

Eroding Potentiometers

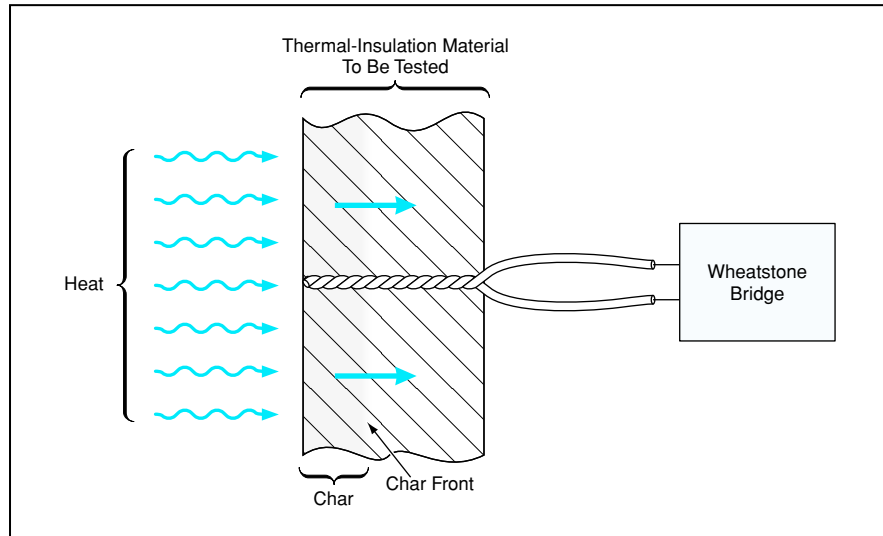
These simple transducers can be used to measure advances of char fronts.

Marshall Space Flight Center,
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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. (≈ 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 ≈ 0.5 in. (≈ 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 ≈ 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.

This work was done by Mark Eggett, John L. Shipley, Alan L. Godfrey, Lloyd T. Johnson, Mont Johnson, Boyd D. Bryner, and Bruce McWhorter of Thiokol Corp. for Marshall Space Flight Center. For further information, please contact George Alford at Thiokol Propulsion at (435) 863-3954. MFS-31437

Common/Dependent-Pressure-Vessel Nickel-Hydrogen Batteries

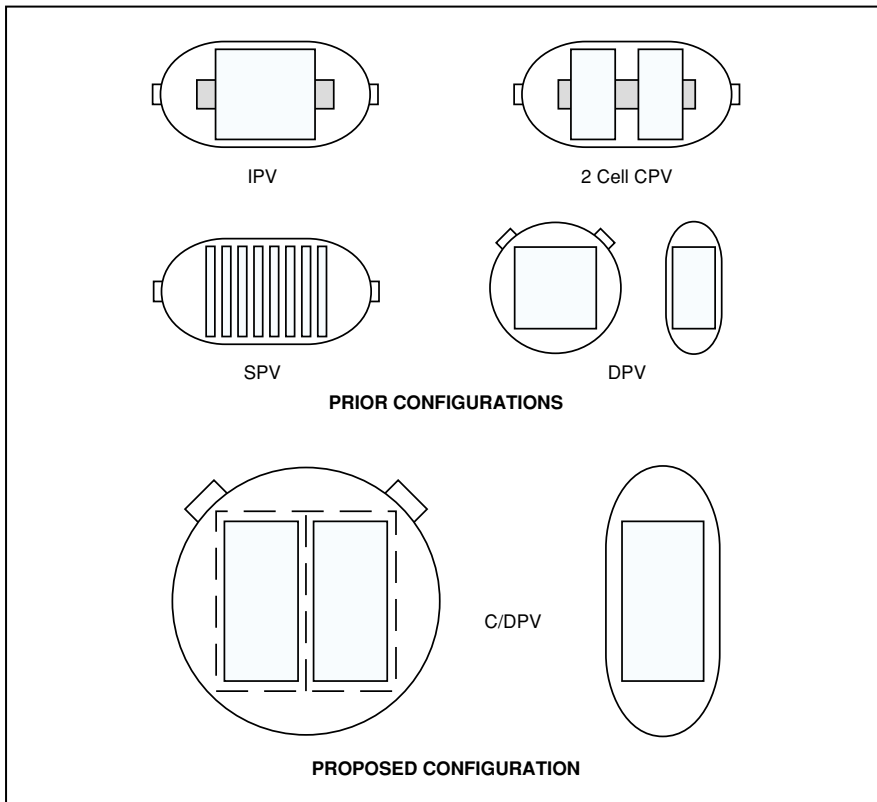
One of the principal advantages would be high volumetric efficiency.

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/H₂-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.



The **C/DPV Configuration** would be a hybrid of the older CPV and DPV configurations (and, to some extent, of the SPV configuration). Modular designs could provide ranges of capacities and voltages.

The figure depicts examples of the proposed C/DPV configuration along with the CPV and DPV configurations and two other prior configurations called “individual pressure vessel” (IPV) and “single pressure vessel” (SPV). The following characteristics of the prior configurations

are particularly relevant to the proposal of the C/DPV configuration:

- A DPV has a pocket-watch shape that is both advantageous and disadvantageous, in comparison with the shapes of the IPV, CPV, and SPV. The advantage is that a battery or cell can be

made relatively flat and thin to fit in a thin space; the disadvantage is that a pressure vessel of this shape is not self-supporting and therefore must be mounted between objects that restrain it. DPV cells have not been widely used.

- The SPV and CPV configurations have been the basis of the established method for designing pressure vessels containing multiple cells.

Like the CPV and SPV configurations, the C/DPV configuration is one of multiple cells contained within a DPV. This configuration would afford the advantages and disadvantages of the DPV configuration (thinness and the need for mechanical restraint, respectively), while making it possible to use an electrolyte-containment system like that of the SPV. Although it is not readily apparent by visual examination of the figure, calculations have shown that for a given small charge capacity, the volumetric efficiency of a battery in the C/DPV configuration would exceed the volumetric efficiencies of batteries in the other configurations mentioned. Other anticipated advantages of the C/DPV configuration include improved thermal properties, greater simplicity and reliability (in comparison with the SPV configuration), lower costs associated with the simpler designs, and amenability to replacement and matching of cells.

This work was done by Paul J. Timmerman of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP [see page 1]. NPO-20769

120-GHz HEMT Oscillator With Surface-Wave-Assisted Antenna

This is a compact, lightweight alternative to vacuum-tube oscillators.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two monolithic microwave integrated circuits (MMICs) have been designed and built to function together as a source of electromagnetic radiation at a frequency of 120 GHz. One of the MMICs is an oscillator and is the highest-power 120-GHz oscillator reported thus far in the literature. The other MMIC is an end-fire antenna that radiates the oscillator signal. Although these MMICs were constructed as separate units and electrically connected with wire bonds, future oscillator/antenna combinations could readily be fabricated as monolithic integrated units. Such units could be used as relatively high-power solid-state microwave sources in diverse applications that include automotive radar, imaging, scien-

tific instrumentation, communications, and radio astronomy. As such, these units would be attractive alternatives to vacuum-tube oscillators, which are still used to obtain acceptably high power in the frequency range of interest.

The oscillator (see figure) includes a high-electron-mobility transistor (HEMT), with gate-periphery dimensions of 4 by 37 μm , in a common-source configuration. The series feedback element of the oscillator is a grounded coplanar waveguide (CPW) at the source. The HEMT is biased for class-A operation (meaning that current is conducted throughout the oscillation cycle) to maximize the output power of the oscillator. Input and output impedance-matching circuit elements are designed to maximize

output power and to establish the conditions needed for oscillation.

The design of the antenna takes advantage of surface waves, which, heretofore, have been regarded as highly disadvantageous because they can leak power and degrade the performances of antennas that have not been designed to exploit them. Measures taken to suppress surface waves have included complex machining of circuit substrates and addition of separate substrates. These measures are difficult to implement in standard MMIC fabrication processes. In contrast, because the design of the present antenna eliminates the need to suppress surface waves, the fabrication of the antenna is fully compatible with standard MMIC fabrication processes.