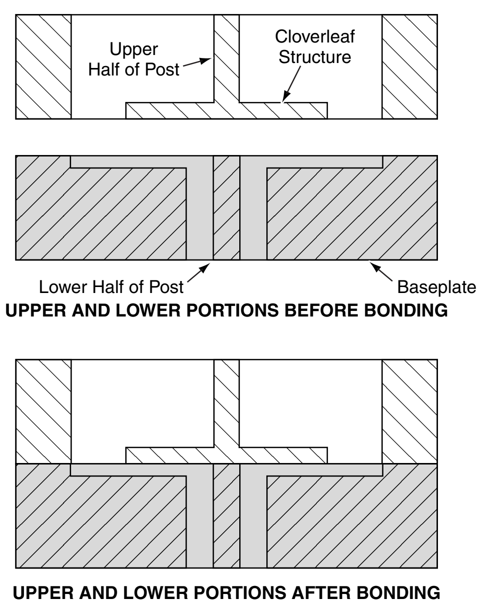
Cloverleaf Vibratory Microgyroscope With Integrated Post

Modifications should lead to greater unit-to-unit consistency.

NASA's Jet Propulsion Laboratory, Pasadena, California

A modified design and fabrication sequence has been devised to improve the performance of a cloverleaf vibratory microgyroscope that includes an axial rod or post rigidly attached to the center of the cloverleaf structure. The basic concepts of cloverleaf vibratory microgyroscopes, without and with rods or posts, were described in two prior articles in *NASA Tech Briefs*, Vol. 21, No. 9 (September 1997): "Micromachined Planar Vibratory Microgyroscopes" (NPO-19713), page 68 and "Planar Vibratory Microgyroscope: Alternative Configuration" (NPO-19714), page 70. As described in more detail in the second-mentioned prior article, the cloverleaf-shaped structure and the rod or post are parts of a vibratory element that senses rotation via the effect of the Coriolis force upon its vibrations.



The **Upper and Lower Portions of the Post and Cloverleaf Structure** are micromachined from silicon, integral with unitary upper and lower portions of a vibratory microgyroscope. The upper and lower portions are then bonded together.

Heretofore, the posts for devices of this type have been fabricated separately, then assembled manually onto the cloverleaf structures. The resulting imperfections in the assembled units have given rise to asymmetric stresses in the cloverleaf structures and, consequently, to changes in resonant frequencies of vibration and in shapes of vibration modes. These changes, in turn, have caused variations in performance among nominally identical devices.

The modified design provides for the fabrication of the upper half of the post as an integral part of the cloverleaf structure; this is accomplished by reactive-ion etching of a single-piece half-post-and-cloverleaf structure from a wafer of silicon. The lower half of the post and a baseplate are also a single piece made by reactive-ion etching from a wafer of silicon. The two pieces are bonded together (see figure) by a thermal-compression metal-to-metal bonding technique to form a cloverleaf gyroscope with an integrated post structure.

This work was done by Tony K. Tang, Roman Gutierrez, and Damien Roger of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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Refer to NPO-20688, volume and number of this NASA Tech Briefs *issue, and the page number.*

Single-Vector Calibration of Wind-Tunnel Force Balances

Improved data quality with an order of magnitude reduction in cost and calibration cycle time over prior methods.

Langley Research Center, Hampton, Virginia

An improved method of calibrating a wind-tunnel force balance involves the use of a unique load application system integrated with formal experimental design methodology. The Single-Vector Force Balance Calibration System (SVS) overcomes the productivity and accuracy limitations of prior calibration methods.

A force balance is a complex structural spring element instrumented with strain gauges for measuring three orthogonal components of aerodynamic force (normal, axial, and side force) and three orthogonal components of aerodynamic torque (rolling, pitching, and yawing moments). Force balances remain as the state-of-the-art instrument that provide these measurements on a scale model of an aircraft during wind tunnel testing. Ideally, each electrical channel of the balance would respond only to its respective component of load, and it would have no response to other components of load. This is not entirely possible even though balance designs are optimized to minimize these undesirable interaction effects. Ultimately, a calibration experiment is performed to obtain the necessary data to generate a mathematical model and determine the force measurement accuracy.

In order to set the independent variables of applied load for the calibration