quired second stage to manage the continual accumulation of water in the shell-side volume. An example would be with the circularization of the tubes so that water would tend to be swirled or slung to the outside of the tube bundle for subsequent removal by a second stage of the separator intended for the fine separation of remaining gas from the product water stream before it exits the separator. Another version could include in-separator reactant pressure regulation, ejector-based reactant pumping, and reactant pre-humidifying thermal control through the use of in-separator thermal conditioning.

The system has few moving parts and is not subject to degradation of performance due to changes in material properties (surface wetting characteristics, etc.). The design eliminates the possibility of flooding of the fuel cell stack during nominal operations, reduces the complexity of the task of maintaining the residual water volume of the separator during periods of non-use of the fuel cell power system, and can be packaged in a manner suitable for spacecraft fuel cell power systems.

This work was done by Arturo Vasquez and Karla F. Bradley for Johnson Space Center. Further information is contained in a TSP (see page 1). ***.*** *MSC-24157-1.*

Counterflowing Jet Subsystem Design

Marshall Space Flight Center, Alabama

A counterflowing jet design (a spacecraft and trans-atmospheric subsystem) employs centrally located, supersonic cold gas jets on the face of the vehicle, ejecting into the oncoming free stream. Depending on the supersonic free-stream conditions and the ejected mass flow rate of the counterflowing jets, the bow shock of the vehicle is moved upstream, further away from the vehicle. This results in an increasing shock standoff distance of the bow shock with a progressively weaker shock. At a critical jet mass flow rate, the bow shock becomes so weak that it is transformed into a series of compression waves spread out in a much wider region, thus significantly modifying the flow that wets the outer surfaces, with an attendant reduction in wave and skin friction drag and aerothermal loads.

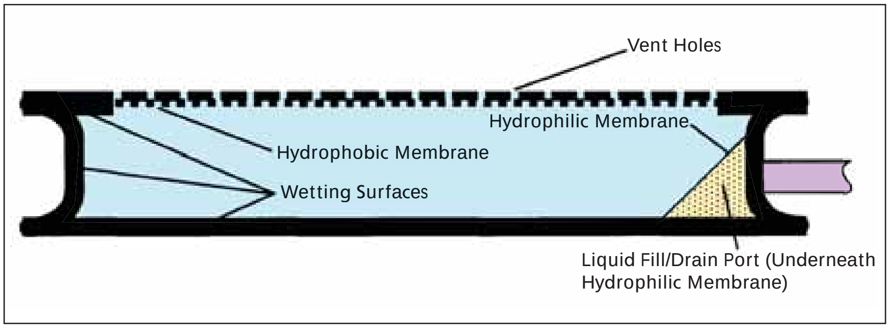
This work was done by Rebecca Farr, Endwell Daso, Victor Pritchett, and Ten-See Wang of Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32604-1.

Water Tank With Capillary Air/Liquid Separation

Tank is filled and emptied as needed in microgravity.

Lyndon B. Johnson Space Center, Houston, Texas

A bladderless water tank (see figure) has been developed that contains capillary devices that allow it to be filled and emptied, as needed, in microgravity. When filled with water, the tank shields human occupants of a spacecraft against cosmic radiation. A membrane that is permeable by air but is hydrophobic (neither wettable nor permeable by liquid water) covers one inside surface of the tank. Grooves between the surface and the membrane allow air to flow through vent holes in the surface as the tank is filled or drained. A margin of wettable surface surrounds the edges of the membrane, and all the other inside tank surfaces are also wettable. A fill/drain port is located in one corner of the tank and is covered with a hydrophilic membrane.



This functional schematic shows key components of the **Radiation-Shield Water Tank.**

As filling begins, water runs from the hydrophilic membrane into the corner fillets of the tank walls. Continued filling in the absence of gravity will result in a single contiguous air bubble that will be vented through the hydrophobic membrane. The bubble will be reduced in size until it becomes spherical and smaller than the tank thickness. Draining the tank reverses the process. Air is introduced through the hydrophobic membrane, and liquid continuity is maintained with the fill/drain port through the corner fillets. Even after the tank is emptied, as long as the suction pressure on the hydrophilic membrane does not exceed its bubble point, no air will be drawn into the liquid line.

This work was done by Eugene K. Ungar, Frederick Smith, and Gregg Edeen of Johnson Space Center and Jay C. Almlie of Hernandez Engineering, Inc. Further information is contained in a TSP (see page 1). ***.*** *MSC-23251-1*