November 1970

Brief 70-10628

# NASA TECH BRIEF



## Accurate, Rapid, Temperature and Liquid-Level Sensor for Cryogenic Tanks

A thermopile sensor has been developed for accurately and rapidly measuring gas temperatures and sensing the liquid level within a cryogenic tank during tank outflow. The thermopiles (thermocouples in series) can measure ullage gas temperatures to within $\pm 1.65^\circ K$ between $20^\circ$ and $300^\circ K$. These thermopiles also can serve as point liquid-level sensors. The liquid level is detected by measuring the inflection point in the temperature-time history of the thermopile caused by its emergence from the cryogenic liquid. Measurements of liquid level to within $+0.453$ centimeter have been made during outflow of liquid hydrogen from a cylindrical tank.

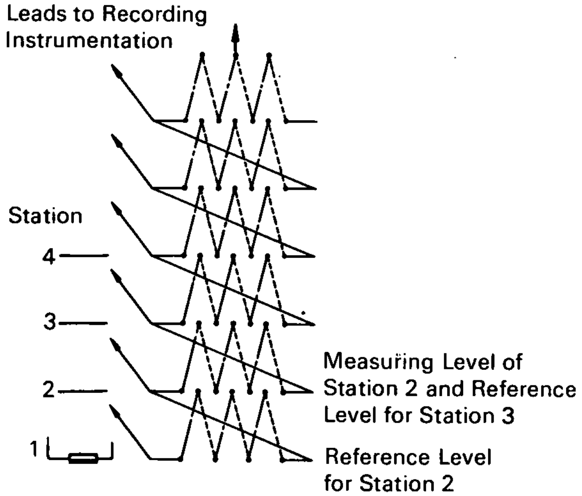


Figure 1. Wiring Schematic

Commercially available temperature-measuring systems were not adequate for the rather stringent requirements of accuracy and precision in the measurement of ullage gas temperatures during experimental studies of the pressurization and expulsion of liquid hydrogen from a tank. Conventional carbon and platinum resistor sensors have response characteristics that are too slow for the accurate measurement of rapid changes in temperature, particularly near the moving liquid-gas interface. They also lack the desired accuracy over the large temperature range of the ullage gas ($20^\circ$ to $300^\circ K$). The thermopiles have a response time approximately an order of magnitude lower than carbon and platinum resistors. The thermopiles increase both the absolute signal output and the signal-to-noise ratio of single thermocouples.

A wiring schematic of the thermopile sensor is shown in Figure 1. Chromel-constantan thermocouples were chosen because of the high signal level and the low thermal conductivity of the wires, which minimize errors caused by heat conduction through the wires.

Three-element thermopile units were used. By stacking the individual thermopile units, as shown in Figure 2, a series of differential temperature measurements were made. The thermopile technique employs a series of "floating" reference temperatures; i.e., the measuring station of any one thermopile unit is used as the reference for the unit directly above. Smaller temperature differences can be measured by keeping the reference junctions inside the tank and near the temperature range of the measuring junction. This technique is more accurate than the conventional one which uses a single reference junction located outside the tank.

The initial reference temperature, the temperature at station 1 of Figure 2, was measured with a commer-

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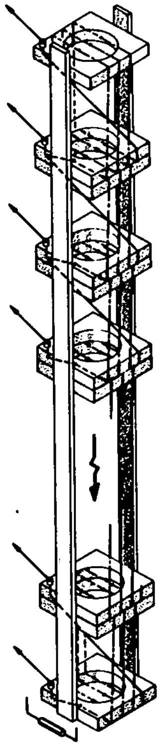


Figure 2. Thermopile Sensor

cial platinum resistance sensor. By keeping the platinum sensor submerged in the liquid hydrogen, constant reference temperature was obtained.

## Notes:

1. Thermopile sensors of this type may find general application in expulsion tests of cryogenic fluids from tanks and for point measurements of liquid level during expulsion and filling of cryogenic tanks. They have an advantage over conventional capacitance type liquid level gages which require known temperatures and pressures within the tank for accurate measurements.
2. The following documentation may be obtained from:

   Clearinghouse for Federal Scientific
   and Technical Information
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.65)

   Reference:
   NASA TN-D-4339 (N68-15893), Temperature and Liquid-Level Sensor for Liquid-Hydrogen Pressurization and Expulsion Studies
3. Technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B70-10628

## Patent status:

No patent action is contemplated by NASA.

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