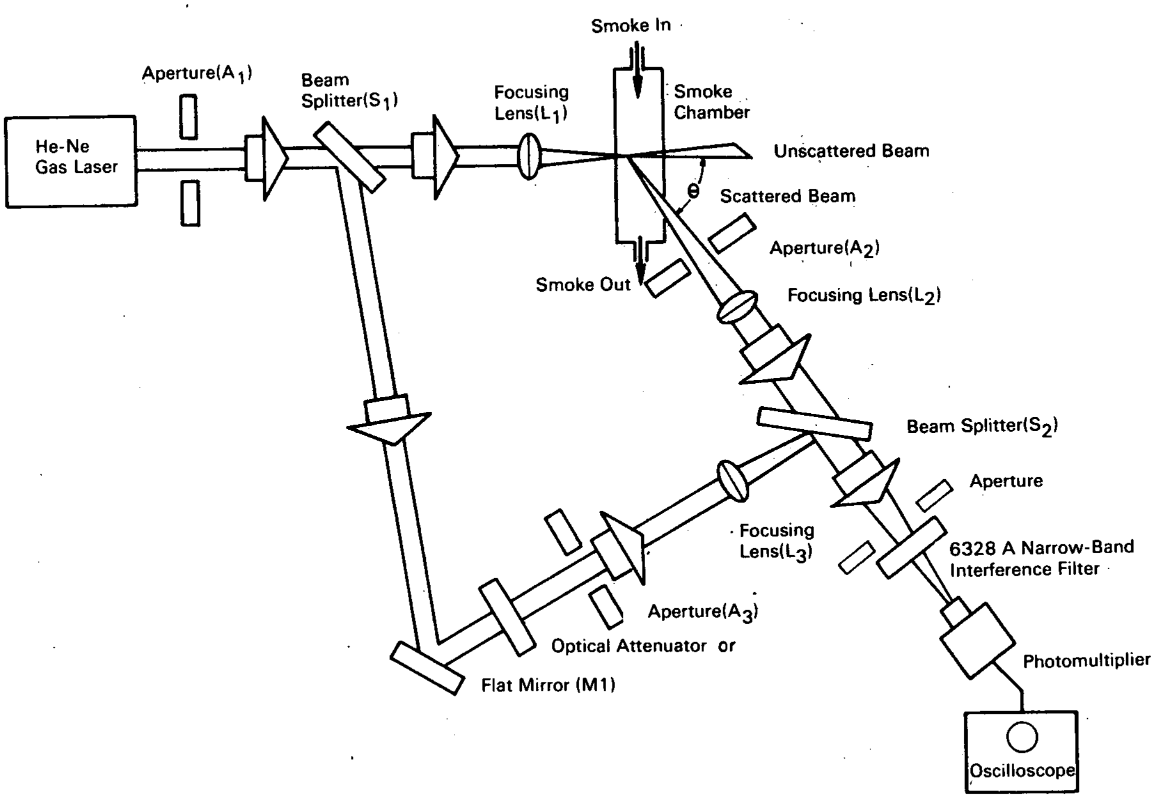
NASA TECH BRIEF

Laser Doppler Flowmeter Measures Gas Velocity



The problem:

To measure local gas flow velocities with reasonable accuracy while maintaining a negligible perturbation on the flow pattern. It was desirable to avoid conventional methods, such as electron beams, gamma rays or X-rays, which required that the detecting apparatus be exposed to radiation for long periods of time or be subjected to pressure limitations.

The solution:

Utilizing the large magnitudes of Doppler shifts obtainable from a CW gas laser, local velocity vectors can be measured by using the visible light from the laser. Optical heterodyning of the laser light scattered from the flowing gas with a portion of the incident laser beam split off from a beam splitter will produce a beat signal at the frequency of the Doppler

(continued overleaf)

shift due to the motion of the gas. Measurement of the beat signal frequency, together with the geometry of the optical system determines the flow velocity of the gas.

How it's done:

The optical Doppler technique makes use of the fact that monochromatic light is scattered from moving particles and that the frequency of the scattered light differs from that of the incident light.

This Doppler frequency shift depends on the velocity of the moving particles and the geometry of the scattering. When the scattering geometry is fixed, as in this system, the measurement of the Doppler shift gives sufficient information to determining the velocity of moving particles.

It is necessary to add an optical scattering contaminant (such as smoke) to the flowing gas to increase the intensity of the scattered light up to a usable level.

The coherent, monochromatic light beam emerging from a He–Ne gas laser passes through an aperture A_1 to remove the blue haze which surrounds the red laser beam. The beam is then split into two parts by the beam splitter S_1. The deflected beam is reflected off a flat mirror M_1, after which it is attenuated by passage through a set of neutral density filters. It then passes through an aperture A_3 and a focusing lens L_3, and is finally deflected into a photomultiplier tube by the beam splitter S_2. The rest of the original laser beam passes through S_1, and is focused to a point by the lens L_1. A glass chamber filled with air contaminated with smoke is placed at the focal point of L_1. The lens L_2 collects the light scattered from the smoke chamber at an angle Θ with the forward direction of the unscattered beam. The aperture A_2 limits the total solid angle over which the scattered light is intercepted by L_2. The scattered light collected by L_2 passes through the beam splitter S_2 and enters the photomultiplier. The lenses L_2 and L_3 are positioned in such a way that the two beams are focused at the same spot on the photocathode, and the optical system is aligned so that the axes of the two converging beams entering the photomultiplier are coincident. The measurement of the frequency shift between the scattered and incident light enables a determination of flow velocities.

Notes:

1. This technique is applicable for the measurement of velocity of any moving surface. Possible uses are the measurement of panel flutter and for calibration of dynamic pressure transducers or other applications where knowledge of particle flow is desired.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10693

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. M. Huffaker
of Marshall Space Flight Center
and W. Foreman
of Brown Engineering Corp.
under contract to
Marshall Space Flight Center
(M-FS-1747)