ductor to the deflecting plate. This damped the shock-excited oscillations of the series resonant circuit comprised of the inductance of internal leads to the deflection plates plus the deflection plate capacity. The RC time constant of this network was then approximately 6×10^{-10} second.

[1] C. G. Kelley and M. Goodrich, Phys. Rev. **77**, 138 (1950).
[2] G. B. Collins, Phys. Rev. **74**, 1543 (1948).

Performance of Pulsed Photo-Multiplier Scintillation Counters*

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In an attempt to develop higher speed counting equipment for use with the Stanford linear accelerators, we have applied pulse methods to the operation of scintillation counters with the following results. We have pulsed several 931-A photo-multipliers to voltages as high as 5 kv, without voltage breakdown. Pulse lengths up to 2.5 microseconds have been used, the upper limit being set by the pulser. Using an Ag_{110} gamma-source, we have observed stilbene scintillation counts with a rise time of about 10^{-9} second, and with a maximum height of about 80 volts. The pulses were delivered from the photo-multiplier into 100-ohm RG7U coaxial cable, terminated at its output end. They were displayed by a 5RP11A high voltage cathode-ray tube with no intermediate amplification. The observed rise-times are probably made appreciably longer by transit time and lead inductance effects within the oscilloscope tube.

Not all of the tubes tried withstood the highest pulse voltages, but those that did gave infrequent and small noise counts. There did not seem to be any consistent correlation between excellence of performance at low d.c. voltages and that under high voltage pulse operation. The single 1P21 tube which was tried, though satisfactory at the usual d.c. voltages, happened to be inferior to any of the several 931A tubes tried, from the standpoint of voltage breakdown and noise. However, this tube may not have been representative. A tendency for noise count rates to increase near the end of the longer pulses was noted for all tubes. This suggests that pulsed operation greatly reduces the incidence of that part of the noise due to accumulative ionization effects in the multiplier. It was also found that the use of an external shield, pulsed to the cathode potential strikingly reduced the noise counts.

From an analysis of photographs of individual counts, and by the use of very short delay line clippers, we have established that the rise time of a typical scintillation pulse is 10^{-9} second or less, and that the total duration of single-electron noise pulses is about 5×10^{-10} second, in rough agreement with the value calculated by Sard.[1] At the high voltages employed, effects due to transit time variations should be reduced by more than a factor of two. In addition to the effects of the oscilloscope characteristics on the measured value of pulse lengths, it is probable that the noise pulses are somewhat lengthened by the effect of lead inductances in the photo-multiplier tube itself, since, from Sard's calculation one would expect to find noise pulse durations of about 2×10^{-10} sec. at these voltages. High voltage operation improves the focusing properties of the photo-multiplier,[2] and increases the current output at which space charge effects become important. This latter fact is borne out by the experimental results. At 5 kv, no saturation effects have been observed, even for output currents approaching one ampere. From the height of the single-electron noise pulses observed, we estimate that the current gain of an average tube is about 10^9 with no saturation up to the highest scintillation pulses observed.

Our pulsing circuit was designed to deliver square pulses of extremely uniform amplitude. However, at the highest pulse voltages used, pulse regulation is less important, since these voltages per stage are near those corresponding to the maximum of the secondary emission multiplication curve. Although we have not tried pulsing at extreme repetition rates, the evidence to date suggests that this would be entirely feasible, especially if d.c. clearing fields were applied to the tube during the time between the pulses.

The pulsed scintillation counter could be used in the investigation of extremely short-lived isomeric states. We are preparing to carry out experiments of this kind, as a test of the method, by photographing the parent and delayed events as presented on a fast oscilloscope sweep. Beta- and gamma-events will be distinguished by the use of two counters, each connected to a single deflection plate. By placing selective absorbers in front of one of the counters, the gamma-events can be identified from their sense on the oscilloscope trace.

We have also applied the method to the measurement of phosphor decay times, with the results quoted in the accompanying letter. A paper describing the method in more detail, as applied to fast counting and coincidence work, is in preparation.

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[1] R. D. Sard, J. App. Phys. **17**, 768 (1946).
[2] G. A. Morton, RCA Rev. **10**, 525 (1949).

Terphenyl and Dibenzyl Scintillation Counters

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Terphenyl (*p*-diphenylbenzene) and dibenzyl[1] (diphenylethane) crystals appear to be two useful additions to the class of aromatic materials used in scintillation counters. Some of the properties of these materials have been determined and are given in Table I, where anthracene and stilbene are listed for comparison. Each of the new materials forms excellent crystals from the melt. Dibenzyl crystals are remarkably clear although they sometimes crack when taken from the mold. On the other hand terphenyl crystals are rugged and appear to be among the most durable of presently known organic scintillators. We have not yet succeeded in growing colorless terphenyl crystals, the present ones being slightly yellow but clear. It is probable that removal of the impurity producing the yellow coloration will increase the pulse height. The speed, good handling characteristics, and pulse height of terphenyl recommends its use in certain applications of scintillation counters. Dibenzyl has been obtained from the Matheson Company and (yellow) terphenyl from the Eastman Kodak Company.

Table I. Properties of scintillation counters.

	Decay constant	Relative efficiency	Spectrum	Melting point °C
	(±10 percent)			
Anthracene	3.4×10^{-8} sec.	1.00	4450A	217
Stilbene	1.2×10^{-8} sec.	0.60±0.10	4080 4200	124
Terphenyl—Sample A	1.0×10^{-8} sec.	0.65±0.10	3900	213
Sample B	1.2×10^{-8} sec.		4050 4300	
Dibenzyl—Sample A	1.5×10^{-8} sec.	0.60±0.10	3520	52.5
Sample B	1.7×10^{-8} sec.		3710 3950 weak	

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[1] Previously investigated by W. S. Koski and C. C. Thomas (Phys. Rev. **76**, 308 (1949)), who found that this material gave pulses only slightly over background and much poorer than stilbene.