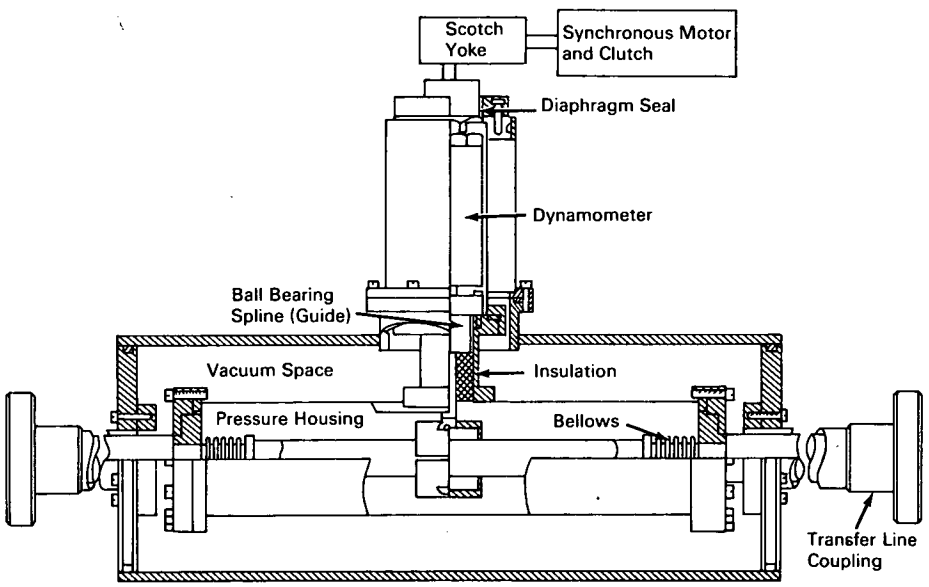
April 1967

Brief 67-10080

NASA TECH BRIEF

Instrument Continuously Measures Density of Flowing Fluids



The problem:

To design an instrument that will continuously measure the densities of either single- or two-phase flowing cryogenic fluids. In addition the measurement must be made on actual flow, and not on a sample whose accuracy is doubtful. It is desirable to know the mass flow rates of cryogenic fuels and oxidizers to rocket engines during tests. The changes in density which can occur during transfer of the fluids make volume flow measurement unsatisfactory. Frequently mass flow rate is determined by obtaining a product of density and volume flow rates. The major difficulty with this method has been the lack of a satisfactory technique for measuring the density of a flowing fluid.

The solution:

An improved electromechanical densitometer based upon the principle that the mass of any vibrating system is a primary factor in determining the dynamic characteristics of the system. Thus if the fluid flowing through a system measurably affects the vibrating mass of the system, a means of measuring fluid density is provided.

How it's done:

The densitometer uses a movable section of the flow passage vibrated transversely at a constant amplitude and frequency as the sensing element. As the fluid passes through this tubular section, supported at each end by a bellows, a driving mechanism imparts an oscillating (sinusoidal) motion to both the

(continued overleaf)

movable flow passage and the fluid passing through it. A dynamometer (force gage) linked between the tubular member and the driver continuously measures the acceleration reaction (product of mass and acceleration) of the fluid in the passage. Since the transverse motion of the movable section of the flow passage is dependent not only upon the force supplied from the mechanical oscillator but also upon the mass of the system (tube plus fluid), the mass of the system or tube motion basically becomes a function of the density of the fluid. Thus by measuring the force with the dynamometer the density of the fluid can be determined. Since the force generates an electrical signal (the output of the dynamometer) in phase with the motion and proportional to resultant maximum force, this signal after rectification by appropriate circuitry provides a resulting signal that is proportional to the maximum force. Consequently, the electrical signal is a measure of the fluid density in the passage.

Notes:

1. Additional advantages of this instrument are its simplicity, reliability, and good frequency response.
2. Mass flow rate is frequently determined by obtaining the product of density and volume flow rates. This densitometer provides a very satisfactory technique for measuring the fluid density necessary for this mass flow measurement.
3. Performance results have indicated that this densitometer is well suited for service in liquid oxygen and nitrogen single- and two-phase flow systems, and with only minor changes for use with liquid hydrogen.
4. Additional details are contained in: *The Review of Scientific Instruments,* vol. 34, no. 1, p 24–27, January 1963.
5. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B67-10080

Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,298,221), and royalty-free license rights will be granted for its commercial development. Inquiries about obtaining a license should be addressed to NASA, Code GP, Washington, D.C. 20546.

Source: C. E. Miller, R. B. Jacobs, and J. Macinko
of the National Bureau of Standards
under contract to
Lewis Research Center

(Lewis-309)