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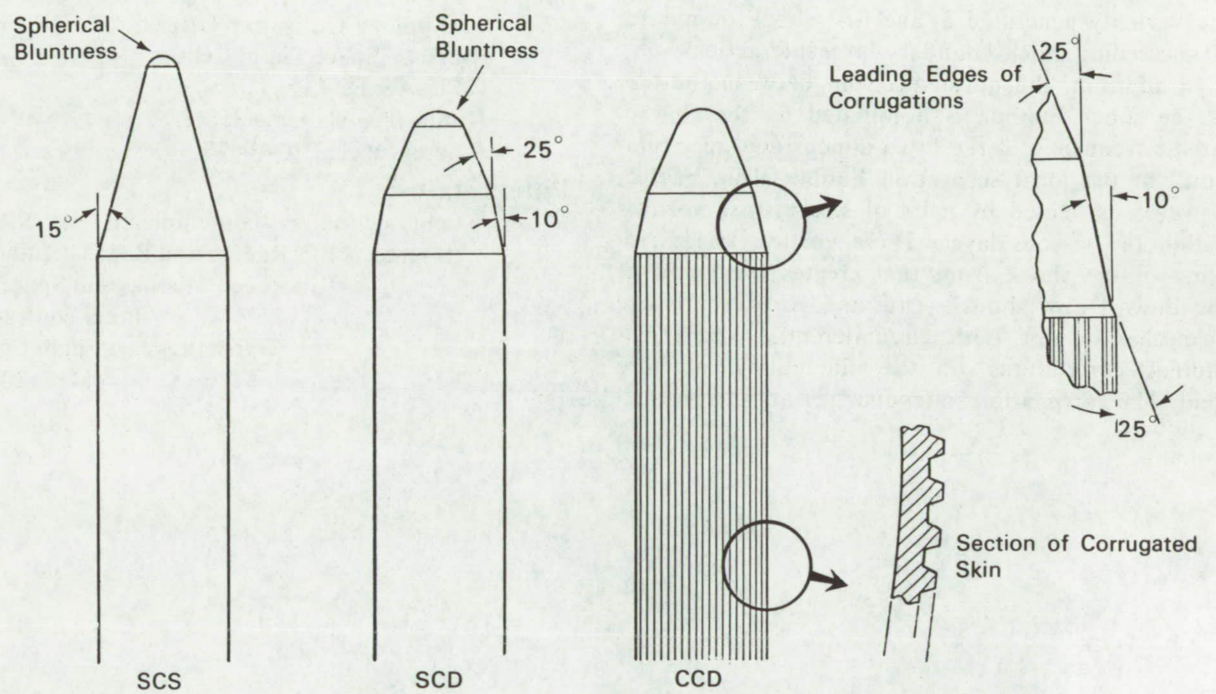
Comparison of Aerodynamic Noise from Three Nose-Cylinder Combinations



The Three Models

Experiments were conducted to determine the flow mechanisms responsible for noise caused by flight configuration. Such information is vital to a clearer understanding of the flow field so that wind-tunnel models can be brought to full scale with greater reliability.

Models of three different cylinder and blunted nose combinations (see fig.) were studied: a smooth cylinder with a single 15° cone (SCS); a smooth cylinder with a double cone of 25° and 10° (SCD); and a longitudinally corrugated cylinder with a similar double cone (CCD).

The CCD model was the flight configuration, and was of primary interest. The SCS model, a base-line configuration, served as a basis for comparison with the double-cone models. The SCD was used for evaluating the effects of the corrugations on the CCD.

The data analysis indicates that the skins of the models may have been vibrating. The resultant accelerations, experienced by the microphones, and the perturbations of the flow precluded valid noise measurements, except at a point directly under the terminal normal shock where the aerodynamic noise

(continued overleaf)

dominated microphone response.

A significant finding was that the SCD combination produced lower shock-induced sound-pressure levels than did the aerodynamically cleaner SCS. This fact primarily reflects the former's reduced turning of the flow at the nose-to-cylinder shoulder, aft of the preseparation, and its reattachment at the downstream "cusp." The CCD combination produced the most severe noise, because of local effect, including vorticity at the leading edges of the corrugations.

Among the conclusions reached was the concept that the vorticity associated with the interaction of a transonic terminal normal shock, with a turbulent boundary layer, may affect not only the local noise spectra but also the downstream spectra such that the vorticity generated at the first shock dominates all succeeding shock-boundary-layer interactions.

In addition, the noise spectrum between the legs of the shock lambda is dominated by the characteristic frequency of the "two-dimensional recirculation" in the local separation bubble. This bubble, however, is vented by pairs of stream-wise vortices within the viscous layer. These vortices cause rippling of the shock front that creates them and of the downstream shocks. Thus the vortices produce a mechanism for both circumferential and longitudinal correlations of the fluctuating pressure field. The corrugations introduce yet another vortex-producing mechanism that may break up the vortex shock-shock coupling, provided vortices sufficiently different in scale are generated.

The information obtained was sufficient to determine the noise environment of the full-scale flight configurations. Static pressure measurements were used to extrapolate the limited amount of valid fluctuating pressure data to define the terminal normal shock environment over the entire range of pertinent Mach numbers ($0.75 \leq M \leq 1.0$). The environment away from the shocks, where excitation of the skin invalidated the measurements, was also estimated by extrapolation.

Note:

Requests for further information may be directed to:

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