Technical Comments

Comment on "Reduction of Noise from Supersonic Jet Flows"

Arthur G. Kurn*
Royal Aircraft Establishment, Farnborough, Hampshire, England

Nomenclature

C_p = base pressure coefficient = $(p_b - p_\infty)/q$
f = frequency
H_j = maximum total head pressure at nozzle exit
H_∞ = tunnel total head pressure
M_∞ = tunnel Mach number
p_b = pressure on base of nozzle
p_∞ = tunnel static pressure
p_ε = rms of unsteady pressure on base of nozzle
q = tunnel kinetic pressure
ε = bandwidth ratio of frequency analyser (= 0.11)
$\Delta C_{p_{rms}}$ = rms of unsteady base pressure divided by q

THE reduction of noise due to mutual interference of two under-expanded coaxial supersonic jet streams[1] bears comparison with the investigation of unsteady pressures on an annular base around a sonic nozzle.[2] The latter test was concerned with the behavior of the base pressure when the pressure of the jet stream from the nozzle was varied in the presence of a freestream. Most of the work was done with a subsonic freestream but Mach numbers of 1.0 and 1.2 were also tested. At these two conditions there is some similarity between Dosanjh's and the RAE experiments, in that both have inner jet streams surrounded by supersonic flow, albeit in Dosanjh's case the external stream is a narrow annular band. There is also marked similarity in the results, that at a certain ratio of inner to outer stream stagnation pressures there is a sudden reduction in the noise level. Although this ratio is greater than 1 in the RAE experiments and less than 1 in Dosanjh's tests, the higher stagnation pressure occurs in the narrower stream in both cases (i.e., the stream with the shorter shock cell system). This suggests that the RAE configuration is effectively the inverse of that investigated by Dosanjh; the outer stream of his coaxial experiment can be looked upon as the jet stream, with the inner flow equivalent to the freestream of the RAE tests.

The RAE base pressure investigation compared the time-average pressure with the pressure fluctuations due to unsteadiness in the flow as jet pressure varied. The upper graphs of Fig. 1 present these pressures in terms of pressure coefficients. Two curves of unsteady pressure coefficients, $\Delta C_{p_{rms}}$, are given; one is the total unsteadiness measured, and the other is the periodic component due to the dominant frequency. The lower graphs of the figure show the variation in frequency of the periodic component. The measured frequency range was limited to 13 kHz which is an unfortunate but not too serious limitation of the experiment. Some schlieren photographs of the jet stream, using a flash tube with a time duration of a few microseconds, show the dominant frequency at the base to be related to a vortex flow pattern which is shed as discrete toroidal rings or as a continuous helix (Fig. 2). Discontinuities are present in the pressure curves (Fig. 1); sudden reductions occur in the unsteady pressure for a small increase in jet pressure. This behavior of the unsteady pressure is similar to that observed by Dosanjh. At $M_\infty = 1.0$ there is one such occurrence at $H_j/H_\infty \simeq 2.6$, and at $M_\infty = 1.2$ two reductions are evident at $H_j/H_\infty \simeq 1.3$ and 2.4. The time-average pressure is of no real interest from the point of view of noise, apart from indicating that a sudden increase in steady pressure on the base accompanies the sudden reduction in the unsteady condition. Amplitude spectra, obtained before and after each discontinuity (Fig. 3), gives more detail about the unsteady pressure (or noise) reduction. Such a reduction appears to be due to an elimination or appreciable lessening in the strength of the

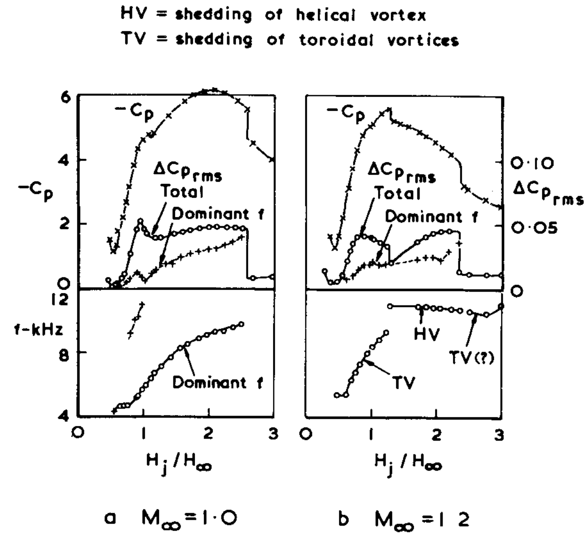

Fig. 1 Time-average and unsteady-base pressures.

a) Toroidal vortex shedding, H_j/H_∞ = 1.10

b) Helical vortex shedding, H_j/H_∞ = 1.31

Fig. 2 Schlieren photographs at M_∞ = 1.2.

Received May 15, 1972; revision received July 31, 1972.
Index categories: Aircraft Propulsion System Noise; Jets, Wakes, and Viscid-Inviscid Flow Interactions.
* Senior Scientific Officer, Aerodynamics Department.

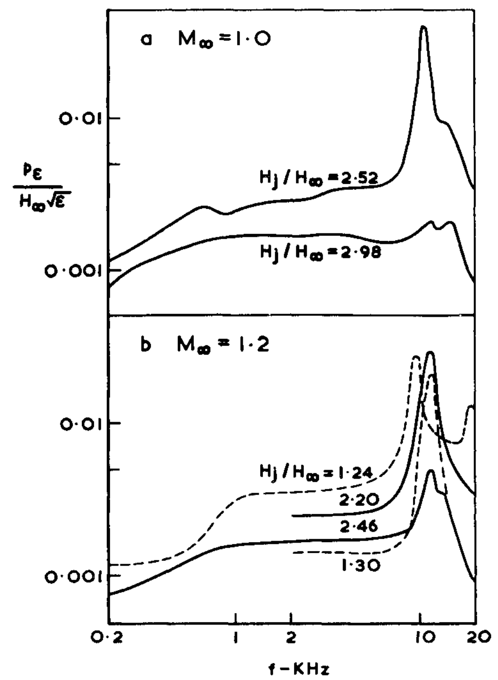

Fig. 3 Amplitude spectra before and after a discontinuity (see Fig. 1).

vortex responsible for the dominant frequency; alternatively a change in character of the vortex may occur (e.g., from toroidal to helical) which can change the frequency without greatly affecting the amplitude. In either case there is a reduction in amplitude of the random intensity level.

As an alternative hypothesis to that presented in Ref. 1, in view of the similarities in the experiments, it is suggested that the reduction in noise level of Dosanjh's coaxial system might be due to a similar vortex shedding phenomenon between the inner and outer streams. At the much smaller scale of his experiment, periodic fluctuations in the flow would also be expected to be small and at a much higher frequency; such conditions would probably be difficult to see with the shadowgraph system that was used for visualization purposes in this experiment.

References

[1] Dosanjh, D. S., Yu, J. C., and Abdelhamid, A. N., "Reduction of Noise from Supersonic Jet Flows," *AIAA Journal*, Vol. 9, No. 12, Dec. 1971, pp. 2346–2353.

[2] Rossiter, J. E. and Kurn, A. G., "Wind Tunnel Measurements of the Effect of a Jet on the Time Average and Unsteady Pressures on the Base of a Bluff Afterbody," ARC Current Paper 903, RAE TR 65187, 1965, Royal Aircraft Establishment, Farnborough, Hampshire, England.

Comment on "Analysis of a Clamped Skew Plate under Uniform Loading"

WILLIAM A. NASH*

The University of Massachusetts, Amherst, Mass.

THE eigenfunction expansion method employed by the authors[1] presents an interesting, although rather lengthy, solution to the problem of deflections of a clamped skew plate subject to uniform normal pressure.

Received May 24, 1972.

Index category: Structural Static Analysis.

* Professor of Civil Engineering. Associate Fellow AIAA.

It is of some interest to point out the rather little-known work of V. Ille who has investigated normally loaded skew plates by a Levy-type approach. Ille employed a simple fourth-degree polynomial that satisfied boundary conditions in the direction of two of the edges, and then obtained a relatively simple ordinary differential equation in the variable describing deflection in the direction of the other two edges. The analytical and numerical effort involved was relatively short.

For the case of the skew plate with all edges clamped, Ille[2] obtained a central deflection coefficient of 0.544 for a skew angle of 45°. This value lies approximately midway between the two values caused by Iyengar and Kennedy as reported in Ref. 1, and somewhat below that obtained by Kale, et al. by their eigenfunction technique. The central deflection coefficient for this same problem was found by N. L. Mikhailov[3] using a Bubnov-Galerkin technique to be 0.550.

It may be of some interest to note that Ille has also investigated the cases of a) uniformly loaded skew plates with two opposite edges simply supported and the other edges either simply supported or free,[4] and b) all four edges simply supported and with the plate having a linear thermal gradient through the thickness.[5] Significant stress and deflection coefficients are presented for all of these situations.

References

[1] Kale, C. S., Gopalacharyulu, S., and Rao, B. S. R., "Analysis of a Clamped Skew Plate under Uniform Loading," *AIAA Journal*, Vol. 10, No. 5, May 1972, pp. 695–697.

[2] Ille, V., "Contributions to the Study of a Plane, Oblique, Isotropic Plate in the Elastic Domain," Ph.D. dissertation, 1966, Inst. of Construction, Bucharest, Romania (in Romanian).

[3] Mikhailov, N. L., "Bending of Parallelogram-Shaped Plates," *Analysis for Strength, Stability, and Vibration*, Mashgiz Publishers, Moscow, Russia, 1955 (in Russian).

[4] Ille, V., "Method of Analysis of a Plane Plate Simply Supported on Two Edges and with Various Conditions of Support on the Other Edges," Publication 7, 1964, Polytechnic Inst. of Cluj, Romania (in Romanian).

[5] Ille, V., "Analysis of A Simply Supported Parallelogram Plate Subject to Temperature Variations," Publication 8, 1965, Polytechnic Inst. of Cluj, Romania (in Romanian).

Optimum Stage Weight Distribution of Multistage Rockets

JAMES A. MARTIN*

NASA Langley Research Center, Hampton, Va.

Nomenclature

w_{o_1} = gross initial weight of rocket
w_i = weight of ith stage
w_L = payload
I_i = specific impulse of ith stage
c_i, n_i = structural weight coefficients

THE purpose of this Comment is to show that a conclusion reached by J. N. Srivastava in a Technical Comment published in the *ARS Journal*, February 1962, was in error. A

Received September 5, 1972.

Index categories: Launch Vehicle and Missile Trajectories; Launch Vehicle and Missile Mission Studies and Economics; Launch Vehicle and Missile Configurational Design.

*Aerospace Engineer, Space Systems Division. Associate Member AIAA.