| *ERID#:* 11669 | ***LOS ALAMOS NATIONAL LABORATORY***<br>***ENVIRONMENTAL RESTORATION (RRES-R)***<br>***Records Processing Facility***<br>***ER Records Index Form*** |
|---|---|

***Date Received:*** 12/1/1992 ***Processor:*** GAA ***Page Count:*** 4

***Privileged: (Y/N)*** N ***Record Category:*** R ***Administrative Record: (Y/N)*** Y

***FileFolder:*** N/A

***Miscellaneous Comments:*** ATMOSPHERIC PRESSURE

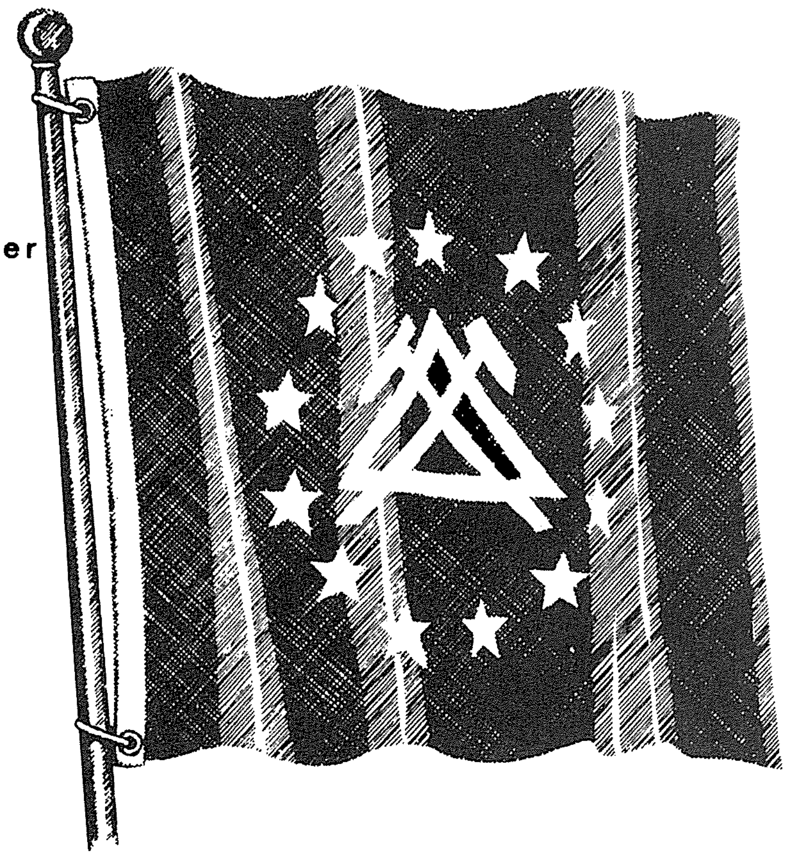
***Record Documents:***

| *Start Pg* | *Doc Type* | *Doc Date* | *Title* | *Box* | *Package* |
|---|---|---|---|---|---|
| 1 | REPORT | 1/1/1969 | MEASUREMENT OF ATMOSPHERIC PRESSURE AND SUBSURFACE-GAS PRESSURE IN THE UNSATURATED ZONE OF THE BANDELIER TUFF, LOW ALAMOS, NEW MEXICO | 24 | |

37182

# MEASUREMENT OF ATMOSPHERIC PRESSURE AND SUBSURFACE-GAS PRESSURE IN THE UNSATURATED ZONE OF THE BANDELIER TUFF, LOS ALAMOS, NEW MEXICO

By J. L. Kunkler



*Reprint from Geological Survey Research 1969*
*Geological Survey Professional Paper 650-D*
*p. 283–287*

WORK DONE IN COOPERATION WITH THE U.S. ATOMIC ENERGY COMMISSION
AND THE LOS ALAMOS SCIENTIFIC LABORATORY

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

# MEASUREMENT OF ATMOSPHERIC PRESSURE AND SUBSURFACE-GAS PRESSURE IN THE UNSATURATED ZONE OF THE BANDELIER TUFF, LOS ALAMOS, NEW MEXICO

By J. L. KUNKLER, Santa Fe, N. Mex.

*Work done in cooperation with the U.S. Atomic Energy Commission and the Los Alamos Scientific Laboratory*

*Abstract.*—Pressure transducers, power supplies, and potentiometric recorders were assembled into portable pressure-monitoring systems which measured pressures in the field with an accuracy of about 0.3 percent. The performance of some of the components was affected by fluctuations in field temperatures; hence these components were operated in a constant-temperature chamber. The data from this study show that the subsurface-gas pressures responded to changes in the atmospheric pressure to depths of 35 meters in the Bandelier Tuff; the response was completely attenuated at some depth between 35 and 89 m.

Several years ago a study was made at Los Alamos, N. Mex., of the gas-storage characteristics of the zone of aeration (unsaturated zone) in the Bandelier Tuff. This study, composed of several phases and covering a period of about 3 years, was sponsored by the U.S. Atomic Energy Commission and the Los Alamos Scientific Laboratory. Studies were made at two test sites, designated as TA–50 and TA–52. A description of TA–52 and of test holes constructed at the site is given in a separate paper (Kunkler, 1969, p. B186). Test site TA–50 is about 2 kilometers south of Los Alamos and about 300 meters north of test site TA–52. The physical and geologic conditions, and the construction of test holes at the TA–50 site, are almost identical with those at the TA–52 site.

During the studies at the test sites, considerable effort was devoted to the problem of designing and constructing pressure-monitoring systems. These systems, composed of several components that could be interchanged to suit the occasion, were used to monitor more or less continuously the atmospheric pressure and the borehole gas pressures of isolated and sealed test zones in the rock.

An accurate, reliable pressure-monitoring system is not difficult to build if the system can be operated indoors where the environmental temperature is rigidly controlled; however, several problems arise if the system is made portable and is operated exposed to the elements. This paper gives an account of some of these problems and their solutions.

## SYSTEM COMPONENTS

Subsurface-gas pressures can be measured with gages, manometers, or pressure transducers. Of these instruments the pressure transducers, which convert pressure changes to electric signals, are the most difficult to use in the field; however, they are capable of sensing very small changes in pressure, and if coupled to a recorder they provide a continuous record of the measurements.

Several types of pressure transducers were tested during this study, and it was decided that the strain-gage types were most suitable. A strain gage is a thin strip of an alloy which has the property of changing its electrical resistance when placed under strain (Stein, 1964, p. 132–135). The mechanism of a simple strain-gage pressure transducer is illustrated in figure 1. The transducer is fitted with four strain gages ($Rg_1$–$Rg_4$) which are wired into a Wheatstone bridge circuit. Two temperature-compensating resistors ($Rt$) are added to the circuit within the transducer to compensate for ambient temperature changes or the thermal effect.

Pressure transducers are classified into two categories according to their mechanical configuration. One type is used to measure absolute pressures, and the second type is used to measure differential pressures

U.S. GEOL. SURVEY PROF. PAPER 650–D, PAGES D283–D287

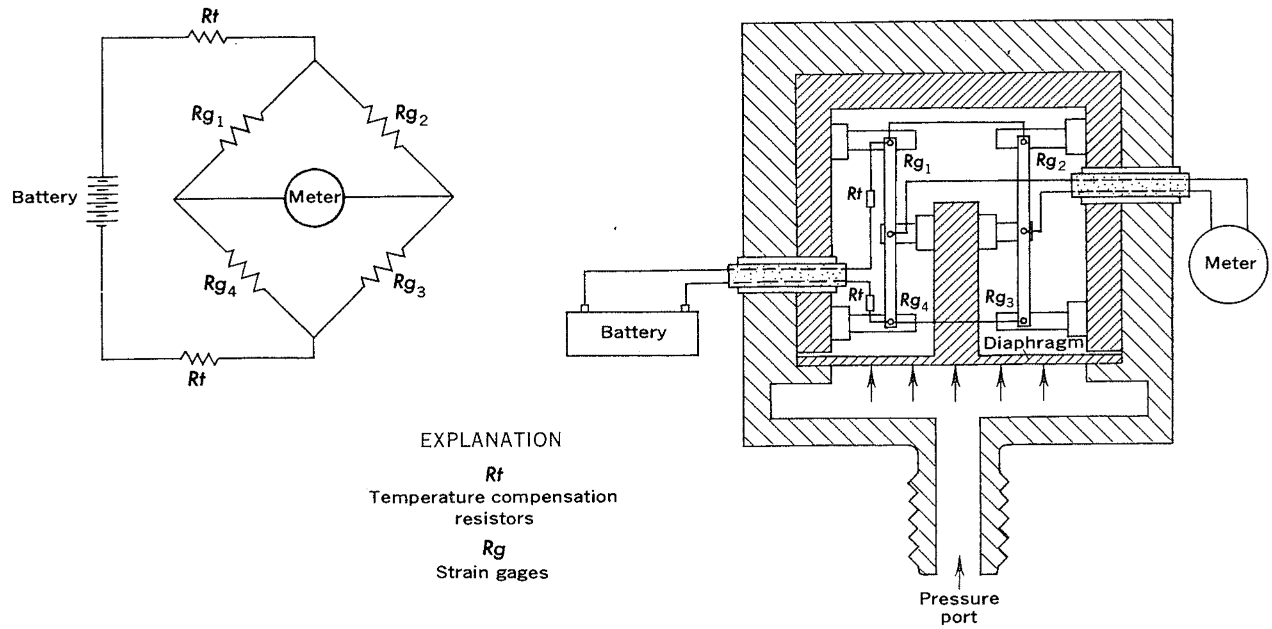



FIGURE 1.—Schematic configuration of a strain-gage pressure transducer.

(the difference in pressure between two sources). Both types were used during this study. The differential-pressure transducers differ in design from the absolute-pressure transducers by having a more complex mechanical configuration and greater sensitivity.

When used, the differential-pressure transducers were referenced to a fixed pressure datum by applying a constant and known reference pressure to one of their pressure ports. The reference pressure can be attained in several ways. For some applications where the ambient temperature is constant it is satisfactory to seal the reference pressure side of the transducer at a desired pressure. A better method, which was used during the study, is to supply an external reference pressure which is attained by pumping a stream of air through a manostat, a sensitive pressure regulator, to the reference pressure port of the transducer.

The electromotive force (emf) of signals from high-quality transducers is a linear function of the pressure, and the newest transducers are advertised as having this characteristic over a wide range of ambient temperatures. The transducers used for this study had lost their temperature-compensating capabilities, but they were capable of providing a linear relation between pressure and the output signal if the ambient temperature was held constant. The histories of these transducers is unknown. It is possible that they had been severely abused by former usage which had caused them to lose most of their temperature-compensating ability. Because their histories are unknown it is unfair to identify them by name. There is little doubt that these instruments had once been of finer quality. A typical pressure-versus-signal relation is shown for an absolute-pressure transducer in figure 2. The same relation for a differential-pressure transducer at reference pressures of 0, 30, and 59 centimeters of mercury is shown in figure 3.

The maximum range of the output emf of the transducers was 0 to 40 millivolts when they were activated with a 10 volt direct-current power supply. It was convenient to operate at lower input voltages so that the range could be adjusted to a convenient pressure scale on the recorder chart; the usual activating emf was about 7 v dc.

The pressure transducers were activated by a rectifier or from a series of batteries. Rectifiers tend to be unsatisfactory for this application; hence several mercury batteries such as Burgess Hg-42R were hooked in series

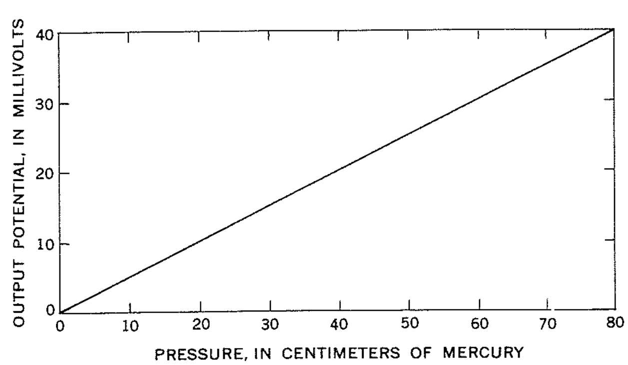



FIGURE 2.—Pressure versus output potential of an absolute-pressure transducer (range 0–80 cmHg).

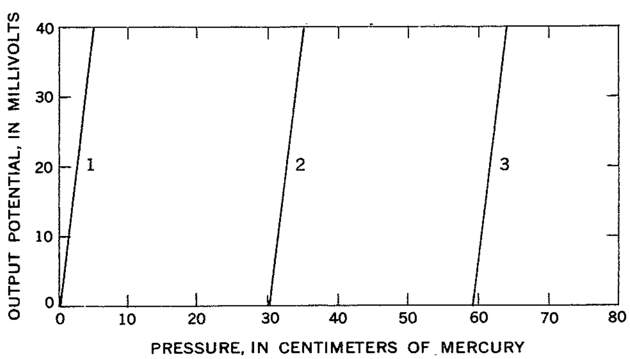



FIGURE 3.—Pressure versus output potential of a differential-pressure transducer at three reference pressures, 1, 2, and 3, which are 0, 30, and 59 cmHg, respectively.

with a variable resistor which could be adjusted to give the proper output emf.

Two types of multirange recorders were used to record the signals from the pressure transducers. The first type had a small zero-displacement capability and was suitable for recording only the signals from a differential-pressure transducer. The second type, an MR recorder (E. H. Sargent and Co.) had a very large zero-displacement capability and was suitable for recording the signals from either type of transducer.

Several methods are used to compensate for the thermal effect of transducers, and most designs incorporate one or more of these methods. Because none of the transducers used during this study had adequate thermal compensation, their ambient temperatures were controlled by placing them in a constant-temperature chamber. The battery potentials and the manostat pressure controls were also affected by changes in temperature. Hence the batteries, the manostat, and its associated air pump were placed in the constant-temperature chamber.

The diagram shown in figure 4 represents a pressure-monitoring system with an absolute-pressure transducer that is continuously monitoring the atmospheric pressure and the subsurface-gas pressure from one test zone. This system was revised for intermittent monitoring by adding eight solenoid valves to the pressure manifold, and by replacing the switching control mechanism with another designed to activate at about 80-minute intervals. While activated, the pressures at nine test points and the atmosphere were measured sequentially.

The pressure-monitoring systems were calibrated intermittently with sensitive manometers. During calibration, the output emf of the battery pack was adjusted with the variable resistor (fig. 4) so that the output emf of the transducer corresponded to a convenient pressure scale on the recorder, and this emf was maintained throughout the monitoring period by fre-

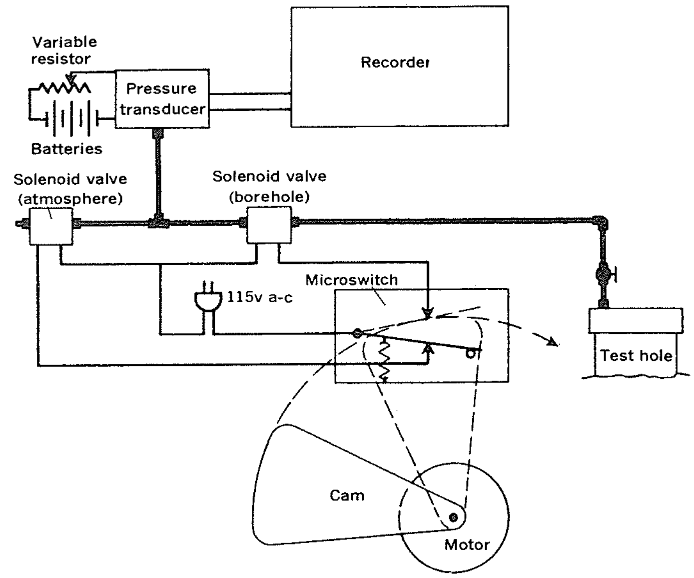



FIGURE 4.—Schematic diagram of a pressure-monitoring system.

quent adjustments of the variable resistor. Data from a typical calibration are shown in figure 5.

## DISCUSSION OF DATA

Subsurface-gas pressures and atmospheric pressures were monitored periodically for several months at the TA–50 and TA–52 test sites. It was expected that the

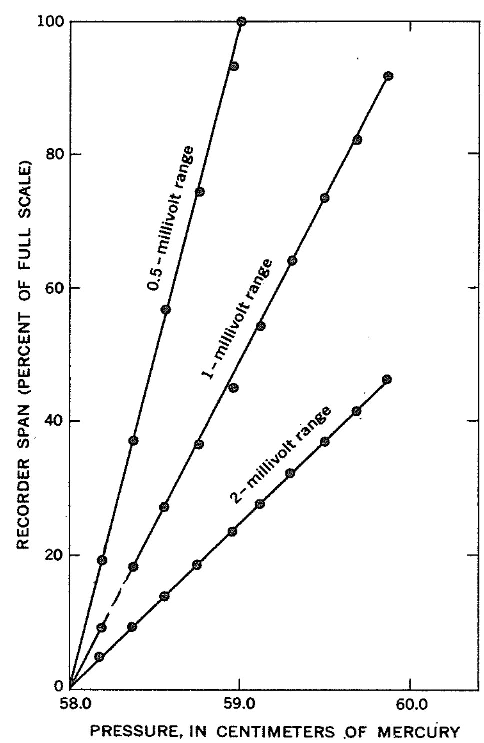



FIGURE 5.—Calibration of an absolute-pressure transducer at three recorder ranges.

subsurface-gas pressures would respond to changes in the atmospheric pressure, and that this response would be attenuated with depth until it would be undetectable at a depth of 30 m. The data showed that the gas pressure in the rock does respond to atmospheric pressure changes; however, there was no recognizable attenuation of this effect at depths less than 35 m, but the pressure changes were completely attenuated at a depth of 89 m. There were no pressure measurements in the interval between 35 and 89 m.

The response of the subsurface-gas pressures to changes of atmospheric pressure was obvious; however, a detailed study of these records showed that the relation was very complicated, and that the complexity increased with the depth of the test zone. For example, it was impossible to predict the beginning, the end, or the magnitude of a given response at depths greater than 10 to 15 m; however, in all recorded events the response at these depths was approximately proportional to the magnitude of the atmospheric-pressure change. This problem was studied for many months, and its cause was finally identified from data of a related study, which indicated that the subsurface gas was exchanged with the atmosphere along both the horizontal and vertical axes of the test zones. Both test sites are on narrow mesas, and the horizontal distance between some test zones and the land surface is not much greater than the vertical distance to the land surface. It was reasoned, therefore, that some, if not most, of the complexity of the relation between subsurface-gas pressures and the atmospheric pressure was due to the topography of the test site (Kunkler, 1969, p. 187).

It was necessary to pump gas from the test zones for various reasons. At times, gas was pumped for chemical and isotope analyses. At other times the test zones were pumped to remove atmospheric contamination or to obtain gas permeability data. The types of pumps and the pumping rates varied with the occasion; the greatest pumping rate was about 20 liters of gas per minute. During some pumping intervals, the borehole gas pressure was monitored; however, a study of these measurements indicates that the data have very little value; hence they are not reported. Copies of the pressure recordings are difficult to present as illustrations; it was necessary to either photograph the recorder charts and trace the pertinent data from the photographs or to plot the data from the charts as bar graphs.

An example of a record traced from a photograph of the recorder chart is given in figure 6. The atmospheric pressure and the subsurface-gas pressure were monitored using a cycle of 1 minute. The atmospheric pressure was monitored for 40 seconds, and the subsurface-gas pressure was monitored for 20 seconds.

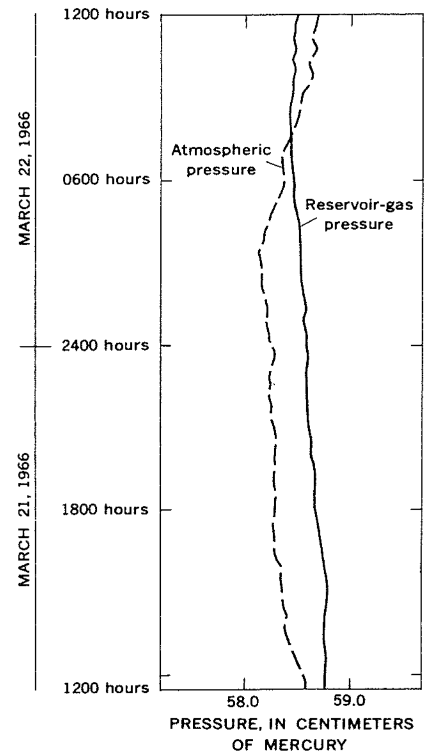



FIGURE 6.—Record of atmospheric and subsurface-gas pressures in test zone 24.7 to 26.2 m below land surface at test hole TA–50–29.

When the atmospheric pressure was monitored contemporaneously with the gas pressure of several test zones, the measurement cycle was only 2 minutes long, repeated at 80-minute intervals. Intermittent monitoring at 80-minute intervals did not provide much useful data because the pressure fluctuations of interest were of shorter duration. A typical problem in interpreting the data is shown in figure 7 where the gas pressure of two test zones only 0.9 m below land surface appears to have been consistently lower than the atmospheric pressure for a period of 2 hours and 42 minutes. This situation is possible but improbable. It is more likely that at times between the periods of monitoring the atmospheric pressure was significantly lower than shown.

## ACCURACY OF MEASUREMENTS

All pressure measurements were made at the same datum and at a constant temperature. Recorded atmospheric pressures were checked with a mercury barometer located about 200 m from the test holes. Usually these measurements checked within 1 millimeter of mercury but varied at times by as much as 3 mmHg.

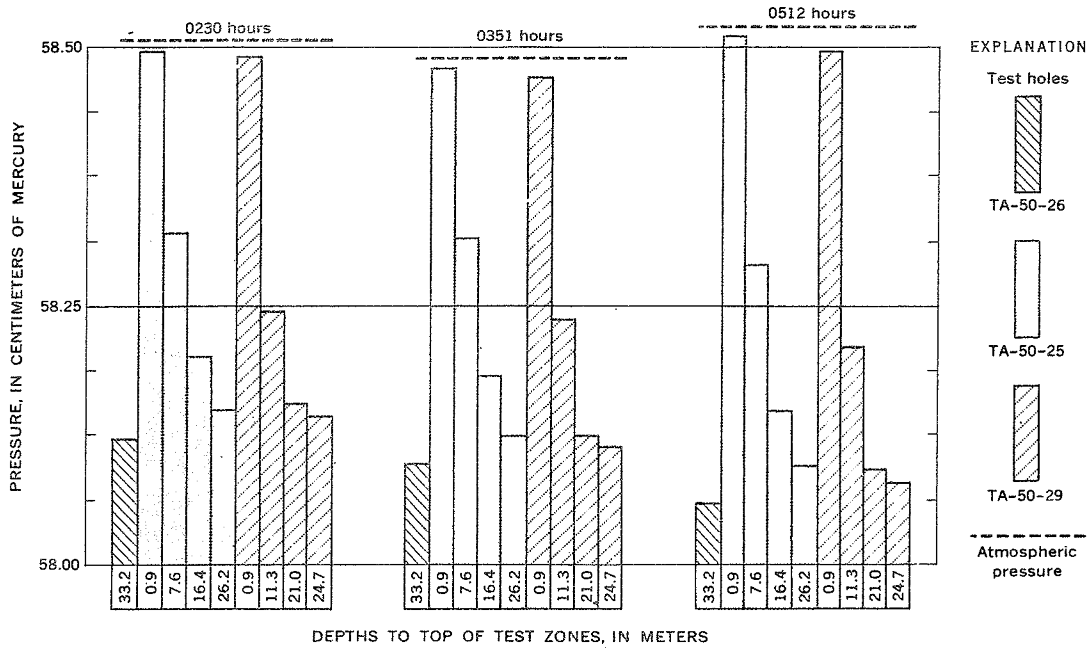



FIGURE 7.—Atmospheric pressure and subsurface-gas pressure of various test zones at 0230, 0351, and 0512 hours, November 4, 1965.

During some of the periods of monitoring at the TA–50 test site, where only the differential-pressure transducer was used, the air pump which supplied the reference pressure was not operating properly. This type of malfunction created an error in the measurement of absolute pressures of about 2 mmHg; however, the differential error between a series of pressure measurements probably did not exceed 0.2 mmHg, which is about equal to the sensitivity of the recorder adjusted to measure a full-scale pressure range of 25 mmHg. The average atmospheric pressure at the test site was about 58.9 cmHg; hence the error of absolute-pressure measurements may be about 0.3 percent, but the error of differential-pressure measurements (between the atmosphere and borehole) may be only one-tenth of this amount or about 0.03 percent.

A pressure-monitoring system containing an absolute-pressure transducer was used at the TA–52 test site. Measurements made with this system were about as accurate as those made at the TA–50 test site where a pressure-monitoring system with a differential-pressure transducer was used because the uncertainty in the value of the reference pressure was sufficient to overcome the greater sensitivity of the differential-pressure transducers.

Most of the difficulties in monitoring gas pressures and atmospheric pressures were related to the large temperature fluctuation in the field; therefore, many problems could have been avoided if a climate-controlled shelter had been provided for the instruments.

## REFERENCES

Kunkler, J. L., 1969, The sources of $CO_2$ in the zone of aeration of the Bandelier Tuff near Los Alamos, New Mexico, *in* Geological Survey Research 1969: U.S. Geol. Survey Prof. Paper 650–B, p. B185–B188.

Stein, P. K., 1964, Material considerations for strain gages: Instruments and Control Systems, Oct. 1964, Rimbach Publications, Div. of Chilton Co., Philadelphia, Pa., p. 132–135.