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Measurement of Converted γ-Radiation by the Proportional Counter Technique

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Corrections for internal conversion with a solid source.

Of late the use of proportional counters has been extended to very high multiplication factors, enabling the determination of unusually low γ- and β-ray energies from pulse amplitude measurements1)2). Whereas for true γ-rays this method always yields the full γ-ray energy, for converted radiation the full energy is observed only in case the source forms part of a counter filling which absorbs practically all the x-ray quanta following the emission of a conversion electron. As there are only relatively few substances available in gaseous form, we will discuss in the following the complications arising from a source deposited on the counter wall. If the counter filling absorbs most of the x-ray quanta involved, then for geometrical reasons the following 4 cases have about the same probability:

case	conversion electron	x-quantum	pulse amplitude corresponds to
1	counted	counted	$\leq \gamma$ (= transition energy)
2	counted	not counted	$\leq \gamma - x$
3	not counted	counted	x
4	not counted	not counted	(no pulse)

Owing to the finite source thickness, the pulse amplitudes observed in cases 1 and 2 will be spread over a considerable range. If the Auger-effect is negligible, case 3 produces a sharp peak in the amplitude distribution, regardless of source thickness. The intensity of these lines corresponding to the different shells gives us valuable information about the conversion coefficients.

Application to measurements of Tc^{99}[*].

These considerations, when applied to the results of a recent investigation3) of the highly converted isomeric transition of Tc^{99}, lead us to a transition energy of 1,8 keV. As neither K- nor L-quanta were found, the conversion must take place either in the M- (additional lines to be expected at 0.5 and 1.3 keV) or in the N-shell (0.06 and 1.7 keV). The experimental evidence for a considerable number of very small pulses indicates that the conversion coefficient α_N exceeds α_M.

In experiments with proportional counters the energy determination depends on the comparison with a calibrating radiation of known energy. We used Fe^{55} for this purpose, produced from Mn by a (p, n)-process [4]), which decays by K-capture followed by emission of x-rays from Mn. With the K-quanta the calibration can easily be effected from outside the counter through a relatively thick Al window. The long half-life and the nearly complete absence of other radiations make Fe^{55} an excellent calibrating substance.

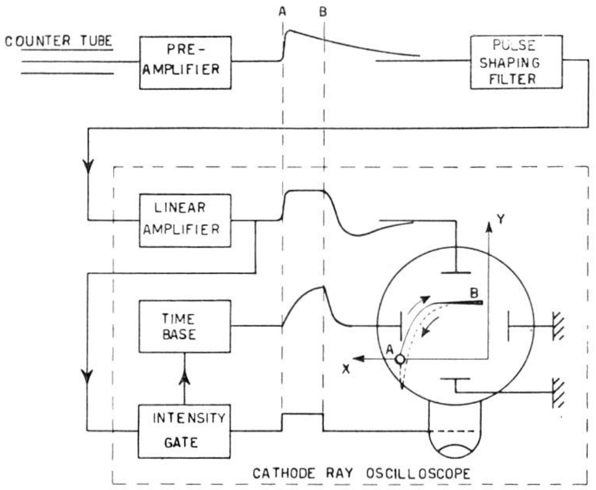

Fig. 1.

Block diagram of a simple pulse spectograph.

Photographic pulse analysing system.

In view of the 6 h-period of Tc^{99*}, it was important to have the analysis of the pulse height distribution ready within a rather short time after each run. As there was no elaborate pulse analysing apparatus available, we recorded the pulses by a conventional cathode ray oscilloscope modified in such a way that the exposure of some 10^4 pulses on a single photographic plate produced automatically an amplitude distribution curve, in a manner similar to the one described previously [5]) in this journal. As is evident from Fig. 1, any commercial cathode ray oscilloscope, if equipped with a single sweep time base and a spot suppressor circuit, can easily be converted into a simplified pulse spectrograph by means of a pulse shaping filter which consists mainly of a short-circuited delay line.

This method of producing rectangular pulses calls for a larger bandwidth than theoretically required for the measurement of pulse heights. The corresponding increase of the noise level is however of no consequence for proportional counter measurements and did not even prevent the use of the same apparatus in crystal counter experiments.

The usual linearising tube in the time base circuit is replaced by an ohmic resistance, so that the sweep voltage follows an exponential law. Hence the exposure at a point (x,y) on the plate is inversely proportional to the deflection x along the time axis, and directly proportional to the number of pulses at an energy corresponding to y. This means that on the photographic plate the curves of constant blackening represent the relative numbers of pulses with an essentially linear intensity scale. Since such a curve can easily be produced by a simple photographic printing process, our recording method saves much time in determining the pulse height distribution curve with good statistics, without the need of a complicated multichannel counting arrangement.

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