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"SUMMARY OF WORK DONE PURSUANT TO PURCHASE ORDER # 3268909

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INTRAMURAL ORDER # 3268909

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49

Summary of Work Done Pursuant to Purchase Order #3268909

G. C. Kennedy, J. Ramakrishnan, and R. Boehler - UCLA

R. Grover - LLL (Technical Coordinator)

This personal services contract with Dr. George Kennedy (UCLA) was intended to be the first of two increments supporting experimental measurements under Kennedy's supervision of the $\alpha T/\alpha P$ in liquid metals and alloys of interest to theoretical physical property programs at LLL.

The status of the work at the completion of this increment is as follows:

1. Attention was shifted (from the original Cs, Li system) to the Na, K, and NaK alkali metals and alloys and to Pb and NaPb alloys. Corresponding work with Cs would have required lengthy efforts to develop a Cs handling procedure. It was found in addition that measurements on Li liquid alloys may not be meaningful due to a tendency towards immiscibility.
2. Sample preparation and handling procedures for NaK system were worked out and preliminary $\alpha T/\alpha P$ data measured at 50° C and 100° C (Appendix 1).
3. A new high temperature assembly was designed, built, and operated to make $\alpha T/\alpha P$ measurements on Pb up to 500° C and 30 kb. (Appendix 2)

It is proposed that the second increment be funded at \$20 K to accomplish the following:

1. A complete study of the liquid $Na_{1-x}K_x$ system up to 500 K and 30 kb at four compositions $x=0, 1/3, 2/3, 1$. This is to be written-up as a joint theoretical-experimental paper under the authorship of J. Ramakrishnan and R. Grover.
2. Study and development of handling procedures for carrying out $\alpha T/\alpha P$ and possibly thermal expansion measurements on the NaPb and/or pure Cs (by R. Boehler).

CONTRACT DIVISION
 PROCEDURE DEPARTMENT
 MAY 1 4 23 PM '71

Task #2 here is aimed at doing a scientific study of the NaPb and/or Ca system in the 80th fiscal year under a similar financing arrangement with LLL.

P. J. J. 4/30/79

Appendix 1 - NaK_2 Measurements

J. Ramakrishnan

Technique and Apparatus

Measurements on NaK_2 were carried out in a piston cylinder apparatus under hydrostatic conditions using pentane + iso pentane mixture as the medium. Bridgman unsupported area seals were used. Essentially the experiment consists of measuring small temperature changes (ΔT) associated with small pressure changes (ΔP).

Sodium-potassium eutectic mixture preparation posed some problems. Oxidation usually occurs on the surface which prevents the metals to mix. Samples were weighed in an argon dry box and transferred to mineral oil contained in a beaker inside the dry box. Later the beaker was heated slowly to 100°C and cooled down slowly. Around 90°C , the fluids were stirred slowly allowing them to mix. At room temperature the mixture is fluid state.

Chromel alumel thermocouples were used to measure the temperature, manganin gauge was used to monitor the pressure. Sample of NaK_2 was contained in a teflon capsule. Pressure vessel was heated by heating tapes from outside. Preliminary results of our measurements are shown in Fig. 1. This measurement has the following drawbacks.

The temperature coefficient of resistance of manganin is 1×10^{-5} and $-8 \times 10^{-5} \text{ deg}^{-1}$ over the range 5° to 100°C compared to the pressure coefficient of resistance of $2.4 \times 10^{-4} \text{ bar}^{-1}$. Even at 50°C the manganin gauge becomes very noisy and the measurement of ΔP is subjected to a large error. Further, it takes an extra long time for the system to get to higher temperatures because of the fact that the whole vessel needs to be heated.

($\Delta T / \Delta P$) $^{\circ}\text{C} / \text{Kb}$

Appendix 2 - Measurement of the Adiabatic Pressure Derivative
of Temperature $(\partial T/\partial P)_S$ of Lead up to 25 kbar and 500° C

R. Boehler

A high pressure cell has been developed that allows adiabatic measurements at both high pressures and high temperatures. This is shown in Fig. 1. The wire seal is a combination of hard fired pyrophyllite (double cone), dental cement, steel and ceramic tubing. It allows the feed through of six lead wires. (Two for the manganin wire gauge, two thermocouple wires, two copper lead wires for the heater.) The manganin gauge is used to measure both pressure and pressure change. It is isolated from the heater by a thick glass ceramic disc with low thermal conductivity. The resistance and pressure coefficient of resistance of the gauge does not change even when the cell is heated to 500° C.

The cell itself is a capsule of glass ceramic that encloses the sample which is kept in a stainless steel container. The heater is a wire wound glass ceramic sleeve. The opening for the thermocouple allows the fluid instantaneously to transmit the pressure to the sample.

Fig. 2 shows the results of the $(\partial T/\partial P)_S$ measurements. The room-temperature results are in good agreement with previous measurements.

A jump in $\partial T/\partial P$ at the freezing point at 400° C and 10 kbar is observed. At 500° C we observe increased scatter in the $\partial T/\partial P$ data because of decreasing quality of the ΔT -signal. A material has to be found with similar thermal properties of molten leads to encapsule the sample. This would slow down the heat flow and improve the shape of the ΔT signal.

High pressure - high temperature cell for
 P/T measurement
 to 30 kbars and 500°C

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