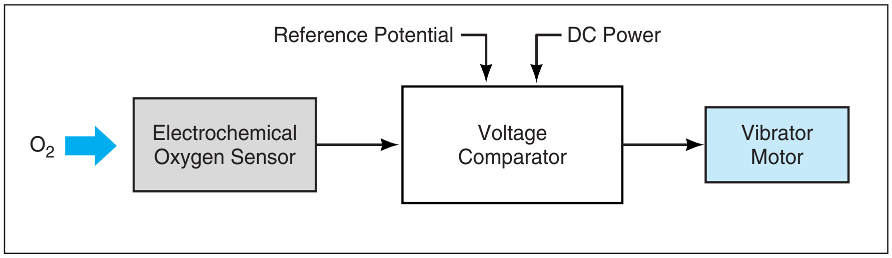
Oxygen-Partial-Pressure Sensor for Aircraft Oxygen Mask

Vibration of the mask against the wearer's nose warns of low oxygen pressure.

Lyndon B. Johnson Space Center, Houston, Texas

A device that generates an alarm when the partial pressure of oxygen decreases to less than a preset level has been developed to help prevent hypoxia in a pilot or other crewmember of a military or other high-performance aircraft. Loss of oxygen partial pressure can be caused by poor fit of the mask or failure of a hose or other component of an oxygen-distribution system. The deleterious physical and mental effects of hypoxia cause the loss of a military aircraft and crew every few years.



The **Comparator Triggers the Motor** into operation when the partial pressure of oxygen, measured by the sensor, falls below a preset value represented by the reference potential.

The device is installed in the crewmember's oxygen mask and is powered via communication wiring already present in all such oxygen masks. The device (see figure) includes an electrochemical sensor, the output potential of which is proportional to the partial pressure of oxygen. The output of the sensor is amplified and fed to the input of a comparator circuit. A reference potential that corresponds to the amplified sensor output at the alarm oxygen-partial-pressure level is fed to the second input of the comparator. When the sensed partial pressure of oxygen falls below the minimum acceptable level, the output of the comparator goes from the "low" state (a few millivolts) to the "high" state (near the supply potential, which is typically 6.8 V for microphone power).

The switching of the comparator output to the high state triggers a tactile alarm in the form of a vibration in the mask, generated by a small 1.3-Vdc pager motor spinning an eccentric mass at a rate between 8,000 and 10,000 rpm. The sensation of the mask vibrating against the crewmember's nose is very effective at alerting the crewmember, who may already be groggy from hypoxia and is immersed in an environment that is saturated with visual cues and sounds. Indeed, the sensation is one of rudeness, but such rudeness could be what is needed to stimulate the crewmember to take corrective action in a life-threatening situation.

The level chosen for triggering the alarm is the partial pressure of oxygen at an altitude of 11,000 ft (≈3.35 km). Because the response time of the electrochemical sensor is about 10 seconds, the device would ordinarily not respond to a sudden but temporary decrease in the partial pressure of oxygen. The device is equipped with a double-pole/double-throw pushbutton switch for turning on the motor temporarily so that the crewmember can verify that the device has power and the vibrations can be felt. When the alarm has been triggered by low oxygen partial pressure, cycling the same pushbutton switch causes the motor to be turned off for a short time (about 30 seconds). There is also a locking power switch that the crewmember can use to turn the device off in the event of a system failure that turns on the vibrator motor.

This work was done by Mark Kelly and Donald Pettit of **Johnson Space Center**. *Further information is contained in a TSP (see page 1).*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23309.

Three-Dimensional Venturi Sensor for Measuring Extreme Winds

Advantageous features include ruggedness, rapid response, and high dynamic range.

John F. Kennedy Space Center, Florida

A three-dimensional (3D) Venturi sensor is being developed as a compact, rugged means of measuring wind vectors having magnitudes of as much as 300 mph (134 m/s). This sensor also incorporates auxiliary sensors for measuring temperature from -40 to +120 °F (-40 to +49 °C), relative humidity from 0 to 100 percent, and atmospheric pressure from 846 to 1,084 millibar (85 to 108 kPa).

Conventional cup-and-vane anemometers are highly susceptible to damage by both high wind forces and debris, due to their moving parts and large profiles. In addition, they exhibit slow recovery times contributing to an inaccurately high average-speed reading. Ultrasonic and hot-wire anemometers overcome some of the disadvantages of the cup-and-vane anemometers, but they have other disadvantageous features, includ-

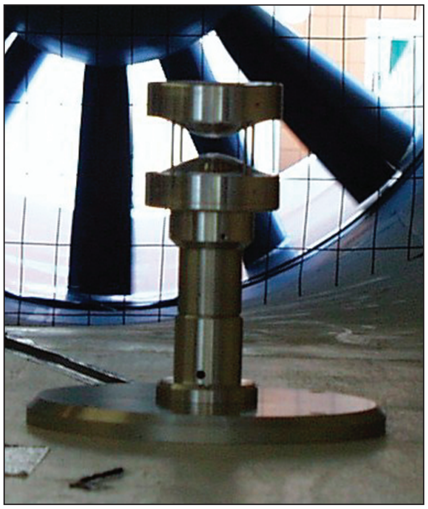


Figure 1. A **Prototype Three-Dimensional Venturi Sensor** is shown here mounted in a wind tunnel for testing at Embry-Riddle Aeronautical University, FL.

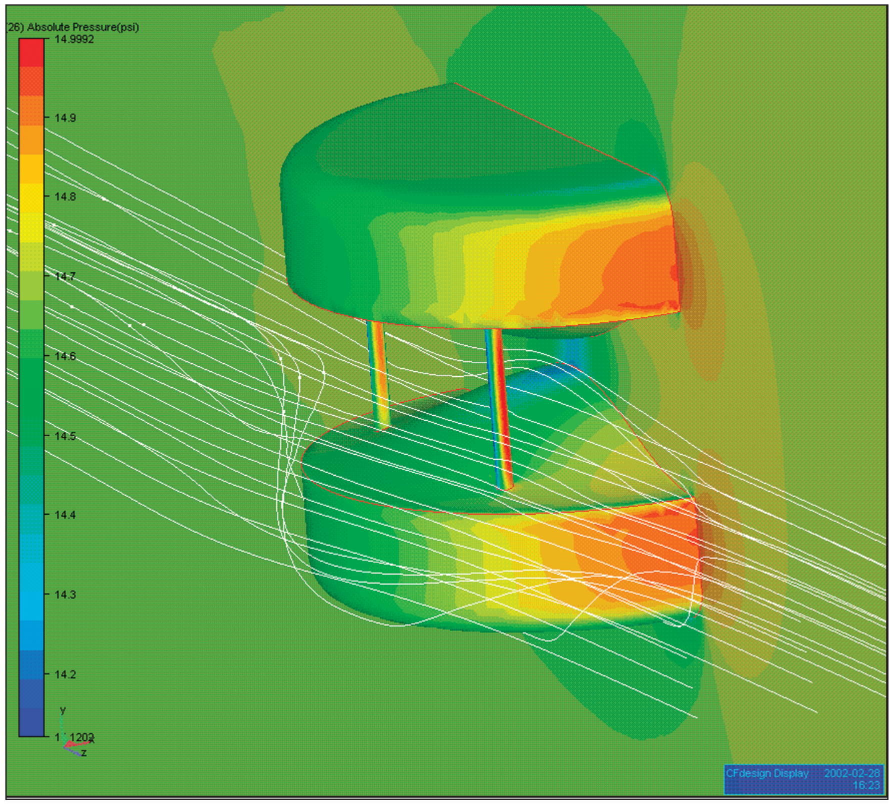


Figure 2. **Pressure and Flow Pattern Results** from simulation of the prototype 3D Venturi sensor are shown at 100-mph (45-m/s) wind velocity.

ing limited dynamic range and susceptibility to errors caused by external acoustic noise and rain.

In contrast, the novel 3D Venturi sensor is less vulnerable to wind damage because of its smaller profile and ruggedness. Since the sensor has no moving parts, it provides increased reliability and lower maintenance costs. It has faster response and recovery times to changing wind conditions than traditional systems. In addition, it offers wide dynamic range and is expected to be relatively insensitive to rain and acoustic energy.

The Venturi effect in this sensor is achieved by the mirrored double-inflection curve, which is then rotated 360° to create the desired detection surfaces. The curve is optimized to provide a good balance of pressure difference between sensor ports and overall maximum fluid velocity while in the shape. Four posts are used to separate the two shapes, and their size and location were chosen to minimize effects on the pressure measurements.

The 3D Venturi sensor has smart software algorithms to map the wind pressure exerted on the surfaces of the design. Using Bernoulli's equation, the speed of the wind is calculated from the differences among the pressure readings at the various ports. The direction of the wind is calculated from the spatial distribution and magnitude of the pressure readings. All of the pressure port sizes and locations have been optimized to minimize measurement errors and to reside in areas demonstrating a stable pressure reading proportional to the velocity range.

This work was done by Jan A. Zysko, Jose M. Perotti, and Christopher Amis of **Kennedy Space Center** *and John Randazzo, Norman Blalock, and Anthony Eckhoff of Dynacs, Inc. Further information is contained in a TSP (see page 1).*
KSC-12435

Swarms of Micron-Sized Sensors

NASA's Jet Propulsion Laboratory, Pasadena, California

A paper presents the concept of swarms of micron-sized and smaller carriers of sensing equipment, denoted generally as controllable granular matter, to be used in exploring remote planets and interplanetary space. The design and manufacture of controllable granular matter would exploit advances in microelectromechanical systems and nanotechnology. Depending on specific designs and applications, controllable granular matter could have characteristics like those of powders, sands, or aerosols, which would be dispersed into the environments to be explored: For example, sensory grains could be released into orbit around a planet, spread out over ground, or dispersed into wind or into a body of liquid. The grains would thus become integral parts of multiphase environments, where they would function individually and/or collectively to gather information about the environments. In cases of clouds of grains dispersed in outer space, it may be feasible to use laser beams to shape the clouds to perform specific functions. To enable the full utilization of controllable granular matter, it is necessary to advance the knowledge of the dynamics and controllable characteristics of both individual grains and the powders, sands, or aerosols of which they are parts.

This work was done by Marco Quadrelli of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30708