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NASA TECH BRIEF

Ames Research Center

Porous Surface Microphone for Measuring Acoustic Signals in Turbulent Windstreams

The problem:

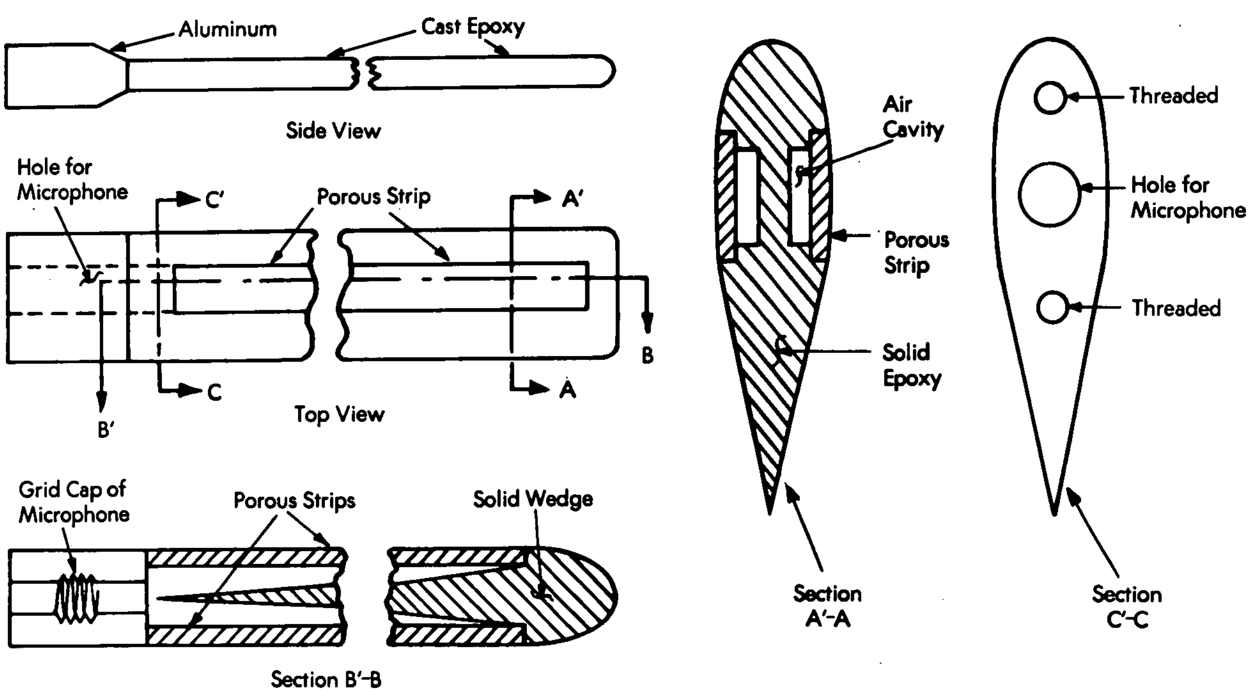
To measure acoustic signals in the turbulent regions of wind tunnels.

The solution:

A microphone sensor which transforms pressure variations caused by acoustic signals and turbulence into an electrical output; the microphone is protected from the direct thrust of the slipstream by a porous barrier.

How it's done:

The diagram indicates the basic features of the design of a porous-surface microphone sensor. The aerodynamic form is an airfoil designed to create no turbulence in the air flow over the porous surface. Two porous surfaces are active, one on each side of the airfoil; the sensing surfaces are selected to have acoustic impedances which are well matched in modulus and phase. The strips shown in the diagram have nearly the same average specific flow resistance with



(continued overleaf)

a standard deviation (normalized to the mean) of approximately 0.1; the correlation length is roughly 3.8 cm. The standard deviation of the response is limited to 9.2×10^{-2}, which is roughly −21 db with respect to the main lobe.

The sensitivity of a porous surface sensor can be separated into two factors, frequency response (which depends only on frequency) and directivity function, which depends on the wavenumbers of the gases inside and outside the sensor. A real porous surface sensor has a frequency response which decreases with frequency; apparently, the viscous boundary layer at the inside surfaces of the sensor contributes to the drop in frequency response, as does the reactive component of the acoustic impedance of the porous surface. The directivity function of a real porous surface sensor follows that of an ideal sensor for its main lobe; the minor lobes deteriorate gradually, depending primarily on the nonuniformity of the porosity (or acoustic impedance) of the surface. The important feature is that the directivity function extends well into the subsonic region and, thus, porous surface sensors have the property of filtering out those components of the pressure field which are predominantly subsonic, like those associated with a turbulent flow.

The porous surface is a set of small holes connecting one face to the other. The cross-section of the holes varies considerably from hole to hole, with larger holes dominating the specific impedance of the surface. In an actual surface, the holes may be either roughly circular or roughly rectangular; for example, in a porous surface made of sintered metal particles there is a ratio of circumference to cross-section which is closer to that of a circular hole, while very narrow rectangular holes are formed in porous materials made from compressed fibers. To achieve a high cutoff frequency (the frequency at which the reactive part equals the resistive part of the acoustic impedance), circular holes must have a very small radius and rectangular holes must have a very small thickness.

It was found that the effective hole radii in the sintered stainless steel used for the porous surfaces varied from below 10 μm to slightly larger than 25 μm. For purposes of calculation, a uniform radius of 30 μm is assumed; thus, the cutoff frequency is 15 kHz, which means that in the region of 10 kHz the frequency response of the porous sensor will drop significantly. A report has been issued which compares the performance of porous sensors of the type shown in the diagram with other microphone sensors and porous-material sensors in wind tunnels.

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single copy price $3.00
   (or microfiche $0.95)
   Reference: NASA CR-114593 (N73-23289), Study of Porous Surface Microphones for Acoustic Measurements in Wind Tunnels.
2. No additional documentation is available. Specific questions, however, may be directed to:
   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B73-10490

Patent status:

NASA has decided not to apply for a patent.

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