Throttling Cryogen Boiloff To Control Cryostat Temperature

Consumption of liquid cryogen and electrical energy could be reduced.

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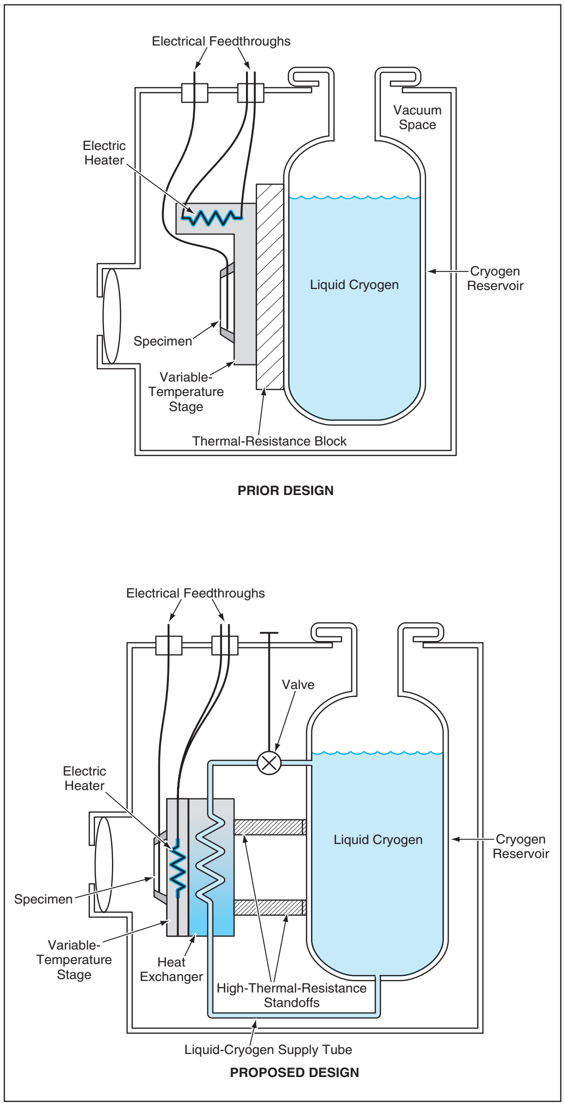
An improved design has been proposed for a cryostat of a type that maintains a desired low temperature mainly through boiloff of a liquid cryogen (e.g., liquid nitrogen) at atmospheric pressure. (A cryostat that maintains a low temperature mainly through boiloff of a cryogen at atmospheric pressure is said to be of the pour/fill Dewar-flask type because its main component is a Dewar flask, the top of which is kept open to the atmosphere so that the liquid cryogen can boil at atmospheric pressure and cryogenic liquid can be added by simply pouring it in.) The major distinguishing feature of the proposed design is control of temperature and cooling rate through control of the flow of cryogen vapor from a heat exchanger. At a cost of a modest increase in complexity, a cryostat according to the proposal would retain most of the compactness of prior, simpler pour/fill Dewar-flask cryostats, but would utilize cryogen more efficiently (intervals between cryogen refills could be longer).

In a typical prior variable-temperature cryostat of the pour/fill Dewar-flask type, a specimen (typically, an infrared photodetector) to be tested at a specified low temperature is mounted, along with a small electric heater, on a variable-temperature stage on one side of a thermal-resistance block. The other side of the thermal-resistance block is in contact with the cold inner wall of the cryogen reservoir (see figure). If it is desired to test the specimen at a temperature above the boiling temperature of the cryogen, then a proportional amount of power is supplied to the electric heater. Of course, the heat that leaks through the thermal-resistance block into the cryogen reservoir causes the cryogen to boil off faster than it otherwise would.

In the proposed cryostat, the variable-temperature stage holding the specimen and electric heater would be mounted on one surface of a heat exchanger that would be held away from the cryogen reservoir by high-thermal-resistance standoffs. A tube would supply liquid cryogen from the bottom of the cryogen reservoir, upward into the heat exchanger, by gravity feed. From the top of the heat-exchanger, boiled-off cryogen vapor would travel through a tube and a valve, returning to the top of the reservoir. By using the valve to throttle the flow of vapor from the heat exchanger, one would control the flow of liquid to the heat exchanger, thereby controlling the rate of cooling and the temperature of the specimen. In addition, as before, one could raise the temperature of the specimen by use of the electric heater. To the extent to which one could maintain the desired temperature by flow control rather than electric heating, one could reduce the consumption of both liquid cryogen and electrical energy.



These **Variable-Temperature Cryostats** of the pour/fill-Dewar-flask type differ in the nature of the thermal resistance between the cryogen reservoir and the variable-temperature stage. The fixed thermal resistance of the prior design would be replaced, in the proposed design, by a variable thermal resistance implemented by use of a heat exchanger with a flow-control valve.

This work was done by Thomas Cunningham of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

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