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A METHOD OF COMPENSATING FOR TEMPERATURE-DEPENDENCE OF A REMOTE AREA GAMMA MONITORING SYSTEM

by
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ADMINISTRATIVE INFORMATION

The work reported was part of a project sponsored by the Office of Civil and Defense Mobilization under Contract No. CDM SR 59-54. The project is described in this Laboratory's USNRDL Technical Program for Fiscal Years 1961 and 1962, 1 August 1960, where it is designated Program B-3, Problem 3.

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ABSTRACT

A remote area gamma radiation monitoring system known as RAMS II, was found to be so temperature-dependent that diurnal variations produced intolerably large output variations.

Addition of a thermistor-resistor combination in the cathode circuit of the electrometer tube successfully compensated for temperature effects. The response of the modified system is constant within ± 10 % between 30°F and 80°F, as opposed to an original factor-of-3 variation over this temperature range.

SUMMARY

The Problem

The Jordan RAMS II Gamma Radiation Monitoring System, when used in an out-of-doors experiment, gave radiation rate readings which differed by a factor of 3 over the temperature range 30^oF to 80^oF.

Findings

Addition of a thermistor-resistor combination in the cathode circuit of the electrometer tube successfully compensated for temperature effects. The response of the modified system is constant within $\pm$ 10 % between 30^oF - 80^oF.

INTRODUCTION

Large-scale decontamination and radiological recovery experiments were conducted recently[1,2] during which it was necessary to measure continuously the gamma dose rate at a number of key points in a fallout target area. The "target complex" consisted of a 3-1/2-acre site at Camp Parks, California, containing paved areas, buildings, lawns, gardens, and other surfaces found in a typical residential area.

The target complex was contaminated to a gamma radiation level of about 100 mr/hr at 3 ft above the ground by a uniform deposit of simulated fallout. This synthetic fallout consisted of size-graded sand particles which were tagged with the gamma-emitting radionuclides $Ba-La^{140}$. The remote area gamma radiation monitoring system* (RAMS II) was used to continuously measure dose rate, indoors and outdoors, for a period of two weeks. Measurements were also taken with hand-held survey meters. During this time the dose rate was changed by weathering (wind and rain), by radioactive decay, and by various decontamination methods which were used to recover the area.

It soon became apparent that wide fluctuations in output indicated by the RAMS II were caused by factors other than changes in gamma radiation flux. An intensive investigation proved that the output fluctuations were caused by atmospheric temperature changes. A temperature change of 50°F (over the range 30°F-80°F) in one 24-hr period caused the output of the RAMS II to change by a factor of 3. The dose rate variations versus temperature are shown in the uncompensated curve in Fig. 1. This error in dose rate readings could not be tolerated and corrective action was required.

DESCRIPTION OF RAMS INSTALLATION

A 24-channel RAMS II was installed with detectors located at strategic points, both indoors and outdoors, throughout the target complex. The detectors were connected through multiple-conductor cables to control panels at a suitable central location. This RAMS II System used

*Jordan Electronics Corporation, Alhambra, Calif.

Neher-White remote-monitoring elements, a control panel for all channels, and a common power supply. The system was capable of detecting and indicating the presence of gamma radiation over the six-decade intensity range, 0.01 mr/hr to 10 r/hr, in two logarithmic ranges. The output of each detector was recorded serially on a multi-channel strip-chart recorder. Individual channels could be read on a panel meter by means of a manual switching system.

DESIGN AND INSTALLATION OF A TEMPERATURE COMPENSATOR

The Neher-White monitoring elements consist of a 50-in.^{3} unsaturated ion chamber and an electrometer tube mounted within the chamber. The electrometer tube used in the monitoring units is a triode-connected 5886 with a floating grid, so mounted in the ion chamber that the grid lead becomes the collecting element of the chamber (Fig. 2). In this configuration incident gamma photons entering the chamber will produce a logarithmic change in plate current proportional to the photon flux.

Plate current in this system is a function of the negative charge on the control grid of the electrometer tube which in turn is dependent on a number of factors. Those of interest here are ion current in the gas volume of the detector, insulation resistance between the electrometer grid and the outer case of the ion chamber, and the electron emission of the filament of the electrometer tube. If it is assumed, for instance, that an increase in temperature causes insulation resistance to decrease, which in turn causes the electron charge on the control grid to decrease in a manner identical to that which occurs when the gas volume is partially ionized by incident gamma radiation, then plate current will increase and an apparent increase in radiation dose rate will occur. The uncompensated curve of Fig. 1 demonstrates this action.

The plate current vs. filament voltage characteristics of the 5886 electrometer tube indicate that if the electron emission of the filament can be caused to increase with an increase in temperature, in a manner that causes the grid to maintain a constant negative charge, then compensation will be achieved and the system rendered temperature-independent.

An examination of the properties of currently available temperature-compensating devices (thermistors) indicated that several types were suitable when used with the proper parallel trimming resistor. It was found that a close approximation to complete compensation could be obtained with a Veeco type 21D2 thermistor and a 50 Ω variable trimming resistance in series with the filament of the electrometer tube as shown in Fig. 2. The compensated curve of Fig. 1 illustrates the degree of compensation achieved.

CALIBRATION AND RESULTS

It was found by experiment that an initial adjustment of the variable resistor in parallel with the thermistor for a total resistance of 14 ohms at 78°F would adequately (within ± 10 %) cover the temperature range 30°F to 80°F. The system could be made to operate over a greater range by readjustment of the variable resistor. After recalibration of the system, test runs were made using small point sources of γ radiation to check the effectiveness of the modification in the actual installation. Later, during a full-scale contaminating event (Complex III), temperatures were recorded at various points in the area and changes in data compared to temperature records with the results (typical for all detectors) shown in Fig. 1. Both curves are for the same detector and show that the dose rate output variations were less than ± 10 % at any point on the scale.

DISCUSSION AND CONCLUSIONS

Introduction of the temperature-compensating network necessitates a complete recalibration of the system, which is most easily done with the aid of a climatic simulator. The improvement attainable, however, is well worth the effort, since the RAMS is effectively upgraded from a qualitative dose rate indicator to a quantitative research tool. Ignoring rate-energy-dependence inherent in this type of system, the temperature-dependent read-out errors at the extremes of 30 and 80°F are within ± 10 % of the dose rate indicated at 55°.

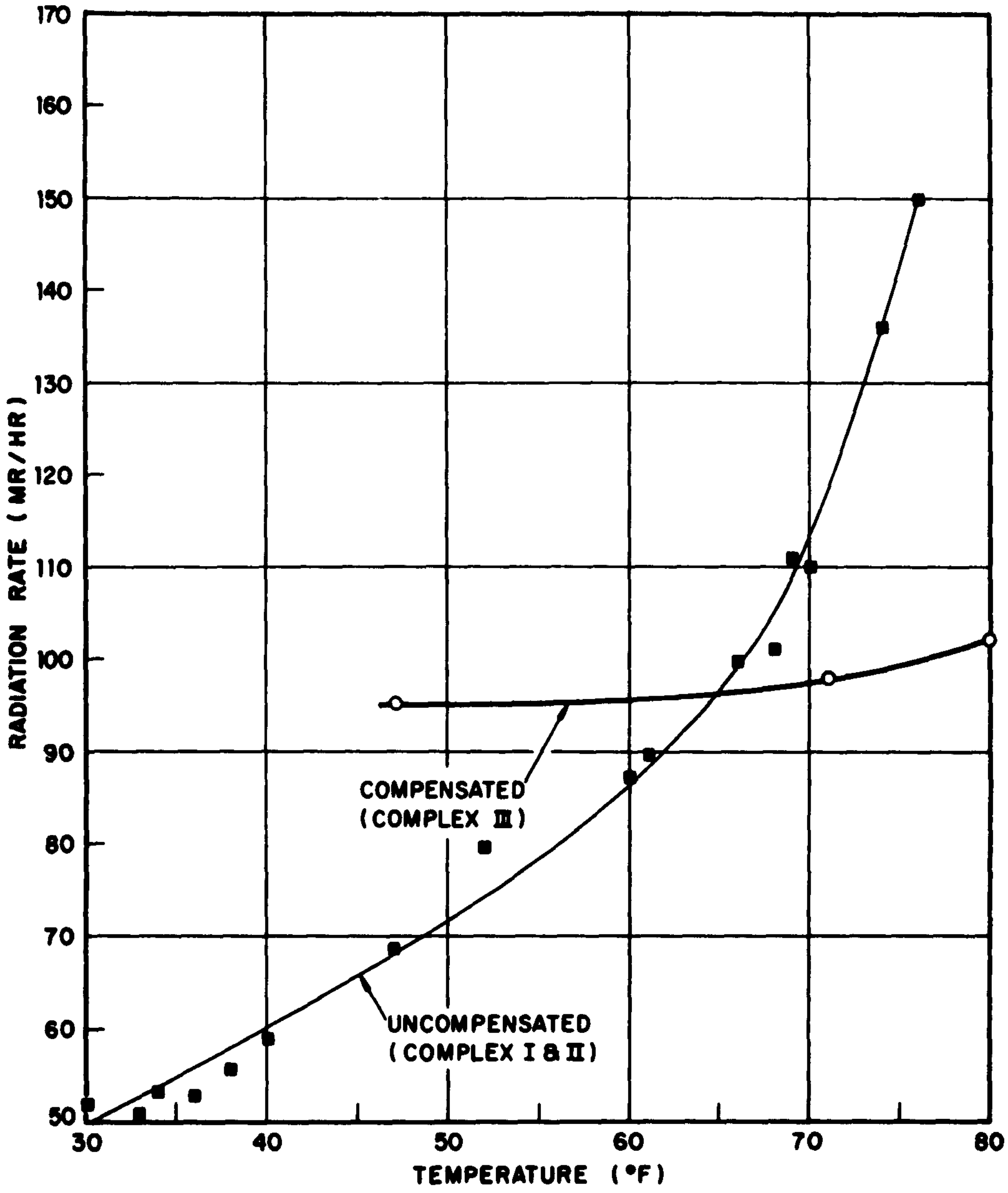

Fig. 1 RAMS II Performance With and Without Temperature Compensation

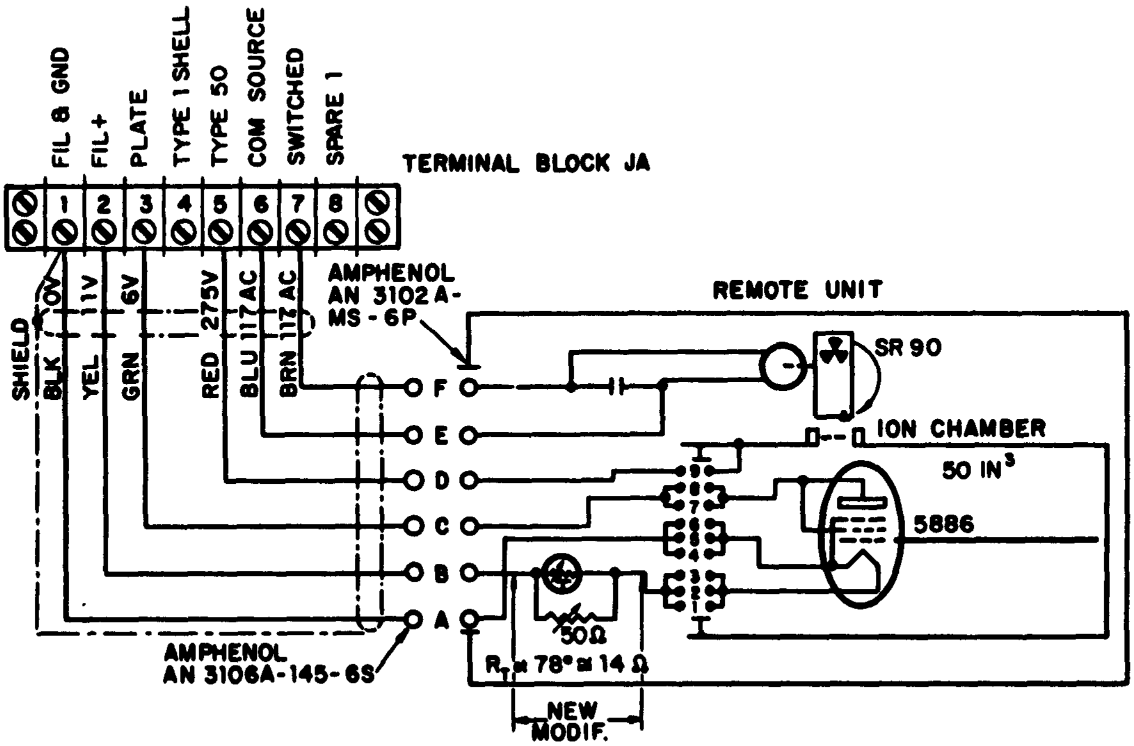

Fig. 2 Schematic of Remote Detector

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