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ARF-B238-7

United States Atomic Energy Commission
Metallurgy and Materials Programs
Division of Research
Washington 25, D. C.

Attention: Dr. W. F. Sheely

Gentlemen:

Subject: Report No. ARF-B238-7 on Contract No.
AT(11-1)-578, Project Agreement No. 19
"Alloying Characteristics of the Rare Earth
Elements with the Transition Elements"

This is report ARF-B238-7 summarizing the technical progress
on the subject contract for the period January 15, 1963, to March 14, 1963.

The metallic alloying characteristics of the rare earth elements
with the transition series elements is quite variable--some systems form
many intermetallic compounds, others are completely immiscible. Laves-
type intermetallic compounds occur with regularity in those systems with
compounds. It has been previously established that the crystal structure of
Laves-type compounds, either $MgCu_2$, $MgZn_2$, or $MgNi_2$, can be correlated
with electronic valency.

The distribution of $MgCu_2$ and $MgZn_2$ Laves phases in rare
earth-transition metal alloy systems indicates that there is a valency trend
for the rare earth elements. Binary alloys that have been examined during
the initial period of the present contract verify the systematic trend of struc-
ture type that was inferred from previously available data. Ternary alloys
made between rare earth-transition metal Laves phases of different crystal
structure but with a constant transition element composition further sub-
stantiate the definite trend of valency with increasing atomic number of the
rare earth elements.

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Work is being concentrated on the determination of a consistent set of relative valencies for the rare earth elements, and from this to establish reasons for the non-occurrence of compounds in other rare earth-transition element binary systems. The principal method of investigation is the X-ray diffraction study of ternary Laves-type alloys. These studies are being augmented with pertinent binary alloys and with ternary compositions to establish the limit of Laves-type compounds.

Experimental Progress

During the past two-month period, work has been accomplished in the following areas:

1. Precision lattice parameters of the MgCu_2 and MgZn_2 type compounds have been determined on the Univac 1105 program. These will be reevaluated when the IBM 1190 program is operative.
2. Investigation of high pressure sintering techniques and induction melting of alloys in BN crucibles.
3. Identification of arc-melted, heat-treated ternary alloys.

A. High Pressure Sintering

In order to circumvent the excessive rare earth losses in arc melting, high pressure sintering techniques have been investigated. Pressures of 3000 atmospheres have been used. The attempts met with little success because of lack of suitable crucible materials and the limitation of 1000°C as a maximum sintering temperature. The rare earths that melt below this temperature were observed to remain solid as a result of the high pressures.

B. Induction Melting in Boron Nitride Crucibles

Induction melting in boron nitride crucibles was investigated as a means of producing alloys where arc melting attempts had previously failed. The compound YbCo_2 has been made by this method. There was apparently no contamination. Additional alloys to be made by this technique had to be delayed until additional boron nitride could be obtained.

Crucibles were made from BN rod $1/2$ in. in diameter. A BN plug was made for the top to prevent excessive evaporation of the rare earth metal; a small gap was left to prevent a large pressure from developing. The entire assembly is degassed at 2000°C .

C. Crystal Structure Identification

The crystal structure of the following alloy compositions has been identified since the last report period:

NdMn ₂	MgZn ₂	In both the as-cast and 800° C-annealed condition. Melted at 900° C.
HoPd ₂	}	same structure, not a Laves phase.
TbPd ₂		
DyPd ₂		
LuPt ₂	}	AuCu ₃ structure, plus another compound, no Laves phase.
LuPd ₂		
YbCo ₂	MgCu ₂	
Tm(Mn + Fe) ₂ system		
1.0 Tm + 1.6 Mn + 0.4 Fe	MgZn ₂	
1.0 Tm + 1.2 Mn + 0.8 Fe	MgZn ₂ + MgCu ₂	(MgCu ₂ predominant)
1.0 Tm + 0.4 Mn + 1.6 Fe	MgCu ₂	
Er(Cr + Mn) ₂ system		
1.0 Er + 0.8 Cr + 1.2 Mn	MgZn ₂	
(Ho + Tm)Mn ₂ system		
0.2 Ho + 0.8 Tm + 2.0 Mn	MgZn ₂	
(Er + Sm)Mn ₂ system		
0.4 Er + 0.6 Sm + 2.0 Mn	MgCu ₂	
0.6 Er + 0.4 Sm + 2.0 Mn	MgCu ₂	
0.8 Er + 0.2 Sm + 2.0 Mn	MgZn ₂	
(Er + Gd)Mn ₂ system		
0.2 Er + 0.8 Gd + 2.0 Mn	MgCu ₂	
0.4 Er + 0.6 Gd + 2.0 Mn	MgCu ₂	
(Dy + Tm)Mn ₂ system		
0.2 Dy + 0.8 Tm + 2.0 Mn	MgZn ₂	
0.4 Dy + 0.6 Tm + 2.0 Mn	MgZn ₂	

0.6 Dy + 0.4 Tm + 2.0 Mn MgZn₂

0.8 Dy + 0.2 Tm + 2.0 Mn MgCu₂

Er(Mn + Fe)₂ system

1.0 Er + 1.4 Mn + 0.6 Fe MgCu₂

Future Work

The melting and identification of both binary and ternary alloys will continue during the coming work period. The development of two IBM 7090 programs to determine precision parameters and to calculate intensities is nearing completion.

Respectfully submitted,

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