Bridgman's phase diagram[3] shows that only $\alpha$ thallium (h.c.p.) should be expected in these experiments. However, quenched $\beta$ thallium (f.c.c.) is stable at room temperature.[4] An elongated specimen selected from particles produced by pouring molten thallium into liquid nitrogen had the same characteristics as previous samples.

TABLE I. Summary of data on the effect of hydrostatic pressure on the superconducting transition of tin and thallium.[a]

| Authors | Pressure (atmos) | $\Delta T_c$ (°K) | $(\Delta T_c/\Delta P)\times 10^5$ deg atmos$^{-1}$ |
|---|---|---|---|
| | For tin | | |
| Sizoo and Onnes[b] | 95 | −0.0027 | −3 |
| | 82[c] | −0.007 | −8.6[c] |
| Alekseyevsky[d] | 21[c] | −0.001 | −5 |
| Kan, Lazarev, and Sudovstov[e] | 1730 | −0.10 | −5.8 |
| Chester and Jones[f] | 11 500 | −0.52 | −4.3 |
| | 17 500 | −0.8 | −4.5 |
| Grenier, Spöndlin, and Squire[g] | 60[c] | −0.0034 | −5.5[c] |
| Present work | <115 | | −4.9±0.5 |
| | For thallium | | |
| Kan, Lazarev, and Sudovstov[h] | 1370 | 0.008 | 0.6 |
| | 1730 | 0.025 | 1.4 |
| Chester and Jones[f] | 13 400 | −0.06 | −0.4 |
| Present work | <48 | | 1.3±0.2 |

[a] Presented at the Third International Conference on Low Temperature Physics and Chemistry, Houston, Texas, December 17, 1953.
[b] G. J. Sizoo and K. Onnes, Leiden Comm. No. 180b (1925).
[c] Hydrostatic value deduced from tensile stress.
[d] N. E. Alekseyevsky, J. Exptl. Theoret. Phys. (U.S.S.R.) 10, 746 (1940).
[e] Kan, Lazarev, and Sudovstov, Doklady Akad. Nauk. 69, 173 (1949).
[f] See reference 2.
[g] Grenier, Spöndlin, and Squire, Physica 19, 833 (1953).
[h] See reference 1.

These measurements, which will be reported in detail later, are being continued on specimens for which the crystal structure is known, using apparatus permitting appreciable increased accuracy of determination of the pressure coefficients at zero pressure.

[1] Kan, Lazarev, and Sudovstov, J. Exptl. Theoret. Phys. (U.S.S.R.) 18, 825 (1948).
[2] P. F. Chester and G. O. Jones, Phil. Mag. 44, 1281 (1953).
[3] P. W. Bridgman, Phys. Rev. 48, 893 (1935).
[4] S. Sekito, Z. Krist. 74, 189 (1930).

## Resistivity Changes in Copper, Silver, and Gold Produced by Deuteron Irradiation Near 10°K*

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PREVIOUS research[1,2] on various metals indicates that radiation damage introduced near liquid nitrogen temperature will anneal when held at the irradiation temperature. The present experiment was designed to obtain damaged specimens in which no thermally activated motion of the lattice defects occurs during irradiation.

99.97±0.02 percent pure wires of copper, silver, and gold were irradiated with 12-Mev deuterons. The wire diameters were 5 mils for the copper and silver and 4 mils for the gold. The maximum temperature during bombardment was 12°K for the first run and 16°K for the second. Even though the temperature difference was small, the resistivity *versus* deuteron flux curves for the second run all lie slightly below those of the first.

TABLE I. Radiation-induced resistivity increases, in units of $10^{-7}$ ohm cm, after a flux of $10^{17}$ deuterons/cm$^2$.

| Point | Copper | Silver | Gold |
|---|---|---|---|
| *A* extrapolating initial 12°K slope | 2.3 | 2.6 | 3.8 |
| *B* (observed 12°K value) | 1.9 | 2.0 | 3.1 |
| *C* extrapolating initial 135°K slope | 0.9 | 1.4 | 2.6 |
| *D* (observed 135°K value) | 0.6 | 1.0 | 1.9 |

If the initial slope of the resistivity *versus* flux curves was valid up to large flux, the resistivity increases produced in copper, silver, and gold after $10^{17}$ deuterons per cm$^2$ would be those given as point *A* in Table I. However a slight decrease in slope does occur, and the observed increases are those denoted as point *B*. These changes are to be compared with the point *C* and *D* values obtained[1] with 12-Mev deuteron irradiation at 135°K, where point *C* represents the values obtained by extrapolating the initial slope to a flux of $10^{17}$ deuterons/cm$^2$ and point *D* the observed values for this flux.

After bombardment the specimens were allowed to warm, first to liquid nitrogen temperature and then to room temperature. The warmup rate was between 15 and 30°C per hour. The annealing out of damage during warmup was obtained by using a similar unbombarded specimen in a Wheatstone bridge circuit[2] so that the resistivity introduced by thermal oscillations can be eliminated if the two specimens are at the same temperature. Corrections for temperature differences of specimen and dummy were obtained by comparison with warmups made before irradiation and after annealing to room temperature.

On holding for 48 hours at or slightly below the bombardment temperature, no change in resistivity (i.e., to ±0.1 percent) was observed. In copper and silver, abrupt drops in resistivity indicated that some rather unique annealing process occurred at about 40°K and 30°K, respectively. In gold no large low-temperature drops were found. The first two rows in Table II indicate the magnitude of these processes and the third gives the percentage left after annealing to liquid nitrogen. Two possible processes that may explain these abrupt recoveries are the motion of interstitial atoms, which Huntington[3] calculated would have an activation energy in the range 0.07 to 0.24 ev, or the recombination of very close interstitial-vacancy pairs as suggested previously.[1,2]

TABLE II. Percentage of initial resistivity increase remaining after annealing to various temperatures.

| Annealing temperature | Copper | Silver | Gold |
|---|---|---|---|
| 35°K | 90 | 78 | 97 |
| 45°K | 50 | 77 | 93 |
| 77°K | 41 | 69 | 86 |
| 220°K | 25 | 32 | 55 |
| 300°K | 7 | 10 | 10 |

A gradual decrease occurs in all three materials during the warmup to 220°K and then a more rapid process becomes important.[1,2] The latter process is complete at about 255°K in copper, at approximately 240°K in silver, and at roughly 285°K in gold. The percentage remaining at both 220°K and 300°K is given in Table II.

We would like to thank Dr. W. K. Jentschke and the cyclotron group as well as Dr. D. E. Mapother and the cryogenics group for aid and assistance. In addition we would like to thank Mr. Frank Witt for the cryostat design.

* This work supported by the U. S. Atomic Energy Commission.
[1] Marx, Cooper, and Henderson, Phys. Rev. 88, 106 (1952).
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## Line-Narrowing by Macroscopic Motion

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THE investigation of nuclear magnetism often demands extremely high resolution. A notable example is furnished by the structure in the groups of proton resonance lines discovered by Arnold and Packard.[1] The separation of the three components of