

## Eroding Potentiometers

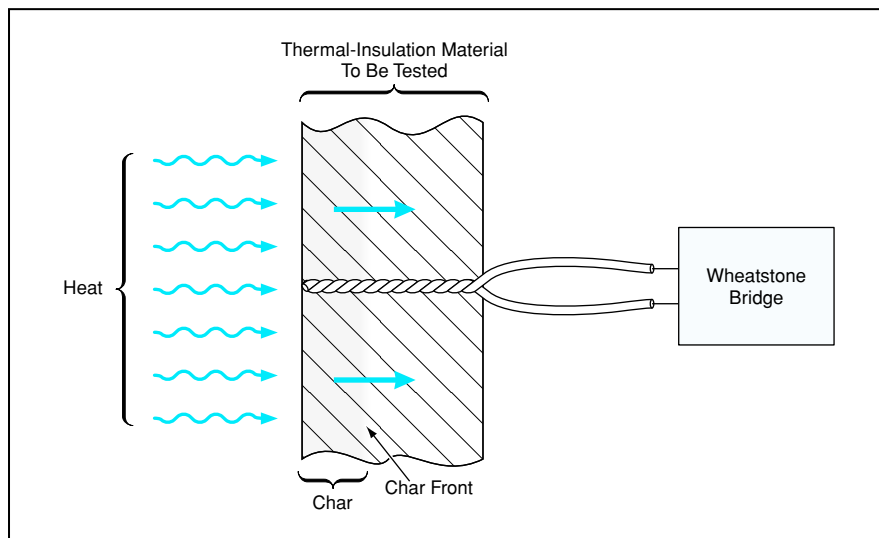
These simple transducers can be used to measure advances of char fronts.

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Eroding potentiometers have been devised for measuring the time-dependent positions of char fronts advancing through layers of insulating material subject to intense heating from one side. In the original application, the material layers of interest are thermal insulators in rocket motors and the heat comes from firing of the motors, but the principle of operation is equally applicable to other insulating materials subject to intense heating (e.g., ablative fire-retardant materials). Measuring the thickness decrement of propellant (in hybrid motors in particular) is another possible application of this transducer. Telemetry informs mission control of the propellant left after each burn.

An eroding potentiometer could be characterized, more precisely, as an eroding two-wire resistor. It includes a twisted pair of thin, insulated wires oriented along the thickness of, and embedded in, the layer of thermal-insulation material to be tested (see figure). The electrical insulation material on the wires should be one for which the charring temperature is about the same as (or perhaps slightly less than) that of the thermal-insulation material to be tested. In the original rocket-motor application, the wires have a diameter of 0.003 in. ( $\approx 0.08$  mm), are made of manganin, and are coated with polyimide for electrical insulation. Outside the thermal insulation on the cold side, the wire leads are connected to a Wheatstone bridge circuit for measurement of electrical resistance change.

Before the formation of the char front, there is an open circuit between the wires, so that the resistance sensed by the Wheatstone bridge is very high. As the char front advances along the twisted pair of wires, the char intermittently forms short circuits between the wires. Optionally, one could add a third, bare wire (possibly made of aluminum) to the twisted pair to increase the likelihood of forming low-resistance short circuits. The intervals between occur-



**A Twisted Pair of Electrically Insulated Wires** can be used to measure the advance of the char front in real time: The intermittent short-circuit resistance of the twisted pair, as measured by the Wheatstone bridge, varies with position of the char front.

rences of short circuits can be considered short in the sense that, during each interval, the char front advances only a small fraction of the thickness of the thermal-insulation material under test.

During each short-circuit interval, the resistance sensed by the Wheatstone bridge is approximately linearly related to the length of remaining wire that has not yet been reached by the char front. Putting it somewhat differently, the decrease in resistance from one short-circuit reading to the next is approximately proportional to the distance traveled by the char front between the readings. Thus, once one has performed a calibration to establish the relationship between the short-circuit resistance reading and the position of the char front, one can, thereafter, infer the instantaneous position of the char front from the most recent short-circuit resistance readings.

In the original rocket-motor application, a decrease in resistance of  $\approx 3 \Omega$  corresponds

to a char-front advance of  $\approx 0.5$  in. ( $\approx 1.3$  cm). In practice, when one uses a typical Wheatstone bridge to measure the resistance in such an application, the output potential of the bridge switches intermittently between a short-circuit value of a few millivolts and an open-circuit value of  $\approx 2.5$  V. One must process the output potential through an amplifier capable of fast recovery to the proper setting point after saturation in order to be able to correctly amplify the small short-circuit potential each time a short circuit occurs and the wire resistance up to the char front is sensed briefly.

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## Common/Dependent-Pressure-Vessel Nickel-Hydrogen Batteries

One of the principal advantages would be high volumetric efficiency.

NASA's Jet Propulsion Laboratory,  
Pasadena, California

The term "common/dependent pressure vessel" (C/DPV) denotes a proposed alternative configuration for a nickel-hydrogen battery. The C/DPV configuration is so named because it is a hybrid of

two prior configurations called "common pressure vessel" (CPV) and "dependent pressure vessel" (DPV). The C/DPV configuration has been proposed as a basis for designing highly reli-

able, long-life Ni/H<sub>2</sub>-batteries and cells for anticipated special applications in which it is expected that small charge capacities will suffice and sizes and weights must be minimized.