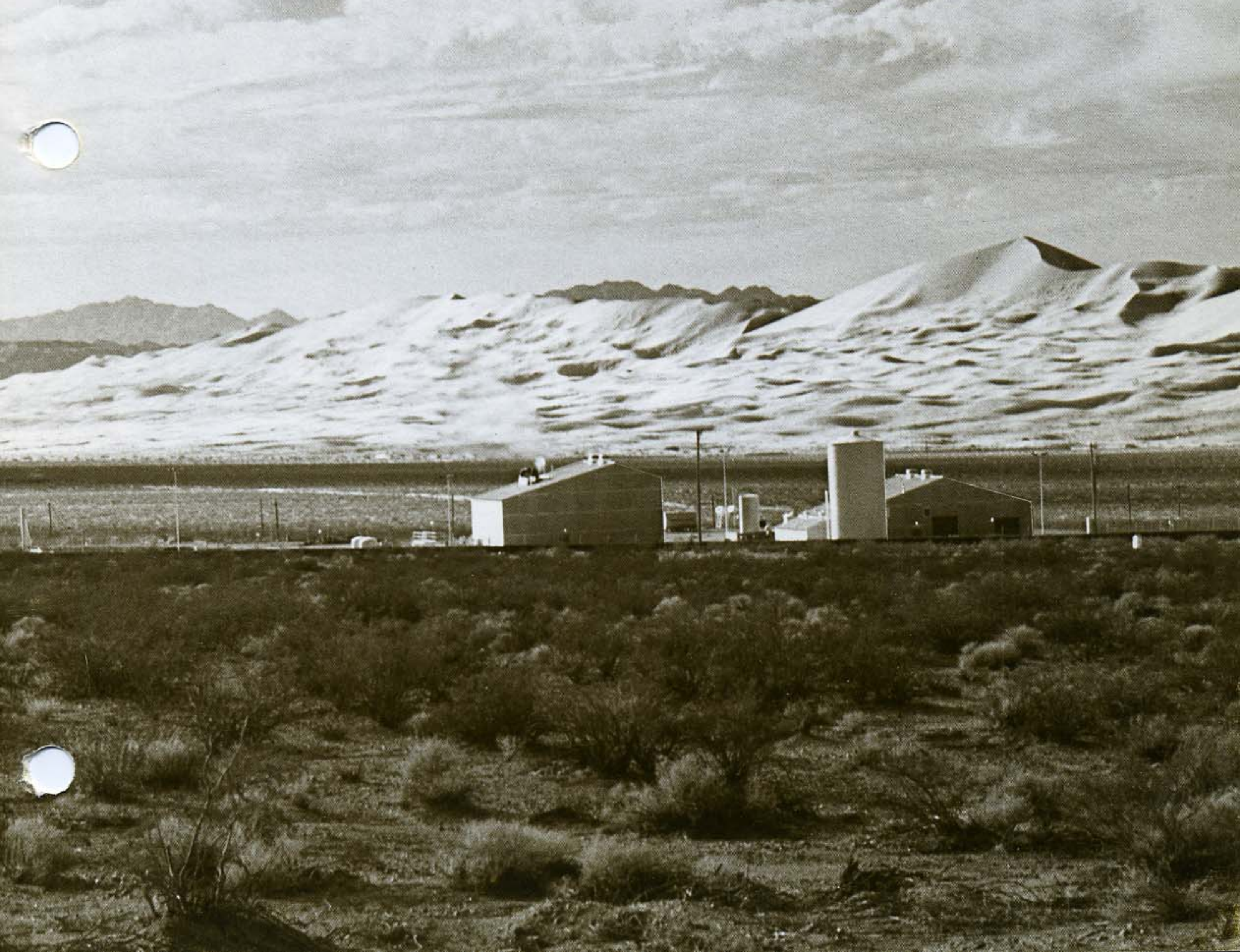
APPLICATIONS OF COMPUTERIZED DIGITAL DATA ACQUISITION SYSTEMS

Computerized data acquisition aids final testing

A Solution to a Measurement Problem for: DRESSER INDUSTRIES, INC.
Machinery Group
Gas Turbine Division
Houston, Texas



THE APPLICATION

The Dresser gas turbine production/development facility in Houston, Texas is responsible for conducting comprehensive performance and development tests on complete gas-turbine-driven compressor systems, as well as other types of related systems. These are large compressors used, for example, in natural gas pipelines (up to 36 inches in diameter), where they are inserted at intervals of 70-80 miles to restore the pressure losses resulting from gas friction within the pipe walls. Normal operating pressures are typically 300-500 psi at the input and 700-900 psi discharge. Such systems consist essentially of a gas generator (jet engine) which provides hot gas to propel a power turbine which in turn is directly connected to the compressor. The systems are designed for unattended operation and make use of the natural gas which is readily available on-site to fire the jet engine.

THE MEASUREMENT PROBLEM

The compressors are manufactured at the Dresser Clark Division plant in Olean N.Y. where they undergo initial testing using air at reduced pressure. At Houston the compressors are completely assembled into gas-turbine-driven compressor systems and then tested under the operating conditions expected to be encountered in field service. Monitoring these tests is a big job because data must be collected from more than 200 points. Broken down into specific requirements, the problem facing Dresser was: *How to automatically measure pressure, temperature, flow, speed, and torque accurately and rapidly with some immediate computer data reduction, and also log data in a form permitting subsequent in-depth analysis on a larger computer.*

THE SOLUTION

To perform the data acquisition task, Dresser Industries selected the test system shown in the block diagram. It consists of standard HP systems-oriented instruments and computer interfaces except for the two customer-furnished pressure scanners. (A pressure scanner is to pressure as the crossbar scanner is to voltage, i.e., both accept multiple inputs and switch them one at a time to a measuring instrument.) The software package includes drivers for all the computer interfaces, diagnostic and verification software, an analog scan routine which simplifies data acquisition operations under interrupt control and allows random or sequential scanning of the analog inputs, plus a data acquisition and control executive (DACE), which schedules and coordinates all data acquisition activities in real time.

RUNNING THE TESTS

Once the test stand is set up and all test data points connected, the entire data acquisition process then operates under program control in real time, through the DACE software system.

Analog inputs measured by the system include 23 differential pressure channels, 48 mixed static and total pressure channels, 37 mixed pressure, flow, speed, and torque channels, plus 100 temperature channels. The actual physical variables of flow and speed are detected as frequency signals while torque, pressure, and temperature are measured as an analog voltage at the corresponding points. While some pressure measurements are made through individual pressure transducers per data point, the bulk of pressure inputs are monitored through two pressure scanners. Under program control, pressure suction channels are selected one at a time and switched to a single strain-gage transducer contained inside the pressure scanner, which in turn provides a voltage output proportional to the pressure input level. Thus, each pressure scanner requires only one input channel in the crossbar scanner. This technique lowered the test costs considerably, since the alternative was to install 71 individual pressure transducers ($200 to $500 each). And, to further increase the value and effectiveness of the scanners, the computer is used to generate a new calibration factor, to correct for transducer error, each time the scanner is read. This is accomplished by reading three reference pressures (200, 400, and 600 inches of water) during each scan. The voltages are equated to the known reference pressures and a new calibration factor is calculated. The resulting data are thus compensated for any power supply deviations.

Using the analog scan routine (FORTRAN callable within the DACE environment), the complete compressor test sequence, as written in-house at Dresser, scans all the temperatures first, followed by pressures, flows, speed, and torque. Parameters measured include: inlet air to, and exhaust stack pressure from, a gas turbine (in the range -2 and +6 inches of water); compressor suction and discharge pressure (up to 1000 psig); barometric pressure; temperatures throughout the compressor system (from ambient to 1000°F). All the pressure transducers are housed in a cabinet at a controlled temperature of 118° ±1°F, isolated from vibration. Temperatures are measured by thermocouples, referenced to a 32°F, double-oven cold junction. Nominal accuracies are: ±1°F to 400°F; ±2°F 400-800°F; ±5°F 800-1000°F. To a great extent, relative measurements are made of temperature and pressure, yielding accuracies in the order of ±0.1°F and ±0.25%, respectively. The individual readings, as measured by the digital voltmeter, are converted to engineering units (°F, RPM, etc.) by a subroutine which compares readings against limits to determine which portion of a linearized curve to use for the conversion factor. The converted data are stored on magnetic tape with date, time, test number, and channel identification. The magnetic tape record is subsequently analyzed at a service bureau where a larger computer is available to perform extensive computations. Another program lists "quick-look" data on the teleprinter, allowing the operator to observe results as the tests are in progress.

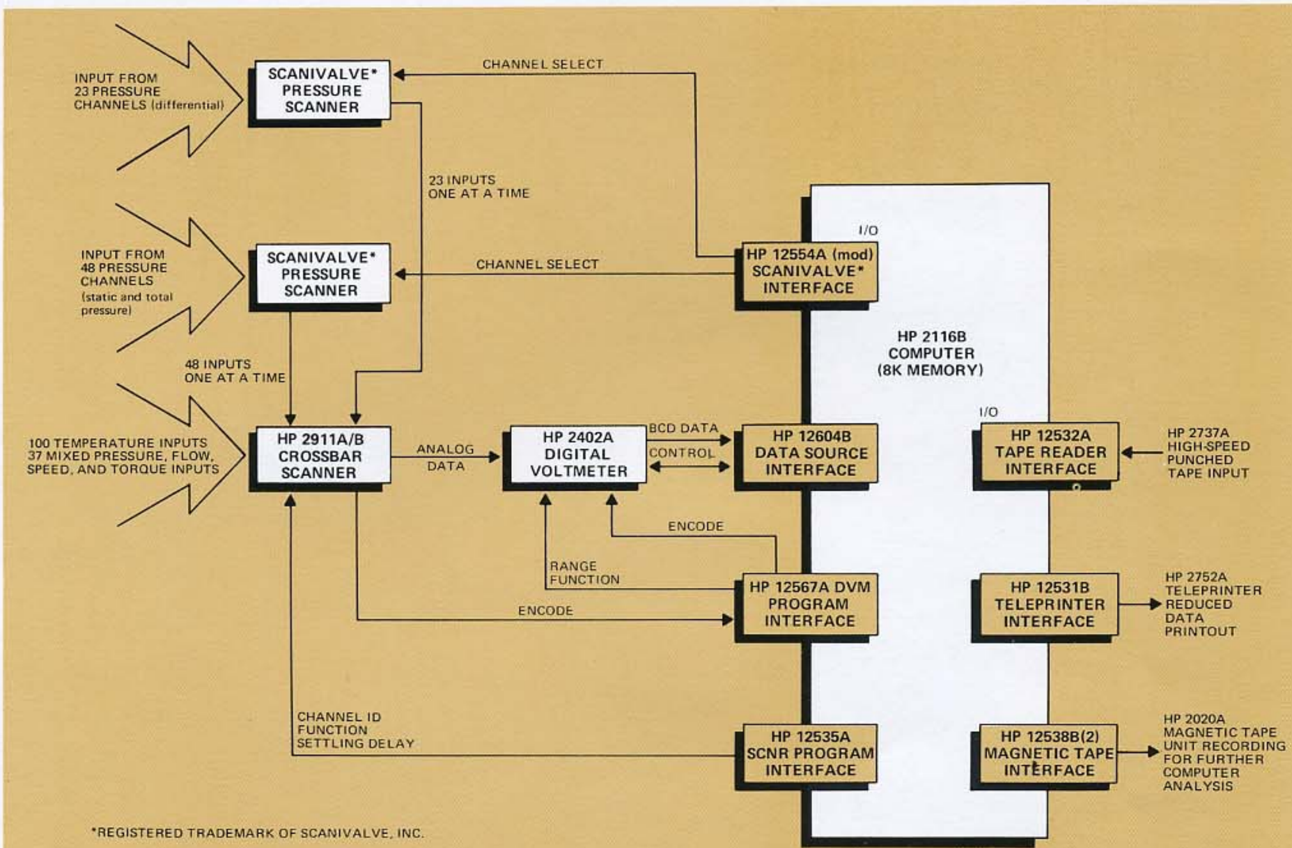
The capability exists (through extended memory and possibly disc storage) to reduce data and conduct on-stand performance analyses while the turbine is running, however, this phase of the program is intended to be implemented at a future date. In-depth performance analyses will still be done off-line using the external computer.

BENEFIT OF COMPUTERIZED DATA ACQUISITION

To quote directly from the chief of Test and Engineering Services at Dresser Industries in Houston, "The obvious benefit is to our customer, who can now expect to receive a fully tested system. This means weeks less debug time in the field, where expenses run very high, and a greater assurance of a reliable, troublefree package."

COVER:

In a Remote Pressure Booster Station on a California Desert a Dresser Industries Compression System Speeds Natural Gas on its Way to Distant Users



Hardware configuration for computerized data acquisition system at Dresser Industries.

The computer-controlled digital data acquisition system (right) and control console are located in a control room overlooking the test area (photo on rear page).

Basic Elements of a Gas-Turbine Compressor Package

POWER TURBINE

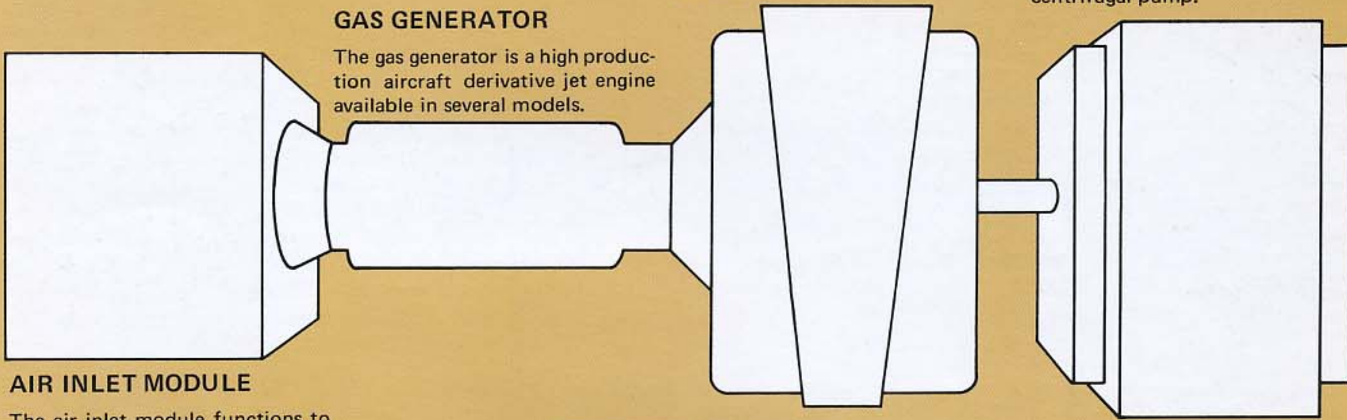
The gas turbine is a single-stage axial flow unit, which powers the driven element.

DRIVEN MODULE

The driven element is typically a Clark centrifugal compressor but can also be elements such as an electrical generator or a Pacific centrifugal pump.

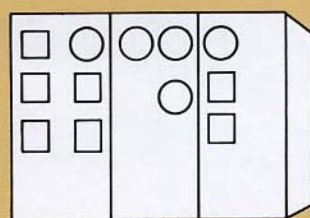
GAS GENERATOR

The gas generator is a high production aircraft derivative jet engine available in several models.



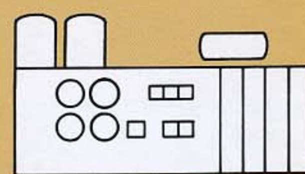
AIR INLET MODULE

The air inlet module functions to direct clean combustion air into the jet gas generator and is designed for the particular climatic, atmospheric and environmental conditions prevailing at the operating site.



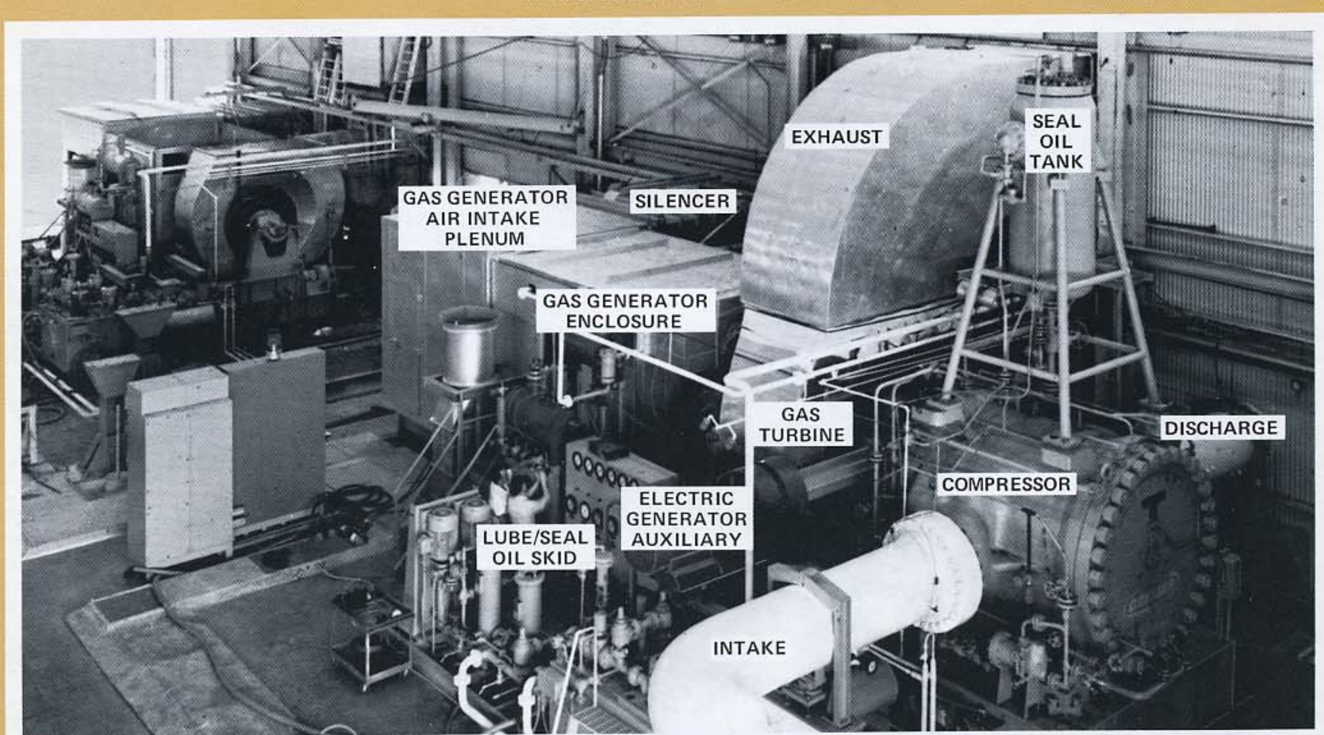
CONTROL SYSTEM

The control system maintains the desired discharge pressure of the compressor or pump while also protecting the package from abnormal conditions.



LUBE, SEAL OIL SYSTEM

Console serves the power turbine and booster systems, with a separate subsystem for the gas generator.



Large compressor (right) undergoing final tests utilizes computer-controlled digital data acquisition system to measure over 200 points with on-line data reduction.

Printed in U.S.A. 7/71 (06)
5952-1587