# Piezo-Operated Shutter Mechanism Moves 1.5 cm

## This shutter is designed for use as part of an atomic clock.

*NASA's Jet Propulsion Laboratory, Pasadena, California*

The figure shows parts of a shutter mechanism designed to satisfy a number of requirements specific to its original intended application as a component of an atomic clock to be flown in outer space. The mechanism may also be suitable for use in laboratory and industrial vacuum systems on Earth for which there are similar requirements. The requirements include the following:

- To alternately close, then open, a 1.5-cm-diameter optical aperture twice per second, with a stroke time of no more than 15 ms, during a total operational lifetime of at least a year;
- To attenuate light by a factor of at least $10^{12}$ when in the closed position;
- To generate little or no magnetic field;
- To be capable of withstanding bakeout at a temperature of 200 °C to minimize outgassing during subsequent operation in an ultrahigh vacuum; and
- To fit within a diameter of 12 in. (≈305 mm) — a size limit dictated by the size of an associated magnetic shield.

The light-attenuation requirement is satisfied by use of overlapping shutter blades. The closure of the aperture involves, among other things, insertion of a single shutter blade between a pair of shutter blades. The requirement to minimize the magnetic field is satisfied by use of piezoelectric actuators. Because piezoelectric actuators cannot withstand bakeout, they must be mounted outside the vacuum chamber, and, hence, motion must be transmitted from the actuators to the shutter levers via a vacuum-chamber-wall diaphragm.

The mechanism inside the vacuum chamber must be fabricated in one piece to eliminate pockets from which trapped gas could later escape, ruining the ultrahigh vacuum. The smallness of the displacement produced by the piezoelectric actuators gives rise to a need for mechanical amplification of the stroke by a factor of about 700. The requirement for mechanical amplification is satisfied by use of two pairs of lever arms that are mirror images of each other. The requirement for one-piece construction dictates the use of flexures, instead of bearings, to accommodate the pivoting of the levers.

The piezoelectric actuators, which are also mirror images of each other, are mounted outside the vacuum system (underneath the frame shown in the figure), where they are connected to the lower ends of the lower levers. The upper ends of the lower levers are coupled to the upper ends of the upper levers through a cross-coupled flexing intertie, which is also connected to supports to fix the pivot locations and to hold the diaphragm against atmospheric pressure. The shutter blades are mounted on the lower ends of the upper levers.

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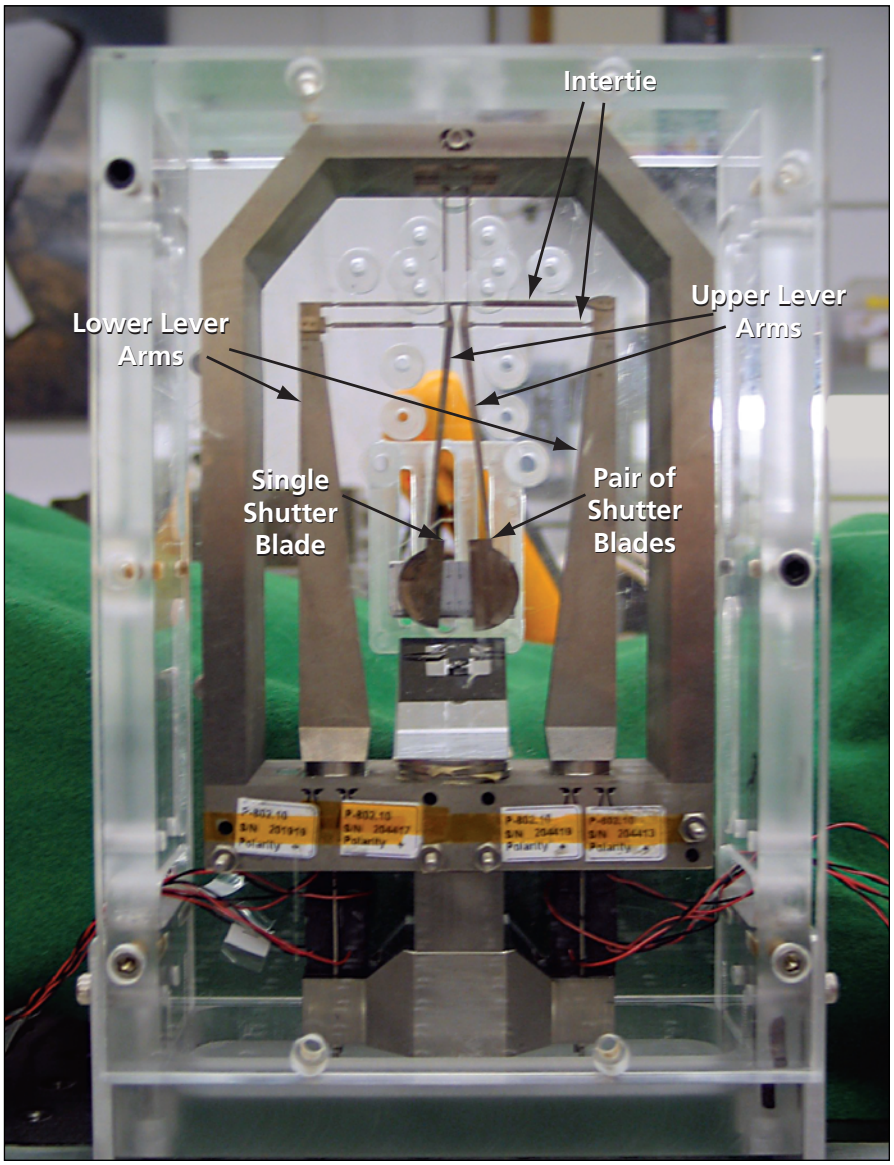


The **Shutter Is Open** in this view. To close the shutter, the levers are pivoted such that the single shutter blade on the left side and the pair of shutter blades on the right side are both brought to the center, so that the blades overlap to block the central aperture.