Radioisotopes have been used by numerous investigators as tracers of the path of an element in biological processes. Such techniques involve a relatively small number of samples and are generally of a qualitative nature. The results of these investigations have indicated that, with certain refinements, the radioisotopes may be utilized in quantitative investigations. Such investigations would show the magnitude and rate of the movements. This suggests the desirability of field and greenhouse experiments.

In order to handle the analyses in such experiments conveniently, special techniques and precautions have been developed. It is the purpose of this discussion to consider these with respect to the quantitative estimation of radio-phosphorus, $^{32}\text{P}$. They are considered from the standpoint of routine procedures wherein a large number of samples are involved. The estimation of the radioisotope is made with the same precision and facility as the associated common isotope.

Although referring specifically to $^{32}\text{P}$, many of the considerations are applicable to the radioisotopes of elements that are measured gravimetrically.

**INSTRUMENTATION**

The Beta particle given off in the decay of $^{32}\text{P}$ produces ionizations that can be measured by various instruments. The choice of the detecting instrument generally is between the electroscope and the Gieger-Muller counter.

The electroscope is a sensitive instrument for detecting all types of radiation. Its sensitivity to a particular type of radiation is varied when the charged portions of the instrument are exposed directly to the source of radiation or separated by several types of absorbing materials. However, this same sensitivity limits the range of its utility when considering routine analysis wherein the samples may have a wide range in activity.

While it is possible to arrange suitable recording accessories to the electroscope, these are mostly of the photographic type and require additional manipulations of the data. This reduces the value of the electroscope for routine procedures, although it has been and is being used with very good success.\(^3\)

The simplicity and low cost of the equipment makes this instrument extremely desirable for exploratory investigations. The sensitivity of the electroscope makes it an essential piece of equipment for monitoring purposes.

The Gieger-Muller counting systems are admirably adapted to routine quantitative investigations involving a large number of determinations. When the range of activities of the samples is wide and unpredictable, such systems are more versatile than the electroscope.

The auxiliary equipment of the G-M counter permits the automatic recording of data. One operator may manipulate three to five instruments simultaneously, increasing the efficiency of the laboratory. The biggest drawback to using G-M tubes are the high cost and the complex equipment which requires numerous precautions in maintenance. Since G-M counter tubes are admirably adapted to routine analysis, the subsequent discussion is based on their usage.

In general, there are three types of tube construction, viz., (a) the immersion or solution counter, (b) the cylindrical or tube-shaped counter, and (c) the end window counter. These are discussed by Zimens (11), Korff (5), and Kamen (4). In this work we have found that the end window counter with a window thickness of 3 mg/m\(^2\) is very satisfactory. A serious consideration for this type tube is the seal of the window. A design that provides a strength to this seal is very desirable. It is essential if the tubes are to be subjected to temperature and humidity conditions widely different from those under which they were constructed.

The counting characteristics of each tube must be determined prior to its use and should be checked at frequent intervals. Prolonged operation at an overvoltage damages the wires which causes the tube to give spurious counts even when reduced to the correct operating potential.

The dead time of a counter is that time during which it is not sensitive to an ionization. The importance of this value is indicated in Fig. 1 which shows the percentage correction of the corrected counts at three dead times at several counting rates. Wilson et al. (10) give a good discussion and procedure for calculating this value. The self-quenched tubes naturally exhibit a shorter dead time than nonself-quenched tubes, but this is dependent upon the construction of the tube and its gas content.

In the self-quenching type the organic vapor is used to serve as the quenching agent, is gradually used up, and the counting characteristics of the tube is altered. Ordinarily these tubes have a life of approximately 108 counts which, if we allow 50,000 counts per sample, indicates about 2,000 samples.