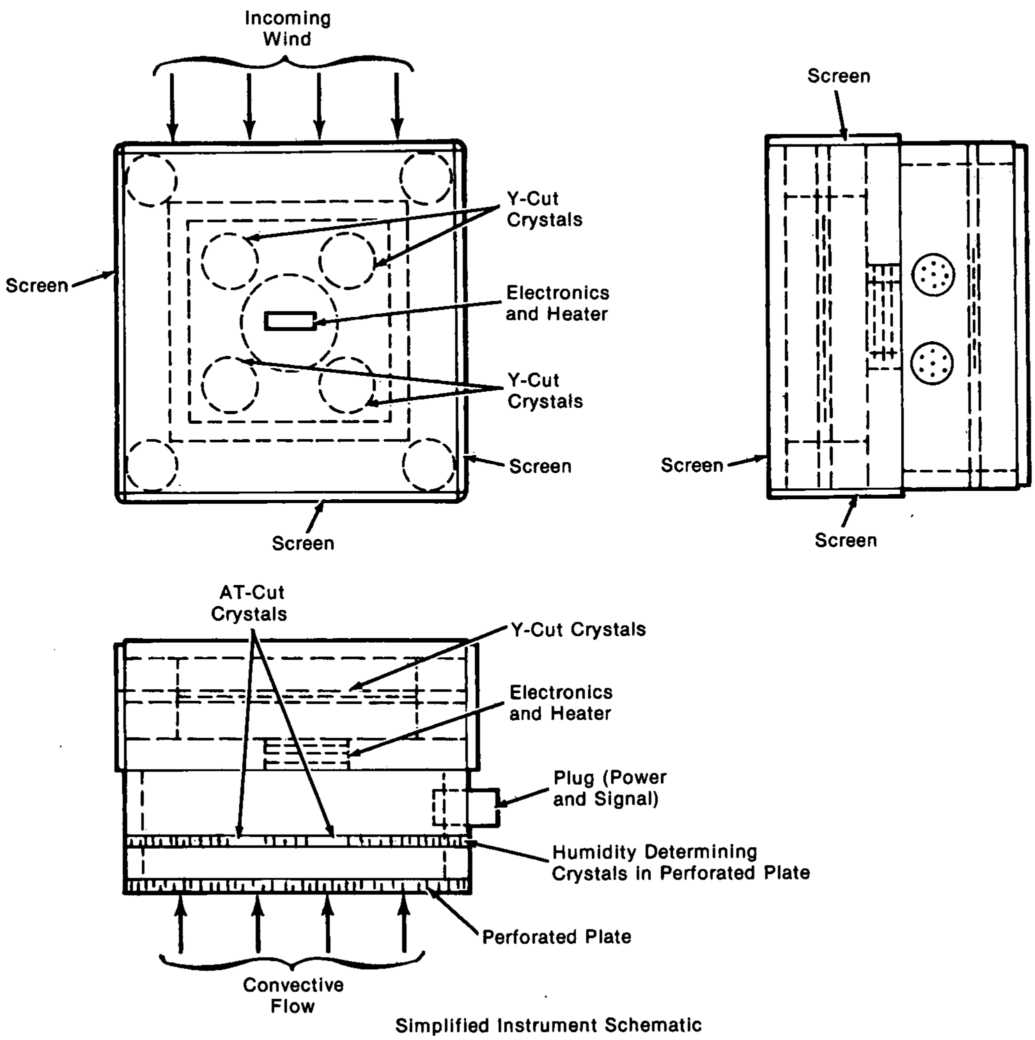
NASA TECH BRIEF

NASA Pasadena Office

Quartz Crystal Microbalances To Measure Wind Velocity and Air Humidity

Two new quartz crystal microbalance (QCM) instruments are proposed which can measure wind velocity, direction, and temperature as well as air humidity all in one package. Separate instruments have been used previously by meteorologists and air-quality researchers to measure each of these quantities.

A simplified schematic of one of the new instruments is shown in the illustration. The instrument includes four temperature-sensing, Y-cut



Simplified Instrument Schematic

(continued overleaf)

quartz crystals to determine wind direction, velocity, and temperature. Two additional AT-cut crystals are used to determine air humidity. The entire signal processing is provided by built-in electronics circuits.

Each of the first four crystals is connected to an oscillator. The oscillators operate at different fundamental frequencies in the 5-MHz band so that different outputs can be easily distinguished. The crystals have a temperature coefficient of approximately 400 Hz/°C and the instrument can resolve temperature changes as small as 0.01° C.

The instrument is enclosed on four sides by a series of screens. The screens are designed to admit wind into the instrument without obstruction. Inside the instrument is a 0.1-W heater which generates warm air current. This air current, forming a vertical stream by convection, is sufficient to raise crystal temperature by 0.5° C.

As the wind strikes the instrument, the air current is deflected downstream of the wind. This changes the temperature level of each crystal. As a result of the temperature changes, the frequencies of the oscillator circuits are shifted by different magnitudes.

Three parameters are determined from these frequency shifts:

1. Wind direction is determined by recording new oscillator frequencies. Each unique frequency combination is indicative of a specific wind direction.
2. Wind velocity is determined by observing the magnitudes of the frequency shifts. Large shifts indicate high wind velocity.
3. Wind temperature is obtained by summing the frequency shifts and comparing with the initial ambient-temperature frequency outputs.

Humidity is measured by the two AT-cut crystals. Again, each crystal is connected to an oscillator. One crystal is coated with a hydrophobic substance, and the other is coated with a hydrophilic substance. When the air humidity is zero, the two oscillator outputs are identical. In the presence of humidity, moisture is absorbed by the hydrophilic substance; no moisture collects on the other crystal which remains as a reference. The collected moisture causes a slight change in mass on the crystal; this change in mass causes a shift in its oscillator frequency. Air humidity is determined directly based on the frequency difference between the two crystals.

The second quartz crystal instrument is similar to the one described. In addition to measuring wind velocity and air temperature, the second system can also measure solar irradiance. This makes it more complete for meteorological applications.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
NASA Pasadena Office
4800 Oak Grove Drive
Pasadena, California 91103
Reference: TSP75-10124

Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:

Patent Counsel
NASA Pasadena Office
4800 Oak Grove Drive
Pasadena, California 91103

Source: James B. Stephens and
Eric G. Laue of
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-13462)

Categories: 03 (Physical Sciences)
02 (Electronics Systems)