Superconductivity of Nb_3Sn

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Intermetallic compounds of niobium and tantalum with tin have been found. The superconducting transition temperature of Nb_3Sn at 18°K is the highest one known.

SOME intermetallic compounds crystallizing with the β-wolfram structure become superconducting, as was first pointed out by Hardy and Hulm.[1] In particular one of these, V_3Si, showed a remarkably high transition temperature between 16.9°K and 17.1°K. These authors made various attempts to raise this temperature by introducing a third component but were not successful.

The β-wolfram structure is a very peculiar structure with rather varying interatomic distances,[2] a fact which may render the addition of a third component rather difficult. It seemed therefore more favorable to look for another β-W compound with a large volume and a favorable electron/atom ratio[3] in order to raise the superconducting transition temperature. There is very little known about the systematic occurrence of intermetallic compounds in this β-W structure. The fact that thus far no niobium compounds have been reported seemed therefore not significant.

It was expected that in the Nb-Sn and Ta-Sn this crystal form would be found, an assumption which was verified. We have determined that Nb_3Sn and Ta_3Sn both crystallize in a β-W structure with a lattice constant of about 5.3A. The Ta_3Sn was measured in the apparatus previously described,[4] and became superconducting near 6°K. The transition temperature of the Nb_3Sn was determined by immersing the sample surrounded by a copper coil in liquid hydrogen. The self-inductance of the coil was measured on a General Radio Model 650A Bridge at 1 kc/sec as the sample was slowly cooled. Figure 1 shows the results for two different samples made under somewhat different conditions which were cooled from 18.5°K to 17.5°K during a period of about 30 minutes. The sharpness of the transition together with the reproducibility between samples indicates that these samples are indeed well-defined compounds. The onset of superconductivity at 18.05°K±0.1° is determined by extrapolating the line of steepest slope to the high temperature line. Temperatures were measured by a copper constantan thermocouple secured to the measuring coil and independently checked with the vapor pressure of hydrogen.

[1] G. Hardy and J. K. Hulm, Phys. Rev. **89**, 884 (1953).
[2] H. I. Wallbaum, Z. Metallkunde **31**, 362 (1939).
[3] B. T. Matthias, Phys. Rev. **92**, 874 (1953).
[4] B. T. Matthias and J. K. Hulm, Phys. Rev. **87**, 799 (1952).

APPENDIX

While the synthesis of an intermetallic compound is generally a rather straightforward process, it may be necessary to describe briefly the formation of these compounds. No reference to Nb-Sn or Ta-Sn was found in the literature. The melting point of niobium is nearly 400° above the boiling point of tin, and an arc furnace is therefore out of place. A complete reaction can, however, easily be obtained by having molten tin run over Nb or Ta powder in a closed-off quartz tube at 1200°C. Nb_3Sn and Ta_3Sn seem to be formed by a peritectic reaction between 1200°C and 1550°C.

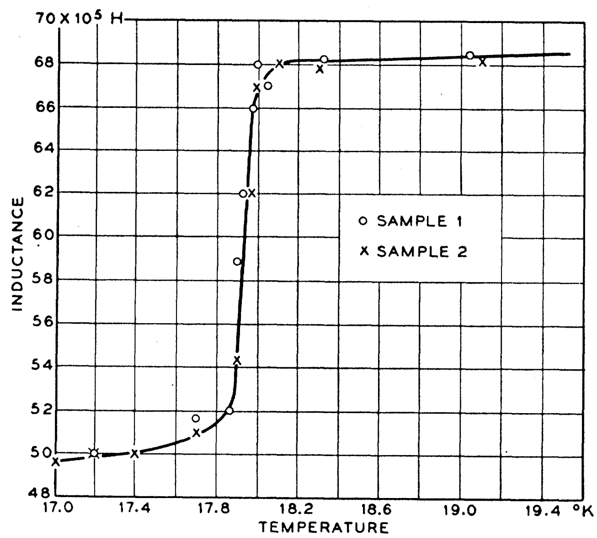

FIG. 1. Variation of susceptibility with temperature of Nb_3Sn.