

MEASUREMENT OF HYDROSTATIC PRESSURE UP TO 100 kbar BY A MANGANIN RESISTANCE DETECTOR

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UDC 532.11

A method of producing a hydrostatic pressure up to 100 kbar is described, and the method of measuring it by means of a manganin resistance detector is presented.

In this article we present a method similar to that in [1] which permits taking electrical measurements under room temperature conditions at a hydrostatic pressure up to 100 kbar. The method amounts to calibrating a manganin detector with respect to pressure by simultaneous measurement of its resistance and the resistance of reference metals undergoing polymorphic transformations at known temperatures.

The cylindrical ampule with a 1 mm wall thickness, having an initial useful volume of 0.7 cm^3 (Fig. 1a), consists of two metal covers 1 tightly fitted on a shaped Teflon tube 2, along the diameter of which are holes for six electrical leads 3; the covers serve as an additional pair of contacts. Spirals of Ba and Bi wires of 0.4 and 0.2 mm diameter, respectively, are soldered by Wood's alloys to copper wires as depicted in Fig. 1b; the six leads provide each of the spirals with two pairs of contacts. The manganin coil 4 (Fig. 1a) is soldered to the covers of the ampule, which contact the measuring wires via the pistons of the high-pressure chamber. The effect of contact resistance in this case is small, since the measurements are accomplished from the moment of establishing a reliable contact, i.e., when the resistance of the circuit becomes practically equal to the resistance of the coil measured outside the chamber. The resistance of manganin is measured by a dc bridge with an accuracy to 0.01Ω . The resistances of the investigated specimens are measured by the potentiometric method with simultaneous output of the data to the recorder tape.

The liquid-filled ampule in an assembled form is placed in a pyrophyllite container, which is charged into the high-pressure chamber. Upon an increase of the load, the walls of the ampule, experiencing the same pressure on both sides, work as a self-sealing seal; i.e., the effectiveness of sealing increases with pressure.

Benzene B-70 was selected as the working liquid. Despite the appreciable increase of viscosity with increase of pressure, even to solidification, the relaxation time of the stresses in benzene, if we judge by the change of resistance of manganin at constant loads, is measured in minutes at 95-100 kbar. If we take into account that this

phenomenon includes relaxation processes in plastically deformed pyrophyllite [2], then the properties of benzene as a hydrostatic medium are completely acceptable. The absence of shear stresses in such a medium is indirectly confirmed by aging of manganin alloy, which makes it possible to do away with traditional annealing for many days. Within the measurement accuracy of about 0.01Ω , the resistance of the manganin coil remains constant when the pressure is removed in further experiments. Finally, the results of auxiliary experiments with a NaCl single crystal indicate hydrostatic conditions. Optical investigations did not reveal residual stresses in the crystal after removing the pressure.

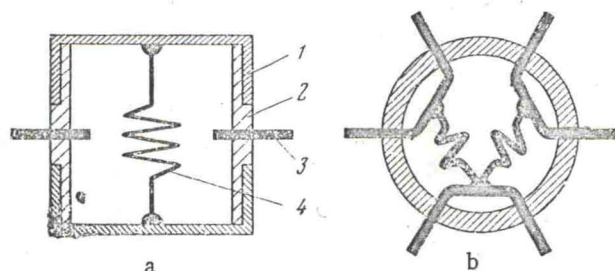


Fig. 1. a) High-pressure vessel with manganin coil; b) diagram of connecting the Ba and Bi specimens to the leads.

Institute of High-Pressure Physics, Academy of Sciences of the USSR. Translated from *Priroda i Tekhnika Éksperimenta*, No. 4, pp. 218-219, July-August, 1970. Original article submitted February 25, 1970.

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The manganin detector was calibrated in the following order. The coil of 0.05-mm-diam wire with an initial resistance of about 100 Ω , which was preliminarily subjected to a high pressure, was calibrated in a device with a free piston to a pressure of 15 kbar, after which we determined the dependence

$$P = A (\Delta R/R_0) + B (\Delta R/R_0)^2.$$

Then followed measurements at high pressure in the manner described. A comparison of the resistance of the coil with the recorded transitions in Bi (25.4 and 89.3 kbar) and Ba (59 kbar) made it possible to determine the constants in the equation

$$P = A (\Delta R/R_0) + B (\Delta R/R_0)^2 + C (\Delta R/R_0)^3.$$

For the investigated detector $A = 449.9$, $B = -812.6$, $C = 8796.8$. Thus, from the resistance of the detector we can determine the pressure in further experiments in the range from several hundred bar to 100 kbar. The sensitivity of the detector is determined by the measurement accuracy and amounts to about 40 bar.

The manganin pressure gauge is a quite reliable and accurate indicator of high hydrostatic pressure. The described method of its calibration permits using any of the existing pressure scales; however, it gives rise to errors in estimates of the absolute pressure values owing to indeterminacy of the reference points themselves. Another possible method [3] provides for calibration against points recorded by precise measurements up to a pressure of about 25-30 kbar with subsequent extrapolation of the dependence found to the high-pressure region; it is obvious that extrapolation from 30 to 100 kbar is not sufficiently correct either.

In conclusion the authors thank M. A. Il'in for help in conducting the electrical measurements.

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