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TITLE A PORTABLE NEUTRON SPECTROMETER/DOSIMETER

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A PORTABLE NEUTRON SPECTROMETER/DOSIMETER

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SUMMARY

As part of the continuing DOE effort to upgrade personnel neutron dosimetry,[1] the Health Division at Los Alamos has developed a portable, battery-operated, computerized neutron spectrometer/dosimeter.[2] The instrument has a built-in tissue-equivalent LET neutron detector, 128-channel pulse height analyzer with integral liquid crystal display,[3,4] and a micro-computer system which calculates dose and dose rate from neutrons incident on the detector. The instrument will, at the user's option, display a raw data spectrum or a spectrum of rad or rem as a function of keV per micron of equivalent tissue. The dosimeter will also calculate and display accumulated dose in millirad and millirem, as well as giving the user neutron dose rates in millirad and millirem per hour.

GENERAL DESCRIPTION

The neutron spectrometer/dosimeter was developed to provide the health protection technician with full capability for field measurements of high energy neutron flux. The instrument, shown in Fig. 1, is packaged in a single case 25 cm in length, 15 cm in width, weighing 8.4 pounds. Controls consist of a power switch and a 16-key keyboard which calls all of the spectrometer and dosimeter functions of the instrument. The spectrometer/dosimeter is powered by a set of 6 AA NiCd batteries which have an average lifetime of 4 to 5 hours.

The neutron spectrometer/dosimeter is designed around a linear energy transfer (LET) proportional counter. This counter consists of a hollow plastic sphere filled with a tissue equivalent gas. The gas reacts to recoil protons generated in the plastic wall in much the same way as a 2-micron sphere of human tissue. Incoming neutrons generate recoil protons in the tissue equivalent wall. The charge deposited by these protons is directly proportional to their LET. The detector pulses thus represent the spectrum of absorbed dose as a function of LET in the small tissue volume.[5] The pulse output from the counter is digitized and converted to spectral information. From the resulting pulse height spectrum accumulated dose is calculated and displayed. The dose rate is determined by dividing accumulated dose by the time elapsed, up to 20 hours. The resulting dose rates are displayed directly below the figures for accumulated dose.

A useful feature built into the LET counter is a calibration system. This system consists of an internal Cm244 alpha source which can be exposed to the detector by activating a built-in magnetic shutter. A spectrum of the alpha source is taken and the gain of the input amplifier is adjusted to place the alpha peak in a predetermined channel number in the 128-channel analyzer. When the alpha peak is in the right position, all the constants used to calculate dose from the pulse height spectrum will be valid.

ELECTRONIC DESCRIPTION

A block diagram of the neutron spectrometer/dosimeter is shown in Fig. 2. It consists of three basic sections: input signal processing unit, microcomputer, and display.

The input section is a standard pulse height analyzer front end. Pulses from the detector are shaped and amplified by a preamp and then are fed, with the proper timing, to an 8-bit analog-to-digital converter. The converter outputs a digital word whose magnitude is proportional to the height of the input pulse.

The microcomputer is designed around an NSC800 low power CMOS microprocessor manufactured by National semiconductor. The microprocessor is supported by 8K bytes of program memory and 8K bytes of data memory, all of which are low power CMOS in order to keep battery drain to a minimum. The memory has been made sufficiently large to allow for future expansion of functions. The user communicates with the computer through a 16-key keyboard located on the front panel of the instrument. With the keyboard all of the functions and display modes can be readily called up.

The display is a dot matrix lcd array 80 dots wide and 28 dots high. The microcomputer communicates with it through two logic cards, one of which is provided by the display manufacturer as part of the display. The display logic contains all the circuits necessary to convert the data from the microcomputer to readable spectral or dose information, as required. Also part of the display logic is an on-board memory array which stores current display information. This array with its associated logic refreshes the display periodically so that the control processor doesn't have to be tied up for long periods rewriting the same data to the display over and over.

FUNCTIONAL DESCRIPTION

All of the functions of the spectrometer/dosimeter are accessible via the keyboard located on the front panel of the instrument. This keyboard includes keys to generate and move pulse spectra, generate dose information, d initiate signal acquisition.

Signal acquisition is controlled by two keys, ACQ and HLT. The acquire key, ACQ, causes the input circuits to be enabled and initiates input signal processing by the microprocessor. Signal processing continues until the halt key, HLT, is pressed. The HLT key inhibits the passage of further input pulses through the system.

There are five keys which allow the operator to generate various types of displays. Of these five, all but the DOSE key cause different types of spectra to be generated. The DOSE key, when pressed, will cause the micro-processor to calculate from the raw data accumulated dose and dose rate. The information is then presented on the display in units of millirad, millirem, millirad/hr, and millirem/hr. A pulse height spectrum of incoming data will be generated on the display when the DATA key is pressed. Pressing the LOG key yields a spectrum of the same data displayed in semilog format. When the RAD key is pressed the instrument will present a plot of the dose in millirads as a function of keV per micron of tissue. The REM key performs a similar function but displays accumulated dose in millirem as a function of keV per micron of tissue.

Four modify keys are provided on the instrument to modify displayed spectra, aiding in the analysis of spectral information. The up arrow and down arrow keys are vertical scale control keys. When pressed, they scale the spectrum up or down. The left arrow key allows the user to roll the display left horizontally, ten channels at a time, so that all 128 channels of any spectra may be viewed. In the same way, the right arrow key rolls the display to the right ten channels at a time.

Finally, there are two control keys on the keyboard. The first of these is the CLR or clear key. The CLR key simply clears whatever is being displayed, be it dose or spectral information. This key serves as an aid in calibrating the gain of input circuits and finds use whenever the operator needs to clear the data memories. The other control key is reset, RST. The RST key reinitializes the instrument. It has the same effect as turning the power off and back on. The RST key is used to start the dosimeter while keeping all the internal power supplies stable.

USE AND APPLICATIONS

The neutron spectrometer/dosimeter was designed to aid those concerned with neutron dosimetry in characterizing higher energy neutron fields. It is important to note that the instrument is not designed for neutrons with energies below about 100 keV. The small size of the dosimeter and its simplicity of operation ensure that it should find wide use in any area where workers might be exposed to fields of high energy neutrons.

ACKNOWLEDGEMENTS

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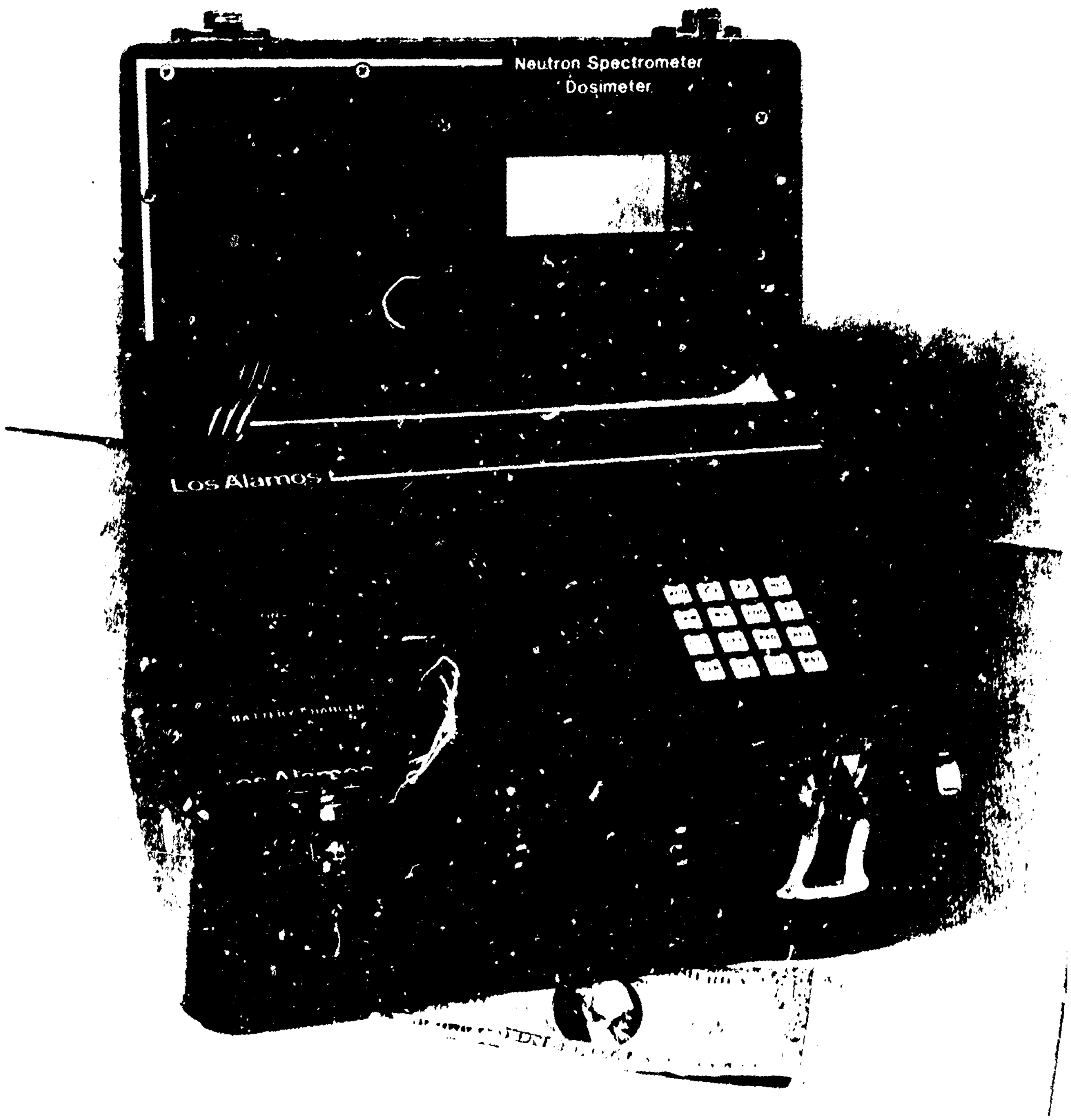
Neutron Spectrometer
Dosimeter
Los Alamos

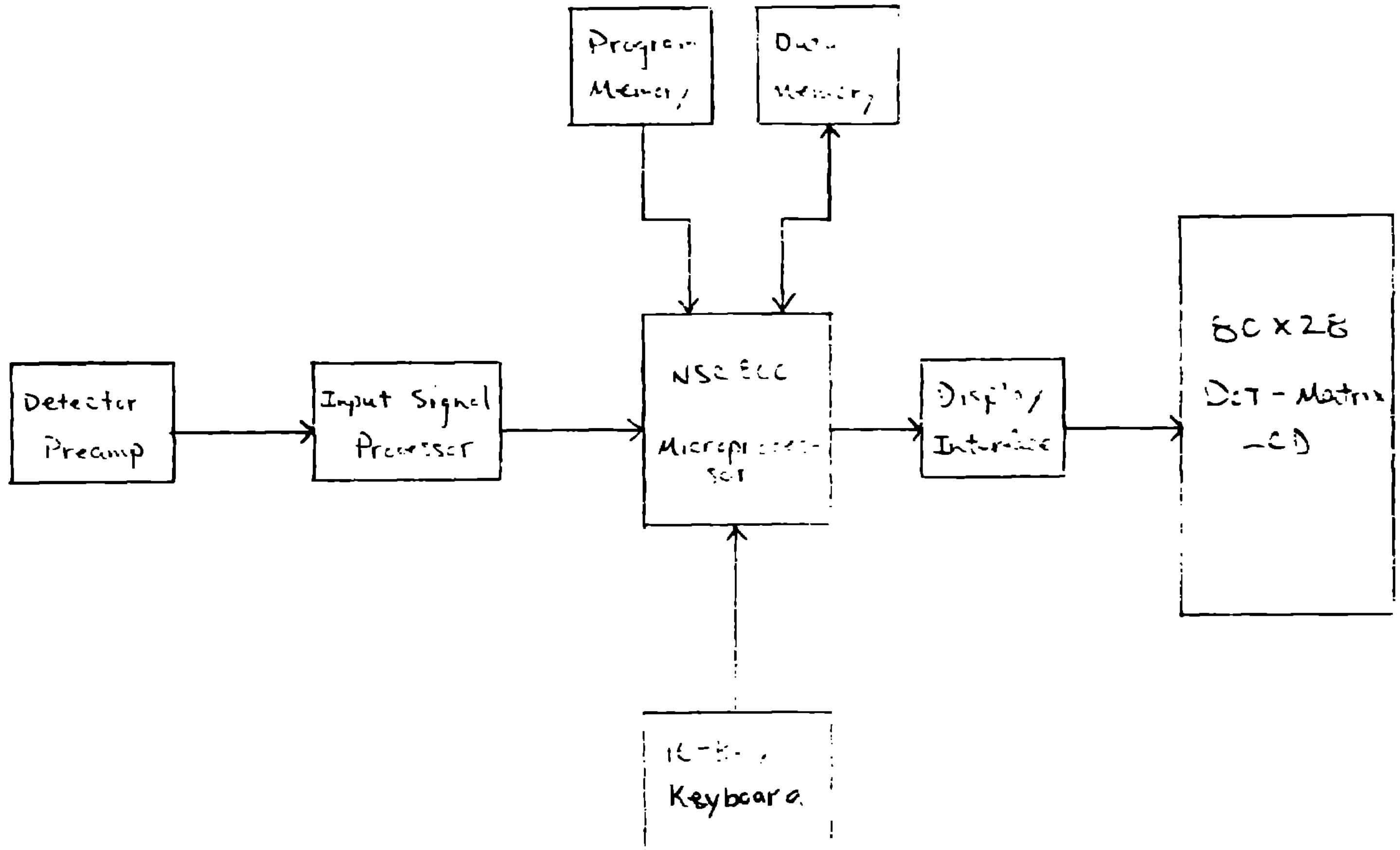

Fig. 2
SYSTEM BLOCK DIAGRAM

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