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FOREIGN TECHNOLOGY DIVISION

AN AUTOMATIC DILATOMETER

by

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AN AUTOMATIC DILATOMETER

By: M. Ye. Gurevich and L. N. Larikov

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13. ABSTRACT

A new and improved form of dilatometer for automatically measuring and recording small changes in dimensions over a wide temperature range is described. The normal working range is 77-1400 degrees K, and special measures are incorporated to prevent damage by extreme heat and cold. The associated electronic circuits are of a high degree of reliability and reasonably simple in construction. Some examples of the use of this instrument in determining the coefi. of linear expansion of superpurity Ni are presented. [AT1002982]

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Nickel Thermal Expansion Ultrahigh Purity Metal Metallographic Analysis Physics Laboratory Instrument						

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All figures, graphs, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

Translator's note: On several occasions, symbols found in formulae and calculations appear to have been rendered incorrectly in the original document. They will be shown exactly as they appear in the original.

U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

AN AUTOMATIC DILATOMETER

M. Ye. Gurevich and L. N. Larikov

The problem of the determination of the true thermal linear expansion coefficient (α) in a wide temperature range is of considerable interest [1, 2]. At the present time, the determination of α is done by the analytical treatment of the results of measurements obtained by means of dilatometers or other instruments which determine the variation of the linear dimensions of the sample with the temperature change. Such a treatment requires a considerable amount of time on the part of the experimenter. In processing the dilatometric curve, which expresses function $\frac{\Delta l}{l} = f(T)$, a sufficiently significant calculated interval is selected by the graphic differentiation method, while the function, in most cases, is approximated. The reduction of the discrete interval for the calculations involves additional expenditures of time and an increase in the requirements for quality in registering the temperature dependence of the change in linear dimensions. This is due to the fact that the average linear expansion coefficient is usually used during the designing. However, the requirements of many areas of new technology advocate the need for a sufficiently strict knowledge of α for a wide temperature range.

Significant difficulties in determining the true linear expansion coefficient value lie in the necessity of accounting for the distortions introduced due to the variation in the coefficient of linear expansion of the parts of the measuring device in contact with a sample, while for a device where there are no such contacts there are other errors connected, for example, with the parallax in the optical systems, and so on. These errors must be considered in processing the measurement results.

The Institute of Metal Physics of the Academy of Sciences of the Ukrainian SSR has developed and built an automatic dilatometer AD-3 (Fig. 1), which measures and records the temperature function of the true thermal expansion coefficient over a wide temperature range (-196 to +1100°C) [3].

Fig. 1. General view of installation AD-3.

Determination of function $\frac{1}{l_0}\left(\frac{dl}{dT}\right) = \alpha(T)$ is conducted by means of the automatic functional conversion of voltage, which simulates the change in linear dimensions of the sample. The elongation of a sample which is heated or cooled at a constant rate is measured by a highly sensitive $\left(\frac{\Delta l}{l} < 10^{-4}\right)$ electronic dilatometer, which converts the change in the linear dimensions into voltage or current oscillations. Thus, determination of the linear expansion coefficient is reduced to the operational computation of the rate of change in the dimension of sample. The use of analog-to-digital differentiator facilitates functional conversion even when the rate of expansion (compression) of the sample is small.[1]

To determine the true value of α, the correction method based on the continuous automatic input of correction immediately during the experiment has been used. The temperature function of the linear expansion of the dilatometer parts, having value in this respect, is premeasured on the same instrument, simulated by means of a functional potentiometer, and is introduced into the summing circuit synchronously with the measured value. In this case, the correction value is reduced to the same scale as the value of linear expansion.

The functional diagram of the instrument is given in Fig. 2. Tested sample 1 is placed into thermostat 2. The maintenance of the thermal condition of the experiment (heating or cooling according to the program given earlier, isothermal holdings, etc.) is accomplished by means of control unit 3, which includes temperature measuring device and program assigning and controlling equipment. The change in dimensions of the sample is transmitted by a pusher to the displacement meter 4. From the displacement meter the voltage, which simulates the changes in linear dimensions together with the voltage produced in correction unit 6 and simulating the temperature function of errors, is fed to the input of adder circuit 5. After algebraic addition in unit 5 the voltage, proportional to the "true" change in dimension of the sample, is fed to the functional converter 7, and from the output of the converter – to the input of the two-coordinate electronic potentiometer 8, also fed to which is the signal concerning the temperature change of the sample.

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[1]The analog differentiator, the use of which enabled us to obtain identical results, was also tested; however, such device has a number of deficiencies (high sensitivity to external influences, the need for precision equipment, etc.).

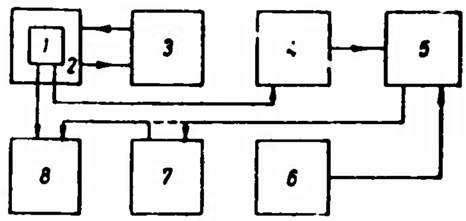

Fig. 2. Functional diagram of installation AD-3.

Thus, instrument AD-3 enabled us to study the quantitative regularities of thermal expansion of the materials and their linear expansion coefficient, and in cases when there is no anisotropy — the magnitude and distribution of volume effects and the volumetric expansion coefficient.

Furthermore, an automatic dilatometer allows us to determine the rates of the processes, connected with the change in dimensions of the sample (phase transformations and others) under isothermal conditions or with temperature variation. In the latter case, a second sample is added (the standard), which together with the investigated sample forms the differential circuit for measuring linear elongations.

Nickel samples of high purity were measured on the automatic dilatometer AD-3. Figure 3 gives the temperature function of linear expansion of the nickel $\left(\frac{\Delta l}{l_0} = f(T)\right)$. As seen from the figure the result obtained on instrument AD-3 is in good agreement with the most reliable literature data, obtained by the interference methods [1]. The instrument very clearly fixes the value and nature of the slight effect of the intermittent variation in the true linear expansion coefficient at the Curie point. The result of the determination of true linear expansion coefficient of nickel (in the same sample) is given in Fig. 4. This result also agrees well with the values of α obtained by the same authors [1] using the calculation method by measuring the length of the sample at various temperatures.

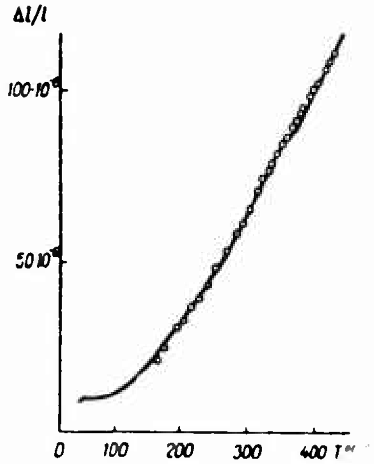

Fig. 3. Change in the linear expansion of nickel as a function of temperature: the points – according to the data of work [1]; the line was obtained on instrument AD-3.

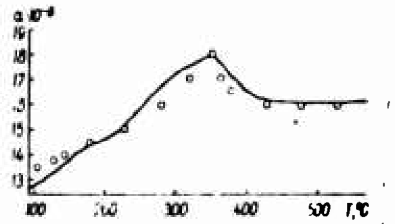

Fig. 4. Thermal linear expansion coefficient of nickel as a function of temperature: the points – according to the data of work [1]; the line was obtained on instrument AD-3.

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