Dr N. F. H. Bright

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TESTS ON A LITHIUM-DRIFT GERMANIUM DETECTOR

by

G. E. ALEXANDER

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G.E. Alexander*

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SUMMARY OF RESULTS

A lithium-drift germanium detector has been tested as a suitable unit for use in gamma-ray spectrometry. The particular unit used displayed lack of sensitivity and no improvement in resolution over the detection system presently employed.

Improved "coaxial" lithium-drift germanium detectors have recently been developed but these are prototype units and not readily available at this time.

*Technical Officer, Mineral Physics Section, Mineral Sciences Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

INTRODUCTION

The following tests were carried out to determine the suitability of a solid-state detector as a substitute for a NaI(Tl) scintillation detector and photomultiplier tube which is currently used in a gamma-ray spectrometer for neutron activation analysis. The test work was instigated and directed by Dr. H.P. Dibbs of Mineral Sciences Division, Mines Branch.

Several papers have been written on lithium-drift detectors (1, 2, 3). The detectors were of interest to this department due to the improved resolution that could be obtained over a NaI(Tl) detector. Although lithium-drift silicon detectors can be operated at room temperature, the sensitivity is lower than with the lithium-drift germanium detector which must be operated at low temperatures.

PREPARATION OF DETECTOR

Test work was carried out on an RCA type SJGG-2 lithium-drift germanium detector on loan from the Applied Physics Division of the National Research Council. The SJGG-2 has a depletion depth of 2 millimeters, an area of 2.8 cm^2, and a typical capacitance of 23 μμf.

This particular unit was received in a liquid nitrogen container. As the detector had not been used for several months it was brought to room temperature and conditioned for 3 hours.

Conditioning the detector requires the application of a back-bias voltage of approximately 200 volts through a 1000-ohm protecting resistor. At the end of the 3-hour conditioning cycle, with the detector at room temperature, a current reading of 5.6 milliamperes was obtained, which is typical for this particular unit. Conditioning was carried out with the detector bolted to a solid copper bar of about 1.5 inches diameter and 13 inches long. This bar served as the heat sink during the conditioning cycle and as a cold finger during the operation of the detector at low temperature.

On completion of the conditioning period, the bar containing the detector was inserted into liquid nitrogen. To avoid thermal shock to the detector the bar was inserted slowly. The detector in the operating position was about 1 inch above the liquid nitrogen level with the copper bar to which it was bolted acting as the cold finger.

ELECTRONIC CIRCUITRY

The electronics in the test consisted of a Tennelec Model 150 solid-state detector preamplifier, the output of which was fed into a Franklin Model 348 pulse amplifier. The signal pulses from the Franklin amplifier were accumulated in a CDC 100-channel pulse-height analyser.

Power for the Tennelec preamplifier and detector bias voltage was obtained from additional commercial power supplies on hand.

DETECTOR TESTS

Initial tests were carried out with a cesium-137 source. High counts in the low-energy channels overloaded the 100-channel analyser. Additional shielding of the detector and grounding the metal case of the liquid nitrogen canister reduced the low channel count-rate, but it was finally necessary to bias-off the low channels in order to obtain a cesium peak. The spectrum obtained showed poor resolution and very low sensitivity.

In view of the poor performance of the detector, it was removed from the liquid nitrogen and put through a second conditioning cycle for 4 hours. The conditioning cycle was started with the heat sink still cool (roughly 5°C). The conditioning current at this time was 3 milliamperes. At the end of the 4 hour conditioning period the current was 5 milliamperes with the heat sink at room temperature.

On completion of the conditioning, a second set of results was obtained employing sources of cesium-137 and cobalt-60 of various intensities. Although typical bias voltage for the RCA detector is 200 volts, spectra were obtained with bias voltages as low as 10 volts.

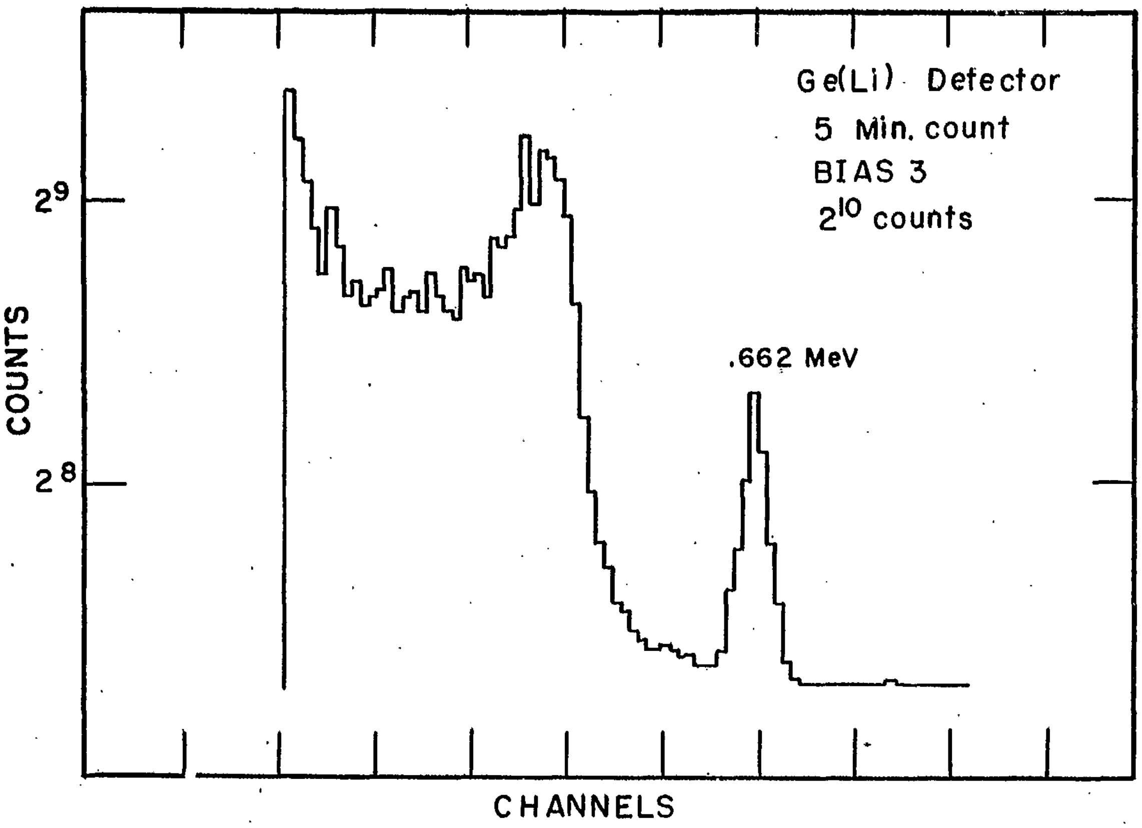
TEST RESULTS

The resolution of the spectra obtained was disappointing. The cesium-137 peak resolution displayed no significant improvement over the NaI(Tl) detector, and an extremely large number of counts had been accumulated in the low-energy channels of the analyser (Figure 1). The loss in sensitivity compared with a 3" x 3" NaI(Tl) crystal was of the order of 50 to 1.

In order to compare results, Dr. J.H. Aitken of NRC repeated his original test. An Ortec preamplifier model 103XL, an Ortec amplifier model 203 and a Nuclear Data ND130 analyser were used. The spectra obtained by Dr. Aitken were comparable to our results.

SUMMARY

A comparison of the recently obtained cobalt-60 spectrum with the spectrum obtained when the detector was originally purchased (approximately 8 months earlier) indicated, without doubt, that the detector had deteriorated in the interim. There was a pronounced deterioration in resolution and no improvement of resolution could be obtained with increased detector bias voltage. The ratio of counts in the low-energy channels to the



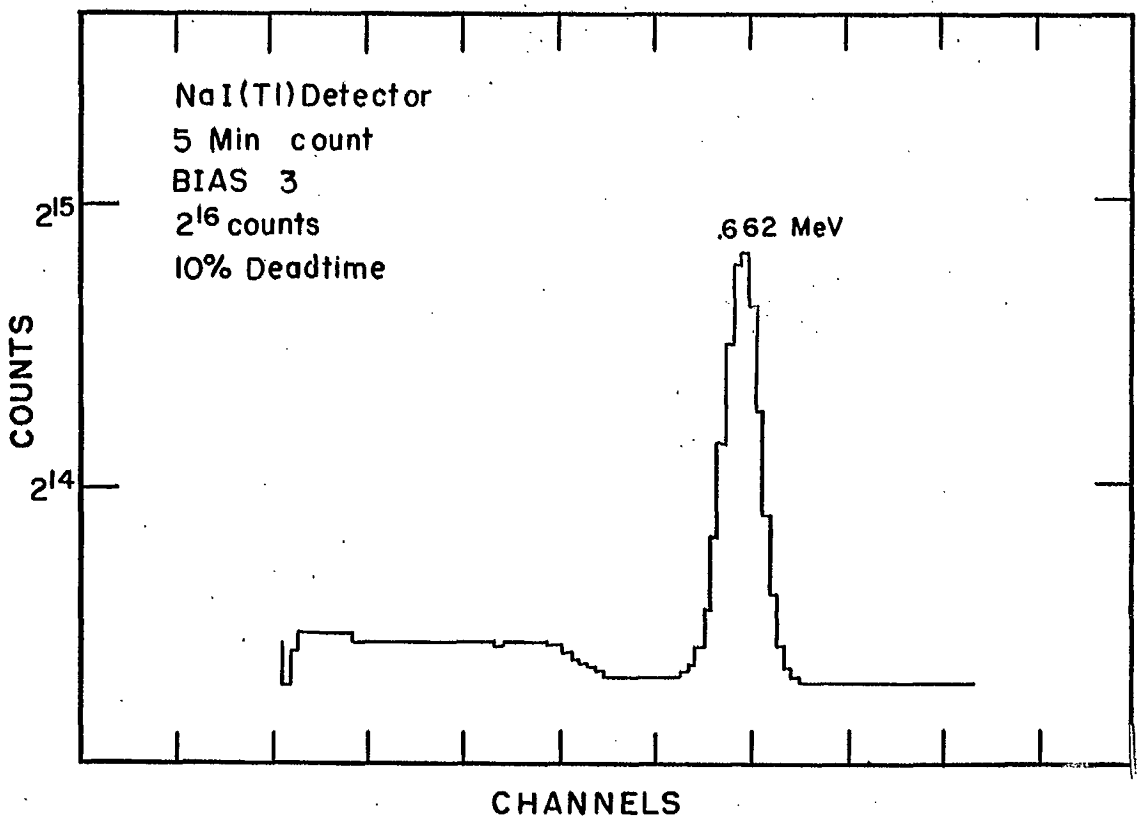


Figure 1 - Spectrum Comparison of Ge(Li) and NaI(Tl) Detectors

counts observed in the spectrum peaks had increased significantly. It was not possible to compare sensitivity as the activity and positioning of the samples in the original NRC tests were not available.

Although results on the particular unit tested were unsatisfactory as a suitable substitute for the NaI(Tl) crystal, work is progressing in the field of solid-state detectors (4). A prototype coaxial lithium-drift detector developed by the Physics Division, Chalk River Nuclear Laboratories, AECL, (5,6) is of particular interest. This detector has a volume of 16 cm^3, shows excellent resolution, and has a sensitivity comparable to a 1 inch long by 1 inch diameter NaI(Tl) crystal.

At present the development of lithium-drift germanium detectors is expanding very rapidly and the application of a solid state detector will be reviewed as commercial units become available.

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