Table 3 Configurations and initial conditions of nozzles

	Ko and Au	Champagne and Wygnanski [11]
D_0 (cm)	4.0	
D_i (cm)	2.0	2.54
Lip thickness (cm)	0.1	
Inner contraction ratio	8:1	144:1
Outer contraction ratio	13:1	100:1
Area ratio	2.73	1.281, 2.94
U_0 (m/s)	50	60
U_i (m/s)	20-40	30
Initial turbulence intensity at inner nozzle	0.4%	0.1%
Initial turbulence intensity at outer nozzle	1.2%	

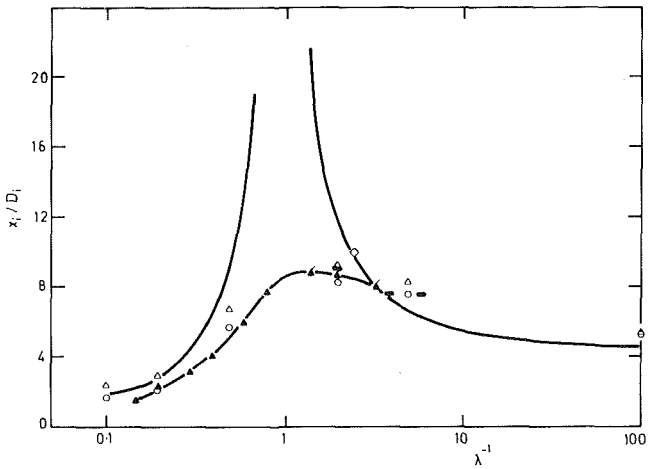

Fig. 10 Variation of inner core length with mean-velocity ratio. —, Abramovich [15]; —, Forstall and Shapiro [1]; △, ○, Champagne and Wygnanski [11]; ◇, Hammersley [6]; ▲, Kwan [17]; ▲, present data.

and Shapiro [1] concern the closed conduit flow. From the figure, fairly good correlation of the inner core length with the mean-velocity ratio is found. At λ^{-1} less than unity the results of Champagne and Wygnanski [11] at the area ratio of 2.94 seem to be slightly higher than those of the authors while the results at the area ratio of 1.28 seem to agree.

Additional References

15 Abramovich, N., *The Theory of Turbulent Jets*, M.I.T. Press, 1963.

16 Hammersley, R. J., "An Experimental Investigation of the Turbulent Characteristics of Coaxial Jet Flows and Their Role in Aerodynamic Noise Generation," Ph.D. thesis, University of Illinois, 1974.

17 Kwan, A. S. H., "Noise Mechanisms in the Initial Region of Coaxial Jets," Ph.D. thesis, University of Hong Kong, 1975.

Combined Simultaneous Flow Visualization – Hot-Wire Anemometry for the Study of Turbulent Flows [1]

P. Freymuth.[2] This discusser would like to point out that mutual reinforcement of flow visualization techniques and hot-wire techniques has been used previously in the context of investigation of stability and transition. Brown [D1] compared flow visualization and hot-wire results to improve the accuracy of the frequency determination for the organized motion which precedes transition in a boundary layer. Freymuth [D2] correlated hot-wire signals with flow visualization signatures for determining the various regions of transition in a free shear layer. Thus, the utilization of several measurement techniques for improved information flow in experimental fluid mechanics has some precedence. The use of this technique by Professor Falco for the investigation of topics of current interest is encouraging, and, hopefully, it will be used even more frequently in the future.

Additional References

D1 Brown, E. N. M., "Boundary Layer Transition," Rep. AD-4059 13 (TISTP1JW), Notre Dame University, Indiana, May 1963.

D2 Freymuth, P., "On Transition in a Separated Laminar Boundary Layer," *J. Fluid Mech.*, Vol. 25, 1966, pp. 683-704.

A Four Hole Pressure Probe for Fluid Flow Measurements in Three Dimensions[1]

M. W. McBride.[2] The velocity vector measuring probe developed by I. C. Shepherd represents a technique which should find a wind range of application. The four-hole probe has advantages over five-hole probes in that fewer data are required and smaller head volumes are possible. The problems associated with the use of these probes should prove to be equivalent to those experienced with five-hole probes. Comprehensive discussion and examples of Reynolds number and near-wall effects may be found in reference [D1]. The effects of high shear rate and turbulence levels are presented in reference [D2]. Both references measure flows associated with rotating turbomachinery in the relative and absolute frames of reference. Comparisons are made with data acquired by other means. In the cases cited, the four-hole probe would have reduced the data handling and test time required.

Measurements of flow with some axial symmetry could be facilitated by use of the four-hole probe. However, the technique of using six calibration quadrants seems cumbersome and could be replaced by a method which requires only a single calibration quadrant. Coefficients based on three indicated static minus total pressures will be well behaved and may be correlated in either rectangular or spherical-polar coordinates. In the later case, the indicated pitch angle is nearly constant with circumferential angle, and the method requires two sets of calibration curves. These curves are fitted with cubic splines and are well behaved.

The accuracy of the probe and data reduction system measuring unknown flows should be documented by direct comparison with measurements taken by independent methods. The laser doppler velocimeter has been shown to produce accurate velocity component measurements and does not suffer from probe response time limitations. Both four and five-hole probes should be compared to LDV data before judgment of absolute accuracy in time dependent flows is made. This is especially true when turbulence levels of ten percent or higher are present.

In conclusion, the four-hole probe offers a relatively simple method of measuring three dimensional flow fields when limitations of use and accuracy are properly taken into account.

Additional References

D1 Treaster, A. L., Youcum, A. M., "The Calibration and Application of Five-Hole Probes," *Transactions of The Instrument Society of America*, Vol. 18, No. 3, 1979.

D2 Pierzga, M. J., "Experimental Verification of the Streamline Curvature Numerical Analysis Method Applied to the Flow Through an Axial Flow Fan,"

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[2] Professor, Department of Aerospace Engineering Sciences, University of Colorado, Boulder, Colo. 80309.

[1] By I. C. Shepherd, published in the December, 1981 issue of the ASME JOURNAL OF FLUIDS ENGINEERING, Vol. 103, No. 4, pp. 590-594.

[2] Research Assistant, Applied Research Laboratory, The Pennsylvania State University, State College, PA. 16801.