

CHARACTERISTICS OF GEIGER-MÜLLER COUNTERS

L. N. HADLEY, Jr., Tonkawa

The construction of a Geiger-Muller counter which will operate satisfactorily over a long period of time still retains all the features of an empirical art. We will describe in brief here a method of constructing the counters, and discuss the operation of these counters when filled with various gases.

The tubes constructed for this work all had the same general design. The cylinders were flared at the ends, either by rolling them out with a lathe, or using a flaring tool. The flared ends were then turned down so that the cylinder would just fit into the glass tube used as an envelope. The cylinder was first cleaned and smoothed with fine emery cloth or steel wool, and then the connecting wire was brazed on. A brazed joint was used rather than solder so that the tube could withstand a high baking temperature. After the joint was made, it was necessary to remove the oxide coat formed by the intense heating, and this was done either by emery cloth or by washing in nitric acid.

The next step was to seal off one end of the glass tube, and round it. The exhaust tube to connect with the vacuum system, and a short side tube to contain the cylinder connection were then joined to the envelope, and the glass was carefully annealed, and after it had cooled, the cylinder was put into place and its electrode sealed in. The other end of the envelope was then drawn off to the proper length and rounded. In the case of the smaller counters, where 5 mil tungsten wire was used as the central wire, this wire was somewhat too small to permit the convenient sealing of glass beads to it for the purpose of sealing it into the counter tube. On this account, larger wires were used at the seals. The tungsten wires were centered as closely as possible by sight. This completed the construction of the tube. The next procedure was to clean and prepare the surface of the cylinder.

Probably the best procedure here is to wash the counter thoroughly with a strong base in order to remove grease films from the surface. Potassium hydroxide was used. The tube was then rinsed with distilled water, and washed with concentrated nitric acid. The acid solution was made continually weaker by the addition of distilled water until it was finally too weak to produce any noticeable action on the cylinder. After this, it was washed once more with potassium hydroxide to neutralize any acid remaining on the cylinder, and then thoroughly rinsed (about 10 times) with distilled water. After the water washing in the case of the copper tubes, the cylinder was left covered with a thin brown oxide coating. The tube was then dried, pumped out to a pressure of 10^{-6} mm. of Hg, filled with dry air, and tried. If a satisfactory plateau was not obtained, the tube was filled with dry air, and heated in an oven at from 300° C. to 400° C. for several hours. This formed a heavier brown coating of oxide on the surface of the copper.

With the tube in operation, if one plots number of counts per minute as ordinate against applied potential as abscissa, the curve obtained is indicative of the quality of the tube. A sharp initial rise followed by a plateau at a hundred volts is desired. A number of different filling gases were tried. Probably the most satisfactory one was hydrogen, from the standpoint of ease of production and purification. It gave very consistent

results in the counters in which it was used. Air and methane were also used successfully.

The effect of pressure on the characteristic curve of the counter was investigated. At pressures less than 30 mm. of Hg, the plateau practically disappears, while for pressures greater than 30 mm. of Hg, the length of the plateau increases with the potential. The threshold potential also increases with pressure, which is to be expected from the equations governing the electric field within the counter.

In order to determine the effect of water vapor on the operation of the counter, a small quantity of water was placed in a tube adjoining the counter, and surrounded with dry ice. At this temperature, the water vapor has a pressure of 5.6×10^{-4} mm. of Hg. The system was then pumped out, and dry hydrogen was admitted. The curve obtained was much the same as previous curves. When the carbon dioxide bath was replaced by an ice bath, raising the pressure of the water vapor to 4.5 mm. of Hg, the threshold potential began to climb steadily as the water vapor diffused through the hydrogen. It rose 300 volts in the course of several minutes, and then suddenly the potential across the tube dropped, showing that sufficient water vapor had collected on the inner walls of the envelope to appreciably lower the surface resistance of the glass. When carbon dioxide was replaced on the containing tube, and the system pumped out thoroughly, it resumed its former characteristic upon admitting a fresh quantity of hydrogen. The water vapor tube was then surrounded with an ice-salt mixture, fixing the temperature at about -20° C. The vapor pressure of water at this temperature is about 0.8 mm. of Hg. The counter became very unstable under this condition, although apparently sufficient water vapor did not collect on the walls of the glass to lower its resistance below the minimum necessary for the operation of the counter.