

Stress Analyzer

At top right is the SPATE 900 Dynamic Stress Analyzer, manufactured by Ometron Limited, London, England and distributed in the U.S. by Ometron Inc., Herndon, Virginia. SPATE is an acronym for Stress Pattern Analysis by Thermal Emission, a title that embraces its purpose and *modus operandi*: it detects stress-induced temperature changes in a structure and indicates the degree of stress.

SPATE is widely used to analyze structural stress in research studies and manufacturing operations involving a wide range of structures, among them air, rail and automotive transportation vehicles, propulsion systems, earth moving equipment, composite materials, transmission towers, mechanical gears, nuclear power plants and marine structures. SPATE 9000 systems, says Ometron, "have established a proven record for cost reduction in product design and testing; an increasing number of everyday products owe their improved performance and structural integrity to the SPATE analyzer."

The SPATE system is based on technology developed under NASA contract a quarter century ago, when Langley Research Center sponsored a study of infrared stress measurement. The study was proposed by Milo H. Belgen, an engineer with the Columbus (Ohio) Aircraft Division of North American Aviation Inc. (later Rockwell International). For his company, Belgen had explored the feasibility of using sensitive infrared radiometers then becoming commercially available to scan aircraft structures for stress concentrations while they were being subjected to repeated oscillating loads that simulated actual flight; it was hoped such research would reduce the cost of developing aircraft structural designs.

Belgen's follow-on work under the NASA contract was essentially a demonstration of a principle postulated more than a century earlier by the British mathematician and physicist William Thomson Kelvin. Lord Kelvin theorized that a material subjected to stress experiences a conversion between mechanical and thermal energy that results in changes of temperature in the

material, and that there was a correlation between the degree of stress and the change in temperature. Lord Kelvin's theory of thermoelastic stress analysis temperature changes remained an intellectual curiosity until the availability of sensitive radiometers.

Belgen's work was a milestone in that he showed the feasibility of using *non-contacting* instrumentation—the infrared radiometer—to make stress measurements, overcoming the skepticism of that time that a system could map stresses in a structure without anything actually attached to the structure. Belgen's work established a departure point for later development of SPATE systems by providing a technology base of technical literature that detailed the basic aspects of infrared stress measurement. This stimulated research on practical applications of the technology.

More than a decade later, when temperature measurement technology had advanced, SIRA Ltd., Chiselhurst, England developed—in 1977—the first practical SPATE system under contract to the British Ministry of Defence. SIRA is the parent company of Ometron Inc. Ometron general manager David E. Oliver, who participated in the SPATE development at SIRA, acknowledges that "Belgen's work in the sixties for NASA helped us have a strong start in a technology that is now revolutionizing experimental stress analysis."

Ometron's SPATE 9000 consists of a scan unit and a data processing console with a keyboard and a visual display. The scan unit contains an infrared channel focused on the test structure to collect thermal radiation, and a visual channel used to set up the scan area and interrogate the stress display; stress data is produced by detecting minute temperature changes—down to one-thousandth of a degree Centigrade—resulting from the application to the structure of dynamic loading. The electronic data processing system correlates the temperature changes with a reference signal to determine stress level.

At near left is a typical visual display showing a fault (blue area) in a composite material; impact damage, not visible under normal visual in-



spection, is readily detected by SPATE 9000. The bottom photo is a scan of a truck frame weld showing stress areas in red (tension) and blue (compression). A wide range of software is available for the great variety of applications; some software programs have been developed in association with Deere & Company.

At left center is Brad Boyce of Deere's Horicon Works, chairman of the U.S. SPATE Users Group. Deere & Company uses SPATE for measuring stress in agricultural, lawn and garden equipment.

The roster of SPATE 9000 users reads like a who's who of industrial research; among them are such familiar names as Ford, Chrysler, General Motors, BMW, Nissan, Honda, Toyota, Renault, Boeing, Rockwell, General Electric, Aeritalia, Pratt & Whitney, and such government research facilities as the USAF's Wright-Patterson Air Force Base, Britain's Admiralty Research Establishment and the Royal Aircraft Establishment, Japan's Research Institute of Industrial Safety and National Aerospace Laboratories, the Royal Military College of Belgium and the Technical University of Denmark.

