USE OF AN ELECTROMAGNETIC "CRUCIBLE" FOR MEASURING THE ENTHALPY OF METALS

V. Ya. Chekhovskoi and B. Ya. Berezin

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The possibility of using the electromagnetic levitation of metals when studying enthalpy by the method of mixing is demonstrated.

The method of electromagnetic levitation has recently become more and more widely employed in experimental research work, principally in connection with the production of alloys from metals which are chemically active at high temperatures, and also when studying the kinetic characteristics of the interaction of molten metals with gases [1].

It has been proposed [2] that electromagnetic levitation should also be employed in using the method of mixtures to measure the enthalpy and specific heat of chemically active and (particularly) refractory metals in the solid and liquid states. This procedure obviates the necessity of using ampules, crucibles, suspensions, etc., so that highly-purified samples may be studied without danger of contamination during the measurements. The experimental apparatus required was described in [3].

In order to verify the suitability of the method, and also the efficiency of the apparatus, a series of measurements was made to determine the enthalpy of molybdenum, which has been recommended as a standard in high-temperature calorimetry [4, 5]. The samples were heated and held in a suspended state in an inductor supplied with alternating current at a frequency of 66 kHz. The enthalpy of molybdenum was studied at 2094-2684°K. The proportion of molybdenum in the original samples was 99.99-99.97 wt. %. The weight of the samples employed was between 6 and 10 g.

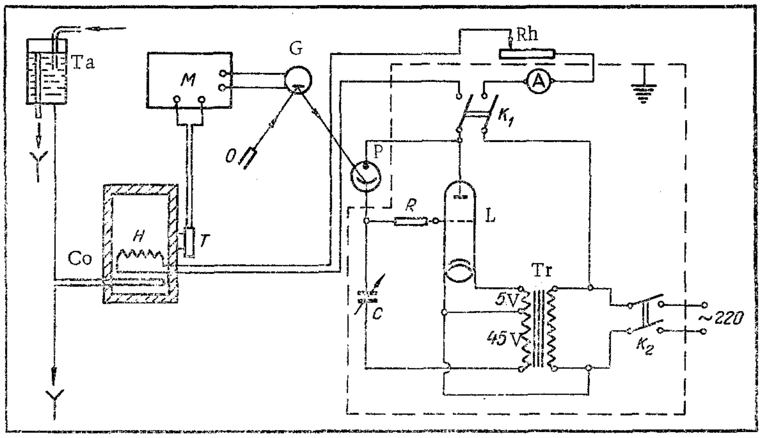

Fig. 1. Arrangement for thermostating the calorimeter [Tr) transformer; L) TG2, 5-1/4 thyratron; R) a 20 kΩ resistance; c) variable capacity, 500 pF; P) TsG-4 photocell; Rh) rheostat; A) ammeter; G) M17/5 galvanometer; M) MOD-54 bridge; T) KMT-4 thermistor; H) heater; Co) cooling system; Ta) tank (pressure head)].

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TABLE 1. Experimental Values of the Mean Specific Heat of Molybdenum

T, °K	$\bar{c}_p$, J/kg·deg	Medium	T, °K	$\bar{c}_p$, J/kg·deg	Medium
2094	313,80	Argon	2286	318,19	Vacuum
2147	315,06	Argon	2344	317,86	The same
2231	316,98	Vacuum	2350	320,70	"
2235	317,78	The same	2381	320,70	"
2253	319,11	"	2388	325,31	Argon
2258	320,49	"	2487	329,70	Vacuum
2263	319,91	"	2604	332,25	The same
2265	317,69	"	2684	339,78	"

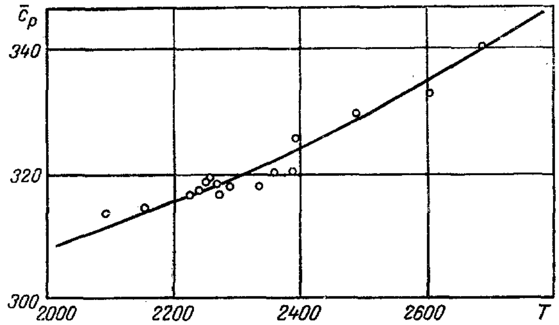

Fig. 2. Dependence of the mean specific heat of molybdenum on temperature ($\bar{c}_p$, J/kg · deg; T, °K). Curve: as recommended in [8, 9]; points: experimental data.

The temperature of the heated samples was measured with a vanishing-filament optical pyrometer of the ÉOP-51 type. The pyrometer was sighted on the model of an absolute black body which had been created in the sample by drilling a cylindrical depression of appropriate dimensions. In all the experiments a stable position of the samples in the inductor was achieved; hence the model of the absolute black body always "emitted" vertically upward, so allowing the optical pyrometer to be used in the proper manner.

The heat content of the samples was measured in a massive copper calorimeter with an isothermal sheath. The temperature of the latter was kept constant to an error of ±0.0002°C by means of a photothyratron regulator of the proportional type, the arrangement of which is illustrated in Fig. 1. The operating principles of the photorelay and thyratron were described in [6, 7]. In the present investigation the sensor for testing the temperature of the oil thermostat surrounding the calorimeter sheath was a KMT-4 thermistor with a nominal resistance of about 20 kΩ at room temperature. The anode current of the thyratron L passes through the heater of the thermostat H. The anode current depends on the illumination of the cathode of the photocell P. The galvanometer G is connected to the measuring diagonal of the four-arm bridge M, three arms being constant and the fourth, the thermistor, varying with temperature. Any disbalance of the bridge causes the light spot of the galvanometer to move relative to the cathode of the photocell P, and this causes a proportional change in the anode current of the thyratron passing through the heater H. The high sensitivity of this arrangement to temperature variations depends on the large temperature coefficient of resistance of the thermistor: 4.5-6%/deg [7].

The rise in calorimeter temperature was measured with a low-inertia copper resistance thermometer of original construction. The experiments were carried out both in a vacuum of the order of 10^{-5} mm Hg and in pure argon (type A) with an excess pressure of 0.05-0.10 atm.

The experimental results as to the mean specific heat of molybdenum are presented in Table 1. In Fig. 2 these are compared with the mean specific heats of molybdenum recommended in [8, 9]. The results of the experiments carried out in vacuum and in argon agree with each other within the limits of experimental error. The maximum scatter of the points is no greater than ±1%, and twice the mean square deviation of these relative to the data presented in [8, 9] (calculated according to the recommendations of [10]) approximately equals ±0.2%.

NOTATION

$\bar{c}_p$ is the mean specific heat at constant pressure (reckoned from 273.15°K);
T is the temperature, °K.

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