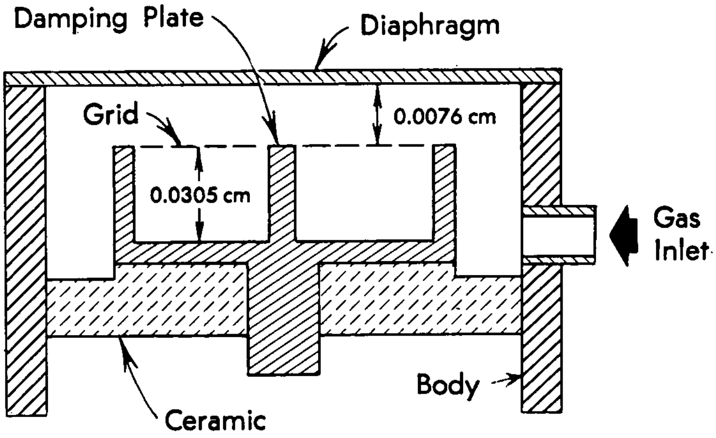
NASA TECH BRIEF

Ames Research Center

Wide-Range Dynamic Pressure Sensor

The problem:

To develop a sensor which can measure pressure over the range 10^{-5} to 10^{3} torr (1.33×10^{-6} to 133 kN/m^2) and can be included in a rugged, lightweight package for use aboard aircraft, meteorological vehicles, and space probes.



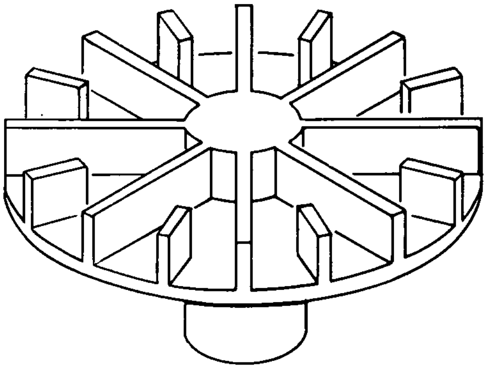
Schematic Representation of Grid-Type Transducer Half

The solution:

A transducer which measures pressure by sensing the damping of a vibrating diaphragm immersed in the atmosphere to be measured.

How it's done:

A vibrating diaphragm pressure transducer consists essentially of a thin metallic diaphragm under radial tension that is situated between closely spaced insulated metal plates or grids. One of the plates or grids serves as a driver and provides a means of electrostatically forcing the diaphragm into vibration; the other is used to detect the amplitude or frequency of vibration. Since the space between the plates and diaphragms is filled with gas at the pressure to be measured, the gas dampens motion of the diaphragm and causes loss of energy, and it is necessary to increase the electrical power input to the driver plate to maintain a given amplitude of vibration. Thus, by vibrating the diaphragm at its resonant frequency and at constant amplitude, the driving force needed to overcome gas dampening can be measured and correlated with the density or pressure of the gas surrounding the diaphragm. Alternatively, the frequency is a function of gas pressure.



Simplified Sketch of Damping Plate

The damping effect of the enclosed gas in a vibrating diaphragm pressure transducer increases with increasing pressure to the point where the sensor may cease to function as a simple mechanical resonant system and is not able to provide pressure indications above 1000 torr (133 kN/m^2). In many instances, the

(continued overleaf)

mechanical frequency of the diaphragm is altered due to gas stiffness to the point where it overlaps an acoustic resonance associated with the interior dimensions of the transducer body. These problems have been minimized by the transducer configuration shown in the diagram. The performance of vibrating diaphragm sensors at high pressures has been significantly improved by substituting a grid-damping plate structure. The functions of the forcing plate and the sensing plate have now been taken over by forcing and sensing grids which are maintained close to the diaphragm (a few thousandths of a centimeter) while the solid plates that control the stiffness introduced by the gas are moved farther from the membrane. One of the main advantages of this configuration is that it provides considerable freedom in choosing the interior transducer geometry without sacrificing effective driving force or displacement sensing sensitivity. Moreover, by orienting the grid area concentric and parallel to the membrane and by proper selection of the grid area, it is possible to suppress the sensing of higher modes of resonant vibration.

The body of the grid-type transducer shown in the diagram is made of 42% nickel-iron alloy; the ceramic insulators are of alumina, and were chosen to provide the necessary thermal expansion coefficient. The diaphragm is 44% nickel-iron annealed at 516°C and it is mounted under tension to one-half of the sensor body by an overlapping spot weld. The grid structure is of 0.1- mil (0.0025-mm) nickel wire mesh (50% open area) spot welded to the top of the damping structure.

An electronic system has also been designed to drive the pressure transducer to yield pressure measurements over the range 10^{-5} to 4000 torr (1.33×10^{-6} to 133 kN/m^2). The displacement of the diaphragm causes a capacitance change which, in turn, generates an input to a velocity sensing preamplifier. The output of the preamplifier is then amplified, filtered, rectified, and compared to a preset DC reference voltage. Any voltage difference is used to provide driving power at the resonant frequency of the diaphragm and at an amplitude sufficiently large so that the voltage difference is reduced to zero, that is, the rectified output of the preamplifier is constant and equal to the reference voltage.

References:

1. Dimeff, J., Lane, J. W., and Coon, G. S.: New Wide Range Pressure Transducer. Review of Scientific Instruments, vol. 33, p. 804, 1962.
2. Southwest Research Institute: Vibrating Diaphragm Pressure Transducer. NASA SP-5020, August 1966.

Notes:

1. One version of the improved sensor gives pressure readings which are substantially independent of gas composition.
2. Reference (2) may be obtained from:
   Superintendent of Documents
   U. S. Government Printing Office
   Washington, D.C. 20402
   Price $0.30.
3. Additional information may be obtained from:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: TSP 72-10196

Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to:

Patent Counsel
Mail Code 200-11A
Ames Research Center
Moffett Field, California 94035

Source: John Dimeff and James W. Lane
Ames Research Center

(ARC-10263)