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THE TECHNOLOGICAL PRODUCTION OF PORTABLE NUCLEAR RADIATION METERS

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ABSTRACT

The study explains the design considerations of Gieger-Muller Tube (GMT). The results obtained from the designed GMT in the laboratory under different conditions is given together with a discussion of the results. The puplication shows also the block diagram of some proposed and designed nuclear radiation meters. It demonstrates also some measured data on the designed instruments that ensure the suitability and accuracy of these designed instruments for use in the nuclear radiation laboratories.

KEYWORDS

Radiatiom / Meters / Technological production / Portable meters / Nuclear Measurement.

INTRODUCTION

The proable nuclear radiation meters consist mainly from sensors and convertor. The sensors detect the nuclear radiation via producing electric pulses whose characteristics depend on the radiation paramaters. The convertors transfere the small DC voltage of small battery to high stabilized one for the operation of detectors that require high stabilized voltage. The majority of radiation meters utilize the GMT as a detector due to its high sensitivity.

GMT is very sensitive for ionizing radiation but it can not be used for measuring energy spectrum. It can measure also UV radiation [1,2]. It consists of thin electrode which is connected with the high positive potential and cathode in a glass tube. The dimensions of the electrodeand the tube as well as the pressure and type of filling gas depend on the trange of measurement in which the GMT will be used , the operating voltage and sensitive volume required for attaining certain required sensitivity of measurements.

The filling gas depends on the purpose of measurement. For measuring neutrons , BF_3 is required. For other types of radiations , Ar , Kr , Xe and He are usually used with a pressure in the order of 100 - 200 cm Hg. The quinching gas of partial pressure 5 - 10 cmHg.

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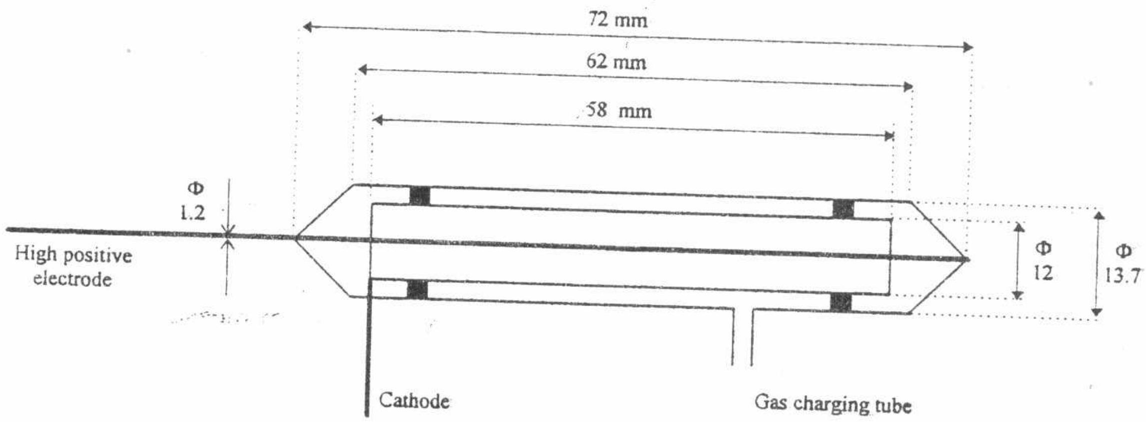
The quinching gas is either organic or inorganic. In organic gas quinching , the GMT has a finite life time of order 10^8 - 10^9 counts due to dissociation of organic molecules. In quenching with halogen , the regeneration process of molecules extends the life of counter but the plateau slope is higher than in case of organic quinching. The inorganic quinching gas is usually halogen (mostly bromine). The organic quinching gas is usually methane , or ethyl alcohol vapour [1,2,3].

The nuclear radiation interacts with the filling gas of the GMT producing ion pairs and excited molecules. In presence of high electric field , the electrons are attracted to the positive electrode and the positive species to the cathode. The electrons are accelerated by the high electric field and acquire enough energy that enables them to cause secondary ionizations. These secondary ionizations are very great near tha positive electrode. Therefore , avalanches are formed near the positive electrode. The electrons are collected rapidely , while the positive ions are still slower in the counter and form a positive sheath around the anode acting as an electrostatic screan. This screan reduces the electric field to such an extent that discharge should stop. When positive ions strike the cathode , their deexcitations take place producing electromagnetic radiation that produce ion pairs and consequently false pulsesare obtained. The role of quinching gas is to exhaust the excitation energy in decomposition of quinching gas and not to produce false pulses [1 - 5].

The number of pulses depend on the radiation level. These pulses do not have the same shape and this is a natural characteristic of GMT [4,5]. Typical values of dead times of GMT are from 10 - 300 μs . Correction of dead time effect must be performed [5]. For approximate measurements , these pulses are integrated directly by simple integration circuit which consists of capacitor paralelly connected with microameter and resistance. For accurate measurements , the pulses must be shaped before their integration.

EXPERIMENTAL PROCEDURE

The following GMT was designed and executed :

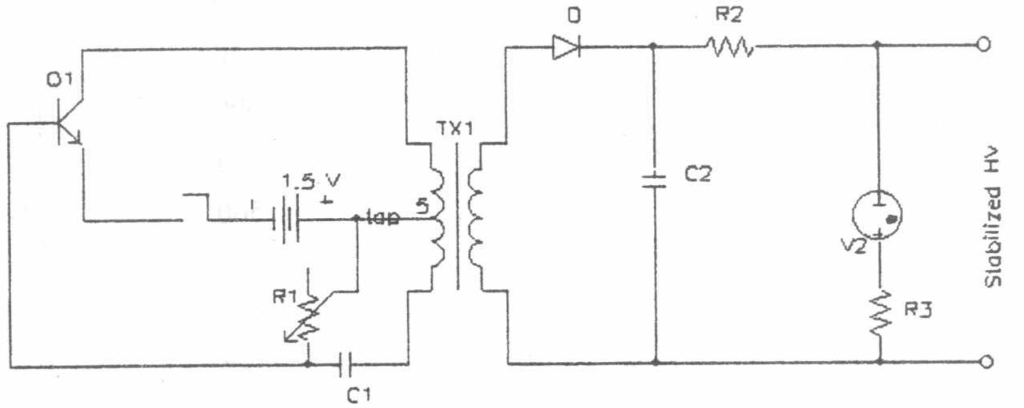


The designed GMT in the laboratory

The GMT was connected to gas circuit with evacuation. The gas circuit was filled with He or Ar gases at different pressures with and without quenching gases. The pressures of gases ranged from 10 - 1520 cm Hg and those of quenching gas ranged from 20 - 152 cm Hg. The GMT was connected to an electric circuit to determine its optimum operating voltage at each condition .

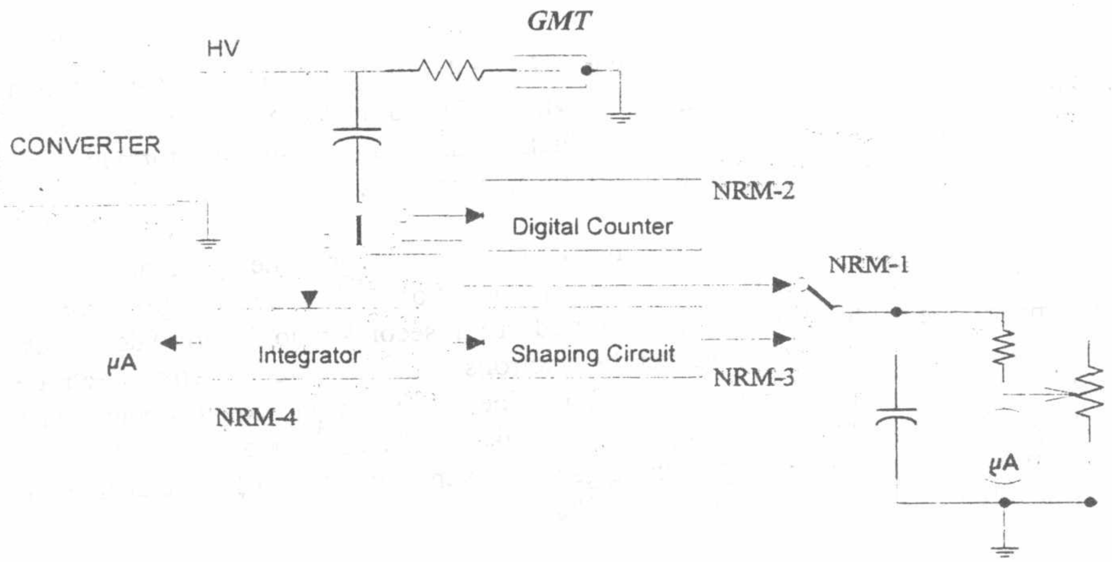
The required converter was designed and executed, to transfer the small DC voltage of small battery (1.5 - 3 volt) to the higher stabilized voltage required for the operation of the GMT (500 - 1000 volts). Its main idea is to transfer the DC current to AC one, and by transformer, the AC voltage can be raised to the required AC value by choosing the required ratio of number of windings of secondary coil to that of primary one.

Rectification of the obtained AC high voltage was performed by a rectifier. Filtration process was performed by a capacitor. Stabilization of voltage was made by corona stabilizer. The designed converter circuit is as follows:



The designed converter suitable for portable radiation meters and GMT

The designs of different radiation meters were performed and different types were made. The block diagram of these instruments can be represented simply as follows:



The block diagram of proposed and designed radiation meters

After the different radiation meters had been prepared, and checked for being sensitive for radiation,, the NRM-1 & NRM-2 were calibrated.

RESULTS AND DISCUSSION

The designed GMT was charged with He and Ar at different pressures. The corresponding operating voltages at each condition is shown in the following table:

Table (1) Pressure of charging gas and corresponding operating voltage of GMT

Pressure (cm Hg)	The corresponding operating voltage (volts)	
	in He	in Ar
10	425	420
135	475	460
260	600	490
385	655	495
510	680	500
635	760	510
760	790	540
1140	948	560
1520	1093	580

The results show that the operating voltages of GMT in case of charging with He are greater than those of charging the Ar at the same values of pressures . Also, when the charging pressure of the GMT increases, the operating voltage increases .

The decrease of ionization potential of Ar than that of He makes the ionization of Ar easier than that of He and this interprets why lower electric field will be needed in case of Ar for acceleration of electrons to produce secondary ionization (which is the main reason for formation of avalanches), As a result, a lower operating voltage will be susbected [7].

Results showed also that the increase of pressure inside the GMT increased the operating voltage. This is expected since at higher pressure, the collisions of electrons with the filling gas increase. As a result, the mean free path of electrons (emitted from secondary ionization) decreases. Therefore, Higher voltage is required to attract the electrons to the positive collecting electrode and hence, higher operating voltage is expected [3,6]. The same reason explains why higher operating voltage is required when quenching gas of higher molecular weight is added. The operating voltages of GMT in presence of quenching gas are given in the table (2). The quenching used gas was ethylalcohol vapour of partial pressure 10%.

Table(2) The operating voltages of GMT in presence of quenching gas

Pressure of ethyl alcohol (cm Hg)	Pressure of He or Ar (cm Hg)	Operating voltage (V)	
		in case of He	in case of Ar
20	180	1030	920
51	459	1160	1110
76	684	1320	1200
114	1026	1580	1300
152	1368	1640	1380

Larger volumes of GMT will require higher operating voltage and they are more sensitive since they have higher sensitive volumes [3,5,6]. Shortly, higher volumes, higher pressure of filling inert gas, lower radius of atoms of filling gas and existance of heavier quenching gas cause increase in required operating voltage of the designed GMT.

The work done in this study needs further development for the routine production of nuclear radiation meters. The calibration process was made for NRM-1 & NRM-2 using cobalt-60 source on the dose rate ranges : 1 - 100 mRad/h & 1 - 100 Rad/h by adjusting the meter at the value 40 and measuring at positions of 10 , 25 , 60 for each range. The errors in readings were less than 21 % compared with 30 % for the similar universal imported portable radiation meters. This result is a good base for the development of technological production of nuclear radiation meters.

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