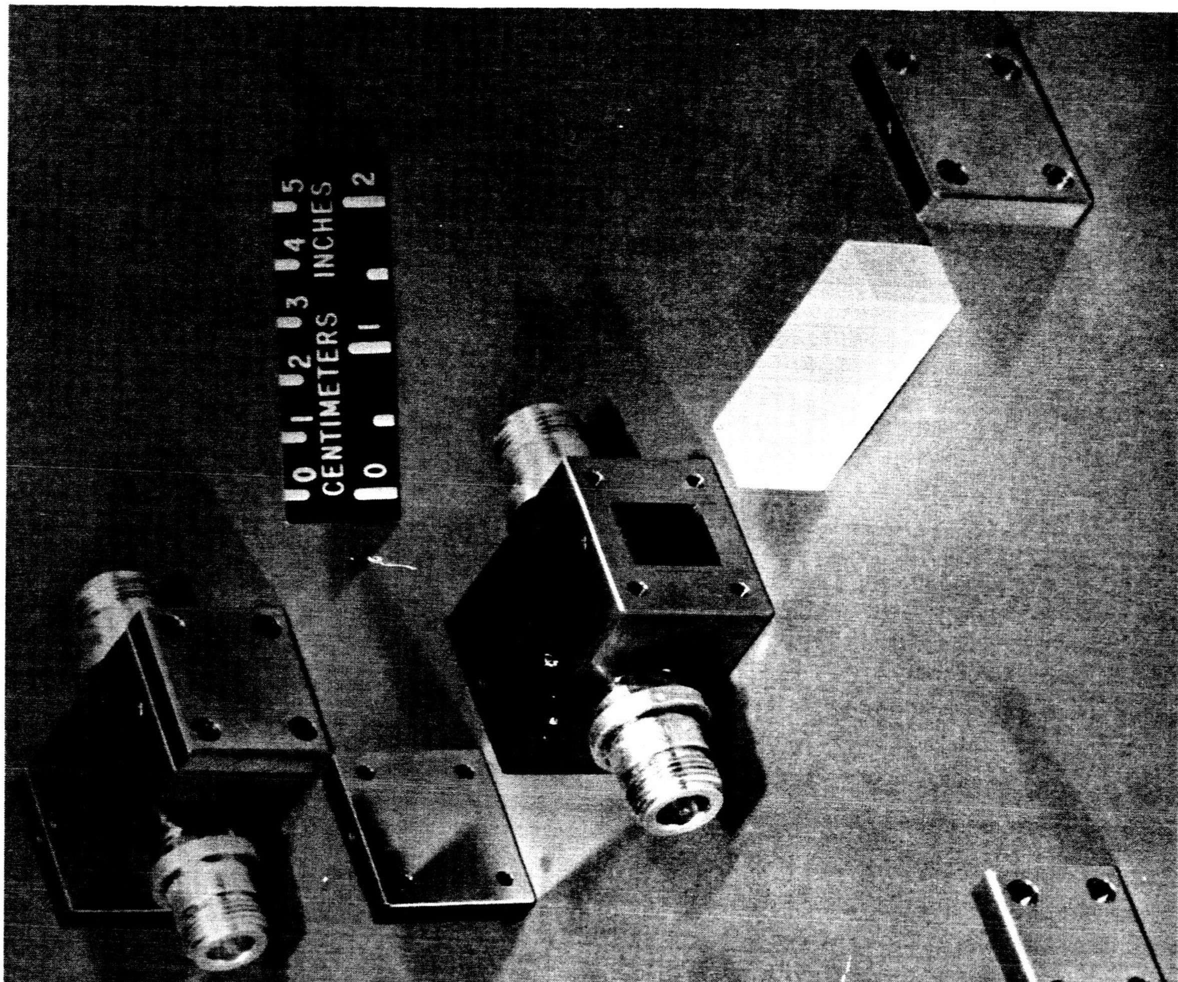
	SUPPLIER	NOMENCLATURE	DESCRIPTION
1.	PHILCO-FORD CORPORATION	AS-3DX	FUSED QUARTZ - REINFORCED SILICA COMPOSITE
2.	RAYTHEON COMPANY	IPBN	ISOTROPIC PYROLYTIC BORON NITRIDE
3.	GEORGIA INSTITUTE OF TECH.	-	SLIP CAST FUSED SILICA
4.	GENERAL ELECTRIC	MARKITE 3-DQ	FIBER BUNDLE REINFORCED
5.	WHITTAKER CORPORATION	-	ALUMINUM PHOSPHATE FOAM (40 - 60 LB./FT.^{3})
6.	LOCKHEED MISSILES AND SPACE CO.	LI-1500	SILICA FIBER, RIGIDIZED COATING
7.	McDONNELL-DOUGLAS ASTRONAUTICS CO.	MULLITE HCF	RIGIDIZED MULLITE FIBER
8.	TETRAHEDRON ASSOCIATES	-	HONEYCOMB, OPEN CELL SILICON COMPOSITE
9.	UNION CARBIDE CORPORATION	HD - 0092	HOT PRESSED BORON NITRIDE

TECHNIQUES FOR MEASURING THE DIELECTRIC PROPERTIES OF CANDIDATE MATERIALS

- ROOM TEMPERATURE MEASUREMENTS (0.100 - 60 GHz)
  - CAVITY PERTURBATION TECHNIQUE (0.100 - 1.0 GHz)
  - RESONANT RECTANGULAR CAVITY METHOD (1 - 14 GHz)
  - FREE SPACE TECHNIQUE USING FABRY-PEROT INTERFEROMETERS (26 - 60 GHz)
- HIGH TEMPERATURE MEASUREMENTS (TEMPERATURES UP TO 2000° F)
  - SHORT CIRCUITED WAVEGUIDE TECHNIQUE (10 GHz)
- HIGH HEATING RATE ARC TUNNEL TESTS
  - TRANSMISSION AND REFLECTION MEASUREMENTS (10 GHz)

RECTANGULAR CAVITIES AND TEST SPECIMENS

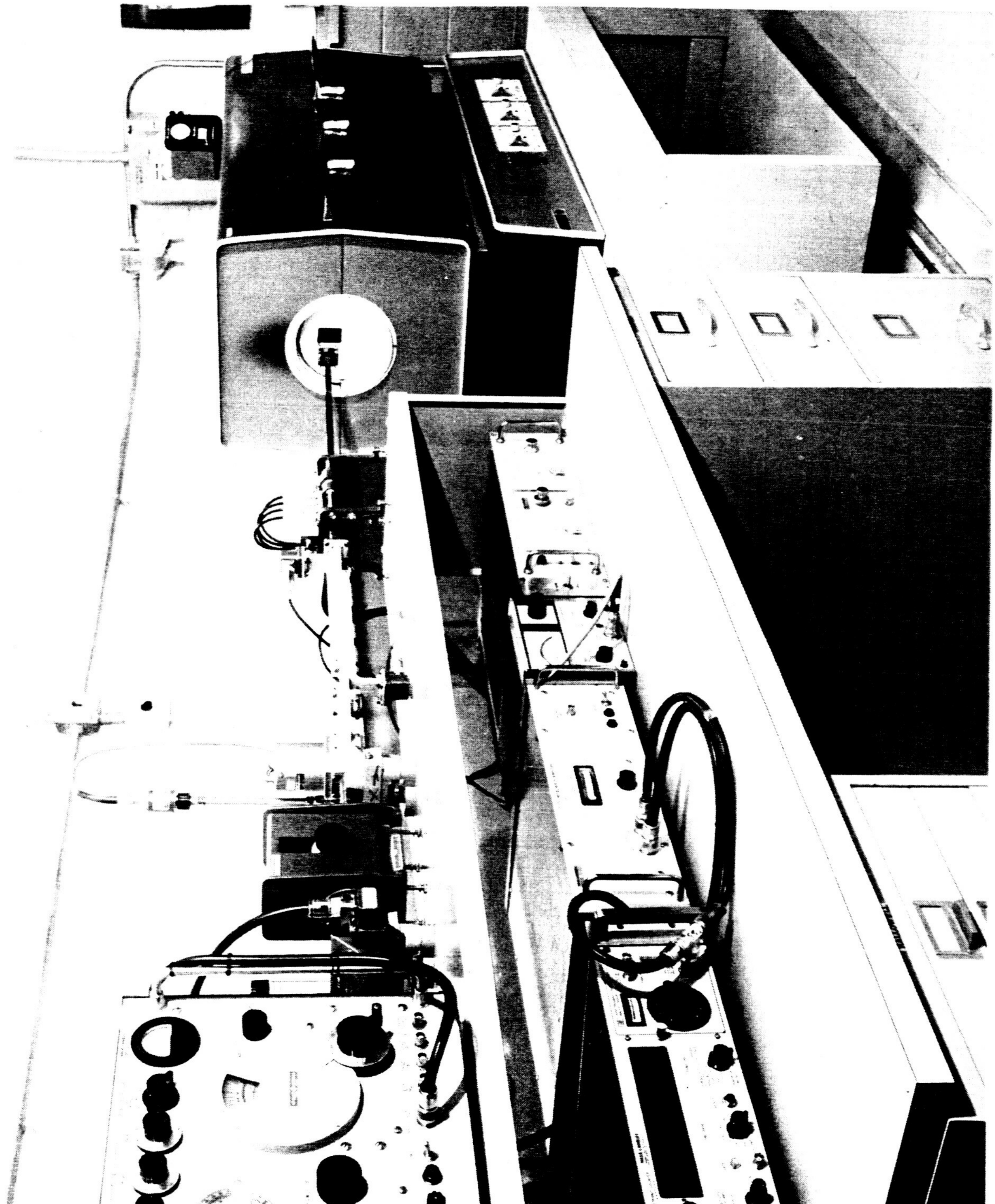
One of the techniques for determining the dielectric properties of candidate materials at room temperature employs the use of resonant rectangular cavities. The dielectric constant and loss tangent values are determined for the candidate materials by comparing the cavity performances with and without the test sample. The interior surfaces of all cavities were gold plated and polished to improve their performance.



RECTANGULAR CAVITIES AND TEST SPECIMENS

HIGH TEMPERATURE TEST FACILITY

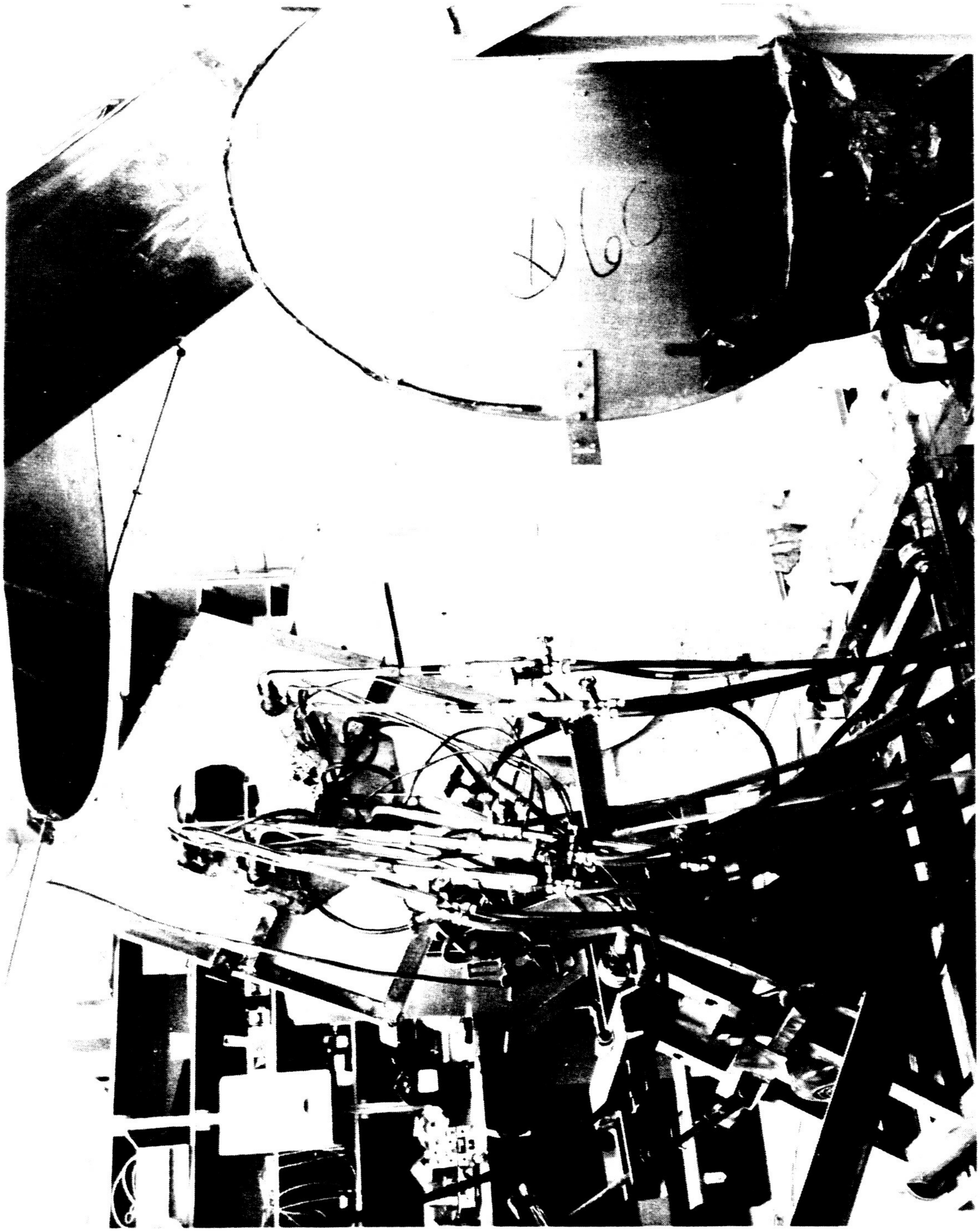
The dielectric properties of most dielectric materials vary as a function of temperature. To determine the changes in the candidate materials being considered here, a short-circuited waveguide technique is being used. Each material will be evaluated from room temperature up to 2000° F. The waveguide test sample holder used in these measurements was constructed from platinum/rhodium material to allow repeated exposure to the high temperatures.



HIGH TEMPERATURE TEST FACILITY

GEORGIA TECH HIGH TEMPERATURE FACILITY

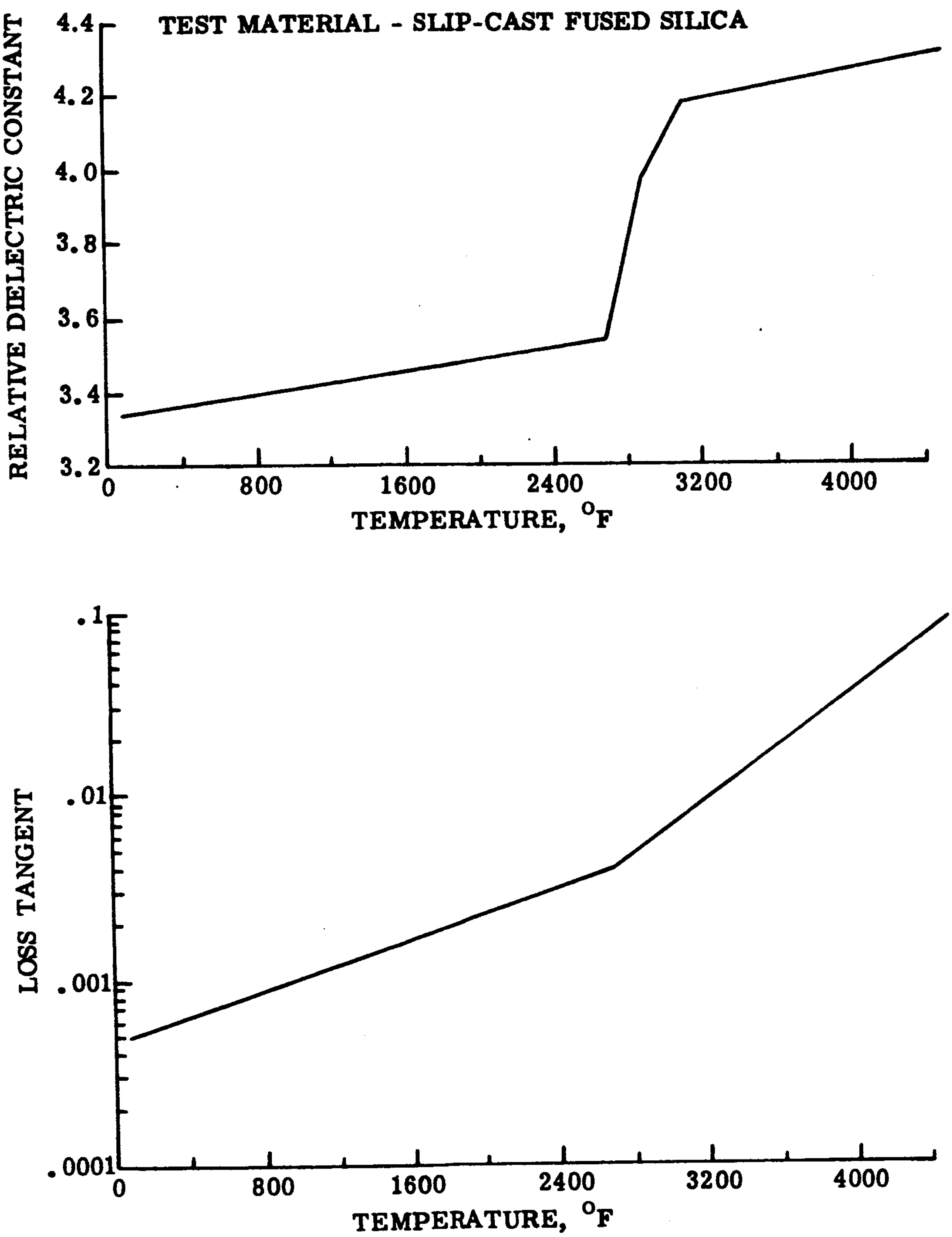
A test technique has been developed at Georgia Tech for determining the complex permittivity of materials from ambient to greater than 4000° F. The system employs a rotating disk sample which is located at the coincident focal point between two prolate spheroidal reflectors; the sample is heated on one side by oxyacetylene flames in such a manner that the microwave beam is not affected by the flames. Dynamic measurements are made of the sample insertion phase and insertion loss. A transient heat conduction analysis is used to determine the temperature profiles within the sample, and the electrical transmission data are correlated with the temperature profiles to give dielectric constant and loss tangent as functions of temperature.



GEORGIA TECH HIGH TEMPERATURE FACILITY

DIELECTRIC PROPERTY MEASUREMENTS PERFORMED AT GEORGIA TECH

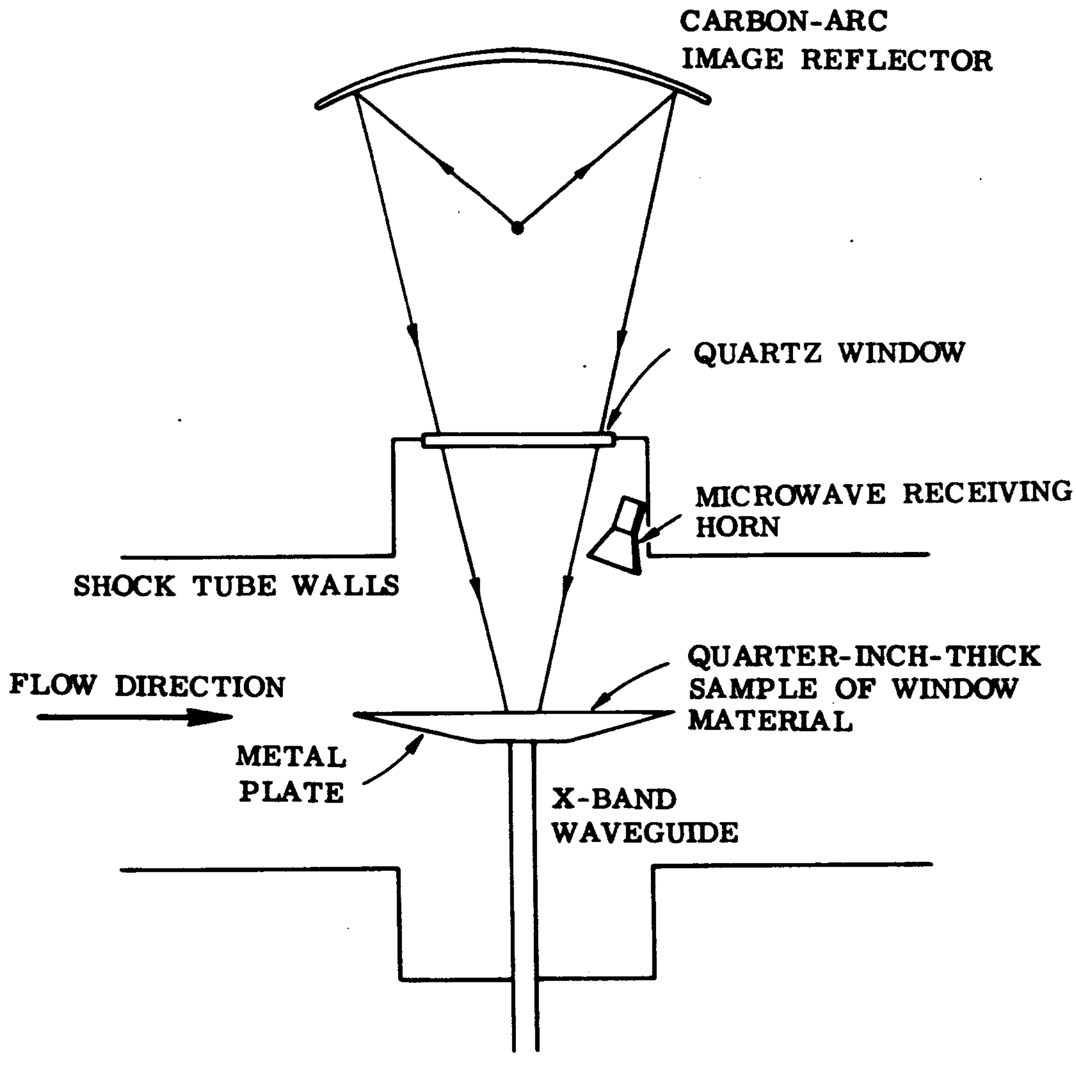
The dielectric constant and loss tangent of slip-cast fused silica were measured from ambient to approximately 4400° F by using the Georgia Tech free-space technique. These data are typical of those that will be obtained for the candidate materials being considered, except that the maximum temperature will be approximately 2400° F.



DIELECTRIC PROPERTY MEASUREMENTS PERFORMED AT GEORGIA TECH

SCHEMATIC PRESENTATION OF APPARATUS FOR MEASUREMENTS IN SHOCK TUBE

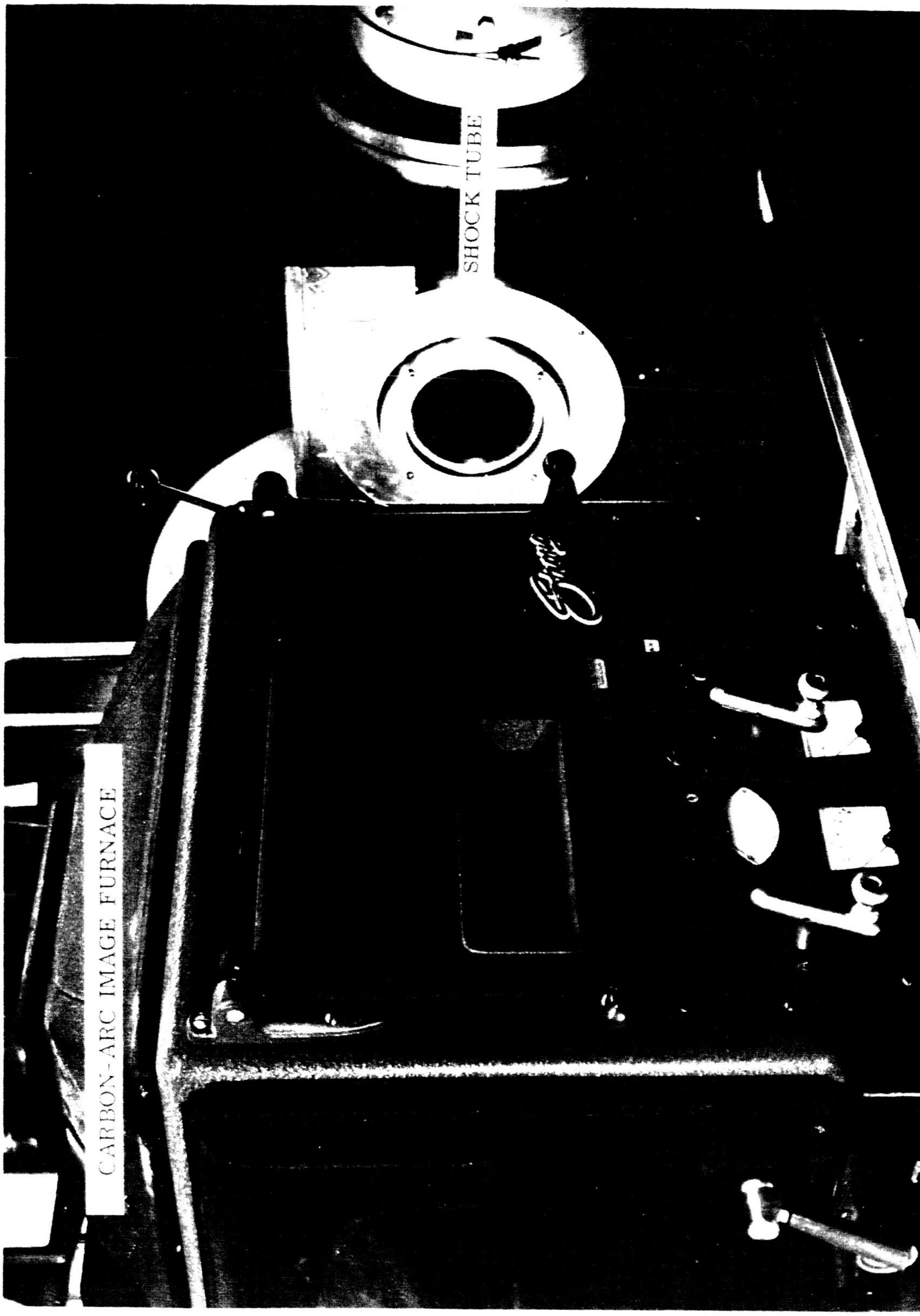
Because of the possibility that high transmitted power levels will be needed for some of the many communications and guidance functions on the shuttle vehicle, a program was conducted at SRI during which a technique was developed for evaluating candidate RF window and TPS materials during exposure to high surface temperatures and high RF power levels. The tests were performed in the SRI 12-inch shock tube facility by using an externally mounted carbon-arc image furnace as the heat source. The tube was used both to serve as a pressure vessel and to furnish a plasma over the samples where breakdown at the plasma/ sample interface was investigated. The measurements were performed at X-band.



SCHEMATIC PRESENTATION OF APPARATUS FOR MEASUREMENTS IN SHOCK TUBE

STANFORD RESEARCH INSTITUTE HIGH TEMPERATURE FACILITY

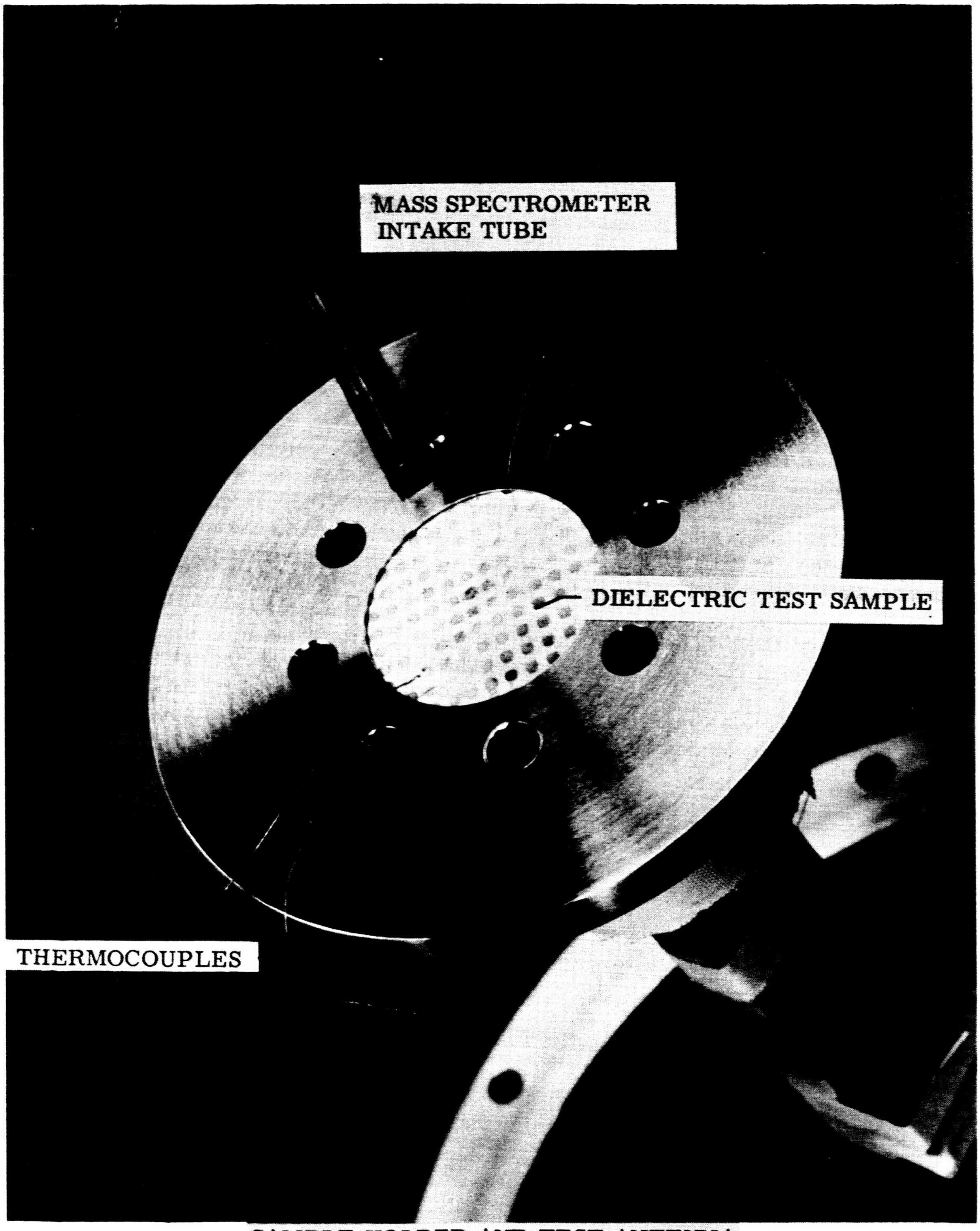
The carbon-arc image furnace used for producing the 2200° F surface temperatures on the various test materials is shown with the shock tube facility. The quartz window through which the samples mounted in the shock tube were heated is also visible.



STANFORD RESEARCH INSTITUTE HIGH TEMPERATURE TEST FACILITY

SAMPLE HOLDER AND TEST ANTENNA

Shown are the stainless steel test sample holder with test material and horn test antenna used for the SRI shock tube tests. Thermocouples were imbedded in the test samples to determine surface temperatures. A mass spectrometer was also used to investigate material outgassing. The horn antenna used had a 0.90-inch-square aperture, and the test sample diameter was 1.4 inches. Test sample thickness was 0.25 inch.



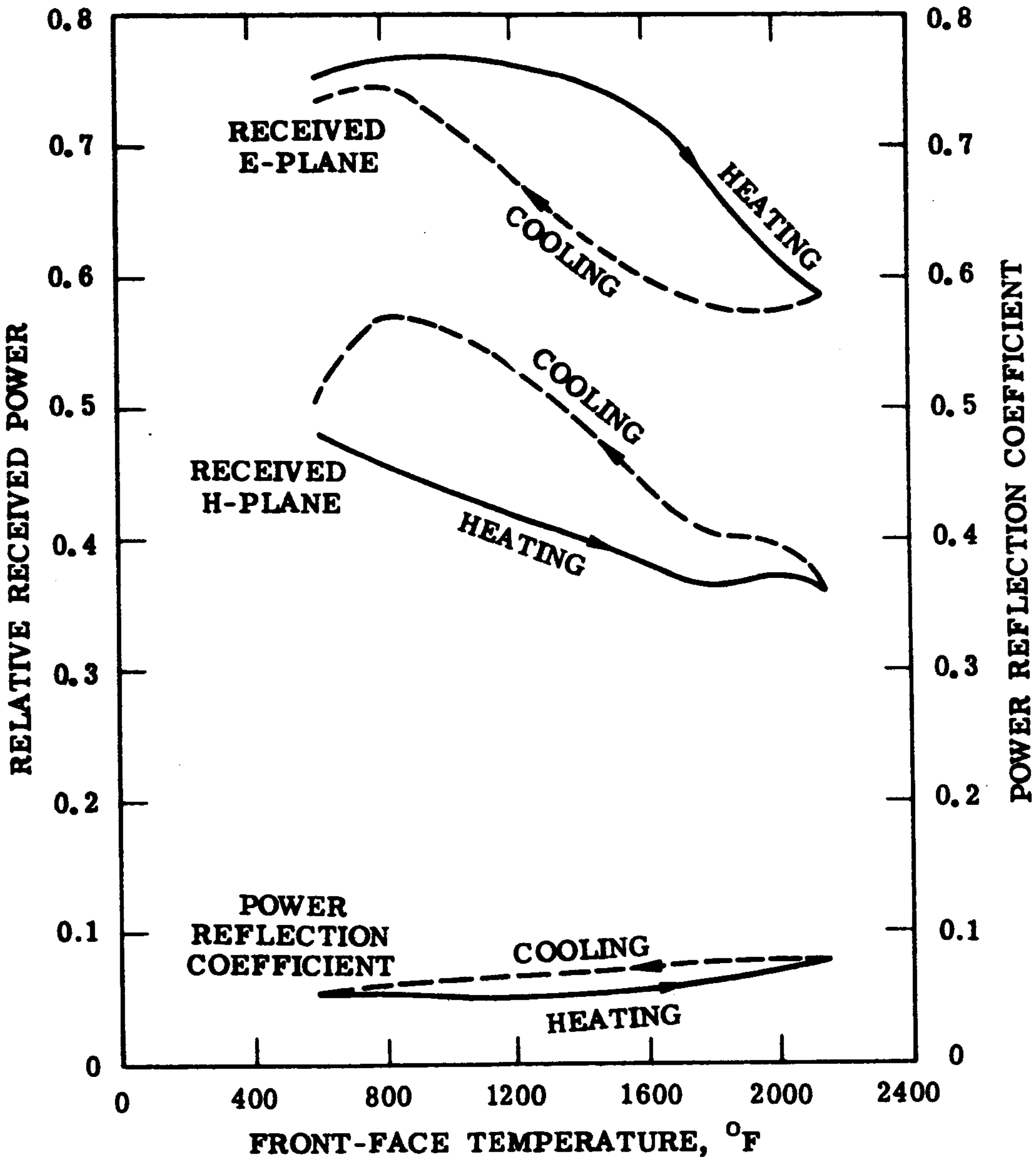
SAMPLE HOLDER AND TEST ANTENNA

MICROWAVE MEASUREMENTS DURING HEATING AND COOLING CYCLES

TEST MATERIAL AS-3DX

Transmission and reflection data similar to those presented here were obtained for six different test materials as a function of surface temperature. Both the E-plane and the H-plane transmitted levels were monitored by using horns located at a 45° angle with the center line (such as to be out of the focused beam of the carbon arc) and 6.5 inches from the sample. Apparently, the differences measured for the two polarizations were caused by pattern effects.

The results of the SRI tests indicated that none of those materials considered showed any evidence of material breakdown. These results were obtained from one test per sample. If it is determined from the Georgia Tech recycling tests that the loss tangent of a particular material increases considerably as the number of cycles increases, additional breakdown testing in the SRI facility may be necessary.



MICROWAVE MEASUREMENTS DURING HEATING AND COOLING CYCLES.
TEST MATERIAL AS-3DX