Machinery/Automation

Rotating Vessels for Growing Protein Crystals

Rotation would ameliorate adverse effects of gravitation.

Lyndon B. Johnson Space Center, Houston, Texas

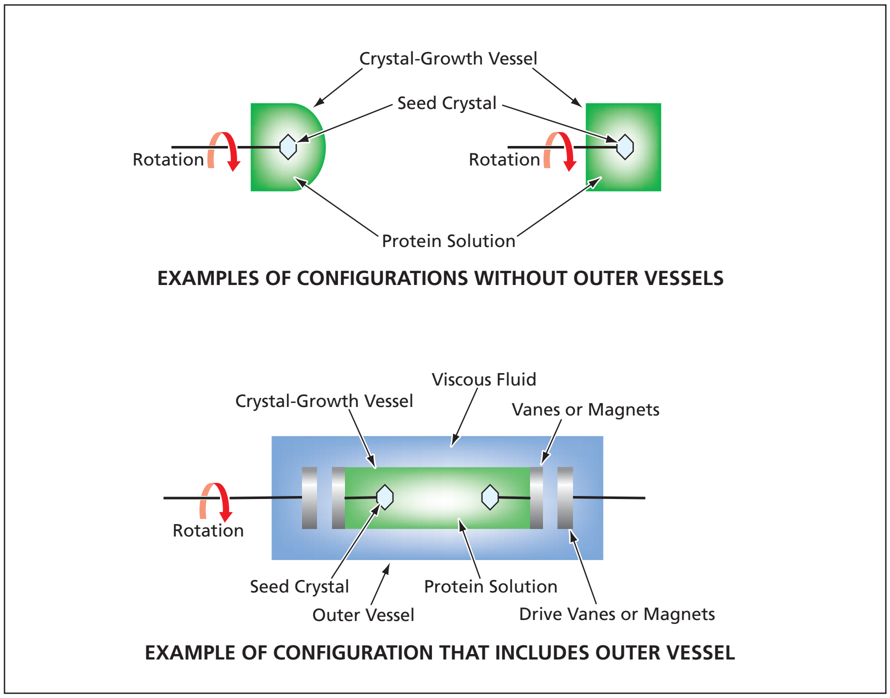
Rotating vessels have been proposed as means of growing larger, more nearly uniform protein crystals than would otherwise be possible in the presence of normal Earth gravitation. Heretofore, nonrotating vessels have been used.

It is difficult to grow high-quality protein crystals in the terrestrial gravitational field because of convection plumes created by the interaction between gravitation and density gradients in protein-solution depletion layers around growing crystals. The density gradients and the associated convection plumes cause the surfaces of growing crystals to be exposed to nonuniform solution densities, thereby causing the crystals to form in irregular shapes. The microgravitational environment of outer space has been utilized to eliminate gravitation-induced convection, but this approach is generally not favorable because of the high cost and limited availability of space flight.

The use of a rotating vessel according to the proposal is intended to ameliorate the effects of gravitation and the resultant convection, relative to the corresponding effects in a non-rotating vessel. The rotation would exert an averaging effect over time, distributing the convective force on the depletion layer. Therefore, the depletion layer would be more nearly uniform and, as a result, the growing crystal would be more nearly perfect.

The proposal admits of variations (see figure), including the following:

- The growing crystal could be rotated about its own central axis or an external axis.
- The crystal-growth vessel could be of any of various shapes, including cylindrical, hemispherical, conical, and combinations thereof.
- The crystal-growth vessel could be suspended in a viscous fluid in an outer vessel to isolate the growing crystal from both ambient vibrations and vibrations induced by a mechanism that drives the rotation.
- The rotation could be coupled to the crystal-growth vessel by viscous or magnetic means.
- The crystal-growth vessel could be supported within the outer vessel by use of a magnetic field.
- The crystal-growth vessel and the outer vessel could be configured in a variety of ways to facilitate heat transfer, instrumentation, and rotation.



A **Hinged Pair of Mechanically Biased Bimorphs** constitutes a unit-cell piezoelectric actuator that can generate a positive or negative displacement. Unit cells can be stacked to obtain a greater stroke.

This work was done by Paul Cottingham of Wyle Laboratories for **Johnson Space Center**. *For further information, contact the Johnson Technology Transfer Office at (281) 483-3809.*

MSC-23212

Oscillating-Linear-Drive Vacuum Compressor for CO_2

Lyndon B. Johnson Space Center, Houston, Texas

A vacuum compressor has been designed to compress CO_2 from ≈1 psia (≈6.9 kPa absolute pressure) to ≈75 psia (≈0.52 MPa), to be insensitive to moisture, to have a long operational life, and to be lightweight, compact, and efficient. The compressor consists mainly of (1) a compression head that includes hydraulic diaphragms, a gas-compression diaphragm, and check valves; and (2) oscillating linear drive that includes a linear motor and a drive spring, through which compression force is applied to the hydraulic diaphragms. The motor is driven at the resonance vibrational frequency of the motor/spring/compression-head system, the compression head acting as a damper that takes energy out of the oscillation. The net effect of the oscillation is to cause cyclic expansion and contraction of the gas-compression diaphragm, and, hence, of the volume bounded by this diaphragm. One-way check valves admit gas into this volume from the low-pressure side during expansion and allow the gas to flow out to the high-pressure side during contraction. Fatigue data and the results of diaphragm stress calculations have been interpreted as signifying that the compressor can be expected to have an operational life of >30 years with a confidence level of 99.9 percent.

This work was done by Michael G. Izenson and Martin Shimko of Creare, Inc. for **Johnson Space Center**. *For further information, contact the Johnson Technology Transfer Office at (281) 483-3809.*
MSC-23269

Mechanically Biased, Hinged Pairs of Piezoelectric Benders

Unit cells can be stacked to obtain greater stroke for a given voltage.

Lyndon B. Johnson Space Center, Houston, Texas

The upper part of the figure depicts an actuator that comprises two mechanically biased piezoelectric benders hinged together at their ends and equipped with tabs at their mid-length points for attachment to the relatively moving objects that are to be actuated. In the example of the figure, the attachment tabs are labeled to indicate that the actuator is used to drive a pump piston relative to a base plate. Actuators of this type could be used to drive low-power, small-volume pumps in consumer, medical, and aerospace applications, and to generate and measure linear displacements in such robotic applications as teleoperation and tactile feedback.

Each bender is a bimorph — a unitary plate that comprises an upper and a lower piezoelectric layer plus electrode layers. Benders may also be made of several layers arranged to produce the same effect at the lower operating voltages. As stated above, each bender is mechanically biased; it is fabricated to have a small permanent curvature (the bias curvature) in the absence of applied voltage. As on other bimorphs, the electrical connections on each bender are arranged so that an applied voltage of suitable polarity causes the upper layer to expand and the lower layer to contract. In this case, the net effect of applying the voltage is that the plate becomes more concave as viewed from below. Conversely, an applied voltage of the opposite polarity causes the plate to become less concave as viewed from below.

The benders in a hinged pair are oriented with their bias curvatures concave inward, so that there is a bias distance between the attachment tabs. The two benders are connected electrically in parallel, with their connection polarities chosen so that an applied voltage of one polarity causes both benders to become more convex inward (more bent), while an applied voltage of the opposite polarity causes both benders to become less convex inward (less bent). An increase or decrease in bend is accompanied by an increase or decrease in distance between the attachment tabs; this increase or decrease is the linear displacement desired for actuation. Because the displacement can be either positive or negative relative to the bias distance, depending on the polarity of the applied voltage, the overall stroke achievable for a given magnitude of applied voltage is double the stroke achievable in the absence of mechanical bias.

Each hinged pair can be regarded as a unit cell that can serve as a building block for a larger actuator: Multiple unit cells can be stacked (mechanically connected in series), as shown in the lower part of the figure, and electrically connected in parallel to multiply the overall stroke achievable at a given applied voltage.

This work was done by Frank E. Sager of Oceaneering Space Systems for **Johnson Space Center**.

Title to this invention, covered by U.S. Patent No. 5,889,354, has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457 (f)}. Inquiries concerning licenses for its commercial development should be addressed to:

Oceaneering Space Systems
Attn: Jeffrey D. Brown, Program Development
16665 Space Center Blvd.
Houston, TX 77058-2268
Phone No.: (281) 228-5300

Refer to MSC-22881, volume and number of this NASA Tech Briefs *issue, and the page number.*