System for Packaging Planetary Samples for Return to Earth

System completes all the necessary steps for proper preservation.

NASA's Jet Propulsion Laboratory, Pasadena, California

A system is proposed for packaging material samples on a remote planet (especially Mars) in sealed sample tubes in preparation for later return to Earth. The sample tubes (Figure 1) would comprise (1) tubes initially having open tops and closed bottoms; (2) small, bellowslike collapsible bodies inside the tubes at their bottoms; and (3) plugs to be eventually used to close the tops of the tubes. The top inner surface of each tube would be coated with solder. The side of each plug, which would fit snugly into a tube, would feature a solder-filled ring groove. The system would include equipment for storing, manipulating, filling, and sealing the tubes.

The containerization system (see Figure 2) will be organized in stations and will include: the storage station, the loading station, and the heating station. These stations can be structured in circular or linear pattern to minimize the manipulator complexity, allowing for compact design and mass efficiency. The manipulation of the sample tube between stations is done by a simple manipulator arm. The storage station contains the unloaded sample tubes and the plugs before sealing as well as the sealed sample tubes with samples after loading and sealing. The chambers at the storage station also allow for plug insertion into the sample tube. At the loading station the sample is poured or inserted into the sample tube and then the tube is topped off. At the heating station the plug is heated so the solder ring melts and seals the plug to the sample tube.

The process is performed as follows: Each tube is filled or slightly overfilled with sample material and the excess sample material is wiped off the top. Then, the plug is inserted into the top section of the tube packing the sample material against the collapsible bellowslike body allowing the accommodation of the sample volume. The plug and the top of the tube are heated momentarily to melt the solder in order to seal the tube.

This work was done by Mircea Badescu, Yoseph Bar-Cohen, Paul G. Backes, Stewart Sherrit, Xiaoqi Bao, and James S. Scott of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46089
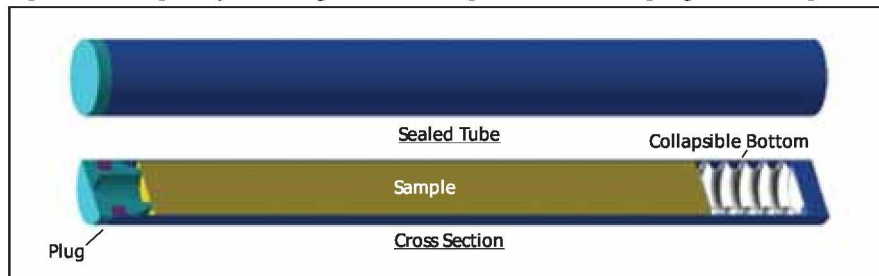
Figure 2: **Containerization System** includes loading, heating/sealing, and storage stations.

Figure 1: A **Sample Tube** is shown with collapsible bottom (on the right), sample, and sealed plug.

Offset Compound Gear Drive

A 50-percent reduction ratio is achieved with two stages utilizing four gears.

John H. Glenn Research Center, Cleveland, Ohio

The Offset Compound Gear Drive is an in-line, discrete, two-speed device utilizing a special offset compound gear that has both an internal tooth configuration on the input end and external tooth configuration on the output end, thus allowing it to mesh in series, simultaneously, with both a smaller external tooth input gear and a larger internal tooth output gear. This unique geometry and offset axis permits the compound gear to mesh with the smaller diameter input gear and the larger diameter output gear, both of which are on the same central, or primary, centerline. This configuration results in a compact in-line reduction gear set consisting of fewer gears and bearings than a conventional planetary gear train. Switching between the two output ratios is accomplished through a main control clutch and sprag. Power flow to the above is transmitted through concentric power paths.

Low-speed operation is accomplished in two meshes. For the purpose of illustrating the low-speed output operation, the following example pitch diameters

are given. A 5.0 pitch diameter (PD) input gear to 7.50 PD (internal tooth) intermediate gear (0.667 reduction mesh), and a 7.50 PD (external tooth) intermediate gear to a 10.00 PD output gear (0.750 reduction mesh). Note that it is not required that the intermediate gears on the offset axis be of the same diameter. For this example, the resultant low-speed ratio is 2:1 (output speed = 0.500; product of stage one 0.667 reduction and stage two 0.750 stage reduction). The design is not restricted to the example pitch diameters, or output ratio. From the output gear, power is transmitted through a hollow drive shaft, which, in turn, drives a sprag during which time the main clutch is disengaged.

High-speed operation is direct-drive (1:1) through the main clutch. During this mode of operation, the above gear train free-wheels the overrunning sprag. A slight reduction in input speed is required to overrun the sprag. The above gear train always spins.

The configuration was conceived to meet a rotorcraft drive design objective to provide a 50-percent reduction ratio. The configuration does so in two stages, or meshes, utilizing only three gears replacing multiple planet gears required in conventional planetary stages. A same-direction 50-percent reduction is not possible with a single-stage simple planetary gear configuration.

In addition, ratios other than 50 percent can be configured to meet specific design requirements. This configuration overcomes a technical design challenge of configuring a simple and ro-

bust two-speed/variable-speed driveline transmission that is lightweight yet capable of transferring high power at high speed for next-generation rotary wing aircraft, which are forecast to require speed range variations on the order of 50 percent.

✿ Low-Dead-Volume Inlet for Vacuum Chamber

John F. Kennedy Space Center, Florida

Gas introduction from near-ambient pressures to high vacuum traditionally is accomplished either by multi-stage differential pumping that allows for very rapid response, or by a capillary method that allows for a simple, single-stage introduction, but which often has a delayed response. Another means to introduce the gas sample is to use the multi-stage design with only a single stage. This is accomplished by using a very small conductance limit. The problem with this method is that a small conductance limit will amplify issues associated with dead-volume.

As a result, a high-vacuum gas inlet was developed with low dead-volume, allowing the use of a very low conductance limit interface. Gas flows through the ConFlat flange at a relatively high flow rate at orders of magnitude greater than through the conductance limit. The small flow goes through a conductance limit that is a double-sided ConFlat.

✿ Simple Check Valves for Microfluidic Devices

No additional materials or fabrication steps are necessary.

NASA's Jet Propulsion Laboratory, Pasadena, California

A simple design concept for check valves has been adopted for microfluidic devices that consist mostly of (1) deformable fluorocarbon polymer membranes sandwiched between (2) borosilicate float glass wafers into which channels, valve seats, and holes have been etched. The first microfluidic devices in which these check valves are intended to be used are micro-capillary electrophoresis (microCE) devices undergoing development for use on Mars in detecting compounds indicative of life. In this application, it will be necessary to store some liquid samples in reservoirs in the devices for subsequent laboratory analysis, and check valves are needed to prevent cross-contamination of the samples. The simple check-valve design concept is also applicable to other microfluidic devices and to fluidic devices in general.

These check valves are simplified microscopic versions of conventional rubber-flap check valves that are parts of numerous industrial and consumer products. These check valves are fabricated, not as separate components, but as integral parts of microfluidic devices. A check valve according to this concept consists of suitably shaped portions of a deformable membrane and the two glass wafers between which the membrane is sandwiched (see figure). The valve flap is formed by making an approximately semicircular cut in the membrane. The flap is centered over a hole in the lower glass wafer, through which hole the liquid in question is intended to flow upward into a wider hole, channel, or reservoir in the upper glass wafer. The radius of the cut exceeds the radius of the hole by an amount large enough to prevent settling of the flap into the hole. As in a conventional rubber-flap check valve, back pressure in the liquid pushes the flap against the valve seat (in this case, the valve seat is the adjacent surface of the lower glass wafer), thereby forming a seal that prevents backflow.