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NEUTRON SOURCE FOR USE WITH A VARIABLE ENERGY CYCLOTRON

J. S. C. McKee

August 9, 1967

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Recent theoretical work on the three nucleon problem by Faddeev[1], Omnes[2], Sitenko and Kharcenko[3] and others, indicates that a solution to the problem may be expected in the not too distant future[4].

For this reason, there is a pressing need for accurate experimental data on the n-d system, involving both polarization and cross section measurements; and this article suggests a design for a neutron source suitable for use in either type of experiment. The source produces polarized neutrons from the $^{2}H(d,n)^{3}He$ reaction, with Q=3.266 MeV, and is intended for use with cyclotron beams of 10 MeV energy and upwards.

The principle source of contamination of such a neutron beam lies in the (d,n) reaction which will occur at the exit window of the gas target. This design seeks to minimize the problem.

It is well known that a suitable window material must possess the qualities of high mechanical strength, thermal conductivity and melting point; while being available in a form that is both uniform and hole free. The additional property for present purposes is that the exit window from the target be made from a material of high atomic number, in order to ensure a reasonably low neutron background in associated experiments.

Of the commonly used foil materials, Aluminum, Nickel, Molybdenum and Tantalum; only the latter can simultaneously satisfy all requirements. Dubbledam

and Walter[5] have shown that for 7 MeV deuterons a tantalum foil gives an order of magnitude fewer neutrons than a molybdenum foil of equal thickness, and sixteen times fewer than an equivalent foil of nickel. At 11 MeV[6] incident energy Livermore workers have also shown tantalum to be highly preferable to nickel in this respect.

The technical problem, however, with the heavier material is to keep the window thin enough to take advantage of the lower reaction cross section, while containing a suitable pressure of gas. Fortunately, the high tensile strength of tantalum suggests a method of doing this, and the resulting design is shown in Figure 1.

This figure shows a target suitable for use with cyclotron beams collimated to 1/4" diameter or less. The beam enters through a 1/2" diameter hole in the front wall over which a 2 mil. molybdenum window has been secured by an electron beam welding technique. The main body of the chamber comprises a 2" long hollow cylinder of 1/16" wall, machined from solid tantalum rod 1-5/8" in diameter and to which the front wall is electron welded. To the open end of this cylinder is further welded[7] a hemisphere of 4 mil. tantalum formed by a process already described in the literature, in another connection[8,9]. This hemisphere acts as an exit foil both for the neutron beam, and for the deuteron beam as it passes through the target. As there are no flanges on the chamber, the neutron beam can be taken off at any angle up to 90° with respect to the incident beam direction, making the target a suitable one with which to study the variation in neutron polarization with angle of emission. The cell can be operated at pressures in excess of 10 atm, and in conjunction with beams of 100 W dissipation when adequate provision is made to refrigerate and circulate the gas while under pressure. In addition, the high flux of 0° unpolarized neutrons can be used to

obtain high precision cross section data when used in conjunction with a suitable fast neutron spectrometer[10]. In this case the source pressure should be reduced to around one atmosphere in order to keep the energy spread of the resulting beam to within 2% at 10 MeV. All charged particles must, of course, be removed magnetically from the experimental area. It should be borne in mind that if tantalum is heated to a temperature of several hundred degrees centigrade by high beam currents, it may become transparent to hydrogen. Because of this, the provision for adequate cooling is regarded as a necessity.

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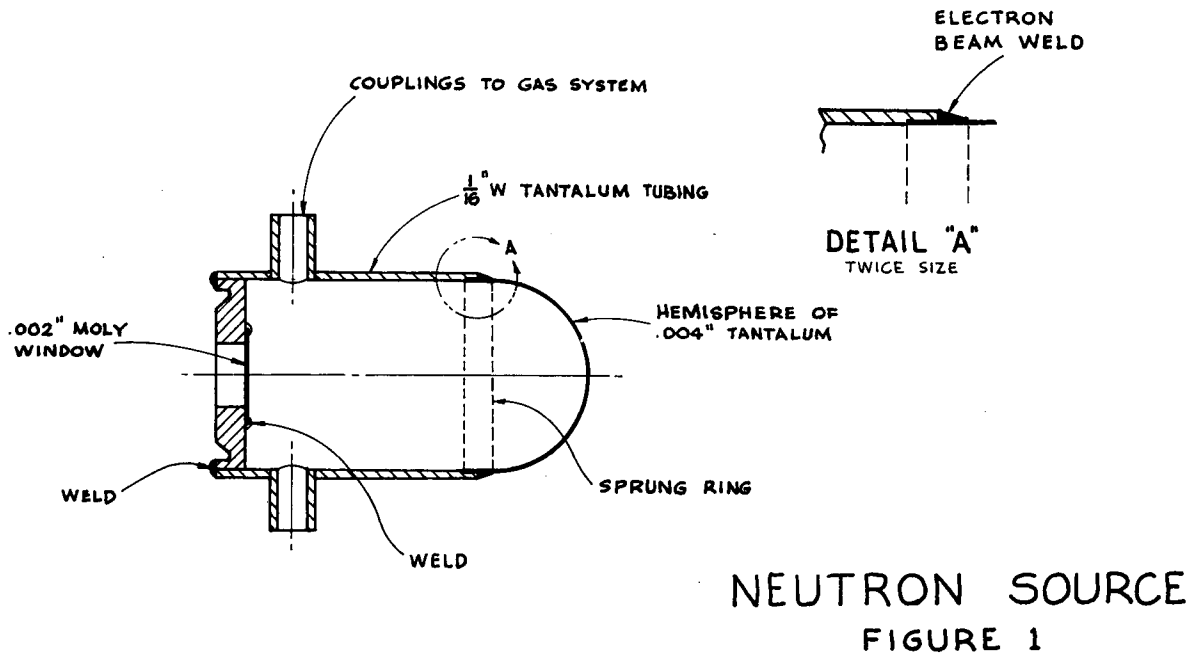

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Fig. 1. Schematic diagram of neutron source.

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