

## Sensors for Using Times of Flight To Measure Flow Velocities

**No calibrations are needed to use these thin-film sensors.**

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Thin-film sensors for measuring flow velocities in terms of times of flight are undergoing development. These sensors are very small and can be mounted flush with surfaces of airfoils, ducts, and other objects along which one might need to measure flows. Alternatively or in addition, these sensors can be mounted on small struts protruding from such surfaces for acquiring velocity measurements at various distances from the surfaces for the purpose of obtaining boundary-layer flow-velocity profiles.

These sensors are related to, but not the same as, hot-wire anemometers. Each sensor includes a thin-film, electrically conductive loop, along which an electric current is made to flow to heat the loop to a temperature above that of the surrounding fluid. Instanta-

neous voltage fluctuations in segments of the loop are measured by means of electrical taps placed at intervals along the loop. These voltage fluctuations are caused by local fluctuations in electrical resistance that are, in turn, caused by local temperature fluctuations that are, in turn, caused by fluctuations in flow-induced cooling and, hence, in flow velocity.

The differential voltage as a function of time, measured at each pair of taps, is subjected to cross-correlation processing with the corresponding quantities measured at other pairs of taps at different locations on the loop. The cross-correlations yield the times taken by elements of fluid to travel between the pairs of taps. Then the component of velocity along the line between any

two pairs of taps is calculated simply as the distance between the pairs of taps divided by the travel time. Unlike in the case of hot-wire anemometers, there is no need to obtain calibration data on voltage fluctuations versus velocity fluctuations because, at least in principle, the correlation times are independent of the calibration data.

*This work was done by Gutave Fralick, John D. Wrbanek, and Danny Hwang of Glenn Research Center and James Turso of QSS Inc. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17944-1.*