HEWLETT hp PACKARD

APPLICATION NOTE 72

FEBRUARY 15, 1966

INTEGRAL COUNTING

Sodium Iodide (Thallium activated) crystal scintillation detectors are now available with unusually broad, flat, well-defined plateaus, a high degree of resolution and stability, and low noise (see Figure 1). These characteristics greatly increase the speed, convenience and reproducibility of gamma ray counting. Details on plateau curves, integral counting and equipment set-up are discussed here.

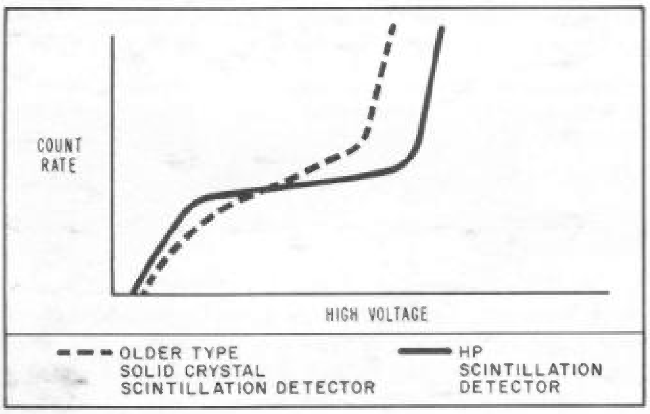

Figure 1. Plateau Curve Comparison

A complete integral counting set-up. Operator is inserting test tube sample into well type scintillation detector in lead shield.

INTEGRAL COUNTING

In counting the pulses produced by a gamma ray detector, the term integral counting is applied when all pulses above a preset minimum level are counted. In counting modes other than integral counting, the scaler discriminator is set to count only pulses within a certain band of voltage amplitudes. Integral counting is useful when working with low count rates if it is desirable to count all possible gammas regardless of energy in order to keep the counting time to a minimum and still maintain acceptable accuracy and stability.

PLATEAU CURVES

A plateau curve is a plot of count rate versus detector high voltage supply setting (Figures 1, 2, and 3). The curves vary slightly for different radionuclides.

To determine the plateau curve for a given radionuclide and detector, set the scaler's discriminator level to approximately 100 mv, progressively increase the high voltage to the photomultiplier in the detector, and record the number of counts at each voltage step. When the high voltage to the photomultiplier is progressively increased, the pulse sizes of gammas of all energy levels will increase. More and more pulses will exceed the discriminator level of the scaler until at the knee of the curve a large percentage of the gammas entering the detector will be counted. The plateau area ensues, and further increase in voltage will not produce much of an increase in counts.

With a scintillation detector the plateau ends when the gain due to high voltage is great enough to amplify the thermionic noise (dark noise) from the photocathode sufficiently to produce pulses that exceed the discriminator level. It is important to use a tube with low noise characteristics and and amplifier with sufficient electronic gain so the photomultiplier may be operated below a value which produces noise pulses.

For integral gamma counting it is good practice to determine the plateau curve for each scintillation detector and for each radionuclide to be measured before selecting the best operating high voltage. With long, flat plateaus such as those in Figure 2 it is not only easy to find the plateau, but it is also possible to choose a high voltage supply setting that is useful for integral counting of a number of gamma emitters.

Good energy resolution (sharper peak in a plot of count rate versus gamma energy level) is important in a detector because it contributes to a broader plateau and

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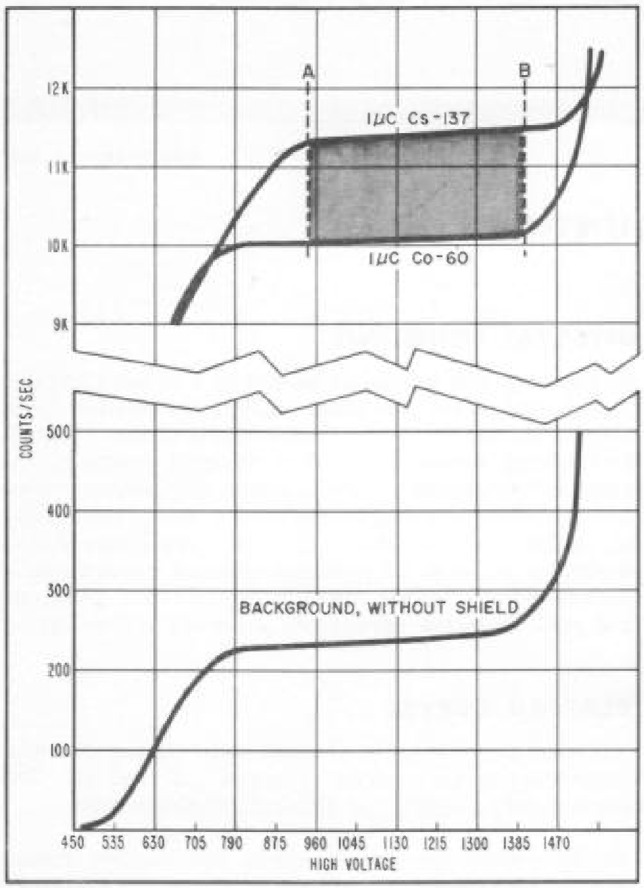

Figure 2. Plateau Curves for Background, Cs-137 and Co-60. Obtained with HP 10601A Scintillation Detector, 5201L Scaler-Timer, 5551A Power Supply. Plateau Lengths and Slopes are: Background Curve, 600 v and 0.25%/100v; Cs-137 Curve, 520v and 0.34%/100v; Co-60 Curve, 600v and 0.20%/100v.

sharp knee, but is more important for resolving double peaks in non-integral counting techniques. Figure 2 illustrates the well defined curves that HP Scintillation Detectors give. This performance is partly due to good energy resolution. Incidentally, the knees of the curves for Co-60 and Cs-137 are different because of the greater abundance of low energy photons from the 31.5 Kev X-ray of Ba-137, which is a decay product of Cs-137.

ADVANTAGES OF GOOD PLATEAUS

Broad plateaus of low slope and with well defined knees produce the following benefits in integral gamma ray counting:

1. Efficiency (cps/μc) is only dependent upon crystal size and geometry, and not upon the particular detector. Consequently, in multi-station counting rooms, detectors of the same model need not be cross-calibrated. As an example, in our own counting laboratory four unselected Model 10611A detectors gave these count rates using the same sample: 20,334 - 20,411 - 20,462 and 20,498 cps.

2. One high voltage value (or a range of values as from A to B in Figure 2) can be found that permits confidently achieving plateau operation even when different radionuclides are counted with either the same or different detectors (different radionuclides produce different plateau curve shapes, see Figure 2).

3. Minor high voltage supply fluctuations will not appreciably change the count rate, and successive measurements will be completely reproducible for practical purposes.

SCINTILLATION AND GEIGER DETECTORS COMPARED

Historically, scintillation detectors have been noted for having poorer plateaus than Geiger detectors (1); poorer because they are narrower, of much greater slope, and have ill-defined knees (compare Figures 1 and 3). Now, however, these disadvantages are virtually eliminated in standard Hewlett-Packard Scintillation Detectors (compare Figures 2 and 3).

Three major advantages of inorganic crystal scintillation detectors over gas (Geiger) detectors for the majority of integral gamma counting applications are:

1. Their markedly greater efficiency.

2. They can measure considerably higher average counting rates.

3. When operated in the recommended range of high voltages, detector output pulse amplitude is proportional to gamma energy lost in the detector; while in Geiger detectors, pulses are of an almost uniform amplitude regardless of energy.

HIGH VOLTAGE SUPPLY REQUIREMENTS

A well-regulated power supply is a critical requirement when using counting techniques other than integral counting but is not generally critical for integral counting. Low output ripple is necessary to keep detector output noise low. A vernier voltage control, in addition to a stepped control, aids in rapid, convenient, accurate system calibration and set-up.

(1) R. W. Engstrom and J. L. Weaver, Nucleonics, Feb 1959, Page 70, "Are Plateaus Significant in Scintillation Counting."

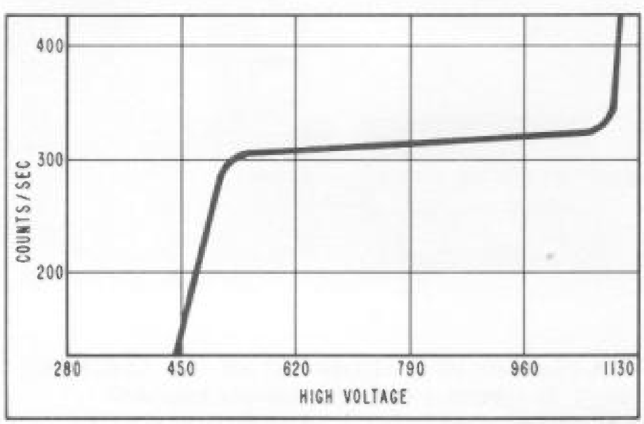

Figure 3. Typical Geiger Plateau (ranges from 150-600 volts with slope of 1-2%/100v).

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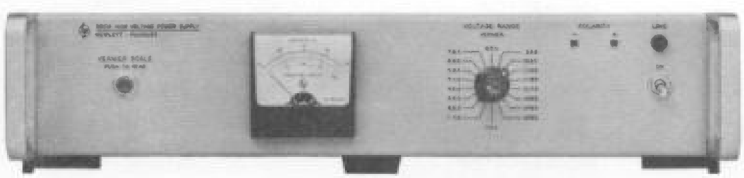
00072-A-1

TYPICAL EQUIPMENT FOR INTEGRAL COUNTING

	**5551A** A well-regulated high voltage supply with stepped and vernier controls (on same shaft) for determining and setting plateaus quickly and reliably.
	**5201L** Front panel controls of a scaler useful in integral counting. Discriminator linearity of 0.25%, stability of 0.01% and odometer type dials for discriminator setting increase the accuracy and reliability of measurement. In-line readout allows rapid error-free readout. Pulse height analyzer (PHA) control selects integral mode, or wide window or narrow window differential counting modes. Pulse pair resolution is 200 nsec. Preset time and preset count capabilities are provided.
	**DETECTORS** Well-type scintillation detector with ±2% stability and better than 10% FWHM resolution. High performance is achieved because of selected photomultiplier tube and premium NaI (Tl) crystal. "0" ring seals make the unit moisture-proof. Rear view shows cable connections, focus control, and gain control for built-in amplifier. Output impedance of 50 ohms allows long coaxial cable between detector and scaler. Other hp detector sizes and types are available with better than ±1% stability and better than 8% FWHM resolution. The preamplifier-amplifier is available separately if the user wishes to assemble a special purpose detector.

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