CHAPTER 1

INTRODUCTION

Applications of nuclear measurement in engineering and agriculture to date deal with gauging in density, thickness, level control and moisture content. The measurement is based on interaction of nuclear particles with matters and appropriate counting systems. Nuclear radiation in one form or another is released from radioactive decay processes and nuclear reactions. The common nuclear radiations in radiogauging are α, β particles, γ-and x-rays and neutron $({}_0n^1)$. All of them have different properties with respect to interactions with matters rendering them to be insight of many possible applications in radiogauging industry.

1.1 Radiogauging Techniques

Technique that uses radiation or emitted nuclear particles for measurement of particular properties of a system is called "radio gauging." There are two types of principle of gauges [1] :

a. transmission type

b. backscattering type

1.1.1 Transmission type

This type of measurement findswide application in sheet thickness control. The sample is placed between source and detector.

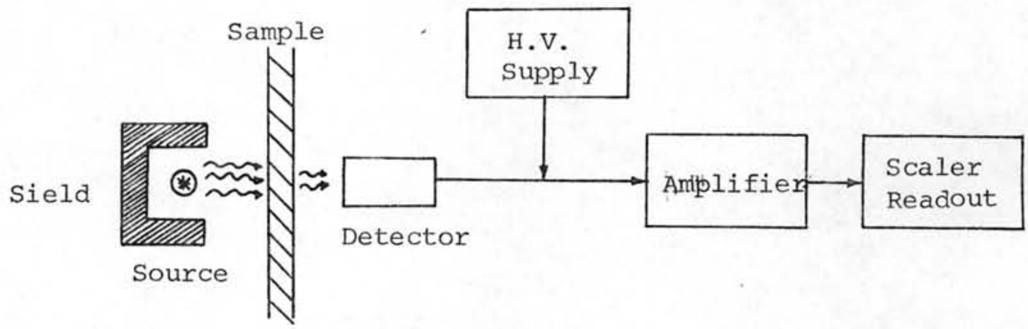

Fig 1.1 Schematic diagram of a transmission type

In the simple transmission gauge shown in Fig. 1.1, the response would be represented by expression

$$R = R_0 e^{-\mu x} \qquad \text{................(1.1)}$$

where R = the counting rate with the absorbing matterial between the source and detector

R_0 = the counting rate with no absorbing material present

μ = the absorption coefficient of the absorbing material

x = the density thickness of the absorbing matterial

This equation can be solved for x to give

$$x = \frac{1}{\mu} \ln \frac{R_0}{R} \qquad \text{................(1.2)}$$

which would give the density thickness of unknown for the corresponding instrument reading R_0 and R. However, this implies a precise knowledge of absorption coefficient. In practice, it is more common to obtain a calibration curve of response versus known density thickness of the material.

1.1.2 Backscattering type

This type of radioguage system is useful in determining sheet thickness and coating thickness on sheet material.

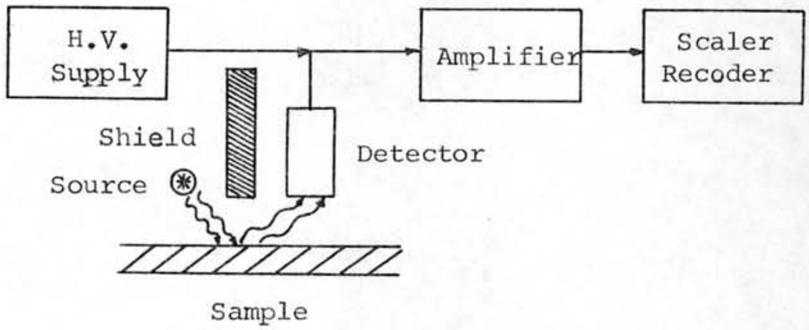

Fig.1.2 Schematic diagram of backscattering type

The relative amount of backscattering of a laboratory sample as a function of source-backing thickness, the amount of backscattering at first increases rapidly with increasing backing thickness and then level off to a constant value when the saturation thickness, is approached. This response curve can be fitted to a relation of the form

$$R = R_S(1 - e^{-kx}) + R_0 \qquad \text{..............(1.3)}$$

where R_S = Saturation response for an infinite sheet thickness

k = an empirical constant (cm^2/mg)

x = sheet thickness (mg/cm^2)

R_0 = response for no sheet thickness

with $R_0 = 0$, eq. 1.3 is put in the form

$$-kx = \ln(1 - R/R_S) \quad \ldots\ldots\ldots\ldots\ldots(1.4)$$

1.2 Measurement in radioguaging

The physical process based on the interactions of α-and β-particles, electromagnetic radiations and neutron are used in radioistope intruments to measure thickness, density and moisture content. In general, thickness is measured by transmission of α-and β particles as well as electromagnetic radiation and also by backscattering of β-particles and electromagnetic radiation.

Density is measured both by β-and electromagnetic radiation transmission techniques, and by backscattering of electromagnetic radiation.

Moisture guage to measure water (hydrogen) content is based on the measurement of flux of moderated neutrons from an isotopic neutron source.

1.3 Portable radiogauging instrument.

The portable radioisotope instrument for radiogauging consists of the followings :

1. radioisotope source.
2. radiation detection system.
3. portable scaler unit.

One of the typical portable radiogauging instrument is schematically illustrated in Fig. 1.3.

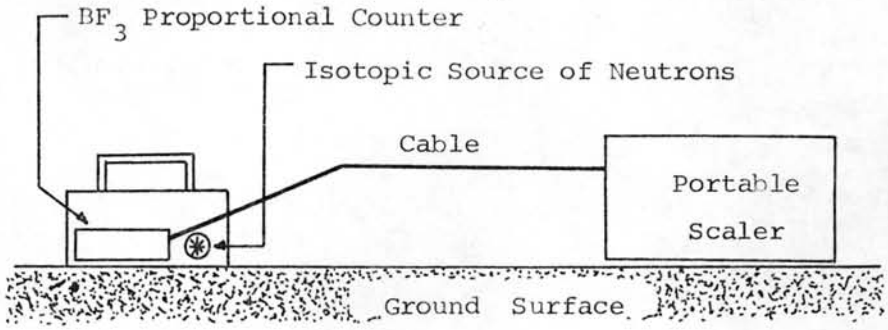

Fig. 1.3 Schematic diagram of surface neutron guage for measuring the water content of soil

1.3.1 Radiation detection system

The most important part in nuclear measurement is the detection system or simply called detector. All detectors work on the principle of energy to charge (electron) conversion. Since neutrons do not interact directly with electrons, it is customary to use one of several neutron reactions that provide secondary charged particle that will, in turn, interact with electrons.

In gas filled detector the interaction produces ionization of the gas. If a voltage is impressed across two electrodes, positive ions move towards cathode and negative ions electrons move to anode; thus a measurable current flow is produced.

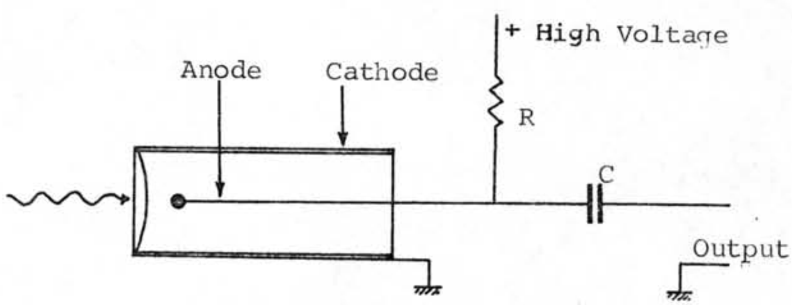

Fig. 1.4 The connection system of gas filled detector

In crystal scintillation detector the electrons that have been raised to a conduction band by ionizing radiation move about for a tiny fraction of a second, give up some of their energy in inelastic collisions, and then drop back into the lower energy valence band and the excessive energy is released and converted to light, and a scintillation occurs. A Photomultiplier tube (PMT) is used to absorb this scintillation and convert it to an electrical signal.

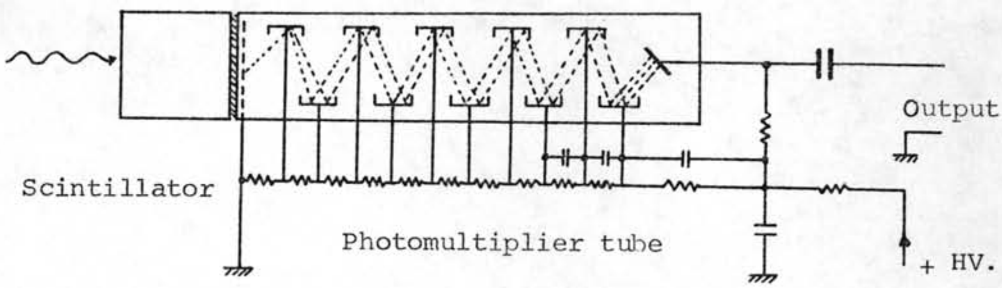

Fig. 1.5 The connection system of scintillation detector

1.3.2 Portable scaler units

A portable scaler is an electronic equipment for radiation-counting system. This instrument consists of four main parts:

1. Adjustable high voltage supply providing suitable operating voltage for detector in operation.

2. Pulse amplifier to amplify electrical signals which are produced from the radiation detection system.

3. Discriminator to discriminate unwanted signals that give rise to interference in radiation counting.

4. Counter and Timer for the accumulation of counting data and displays during a preset time in the timer .

The Basic diagram of a portable scaler is shown in Fig. 1.6.

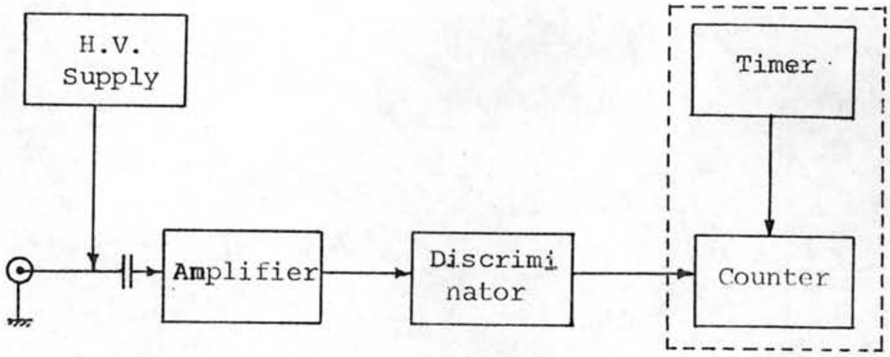

Fig. 1.6 **Basic** diagram of a portable scaler

An ideal portable scale for field use is characterized by : small dimensions, light weight, low cost, low power consumption and easy to be moved from one place to another. These requirements can be achieved by using the low power integrated circuits (ICs.), small size electronic components and batteries available locally.

1.4 Some properties of low power ICs.

CMOS. (Complementary-Metal-Oxide-Silicon) a new family of linear and logic integrated circuits, has some very important advantages over older IC families. It consumes very low power, noncritical power needs, good noise performance, low cost and it uses zero power when the inputs are not changing. CMOS are surface effect devices the operation of which are rather sensitive to nuclear radiation. However, their radiation resistance is improved through gate oxidation, P-tub surface concentration and metalization of the substrate. [2,3]

So, to day, CMOS. often ends up to the top choice for many electronic system, particularly if low cost, portabily, low power supply and good noise perfomance are important.