oil flow and produce chalk streaks that mark the streamlines.

The instantaneous rate of thinning of the oil film at a given position on the surface of the model can be expressed as a function of the instantaneous thickness, the skin-friction distribution on the surface, and the streamline pattern on the surface; the functional relationship is expressed by a mathematical model that is nonlinear in the oil-film thickness and is known simply as the thin-oil-film equation. From the image data acquired as described, the time-dependent oil-thickness distribution and streamline pattern are extracted and by inversion of the thin-oil-film equation it is then possible to determine the skin-friction distribution.

In addition to a quasi-monochromatic light source, the SISF system includes a beam splitter and two video cameras equipped with filters for observing the same area on a model in different wavelength ranges, plus a frame grabber and a computer for digitizing the video images and processing the image data. One video camera acquires the interference pattern in a narrow wavelength range of the quasi-monochromatic source. The other video camera acquires the streamline image of fluorescence from the chalk in a nearby but wider wavelength range. The interference-pattern and fluorescence images are digitized, and the resulting data are processed by an algorithm that inverts the thin-oil-film equation to find the skin-friction distribution.

This work was done by James L. Brown of **Ames Research Center** *and Jonathan W. Naughton of MCAT, Inc. Further information is contained in a TSP (see page 1).*

This invention has been patented by NASA (U.S. Patent No. 5,963,310). Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at (650) 604-2954. Refer to ARC-14189-1.

Improved Apparatus for Testing Monoball Bearings

Automated tests can be performed over wide ranges of conditions.

Marshall Space Flight Center, Alabama

A desk-sized apparatus for testing monoball bearings and their lubricants offers advantages, relative to prior such apparatuses, of (1) a greater degree of automation and (2) capability of operation under wider and more realistic ranges of test conditions. The ranges of attainable test conditions include load from 100 to >50,000 lb (445 to >2.22×10^5 N), resisting torque up to 30,000 lb-in. (≈3,390 N-m), oscillating rotation through an angle as large as 280°, and oscillation frequency from 0 to 6 Hz. With addition of some components and without major modification of the apparatus, it is also possible to perform tests under environmental conditions that include temperature from –320 to 1,000 °F (–196 to +538 °C), relative humidity from 0 to 100 percent, and either air at ambient pressure, high vacuum, or an atmosphere of monatomic oxygen.

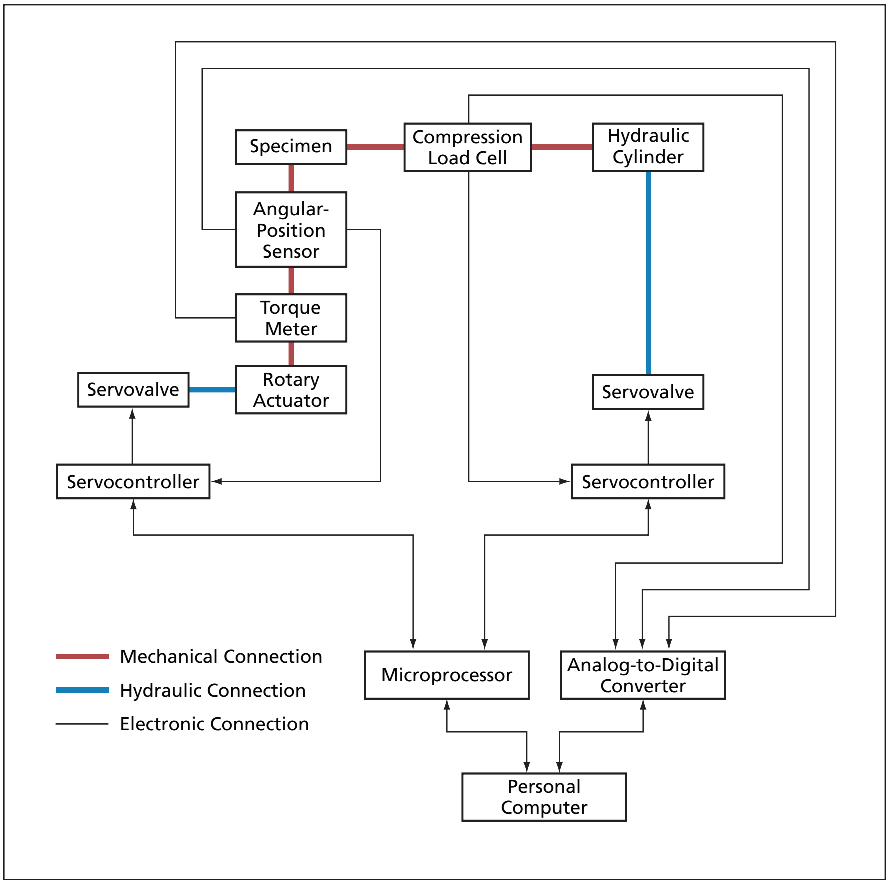

Figure 2. The **Data-Acquisition-and-Control System** of the testing apparatus automates all aspects of testing and processing of test data, once a human operator has initiated a test.

In the apparatus (see Figure 1), a monoball bearing specimen is driven in oscillating rotation by a hydraulic rotary actuator through a series of shafts, one of which incorporates a torque meter and one of which is a flexible coupling. The torque meter measures the resisting torque; the flexible coupling accommodates misalignment, wear, and compression of the specimen and ensures equal loading on opposite sides of the monoball. Not shown in the figure is an angular-position sensor that is used for measuring the angle of rotation of the shafts.

The bearing surfaces that mate with the monoball are supported by an angle plate on one side of the monoball and a trolley on the opposite side. The trolley is supported by very-low-friction cam rollers on its bottom and sides to allow motion in the loading direction only. Rigid side supports absorb the side loads transmitted by the cam rollers. On the opposite end of the trolley from the specimen is a compression load cell, which measures the load, applied by a hydraulic cylinder via a piston that bears against the load cell.

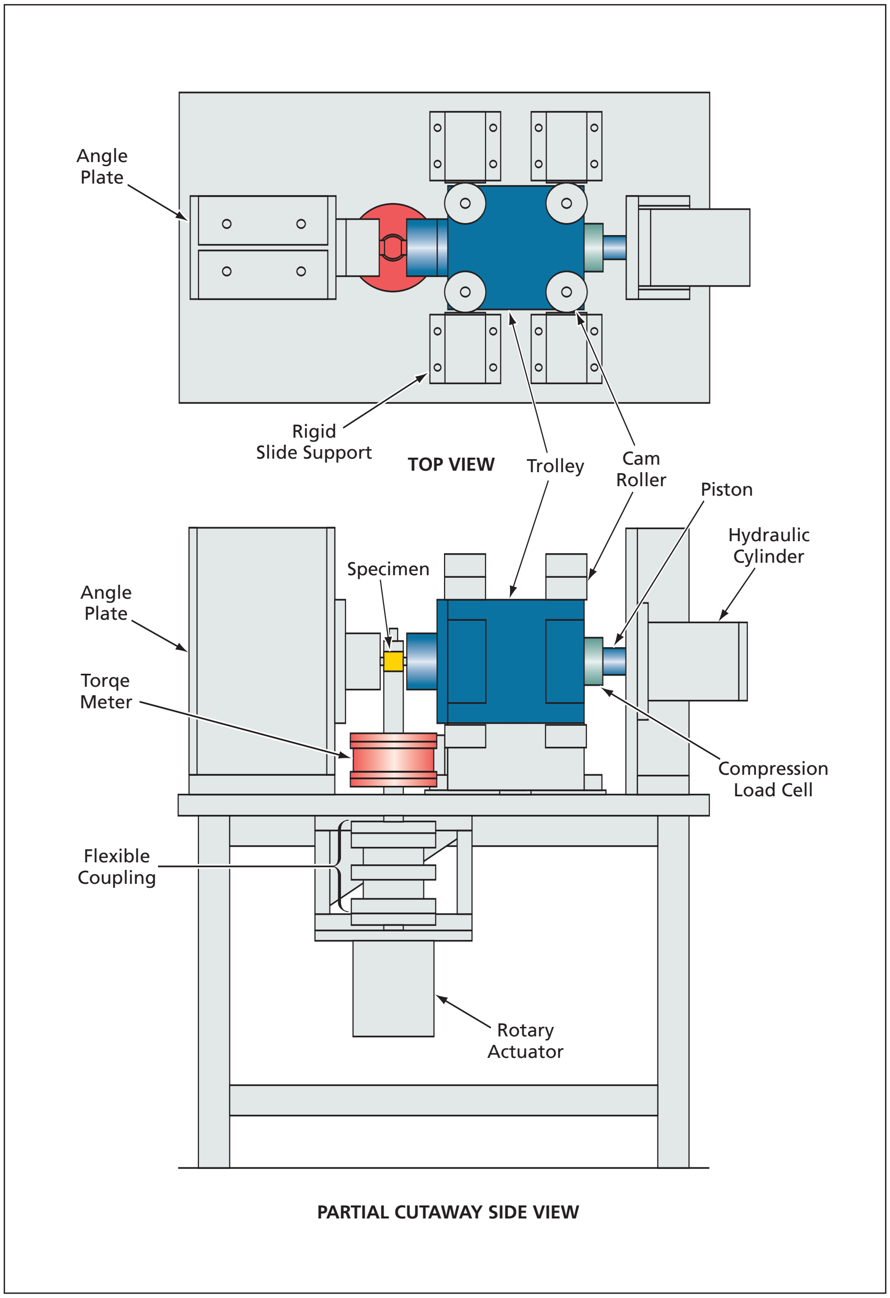

Figure 1. This **Monoball-Bearing-Testing** apparatus subjects a specimen to oscillating rotation at a controlled frequency and amplitude and to a controlled load perpendicular to the axis of rotation.

The apparatus includes a data-acquisition-and-control system (see Figure 2), based on a personal computer and a microprocessor, that controls a test from beginning to end and calculates, displays, and stores test information. An operator enters test instructions into the personal computer, which runs software that translates the instructions into commands. The microprocessor transmits the commands to electronic servocontrollers. Once the operator has initiated a test by entering the instructions, no further intervention by the operator is necessary to ensure successful completion of the test.

The servocontrollers control servovalves that, in turn, control pressures and flows of hydraulic fluids in the hydraulic rotary actuator and the load-applying hydraulic cylinder. Digital signals generated by sensors are fed back to the microprocessor; analog signals from sensors and actuators are fed back to the computer via a fast analog-to-digital converter, and the computer relays these signals to the microprocessor if so required by the test instructions.

The signals from the compression load cell, the torque meter, and the angular-position sensor are used by the control system as both control feedback signals and data. The apparatus measures the applied load, the resisting torque, and the angle of rotation, and the computer calculates the number of cycles and the coefficient of friction in real time. The data are also stored for postprocessing.

This work was done by Phillip B. Hall of **Marshall Space Flight Center** *and Howard L. Novak of USBI/USA Co. Further information is contained in a TSP (see page 1).*

This invention has been patented by NASA (U.S. Patent No. 6,886,392). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31706-1.

High-Speed Laser Scanner Maps a Surface in Three Dimensions

Surface flaws can be scanned automatically and displayed in real time.

Ames Research Center, Moffett Field, California

A scanning optoelectronic instrument generates the digital equivalent of a three-dimensional (X,Y,Z) map of a surface that spans an area with resolution on the order of 0.005 in. (≈0.125mm). Originally intended for characterizing surface flaws (e.g., pits) on space-shuttle thermal-insulation tiles, the instrument could just as well be used for similar purposes in other settings in which there are requirements to inspect the surfaces of many objects. While many commercial instruments can perform this surface-inspection function, the present instrument offers a unique combination of capabilities not available in commercial instruments.

This instrument utilizes a laser triangulation method that has been described previously in *NASA Tech Briefs* in connection with simpler related instruments used for different purposes. The instrument includes a sensor head comprising a monochrome electronic camera and two lasers. The camera is a high-resolution