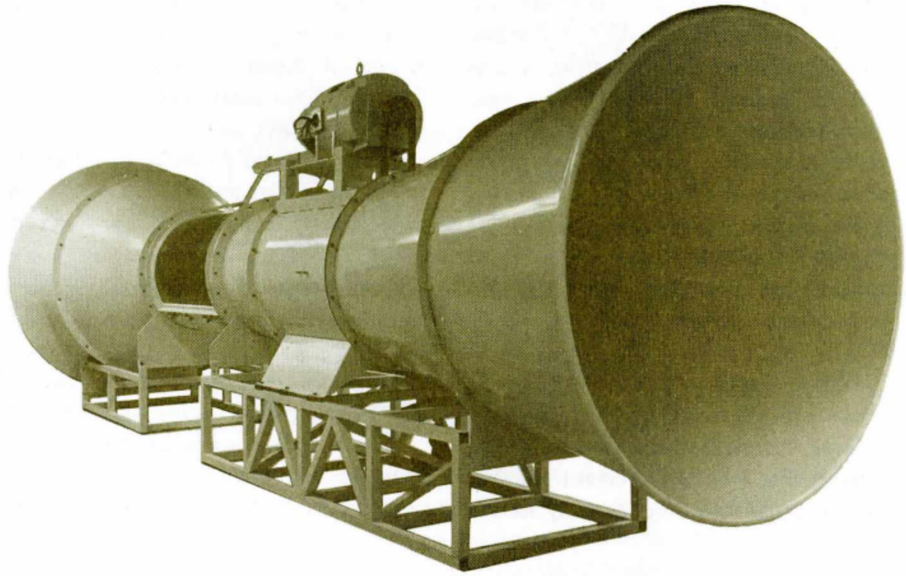


NCAR Wind Tunnel

Adjustable wind speeds enable improved wind sensor calibrations.

A wind tunnel with variable speed settings and both manual and automatic controls has been built for the NCAR Field Observing Facility (FOF) for wind sensor calibrations. The wind tunnel produces a uniform, nonturbulent airflow with speeds up to 28 m/sec (62 mph), selectable in 15 equal steps over the full speed range. Wind speed units can be selected in meters per second, feet per second, kilometers per hour, miles per hour, or knots. Reference speeds are measured by a pitot tube, a Hook gage, and manometers.

The tunnel is available for use by university and other non-NCAR experimenters, usually with the assistance of an FOF technician. Scheduling will be most flexible during winter months. To date, the tunnel has been used to calibrate wind sensors for NOAA's Boulder Research Laboratories and National Severe Storms Laboratory, the NCAR Research Aviation Facility, and FOF.

The tunnel is 732 cm long and has a circular cross section with diameters varying from 218 cm at the inlet to 89 cm in the test section. It is constructed of sheet aluminum and fiber glass with a Plexiglas window over the test section that opens for installation of wind sensors. A nine-blade aluminum fan, driven by a 25 - hp dc motor, pulls air through the length of the tunnel; the air then circulates through the room (with no enclosed ducts) back to the intake. Such a tunnel is termed an "open return" tunnel.

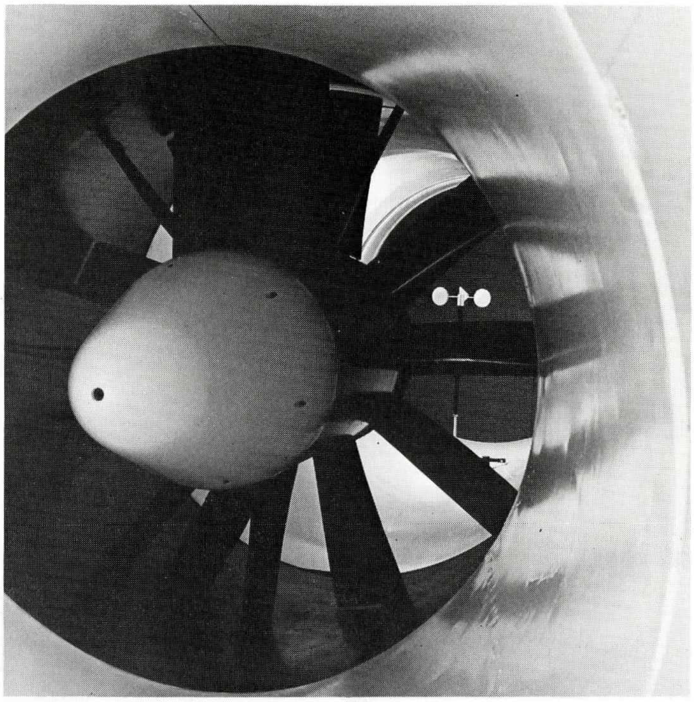
The flared intake bell at the tunnel's front opening contains an aluminum honeycomb and three layers of wire mesh to smooth the flow of entering air. A contraction cone, in which the tunnel narrows to the 89 - cm diameter test section, is aerodynamically shaped to prevent turbulence as the airflow accelerates. Although the velocity profile of the tunnel has not been determined, strobe analysis of the motion of the helicoid propeller in the test section indicates that the airflow is free from turbulence.

The tunnel's most important feature, perhaps nowhere else available, is the technique by which it creates variable wind speeds. The helicoid propeller in the test section continuously measures wind speeds and provides a servo feedback to the motor drive controller (a silicon-controlled rectifier type) for continuous adjustment of any given wind speed. When a new speed is chosen, the required electric voltages are introduced into the servo system. A smooth, continuous increase of wind speed from below typical anemometer starting speeds to the tunnel's full output can be maintained either manually or automatically by a 0- to 5-mA control current.

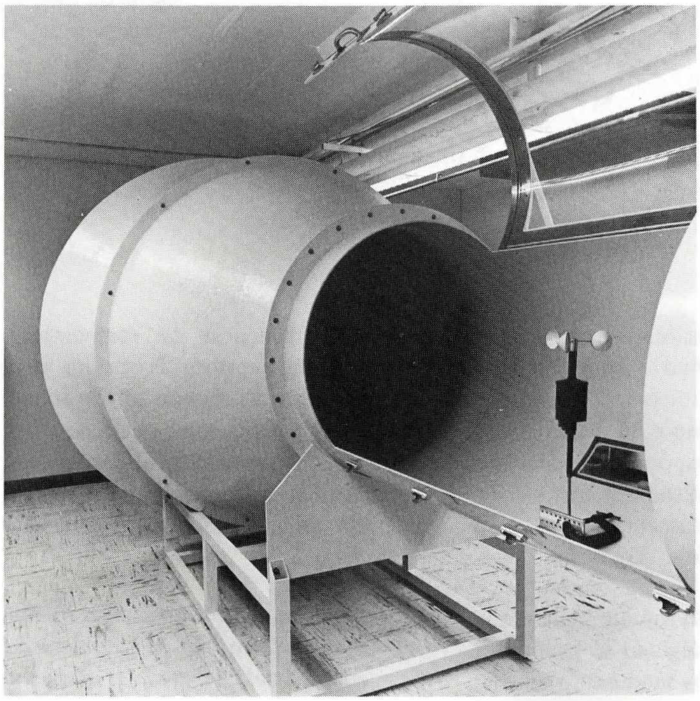
Julian Pike of the NCAR Research Systems Facility (RSF) designed the tunnel, basing many features on a design by Gerald Gill of the University of Michigan. Pike's design differs from Gill's in the use of electronic rather than mechanical controls, and a circular rather than a rectangular cross section. The tunnel was constructed by RSF, with Ed Lambdin carrying out the mechanical design.

Calibration Experiments

During January, Fred Brock of the University of Oklahoma Meteorology Department conducted tests to evaluate new methods of anemometer calibration made possible by the tunnel's variable speed controls. An anemometer's lag characteristics—its delay in responding to changes in wind speed—are measured by the distance constant; this quantity is defined as the length of an air column required to bring the anemometer rate to 63% of the new equilibrium after a sharp-edged gust or partial lull has occurred. The distance constant is usually determined by restraining the instrument's rotation in a wind of constant speed and then releasing it and measuring the time it requires to attain the 63% step change.[1] Brock was able to obtain a continuous dynamic calibration by altering the tunnel's wind speed in known sequences and measuring the ability of the anemometers to follow these changes. He installed electronic circuits to control the frequency of the motor's on and off switching, the duty cycle (percent on vs percent off), and the speed of the motor. He was thus able to produce variable fluctuations in the tunnel's wind speeds which corresponded to atmospheric gusts of known speeds.



(a)



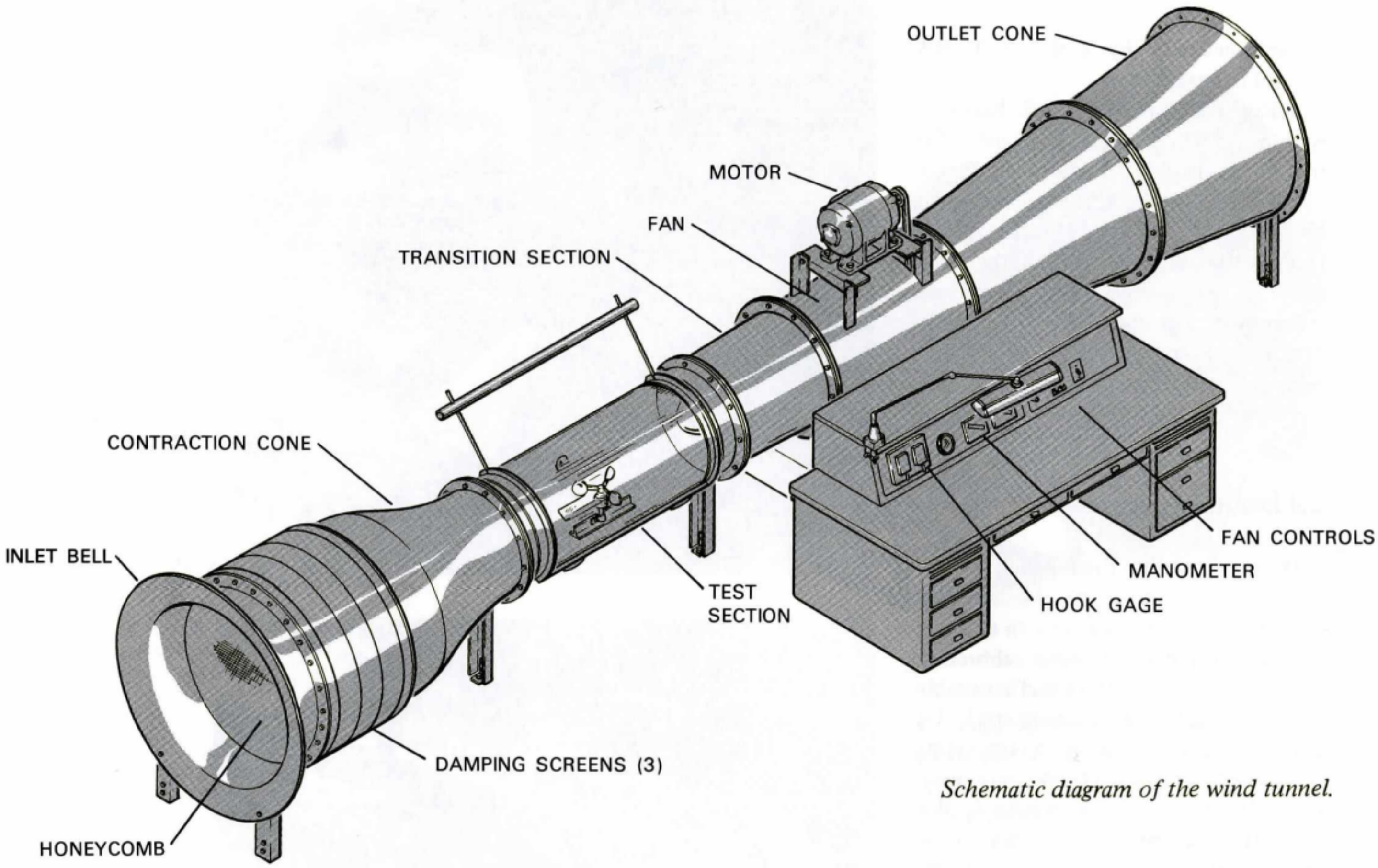
(b)

(a) View from back to front showing fan, test section, and wire mesh in the inlet bell; (b) Plexiglas window opened for installation of instruments in the test section.

Data from one hot-film and two rotating anemometers were recorded on four-channel magnetic tape and were later used to determine which of several mathematical models best described the performance of the anemometers in gusty winds. The analyses provided not only better calibrations but also revealed other aspects of performance in turbulent winds not revealed by the usual calibration method.

Brock was able, for example, to investigate the extent to which a rotating

[1] For example, if the tunnel's wind speed is 10 m/sec and an anemometer requires 0.8 sec to reach 6.3 m/sec from a stationary position, its distance constant is 0.8 sec × 10 m/sec = 8 m.



Schematic diagram of the wind tunnel.

anemometer overestimates the mean value in a gusty wind––an effect that has been observed for over 70 years but is difficult to measure in a controlled experiment. Fast-response anemometers constructed with extremely lightweight blades are least susceptible to wind speed overestimation. To obtain comparative data, Brock tested two instruments with Styrofoam blades, one of which he had weighted to produce a known change in the moment of inertia. Both instruments registered the same peak wind values, but the weighted one registered higher minimum values and thus overestimated the mean wind speeds. Although the effect was predictable, Brock was able to obtain exact quantitative data not available before.

Computer Control

Future plans call for installation of the tunnel next to a computer-controlled environmental chamber. The chamber will be used to provide programmed sequences of temperature, humidity, and pressure. Provisions were made in the construction of the tunnel for control by the same minicomputer used for the environmental chamber. Automatic programming of calibration runs and on-line processing of the calibration results with teletype printout will be possible, and minimal operator control will be necessary. Addition of a coupler, digital printer, and digital tape recorder will permit total machine handling and storage of all calibration data. ●

Wind speed fluctuations recorded by identical anemometers with standard and weighted Styrofoam blades. A variety of similar data, recorded in digital form, enabled detailed analysis of anemometer performance characteristics. (Data courtesy of F. Brock, University of Oklahoma.)