References

[1]Chin, S., Lan, C. E., and Gainer, T. G., "Calculation of Asymmetric Vortex Separation on Cones and Tangent Ogives Based on a Discrete Vortex Model," *AIAA Journal*, Vol. 27, No. 12, 1989, pp. 1824–1826.

[2]Dyer, D. E., Fiddes, S. P., and Smith, J. H. B., "Asymmetric Vortex Formation from Cones at Incidence—A Simple Inviscid Model," *Aeronautical Quarterly*, Vol. 33, Nov. 1982, pp. 293–312.

[3]Bryson, A. E., "Symmetric Vortex Separation on Circular Cylinders and Cones," *Journal of Applied Mechanics, Transactions of the ASME*, Vol. 81, Ser. E, 1959, pp. 643–648.

[4]Sarpkaya, T., "An Analytical Study of Separated Flow About Circular Cylinders," *Journal of Basic Engineering, ASME*, Vol. 90, 1968, pp. 511–520.

[5]Davis, M. D., "An Analytical Study of Separated Flow about a Circular Cylinder," M. Sc. Dissertation, Naval Postgraduate School, Monterey, CA, 1969.

[6]Hall, R. M., "Forebody and Missile Side Forces and the Time Analogy," AIAA Paper 87-0327, 1987.

[7]Sarpkaya, T., and Shoaff, R. L., "An Inviscid Model of Two-Dimensional Vortex Shedding for Transient and Asymptotically Steady Separated Flow Over a Cylinder," *AIAA Journal*, Vol. 17, No. 11, 1979, pp. 1193–1200.

[8]Almosnino, D., "High Angle-of-Attack Calculations of the Subsonic Vortex Flow on Slender Bodies," *AIAA Journal*, Vol. 23, No. 9, 1985, pp. 1150–1156.

[9]Sarpkaya, T., "Computational Methods with Vortices—The 1988 Freeman Scholar Lecture," *Journal of Fluids Engineering, Transactions of the ASME*, Vol. 111, No. 1, March 1989, pp. 5–52.

Reply by the Authors to T. Sarpkaya

S. Chin* and C. E. Lan†
University of Kansas, Lawrence, Kansas 66095
and
T. G. Gainer‡
NASA Langley Research Center, Hampton, Virginia 23665

SARPKAYA'S comments on numerical instability associated with Bryson's vortex model are applicable only to a two-dimensional problem (a circular cylinder), and are not correct to the three-dimensional problems (cones and tangent ogives) we solved. The main differences between the two are the second term on the right side of Eq. (2), and the second term on the right side of Eq. (3) of Ref. 1. These terms play heavily on the force-free condition we used, $\mathbf{\Gamma} \times \mathbf{V} = 0$, where $\mathbf{\Gamma}$ is the vector of the line vortex strength. Therefore, Sarpkaya's statement that in our model, "the line vortex does not lie along a streamline ..." is totally incorrect.

In addition, since there is no force on the feeding sheet of vanishing small vorticity, there is no couple acting on the vortex in our model. The model does ignore the secondary separations.

In our model, the solution of each branch is very stable. In other words, if a solution is disturbed in any different way, the same final solution is always obtained. We are fully aware of the numerical problem associated with Bryson's model for a circular cylinder. This means that Bryson's model must be reformulated. However, this does not mean that the same numerical problem would occur in our three-dimensional solutions, since different models and equations are being used.

Reference

[1]Chin, S., Lan, C. E., and Gainer, T. G., "Calculation of Asymmetric Vortex Separation on Cones and Tangent Ogives Based on a Discrete Vortex Model," *AIAA Journal*, Vol. 27, No. 12, 1989, pp. 1824–1826.

Received Jan. 31, 1990; accepted for publication March 8, 1990.

*Graduate Research Assistant. Student Member AIAA.
†Professor, Aerospace Engineering, Associate Fellow AIAA.
‡Aerospace Engineer, Mail Stop 156.