Counter tube type A
09025.11

Fig 1: Counter tube type A, Order No. 09025.11; alongside it the shield for the counter tube, Order No. 09019.00

1. PURPOSE AND DESCRIPTION

The counter tube type A (Fig. 1) is a self-quenching halogen counter tube for detecting α, β and γ radiation. Its long plateau (approx. 425 to 650 V) with only a gentle slope means that selection of the operating point is not critical for proper functioning; the same applies to mains voltage variations.

The counter tube itself (Fig. 2) which is mounted in an adaptor with a BNC socket has a thin metal casing *1* with wall thickness 0.3 mm, of about 40 mm length and 15 mm external diameter. The counter wire *3*, axially arranged inside the tube is insulated by one of the ends *2* and is led out to the exterior. The other end is sealed by a sheet of mica *4* a few µm thick, constituting the counter tube window; because of its sensitivity to mechanical stress this is protected by a plastic cap *5*. Outside the tube the counter wire is connected to the central conductor of the BNC socket, via a 10 MΩ resistance. The counter tube casing is connected to the outer conductor of the socket.

The counter tube casing is permeable to γ quanta and β particles with sufficient energy, with a probability of detection of about:

20% for an energy level of 0.73 MeV
60% for an energy level of 1.01 MeV
85% for an energy level of 1.37 MeV
95% for an energy level of 1.70 MeV

α particles and low-energy β particles unable to penetrate the casing are detected via the mica window (with the plastic cap removed). If their angle of deflection in a magnetic field is to be determined, the mica window can be fitted with an apertured shield (Order No. 09019.00).

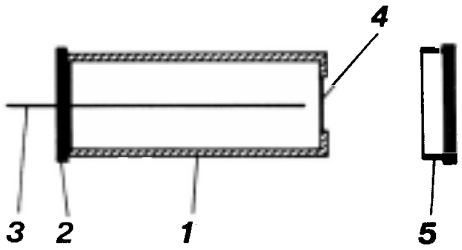


Fig. 2: Counter tube, schematic diagram for parts identification see text

2. PRINCIPLE OF OPERATION

To operate the counter tube the counter wire is connected to a voltage via a suitable working resistance; generally speaking this is positive with respect to that of the casing. For the type A tube, if the voltage is some 425 to 650 V it will be operating in the emission region (Geiger-Muller counter), i.e. every ionising particle entering the tube will, regardless of the primary ionisation level, cause a discharge pulse of practically constant magnitude. The halogen component of the filling gas ensures that the discharge is automatically cut off (self-quenching counter tube). As a result of the discharge pulse the voltage between wire and casing is briefly reduced. This generates a (negative) voltage pulse

at the working resistance which can be picked up from a coupling condenser and passed to an electronic amplifying circuit. The basic circuit diagram for connecting the counter tube to counting apparatus is shown in Fig. 3.

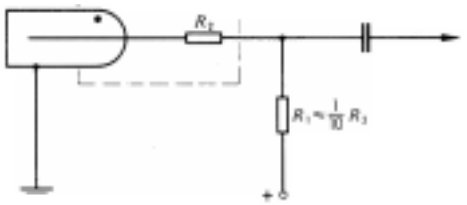


Fig. 3: Basic circuit diagram

The portion R_2 = 10 MΩ of the working resistance is embodied in the type A counter tube adaptor; condenser and resistance R_1 are among the items in the equipment list.

After every pulse, for a short time (dead time) the counter tube is insensitive to further ionising radiation.

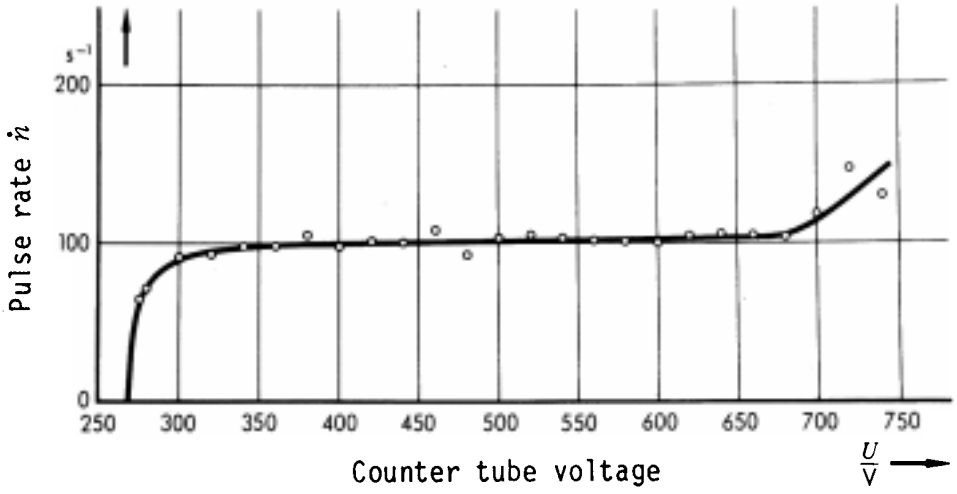
However, the resolution time of the counting apparatus is longer than the dead time of the tube, because the discharge pulses which the latter is able to deliver immediately following the dead time are below the response threshold of the counting apparatus.

The time interval from initiation of the pulse to return to operating level (achievement of maximum pulse amplitude) is called recovery time; it is somewhat longer than the resolution time.

Apart from depending on the choice of operating point for the counter tube, resolution and recovery times depend on the characteristics of the counting apparatus. For comparative measurements, therefore, such as the determination of the range of a particular form of radiation, there must be no variation of these parameters.

For practical use, knowledge of the counter tube's characteristics is important. This gives the pulse rate, i.e. the number of pulses measured per unit time, as a function of the tube voltage if the (mean) number of ionising particles entering the tube remains constant (cf. Fig. 4).

Fig. 4 Counter tube characteristics obtained from a type A tube



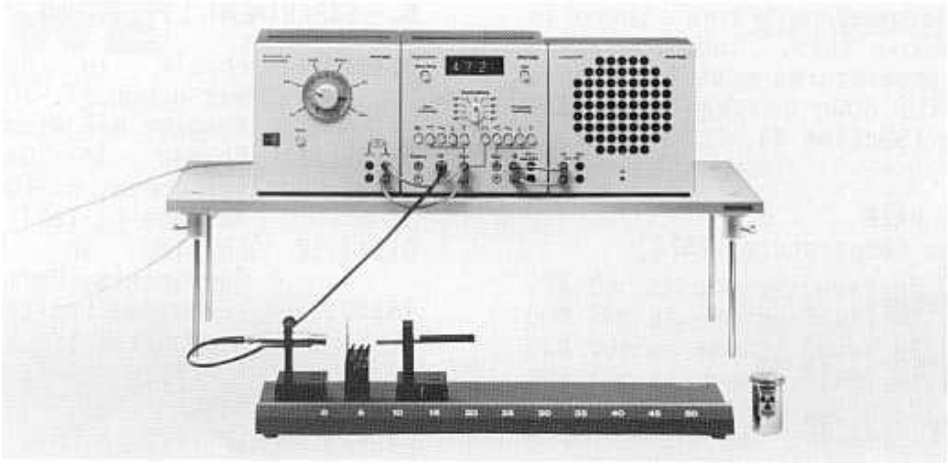


Fig. 5: Experiment set-up for determination of absorption and range of radioactive emission

The characteristics show that the tube starts counting pulses only after a certain threshold voltage has been reached - 275 to 325 V for a type A tube. They also show that over a certain voltage range, (the "plateau"), the number of pulses measured is practically independent of the voltage applied. To eliminate any influence on the count by voltage variations, the operating voltage chosen for the tube will therefore be in the centre of the plateau, i.e. around 500 V. At voltages beyond the upper end of the plateau the pulse rate increases steeply, ending in a continuous discharge known as "flashover" or "breakdown" of the tube. In this condition the tube is useless for measurement purposes. Operation of a tube at voltages beyond the upper end of its plateau is therefore to be avoided.

Different specimens of a given type of counter tube may have different characteristics, so these may have to be determined by experiment. A tube may also experience a change of characteristics over a long period of use. It is then worthwhile to redetermine them and reselect the operating point.

Even if there is no radioactive substance in the vicinity, a counter tube ready for operation will deliver a certain number of pulses, mainly due to cosmic radiation. This additional pulse rate is called the natural background of the tube.

3. OPERATION

To operate it, the counter tube is connected by means of a BNC cable to the counter tube input socket of the counting apparatus. For suitable apparatus, with operating voltage for the tube made available internally at the counter tube input socket, see the equipment list. Information concerning operation of this apparatus is available in the appropriate operating instructions.

To ensure secure mounting in the experiment set-up, the use of the demonstration set of equipment for nuclear physics (Order No. 09053.88) is recommended. Magnetic feet allow experiment set-ups to be arranged with ease on its base. The counter tube with its adaptor (d = 22 mm) is fixed in its holder. A specimen experiment set-up is shown in Fig. 5.

The counter tube may be operated in any position. It must be kept clean and dry. External air pressure should not be less than 320 mbar and should not exceed normal atmospheric values; any pressure changes must be effected slowly. Shock and major mechanical stress is to be avoided, especially as regards the very thin mica window which must not be touched under any circumstances. It is therefore covered by a plastic cap whenever the tube is not in use (see Section 1); for measurement of

γ and high-energy β radiation there is no need to remove this. Tube operating and storage temperatures must lie within the limits laid down in the "Technical Data" Section (Section 4).

4. TECHNICAL DATA

(Valid at room temperature, 25°C)

External diameter	
without adaptor	15 mm
with adaptor	22 mm
Type	Emitting counter tube, self-quenching
Quenching substance	Neon-argon-halogen mixture
Casing	Chrome-iron
Casing weight per unit area	250 mg/cm^2
Inner diameter	14.4 mm
Length	40 mm
Usable diameter of mica window	9 mm
Mica window weight per unit area	2 to 3 mg/cm^2
Capacitance	approx. 2 pF
Types of radiation	α, β, γ
Threshold voltage	approx. 275 to 325 V
Plateau	approx. 425 to 650 V
Operating voltage	within the plateau range, e.g. 500 V
Plateau slope	approx. 1%/100 V
Dead time	approx. 100 μs ± 15%
Natural background (without lead screening)	approx. 15 Imp./min.
Operating temperature	-55 to +75°C
Working ife	approx. 5 10^{10} Imp.

5. EXPERIMENT LITERATURE

01141.71	Physik in Demonstrationsversuchen, 7.-10. Schuljahr, Ausgabe A/B Atomphysik
01146.11	Physik in Demonstrationsversuchen, 5.-10. Schuljahr, Ausgabe C, Teil 2
01146.12	Physics in Demonstration Eperiments, Part 2
16150.01	Versuchseinheiten Physik, Atomphysik 1

6. EQUIPMENT LIST

Listed below is equipment suitable for use in conjunction with the counter tube, together with order numbers. Information concerning the full set of equipment necessary for the various experimental objectives can be obtained from the experiment literature specified.

Order No.	Description
09025.11	Counter tube type A
09019.00	Shield for counter tube
07542.10	Shielded cable BNC, 30 cm
07542.11	Shielded cable BNC, 75 cm
07542.12	Shielded cable BNC, 150 cm
11747.93	Counter/timer, 3-dec., 220 V
11755.93	Counter/timer, 4-dec.,
11748.93	Counter/timer, 5-dec., together with
11745.93	Counting rate meter, 22 V AC
11750.93	Time switch with time preselector, 220 V
09053.88	Nuclear Physics demonstration set
09047.10	Radioactive sources, set of 4
09047.37	Radioisotope generator Cs-137/ Ba-137
09023.88	Absorption material for γ-rays
09024.03	Absorption material for β-rays