Proportional Counter

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- Operation
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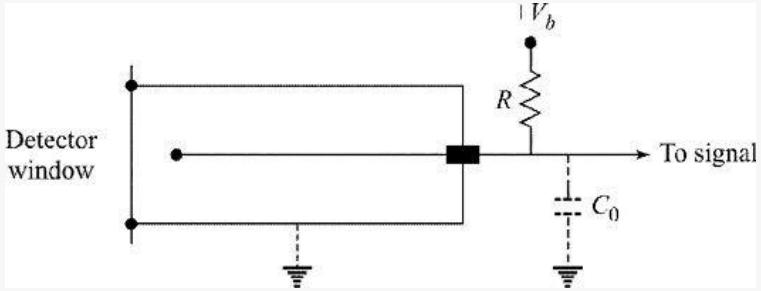
Proportional Counter

A proportional counter is a device to count particles of ionizing radiation and measure their energy.

Principle

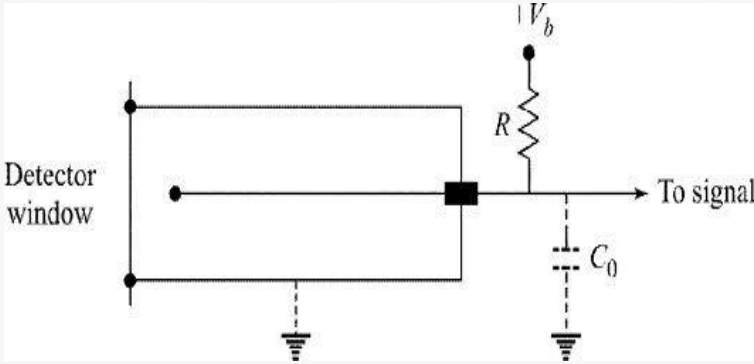
Proportional counters use the principle that nuclear radiations while passing through a medium ionize the medium.



•Ionization chamber is not able to detect low energy ionizing particles, as they produce the pulses of very small height (less than 30μV). In order to increase the height of these pulses the electric field and voltage must be increased between the electrodes.

•If the voltage between the electrodes is increased beyond the saturation region so that it works in proportional region (region III) then this gas filled detector is called **proportional counter**

Construction of Proportional Counter



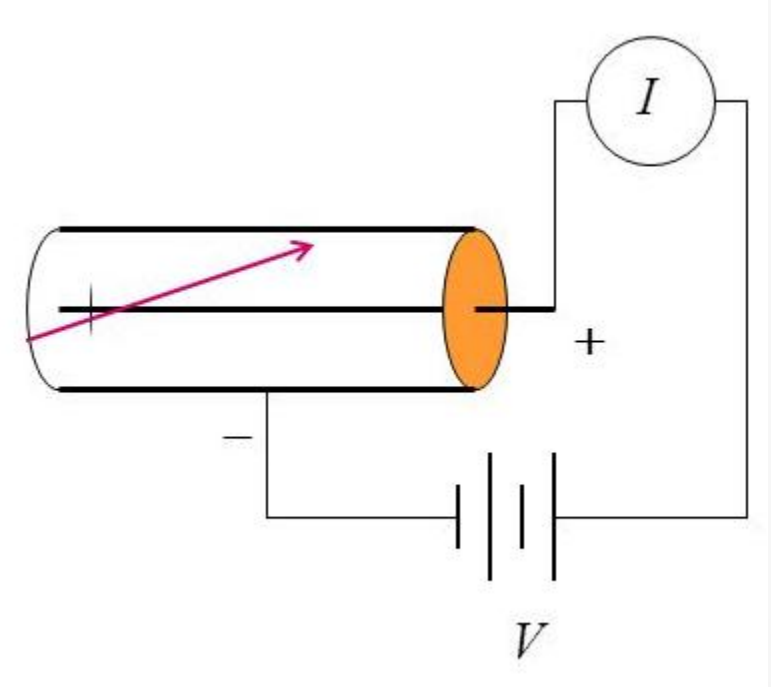
- The most commonly used proportional counters are cylindrical in shape.
- The cylinder is made up of metal, which acts as a cathode
- In the centre of the cylindrical cathode, a straight conducting wire, which is insulated from the outer cylinder, acts as anode.
- Usually a mixture of gases is used containing gases like neon, argon, krypton, etc. which favor high amplification and a complex gas like carbon dioxide, methane, pentane etc., which helps in stopping the phenomenon of secondary ionization. Common proportional counters used in the laboratories contain a mixture of about 90% argon and 10% methane.
- The total gas pressure in the tube is generally less than one atmosphere.
- A thin glass, mica or polymer window (~10 μm) isolates the gases present in the proportional counter from the atmosphere.

Operation of Proportional Counter

- A high voltage (V) applied to anode is so adjusted that the tube operates in the proportional region
- For cylindrical geometry, the strength of electric field at a radial distance r from the central wire is given by $E(r) = \frac{V}{r \log\left(\frac{b}{a}\right)}$

where a and b are the radii of the central wire and the inner radius of the cylinder, respectively.

- The electric field in the neighbourhood of anode wire is extremely high
- *Gas multiplication* sets in such a high electric field gradient



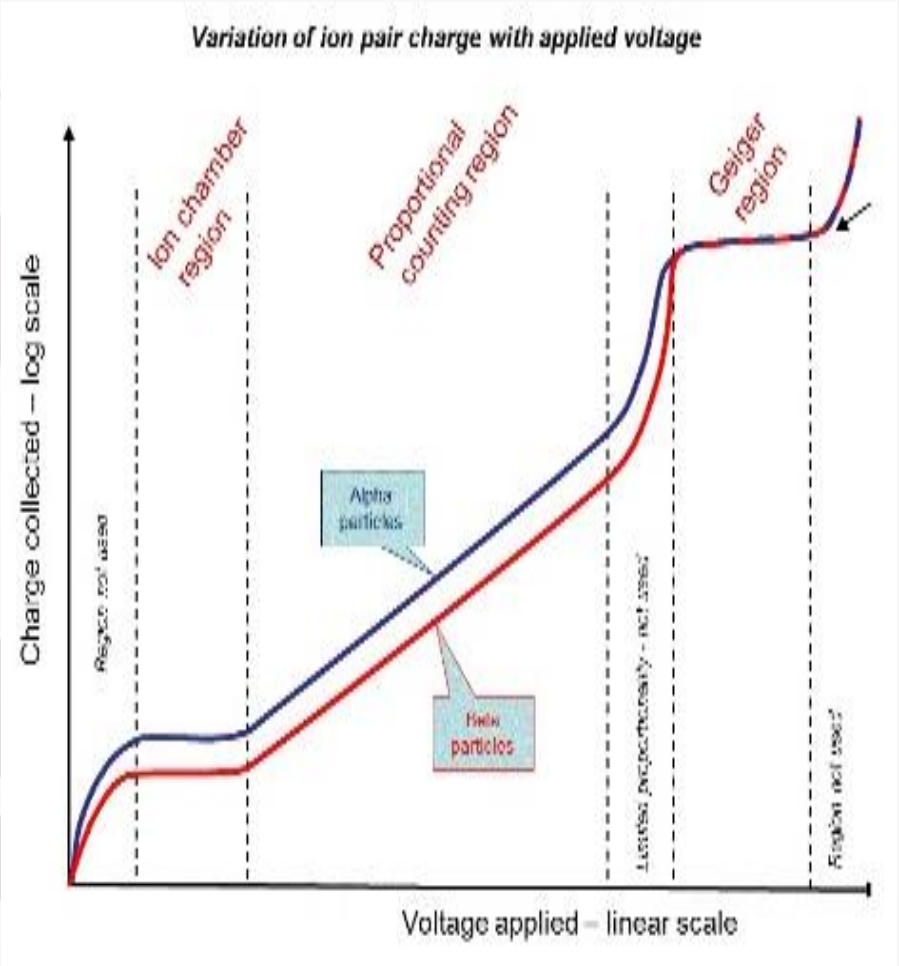
Operation of Proportional Counter

•Because of the increasing voltage, the electrons librated by the primary ionizing event get sufficient kinetic energy. These energetic electrons while moving towards the anode collide with neutral gas atoms, causing ionization of the neutral atoms.

•The electrons so produced may cause further ionization. This multiplication effect is often called a ***Townsend avalanche* or *Townsend cascade*.** The total number of ion-pairs produced by a single primary ion-pair is called the *gas multiplication factor*. This factor is unity in ionization chamber and is 10^2 to 10^4 in proportional counters.

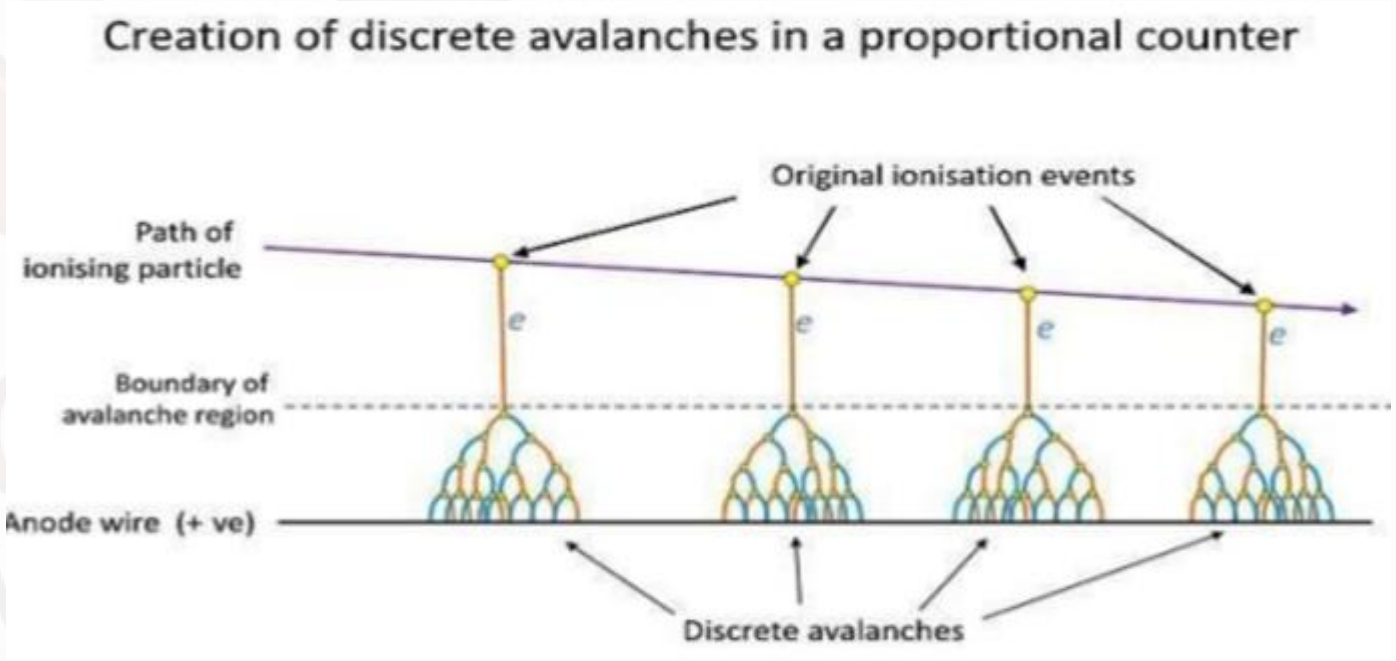
•At such a high field, the electrons acquire sufficiently high velocities. For example, if the field gradient is 10^4 V m^{-1}, the velocity of the electrons is approximately 4×10^4 m/s, electrons generated near the cathode take less than 1 μs to reach the anode.

•Thus, the proportional counter works at a much faster rate compared to the ionization chamber



Gas Amplification of Proportional Counter

In this multiplication or gas amplification, the number of ions increases exponentially, this process is cumulative and is called avalanche



Uses of Proportional Counter

1. It is used to detect the particles of low energy.
2. It has an excellent energy resolution at low energies and hence it is used widely for the energy analysis of X-rays and low energy gamma rays.
3. Large sized proportional counters are used to measure the low activity of radio samples.
4. It is used for counting α-particles in the presence of β-particles and γ-rays
5. They are also used for detection of neutrons, fission fragments etc.
6. It is also used to measure soft radiations as in case of β-rays, mesons and fast neutrons.

Disadvantages of Proportional Counter

Amplification factor depends upon the applied voltage and therefore this voltage must be maintained constant within narrow limits because a slight change in voltage changes the gas amlification

References

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2. Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill).
3. Introduction to nuclear and particle physics by V.K. Mittal, R.C verma, S.C. Gupta (PHI Learning Private Ltd.)
4. https://www.slideshare.net/Harishkumawat7/proportional-counter

Thank you