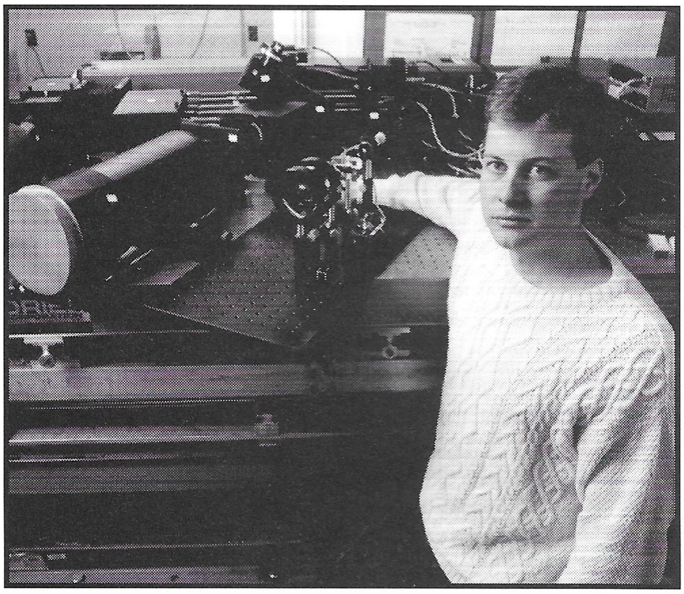
Mini·Measuring

by A'ndrea Elyse Messer

Movie makers and computer manufacturers are not the only people shrinking things. Penn State researchers have developed an anemometer that is much smaller than commercially available units and much more rugged.



Chris McLean balances his mini-anemometer on the conventional laser anemometer it can replace. Using laser diodes, McLean and Cengiz Camci created a miniaturized, hardy device that can be mounted and adapted to the equipment it is measuring. They plan an even smaller, three by eight version.

"Laser Doppler Anemometry is currently used to nonintrusively measure flow velocities of liquids and gases, such as the air flow in gas turbine engines," says **Cengiz Camci**, associate professor of aerospace engineering. "However, the conventional equipment is very large and very fragile."

Conventional laser anemometers use helium-neon or argonion gas lasers, have 100-pound power sources and can range in length from two to six feet. These instruments measure the velocity of air, water or any fluid that is transparent enough for the laser light and scattered light to penetrate.

"LDA is used in food processing to measure the flow, in medicine to measure blood flow, in wind and water tunnels to measure flow around automobiles, aircraft, ships and submarines," says Camci.

The Penn State Miniature Laser Doppler Anemometer—developed by Camci and aerospace graduate student **Chris McLean**—is only the size of a shoe box, runs on four AA batteries, and does the same job, without sacrificing quality. And they have plans to make the device even smaller—three by eight inches.

"The thing that makes our mini-anemometer possible is a laser diode," says McLean. "These are from the same class of semiconductor devices used in the laser pointers and scanners that have become so common at conferences and cash registers."

The problem, however, is that LDA requires a very optically clean beam. The researchers had a laser custom designed to meet their specifications.

"We also had to try several laser and optics combinations before the system would work," says McLean.

Laser diode technology is not new, but according to McLean, the early diodes generated large amounts of heat and had to be cooled by coolants such as liquid nitrogen. It was only

Cengiz Camci

when demand for the devices increased that the efficiency was improved to the point where waste heat was no longer a problem.

"Infra-red laser diodes became common in the 70s and 80s, but we didn't want to use IR because the beam is invisible," says McLean. "Visible light diodes of high quality have only been around for about 10 years."

Dantec Electronics Inc., the US subsidiary of Dantec Measurement Technology of Denmark, is interested in the mini version of the anemometer, notes Camci.

"The company now markets devices in which large lasers send their beams via fiber optics to beam heads that can be aimed. We have figured out a way to place the entire device inside the existing beam head," he says.

The idea of building a mini-anemometer arose because McLean and Camci wanted to measure the flow inside rotating turbomachinery flow passages under laboratory conditions. They hoped to mount the device onto the rotating equipment and alleviate some problems caused by the rotating blades.

"Only a solid state device without gas filled glass tubes could be used in that way," says McLean.

The Penn State Miniature Laser Doppler Anemometer consists of a solid state laser and a series of optics including beam splitters, mirrors and lenses.

LDA works by measuring the light scatter caused by particles passing through an interference fringe. The coherent light produced by the laser is passed through a beam splitter and then the two beams pass through lenses that optically condition the beams. The two beams come back together at an angle that causes interference and produces an area of light and dark bands or interference fringes.

When a small particle caught in the air or liquid flow passes through the interference fringe, it scatters light to the photomultiplier. The pattern of backscattered light provides the flow information.

"The interference pattern produced by the semiconductor lasers differs from that of the gas laser devices," says Camci. "We give special attention to the variations in post processing of Doppler bursts in the computer."

The mini-anemometer has been validated against a gas laser LDA system as well as a hot-wire system and a five-hole probe system. According to McLean, the mini-anemometer agreed within a percentage or two with these conventional measurement systems.

"One nice thing about the miniature system is its fourfold cost reduction," says Camci. "While a conventional system costs about $40,000, the solid state system should cost about $10,000 to build. The significant cost reduction obtained makes this modern equipment easily accessible to undergraduate fluid dynamics laboratories in the universities and high school science laboratories."

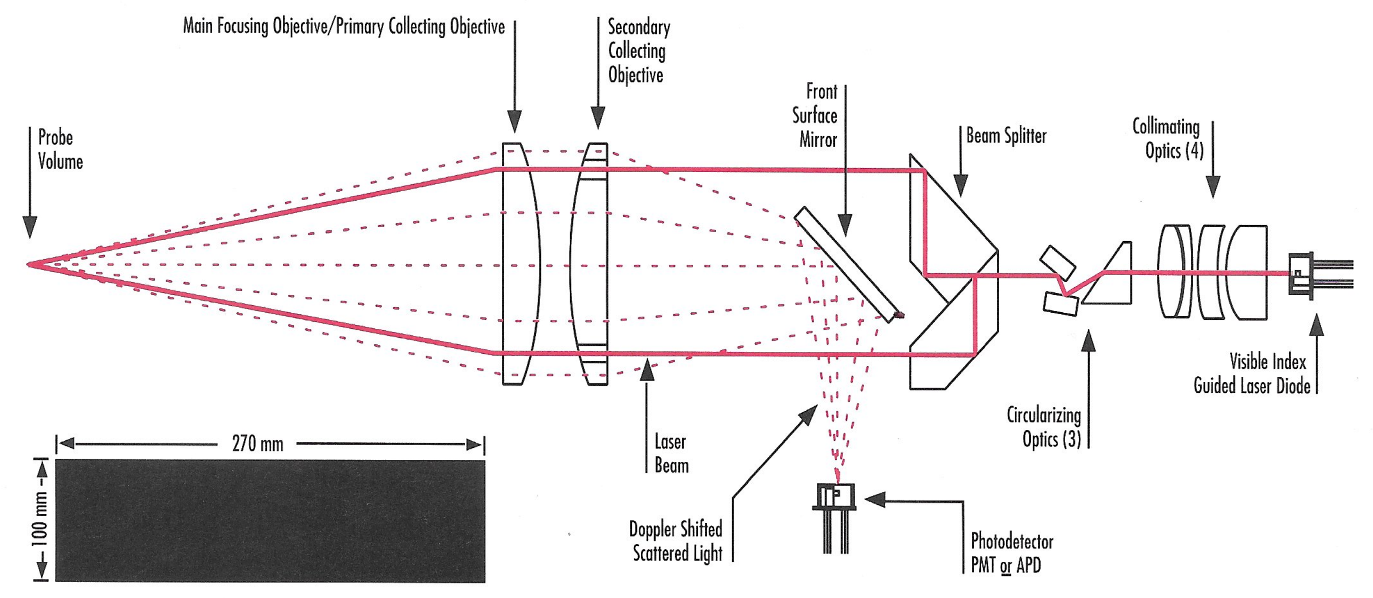
McLean developed the mini-anemometer as his master's degree research under Cennggiz Camci's guidance. In his doctoral studies, McLean plans to develop a multi-component system.

"We're using current semiconductor technology, to devise new configurations to allow measurements from more than one significant direction," concludes McLean. "We have it built in our minds. All we need to do now is test it."

IN THE CLASSROOM

A copy of the existing mini-anemometer is currently being built by the Department of Aerospace Engineering for use in its undergraduate fluid dynamics laboratory.

"This is a unique facility for undergraduate use," says Cengiz Camci. "Before now, such instrumentation was too expensive and complex for undergraduate laboratories. Our system is very low cost and efficient and can be built simply by referring to our publications."



MINIATURE LASER DOPPLER ANEMOMETER SYSTEM

Schematic Representation (Not to Scale)