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DOCUMENT NO.

HW-34368

DATE

January 3, 1955

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HANFORD ATOMIC PRODUCTS OPERATION – RICHLAND, WASHINGTON

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TITLE

GRAIN REFINEMENT PRODUCED BY AN ALPHA PHASE ANNEAL OF BETA PHASE HEAT TREATED AND WATER QUENCHED URANIUM

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Chief Declassification Branch

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January 3, 1955

GRAIN REFINEMENT PRODUCED BY AN ALPHA PHASE ANNEAL OF BETA PHASE HEAT TREATED AND WATER QUENCHED URANIUM

During an experiment involving alpha phase annealing (at 610 to 655 C for five and ten minutes) of beta-quenched* uranium, it was determined that the relatively coarse, irregular shaped grains (0.08 to 0.150 mm diameter) in the beta-quenched structure, ~~Figure 1B~~ were replaced by fine equiaxed grains (0.04-0.09 mm diameter), (cauth) ~~Figure 2C~~

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* Beta heat treated in a salt bath at 720-740 C for 13 minutes and water quenched within 30 seconds after removal from the bath.

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This experiment has since been duplicated several times and it was determined that two satisfactory conditions for the complete replacement of the coarse, beta-quenched grains in a Hanford rod or slug section are either 12 minutes at 650 C or 15 minutes at 640 C. In addition it has been determined that:(a) the extent of grain refinement obtained is dependent upon time and temperature, and proceeds from the periphery of an annealed section towards the center; (b) the grain refinement produced in beta-quenched uranium during annealing is not affected by the cooling rate from the alpha annealing temperature ; (c) the grain structure of beta heat treated and air cooled uranium is not affected by an alpha phase anneal at 640 C for 20 minutes, Figures 3 and 4; also, an alpha anneal at 640 C for 20 minutes produced no change in the grain structure of alpha rolled uranium; (d) there is no apparent growth of the equiaxed grains,once they are formed,for various times of annealing up to a maximum of one hour at 640 C.

The fact that alpha annealing of both beta heat treated and air cooled uranium and alpha rolled uranium produces no effect upon their grain structures indicates that water quenching from the beta phase imparts sufficient strain energy to the uranium lattice to cause the observed formation of fine equiaxed grains by recrystallization.

Intrinsically a fine-grained recrystallized structure appears more desirable for HAPO fuel element cores than the coarse beta-quenched structure presently in use. In view of the fact that an alpha anneal may be a beneficial addition to HAPO uranium heat treating procedures, it is recommended that the following investigations be initiated:

A. Characteristics of the Alpha Anneal

(1) Establish the relationship between time and temperature for complete grain refinement in HAPO rod and slug sections at various temperatures.

(2) Determine the effect of prior beta grain size on the equiaxed grain size obtained during alpha annealing.

(3) The mechanism for the recrystallization of the irregular shaped beta-quenched grains.

(4) Determine the effect of cooling rate after an alpha anneal on the physical and mechanical properties of uranium.

B. Effect of the Alpha Anneal on the Following Properties of Uranium

(1) Orientation

(2) Tensile strength

(3) Coefficient of thermal expansion

(4) Circumferential strain as measured by burst testing.

(5) Longitudinal splitting tendency as measured by "Woodsplitter testing."

(6) Hydrogen concentration.

H. R. Gardner

Fuel Element Development
Technical Section
ENGINEERING DEPARTMENT

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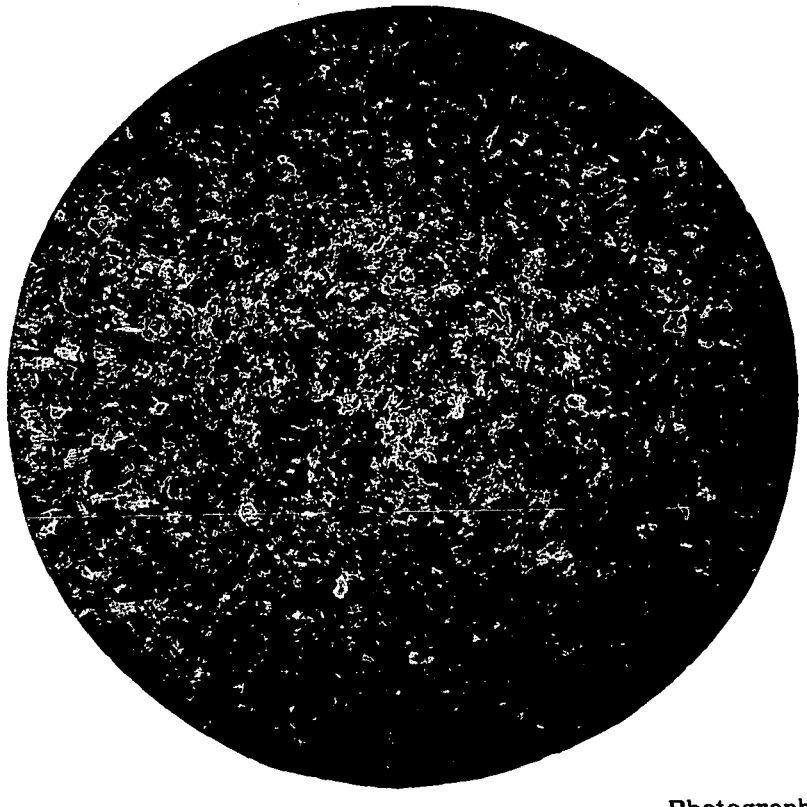

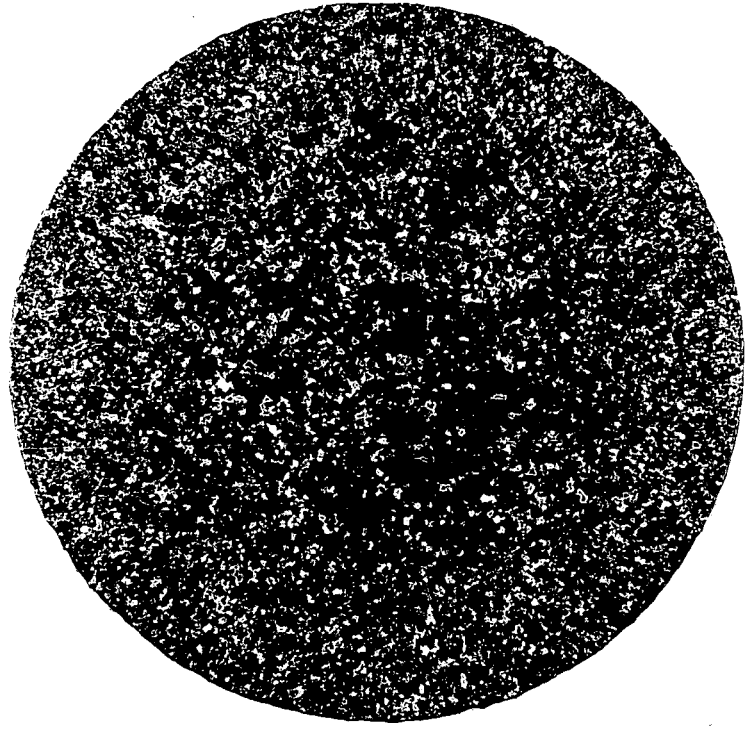

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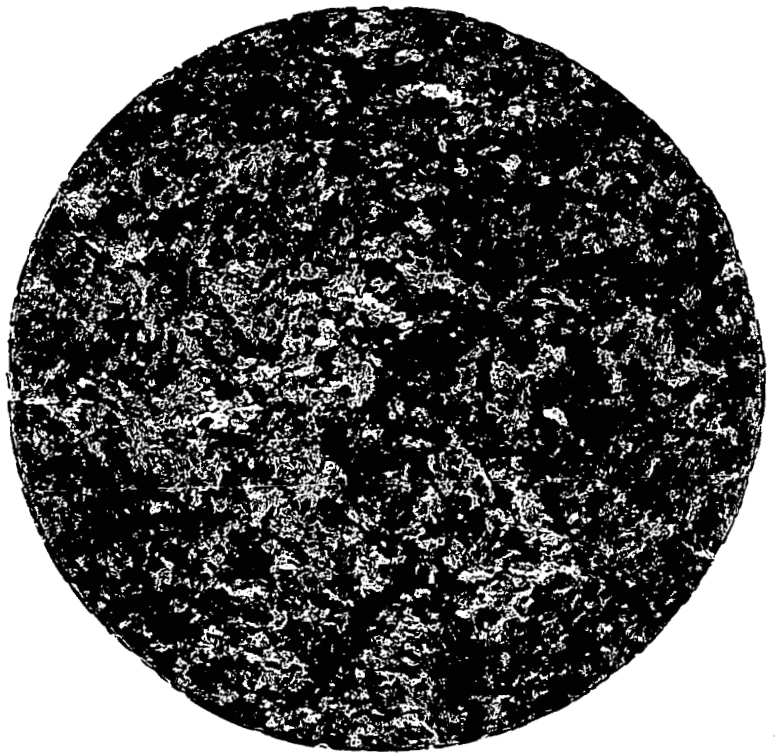
FIGURE I

Photomacrograph (3x) of transverse surface of a uranium slug machined from a rod salt bath beta heat treated for 13 minutes at 730°C and water quenched within 30 seconds after removal from the bath. Standard macroetch

FIGURE 2

Photomacrograph (3x) of transverse surface of slug in Figure 1 after an anneal at 640°C for 20 minutes. Note the much finer grain size as a result of the anneal. Standard Macroetch



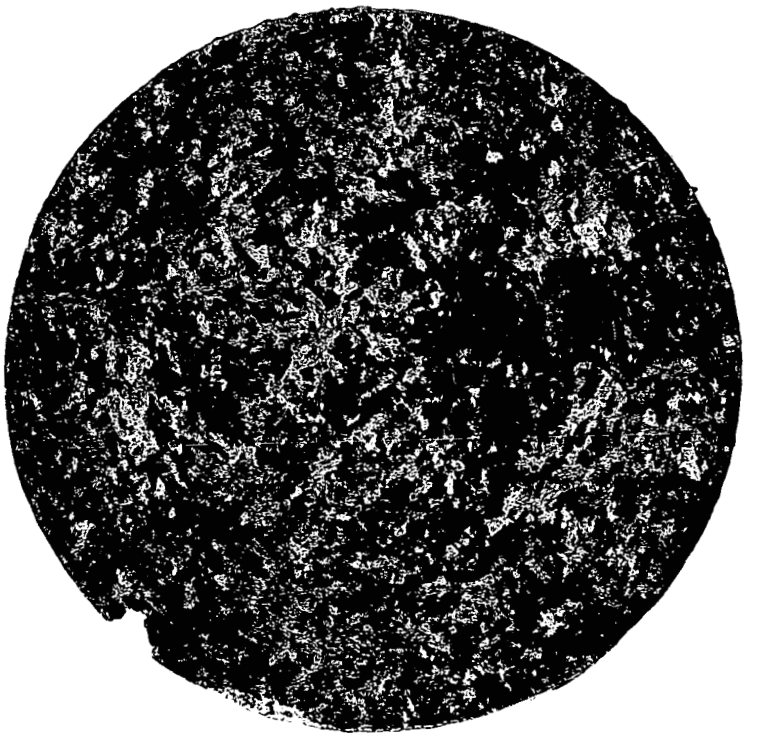


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FIGURE 3

Photomacrograph (3x) of transverse surface of a uranium slug salt bath beta heat treated for 13 minutes at 730°C and air cooled. Note contrast in grain size with Figure 1 caused by much lower cooling rate through beta to alpha transformation. Standard macroetch

FIGURE 4

Photomacrograph (3x) of transverse surface of a uranium slug in Figure 3 after an anneal at 640°C for 20 minutes. Note that the anneal does not cause any refinement of the grain structure. Standard macroetch.

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