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An Automatic Data Acquisition System for Underground Measurements

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AN AUTOMATIC DATA ACQUISITION SYSTEM FOR UNDERGROUND MEASUREMENTS

by

J. R. McVey[1] and T. O. Meyer[2]

ABSTRACT

A 10-channel automatic data acquisition system has been designed and environmentally packaged for use with underground strain-gage applications and associated instruments. The system uses commercially available components and is assembled in two plastic enclosures. Environmental control is provided through a specially designed (compressed-air) air-conditioning system and water-resistant cabling. Accuracies of 0.01 pct and resolution of 1 μV have been obtained in underground tests.

INTRODUCTION

A 10-channel automatic data acquisition system (figs. 1-2) has been assembled for underground use with the Bureau of Mines tunnel stress relaxation (TSR) gage previously described by Waddell, Crocker, and Skinner.[3] The automated system was needed to improve data collection by providing a more rapid, long-term printout of measurement data in TSR experiments.

This Bureau of Mines report describes special unit assembling and packaging of measurement equipment to be used in typically hostile mine environments. Even though automatic data acquisition systems have been in use for years, to the author's knowledge, none have been developed with the accuracy herein described for use in such an environment. The object of this report is to inform researchers of a workable, proven, dependable underground data acquisition system. It was found that giving attention to these packaging details in many instances determines the success or failure of underground tests.

The system described here is programable and consists of a six-digit 0.01-pct voltmeter, 10-channel scanner, digital clock, strain-gage signal conditioner, printer, and system controller. All are commercially available. However, the equipment is housed in two specially modified plastic cases. The

[1] Supervisory electronic technician.

[2] Physicist.

[3] Waddell, G. G., T. J. Crocker, and E. H. Skinner. Technique of Measuring Initial Deformation Around an Opening--Analysis of Two Raise-Bore Tests. BuMines Rept. of Inv. 7505, 1971, 60 pp.

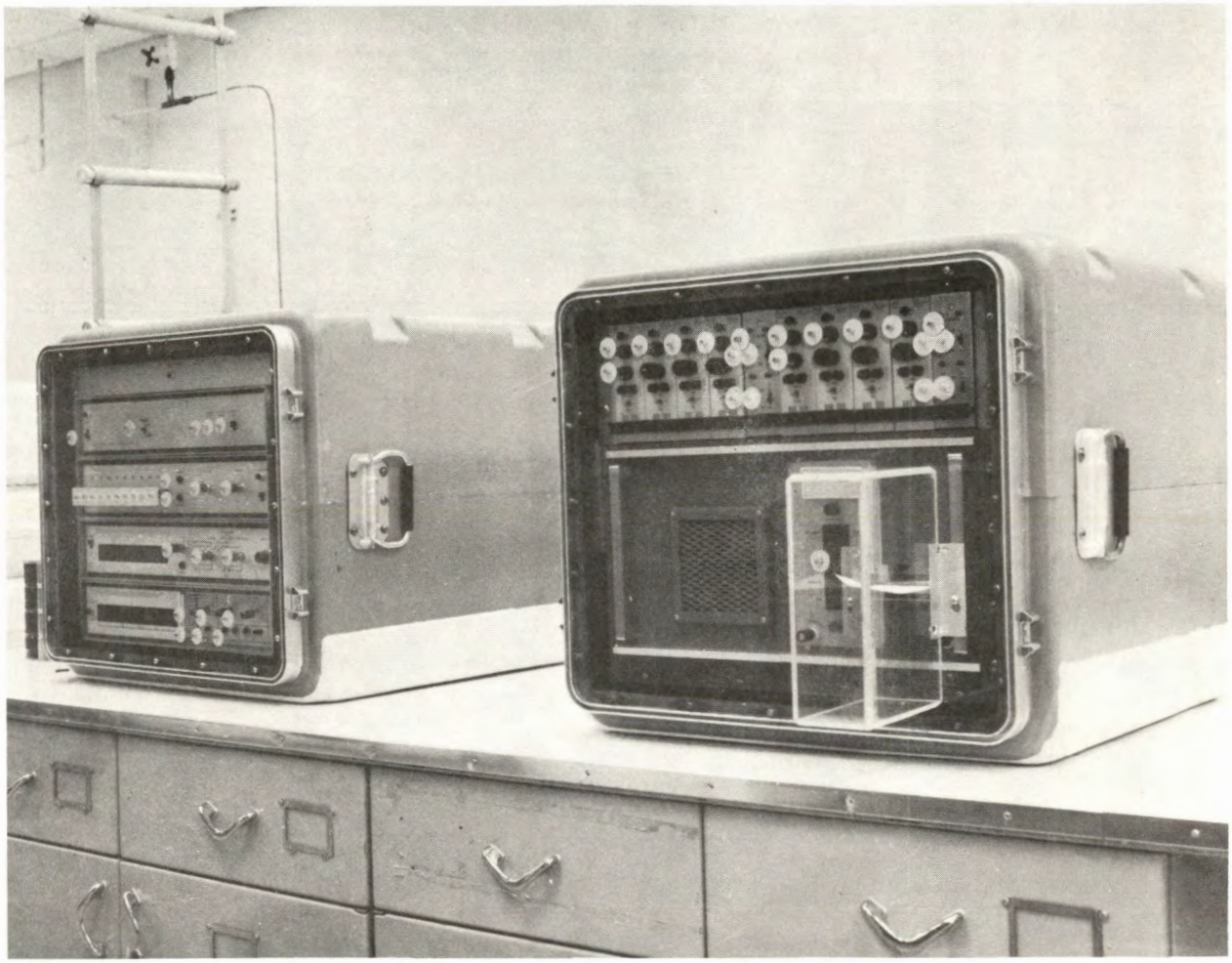

FIGURE 1. - Enclosed data acquisition system (front view).

cases are equipped with air conditioning and overtemperature protection as well as protection against overvoltage and undervoltage. Case interconnection is provided by water-resistant cabling that has waterproof covers attached. The system requires 115 v 60 Hz and 25 to 60 cfm of compressed air at 40 to 120 psi for operation and has been designed to operate up to 30 days unattended.

MEASUREMENT SYSTEM

The electronic measurement system (fig. 3) provides excitation and standard signal conditioning for 10 individual strain-gage bridges in quarter, half, or full configuration. These 10 bridges are then sequenced automatically by a 10-channel electronic scanner and measured by a digital voltmeter programed by a digital clock. Two channels were bypassed to monitor the operational accuracy of the system, thereby limiting actual bridge measurement capability to eight. This will be described more fully in the "Field Test" section of this report.

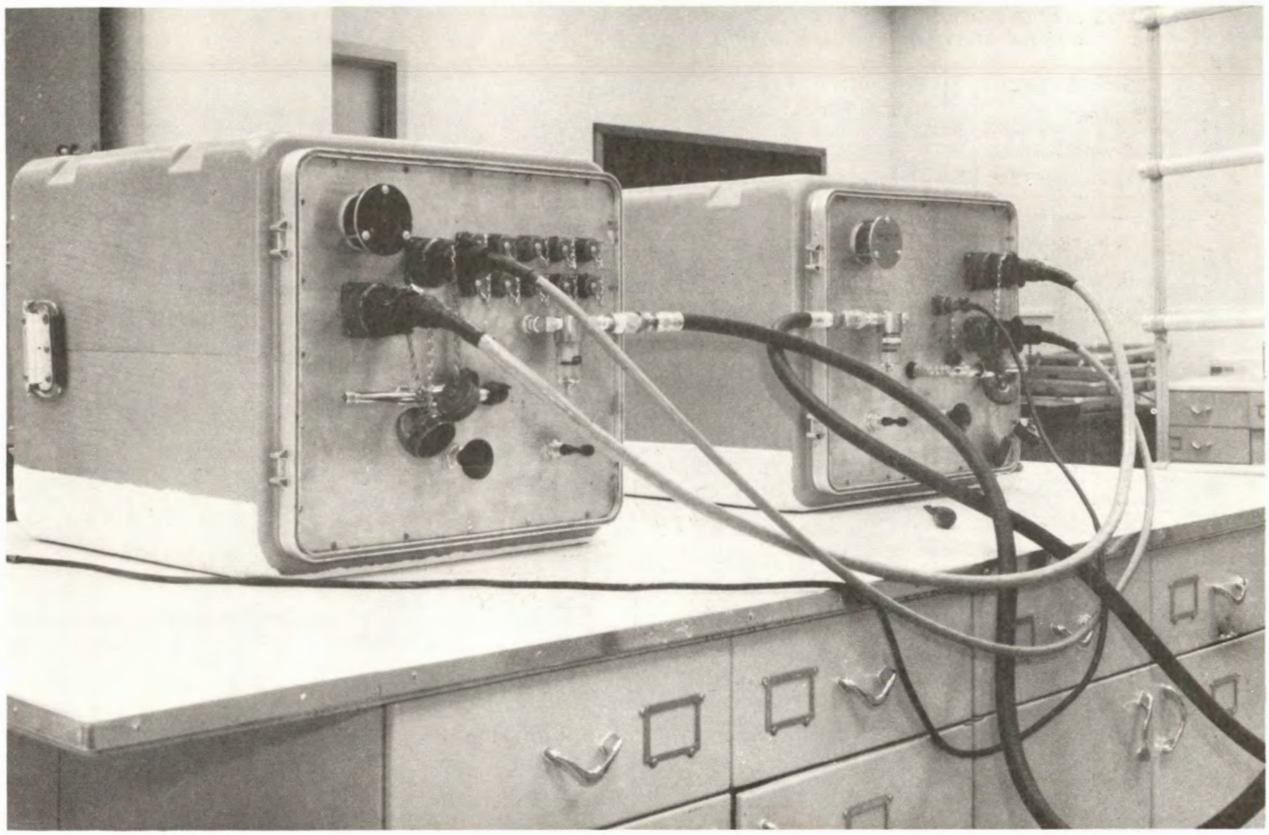

FIGURE 2. - Enclosed data acquisition system (rear view).

The clock allows a visual display as well as a binary coded decimal output to the printer for recording the day, hour, minute, and second the data was recorded. The clock can be programed to provide a scan of all 10 channels at any desired time and is programable in seconds, minutes, and hours. Each scan time is adjustable but is limited to 2-1/2 prints/sec by the printer. Each time the clock reaches the preselected time, a log pulse is generated and automatically starts the scanner.

The scanner steps to the first measurement point, and after a preset settling time (0 to 10 sec), the point is measured by the digital voltmeter. Completion of the voltmeter reading allows the data to be printed. A print-complete signal from the printer steps the scanner to the next channel (measurement point). This action continues until all selected channels are measured. When the last measurement point is completed, the scanner stops and is recycled by the next clock log pulse. The scanner can be placed in three modes of operation: manual, single scan, or continuous.

The digital voltmeter is a full 5-1/2-digit autoranging unit that provides 1-μV resolution in 120-mV signals. These data, along with signal identification, polarity, and time, are printed out on pressure-sensitive paper by a 10-column digital printer.

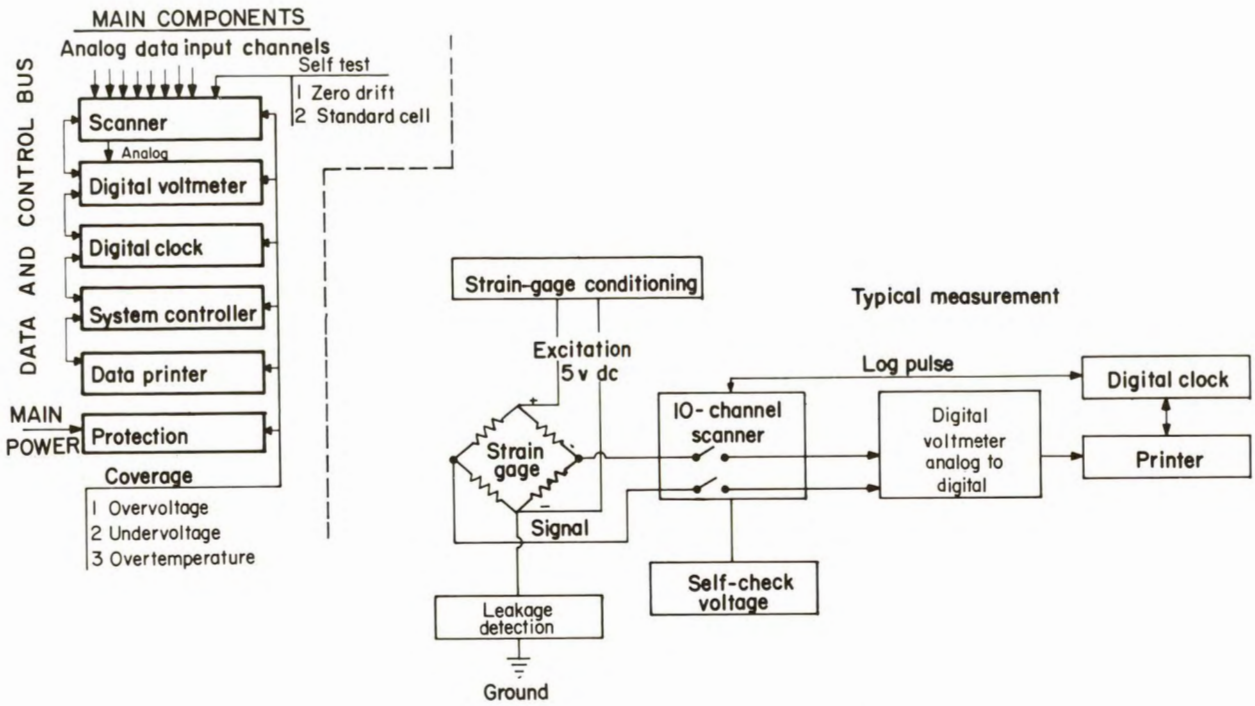

FIGURE 3. - Flowsheet of measurement system data.

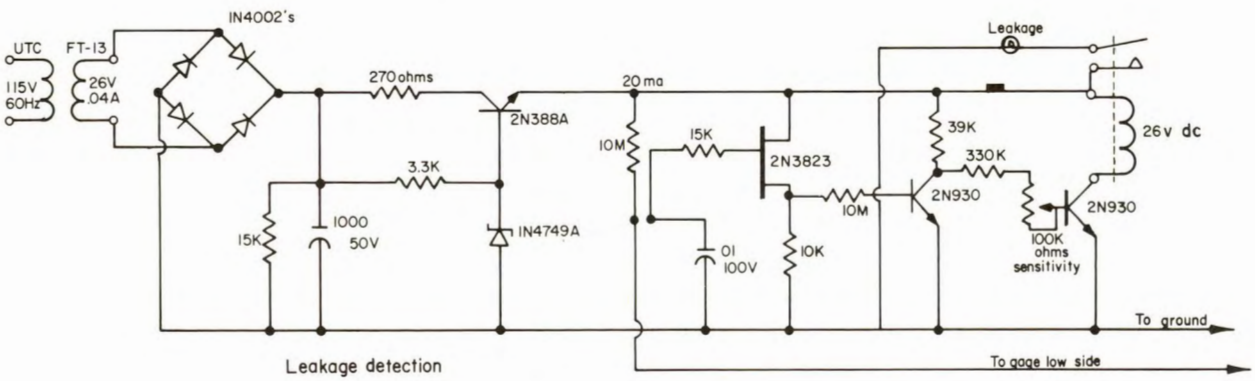

FIGURE 4. - Leakage detection circuit.

The leakage-detection circuit shown in figure 4 is a simple field effect megohmmeter circuit to provide an indication any time electrical leakage of less than 10 MΩ occurs between earth ground and an external measurement circuit. The leakage-detection circuit gives protection against errors in measurement. Individual front panel indicator lamps provide a visual leakage indication. Electrical leakage problems occur frequently in mining environments.

A standard voltage cell that produces 1.0191 v and a zero-voltage input have been provided on channels zero and nine as a system check during each scan. This system check provides immediate indication of signal drift or system malfunction. Accuracies of 0.01 pct and repeatability of ±1 count are evidenced in figure 5 by the underlined standard cell data taken during field tests.

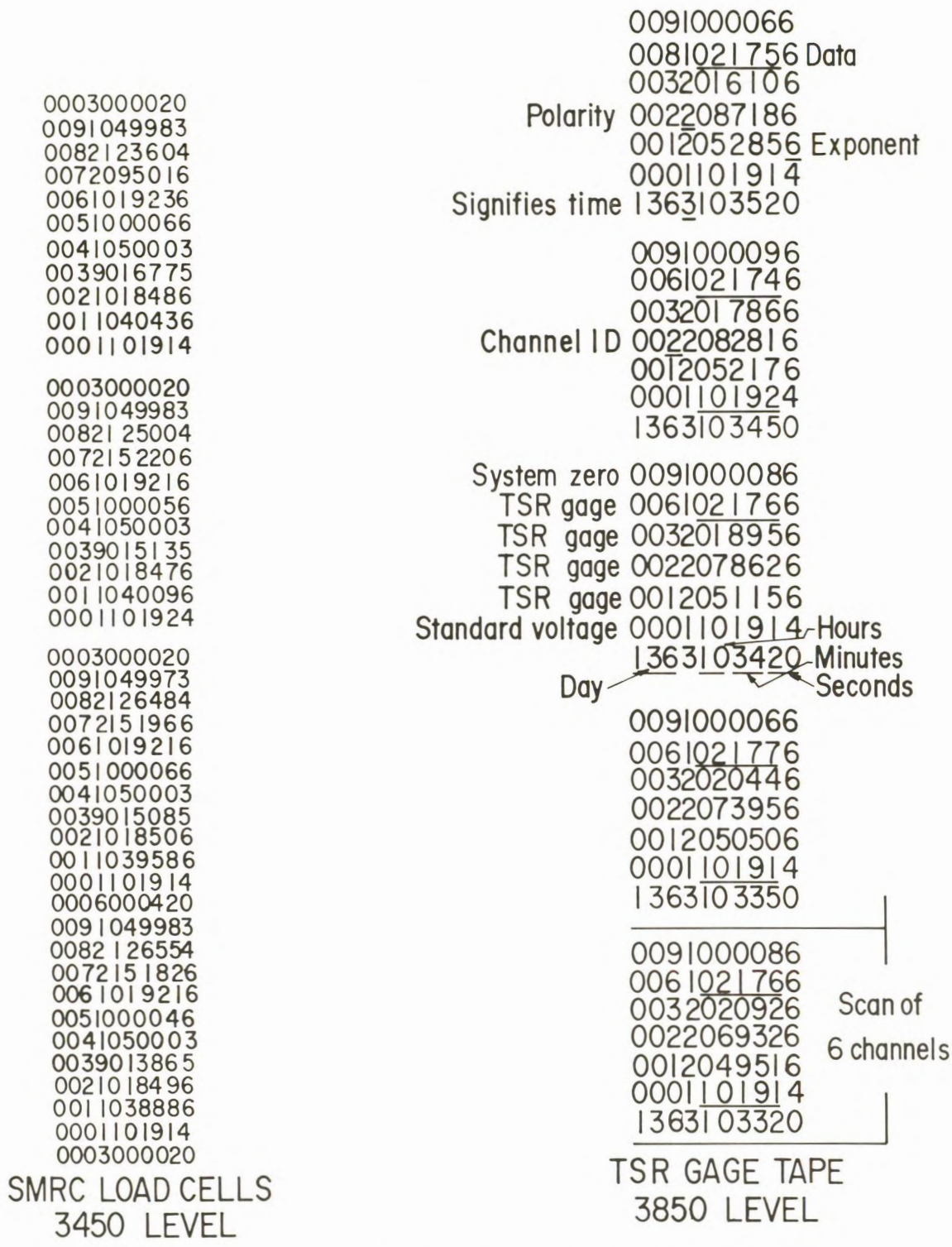

FIGURE 5. - Representative data of field tests.

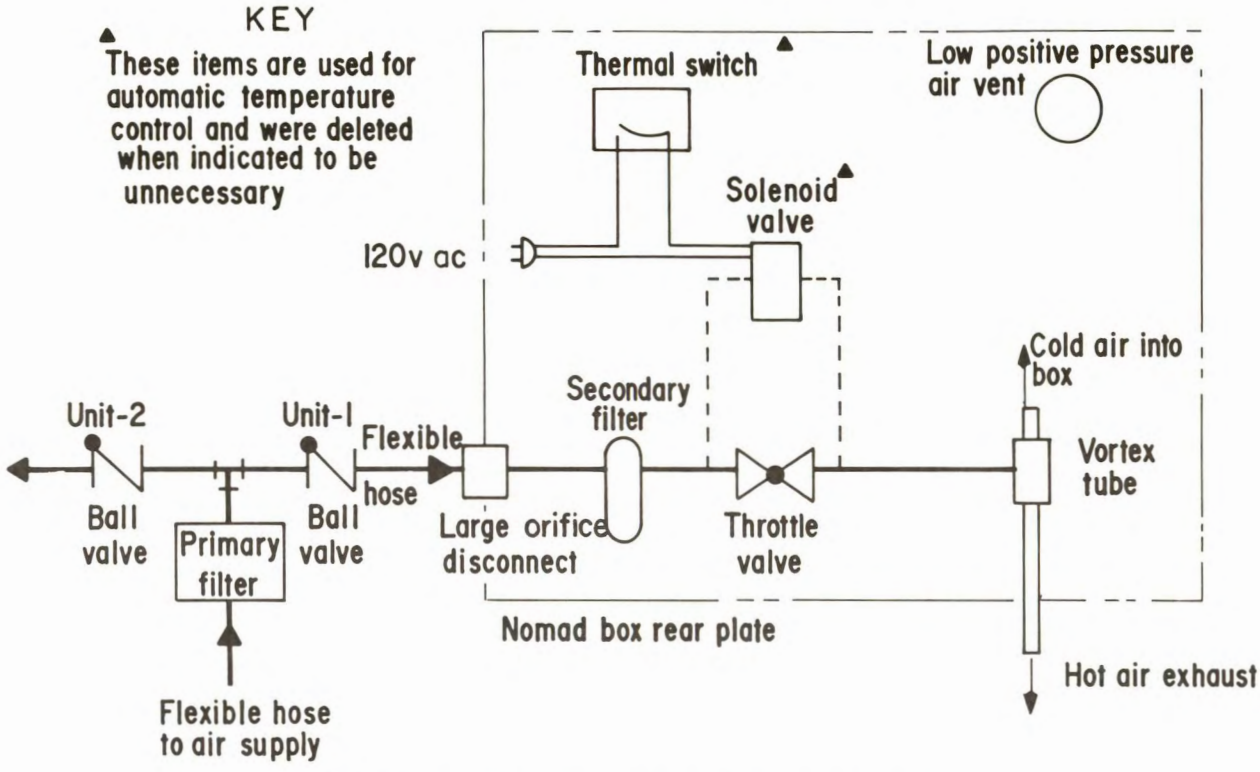

FIGURE 6. - Diagram of air-conditioning system.

SYSTEM PACKAGING

Two Nomad[4] equipment cases, 20 by 23 by 32 in, were purchased to house the data acquisition equipment. Special mounting frames were then inserted in the front and rear of each case to allow screw attachment of the front (clear plastic) and rear (metal) cover plates. The plastic front plates were drilled to allow system controls to be reached with a special tool, and all holes were then covered with small rubber self-sealing disks to allow minimum loss of air before and after tool insertion. Electrical connections enter through the rear aluminum cover plate via military-specification-type water-resistant connectors. All connectors are provided with chain-attached covers. Each case, including all equipment, weighs approximately 135 lb.

AIR CONDITIONING

Air conditioning (fig. 6) is provided by compressed air that has been cooled by a Vortec Corp. model 208-25-H vortex tube. Each of the two Nomad cases has its individual cooling unit, complete with throttle valve and filter for removal of water droplets and particulate matter. A larger filter is incorporated into the common air-supply line for initial cleaning. Depending on ambient temperature, the air supply required for the two-unit system ranges

[4] Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

from 40 to 120 psi with corresponding airflows of 25 to 60 scfm. Cooling capacity gains associated with increased flow rate occur in the form of a larger volume of air at a cooler temperature. An automatic control system was initially used to maintain a system temperature of 76°±2° F through regulation of the air supply for each vortex tube. Actual operation indicated such control was not necessary. Temperature control is now effected by means of a manually operated valve. A relative humidity indicator and a thermometer are provided for monitoring environmental conditions within the boxes.

PROTECTION SYSTEM

The entire system is protected by specially designed circuits shown in figure 7. In the event of voltages over 125 v or under 100 v and temperatures above 95° F, main protection is provided by interrupting the 125-v ac power line that provides equipment power. The 115-v power is routed through the protection relay contacts in an "AND GATE" or series fashion. Each relay has a built-in time delay to prevent relay chatter in the event of fluctuating line voltages or temperature at the set points.

More detailed drawings and explanation can be obtained on request.

SYSTEM STARTUP

Air and power are connected to the system and started. The cooling air should be set between 40 and 60 psi and have a minimum volume capability of 50 cfm. Care should be taken when connecting all interconnecting cables to prevent moisture and dirt from entering these connections. Lack of care would result in electrical leakage paths. After the system has been operating 30 min, the air-supply valves can be set to provide a relatively constant

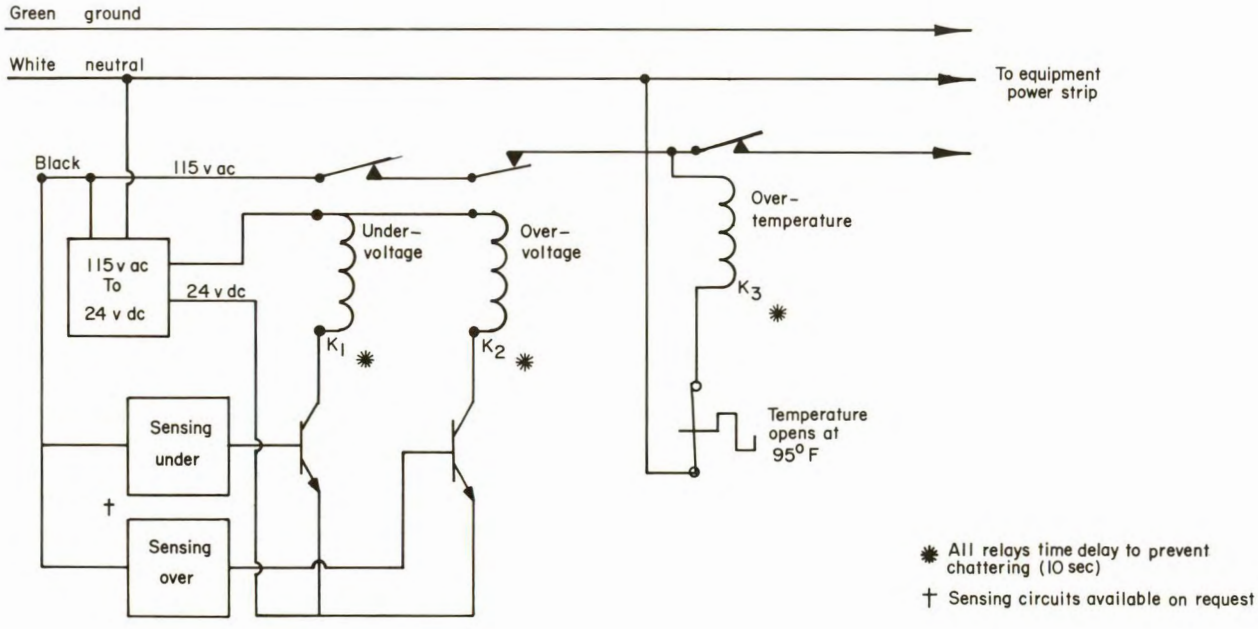

FIGURE 7. - Undervoltage, overvoltage, and overtemperature protection system.

76° F at the necessary regulated pressure. Then, the electronics can be programed to provide the measurement functions.

FIELD TESTS

Two field tests have been made with the system. One test that lasted 2 days consisted of monitoring eight SMRC (Spokane Mining Research Center) earth load cells buried in backfill on the 3450 level of the Lucky Friday mine, Hecla Mining Co. at Mullan, Idaho (fig. 8); a second, 10-day test was conducted with the TSR gages on the 3850 level (fig. 9). In both experiments, the system provided excellent results as indicated by reproductions of portions of the actual data (fig. 5). Underlined data shows reproductions of ±1 count

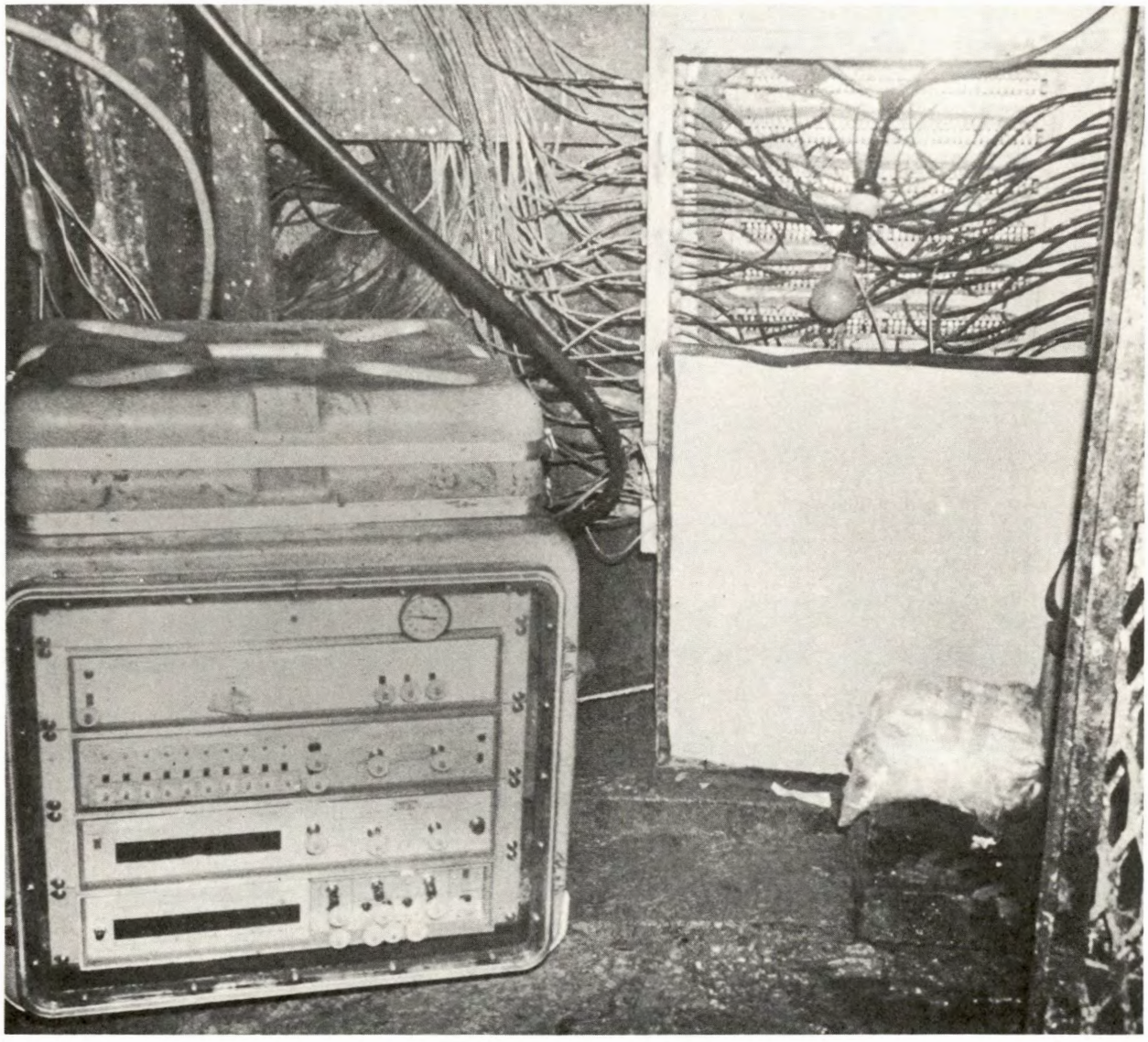

FIGURE 8. - Underground test site at 3,450-ft level.

FIGURE 9. - TSR gage experiment at 3,850-ft level.

and microvolt resolution. The standard voltage cell repeated to this degree throughout the field test.

In each experiment, at least two channels were used to test the accuracy of the data acquisition system measurement. For example, in the TSR gage experiment, channel zero was chosen to measure a standard voltage cell of 1.0191 v to assure system measurement accuracy. Channel 6 was used to measure a dummy TSR gage that was located near the actual measurement site to check gage drift. Channel 9 provided a shorted input (zero voltage) to monitor the drift of the long-term data system. The combination of these three measurements allow the operator to isolate the source of erroneous readings.

CONCLUSIONS

The system packaging has been proven adequate through actual usage in two underground locations (figs. 8-9). Adequate equipment protection and reliability have been provided. It is felt that this unit represents a significant step toward providing quicker, safer, and more reliable underground

measurements. The system is not limited to strain-gage measurements and can be used for any direct-current voltage parameter from 0 to 1,000 v. Signal conditioning was required in our strain-gage application. Circuit operation and equipment wiring details can be obtained on request.

Spokane Mining Research Center now has two such systems in use in the field--the 10-channel system described in this report and a 32-channel system--and a 50-channel system is planned.

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