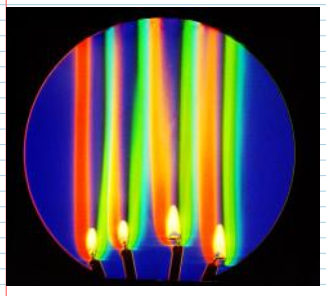
17.IndexOfRefraction

Wednesday, April 21, 2010
8:50 AM

Index of Refraction Techniques

Requires no seed. Can visualize differences and gradients in temperature and chemical concentration, as both change the index of refraction of the media.
Techniques discussed in detail: schlieren and shadowgraphy

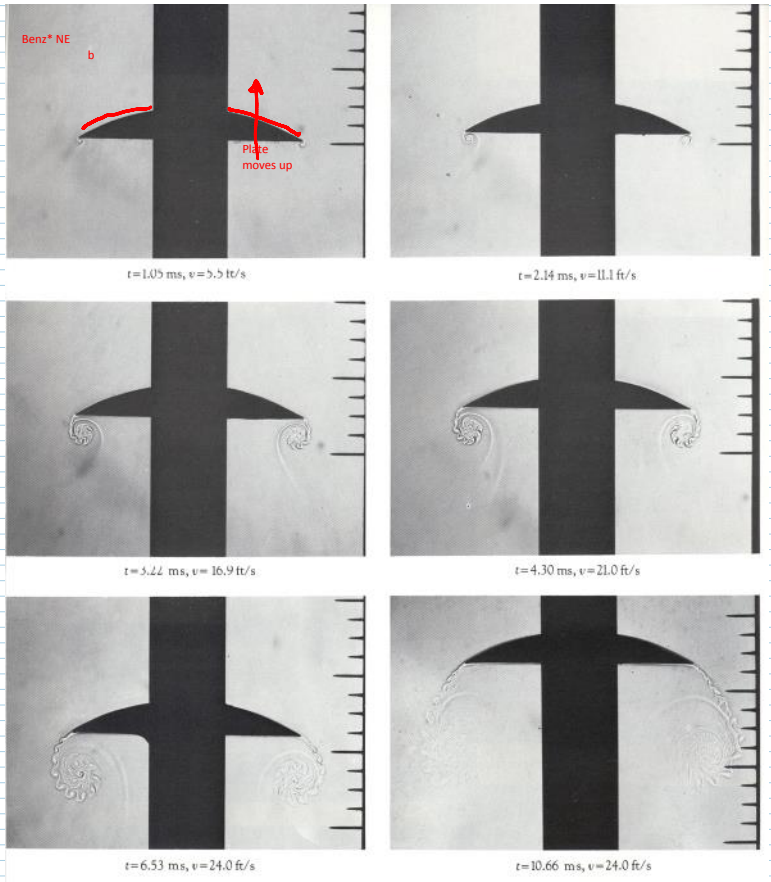


color SCHLIEREN

Pasted from <http://www.compadre.org/informal/images/features/schlierenlarge-11-29-06.jpg>

A. DAVIDHAZY,
RIT = Rochester Institute of Technology,
offers engineering and BS through PhD in Imaging Science.

SHADOWGRAPH



$t = 1.05$ ms, $v = 5.5$ ft/s

$t = 2.14$ ms, $v = 11.1$ ft/s

$t = 3.22$ ms, $v = 16.9$ ft/s

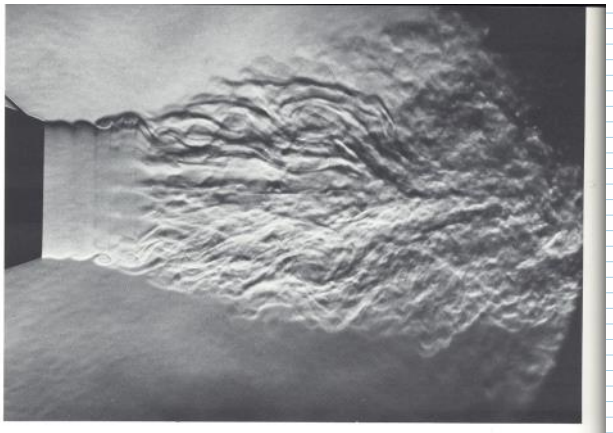
$t = 4.30$ ms, $v = 21.0$ ft/s

$t = 6.53$ ms, $v = 24.0$ ft/s

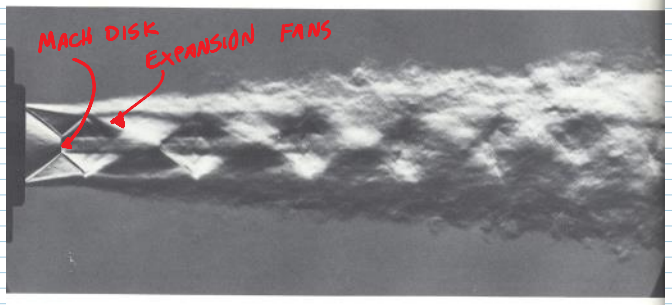
$t = 10.66$ ms, $v = 24.0$ ft/s

81. Growth of vortices on an accelerated plate. Spark shadowgraphs show the history of a 3-inch-square plate in air, accelerated from rest to 24 ft/s. The sharp edge of the plate is initially opposite the first of a series of pins spaced ¼ inch apart. The motion is actually vertical, and the flow is visualized by painting a narrow band of benzene across the center of the balsa-wood plate, so that when the plate accelerates benzene vapor is drawn into the vortex sheet. The difference in density between the vapor and the air makes the paths of their boundaries visible. Care was taken to ensure that the undulations observed in the vortex sheet were not caused by vibrations of the model. *Pierce 1961*

48

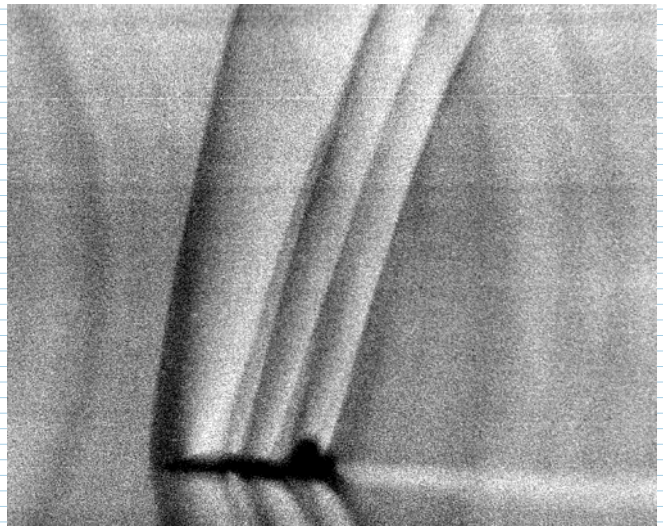


167. Subsonic jet becoming turbulent. A jet of air from a nozzle of 5-cm diameter flows into ambient air at a speed of 12 m/s. The laminar interface becomes unstable as in figure 102, and the entire jet eventually becomes turbulent. *Bradshaw, Ferriss & Johnson 1964*



168. Supersonic jet becoming turbulent. At a Mach number of 1.8 a slightly over-expanded round jet of air adjusts to the ambient air through a succession of oblique and normal shock waves. The diamond-shaped pattern persists after the jet is turbulent. *Oertel 1975*

98



Pasted from <http://commons.wikimedia.org/wiki/File:Schlieren_photograph_of_T-38_shock_waves.jpg>

Mach 1.1, full size T-38 in flight, 1993. L. Weinstein, NASA
example of Background Oriented Schlieren (BOS). Correlate patterned background from image to get schlieren

http://fuckyeahfluiddynamics.tumblr.com/post/47622561173/this-high-speed-video-shows-schlieren-photography

CO_2 bottle rocket video. Shows Mach diamonds and expansion fans.

How it works: $\eta = \frac{C_{VACUUM}}{C_{MEDIUM}}$

n = index of refraction

Light is deflected towards more dense medium

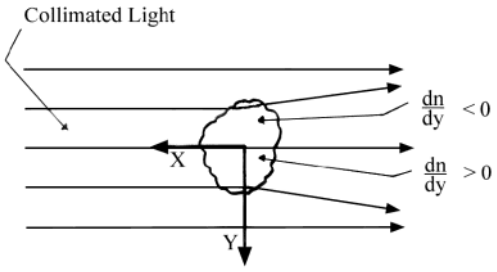
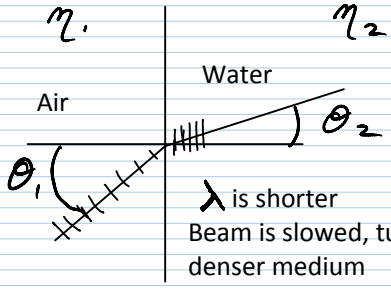


Figure 1. Disturbance in Collimated Beam

$\frac{1}{n}\frac{dn}{dy} = \frac{d^2y}{dx^2}$

curve of disturbed line

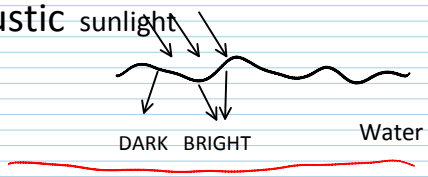
SNELL'S LAW



λ is shorter

Beam is slowed, turns into, i.e towards the denser medium

like a caustic sunlight



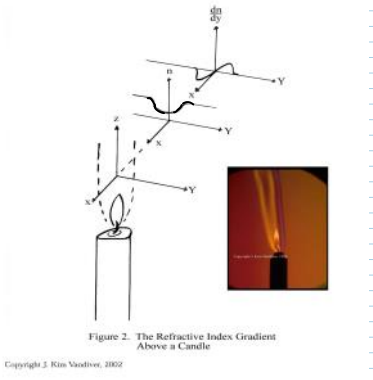


Figure 2. The Refractive Index Gradient Above a Candle

http://web.mit.edu/Edgerton/www/schlieren5.html

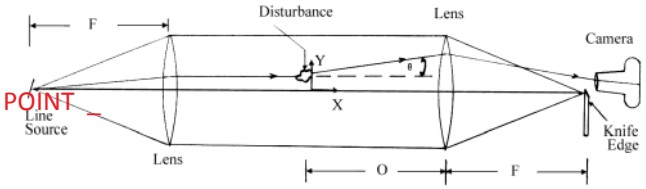
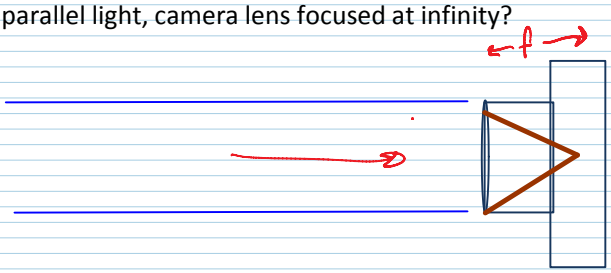


Figure 3. Schlieren System with a Small Disturbance

Minute paper: What would camera see looking at parallel light, camera lens focused at infinity?



Works the other direction too; a light source at the focal point becomes parallel light exiting the lens.