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STUDY ON SOLIDIFICATION OF IMMISIBLE ALLOYS
M-10

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Alloying of immiscible alloys under microgravity is of interest in metallurgical processes. Several experiments investigating the alloying of immiscible alloys, such as Al-In, Al-Bi, Zn-Bi and Zn-Pb, have been done in space. Homogeneous distribution of small L_2 particles in the matrix, such as an emulsion structure, was expected in the space-solidified alloys. However, the alloys demonstrated an extremely segregated structure. To date insufficient information has been obtained to explain these unexpected results. We proposed our experiment to clarify the solidification manner of immiscible alloys and to obtain fundamental information concerning structural control of the alloys. In space, density differences between the two liquids separated in immiscible regions can be neglected, so that no sedimentation of L_2 phase will take place. When the growth of the alloys is interrupted and this status is frozen by an adequate rapid cooling procedure, it will provide much information concerning decomposing homogeneous liquid and the interaction between the monotectic growth front morpohology and the distribution of L_2 phase. It is anticipated that the results will be useful for elucidating the monotectic solidification manner and it will be instructive to explain the segregated structures obtained in the past space experiments.

Equipment Functions

Separation Chamber	62 x 10h (cm)
Thickness	4.0 (mm)
Electric Field Grad.	100 V/cm Max.
	Const. Volt.
Electric Current	100 mA Max.
Buffer Flow Rate	2-10 cm/min
Sample Flow Rate	2-10 cm/min
Operating Temperatures	<5 °C (wall)
Number of Fractions	2.5 ml x 60 Max.
Detector System	Real Time Monitor
Wavelength	280 nm
Resolution	512 ch (0.1 mm)
Scale	0-1.02 OD
Sensitivity	<0.005 OD
Buffer Capacity	>1200 ml

Experiment Objectives

1. Mixing of immiscible melts of Al-In and Cu-Pb alloys by ultrasonic vibration

2. Unidirectional solidification of Al-In and Cu-Pb hyper-monotectic alloys

3. Observation of distribution of immiscible L_2 liquid phases ahead of monotectic growth front.

Expected Results

1. Techniques to obtain homogeneous liquid in melting of immiscible alloys under microgravity

2. Alloying of immiscible alloys having uniform dispersion of small unsolutionable particles

3. Separating manner of L_2 liquid in miscibility gap of monotectic system alloys

4. Interaction between monotectic growth front and separated L_2 liquid phase

5. Formation mechanism of solidification structure in monotectic and hyper-monotectic alloys

6. Production of in situ composite materials having arrayed structure under microgravity.

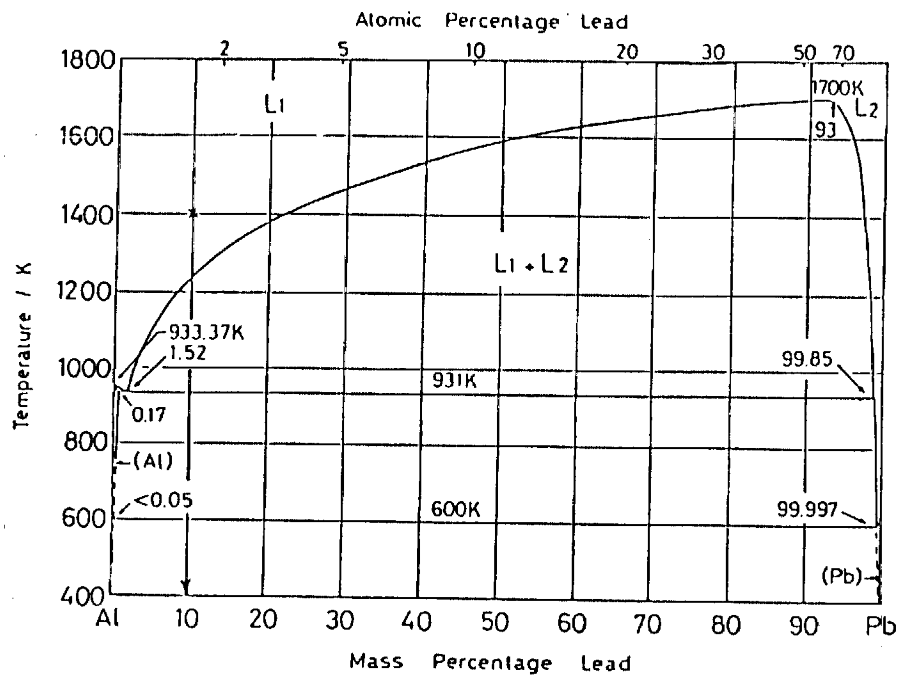


Figure 1. A1-Pb phase diagram.

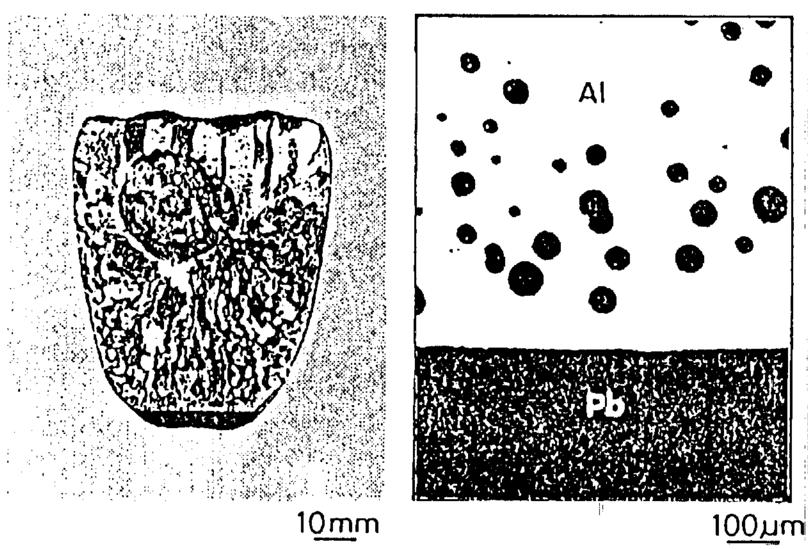


Figure 2. Macro- and microstructure showing gravity segregation in hypermonotectic A1-10 mass%Pb alloys solidified non-directionally.

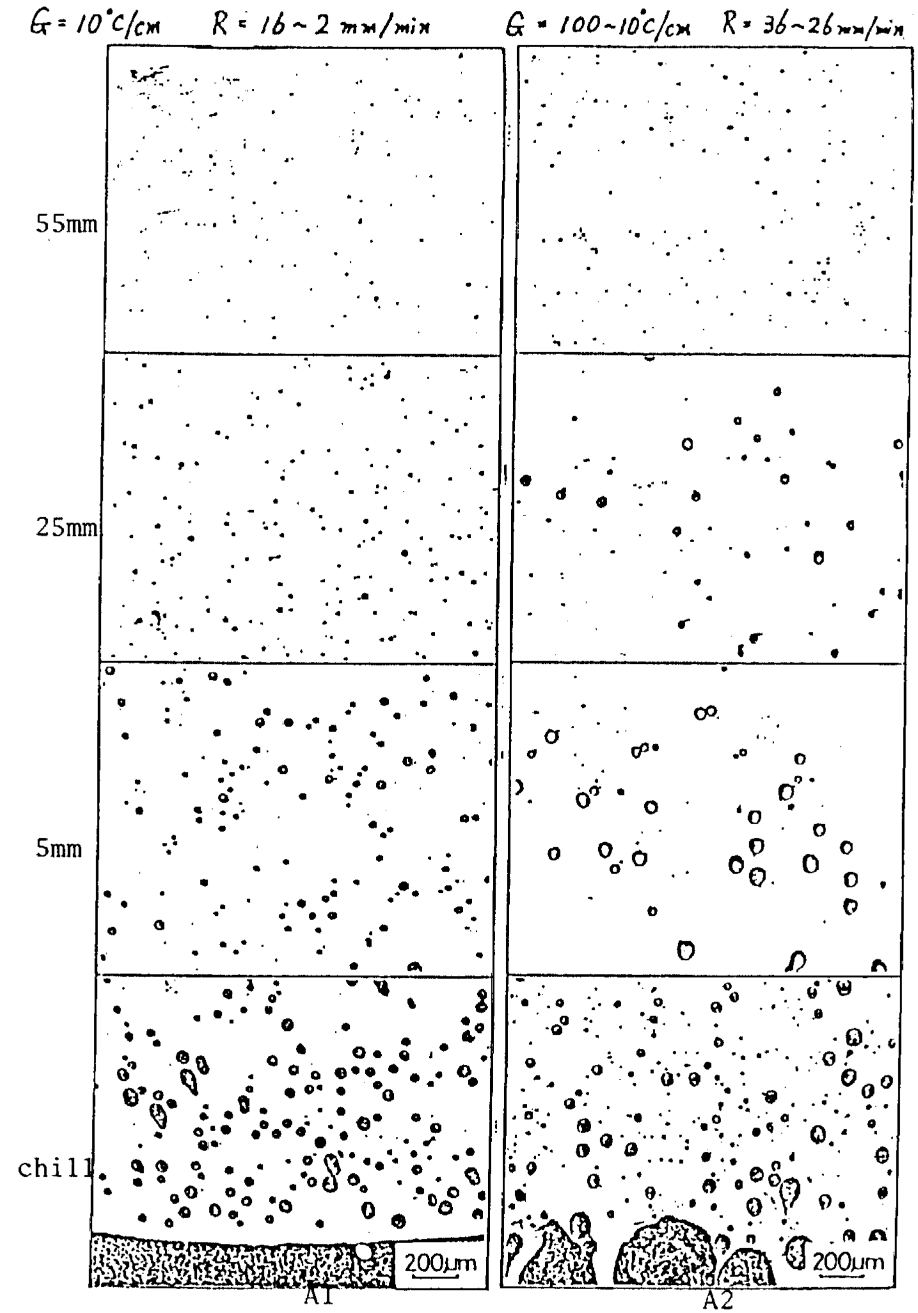


Figure 3. Microstructures of A1-10%Pb alloy solidified unidirectionally.

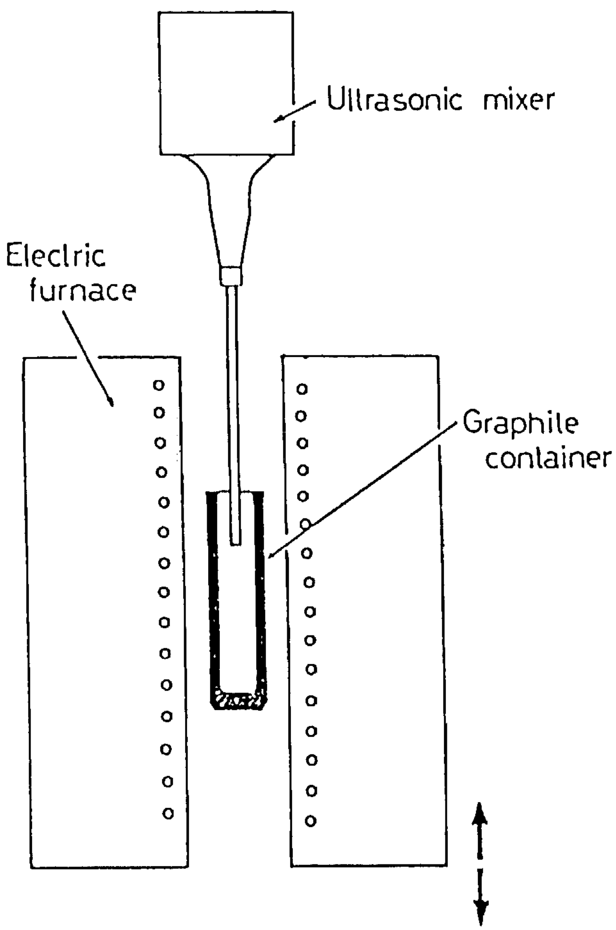


Figure 4. Apparatus for alloying under terrestrial conditions.

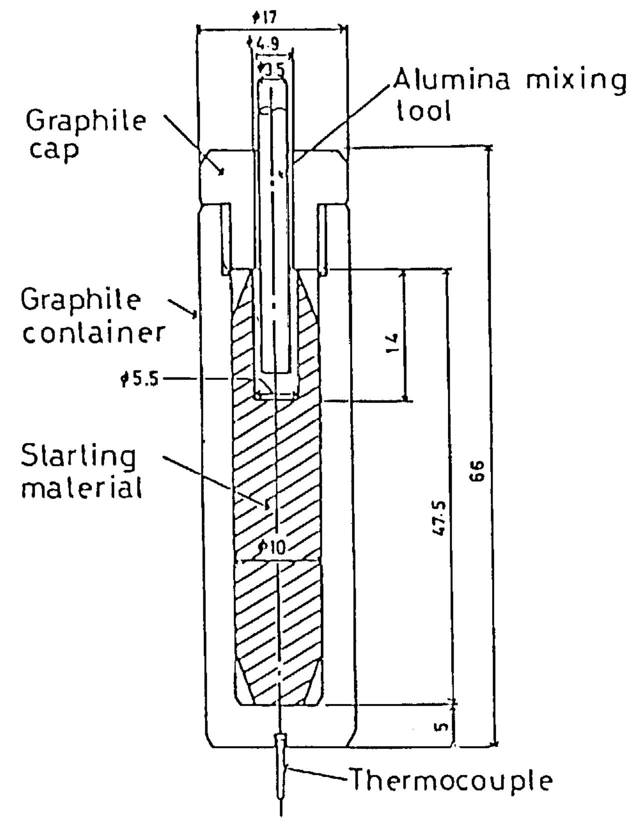


Figure 5. Dimensions of starting material and graphite container.

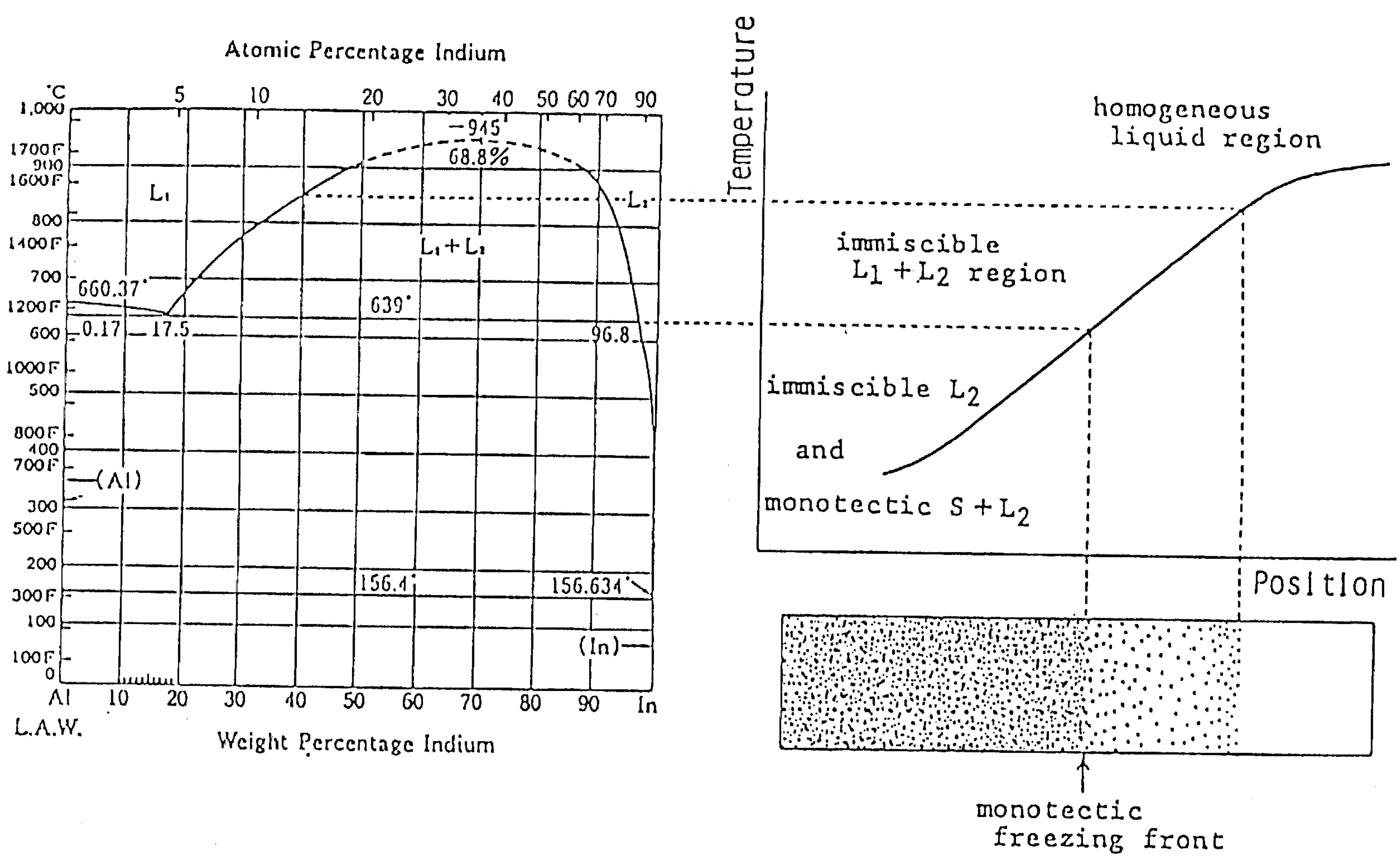


Figure 6. Unidirectional solidification of hypermonotectic A1-In alloy.

Table 1. Composition of Samples

A1-40 mass%In alloy	(ϕ 9 x 65 mm)
A1-17.5 mass%In alloy	(ϕ 4 x 67 mm)
A1-20 mass%In alloy	(ϕ 4 x 67 mm)
A1-40 mass%In alloy	(ϕ 4 x 67 mm)
Cu-36 mass%Pb alloy	(ϕ 4 x 67 mm)

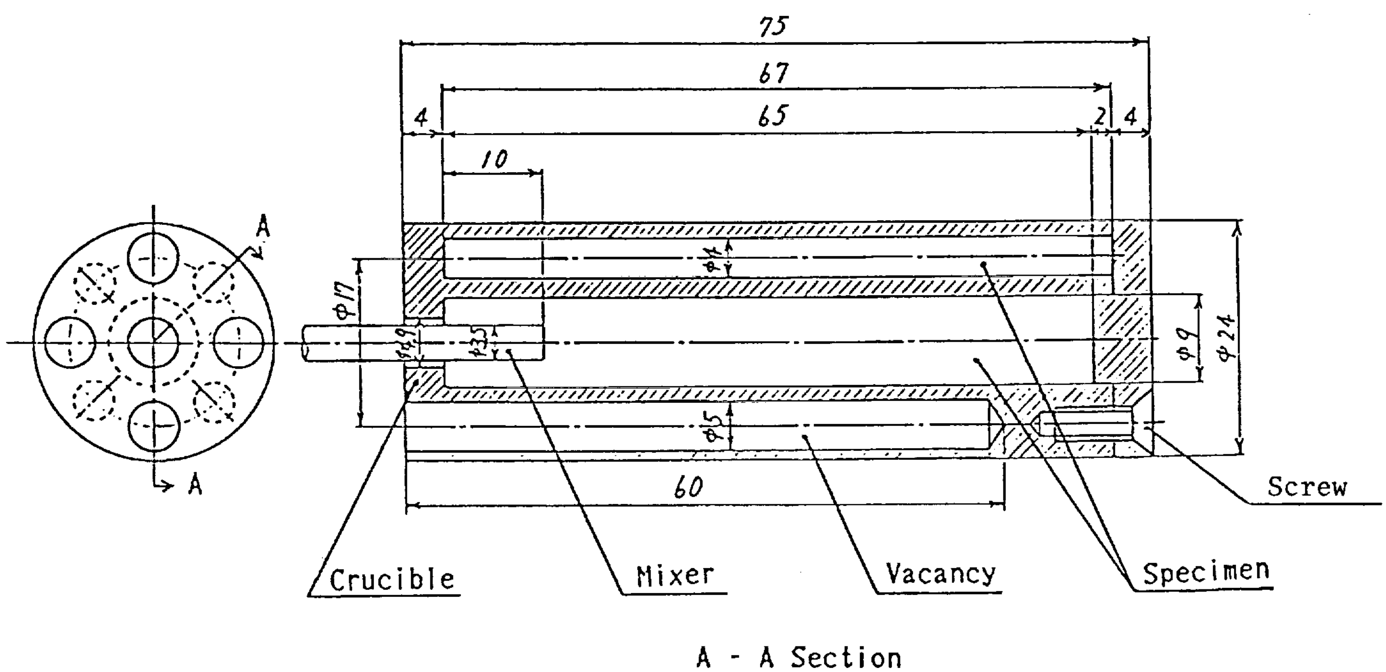


Figure 7. Specimen and crucible size.

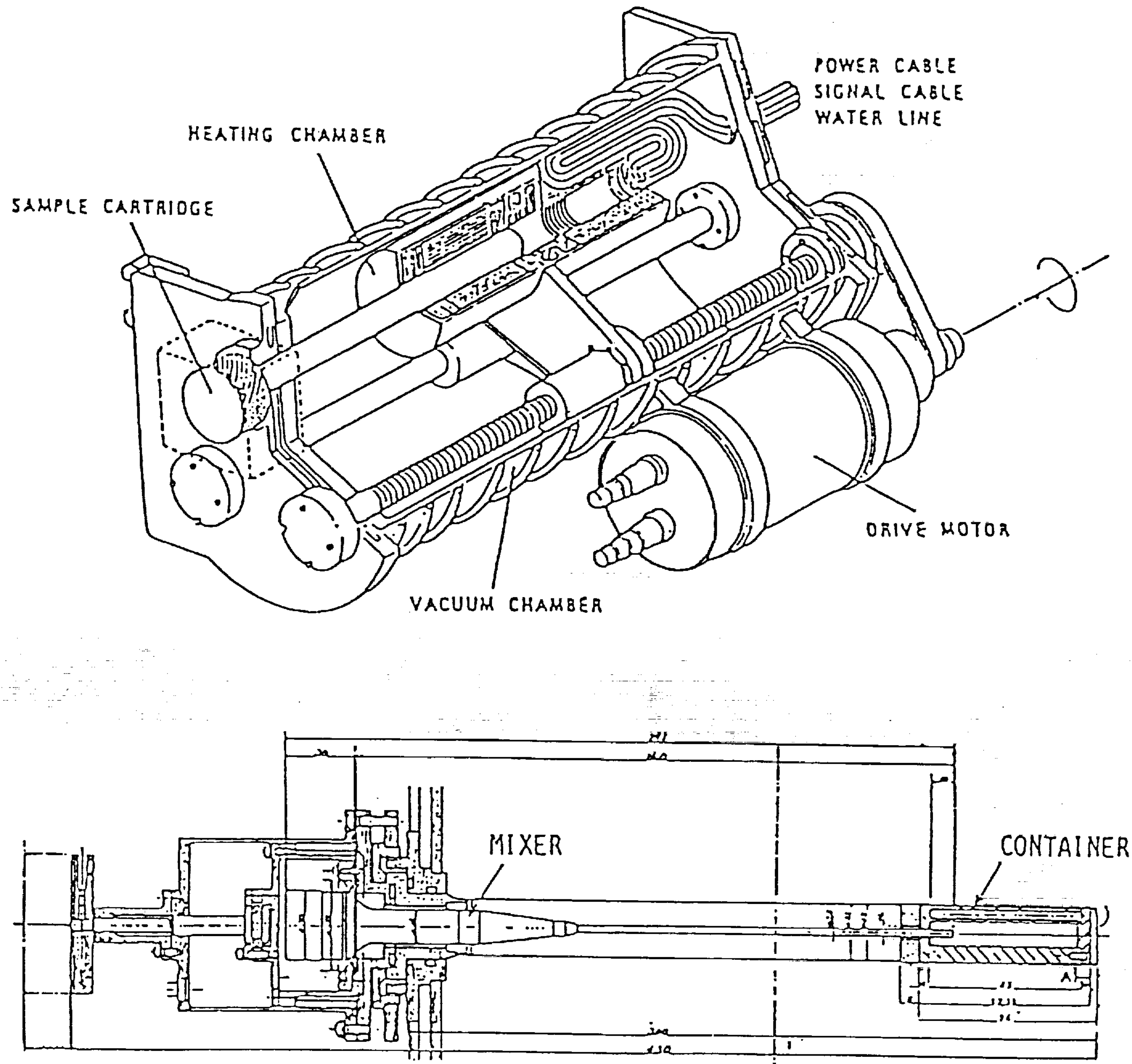
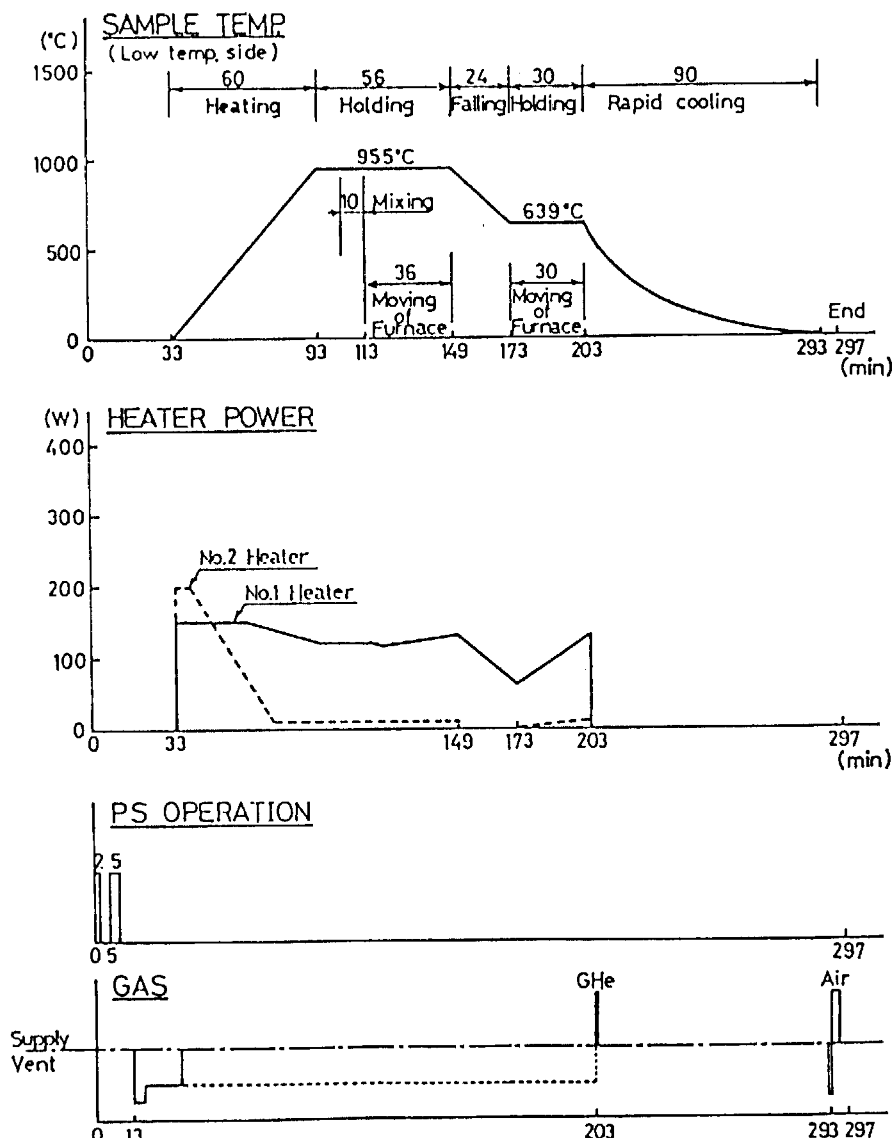


Figure 8. GHF-MP Furnace.



EXPERIMENTAL PROCEDURE

No	Sequence	Elapsed time, min.	Time, min.	remarks
1	Switching on electric souce of the equipment and preparing the experi- ment.	0	2	P.S.
2	BIT check	2	3	
3	Set of sample cartridge	5	5	P.S.
4	Furnace translation to start position	10	3	9mm/min
5	Roughly evacuating GHF	13	5	
6	Highly evacuating GHF	18	15	
7	Heating	33	60	
8	Heating and holding	93	56	
9	Mixing the molten sample	103	10	
10	Furnace Translation	113	36	50mm/h, 30mm
11	Falling of furnace temperature	149	24	
12	Heating and holding/Furnace translation	173	30	50mm/h, 25mm
13	Rapid cooling by He gas	203	90	
14	Furnace translation to start position	287	6	9mm/min
15	Evacuating GHF	293	1	
16	Filling up dry air into GHF	294	3	
17	End of the experiment	297		

EXPERIMENTAL SEQUENCE

‡ Sample cartridge is taken out of GHF after landing.

Figure 9. Experimental procedure and sequence.

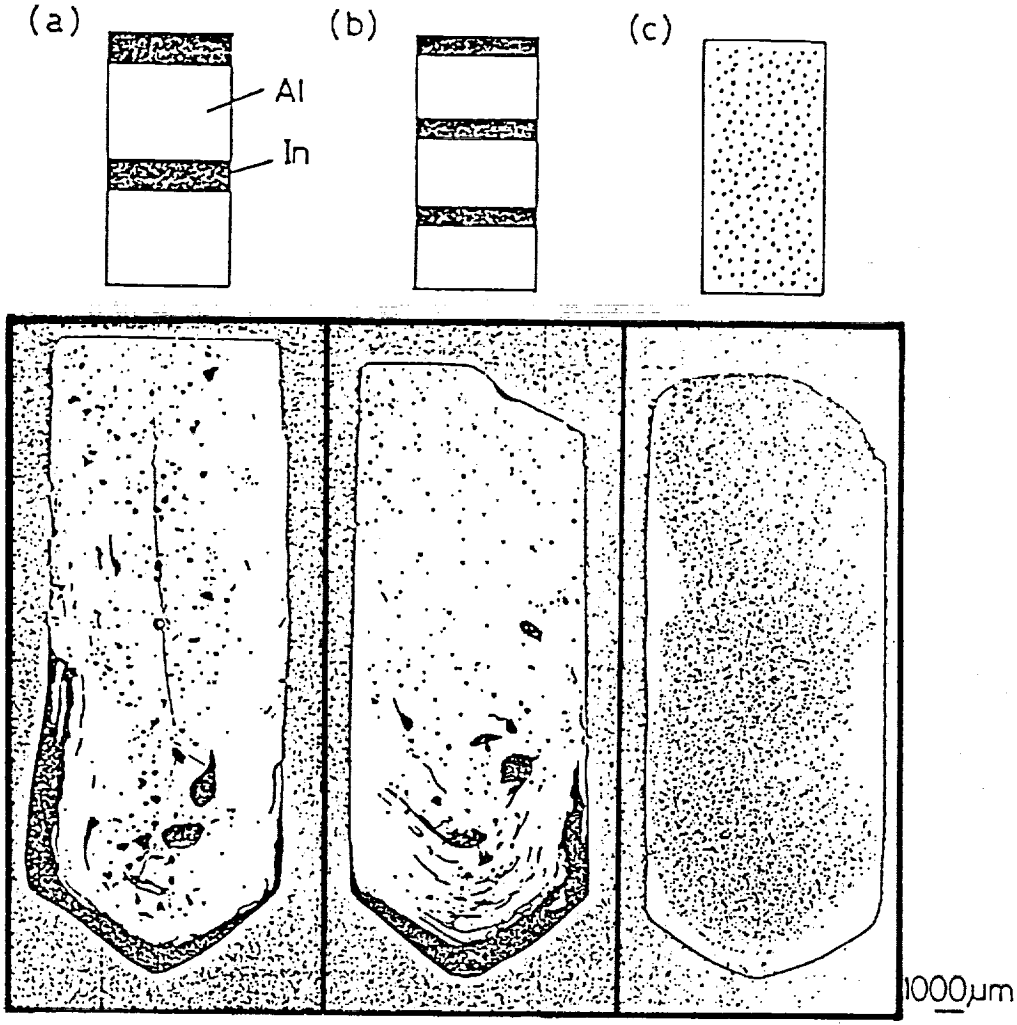


Figure 10. Influence of configuration of starting materials on alloying of Al-30 mass% In alloys under terrestrial condition.

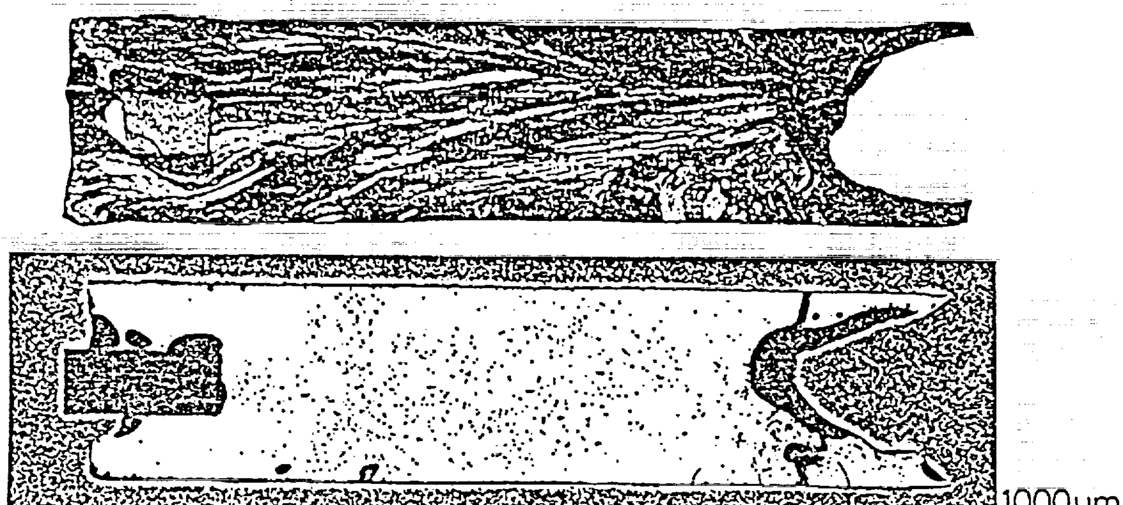


Figure 11. Macro- and microstructure of Al-30 mass% In alloy melted and solidified under microgravity condition.