Physical Sciences

Generating Breathable Air Through Dissociation of N_2O

Air-supply systems can be made to weigh less and/or operate longer.

Lyndon B. Johnson Space Center, Houston, Texas

A nitrous oxide-based oxygen-supply system (NOBOSS) is an apparatus in which a breathable mixture comprising 2/3 volume parts of N_2 and 1/3 volume part of O_2 is generated through dissociation of N_2O. The NOBOSS concept can be adapted to a variety of applications in which there are requirements for relatively compact, lightweight systems to supply breathable air. These could include air-supply systems for firefighters, divers, astronauts, and workers who must be protected against biological and chemical hazards.

A NOBOSS stands in contrast to compressed-gas and cryogenic air-supply systems. Compressed-gas systems necessarily include massive tanks that can hold only relatively small amounts of gases. Alternatively, gases can be stored compactly in greater quantities and at low pressures when they are liquefied, but then cryogenic equipment is needed to maintain them in liquid form. Overcoming the disadvantages of both compressed-gas and cryogenic systems, the NOBOSS exploits the fact that N_2O can be stored in liquid form at room temperature and moderate pressure. The mass of N_2O that can be stored in a tank of a given mass is about 20 times the mass of compressed air that can be stored in a tank of equal mass.

In a NOBOSS, N_2O is exothermically dissociated to N_2 and O_2 in a main catalytic reactor. In order to ensure the dissociation of N_2O to the maximum possible extent, the temperature of the reactor must be kept above 400 °C. At the same time, to minimize concentrations of nitrogen oxides (which are toxic), it is necessary to keep the reactor temperature at or below 540 °C. To keep the temperature within the required range throughout the reactor and, in particular, to prevent the formation of hot spots that would be generated by local concentrations of the exothermic dissociation reaction, the N_2O is introduced into the reactor through an injector tube that features carefully spaced holes to distribute the input flow of N_2O widely throughout the reactor.

A NOBOSS includes one or more "destroyer" subsystems for removing any nitrogen oxides that remain downstream of the main N_2O-dissociation reactor. A destroyer includes a carbon bed in series with a catalytic reactor, and is in thermal contact with the main N_2O-dissociation reactor. The gas mixture that leaves the main reactor first goes through a carbon bed, which adsorbs all of the trace NO and most of the trace NO_2. The gas mixture then goes through the destroyer catalytic reactor, wherein most or all of the remaining NO_2 is dissociated.

A NOBOSS can be designed to regulate its reactor temperature across a range of flow rates. One such system includes three destroyer loops; these loops act, in combination with a heat sink, to remove heat from the main N_2O-dissociation reactor. In this system, the N_2O and product gases play an additional role as coolants; thus, as needed, the coolant flow increases in proportion to the rate of generation of heat, helping to keep the main-reactor temperature below 540 °C.

This work was done by Robert Zubrin and Brian Frankie of Pioneer Astronautics for **Johnson Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MSC-23105, volume and number of this NASA Tech Briefs *issue, and the page number.*

High-Performance Scanning Acousto-Ultrasonic System

This system reveals flaws that cannot otherwise be detected nondestructively.

John H. Glenn Research Center, Cleveland, Ohio

A high-performance scanning acousto-ultrasonic system, now undergoing development, is designed to afford enhanced capabilities for imaging microstructural features, including flaws, inside plate specimens of materials. The system is expected to be especially helpful in analyzing defects that contribute to failures in polymer- and ceramic-matrix composite materials, which are difficult to characterize by conventional scanning ultrasonic techniques and other conventional nondestructive testing techniques.

Selected aspects of the acousto-ultrasonic method have been described in several *NASA Tech Briefs* articles in recent years. Summarizing briefly: The acousto-ultrasonic method involves the use of an apparatus like the one depicted in the figure (or an apparatus of similar functionality). Pulses are excited at one location on a surface of a plate specimen by use of a broadband transmitting ultrasonic transducer. The stress waves associated with these pulses propagate along the specimen to a receiving transducer at a different location on the same surface. Along the way, the stress waves interact with the microstructure and flaws present between the transducers. The received signal is analyzed to evaluate the microstructure and flaws.

The specific variant of the acousto-ultrasonic method implemented in the present developmental system goes beyond the basic principle described above to include the following major additional features:

Computer-controlled motorized translation stages are used to automatically position the transducers at specified locations. Scanning is performed in the sense that the measurement, data-acquisition, and data-analysis processes are repeated at different specified transducer locations in an array that spans the specimen surface (or a specified portion of the surface).

A pneumatic actuator with a load cell is used to apply a controlled contact force.

In analyzing the measurement data for each pair of transducer locations in the scan, the total (multimode) acousto-ultrasonic response of the specimen is utilized. The analysis is performed by custom software that extracts parameters of signals in the time and frequency domains.

The computer hardware and software provide both real-time and post-scan processing and display options. For example, oscilloscope displays of waveforms and power spectral densities are available in real time. Images can be computed while scanning continues. Signals can be digitally preprocessed and/or postprocessed by filtering, windowing, time-segmenting, and running-waveform-averaging algorithms. In addition, the software affords options for off-line simulation of the waveform-data-acquisition and scanning processes.

In tests, the system has been shown to be capable of characterizing microstructural changes and defects in SiC/SiC and C/SiC ceramic-matrix composites. Delaminations, variations in density, microstructural changes attributable to infiltration by silicon, and crack-space indications (defined in the next sentence) have been revealed in images formed from several time- and frequency-domain parameters of scanning acousto-ultrasonic signals. The crack-space indications were image features that were not revealed by other nondestructive testing methods and are so named because they turned out to mark locations where cracking eventually occurred.

This work was done by Don Roth of **Glenn Research Center***; Richard Martin, Harold Kautz, and Laura Cosgriff of Cleveland State University; and Andrew Gyekenyesi of Ohio Aerospace Institute. Further information is contained in a TSP (see page 1).*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17601-1.

Correction for Thermal EMFs in Thermocouple Feedthroughs

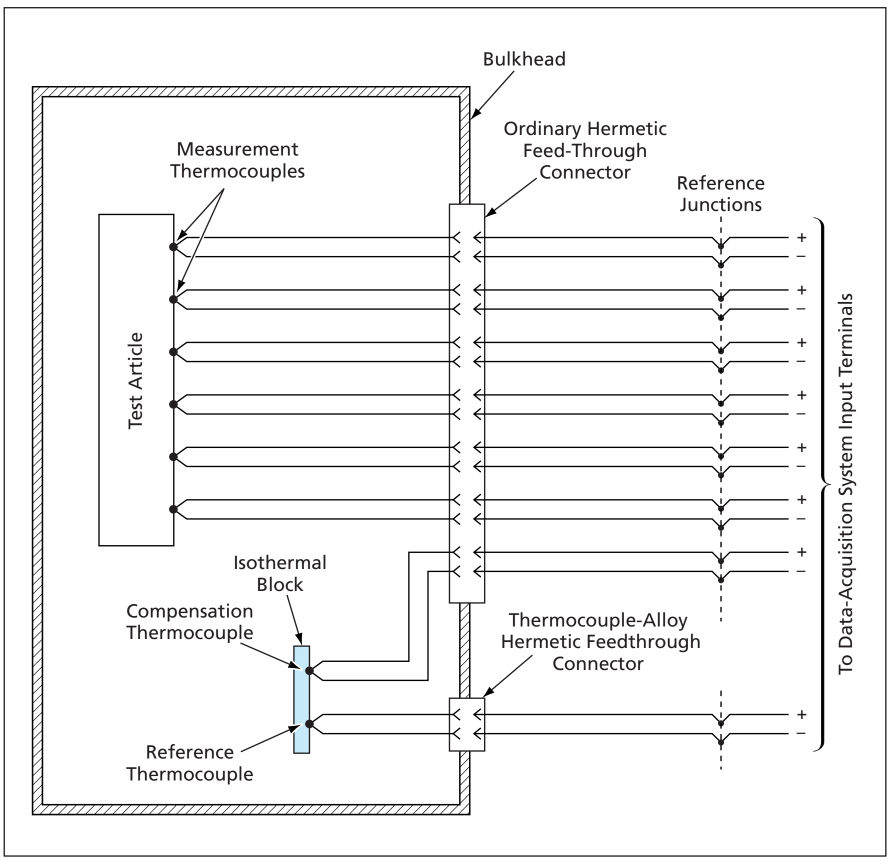
Expensive thermocouple-alloy multipin hermetic feedthrough connectors are no longer necessary.

John H. Glenn Research Center, Cleveland, Ohio

A straightforward measurement technique provides for correction of thermal-electromotive-force (thermal-EMF) errors introduced by temperature gradients along the pins of non-thermocouple-alloy hermetic feedthrough connectors for thermocouple extension wires that must pass through bulkheads. This technique is an alternative to the traditional technique in which the thermal-EMF errors are eliminated by use of custom-made multipin hermetic feedthrough connectors that contain pins made of the same alloys as those of the thermocouple extension wires.

One disadvantage of the traditional technique is that it is expensive and time-consuming to fabricate multipin custom thermocouple connectors. In addition, the thermocouple-alloy pins in these connectors tend to corrode easily and/or tend to be less rugged compared to the non-thermocouple-alloy pins of ordinary connectors. As the number of thermocouples (and thus pins) is increased in a given setup, the magnitude of these disadvantages increases accordingly.

The present technique is implemented by means of a little additional hardware and software, the cost of which is more than offset by the savings incurred through the use of ordinary instead of thermocouple connectors.



The **Compensation and Reference Thermocouples** and associated components provide the voltages needed to correct for thermal-EMF errors that occur when an ordinary (non-thermocouple-alloy) hermetic feedthrough connector is used.