EXPERIMENT IV

OPERATION AND CHARACTERISTICS OF A PROPORTIONAL COUNTER

Various types of proportional detectors were discussed in Chapter 5. It will be recalled that they too are ionization-type detectors that are operated within a potential range where moderate gas amplification occurs. A distinctive feature of this level of gas amplification is that proportionality is maintained between the size of the output pulse from the detector and the magnitude of the initial ionization within it. The following experiment is designed to serve as an introduction to some of the component functions and operating characteristics of an entire proportional counter assembly.

A. FUNCTIONS OF THE COMPONENTS OF A PROPORTIONAL COUNTING ASSEMBLY

1. Power Supply

The d-c potential needed across the proportional chamber electrodes to facilitate gas amplification varies widely with the type of chamber and the composition and pressure of the counter atmosphere. Normally a power supply that can be regulated up to at least 2500 volts is adequate, but in some counting assemblies 5000 volts may be required. The voltage output must be reasonably stable for proportional counting, since the gas amplification factor is heavily dependent on the potential gradient across the electrodes within the chamber.

G-M counters require a stability of power supply of only about ± 1 per cent, but the proportional counter requires better than ± 0.1 per cent.

2. Proportional Detector Assembly

Proportional detectors may take various forms. Since this type of detector is generally used for the detection of alpha particles, one finds they are commonly of the windowless flow chamber variety. To avoid surface charge of the sample, some manufacturers recommend thin-window varieties with window thickness as low as 0.15 mg/cm². The following discussion pertains particularly to the windowless type of detector. (See Figure IV-1).

In the windowless flow counter, the radioactive sample is placed inside the counting chamber and exposed to the counting atmosphere directly, without a window barrier intervening. The counting gas mixture, usually methane or an argon-methane mixture (90-10 $^{v}/_{v}$), passes through the chamber continuously during the counting operation. When a new sample is inserted, air that has been unavoidably introduced must be "purged" from the chamber atmosphere by a brief increase in the flow rate of the counting gas.

The counting chamber is commonly hemispherical in shape with a thin anode loop suspended from the top. The chamber wall serves as the cathode. The sample-holding planchet itself acts as the lower side of the chamber. The planchet is introduced and held firmly in place by means of a movable piston to give a defined geometrical relationship of sample-to-chamber. The geometry of sample-to-chamber is close to a solid angle of 2π, which provides good detection efficiency. Lead shielding is normally used to reduce the interference of background radiation.

3. Preamplifier

The output signal from a proportional detector will seldom exceed 50 mv. Thus, in situations where the pulses from the detector must pass to the scaler through cables of even a few feet in length, a preamplifier is necessary. This is not usually the case where the detector is an integral part of the scaler itself.

4. Amplifier

Since the gas amplification factor is considerably lower in the proportional region than that in the Geiger region, a high gain amplifier is usually required. This amplifier must be highly stable. In addition, the pulse sizes initiated by different ionizing particles vary considerably. Consequently this component must be able to amplify a wide range of pulses linearly without distortion.

5. Scaling Unit

What has been previously said concerning scaling units in G-M counters applies here as well. Whereas the dead time of a G-M detector is relatively long (up to several hundred microseconds), the proportional detector generally has a very short dead time (as low as a few microseconds). Consequently,

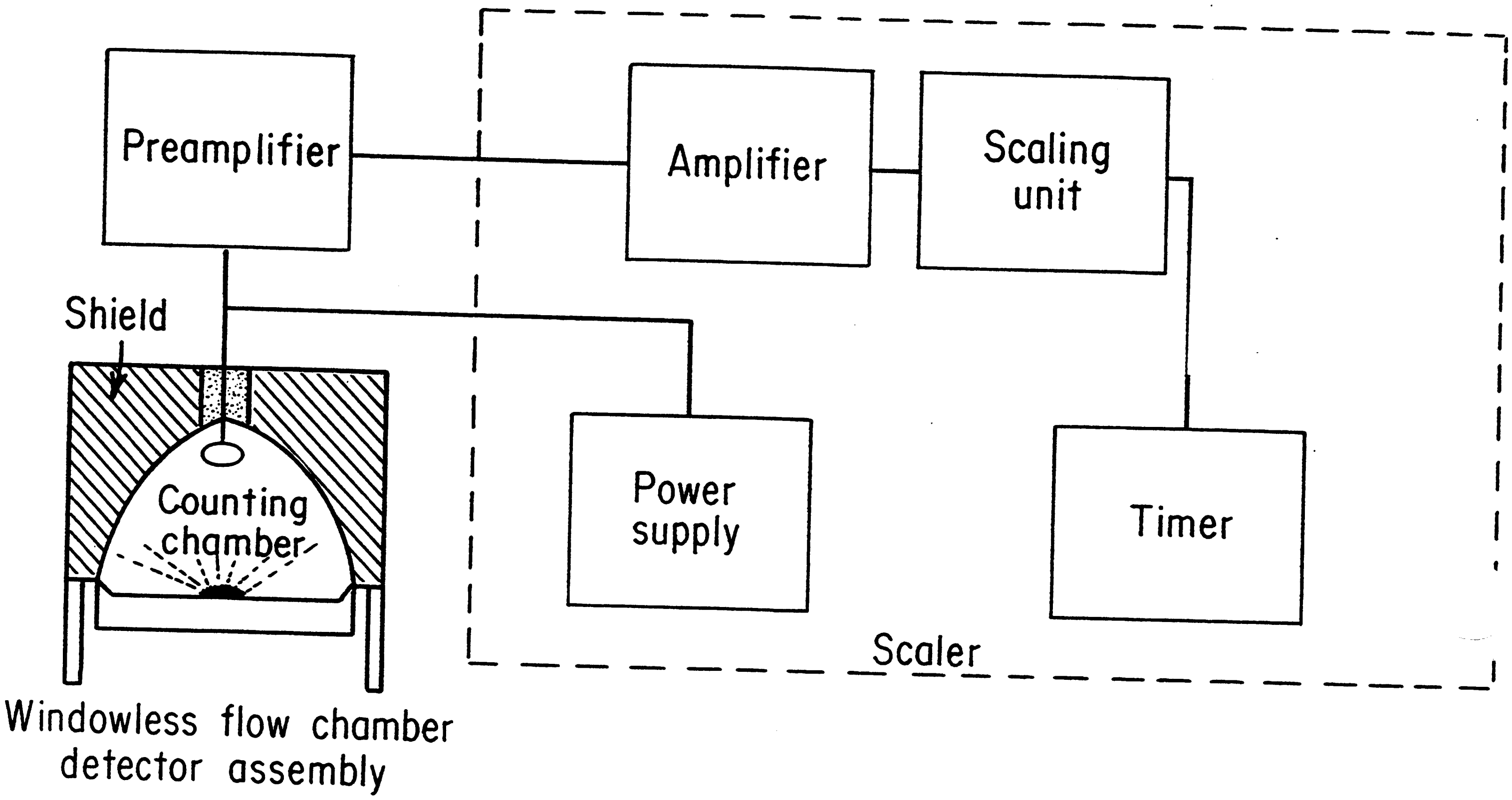

Figure IV-1. Block diagram of a proportional counter assembly.

a compatibly fast scaling unit is essential in order to take advantage of this feature.

B. OPERATION OF THE PROPORTIONAL COUNTING ASSEMBLY

Always read the instruction manual furnished with a particular counting assembly thoroughly before attempting to operate the counter. For the windowless flow counter, it is especially important to become familiar with the technique of introducing a sample into the counting chamber and controlling the gas flow.

1. <u>Proportional Counter Plateau and Optional Operating Voltage</u>

<u>Procedure</u>

a. Make sure that the high-voltage control is turned as low as possible. Then turn the instrument "on" and wait a few minutes before proceeding.

Insert into the counting chamber a prepared sample which emits both alpha and beta particles. Often these are furnished with the instrument. Otherwise a thorium or a uranium salt, or a radium DEF preparation is suggested for this purpose.

Purge the counting chamber with the counting gas for about 1-2 min. Then reduce the gas flow to the continuous rate specified by the manufacturer, usually one bubble per second through the bubbler.

b. Slowly raise the potential across the detector electrodes to the point where pulses begin to be registered (about 700 volts), and collect at least 3000 to 5000 counts at this potential setting. If counting does not begin at about the voltage specified, the chamber may have been incompletely purged. Repeat this procedure at 50-volt intervals up to the point at which the count rate begins an abrupt rise from the second (beta) plateau (usually about 2000 volts). Record the data in Table IV-1.

c. Plot a graph of count rate (cpm) vs. applied voltage. This should give a curve similar to Figure 5-9. The plateau at lower voltage (the α-plateau) reflects the counting rate of the α-components of the sample; the plateau at high voltage (the β- plateau) includes both the α and β counting rates.

The optimum operating voltages are usually determined as the center of the respective plateaus.

The optimum operating voltage for α-counting is _________v.

The optimum operating voltage for β-counting is _________v.

2. Differential Counting of Alpha versus Beta Particles

Note that for mixed alpha-beta samples the pulses resulting from beta particles cannot be directly counted apart from those resulting from the alpha component. The count rate at the alpha plateau can, however, be subtracted from the rate on the beta plateau to find approximately the net beta count rate if desired. In addition, where the beta particle energy is sufficiently high, a thin absorber placed over the sample allows nearly all the beta particles to pass

TABLE IV-1

Applied Voltage	Total Number of counts	Counting Time	Count Rate (cpm)

through, while completely absorbing the alpha radiation. Alpha particles can be counted in the presence of beta emission (and gamma, too), by operating the detector at the alpha plateau. This feature is one of the great advantages of the proportional counter over the G-M counter. (See the discussion of gas amplification in Chapter 5 for further explanation.)

Procedure

a. From the plateau curve measured above, determine the net α and β counting rates of your sample

Net α-counting rate = ____________ cpm.

Net β-counting rate = ____________ cpm.

3. Counter Resolving Time

Paired radioactive sources, such as those used to determine counter resolving time with the G-M counter but with count rates of 50,000 to 100,000 cpm each, should now be used for the same purpose with the proportional counter.

Procedure

a. Set high voltage to the value corresponding to the β-plateau. Follow the directions given in Experiment III for the determination of resolving time with a G-M counter. Record all data in Table IV-2.

b. Use Equation III-1 to calculate τ, the resolving time.

τ for the proportional counter was ______ μsec.

Ratio of $\frac{\tau_{GM}}{\tau_{prop.}}$ =

TABLE IV-2

Sample	Counting Time	Total Counts	CPM	Average cpm	Background	Net Average cpm