Design and Contemporary Applications of the Geiger Counter

Hans Geiger first developed his device for detecting ionizing radiation in 1908. In 1928, based on suggestions from his colleague Walther Müller, he refined his design to create the Geiger-Müller tube, upon which most contemporary Geiger, or Geiger-Müller, counters are based.

The basic design consists of a metal tube, often with a glass or mica window at one end (see Figure 1). At the center of the tube runs a wire with a strong positive charge. The tube is sealed and filled at low pressure with an inert gas such as argon.

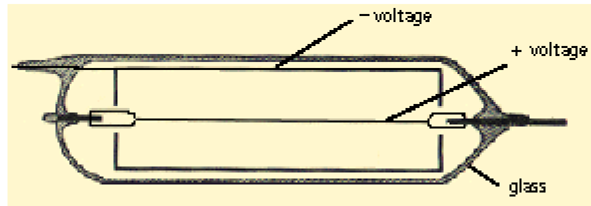

Figure 1: Diagram of a Geiger-Müller tube (NASA)

When an ionizing particle enters the device, it knocks electrons off atoms in the filler gas. An ionizing particle striking the outside of the tube can also knock electrons off the metal casing. In either case, these free electrons are attracted to the positively charged central wire, and gain energy by the attraction. As they approach the wire they knock electrons off other atoms, creating an avalanche or cascade effect (see Figure 2) which results in a pulse of current large enough to be detected. A "quenching gas" such as ethyl alcohol is usually added to the filler gas so that these avalanches cannot continue indefinitely, which would cause inaccuracy or electronic failure.

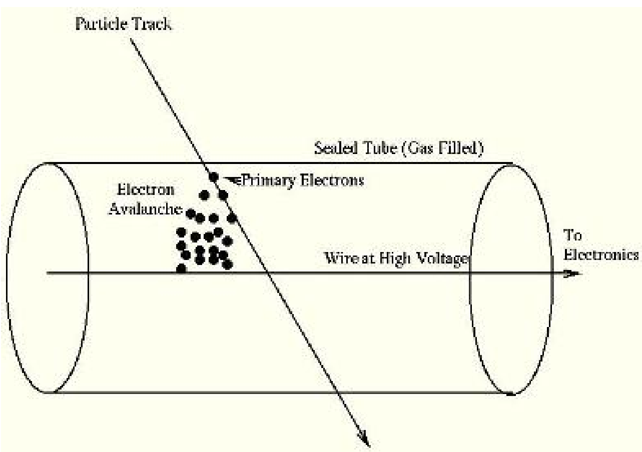

Figure 2: Electron avalanche effect (Boston University)

The Geiger counter can detect the pulses produced by ionizing particles because the metal casing of the Geiger-Müller tube acts as a cathode, with the central wire acting as an anode (see Figure 3). The anode transfers the pulses of current through a resistor, where they are converted to pulses of voltage.

The voltage pulses are then recorded by a counting device. Finally, an oscilloscope, LED screen, or other display conveys the particle count to the user.

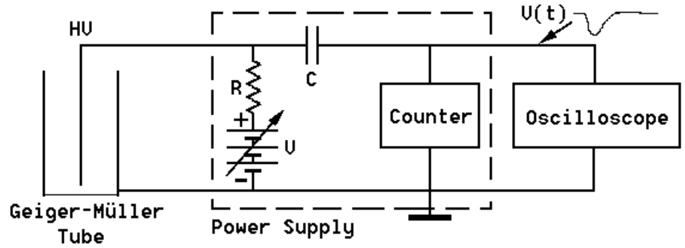

Figure 3: Basic circuit diagram of a Geiger counter (SUNY)

Geiger counters are capable of detecting alpha, beta, gamma, and x-radiation, although they cannot determine the type, energy, or vectors of the detected particles. The design of the specific counter determines how well it can detect the various types of radiation. For example, gamma and x-radiation can penetrate a metal casing without difficulty, but a glass or mica window is necessary to allow the low-penetration particles that comprise alpha and beta radiation to reach the inside of the detector. Other factors, including the gas used to fill the tube, also affect the efficiency of detection.

The most straightforward reading from a Geiger counter is simply the count of particles detected, or counts per minute (cpm). Conversion to other measures can be misleading, since various designs will detect more or less of any given type of radiation. Nevertheless, a well-constructed and well-calibrated Geiger counter can offer several standard units of measurement, with the understanding that the readings apply only to the types of radiation that particular model is able to accurately detect. The Sievert and the rem are the most common measures of radiation dosage, with 1 Sievert (Sv) equal to 100 rems (R). A rem can be further divided into 1,000 millirems (mR or mrem). The U.S. Nuclear Regulatory Commission (NRC) states that a person in an occupation not involving radioactive materials is exposed to 100 mrem per year of normal background radiation, and should avoid more than 100 additional mrem per year.

The Geiger counter is distinguished from the dosimeter in that a dosimeter is designed to measure the amount of radiation, of all types, absorbed in a certain amount of time. In simplest terms, a Geiger counter is used to detect radiation in an area or on an object, while a dosimeter is used to monitor radiation exposure to a person over an extended period of time. For example, laboratory technicians who work with radioactive materials use film-badge dosimeters, which are worn for weeks or months, then processed to show the amount of radiation absorbed during that time. If the dosimeters indicate that a laboratory's personnel are receiving unexpected levels of radiation, a Geiger counter would be used to pinpoint the specific source of the unintended radiation.

Modern Geiger counters are compact (see Figures 6 and 7) and can range in price from $150 to over $1,000. Their uses include the following:

- assisting in the identification of certain minerals, such as uraninite
- examining irradiated gemstones for residual radiation
- detecting residual radiation on metals that have been used in mining or oil drilling
- checking for leaks in the shielding of x-ray equipment
- measuring the residual radioactivity of a patient undergoing radiation therapy
- assessing the safety of an area that has been exposed to a nuclear bomb or nuclear accident

Figure 4: 1932 counter made by Hans Geiger (Science and Society Picture Library)

Figure 5: 1946 Victoreen model X-263 Geiger counter (ORAU)

Figure 6: Medcom® Geiger counter

Figure 7: Mineralab® counter with probe

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