INTRODUCTION

General:

When a substance absorbs energy in some form or other, a fraction of the absorbed energy may be re-emitted in the form of electromagnetic radiation in the visible or near-visible region of the spectrum. This phenomena is called luminescence. Luminescence is a process which involves at least two steps : the excitation of the electronic system of the phosphor and the subsequent emission of photons. These steps may or may not be separated by intermediate processes. Excitation may be achieved by bombardment with photons (photoluminescence), with electrons (cathodoluminescence), or with other particles. Luminescence can also be induced as the result of a chemical reaction (chemiluminescence) or by the application of electric field (electroluminescence).

An important distinction is made between two major luminescent processes, fluorescence and phosphorescence[(1)]. The term fluorescence was suggested in 1852 by G. Stokes, who derived it from "fluor - spar", a fluorescent mineral (calcium fluoride)[(2)]. Emission of radiation by fluorescence practically stops about 10^{-8} sec- the average life of excited molecule - after irradiation by the exciting radiation. However, certain substances remain in metastable excited states for much longer periods, perhaps up to several hours or even weeks, and radiation is then re-emitted by phosphorescence. Both fluorescence and phosphorescence are designated by the general term of luminescence.

I- Scintillations:

When the particle impinges on certain liquid or solid materials known as phosphors, part of the energy dissipated in molecular excitation and ionization is re-emitted as visible or ultraviolet photons[(1)]. The observation and measurement of the light "flashes" or scintillations produced in phosphors by individual ionizing particles is the basis of the scintillation counter instrument. Initially the scintillations were only observed visually, but in the modern instrument they are observed and converted into voltage pulses by photomultiplier tube. In a related type of instrument, the recent scintillation Geiger counter, the scintillations are used to trigger a photosensitive Geiger-Müller tube.

II- Luminescent materials:

Scintillators are of two general types[(3)]. Organic phosphors, such as large crystals of anthracene or stilbene, are primarily useful for the measurement of B-radiation. The other type is the inorganic phosphors, large transparent crystals of salts containing heavy elements are most useful for γ-rays. An important group among them are organic compounds, either as pure crystals or in various combinations as liquid or solid solutions[4]. The applied luminescent material must be characterised by the following[5]:

(1) The luminescent material must have a high efficiency for conversion of the energy of the incident radiation or particles into that of the emitted luminescence.

(2) The spectrum of the emitted light must match as closely as possible the spectral responce of the cathode of the photomultiplier tube with which it is used. It is desirable that the photocathode spectral response should lie in the blue-violet or ultraviolet regions since responce to the red is linked with a high value of the thermionic emission of the chathode.

(3) It is essential that the luminescent materials should be transparent to their own luminescence emission.

(4) It is desirable that the luminescent substance can be obtained as a large optically homogeneous mass, either as a single crystal without flaws, or in solution (solid or liquid). It should also be possible to mould or machine the material to any convenient shape.

(5) An important quantity is the refractive index of the luminescent solid or liquid. In case of many inorganic

phosphors used in counters the value of the index is rather high (about 2) and difficulty is experienced in getting the emitted light out of the solid.

(6) The material should have a high stopping power for the radiation to be detected. This involves not only consideration of its density but also of the particular mechanism of energy conversion. For example, hydrogenous materials are more favourable when fast neutrons are to be detected[6].

(7) One of the most important factors in the choice of a luminescent material for counting is the rise and decay of the luminescence during and after excitations. It is desirable that both rise and decay should occur in as short a time as possible.

(8) The luminescent detector must be as stable as possible both under the conditions of the experiment, that is, particular atmosphere or vacuum conditions, and also under prolonged exposure to the radiation being detected.

III. Scintillation counters:

A typical scintillation counter tube can be discriped shortly, as shown in Fig. (1). A block of fluorescent material is mounted on the flat end of a special photomultiplier tube and then enclosed in a thin-walled, light-tight aluminum shield. An incident ionizing particle of