Mechanics

Alignment Stage for a Cryogenic Dilatometer

A low-friction, low-thermal-expansion kinematic design affords stability and precise adjustability.

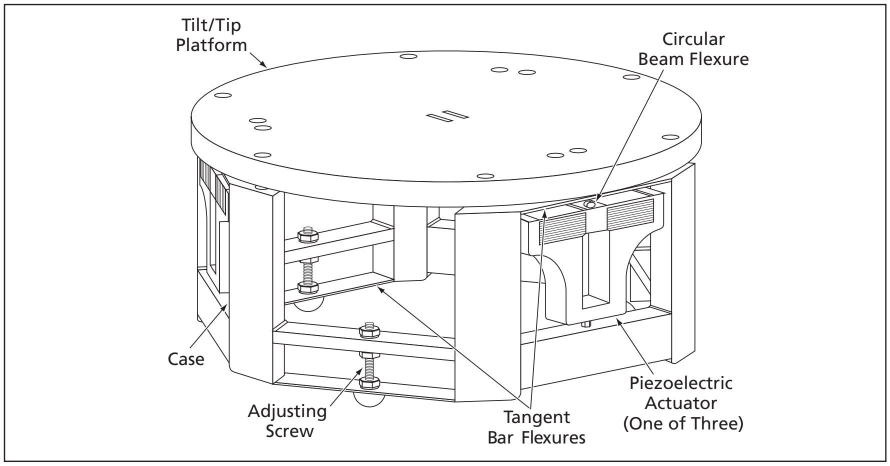
NASA's Jet Propulsion Laboratory, Pasadena, California

A three-degree-of-freedom alignment stage has been designed and built for use in a cryogenic dilatometer that is used to measure thermal strains. The alignment stage enables precise adjustments of the positions and orientations of optical components to be used in the measurements and, once adjustments have been completed, keeps the components precisely aligned during cryogenic-dilatometer operations that can last as long as several days.

The alignment stage (see figure) includes a case, a circular tilt/tip platform, and a variety of flexural couplings between the case and the platform, all machined from a single block of the low-thermal-expansion iron/nickel alloy Invar, in order to minimize effects of temperature gradients and to obtain couplings that are free of stiction and friction. There are three sets of flexural couplings clocked at equal angles of 120° around the platform, constituting a three-point kinematic support system.

Associated with the three sets of flexural couplings are three sets of two actuators each, also clocked at equal angles, which serve to deflect the couplings to adjust the platform in tilt, tip, and/or piston.

By use of actuator/flexural coupling sets that include tangent bar flexures and Invar screws and nuts, one can make coarse adjustments of axial displacement over a range of 1.79 mm with a resolution of 1 mm (corresponding to a tilt/tip angle range of 23.5 milliradians with resolution of about 13 microradians or perhaps somewhat less).



The **Alignment Stage** comprises a monolithic Invar structure that contains flexures plus screw and piezoelectric actuators that deform the flexures to effect adjustments.

Fine adjustments are made by use of piezoelectric actuators in combination with three different types of flexures that apply the proper axial preload and transmit the piezoelectric displacements to the platform while preventing the coupling of shear and bending loads, which could damage the piezoelectric actuators. The fine adjustments are characterized by axial displacement over a range of 15 µm with a resolution of 10 pm (corresponding to a tilt/tip angle range of 222.85 microradians with a resolution of about 0.15 nanoradian or perhaps somewhat less). The piezoelectric actuators are driven by circuits that are parts of a computer-based feedback tilt/tip/piston control system.

By virtue of the low thermal expansion of the monolithic Invar body and the negative thermal expansion of the piezoelectric actuators, the alignment stage is athermalized to within about 7 picometers of axial displacement and 0.1 nanoradian of tip and/or tilt in the presence of an axial temperature gradient of 0.1 K across its structure. Inasmuch as all adjustments are symmetric about the center and are kinematic, any tip or tilt adjustment of the stage is made about its center, with minimal cross-coupling.

This work was done by Matthew Dudik and Donald Moore of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (818) 393-2827. Refer to NPO-40390

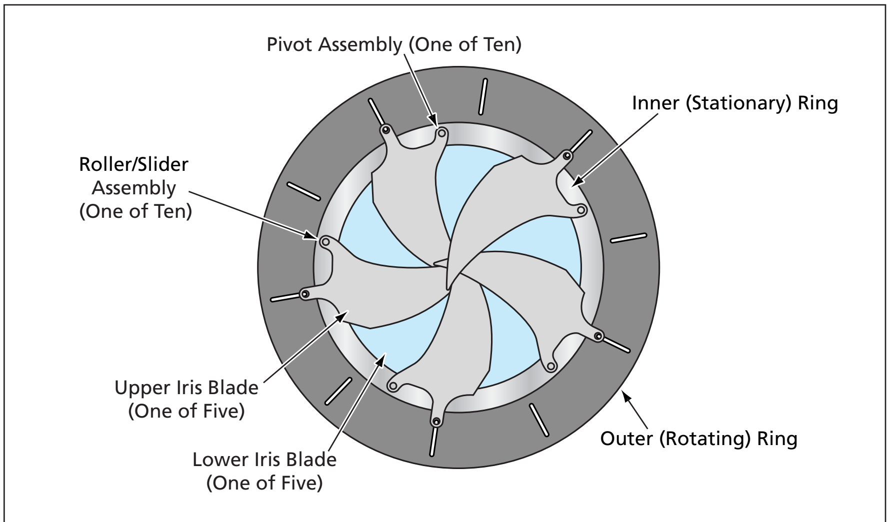
Rugged Iris Mechanism

Advantages include capability for full obscuration, low friction, and general adaptability of design.

Goddard Space Flight Center, Greenbelt, Maryland

A rugged iris mechanism has been designed to satisfy several special requirements, including a wide aperture in the "open" position, full obscuration in the "closed" position, ability to function in a cryogenic or other harsh environment, and minimization of friction through minimization of the number of components. An important element of the low-friction aspect of the design is maximization of the flatness of, and provision of small gaps between, adjacent iris blades. The tolerances of the design can be very loose, accommodating thermal expansions and contractions associated with large temperature excursions. The design is generic in that it is adaptable to a wide range of aperture sizes and can be implemented in a variety of materials to suit the thermal, optical, and mechanical requirements of various applications.

The mechanism (see figure) includes an inner flat ring, an outer flat ring, and an even number of iris blades. The iris blades shown in front in the figure are denoted as "upper," and the iris blades shown partly hidden behind the front ones are denoted as "lower." Each iris blade is attached to the inner ring by a pivot assembly and to the outer ring by a roller/slider assembly. The upper and lower rings are co-centered and are kept in sliding contact. The iris is opened or closed by turning the outer ring around the center while holding the inner ring stationary.



The **Iris Is Opened or Closed** by turning the outer ring with respect to the inner ring.

The mechanism is enclosed in a housing (not shown in the figure) that comprises an upper and a lower housing shell. The housing provides part of the sliding support for the outer ring and keeps the two rings aligned as described above. The aforementioned pivot assemblies at the inner ring also serve as spacers for the housing. The lower housing shell contains part of the lower sliding surface and features for mounting the overall mechanism and housing assembly. The upper housing shell contains part of the upper sliding surface.

This work was done by Nelson J. Ferragut of **Goddard Space Flight Center**. *Further information is contained in a TSP (see page 1).*

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