DISCUSSION

M. Kurosaka[1]. The authors' encounter with the "vortex whistle" appears to remind us, once again, that, whenever swirling in-flow is involved, one has to be always on the lookout for the possible contamination of flow field induced by these vigorous unsteady dynamic disturbances.

As reported in the authors' references [8, 9], in at least three instances of the radial flow test rigs known to the discusser, a loud screech sound, or the "vortex whistle," emerged when the swirl became sufficiently large; the frequency spectrum revealed the presence of spiky peaks of a pure tone and its harmonics, the frequency of which increased proportionately to swirl. As soon as the "vortex whistle" appeared, the time-averaged, steady flow became distorted: the swirl angle distribution became drastically different from the one before the emergence of the whistle. At the same time, the total pressure near the outer casing exceeded its value upstream of the vanes(!), in exactly the same manner as reported by the authors, and this was compensated by the decrease of total pressure near the inner casing. Furthermore, the total temperature became separated in the radial direction, with hotter air found near the outer casing and colder air found near the inner wall, a phenomenon evocative of the Ranque-Hilsch effect. The degree of temperature separation was such that, in one instance, the outer casing became noticeably warm to the touch, while icing was observed on the inner casing.

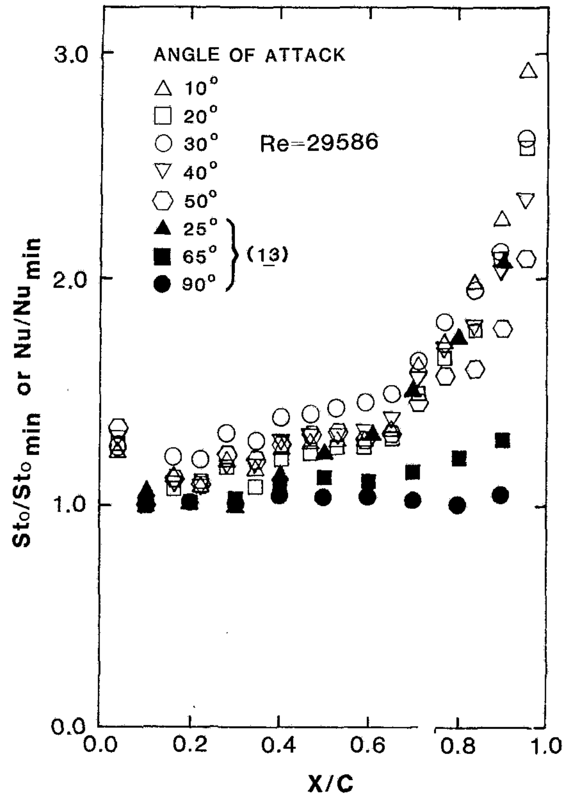
What is intriguing is the fact that once the vortex whistle is eliminated by the installation of acoustic suppressors, this distortion in the flow field disappears at once. This implies that the distortion in the steady flow is caused by none other than unsteady disturbances, through the mechanism of acoustic streaming. In fact, these observations led us to demonstrate ([17, 18] that the dominant cause of the Ranque-Hilsch effect, so far a little-understood phenomenon, is precisely this dimly foreseen mechanism of acoustic streaming.

To all of this may be added a caveat: some of the "steady" flow data taken in the presence of intense disturbances in swirling flows of gas turbines may be suspect – they may be highly contaminated by the unsteady disturbances, as found by the authors.

Parenthetically, the data showing the excess total pressure over its incoming value appear to have been measured also in [19]; although the author did not state any connection with the whistling sound and the subsequent discussions are not clear, the measurements taken downstream of vanes (Figure 26) unmistakably show a distribution similar to the one obtained in the presence of the vortex whistle.

Authors' Closure

The authors appreciate very much the comments of Professor Kurosaka on the "vortex whistle" phenomenon



and thank him for providing other examples of swirling flow test results in which an increase in the total pressure over that of the incoming flow was measured. In our tests, the acoustic streaming associated with this unsteady flow almost eliminated the leading edge vortices from the graphite powder-oil traces, and in one case it even tore the paper attached to the walls.

There is one possible explanation of the total pressure rise observed during the presence of the "vortex whistle" in our tests. In the exit pipe from our test rig, near the rig itself, we observed a high-frequency transient backflow caused by pressure falling below atmospheric. It appears possible, therefore, that at least in our tests, the observed total pressure increase was caused by the atmosphere doing work on the oscillating core flow at the exit from the test rig.

[1] Kurosaka, M., Professor, Department of Aerospace and Mechanical Engineering, The University of Tennessee Space Institute, Tullahoma, Tenn. 37388. Mem. ASME

Additional References

17 Kurosaka, M., "Acoustic Streaming in Swirling Flow and the Ranque-Hilsch (Vortex-Tube) Effect," *Journal of Fluid Mechanics*, Vol. 124, 1982, pp. 139–172.

18 Kurosaka, M., Goodman, J. R., Kuroda, H., and Chu, J. Q., "An Interplay Between Acoustic Waves And Steady Vortical Flow," AIAA Paper 83-0740, 1983.

19 Beshoven, R. L., "An Investigation of Compressible Flows with Large Whirl Components," Aeronautical Engineers thesis, Naval Postgraduate School, 1967.