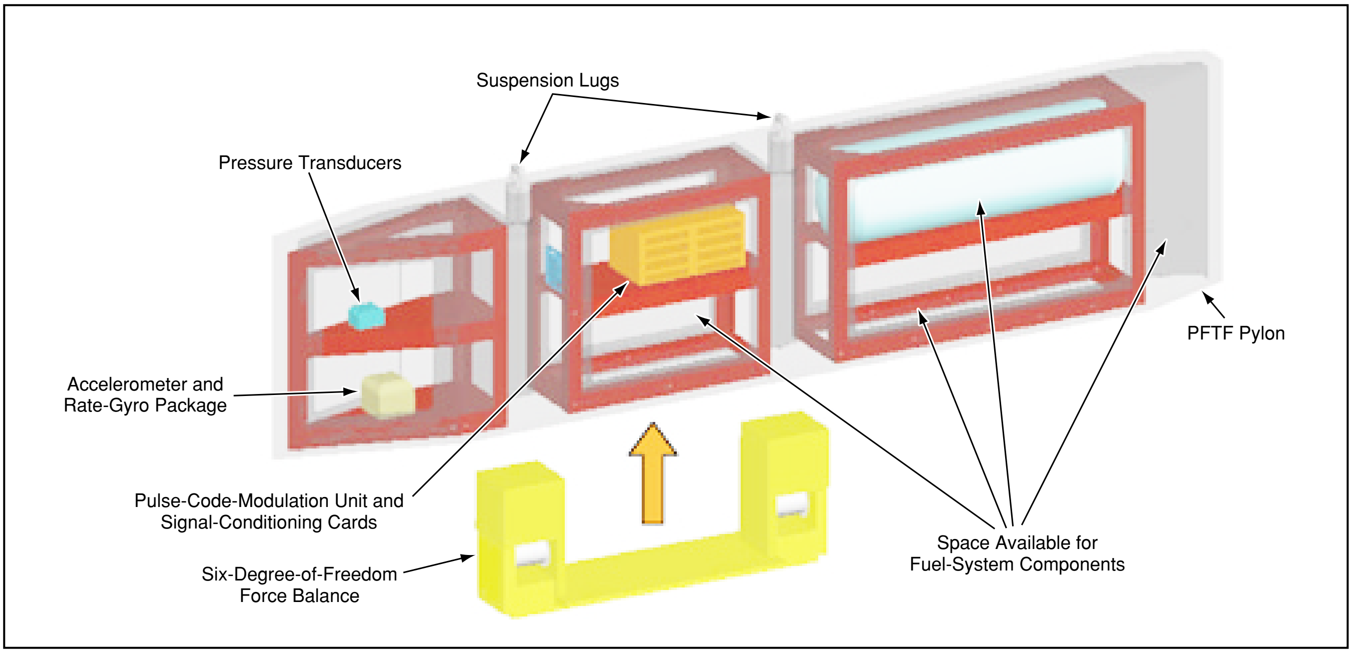


Figure 2. The **Interior of the PFTF** accommodates instrumentation and fuel-system hardware needed for an experiment.

flights, a surrogate engine-shape body denoted the cone drag experiment was flown attached to the force balance. The cone drag experiment inertially and spatially approximated a large engine test article. This cone drag experiment produced drag forces of up to 1,400 lb (≈6.2 kN) at high speeds. A top speed of mach 2.0 and a dynamic pressure of 1,100 psf (≈53 kPa) were attained in this configuration.

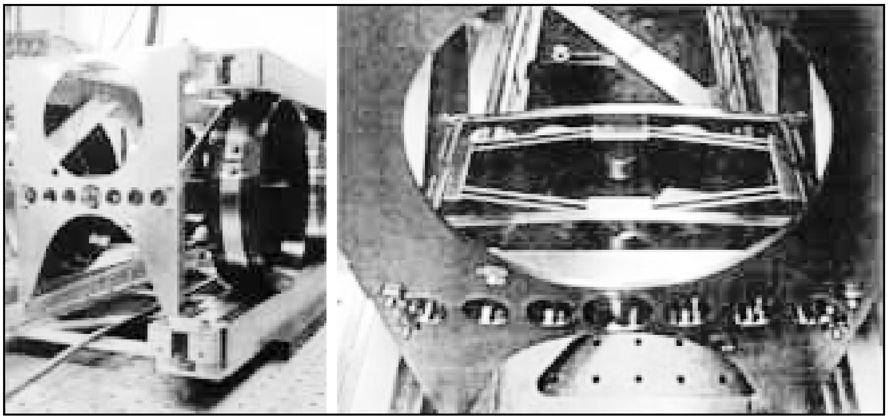
This work was done by Nate Palumbo, M. Jake Vachon, Dave Richwine, and Tim Moes of **Dryden Flight Research Center** *and Gray Creech of AS&M. Further information is contained in a TSP [see page 1].*
DRC-02-23

Mechanical Amplifier for a Piezoelectric Transducer

In addition to multiplication of stroke, the design affords momentum compensation.

NASA'S Jet Propulsion Laboratory, Pasadena, California

A mechanical amplifier has been devised to multiply the stroke of a piezoelectric transducer (PZT) intended for use at liquid helium temperatures. Interferometry holds the key to high angular resolution imaging and astrometry in space. Future space missions that will detect planets around other solar systems and perform detailed studies of the evolution of stars and galaxies will use new interferometers that observe at mid- and far-infrared wavelengths. Phase-measurement interferometry is key to many aspects of astronomical interferometry, and PZTs are ideal modulators for most methods of phase measurement, but primarily at visible wavelengths. At far infrared wavelengths of 150 to 300 μm, background noise is a severe problem and all optics must be cooled to about 4 K. Under these conditions, piezos are ill-suited as modulators, because their throw is reduced by as much as a factor of 2, and even a wavelength or two of modulation is beyond their capability. The largest commercially available piezo stacks are about 5 in. (12.7 cm) long and have a throw of about 180 μm at room temperature and only 90 μm at 4 K. It would seem difficult or impossible to use PZTs for phase measurements in the far infrared were it not for the new mechanical amplifier that was designed and built.



A **Four-Bar Linkage** provides stroke amplification and momentum compensation for the PZT mounted inside it.

To compensate for the loss of travel at cryogenic temperatures, the PZT is mounted in a novel mechanical amplifier that supports one of the mirrors of the interferometer. The mechanical amplifier, shown in the figure, was designed based on an original concept at JPL dating from 1993. The mechanical amplifier resembles an elongated parallelogram with pairs of parallel flexures along each side. The PZT is compressed along the axis of the long diagonal of the parallelogram by support flexures at each end. The expansion of the PZT along the long diagonal causes the ends of the short diagonal to move towards each with a motion amplified by a factor of 3 or 4. The parallel flexures are used to eliminate unwanted twisting and vibration modes such that a small mirror will not tilt when translated by the amplifier. The support flexures that hold the PZT allow a symmetrical expansion of the piezo within the amplifier. The amplifier is designed to be completely symmetric and balanced such that inertia forces are nulled. This provides mechanical stability that allows rapid (100-Hz) sampling without inducing vibrations. Optical interferometers normally obtain the mechanical stability and momentum compensation by using an additional piezo stack mounted back-to-back with the first piezo so that the second one has motions that are equal but opposite in direction. By mounting the stack symmetrically with the support flexures the stack expands equally about its center, does not induce vibrations, and does not require momentum compensation.

This new mechanical amplifier provides both a longer stroke for standard piezo stacks and the necessary mechanical stability through an ingenious mounting arrangement. The device is made of titanium and machined using a wire EDM (electrical-discharge machining) process so as to be as strong and lightweight as possible. It is compact using only a single piezo stack, making it ideally suited for phase-measurement in a cryogenic environment.

This work was done by James Moore, Mark Swain, Peter Lawson, and Robert Calvet of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP [see page 1].*
NPO-30289

Swell Sleeves for Testing Explosive Devices

A device is detonated in a sleeve and the resultant swelling is measured.

Lyndon B. Johnson Space Center, Houston, Texas

A method of testing explosive and pyrotechnic devices involves exploding the devices inside swell sleeves. Swell sleeves have been used previously for measuring forces. In the present method, they are used to obtain quantitative indications of the energy released in explosions of the devices under test.

A swell sleeve is basically a thick-walled, hollow metal cylinder threaded at one end to accept a threaded surface on a device to be tested (see Figure 1). Once the device has been tightly threaded in place in the swell sleeve, the device-and-swell-sleeve assembly is placed in a test fixture, then the device is detonated.

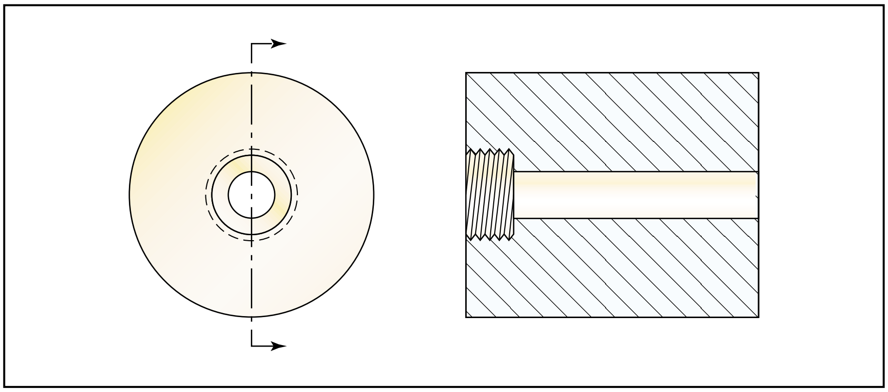


Figure 1. A **Swell Sleeve** is designed and fabricated to accept an explosive device. It is so named because its wall is thick enough not to burst yet thin enough to swell measurably when the device is exploded within it.

After the explosion, the assembly is removed from the test fixture and placed in a coordinate-measuring machine for measurement of the diameter of the swell sleeve as a function of axial position. For each axial position, the original diameter of the sleeve is subtracted from the diameter of the sleeve as swollen by the explosion to obtain the diametral swelling as a function of axial position (see Figure 2). The amount of swelling is taken as a measure of the energy released in the explosion. The amount of swelling can be compared to a standard amount of swelling to determine whether the pyrotechnic device functioned as specified.

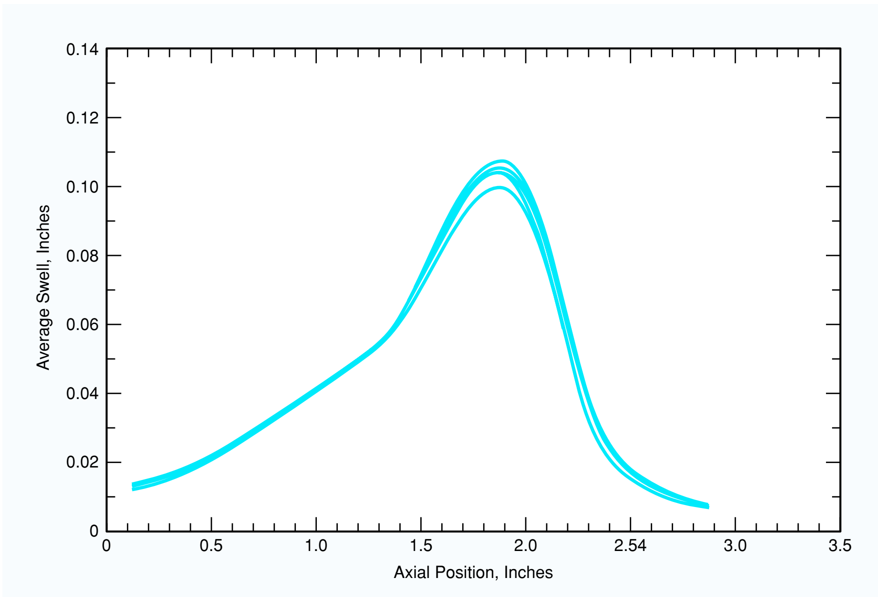


Figure 2. These **Diametral Swells** as functions of axial position were obtained in swell-sleeve tests of explosive devices used to separate an external-tank assembly from a space shuttle.

This work was done by Todd J. Hinkel, Richard J. Dean, Carl W. Hohmann, Scott C. Hacker, and Douglas W. Harrington of **Johnson Space Center** *and James W. Bacak of Lockheed Engineering and Sciences Co. Further information is contained in a TSP [see page 1].*
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