light of earlier observations in this laboratory on extruded uranium, it appeared that a substantial portion of the uranium could reach temperatures above the alpha-beta transus, thus undergoing beta treatment immediately subsequent to the extrusion. Such transformation as a result of heating during alpha working has been reported during rolling at 630° C [2]). The transformation is believed to be delayed until after the metal leaves the die and is no longer subject to the extrusion pressure which has raised the alpha-beta transus [†]. The consequent beta treatment can affect all of the extruded metal, which then acquires the typical structure of beta-treated uranium, with a random orientation but relatively coarse grains. It was also found that an interesting duplex structure could be obtained: the bulk of the rod acquired the beta-treated structure; it was surrounded by a rim of fine-grained, textured metal that apparently had not been heated sufficiently to undergo transformation into the beta phase. To extend the application of the method of achieving a suitable combination of minimum texture and minimum grain size, alloying with silicon (0.16 wt %) was also tried.

2. Materials and procedures

2.1. Materials

Two billet compositions were used in the extrusion experiments: unalloyed ingot uranium and a uranium-0.16 wt % silicon alloy. Most of the extrusions were made with the unalloyed uranium. Both billets were triple-beta-treated with a water quench to eliminate effects of prior working history.

2.2. Extrusion

The billets were enclosed in 16-gage (1.63 mm) copper cans, heated to the extrusion temperature and extruded from a 2.800″ (71 mm) dia. container through a die having a diameter in the range of 0.5″ to 0.9″ (12 to 23 mm). Details of the extrusion conditions are presented in table 1. Heating time for the billets was 3 h and temperatures were held to within ± 5° C.

2.3. Post-extrusion cooling

The copper-clad uranium rods went from the press into a steel catch tube, where they cooled in still air or in a water quench. Two types of water-quenching devices were used: 1. In one, the rods were exposed to water in the catch tube when they penetrated a rubber diaphragm at 10″ (254 mm) from the die. 2. In the other, the rods were sprayed with water as they left the die, starting at one inch from the die. The diaphragm device was used in the initial extrusions; the spray device, which gives a more drastic quench, was installed to reduce the grain size of the extruded rods.

2.4. Methods of evaluation

Short sections were cut from the extruded rods to obtain specimens for metallographic examination and X-ray diffraction studies of the uranium. The results listed in table 1 are for specimens from the mid-length of the rods; in a few rods, specimens were cut from the front and rear of the rod for comparison with the specimens from the middle.

2.4.1. *Metallographic examination*

The grain size and the general appearance of transverse sections from the rods were viewed at two magnifications. A magnification greater than 50× (micro) was used on specimens with grains smaller than 100 μm; a low magnification of 3× (macro) was used on specimens with grains larger than 100 μm.

2.4.2. *Crystallographic orientation*

Crystallographic orientation was determined by an X-ray diffraction technique in which the intensity of significant poles was measured relative to the intensity of the poles of a random sample. The crystallographic orientation is expressed in table 1 in terms of longitudinal growth index values (GI_L) [4]). The GI_L value is related to the expected positive or negative anisotropic growth in the longitudinal direction in nuclear irradiation; one unit of GI_L is equivalent to one percent dimensional change per 1000 ppm burn-up for ordinary beta-