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Brief 71-10235

NASA TECH BRIEF

Ames Research Center

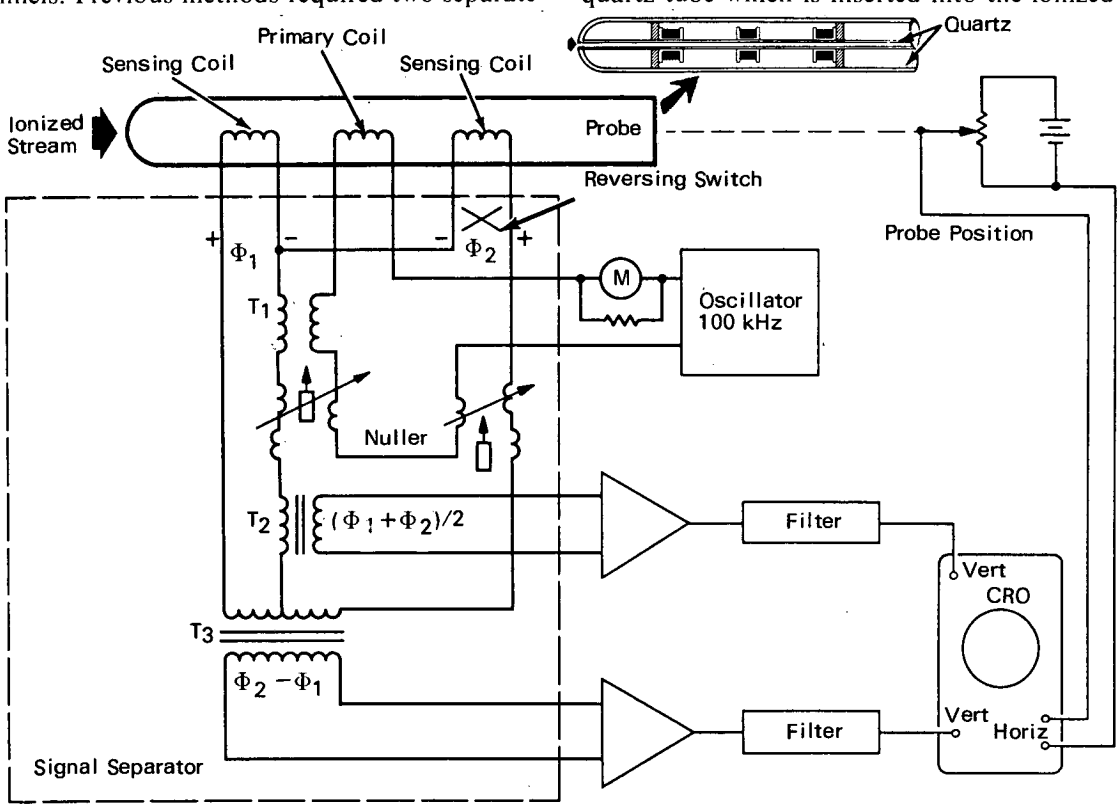
Device Measures Conductivity and Velocity of Ionized Gas Streams

The problem:

To accurately measure the local electrical conductivity and linear velocity of ionized streams in plasma wind tunnels. Previous methods required two separate instruments to determine conductivity and velocity. The conductivity values yielded by such systems were averages over the bulk of the flow field rather than a localized region. In addition, the performance of these methods does not readily relate to theoretical analysis.

The solution:

A coaxial arrangement of a primary coil and two sensing secondary coils contained inside a slender quartz tube which is inserted into the ionized stream, permitting simultaneous determination of conductivity and velocity. The results obtained with this system agree favorably with theory.



How it's done:

The three-coil probe system and associated circuitry (see fig.) permit measuring the extent to which the

(continued overleaf)

magnetic field generated by the primary coil is perturbed by the electrically conducting, high velocity stream. The field is produced by exciting the primary coil with 0.125 W from a 100 kHz oscillator, and the distortion of the field is detected by the voltage induced in the secondary coils which are equidistant from the primary coil. Energy transfer across such a loosely coupled transformer depends on the manner of excitation of the primary, the positions and direction of the secondary coil windings relative to the primary coil, and the nature of the surrounding medium and its velocity relative to the primary coil. The sum and difference of the secondary output voltages are linearly related to the conductivity and to the product of the conductivity and the velocity of the surrounding medium.

The three-coil system is supported axially by a quartz rod mounted inside a quartz tube heat shield. The probe is 10.2 cm long and 0.4 cm in diameter. Capacitive shielding is accomplished with a single-layer winding for each coil. The probe assembly is mounted on a hydraulically driven rack and pinion to permit a traverse of the plasma stream. A variable resistor mounted on the pinion shaft controls the horizontal sweep of the oscilloscope used to monitor coil outputs. In tests performed, probes traversed a 16.5 cm plasma jet in 0.12 sec.

The average sum and difference signals of the sensing coil outputs are separated and nulled by means of a transformer-coupled bridge circuit, which incorporates differentially wound coils in the center and in one side leg, with outputs controlled by the positions of ferrite and steel slugs. The coils effectively add "buck-out" voltages of proper amplitude and phase to null the system before measurements are made. Signals from the bridge circuit are fed through amplifier-filter units and displayed on a dual-trace oscilloscope having a sensitivity of 0.01 mV/cm.

Calibration of the nulled system is performed in room air by simply reversing the leads to one of the sensing coils. Comparison of the probe-determined conductivity with that of a standard saturated salt solution, and probe-determined velocities of the plasma stream with those of a nonelectrical measurement, showed good agreement.

References:

1. Coil Systems for Measuring Conductivity and Velocity of Plasma Streams, Rev. Sci. Instr., 37, 1232 (1966).
2. A Coaxial, Three-Coil Probe for Measuring Local Values of Electrical Conductivity and Velocity in Plasma Streams, AIAA Journal, Vol. 8, No. 8, 1399-1404 (Aug. 1970).

Notes:

1. Other coil arrangements can be used to measure conductivity and velocity in plasma streams.
2. Computation of the performance of the coil system must take boundary corrections into consideration.
3. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference:
   NASA-TN-D-4538 (N68-21691), Boundary Corrections for a Three-Coil Conductivity/Velocity Plasma Probe, 1968
4. Technical questions may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: TSP71-10235

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,517,302), and royalty-free license rights will be granted for its commercial development. Inquiries about obtaining a license should be addressed to:

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