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SELF-SUPPORTED CYCLOTRON TARGETS OF BORON AND MAGNESIUM

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Self-Supported Cyclotron Targets of Boron and Magnesium

G. R. Hoke* and E. Newman

The advantage of self-supported thin targets in nuclear experimentation is obvious where good resolution with low energy particles is required. In heavy-ion experiments with triply-charged N^{14} ions produced by the 63-inch cyclotron at ORNL the target thickness is often a major factor in determining whether a particular reaction can be investigated. This is due to the use of a coincidence system[1] in which both the scattered and recoil particles are detected. The recoil nucleus is produced with very little energy at small angles in the center-of-mass system. A very thin target offers three distinct advantages: 1) the probability that all particles get out of the target is greatly enhanced, 2) the energy spread due to straggling within the target is reduced, and 3) the effect of plural and multiple scattering is decreased.

Because of the success achieved in routinely preparing self-supporting 25-100 $\mu g/cm^2$ carbon films, an attempt was made to produce targets of boron-10 and magnesium-24 of the same caliber. This note describes the method found to be most successful.

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Boron Targets

Of the various methods for the evaporation of boron which have been described[2,3], Safford's method[2] was most closely followed in this work. It was found necessary, however, to use a covered carbon boat both to reduce the radiation cooling of the boron and to prevent scattering of the material during the heating. A Veeco model VE-400 evaporator with water-cooled terminals was used. The boats were machined from 5/16-in. dia. spectroscopic grade carbon rods, as shown in Fig. 1. The cavity was packed with approximately 250 mg of amorphous boron (black powder). Pressure was maintained below 1×10^{-5} mm of Hg while the boat was being brought to temperature. Then, by passing a current of about 280 amp at 8 volts through the boat, a sufficiently high temperature was reached (white heat) to vaporize the boron. The progress of the evaporation was followed by observing the material as it heated in the boat. The boron remained darker than the boat until just before vaporization, then it became bright and quickly disappeared. The boron was evaporated onto 3 1/4 x 4-in. glass plates. The boats are useful for only two evaporations at most since the slot rapidly becomes clogged with boron carbide.

Many substrates have been used[4,5] for removing films collected on glass. Several of these methods were tried; the method found successful here was to float the boron off the plate with warm tap water. Prior to evaporation the plate was cleaned by washing in a Calgonite solution and rinsed with water. The plates were placed at an angle of about 20 deg to the horizontal and water was allowed to run in slowly. The floating film was then cut into appropriate sizes, and the

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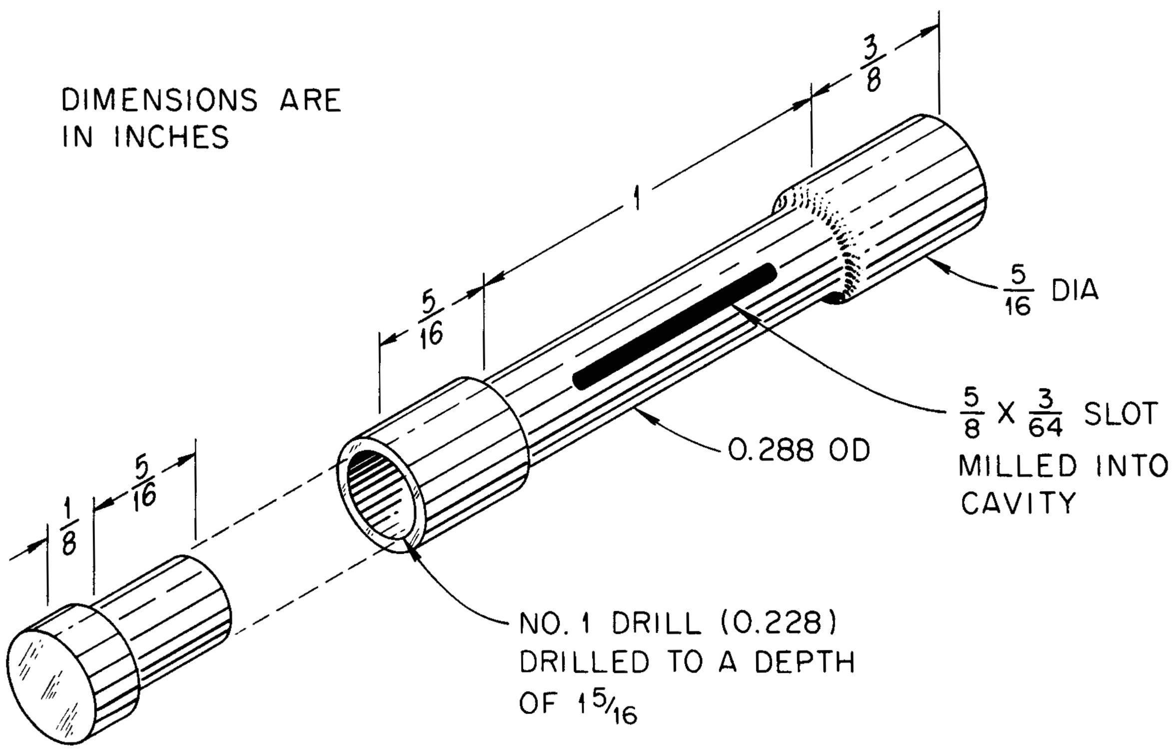

Figure 1 Spectroscopic grade carbon boat used for the evaporation of amorphous boron. The slot becomes clogged with boron carbide and the boat must be discarded after no more than two runs.

pieces were picked up on square target frames of aluminum 0.030 in. thick. Films of single thickness could be obtained with considerable difficulty and were quite fragile. Stronger double films, which proved to be much easier to make, were made by bringing the frame up in the middle of the film. The film then folded over the frame as it was raised and the two portions adhered to one another to form the target. As has been pointed out[4], breakage of films can be greatly reduced by adding a pinch of detergent, such as Calgonite, to the water to reduce surface tension just before the film is picked up, and also by stopping just before removing the frame from the water to allow trapped water to drain off. The double-thickness enriched B^{10} targets were between 50 and 100 $\mu g/cm^2$ thick.

Magnesium Targets

To prepare a target of isotopically enriched magnesium-24, the MgO source material must first be reduced. This may be accomplished prior to evaporation but a simple method has been reported by Russel, Taylor, and Cooper[6]. The oxide is placed on a tantalum boat in the evaporator and the temperature raised. At a temperature of 1200° C, well below the melting point, a shiny, essentially metallic, film appears on the collector. This is attributed to the reduction of MgO to form tantalum oxide and metallic magnesium. It should be pointed out that with this process there is the possibility of target contamination by oxygen and also by tantalum from the decomposition of Ta_2O_5 at 1470° C.

For the evaporation of magnesium, boats of 3-mil tantalum about 3/4-in. wide were used. The pressure was maintained below 2×10^{-5} mm of Hg, and the current was increased to about 100 amperes. The scattering of the MgO by violent outgassing can be minimized by increasing the current slowly over a period of 10 to 20 minutes so that the outgassing can occur quietly.

The magnesium was collected on glass plates. In this case, however, to remove the film from the glass the best procedure was as follows: the glass was coated with a weak soap solution (Calgonite) and allowed to dry before it was coated with about 5 to 10 $\mu g/cm^2$ of carbon from an arc by the method of Dearnaley[4]. One function of the carbon layer is to help keep the magnesium from making contact with the water; magnesium is slightly soluble in water and decomposes to form $Mg(OH)_2$. The carbon also helps hold the magnesium film together both while it is being removed from the glass and afterwards. After the magnesium was evaporated onto the glass the films were floated off in ordinary tap water, starting with warm water and then adding cold water to slow any reaction of the magnesium with the water due to pin holes in the carbon. The best foils were obtained when the steps described above were performed in immediate sequence. Single thickness films ranging from 30 to 80 $\mu g/cm^2$ were prepared in this way. To conserve the expensive source material, enriched Mg^{24}, a glass hood was constructed from lantern slide covers so that all of the collected material could be recovered.

The targets are being used in studies of transfer reactions in B^{10} and the elastic and inelastic scattering of N^{14} from Mg^{24}.

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