Lecture Notes of B.Sc.(HONS.) PHYSICS ,Part-II, Paper -IV

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TOPIC:------ G-M (Geiger -Muller) Counter

Introduction: When nuclear radiation passes through a gas enclosed between two electrodes, it ionises the gas molecules. If a potential difference is applied across the electrodes ,the positive ions moves towards the electron towards the positive electrodes. Thus pulses of electric current are produced which detects and measures the ionising radiation. Such detectors are called **'Gas filled detector'** and includes ionisation chamber, proportional counter and Geiger-Muller counter. Each one of them has its own condition of ionisation under which it can work. Let us consider the variations of ionisation current with the potential difference applied across the electrodes as shown in fig(1).The curve I corresponds to the ionisation current produced by a charged particle of lower energy; while the curve II corresponds to a particle of higher energy.

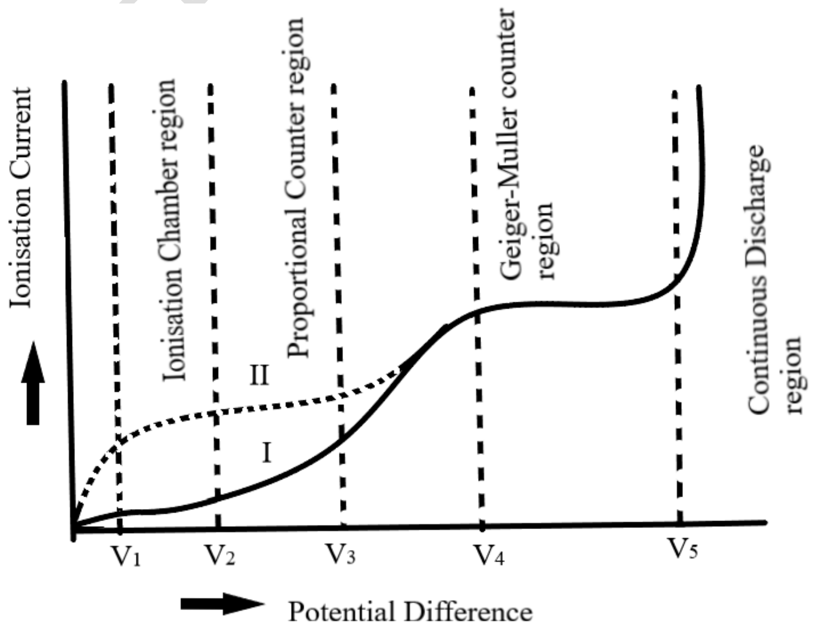

fig.(1)

G-M (Geiger -Muller) Counter: It is basically the combination of G-M tube and recorder.

<u>G-M Tube</u> : A Geiger-Muller tube is the most versatile and useful of the instrument s used for detecting and measuring the energies of $\alpha-, \beta-, \gamma-$, and X-rays.It is sufficiently sensitive to detect individual $\alpha-, and\ \beta$ particle.It is widely used in industry and medicines to locate radio isotopes, and in the laboratory for comparing the activities of radioactive specimen.

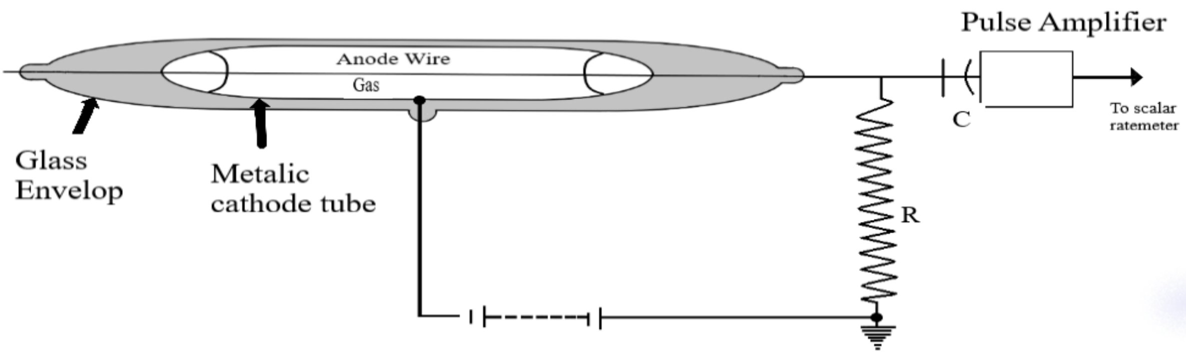

fig.(2)

One of the simple form of G-M tube is shown in fig(2).It consists of a metallic cylindrical cathode tube enclosed in a glass envelop. A fine tungsten wire anode is stretched along the axis of the tube. The rays to be detected enters the tube through the glass envelop**.**

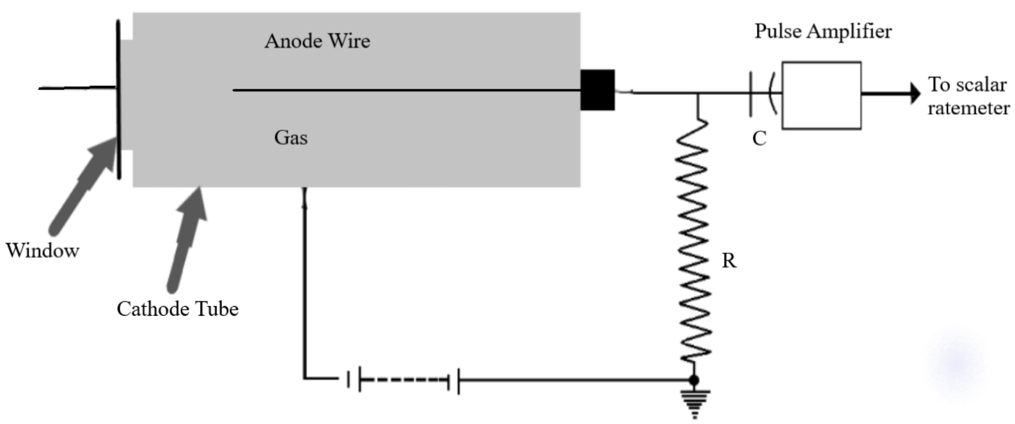

fig.(3)

A slightly different form of G-M tube is used for α-particle and the less energetic $\beta-$particles which are unable to penetrate the glass envelop. It is known as "$\boldsymbol{end-window\ G-M\ tube}$" and is shown in fig(3).In it the cylindrical cathode tube carries a thin mica window to let the particles enter. The wire anode instead of extending through the length of the tube, terminate in a point.

The tube contains a monoatomic gas such as argon and neon at a pressure of about 10 cm of mercury, together with a small trace of halogen such as chlorine or bromine. (The halogen acts as a quenching agent). A potential difference of several hundred volts is applied between the anode wire and cathode tube.

<u>Working:</u> When an ionising particle enters the G-M tube, it ionises some of the argon atoms, forming positive ions and free electrons. Because of the shape of the electrodes, the electrostatic field is radial and is very strong near the anode wire. Any free electrons in this region are rapidly accelerated to cause further ionisation. This process is cumulative, and a large **"avalanche"** of electrons is produced. Besides but ,some of the free electrons colliding argon atom merely excite them .The excited atom returns to their normal state emitting light photons. If a photon is absorbed by another excited atom, the atom is ionised by releasing more electrons which produces further avalanches. Since photons are unaffected by electric field, they can go in any direction. Hence avalanche spreads rapidly in entire volume of the tube and an amplification as high as 10^8 is reached. The total number of ions produced is now independent of the initial no. of ions formed by the entering particle. The electrons being very light, are collected at once, at the anode leaving behind a space charge due to massive, slow moving positive ions. In a short time around one microsecond, space charge becomes enough dense to cancel the electric field round the anode. The ionisation then stops. Therefore positive ions are drawn to the cathode and ionisation again starts. The period during which ionisation remains suspended is called **"Dead Time".** Thus, the entry of a single particle in the tube causes a pulse of current. The magnitude of this pulse is independent of the energy and nature of the ionising particle. The current pulse causes a corresponding voltage pulse across the resistance R in series with it. This voltage pulse is fed to a pulse amplifier through a capacitor

C. The amplified pulse is finally passed on either to a scalar or to a ratemeter. The scalar records the arrival of each pulse separately, and so gives the exact no. of particles entering the G-M Tube in a given time interval. The ratemeter records the no. of pulses in a given time.i.e.it gives the average rate at which the particles enter the tube. Because the magnitude of the pulse produces does not depend upon the

Self -quenching action of G-M tube: The G-M tube must produces a single pulse due to the entry of a single particle. It should not give any spurious pulses ,but should recover quickly to record the next entering particles. Unfortunately ,the positive argon ions which eventually strikes the cathode gain electrons from it and becomes neutral argon atoms which are left in an excited state. These excited atoms return to the normal state with the emission of photons, and these photons causes avalanches and hence spurious pulses.

These unwanted pulses are avoided by the use of polyatomic or diatomic gas, such as bromine, in the tube. The positive argon ions move slowly towards the cathode, collide many times with the bromine molecules and transfer their charge to them. Thus only neutral argon atoms reach the cathode. On the other hand, now bromine molecular ions reach the cathode where they gain electrons to become neutral bromine molecules in an excited state. However ,the excited bromine molecules lose their excitation energy by dissociation into bromine atoms, and not by photon emission, and thus no spurious pulses are produced. The bromine atoms recombine to form bromine molecules. Thus, bromine quenches the discharge ,and the tube is ready to receive the next particle within about 1/10000 th of a second.

Advantages of G-M counter:

1. Simple to build
2. Easily available

Disadvantages of G-M counter:

1. It has high dead time, hence cannot be used for high counting rate
2. It cannot distinguish between the energies of two different nuclear particles