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Department of Biomedical Engineering

Course Name: 19BME301 – Medical Physics

III Year : V Semester

Unit IV –PRINCIPLES OF RADIATION DETECTOR

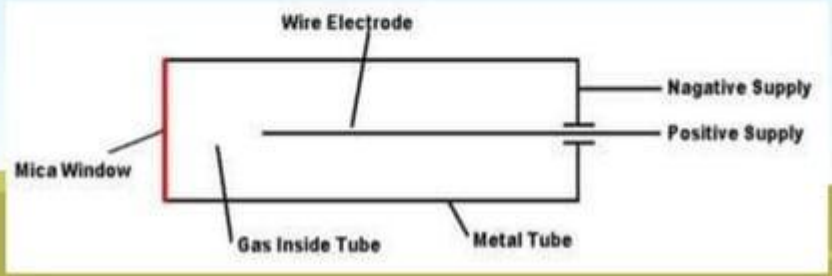
Introduction

- The **Geiger counter** is an instrument used for measuring **ionizing radiation** used widely in such applications as **radiation dosimeter**, **radiological protection**, **experimental physics** and **the nuclear industry**.
- It detects ionizing radiation such as **alpha particles**, **beta particles** and **gamma rays** using the ionization effect produced in a **Geiger–Müller tube**; which gives its name to the instrument.
- In wide and prominent use as a **hand-held radiation survey instrument**, it is perhaps one of the world's best-known radiation detection instruments.

- The original detection principle was discovered in 1908, but it was not until the development of the Geiger-Müller tube in 1928 that the Geiger-Müller counter became a practical instrument.
- Since then it has been very popular due to its robust sensing element and relatively low cost.
- However, there are limitations in measuring high radiation rates and the energy of incident radiation.

Basic components

- A Geiger counter consists of a Geiger-Müller tube, the sensing element which detects the radiation, and the processing electronics, which displays the result.
- The Geiger-Müller tube is filled with an inert gas such as **helium**, **neon**, or **argon** at low pressure, to which a high voltage typically 400-600 V is applied.

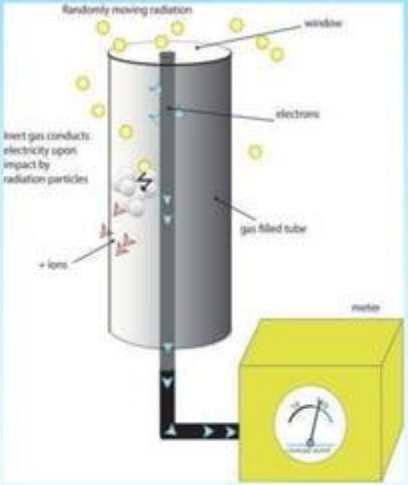


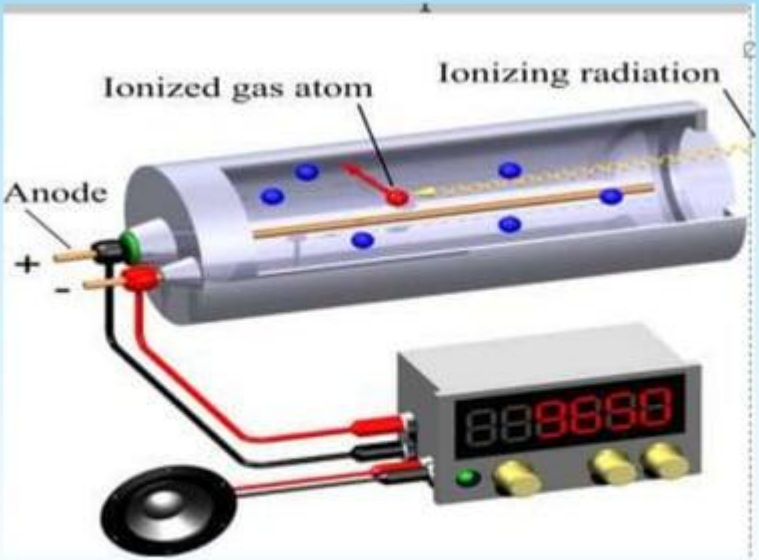
Principle of operation

1. When a single gamma or beta ray entering the tube, a small amount of ionization is produced.
2. The center electrode which is at high positive potential attracts the electrons and gives them energy to produce further ionization until the whole volume contains ion pairs.
3. The electrons are rapidly collected.

4. The voltage on the center electrode drops and the slow positive ions go to the outer wall.

5. After 400µsec (Dead time) the tube is ready to repeat the Process.




Ionized gas atom
Ionizing radiation
Anode
+
-

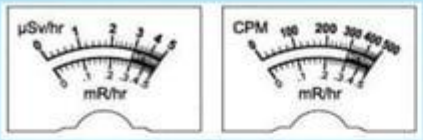
TOWNSEND DISCHARGE

- The Townsend discharge or Townsend avalanche is a gas ionization process where free electrons are accelerated by an electric field, collide with gas molecules, and consequently free additional electrons.
- Those electrons are in turn accelerated and free additional electrons.
- The result is an avalanche multiplication that permits electrical conduction through the gas.
- The discharge requires a source of free electrons and a significant electric field; without both, the phenomenon does not occur.

READ OUT

- There are two types of radiation readout;

- Counts :- The counts display is the simplest and is the number of ionizing events displayed either as a count rate, commonly "counts per second" , or as a total over a set time period (an integrated total).
- The counts readout is normally used when alpha or beta particles are being detected.
- Radiation Dose:- It is displayed in a unit such as the "Sievert" which is normally used for measuring gamma or X-ray dose rates.


µSv/hr
mR/hr
CPM
mR/hr


Count/Sec 5
mR/hr 00.260
Shown with Optional Acrylic Stand


TERRA-P
66.12 µSv/h

TYPES OF GEIGER–MULLER COUNTER

- Broadly, there are two main types of Geiger–Müller counter:

End Window Type: -

- For alpha particles, low energy beta particles, and low energy X-rays, the usual form is a cylindrical end-window tube.
- This type has a window at one end covered in a thin material through which low-penetrating radiation can easily pass.. The other end houses the electrical connection to the anode.

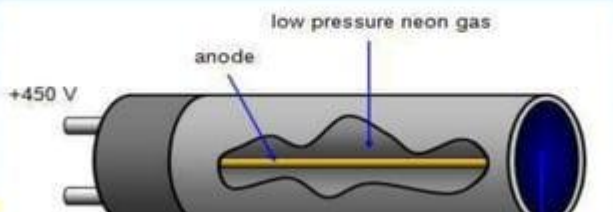


Figure 1

Pancake tube type: -

- The pancake tube is a variant of the end window tube, but which is designed for use for beta and gamma contamination monitoring. It has roughly the same sensitivity to particles as the end window type, but has a flat annular shape so the larges window area can be utilized with a minimum of gas space.

- The anode is normally multi-wired in concentric circles so it extends fully throughout the gas space.

Windowless Type:-

- This general type is distinct from the dedicated end window type, but has two main sub-types, which use different radiation interaction mechanisms to obtain a count.

1. Thick walled:

- Used for high energy gamma detection, this type generally has an overall wall thickness of about 1-2 mm of chrome steel. Because most high energy gamma photons will pass through the low density fill gas without interacting, the tube uses the interaction of photons on the molecules of the wall material to produce high energy secondary electrons within the wall.

Thin walled

Thin walled tubes are used for:

- High energy beta detection, where the beta enters via the side of the tube and interacts directly with the gas, Low energy gamma and X-ray detection.
- The lower energy photons interact better with the fill gas so this design concentrates on increasing the volume of the fill gas by using a long thin walled tube and does not use the interaction of photons in the tube wall.

Application

- To detect or estimate radioactivity in a tissue or organ *in situ*
- To detect radioactive emission from a biological sample
- To estimate or detect radioisotope in metabolites

Thank You