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NASA TECH BRIEF

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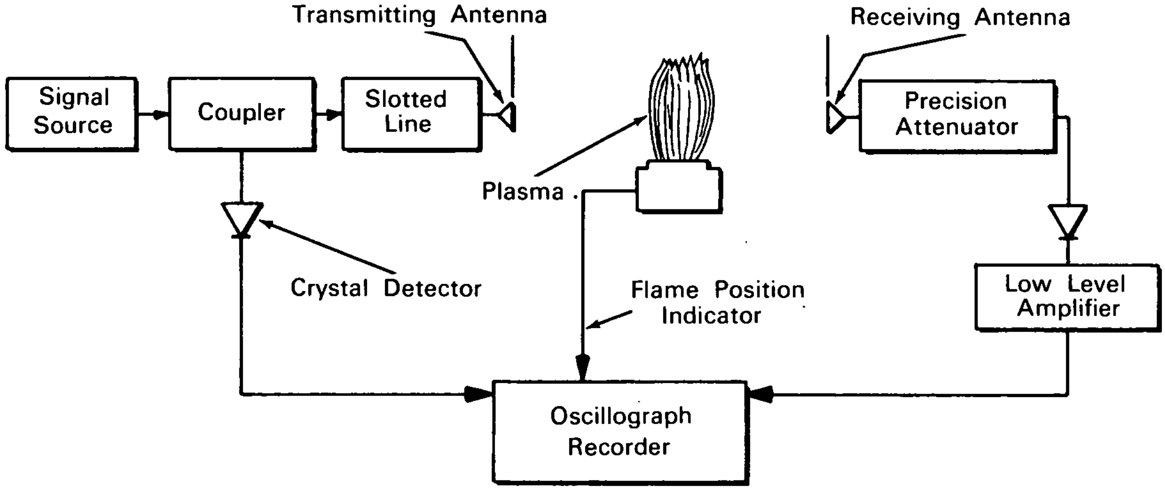
Microwave Technique Measures Plasma Characteristics



The problem: To obtain good spatial resolution in the measurement of plasma electron density and temperature distribution. This cannot be done using metallic probes because of: (1) the disturbance introduced into the plasma by the insertion of the probe; and (2) the effect that the plasma has on the probe.

The solution: Pass a high frequency millimeter wave through the plasma to be measured. The electron density and the temperature variations can be determined by measuring the insertion loss experienced by the measuring system as the plasma travels between the microwave transmitting and receiving antennas.

How it's done: The electron density and temperature of a thermal plasma can be found from the electromagnetic (EM) properties of the plasma and known gas equilibrium constants. Therefore, based on the assumptions that: (a) The plasma is nonreflecting at the EM frequency used; (b) The plasma is cylindrical, having radial variations only; (c) The ratio of the plasma diameter to the width of receiving antenna aperture is large; and (d) The ionization potential, total gas pressure, and collision frequency of the plasma are known, the electron density and temperature distributions in a thermal plasma can be determined from attenuation measurements as a function of flame diameter.

The cylindrical plasma stream is divided into concentric zones. It is assumed that these zones will have constant attenuation per unit length. Each zone's width is equal to that of the receiving microwave antenna aperture.

A millimeter wave signal source feeds a transmitting antenna by way of a coupler and a slotted line. The EM signal passes through the plasma and is received by the receiving antenna. The received signal passes through a precision attenuator and a crystal detector.

(continued overleaf)

The slotted line measures the electromagnetic frequency, and the precision attenuator is used to calibrate the system. The signal is then amplified and fed to an oscillograph recorder. The input signal is also detected and fed to the recorder. This system measures the transmission losses as a function of the flame diameter, thus, yielding electron density and temperature distributions of the plasma.

Notes:

1. An advantage of this technique is that, if the collision frequency should be in error by an order of magnitude, the attenuation constant versus electron density curve will be shifted only slightly, resulting in small errors of a few percent for the electron density and temperature values.
2. This is an adaptation of the technique previously used at optical wavelengths.
3. Inquiries concerning this innovation may be directed to:

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   Reference: B65-10122

Patent status: NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: William F. Leonard
(Langley-134)