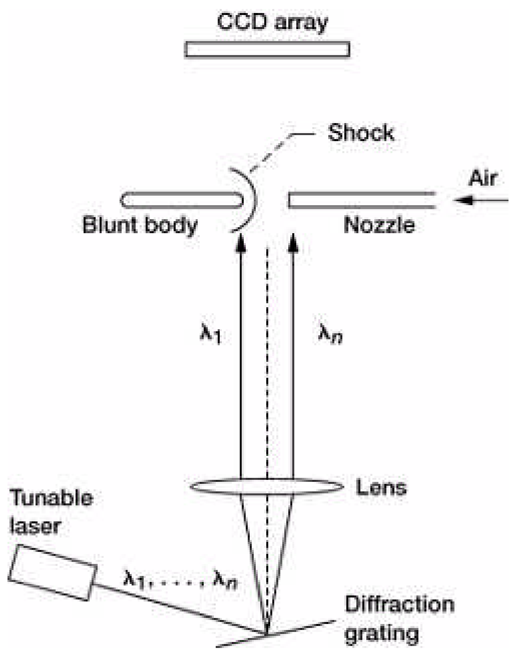
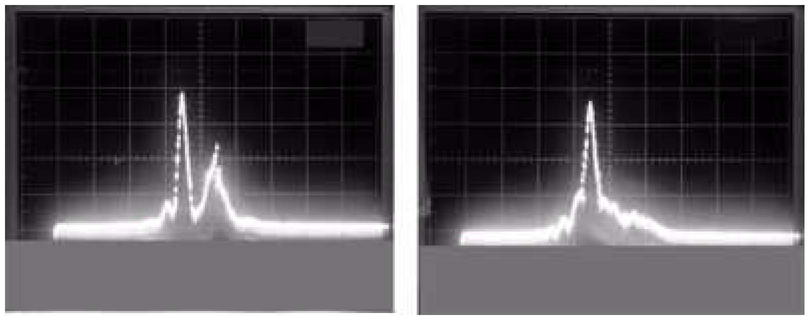
Scanning Mode Shock Position Sensor Invented and Demonstrated

A flow-visualizing system with a scanning optical beam offers greater advantages than the conventional approaches. In addition to a higher signal-to-noise ratio and lower source power, the scanning permits visualization of weak phenomena such as the scattering and diffraction of light on shocks. Scanning beam flow-visualization techniques were evaluated at the NASA Lewis Research Center for shock position sensing. In an effort to eliminate moving parts, a spectral scanning technique was invented and demonstrated.



Principle of operation of a spectral scanner.

This spectral scanner consists of a tunable laser, a diffraction grating, and a lens. The tunable laser generates a narrow beam of light whose wavelength changes in a prescribed manner. When a light beam emitted by the laser interacts with the grating, the grating causes the beam to change its direction, producing a phenomenon called diffraction. The new direction depends on the wavelength. This space-wavelength scanning generates a "rainbow" in the time domain, where each "color" appears in its place at a given time. Thus, if the wavelength λ changes monotonically in time, the diffracted beam draws a cone with the apex being the point of impact of the beam on the grating. The lens is positioned so that its focal point coincides with the point of impact. It transforms the cone of light into a number of beams of different wavelengths separated from each other in time and parallel to each other in space. In other words, the lens converts an angular scanning into a linear one. When a beam encounters a shock or another type of inhomogeneity, it diffracts, splits, and forms secondary fringes and tails. The drawing shows a blunt body inserted into a stream of air. The blunt body generates the shock, and a charge-coupled discharge (CCD) camera array behind the shock observes the phenomenon. The following graphs demonstrate splitting a beam of light. At a certain wavelength (left graph) the beam strikes the shock. At a different wavelength (right graph), the light beam misses the shock and the beam shape, in this case, is not affected. This information can be used to determine the location of a shock wave.



Intensity profiles observed by a CCD array at two wavelengths during the spectral scanning. Left: At the wavelength corresponding to the beam striking the shock. Right: At the wavelength corresponding to the beam missing the shock.

Bibliography

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