



## Sandwich Core Heat-Pipe Radiator for Power and Propulsion Systems

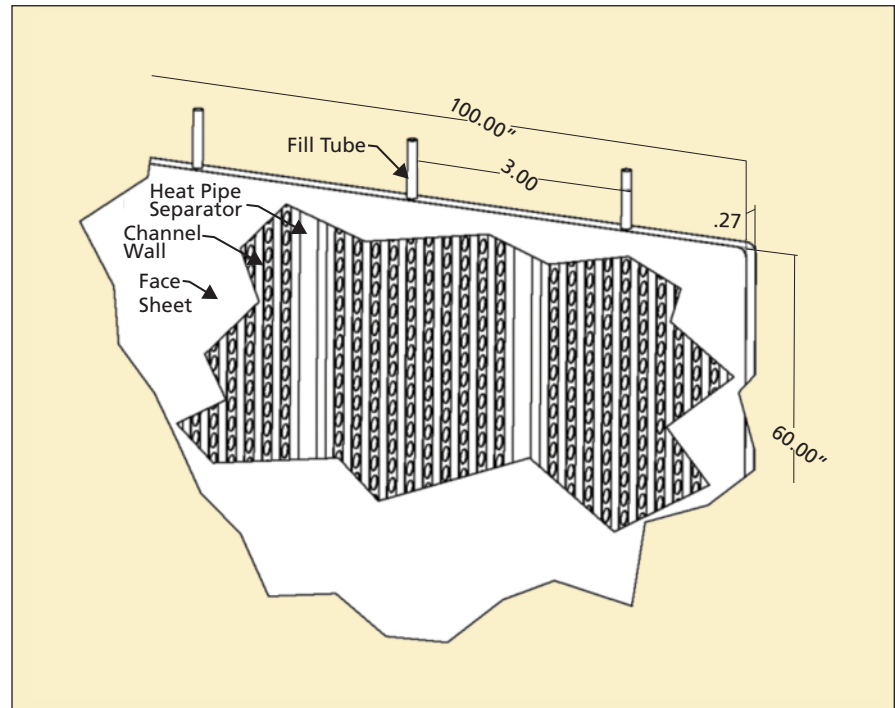
This technology has a potential use for residential or commercial radiant heating systems using lower-cost materials of construction.

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

Next-generation heat-pipe radiator technologies are being developed at the NASA Glenn Research Center to provide advancements in heat-rejection systems for space power and propulsion systems. All spacecraft power and propulsion systems require their waste heat to be rejected to space in order to function at their desired design conditions. The thermal efficiency of these heat-rejection systems, balanced with structural requirements, directly affect the total mass of the system.

In testing space radiators for nuclear power systems, it was found that current technology had significant thermal losses due to the long chains of thermal resistance, stemming from multiple materials, their respective bonds, and physical geometries. Tubular heat pipes connected to flat fins, typically made of different materials, have traditionally been thought of as the best way to drive down radiator system mass. Dissimilar materials inherently had coefficient of thermal expansion mismatches, which created complex designs and additional mass.

Combining structural and thermal components of a heat-pipe radiator into a unique design may produce advantages to both heat transfer characteristics and structural integrity. The Sandwich Core Heat Pipe (SCHP) technology being developed at the Glenn Research Center addresses this by using thin titanium sheets in a unique structural configuration to make a highly efficient rectangular heat-pipe array that can be used as a thermal-control radiator. The concept is the first of its kind to combine heat pipes, radiator, and structural components into one system using a single material of construction. Although numerous concepts are under development, the basic design allows the internal sandwich core structure to double as the heat pipe vapor space, allowing the radiator facesheet to reach near-vapor temperatures without the



The **Titanium Radiator** incorporates multiple rectangular heat pipe channels, and an enclosed pressure boundary using a single facesheet, all from the same material. Each channel can be shared with neighboring channels to create a multi-channel heat pipe.

losses associated with a conduction fin, common to current state-of-the-art technology. This “no fin” feature reduces the overall temperature drop associated with current heat-pipe radiator designs and ultimately reduces unwanted mass through improved thermal efficiency. Additionally, the configuration of the internal core using thin metal construction provides rigidity as well as a reduction in mass over current technologies. The combination of the reduced mass and increased thermal efficiency are appealing to power and propulsion designers needing improved performance.

Although the materials of choice for current fission power systems are titanium and water, many different heat-pipe configurations could be developed using other metals and working

fluids. The significance of this approach is that the same basic design could be used for multiple temperature ranges, dependent only on the material of construction, working fluid thermophysical properties, and the material/fluid compatibility.

Terrestrially, this technology could be used for thermal control of structural systems. One potential use is radiant heating systems for residential and commercial applications. The thin cross section and efficient heat transportability could easily be applied to flooring and wall structures that could evenly heat large surface areas. Using this heat-pipe technology, the evaporator of the radiators could be heated using any household heat source (electric, gas, etc.), which would vaporize the internal working fluid and carry the

heat to the condenser sections (walls and/or floors). The temperature could be easily controlled, providing a comfortable and affordable living environment. Investigating the appropriate materials and working fluids is needed to

determine this application's potential success and usage.

*This work was done by Marc Gibson, James Sanzi, and Ivan Locci of Glenn Research Center. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18900-1.*

## ⚙️ Apparatus for Pumping a Fluid

**There are no rotating or moving parts apart from bellows.**

*Marshall Space Flight Center, Alabama*

A fluid pump has been developed for mechanically pumped fluid loops for spacecraft thermal control. Lynntech's technology utilizes a proprietary electrochemically driven pumping mechanism. Conventional rotodynamic and displacement pumps typically do not meet the stringent power and operational reliability requirements of space applications. Lynntech's developmental pump is a highly efficient solid-state pump with essentially no rotating or moving components (apart from metal bellows).

Figure 1 schematically illustrates the electrochemically-driven actuator. The conversion of electrical energy to mechanical work is achieved by transporting hydrogen across an electrochemical cell. Hydrogen is dissociated at the anode; protons that are formed from the dissociation are driven across the membrane by an applied potential, while electrons are conducted through an external circuit; protons and electrons recombine at the cathode to form hydrogen. The transport of hydrogen into and out of the attached bellows results in a pressure variation that is used to actuate the fluid pumping diaphragms. Each electrochemical cell is made up of a proton exchange membrane, typically Nafion®, with platinum catalyzed electrodes on either side, called a membrane electrode assembly (MEA). The use of hydrogen and its low oxidation and reduction potentials results in high electric-to-mechanical work conversion efficiency.

For size and convenience, a plurality of individual MEAs is used to transport the hydrogen, rather than a single electrochemical cell. The MEAs are connected electrically in series and fluidically in parallel. The stack of MEAs is sandwiched between two current collectors, and a voltage is applied across the stack, driving hydrogen gas from one

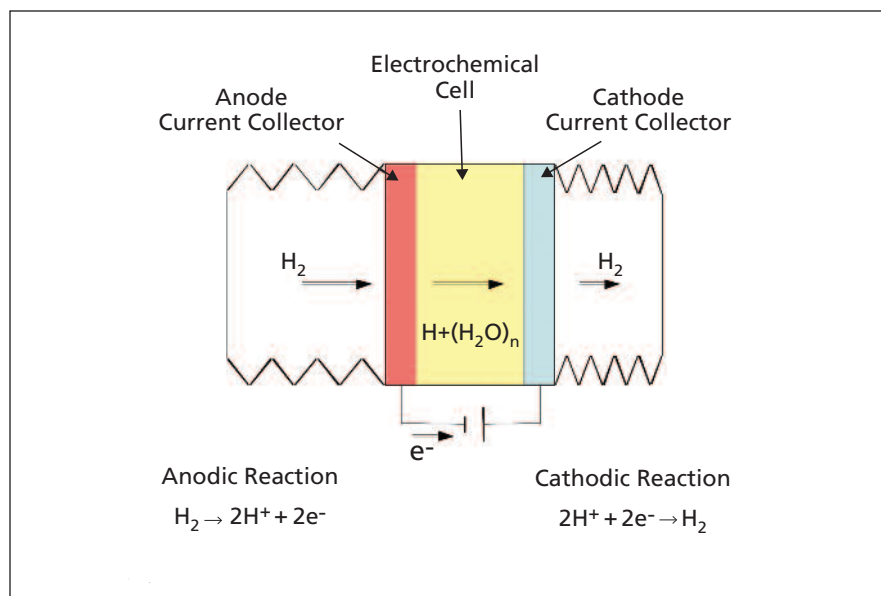


Figure 1. **Hydrogen** is dissociated at the anode; protons formed from the dissociation are conducted through the membrane, while electrons are conducted through an external circuit; protons and electrons recombine at the cathode to form hydrogen.

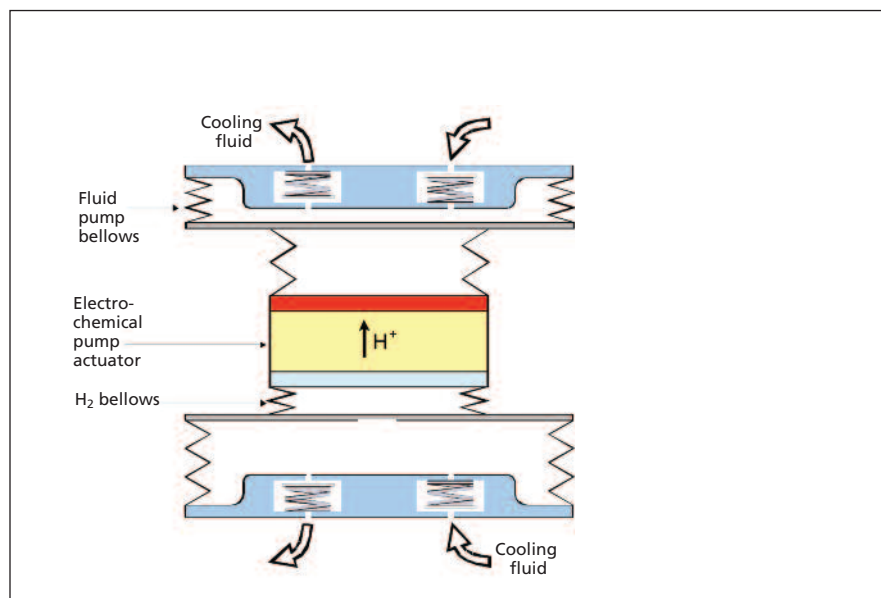


Figure 2. The **Smaller Hydrogen-Filled Bellows** actuates the second larger set of bellows, which displace fluid in the pump heads. Fluid is expelled from one pump head while being drawn into the other.