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## Force-Measuring Clamps

**Clamping forces can be measured easily and quickly.**

*Dryden Flight Research Center, Edwards, California*

Force-measuring clamps have been invented to facilitate and simplify the task of measuring the forces or pressures applied to clamped parts. There is a critical need to measure clamping forces or pressures in some applications — for example, while bonding sensors to substrates or while clamping any sensitive or delicate parts. Many manufacturers of adhesives and sensors recommend clamping at specific pressures while bonding sensors or during adhesive bonding between parts in general.

In the absence of a force-measuring clamp, measurement of clamping force can be cumbersome at best because of the need for additional load sensors and load-indicating equipment. One prior method of measuring clamping force involved the use of load washers or miniature load cells in combination with external power sources and load-indicating equipment. Calibrated spring clamps have also been used. Load washers and miniature load cells constitute additional clamped parts in load paths and can add to the destabilizing effects of loading mechanisms. Spring clamps can lose calibration quickly through weakening of the springs and are limited to the maximum forces that the springs can apply.

The basic principle of a force-measuring clamp can be implemented on a clamp of almost any size and can enable measurement of a force of almost any magnitude. No external equipment is

needed because the component(s) for transducing the clamping force and the circuitry for supplying power, conditioning the output of the transducers, and displaying the measurement value are all housed on the clamp. In other words, a force-measuring clamp is a complete force-application and force-measurement system all in one package. The advantage of unitary packaging of such a system is that it becomes possible to apply the desired clamping force or pressure with precision and ease.

Like many other load-measuring devices, a force-measuring clamp contains strain gauges and exploits the well-known proportionality between strain and applied force or pressure. More specifically, a force-measuring clamp contains four strain gauges electrically connected in a Wheatstone bridge. The bridge output is fed to zero and span circuitry, the output of which is digitized and displayed. The span and zero circuitry make it possible to calibrate the bridge output to indicate force or pressure in any suitable unit of measure.

The strain gauges can be installed by use of Measurements Group M-Bond 610 (or equivalent) epoxy-phenolic adhesive or Measurements Group AE 10 (or equivalent) epoxy adhesive. The strain gauges are connected to a terminal strip for incorporation into the bridge by wires of 34 American Wire Gauge [ $\approx 6.3$  mils ( $\approx 0.16$  mm) in diameter]. Wires of the same size

are used for connections between the terminal and a printed-circuit board. The printed-circuit board contains a voltage-regulation circuit, the span and zero circuits, two watch batteries, and a power switch. The final-stage output of the printed circuit is fed to a digital-display device that is plugged into the printed-circuit board, and is controlled by the zero and span circuits. Operation of the force-measuring clamp is easy: One simply slides the power switch to “on,” adjusts the display to zero if necessary, applies a clamping force, and reads the display.

The functionality of a “breadboard” prototype force-measuring clamp was tested in a laboratory by use of the combination of certified weights, a load washer, a strain indicator, and a voltmeter. Some alternate or future embodiments of force-measuring clamps may include smaller batteries and/or smaller digital displays for the sake of compactness, more options, and better packaging of all components. Force-measuring clamps and/or similar devices could also be incorporated into other mechanisms.

*This work was done by Mark Nunnelee of Dryden Flight Research Center.*

*This invention has been patented by NASA (patent pending). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to Yvonne Kellogg, Technology Commercialization Specialist, Dryden Flight Research Center, (661)276-3720. Refer to DRC-99-37.*

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## Cellular Pressure-Actuated Joint

**Pockets in one of the sealing members would help maintain differential pressure.**

*Marshall Space Flight Center, Alabama*

A modification of a pressure-actuated joint has been proposed to improve its pressure actuation in such a manner as to reduce the potential for leakage of the pressurizing fluid. The specific joint for which the modification is proposed is a field joint in a reusable solid-fuel rocket motor (RSRM), in which the pressurizing fluid is a mixture of hot combustion gases. The proposed modification could also be applicable to other pressure-actuated joints of similar configuration.

The RSRM field joint (see figure) includes a pressure-actuated member denoted the J-leg, which is part of a body of insulation. A pressure-sensitive adhesive (PSA) is used to bond the sealing surface of the J-leg to the sealing surface of another body of insulation. The pressure actuation is supposed to push these two sealing surfaces together. However, experience with the joint indicates that it may not behave as a truly pressure-actuated system.

The modified version of the joint would be the same as the unmodified version, except that pockets of empty volume would be introduced into the body against which the J-leg is pressed. The size, shape, and orientation of the pockets would be such upon the application of pressure to the hot-gas side of the J-leg, the volumes of the pockets would not change significantly and hence the pressures in the pockets, would not change significantly; the net result would be that the pockets would support

the buildup of enough differential pressure across the J-leg so that the joint would behave more nearly like a truly pressure-actuated system.

The breakup of the empty volume into multiple pockets would counteract the tendency toward leakage that would be incurred by introducing a single

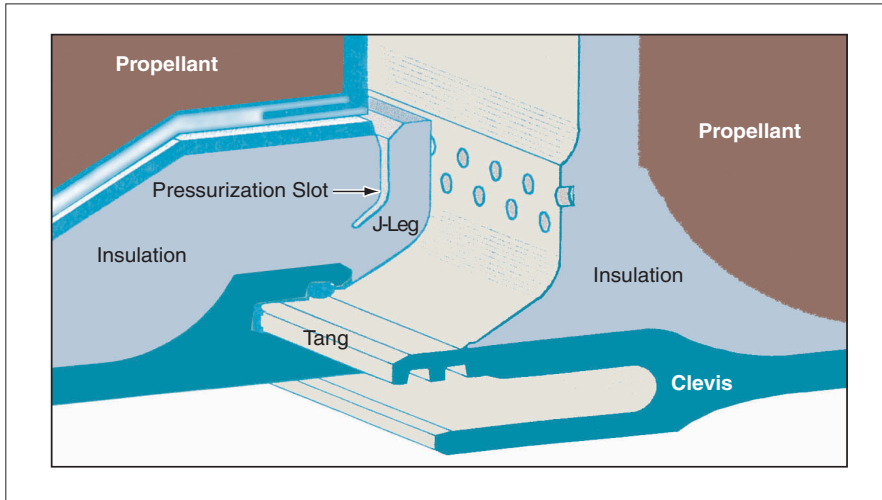
larger pocket. In the unlikely event that a gas path penetrated the joint, only one pocket would be compromised, while the others would continue to maintain the differential pressure needed for pressure actuation.

*This work was done by John R. McGuire of Thiokol Propulsion for Marshall Space Flight Center.*

*Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)} to Thiokol Propulsion. Inquiries concerning licenses for its commercial development should be addressed to*

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The **Modified RSRM Field Joint** would be the same as the unmodified one, except for the introduction of the pockets.