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MULTIPURPOSE RADIATION MONITORS

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**NEW GENERATION OF RADIACS:
SMALL COMPUTERIZED MULTIPURPOSE RADIATION MONITORS**

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SUMMARY

The Health Division at Los Alamos has developed a multipurpose radiation monitoring device that is computer-controlled, light weight (3 lb), includes multiple radiation detectors running simultaneously, and is simple to use. LCD displays indicate the various radiation parameters in both alphanumeric and graphics format. Internal batteries allow 100 hours of use.

I. INTRODUCTION

As a continuation of our work on small computerized radiation spectrometers and dosimeters,¹⁻⁴ the Health Division at Los Alamos has developed a new battery-powered portable survey instrument that combines various radiation detectors with a low battery power CMOS computer to acquire, process, store, and display a wide variety of radiation data. This multipurpose "radiac" is generic in nature and can use any of the standard radiation detectors such as NaI, ³He, LET proportional gas counters, solid state surface barrier detectors, etc. More than one detector can be operating at any one time. For the first time, a single, one-handed operation, lightweight, "smart" instrument can be carried into the field to provide α , β , γ , and neutron monitoring, thereby eliminating, to a large extent, the use of multiple single purpose instruments. This development will make it even easier than previously possible for workers in the nuclear industry to carry accurate and sophisticated, yet simple to operate, radiation measuring instruments any time they are in a potentially hazardous location. This will provide less opportunity for serious exposures to occur by timely measurement and warning.

II. MULTIPURPOSE RADIAC: GENERAL DESCRIPTION

The radiac is shown in Figure 1, along with a mockup of what a field service and calibration kit might look like. The radiac has a mass of 1.4 kg and has dimensions of 20 cm long x 6 cm x 6 cm. Three detectors are included

in the case behind sliding doors built into the bottom of the device. A sensitive thin window "pancake" GM tube is used for low level β and γ monitoring while a peanut sized GM detector is used for high ranges up to 500 R/h. Crossover between the two detectors is automatic and controlled by the computer. A surface barrier detector (2.5 cm dia x 100 μ thick) monitors for alpha contamination when its "door" is open. When closed, the door with its polyethylene backing acts as a radiator for knockout protons caused by neutron collisions. Present neutron sensitivity is only .5 cpm/mRem/h. This sensitivity can be significantly improved by better radiator/detector geometry. A 12 key keypad allows selection of the various detectors and data display modes. An analog bar graph is displayed on the 28x80 dot matrix LCD with appropriate scale factors with autorange capability. For example, the gamma exposure scale starts at .01 mR/h. The beta, alpha, and neutron scales read in cpm starting at 100 cpm. The scales can easily be changed by minor modifications of the display driver software. A Piezo electric chirping device sounds for each detected event by the selected detector. Via software, the chirper can sound alarms as radiation levels reach predetermined hazardous levels. Four AA batteries power the device for up to 100 hours. Other functions of the radiac include multi-scaling with up to 60 channels of data stored as a function of time. Dwell time for each step is currently programmed for either 1 or 10 sec. A manual multiscale mode is also provided for storing radiation data by, for example, container or location. A small pushbutton located on the handle allows the operator to store up to 60 individual radiation readings with no predetermined dwell time between readings. The multiscale data can be displayed as a bar graph for visual inspection or as individual channel readout in numeric form. Because of the computerized nature of the device, the stored information could be readout in digital fashion via appropriate interface (not currently included in the instrument).

The use of custom software, easily changed, and integrated circuits will make the servicing and calibration of such instruments much easier. Indeed, this instrument should, in reality, have very few "parts" that require service. When servicing or calibration is required, it could even be accomplished at remote field locations via a yet-to-be developed computer service module (see mockup in fig. 1). A computer of more than adequate capability for such tasks was reported last year.⁵

III. ELECTRONIC DESIGN

The electronics which make up the radiac are shown by block diagram in Fig. 2. They can be broken down into 3 basic blocks: the detectors and their associated parts; the computer section; and the display section. A regulated high voltage supply provides bias voltages suitable for a number of types of detectors. It is variable over the range of 100-2500 volts. The detectors used in the prototype instrument are a thin window pancake Geiger for beta and gamma, a small high range Geiger for high gamma fields, and a silicon surface barrier detector for alphas. Each detector has associated circuitry to convert their output signals to logic pulses. The pulses from the detectors go to a series of logic gates which select which detector pulses go to the scaler. The scaler is part of the 146805 microprocessor which is the heart of the instrument. The 146805 and its associated memory form a computer which has a number of functions in the instrument. First, it counts the pulses coming from the selected detector for time intervals determined by the clock circuits. Then it computes a value for display based on the integral of the number of pulses counted during a preset interval of time. It then displays this value in one of several ways on the 28x80 dot matrix liquid crystal display (LCD). The computer also tests the display value to see if it is within the display scale and autoranges the display if it is out of limits. The computer also scans the 12-key keyboard for operator input and checks the battery condition. A serial interface is provided for communication with a variety of peripheral devices such as telemetering devices or the autocalibration feature previously mentioned.

IV. FUNCTIONAL DESCRIPTION

As the operator sees it, the controls on the radiac consist of a 12-key keypad and a handle switch. The keys are labeled ON, OFF, RESET, TYPE, MULTISCALE MANUAL, MULTISCALE 1 SEC, MULTISCALE 10 SEC, MS STOP, MS READ and MS GRAPH. ON and OFF control the power to the radiac; RESET is used to return to the normal mode from the multiscale mode; TYPE is used to select the detector and, in combination with the detector cover slides, to select the type of radiation to be sensed. Depressing the key advances the selection to ALPHA, BETA+GAMMA, GAMMA, AND NEUTRONS, in a rotating or stacked sequence. The type detector selected is written on the display.

The multiscale keys control the multiscale function which displays a histogram of the radiation intensity as a function of time or manual entries. Data are collected for specific time intervals (1 or 10 seconds programmed in this unit) and stored in a table in memory. There are 60 locations in the table. The data can be acquired automatically (Multiscale 1 or 10) or upon depression of the handle switch (Multiscale Manual). The data are displayed in two formats: either a bar graph (MS GRAPH) or one channel at a time digitally (MS READ). MS STOP is used to stop the mode if less than 60 data points are desired.

The display is a dot matrix graphics type LCD. Since it is a graphics type display, it is capable of displaying the information in a number of ways. The basic display is a bargraph giving somewhat the same format as an analog meter but with one major difference. The scale values are written on the display; thus, the displayed data is unambiguous. When the range changes, the scale numbers also change; there is no need to mentally multiply the meter reading by a multiplier or remember which of several scales printed on the meter face to read. This, in combination with the autoranging feature, makes it quite easy for the operator to use. In addition to the meter function, the display also shows what detector is currently selected and the units of measure, either counts per minute or mR per hour, as previously mentioned. The versatility of the display allows special display formats to be used for special functions such as the multiscale function. The unambiguous display and ease of operation clarify the interface between the operator and the instrument and greatly lessen the chances of erroneous readings.

V. USE AND APPLICATION

This generic radiac offers field inspection personnel sophisticated radiation measurement and data storage capability in a convenient hand-carried package. It will find wide application in the fields of health physics, nuclear safeguards, and related fields.

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Fig. 2