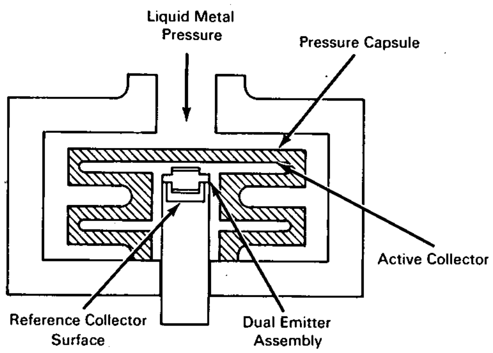
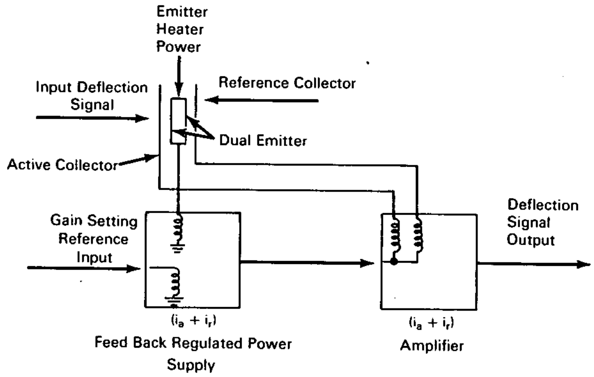
NASA TECH BRIEF

Design for High-Temperature (1800° F) Liquid Metal Pressure Transducer



HIGH-TEMPERATURE TRANSDUCER



THERMIONIC DIODE DEFLECTION MEASUREMENT SYSTEM

The problem:

To design pressure transducers (one absolute and one differential) to be used in advanced space power systems using liquid metals (e.g., sodium, potassium, lithium) as working and heat transfer media at temperatures up to 1800°F. The transducer should be as small and lightweight as possible and capable of enduring long periods of unattended operation.

The solution:

A thermionic diode sensor which converts the motion of a pressure actuated refractory alloy capsule into a suitable electrical output.

How it's done:

The use of a high vacuum thermionic diode as a pressure sensing element is based on diode operation in the space charge limited mode, where the current flowing between the emitter and collector is distance dependent. If one of the electrodes (such as the collector) is moved as a function of pressure, the current is also a function of pressure. Now, if all other terms influencing the diode current can be controlled, an accurate high-temperature transducer can be constructed.

The current-spacing relation is nonlinear with the current varying as the inverse square of the space. To achieve linearity, a system is used which measures the difference between the currents i_a and i_r flowing through a pressure actuated collector (the refractory alloy pressure capsule) and a fixed reference collector. The power supply for the system is programmed such that the voltage applied to the collectors maintains the sum of the two currents at a constant level determined by the voltage and distance corresponding to zero pressure.

Under zero pressure conditions, the emitter-active collector distance and the emitter-reference collector distance are equal, resulting in $i_a = i_r$ and $(i_a - i_r) = p$. Depending upon the choice of the dc voltage, the current sum $(i_a + i_r)$ will have a definite value. Under pressure, the active collector will approach the emitter, causing i_a to rise while i_r remains constant. The dc voltage is then lowered to bring the sum $(i_a + i_r)$ back

(continued overleaf)

to its original value and the difference ($i_a - i_r$) is taken as indicative of the pressure (active collector travel).

Notes:

1. The original equipment was designed in accordance with the following requirements.
   a. The absolute pressure transducer should have a range from 0 to 80 psia. The differential pressure transducer should have a range from −5 to +5 psid.
   b. The transducers should operate at ambient and fluid temperatures up to 1800°F.
   c. The transducers should have an accuracy of at least 5% of full scale. The accuracy should include the effects of linearity, hysteresis, sensitivity, change with temperature, zero shift (other than that caused by temperature), dynamic response characteristics up to 100 cps, and repeatability. The zero shift with temperature should not exceed 0.001% of full scale per degree.
   d. The transducers should have an operating life of 2000 hours at maximum fluid temperature with pressure cycling or 40,000 pressure cycles, whichever could be reached first.
   e. The transducers should have a frequency response of at least 100 cps to fluid pressures.
2. Tests conducted on these transducers have not progressed to the point at which definite operating characteristics may be established but indications are that the transducers are capable of successful operation for periods of thousands of hours.
3. This device is not limited to pressure applications but could also be used for the measurement of force, vibration, temperature, flow, and speed.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B67-10458

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: R. E. Engdahl
of Consolidated Controls Corporation
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Lewis Research Center
(LEW-10144)