AN EVALUATION OF A NEW NEUTRON TUBE
(PHILIPS TYPE 18604)
FOR TOTAL BODY IN VIVO ACTIVATION ANALYSIS

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A 14 MeV neutron generator system with a new sealed tube (Philips 18604) was evaluated for total body in vivo neutron activation analysis (TBIVNAA). The neutron output, angular distribution, rise time, reproducibility of short irradiations and leakage of tritium were investigated. The 18604 tube meets all the requirements of TBIVNAA within its normal operating specification.

Introduction

Sealed tube neutron generators promise to provide a safe, compact, low-maintenance source of 14 MeV neutrons with high enough output for total body in vivo neutron activation analysis (TBIVNAA). This would encourage TBIVNAA installations on hospital premises promoting wider use of TBIVNAA studies. However the commercial development of sealed tube generators has not been primarily directed at TBIVNAA. In a new type of tube it is therefore necessary to test those parameters which are of specific importance in TBIVNAA. Such tests have been carried out on the Philips Neutron Tube type 18604 with particular reference to the requirements of the total body IN VIVO activation analysis facility IVANHOE.*

The neutron tube

The Philips type 18604 is a sealed off accelerating tube which uses the $^{3}\text{H}(d, n)^{4}\text{He}$ reaction to generate 14 MeV neutrons. A schematic diagram of the tube is shown in Fig. 1 and a photograph is reproduced in Fig. 2. The working gas is a mixture of stoichiometrically equal parts of deuterium and tritium. The gas mixture is ionized in a Penning ion source maintained at a high positive potential with respect to the target. The ionic mixture produced is accelerated towards the deuterated/tri-

*In Vivo Analysis of Human Organism Elements.
tiated titanium target where the above reaction takes place. A gas pressure regulating system is implemented which consists of an ion gauge and replenisher. By means of a heater filament the replenisher releases gas from storage in titanium at a rate controlled by the ion gauge pressure (or by the target current). The ion source is connected to the ionising and high tension supplies via a damping system as a restraint in case of high voltage breakdowns in the tube. The ion source and damping system are cooled by oil while the target and accelerating electrode are water-cooled.

Operating experience

All experiments were carried out using the same tube and were spread over a period of approximately eighteen months. In vivo neutron activation analysis usually calls for several short irradiations (2 or 3 minutes) per day which means that a tube must tolerate many on/off cycles for each milliamperehour of operation. The total operation in this mode was 102 mAh at 150 kV high tension during which an estimated 500 on/off cycles were performed.