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HIGH-DENSITY ALLOYS OF RARE EARTHS

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ABSTRACT

Studies are reported of the preparation of rare-earth metals and of the alloying properties of the rare earths with matrix metals of high density.

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HIGH-DENSITY ALLOYS OF RARE EARTHS

Since the report*) of July 10, the following alloys have been prepared:

1. Gold-Didymium

(a) 23.4% rare earths: Figures I and II. This alloy is apparently a eutectic between two compounds. ($LaAu_3$, $LaAu_2$).

(b) 3.73% rare earths: Figures III and IV. This alloy contains less of the eutectic phase than the 6.26% alloy previously reported.

(c) 2.15% rare earths: Figure V. This alloy shows a further decrease in the amount of eutectic phase as compared with (b). Relative amounts of the gold and eutectic in this alloy indicate that, if a solid solution is formed, the solubility of rare earths in gold is low.

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*) C - (MUC-FHS-61)

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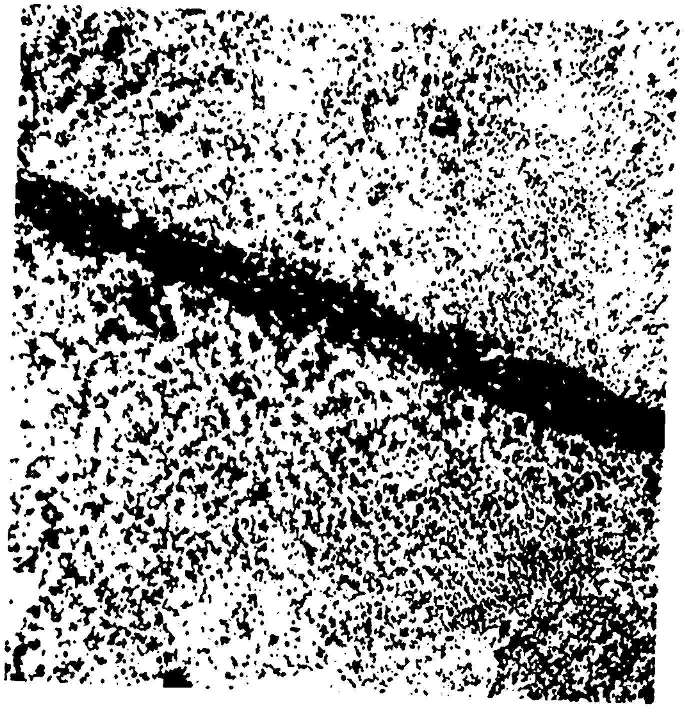

Figure I
X500
Au-Didymium, 23.4% Rare Earths

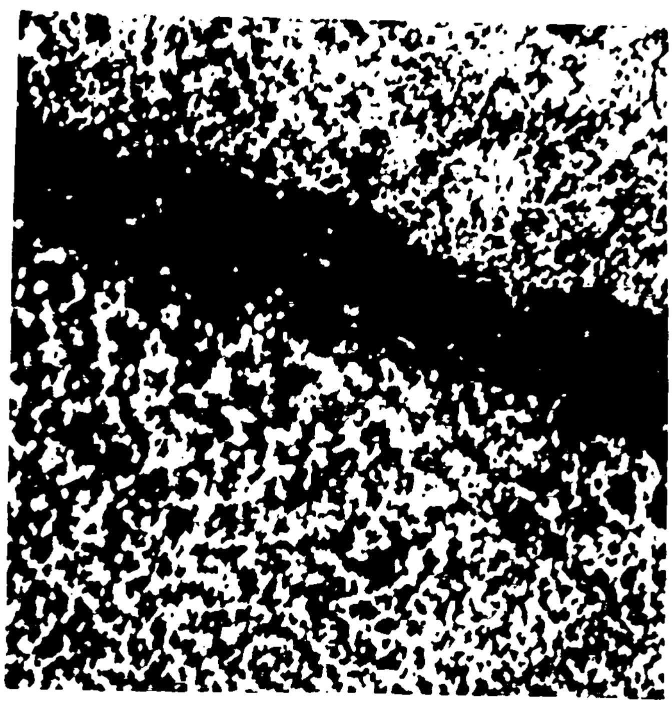

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Figure II
X1000
Au-Didymium, 23.4% Rare Earths

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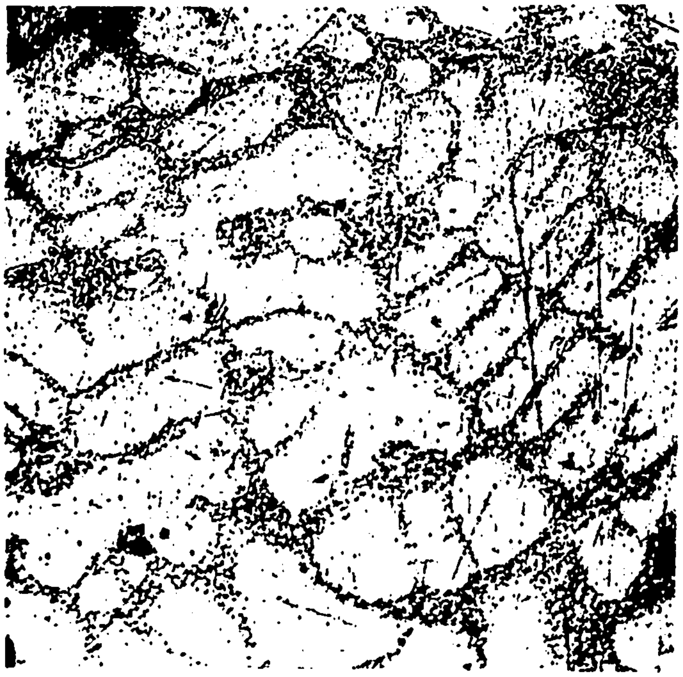

Figure III
X200
Au-Didymium, 3.73% Rare Earths

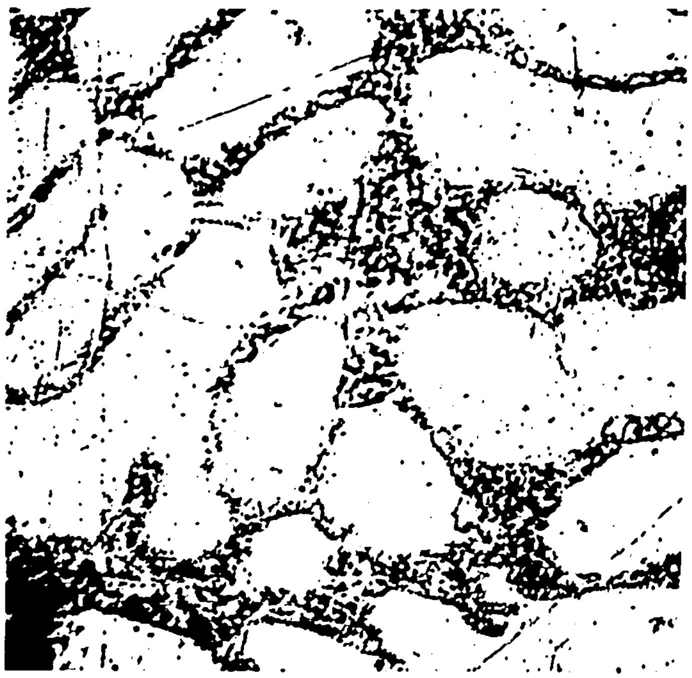

Figure IV
X500
Au-Didymium, 3.73% Rare Earths

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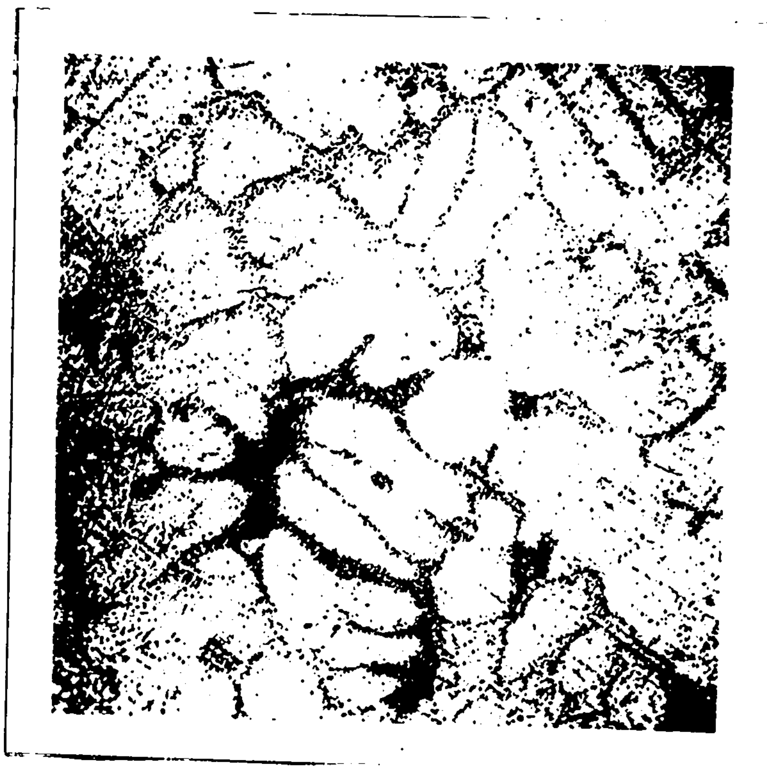

Figure V
X200
Au-Didymium, 2.15% Rare Earths

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2. Gold Mischmetal

(a) 7.48% rare earths: Figure VI. This alloy has a eutectic structure similar to that in the gold-didymium alloys, indicating that the addition of cerium to the rare earths present does not change the metallographic features of the alloy. The iron present in the mischmetal (2.6%) did not introduce additional structure.

(b) 8.74% rare earths: Figures VII and VIII. This alloy shows the eutectic plus a compound while the 7.48% (a) shows the eutectic plus the gold phase. By comparing areas covered by eutectic and gold in the 7.48% alloy and the areas covered by the eutectic and compound in the 8.74% alloy, the eutectic between gold and rare earths was estimated to contain 8% rare earths. This agrees well with the Au-La diagrams given by G. Canneri, Met. ital, 23, 803-23 (1931).

(c) 17.7% rare earths: Figure IX. This alloy contained large amounts of compound which showed a definite grain structure.

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Figure VI
X500
Au-Mischmetal, 7.48% Rare Earths

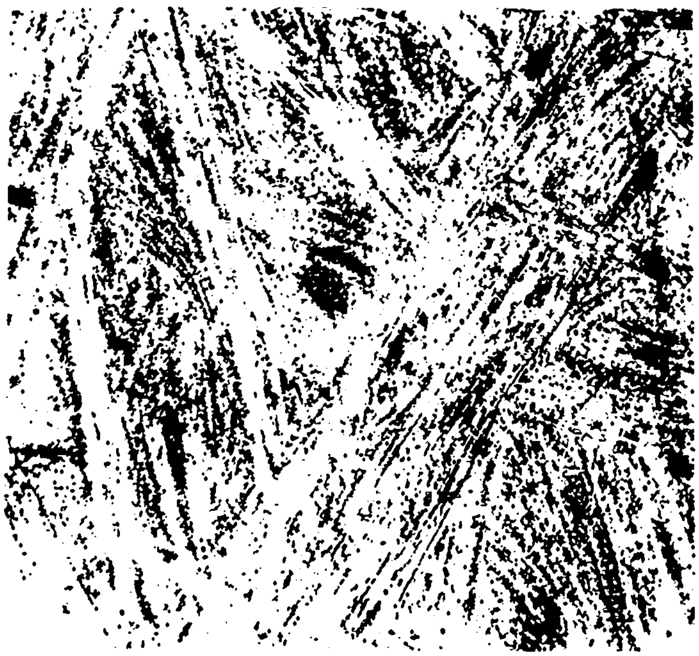

Figure VII
X100
Au-Mischmetal, 8.74% Rare Earths

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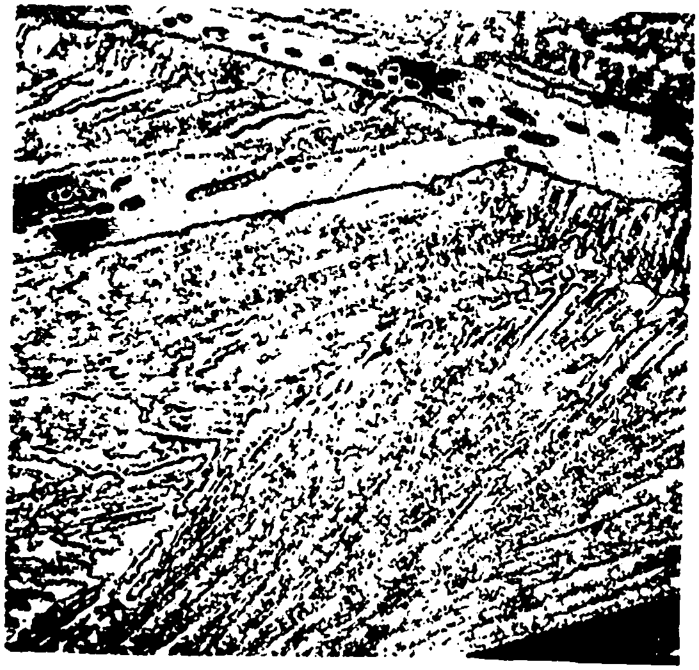

Figure VIII
X500
Au-Mischmetal, 8.74% Rare Earths

Figure IX
X500
Au-Mischmetal, 17.7% Rare Earths

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Summary and Conclusions

The preliminary investigation for the preparation of a high-density alloy, containing approximately 10% rare earth metals in a very fine and uniformly dispersed state, was divided into two phases:

(1) Study of the preparation of the rare earth metals;

(2) Study of the alloying properties of the rare earths with matrix metals of high density.

I. Preparation of the Rare Earth Metals

Attempts to produce rare earth metals by thermo-chemical reduction of the rare earth fluorides with Na, Ca, and Mg were unsuccessful. The metal produced was in a finely divided state and could not be separated from the other products. Addition of $KClO_4$ as a booster to supply additional heat for the melting of the products did not alter the results. Experiments designed to prepare lead-rare earth and uranium-rare earth alloys by the simultaneous reduction of $PbCl_2$-XF_3 and UF_4-XF_3, respectively, produced such small amounts of metallic rare earths that they were abandoned.

The electrolysis of molten anhydrous rare earth chlorides is believed by the investigators to be the method by which rare earth metals should be prepared. Some metal was produced in iron and in graphite electrolytic cells and experiments in ceramic vessels were attempted. Experimental results were so erratic that the exact conditions for production have not been determined.

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II. Rare Earth Alloys

Some alloys of rare earths with uranium, lead, gold, tantalum, and tungsten were studied. A commercially prepared mischmetal containing 2.6% Fe was used for the majority of the experiments. A small amount of laboratory prepared cerium-free, iron-free metal was used in studying some of the gold alloys.

A. Uranium - Cannot be used as a matrix metal. The solubility of the rare earths is well below one percent and apparently no intermetallic compounds are formed. Segregation of the rare earth metal indicates that solubility even in the molten state is small.

B. Lead reacts vigorously with mischmetal to form an intermetallic compound PbX_3 containing approximately 20% rare earths. This compound is insoluble in lead and does not form a eutectic with it. By rapid cooling a 6.75% alloy containing approximately one-third compound was prepared in which the dispersed compound had an average particle size of about 0.1 mm. The alloy was malleable, stable in air and had a density in air of 10.9. The investigators believe that an alloy of similar properties could be prepared containing 50% compound (10% rare earth).

C. Gold also alloys with the rare earths to form a compound, AuX_3, of approximately 20% rare earth content. The solubility of the compound in the solid gold is negligible but a eutectic containing some crystals of compound was malleable and stable in air. The investigators believe that a 10% alloy with the same properties and

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a density of about 17 could be prepared.

D. The high density of tungsten and tantalum made it necessary to consider them as matrix elements but their highly refractive nature made it impossible to prepare alloys in the molten state. Porous pieces of tantalum and of tungsten were prepared by pressing 400 mesh Ta and 200 mesh U powder into blocks. These porous pieces were impregnated by immersion in molten mischmetal. They then had metallic properties, were machinable and were stable in air. The final densities were slightly less than the density of the matrix metal.

Since tantalum and tungsten may be produced commercially in very fine form by thermo-chemical reduction (tungsten as small as 0.5 microns) the investigators believe that a study involving particle size and forming pressure would be profitable.

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