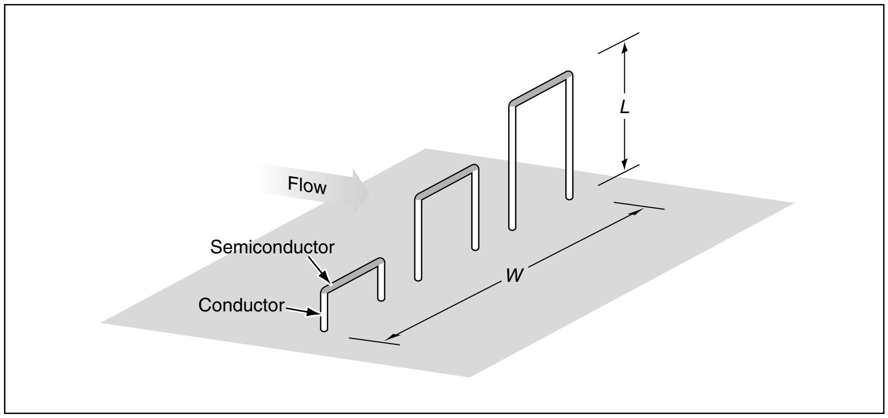
Nanoscale Hot-Wire Probes for Boundary-Layer Flows

Flow parameters near walls would be measured with unprecedented resolution.

Langley Research Center, Hampton, Virginia

Hot-wire probes having dimensions of the order of nanometers have been proposed for measuring temperatures (and possibly velocities) in boundary-layer flows at spatial resolutions much finer and distances from walls much smaller than have been possible heretofore. The achievable resolutions and minimum distances are expected to be of the order of tens of nanometers — much less than a typical mean free path of a molecule and much less than the thickness of a typical flow boundary layer in air at standard temperature and pressure. An additional benefit of the small scale of these probes is that they would perturb the measured flows less than do larger probes.

The hot-wire components of the probes would likely be made from semiconducting carbon nanotubes or ropes of such nanotubes. According to one design concept, a probe would comprise a single nanotube or rope of nanotubes laid out on the surface of an insulating substrate between two metallic wires. According to another design concept, a nanotube or rope of nanotubes would be electrically connected and held a short distance away from the substrate surface by stringing it between two metal electrodes. According to a third concept, a semiconducting nanotube or rope of nanotubes would be strung between the tips of two protruding electrodes made of fully conducting nanotubes or ropes of nanotubes. The figure depicts an array of such probes that could be used to gather data at several distances from a wall.



Nanoscale Hot-Wire Probes would be used to characterize a flow at several distances from a surface, typically ranging from tens of nanometers to a few micrometers. The lateral dimension, *W*, of the array of probes would be made much less than the expected characteristic dimension of lateral nonuniformity of the flow. The distance from the surface (*L*) of the most distant probe would be made much less than the expected thickness of the boundary layer of the flow.

It will be necessary to develop techniques for fabricating the probes. It will also be necessary to determine whether the probes will be strong enough to withstand the aerodynamic forces and impacts of micron-sized particles entrained in typical flows of interest.

The proposed probes may or may not be based on the same principles as those of larger hot-wire anemometer and thermometer probes. The potential for unexpected effects (e.g., quantized current or heat flow) in the nanometer size range makes it necessary to perform research on the basic physics of these probes in order to be able to calibrate them, operate them under conditions (e.g., constant current, or constant temperature) that will yield useful data, and interpret their thermal and electrical responses in terms of flow parameters.

This work was done by Ken T. Tedjojuwono and Gregory C. Herring of **Langley Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www. nasatech.com****.*

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Theodolite With CCD Camera for Safe Measurement of Laser-Beam Pointing

The risk of looking directly at the laser beam is eliminated.

Goddard Space Flight Center, Greenbelt, Maryland

The simple addition of a charge-coupled-device (CCD) camera to a theodolite makes it safe to measure the pointing direction of a laser beam. The present state of the art requires this to be a custom addition because theodolites are manufactured without CCD cameras as standard or even optional equipment.

A theodolite is an alignment telescope equipped with mechanisms to measure the azimuth and elevation angles to the sub-arc-second level. When measuring the angular pointing direction of a Class II laser with a theodolite, one could place a calculated amount of neutral density (ND) filters in front of the theodolite's telescope. One could then safely view and measure the laser's boresight looking through the theodolite's telescope without great risk to one's eyes. This method for a Class II visible wavelength laser is not acceptable to even consider tempting for a Class IV laser and not applicable for an infrared (IR) laser. If one chooses insufficient attenuation or forgets to use the filters, then looking at the laser beam through the theodolite could cause instant blindness.

The CCD camera is already commercially available. It is a small, inexpensive, black-and-white CCD circuit-board-level camera. An interface adaptor was designed and fabricated to mount the camera onto the eyepiece of the specific theodolite's viewing telescope.

Other equipment needed for operation of the camera are power supplies, cables, and a black-and-white television monitor. The picture displayed on the monitor is equivalent to what one would see when looking directly through the theodolite. Again, the additional advantage afforded by a cheap black-and-white CCD camera is that it is sensitive to infrared as well as to visible light. Hence, one can use the camera coupled to a theodolite to measure the pointing of an infrared as well as a visible laser.