different degrees of thermal stability (see Table I). That a similar phenomenon can happen to S-state atoms in a different manner is brought out by recent reports[3] on the positive and negative frequency shifts produced by various buffer gases on the hyperfine coupling constant of Cs. Photolytic experiments with hydrogen atoms in other inert matrices are in progress.

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MEASUREMENT OF FAST LUMINESCENCE DECAY TIMES*

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Measurement of luminescence-decay curves of organic scintillators has important applications both for radiation chemistry and for nuclear physics. The basic problems of such work are amplification of a light signal and time measurement. The usefulness of the measurements depends on the time resolution and the number of half-decay intervals over which a decay curve may be measured. In all previous work[1-4] in this field, essentially the first stage of the measurement apparatus has involved amplification via a photomultiplier. Such technique limits subsequent time resolution to the transit-time spread of the signal in a photomultiplier[5] (i.e., at least 1 mμsec). In experiments in which the time measurement is effected by display of the scintillation signal on a cathode-ray tube, the signal is always markedly deteriorated after a decay of about one decade because of processes inside the photomultiplier and the connecting cable.[6,7] On the other hand, the so-called phase-shift method involves an assumption as to the form of the decay curve.

In the method here reported, which represents a new approach to the problem, the time "point" of the light signal is first established and the signal is thereafter amplified. In this way both time resolution and measurements at the far tail of the decay-curve are improved.

Figure 1 shows the apparatus used: the pulse generator, *PG* (Spencer-Kennedy Laboratory Model 203) delivers fast-rising positive square pulses into two 95-ohm coaxial lines. One of these pulses opens the grid of a 30-kv x-ray tube.[2] X-rays penetrate through a thin target into the scintillators. The scintillation light passes through an aperture A_1 (4 mm × 12 mm) and strikes the photocathode of an image converter, *IC* (RCA developmental type C73435B).[8] The photoelectrons there produced are accelerated and focused onto the luminescent screen. If the resultant light signal on the screen is directly in front of aperture A_2 (3×10 mm), the photomultiplier, *PM*, is energized. Normally, a dc bias voltage on the deflection plates of the image converter so controls the electron beam

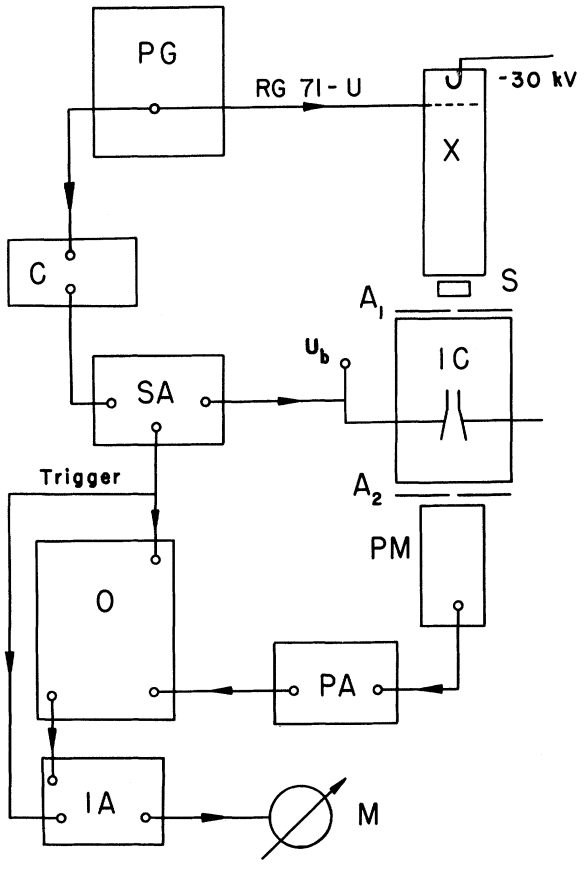

FIG. 1. Block diagram of apparatus for measurement of decay curves.

that no signal reaches the photomultiplier. A second pulse out of the pulse generator operates the sweep amplifier, *SA*, which produces a sweep speed of about 100 v/mμsec on the deflection plates of the image converter. Only those electrons which pass between the deflection plates at a time when the sweep voltage is about 0, and therefore hit the screen of the image converter directly in front of aperture A_2, will register their light signal on the photomultiplier.

Sweep speed together with the width of the apertures and deflection sensitivity give a calculated time resolution in the present apparatus of 0.5×10^{-9} sec. The signal to the sweep amplifier may be delayed by any desired time relative to the signal to the x-ray tube by a set of cables, *C*, of different length. It is thus possible to measure the amount of light released from the scintillator in a time interval Δt ($=0.5\times10^{-9}$ sec in our case) at a certain variable time after the x-ray pulse starts. Subsequent detection of this signal by the photomultiplier, *PM*, preamplifier, *PA*, and oscilloscope, *O*, is then no longer complicated by need for ultrafast response.

The shape of the signal is, of course, representative of long decay of the image converter fluorescent screen. Weak fluorescent signals exhibit a statistical fluctuation. Consequently, precise readings were taken from a phase-sensitive, integrating amplifier, *IA*, and a dc meter, *M*. For elimination of noise, the amplifier, triggered by the sweep amplifier, *SA*, is adjusted to respond only within 50 μsec of the trigger; for reduction of statistical fluctuation, the signals are integrated over a period of 4 sec (i.e., about 240 signals in this work).

Figure 2 shows, on a semilogarithmic plot, the intensity-time relationship for light emitted by different scintillators under excitation by an x-ray signal of about 10 mμsec length. The liquid scintillator shows a simple exponential decay over two decades, the commercial plastic scintillators show in each instance two different decay times, the second of which reflects the presence of some longer lived scintillator component.

Consideration of the time resolution of the apparatus indicates that, in its present state, the rise and cutoff time of the x-ray signal (about 1.2 mμsec) is the only limiting factor. Both emission of x-rays and emission of photoelectrons are very fast processes[9;10] ($<10^{-10}$ sec after excitation). Also the transit-time spread

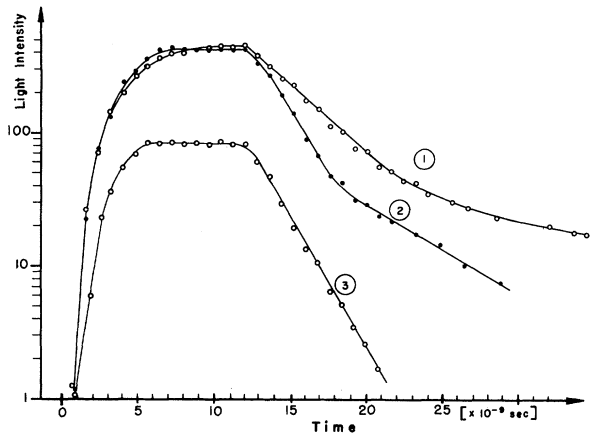

FIG. 2. Decay-curves of scintillators. (1) Plastic scintillator "Sintilon," National Radiac; τ initial $=4.2$ mμsec. (2) Plastic scintillator; $\tau_1=2.3$ mμsec, $\tau_2=6.3$ mμsec. (3) Liquid scintillator, 5 g/liter *p*-terphenyl in benzene; $\tau=2.2$ mμsec.

inside the image converter, *IC*, is rather small (estimated $<2\times10^{-10}$ sec) because of high acceleration voltage (5-15 kv) and a small effective photocathode. Consequently, the time resolution of measurement of decay-times by this method is well below 1 mμsec. Presently, there is no scintillator known to have a decay time short enough to verify this conclusion experimentally.

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