

This **Microfluidic Check Valve** is a simplified version of a conventional rubber-flap check valve.

A typical sequence for fabricating a microfluidic device for the original intended microCE application includes the following steps:

1. Channels and valve seats are patterned in the two glass wafers between which

2. Holes are drilled through the wafers in predetermined locations for flowpaths.
3. The deformable membrane is fabricated.
4. Holes are punched in the membrane at locations matching those of holes, valve seats, and flow-channel orifices in the upper and lower glass plates. However, holes are not punched at locations where check valves are required.
5. At each check-valve location on the membrane, the check-valve flap is formed by use of an approximately semicircular punch. No membrane material is removed.

The ideal cut for forming a check-valve flap is an arc somewhat greater than a semicircle but less than a full circle. The resistance to flow through the check valve can be reduced by increasing the arc length of the punch. It is worth emphasizing that implementation of this concept entails nothing more than the use of additional punches for forming the flaps in the fabrication process.

*This work was done by Peter A. Willis, Harold F. Greer, and J. Anthony Smith of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-45933*

## ⚙️ A Capillary-Based Static Phase Separator for Highly Variable Wetting Conditions

**Commercially viable two-phase flow/ liquid management field applications have been developed for microgravity.**

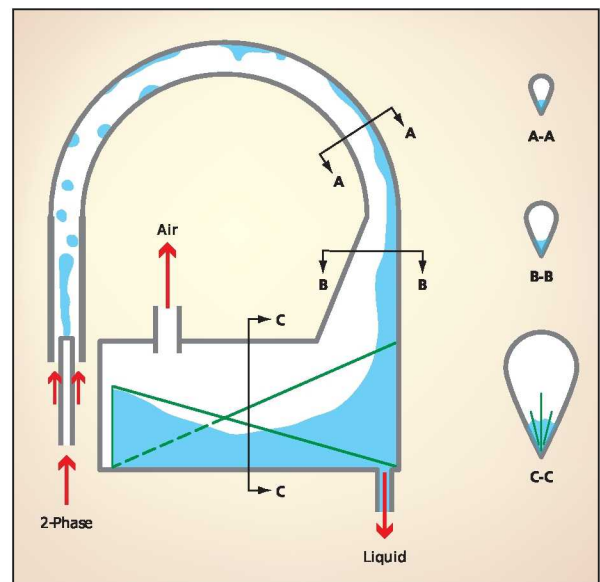
*Lyndon B. Johnson Space Center, Houston, Texas*

The invention, a static phase separator (SPS), uses airflow and capillary wetting characteristics to passively separate a two-phase (liquid and air) flow. The device accommodates highly variable liquid wetting characteristics. The resultant design allows for a range of wetting properties from about 0 to over 90° advancing contact angle, with frequent complete separation of liquid from gas observed when using appropriately scaled test conditions. Additionally, the design accommodates a range of air-to-liquid flow-rate ratios from only liquid flow to over 200:1 air-to-liquid flow rate.

The SPS uses a helix input section with an ice-cream-cone-shaped constant area cross section (see figure). The wedge portion of the cross section is on the outer edge of the helix, and collects the liquid via centripetal acceleration. The helix then passes into an increasing cross-sectional area vane region.

The liquid in the helix wedge is directed into the top of capillary wedges in the liquid containment section. The transition from diffuser to containment section includes a 90° change in capillary pumping direction, while maintaining inertial direction. This serves to impinge the liquid into the two off-center symmetrical vanes by the airflow.

Rather than the airflow serving to shear liquid away from the capillary vanes, the design allows for further penetration of the liquid into the vanes by the air shear. This is



A sketch of the **Static Phase Separator** illustrates the geometry.

also assisted by locating the air exit ports downstream of the liquid drain port. Additionally, any droplets not contained in the capillary vanes are re-entrained downstream by a third opposing capillary vane, which directs liquid back toward the liquid drain port. Finally, the dual air exit ports serve to slow the airflow down, and to reduce the likelihood of shear. The ports are stove-piped into the cavity to form an unfriendly capillary surface for a wetting fluid to carryover. The liquid

drain port is located at the start of the containment region, allowing for draining the bulk fluid in a continuous circuit.

The functional operation of the SPS involves introducing liquid flow (from a human body, a syringe, or other source) to the two-phase inlet while an air fan pulls on the air exit lines. The fan is operated until the liquid is fully introduced. The system is drained by negative pressure on the liquid drain lines when the SPS containment system is full.

*This work was done by Evan A. Thomas and John C. Graf of Johnson Space Center and Mark M. Weislogel, independent consultant. Further information is contained in a TSP (see page 1).*

*This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-1003. Refer to MSC-24441-1.*

## ⚙️ Gimballing Spacecraft Thruster

*Marshall Space Flight Center, Alabama*

A gimballing spacecraft reaction-control-system thruster was developed that consists of a small hydrogen/oxygen-burning rocket engine integrated with a Canfield joint. (Named after its inventor, a Canfield joint is a special gimbal mount that is strong and stable yet allows a wide range of motion.) One es-

pecially notable aspect of the design of this thruster is integration, into both the stationary legs and the moving arms of the Canfield joint, of the passages through which the hydrogen and oxygen flow to the engine. The thruster was assembled and subjected to tests in which the engine was successfully fired

both with and without motion in the Canfield joint.

*This work was done by Tim Pickens and John Bossard of Orion Propulsion, Inc. for Marshall Space Flight Center. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at [sammy.a.nabors@nasa.gov](mailto:sammy.a.nabors@nasa.gov). Refer to MFS32520-1.*

## ⚙️ Finned Carbon-Carbon Heat Pipe With Potassium Working Fluid

**The heat pipe can be used in terrestrial power plants.**

*John H. Glenn Research Center, Cleveland, Ohio*

This elemental space radiator heat pipe is designed to operate in the 700 to 875 K temperature range. It consists of a C-C (carbon-carbon) shell made from poly-acrylonitrile fibers that are woven in an angle interlock pattern and densified with pitch at high process temperature with integrally woven fins. The fins are 2.5 cm long and 1 mm thick, and provide an extended radiating surface at the colder condenser section of the heat pipe. The weave pattern features a continuous fiber bath from the inner tube surface to the outside edges of the fins to maximize the thermal conductance, and to thus minimize the temperature drop at the condenser end. The heat pipe and radiator element together are less than one-third the mass of conventional heat pipes of the same heat rejection surface area.

To prevent the molten potassium working fluid from eroding the C-C heat pipe wall, the shell is lined with a thin-walled, metallic tube liner (Nb-1 wt.% Zr), which is an integral part of a



The finned Carbon-Carbon Heat Pipe is shown with an Nb-1Zr evaporator liner.

hermetic metal subassembly which is furnace-brazed to the inner surface of the C-C tube. The hermetic metal liner subassembly includes end caps and fill tubes fabricated from the same Nb-1Zr alloy. A combination of laser and electron beam methods is used to weld the end caps and fill tubes. A tungsten/inert gas weld seals the fill tubes after cleaning and charging the heat pipes with potassium.

The external section of this liner, which was formed by a "Uniscan" rolling process, transitions to a larger wall thickness. This section, which protrudes beyond the C-C shell, constitutes the "evaporator" part of the heat pipe, while the section inside the shell constitutes the condenser of the heat pipe (see figure). The metal liner contains a concentric tubular perforated wick sized and located to form an annu-