SCINTILLATION COUNTERS WITH PULSE SHAPE SELECTION TO DISTINGUISH NEUTRONS FROM GAMMA-RAYS

F. D. Brooks

Atomic Energy Research Establishment, Harwell, England

Following a paper by G. T. Wright[1] concerning scintillation pulse shapes and decay times of organic crystals, scintillation counters have been developed which distinguish alpha-particles or neutrons from gamma-rays by pulse shape selection. Wright reported that the shapes of anthracene scintillation pulses are different when excited by alpha-particles and gamma-rays respectively. A similar property has been found in other organic scintillators and when fast neutrons (i.e. recoil protons) are substituted for alpha-particles; the counters developed here use this property to discriminate promptly between different types of particle. Efficient discrimination is obtained using anthracene, stilbene or quaterphenyl crystals and various liquid scintillators.

The pulse shape selection is effected by deriving two output pulses per scintillation from the last dynodes in the photomultiplier. In one channel the scintillation current pulse is integrated to produce a pulse height, h, proportional to the total light output. In the other channel the scintillation current is passed through a network of non-linear response and then integrated; consequently the pulse height, h_c, produced in this channel depends on the scintillation pulse shape as well as on the total light output. For a given h, h_c is smaller when the decay time of the scintillation pulse is longer.

Differences in pulse shape may be demonstrated by applying the h and h_c pulses to the X and Y plates respectively of a cathode-ray tube. The CRT-trace is brightened only while the applied pulses are at their peak values, hence each scintillation registers as a point (h, h_c) on the CRT screen. Similarly a series of scintillations of different light outputs (e.g. a Compton distribution) form a locus on the screen. For example with a Co^{60} gamma source and a 1 in^3 stilbene crystal a single continuous locus is obtained (Fig. 1). Using the same crystal and a Po–Be (gamma + neutron) source two distinct loci are obtained (Fig. 2), the upper locus coincides with that in Fig. 1 and the lower one is attributed to recoil proton scintillations. In practical applications one requires to select pulses on either the 'neutron locus' or the 'gamma locus' only; this may be done by using a simple electronic circuit which operates directly from the h and h_c information.

Crystal, liquid and plastic scintillators have been investigated with respect to their suitability for pulse shape discriminators of this type. The dependence

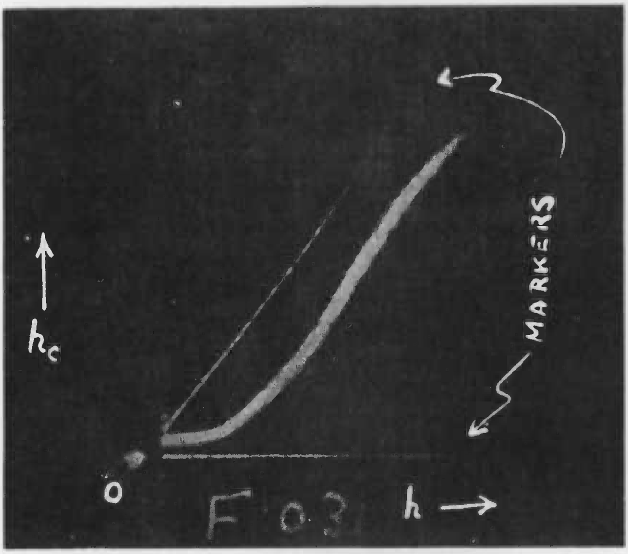

Fig. 1. Co^{60} source γ-rays.

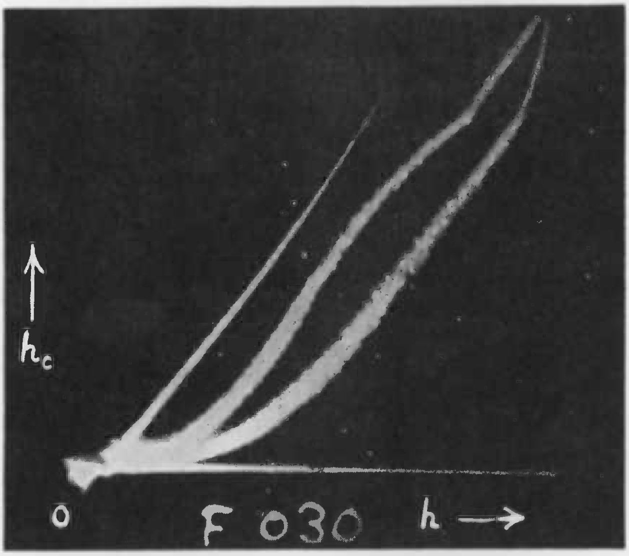

Fig. 2. Po–Be source γ-rays and neutrons.

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of the discrimination on factors which are known to affect photomultiplier output pulse shapes has also been studied, e.g. the temperature of the scintillator and transit time spreads of light in the scintillator or electrons in the multiplier; with liquids the dependence on concentrations of scintillator solutes and dissolved oxygen have also been studied. These studies, besides providing practical information, help to explain the mechanisms responsible for the pulse shape differences.

Scintillation counters which employ pulse shape selection to discriminate against gamma-rays are being used as neutron detectors in neutron time-of-flight experiments. Fast neutrons are detected in a crystal or liquid as in Fig. 2. In another counter slow neutrons are detected by the B^{10} (n, α) Li^7 reaction in a boron-loaded liquid scintillator.

REFERENCE

[1] G. T. WRIGHT. *Proc. Phys. Soc.* B **49** 358 (1956).