and when the sample volume is such that close to 4π geometry is obtained.

The consideration of the decay of Hg-197 is also made somewhat simpler, since there are no K x-rays produced from internal conversion of the 77 keV gamma, and angular correlation effects must be minimal.

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Reply

In my letter to the editor (*1*) I pointed out a fundamental error in a formula by Harper et al. Although their expressions (a) and (b) are correct, expression (c) is not.

This is demonstrated in the special case of 4π geometry, 100% photoelectric detection efficiency, no attenuation, and all photons occurring in pairs cascaded, γ_1 and γ_2, with abundances $\eta_1 = \eta_2 = \eta_{12}$. This means that in formulae (a) and (b) of the referenced paper, $\epsilon_i = \eta_i$ (i = 1,2). For the counting rate in the coincidence peak, however, the following expression holds: $N_{12} = A. \eta_{12}$ and *not* according to (c) $N_{12} = A. \eta_1 \times \eta_2$, where *A* is the source activity.

It will be the task of Hudson, Waters, and Davis to explain their procurement of satisfactory results while using an erroneous equation.

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Coincidence-Counting Techniques

A number of letters have recently appeared in this journal (*1–3*) discussing the basis of the coincidence technique as applied to the absolute assay of I-125, I-123, and Hg-197. Van Damme (*1*) has questioned the validity of the use of a random coincidence term in calculating the sum-peak intensity, and has drawn attention to the possibility of angular correlation effects.

Harper and Lathrop (*2*) and Hudson, Waters, and Davis (*3*) have justified the application of their approach to I-125 and to Hg-197, but there appears to be value in amplifying their comments to draw particular attention to the physical situation met in $x - \gamma$ and in $x - x$ coincidence summing and to contrast this with $\gamma - \gamma$ cascade summing.

We may do this by considering the decay of Hg-197 (Fig. 1). More than 98% of the disintegrations proceed via EC_1 to the 77.3-keV level of Au-197. Thus, to an acceptable degree of accuracy, those transitions proceeding via EC_2 may be ignored. Considering the electron-capture process that occurs in EC_1, we should note that this may proceed *either* by K capture, subsequently yielding a K x-ray, *or* by other modes such as L capture, which do not yield a K x-ray. Nonetheless, all these disintegrations lead to the 77-keV level whether or not a K x-ray was emitted in the process. The fraction yielding K x-rays, $\eta_1 = 0.72$.

The decay of the 77-keV state of Au-197 proceeds by the emission of γ_1, which may be internally converted so that the yield of externally detectable gamma photons *per disintegration* is reduced to $\eta_2 = 0.195$. The probability of internal conversion is clearly independent of whether or not a K x-ray was emitted in the previous electron-capture process.

The probability, per disintegration, for the detection of

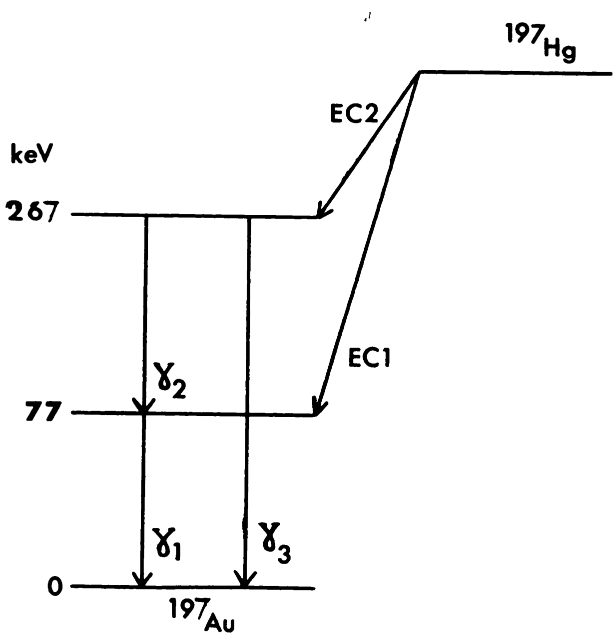

FIG. 1. The decay scheme of Hg-197.

both a K x-ray and a γ photon is therefore correctly given by the *product* of η_1 and η_2. In van Damme's notation, $\eta_{12} = \eta_1\eta_2$, as used by Hudson et al. The essential point is that both the electron-capture process and the subsequent decay of the 77-keV state of Au-197 may occur via parallel pathways only one of which, in each case, can contribute to the potentially observable sum coincidence. This is not so in the simple cascade process discussed by van Damme (*1*), in which (in his notation) the gamma transition γ_1 invariably precedes the second gamma transition γ_2.

The same arguments may be applied to the decay of I-125 and to other nuclei where electron capture is the first stage of the decay process.

The good agreement found by Hudson et al. for the assay of Hg-197, and by Harper et al. for I-125, support this interpretation of the coincidence process. For complete accuracy some allowance should, of course, be made for any weak alternative modes of decay.

We conclude, accordingly, that both Hudson et al. and Harper et al. have used an appropriate formulation for coincidence rates in the decay of these nuclei. So have those other authors who have used the coincidence-assay technique for the assay of I-125—in particular, Eldridge and Crowther (*4*), Bordell, Sayeg and Wald (*5*), and Ackers (*6*).

We take this opportunity to draw attention to earlier work on the comparison of I-125 and Hg-197 by Eldridge (*7*) and by Taylor (*8*).

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Inexpensive EKG Gate for Use with Computer-Processed Studies

A recent technical note by Kan (*1*) describes an inexpensive EKG gate for use with computer-processed studies. A similar device has been in use in this department for several months. There are a couple of enhancements that make the device easier to use. One is to add two monostable univibrators (74121s) in series to provide a delayed output. This delay allows the start of the data acquisition sequence to be placed anywhere within the cardiac cycle. Initiating the gate at the QRS complex tends to put the end diastolic image near the end of the image sequence. By delaying the gate, we ensure that both the systole and diastole images are well within the image sequence.

The second enhancement is related to display of the EKG signal and corresponding gate. Presently we are using a standard laboratory oscilloscope with a persistence screen and two vertical inputs. The EKG and gate signals are displayed in chopped mode with a horizontal trace rate of 20 msec/div. This displays two to three R-R intervals; and with the scope triggered by the EKG signal, one can easily observe any changes in interval by an appropriate setting of the persistence time. This display is especially convenient for setting the gate trigger level as one can observe both missed QRS complexes, as well as triggers erroneously generated by other parts of the complex.

In our department, this scope is used as a general laboratory scope, as well as a backup for some of our camera P-scopes when they need repair. We do, however, plan to add a closure-to-ground driver to activate the external marker on the EKG monitor. In this manner, EKG hard copy with gate superimposed will be obtained. Although this is not as convenient for setting up as the scope is, it will prevent blind operation.

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REFERENCE

1. KAN MK: Inexpensive EKG gate for computer-processed cardiac motion study. *J Nucl Med* 19: 320–321, 1978

Reply

I thank J. R. Tatarczuk and L. H. Flesh for pointing out that the basic EKG gate (described in my earlier paper) can be conveniently modified to enhance its performance. One example is the use of a delay circuit as described in the above letter so that gating can be initiated at any selected portion of the heart cycle. This is true and delay gating has been employed for gating end-systolic images on film using the downslope of the T-wave, although this technique is not quite as accurate as prediction of end-systole by phonocardiography (*1*). The use of delay circuitry in computer processed cardiac motion studies, as suggested by Tatarczuk and Flesh however, will pose some synchronization problems for the following reason.

In computer-processed cardiac motion studies, all scintillation events throughout the heart cycle are analyzed and they are usually sorted into 10–30 frames representing the sequence of events throughout the heart cycle. Because of the limited counts from each heart cycle, a reference point is necessary for synchronization for the collection and analysis of scintillation events spanning approximately 400–800 heart beats. At the end of the study the sorted frames represent an overall average of the sequential events in the heart cycle. In an ideal situation, each of the 400–800 heart beats would have the same duration. In this case, the delay