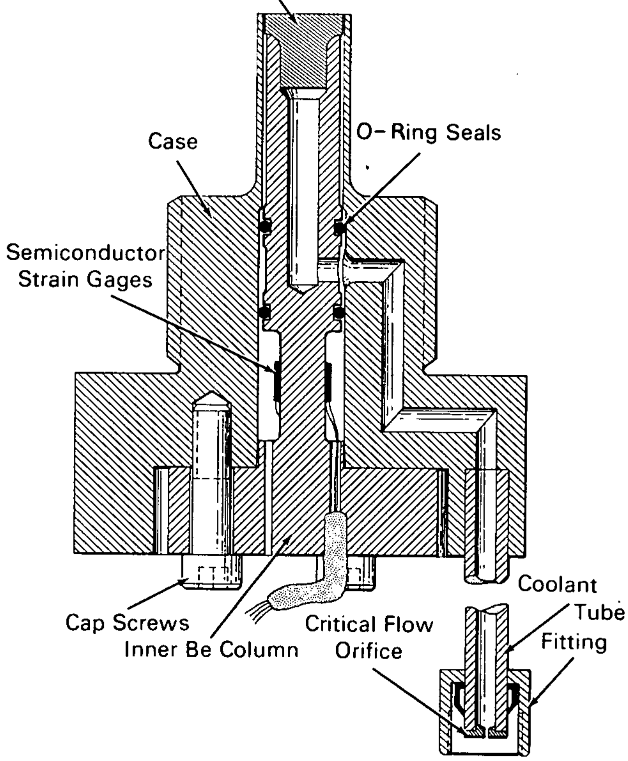
NASA TECH BRIEF

New Type Pressure Transducer for Severe Thermal Environments



Sectional View Of Transpirational Cooled Pressure Transducer

A pressure transducer has been developed which enables the measurement of pressures exceeding 2000 psi in ambient temperatures approaching 7000°F. The application of this transducer can be utilized in various metal processing techniques which require these high temperature and pressure environments in addition to the original development application.

The problem:

To design, develop and fabricate a pressure transducer for use in a rocket motor chamber to measure the amplitudes and frequencies of the dynamic pressures occurring during unstable combustion. The transducer, mounted in the chamber wall, must be capable of measuring dynamic pressures with amplitudes up to 2,000 psi with a frequency response flat within 1% to 10 kHz. In addition, the pressure transducer must be capable of sustained operation in a thermal environment where temperatures reach 7000°F (heat fluxes up to 25 BTU/in^2-sec) as a result of the unstable combustion in the rocket engine.

The solution:

In order to maintain the high frequency response with good heat-transfer capabilities, a new transducer was designed utilizing a transpirational-cooled porous beryllium plug and pressure transmitting column. A four-arm semiconductor strain gage bridge, mounted on the lower portion of the column, senses the compressive strains as a result of the rocket chamber pressure.

How it's done:

The figure is a sectional view of the transpirational-cooled pressure transducer: the view is approximately twice the actual size and shows the important components of the transducer.

The porous beryllium plug at the upper end of the transducer is flush-mounted in the rocket chamber at the desired location. Pressure (both static and dynamic) in the rocket chamber acts upon the porous plug, and the force is transmitted down the inner column to the strain gage.

(continued overleaf)

Heat fluxes are kept from the sensing element by bleeding a gaseous coolant, helium or hydrogen, through the porous beryllium plug. Because of the micron-size passages in the porous material, transient pressures essentially "see" a solid; thus, imposed strains in the lower portion of the column are the same as if a solid plug were used. The coolant is introduced at a constant pressure higher than that encountered in the combustion instability regions. Because of the presense of the upper and lower seals, the coolant pressure is completely balanced within the unit and only strains created by pressure in the rocket chamber are sensed. The only requirement for the coolant mass flow rate maintained by the critical flow orifice is that the coolant pressure must be higher than the maximum rocket chamber pressure.

Beryllium, which has an exceptionally high stiffness-to-weight ratio, was selected for both the pressed-fit porous plug and inner column in order to achieve the required frequency response characteristics. In addition, a very high natural frequency for this system was attained by using a small column in compression and maintaining low strains for the maximum design pressure. Semiconductor gages were used rather than resistance gages in order to achieve the required sensitivity commensurate with the low strains.

Notes:

1. Due to minor variations in material properties, tolerances, and strain gage characteristics, the absolute calibration of each transducer must be determined experimentally. Typical salient performance characteristics for this transpirational-cooled pressure transducer are as follows:

Dynamic Range	0 to 2000 psi
Nominal Output Sensitivity	0.003 mV/V-psi
External Vibration Sensitivity	
Axial	0.015% F.S. per peak g
Transverse	0.007% F.S. per peak g
Thermal Shift (80°F to 130°F)	0.5% F.S.
Hysteresis and Repeatability	1.5% F.S.
Resonant Frequency (axial)	100 kHz
Response Characteristics	Flat within 1% to 10 kHz
Coolant Supply Pressure for a Heat Flux of 25 BTU/in^2-sec	5000 psi

2. For additional information, write to:
   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B69-10652

Patent status:

No patent action is contemplated by NASA.

Source: Battelle Memorial Institute
under contract to
Marshall Space Flight Center
(MFS-20208)