POTENTIOMETRIC CIRCUIT FOR MEASURING HEAT CAPACITY BY A MODULATION METHOD

Ya. A. Kraftmakher

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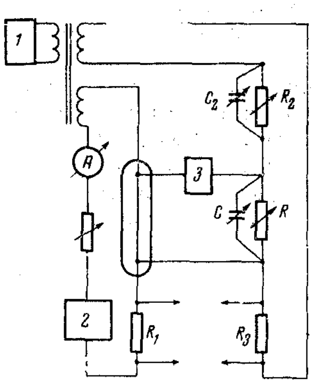
The true heat capacity of a number of metals has been measured at high temperatures by a modulation method [1], and from these results the energies of formation and the concentrations of vacancies in these metals have been determined. However, the bridge compensating circuit used for measuring heat capacity cannot be used for measurements at relatively low temperatures (below 1000° K), especially on samples with high heat conductivity. This is due to the fact that at low temperatures the influence of the cold ends of the sample is significant. In such cases the bridge compensating circuit can only be used if the samples are long enough or the leads, to which the ends of the sample are fastened, are preheated. It is more convenient to use the potentiometric circuit described below, which is a natural modification of the bridge circuit for measuring heat capacity [1].



The potentiometric circuit for measuring heat capacity is shown in the figure. The sample, in the form of a wire or tape, is heated by a current having direct and alternating components. Power is supplied to the sample via a variable rectifier (2) and a low-frequency generator (1). The potential wires isolate the central portion of the sample sufficiently far from its ends. Using selective amplifier (3), tuned to the frequency of temperature modulation of the sample, potential drops across the standard resistances R_1 and R_3 were compared. The resistance R_2 and capacity C_2 are adjusted so that the alternating current in the potentiometer circuit has the necessary amplitude and is in phase with the alternating current component supplying the sample. In this case accurate control of the phase relationship is very essential. The selective amplifier is then switched over for measurement, by the compensating method, of the resistive and reactive voltage components on the sample. Resistance R and Capacitance C are used as compensating elements. It has been shown [1] that the electrical impedance of the sample is equivalent to that of resistance R shunted by capacitance C. Thus,

$$mc = \frac{2i_0^2}{\omega^2 RC}\,\frac{dR}{dT}.$$

Here m and c are the mass and specific heat of the sample i_0 and ω are the direct current component and the frequency of the alternating current component supplying the sample, and T is the temperature. The heat capacity of the sample can be determined from this relationship from the values of R and C corresponding to the balance point of the potentiometer. As in the case of the bridge compensating circuit, the conditions at balance do not depend on the amplitude of the alternating current component supplying the sample. The balance point is indicated on a cathode-ray oscilloscope, to which the output voltage from the selective amplifier is fed. Using the method of Lissajou figures, by setting up a suitable phase shift between the voltages supplied to the oscilloscope, equilibration of the resistive and reactive voltage components can be carried out separately and the measurements completed more quickly. In-phase detection can also be used.

The circuit described above was checked by measuring the heat capacities of tungsten and platinum at high temperatures. The results agreed with those obtained using the bridge circuit. The heat capacity of gold at temperatures from 700–1300° K was also measured using the potentiometric circuit, making it possible to determine the energy of formation and concentration of vacancies in this metal [2].

REFERENCES

1. Ya. A. Kraftmakher, "The modulation method of determining heat capacity," PMTF, no. 5, 1962.

2. Ya. A. Kraftmakher and P. G. Strelkov, "The energy of formation and concentration of vacancies in gold," Fizika tverdov tela, vol. 8, no. 2, 1966.

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